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HISTORY AND OVERVIEW OF CSNET

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Abstract: CSNET is the acronym for the Computer Science Research Network, a project supported by NSF to provide advanced computer network services to the computer research community. CSNET is a "logical net" -- a high-level communication environment spanning several physical nets, including the ARPANET, Phonenet, and Telenet. This paper reviews the history, the goals, the organization, the components, and the status of CSNET.

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CSNET stands for the *Computer Science Research Network*, a project sponsored by NSF to provide advanced computer network services to the computer research community. CSNET is a "logical net" -- a high-level communication environment spanning several physical nets, including the ARPANET, Phonenet, and X.25 public packet-switched networks (e.g., Telenet). This paper reviews the history, the goals, the organization, the components, and the status of CSNET as of Fall 1982.

Background[2]

The seeds of CSNET were planted in May 1979. L. H. Landweber arranged a special meeting at the University of Wisconsin to discuss how computer network services like those of ARPANET could become available to the entire community of computer science researchers. The ARPANET served only a dozen university sites and DARPA was unable to include the rest of the community.

It was clear to the participants that mail, file transfer, and remote login services had greatly enhanced research productivity and had generated a strong community spirit among ARPANET sites. It was also clear that the ARPANET experiment had produced a split between the "haves" of the ARPANET and the "have-nots" of the rest of the computer science community. The participants at

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[2] More detailed information on the background and history of CSNET can be found in the article by Comer [1]. More detailed information about CSNET's multinet architecture can be found in the paper by Landweber and Solomon [2].

the meeting wanted to unify the computer research community and to improve research conditions for all its members.

Each participant at the meeting had previous, favorable experience with computer-based mail services for a small research community. One was "THEORYNET", a mailbox facility on a machine at the University of Wisconsin accessible via Telenet login to some 200 theoretical computer scientists. Another was "SAMNET", a mailbox facility on a machine at the University of Toronto accessible to some 50 performance analysts. A third was "SYMBOLNET", a network linking four sites comprising researchers in symbolic computation; the goal was a network based on Telenet with services to mirror ARPANET (but to be independent of ARPANET). Each of these primitive electronic mail services had significantly aided its special community. Each community was anxious to obtain the more advanced services of machine-to-machine mail transfer, file transfer, and remote login.

Also present at this meeting were observers from NSF and DARPA. The NSF was the sponsor of THEORYNET and SYMBOLNET and, on the advice of its advisory panel, had been alert for possible extensions of network services to the rest of the community. DARPA was interested in furthering computer science research and believed that network services might be a step of high leverage. These observers offered advice and encouragement.

The group determined to submit a proposal to the NSF. They envisaged a network available to all members of the computer science community. The network would have low entry costs and other costs proportional to usage. Public packet-switched networks, notably Telenet, would be the underlying medium. (At the time, a DARPA IMP cost about $90K per year, a price well beyond the means of most computer science departments. Moderate speed Telenet connections were then available for entry fees of about $20K per year.)

In November 1979 the University of Wisconsin submitted a proposal to NSF containing the above plan on behalf of a consortium of universities (Georgia Tech, Minnesota, New Mexico, Oklahoma, Purdue, UC-Berkeley, Utah, Virginia, Washington, Wisconsin, and Yale). The cost would be $3 million over a five-year period. The NSF had the proposal reviewed and returned comments to the proposers in March 1980.

The reviews revealed a much higher level of skepticism than the proposers had anticipated. The skepticism had three roots. One was a belief that the CSNET project was proposing to reinvent ARPANET technology; this perception was reinforced by the lack of any gateway between the ARPANET and the proposed CSNET. The second was a belief that insufficient attention had been given to project management and task distribution. The third was a belief that NSF might have to obtain funds for CSNET by reducing basic research budgets. On the basis of these reviews the NSF could not fund the project as proposed.

But the NSF's advisors and some of the reviewers adamantly maintained that CSNET would so improve research productivity that the potential diversion of funds from basic research would pay off handsomely in the long run. Accordingly, the NSF offered to fund a thorough study of the CSNET concept. The purpose of the study was to determine the most cost-effective architecture, to develop a sound management plan, and to assess the extent of community support. With sufficiently strong peer approval, CSNET would be possible.

During the summer of 1980, Landweber convened a CSNET planning committee comprising nineteen computer scientists, a cross section of leaders of the community who had extensive computer network experience. Two major new factors entered the discussion. One was the existence of MMDF, software for "multi-channel memo distribution facility," under development at the University of Delaware [3]. MMDF is a UNIX-based mail transport system that sends and receives mail over a variety of channels including ARPANET and telephone. (The latter is functionally similar to the "uucp" facility of UNIX.) With MMDF, CSNET could bring a large number of sites online in a short period at low cost.

The second factor was DARPA's decision to proceed with "internet protocols" (IP) that permit a host in one net to communicate with a host in a different net. With the internet protocols, CSNET could be regarded as a logical organization of users on different nets. DARPA offered to make its new protocol software (TCP/IP) available to the CSNET project. In return, DARPA expected that the existing ARPANET university community would be a component of CSNET at no cost to DARPA.

The planning committee quickly reached a consensus. CSNET would include subnets based on ARPANET, X.25 nets, and Phonenet (the MMDF service). The internet protocols would hide these components from their users. CSNET would develop an interface between ARPANET's protocol software (IP) and the X.25 public networks (initially Telenet); this would make the standard ARPANET services available to non-DARPA hosts. CSNET would provide a name server that registers all CSNET users and quickly locates the mailbox of any registered user. CSNET would initially receive full support from NSF, but would become self supporting within five years via dues and usage fees.

A proposal containing this plan was submitted by Wisconsin on behalf of a consortium of institutions (Wisconsin, Purdue, Utah, Delaware, and The Rand Corporation) in November, 1980. It was reviewed by late December, 1980 and then submitted to the National Science Board, which approved the project in January 1981. The Board stipulated that the NSF would provide a full time project manager for the first two years but would withdraw from project management by February, 1983, when the CSNET organization would be strong enough to take over. Contracts for CSNET were let to Wisconsin, Purdue, Delaware, and Rand in late spring, 1981. After 20 months, the seeds of CSNET had begun to sprout. The real work lay ahead.

Goals

The goals of CSNET are summarized in Figure 1. The net is to be open to all computer researchers throughout the United States (later, the world). It is to be self-supporting. Its users will pay fixed annual dues plus usage fees. (The dues for 1983 are shown in the bottom part of the table.) CSNET will initially comprise three subnets -- ARPANET, Telenet, and Phonenet — but will be expandable to others as they become available, e.g., other X.25 public nets and satellite nets. CSNET will initially provide the same services as ARPANET -- mail, file transfer, remote login, and an on-line name server. Later, it will provide additional services such as messages containing voice segments, software libraries, technical report repositories, and an on-line journal.

The four project teams must carry out these goals within two important constraints. First, the total project budget, $5 million over five years, places a severe limit on the number of personnel who can be hired. It also means that satisfactory service must be available by 1983 to permit collection of dues. Second, the project must develop its own stable management organization by Spring 1983, when NSF withdraws officially from project management.

COMPUTER SCIENCE RESEARCH NETWORK GOALS

- Open to all computer researchers.
- Logical net comprising physical subnets (initially ARPANET, Telenet, Phonenet).
- Advanced network services (initially mail, file transfer, remote login, name server).
- Self-governing, -sustaining, and -supporting
- Low entry fee

DUES FOR CALENDAR 1983

Industry site -- $30,000
Government site -- $10,000
Non-Profit site -- $10,000
University site -- $5,000

Note: Sites with a very small number of researchers can negotiate lower dues.

FIGURE 1: Goals and Dues Structure of CSNET.

Users who have accounts at ARPANET hosts already have the full services of CSNET except for the name server. Until Telenet sites are operational, all other users are at Phonenet sites; they will not have file transfer or remote login services and will interact with the name server by mail. At the start of the project, mailboxes are also provided on a machine called the CSNET Public Host for users who have no accounts at ARPANET or Phonenet sites; this service is not heavily used.

CSNET protocol and name-server software development is limited to the Berkeley UNIX operating system on VAX computers. The MMDF software works with Berkeley UNIX and Bell Labs' Version 7 UNIX. CSNET is encouraging vendors to develop compatible software and hardware for other machines and operating systems.[3]

Technical Projects

Figure 2 lists the three technical subprojects of CSNET: Phonenet, Name Server, and Protocols. The following subsections give overviews of these projects. Companion papers describe these projects in detail [1,2,3].

Phonenet

The Phonenet project is being conducted jointly at the University of Delaware and the Rand Corporation. Its first goal is to set up and operate mail relay computers on the east coast (at the University of Delaware) and on the west coast (at the Rand Corporation). Its second goal is to provide each CSNET site with the MMDF mail transport to permit automatic mail exchange between that site's machine and the nearest relay.

Each relay will route mail to the destination site via ARPANET, Telenet, Phonenet, and possibly the other relay. CSNET sites can poll the relays as often as they desire and are willing to pay telephone line charges. Phonenet messages can incur usage charges if they are routed over paths for which CSNET must

[3] For example, the IBM Corporation has an agreement with the University of Wisconsin to develop CSNET-compatible protocols for IBM machines running the VM operating system. Also, a Pascal version of the Phonenet software has enabled Phonenet participation by users of DEC VMS and IBM VM operating systems.

PROJECT	INVESTIGATORS	GOAL
Phonenet	D. Farber (Delaware) A. Hearn (Rand)	Install and operate mail relays (VAX 11/750) at Delaware and Rand, connected by phone, Telenet, and ARPANET. Distribute copies of MMDF software to CSNET Phonenet sites. Goal is 100 operational sites by 1983.
Name Server	L. Landweber (Wisconsin) M. Solomon (Wisconsin)	Develop the CSNET name server, a database of all CSNET users, and install it on the CSNET Service Host. Final version distributed to CSNET sites by end of 1983.
Protocol	D. Comer (Purdue) P. Denning (Purdue) T. Korb (Purdue)	Construct interface between ARPA's Internet Protocol (IP) and the X.25 public network protocol to permit using X.25 nets for full ARPANET services. Working version available for distribution by 1983.

FIGURE 2: Technical Subprojects of CSNET.

pay, e.g., telephone lines or Telenet.

The design goals of MMDF have been reported at the 1979 Data Communications Symposium [3]. They are: 1) a mail transport that provides a high-level, channel-independent interface, 2) error checking of message formats, and 3) robustness under load. The main components of MMDF are illustrated in Figure 3.

The first goal is achieved by implementing the delivery mechanism as a process that takes messages one at a time from its work queue and sends them

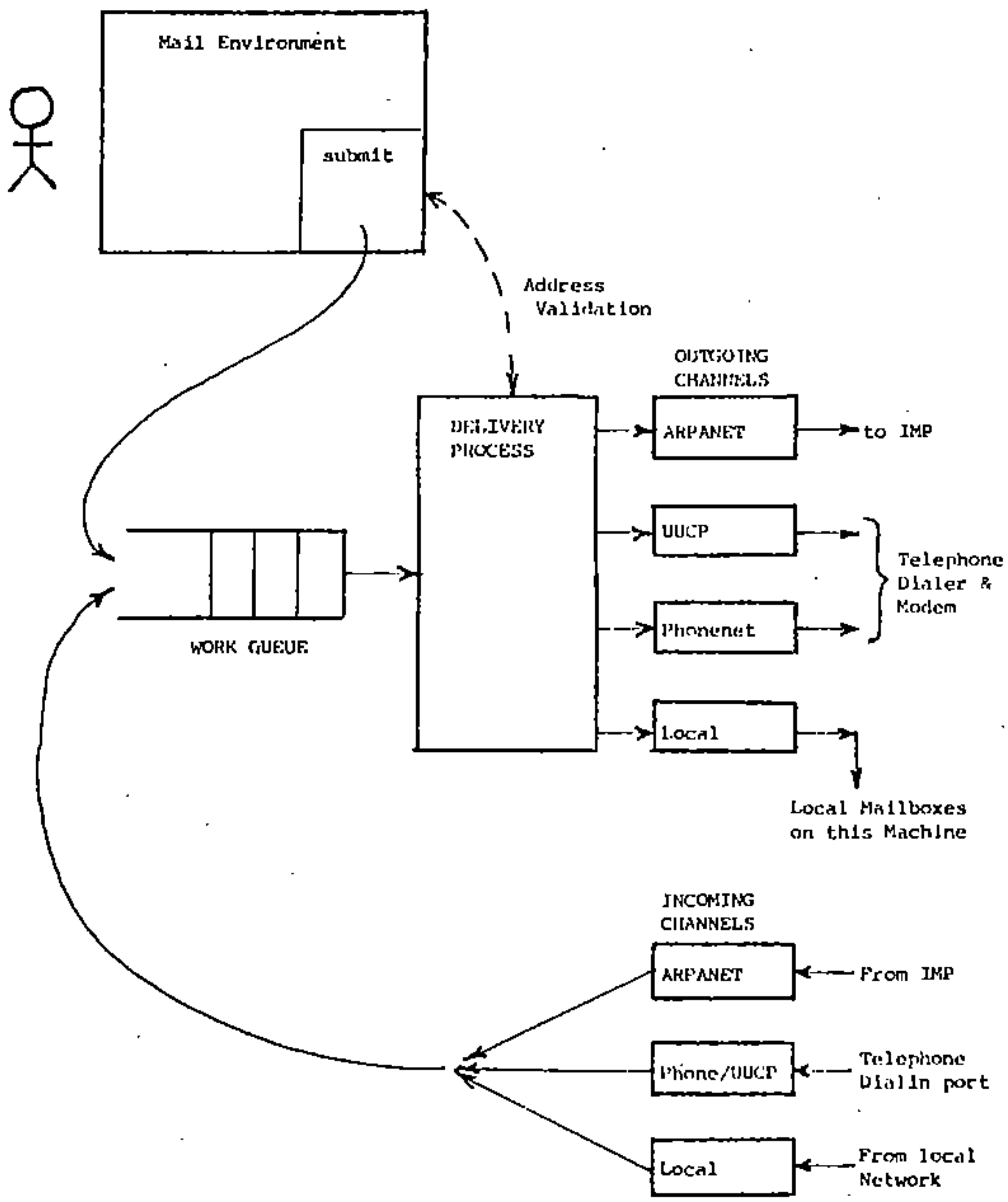

FIGURE 3: Architecture of MMDF.

over one of several channels connected to its output. The incoming messages must consist of a body and a header in a standard (internal) format. The delivery process uses the address in the header to select a channel for sending the message. Each channel is a driver that sends the message in the protocol of a particular network, e.g., local delivery, ARPANET, UUCP, or Phonenet.

The second goal is met by requiring that every user mail environment contain a certified "submit" subprogram for interacting with the MMDF delivery process. When a user forms an address in the header of a message, the submit subprogram converts it to the standard internal form and checks with the delivery process to verify its validity; if the address is invalid, the user is immediately notified. When the user completes the message body, the submit subprogram deposits the ready message with validated address in the work queue of the delivery process.

Mail incoming on any channel is also placed in the work queue of the delivery process, which will eventually deposit it in a local mailbox via the local delivery channel.

The third goal is met by storing the work queue of the deliver process on secondary storage, which can allow it to become quite large without overloading the system.

CSNET soon encountered difficulties on account of an essential incompatibility between the MMDF transport and the one already in the UNIX operating system at each of the Phonenet sites. The regular UNIX mailer programs do no address checking; instead, the delivery process parses and interprets addresses of many formats. There is no simple way to convert these mailers to interact with the MMDF delivery process directly. Because of this, many Phonenet sites had to deal with two mail systems -- the one already in their UNIX operating systems and the new one provided by MMDF. This was a major inconvenience that created many complaints.

To provide a temporary solution, the Purdue and Delaware contractors cooperated on minor modifications of delivery processes of Berkeley UNIX and MMDF. The outgoing ARPANET channel on the Berkeley delivery process was replaced with a driver that hands mail intended for the ARPANET to the MMDF delivery process, which in turn routes it to its destination via the Phonenet channel. (Because Phonenet sites cannot send directly to the ARPANET, this loses no function.) The MMDF local delivery channel was modified to store mail in the mailboxes and in the formats expected by the Berkeley mail programs. The disadvantage of this solution is that it requires each Phonenet site to install and maintain two mail transport systems.

A long-term solution is being discussed between CSNET and the Berkeley UNIX developers. The goal is a single mail transport that incorporates the best features of Berkeley's current mail system and MMDF. This system would be distributed with releases of Berkeley UNIX.

Name Server [4]

The name server is a database of all CSNET users held online at a site called the CSNET Service Host. (This machine is now at the University of Wisconsin.) Each record of this database contains the name, mailbox identifier, and descriptive keywords of a registered CSNET user. CSNET sites can query the name server to obtain the mailbox address of any user. CSNET users can update the keywords in their records at any time. The name server project is also implementing the programs to be installed at each CSNET site for the proper protocols with the name server.

The user interface with the name server consists of commands to implement these operations:

register
unregister
move
whois
update

The "register" command is used by a user to enter a new record in the database; the "unregister" command is used to remove a record; the "move" command is used to change the field in a record indicating the location of the user's mailbox. A password scheme prevents unauthorized use of these commands. The "whois" command is used to retrieve a set of records matching keywords; for example

whois Peter Denning

and

whois past ACM president

will return the same record. The mailbox identifier field of this record can be extracted and put in a local alias table so that future queries can be bypassed. The "update" operation is used by a user to alter the descriptive keywords in his record of the database; the system requires him to present his login password before installing any changes.

Future versions of the name server software distributed to CSNET sites will automatically encache information locally to reduce traffic with the name server. For example, a user's alias table will hold pairs (nickname, mailbox-identifier) to help avoid unneeded invocations of the whois command by that user. A system table will encache pairs (mailbox-identifier, internet address) so that unneeded requests for the internet address of a given site can be omitted. Messages will be automatically forwarded to users whose mailboxes have been moved.

Users at Phonenet sites will have to conduct the above interactions by sending mail to the name server. The name server will, by return mail, send records matching a whois query.

Protocols [5]

The IP-to-X.25 protocol project is the least visible component of CSNET. Its goal is an interface between the datagram-oriented DARPA Internet Protocol (IP) and the virtual-circuit-oriented X.25 public packet network protocol. This interface will enable the high-level ARPA Transport Control Protocol (TCP) to work with X.25 nets, which in turn will allow CSNET users full access to ARPANET services. Because all user services interact with TCP, any new DARPA network services will become available throughout all of CSNET with new software distributions.

DARPA's protocol design relies on the TCP layer in one machine to establish a process-to-process channel with a corresponding TCP layer on another machine. The sender's TCP breaks a message into packets, which are handed over to its IP for transmission as independent datagrams over the ARPANET. The receiver's IP hands the received datagrams to its TCP, which reassembles them into messages. Purdue's modification extends IP so that it can selects the

Purdue X.25 interface when the recipient host's internet address is on Telenet.

Because Telenet charges for opening virtual circuits in X.25, the Purdue interface cannot transmit an IP datagram simply by opening a circuit, sending a packet containing the datagram, and then closing the circuit. Instead, it must leave open a circuit to the target host as long as it or the target is actively using that circuit. An algorithm resembling a page replacement algorithm for a virtual memory system closes an open circuit when IP requires a new circuit beyond the maximum number Telenet permits a given host to open.

The Purdue interface is connected to an Interactive Systems INcard, which is a board that connects the Telenet modem to the VAX backplane. A future project is to provide the X.29 protocol extension of X.25; this will allow the INcard to connect to a login port of UNIX so that authorized users can access the machine by ordinary Telenet remote login. Interactive Systems is considering extending the design of its INcard to include X.29 on the board.

Organization of the Project

The CSNET management structure provides central management over a project whose components are at different locations. Figure 4 outlines the management components.

PROJECT DIRECTOR
R. Adrion (NSF)[5]

MANAGEMENT COMMITTEE
L. Landweber, Chair
R. Adrion
P. Denning
R. Edmiston
D. Farber
A. Hearn
C. W. Kern

SUPPORT GROUPS
Policy (L. Landweber, Chair)
Technical (D. Farber, Chair)
Organization (A. Hearn, Chair)
Coordination & Information Center (R. Edmiston, Director)

FIGURE 4: CSNET Management Structure.

[5] Until October 1982, C. W. Kern of NSF was the project director.

The Management Committee consists of the principal investigator of each contract, the director of the Coordination and Information Center (CIC), and the NSF project manager. This committee meets every six to eight weeks to review the status of the project, settle policy questions, and give guidance to the technical subprojects. It is responsible for keeping the entire project on schedule and for initiating corrective action when needed. Until a separate CSNET organization is established in 1983, the NSF project director can overrule the committee on any matter.

The Policy Support Group consists of the Management Committee plus other senior computer scientists.[6] It meets as needed (but at least once a year) to review the status of the entire project, give general guidance to the Management Committee, and determine overall policies for CSNET. When CSNET becomes a separate corporation, this group will be replaced by a board of directors and the Management Committee will be replaced by an executive committee.

The Technical Support Group meets from time to time to consider technical problems facing CSNET and recommend solutions to the Management Committee.[7] It consists of the principal investigators of each project (or their designees) plus other computer scientists whose technical areas are relevant to the project.

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[6] As of September 1982, the other members of the Policy Support Group were A. Aho (Bell), B. Arden (Princeton), J. Birnbaum (HP), F. Corbato (MIT), K. Curtis (NSF), R. Eckhouse (DEC), N. Habermann (Carnegie-Mellon), R. Kahn (DARPA), L. Kleinrock (UCLA), M. Marcus (FCC), R. Miller (Georgia Tech), R. Ritchie (Washington), H. Schorr (IBM), R. Spinrad (Xerox), and S. Sedelow (Kansas).

[7] As of September 1982, the members of the Technical Support Group were E. Allman (Berkeley), V. Cerf (MCI), D. Crocker (Delaware), P. Enslow (Georgia Tech), J. Feldman (Rochester), L. Hollaar (Utah), J. T. Korb (Purdue), K. Lantz (Stanford), M. O'Brien (Rand), J. Postel (USC), L. Rowe (Berkeley), F. Schneider (Cornell), and M. Solomon (Wisconsin).

The Organization Support Group has been studying models for the CSNET organization -- e.g., consortium of universities, embedding in an existing consortium, or separate corporation.[8] It drafted a constitution and bylaws that is serving as the charter of CSNET until a formal organization is established. After considering the alternatives proposed by this committee, the NSF decided that embedding CSNET into an existing organization would be the best choice; it issued a program solicitation in October 1982 inviting potential host organizations to submit proposals.

The Coordination and Information Center is to provide the management services needed to register and install new users and sites, distribute CSNET software, provide documentation and regular newsletters, and answer users' questions. After a public announcement in Fall 1981, NSF received and reviewed proposals. A contract was awarded to Bolt Beranek and Newman of Cambridge, MA, for this function. The CIC became operational in July 1982.

The CIC has been advising the Management Committee on possible methods of accounting for CSNET use and billing sites their fair shares of these charges. The accounting problem is complicated by several factors: a) Some messages will travel through several subnets each with different charging policies. For example, an east coast Phonenet site will communicate with a west coast Phonenet site by two phone calls (site to Delaware relay, Rand relay to site) and a Telenet call (relay to relay). b) It is impractical for the relays to provide itemized lists of load generated by each user at a site. It can provide a total of load generated by a site. The site will have to allocate the cost of that load locally.

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[8] As of September 1982, the members of the Organization Support Group were A. Dalson (Virginia), W. Franta (Minnesota), M. Harrison (Berkeley), G. Heller (EDUCOM), L. Travis (Wisconsin), and K. Uncapher (USC).

among its users; CSNET will provide accounting software for this purpose. c) By agreement with DARPA, CSNET will not charge ARPANET users for CSNET use. Assuming that traffic from CSNET to the ARPANET is approximately the same as traffic from ARPANET to CSNET, an approach would be to charge CSNET users twice the cost of the CSNET leg of their messages to ARPANET users. d) Duplex telephone and Telenet circuits can be used by a receiver to send mail back to a caller -- at the caller's expense. Special controls may be needed if some frequently called sites are found not to be paying usage fees proportional to their actual outbound traffic.

Status of the Project

As of October 1982 both the Rand and Delaware relays were operational. The two relays communicated by telephone and ARPANET, and will communicate by Telenet as soon as practicable. Some 76 Phonenet sites were operational or about to become so, as shown by the CSNET map in Figure 5.

As of September 1982, a preliminary version of the name server software was being tested at the contractors' sites. All users at all operational CSNET sites were registered in the database. All the commands in the user interface were implemented. Later versions making use of the alias facility and of encaching internet addresses were under development but were not yet under test.

As of September 1982, the protocol software was under test and was being installed at each of the other contractor's machines. During the test period, all communication among the contractors will use Telenet instead of ARPANET.

FIGURE 5.

GEOGRAPHIC MAP, SEPTEMBER 1, 1982

Around January 1983 this software will be available for other CSNET sites to install if and when they obtain the necessary Telenet connections. Initial tests revealed that Telenet window restrictions limited effective throughput to less than 1200 baud even on lines rated at 9600 baud. Negotiations with Telenet were initiated to loosen these restrictions.

As of July 1982 Bolt Beranek and Newman had been accepted under contract to provide the Coordination and Information Center. Complete plans for documentation and software distribution were approved by the Management Committee and were being implemented. A hotline phone number was operational for any CSNET user or site having questions or comments (617-497-2777). The CIC personnel had assisted the management committee in devising a dues structure and were assisting in the development of accounting and billing procedures.

As of September 1982 the Policy Support Group had approved a draft of the constitution and bylaws of CSNET. Until CSNET is converted to a separate organization, this document will serve as the charter. In October 1982, the NSF issued a formal solicitation for an institution to serve as host for CSNET, Inc., during the next period.

As of September 1982 the Management Committee had received approval from NSF for the dues structure (Figure 1) and was proceeding to its implementation. During 1983 member institutions will begin paying dues and usage fees. The Coordination and Information Center has provided estimates of the annual usage costs that can be expected by each type of site. Examples of costs from these estimates are summarized in Figure 6. (These examples assume a moderate user will generate about $250/year charges at Phonenet sites and $75/year at Telenet sites; they assume a heavy user will generate about

Site Type	Initial Equipment Cost	Annual Connect Charges	Annual Usage Charges	Annual COST
PHONENET	1500	250		
Moderate (1)			8750	9000
Heavy (2)			24250	24500
TELENET	10000	12000		
Moderate (1)			3250	15250
Heavy (2)			9000	21000
ARPANET	—	107,000	--	--

(1) Moderate = 10 moderate users plus 10 heavy users.
(2) Heavy = 20 moderate users plus 30 heavy users.

FIGURE 6: Example Usage Cost Estimates.

$625/year at Phonenet sites and $250/year at Telenet sites.) Phonenet usage charges are a combination of telephone line charges and Telenet packet charges for messages that have Telenet legs in their journeys. For a sufficiently active site, Telenet is cheaper than Phonenet. Moreover, Telenet gives interactive access to CSNET services; Phonenet does not. The ARPANET figures are included for comparison: CSNET will be able to provide similar services at much lower cost to many members of the computer research community.

As of September 1982 the Management Committee had admitted to membership only U.S. institutions conducting or directly supporting computer research. Several industrial applications from firms engaged in product development had been deferred until the CSNET organization is more stable and net use policies have been set forth. Several applications from foreign research sites (in Canada, Israel, and Europe) had been deferred until the U.S.

government's policies on transborder flow in respect to CSNET can be ascertained.

Acknowledgements

We are grateful to the many colleagues with whom we have interacted during the formative stages of CSNET, to the people at NSF and DARPA for their constant advice and encouragement, to the National Science Board for its faith in computer community, and to the computer community for its continued support for this project. Three persons in government played critical key roles. Bob Kahn and Vinton Cerf of DARPA gave constant support and a major commitment of DARPA resources. Kent Curtis of NSF spent uncounted hours behind the scenes selling the concept of CSNET to the NSF administration, to OMB, and to DARPA; his insistence on wide community support significantly strengthened the project and assured its success. We are also grateful to Fred Schneider and Larry Landweber for comments on this manuscript.

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