FEASIBILITY STUDY OF NETWORKS

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ABSTRACT

The Laboratory for Nuclear Science has continued its study of resource sharing via general purpose computer networks. This report describes experiments performed with the Lawrence Berkeley Laboratory and the Argonne National Laboratory in using the network for off-loading calculations and obtaining access to unique hardware and software. It also gives performance statistics of the network and cost comparisons. Continued investigation of message and teleconferencing systems is described. Plans for improved usage of the ARPANET, for expansion of computer aided communication facilities, and for investigation of networks other than the ARPANET are proposed.

To date the study has demonstrated that resource sharing via networks will provide LNS with access to computer facilities not available on site and thus improve the quality of energy research done in the laboratory. However, certain barriers, both technical and non-technical, exist that must be overcome. In the technical area we plan to continue investigation into improving the user interface to the network with cooperative projects at other sites, such as the development of a standard command language, expanded network oriented documentation, and consulting facilities. Methods of managing network services and allocating costs will be studied in an effort to eliminate some of the non-technical barriers.

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I. INTRODUCTION

1. Current Status of the Study

During the past year our study on the feasibility of networks has concentrated on the use of the ARPANET in two areas; one was experiments in which end-users ran actual production jobs at other ERDA sites and the other was investigation and use of various message sending and teleconferencing facilities. Access to the ARPANET continues to be through the Multics System on the Honeywell 6180 computer in the M.I.T. Information Processing Services (IPS). Jobs have been run on the CDC 7600 at the Lawrence Berkeley Laboratory (LBL) and the IBM 360/195 at the Argonne National Laboratory (ANL). Our experiences in using these centers, the benefits obtained, problems encountered, and our plans for continued experimentation are described in this report. In addition to using the network for performing scientific calculations remotely, we have used it for electronic mail and have worked on the beginnings of the development of a teleconferencing system on Multics.

The network research has been conducted by members of

the LNS Systems Programming group with the cooperation of interested users of the LNS Computer Facility. The members of the network team are: Elizabeth J. Campbell, Manager of the LNS Computer Facility; Michael T. Ford, Manager of Systems Programming and Development; Muriel S. Kannel, Systems Programmer; and Lyman R. Hazelton, Network Consultant. Ms. Campbell has been directing the study and representing the LNS on the ERDA Network Objectives Panel. Ms. Kannel is the liaison person for members of the ERDA community using Multics. She also represents the LNS on the ERDA Network Investigators Panel. Mr. Ford joined the group during the year. He will be conducting an investigation on the use of the X.25 protocol with Telenet. Mr. Hazelton has an in-depth knowledge of the Multics systems and the systems of the other M.I.T. hosts on the ARPANET. He has been trouble shooting network software problems, developing a teleconferencing system on Multics, and acting as liaison for LNS with the Multics development group. He represents LNS on the ERDA Network Implementation panel and the ESCL (ERDA Standard Command Language) committee.

2. Goals Realized by the Study

The principal goal realized by the study has been the establishment of the feasibility of using remote resources accessed via a general purpose computer network for off-loading many of the calculations from the local on-site facilities, and for obtaining access to unique hardware and software. We have

established the benefits that can be obtained and the remaining barriers to be overcome. We have determined which types of calculations are suitable for export over the network, and those which would be more efficiently done at the local site.

The secondary goal of our investigation has been the realization of the potential of the network in the area of communication. Our experience in using message and teleconferencing systems has given us insight into both the advantages and limitations of such systems over the more conventional methods, such as the telephone and the U.S. Mail system. We realized that the use of the computer for communications can be a powerful management tool.

3. Publication of Results to Date

The members of the ERDA working group on computer networking collaborated on writing a four volume report describing the results of their four year networking study. The report, titled "General Purpose Computer Networks and Resource Sharing in ERDA", was published July 15, 1977. Volume 1, subtitled "Summary, Conclusions and Recommendations", summarizes the investigation and makes recommendations for future research and development. Volume 2, subtitled "Implementation of ARPANET Facilities", discusses the technical and financial issues involved in connecting ERDA sites to a geographically distributed heterogeneous network such as the ARPANET. Volume 3, subtitled "Remote Resource Sharing Experiences and Findings", analyzes the

benefits derived from resource sharing and the barriers encountered, and presents typical case histories. Volume 4, subtitled "ARPANET Resource Handbook for ERDA Sites", is a guide for use in accessing the ERDA sites currently on the ARPANET.

The method by which the report was generated is in itself interesting as an example of use of the network. The authors of the report stored the various sections of it in files at MIT-Multics which could be read and critiqued by the rest of the group. Alternate versions were at times proposed and stored in TENEX files at BBN. A lively and sometimes heated discussion was carried on via the PLANET teleconferencing system at BBN as to the content and style of the report. The voting mechanism of PLANET was used to decide which version to accept, what recommendations to include, etc. When a consensus was reached each volume was assembled into a file and edited on the PDP-KL10 (belonging to the Macsyma Consortium at the M.I.T. Laboratory for Computer Science) into a form for multi-font printing on a xero-graphic printer. Actual production of the document was then accomplished using the xero-graphic printer (XGP) at the PDP-10 belonging to the M.I.T. Artificial Intelligence Laboratory (also in the Laboratory for Computer Science). The production of a font to be used by the XGP involves creation of an ASCII file describing each character in detail, including its height and width as well as a "drawing" of each character, e.g.

101 CHARACTER CODE DSK:LRH;25FR4 KST 16 RASTER WIDTH 16 CHARACTER
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The information in such a file is then compiled into a binary form which is usable by the XGP itself. Such translation can be bi-directional, and there is a "font editor" that allows one to either compile or decompile a font to make changes until the font takes the desired form. Thus the number of fonts one may have is limited only by one's imagination, though it may be a painstaking and slow process. One of the principal fonts used in the report was created by Lyman Hazelton of LNS-MIT. Also, he performed the sometimes tedious task of editing the report to include the font changes.

One could discuss the pros and cons of such a communal method of report writing and generation. Certainly a great deal of effective collaboration was achieved. Although feelings ran high, everyone survived and no friendships were broken. The cost

of storing the files on Multics was extremely high. The volume of messages generated on Planet was incredibly large. Anyone who tried to take a few days of vacation was inundated on their return. It was certainly a unique experience for all the participants.

II. NETWORK EXPERIMENTS

1. Description and Status of Experiments

During the year, experiments already being done with LBL and ANL were continued. In addition, measurements were made on network performance. An update on the principal experiments is given below.

A. Density Dependent Hartree-Fock Calculation

The scientific motivation of this experiment was to compare the cross sections obtained from theoretical prediction of the density of deformed nuclei in the Rare-Earth and Actinide regions with the results of a series of electron scattering experiments recently completed at the Bates Linear Accelerator at M.I.T. Data was collected for $(150)\text{Nd}$, $(156)\text{Gd}$, $(166)\text{Er}$, $(176)\text{Yb}$, $(232)\text{U}$. (1) The physicists

(1) To facilitate use of computer generated documentation, we have adopted the following notation for specification of nuclear species:

($\langle$ nuclear mass $\rangle$) $\langle$ atomic name $\rangle$

for example, $(238)\text{U}$ refers to the isotope of uranium having 146 neutrons

Involved used the density matrix expansion (DME) interactions, a zero-range approximation to the finite range interaction, proposed by Professor John Negele of the M.I.T. Center for Theoretical Physics.

The motivations for doing these calculations as a network experiment was to monitor network performance in converting and off-loading a large-scale scientific computation. A large (2500 lines) density dependent Hartree-Fock code, originally developed at the Los Alamos Scientific Laboratory (LASL), was converted to run on the LBL CDC 7600 and modified to send intermediate results to M.I.T. Because this code was developed at LASL for a CDC 7600, it was hoped that the conversion and modification tasks would be more easily accomplished on CDC equipment than on IBM equipment. Moreover, for a complete nucleus, it was estimated that the program would require up to ten hours on the IBM 360/65 at LNS versus about an hour on the CDC 7600. Such a large consumption of computing power would obviously be detrimental to other groups at LNS who depend on the IBM 360/65. Therefore, use of the LBL CDC 7600 was not only interesting as a resource sharing application, but very nearly mandatory because of the limited capacity of the LNS computer.

The procedure for carrying out the experiment was as follows. The program, as received from LASL, was placed on a disk file at MIT-Multics and shipped to LBL via the network. At LBL, substantial modification was carried out by the

physicists themselves, using the network to access the LBL time sharing and batch submittal facility, SESAME. They spent most of the summer and fall of 1976 learning the LBL system, converting the code and modifying it to store intermediate results of the interactive process used to compute the theoretical densities. These intermediate results were returned to M.I.T. and examined for convergence. Once convergence was reached, the calculated densities were used as input data to the HEINEL code being run on the IBM 360/65 at LNS to compute cross sections from the theoretical densities. The calculated cross sections were then compared to experimental ones measured on the LINAC. Comparison was made by hand-plotted curves. Other calculations were performed at LBL in order to produce curves showing the sensitivity of the Hartree-Fock calculations to the physical parameters involved. The physicists have written a paper, "Electron Scattering Studies of Some Permanently Deformed Nuclei in the Rare-Earth and the Actinide Regions: $(150)\text{Nd}$, $(156)\text{Gd}$, $(166)\text{Er}$, $(176)\text{Yb}$, $(232)\text{Th}$, and $(238)\text{U}$ ", to be published in the Physical Review C this year. In the paper, they emphasized the new method of analysis on which their calculations were based. This method is the microscopic approach from realistic nuclear forces rather than from phenomenological parameterization of nuclear densities. They are willing to give the program that does this to anyone interested in using it.

The benefits accrued from this experiment were very

worthwhile. First, the results obtained were highly-significant physics. Second and more important, it proved that our method of accessing LBL via the ARPANET could be adapted to the end-user and that practical production work, leading to the solution of current physics problems, could be done. Due to the persistence of our staff and the physicists doing the calculations, the difficulties with network access were resolved, and use of the LBL system via Multics and the ARPANET became quite stable. It established that off-loading can be done successfully, if somewhat inconveniently at the moment. It is a practical solution for a certain class of jobs, i.e. large theoretical calculations requiring a fast central processor and large memory to run efficiently. Interest in the LNS network research has been sufficiently aroused to encourage use of the network for other calculations. For example, the physicists who did this experiment wish to investigate the use of several of the phenomenological Skyrme interactions and to study the sensitivity of the calculations to various parameters of the study.

The experiment also proved that there was a reduction in software development effort through access to a computer similar to the one on which the original code had been developed. Both of these benefits indicate the need for network access to large scale computers in energy related scientific research. For the purpose of network research,

this experiment showed both the potential of networking and the barriers to be overcome. In the course of the experiment, solutions to some of the barriers were found.

Among the barriers observed was the lack of a standard command language. CDC command language differs considerably from the IBM command language (JCL) which the LNS physicists normally use. In addition, to submit jobs remotely to LBL, it is necessary to learn SESAME, the LBL interactive system. Since LNS operates a batch system, their users do not have extensive experience with time-sharing systems. The LBL SESAME system is quite different in design from the interactive systems with which they do have some familiarity, i.e. the Multics system and IBM's TSO system. This meant valuable time had to be spent in learning SESAME, which in turn prolonged the development effort.

Another barrier to network use in this experiment was inadequate remote consulting facilities. With the present differences in operating systems, new users of a remote system need more help than can be provided by consultants via the telephone. Because of the long-term importance to ERDA computing, the LBL computing center sent a consultant to LNS to assist the physicists with their calculations and to give lectures on the use of the LBL system. While this was of great benefit to the project, it is obviously an expensive way to solve the problem in general.

The physicists were plagued with many problems with

the network software. One of the most frustrating of their experiences was finding the network inaccessible due to the host or host interface at either end being down. Most of these occurred under circumstances not likely to be repeated. Since most of the network implementations are in the development stage, some down time is expected. However, since it would be a less frustrating situation if network host status information was more readily available to the network users, Lyman Hazelton of the LNS Staff has written a short guide on how to obtain any available information on the status of the ARPANET and any of the hosts. His guide also describes how to obtain for Multics the daily schedule of planned shutdowns for maintenance, testing, etc.

Probably the major problem encountered, was the difficulty in transferring large files. At first, the only way it could be done successfully, was to segment the file into approximately 10,000 characters each and recombine the segments at LBL. Finally, Lyman Hazelton, investigating the problem, found the cause. When transferring files via the new user-ftp protocol, it appeared that the buffer size in Multics limited the size of the file to $2^{*}18$ bits. Until the problems in Multics could be fixed, a bypass to the problem was devised by transferring files from LBL to the MIT-MC host (the Macsyma's Consortium's PDP-KL10) using the new protocol, and then from the MC to Multics using the old protocol.

Another barrier encountered was the slow transfer

rates. The best obtained were four to five kilobaud.

One of the non-technical barriers in this experiment was budgetary. One of LNS's major problems is that of obtaining funding to use other computers. Throughout the period of the debugging and testing of the code, the network study funded the work at LBL. When the code became fully productional, the physicists spent \$17,000 to \$18,000 out of LINAC funds to finish up the work. As can be imagined, use of an outside computer gave rise to the fear that money needed to support the LNS Computer Facility might be diverted to LBL and other ERDA sites. The program was converted to run on the LNS IBM 360/65 in order to compare cost and time. Two additional nuclei have been calculated on the LNS computer. Future work will be split between LNS and LBL. The code was also run on the IBM 370/168 at the M.I.T. Information Processing Services and on the Argonne IBM 370/195. The following table summarizes the time and cost to do the five iterations of a twelve space calculation on the four systems on which the code has been run.

LBL CDC 7600
\$ 38.00 (945 CU*s)
\$ 5.50 To print results on Multics
\$ 10.32 To transfer the results from LBL to Multics,
3.92 for Multics, 6.32 on LBL end.
Total \$ 53.82 (Regular priority weekdays)
Total cost for deferred priority weekdays or regular priority
weekends was \$31.58.
Total cost for deferred priority weekends was \$20.00.
Time: 42 seconds per iteration.

LNS IBM 360/65
\$ 36.36 CPU time
\$ 1.44 Lines printed
\$ 2.04 I/O calls
Total \$ 39.84
LNS does not have either special priority or weekend rates.
Time: approx. 510 seconds per iteration.

IPS IBM 370/168
\$ 45.07 CPU time
\$ 6.54 I/O, Disk
\$ 44.90 Memory charges
\$ 6.66 Lines printed
Total \$103.17 (Regular priority)
Run on their lowest priority (Sunday only), cost would be \$51.58.
Time: approx. 116 seconds per iteration.

ARGONNE IBM 370/195
\$ 10.53 CPU and Memory charges
\$ 5.50 Multics print
\$ 3.92 Transfer charges for Multics, none for Argonne
Total \$ 19.95 (Regular priority)
Time: approx. 49 seconds per iteration.

B. Molecular Dynamics

James O'Dell and Sidney Yip of M.I.T.'s Nuclear Engineering Department are continuing their collaboration with A.Rahmen and S.H. Chen of the Argonne National Laboratory (ANL). Their goal is to determine how accurately the Boltzman Equation can predict the properties of fluids. By using the Computer Molecular Dynamics (CDM) method, Newton's equations

of motions are solved exactly for a system consisting of the order of about 500 molecules. They hope to go to Argonne to compare the results of Boltzman Equation with experimental ones.

The various codes that have been written in IBM FORTRAN, are approximately 1000 lines each and take about one-half hour to run on ANL's 360/195 as opposed to ten hours on Columbia's 360/91. The M.I.T. people have succeeded in using the network to submit jobs to Argonne's batch system and to retrieve the output back at M.I.T. Dr. O'Dell also uses TSO and the Wylbur system to manipulate and edit several large data sets kept at ANL. Drs. O'Dell and Yip now consider the ARPANET connection stable enough in spite of slow transfer rates (about 20 minutes for an output file of 110K bytes), so that they are willing to commit the necessary funds to access the resources at ANL. They consider their results significant and hope to publish them in the literature soon. Ms. Kannel of the LNS staff has prepared for general use a scenario for using the ARPANET to submit a FORTRAN job to the batch operating system on the IBM 360/195 at Argonne. It is contained in Appendix A.

C. Time Dependent Hartree-Fock

Professor Negele of the Center for Theoretical Physics continued to access the LBL CDC 7600 via the ARPANET

to complete his time dependent Hartree-Fock calculations. He was using a code which he had developed at LBL during the summer of 1976. Early results of this work were reported in the previous progress report, C00-2487-4. The main benefits of this experiment were derived from the facts that Professor Negele did not have to spend time converting his code and had access to hardware sufficiently powerful to run the program. The arrangement also allowed him to work at a terminal either at his home or his office, a style he much prefers to batch submittal at the LNS Computer Facility. An important aspect of this experiment was that it involved a member of the faculty of the Physics Department. Originally he was a skeptic, believing the network to be feasible only in five to ten years. Now he sees it as a possibility for satisfying the suppressed need for large-scale theoretical physics computations that cannot be accommodated on the LNS IBM 360/65.

As with others, there was the problem of using the LBL Command Language and SESAME system. However, for him, the problem was not as severe, because he had spent a summer at LBL using the LBL system. He had the usual budgetary problems of obtaining the necessary operating funds for the computer time at LBL.

D. Performance Analysis Experiments

Experiments were performed to measure the actual performance of systems during a typical task for the network

and to measure the relative charges at two sites for accomplishing the same task. One task measured was the transfer of a file between two sites, MIT-Multics and LBL. This experiment was done twice, once with only one file and again with a set of four files, to get some information about transferring multiple files in a single invocation of the file transfer protocol (FTP) program. The output from a large Hartree-Fock nuclear model was stored in a medium large file (~500,000 characters, 183 PRU's on LBL's PSS storage system) on the LBL B machine. The file was transferred to MIT-Multics for output on a local line printer. The transfer was accomplished with the LBL user FTP and the Multics server FTP because LBL's server was not yet available.

The real time for the transfer of the file of 484,349 characters was 12 minutes 22 seconds. The total cost at LBL from login through completion of the transfer was \$19.67 including overhead. The cost at MIT-Multics was \$6.52 including connect time. Resources used at M.I.T. were 45 CPU seconds and 271 memory units. The transfer rate was 6527.6 bits/second. The load at MIT-Multics, while the experiment was being performed, was 46 of a possible 60 users active.

In the second part of the experiment four files were transferred. Together the four files consisted of 806,403 characters. The total cost at LBL was \$34.37. The cost at MIT-Multics was \$4.32. Baud rate varied from 5590.5 to 71498.4.

This experiment shows that the measurement of performance and cost of tasks running in a distributed environment can be accomplished. Lack of more sophisticated measurement software at one of the sites prevented more accurate determination of the data. Lack of a server FTP at one of the sites made the task more complicated (i.e., necessitated telnetting to the foreign site, invoking the on-site user FTP back to the local site, and then doing the transfer). This experiment seems to indicate that further study in this area would be of use. Further work on the development of tools to help in the measurement of distributed processing performance is needed.

2. Benefits and Barriers

From our network experiments that we have performed to date, we have observed three major benefits. Off-loading of large compute-bound jobs is both possible and desirable under the present capability of the network. Software development can be significantly reduced. This can occur in two ways. First, codes already existing on remote computers can be used. Second, new code development can be done on remote computers when the resources, both hardware and software, are more suited to the particular code than are the local resources. Our experiments have lead to the improvement of existing network software. We have uncovered problems in the software and made recommendations for correcting them.

Our experiments have defined the current barriers, both technical and non-technical, to full use of the network for remote computing. The first type of technical barriers can be considered as start-up barriers. These are the lack of facilities to help the new user or the user unfamiliar with the remote site. As described under our experiments, these consist primarily of the diversity of command languages existing at the various sites on the ARPANET and inadequate remote consulting facilities. Other technical barriers exist in the continuing need for refinement of network software and the ability to transmit at higher bandwidths than now possible on the ARPANET.

We have also uncovered certain non-technical barriers. These fall into two classes. The first are administrative ones concerned with the red tape of setting up new accounts, etc. Procedures for these can be worked out. More serious is the second class of non-technical barriers which are budgetary. It is not easy to divide operating funds between local and remote computer use. The question of fairness in rates becomes important. Does the user whose work is off-loaded pay a penalty in higher rates for not being able to use the local site? The converse could also be true. At times heavy use of a remote site may divert operating funds from the local computer. The problem of keeping the load balanced between the local site and the remote ones can be a complicated one.

3. Conclusions and Recommendations for Future Experiments

The primary conclusion from our networking experiments is that access to remote computing resources has a great deal of future potential for energy related research, not to mention certain benefits which are immediately available. Calculations can be successfully off-loaded, provided the following conditions are met. The amount of data to be sent does not exceed reasonable time or cost limitations imposed by the present baud transmission rate. The command language associated with the program is relatively straight forward. Otherwise developing the command language for a new program or converting it for an already existing one becomes an excessive burden on the user. The program itself is either developed on the remote site or written in a compiler available at both sites and does not use any of the features which are machine dependent or implemented only by one of the sites. For LNS, the best types of calculation to be exported are the large theoretical calculations that require either both large core and/or large amounts of CPU time, i.e. jobs more suited to a CDC 7600 or IBM 360/195 than the IBM 360/65 at LNS. Another restriction on LNS use is that we adapt our work to the Multics schedule, i.e. not try to submit jobs when Multics is overloaded, use it on off hours when rates are lower, and not run programs with deadline requirements that could not be met if Multics should go down. We do not have the same control over Multics that we would on a host computer of our own.

Increased use of remote resource sharing will take place when some of the present barriers discovered in our

experiments are removed. An ERDA standard command language must be developed if widespread resource sharing is to occur for applications similar to those tried in our experiments. Remote consulting facilities are at present inadequate for the remote user. Neither can the user obtain enough help with the remote system from the consultants at the home site, as they too lack experience on the remote site. Training of consultants at both sites, increases in on-line consulting services, development of better remote user guides, and a more standard method of accessing the network, are among the things we must do to make network access to remote resources attractive to the end user.

For future experiments we plan to try additional running at LBL and to revise our guide to the use of the LBL facilities. We shall also expand our scenario for running at Argonne. We plan to develop similar scenarios for use at both New York University and Brookhaven National Laboratory. In other words, we will assemble a handbook guide to remote resources designed specifically for LNS users and the type of calculations that they perform. LNS will participate in the work of the committee designing an ERDA standard command language. We will perform experiments with users designed to test both the reliability and ease of use of such a command language.

III. COMPUTER AIDED COMMUNICATION SYSTEMS

1. Update in Message Systems

In the progress report, a summary and comparison was made on three computer aided communication systems; the TDA message service of the Computer Corporation of America, the PLANET 2 system of the Institute of the Future, and the mail systems available on MIT-Multics. We concluded at that time, that the TDA system was the simplest to use if an electronic message service on a dedicated computer was desired. PLANET served best for teleconferencing and the Multics mail systems offered more flexibility and potential for development but were more difficult to learn. Figures for cost comparisons were not available.

Since the last progress report, we have become familiar with HERMES, a system for reading and processing messages through a computer network. HERMES is a product of Bolt, Beranek & Newman and is available on the various TENEX systems. The documentation available includes a self-prompting on-line help file, a Users Reference Guide, and a tutorial type Introductory Manual.

The HERMES system can be used on a primitive level to read, file and send messages, much as TDA and Multics are. A user can read or survey messages from either the current message file or another file and then file, delete, forward, or reply to them. The messages can also be printed on a line printer if

overly long. When sending a message to an individual or a group of individuals, the user will be prompted for the appropriate headings, whether replying to an existing message or composing a new one. HERMES operates on a default system so that for many of the commands the user can specify as little or as much as he wants. The new user will usually let HERMES make the default choices and have them echoed. Beyond these well-documented basic features, HERMES offers a very sophisticated array of facilities not available on other mail systems. The concepts are not always simple and it would require a trained user to take full advantage of this very flexible, modular system. The following paragraphs mention some of the features currently available on HERMES.

There are a number of ways to correct mistakes and edit files. A user can simply use the standard TENEX editing characters to delete and then retype characters, words, lines, or entire entries. There is a message editor available which allows the user to build up the message, field by field, in any order. In addition to the above methods, the context editors NETED, TECO and XED can be entered for creating text. Relatively complex files can be worked on and saved over a period of time before being sent via the mail system. A message that has been received can also be edited.

The HERMES filing and sequencing capability gives the user a management tool for organizing messages. In addition to creating files for storing messages, HERMES provides a sequence editor which allows the user to set up series of pointers to

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various messages in a particular file. He can later perform such operations as sorting, moving, reversing, printing, deleting, etc. for these named sequences.

Two other features available in HERMES are Filters and Templates. A named Filter is a sequence of criteria to be used for selecting or rejecting messages to be operated on. Filters can be created on combinations of textual keywords, dates, to and from fields, subjects, etc.

A HERMES Template can be used to control the form in which messages can be outputted as well as the form of the prompted message input. The standard default templates are described in the HERMES Users Guide. HERMES allows the user to create a profile including filters, templates and switch settings other than those in the default profile provided by the system. In conclusion, it has been shown that HERMES can be used very much in the same way as TDA or the Multics mail systems. It cannot be used for teleconferencing.

It might be mentioned here that some changes have been made to the TDA system since the C00-2487-4 progress report was released. The text editor has been removed from TDA, and CCA hopes to replace it with a more streamlined version sometime this fall. In the meantime, the programmer has to use the line editing characters or the new compose command for any editing. The "compose" command allows fields to be replaced or to be added to. It also provides for text formatting.

What HERMES does provide over and above the other

system is some very sophisticated, flexible ways of creating, filing and transmitting electronic mail and other text.

2. Teleconferencing Research

Lyman Hazelton has been investigating methods of implementing a teleconferencing system in Multics. The procedure has been to define and test several different options. For example, he has tried a multiple message system with single files, i.e. each person having his own file. This proved unsatisfactory due to Multics internals. It gave too many wake-up signals. A multiple line message system with a single wake-up will work for a small conference, not more than ten people.

At the present time, the most feasible option is to use a ring 3 single segment approach. This has been tested sufficiently to show that it will work. It means writing ring 3 primitives for which we must get approval from Multics management. This is a more sophisticated approach to teleconferencing than previously tried. It has the advantage of using less storage since it is a single segment. It maintains security by the use of ring 3 storage. It will have an "automatic garbage" collection feature, i.e. when the conference files become too large, they will automatically be sent to the Data Computer at the Computer Corporation of America. Another desirable feature will be the ability to send a registered

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message, so that the sender will receive an indication his message has been delivered, much like the return receipt for a registered letter sent via the U.S. Mail.

The proposed name for the teleconferencing system is TELCON. It will have several improvements over the PLANET system currently used by the ERDA networking group. For example, it will be possible to send a single message to multiple conferences, which is difficult to do on PLANET. It will be completely secure. A user will be able to retrieve a private message at any time, i.e. he will have his own file of private messages. It will be possible to set an option on private messages, allowing them to be forwarded or not forwarded according to sender's choice. The cost of TELCON should be no more than PLANET, hopefully less. Since TELCON will be in Multics, the user will have both a message facility and a teleconferencing facility available in the same system.

Mr. Hazelton has worked out the required description of the primitives, i.e. the minimum set of commands. If our proposal to continue our network research for another year is approved, we shall ask Multics Management for permission to use ring 3 and hire a student to do the programming under Mr. Hazelton's direction.

IV. INVESTIGATION OF X.25 STANDARD INTERFACE FOR TELNET USE

With the announcement by the CCITT (Consultative Committee, International Telephone and Telegraph) of a new standard protocol for connecting to packet switched networks, and the increasing interest in commercial networks, we decided to investigate the possibilities of producing and experimenting with a standard interface for Multics. Since the new standard, X.25, only specifies host-to-network and host-to-host protocols, much like the lower levels of existing ARPANET protocols, it was hoped that, if we could implement the new interface, we could use the same existing higher levels of protocol which are now in use on Multics to access the ARPANET. These would include: user and server telnet, user and server file transfer, and network mail. Of course these would only be useful if we had another host using X.25 connected to the same network.

As a first step we approached the systems people for Multics at M.I.T., and then later the computer center management. The response was certainly favorable, and we were directed to talk to the Honeywell people at the Cambridge Information Systems Lab. The people there are responsible for the development and maintenance of the Multics system. The Honeywell people were also very interested, and we discussed various implementation considerations.

While the above was going on we also talked to people at Telenet. It was easy to make contact since Multics is already

attached to Telenet. However, the interface that is now being employed is a terminal emulation interface, the only type Multics could handle, at least until it can talk host protocol. Therefore, we would have to get another line to Telenet in order to test the interface. Another host line would also have to go to the Cambridge Information Systems Laboratory to connect to their Multics machine in order to have a complete loop to test. Telenet appeared quite willing to provide support (in the form of line costs, test equipment, and consultation) since they are always anxious to get more machines and operating systems interfaced to the network.

Investigations were also made into the implementation techniques which were employed to connect Multics to the ARPANET. In the interest of performance this interface is incorporated into the kernel of the operating system. While developing an interface on the M.I.T. Multics machine, it would not be possible to alter the kernel, but the program could be tested by running it as a normal user on the system. This would place restrictions on creating any new processes (ie. logging in additional users), but it would be a safe and very helpful environment in which to test. Also, integrating the interface into the kernel of the operating system appears almost certainly to be a job for experts. It was agreed with the people from Honeywell that it would be best if they performed this part of the task.

The Multics management people at M.I.T. are willing to provide computer time for the job, and Honeywell will provide

stand-alone time on their machine if it is necessary, and also time for testing, once both machines are interfaced. It is estimated that from four to six man-months would be required for the coding and initial testing. The programming will be done, under the direction of Mr. Ford, by a student that we plan to hire.

V. CONCLUSIONS AND RECOMMENDATIONS

Our network study has demonstrated that accessing remote computer resources via a general purpose computer network can produce both a more efficient utilization of computer resources within ERDA and an improved quality of research. For laboratories such as LNS, who have limited computing facilities on site, it can provide a solution to saturation of the local computer by off-loading to remote sites, and also provide access to hardware and software not available on site. Thus, calculations either too time consuming on the local computer or requiring more storage and CPU power than available locally, can be shipped over the network. Certain restrictions on calculations to be done remotely apply at the moment. They must be codes easily adapted to other sites and not involve frequent transfer of large data files. Ease of access to remote sites must be improved before resource sharing will be practical on a large scale.

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In addition, our experience with computer message and teleconferencing systems has demonstrated the ability of these systems to enhance scientific collaboration and management coordination. Our major contact with the ERDA working group on networks has been via the PLANET teleconferencing system and Multics mail.

Our recommendations for future network research and for making the use of remote computer resources a practical reality for the scientific community are the following:

In the technical area the design and development of an ERDA Standard Command Language and the implementation of this language at all ERDA sites on the ARPANET are necessary if there is to be widespread use by end-users. The basic network interface programs should be upgraded to include facilities such as automatic job entry protocol. Maintenance of existing software should be continued to ensure error free transmission and twenty-four hour availability. New wide band communication technologies should be explored in order to make practical the transfer of very large data files. Networks other than ARPANET should be investigated.

Research and development should continue in the area of human/machine interfaces. Efforts should be made to reduce the start-up barriers associated with accessing the remote systems for the first time. Standard procedures should be implemented. Network usage must be made attractive and easy for the end-user.

Investigation of current message and teleconferencing

systems should be continued and thought given to setting up a standard system for ERDA-wide use. More people in management positions should be encouraged to use these forms of communication.

In the non-technical area, the problems of administering and managing network use must be attacked. Budgetary and funding problems must be resolved before the use of remote resources can be seriously considered as either an alternative or a supplement to use of local facilities. As scientists now do experiments on the most appropriate accelerator, they should be able to analyze the resulting data at the most appropriate computer site. Funds required for remote computers should not be diverted from operating funds required on the local computer. Users should not have to perform elaborate calculations to determine the costs of running remotely. Some guarantee must be made to users, that if a calculation is started on a remote site, it can be continued until completion. Conversion both slows down the research effort and adds to the cost. Administrative procedures for setting up user accounts at remote sites should be made smoother. More ERDA sites should be added to the ARPANET to increase the number of shareable resources within ERDA. Available network resources should be taken into consideration in program planning and management. New equipment acquisitions should allow for remote access via the network wherever feasible.

VI RESEARCHERS' ALLOCATION OF TIME

The principal investigator, Elizabeth J. Campbell, has spent 20% of her time on the network study. She has been assisted by members of the LNS Systems Group, Kalman Saffran, Michael Ford and Muriel Kannel, who have put in together the equivalent of half a person year. In addition, Lyman Hazelton has worked half time consulting on network research.

All the participants in the study are members of the sponsored research staff of M.I.T. We would like to thank members of the staff of the M.I.T. Information Processing Services and of the M.I.T. Laboratory for Computer Sciences for their consulting assistance with Multics and with ARPANET problems.

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ANL SCENARIO

SCENARIO FOR USE OF IBM 360/195
AT ARGONNE NATIONAL LABORATORY

The following is a scenario for using the ARPANET to transfer an MIT-Multics Fortran job to the Argonne National Laboratory (ANL) to be run on their batch operating system. User input lines are preceded by a double asterisk (**). Comments (hopefully helpful) which are sprinkled through out the sample session are indicated by quotation marks. In this scenario ANL is initially reached from Multics using the user_telnet protocol. It can also be reached by dialing the local TIP and logging into host 55 (ANL). The listing of the sample program and the Argonne JCL required follows the scenario itself.

** nhs ANL

55 UP ANL
Multics ready Message
** TELNET ANL
Segment TELNET not found.
Multics Ready Message/
** telnet ANL

ARGONNE NATIONAL LABORATORY

WELCOME
xxxxxx ENTER PASSWORD ** TYPE ANL PASSWORD HERE
NOW AUTHORIZED
** ^FTP
FTP ACTIVE
"Note that only uppercase letters work at ARGONNE."
"Now attempt to connect to MIT-Multics (host 6) for file transfer."
** ^connect 6
NOT CONNECTED
** ^CONNECT 6
ATTEMPTING CONNECTION
300-Multics 31.13ex: MIT, Cambridge, Mass.
300 Load = 27.0 out of 85.0 units: users = 27
** USER KANNEL._____annel.ERDA

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ANL SCENARIO

"Octal 137 (underscore or back arrow) indicates ANL character delete"
"Octal 30 (ctrl x) indicates ANL line delete"

330 Password:

** PASS (type Multics password here)

230 Kannel ERDA logged in for file transfer: 09/07/77 1714.5 edt Wed

"At this point transfer the Multics job file >udd>ERDA>0°Dell>arptest"
"to ANL to be run on their batch system."

** 195 CARD

** RETR >udd>ERDA>0°Dell>arptest

255 SOCK 13315

250- Beginning transfer of >udd>ERDA>0°Dell>arptest

250 to ANL in Stream 8-bit ASCII.

252 Transfer complete.

** ^bytes

501 Command name longer than four characters: ^^BYTES"

** ^BYTES

00300

** ^BYTES

00427

** ^BYTES

00427

"The transfer is complete only when the byte count"
"remains constant. Only then can the connection be"
"closed and then reopened to check the status of the job"

** ^CLOSE

CLOSE COMPLETED

** ^CONNECT 6

ATTEMPTING CONNECTION

300 Load = 24.0 out of 85.0 un lts: users = 24

** USER Kannel.ERDA

330 Password:

** PASS (type your Multics password here)

230 Kannel ERDA logged in for file transfer: 09/07/77 1729.1 edt Wed

"Check the status of any jobs called ARPTEST"

** CON *I J=ARPTEST

162647 IQ906 6613,ARPTEST (9,N,250K,A) F24603 G=ARPA1 HOLD=(T) RI(C),
A(C),PR(R),PU(C)

162647 IQ906 7689,ARPTEST (9,N,250K,A,M(128,986)) F24603 G=ARPA1 RI(C)
MA(Q),PR,PU

CONSOLE END

"Two jobs call ARPTEST have been run, only the earlier"
"of the two is completed. The following PRINT command"
"gets the job from the 370/195 queue and then the"
"STOR command initiates the file transfer of the results."

** 195 PRINT,6613

** STOR AROUT

255 SOCK 13058

250- Beginning transfer of >udd>ERDALNS>Kannel>AROUT

250 from ANL in Stream 8-bit ASCII.

252 Transfer complete.

"The CLOSE command breaks the FTP connection between"
"ANL and MIT-Multics. The RESET command leaves the FTP"

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ANL SCENARIO

"protocol and returns to MIT-Multics user_telnet"

```
** CLOSE
CLOSE COMPLETED
** RESET
RESET COMPLETE
** !EXIT
user_telnet: Unrecognized request: EXIT; Type the request "?" for request list
** !exit
Multics Ready Message
    "Keep the cases of the letters straight."
** dprint >udd>ERDALNS>Kannel>AROUT
    "Print the results on the Multics off_line printer"
```

The following is a listing of the program ARPTEST.

```
//ARPTST JOB (F08028,06,01,002),*ODELL*,CLASS=A,REGION=250K,PRTY=N,
//      MSGLEVEL=(0,0)
      CHEN S H      24603      59001-00125
// EXEC FTGCEG,PARM.FTG="NOLIST"
//FTG.SYSIN DD *
      NAMELIST /DATA/ A,B
C READ A AND B AND ADD THEM, THEN OUTPUT.
      READ(5,DATA)
      C=A+B
      WRITE(6,100) A,B,C
100  FORMAT(' ',E16.5,' PLUS ',E16.5,' EQUALS ',E16.5)
      CALL EXIT
      END
/*
//GO.SYSIN DD *
&DATA
A=2.0E0,B=2.0E0
&END
/*
```