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I. INTRODUCTION

Advanced Research Projects Agency funds, provided under Contract No. DAHC15-73-C-0198, supported research and development projects of the UCSB Computer Systems Laboratory (CSL) in the areas of Network* improvements, Network evaluation, and implementation of Host computer resources for use by other Network sites.

During the project period, CSL approached the ARPANET in a dual role, both as *User* and as *Server*. As *User* we were active in developing new Network protocols and Host-to-Host communications techniques while we evaluated various Network operations with the intent to suggest improvements or new approaches. As a *Server* we provided consulting service in both software and hardware development, new site planning, and in general became a source of information assisting new sites to come into the Network. In addition, our computer center made its resources available to the Network at large. Several sites utilized the 360/75 facility for storage of large data bases accessible from the ARPANET.

Two documents that cover parallel work and which provide supporting information are:

Report No.: CSL-22, "Research in On-Line Computation," 30 June 1972

Report No.: CSL-30, "Research in On-Line and Computer Network Development,"
31 October 1973

* Network refers to the ARPANET, Computer Telecommunications Network.

II. Background

Prior to the contract period (September 1972 through October 1974) the Computer Systems Laboratory developed time-shared computer services and digital telecommunication systems which provided a basis for later CSL involvement in ARPANET design and use.

With ARPA support, CSL developed the unique Culler-Fried interactive graphics computational system referred to as the UCSB On-Line System (OLS). This time-shared system was blended with the standard IBM 360 Operating System (OS) at the UCSB Computer Center to provide service to a network of graphics display consoles located in many parts of the country. The CSL staff was responsible for making the same service available on the ARPANET and has subsequent involvement with other Network sites in developing Network protocols and techniques.

As the ARPANET evolved CSL provided consulting service for numerous Network sites and other governmental agencies, and supplied both software and hardware assistance to other nodes of the ARPANET in multi-node cooperative projects. A partial list of CSL "clients"^{**} includes:

USC	MITRE Corporation
RAND	Teledyne Geo-Tech
UCLA	Culler-Harrison Inc.
AFTAC	Defense Communications Agency
NORSAR	Systems Development Corporation
NASA-AMES	Information Sciences Institute-USC
MIT Lincoln Labs	Speech Communications Research Lab

Cooperative projects included:

- . Very Distant Host development for the PDP-11 at SCRL. We designed hardware and software for this connection. SCRL planned to store a speech dictionary at UCSB.
- . Data Reconfiguration Service software for the Network, designed in conjunction with RAND and tested by the USC Information Sciences Institute.
- . New Graphics Software for the IMLAC developed in cooperation with MITRE. The Culler-Fried OLS was made available in graphic form on IMLAC and Tektronix terminals throughout the Network.
- . Research in Network conferencing and the channelizing of data carried out in cooperation with the Information Sciences Institute. Personnel from CSL took part in this project under a separate contract.

^{**} No fees were charged for services. Consultation and software was supported by ARPA Contract. Hardware was paid for by the client.

III. SUMMARY

A. Service Site and Network Development

The following paragraphs discuss projects that are Network related but oriented to the UCSB site in general.

UCSB Remote Job Service Enhancement - The computing facility at UCSB is a batch-oriented system. A large portion of our effort was focused upon integrating the batch processing system with the ARPA Network. Implementation of the Network standard Remote Job Service protocol was completed and this service replaced the rudimentary RJE service for IBM 360 that was developed at UCSB earlier. High-level language subroutine calls were developed which permit most batch programs submitted at UCSB to access the Network. The implementation of a facility which permits batch jobs processed at UCSB to access Network files directly, using standard IBM access methods and Job Control Language, was developed for Network users.

Network File Service - Second level and third level file storage is another service which UCSB provided to the Network community. This service was available through the UCSB Simple-Minded File System (SMFS). However, inefficiencies inherent in the design of SMFS dictated the adoption of a new standard File Transfer Protocol to replace this service.

Network Control Program (360-75) - The ability of UCSB to successfully function as a reliable and cooperative service node on the ARPA Network depended largely upon the sophistication of our local Network Control Program (NCP).

UCSB's current implementation of the Network Control Program has been operational since August 1970. Modifications have been made which resulted marked improvement in system performance, increased flexibility at the user program level, and more efficient use of system resources. Furthermore, an exportable version of the NCP for use by new 360- or 370-type Network sites became available. Most Network sites with 360 or 370 equipment have utilized our NCP as the basis for their own development.

Other Network Projects - Support was also provided for a variety of smaller, but nonetheless, important Network-related activities. Three such projects that we participated in were:

- 1) Development of a Network Graphics Protocol (NGP-0) interpreter for IMLACs;
- 2) Experimentation and evaluation of the Data Reconfiguration Service (DRS);
- 3) Improvements to OLS which enhanced Network use.

B. Cooperative Network Projects and Facilities Support

During the contract period several CSL personnel were assigned to work on Network conferencing with the USC Information Sciences Institute. General Network consultation to other sites was carried out as well.

Through Facilities Support for Network users, a number of sites on the ARPANET utilized services at the UCSB Computer Center. Aside from general network access like RJS, use of the OLS graphics system, and experimentation in association with other sites (Graphics protocol and Data Reconfiguration), UCSB provided direct access file storage for use by SCRL and SRI.

IV. PUBLICATIONS

Announcement of RJS at UCSB-Krilanovich-NI

NIC #13700 "Announcement of RJS at UCSB," Krilanovich.

NIC #13701 "Data Reconfiguration Service at UCSB," Faeh

NIC #14922 " Remote Job Service at UCSB," Krilanovich

NIC #15063 " MIX and MIXAL at UCSB," Pickens

NIC #15355 "Surrogate RJS for UCLA-CCN," Pickens

NIC #16117 "IBM System 360 (370) to IMP-Interface, Installation, and Planning," Bryan

NIC #16159 "Real-time Data Transmission on the ARPANET," McAfee and Pfeiffer

NIC #16409 "Briefly-The Very Distant Host for ARPA-style Nets," Bryan

NIC #16817 "ARPANET Accounts," Vaughn

NIC #16818 "Resource Evaluation," Pickens

NIC #17161 "MIT-MATHLAB Meets UCSB-OLS, An Example of Resource Sharing," Pickens

NIC #17791 "Of What Quality be the UCSB Resource Evaluation?," Pickens

NIC #18978 "Experimental Input Mapping Between NVI-ASCII and UCSB On-Line System," Pickens

NIC #19144 "Announcement of a Mail Facility at UCSB," Krilanovich

NIC #16306 "HASP System Operators Guide," Krilanovich

NIC #21255 "Comments on FTP," Krilanovich

NIC #22004 "Comments on On-Line Host Name Service," Krilanovich

NIC #22054 "Comments on FTP," Krilanovich, Gregg, and Hathaway

NIC #21718 "Computer Systems Laboratory," Bryan

Report CSL-33, "Linking Resources to Support an Interactive System for Acoustic Image Processing," 4th Annual Symposium of the EIA, Committee on Automatic Imagery Pattern Recognition, Berggreen, Pickens, and Bryan

Report CSL-36, "A Description of an Adaptive Delta Modulation Technique for Real-Time Transmission of Speech over the ARPA Network," 12 April 1974, Pfeiffer

Report CSL-41, "UCLA-CCN Benchmark," 15 June 1974, Zumstein

NETWORKING RESEARCH AT UCSB 1970 THROUGH 1974

1970

The UCSB system development has been concentrated in two major areas: On-Line System software revision and ARPA Network development. With respect to the On-Line System, all goals outlined in our technical reports were met or exceeded. The new version of our software was released 1 July 1970 as scheduled. Reliability immediately improved. Currently software failures are virtually non-existent. The system is completely exportable, and several computer centers have indicated an interest in obtaining our system for their installation.

Network development has proceeded at a rapid pace. A Network Control Program (NCP) has been written which supports the Host-to-Host protocol of 3 August 1970, and makes the full capabilities of the network available to any assembly-language program which executes in the 360/75. Assembly-language subroutines have been written for call by Fortran and PL/1 programs, extending network accessibility to other than systems programmers. Network operators have been written for and added to the developmental version of the UCSB on-line system, enabling users to invoke the services of the NCP from an on-line environment. A network interface to the UCSB on-line system has been written, and accepts keyboard-like input over one network connection and returns alphameric, curvilinear, and special character output over another. This interface is invoked through the Logger, and specifications have already been distributed to members of the Network Working Group. Work is now in progress to develop a remote job entry facility which other nodes in the network may use. The card image input has been completed. Data set writers are not being written to process RJE output.

With the exception of jobs run via the network by RAND, all of UCSB's network experience has so far involved connection with both ends in local processes. UCSB is anxious to conduct tests involving NCP's at other sites, and will upon request, write short test processes to suit specific sites - establish connections with specified sockets, perform specified data transformations, etc.

1971

In this contract period, a Network Control Program was designed, implemented and modified as required to fully support the Host-to-Host protocol currently specified by the Network Working Group.

UCSB's NCP implementation has been thoroughly documented in a paper entitled "An NCP for the ARPA Network" (21 December 1970, NIC 5480) and distributed to Network participants through the Network Information Center (NIC) at Stanford Research Institute in Menlo Park.

Access to the Network has been extended to include Fortran and PL/1 programs and On-Line System users, as well as assembly-language programs.

A subsystem of OLS called NET has been created to house, among other things, a set of operators providing access to basic NCP functions from an OLS terminal.

These operators were heavily used in early, interactive Network experimentation with (in particular) the Rand Corporation in Santa Monica. All of these operators have been described in detail in an RFC entitled "Network On-Line Operators" (21 April 1971, NIC 5833) distributed to Network participants through the NIC. They are briefly described in the following paragraphs.

A User Telnet has been written in accordance with the protocol adopted to handle such teletype-like communication. The program conforms to the protocol adopted by the NWG to handle such communication. UCSB's User telnet implementation is described in detail in an RFC entitled "A User Telnet - Description of an Initial Implementation" (9 August 1971, NIC 7176) distributed to Network participants through the NIC.

A number of services have been made available to Network users. Two separate specifications for access to the On-Line System have been designed and implemented, each supporting the graphic display features of the system. Both included provision for transmitting curvilinear display in line, dot, dot-dot, and character modes, and the first for transmitting special character display. The first such implementation was made available to Network users shortly after the adoption by the NWG of its initial Host-Host protocol specification, and was never used by any but local users. It was fully documented in an RFC entitled "Specifications for Network Use of the UCSB On-Line System" (16 October 1970, NIC 5417) distributed to Network participants. Support for this specification was terminated by UCSB this August, and replaced by generation of a new specification to which the Rand Corporation in Santa Monica has already interfaced its video-graphics system.

A remote job entry facility has been written, providing Network users with access to UCSB's batch processing facilities. Two independent processes were written to provide this service, each addressed by a standard ICP to a separate socket. One supports remote job entry (RJE) by accepting files of card images from the Network and transmitting them to UCSB's Houston Automatic Spooling Priority System (HASP) through an internal reader. The second retrieves output from remotely submitted jobs from a PDS and relays it to the Network user. These facilities have been in use on a productive basis by user groups at the Rand Corporation in Santa Monica for a number of months, and are fully documented in an RFC entitled "Network Specifications for Remote Job Entry and Remote Job Output Retrieval at UCSB" (22 March 1971, NIC 5775) distributed to Network participants through the NIC.

A Network file system has been written, making on-line, direct-access storage available to the Network community. This process (known as UCSB's Simple-Minded File System (SMFS)) has been fully documented in an RFC entitled "Network Specifications for UCSB's Simple-Minded File System" (26 April 1971, NIC 5834) distributed to the Network community through the NIC.

Finally, a teletype-oriented interface to the On-Line System has been implemented according to the Telnet protocol adopted by the Network Working Group.

Maintenance and functional improvement of the UCSB IMP-HOST Interface has continued over the last year. Design improvements have been incorporated in a newly designed I.C. version of the interface for 360 operation. Several ARPA sites are interested in using the new interface, one of which is presently operational at MIT Lincoln Laboratory.

Hardware assistance in support of the UCSB On-Line System (OLS) has resulted in the development of a new Multi-Line Controller and a new version of the graphics display console used in the OLS. The Multi-Line Controller (MLC) will allow the attachment of any type of user equipment to our 360 system.

The high-speed serial data link between the UCSB Network Host (IBM 360) and the speech analysis computer (SEL-810) has been designed and all purchasing has been completed. This link will be made operational in the next quarter, and will provide the hardware to link our speech system to the network. The speech software on the 810-B side of the 810B to 360 link has been completed and final checkout is underway. The speech software for the 360 side of the link should be completed during the next quarter. The 810-B to 360 link will allow up to two minutes of contiguous speech to be processed. In addition the 360 resident ASCOF speech software (analyzer, synthesizer, and filtering packages) will be available to network users.

1972

Simple Minded File System (SMFS) - This file storage facility was initially developed by Jim White for short-term storage on a 2314 resident disk (#122)*. Recently SMFS has been reshaped with Network login, control features, accounting, and storage mapping (#431). It has become a resource for general network use (#409). The present UCSB link to SMFS is now being replaced by the Network standard FTP. SMFS is also the basis for a more complicated network file service that will be completed in 1973.

Remote Job Service (RJS) - The network standard RJS has been put into service at UCSB. In addition, alternatives such as a link to HASP and a user oriented syntax have been made available (#436).

Network Control Program (NCP) - The NCP for IBM 360 continues to be refined for better efficiency and control. Methods of billing, reporting, and new handles to allow the easy appendage of service routines have been added. This NCP has served as a guideline for each new 360-type host that has joined the Network.

User TELNET - Links to the Network were provided to allow use of local Tektronix and IMLAC terminals. These terminals are used by the UCSB research staff in their Network activities, and have been instrumental when UCSB assists other sites in Network software development or diagnosis.

Data Reconfiguration Service (DRS) - Initially developed in conjunction with RAND this service will assist in the inter-communication between dissimilar systems on the Network. DRS has been checked out and used in local applications. It is now available for use by the Network at large (#437).

Network Graphics - The UCSB On-Line (OLS) continues to serve as a test-bed for network graphics development. Depending upon the UCSB socket number specified, a

* Refers to RFC number.

wide-range of terminal support exists for the user (#398). Tektronix 4002, 4010, and 4013 as well as IMLAC terminals may be used with various I/O formats. Level 1 Network graphics Protocol is also supported. Several IMLAC support packages were written in conjunction with MITRE.

Distributed File System - Work continues on this system in conjunction with MITRE. Files are stored at UCSB, UTAH, and BBN with the control program located at RAND. One-time diagnostics have been implemented at UCSB to assist in locating problems with this as well as other developmental systems.

Using the Network - Automatic login and data conversion programs were developed on the User level of the UCSB On-Line System (OLS). These programs have allowed local Network users to readily login to Network sites, to bring data from other sites for hard copy printout, or as in the case of data from the Network Measurement Center, plot measurement data graphically on the OLS.

File Transfer Via TELNET - Utilizing the programs referred to above, in concert with TELNET, UCSB users have moved files and batch processing jobs between various sites on the Network. Early in 1971 file transfers between 10X and local O/S Data Sets were accomplished to assist NASA-AMES. Subsequent experimentation has allowed comparative testing to take place by running jobs at UCLA with results returned to UCSB. This work has been basic to standard FTP development, now nearing completion at UCSB.

Evaluation - A test group, formed early in 1971 used a multi-console classroom at UCSB to perform a prolonged assessment of the problems encountered by new users. Their critique and recommendations were summarized with the result that changes have been made at various nodes to assist users (#369).

Seminars and Demonstrations - Seminars have been given locally and at other ARPANET sites on Network applications. Recent ICCC participation demonstrated the use of Tektronix and IMLAC terminals attached through the Network to UCSB (NIC #12529).

Speech Recognition and Data Compression - Techniques for single speaker identification by phonemic representation and reduction of the bandwidth needed to transmit continuous speech were developed using the waveform analysis approach. This project was discontinued in mid-year; however the legacy has been both hardware and software that link an SEL 810B signal processing system to the Network by way of the 360 Host.

Interactive Signal Processing System - In support of speech analysis an interactive Culler-Fried On-Line System with graphics console was adapted to signal processing. A high speed link to the 360 plus attachments to abundant disk and drum storage were designed and implemented. This facility was used for speech analysis and is now being employed for Network Conferencing and Data Channelizing experiments. Techniques for integrated speech and data transmission over low-bandwidth connections are being developed.

Very Distant Host Development (VDH) - The specification and design of a VDH connection for use by SCRL on their PDP-11/20 has been completed. Installation of the new hardware and diagnostic software will soon take place.

IMP Attachments for 360 Systems - This hardware interface went through one last modification to convert latent discrete components to integrated circuitry early in 1972. Units were supplied to MIT, NASA-AMES, USC, and UCSB. Orders have been received from AFTAC and RAND.

1973

Modifications to 360 NCP - The 360/270 NCP has undergone refinements which include billing for traffic, variable length reads, interhost connection of processes, measurement of overhead for NCP operation, and Surveyor.

Logger and De-Debugger - Two new facilities were added to the 360 system software that allow developmental work to be carried on in a "virtual" manner. Now network programs can be brought into the 360 and de-bugged during prime-time without affecting overall systems operation.

User and Server FTP - Users of the On-Line System may now transfer text files between FTP servers and the OLS-COL file system. Also a PL-1 user FTP which runs in batch was added. An interim FTP server was added to accept mail and print files. The mail or files may be accessed on-line or directed to a line printer through HASP.

NCP Exportation - The 360 NCP has been made exportable and during the last year it was adopted and modified for use by RAND (370/158) and SDC (370/145).

Network Resources Summary - This compilation of available Network services is arranged according to areas of application. It is now being made a part of an overall Network guide to services.

Modifications to SEL-810B Signal Processor - The graphic interactive signal processing system is being modified for multiple console use, including Network access. In addition to running local analysis and from the Network, users will have access to the Culler-Harrison signal processor when CHI comes into the Network.

Conferencing and Real-Time Data Transfer - Programs were added to the SEL system and its NCP to allow the movement and measurement of force-fed serial data to other Network sites. Following the experiments carried out earlier this year, modification of the programs and addition of special I/O hardware for transfer of speech and video data is presently underway.

Image Processing - Acoustic and Holographic images produced at UCSB are being digitized at USC and brought over the Network into the 1800 image processor at CSL. Stored in this machine they are accessed from consoles on either the 1800 or the SEL. Under direction of the researcher at a graphics console, computation can be invoked in

the SEL or at the 360. Soon the CHI signal processor will also be available.

Information Resources - Terminals at UCSB are being used to access MEDLINE by way of the Network and many of the other information services available on the west coast by way of tie-line connection. Introduction of users to the available resources may help to bring other library files onto the Network.

Experiments in Resource Sharing - Students and researchers at UCSB are collaborating with other sites to bring about results not easily obtained independently. For example, the results of computation at MIT-MATHLAB are passed over to the UCSB On-Line System for graphics display.

Cooperative Graphics - Experimentation is on-going in the area of graphics "conferencing" between UCSB and Illinois, using IMLAC terminals and the OLS.

Plasma Terminal Use (PLATO) - A prototype unit was developed that allows the attachment of an Illinois Plasma Terminal to the ARPANET. The terminal can operate as a standard ASCII unit on the Net and as a PLATO-driven terminal as well. Another hardware adaptor has been inserted between the Illinois PLATO system and the ANTS/1. Experimentation is presently underway to assess the impact of the Network on its operation. A micro-processor front-end is also being implemented for the terminal with funds from ARPA-HRRO.

Very Distant Host (VDH) Development - The installation of the VDH/11 at SCRL was completed on their 11/20 and subsequently on the 11/45. Diagnostic routines for the hardware and a total programming system were completed. VDH/11 units are being placed into operation at Stanford, Hasking Laboratories, and Berkeley (See NIC 18439 and 18242).

IMP Attachments for 360/370 Systems - Two more installations were brought on the Network using the UCSB INTERFACE-IMP/360 Hardware. These units were added to SDAC (360-44) and RAND (370-158).

Speech Data Base Experiment - Using a sample speech dictionary provided by SCRL, an experiment in interactive file access was carried out on the 360-75 using the IBM Information Management System (IMS-2). It was found that the amount of storage required to run such a system was prohibitive.

1974

NCP 360/370 - Work on the UCSB Network Control Program was completed in August. The last additions were completion of billing routines to incorporate traffic charges to Network users both on and off site; to finalize RJS, Network File Service and to complete documentation for continued maintenance. The NCP has been replicated at most of the 360 and 370 sites on the Network. Specifications for the addition of the Stanford WYLBUR System were completed. This was to be added for Network use as well.

User Support Services, Hardware and Software - Assistance was provided to other sites so that testing of Network program additions could take place. This work included

Very Distant Host connection for CHI, Benchmark testing on services provided by various sites, development of Graphics Protocol Level 0 as a test front-end to the UCSB On-Line system, export to 370 sites of 370/IMP controllers with NCP programming support, and consulting to other sites on techniques for Network attachment.

Remote Conferencing by ARPANET - This work was to develop techniques for both voice and visual transmission on the packet-switched Network. The basic goal was to find ways to smooth the flow between conferencing sites by design of a data "Streaming" processor.

Equipment for the task was late in arriving which resulted in the substitution of a plasma terminal from the Illinois PLATO system as a test unit. This terminal requires the continuous flow of display information to produce dynamic CAI presentations. Hardware and software additions were made to Network interfaced at UCSB and at Illinois ANTS. Protocol modifications were implemented to allow this equipment to operate on the Network, and the flow of information was monitored in order to assess buffer size and the effect of packet switching upon the display flow. This work is continuing under a separate contract from ARPA-HRRO and includes the fabrication of a number of special processors for operation of plasma terminals in Network conferencing. Methods for delta modulation were explored and algorithms written for voice communication between the UCSB SEL-810B Signal Processor and alternate Network sites.