
Numerical Aerodynamic Simulation Program Long Haul Communications Prototype

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NUMERICAL AERODYNAMIC SIMULATION PROGRAM LONG HAUL COMMUNICATIONS PROTOTYPE

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SUMMARY

This document is a report of the Numerical Aerodynamic Simulation (NAS) Long Haul Communications Prototype (LHCP). It describes the accomplishments of the LHCP group, presents the results from all LHCP experiments and testing activities, makes recommendations for present and future LHC activities, and evaluates the remote workstation accesses from Langley Research Center, Lewis Research Center, and Colorado State University to Ames Research Center. The report is the final effort of the Long Haul (Wideband) Communications Prototype Plan (PT-1133-02-N00), 3 October 1985, which defined the requirements for the development, test, and operation of the LHCP network and was the plan used to evaluate the remote user bandwidth requirements for the Numerical Aerodynamic Simulation Processing System Network.

1. INTRODUCTION

This report consists of four sections and six appendixes. A short description of each follows:

Section 1: An overview of the purpose and scope of the Long Haul (Wideband) Communications Prototype (LHCP) network.

Section 2: Referenced documents used in the preparation of this report.

Section 3: Summary of the objectives of the LHCP and the results of each objective, and the accomplishments and recommendations of the LHCP group.

Section 4: The technical report, which describes in detail how the objectives were accomplished; this section discusses the LHCP configuration, experiments, and resource requirements.

Appendix A: List of acronyms used in this report.

Appendix B: Description of the LHCP hardware and Electronics Laboratory testing equipment.

Appendix C: Reports of the LHCP experiments.

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Appendix D: Monthly reports received from the remote sites by the LHCP group.

Appendix E: Problem history and resolution during the course of establishing the LHCP.

Appendix F: Contributors to the Long Haul Communications Prototype Report.

1.1 Purpose

The purpose of this document is to report the steps taken in the development, test, and operation of the Long Haul (Wideband) Communications Prototype (LHCP). (See Numerical Aerodynamic Simulation (NAS) Projects Office ref. 1 for the LHCP Plan, which proposed the initial design and direction of the LHCP network. References are listed in Section 2, Applicable Documents, of this paper.) This LHCP network was designed to evaluate the remote user bandwidth requirements for the NAS Processing System Network (NPSN), and to initiate access to the NPSN Initial Operating Configuration (IOC) by remote computational fluid dynamics users. (See NAS Projects Office ref. 2 for a more detailed description of the IOC.) The NPSN is being developed under the direction of the NAS Projects Office of the National Aeronautics and Space Administration (NASA), Ames Research Center, Moffett Field, California.

This report defines and evaluates the remote workstation accesses to Ames Research Center (ARC) from the NASA Langley Research Center (LaRC), Hampton, Virginia; the NASA Lewis Research Center (LeRC), Cleveland, Ohio; and Colorado State University (CSU), Fort Collins, Colorado.

1.2 Scope

The LHCP effort was used to establish computer communications between ARC and the remote sites, and to evaluate the Vitalink VB/1 bridge boxes, TransLAN software, communications equipment, communications links, and the bandwidth requirements of the remote users.

The LHCP effort consisted of using NAS workstations at LaRC and LeRC, and a non-NAS workstation at CSU, all of which are connected to their local area networks via Ethernets, to access the NPSN via a gateway host at ARC.

Three experiments--the user bandwidth experiment, the hardware experiment, and the transmission control protocol/internet protocol (TCP/IP) tuning experiment--were used to evaluate the LHCP. The report on the user bandwidth experiment can be found in NAS Projects Office reference 8, and the reports on the hardware and TCP/IP experiments are presented in appendix C.

The results of the experiments were used to establish the remote user needs within the development of the LHC subsystem. The LHCP provided NAS personnel with valuable experience in wideband communications and computer networking. This

experience aided in the design, development, implementation, and operation of the LHC subsystem portion of the Integrated Support Processor Complex (ISPC). (See NAS Projects Office ref. 4 for a more detailed description of the ISPC.)

The LHCP effort (i.e., the prototype as a whole) was divided into two phases, which allowed early user involvement in the development of the LHCP network (i.e., the wideband communications links).

1. The first phase used remote NAS workstations (Silicon Graphics, Inc.'s (SGI) IRIS 1500s, which were upgraded to 2500s), a remote non-NAS workstation (Sun 160 workstation), and the NAS Ethernet network via a VAX 11/780 (the Cray gateway) to access the Cray X-MP/12. This phase allowed LHCP testing to start before the NAS Cray-2 was connected to the NPSN. (See NAS Projects Office ref. 3 for a description of the IRIS workstation, and NAS Projects Office ref. 2 for a description of the Cray.)

2. The second phase used both NAS and non-NAS type remote workstations to access the Cray-2 when it was operational and connected to the NPSN.

These phases did not include additional bandwidth capabilities, such as T1 data rate (1.544 megabits per second, Mbps), since that capability was not available for use at that time. The LHCP high-speed wideband T1 network will be supplied by the NASA Program Support Communications Network (PSCN) when it becomes available. The PSCN contract was awarded to Boeing Computer Services on 1 April 1985. A commercial communications network was used in the early phases of this experiment. Boeing/RCA supplied the interim service at 224 kbps; the 56-kbps line was obtained from Boeing/AT&T. All NASA communications requests for resources, such as NASA PSCN circuits and interim circuits, were channeled through the Marshall Space Flight Center. The circuits were transferred to PSCN administration and control on 1 April 1986.

2. APPLICABLE DOCUMENTS

Although the LHCP plan is not a controlled document, there was an effort to make it consistent with the other documents governing the NAS program. The applicable NAS documents are listed below.

1. PT-1133-02-N00 Numerical Aerodynamic Simulation Program
Long Haul (Wideband) Communications Prototype Plan for Remote Workstation Access to ARC from LaRC, LeRC, and CSU.
3 October 1985
2. PP-1100-01-C01 Numerical Aerodynamic Simulation Program
Development Plan for the NPSN Initial Operating Configuration
24 April 1985

3. PP-1126-00-N00 Numerical Aerodynamic Simulation Program
User Interface Prototype Development Plan
14 May 1984
4. RFP2-31373(DHC) Integrated Support Processing Complex (ISPC)
Numerical Aerodynamic Simulation
Processing System Network (NPSN)
5. PT-1133-01-N00 Numerical Aerodynamic Simulation Program
Long Haul Communications Prototype Experiments Plan
24 June 1985
6. TBD Numerical Aerodynamic Simulation Program
Operational Policy and Procedures for Remote Workstations
26 February 1986
Program Configuration Control Board Recommended 25 March 1986
7. TBD Numerical Aerodynamic Simulation Program
Long Haul Communications Prototype Transition to Operations
Plan
21 April 1986
8. TBD Numerical Aerodynamic Simulation Program
Long Haul Communications Prototype Experiments Results
(to be determined)

3. EXECUTIVE SUMMARY

This summary consists of three subsections. The first subsection sets forth the initial objectives of the LHCP and discusses how each objective was satisfied. The second subsection reports the accomplishments of the LHCP group in establishing the network. The third subsection presents the recommendations of the LHCP group as they relate to future NAS Projects Office activities dealing with long-haul communications.

3.1 Initial Objectives and Results of Objectives

The results of the initial objectives, as defined in NAS Projects Office reference 1, are summarized below after each of the stated initial objectives. The initial objectives were as follows.

1. *Establish and evaluate the LHCP wideband network design.* The LHCP wideband network design that was established consisted of three remote sites: LaRC, LeRC, and CSU. Langley Research Center and LeRC are communicating with ARC over 224-kbps satellite links provided by Boeing/RCA. Colorado State University is communicating

with ARC over a 56-kbps terrestrial link provided by Boeing/AT&T. Vitalink VB/1 bridges and related TransLAN software are used to connect the remote sites with ARC. The evaluations of the Vitalink VB/1 bridges have shown that their use is a feasible method of meeting long-haul communications requirements and providing long-haul communications capabilities to remote sites at those data transmission rates. The LHCP hardware experiment consisted of evaluating the Vitalink VB/1 bridge boxes, learning how to use the TransLAN software, the satellite delay simulator, modems, and other communications equipment; and evaluating the communications links. Several hardware tests were designed to determine workstation data transmission characteristics and to measure data transfer rates of various sizes between workstations. One test evaluated transmissions between workstations that were on the same Ethernet. Other tests evaluated transmissions between workstations connected to two separate Ethernets but bridged together with VB/1s over a simulated communications link and over the 56- and 224-kbps communications links. The complete report on the hardware experiments is presented in appendix C.

2. **Initiate early remote user activity.** The LHCP effort initiated early remote-user activities by allowing the remote users from LaRC, LeRC, and CSU to access NPSN resources before IOC and the establishment of the LHC subsystem.

3. **Evaluate and establish the LHCP bandwidth requirements.** The LHCP bandwidth experiment as defined in NAS Projects Office reference 5 started in the third quarter of 1985, before the NPSN IOC was fully operational, and continued over several months. The purpose of this experiment was to provide experience in high-speed communications, initially at 56 and 224 kbps, and, it was hoped, at 1.544 Mbps (which did not occur), and to provide experience with remote communications capabilities. Emphasis was on the evaluation of remote NAS workstation communications from both LaRC and LeRC to ARC and remote non-NAS workstation communications from CSU to ARC. The results from the bandwidth experiment will be used to help establish the bandwidth requirements for future remote sites wishing to get on the LHC subsystem. (See NAS Projects Office ref. 5 for a detailed description of the LHCP user bandwidth experiment plan.)

4. **Generate cooperative user involvement.** The LHCP effort was also a means by which to generate cooperative user involvement. The remote users (specifically the site/system administrators) were involved from the very beginning of the implementation of the LHCP wideband communications network and installation of the Vitalink and related communications equipment. The LHCP could not have been implemented successfully without the cooperative involvement of the administrators.

5. **Provide user feedback through use of NAS workstations (IRIS 1500/2500) from remote-user sites.** NAS workstations (IRIS 1500/2500) were shipped to LaRC and LeRC for use from these remote sites to access the NPSN resources. Feedback regarding the use of the NAS workstations and access to the NPSN resources was provided by the remote users in form of monthly reports and trouble calls to the LHCP group. The reports and trouble calls will be handled by the NAS Projects Office User Services in the future.

6. *Provide user feedback through use of a non-NAS workstation (Sun 160) from a remote user site.* A non-NAS workstation (Sun 160) was used from CSU to access the NPSN resources. Feedbacks regarding the use of the non-NAS workstation and access to the NPSN resources was provided by the remote users in form of monthly reports and trouble calls to the LHCP group. The reports and trouble calls will continue to be handled by the NAS Projects Office User Services.

7. *Transfer knowledge and experience gained in working with PSCN and commercial communications services to the IOC.* The knowledge and experience gained in working with the NASA PSCN, and commercial communications services have been transferred to the LHC subsystem group. The LHC subsystem group has used and will continue to use the knowledge to further develop the LHC subsystem for IOC implementation. (A list of problems and experiences encountered during the LHCP is included in appendix E.)

8. *Transfer development resources (i.e., hardware and software) acquired to the IOC.* The functional Vitalink VB/1 bridges communicating with LaRC, LeRC, and CSU were transferred to NAS Projects Office Operations. (See NAS Projects Office ref. 7 for a full description of the transition to operational activities.) The user services activities were transferred to NAS Projects Office User Services. Additional development resources (i.e., hardware and software) acquired during the LHCP including the LHC Electronics Laboratory, laboratory equipment, and communications equipment will be transferred to the LHC subsystem group or to the NAS Projects Office Operations or to both.

3.2 Accomplishments

The LHCP was concluded on 30 April 1986; the following had been accomplished.

1. The LHCP development plan was written and approved on 3 October 1985 by the NAS Projects Office Engineering Review Board. The plan described the scope, activities, and schedules of the prototype. (NAS Projects Office ref. 1.)

2. This report on the LHCP development was written at the conclusion of LHCP activities. It noted modifications to the original plan to better document the actual activities of the LHCP. An executive summary, which included the accomplishments and recommendations of the LHCP group, was also included with the technical report. Appendixes were included that present the communication and testing hardware descriptions, LHCP experiment reports, remote monthly reports, and the LHCP problem history and resolution reports.

3. The Vitalink boxes (VB/1 and CS/100) connected the remote sites to the NPSN. The Vitalink communication equipment interfaced to the LHCP communication circuits and joined the remote site Ethernets to the local NAS Processing System Ethernet subnetwork. A checkout list of equipment was designed to facilitate connections to NPSN from other remote sites.

4. Three remote sites were requested to participate in evaluating the LHCP: CSU, LaRC, and LeRC. The following describes the activities establishing the LHCP communication links with those sites. (a) A communication link was established via a 56-kbps AT&T circuit from ARC to CSU. The Vitalink box (VB/1) was first tested by the LHCP group, and then delivered to CSU on 22 July 1985. The circuit was activated on 21 June 1985. The connection of the Sun workstation at CSU to the NPSN at ARC communication was established 2 August 1985. The long delay between circuit activation and data communication was due to a delay in delivery of the Data Service Unit (DSU) modems by Boeing. (b) A communication link was established via a 224-kbps RCA Americom Satellite circuit from ARC to LaRC. The VB/1 was delivered to LaRC on 6 September 1985. The IRIS workstation at LaRC was on loan from the NAS Projects Office for this purpose and was received by LaRC on 6 September 1985. The satellite circuit was activated on 6 September 1985, and completely tested and released by RCA on 30 September 1985. The connection of the IRIS workstation at LaRC to the NPSN at ARC communication was established 10 October 1985. An upgrade from the IRIS 1500 model to an IRIS 2500 model was completed by LaRC on 5 February 1986. (c) A communication link was established via a 224-kbps RCA Americom Satellite circuit from ARC to LeRC. The VB/1 was delivered to LeRC on 12 September 1985. The IRIS workstation at LeRC was on loan from the NAS Projects Office for this purpose and was received by LeRC on 12 September 1985. The satellite circuit was activated on 16 September 1985, and completely tested and released by RCA on 18 October 1985. The connection of the IRIS workstation at LeRC to the NPSN Network at ARC communication was established 18 October 1985. An upgrade from the IRIS 1500 model to an IRIS 2500 model was completed by LeRC on 2 April 1986.

5. The LHCP experiments plan was written and approved on 6 June 1985 by the NAS Projects Office Engineering Review Board. This plan described the user bandwidth experiments scope, schedule, and activities that were to take place between ARC, CSU, LaRC, and LeRC. This experiment was to evaluate user satisfaction with the LHCP remote circuits. A primary result of this experiment was to obtain information so that bandwidth requirements for future remote users could be evaluated (NAS Projects Office ref. 5).

6. The user bandwidth experiment was partially completed. The experiment was successful for the CSU participants; however, in performing the LaRC user bandwidth experiment and the hardware experiment, it was discovered that the TCP/IP protocol used did not perform satisfactorily over satellite links, and that the maximum performance observed was approximately 10% of the 224-kbps satellite bandwidth. Further experiments were canceled until either the problem is resolved or additional bandwidth requirements data are needed (NAS Projects Office ref. 8).

7. The hardware experiment was designed to test various portions of the communication circuits of the LHCP. These tests primarily tested the Ethernet transfer rates to obtain a baseline, and Vitalink-to-Vitalink transfer rates with comparisons to the baseline. The baseline portion was completed; however, the full Vitalink-to-Vitalink tests are still in process. The results are presented in appendix C.

8. A third experiment that was performed involved limited tuning of the TCP/IP protocol to observe improvements in satellite file transfer performance. A memo was written to describe the change from ~10% to ~75% bandwidth utilization. The final results are presented in appendix C.

9. A fourth experiment that was performed involved a comparison of the TCP/IP protocol versus the Xerox Network Services (XNS) protocol. This test was requested by the workstation subsystem manager, Tom Lasinski. Completed in January 1986, these test results show that XNS performs better than TCP/IP. The final results are presented in appendix C.

10. The LHC Electronics Laboratory was established, and test equipment for monitoring or repairing the communication links was purchased. Appendix B lists all test equipment and the equipment's functions. The LHC Electronics Laboratory and personnel were transitioned to the LHC subsystem development group at the conclusion of the LHCP.

11. Two additional documents were written to complete the LHCP. (a) The first is a draft of the Numerical Aerodynamic Simulation Remote Workstations Operational Policy and Procedures for Remote Workstations. This document established initial recommendations to be followed by both NAS Projects Office and the remote sites to smooth workstation configurations and administration (NAS Projects Office reference 6). And (b), the Long Haul Communications Prototype Transition to Operations Plan. This plan describes all LHCP activities and procedures and when and to whom these activities and procedures will be transferred (NAS Projects Office ref. 7).

3.3 Recommendations

Based on the results and knowledge gained during the LHCP effort, the LHCP group makes the following recommendations:

1. Terrestrial circuits were observed to be more stable than satellite circuits; therefore, if cost is not a major factor, terrestrial circuits would be preferred.

2. Based on the results of the prototype experiments (NAS Projects Office ref. 8), a 56-kbps terrestrial circuit appears to be able to support one or two Sun 2.1 or IRIS 2500 workstations. Also, a 224-kbps satellite circuit was deemed to poorly support three or four IRIS 2500 workstations, whereas a 224-kbps terrestrial circuit was estimated to adequately support the same number of workstations.

3. The TCP/IP protocol on each host, as currently implemented, is not tuned for satellite performance. If satellite circuits are to be used, then the TCP/IP protocol must be tuned to account for the transport delay in satellite circuits.

4. The Vitalink method of bridging Ethernets is a feasible way of linking remote sites; however, problems exist in maintaining NAS Projects Office control of the remote Ethernet network addresses on the remote sites. Other methods, such as

gateways, should be explored. Also, the Vitalink method may not be practical for bandwidths higher than 224 kbps.

5. As remote users use the LHC network, it should be monitored by the LHC Electronics Laboratory to determine the performance and behavior of the link. For example, if the link is degrading or if the link is constantly used too lightly or heavily, then action should be taken to reconfigure the link.

4. TECHNICAL REPORT

The LHCP effort evaluated the capabilities for remote users to communicate with a Cray and the performance of the LHCP network via LHCP experiments.

4.1 LHCP Configuration Changes

4.1.1 Phase 1 test configuration and schedule.- The first phase of the LHCP effort used remote IRIS 1500/2500s, a remote Sun 160, an interim LHCP network (supplied by PSCN/Boeing/RCA/AT&T), and the NAS Processing System Ethernet subnetwork to access the Cray X-MP/12 via the gateway host VAX. Figure 1 is a diagram of the LHCP configuration depicting remote workstation accesses to the Cray X-MP/12 via the NAS Processing System Ethernet subnetwork and gateway host VAX.

This first phase of the remote NAS workstation test configuration allowed remote workstations to access and use the Cray X-MP/12 (running COS and accessed through CRINT) via the gateway host VAX. This test configuration used remote NAS workstations at LaRC and LeRC, and a Sun 160 at CSU, all of which were connected to their respective local area networks using Ethernets. Two remote NAS workstations were shipped, one to LaRC and the other to LeRC.

A product offered by Vitalink Communications Corporation was used to interface each Ethernet to the satellite gateway. The Ethernet adapter was manufactured by Bridge Communications Inc. using the TransLAN software package developed by Vitalink. The hardware-software product combination was referred to as VB/1. The VB/1 supported data rates up to 224 kbps and provided standard interfaces to Ethernets and satellite Earth terminals. A VB/1 was required at each Earth terminal location. At the time, the VB/1 did not support T1; however, it was planned to increase its capacity to this level.

The Vitalink VB/1s and TransLAN software were delivered to ARC in April 1985 and went through an extensive checkout and hardware testing by LHCP technicians.

The Phase 1 test schedule was dependent on the availability of the 56-kbps terrestrial line to be installed by Boeing/AT&T and the 224-kbps satellite links to be provided via the PSCN by Boeing/RCA.

The 224-kbps LaRC satellite circuit was installed by RCA on 2 September 1985. The ARC-to-LaRC link was completed and tested by RCA on 20 September 1985. Computer-to-computer communications between ARC and LaRC was established by the LHCP group on 10 October 1985, 1 day after the ARC-LaRC circuit was turned over by RCA. The user bandwidth experiment began on 30 September 1985 at ARC and was completed at ARC on 4 October 1985. Preliminary results from testing of the LaRC-ARC link suggested that additional user bandwidth experiments be canceled because of problems pertaining to the TCP/IP protocol caused by satellite transport delay (refer to appendix C for further details).

Similarly, the 224-kbps LeRC satellite circuit was installed by RCA on 16 September 1985. The ARC-to-LaRC link was tested by RCA and completed on 18 October 1985. Computer communications between ARC and LaRC was established by the LHCP group on 21 October 1985. The ARC-to-LeRC user bandwidth experiment was canceled due to the problem found during the LaRC user bandwidth experiment.

4.1.2 Phase 2 test configuration and schedule.- The second phase of the LHCP used the remote workstations and the LHCP network to access the NAS Cray-2. Access to the LHCP network was via the LHC subsystem gateway on the ISPC, since the NPSN UNIX-like (Universal Timesharing System) on the ISPC became operational for remote users in January 1986. This configuration is closer to the operational IOC for remote access. (Note: The Cray-2 and ISPC were not vital equipment required in the completion of the early phase of the bandwidth experiment.)

This second phase of the LHCP test configuration allowed the remote NAS workstations at LaRC and LeRC, and the non-NAS workstation at CSU, to access and use the NAS Cray-2. The NAS Cray-2 was available for pilot use in the first quarter of 1986. The simple effective protocol (SEP) was used to access the NAS Cray-2.

4.2 LHCP Experiments

The LHCP provided an opportunity to study the following remote-user needs in terms of response and performance during the above two phases of the LHCP effort.

1. Bandwidth requirements
2. Access to transmission facility
3. Large file transfers (1 to 40 MB)
4. Distribution of file storage and use (remote versus NPSN file storage)
5. Preprocessing of graphics at NPSN
6. Workstation-to-workstation communications and data transfer

4.2.1 Summary.- The LHCP effort consisted of four experiments: the user bandwidth experiment, the hardware experiment, the TCP/IP tuning experiment, and an XNS versus TCP/IP comparison test.

1. The user bandwidth experiment evaluated the use of remote communications links between IRIS 1500/2500 and Sun 160 workstations and the NPSN resources to determine remote-user bandwidth requirements. The result of the user bandwidth experiment is documented in NAS Projects Office reference 8.

2. The hardware experiment tested and analyzed the hardware and communications links. The results of the hardware experiment is documented in appendix C.

3. The TCP/IP tuning experiment evaluated the protocol limitations, a result of the effect of satellite delays. The result of the TCP/IP tuning experiment is also documented in appendix C.

4. The XNS versus TCP/IP test compared the transfer rates of the protocols over communication links with and without satellite delays. The result of the XNS versus TCP/IP tests is also documented in appendix C.

The LHCP experiments described in this report were based on using Ethernets as the interconnecting media for Local Area Networks at LaRC, LeRC, and CSU.

4.2.2 Experimental philosophy.- The experiments and tests followed the sequence outlined below. "Local site" refers to ARC and the "remote sites" refer to LaRC, LeRC, and CSU.

1. The NAS Projects Office acquired Ethernet transceivers, Vitalink VB/1 hardware and TransLAN software, and NAS workstations to connect to the Ethernets at LaRC, LeRC, and CSU. Colorado State University acquired a Sun 160 workstation independently.

2. All the hardware and software at ARC underwent installation and acceptance testing. Local loopback testing was performed through the LHCP network to validate the transmit-and-receive paths of the LHCP network and associated equipment.

3. After acceptance testing at ARC, the VB/1s and transceivers were shipped to LaRC, LeRC, and CSU; NAS workstations were sent to LaRC and LeRC. LaRC, LeRC, and CSU also performed loopback tests through the LHCP network using this equipment.

4. End-to-end testing from remote workstations to the high-speed processor (HSP), which is described in the user bandwidth experiment, were conducted. Remote-to-local NAS workstation communications were also tested.

5. Hardware experiments using different variations (configurations) of communications equipment, computers, circuit rates, and transport delays were performed.

6. Other experiments, such as tuning TCP/IP and an XNS versus TCP/IP comparison were conducted when previous tests indicated a need for further investigation.

The LHCP access and use of the NPSN resources were evaluated using NAS Projects Office supplied software. Vendor-supplied test equipment, test procedures, and diagnostic routines were used wherever possible.

4.2.2.1 Hardware experiment objectives: The objectives for each of the five hardware experiments were as follows.

1. To transfer data files of various lengths between two workstations connected to the same Ethernet (private Ethernet cable); to measure the time it required to transfer the file; and to determine the transfer rates.

2. To transfer data files of various lengths between two workstations connected to two Ethernets (private Ethernet cables); to measure the time required to transfer the file; and to determine the transfer rates. VB/1s are introduced into the system for this test. Its objective is to make the same measurements as in Test 1, that is, to determine the data transfer characteristics when a pair of VB/1s was used to connect two physically separated Ethernets. For this test and all subsequent tests, the Digital Satellite Communications Simulator (DSCS) was used to connect the two VB/1s to establish a communication link; however, no transport delays were introduced for this test. The DSCS was used to simulate typical satellite delays.

3. To make the same measurements as in test 2, however, the measurements taken between the two workstations included transport delays introduced via the DSCS.

4. To make the same measurements as in test 2, but with bit error rates (BERs) injected into the communications link between the two VB/1s. A BER test set was to be connected at both ends of the DSCS to measure the BERs. (This test will be completed at a future time by the LHC subsystem group.)

5. To make the same measurements as in test 3, but with BERs injected into the communications link between the two VB/1s. A BER test set was to be connected at both ends of the DSCS to measure the BERs. (This test will be completed at a future time by the LHC subsystem group.)

When executed, each one of these tests generated a header message indicating the nature of the test, size of the file being transferred, the time it took to transfer the file, and the transfer rate. The appropriate hardware configuration was set up prior to the invocation of each test. The results, tabulated and plotted, appear in appendix C.

4.2.2.2 User bandwidth experiment measurement objectives: The experiment measurement objectives and the specifications of the measurement software being developed for the LHCP user bandwidth experiment are discussed briefly here and in more detail in the "Long Haul Communications Prototype Experiments Plan (NAS Projects Office ref. 5).

The formal objective of the LHCP user bandwidth experiment was to evaluate the services provided to remote users via two different communications links: one service at 56-kbps terrestrial and the other at 224-kbps satellite. Even though the evaluation of these two types of services was concerned with the actual end-to-end transfer rates achieved, it also focused on the subjective differences between the two as experienced by the remote users. In addition to evaluating the

communications bandwidth requirements of remote users, these experiments also provided a structure within which NPSN (i.e., ARC) personnel can formally address communications issues and which permitted early user involvement.

The bandwidth measurement was primarily concerned with file transfers and other activities between the remote sites and ARC. Access to a Cray was desirable but not necessary for this experiment.

The results of this experiment will be given in more detail in NAS Projects Office reference 8.

4.2.2.3 Protocol tuning tests: Early (initial) measurements of data transfers between the remote workstation at LaRC and the gateway host VAX at ARC indicated rates far below the maximum bandwidth capacity. It was determined that some tuning of the TCP/IP protocol, such as varying the window size for the maximum buffer of outstanding data, was needed to see if any improvement in the data transfer rates could be obtained from the existing satellite link to LaRC. The software consisted of the same "netpush" program that was used in the hardware experiments, except for patches to the system kernel code to allow dynamic tuning of the various parameters needed to control the window size.

An informal agreement between the NAS project at ARC and the Institute for Computational Applications in Science and Engineering (ICASE) project at LaRC was made to use dedicated time on the NAS AMELIA VAX and the ICASE VAX to perform the TCP/IP tuning tests. Appendix C contains the final results of the TCP/IP tuning tests.

4.2.2.4 XNS versus TCP/IP protocol comparison tests: Tests were also run to compare the effects of XNS versus TCP/IP protocols on data transfer rates. The tests consisted of comparing results of two identical IRISs running on the NAS network using the rcp program, which uses the TCP/IP protocol, with the IRISs using the xcp program, which uses the XNS protocol. Appendix C contains the report of the TCP/IP-XNS tests.

4.3 Resource Requirements

4.3.1 Minimum requirements/conditions for testing.- The minimum resources and dependencies required in order to perform the LHCP experiments are itemized below.

1. Communications network requirements: (a) 224-kbps data links between ARC and LaRC and also between ARC and LeRC supplied by PSCN/Boeing/RCA; (b) 56-kbps data link between ARC and CSU provided via PSCN/Boeing/AT&T

2. Workstation requirements: (a) NAS workstations (IRIS 1500) at ARC, LaRC, and LeRC; (b) Sun workstations at CSU and ARC; (c) NAS Ethernet network and remote Ethernets for workstations

3. Software: software for network communication and network testing

4. Laboratory: an LHC Electronics Laboratory for test equipment to monitor network performance and measure data transfer characteristics

5. Facilities: for all above mentioned equipment

6. Voice coordination: telephones to coordinate the pretests and LHCP experiments activities

7. Budget and personnel to perform tests consisting of the following:
(a) personnel at ARC for the LHCP group; (b) personnel at LaRC and LeRC qualified in use of NAS workstations and communications; (c) personnel at CSU qualified in use of a Sun workstation and communications

8. LHCP development plan: the LHCP development plan, which is NAS Projects Office reference 1

Each of the above requirements, except the LHCP development plan, is discussed in more detail in the below subsections.

4.3.2 Communications network requirements.- In order to start these tests at the earliest possible time, an interim LHCP network was used. This network had full-duplex (FDX) communication lines, at 224 kbps, connecting LaRC and LeRC to the NAS Interim Facility (ARC Building N233A). Also, a 56-kbps terrestrial line was used to connect CSU to ARC.

The LHCP network was supplied through Marshall Space Flight Center, which has contracted with Boeing to provide the interim circuits until the PSCN circuits that Boeing is also developing are available.

This network included all the necessary equipment (modems, Earth stations, etc.) needed to provide data communications paths between ARC and LaRC, LeRC, and CSU.

The LHCP network components at ARC, LaRC, LeRC, and CSU were connected to their respective Vitalink VB/1 hardware.

4.3.2.1 Communications hardware: The LHCP hardware configurations showing the VB/1s, modems, fiber optic systems, and Earth stations (ESs) for ARC, LaRC, LeRC, and CSU are shown in figures 2, 3, 4, and 5.

The communication equipment required at each site and the major components of the communications links are discussed in appendix B.

4.3.2.2 Availability of service: The interim network was to be used until the operational PSCN was ready. The PSCN was scheduled to begin operations on 1 April 1986. Currently, the expected implementation date is July 1986, owing to delays in construction of Earth station facilities.

The scheduled dates for readiness of the interim data communications lines were all met. The actual dates on which the lines were ready are enclosed in parentheses.

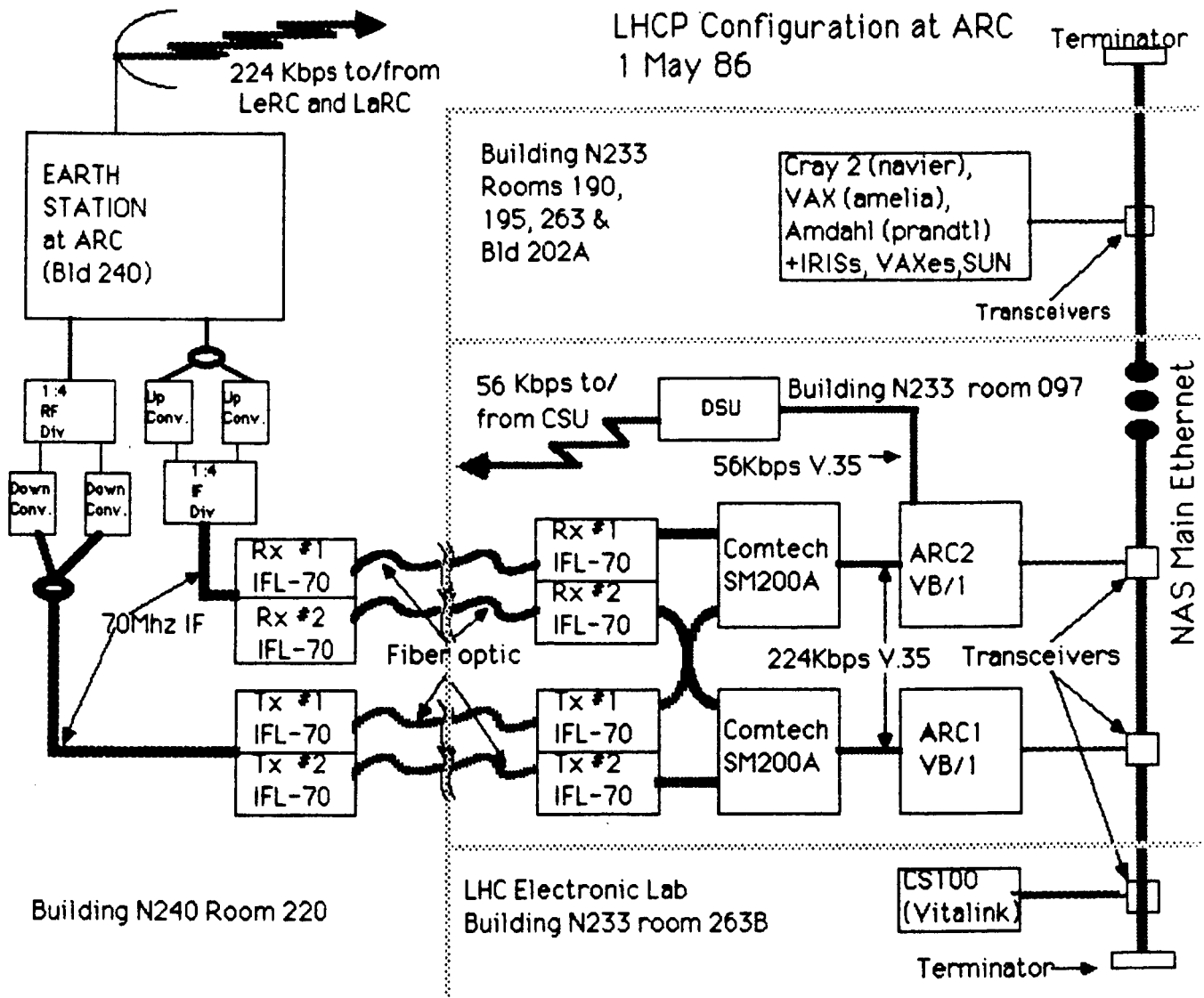


Figure 2.- Ames Research Center local LHCP configuration.

1. 56-kbps terrestrial line between ARC and CSU: 21 June 1985 (actual, 21 June 1985)
2. 224-kbps satellite link ready at ARC: 30 August 1985 (actual, 15 August 1985)
3. 224-kbps satellite link ready between ARC and LaRC: 16 September 1985 (actual, 2 September 1985)
4. 224-kbps satellite link ready between ARC and LeRC: 16 September 1985 (actual, 16 September 1985)

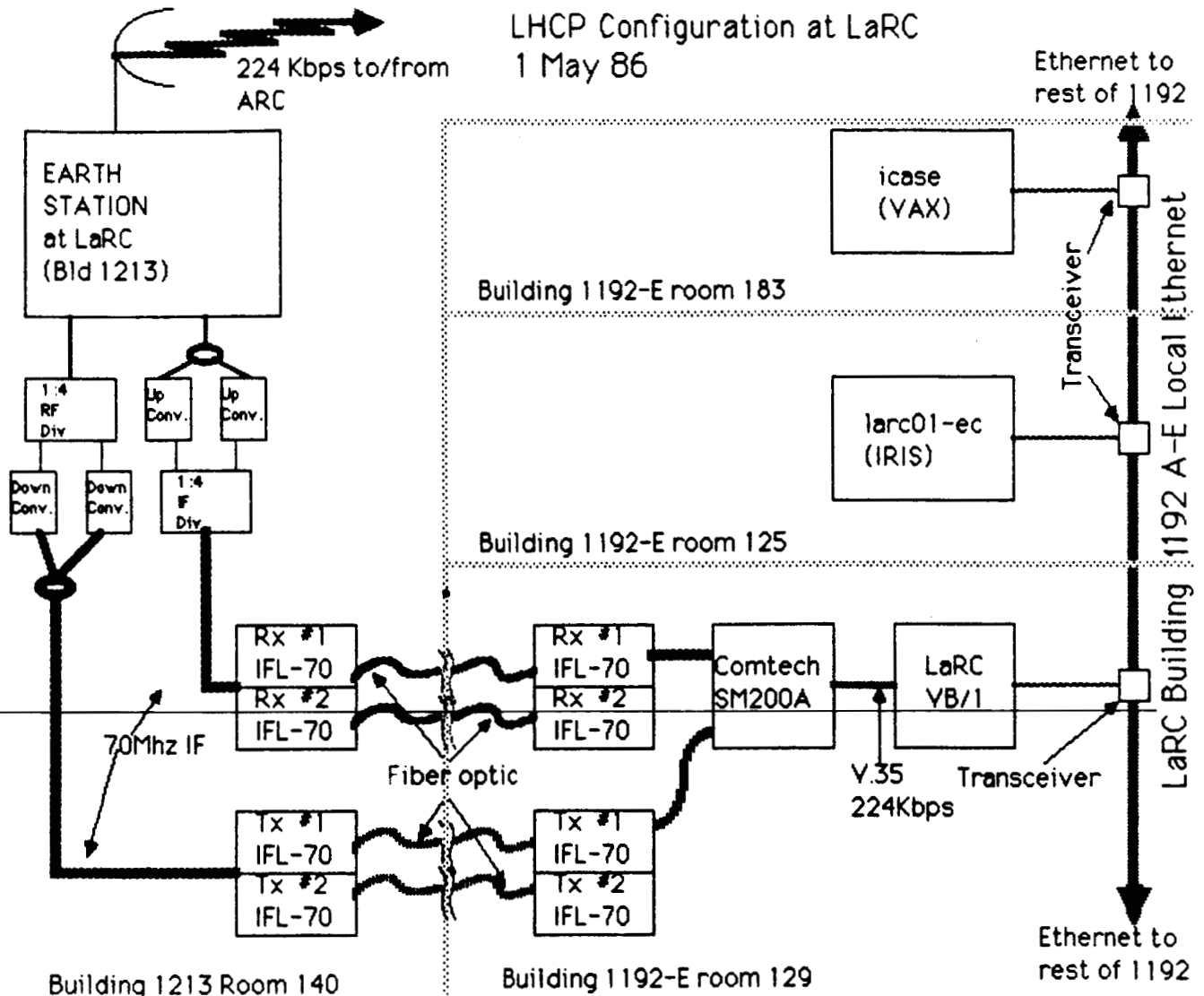


Figure 3.- Langley Research Center local LHCP configuration.

Computer-to-computer communication connections were to follow as soon as possible after the communication links were established. The computer-to-computer connection dates were as follows.

1. 56-kbps terrestrial connection between ARC and CSU: 2 August 1985; the delay was due to slow delivery of DSU equipment by Boeing
2. 224-kbps satellite connection ready between ARC and LaRC: 10 October 1985; RCA required approximately 4 weeks to coordinate the initial ARC/LaRC link

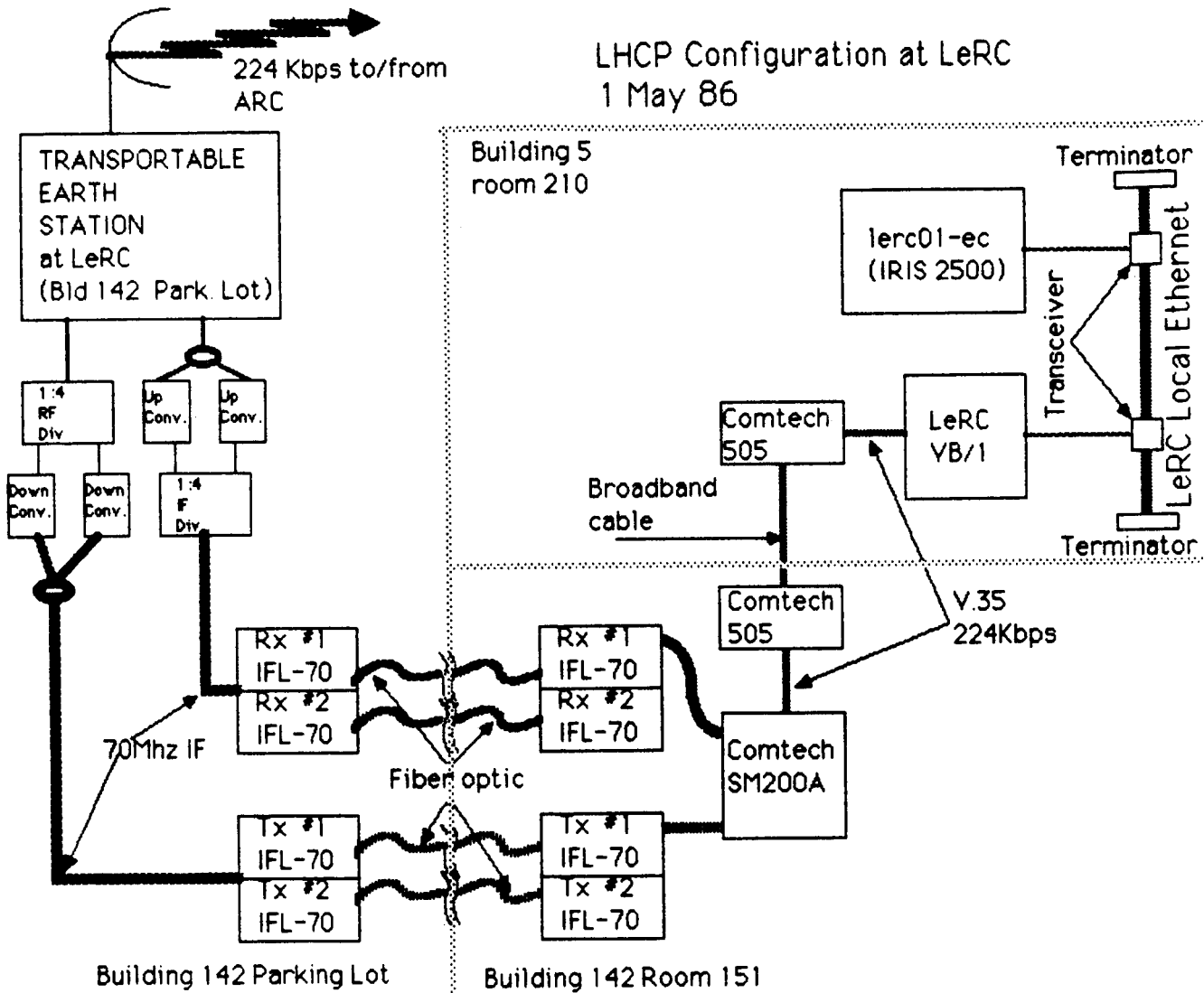


Figure 4.- Lewis Research Center local LHCP configuration.

3. 224-kbps satellite connection ready between ARC and LeRC: 21 October 1985

4.3.2.3 Performance monitoring: The PSCN service supplying the T1 capability provided centralized maintenance control, real-time status, and traffic monitoring. The ARC site monitored all link performance with the Vitalink Management Station (CS/100). Each site could perform monitoring activities on its tail circuits, if desired. (Note: During future performance/network testing, each site could monitor and record BER, block error rate, impulse noise, etc., with monitoring equipment that could be supplied by ARC, such as, the FIREBERD 2000 data error analyzer. This monitoring might be required for timely isolation of faults.)

LHCP Configuration at CSU
1 May 1986

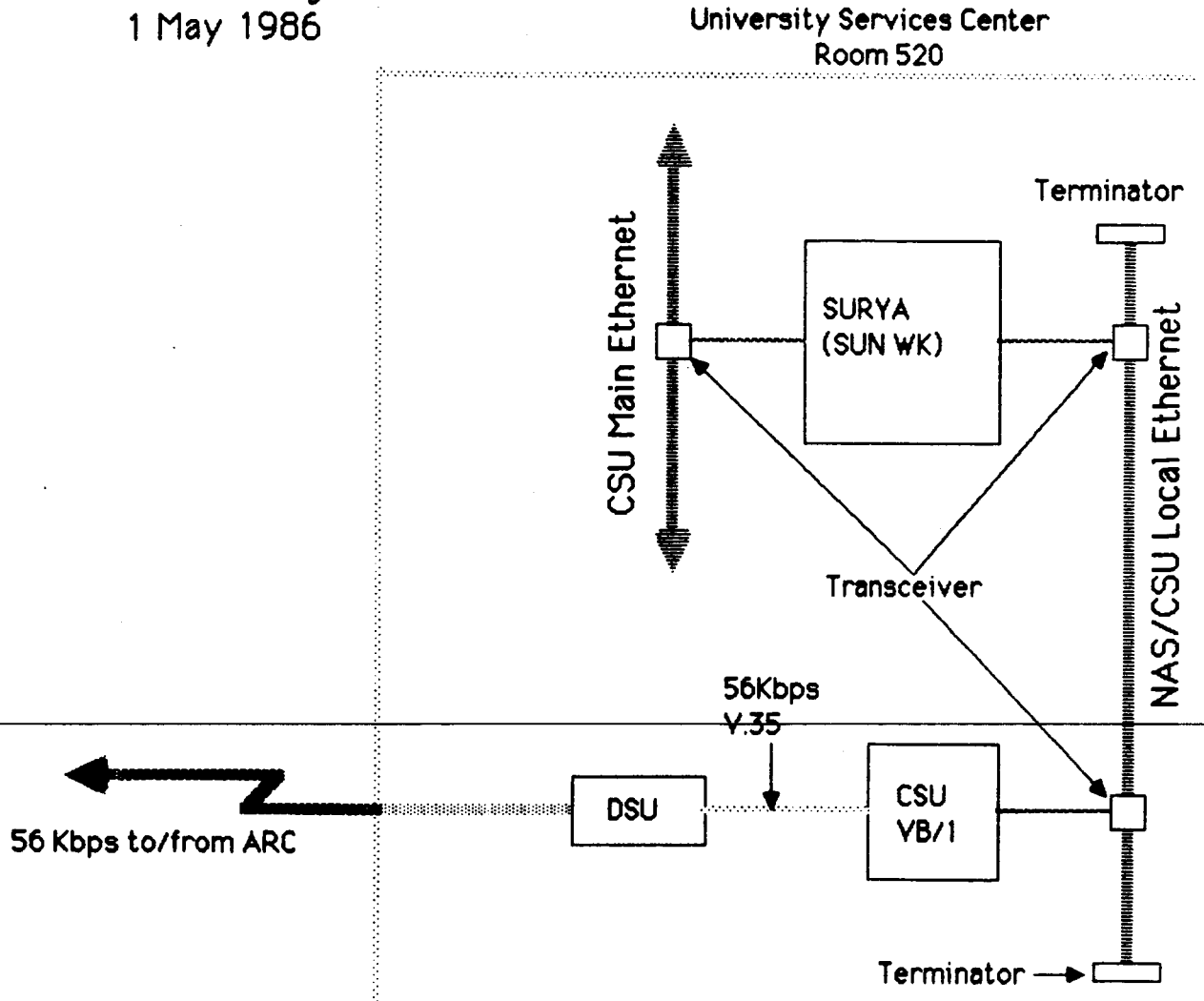


Figure 5.- Colorado State University local LHCP configuration.

4.3.3 Workstation requirements.- The NAS workstation is an IRIS 1500 workstation (was upgraded to 2500); manufactured by Silicon Graphics Inc. (SGI), with the following features (see NAS Projects Office ref. 3 for a full description).

1. MC68010 central processor
2. Multibus
3. IKON 10077-NSC (NSC HYPERchannel interface adapter)
4. Interlan Ethernet interface
5. UNIX System V + 4.1c bsd enhancements
6. TCP/IP protocol

Other workstations, such as the Sun 160 at CSU, that were used in the LHCP experiments had capabilities similar to the NAS workstation.

Initially, the remote NAS workstations located at LaRC and LeRC and the non-NAS workstation at CSU accessed a Cray via the gateway host VAX using the LHCP network. This provided early user involvement and feedback regarding the development of the LHC subsystem network.

4.3.4 Software requirements.- The following paragraphs describe the software required for the LHCP bandwidth and hardware experiments:

The NAS workstations and gateway host machines required that TCP/IP, file transfer protocol (FTP), and some LHCP developed software be installed before the hardware and user bandwidth experiments could be performed.

All systems ran UNIX (UNIX is a product of AT&T) with TCP/IP and FTP, and were compatible with UNIX 4.2 bsd r commands such as rlogin and rcp. The IRIS 1500/2500 ran with SGI's Version 2.1.1 which is equivalent to System V + 4.2 bsd.

Measurement software for the hardware experiments was developed by the LHCP group to test the transfer of data between the remote workstations and the gateway host, and to measure the data transfer rates and other characteristics, such as number of errors detected during the transfer. The software developed consisted of a C program called netpush which did memory-to-memory data transfers. Also, a number of UNIX shell scripts were written to automate the testing. Existing software such as the TCP/IP, rcp, and rlogin, was incorporated into the systems. These high-level test routines that exercised the hardware required that all associated system software be installed and operational. Refer to appendix C for a listing of the test software netpush.

Measurement software for the bandwidth experiment, which was designed and developed by the LHCP group, consisted of a series of routines and shell scripts. These routines automatically recorded the timing for a predetermined sequence of steps that a remote user followed while using a workstation. Using these routines, different timing measurements were taken. Refer to NAS Projects Office reference 5 for more details on the test software.

In order to use the Cray, software was required in the gateway host VAX. This software was the Cray station package under UNIX 4.2 bsd (CRINT). Similarly, in order to use the NAS Cray-2, a comparable Cray station package such as CXINT and SEP was developed.

4.3.5 NAS LHC prototype laboratory requirements.- The following paragraphs will briefly discuss the philosophy of the NAS LHCP laboratory along with the reasons for the test equipment required for the LHCP experiments. The descriptions of each major piece of equipment are given in appendix B.

Data-line and performance-monitoring equipment were required for the hardware tests and for the IOC. This equipment monitored the characteristics and performance

of the network to detect and record bit errors, block errors, and noise as a function of time. Data-line analyzers and data-monitor sets were required to selectively monitor and troubleshoot, and to detect speed, protocol, bit-per-character value, and parity of the network.

All test equipment for the LHCP laboratory was provided by the NAS Projects Office. Any equipment needed to perform additional testing, if deemed necessary, was also provided by the NAS Projects Office. (Note: When the line is leased (e.g., the 56-kbps line), some of the test equipment may not be needed because the line monitoring will normally be performed by the communications service vendor.)

To insure reliable low error data transmissions between remote workstations and the NAS computers it was important to determine the transmission quality of each LHCP link and of the overall LHCP network on a continuing basis.

An LHCP laboratory was set up to measure and record parameters such as bit error rate and data transmission statistics. It was determined that there is a correlation between data transmission statistics from the Vitalink bridge boxes and parameters such as transport delay. These measurements were made independently of the routine maintenance procedures.

The laboratory also helped locate failures in the NPSN and the communications links via network analysis and loopback checks.

Future laboratory activities will consist of assisting the LHC subsystem development group in testbed activities, and the operations group in problem solving of faulty operational LHC links.

4.3.6 Facilities requirements.- Each site (ARC, LaRC, LeRC, and CSU) was responsible for its site preparations. However, the NAS Projects Office provided site-preparation guidelines to assist in the installation of the VB/1s.

Facilities preparation required the installation of the data communications network cables, modems, RF equipment, etc., and the identification of the location of all demarcation (demarc) points that were established.

A table of all known demarc points for the LHCP is shown below:

<u>Site location</u>	<u>Circuit</u>	<u>Building</u>	<u>Room</u>
ARC	T1	N240	220
ARC	224 kbps	N233A	097
ARC	56 kbps	N233A	097
LaRC	T1	1213	140
LaRC	224 kbps	1192-E	129
LeRC	T1	142	Parking lot
LeRC	224 kbps	142	160
CSU	56 kbps	University Service Center	520

4.3.7 Voice coordination network requirements.- Telephones were required during the hardware experiments, user bandwidth experiments, and TCP/IP tuning tests for coordination and to resolve any technical problems. A standard voice-grade telephone line with the telephone located in the area near the LHCP equipment was required at ARC, LaRC, LeRC, and CSU.

The telephones were required during the pretests and during all LHCP experiments to provide voice communications between the NAS test coordinator; ARC Communications Division; Marshall Space Flight Center; LaRC; LeRC; and CSU personnel.

4.3.8 Personnel requirements.- Each site provided personnel to install, acceptance test, and assist the LHCP group with the prototype experiments. A list of responsible personnel from each site is provided in appendix D of reference 1.

It was envisioned that the NAS Projects Office, in addition to the LHCP manager, needed the following NAS Projects Office/ISC personnel to assist in the LHCP:

1. Data communications engineer or systems engineer
2. Two systems programmers or software engineers (one full time, one part time)
3. Two technicians
4. Part-time engineer/technician with current NAS workstation experience

APPENDIX A
ABBREVIATIONS

AB	A box that can switch one input to either of two outputs
AI	Action item
ARC	Ames Research Center
ARPAnet	Advanced Research Projects Agency Network
ASCII	American National Standard Code for Information Interchange
AT	Acceptance test
AT&T	American Telephone & Telegraph
b	bit
B	byte
BCS	Boeing Computer Services
BER	Bit error rate
BSC	Bisynchronous
BSD	Berkeley Software Distribution (version of UNIX, which is a trademark of Bell Telephone Laboratories)
CBD	Commerce Business Daily
CCF	Central Computer Facility (Ames)
CCITT	Consultative Committee for International Telegraphy and Telephone
CDC	Control Data Corporation
CFD	Computational fluid dynamics
CM	Configuration management
COS	Cray operating system
CRINT	Cray interactive station package for COS
CRT	Cathode ray tube

CSP Cray station package

CSU Channel service unit

CTO Contract task order

CXINT Cray interactive station package for UNIX

DCA Data carrier available

DCE Data communications equipment

DEC Digital Equipment Corporation

DI Device independent

DSCS Digital satellite communications simulator

DSU Data service unit

DTE Data terminal equipment

EC ARC Computer Systems Division (now RC)

ECO ARC Computer Systems Division, Operations Branch (now RCO)

ED ARC Information and Communications Division

EIA Electrical Institute of America

ERB Engineering review board

ES Earth station

ETI ARC Technical Services Division, Electronic Instrument Services Branch

FDX Full duplex

FG Function generator

FM Frequency modulation

FTP File transfer protocol

GE General Electric

H/W Hardware

HDX	Half duplex
HP	Hewlett-Packard
HQ	NASA Headquarters
HSP	High-speed processor
I/O	Input/output
IBM	International Business Machines Corporation
IBM/PC	International Business Machines Corporation personal computer
ICASE	Institute for Computational Applications in Science and Engineering (at LaRC)
ID	Identification
IEEE	Institute of Electrical and Electronic Engineers
IOC	Initial operating configuration
IP	DARPA Internet protocol
ISC	Integration support contractor (General Electric)
ISO	International Standards Organization
ISPC	Integrated support processor complex
LAN	Local area network
LCD	Liquid crystal display
LHC	Long-haul communications
LHCP	Long-Haul Communications Prototype
LHCS	Long-Haul Communications Subsystem
MB	Megabytes (1,048,576 bytes)
MR	Material request (via General Electric)
MS-DOS	Personnel computer operating system
MSFC	Marshall Space Flight Center

NAS Numerical Aerodynamic Simulation

NASA National Aeronautics and Space Administration

NMC Network Message Center

NPO NAS Projects Office

NPSN NAS Processing System Network

NSC Network Systems Corporation

OBE Overtaken by events

OEM Original equipment manufacturer

OPS Operations

PC Personal computer

PC-XT IBM personal computer, model XT

PCCB Program configuration control board

PG Pulse generator

PR Purchase request (government)

PRB Program review board

PSCN Program support communications network

RCA RCA Corporation

RF Radio frequency

RFP Request for proposal

RMS AC voltage measurement, root mean squared

RN Numerical Aerodynamic Simulation (NAS) Projects Office

RND NAS Systems Development Branch

RNF NAS Facilities and Operations Branch (now RNS)

RNS NAS Computational Services Branch

S/W	Software
SEP	Cray 2 simple effective protocol
SGI	Silicon Graphics Incorporated
SND	NAS Systems Development Branch (now RND)
SNF	NAS Facilities and Operations Branch (now RNS)
SR	Service request (government)
SSC	Systems software contractor (Informatics General)
STD	Standard
TBD	To be determined
TBS	To be supplied
TCP	DARPA transmission control protocol
TCP/IP	ARPAnet transmission control protocol/Internet protocol
TDMA	Time division multiplexing access
TTC	Telecommunications Techniques Corporation
UNIX	Operating System developed by Bell Telephone Laboratories
UTS	Universal Timesharing System (Amdahl)
VAX	Virtual address extension (DEC 32-bit minicomputer)
VCF	Voltage-controlled frequency
VINOS	Vendor-independent NAS operating system
VMS	DEC virtual memory operating system
WK	Workstation
WKS	Workstation subsystem
WO	Washington office
XNS	Xerox network services protocol

APPENDIX B

LHCP COMMUNICATIONS AND TESTING EQUIPMENT

B.1 COMMUNICATIONS HARDWARE

The following paragraphs will discuss the equipment required at each site and will describe the major components of the communications links. Refer to Figures 2, 3, 4, and 5 within section 4.3 for the configurations of each site. The description of some of the communication equipment was obtained from the vendor brochures and/or operating manuals, when available.

B.1.1 Vitalink

Vitalink Communications Corporation provided a product called VB/1 which used hardware manufactured by Bridge Communications Inc. and a software package called TransLAN developed by Vitalink to interface with Ethernet. The model number for this hardware is Communications Server/1 or CS/1, but is referred to as VB/1. Each remote site did have one VB/1. The ARC site did have two VB/1s to communicate with LaRC, LeRC and CSU. In addition to the two VB/1s at ARC, a Network Management Station or Communications Server/100 (CS/100) was connected to the NAS Ethernet at ARC to allow monitoring of the remote VB/1s.

The CS/100 serves as an interface between individual devices and an Ethernet network by establishing virtual circuit connections between these devices. The CS/100 supports most terminals, printers, personal computers, host computers, modems, word processors and other devices with serial interfaces. Complete networks of non-Ethernet devices can be implemented by connecting all elements to the network through the CS/1 and CS/100.

The CS/100 has the following features and capabilities:

- (1) CS/100-BSC (Bisynchronous) supports character synchronous communications through an RS232 interface on all ports.
- (2) CS/100 can include both host and user interfaces.
- (3) CS/100 is a master controller that can control or look at any of the CS/1 Bridges configurations located at the remote locations.

The CS/1 with the TransLAN software is a hardware and software system designed to connect any number of Ethernet or IEEE-802.3 Local Area Networks (LANs) so they appear as one large "Local Area Network".

The CS/1 has the following features and capabilities:

- (1) The bridge and communications software interconnects LANs with digital transmission systems. TransLAN may thus interconnect LANs via public communications

networks (telephone lines) or through private or public satellite or microwave systems.

(2) The VB/1 Bridge stores and forwards entire LAN frames and automatically "learns" which are local and which are remote. The VB/1 Bridge, therefore, is able to filter and discard messages addressed to local stations, keeping local traffic on one LAN from congesting the interconnect media or the remote LANs. Filtering allows bridges to use substantially lower link speed than those used on the LAN.

(3) Each VB/1 Bridge can support up to eight V.35/RS232 satellite channels/terrestrial ports. Port card capacity is 224kbps.

(4) TransLAN can be used to expand networks indefinitely in a modular fashion by linking VB/1 Bridges together.

The LHCP group is responsible for all Vitalink equipment supplied to the sites.

A short description of the Vitalink company and cost information for the Vitalink equipment used in the LHCP is discussed in NPO reference 1, appendixes B and C.

B.1.2 Fibercom IFL-70

The Fibercom IFL-70 analog fiber optic system is used to convert a 70 MHz signal to a fiber optic signal and vice versa. The IFL-70 devices allowed data from the satellite Earth station to be transmitted to the COMTECH SM200A modems which interface with the Vitalink VB/1s via a V.35 interface.

Code ED is responsible for the Fibercom IFL-70s located at ARC. RCA is responsible for those installed at LaRC and LeRC.

B.1.3 COMTECH SM200A

The COMTECH SM200A converted the 70 MHz signal from the IFL-70 to be compatible with V.35 so that the signal can be transmitted to the Vitalink VB/1s. The COMTECH SM200As installed at ARC, LaRC and LeRC have the (dual) redundant feature. This feature provided for backup in case the primary channel interface board fails.

RCA is responsible for the COMTECH SM200As installed at ARC, LaRC and LeRC.

B.1.4 Fiber Optic Cable

At ARC, fiber optic cables are being strung between the IFL-70s to connect the Earth station at Bldg. N240 Room 220 with the VB/1s at Bldg. N233A Room 097. Fiber optic cables also were used at LaRC and LeRC to connect their Earth stations to VB/1s. The fiber optic cables did meet or exceed the specifications of Belden Series 227400 fiber optic cable.

Code ED is responsible for the fiber optic cables at ARC. Each site was responsible for the fiber optic cables that were strung.

B.1.5 CSU/DSU

A Channel Service Unit/Data Service Unit (CSU/DSU) is used to connect the VB/1 to the 56kbps terrestrial line at ARC. Another CSU/DSU is used at Colorado State University to tie their VB/1 to the other end of the 56kbps line. A CSU/DSU is essentially a high-speed modem. The CSU/DSU units at ARC and CSU are supplied and were maintained by Boeing under the PSCN effort.

B.1.6 Earth Station

For the satellite links, Earth stations (ES) with up and down converters are used to send and receive data via satellite networks. Satellite links and/or Earth stations were provided by RCA at ARC, LaRC and LeRC. These services are being supplied under the PSCN contract by Boeing/RCA.

At ARC and LaRC, existing RCA/NASA Earth stations were used. A RCA transportable Earth station was provided at LeRC. The interface will be V.35 on a Winchester 34 pin connector. RCA provided the clocking for the signals.

RCA is responsible for all services delivered to the Earth stations at each site.

B.2 LHCP ELECTRONIC LABORATORY TESTING EQUIPMENT

The following paragraphs present a description of each major piece of testing equipment required by the LHCP Electronics Laboratory. The description of some of the test equipment was obtained from the vendor brochures and/or operating manuals, when available.

B.2.1 Digital Satellite Communications Simulator

The Digital Satellite Communications Simulator (DSCS) is a microprocessor-based system designed to simulate the time delay, error conditions and electrical interfaces which characterize a full duplex digital satellite circuit. The DSCS consists of two distinct units: the model 1010B Satellite Digital Delay Simulator and the 1020B Satellite Digital Error Simulator. The DSCS is made by Telecommunications Techniques Corporation (TTC).

The 1010B Satellite Digital Delay Simulator is used to create a delay satellite circuit environment in the lab. The 1010B has the following features and capabilities:

(1) Capable of introducing up to 999 milliseconds of delay to both data paths of a full duplex (FDX) channel allowing simulation of a single or multiple hop satellite transmission path.

(2) Capable of interfacing with data terminal equipment (DTE) through RS232, RS449, V.35 and DS1 (T1).

(3) Capable of varying bit rates from 2400 bps to 6.312 Mbps.

(4) Capable of being remotely controlled through IEEE-488 interface.

The 1010B works by having the delay controller store data in the delay memory until the programmed delay time has expired. The delay memory then sends the data out as received data.

The 1010B Satellite Digital Delay Simulator is designed to operate either as a standalone instrument or in conjunction with the 1020B Satellite Digital Error Simulator.

The 1020B Satellite Digital Error Simulator is used to create an error satellite circuit environment in the lab. The 1020B has the following features and capabilities:

(1) Capable of introducing Gaussian distributed bit errors, with or without burst characteristics, over a wide range of bit error rates to both data paths of a FDX channel allowing realistic simulation of a satellite channel error characteristics.

(2) Capable of interfacing with data terminal equipment (DTE) through RS232, RS449, V.35 and DS1 (T1).

(3) Capable of varying bit rates from 2400 bps to 6.312 Mbps.

(4) Capable of being remotely controlled through IEEE-488 interface.

The 1020B is composed of two parts, the error controller and the error generator. The error controller is programmed by the processor to the specific error rate selected. The error controller then sets the error generator to this error rate and sends the data through the error generator circuitry where the errors are introduced into the data.

The 1020B can be used to develop and test virtually any type of terminal equipment and supporting software prior to using expensive satellite facilities.

The 1020B Satellite Digital Error Simulator is also designed to operate either as a standalone instrument or in conjunction with the 1010B Satellite Digital Delay Simulator.

B.2.2 Data Error Analyzer

The Data Error Analyzer is a microprocessor-based system designed to measure bit error rates, errors, seconds of testing, errored seconds, blocks, and block errors simultaneously. The Data Error Analyzer performs bit and block error measurements under local or remote control for testing the quality of data communications circuits.

Three FIREBERD 2000 Data Error Analyzers manufactured by Telecommunications Techniques Corporation (TTC) were procured for use at ARC, LaRC and LeRC. The FIREBERD 2000 was used to support the LHCP experiments and is essential for the detection and measurement of bit and block errors during the transmission of data via the VB/1s and communications lines.

B.2.3 Electronic Counter

The Hewlett-Packard HP Model 5335A is a Universal Counter capable of measuring signals in the 200 MHz range. The instrument's basic measurement functions include frequency, period, time, ratio, and totalize. The resident microprocessor and multiple-register-counter expand the usefulness of the counter by allowing post-measurement data manipulation. This allows the additional power and convenience of user-defined measurement function keys for statistical data, math functions, pulse width, rise/fall time, slew rate, duty cycle, and phase relationships. Interpolating oscillators, phase-locked to the instrument's time base, allow measurements to be resolved near a nanosecond.

The 5335A input provides two independent channels, featuring matched high performance 200 MHz input amplifiers. Each input channel includes a full complement of signal conditioning controls. Additionally, the 5335A offers extensive control of triggering and arming. Most measurements are displayed in scientific notation, with the digits grouped into three's for convenience. Four modes of gate selection are provided on the front panel.

B.2.4 Ethernet Analyzer

The LANalyzer EX 5000E Ethernet Network Analyzer is a sophisticated yet easy-to-use tool for developing, debugging, and characterizing LAN; for monitoring network traffic and measuring network performance; and for testing, troubleshooting, and maintaining LANs. The LANalyzer EX 5000E is designed for operation on Ethernet (Versions 1.0 and 2.0) and IEEE 802.3 compliant LANs. All LANalyzer functions are realized by running tests. Test results can be viewed immediately on completion of a test, or stored to an MS-DOS file for later examination and analysis.

The LANalyzer is a product of EXCELAN. The LANalyzer hardware and software are available in a kit form that easily installs and operates on an IBM PC XT, IBM PC AT, or compatible. The LANalyzer system is also available pre-installed (and

tested) in a COMPAQ PORTABLE 286, which is ideal for applications requiring portability.

The LANalyzer has the following features:

- (1) Monitors/captures up to 1000 packets/second on sustained basis, independent of protocol
- (2) Captures packets according to user-defined criteria and start/stop triggers
- (3) Accurately time-stamps captured packets
- (4) Displays statistics graphically in real time
- (5) Generates controlled amounts of traffic

B.2.5 Logic Analyzer

The Hewlett-Packard 1630A/D is a general purpose logic analyzer for use in the design, debug, and functional test of digital hardware and microprocessor hardware and software. It features measurement capability in two domains of interest to the digital system designer: state and timing. Functionality in either of these two domains is available to the user separately or in interactive combination.

The 1630 is a stand alone, benchtop instrument with integral keyboard and display, but it may be remotely programmed by an external controller over its built in HP-IB (Hewlett-Packard Interface Bus). HP-IB also provides linkage to the peripherals such as a number of disks and printers. A micro floppy disk can be connected to the 1630 for the store and recall of measurement configurations and acquired data. A printer will provide hardcopy of waveforms, listings, and instrument configurations at the touch of a key.

B.2.6 RS232 Interface Analyzer

The Electro Standards Laboratory, Inc. Model 700 EIA RS-232 Interface Analyzer is a diagnostic tool designed for use at the standard EIA RS-232 or CCITT V.24 data interface of modems, multiplexers, terminals, and computers. It is simply inserted in series between the data terminal equipment (DTE) and the data communications equipment (DCE) to provide access to and monitoring of all data, timing, and control signals.

The unit is of optimum design utilizing state of the art tri-state light emitting diodes to clearly display polarity, activity, and validity of all interface signals. Miniature rocker switches allow the user to program a 'make' or 'break' for each signal at the DCE/DTE interface. Mini-patchcords are provided for cross-patching or loopback patching of signals at the front panel test point array.

A complete table of EIA/CCITT standard interface signal description is provided inside the unit for ready reference during testing. A covered compartment provides secure storage for mini-patchcords and an EIA ribbon cable. The unit is battery powered for complete portability, pocket-sized for convenience and packaged in a sturdy aluminum case for durability in field service use.

B.2.7 Signal Generator

FG 504 Function Generator- The TEKTRONIX FG 504 Function Generator provides low distortion sine, square, triangle, ramp, and pulse waveforms over the frequencies from 0.001 Hz to 40 Hz in 10 decades. A user-definable custom frequency range is also available. The output amplitude is 10 mV to 30 V peak-to-peak into an open circuit and 5 mV to 15 V peak-to-peak into a 50-ohm load. The output impedance is 50 ohms. The FG 504 may be swept between the START and STOP FREQ dial settings with a linear or logarithmic sweep. The output may be phase locked, gated, or triggered for single cycle output. The output waveform may be shifted + or - 80 degrees from the triggering waveform. The symmetry of the output waveform may also be varied. For the slower frequencies, the output may be held at any level by pushing the front panel button labeled HOLD.

A voltage-controlled frequency (VCF) input controls the output frequency from an external voltage source. The output frequency can be swept above or below the selected frequency, to a maximum of 1000:1, depending on the polarity and amplitude of the VCF input and the selected output frequency. Provision is also made for amplitude modulating the sine wave output from an external source.

The variety of swept and modulated signals available from the FG 504 make it especially useful for such applications as testing amplifier or servo-system response, distortion, and stability. It is useful for FM generation, as a beat frequency oscillator, as a gated triggered or phase-locked logic interface, or as a source for various ramp or pulse waveforms. It is also useful as a source for amplitude modulated signals for various purposes.

PG 502 Pulse Generator- The TEKTRONIX PG 502 is a 250 MHz general purpose pulse generator usable in the TM 500-series power modules only. Major capabilities of the instrument include high repetition rate, narrow pulse width, fast rise-time, and independent pulse top and bottom level controls. Front-panel controls provide manual trigger, square-wave output, complementary pulse output for high duty factors, and selectable back termination in the pulse output circuitry. All other inputs and outputs are internally terminated at 50 ohms. Triggers preceding the output pulse are available at the front panel. The pulse output may also be externally triggered.

The front panel is color coded for easy reference to controls and their associated functions. Orange denotes pulse duration controls and settings; green, triggering functions; and the frequency equivalents for the pulse period settings are listed in red.

B.2.8 Standard Bus (STD BUS)

The Standard Bus was not procured by the LHCP group since no time was available to fully explore its possible uses. However, the LHCP group does recommend that the LHCS group investigate the functionality of the STD BUS and perhaps procure it for use in future development activities.

The Standard Bus (STD BUS) with the IBM PC-XT is a digital/analog developmental system. It allows many different functioning circuit boards to be configured together into a working system under microcomputer control. Depending on the type of cards and software installed, it can be used to control tests, and to collect, process, and plot data for systems such as the NAS LHCS.

The main component of the system is the 702A Standard Bus Chassis. It contains a 13-slot card cage, 2 floppy disk drives (8 inch), fan and power supply. The system can be set up and programmed to gather, plot, store and process data from the Vitalink VB/1 bridge box, the Network Management Station, the Satellite Delay Simulator and the Bit Error Rate Test Set.

The IBM PC-XT will be used for system control, software development, and data and program storage. By connecting the STD BUS System to an IBM PC-XT via an interface board and software, applications programs can be written in languages such as Pascal, Assembly or Fortran. The programs are compiled by the IBM PC-XT and then downloaded to the STD BUS system.

Examples of uses are:

- (1) Receive and integrate data from Ethernet Analyzer, Bit Error Rate Test Set, and Vitalink VB/1 bridges to determine the correlation between Ethernet packet load activity, Ethernet retransmissions and packet errors and traffic density, retransmissions in the VB/1 bridge and bit error rate.
- (2) Run a Fourier Analysis of digital data coming from a remote site to convert from the time domain to the frequency domain looking for noise frequency components that will help locate problems in the transmission links.
- (3) The STD BUS/IBM PC-XT system will automatically control the collection of data 24 hours a day and generate reports periodically. This system will be accessible to NAS Operations when the LHCP experiments are concluded.

Data can be sent to the STD BUS several different ways: IEEE 488 - Bit Error Rate Test Test; RS232 - Vitalink VB/1 Bridges; parallel digital - Ethernet Analyzer.

B.2.9 Multimeter

The Hewlett-Packard 3468A/B is a fully programmable HP-IL (Hewlett-Packard Interface Loop) digital multimeter. HP-IL is a serial interface allowing the HP Model 41C/CV family of calculators or desktop computers such as the HP Model 85 to control your 3468A/B. In an automatic test or on the bench, the 3468A/B offers

3 1/2 to 5 1/2 digit resolution for measuring dc volts, true rms ac volts, 2- and 4-wire ohms, and dc and rms ac current. The 3468A/B offers dc voltage performance from 1 μ V sensitivity up to 300 V (full scale), true rms ac voltage capability up to 300 kHz, and resistance measurements from 1 m Ω sensitivity to 300 M Ω (full scale). Its dc and true rms ac current measuring capability is from 10 μ A sensitivity up to 3 A. The optional battery pack provides up to 5 hours of continuous portable operation.

By selecting the number of digits displayed and using the autozero feature, the 3468A/B allows you flexibility in measurement speed and accuracy. Up to 31 readings per second can be made with the 3468A/B in the 3 1/2 digit mode. The fast autorange feature of the 3468A/B allows fast bench measurements over a wide dynamic range.

The alphanumeric liquid crystal display (LCD) gives you measurement units as part of the reading for easy-to-read, unambiguous answers. The HP-IL talk, listen, remote, and SRQ status information is also available with the LCD annunciators. The SRQ button can be used to flag or interrupt your calculator from the front panel of the 3468A/B.

The 3468A/B is calibrated electronically, either manually from the front panel or remotely in an automatic calibration system. There are no internal adjustments and the calibration of all functions is done without the removal of covers. The self-test function verifies most of the internal circuitry of the 3468A/B indicating proper operation of the multimeter.

B.2.10 Lab Oscilloscope

The TEKTRONIX 7603 Oscilloscope is a solid state, lightweight instrument designed for general-purpose measuring applications. This instrument has three plug-in compartments that accept TEKTRONIX 7-series plug-in units to form a complete measurement system. The two plug-in compartments on the left are connected to the vertical deflection system. The right plug-in compartment is connected to the horizontal deflection system. Electronic switching between the vertical plug-in compartments allows a multi-trace vertical display. The flexibility of this plug-in feature and the variety of plug-in units available allow the system to be used for many measurement applications. In addition, the instrument contains a readout system to provide a CRT display of alphanumeric information from the plug-in units. Data such as deflection factor and sweep rate can be encoded and displayed on the CRT.

The instrument features a large-screen, 8 X 10 division display; each division equals 1.22 centimeters. The CRT provides small spot size and fast writing speed. Regulated dc power supplies ensure that performance is not affected by variations in line voltage and frequency, or by changes in the load due to the varying power requirements of the plug-in units. Maximum power consumption is about 170 W (60 Hz, 115-V line).

APPENDIX C

LHCP EXPERIMENTS

LHCP Hardware Experiments 1, 2, and 3
Test Results
By Bohden K. Cmaylo and Trevor Eisenman
May 1, 1986

This report describes the results of the LHCP network performance tests (H/W tests) run between various components and/or hosts on the LHCP network. Section C.1 contains the report of the H/W tests.

Impact of TCP Send/Receive Window Size on Network Performance
Test Results - Second Test Date
By Jonathan Hahn
March 17, 1986

This report describes the results of some follow-up network performance tests run between Amelia and ICASE, two VAX 11/780 computers networked together over a satellite communications link. Section C.2 contains the report of the TCP/IP tests.

LHCP TCP/IP and XNS Comparisons
Test Results
By Bohden K. Cmaylo
23 September 1986

This report describes the results of the LHCP network testings run between two identical IRISs on the LHCP network using either the rcp program, which uses the TCP/IP protocol, or the xcp program, which uses the XNS protocol. These tests were performed at the request of the NAS Workstation Subsystem Manager, Tom Lasinski. Section C.3 contains the report of the TCP/IP-XNS tests.

Long Haul Communications Prototype Experiments Results
Test Results
By Judy McWilliams
TBD

The User Bandwidth experiment evaluated the use of remote communications links between IRIS 1500/2500 and Sun 160 WKS and the NPSN resources to determine remote user bandwidth requirements. The report on the User Bandwidth experiment will be found in NPO reference 8.

C.1 LHCP HARDWARE EXPERIMENTS

This report describes the results of the LHCP network performance tests (H/W tests) run between various components and/or hosts on the LHCP network. The components included: Ethernet, Vitalink VB/1s, Satellite Delay Simulator, and computers such as VAX 11/780, Sun 160, IRIS 1500 & 2500. Each computer had a UNIX type operating system and had a TCP/IP protocol implementation for remote communication. These tests were performed from April 1985 through April 1986.

C.1.1 Scope

The scope of these H/W tests was to exercise all portions of the LHCP network. Possible problems, such as poor performance, could be isolated to a specific portion of either the hardware or software by varying these parameters for each test. An other reason for performing these tests included LHCP familiarization with every portion of the LHCP network. In order to obtain a "feel" of the LHCP network, it was necessary to exercise the network over and over.

C.1.2 Tests Performed

The key to each entry for the "Hardware Test Matrices" is defined in the below Figure C.1.2-1. The entries within each TEST MATRIX of figure C.1.2-2 indicate what data were collected over a simulated communication link. Unfortunately only H/W tests 1, 2, and 3 were completed. H/W tests 4 and 5 will be completed (and/or revised) at a later date by the LHCS group.

LHCP HARDWARE TEST NOTES

VAX	A VAX 11/780 running BSD 4.2 system
IRISo	An IRIS 1500 (Excelan model 101 Ethernet board) running UNIX System 5
IRISn	An IRIS 2500 (Excelan model 201 Ethernet board) running UNIX System 5
Sun	A Sun model 160 running BSD 4.2 UNIX
UTS	An Amdahl 5840 running UTS 5

Y	Collected data for this entry
y	Collected data for this entry, but they are not needed
N	No data collected for this entry, but wanted data
n	Do not want data collected for this entry
M	Collected some data for this entry, but need more data
m	Collected some data for this entry, but they are not needed
5	Used as a suffix for the above notes indicate 56kbps test results also
r	Used as a suffix for the above notes indicate using a real link only

Figure C.1.2-1 LHCP Hardware Test Notes.

TEST 1 - Ethernet Baseline

from/to	VAX	IRISo	IRISn	SUN	UTS
VAX	N	Y	Y	Y	n
IRISo	Y	Y	n	n	n
IRISn	Y	n	Y	n	n
SUN	Y	n	n	N	y
UTS	n	n	n	n	n

TEST 2 - Vitalink standalone 224Kb/s with 0 sec delay

from/to	VAX	IRISo	IRISn	SUN	UTS
VAX	N	N	Y5	Y5	n
IRISo	N	Y	n	n	n
IRISn	Y5	n	M	m	m
SUN	Y5	n	m	N	n
UTS	n	n	m	n	n

TEST 3 - Vitalink 224Kb/s with .25 sec delay

from/to	VAX	IRISo	IRISn	SUN	UTS
VAX	Y	Y	Y5r	Y5r	n
IRISo	Y	Y	n	n	n
IRISn	Y5r	n	M5	n	m
SUN	Y5r	n	m	N	n
UTS	n	n	n	n	n

TEST 4 - Vitalink 224Kb/s with 0 delay and bit error rates

from/to	VAX	IRISo	IRISn	SUN	UTS
VAX	N	N	N	N	n
IRISo	N	N	n	n	n
IRISn	N	n	N	n	n
SUN	N	n	n	N	n
UTS	n	n	n	n	n

TEST 5 - Vitalink 224Kb/s with .25 delay and bit error rates

from/to	VAX	IRISo	IRISn	SUN	UTS
VAX	N	N	N	N	n
IRISo	N	N	n	n	n
IRISn	N	n	N	n	n
SUN	N	n	n	N	n
UTS	n	n	n	n	n

Figure C.1.2-2 Hardware Test Matrices.

C.1.3 Testing Conditions

The following five conditions were needed to be satisfied in order to run the H/W tests.

(1) Segments of an experimenter's time of at least two hours were required for each test point. Usually more time was required for each test point because of difficulties that would arise during the test, such as losing the link.

(2) The availability of computer accesses on two different computer systems. Whenever a workstation was used, standalone time was requested because other users on the workstation would degrade the data transmission rate. Whenever a mainframe, such as a VAX, was used, the tests were performed during a low usage period so that the loading on the computer would not have a great effect on the data transmission rate.

(3) A dedicated (or an unloaded) communication link between the two computers. This usually required that the Vitalink equipment be dedicated for the tests, therefore the remote users would not be able to communicate with the NAS system.

(4) Both computers had to communicate with each other via the communication link. TCP/IP was selected since this was the protocol of choice for the NAS. Unfortunately this protocol was not always in use on the workstations at ARC, especially since the initial workstation to the Cray X-MP/12 connection was through a VMS VAX running an XNS protocol. Therefore, dedicated time was required on the IRIS workstation to switch the XNS kernel to a TCP/IP kernel.

(5) Software was needed to perform the data transmissions and to report on the transmission rates.

Netpush(local) was developed for the LHCP group to perform memory-to-memory transmissions of varying buffer sizes using the TCP/IP protocol. Test shell scripts were also developed to use *netpush* over various parameters. See Sections C.1.22, C.1.23, C.1.24, C.1.25, and C.1.26 for listings of shell scripts and program listings.

C.1.4 Test H/W Configurations

There were five types of H/W tests planned. They were:

(1) An Ethernet Baseline test. This test was to get initial data so that future tests could be analyzed against this baseline. Figure C.1.4-1 is an example of the computers and communication link needed for performing H/W test 1.

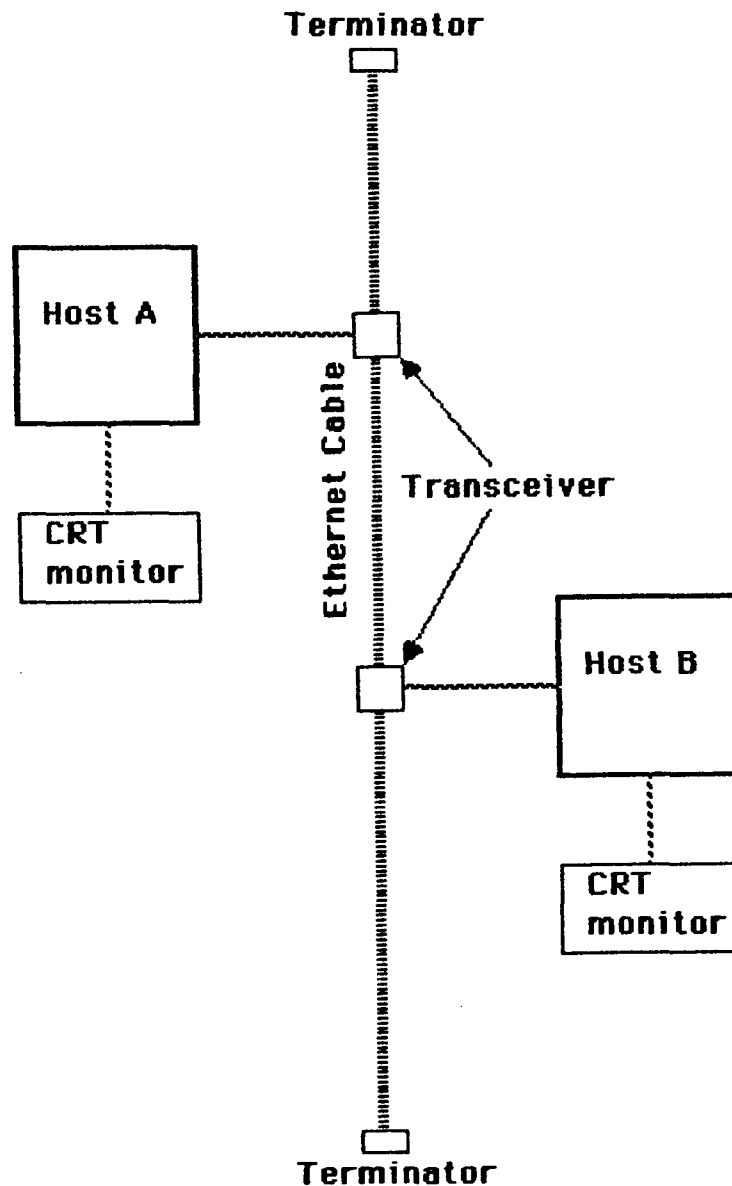
(2) A Vitalink Baseline test. This test was to see how the Vitalink equipment performed compared to the previous test. Figure C.1.4-2 is an example of the computers and communication links needed for performing H/W test 2.

(3) A modified Vitalink test using transport delays. This was to introduce delays in the data communication by placing a satellite delay simulator into the circuit. Figure C.1.4-3 is an example of the computers and communication links needed for performing H/W test 3.

(4) A bit error rate baseline test. This was to repeat H/W Test 2 except that various levels of bit error rates were to be introduced into the circuit. Figure C.1.4-4 is an example of the computers and communication link needed for performing H/W test 4.

(5) A bit error rate with transport delay test. This was to repeat H/W Test 3 except that various levels of bit error rates were to be introduced into the circuit. Figure C.1.4-5 is an example of the computers and communication link needed for performing H/W test 5.

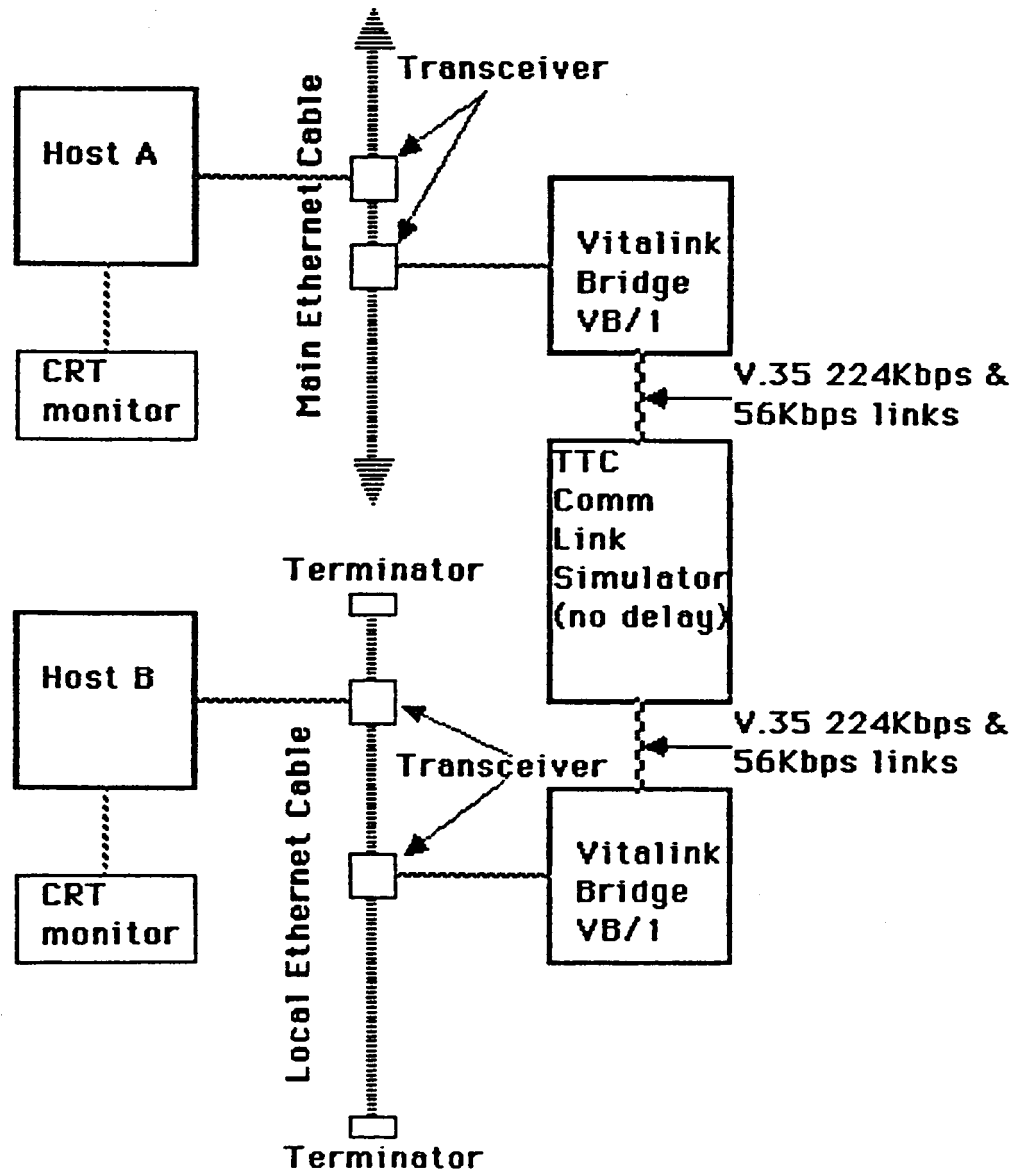
LHCP Hardware Test 1



Purpose: Determine data transmission characteristics between two computers connected via Ethernet. (Ethernet Baseline Test)
Data transfers (memory to memory) from 8 bytes to 1 megabyte, increasing sizes by power of two.

Figure C.1.4-1 H/W Test 1 - Ethernet Baseline Configuration

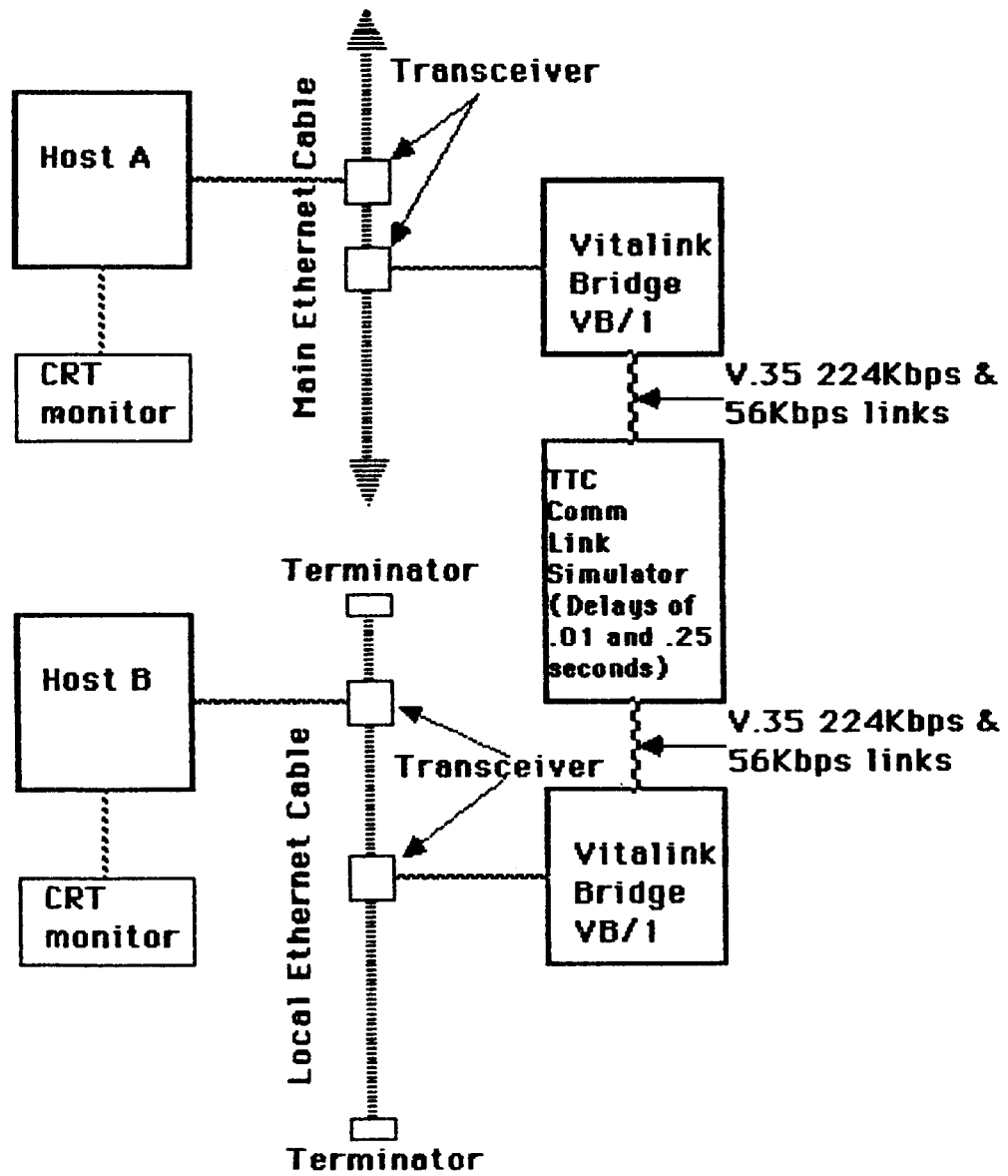
LHCP Hardware Test 2



Purpose: Determine data transmission characteristics via Vitalink boxes between two computers on different Ethernets. (Vitalink Baseline Test) Data transfers (memory to memory) from 8 bytes to 1 megabyte, increasing sizes by power of two.

Figure C.1.4-2 H/W Test 2 - Vitalink Baseline Configuration

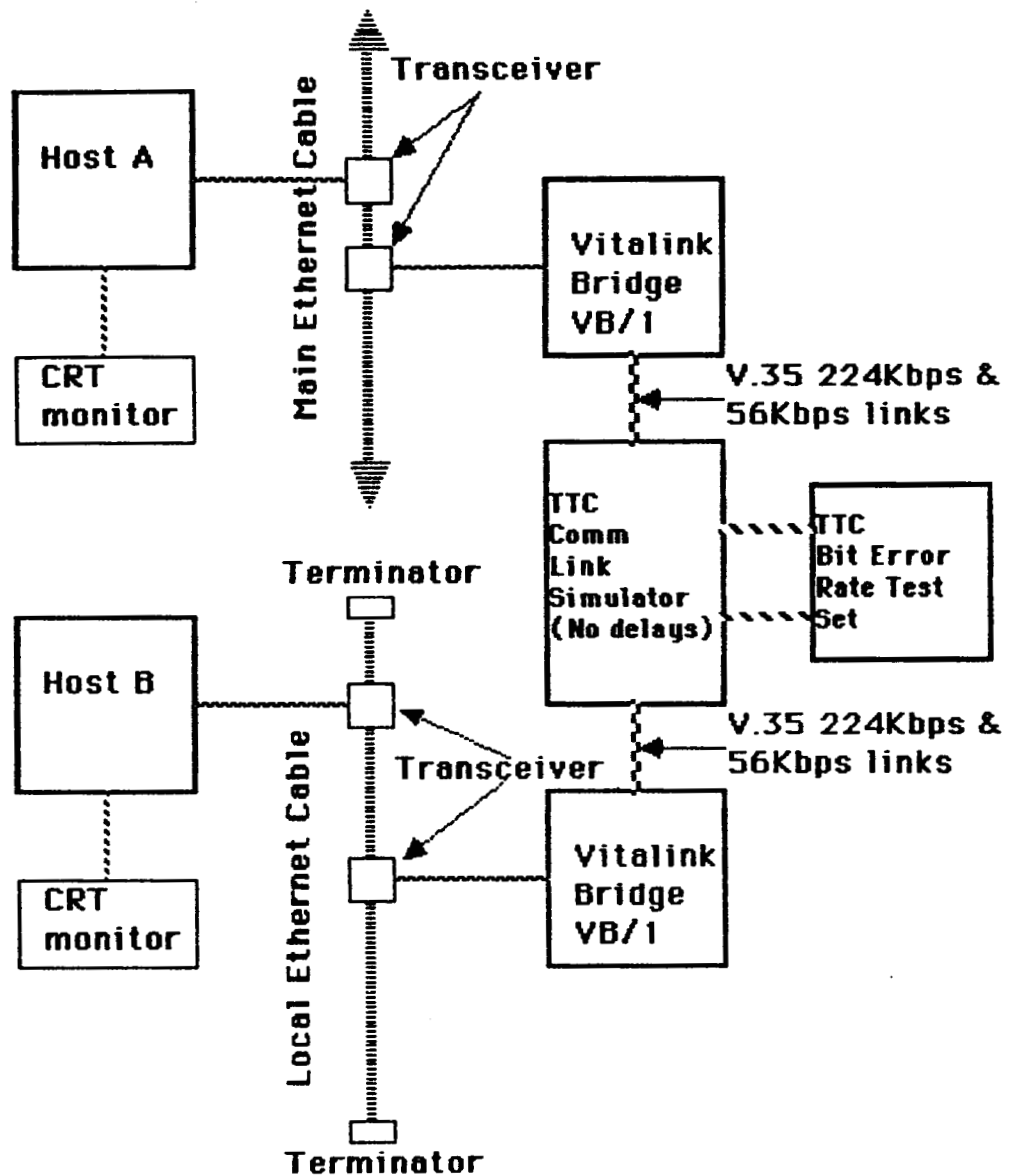
LHCP Hardware Test 3



Purpose: Determine data transmission characteristics via Vitalink boxes, given transport delays of .01 and .25 seconds, between two computers on different Ethernets. (Terrestrial and Satellite simulation) Data transfers (memory to memory) from 8 bytes to 1 megabyte, increasing sizes by power of two.

Figure C.1.4-3 H/W Test 3 - Transport Delay Configuration

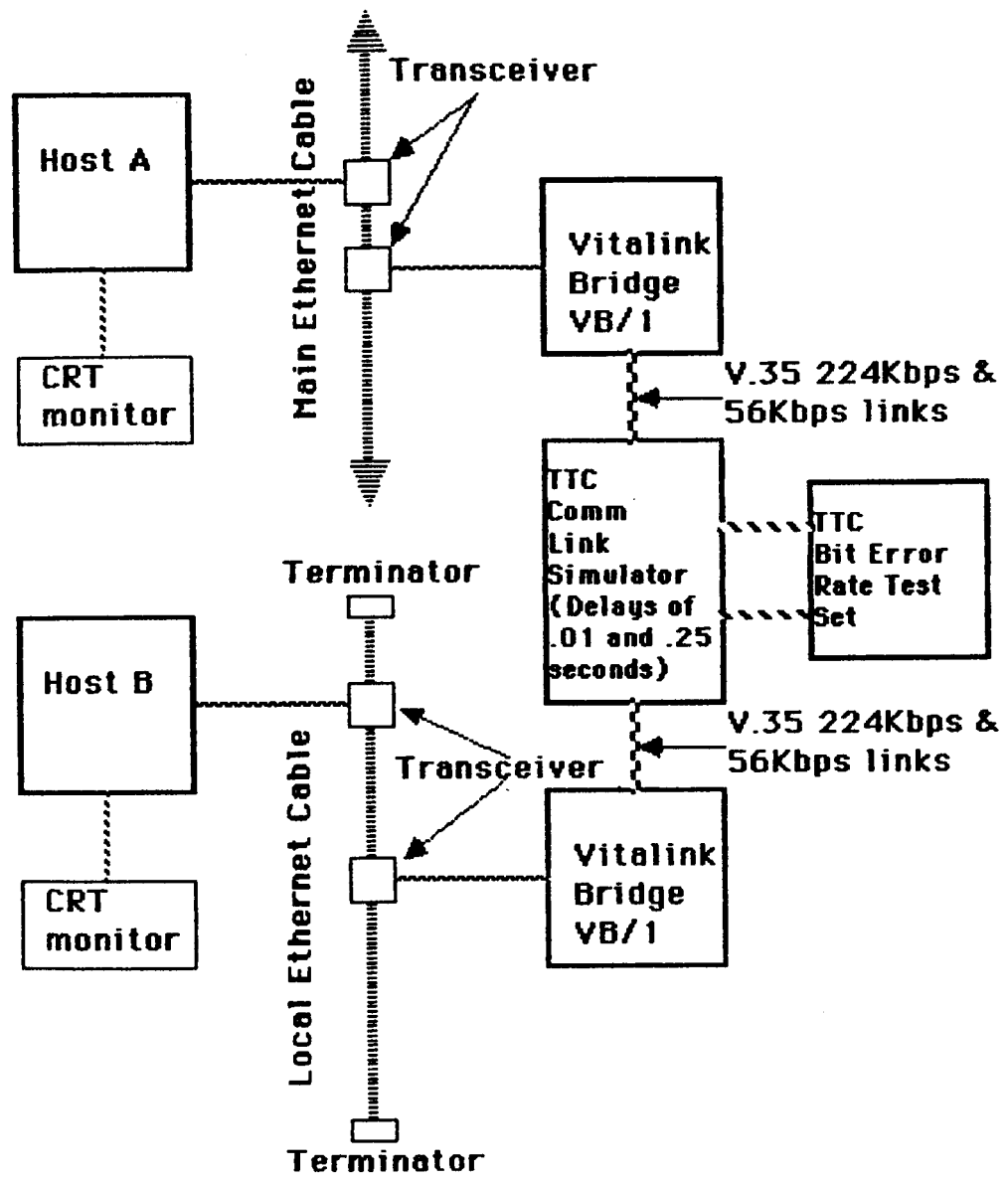
LHCP Hardware Test 4



Purpose: Determine data transmission characteristics via Vitalink boxes, given selected bit error rates, between two computers on different Ethernets. (Bit Error Rate Baseline Test)
Data transfers (memory to memory) from 8 bytes to 1 megabyte, increasing sizes by power of two.

Figure C.1.4-4 H/W Test 4 - Bit Error Rate Baseline Configuration

LHCP Hardware Test 5



Purpose: Determine data transmission characteristics via Vitalink boxes, given transport delays of .01 and .25 seconds and selected bit error rates, between two computers on different Ethernets. Data transfers (memory to memory) from 8 bytes to 1 megabyte, increasing sizes by power of two.

Figure C.1.4-5 H/W Test 5 - Bit Error Rate with Transport Delay Configuration

C.1.5 Raw H/W Test Data

Figure C.1.5-1, on the following page, describes the definitions of the headings of the following tables of "raw data" collected. The headings are a brief description of the computers used, the type of simulated communication medium, the transport delay, and a suffix "r" for when a real link was used. The format of the header column is: Field1-Field2/Field3/Field4. An example "raw data" table follows:

BUFFER (size in bytes) Field1-Field2/Field3-Field4 . . .	
BYTES	DATA (in 1000 bytes per second)
.
.

C.1.6 Analysis of Selected Tests

Various combinations of logical comparisons were selected to observe how the data transmission rates varied. The comparisons generally followed five guidelines:

- (1) If a measurement was taken in one direction, that is machine A transferring data to machine B, then the reverse direction was also measured.
- (2) Identical systems were compared at different link transmission rates.
- (3) Identical systems were compared with different transport delay rates.
- (4) Different systems were compared using identical conditions.
- (5) Peak rates were selected to minimize loading effects.

Graphs follow the below guidelines:

- (1) X-axis is in terms of bytes in a *netpush* buffer transmission, that is, one request of the program to transfer that many bytes. Multiple requests were always used so that the total time per program execution was between 10 to 30 seconds.
- (2) Y-axis is in terms of kilobytes per second.
- (3) The legend titles follow the same format as in the raw H/W data tables.

Axis	Description
Y-axis	The "Buffer" identifies the "Y" axis of each table which consists of the number of bytes given to <i>netpush</i> for a memory to memory transmission
X-axis "CELL"	The "X" Axis Heading Identifies a single type of test configuration Each entry within the table not identified by the heading "Buffer" is in units of "Kilobytes (1000) per second" transmission rate.
COMPUTER	Field1 and Field2 - Description of Computers
Ia	IRIS 2500 workstation at ARC called "annie" with a 201 Ethernet board
ILa	IRIS 1500 workstation at LaRC called "larc" with a 101 Ethernet board
ILe	IRIS 1500 workstation at LeRC called "lerc" with a 101 Ethernet board
Io	IRIS 1500 workstation at ARC called "igor" with a 101 Ethernet board
Iw	IRIS 2500 workstation at ARC called "wks" with a 201 Ethernet board
I1	IRIS 1500 workstation at ARC called "wk01" with a 101 Ethernet board
I4	IRIS 1500 workstation at ARC called "wk04" with a 101 Ethernet board
Ss	Sun 160 workstation at CSU called "surya"
Sw	Sun 150 workstation at ARC called "wiley"
UTS	Amdahl 5840 at ARC called "prandtl"
Va	VAX 11/780 at ARC called "amelia"
VLa	VAX 11/780 at LaRC called "icase"
LINK	Field3 - Link Description
mem	Indicates internal computer memory to memory transfers only.
E	10 Megabits per second Ethernet
2	224 Kilobits per second communication link
5	56 Kilobits per second communication link
TRANSPORT	Field4 - Transport Delay
0	No delay introduced
1	.01 second transport delay introduced (Terrestrial line)
2	.25 second transport delay introduced (Satellite line)
r	When used as a suffix, then the real communications link was used.

Figure C.1.5-1 Definition of Raw H/W Test Data Matrices.

Buffer	Va-Va/mem	Va-Sw/E/0	Va-Iw/E/0	Va-Io/E/0	Ia-Va/E/0	Iw-Va/E/0
8	0.8	2.4				
16	2	4.5				
32	4	5.9				
64	7.5	11.8				
125	6.4	24.2	11.6	10.4	13.4	12.5
250	19.1	33.7	39.1	13.9	22.1	22.1
500	11.3	33.2	32.9	20	34.9	31.3
1000	40.1	39.2	50	27	54.5	68.2
2000	63	57.1	54.9	26.7	10.2	62.5
4000	85.3	62.3	61.7	27.7	28.9	26.5
8000	72.6	59	67.6	29.9	18.6	19.3
16000	33.2	57.5	74.8	33.1	16	16.1
32000	88.4	64.6	75	34.2	16.3	15.6
64000	115.5	63.1	75.3	35	15.8	19.2
128000	113.7	76.8	72.2	35.4	15.3	15.7
256000	122.5	75.2	73.1	35	15.3	15.4
512000	125.4	77.2	72.6	34.1	15.4	15.7
1024000	72.1	76.8	66.3	29.1	15.4	15.4
8	0.5	1.9				
16	1.1	4.2				
32	2	7.8				
64	4.7	9.1				
125	13.5	23.9	26	10.1		12.5
250	26.9	38.2	39.1	16.9		20.8
500	43.3	53.4	48.1	22.7		32.6
1000	52.1	66	55.6	29.2		75
2000	80.7	63.8	57.5	26.3		69.8
4000	84.9	62.9	59.5	28.9		33.7
8000	83.9	65.1	64.4	30.5		17.8
16000	78.4	67.3	67.4	34		16.1
32000	59	69.4	69.1	34.8		15.6
64000	65.2	79.2	67.8	34.9		15.7
128000	82.5	78		35.6		16.6
256000	84.4	77		33.8		15.6
512000	75.3	79.6		32.7		15.4
1024000	56.9	71.5		26.3		15.5

Figure C.1.5-2 Table 1 - H/W Tests Raw Data.

Buffer (cont)	Va-Va/mem (cont)	Va-Sw/E/0 (cont)	Va-Iw/E/0 (cont)	Va-Io/E/0 (cont)	Ia-Va/E/0 (cont)	Iw-Va/E/0 (cont)
10	0.4		2.5	2.5	1.5	1.5
100	20		25	11.1	15	15
1000	52.6		62.5	21.7	75	75
10000	94.3		64.9	34.8	20.8	21
100000	117.6		66.6	37.1	15.6	15.6
1000000	130.9		66.2			
10	0.8		2.5	3.33	0.9	1.5
100	7.1		25	25	12	12
1000	37		62.5	28.6	54.5	54.5
10000	75.2		65.4	36	18.1	19.5
100000	86.9		66.4	37.4	15.5	15.5
1000000	86		64.9	38.3		
10	1				1.5	
100	16.7				8.6	
1000	66.7				75	
10000	90.1				17.2	
100000	121.4				15.7	
1000000	124.5					
10	0.6				1.3	
100	10				12.5	
1000	41.7				69	
10000	93.5				18.8	
100000	104					
1000000	121.4					

Figure C.1.5-3 Table 1 (cont) - H/W Tests Raw Data

Buffer	Va-VLa/2/2r	Va-Iw/2/0	Va-ILa/2/2r	Va-ILe/2/2r	VLa-Iw/2/2r
8	2.1	0.263	0.364	0.723	0.96
16	2.7	0.557	6.656	0.629	2.043
32	2.8	1.081	0.592	0.712	2.551
64	2.8	3.582	1.147	0.883	2.601
125	4.3	9.92	2.34	1.798	2.847
250	3.2	8.823	3.015	2.606	2.844
500	2.9	12.305	2.714	2.787	2.724
1000	3.1	10.589	2.675	2.842	2.677
2000	3.1	15.24	2.614	2.66	2.662
4000	3	15.645	2.663	2.663	2.793
8000	3	16.096	2.69	3.022	2.713
16000	3.1	15.655	2.735	2.707	2.679
32000	2.9	15.576	2.687	2.672	2.675
64000	3.1	14.712	2.747	2.597	2.825
128000	3	14.275	2.622	2.704	2.592
256000		14.341	2.567	2.562	2.571
512000		14.063	2.565	2.547	2.531
8	1.8	0.409	0.481	0.682	1.324
16	2.6	0.887	0.641	0.629	1.646
32	2.5	2.182	0.668	0.574	2.49
64	2.8	3.263	1.206	0.678	2.341
125	3.6	9.469	2.345	2.306	2.676
250	3	8.055	2.662	2.429	2.815
500	3	10.33	2.552	2.785	2.741
1000	3.2	12.755	2.677	2.674	2.696
2000	3	15.616	2.645	2.692	2.797
4000	3	15.81	2.888	2.762	2.734
8000	3.2	15.296	2.695	2.687	2.712
16000	3	15.946	2.699	2.75	2.755
32000	3	16.279	2.666	2.669	2.673
64000	3.1	15.533	2.606	2.682	2.619
128000		15.616	2.577	2.592	2.531
256000		15.323	2.652		2.583
512000		15.867	2.55		2.689

Figure C.1.5-4 Table 2 - H/W Tests Raw Data.

Buffer size	Ia-UTS/2/0	Ia-UTS/2/2	Ia-Sw/2/0	Iw-Ia/E/0	Iw-Ia/2/0
10	1.4	1.7	1.2	0.9	14.6
100	12.5	4.5	6	8.6	12.7
1000	13	3.3	23.1	60	23.2
10000	10.2	2.4	12.4	57.1	11.8
100000			11.8	42	
10	1.4	1	1.2	0.9	14.3
100	14	3	12	15	13
1000	13.5	2.9	28.6	54.5	23.3
10000	10.7	2.3	12.8	61.2	12.4
100000			11.4	20.8	

Figure C.1.5-5 Table 3 - H/W Tests Raw Data.

Buffer	Iw-Ia/2/2	Sw-Ia/2/2	UTS-Ia/2/0	Sw-Ia/2/0
10	1.5	3.3	4.3	5
100	10.9	25	5	25
1000	6.5	3.3	14.6	17.9
10000	3.8	3.1	15.2	19.2
100000				18
10	1.1	3.3	1.3	2.5
100	5.9	25	10.4	25
1000	5.4	3.3	8	20
10000	3.6	2.9	13.6	18.7
100000				16.1
10	1.4			
100	5.9			
1000	5.1			
10000	3.5			

Figure C.1.5-6 Table 4 - H/W Tests Raw Data.

Buffer	VLa-Sw/2/2r	Ia-Iw/E/0	Iw-Va/2/0	Sw-VLa/2/2r	Sw-Va/E/0	Iw-Ia/5/2
8	0.46		1.211	2.277	2.5	0.9
16	1.18		2.389	2.323	4.9	1
32	1.984		4.626	2.704	7.8	1.2
64	2.538		8.755	2.778	15.6	2.3
125	2.692	13.4	13.992	2.938	24.3	2.1
250	2.684	22.7	19.328	2.932	6.7	3.2
500	2.758	35.7	20.408	2.932	44.2	3.3
1000	3.04	79	16.939	3.068	66.2	2.7
2000	3.015	81.1	18.61	2.998	57.3	2.3
4000	3.037	75	15.831	3.031	8.1	2.5
8000	3.022	74.3	14.625	3.038	51.9	2.1
16000	2.941	19	13.132	2.925	46.9	2
32000	2.978	19.4	13.138	2.974	20.1	1.9
64000	3.054	23.9	12.774	3.11	65.8	2
128000	3.053	15.4	13.273	3.027	17.9	1.9
256000	3.044	15.4	12.929	3.022	28.7	1.9
512000	3.094	15.2	12.938	3.091	57.9	1.9
1024000		13.9			44	1.9
8	0.373		1.211	2.173	2.6	0.9
16	0.788		2.396	2.487	4.7	1.4
32	1.099		4.105	2.503	7.2	1.5
64	1.967		9.099	2.784	2.2	2.1
125	2.639	13.9	14.062	2.92	10.1	1.7
250	2.855	22.7	20	2.825	35.5	2.4
500	2.667	34.9	18.682	2.686	30.7	3.2
1000	2.997	79	19.955	3.016	50.4	3.1
2000	3.031	81.1	18.681	3.025	49.3	2
4000	3.069	78.4	15.72	2.951	26.8	
8000	2.91	61.1	13.15	2.998	53.4	
16000	2.912	71.3	12.92	2.972	44.9	
32000	3.001	22.2	11.957	3.061	46	
64000	3.083	69.3	13.256	3.092	58.3	
128000	3.04	43.4	12.666	2.996	40.4	
256000	3.087	22.2	13.083	3.086	61.6	
512000	3.091	15.4	12.585	3.017	64.1	
1024000		13.8			41.3	

Figure C.1.5-7. Table 5 - H/W Tests Raw Data.

Buffer (cont)	VLa-Sw/2/2r (cont)	Ia-Iw/E/0 (cont)	Iw-Va/2/0 (cont)	Sw-VLa/2/2r (cont)	Sw-Va/E/0 (cont)	Iw-Ia/5/2 (cont)
8	0.23		0.889	1.78	2.6	
16	0.312			2.497	4.4	
32	0.601			2.419	7	
64	1.965		8.888	2.87	15.5	
125	2.388	6.8	13.975	3.038	25.2	
250	2.327	25	22.5	2.945	39.1	
500	2.784	42.9	20.547	2.72	50	
1000	2.976	60	15.873	3.007	61.7	
2000	2.979	30	19.533	2.964	53.2	
4000	3.075	50	7.947	3.039	57.5	
8000	3.029	55.8	14.53	2.994	58.1	
16000	2.933	26.9	12.834	2.939	59.8	
32000	3.039	20.2	12.723	3.008	56.5	
64000	3.076	36.3	13.12	3.06	65	
128000	3.074		13.264	3.082	64	
256000	3.086		12.962	3.109	60.1	
512000	3.107		13.079	3.069	64.7	
1024000					48.4	
8	0.65			2.325		
16	0.795			2.539		
32	1.679			2.687		
64	2.3			2.816		
125	2.27	12.5		2.911		
250	2.267	20.8		2.925		
500	2.394	28.8		2.739		
1000	2.196	71.4		2.987		
2000	2.171	75		2.972		
4000	2.208	50		3.004		
8000	2.191	65.2		2.976		
16000	2.145	33.8		2.986		
32000	2.161	17.8		2.969		
64000	2.174	27.9		3.079		
128000	2.158	16.4		3.037		
256000	2.141			3.068		
512000	2.166			3.036		

Figure C.1.5-8 Table 5 (cont) - H/W Tests Raw Data

Buffer	Va-Sw/2/0	Sw-Sw/mem	Sw-Va/2/0	I1-I4/2/1	I1-I4/2/2	Iw-VLa/2/2r
8	0.94	1.3	2.373			1.185
16	2.488	2.5	5.031			2.307
32	6.852	4.9	8.02			3.282
64	3.374	9.6	12.524			3.002
125	9.96	14.9	17.361	6	6.3	3.588
250	8.96	25	18.796	10.3	1.3	3.456
500	14.144	37.3	20.661	15.4	3.8	3.257
1000	15.037	48.2	21.834	24.5	5.9	2.746
2000	18.298	67.8	21.436	23.5	5.6	2.733
4000	18.957	64.3	21.621	14.7	3.8	3.157
8000	19.138	69	21.563	9.8	3.3	2.9
16000	18.369	73.7	21.447	9.6	2.9	2.703
32000	18.642	88.2	20.539	8.8	3.3	2.62
64000	15.311	91.4	21.333	7.7	2.9	2.683
128000	14.198	100	21.955	8.2	2.8	2.783
256000	16.176	97.4	22.397	8.8		2.618
512000	16.778	100.1	19.976			2.61
1024000		79.7				
8	1.258	1.3	2.484			1.185
16	2.651	2.6	4.678			2.347
32	8.779	4.9	8.184			3.327
64	9.026	9.6	12.307			3
125	17.123	14.8	17.123	5.8	5.7	3.571
250	18.382	25.7	18.656	9.4	6.3	2.581
500	19.723	37.3	20.746	14.6	3.9	3.218
1000	20.02	47.8	21.276	23.8	5.4	2.908
2000	20.253	67.9	20.408	23.2	5.3	2.734
4000	20.997	63.5	21.857	11	5	3.217
8000	21.534	70.8	20.565	10.3	3.3	2.952
16000	21.066	71.9	20.942	9.1	2.9	2.746
32000	20.853	85.1	21.476	8.4	3.7	2.57
64000	21.658	96.7	20.447	8	3	2.861
128000	21.639	98.2	18.823	7.5	2.9	2.846
256000	21.557	100.3	17.889	8.1		2.645
512000	21.165	101.1	21.368			2.636
1024000		79.9				

Figure C.1.5-9 Table 6 - H/W Tests Raw Data.

Buffer	Sw-UTS/E/0	Ss-Va/5/1r	Io-Va/E/0	I1-I4/E/0	I1-I4/2/0
8	1.2	0.8			
16	1.9	1.4			
32	0.7	2.5			
64	0.8	3.7			
125	19.5	4	5.4	5.9	5.9
250	16.4	5.4	9.1	12.5	9.8
500	39.7	5.9	13.6	14.9	14.8
1000	42	6.1	28.8	33.3	23.8
2000	26.4	6.1	29.4	33.9	23.4
4000	12.7	5.6	29.9	33.6	12
8000	37.4	6.1	29.8	32.3	8.3
16000	32.4	6.1	19.3	32.5	8
32000	30.4	5.9	21.9	17.5	8
64000	20.8	6.2	23.8	27.2	7.7
128000	18.7	6.1	18.1	25.8	7.7
256000	29.4	6.1	18.4		7.7
512000	39.4	5.8	17.8		7.7
1024000	34.9	6.1	20		7.6
8		0.9			
16		1.5			
32		2.7			
64		3.7			
125		5.2	5.6	6.3	6.3
250		5.5	9	12.5	10.3
500		6	14.4	15	15.8
1000		6.2	28.8	33	25
2000		6.2	29.4	33.9	23.8
4000		6.3	24.3	33.4	13.9
8000		6.1	28	32.5	11.9
16000		6.2	15.8	32.4	7.9
32000		6.1	17.1	19.6	8
64000		5.6	24.2	12.9	7.8
128000		5.5	26.7	12.6	7.7
256000		6.2	25.3		7.7
512000		5.5	22.6		8.6
1024000		6	23.8		7.7

Figure C.1.5-10 Table 7 - H/W Tests Raw Data.

Buffer (cont)	Sw-UTS/E/0 (cont)	Ss-Va/5/1r (cont)	Io-Va/E/0 (cont)	I1-I4/E/0 (cont)	I1-I4/2/0 (cont)
10	3.1	1.3	0.6	0.6	0.6
100	1	12.5	5	5.5	5.7
1000	42.3	7.2	26.1	33.1	25
10000	38.9	6.2	29.6	32.9	9.7
100000		6.1	28.5	31.3	8.3
1000000				23.3	
10	2.9	1.7	0.5	0.6	0.6
100	22.7	16.7	4.3	5.6	5.5
1000	22.7	7.2	27.3	33.1	23.6
10000	28.4	6	29.3	33	10
100000		6.1	29.1	33.2	
1000000				23.7	
10		1.9	0.5	0.7	
100		5.2	4	6	
1000		6.2	26.1	35.3	
10000		6.1	26.9	29	
100000			28.2	29.1	
1000000				29.1	
10		1.7		0.6	
100		5.6		5	
1000		6.2		33.3	
10000		6.1		28	
100000				17.4	
1000000				25.5	

Figure C.1.5-11 Table 7 (cont) - H/W Tests Raw Data.

Buffer	Va-Sw/2/2	Sw-Va/2/2	Sw-Va/5/0	Va-Sw/5/0	Va-Sw/5/2	Sw-Va/5/2
8	1.418	2.352	0.931	0.599	0.66	0.7
16	1.946	2.768	1.153	0.921	0.753	0.823
32	2.379	2.792	1.993	1.466	1.471	1.691
64	2.605	2.839	2.557	1.76	1.604	2.044
125	2.99	3.125	3.453	3.156	1.733	2.055
250	3.008	2.906	3.72	3.227	2.004	2.039
500	2.881	2.84	3.897	3.668	1.992	1.963
1000	3.016	2.826	4.078	3.827	1.985	1.981
2000	3.028	3.036	4.089	3.711	1.922	1.845
4000	3.115	3.169	4.219	3.892	1.853	2.049
8000	2.967	3.062	4.217	3.8	1.931	1.89
16000	2.905	2.852	4.138	3.818	1.982	1.914
32000	3.095	3.081	4.115	3.701	1.945	1.935
64000	2.983	2.922	4.188	3.842	2.014	2.068
128000	3.114	3.021	4.373	3.726	2.012	2.014
256000	3.096	3.085	4.061	3.795	1.885	1.932
512000	3.111	3.092	4.168	3.77	1.904	1.915
8	1.818	2.424	0.94	0.507	0.246	0.701
16	2.247	2.209	1.141	0.521	0.808	0.77
32	2.668	2.807	1.986	1.314	1.364	1.807
64	2.622	2.799	2.63	2.41	1.801	2.02
125	3.18	3.078	3.633	3.246	1.902	1.959
250	2.955	3.012	3.787	3.676	2.012	
500	2.705	2.512	4.152	3.762	1.984	
1000	3.08	3.113	4.159	2.787	1.929	
2000	3.033	2.983	41.62	3.627	1.927	1.923
4000	3.041	2.998	4.192	3.78	2.046	1.879
8000	3.001	3.041	4.203	3.825	1.961	1.927
16000	3.012	2.888	4.186	3.623	1.876	1.902
32000	3.1	3.056	4.172	3.525	1.912	1.909
64000	3.135	2.993	4.199	3.678	2.021	1.98
128000	2.958	2.957	4.189	3.621	2.025	1.92
256000	3.07	3.028	4.165	3.411	1.905	1.921
512000	3.054	2.992	4.18	3.682	1.971	1.94

Figure C.1.5-12 Table 8 - H/W Tests Raw Data.

Buffer	Va-Iw/5/0	Iw-Va/5/0	Iw-Va/5/2	Va-Iw/5/2	ILa-Va/2/2r	ILe-Va/2/2r
8	1.333	1.243	1.118	0.701	0.5	0.5
16	1.273	2.227	1.594	0.803	0.9	0.9
32	1.817	4.314	2.15	1.441	1.9	1.8
64	2.386	4.643	2.107	1.743	3.1	2.7
125	3.396	5.597	2.373	1.987	3.4	3.4
250	3.09	5.208	2.173	2.122	3.1	3.2
500	3.443	4.854	2.094	2.115	3.1	3.1
1000	3.481	4.669	2.104	2.098	2.5	2.6
2000	3.773	4.643	2.062	2.094	2.2	2.2
4000	4.166	4.678	2.065	2.065	3.1	3.2
8000	3.992	4.473	2.05	2.055	2.4	2.5
16000	3.924	4.473	1.89	2.048	2.5	2.4
32000	3.766	4.44	1.823	2.045	2.1	2.1
64000	4.081	4.604	1.972	2.022	2.9	2.7
128000	3.808	4.457	1.714	2.023	2.4	2.7
256000	3.894	4.391	1.938	2.048	2.2	2.3
512000	3.851	4.366	2.006	1.983	2.3	
1024000					2.1	

Figure C.1.5-13 Table 9 - H/W Tests Raw Data.

C.1.7 IRIS(101) to IRIS(101) via 10Mbps and 224kbps, no delay

This was the first comparison test for the IRIS using the old Ethernet 101 board. This test noted the difference of transmission rate due to the communication link. The analysis reveals that the 10Mb Ethernet link displayed the maximum transmission rate, as expected, while the 224kbps link showed degradation of transmission speed due to link loading. Fall-off of transmission rates also occurred at higher buffer sizes for *netpush*, which was assumed to be a buffer fragmentation effect. Figure C.1.7-1 presents the graph of the results.

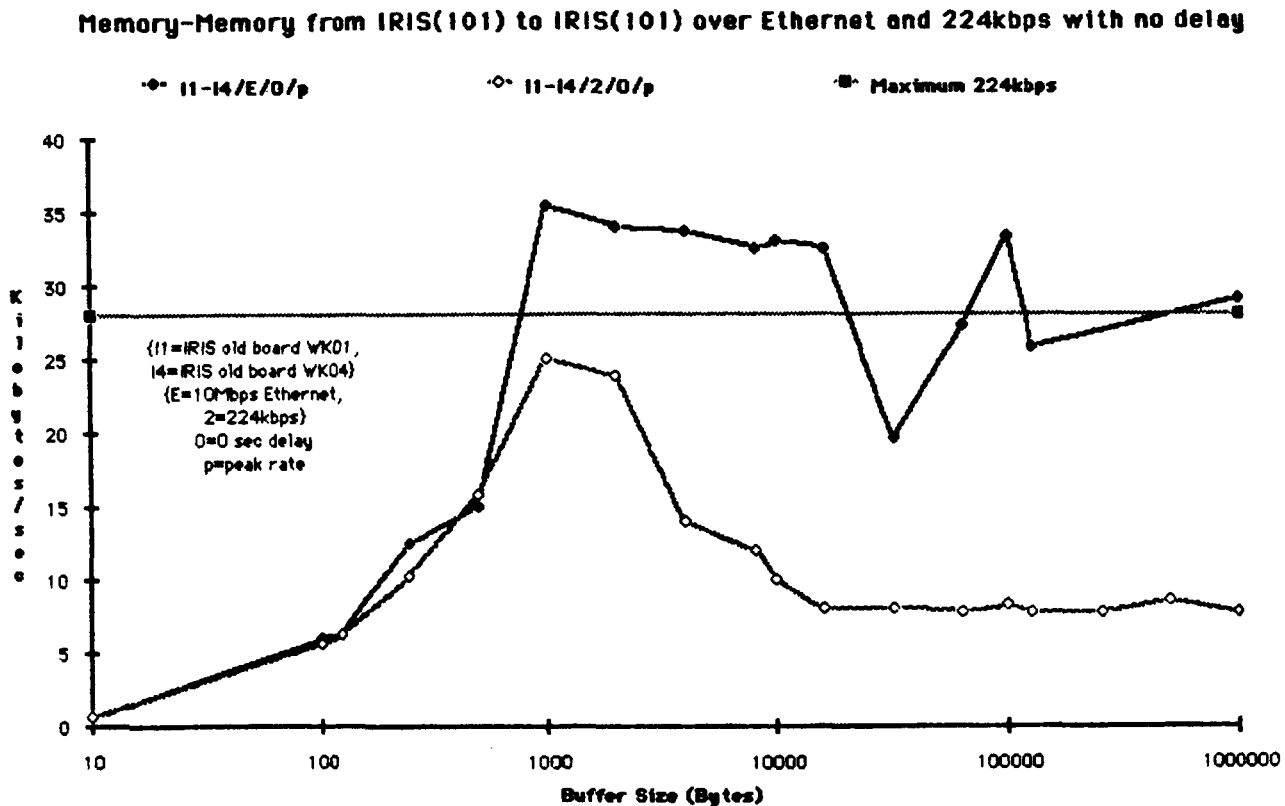


Figure C.1.7-1 IRIS(101) to IRIS(101) via 10Mbps and 224kbps, no delay.

C.1.8 IRIS(201) to IRIS(201) via 10Mbps and 224kbps, no delay

This was the first comparison test for the IRIS using the newer Ethernet 201 board. This test noted the difference of transmission rate due to the communication link. Again, as expected, the analysis revealed that the 10Mb link displayed the maximum transmission rate, while the 224kbps link showed degradation of transmission speed due to link loading. Fall-off of transmission rates also occurred at higher buffer sizes for *netpush*. Figure C.1.8-1 presents the graph of the results.

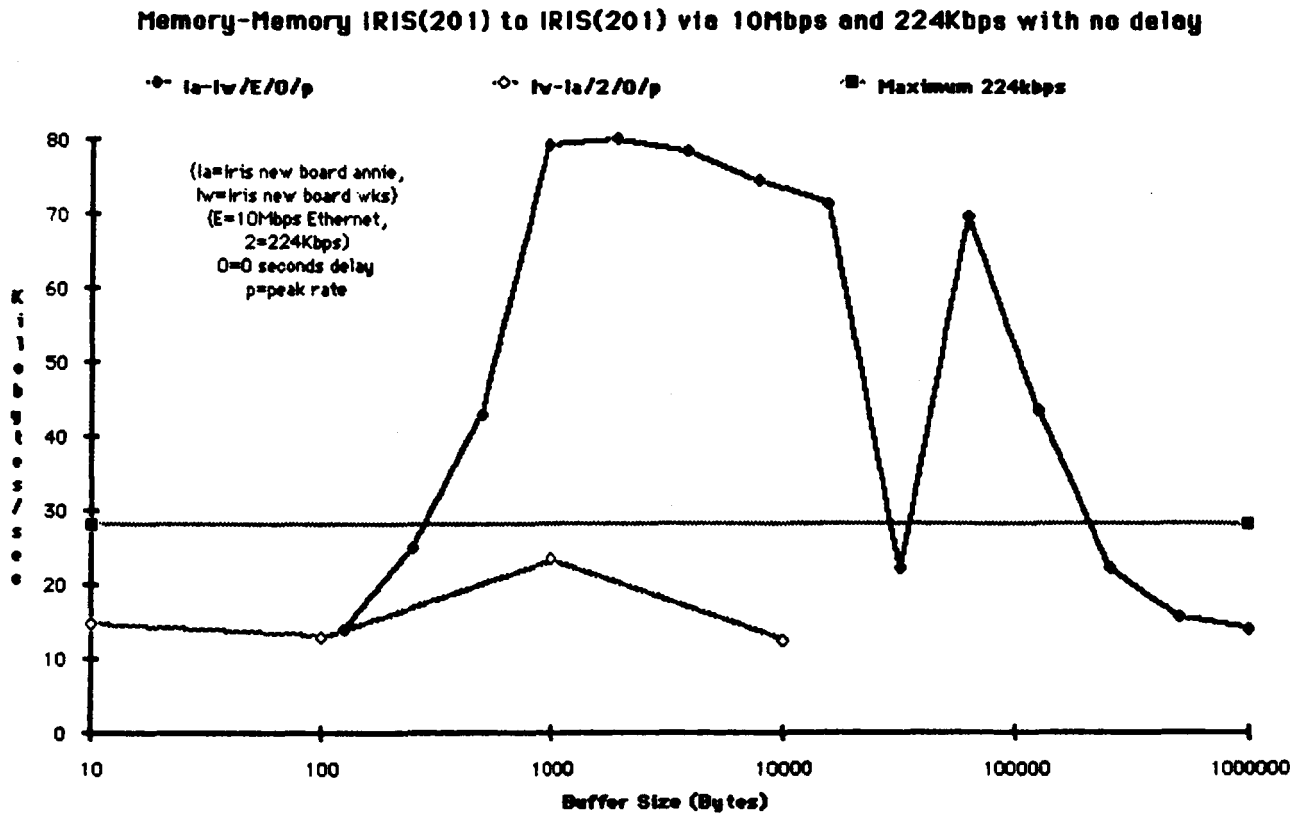


Figure C.1.8-1 IRIS(201) to IRIS(201) via 10Mbps and 224kbps, no delay.

C.1.9 IRIS(101) to IRIS(101) & IRIS(201) to IRIS(201) via 10Mbps, no delay

This was a comparison test for the IRIS using the old and new Ethernet boards over the 10Mbps Ethernet link. This test noted the difference of transmission rate due to the Ethernet boards. The analysis revealed that the new board displayed at least double the transmission rate of the old board, except at 32000 buffer size where an unknown dip in rates occurred, and over 128000 buffer sizes where the fall-off of transmission rates occurred for the new 201 board. The old 101 board did not exhibit the fall-off due to larger buffers. Figure C.1.9-1 presents the graph of the results.

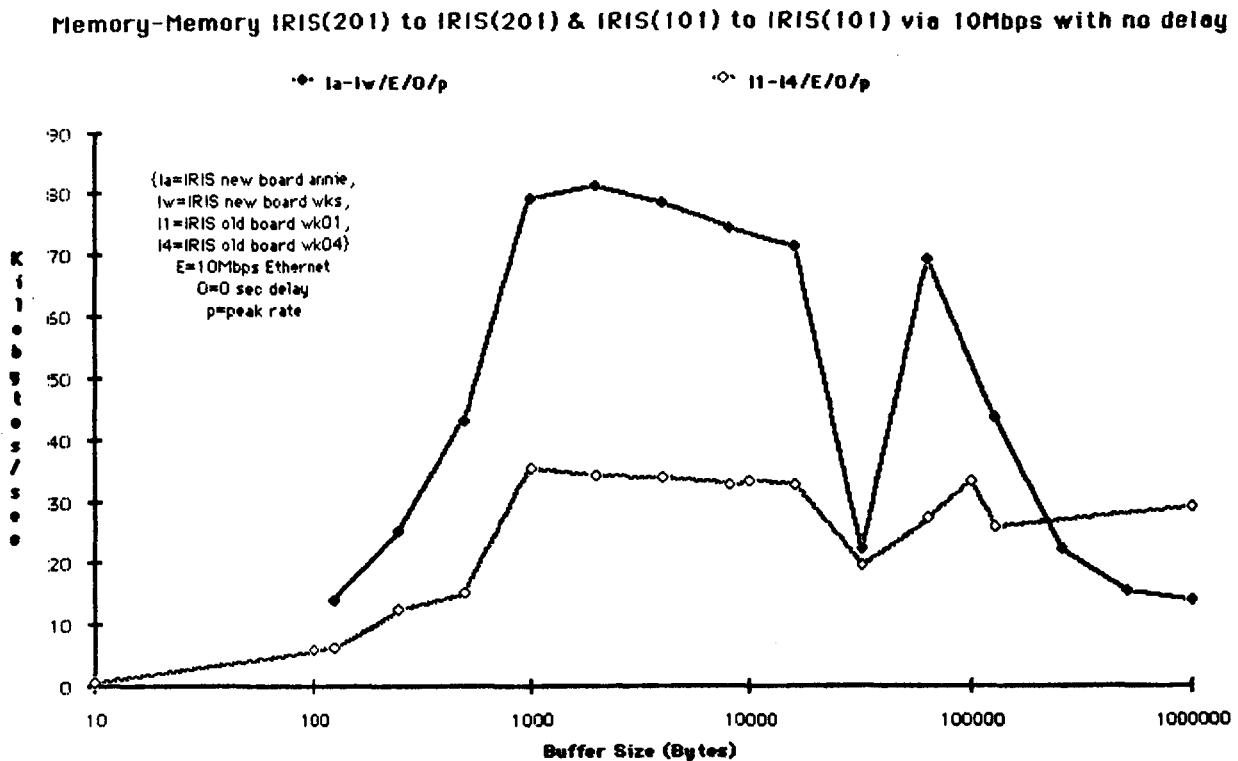


Figure C.1.9-1 IRIS(101) to IRIS(101) & IRIS(201) to IRIS(201) via 10Mbps, no delay.

C.1.10 IRIS(101) to IRIS(101) & IRIS(201) to IRIS(201) via 224kbps, no delay

This was a comparison test for the IRIS using the old and new Ethernet boards over the 224kbps link. This test noted the difference of transmission rate due to the Ethernet boards. The analysis revealed that while the 224kbps link degraded both sets of tests, the new board displayed higher transmission rates than the old board at low buffer sizes (less than 1000 bytes), but showed a similar maximum rate as the old board. Figure C.1.10-1 presents the graph of the results.

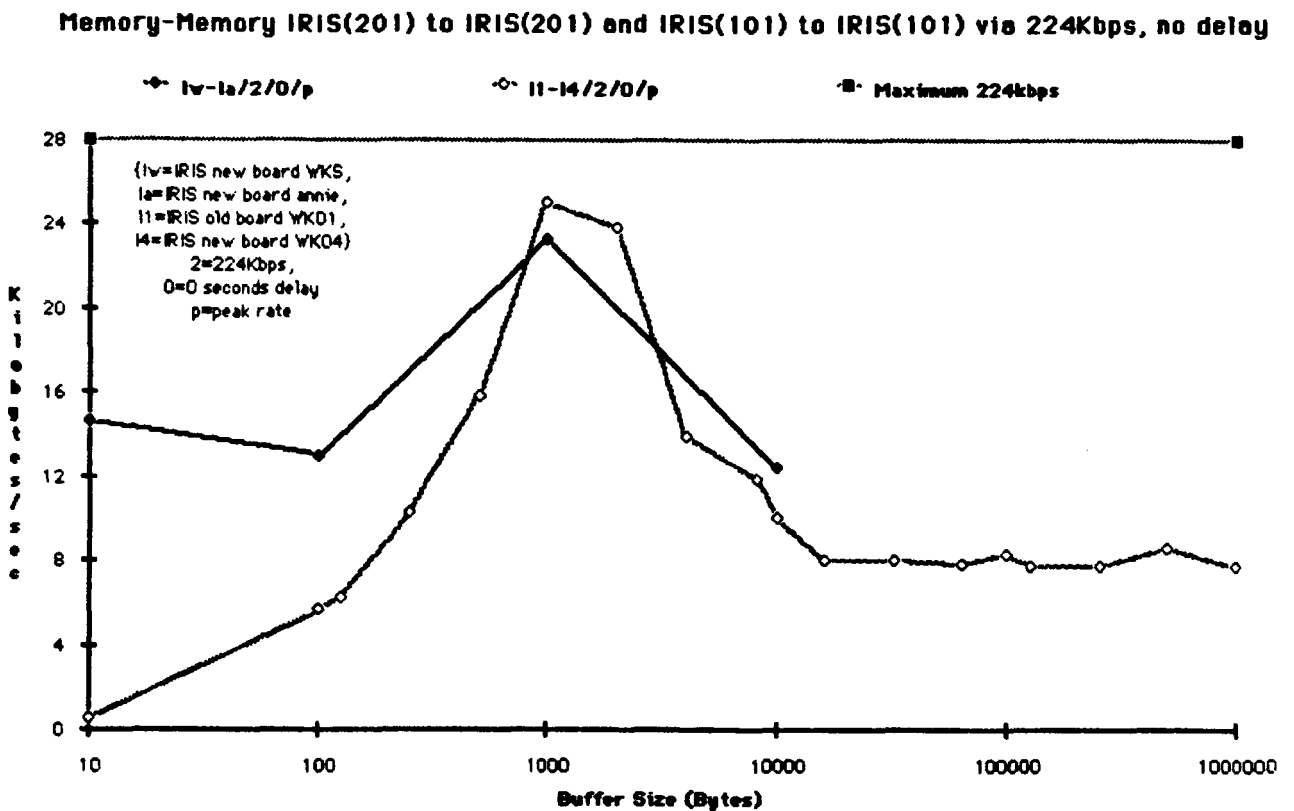


Figure C.1.10-1 IRIS(101) to IRIS(101) & IRIS(201) to IRIS(201) via 224kbps, no delay.

C.1.11 IRIS(101) to IRIS(101) via 224kbps with 0, .01, and .25 delay

This was a comparison test for the IRIS using the old Ethernet 101 board over a local 224kbps link, a long (2000 mile) simulated 224kbps terrestrial link, and a 224kbps satellite link. It noted the difference of transmission rate due to the type of communication link. The analysis revealed that the local and long terrestrial link showed almost identical rates, while the satellite link was greatly affected by the .25 second each way transport delay. A large (~60%) drop-off of transmission rates occurred for buffer sizes greater than 2000 bytes. This was attributed to buffer fragmentation. Figure C.1.11-1 presents the graph of the results.

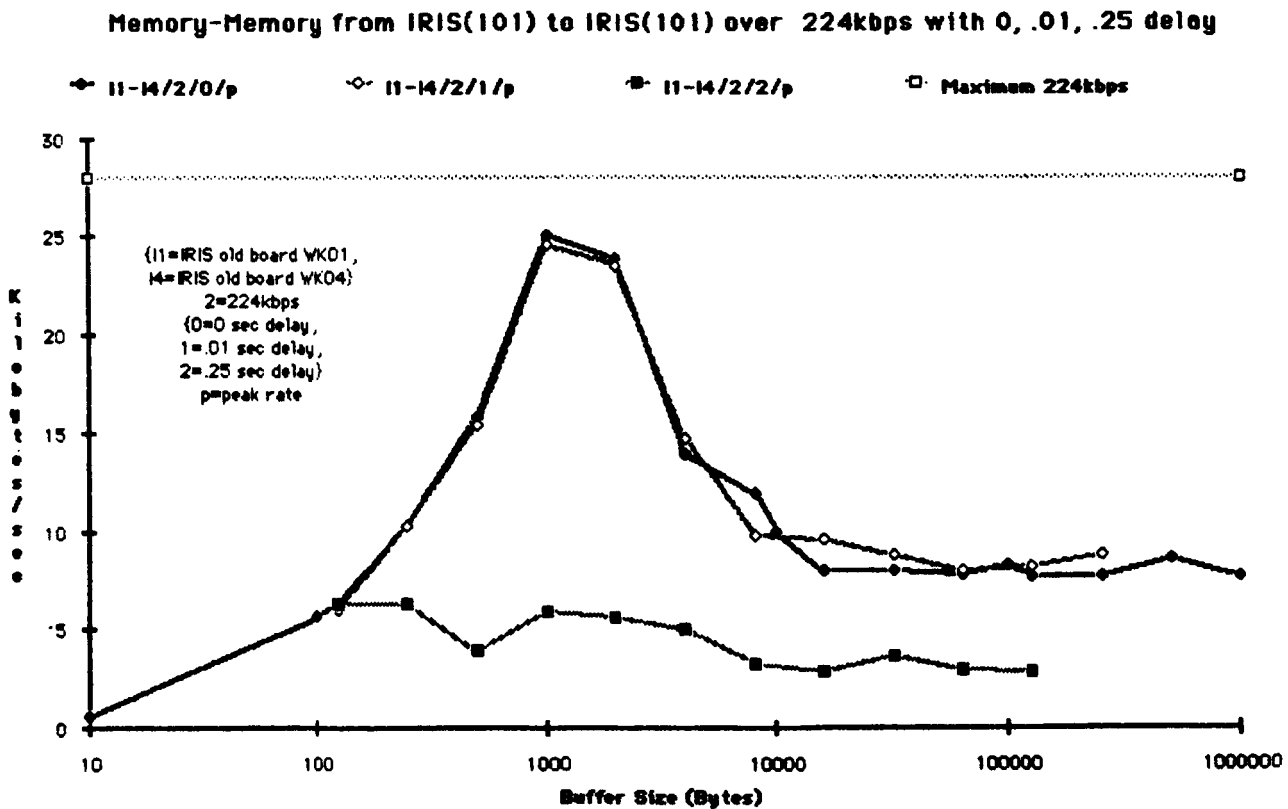


Figure C.1.11-1 IRIS(101) to IRIS(101) via 224kbps with 0, .01, and .25 delay.

C.1.12 VAX to/from IRIS(101) and IRIS(201) via 10Mbps, no delay

This was a comparison test which paired two different types of computers, a VAX 11/780 going to either an IRIS with a new or old type Ethernet board. It noted the change of transmission rate due to the effect of the VAX computer speed on the different IRIS Ethernet boards. The analysis revealed that while the VAX was transferring data to the IRIS (both 101 and 201 boards), the transmission rates generally increased with the increase of buffer sizes, and the IRIS(201) was generally twice as fast as the IRIS(101). However, when the IRIS(201) transferred data to the VAX, the transmission rate suffered a ~75% drop in speed at buffer sizes greater than 2000 bytes, while the IRIS(101) only dropped ~30%. These drops made the IRIS(201) perform ~25% worse than the IRIS(101) board at buffer sizes over 4000 bytes. Figure C.1.12-1 presents the graph of the results.

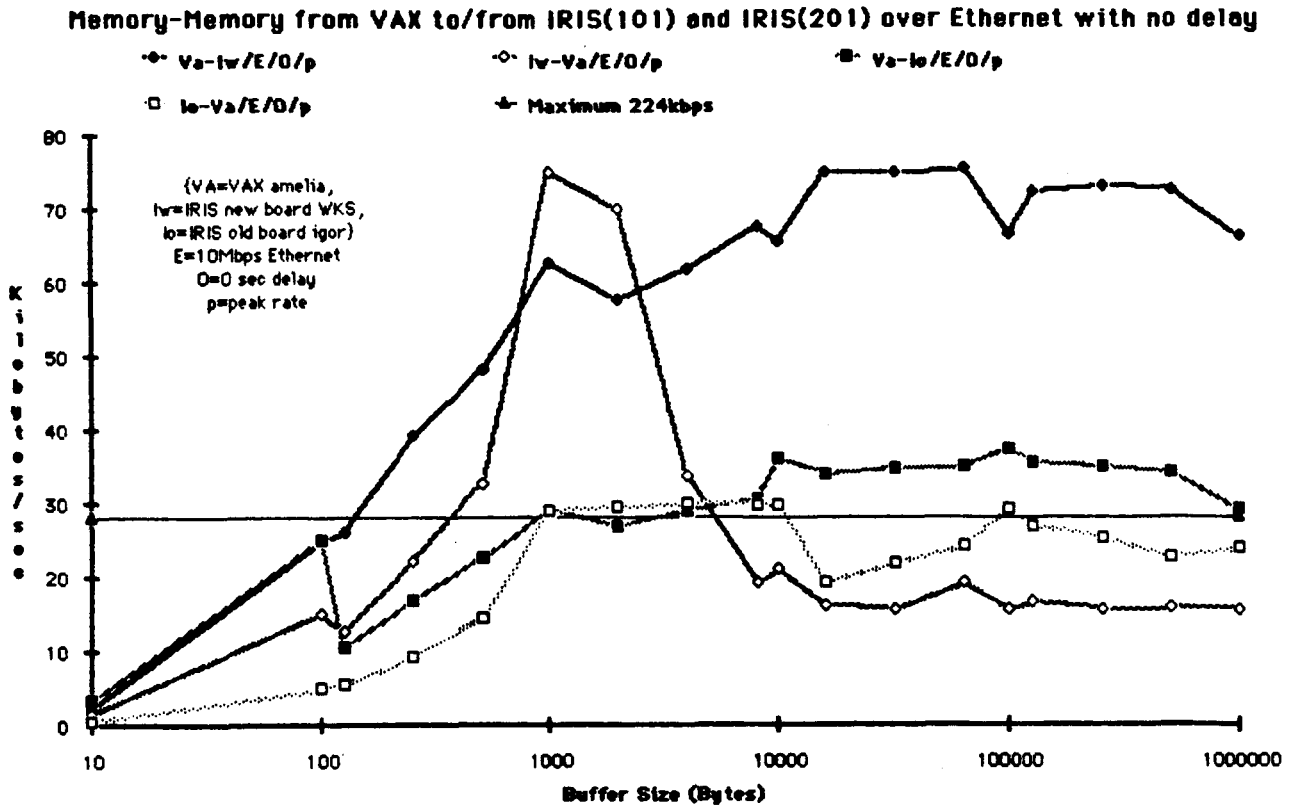


Figure C.1.12-1 VAX to/from IRIS(101) and IRIS(201) via 10Mbps, no delay.

C.1.13 VAX to/from IRIS(201) via 224kbps and 10Mbps, no delay

This was a comparison test for a VAX and IRIS(201) over two types of communication links. It noted the difference of transmission rate due to the type of communication link. The analysis revealed that the 10Mb link displayed the maximum transmission rate, while the 224kbps link showed degradation of transmission speed due to link loading. It also showed that the IRIS(201) to VAX transmission drop produced a similar end rate as the end rate for the 224kbps communication link. Figure C.1.13-1 presents the graph of the results.

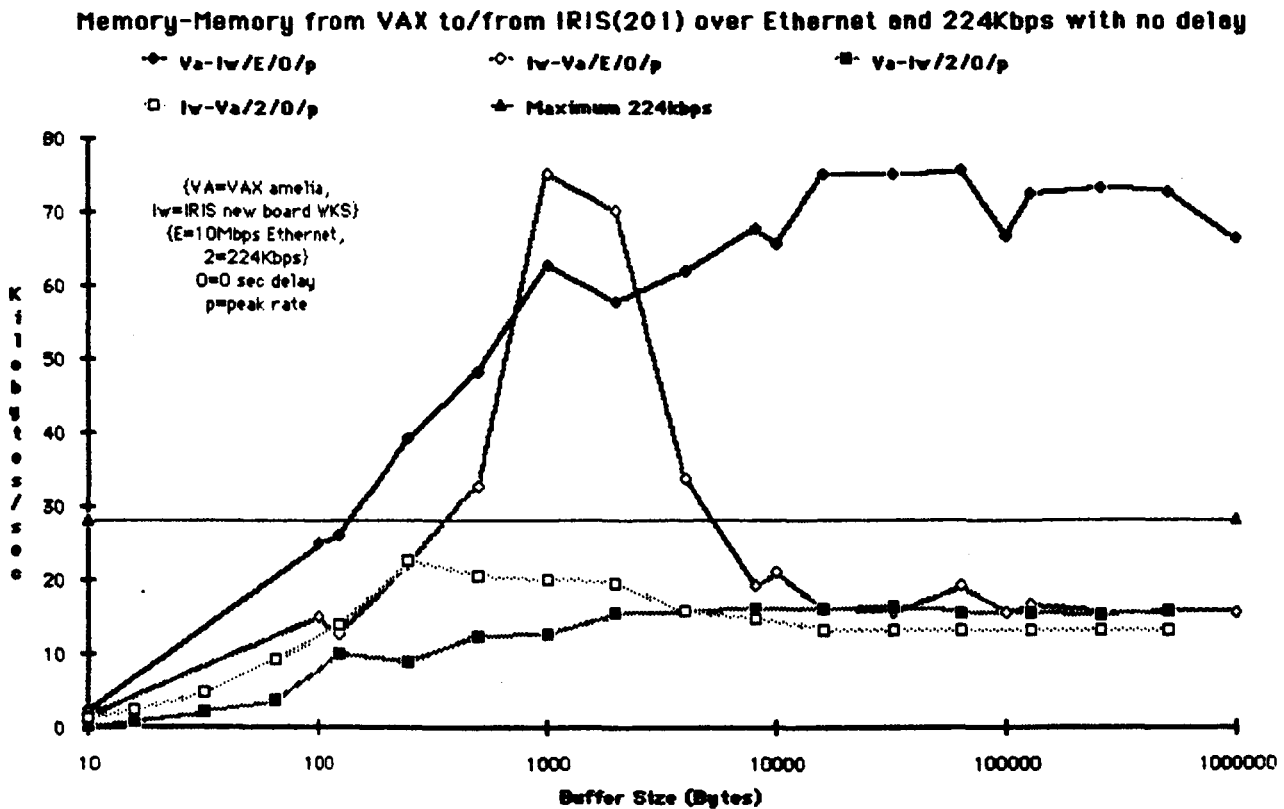


Figure C.1.13-1 VAX to/from IRIS(201) via 224kbps and 10Mbps, no delay.

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C.1.14 VAX to/from IRIS(201) via 224kbps and 56kbps, no delay

This comparison test for the VAX to IRIS(201) noted the difference over a medium and low speed communication link. The analysis revealed that the 224kbps link displayed the higher transmission rate as expected, but the rate was not constantly higher in one direction. The 56kbps was limited to link loading, but the transmission speed was constantly higher in the IRIS(201) to VAX transmission direction. Figure C.1.14-1 presents the graph of the results.

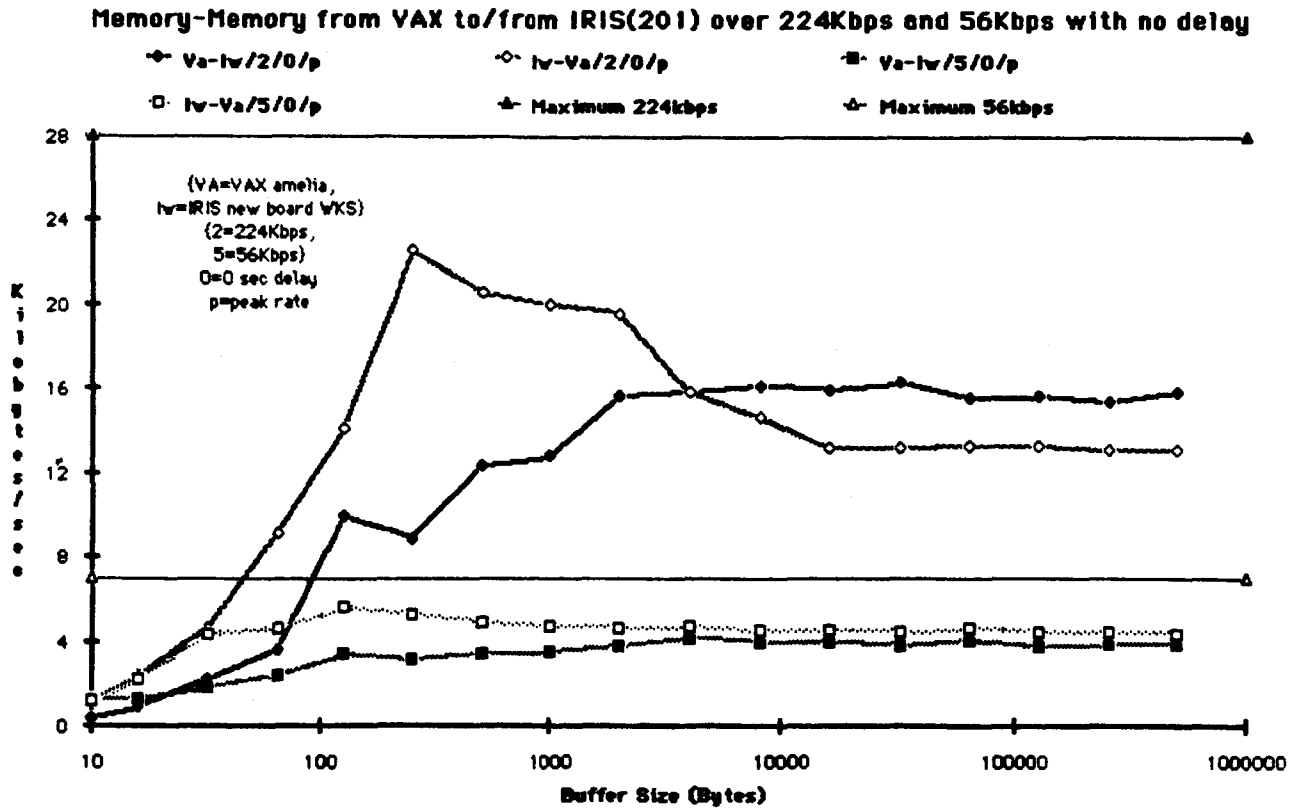


Figure C.1.14-1 VAX to/from IRIS(201) via 224kbps and 56kbps, no delay.

C.1.15 VAX to/from IRIS(201) via 56kbps with and without .25 delay

This was a comparison on a lower rate communication link with an introduced satellite delay. The results indicated that the satellite delay accounted for approximately 50% of the communication. Figure C.1.15-1 presents the graph of the results.

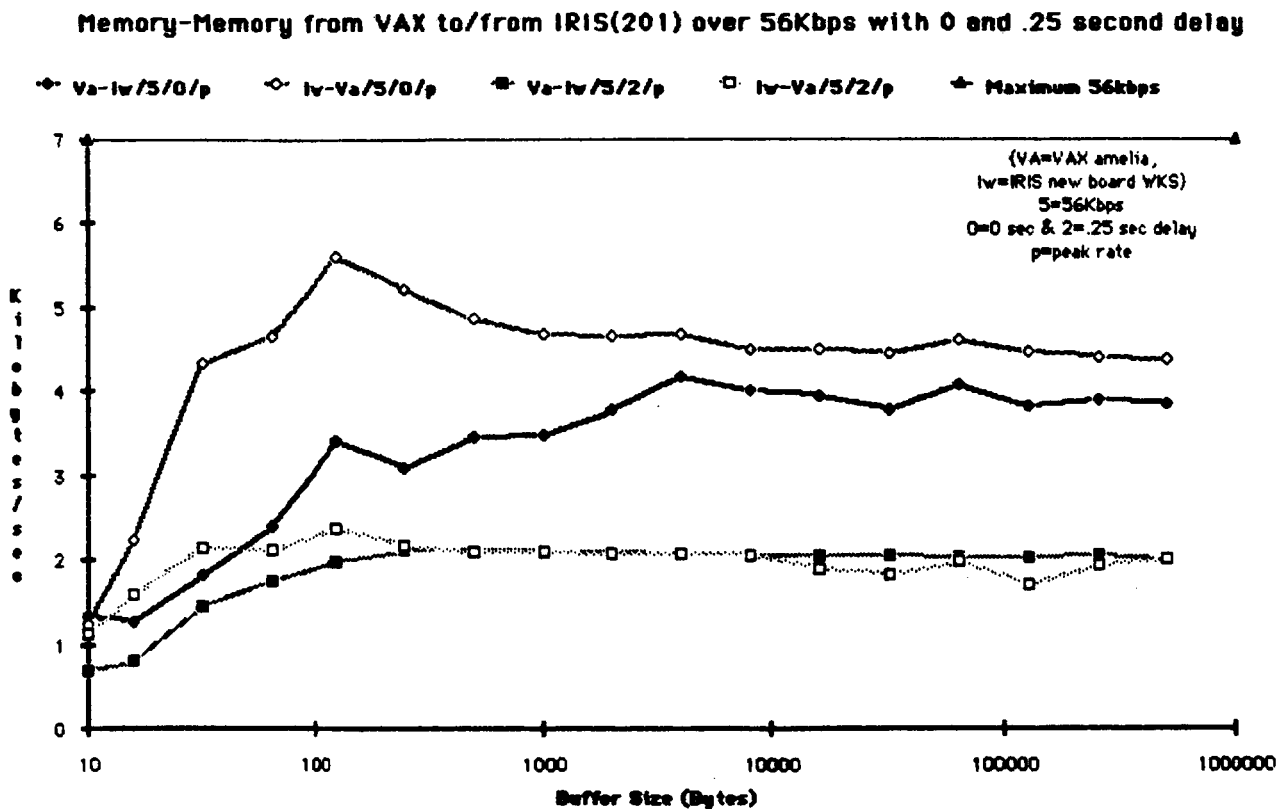


Figure C.1.15-1 VAX to/from IRIS(201) via 56kbps with and without .25 delay.

C.1.16 VAX to/from IRIS(201) via 224kbps with and without .25 delay

This was a comparison on a higher rate communication link with an introduced satellite delay. The results indicated that the satellite delay accounted for approximately 90% of the communication. The rest, 10%, was the effective transmission rate. Also indicated was the fact that the TCP/IP protocol was not tuned for the satellite delay. See section C.2 for more information on TCP/IP tuning. Figure C.1.16-1 presents the graph of the results.

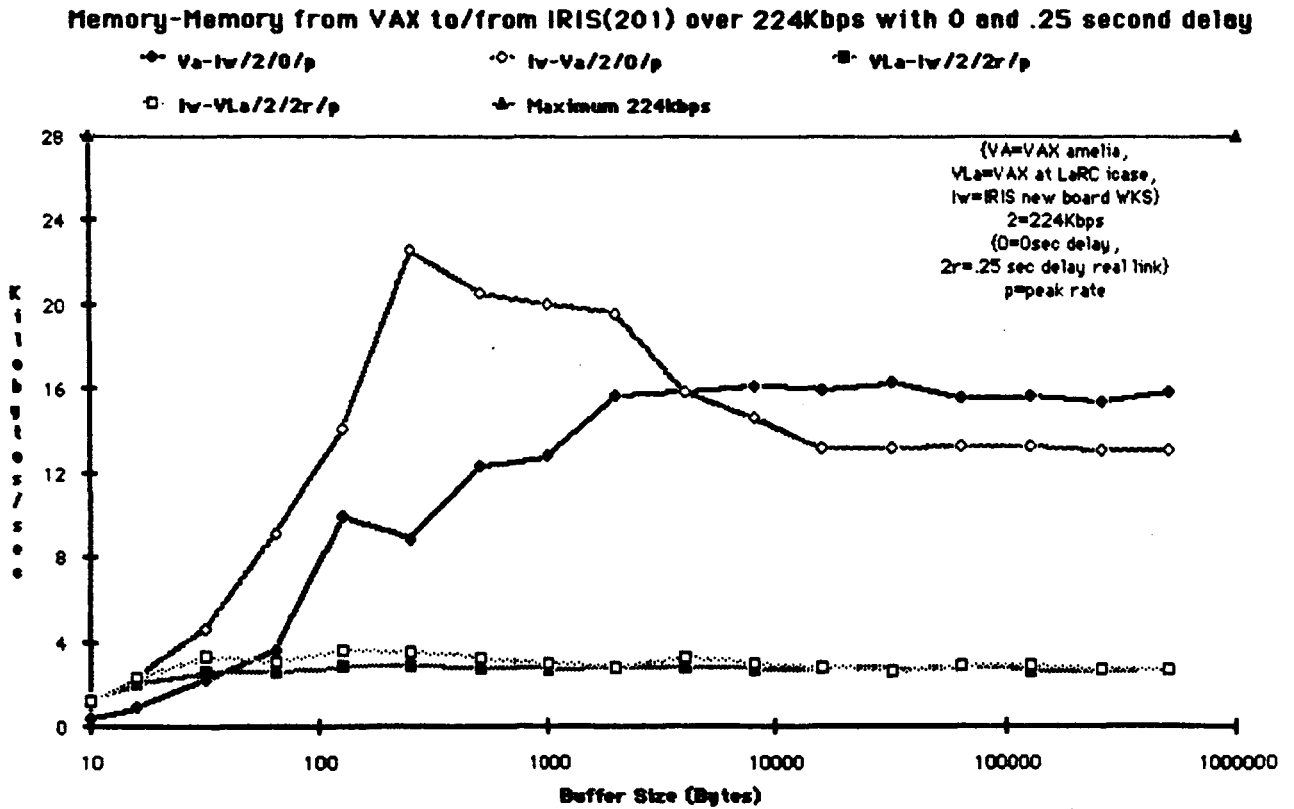


Figure C.1.16-1 VAX to/from IRIS(201) via 224kbps with and without .25 delay.

C.1.17 VAX to/from Sun via 224kbps and 10Mbps, no delay

This was a comparison test for a VAX and a Sun over two types of communication links. It noted the difference of transmission rate due to the type of communication link. The analysis revealed that the 10Mb link displayed the maximum transmission rate, while the 224kbps link showed degradation of transmission speed due to link loading. It also showed that the Sun to VAX transfer did not drop on the end rate as did the end rate for the IRIS(201) to VAX in Figure C.1.13-1. Note that the Sun/VAX rates appear faster over all buffer sizes and communication link types than the IRIS(201)/VAX rates. Figure C.1.17-1 presents the graph of the results.

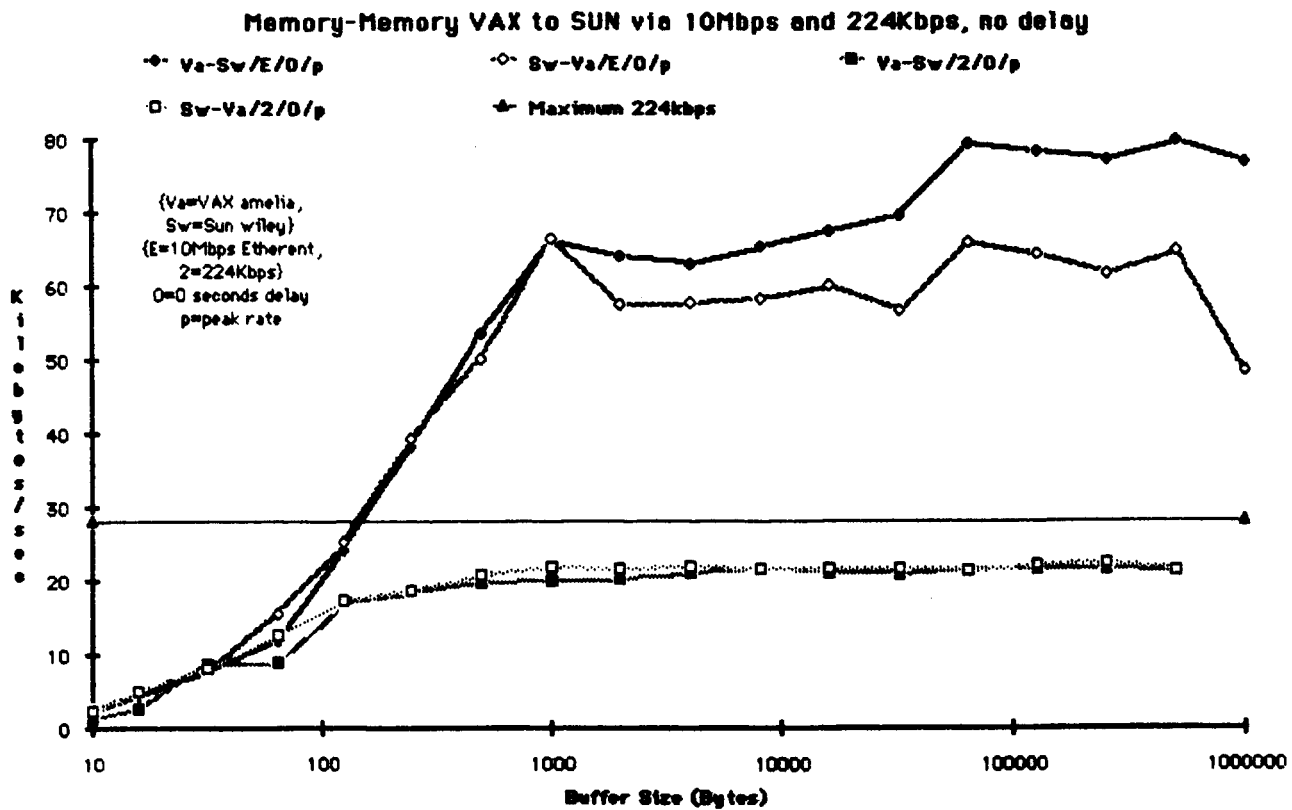


Figure C.1.17-1 VAX to/from Sun via 224kbps and 10Mbps, no delay.

C.1.18 VAX to/from Sun via 224kbps and 56kbps, no delay

This comparison test for the VAX to Sun noted the difference over a medium and low speed communication link. The analysis revealed that the 224kbps link displayed the higher transmission rate as expected and was limited to link loading. The 56kbps was also limited to link loading. Note that the VAX/Sun 224kbps rates appear faster and smoother than the VAX/IRIS(201) rates in the similar Figure C.1.14-1. Figure C.1.18-1 presents the graph of the results.

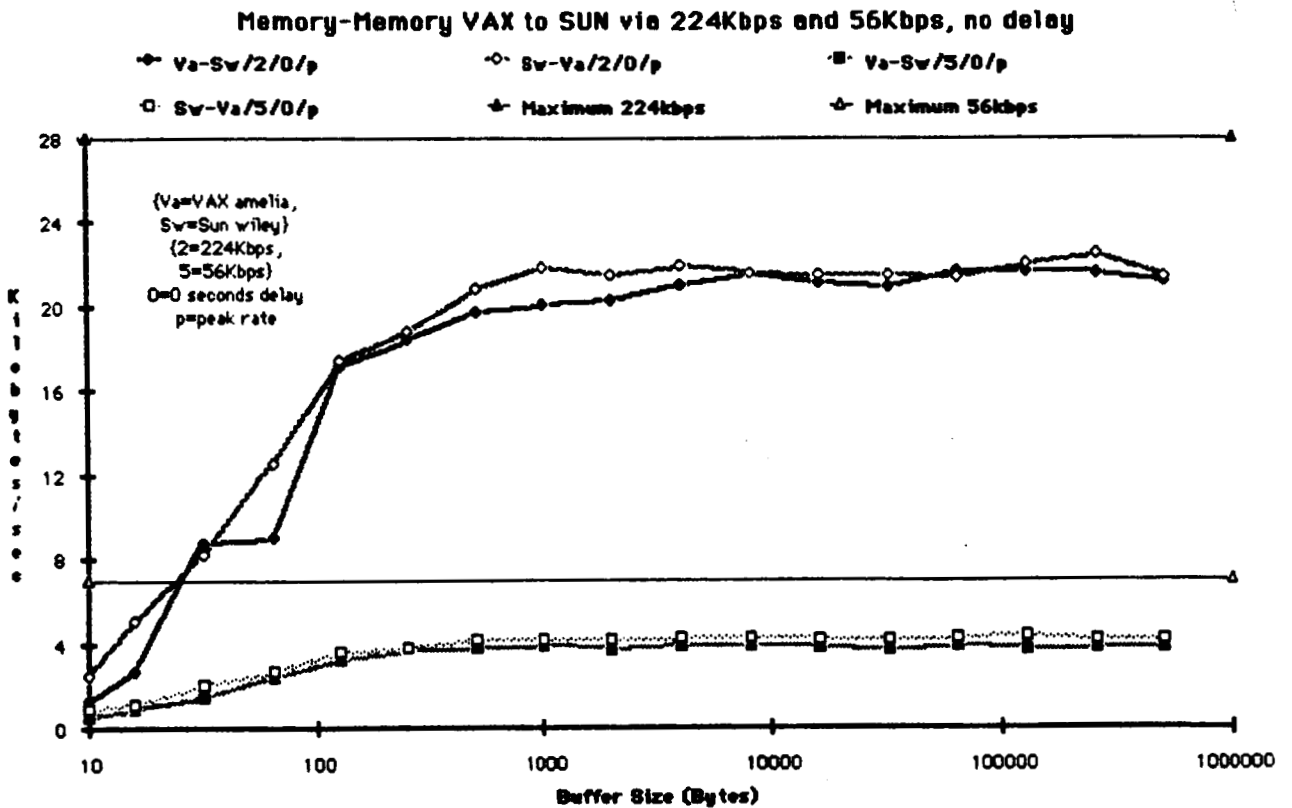


Figure C.1.18-1 VAX to/from Sun via 224kbps and 56kbps, no delay.

C.1.19 VAX to/from Sun via 56kbps with and without .25 delay

This was a comparison on a lower rate communication link with an introduced satellite delay. The results indicated that the satellite delay accounted for approximately 50% of the communication. The results from Figure C.1.15-1 indicate similar results for this test, except for the IRIS(201) to VAX rate, which was almost twice the rate at buffer sizes under 1000 bytes to slightly higher (+10%) over 1000 bytes. Figure C.1.19-1 presents the graph of the results.

Memory-Memory VAX to SUN via 56Kbps, with and without .25 delay

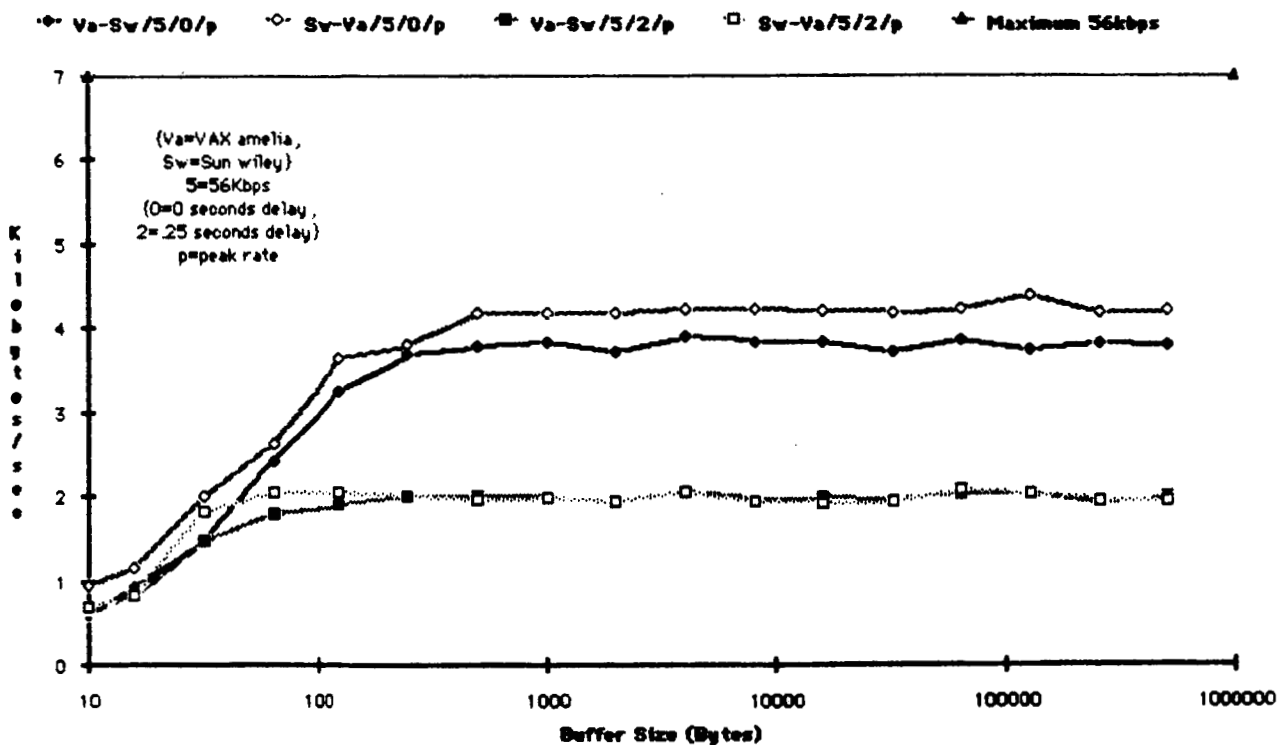


Figure C.1.19-1 VAX to/from Sun via 56kbps with and without .25 delay.

C.1.20 VAX to/from Sun via 224kbps and 56kbps with a .25 delay

This was a comparison on a medium and low rate communication link with an introduced .25 second satellite delay. The 224kbps was ~1000 bytes per second faster than the 56kbps link over all buffer sizes. This result indicated that the satellite delay accounted for approximately 50% of the communication for the low rate, and up to 90% for the medium rate. This result is similar to the one described in both Figure C.1.15-1 and Figure C.1.16-1. Figure C.1.20-1 presents the graph of the results.

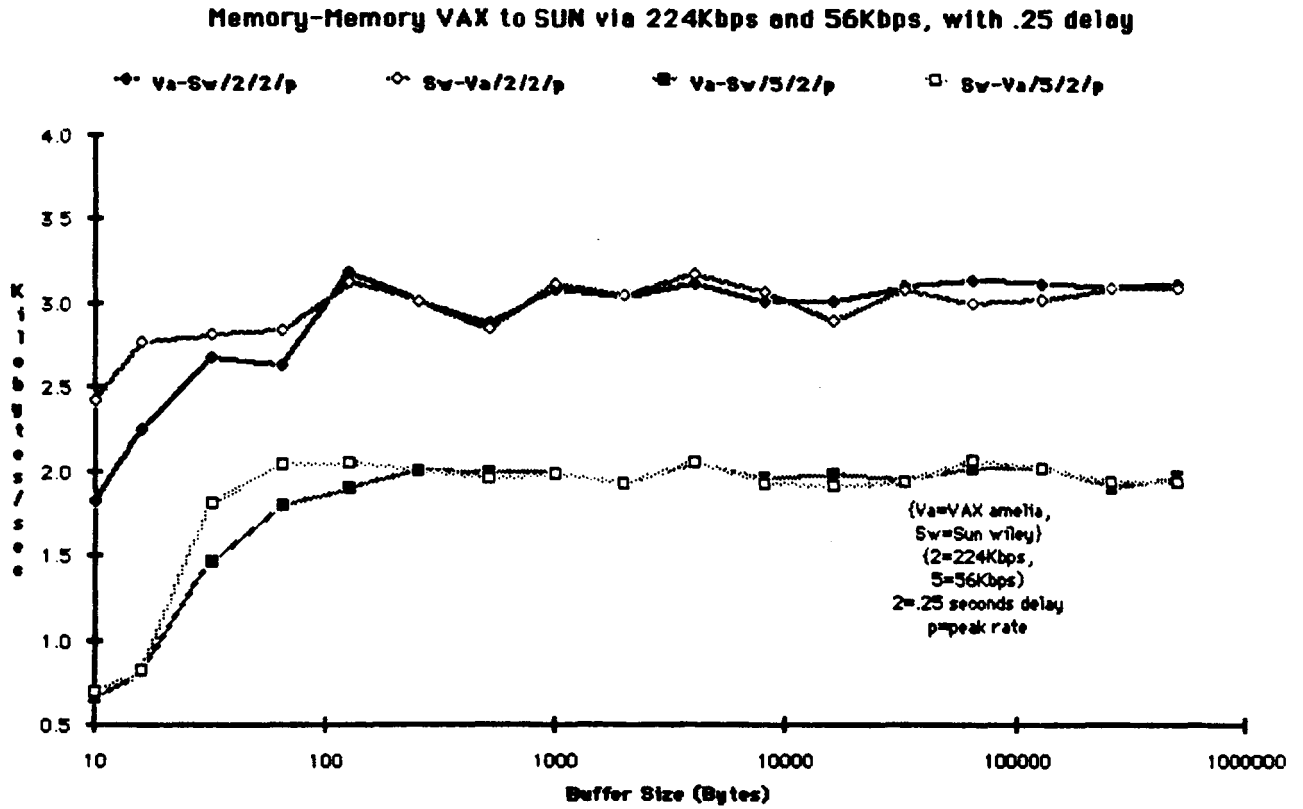


Figure C.1.20-1 VAX to/from Sun via 224kbps and 56kbps with a .25 delay.

C.1.21 IRIS(101) & IRIS(201) to VAX via real 224kbps with .25 delay

This comparison shows the differences between the IRIS(101) and IRIS(201) transferring to a VAX over a real 224kbps satellite link. The results show that all the transmission rates were almost identical in their slowness. This result compares favorably with the previous simulated result in Figure C.1.20-1. Figure C.1.21-1 presents the graph of the results.

Memory-Memory from IRIS(101 and 201) to VAX over 224Kbps with .25 second delay

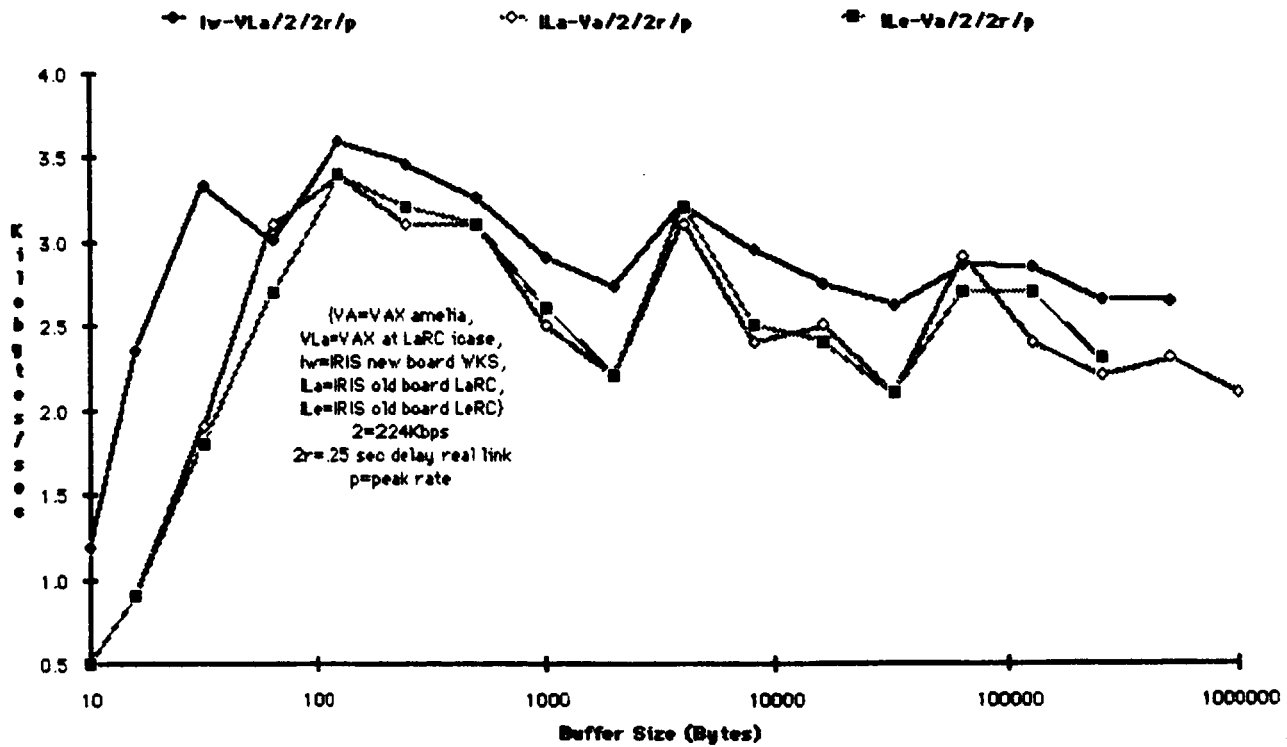


Figure C.1.21-1 IRIS(101) & IRIS(201) to VAX via real 224kbps with .25 delay.

C.1.22 H/W Test Shell Scripts

TEST - Shell Script for controlling shell script TEST2

```
# control for test2 over all testing
# params: $1 = to host, $2 = 1st digit buffers, $3 = socket #
echo test $*
set num=$2
if ($2 == "") set num=1
set sock=$3
ruptime
test2 $1 8 2 ${num}000 4 $sock
ruptime
test2 $1 125 2 ${num}00 5 $sock
ruptime
test2 $1 4000 2 ${num}0 4 $sock
ruptime
test2 $1 64000 2 $num 4 $sock
ruptime
```

TEST1 - Shell Script for controlling "netpush"

```
# h/w testing ... to $1 starting at $2 adding $3 buffers $4 and $5 passes
echo ::: Start of test 1 on 'date' :::
echo :
echo test1 $*
echo 'hostname' to $1, bytes $2, adding $3, buffers $4, passes $5
echo :
@ cnt = 0
@ buff = $2
loop:
@ cnt = $cnt + 1
echo :
echo ::: pass $cnt :::
echo :
date
netpush -v $1 $buff $4
@ buff = $buff + $3
if ( $cnt < $5 ) goto loop
echo :
echo ::::: completed test 1 :::::
```

TEST2 - Shell Script for controlling program "netpush"

```
# h/w testing .. to $1 starting at $2, times $3 each pass, $4 buffers
# $5 passes, socket $6
echo :
echo ::: Start of test 2 on 'date' :::
echo :
echo test2 $*
echo 'hostname' to $1, start bytes $2, times $3/pass, buffers $4, passes $5
if ($6 != "") echo -- socket number $6 --
@ cnt = 0
@ buff = $2
loop:
@ cnt = $cnt + 1
echo :
echo ::: pass $cnt :::
echo :
date
netpush -v $1 $buff $4 $6
@ buff = $buff * $3
if ( $cnt < $5 ) goto loop
echo :
echo ::::: completed test 2 :::::
```


C.1.23 Netpush.c Program Listing for a VAX running BSD 4.2 Unix

```
/*
 *
 * NOTE: THIS SOURCE CODE WILL ONLY RUN ON A 4.2BSD VAX.
 *
 * Author: Steve Wall
 * Modified: Bohden K. Cmaylo
 *
 * netpush.c
 *
 * Synopsis: netpush [-v] host buffersize #blocks #port
 *
 * "Netpush" is used to test transfer rates across the network using a stream
 * socket. We are attempting to do memory to memory transfers to measure
 * raw throughput rates, but of course the TCP protocol will cause some
 * overhead.
 *
 * We allow for different sized buffers to be transferred to account for
 * any discrepancies that may occur between small bulk transfers and large
 * bulk transfers. I really don't know if the size of the buffer transferred
 * affects the performance of the network subsystem.
 */
#include <sys/types.h>
#include <sys/socket.h>
#include <sys/time.h>
#include <netinet/in.h>
#include <netdb.h>
#include <stdio.h>

#include "netpush.h"

main(argc, argv)
char *argv[];
{
    int sock;          /* our socket */
    char *buffer;     /* our buffer */
    double fend,      /* floating pt. representation of ending time */
           fstart;    /* " " " " " starting " */
    long x,           /* scratch variable */
```

```

    portnumber, /* variable port input number */
    bufsize,    /* size of buffers that we will transfer */
    nbufs;     /* number of buffers we will transfer */
struct timeval start, /* start time */
               end;   /* end time */
struct sockaddr_in server; /* address of remote host */
struct hostent *host, /* host information */
               *gethostbyname();

/*
 * Verbose mode?
 */
if (strcmp(argv[1], "-v") == 0) {
    verbose = 1;
    ++argv; --argc;
}

/*
 * Check for command line arguments.
 */
if (argc == 5)
    portnumber = atoi(argv[4]);
if (argc < 4 | argc > 5)
    usage();

/*
 * If bufsize is too long, default to MAXBUFSIZE as defined
 * in netpush.h
 */
if ((bufsize = atoi(argv[2])) > MAXBUFSIZE) {
    printf("Buffer size requested too large; using %d ", MAXBUFSIZE);
    printf("byte buffers.(newline)");
    bufsize = MAXBUFSIZE;
}

nbufs = atoi(argv[3]);
gethostname(hostname, (int) sizeof(hostname));

/*
 * Set up the socket.
 */
if ((sock = socket(AF_INET, SOCK_STREAM, 0)) < 0) {

```

```

    perror("netpush: Couldn't open stream socket");
    exit(1);
}

if ((host = gethostbyname(argv[1])) == NULL) {
    fprintf(stderr, "Unknown host: %s(newline)", argv[1]);
    exit(1);
}

server.sin_family = AF_INET;
bcopy(host->h_addr, &(server.sin_addr.s_addr), host->h_length);
if (argc == 4)
    server.sin_port = htons(PORTNUMBER);
if (argc == 5)
    server.sin_port = htons(portnumber);
if (verbose) {
    printf(" (socket # %d)(newline)", htons(server.sin_port));
}

if (connect(sock, &server, sizeof(server)) < 0) {
    close(sock);
    perror("netpush: Couldn't connect stream socket");
    exit(1);
}

/*
 * Get the buffer space needed.
 */
if ((buffer = (char *) malloc((unsigned) bufsize)) == NULL) {
    close(sock);
    fprintf(stderr, "Couldn't get enough memory for buffer.(newline)");
    exit(1);
}

if (verbose) {
    printf("%s: Transferring %ld buffers of %ld bytes each -",
           hostname, nbufs, bufsize);
    printf(" Total bytes: %ld(newline)", (long) nbufs * bufsize);
}

/*
 * Get starting time.

```

```

*/
gettimeofday(&start,(struct timezone *) NULL);

/*
 * Send a header to the remote machine informing it of the total
 * number of bytes to expect.
 */
x = nbufs * bufsize;
sprintf(szbuf,"%ld",x);
write(sock, szbuf, sizeof(szbuf));

/*
 * Transfer the buffers.
 */
x = nbufs;
while (x--){
    if (write(sock, buffer, bufsize) < 0) {
        perror("netpush: Trouble writing to socket");
        close(sock);
        break;
    }
}

/*
 * Get ending time.
 */
gettimeofday(&end,(struct timezone *) NULL);

if (verbose) {
    printf("%s: Waiting for verification of successful transfer.(newline)",
           hostname);
}

/*
 * Wait for verification from remote host.
 */
read(sock, szbuf, sizeof(szbuf));
x = atol(szbuf);
if (x != nbufs * bufsize) {
    printf("(Bell)Transfer botched - Sent: %d Recv: %d(newline)",
           nbufs * bufsize, x);
    exit(1);
}

```

```

}
if (verbose)
    printf("%s: Received verification.(newline)", hostname);

/*
 * Print out timing information.
 */
fend = end.tv_sec + (end.tv_usec / 1000000.0);
fstart = start.tv_sec + (start.tv_usec / 1000000.0);

printf("Size: %ld Count: %ld Total: %ld ",
        bufsize, nbufs, nbufs * bufsize);
printf(" Time: %.2f Rate (bytes/sec): %.2f(newline)", fend - fstart,
        (nbufs * bufsize) / (fend - fstart));

shutdown(sock);
close(sock);
}

/*
 * Print usage info and exit.
 */
usage()
{
    fprintf(stderr, "Usage: netpush [-v] hostname buffersize #buffers #port(newline)");
    exit(1);
}

```

C.1.24 Netpushd Program Listing for a VAX running BSD 4.2 Unix

```
/*
 *
 * NOTE: THIS SOURCE CODE WILL ONLY RUN ON A 4.2BSD VAX.
 *
 *
 * Author: Steve Wall
 * Modified: Bohden K. Cmaylo
 *
 * netpushd.c
 *
 * Synopsis: netpushd [-v] #port
 *
 * "Netpushd" accepts connections on port PORTNUMBER (see netpush.h)
 * or portnumber if entered,
 * and reads in all the data that comes in on the socket. Basically,
 * netpush is a network /dev/null.
 *
 */
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <netdb.h>
#include <stdio.h>

#include "netpush.h"

char buffer[MAXBUFSIZE];      /* buffer for storing data */

main(argc, argv)
char *argv[];
{
    long    portnumber; /* variable port number */
    int     sock,       /* our socket */
           pid;        /* process id of daemon (child) */
    struct sockaddr_in server; /* address info */

    /*
     * Verbose mode?
     */
}
```

```

*/
if (strcmp(argv[1], "-v") == 0) {
    verbose = 1;
    ++argv; --argc;
}
/*
 * Check for command line arguments.
 */
if (argc == 2)
    portnumber = atoi(argv[1]);
if (argc > 2)
    usage();

/*
 * Fork the child daemon process and exit the parent.
 */
pid = fork();
if (pid == -1) {
    fprintf(stderr, "Couldn't fork()(newline)");
    exit(1);

} else if (pid)
    exit(0);

printf("%d", getpid());

gethostname(hostname, (int)sizeof(hostname));

/*
 * Set up the socket.
 */
if ((sock = socket(AF_INET, SOCK_STREAM, 0)) < 0) {
    perror("netpushd: Couldn't open stream socket");
    exit(1);
}

server.sin_family = AF_INET;
server.sin_addr.s_addr = INADDR_ANY;
if (argc != 2)
    server.sin_port = htons(PORTNUMBER);
if (argc == 2)
    server.sin_port = htons(portnumber);

```

```

if (verbose) {
printf(" (socket # %d)(newline)",htons(server.sin_port));
}

if (bind(sock, &server, sizeof(server)) < 0) {
close(sock);
perror("netpushd: Couldn't bind stream socket");
exit(1);
}

listen(sock,5);

/*
 * Loop, waiting for connection requests.
 */
for (;;) {
int insock, /* socket that is requesting connect */
x; /* scratch variable */
long bytes_expected, /* # of bytes expected from remote */
bytes_rcv = 0; /* # of bytes received so far */

insock = accept(sock,0,0);
if (verbose)
printf("%s: Accepted connection.(newline)", hostname);

/*
 * Read the header from the remote host. The header tells us
 * the total number of bytes expected to be coming.
 */
read(insock,szbuf,sizeof(szbuf));
bytes_expected = atol(szbuf);
if (verbose)
printf("%s: Expecting %ld bytes.(newline)",hostname,
bytes_expected);

/*
 * Read the data.
 */
while((x = read(insock, buffer, sizeof(buffer))) > 0) {
bytes_rcv += x;
if (bytes_rcv >= bytes_expected)
break;
}
}

```



```

    }
    if (verbose)
        printf("%s: Sending verification -- Received %ld
bytes.(newline)", hostname, bytes_expected);

    /*
     * Send verification of the number of bytes we received on
     * this end.
     */
    sprintf(szbuf, "%ld", bytes_rcv);
    write(insock, szbuf, sizeof(szbuf));

    /*
     * Clean up.
     */
    shutdown(insock);
    close(insock);
    if (verbose) {
        printf("%s: Total bytes received: %ld(newline)",
            hostname, bytes_rcv);
    }
}

}

/*
 * Print usage info and exit.
 */
usage()
{
    fprintf(stderr, "Usage: netpushd [-v] #port(newline)");
    exit(1);
}

```

C.1.25 Netpush.h Header File Listing for a VAX running BSD 4.2 Unix

```
/*
 * Author: Steve Wall
 * Modified: Bohden K. Cmaylo
 *
 * netpush.h
 *
 * Globals/defines for the netpush programs.
 */
#define PORTNUMBER 1099 /* port # we'll use */
#define MAXBUFSIZE 512000 /* maximum buffer size */
#define PRINTF if (DEBUG) printf

char szbuf[50];
char hostname[20];
int verbose;
```

C.1.26 Netpush Makefile

```
#
# Misc. makefile for 4.2BSD VAX.
#
DESTDIR = ..

all:      start netpush netpushd

install:  all
          mv start $(DESTDIR)/_start
          mv netpush $(DESTDIR)/netpush
          mv netpushd $(DESTDIR)/netpushd

start:    start.o getload.o
          cc -O -s -o start start.o getload.o

netpush:  netpush.o
          cc -O -s -o netpush netpush.o

start.o:  cc -c start.c

getload.o:
          cc -c getload.c -DBSD4.2

netpush.o: netpush.h
          cc -c netpush.c

netpushd: netpushd.o
          cc -O -s -o netpushd netpushd.o

netpushd.o: netpush.h
          cc -c netpushd.c

clean:;   rm -f *.o start netpush netpushd
```

C.2 TCP/IP TUNING EXPERIMENT

This report describes the results of some follow-up network performance tests run between Amelia and ICASE, two VAX 11/780 computers networked together over a satellite communications link. The first set of tests was performed on March 2, 1986. The tests described here were desired because an earlier TCP/IP tuning test was restricted in scope due to technical problems. Some, but not all, of the technical problems were resolved in this round of testing.

C.2.1 Purpose

The purpose of these tests is to see to what extent TCP performance can be improved by increasing the size of the send/receive windows.

C.2.2 Tests Performed

The tests consist of the following:

1. *Netpush(LOCAL)* was used to time memory-to-memory data transfers of 1,000 bytes (x 250 transfers), 10,000 bytes (x 50 transfers), and 100,000 bytes (x 5 transfers). The tests were run in one direction only, with *netpush* run on ICASE and *netpushd* on Amelia. Various window sizes between 2K and 28K bytes inclusive were sampled. (The default 4.2 BSD window is 2K bytes in each direction.)

2. *Ftp(1)* was used to time disk-to-disk data transfers of 1,000 bytes (x 4 transfers), 10,000 bytes (x 3 transfers), and 100,000 bytes (x 3 transfers). The tests were run in one direction only, with ASCII mode PUTs issued to *ftp* run on ICASE and *ftpd* was run on Amelia.

C.2.3 Testing Conditions

The tests were run on the afternoon of Sunday, March 17. The computers were dedicated to running the tests: users were prohibited from logging on or running background processes, but system daemons were allowed to run. However, during some of the tests, a few users (at most 4) were logged in to Amelia. During the tests, the five minute load average on Amelia averaged 0.55, on ICASE it averaged 0.43. The network traffic on the Ethernet during testing was not assessed. Both computers have Interlan Ethernet controllers.

C.2.4 Kernel and Test Utility Modifications

In order to control the size of the send/receive windows during network transfers, modifications were added to *netpush*, *ftp*, and the 4.2 BSD UNIX kernels running on Amelia and ICASE.

The modifications consisted of socket options to adjust and query the ceiling and size of the send/receive windows. It had been hoped that the rigid fixed-size received window advertisement algorithm used in the March 2 tests could be supplanted with a more typical 4.2-style algorithm which recognized the larger windows. Unfortunately, the new code to achieve this wouldn't run on ICASE due to configuration problems. Due to scheduling restrictions the old fixed-size code was used.

Data structures on Amelia were enlarged to accommodate windows \geq 16Kbytes. As a result the crashing and hanging which restricted the previous tests was not a problem. Amelia only crashed once during the testing period, and it occurred while other users were on the system and not during an actual test.

C.2.5 Test Results

The raw test result files, as well as the kernel modifications and modified utilities are in the directory `~hahn/ptest/ame-icase2` on Prandtl and are described here:

<code>ftp/</code>	The modified <i>ftp</i> source files.
<code>ftpd/</code>	The modified <i>ftpd</i> source files.
<code>netpush/</code>	The modified <i>netpush</i> and <i>netpushd</i> source files.
<code>results/test.N</code>	Results of <i>netpush</i> with NK-byte windows.
<code>results/report</code>	This report in <i>troff</i> (-ms) source format.
<code>sys/</code>	The kernel modifications.

Figure C.2.5-1 displays a graph of all the test results. The tests results data that follow give the numerical values of the effective transfer rates obtained. The five-minute load averages for the machines as reported by *ruptime* after each test are also given. Note that *Kbytes* = 1024 bytes.

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16Mar86: Amelia to Icase Test 2 using "netpush" with 1KB, 10KB, and 100KB buffers and windows from 2KB-28KB

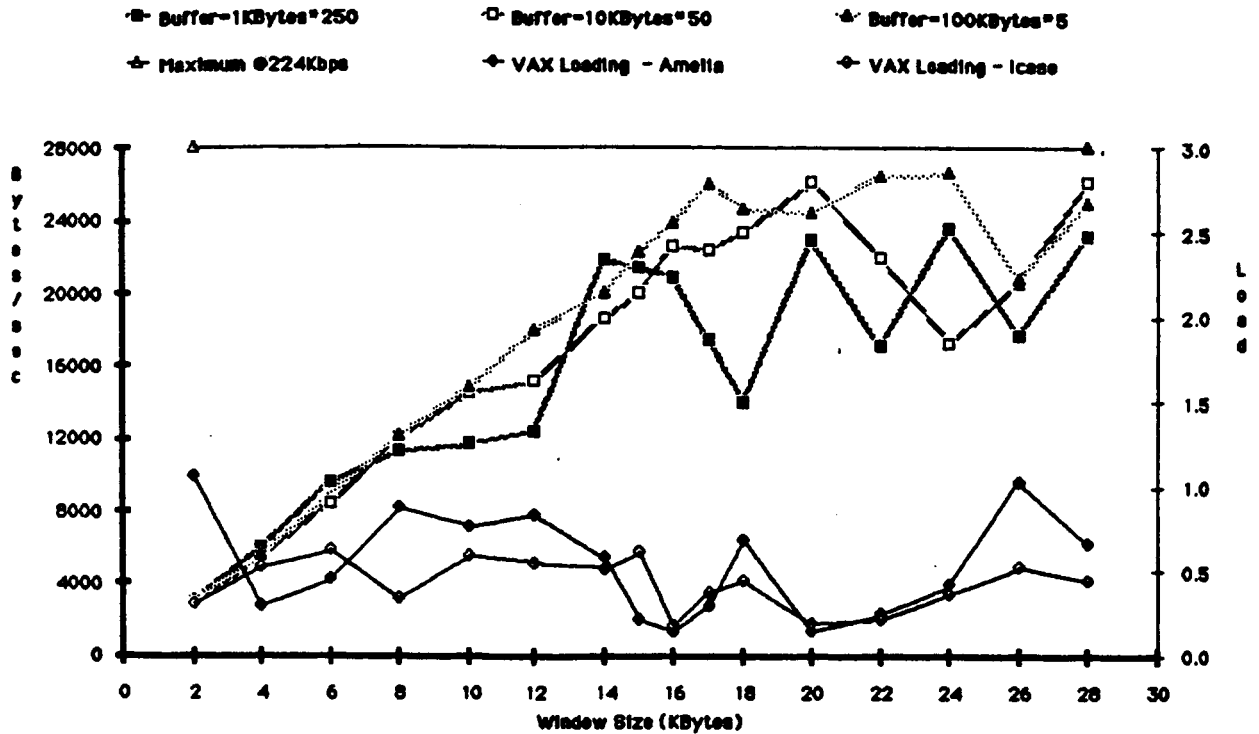


Figure C.2.5-1 TCP/IP Graph of Test Results.

C.2.6 Netpush

Window Kbytes	Transfer Rate					
	1,000 bytes		10,000 bytes		100,000 bytes	
	bytes/sec	bits/sec	bytes/sec	bits/sec	bytes/sec	bits/sec
2	3,039	24,319	2,974	23,795	3,090	24,726
4	5,970	47,766	5,403	43,224	5,507	44,062
6	9,619	76,952	8,454	67,636	-	-
8	11,337	90,702	12,138	97,110	12,245	97,967
10	11,742	93,940	14,526	116,211	14,876	119,012
12	12,437	99,502	15,160	121,285	17,934	143,472
14	21,834	174,672	18,635	149,086	20,024	160,192
15	21,385	171,086	19,968	159,744	22,261	178,094
16	20,885	167,084	22,563	180,505	23,889	191,113
17	17,445	139,567	22,341	178,731	25,974	207,792
18	14,044	112,359	23,386	187,090	24,606	196,850
20	22,956	183,654	26,096	208,768	24,390	195,121
22	17,099	136,798	21,939	175,515	26,455	211,640
24	23,584	188,679	17,277	138,217	26,624	212,992
26	17,705	141,643	20,584	164,676	20,729	165,837
28	23,169	185,356	26,082	208,659	24,900	199,203

C.2.7 FTP*

Window Kbytes	Transfer Rate					
	1,000 bytes		10,000 bytes		100,000 bytes	
	<i>bytes/sec</i>	<i>bits/sec</i>	<i>bytes/sec</i>	<i>bits/sec</i>	<i>bytes/sec</i>	<i>bits/sec</i>
2	12,195	97,560	3,628	29,027	3,136	25,094
4	16,129	129,032	3,236	25,889	2,604	20,838
6	12,500	100,000	3,024	24,198	2,597	20,777
8	16,666	133,333	3,105	24,844	2,597	20,777
10	16,666	133,333	3,036	24,293	2,597	20,781
12	12,500	100,000	3,102	24,821	2,596	20,773
14	13,888	111,111	3,061	24,494	2,594	20,754
15	13,888	111,111	3,080	24,645	2,596	20,770
16	14,285	114,285	3,043	24,345	2,599	20,792
17	17,543	140,350	3,064	24,517	2,599	20,793
18	15,384	123,076	3,021	24,169	2,595	20,766
20	17,543	140,350	3,090	24,721	2,595	20,765
22	15,384	123,076	3,093	24,744	2,601	20,808
24	17,543	140,350	3,043	24,345	2,591	20,732
26	14,925	119,402	3,036	24,293	2,598	20,788
28	11,764	94,117	3,021	24,169	2,597	20,779

*The problem preventing ftp from working during the March 2 tests was resolved, and to the best of my knowledge, FTP used the enlarged TCP send/receive windows. However, the data don't strongly suggest that this was the case.

C.2.8 Load Averages

Window <i>Kbytes</i>	Load Average							
	Amelia				Icase			
	<i>users</i>	<i>1 min</i>	<i>5 min</i>	<i>15 min</i>	<i>users</i>	<i>1 min</i>	<i>5 min</i>	<i>15 min</i>
2	5	1.46	1.07	1.02	1	0.25	0.31	0.27
4	4	0.37	0.30	0.31	1	0.55	0.53	0.34
6	4	0.49	0.46	0.37	1	0.61	0.63	0.47
8	5	2.03	0.88	0.56	1	0.43	0.34	0.32
10	4	0.45	0.77	0.66	1	0.81	0.59	0.44
12	5	0.74	0.84	0.75	1	0.46	0.55	0.48
14	5	0.37	0.58	0.64	1	0.77	0.52	0.46
15	1	0.06	0.22	0.27	1	0.75	0.62	0.47
16	1	0.11	0.15	0.21	1	0.05	0.18	0.32
17	1	0.56	0.30	0.25	1	0.23	0.38	0.38
18	5	0.20	0.69	0.65	1	0.61	0.45	0.39
20	1	0.12	0.15	0.19	1	0.17	0.19	0.28
22	1	0.06	0.25	0.26	1	0.09	0.22	0.28
24	2	0.42	0.42	0.36	1	0.13	0.37	0.37
26	4	1.54	1.03	0.65	1	0.56	0.53	0.47
28	5	0.44	0.66	0.70	1	0.38	0.44	0.45

C.3 LHCP TCP/IP VERSUS XNS PROTOCOL EXPERIMENTS

This report describes the results of the LHCP network performance tests run between two identical IRISs on the LHCP network using two different protocols.

C.3.1 Scope

The scope of these performance tests was to observe which protocol performed better over Ethernet, 224kbps, and 56kbps communication links. Each communication link was tested with either no transport delay or with an introduced satellite transport delay.

C.3.2 Testing Conditions

Two dedicated IRIS workstations were required for each test. Each workstation had an identical software and hardware configuration. During a test, each workstation had installed either an XNS or a TCP/IP protocol implementation for remote communication. Other components included: Ethernet, Vitalink VB/1s, and a Satellite Delay Simulator. The Ethernet was either the main NAS Ethernet, or a local Ethernet when using the Vitalink VB/1 for a communication link. The Satellite Delay Simulator provided clocking and transport delay when required. These tests were performed in January 1986.

C.3.3 Tests Performed

The test matrices that follow Figure C.3.3-1 describe the definitions of the headings for the following tables of raw data collected. The headings are a brief description of the computers used, the type of simulated communication medium, the transport delay, and a suffix "r" to indicate when a real link was used. The format of the header column is: Field1-Field2/Field3/Field4. An example "raw data" table follows:

FILE (size in bytes)	Field1-Field2/Field3-Field4 . . .
BYTES	DATA (in 1000 bytes per second)
.
.

Axis	Description
Y-axis	The "File" identifies the "Y" axis of each table which consists of the number of bytes in a file for either a <i>xcp</i> or <i>rcp</i> file transfer.
X-axis "CELL"	The "X" Axis Heading Identifies a single type of test configuration Each entry within the table not identified by the heading "File" is in units of "Kilobytes (1000) per second" transfer rate.
COMPUTER	Field1 and Field2 - Description of Computer
Ia	An IRIS 2500 called annie running a SGI UNIX System 5.
Iw	An IRIS 2500 called wks running a SGI UNIX System 5.
ILa	An IRIS 1500 at LaRC running a SGI UNIX System 5.
ILe	An IRIS 1500 at LeRC running a SGI UNIX System 5.
PROTOCOL	Field3 - Protocol and type of communication link
EX	Ethernet using XNS Protocol
ER	Ethernet using TCP/IP Protocol
2X	224Kb/s using XNS Protocol
2R	224Kb/s using TCP/IP Protocol
5X	56Kb/s using XNS Protocol
5R	56Kb/s using XNS Protocol
TRANSPORT	Field4 - Transport delay
0	No transport delay
1	.01 second transport delay, terrestrial simulation.
2	.25 second transport delay, satellite simulation
r	suffix to indicate a real link, not simulated.

Figure C.3.3-1 Definition of Raw TCP/IP vs XNS Test Data Matrices.

C-2

File	Ia-Iw/EX/0	Ia-Iw/2X/0	Ia-Iw/ER/0	Ia-Iw/2X/2	Ia-Iw/2R/0	Ia-Iw/2R/2	Ia-Iw/5x/0
300			0.04		0.03		0.06
1000			0.2		0.2	0.1	0.25
3000			0.6		0.6	0.4	1
10000			2		1.4	0.9	3.3
27080	5.4	4.5	5.4	2.5	3.4	1.8	2.7
53248	13.25	10.6	7.8	4.4	5.3	2.7	3.8
117140	16.7	13	14.6	5.3	6.5	2.9	3.8
484839	32.3	18.7	23.1	7	8.7	3.2	4.1
969726	36	19.8	27.7	7.2	9.3	3.1	4.3
1507813	37.5	20.5	29	7.4	9.4		4.3
300			0.04		0.04	0.03	0.06
1000			0.2		0.2	0.1	0.33
3000			0.6		0.6	0.4	1.5
10000			2		1.7	0.9	2.5
27080	5.4	5.4	5.4		3.4	1.7	3
53248	13.25	8.8	7.6		4.8	2.2	3.3
117140	19.5	11.7	13		6.5	2.7	3.5
484839	34.6	18.7	23.1		8.7	3.1	4.4
969726	36	20.6	29.4		9.2	3.3	4.4
1507813	37.5	20.5	31.4		9.5		4.4
300			0.04				
1000			0.2				
3000			0.6				
10000			2				
27080	5.4		4.5				
53248	13.25		7.6				
117140	16.7		13				
484839	34.6		25.5				
969726	33.2		30.3				
1507813	35.25		29.6				

Figure C.3.3-2 Table 1 - TCP/IP vs XNS Tests Raw Data.

File	Ia-Iw/5x/1	Ia-Iw/5x/2	Ia-Iw/5r/0	Ia-Iw/5r/1	Ia-Iw/5r/2	Ia-ILa/2R/2r	Ia-Il/EX/0	Ia-ILe/2R/2r
300	0.05	0.04	0.04	0.04	0.02			0.05
1000	0.25	0.17	0.14	0.17	0.1	0.1		0.1
3000	1	0.8	0.5	0.5	0.3	0.3		0.5
10000	1.1	1.3	1.4	1.3	0.8	0.8		1.1
27080	2.7	2.5	2.5	2	1.3	1.7	4.5	2.2
53248	3.3	2.6	3.1	2.8	1.6	2.3	13.25	2.7
117140	3.8	2.5	3.4	3.3	1.1	2.5	23.4	2.6
484839	4.3	3.4	3.9	3.9	1.9	3.3	30.3	3.2
989726	4.4	3.6	3.9	3.8	2	3.3	33.4	3.2
1507813	4.4	3.6				3.2	36.6	3.2
300	0.06	0.04	0.04	0.02	0.02	0.04		
1000	0.33	0.17	0.17	0.17	0.1	0.1		
3000	1	0.6	0.5	0.5	0.3	0.5		
10000	1	1.4	1.3	1.3	0.8	1.3		
27080	3.4	1.7	2.5	2.3	1.2	2.3	5.4	
53248	3.8	3	2.8	2.8	1.5	2.5	10.6	
117140	3.9	2.3	3.3	3.3	1.1	2.4	19.5	
484839	4.3	2.8	3.9	3.6	2.1	3.3	30.3	
989726	4.4	3.2	3.8	2.6	2	3.2	33.2	
1507813	4.3	3				3.2	33.4	

Figure C.3.3-3 Table 2 - TCP/IP vs XNS Tests Raw Data.

C.3.4 Analysis of Selected Tests

Various combinations of logical comparisons were selected to observe how the data transmission rates varied. The comparisons generally followed the below five guidelines:

- (1) If XNS protocol was being used, then the "xcp" file copy program was used. If TCP/IP protocol was being used, then the "rcp" file copy program was used.
- (2) If a measurement was taken in one direction, that is machine A transferring data to machine B, then the reverse direction was also measured.
- (3) Identical systems were compared at different link transmission rates.
- (4) Identical systems were compared with different transport delay rates.
- (5) All points were selected to indicate rate ranges.

Graphs follow the below guidelines:

- (1) X-axis is in terms of bytes in a "rcp" or "xcp" file copy operation.
- (2) Y-axis is in terms of Kilobytes (1000) per second.
- (3) The Legend titles follow the same format as in the raw data tables.

C.3.5 RCP & XCP via Ethernet and 224kbps, no delay

This comparison indicated that "xcp" copied faster than "rcp" over both 10Mbps Ethernet and 224kbps. On the Ethernet link, "xcp" was identical to "rcp" for file sizes under ~30,000 bytes, but the transmission rate increased to more than 10,000 bytes per second, or 40% faster, for file sizes greater than ~30,000 bytes.

On the 224kbps link, the transmission speed was degraded by link loading for both protocols. However, the XNS protocol reached over twice the transmission rate as TCP/IP, for large file sizes.

Figure C.3.5-1 presents the graph of the results.

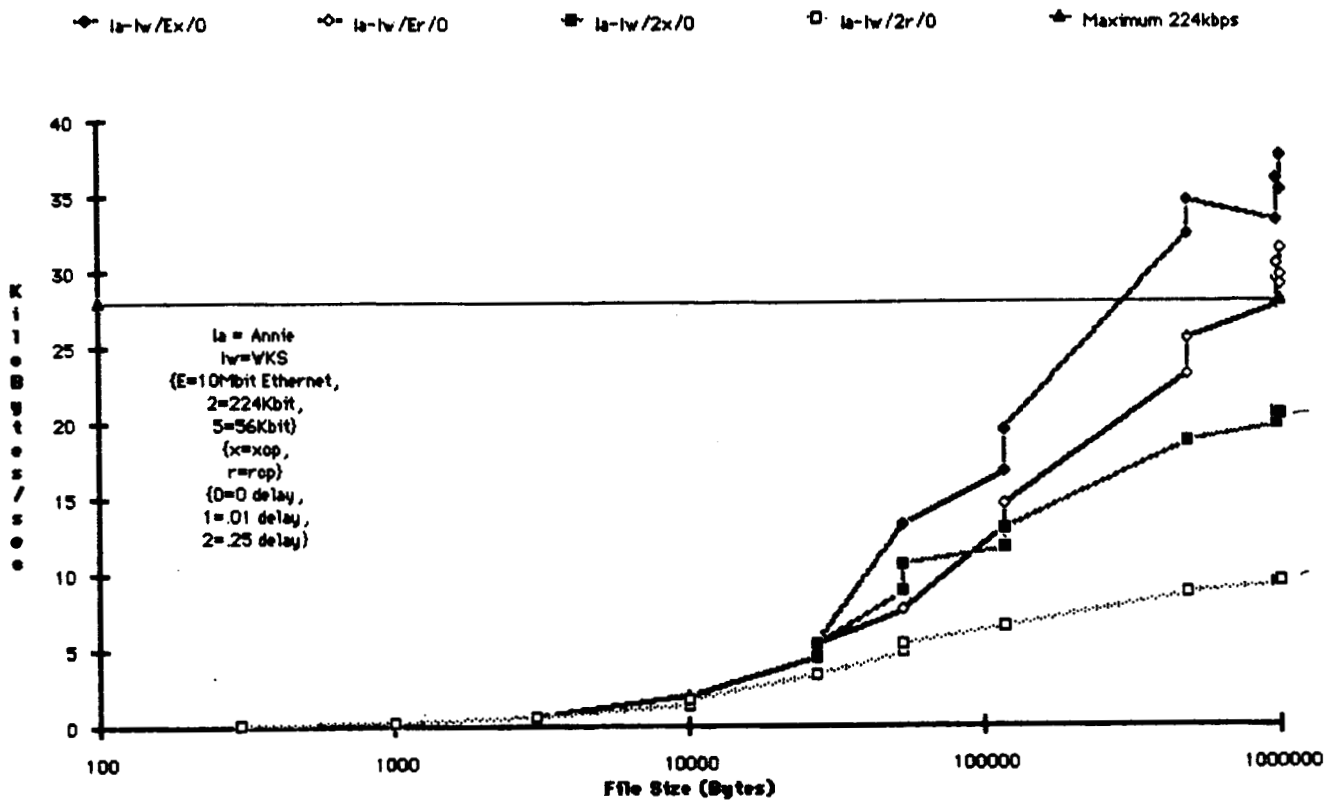


Figure C.3.5-1 RCP & XCP via Ethernet and 224kbps, no delay.

C.3.6 RCP & XCP via 224kbps and 56kbps, no delay

This comparison again shows that the link loading is the primary mechanism for limiting the transmission speed of both protocols. However, in the 56kbps test, "xcp" shows only a slightly higher transmission rate than "rcp".

Figure C.3.6-1 presents the graph of the results.

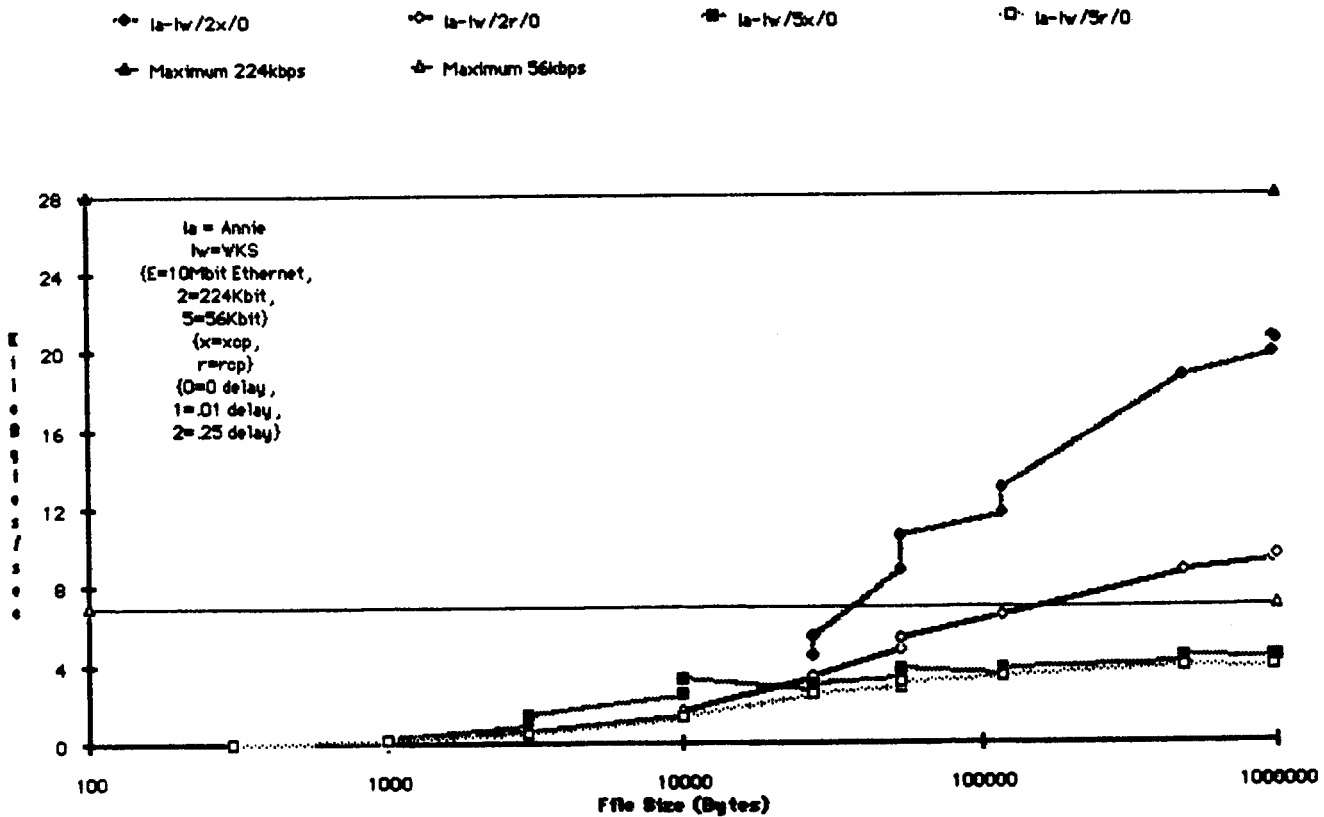


Figure C.3.6-1 RCP & XCP via 224kbps and 56kbps, no delay.

C.3.7 RCP & XCP via 56kbps, with and without delay

This comparison again shows that the link loading is the primary mechanism for limiting the transmission speed of both protocols. However, in the 56kbps test with delay, "xcp" shows almost double the transmission rate of "rcp" for file sizes larger than 50,000 bytes. Also, "xcp" does not show as great of a drop-off of transmission rates due to the satellite delay as does "rcp".

Figure C.3.7-1 presents the graph of the results.

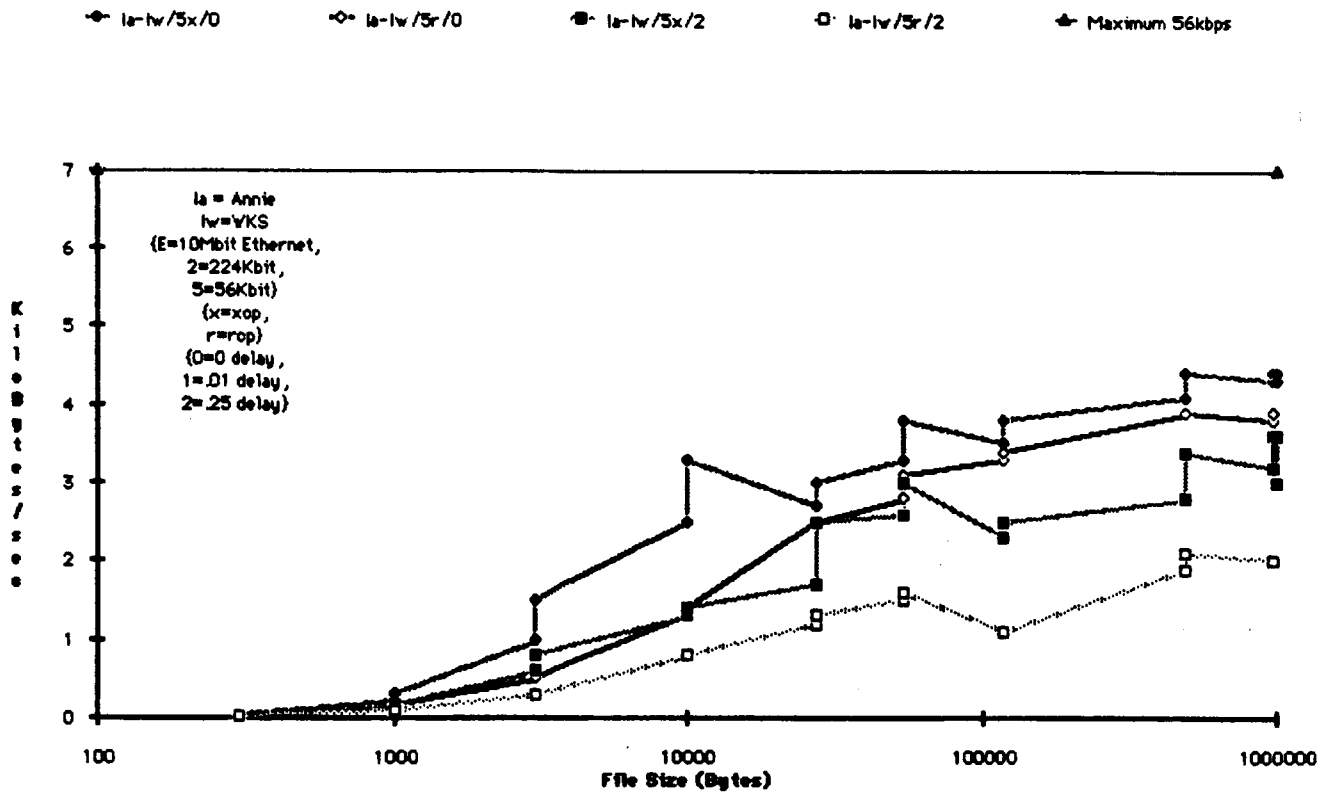


Figure C.3.7-1 RCP & XCP via 56kbps, with and without delay.

C.3.8 RCP & XCP via 224kbps and 56kbps, with delay

In the 224kbps test with delay, "xcp" shows over double the transmission rate of "rcp" for file sizes larger than 50,000 bytes. Also, "xcp" does not show as great of a drop-off of transmission rates due to the satellite delay as does "rcp". Also, while the transmission rate for "rcp" does not greatly increase when increasing the bandwidth from 56kbps to 224kbps, it more than doubles for "xcp". This shows a larger capacity of internal buffers for "xcp". Section C.2 (TCP/IP TUNING TESTS) indicated that larger internal buffers (window size) generally mean faster transmission rates.

Figure C.3.8-1 presents the graph of the results.

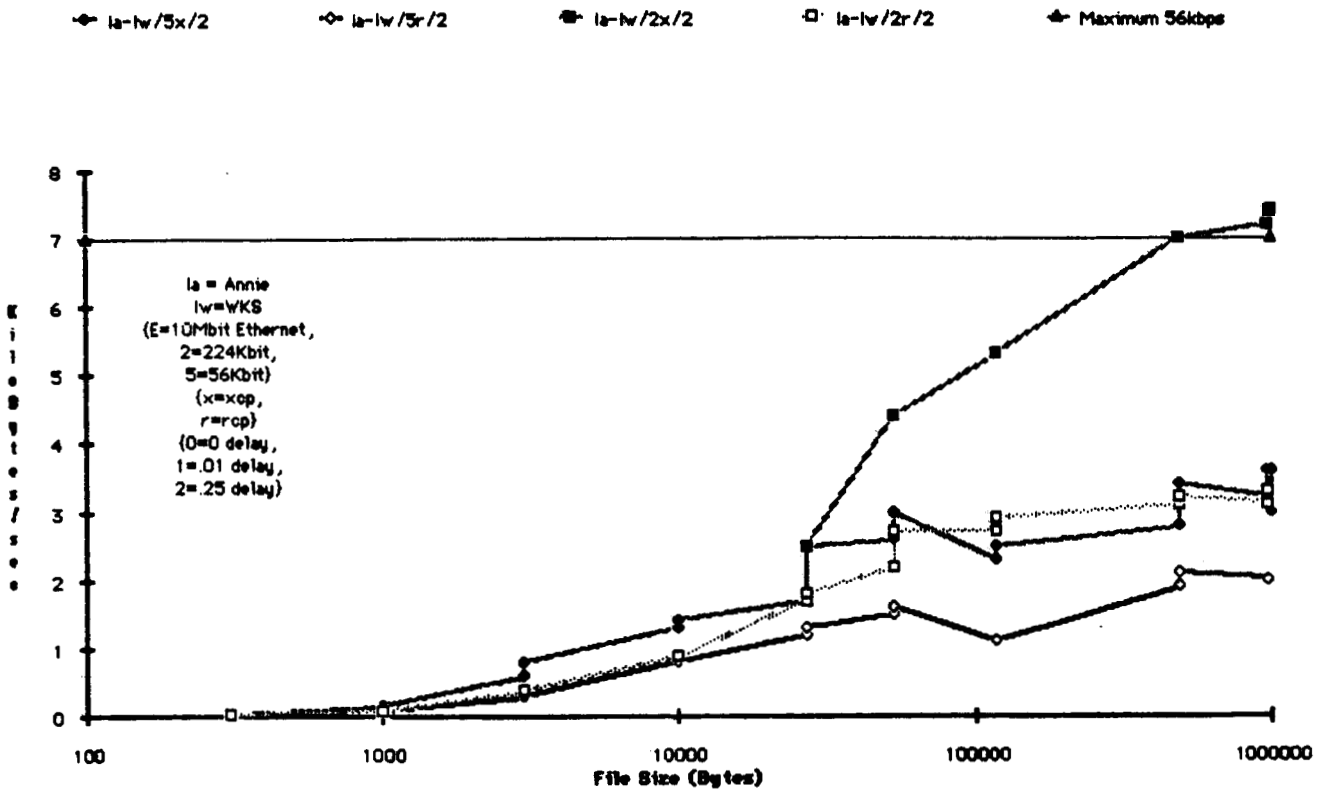


Figure C.3.8-1 RCP & XCP via 224kbps and 56kbps, with delay.

C.3.9 Conclusions

With the results of the previous tests, it was concluded that the XNS protocol was indeed faster than the TCP/IP protocol over all conditions tested. However, it was also noted that both protocols were not tuned for satellite transport delays. One can assume that if indeed both protocols were tuned for a satellite delay, then XNS will still out perform TCP/IP.

APPENDIX D

LHCP REMOTE MONTHLY REPORTS

Each of the remote sites, Colorado State University, Langley Research Center, and Lewis Research Center, was asked by the NAS Projects Office to send a monthly report to NAS. This monthly report was to describe the status of each site in its progress with using the NAS as a remote facility. Also included within their reports was to be descriptions and progress reports on CFD activity, so that the remote use of the Cray could be better understood with respect to file transfer and other requirements. Problems with either the communication links or workstation support were also requested, so that the LHCP group could resolve them.

These reports were distributed to the NAS project personnel. Whenever a problem was observed within a report by the LHCP group, it was highlighted by the symbols ****. These problem areas were examined and resolved by the appropriate people, as noted by the highlighted symbols, when the LHCP group distributed the reports.

D.1 REMOTE STATUS REPORTS FROM CSU

This appendix contains Colorado State University status reports from October 1985 to the conclusion of their NAS grant in April 1986. Another reference to consult for the Colorado State University NAS activities is their final report for NAS, "Remote Access for NAS: Supercomputing in a University Environment," which was printed in April 1986 and is available through Colorado State University, Institute for Computational Studies, P.O. Box 1852, Ft. Collins, Colorado 80522. The NAS library also has a copy.

D.1.1 October 1985 Status Report for CSU

To: Bohden Cmaylo
From: Becky Olson
Institute for Computational Studies
Colorado State University, Fort Collins, Co.

The work done in October was part of the effort to incorporate Cray's micro-tasking into a multigrid flow code which had previously been multitasked. There is quite a bit of work involved in the microtasking effort, because of the current restrictions in effect with that 'product'. (It is not yet an officially released and supported Cray product.) Obviously, we will not be able to test for speedup factor on the Ames Cray X/MP-12, but we are doing almost all of the code development on that machine. The code models viscous and inviscid 3-D flow through a channel

with a swept wing mounted on one wall. We are also investigating the use of locally embedded grid refinements in order to be able to model the full Navier-Stokes equations with adequate resolution of the flowfield near the walls and corners of the 3-D channel. This grid structure will also allow the patching together of thin-layer, full Navier-Stokes and Euler regions while retaining the multigrid convergence acceleration capability. Preliminary 2-D research will be carried out on the X/MP-12, while, for the complicated 3-D computations with very large memory requirements, we anticipate using the Cray-2.

We have also created various shell scripts on the Sun workstations. These shell scripts allow our users to get a file from Amelia, put a file on Amelia, submit a job to the Cray, and get the status of that job on the Cray, thereby eliminating the need for our users to logon to Amelia. These shell scripts use the 4.2bsd remote commands such as rcp and rsh.

We have also got the latest version of PLOT3D running on our IRIS. Work is still being done to get the Sun's version of PLOT3D up to speed by continuing development of it. One particular area of development has been the addition of the particle tracing code. Also particular areas of the sun code are being converted to the C language in an attempt to improve its speed.

The constant failing of Vitalink that we had experienced earlier has been fixed by NAS's long haul communication group and Vitalink. The problem of response time on Amelia has also been fixed by the shell scripts, since there is no need to log on to Amelia anymore. The only problem related to the Cray computer was a compiler bug in the 1.13 version of CFT. The Cray analyst told us how to access the 1.14 version, and the problem went away.

D.1.2 November 1985 Status Report for CSU

To: Bohden Cmaylo
From: Becky Olson
Institute for Computational Studies
Colorado State University, Fort Collins, Co.

The effort to develop a microtasked version of the concurrent Navier-Stokes code (CNS3D) has continued. Some of the development could be done on the Ames X-MP/12, but since the microtasking package is not presently available on the X-MP/12 at Ames, most of the work was done on the X-MP/48 at Mendota Heights. Our multitasking experience indicates that microtasking is superior to macrotasking and we strongly recommend that it be made available at Ames both on the presently installed X-MP/22 (and the X-MP/48 which will replace it shortly) and on the Cray 2.

We have also been in the process of installing a second Ethernet board to one of our Sun's. This will enable us to have our own internet network numbers instead of being part of Ames-NAS. This entailed upgrading the operating system and changing the kernel to add the second device and changing the HOSTS file. It should be operational in another week.

Procedures have been written to post-process output files from Ames for display on our Sun workstations and for printing on our Printronix laser printer.

Software has been written to obtain hardcopies of plots displayed on our Sun workstations. Software is being written to do the same from the IRIS.

We are currently experimenting with photographing images from IRIS/Sun screens.

Work on embedded gridding for 3-D flow computations is presently in progress on the IRIS.

An abstract is in progress on "Multitasked Embedded Multigrid for Three-Dimensional Flow Simulation" - The text of this abstract will be forwarded to you in January.

Amelia availability - In the past we have noticed problems with the availability of Amelia, but recently its availability seems to have improved. There is one remaining problem that could benefit from some attention; that is, sometimes over weekends and holidays, Amelia seems to be up but the Cray station package is down. If we had the capability to do a remote restart of the station package it would improve our productivity.

We have requested a NAS sponsorship of the supercomputing applications local area network for connection to ARPANET.

D.1.3 December 1985 Status Report for CSU

To: Bohden Cmaylo
From: Becky Olson
Institute for Computational Studies
Colorado State University, Fort Collins, Co.

The second Ethernet board is up and operational. Surya is now a gateway to our network from NASA Ames. Our hosts file has been updated accordingly, and Prandtl and Mercury have also been put in the host file. The only restriction on NASA Ames part is the internet number ending with 98 cannot be used because that is Surya's internet number on our network.

The EMACS editor has been installed on the Sun workstations and now will be evaluated and also moved to the IRIS.

We are currently developing an efficient algorithm (CNS3D) to be used for Navier-Stokes simulations of complex aircraft and turbomachinery geometries. The algorithm incorporates an explicit three-dimensional flow solver, embedded mesh refinement, a model equation hierarchy ranging from the Euler equations through the full Navier-Stokes equations, multiple-grid convergence acceleration and extensive vectorization and multitasking for efficient execution on parallel-processing computers. An abstract of this work has been submitted for presentation at the Tenth International Conference on Numerical Methods in Fluid Dynamics to be held this

summer. The text of this abstract has been forwarded to Ron Bailey, under separate cover.

A code to do the embedded multigriding for use in the algorithm has been developed on the Sun workstations/CSU Cyber 205 for a rectilinear cascade of finite-span, swept blades mounted between endwalls. The code is now operational on the Sun/Cyber 205 system. This code is now being made operational on the NAS system. This will allow the code to use the large memory capability so that realistically fine meshes for this current turbomachinery test geometry can be generated and will allow extensions of the code to include complete aircraft and turbomachinery geometries. Due to the extent of down time for Amelia this month, this work has been delayed and will be continued through January.

In order to further develop and verify the CNS3D code it would be very helpful to have access to the F-16 geometry and some typical transport geometry if available.

We have begun to develop new code and convert old code to run on the Cray 2. So far we have converted a library of I/O routines that we have found helpful in debugging code on both the Cray X-MP and the Cyber 205. Unfortunately, all of them used features not currently supported by the Cray 2 FORTRAN compiler. In addition to that library, a set of routines that interpolate efficiently between grid levels in multiple grid problems has been developed, with the Cray 2 as the target machine. That is, we have been careful to build into the code several parameters that can be adjusted if the long memory access time becomes a problem. The micro-tasking of existing code for the X-MP series has continued.

D.1.4 January 1986 Status Report for CSU

To: Bohden Cmaylo
From: Becky Olson
Institute for Computational Studies
Colorado State University, Fort Collins, Co.

We received a set of manuals for the Cray 2 from User Services. We've also received several user guides as well. Conversion of our codes from the Cyber 205 for use on the Cray 2 has been completed and was successful.

Initial testing of the CNS3D code on the Cray 2 has begun. This code will be used for Navier-Stokes simulations of complex aircraft and turbomachinery flows. The algorithm incorporates an explicit three-dimensional flow solver, embedded mesh refinement, model equation hierarchy ranging from the Euler through full Navier-Stokes equations, multigrid convergence acceleration, and extensive vectorization and multitasking for parallel-processing computers.

Development of grids for complex three-dimensional configurations is now under way on the Cray 2; previously only fairly coarse meshes could be generated because

of the memory limitations on available computers. The graphics capabilities of the workstations will be used extensively in examining and optimizing new grids.

We are anticipating the installation of multitasking on the Cray 2 with ongoing research into parallel processing on a four-processor X-MP. Dan Pryor spent the week of Jan 20 at Cray Research in Mendota Heights working out some microtasking problems with several people there. The multiple grid Navier-Stokes code was micro-tasked almost completely. Sample runs showed wall clock speedup of 1.9 using two processors. Four processors were unavailable for use at that time. We think that with larger test cases we can come even closer to a speedup factor equal to the number of processors. We are setting some up now.

We have been testing some of our home-grown utilities on the Cray-2, but have discovered some problems involving the use of Hollerith data. The 32-bit representation of integers seems to cause problems when Hollerith data are passed as arguments to subroutines. We have several easy things to try before we decide what to do next about the problem.

An abstract entitled "Large-Scale Flow Simulations on the Cray 2" is being prepared for submission to the First World Congress on Computational Mechanics to be held in the fall.

Our IRIS has been upgraded to the turbo option, with 4 megabytes of memory and the floating point accelerator added. From initial testing, it appears the I/O speed has increased by a factor of 3 and the graphics by a factor of 2. We are now looking into the possibility of adding another disk to the system. We are now at operating system 3.3.

D.1.5 February 1986 Status Report for CSU

To: Bohden Cmaylo
From: Becky Olson
Institute for Computational Studies
Colorado State University, Fort Collins, Co.

The expansion of the grid generation capability in the CNS3D code has been completed. This allows realistically fine meshes to be generated for full Navier-Stokes viscous calculations. Also available with this is the capability to embed meshes so that multigrid convergence acceleration can be achieved for realistic flow problems.

A code to do three-dimensional incompressible viscous calculations has also been implemented on the Cray 2. Initially this code is being run for the internal flow through the hot gas manifold of the space shuttle main engines.

Visual display of the grids and of the flow results is being accomplished by transferring the grid or output files back to the Sun workstations. The plotting can be done on either the Suns or on the IRIS workstation. This process of

transferring files and then plotting has thus far been acceptable although if faster transfer rates were available no one would complain. With our 56 kilobit connection to Amelia it takes about 8 minutes to transfer a 3055850 byte file from our Sun to Amelia using rcp. FTP is much slower, taking 11 minutes to transfer the same size file. Using rcp and the to2 command to transfer that same file from our Sun to the Cray takes 11 minutes.

Our paper entitled "Multitasked Embedded Multigrid for Three-Dimensional Flow Simulation" has been accepted for presentation at the 10th International Conference on Numerical Methods in Fluid Dynamics. We are using the Cray 2 extensively in computing three-dimensional Navier-Stokes flows to be included in this work. The algorithm incorporates an explicit three-dimensional flow solver, embedded mesh refinement, model equation hierarchy ranging from the Euler through full Navier-Stokes equations, multigrid convergence acceleration, and extensive vectorization and multitasking for parallel-processing computers.

One of our codes does not yet compile on the Cray 2, because of a bug in the compiler. The Cray analysts are aware of the problem, but fixes to the compiler have so far not corrected the problem. We are tracking the situation. Also the command "nohup" does not seem to be working on the Cray 2; when we use it in conjunction with executing code (as described in the NAS User Guide on page 4-8) and then logoff the Cray 2, execution is terminated.

(USER SERVICES - Please submit SPRs for the Cray compiler bug and the Cray nohup command with Becky Olson of CSU as the submitter - Bohden)

D.1.6 March 1986 Status Report for CSU

To: Bohden Cmaylo
From: Becky Olson
Institute for Computational Studies
Colorado State University, Fort Collins, Co.

Bohden,

Here is March's report and the final technical report. Other copies are being mailed to the appropriate people. Sorry the March is so late. We had a storm yesterday which played havoc with the power so all machines were powered off. I do apologize.

Becky

March Monthly Report/Final Technical Report
Long Haul Communications Experiment
April 1985 - April 1986

The experiment was designed to assist the NAS (Numerical Aerodynamic Simulation) Project Office in the testing and evaluation of long haul communications for remote users. The objectives of this work were:

Use a foreign workstation to remotely access NAS so NAS could explore potential problems and find solutions likely to result from interfacing equipment commonly used by university and industrial investigators to the NAS facility.

Provide NAS with a linkage to a large university-based computing facility which can serve as a model for a regional node of the (LHCS) long-haul communications subsystem.

Provide a tail circuit to the University of Colorado at Boulder, thereby simulating the complete communications path from NAS through a regional node to an end-user.

To meet these objectives ICS took delivery of a Sun-2 160 color workstation the first part of June. Another Sun-2 160 color workstation arrived the first part of July.

The first problem encountered by NAS/ICS was the inability of the Sun workstation to run a graphics software package available on NASA's Silicon Graphics IRIS workstation. Becky Olson spent a week in May 1985 at NASA Ames learning about the graphics package and the IRIS. She spent the next month converting it to the Sun workstation so the communication experiment could take place.

The 56 kilobaud line and the data service unit were installed the week of July 29 through August 1. By August 1, NASA Ames and ICS were talking through the 56 kilobaud line, providing NAS with a linkage to a university.

The next phase of the objective was to determine if the 56 kilobaud line was adequate for actual development work and data and graphic file transfers. Julie Swisshelm, a graduate student in mechanical engineering, spent the week of August 19 through 23 actually conducting computational fluid dynamics (CFD) runs at NASA Ames to have a base in determining the time it takes to run a CFD problem and transfer files locally at NASA Ames.

The next week (August 26 through August 30) the CFD runs were done at ICS through the 56 kilobaud line where statistical data was accumulated to see if the line speed was acceptable. This data are being processed by NASA Ames to see what the difference is between on-site users and remote users. In September ICS took delivery of a Silicon Graphics IRIS workstation. This was added to our local area network and used also to access NASA Ames.

By October most of the problems associated with the long haul communications experiment, such as the instability of Vitalink and the reponse time of Amelia, had been fixed and a test production mode was begun.

During the next few months, an efficient algorithm (CNS3D) to be used for Navier-Stokes simulations of complex aircraft and turbomachinery geometries, was developed. A code to do the embedded multigriding for use in the algorithm was developed on the Sun workstations/CSU Cyber 205 for a rectilinear cascade of finite-span, swept blades mounted between endwalls. This code was made operational on the NAS system. This allowed the code to use the large memory capability so that realistically fine meshes for this current turbomachinery test geometry can be generated and will allow extensions of the code to include complete aircraft and turbomachinery geometries. Other code was developed and old code converted to run on the Cray 2. So far we have converted a library of I/O routines that we have found helpful in debugging code on both the Cray X-MP and the Cyber 205. Unfortunately, all of them used features not currently supported by the Cray 2 Fortran compiler. In addition to that library, a set of routines that interpolate efficiently between grid levels in multiple grid problems has been developed, with the Cray 2 as the target machine. That is, we have been careful to build into the code several parameters that can be adjusted if the long memory access time becomes a problem. A code to do three-dimensional incompressible viscous calculations has also been implemented on the Cray 2.

During this time the first two objectives of the experiment were met. We discovered that the researchers preferred to do most of the editing on the local workstations and ship the code over as opposed to doing it at the remote site. Utilities were created that allowed the researchers to bypass any interaction with Amelia and move files directly from the local workstation to the Cray, and from the Cray to our local workstations. The researchers preferred to use the local workstations and just submit files to the Cray. It was discovered that 56 kilobits was an adequate line speed but a higher speed would not hurt. Our calculations demonstrate a 56 kilobit connection to Amelia takes about 8 minutes to transfer a 3,055,850 byte file from our Sun to Amelia using the command "rcp." The command "ftp" is much slower, taking 11 minutes to transfer the same size file. Using rcp and the "to2" command to transfer that same file from our Sun to the Cray takes 11 minutes. Finally, the researchers preferred to generate the graphics files on the workstations as opposed to generating them on the remote machine.

The third objective, that of providing a tail circuit to Boulder, has not yet been accomplished. Completion of this circuit has been delayed by slippage in the schedules for LAN interconnections at both CU Boulder and CSU and by slippage in the schedule for the reconfiguration of the CATI-funded (Colorado Advanced Technology Institute) 56Kb link between the CU Boulder and CSU computing centers. To date, we have no indication that these delays are indicative of anything more than normal schedule slippage. Work is continuing, beyond the period of performance of the present grant, and should be complete by mid-summer.

Elizabeth "Becky" Olson

D.2 STATUS REPORTS FROM LaRC

This appendix contains Langley Research Center's monthly reports from October 1985 to the present. Gordon Erlebacher has undertaken the responsibility of generating the reports each month. The NAS User Services Manager, Lynda Haines, has undertaken the responsibility to collect, examine, and distribute the LaRC report to all interested parties after the conclusion of the LHCP.

D.2.1 October 1985 Status Report for LaRC

From: Gordon Erlebacher
Mail stop 156
NASA Langley Research Center
Hampton, VA., 23665

To: Bohden Cmaylo
NASA Ames Research Center
Moffett Field, CA.

Bohden,

Nasa Langley took possession of their first IRIS 1500 (to be upgraded to 2500) during the second half of the month of September 1985. Two weeks were required to boot up the system, due to a lack of information, as well as insufficient expertise. Since then, an increasing number of users have become interested and have been steadily applying the PLOT3D package sent to us by Pieter Buning to the visualization of their computer generated flow simulations.

During my recent visit to Ames, the 224 kbps satellite link between the two centers (ARC and LaRC) was successfully established, and (to my knowledge) has not had any non-scheduled downtime. Typical transfer rates have been clocked at around 3000 kBytes/sec for medium to large files (< 1 MByte). File transfers have been performed between Langley, Ames and Colorado, with no noticeable problems. Furthermore, codes transferred from Ames to Langley have so far been error-free.

Shortly after my return from Ames various aspects of IRIS system administration have been examined. A VAX750 (name: ICASE) has been connected to the NAS net. It is accessible from IGOR and Amelia. Currently, the of problems encountered are as follows.

1. The FTP daemon does not automatically start up at boot time, even though it can be started up manually.
2. Mail does not work across the satellite link, or across our local Ethernet link to the ICASE VAX750.

3. We have not yet succeeded in booting up the system using the b: command. We currently type in the command: b:ip0a <C/R>. It works, so the matter has been pursued.

Mr. Michael Fischbein has recently been hired and has, as part of his duties been actively researching the causes for the problems mentioned above. Further information can be obtained from him.

The IRIS has in the month of October operated without any hardware failures. However, Mr. Fischbein is researching various methods of protecting the user and system software against such an eventuality. No conclusions have as yet been reached. To reiterate, the majority of IRIS users are using graphic tools to visualize their data.

Several large source programs have been uploaded to Amelia with the intention of running them on the Cray X-MP. They will be ported to the Cray 2 as soon as it is available. These program will be run as test cases at Ames Research Center. Use of Amelia and Igor is still very minimal, even though a handful of people have already requested accounts.

If you require further information, please let me know.

Sincerely yours,

Gordon Erlebacher.

D.2.2 November 1985 Status Report for LaRC

From: Gordon Erlebacher
Mail stop 156
NASA Langley Research Center
Hampton, VA., 23665

To: Bohden Cmaylo
NASA Ames Research Center
Moffett Field, CA.

Bohden,

In the month of November, usage of the IRIS has increased slightly, but as of now it is by no means saturated by our users. The primary use it is being put to is running Pieter Buning's package PLOT3D which has gained in popularity (no competition). User's are waiting for the latest versions of Grafix and View to do more sophisticated analyses.

The satellite link has been used primarily by myself to keep up with the daily activities of the NAS project. Communications are excellent. Several source files

were transferred down from Ames to the IRIS and executed with no problem. The transfer rates are still hovering around 3 kBytes/sec.

Mike Fischbein has been working with the UNIX environment to tailor it to our needs. The only major problem of interest that was fixed this month is uuep which now works correctly between the IRIS and the ICASE VAX in the mode mail name!icase. Both the mail name@icase and direct mail sending to Ames has not yet been tried. Miscellaneous files were removed from the system, including all ARC accounts except for the NAS accounts and those of Kehoe, Buning and Fouts.

New software is now available on the IRIS. Mike has written a utility to convert formatted data to unformatted data to use as input to Buning's PLOT3D. It has error checking and is fairly general.

A couple of weeks ago, several accounts were requested for the Cray 2 by users not presently working on the IRIS. Consequently, it is surmised that in a month or two, when the Cray 2 is made available to us, that the Iris user base will increase and a host of new problems will surface.

More information can be obtained by either sending mail to gerl!clyde or msf!clyde. Clyde is the new official name given to the IRIS; please update your host file accordingly. Contrary to the tradition at Ames, we have decided to name our workstations after some of our most prominent CFD researchers.

Gordon Erlebacher

D.2.3 December 1985 Status Report for LaRC

From: Gordon Erlebacher
Mail stop 156
NASA Langley Research Center
Hampton, VA., 23665

To: Bohden Cmaylo
NASA Ames Research Center
Moffett Field, CA.

Bohden,

December can properly be termed the month of stabilization. The average number of serious users is in the neighborhood of 10. They use the machine on a regular basis for plotting and animation. However, we are slowly building up a Cray 2 user base who use the IRIS and the ICASE VAX to access the NASNET. Currently the IRIS is only accessible from the ICASE VAX or from its console, so that the small number of users is a bonus.

Several large files have been shipped to Ames and manipulated (compile and linked) on the Cray 2 and Cray X-MP. The transfers were error free.

Mail can now be sent to Ames from the ICASE VAX, but not yet directly from the IRIS. The reasons for this are presently unknown. A user on the IRIS can communicate with Ames by including the ICASE VAX in the mail path.

A special guest account with a restricted number of commands has been implemented by M. Fischbein. The objective is to provide a minimum amount of protection against outsiders who might wish to break in.

It has been observed by Tom Zang and myself that the station package on Amelia is very erratic and is prone to failures quite often. It is felt here that this can hamper Cray usage rather severely. Is there an alternative?

Finally it must be mentioned that the NAS support group has been very helpful in providing for our needs and in answering the numerous questions asked by our user. Thank you.

Gordon Erlebacher

D.2.4 January 1986 Status Report for LaRC

From: Gordon Erlebacher
Mail stop 156
NASA Langley Research Center
Hampton, VA., 23665

To: Bohden Cmaylo
NASA Ames Research Center
Moffett Field, CA.

Bohden,

Finally misfortune struck! Our IRIS 2500 upgrade arrived early in the month, and the spells of bad luck began. The upgrade came without a bootable tape, so the field representative had to bring his own. Then we found out that the IRIS could only be booted via an ASCII terminal for reasons I do not fully understand (Mike Fischbein can provide any amount of detail). After the departure of installer, we discovered we had forgotten to copy over the optional FORTRAN graphic libraries. So another 1.5 weeks were wasted while waiting for a fresh tape to arrive. Unfortunately, one day prior to the long awaited fortran tape, the disk crashed while Mike was executing makedevice. It was then that he found out that the new version of ipfex, utility which is indispensable to boot up the IRIS from the disk, had a bug, and that the previous released version was required. This version has arrived today, but has not yet been tested. You should check the software you have received with your IRIS 2500 upgrades to make sure that you have the old version of ipfex. Note that your problems are not as severe as ours since your IRISs are networked together, and should a disk fail, you could always reboot from another IRIS.

Tom Zang and Ajay Kumar have entered production mode on the Cray 2. They are running jobs ranging between 4 and 12 million words each, and have recently started increasing their run times. We are all awaiting a more sophisticated compiler from Cray.

Gordon Erlebacher

D.2.5 February 1986 Status Report for LaRC

From: Gordon Erlebacher
Mail stop 156
NASA Langley Research Center
Hampton, VA., 23665

To: Bohden Cmaylo
NASA Ames Research Center
Moffett Field, CA.

Bohden,

Usage of the IRIS has stabilized. Mostly, researchers are using PLOT3D to view their numerical data. As yet, no Cray 2 results have been visualized.

Communications between the Iris and the NAS network has presented no problems, with the exception of the loss of transmission due to snow on the satellite dish. This resulted in a 2 to 3 day loss of Cray compute time.

Recently, users have begun to use Prandtl for run-of-the-mill operations which do not involve the Cray 2. However, problems have manifested themselves when login on over the LHC. It is probably related to the delay in the transmitting/receiving characters across the link. The Langley user typically gets a timed out message from Prandtl. A fix to the problem is highly desirable to ease transfer of information across the NAS network.

(USER SERVICES - Please submit an SPR for the above problem with Mike Fischbein of LaRC as the submitter - Bohden)

A major concern among our Cray 2 users is file storage. Procedures to store information on tape are being developed at Ames. However, the maximum file size permitted on Amelia is around 40Mbytes. This should be increased if reasonable restart files are to be generated. Breaking up files into sections has been suggested, but is impractical considering the number of transfers we have to go through to get the information from Langley to Ames and/or back.

(USER SERVICES - Please submit an SPR for the above problem with Mike Fischbein of LaRC as the submitter - Bohden)

More information can be obtained from Mike Fischbein (FTS 928-2396 @ Langley).
Gordon Erlebacher, NASA Langley Research Center

D.2.6 March 1986 Status Report for LaRC

From: Gordon Erlebacher
Mail stop 156
NASA Langley Research Center
Hampton, VA., 23665

To: Bohden Cmaylo
NASA Ames Research Center
Moffett Field, CA.

Bohden,

Use of the IRIS workstation during the month of March remained stable at about 20 users. For the most part, plotting with PLOT3D is still the major activity. However, new software is being developed on two fronts. First, I have partially rewritten, and extended a program put together by one of our Co-ops last summer. It reads a file with stream- or vortex-lines and surfaces, and allows the user to visualize them. Unlike the static properties of PLOT3D and view, the user can interactively select the streamlines he wants to see on the object itself with the use of the mouse, as opposed to entering numbers at the console. Extensive use is made of dynamic memory allocation to conserve memory. Second, a student in the Theoretical Aerodynamics Branch is developing a program to plot vortex lines in an axisymmetric configuration. The motivation is to allow users to store a 2-D database, yet plot 3-D vortex lines with no loss of resolution, and without having to store variables on a 3-D grid.

Mike Fischbein is currently experimenting with low level UNIX daemons that he is writing himself. He has developed the knowledge to develop the "talk" routine from scratch on a UNIX 4.2BSD system. His progress could potentially affect our future network communications.

The Cray 2, Navier, is usually accessed from the ICASE VAX, leaving Clyde for program development or flow visualization. Problems and potential problems that have, or will occur are as follows:

1. Navier has been down a lot lately. If, as we are told, the problem is one of the cpu's malfunctioning, wouldn't it be possible to shut it down, and work on it during dedicated time? Substantial computing time has been lost to the users this month. Furthermore, during a working session, Navier often issues the message "not responding" without actually crashing. What does it mean?

*** (User Services - Please respond to Gordon with an answer - Bohden)

2. I noticed that FTP was operational between Navier and Amelia. Does it work properly between Navier and your IRIS workstations? FTP between Navier and Clyde functions properly when changing remote directories, but Clyde freezes up as soon as a file transfer is initiated. Any clues? FTP has not been tried between Navier and the ICASE VAX.

*** (User Services - Please respond to Gordon with an answer - Bohden)

3. Recently, we have been able to communicate directly from one of our VMX VAXes to Euler and Europa, and from there to Navier, via DECNET. I do not know the details, and have not personally tried out any file transfers. Details will be provided in next month's report.

4. File space is not an immediate problem. However, files of 40 Mbytes are common in the laminar transition problems we are working on. Sooner than expected, a file space crunch will occur again. Please prepare for it.

5. All Cray users now have Prandtl accounts. Prandtl had been unreachable for several days, but I have recently been able to log on from Amelia.

*** (User Services - This is currently SPR #860 - Bohden)

6. According to User Services, DI-3000 will be available on Prandtl in the near future. The month of April will supposedly be spent fine-tuning the software. I personally possess a 2-D plotting package that uses DI-3000. The code could be made available to the system people working on the project. If possible, I'd like to participate in the testing of the software over the network. It would be interesting if I could interactively plot a file on one of our terminals using the software at Ames. This would be greatly appreciated.

*** (User Services - Please respond to Gordon with an answer - Bohden)

This concludes the report.

Gordon Erlebacher, Computational Methods Branch

D.2.7 April 1986 Status Report for LaRC

From: Gordon Erlebacher
Mail Stop 156
NASA Langley Research Center
Hampton, VA. 23665

To: Lynda Haines
NASA Ames
Moffet Field, CA.

April report on the usage of NAS from Langley

Dear Lynda,

This month's report is divided into three sections. First, routine problems with the IRIS workstation are discussed. Second, an brief overview of our current communication links with the NAS computer complex is presented, and third, some of the difficulties encountered by users of Navier are elaborated on and suggestions for further improvement are made.

Iris workstation

As a protection against disk failure, incremental backups of the file system are performed every evening, with a full backup at the end of every week.

New software has been downloaded from wk01 out at Ames. Specifically, your version of EMACS and version 3.4 of PLOT3D. Documentation is now being distributed to the users. Eric Hibbard has help with the installation of ArcGraph on our system. This package has already been tested in conjunction with the recently released version of GAS, made available by P. Buning on his recent visit to Langley. During his stay, he interacted with IRIS users and fielded questions on the various graphic software currently available.

Communications

Presently, there are two paths to Navier. Remote logins are routinely performed from the ICASE VAX or from Clyde (IRIS) across NASNET. However, this route is impractical if listings of source code, or short listings of output files are desired, since a tape transfer from ICASE to another VAX is required to bring the files back to our main complex. To remedy the situation, accounts were given to the Cray 2 users on Earth, which is accessible from Amelia. A file transfer from Navier proceeds as follows:

1. Execute toame or touts to transfer file from Cray 2 to either Amelia or Prandtl. (FTP can be used as well)
2. From the VAX, FTP the file to earth VMS VAX.

3. Telenet to the VAX and copy the file over the one of two VMS VAXes at Langley, across DECNET. From there, they can be directly routed to the printer.

The process is long and involved, but nonetheless faster than using tapes. On the other hand, large files are more easily managed with tapes.

If NASNET is unavailable, a remote login from our VMS VAXes through Earth should be possible, although it hasn't been tried out. If both DECNET and NASNET are down, we can still access Amelia and Prandtl through remote dial-in. In the last month, we have found out that if Navier is inaccessible to us, it is also inaccessible to the users at Ames. The major improvement we feel is important in the area of communications is to speed up the transmission rate across the satellite link. Presently, a 1 megabyte file can be transferred over to Langley from Ames in about 10 minutes.

***** LHC: Can anything be done now to improve their file transfers?
***** --Haines

Graphics

In the last 2 weeks of this month, concern has grown over the subject of graphic representation of the data bases generated on Navier. The solution Zang and myself have adopted, is to run a separate program on the Cray 2 which extracts subsets of the data base. We then send this subset to the IRIS or to Clyde where it is plotted up. With the advent of DI3000 and ArcGraph on Prandtl and the Cray 2, graphic metafiles can be generated at Ames and sent down directly.

Difficulties with Navier

The following list of problem areas reflects the small NAS user community at Langley. It has been communicated to Leslie Chow on her visit to Langley on May 1st, 1986.

1. A message command should be installed on Navier to provide users with information on system problems (both hardware and software). It could also be used to inform the users about special features available on the new compilers and linkers as they become available, instead of letting them find out by more devious means. For example, the open statement in Cray FORTRAN does not account for unformatted I/O, or if it does, it is not properly documented. It is more than likely that this will be remedied in a future compiler, but unless we are informed, how will we know?

***** I will ask Operations and Development to check into how we can
***** best transmit this information. --Haines

2. The /tmp files has been heavily abused lately. Files of over 500 Mbytes sometimes reside there for days on end. As a result, Langley jobs have crashed a couple of times due to insufficient disk space. This problem occurred in the light of the Langley disk crash when most of our files were lost. The disk was taken back

to Cray with no replacement for the Langley users. Our file space was reduced accordingly. This brings up the next item.

***** Abuse of /tmp will no longer be tolerated. If you see evidence
***** of abuse, please send a message with the pertinent information
***** to me for action. --Haines

3. In the event of a similar disk crash, it should be possible to allocate a portion of the tmp space to the affected organization. This would in a sense impose an equal file space restriction on all the users.

4. Several times, we have noticed one or two users running three or four long batch jobs simultaneously. To prevent a total saturation of the system, we propose to limit the maximum number of batch jobs to two per user, if their time limit exceeds 1 hour, for example.

***** I will ask Operations and Development to check into #3 and
***** #4. --Haines

5. We have been adversely affected by the HYPERchannel problems between Amelia and Navier. As a result, users typically log in to Navier through Prandtl, although its HYPERchannel link the the Cray is not fully reliable either.

D.3 STATUS REPORTS FROM LeRC

This appendix contains Lewis Research Center's monthly reports from October 1985 to the present. Dan Whipple has undertaken the responsibility of generating the reports each month. The NAS User Services Manager, Lynda Haines, has undertaken the responsibility to collect, examine, and distribute the LeRC report to all interested parties after the conclusion of the LHCP.

D.3.1 October 1985 Status Report for LeRC

To: Bohden Cmaylo
From: Dan Whipple
LeRC NAS Remote Station

Larry says you want a short report.

1) Remote ASCII terminals hooked to IRIS via the Lewis CATV system so we can work from our desks

2) Various new users joined to IRIS/UNIX and getting to know things better

Hope this is sufficient for next week.

D.3.2 November 1985 Status Report for LeRC

To: Bohden Cmaylo
From: Dan Whipple

November Events

- 1) Remote ASCII terminal access to IRIS via LeRC LINK network
- 2) November issue of LeRC computer newsletter had four page article on NAS and the equipment at LeRC complete with pictures
- 3) Still waiting for modem parts to allow IRIS to move to bldg 5

D.3.3 December 1985 Status Report for LeRC

To: Bohden Cmaylo
From: Dan Whipple
LeRC NAS Remote Station

- 1) IRIS down time due to lack of personal attention due to leave
- 2) IRIS 2500 upgrade parts have arrived
- 3) Expecting to move IRIS to Bldg 5 this month
- 4) Received a copy of NAS Users Guide

Dan Whipple FTS 297-5859

D.3.4 January 1986 Status Report for LeRC

To: Bohden Cmaylo
From: Dan Whipple LeRC NAS Remote Station

- 1) The parts necessary to move the IRIS workstation to building 5 have been shipped to LeRC and the move is now planned for the first week in February.
- 2) The upgrade is still pending due to scheduling with the Detroit office of SGI. We will probably combine the upgrade with the move and subsequent checkout at the new location.
- 3) The User Services office at ARC has been very helpful in various areas including the load of some IRIS tapes to overcome local procurement delays as well as help with an EMACS problem due to the VT100 emulation terminals we are using to access the system.

4) The IRIS has been used to access NAS computers and run some test cases of our codes. Additional users have been joined and are learning UNIX and will shortly be running additional codes. This effort should proceed rapidly as a sloppy but working way has been developed to link the IRIS with the LeRC central computers for file transfer.

5) Scientific data base and graphics codes including PLOT3D are being implemented to support user codes and to provide a consistent interface across computer systems.

6) A list of users has been compiled and sent to ARC for the initial distribution of NAS user manuals.

D.3.5 February 1986 Status Report for LeRC

To: Bohden Cmaylo
From: Dan Whipple
LeRC NAS Remote Station

Lewis Remote Station-February Report

Various users have been joined to IRIS UNIX and NAS computers and are in the process of sending tapes to ARC to install their codes for running. Action to move the IRIS to Bldg 5, installing the upgrade, and interfacing to the LeRC computers are underway by the Computer Services Division at Lewis.

D.3.6 March 1986 Status Report for LeRC

To: Bohden Cmaylo
From: Dan Whipple
LeRC NAS Remote Station

1) The modems necessary to move the IRIS to bldg 5 arrived and turned out to have the wrong baud rate..estimate 30 day additional delay to get resolved; 2) because of (1) an area in bldg 142 was cleaned up and the full IRIS system, including printer, was set up and made available to users there on a temporary basis; 3) the entire system was backed up on tape and regular operations initiated; 4) major problem installing new Ethernet addresses..new /etc/hosts file had format problems..all resolved within 1 day with excellent assistance from ARC; 5) finished and started to distribute a beginners writeup for LeRC/UNIX/IRIS users as its our first UNIX exposure; 6) requested and received Build 3 material from J. Vukelich; 7) SGI has scheduled 4/1/86 for the upgrade to the 2500 configuration. Expect to move to bldg 5 shortly after if replacement modems arrive and work; 8) user codes have been mailed (USPS type) to ARC and are beginning to sprout on the NAS system so we are

starting to see real users do real jobs at last. We have many users lined up and as they learn UNIX etc. the load should start to pick up.

Dan Whipple-LeRC

D.3.7 April 1986 Status Report for LeRC

To: Lynda Haines
From: Dan Whipple
LeRC NAS Remote Station

NAS-Lewis report for April 1986

The following major events occurred this month

1) The upgrade to a model 2500 IRIS was performed, then the ipfex version on SGI tape was bad, received correct tape next day from SGI, rebuilt the file system and got running with much help from Bill Kehoe, reworked about a dozen files to restore all system functions to their pre-upgrade state including remote communication with ARC2.

2) Bill Kehoe downloaded the current version and documentation for PLOT3D.

3) Started to notice many tcp errors which would sometimes lockup the system Execlan model 201 board ordered from SGI; also notified NAS of same.

4) Our special modems arrived and were made to work so the entire pile was moved to Building 5 room 210 so we can have real access; however, the room wiring had to be redone as the initial job was performed by someone who put half the outlets on one circuit breaker and left the other five almost unused. Due to work elsewhere the air conditioning was off and room temp went up to 95° so we shut everything off. Finally got everything fixed and the system is fully operational.

5) Installed the new Ethernet board in the IRIS but we are still getting the checksum errors sometimes followed by the link totally going down which if the user is on the console terminal hangs the system after the message 'EXOS PANIC' comes out. This is very often the result when trying to send anything more than a few lines across the link to/from ARC. This now seems to be the biggest problem we have as it inhibits file transfer of data and programs.

***** Workstation Systems Administrators need to check with Dan on this
***** problem. L. Haines

Dan Whipple 5/1/86

APPENDIX E

PROBLEM HISTORY/RESOLUTION

The following sections deal with actual communication problems and their solutions. The problem reports are ordered chronologically from the initial connection on 6 August 1985 to the end of the LHCP on 30 April 1986.

E.1 Symptom: CSU Vitalink Box Not Talking to ARC Vitalink Box

Problem report #1 10am 6Aug85

Submitted: Bohden Cmaylo/ARC/x5225 Closed: 6 Aug 85

NAS SPR #702, severity=1 Assigned: Cmaylo

Hypothesis: AT&T line down since DSU boxes appear ok on both sides.

Actions:

(1) 10am 6Aug85 - Investigated problem locally. Vitalink box and DSU unit this end OK.

(2) 10:15am 6Aug85 - Called CSU. Their Vitalink box and DSU unit ok.

(3) 10:30am 6Aug85 - called Boeing contact at MSFC. Out to lunch. Left message.

(4) 10:45am 6Aug85 - went to Randy Parrella (McGuire not here) and asked about data network problem procedures. He explained about MSFC Trouble Center.

(5) 11:00am 6Aug85 - called MSFC Trouble Center, explained situation, gave circuit number and appropriate contacts, requested a ticket number (but was denied because they did not know if it was a NASA circuit), and was told that they would get back to me.

(6) 12:30pm 6Aug85 - Darren Norris (Boeing contact at MSFC) called and asked what's wrong. Told him and actions being taken. He said he would follow up actions.

(7) 1:30pm 6Aug85 - Gunn of MSFC called and said line was fixed. The line was cut in Nevada. He waited until I verified communications.

E.2 Symptom: CSU VB/1 at ARC Crashing Every 2-3 Days

Problem report #2 20 Sep 85

Submitted: Bohden Cmaylo/ARC/x5225 Closed: 15 Oct 85

NAS SPR #701, severity=1 Assigned: Cmaylo

Hypothesis: VB/1 software problem.

Actions:

(1) 20Sep85 - frequencies of crashes increasing. Foo to push Vitalink for answers. Vitalink said to increase buffer sizes. Did, but CSU still crashed.

(2) 20Oct85 - CSU has new S/W for VB/1. Installed. Crashed later.

(3) 15Oct85 - Vitalink stated inactive 4.8Kb CSU and LeRC links caused buffer overflow. Deactivated those links. CSU now stable. If more than one link in a VB/1, then all links must be active, else forwarding buffers will eventually crash the box.

E.3 Symptom: Initial LaRC Connection Not Working

Problem report #3 20 Sep 85

Submitted: Bohden Cmaylo/ARC/x5225 Closed: 1 Oct 85

NAS SPR #700, severity=1 Assigned: Cmaylo

Hypothesis: Faulty installation of RCA equipment.

Actions:

(1) 20Sep85 - Tried loopback mode initially; could not loopback. Investigated problem using Vitalink boxes. Could communicate via satellite simulator, but not via COMTECHs. Asked RCA to investigate.

(2) 23Sep85 - RCA appeared late in afternoon. COMTECH boxes needed to be internally clocked. Change made them work with loopback.

(3) 24Sep85 - LaRC ready for connection, ARC not (loopback testing)

(4) 25Sep85 - ARC ready for connect, LaRC not (dish realignment due to hurricane)

(5) 1 Oct 85 - RCA reconfigured for LaRC. COMTECH box externally clocked at LaRC, needed to be internally clocked. After fix, connection established.

E.4 Symptom: Initial LeRC Connection Not Working

Problem report #4 18 Oct 85

Submitted: Bohden Cmaylo/ARC/x5225 Closed: 21 Oct 85

NAS SPR #699, severity=1 Assigned: Cmaylo

Hypothesis: Faulty installation of RCA equipment.

Actions:

(1) 18Oct85 - RCA established circuit late in the day...Did not work. Asked RCA to investigate COMTECH boxes. They stated could not do until next week.

(2) 21Oct85 - Asked Al Ross to assist in COMTECH debugging. Assumed same clocking problem as LaRC. Al Ross confirmed with Larry McFarland of LeRC. After both COMTECHs at LeRC fixed, connection was established (after McFarland jiggled some boards in the COMTECHs).

E.5 Symptom: Very Long Delays to/from LaRC

Problem report #5 9am 25 Nov 85

Submitted: Bohden Cmaylo/ARC/x5225 Closed: 26 Nov 85

NAS SPR #694, severity=2 Assigned: Cmaylo

Hypothesis: Bad Satellite line to LaRC.

Actions:

(1) 9:00am 25Nov85 - Noticed long delays to/from LaRC.

(2) 11:00am 25Nov85 - Investigated problem locally. ARC1 Vitalink box this end OK.

(3) 11:15am 25Nov85 - Connected to LaRC Vitalink box; unit ok.

(4) 1:00pm 25Nov85 - Contacted LaRC. They had not noticed anything.

(5) 4:30pm 25Nov85 - Still Long delays.

(6) 4:45pm 25Nov85 - Rebooted both Vitalink boxes; problem went away.

(7) 10:00am 26Nov85 - Had Foo call Vitalink about problem. They did not know what did happen.

E.6 Symptom: LeRC Not Connected

Problem report #6 9am 25 Nov 85

Submitted: Bohden Cmaylo/ARC/x5225 Closed: 27 Nov 85

NAS SPR #693, severity=1 Assigned: Cmaylo

Hypothesis: Bad Satellite line to LeRC.

Actions:

- (1) 9am 25Nov85 - Investigated problem locally. ARC2 Vitalink box this end OK.
- (2) 9:15am 25Nov85 - Could not connect to LeRC Vitalink box. Left message at LeRC for Whipple/McFarland.
- (3) 8:30am 26Nov85 - Called LeRC. Could not reach Whipple/McFarland. Towne left message.
- (4) 8:30am 27Nov85 - Tried to contact Whipple. Left another msg.
- (5) 11:10am 27Nov85 - Whipple called. Said that RCA did some work Monday. Said that McFarland tracking down what RCA did. Will return answer.
- (6) 1:00pm 27Nov85 - observed VB/1 ARC2. Noticed LeRC sporadic. Went to 097 and observed COMTECH sm200. Everything looked ok. Noticed small green light was flashing on LeRC but not on LaRC. Reset both COMTECHs for LeRC. Tested connection to LeRC via rlogin. Worked!!

E.7 Symptom: Problem with LeRC Connections

Problem report #7 2 Dec 85

Submitted: Bohden Cmaylo/ARC/x5225 Closed 4 Dec 85

NAS SPR #692, severity=1 Assigned: Cmaylo

Hypothesis: Bad Satellite line.

Actions:

- (1) 9am 2Dec85 - Investigated problem locally. ARC2 Vitalink box this end OK. COMTECH box to LeRC faulting. Tried to contact LeRC and ARC ES; no luck, nobody anywhere. Left msgs for everybody. Contacted ARC ES later - they stated that no receive from LeRC coming in.

(2) 2:30pm 2Dec85 - Contacted RCA service center. They gave ticket # L536, circuit type 224Kb, circuit # 8396.

(3) 11am, 3Dec85 - RCA at LeRC. Waiting on cable (FO) from Goddard ES. Appears to be a fiber Interface problem.

(4) 10am, 4Dec85 - Called RCA Service center. They stated problem fixed. Gave Goddard number (301 474 2330) as a future number to call for problems. LeRC was up.

E.8 Symptom: Problem with LaRC/LeRC Connections

Problem report #8 5 Dec 85

Submitted: Bohden Cmaylo/ARC/x5225 Closed 11 Dec 85

NAS SPR #691, severity=1 Assigned: Cmaylo

Hypothesis: Bad Satellite lines.

Actions:

(1) 1:30pm 5Dec85 - Televideo conference this morning. After conference, LeRC and LaRC connections unavailable. Investigated problem locally. ARC1/ARC2 Vitalink box this end OK. COMTECH box to LeRC faulting. Rebooted COMTECHs and VB/1s - no change. Tried to contact LaRC, LeRC and ARC ES; no luck, nobody anywhere. Left msgs for everybody.

(2) 9am 6Dec85 - No LeRC/LaRC communication yet. Contacted ARC ES. LaRC line ok, LeRC line no receive. Left more msgs at LaRC and LeRC. Not returned. LeRC stated that communication was available for a while on 6Dec85 after RCA left.

(3) 9am 9Dec85 - LeRC/LaRC still down. Contacted Bill Shinn at LaRC. He said he would investigate why LaRC down. Rebooted both VB/1s. LeRC came up, LaRC stayed down. COMTECHs show LaRC ok while LeRC had 50+-30 bers. Called ARC ES - they stated RCA working LeRC problem but LaRC looks ok.

(4) 10:30am 9Dec85 - Called LeRC - they stated that they were up and connection to Amelia was established. Could not confirm.

(5) 12:30pm 9Dec85 - LeRC and LaRC both came up. LaRC came up after we rebooted the COMTECH and VB/1 box at LaRC and waited ~8 minutes. LeRC came up for some other unknown reason.

(6) 4:30pm 9Dec85 - Checked connections. LaRC was up, CSU and LeRC down. Rebooted ARC2. CSU came up, LeRC stayed down. Called Al Ross (ARC ES) and he said that at 2pm LeRC was weak and that RCA was still working on it. Said also that he would check 6:30am 10Dec on status of LeRC.

(7) 10am 10Dec85 - Al Ross called, said LeRC fixed and televideo conference was over. Checked connections. LeRC up, CSU and LaRC down. Rebooted ARC1 and ARC2 - CSU came up; rebooted LaRC COMTECH and LaRC VB/1- still down. LaRC contacted 11:30, they rebooted COMTECH and VB/1, and they came up.

(8) 8:30am 11Dec85 - LeRC down. LeRC stated they went down at 1:39pm PST. Rebooted both VB/1s at 10am, no change. Rebooted both COMTECHs and VB/1s at 11:35, LeRC now up. No rlogind at LeRC ... rebooting LeRC at 11:50.

(9) 11:30am 11Dec85 - Al Ross (ED) stated that RCA boosted power at both LeRC and ARC. Also realigned antenna at LeRC. Problem seems fixed now.

E.9 Symptom: Problem with LaRC Connections

Problem report #9 11 Dec 85

Submitted: Bohden Cmaylo/ARC/x5225 Closed: 28Jan86

NAS SPR #690, severity=1 Assigned: Cmaylo

Hypothesis: Bad Satellite lines.

Actions:

(1) 17:30pm 11Dec85: LaRC not on line. Rebooted VB/1, no change. Too late to get LaRC help.

(2) 8am 12Dec85: investigated local connections, all seems ok. Hard to contact LaRC. Obtained slight help from Gordon Erlebacher in rebooting VB/1 at LaRC; no help. Still down. Asked Foo and Eisenman to continue investigation Friday.

(3) 9am 13Dec85: Investigation proceeding. No complaints from LaRC.

(4) 8am 16Dec85: LaRC still down. Asked Al Ross to assist. Discovered at 14:30 that primary COMTECH faulty. Asked Al Ross to report and return dates of repair.

(5) 2pm 19Dec85, Larry of RCA wanted 2-4pm for testing. Confirmed that LaRC COMTECH is bad. Switch board is bad.

(6) 2Jan86, Larry of RCA repaired the primary COMTECH to LaRC and stated it was ok. LaRC went down at approx: 1630 that day. Primary COMTECH was again at fault. Called Ross for him to contact Larry of RCA.

(7) 2pm, 16Jan86: Larry of RCA took LaRC primary COMTECH for repair.

(8) 2pm, 21Jan86: Larry of RCA returned LaRC primary COMTECH. Still appears faulty.

(9) 3:30pm, 28Jan86: Closed via problem report #14.

E.10 Symptom: CSU Down

Problem report #10 23 Dec 85

Submitted: Bohden Cmaylo/ARC/x5225 closed: 23 Dec 85

NAS SPR #698, severity=1 Assigned: Cmaylo

Hypothesis: Bad AT&T line

Actions:

(1) 10am 23Dec85 - Becky of CSU called... cannot get on. Tried rebooting both VB/1, no luck. Asked about modems...transmit light on, no receive light at CSU. Checked here, same situation. AT&T line appears down. Reported to CSU.

(2) 10:30am 23Dec85, called MSFC trouble center to report fault. Ticket number received is 861828. They will call back.

(3) 12:05pm 23Dec85, MSFC called back and asked to verify line up. Line was up. AT&T had replaced a jumper in Oakland Ca., which was wrongly removed.

E.11 Symptom: CSU, LeRC, and LaRC Down

Problem report #11 6 Jan 86

Submitted: Bohden Cmaylo/ARC/x5225 Closed: 5Mar85

NAS SPR #685, severity=1 Assigned: Cmaylo

Hypothesis: Vitalink down

Actions:

(1) 8:30am 6Jan86: "ruptime" showed surya and icase down. Went into LHCP lab and saw error message on vitalink box:

```
"Warning: ARC2 080002001328 PID=1102 code=2 time=(several)
```

```
attempt to free CB without WRITE_CMPLT at line 0"
```

Foo to investigate.

(2) Jiggled Ethernet cable for ARC1, then LaRC came back up. Eisenman to get techs to fix. This has happened several times before.

(3) 10Jan86: Foo Lee stated that Anna Stevenson of Vitalink said that you get the warning message when you lose the clear-to-send (CTS) signal on the modem (COMTECH?) or due to a loose connection.

(4) 13Jan86: Placed AB box for V.35 modem cable between ARC2/LeRC, COMTECH modem, and satellite simulator, to assist in cable switching for testing. Want Bendix to purchase another AB box for ARC1/LaRC. Also want Bendix to check/fix cable ends.

(5) 5Mar86: Bob Renfro/Bendix replaced and/or repaired V.35 cables. Pat Jacquemet/ETI checked/repaired Ethernet drop lines. Item appears closed.

E.12 Symptom: LeRC Signal in Flux from ARC Signal

Problem report #12 8 Jan 86

Submitted: Al Ross/ARC/x6519

Closed: 11Mar86

NAS SPR #684, severity=1

Assigned: Cmaylo

Hypothesis: 1/2 of COMTECH down

Actions:

(1) 8:30am 8Jan86: Larry of RCA called and said that Al Ross called him and said that LeRC signal was in flux. He said to turn off whatever COMTECH modem was on, and have Al check on the resultant signal. Turned the backup modem off, which resulted in a better signal. Al will contact Larry to further fix the problem.

(2) 2pm, 16Jan86: Larry of RCA took LeRC modem for repair.

(3) 3pm, 29Jan86: Larry of RCA returned modem. I had to go to a branch meeting, therefore, I could not check on status of installation.

(4) 8:15am, 30Jan86: See LHCP Problem #15. LeRC modem still bad, except that it is the backup modem this time.

(5) 8-10am, 11Mar86: Larry Simonis/RCA + Marty Suzuki/Bendix replaced sync board during a video teleconference. They left after checking out both LaRC and LeRC systems.

(6) 10:30am, 11Mar86: LaRC/LeRC not up after video teleconference completed. LeRC was visible on the Vitalink equipment (see LHCP Prob 17), while LaRC was not (see LHCP Prob 18). Therefore, the LeRC modem problem is considered fixed.

E.13 Symptom: LeRC Down

Problem report #13 22 Jan 86

Submitted: Trevor Eisenman x5485 Closed: 22Jan86

NAS SPR #688, severity=1 Assigned: Cmaylo

Hypothesis: Signal loss from LeRC.

Actions:

(1) 10:00am 22Jan86, on checking LeRC local lines, the COMTECH showed fault lights on indicating receive signal loss. Called Al Ross to check on incoming signal, which was none. Al Ross to call Goddard and carry on checking.

(2) 11:30am, 22Jan86: Al Ross called and said that high winds moved satellite dish at LeRC. Satellite dish was repositioned and communication reestablished.

E.14 Symptom: LaRC Down

Problem report #14 27 Jan 86

Submitted: User Services x6771 (Ellen Figueira) Closed: 28Jan86

NAS SPR #687, severity=1 Assigned: Cmaylo

Hypothesis: Signal loss from LaRC.

Actions:

(1) 9am, 27Jan86: User Services called and stated that 2 LaRC callers said that they could not connect with NAS.

(2) 9:10am, 27Jan86: Checked out VB/1. Appeared ok but no LaRC connection. Called Al Ross/ARC Earth station to check on LaRC signal. He stated signal was weak and would followup with RCA. Reported back to User Services.

(3) 9:40am, 27Jan86: Al Ross called and said that RCA said that LaRC dish was covered with snow and that they would not sweep it away. Reported back to User Services.

(4) 9:55am, 27Jan86: Called Bill Shinn at LaRC (Brad Ball not in) and stated problem. He said he would get someone on it and call back. He called back later and said that they wanted to wait until the next day to see if new snow fell.

(5) 8:15am, 28Jan86: called Bill Shinn at LaRC. He said that problems existed in turning off the dish, because of microwave hazards. Said he would call back in an hour after he got hold of Frank Thames.

(6) 11:30am, 28Jan86. Called Shinn who stated that the Shuttle disaster, which occurred earlier, postponed action on clearing dish.

(7) 1:35pm, 28Jan86: Shinn called and said that dish was cleaned. Still no LaRC connection. Checked with Ross and he said that LaRC coming in ok now. He will contact RCA to indicate possible COMTECH problem here.

(8) 3pm, 28Jan86: Mike Suzuki of Bendix called and said John of RCA here to inspect COMTECH modems. John fiddled around and stated that the attenuation for the LaRC backup was set too high. Asked him to check both primary and back up. Did both, now everything appears ok.

E.15 Symptom: LaRC & LeRC Down

Problem report #15 30 Jan 86

Submitted: Bohden Cmaylo x5225 Closed: 31Jan86

NAS SPR #686, severity=1 Assigned: Cmaylo

Hypothesis: Signal loss from LaRC & LeRC.

Actions:

(1) 8:15am, 30Jan86: Checked both LaRC and LeRC; Both were down. Called Al Ross, x6519, and he said that LaRC had been down since 7:15 and he had called it in. I told him that LeRC was down, and he stated that it was up at 6:30 when he last checked. The LeRC db level was 8; should be 16. I called Larry McFarland of LeRC and stated the problem. I also gave Al Larry's phone at LeRC.

(2) 8:50am, 30Jan86: LaRC connection now up. Called Al Ross/ARC Earth station to check on LaRC & LeRC signal. He stated LaRC signal was weak (12db) but acceptable. LeRC still bad.

(3) 9:30am, 30Jan86: Received a call from MSFC. It seems that Alan Black from LeRC called them and they did not know about the LHCP circuits but wanted to be in the loop. I told them that I was the end user, and that my contact was with Al Ross at ARC, Brad Ball at LaRC, and Larry McFarland at LeRC. They then called Ross. Ross to straighten out problem reporting procedures with MSFC/Goddard/ED.

(4) 8am, 31Jan86: Called Al Ross who said that LeRC signals ok. Checked COMTECH and discovered that IF Loop switch was set in backup modem and that backup modem was set to online. (This caused confusion in the LHCP Electronics Lab for several days due to loopback being shown on the Vitalink ARC2 box). Switched off IF

loop and backup modem went into fault mode. Switched offline backup modem and placed prime online with IF loop set, detected loop condition on ARC2-VB/1. Turned off IF Loop on the prime and connected to LeRC at approx 8:45am.

E.16 Symptom: CSU Down

Problem report #16 20 Feb 86

Submitted: Becky Olson (303 491-6952) CLOSED 20 Feb 86

Assigned to: Bohden Cmaylo

NAS SPR #786, severity=1

Assigned: Cmaylo

Hypothesis: 56Kb AT&T line down

Actions:

(1) 9am, 20Feb86: Becky called stating "Is Amelia down?." I checked and said no. She then stated that she could not see our vitalink box from her vitalink box, so I checked ARC2 and discovered that a) LeRC was still up and b) CSU was not visible. I asked Becky to check out her modem xmit and recv lights, and she stated that the xmit was on and the recv was not. I said that that indicates a line problem. I then reported the problem to user services for SPR tracking and requested that Paul Robinson call me.

(2) 9:30am, 20Feb: Larry Flynn and I checked our DSU/CSU modem. It also showed xmit on but no recv. Called MSFC trouble center to report that the 56Kb line was down (at 9:50am). Ticket #863073 was given for the problem. Notified CSU.

(3) 13:05pm, 20Feb: Called MSFC and asked for status. They replied that a California mudslide carried away the carrier and the estimate for repair is 24 hours. Notified CSU.

(4) 16:10pm, 20Feb: Noticed CSU is up. Called MSFC and asked for status. They said no change from previous status. They stated that since CSU is up, they want to close ticket. I said ok, but I will call next week to find out final status. Item is considered closed.

(5) MSFC said Monday, Feb 24, that AT&T routed the circuit around the slide. No further interruptions should come from that slide.

E.17 Symptom: LeRC Not Communicating with NAS Network

Problem report #17 Opened: 11 Mar 86

Submitted: Dan Whipple/LaRC

Closed: 11 Mar 86

NAS SPR #896, severity=1

Assigned: Cmaylo

Hypothesis: bad /etc/hosts information

Actions:

(1) 8:30am 11Mar86: Dan Whipple called user services and said that he could not talk to NAS. User Services then called me. I then called Dan. He said that he used the "localhosts" and "hosts" file as instructed by J.Lekashman/GE but nothing works. He also tried to use the old tables, which also did no good. I stated that I remembered that the IRIS required that the local address be first in the table.

(2) 10:30am, 11Mar86: Since local help was not available, I talked to Mike Fischbein/LaRC. He said that in order to use the tables as supplied by J. Lekashman/GE, you needed to replace all tabs by a space and have no more than 1 space between the address and the aliases. I left a message at LeRC for Dan to that effect.

(3) 11:30am, 11Mar86: Spoke to Kehoe about problem. He said that he has a fix where the local host need not be the first item and that a easy fix should be placed within the IRIS system to accept white space instead of a single blank.

(4) 12:45pm, 11Mar86: Spoke to Dan Whipple/LeRC, who just got my message and was leaving to try to bring up the IRIS.

(5) 2:49pm, 11Mar86: E-Mail from Dan Whipple/LeRC indicating connection. He also said that all comment lines must be removed, in addition to the above requirements. Item closed.

E.18 Symptom: LaRC Not Communicating with NAS Network After
Video Teleconference

Problem report #18 Opened: 11 Mar 86

Submitted: Mike Fischbein/LaRC Closed: 11 Mar 86

NAS SPR #897, severity=1 Assigned: Cmaylo

Hypothesis: Bad Satellite link switchover to NAS circuits

Actions:

(1) 9am 11Mar86: Mike Fischbein called me and said that he could not sign on to NAS. I replied that there was a message sent out last week to him (and all other NAS users) that a video conference was scheduled this morning and also the next. I said that I would check it out after the circuits were restored.

(2) 10:30am, 11Mar86: Checked LaRC link, it did not work. I checked out all our local equipment (Vitalink and COMTECH) and the status looked ok. Called Mike/LaRC who also said all local equipment looked ok. Next step is to check out Earth stations at both ends.

(3) 11:30am, 11Mar86: Finally reached ARC Earth station (AL Ross). He stated signals to/from LaRC ok. He mentioned that RCA was over doing some work on the COMTECHs and would see what they had done.

(4) 11:55am, 11Mar86: Ross/ARC called and said for me to talk to Larry Simonis/RCA. Spoke to him and he mentioned that he did some testing on the LaRC COMTECH box when he fixed the LeRC COMTECH box. I went down to room 097 to check on some information that he gave me, but it still did not work. He said he would be here within 20 minutes.

(5) 12:15pm, 11Mar86: Larry/RCA arrived. Went down to check on boxes. Appeared that LaRC backup was set to test mode. Reset to normal, still did not work (via rlogin to larc from amelia). Larry/RCA set primary modem off line, then connection worked. He then switched both demod boards from the primary to backup, which caused the connection to then work from either the primary modem and the backup modem.

(6) 1pm, 11Mar86: Larry said that there still exists the problem that the LaRC link may go down. If it does, he said to switch over whatever modem was on to the other modem. If it does it again, he will want to switch over some boards to the LeRC modems to see if the problem switches with the boards.

E.19 Symptom: LeRC Not Communicating with NAS Network

Problem report #19 Opened: 6 Mar 86

Submitted: Al Ross/x6519

Closed: 6 Mar 86

NAS SPR #876, severity=1

Assigned: Cmaylo

Hypothesis: Bad Satellite link.

Actions:

(1) 8:30am 6Mar86: Al Ross, ARC Earth Station technician, called me and stated that the receive signal from LeRC is at 1DB, which is 11DB above the required margin. Al notified MSFC at 8:15am 6Mar86 and MSFC is working to correct the problem. No estimate of repair was given by MSFC. (MSFC will notify Al Ross of the situation and give him a ticket number). This is a #1 SPR since the LeRC link to ARC is dead.

(2) 10am 6Mar86: Marshall Space Flight Center (MSFC) returned Al Ross's initial trouble call and gave him ticket number 863383 at approx 9:30am. MSFC insisted the problem was with the SUN-OUT that was scheduled for this week.

(3) 12:15pm 6Mar86: At approx 12:00noon, MSFC reported to Al Ross/ARC that the link was up, however, Goddard Space Flight Center (GSFC) did not report to MSFC what the problem was. Item is closed with no solution reported.

E.20 Symptom: LaRC Not Communicating with NAS Network

Problem report #20 Opened: 12 Mar 86

Submitted: Cmaylo x5225

Open

NAS SPR #903, severity=(2) 4

Assigned: Cmaylo

Hypothesis: Bad COMTECH modem

Actions:

(1) 13:50pm, 12Mar86: Did check with ruptime and discovered "ICASE" at LaRC was down 13 minutes. Checked if could connect to the "larc01-ec" IRIS, no! Checked Vitalink ARC1 box, it did not see LaRC box. See LHCP Problem #18 (NAS SPR #897) sub-item 6 for discussion of probable fault.

(2) 14:00pm, 12Mar86: Went to room 097 to check on COMTECH modems. All looked ok. Reset "demod" from the backup COMTECH to the primary COMTECH. LaRC came back up on line. Marty Suzuki/Bendix was with me so he will call Larry Simonis/RCA to report problem.

(3) 22Apr86: Larry Simonis/RCA stated that since the satellite service is to go away in a couple of months, that it is not necessary to fix the backup modem. The reason is that RCA contracted for the service, and NAS is getting the service, so there is no need to do anything. The backup capability exists in that there is the other backup modem for the LeRC circuit, so that one could be used in case of a severe failure. Recommend to the SSG that the priority be lowered to 4.

E.21 Symptom: LeRC Transmit to ARC Dropped

Problem report #21 Opened: 26 Mar 86

Submitted: Al Ross (x6519)

Closed: 26 Mar 86

NAS SPR #NEW, severity=1

Assigned: Cmaylo

Hypothesis: Bad Satellite connection

Actions:

(1) 7:35am, Al Ross detected no LeRC transmit signal. He notified MSFC and Bohden Cmaylo.

(2) 9:25am, 26Mar86: Al Ross called and said the problem should be resolved. Bohden Cmaylo tried to "rlogin lerc" and was unable. The ARC2 Vitalink VB/1 needed rebooting for communication to resume. The problem at LeRC was twofold, 1) High winds moved the satellite dish and 2) There was an excessive temperature (~100 degrees F) within the RF shelter. The dish was realigned and the backup air conditioner was turned on. Problem is closed.

APPENDIX F

CONTRIBUTORS TO THE LONG HAUL COMMUNICATIONS PROTOTYPE REPORT

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16. Abstract <p>This document is a report of the Numerical Aerodynamic Simulation (NAS) Long Haul Communications Prototype (LHCP). It describes the accomplishments of the LHCP group, presents the results from all LHCP experiments and testing activities, makes recommendations for present and future LHC activities, and evaluates the remote workstation accesses from Langley Research Center, Lewis Research Center, and Colorado State University to Ames Research Center. The report is the final effort of the Long Haul (Wideband) Communications Prototype Plan (PT-1133-02-N00), 3 October 1985, which defined the requirements for the development, test, and operation of the LHCP network and was the plan used to evaluate the remote user bandwidth requirements for the Numerical Aerodynamic Simulation Processing System Network.</p>					
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