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STATUS OF NETWORKING FOR HIGH ENERGY PHYSICS IN THE UNITED STATES*

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Networks are used extensively for High Energy Physics in the United States. Although the networks have grown in an ad hoc manner with connections typically being made to satisfy the needs of one detector group, they now encompass to large fraction of the U.S. HEP community in one form or another. This paper will summarize the current status and experience with networks.

INTRODUCTION

A variety of network services are being provided for High Energy Physics with a variety of network protocols in the United States. This diversity reflects the diversity of opinion of what are the most important perceived needs. This diversity is also influenced by the style of computing for a particular collaboration. For example, a collaboration based on centralized computing, typically the mainframe computer at the national laboratory, puts emphasis on remote logon and remote printing, while one that is based on distributed computing puts emphasis on file transfer and process to process communications. In both styles and for communications outside the collaboration, electronic mail and file transfer are important.

The major networks in use by HEP in the States are BITNET, the SLAC/LBL DECnet, X.25 with and without Coloured Books, Data switches/terminal multiplexors, and MFENET. Note that there is very little development of networking software or hardware being done by HEP in the States. All of the above are off-the-shelf items that can be bought from various vendors or available from other sources. They may only require minor maintenance or modification to be used. This, however, is only true for wide-area networking as within the local area of one site, there are development projects which this paper will not cover.

BITNET

BITNET is an international network of more than 500 computers at over 200 institutions in 12 countries. In Europe, BITNET is called EARN and in Canada it is called NETNORTH, but there are no apparent differences to the user. Although the network protocol is IBM's VM-based RSCS (Remote Spooling Communications Subsystem), the current composition of operating systems on the network is 47% VM, 25% VAX VMS, 13% MVS, 5% UNIX, and 10% all others. The computers on BITNET are interconnected by leased land lines at 9600 baud (land lines are required by RSCS). Figure 1 shows the current topology of the network. In the States, the costs of leased lines vary from US$ 400 per month for 20 miles in states with high tariff rates to US$ 2,700 per month for coast to coast lines. Each site pays the cost for line it used to join the network and may help another site defray the costs of a long line. There is no other charges related to the use of the network.

About 90 computers used by HEP at nearly 50 institutions are on BITNET with about 20 of these at 15 institutions being in Canada or Europe. BITNET is extensively for its fast reliable electronic mail and small file transfer. As an example, SLAC sends out on BITNET over 7000 files per month totaling over 120 MBytes, with about an equal amount of traffic being received. To Europe alone, SLAC sends over 3000 files totaling 30 MBytes per month. Mail delivery times

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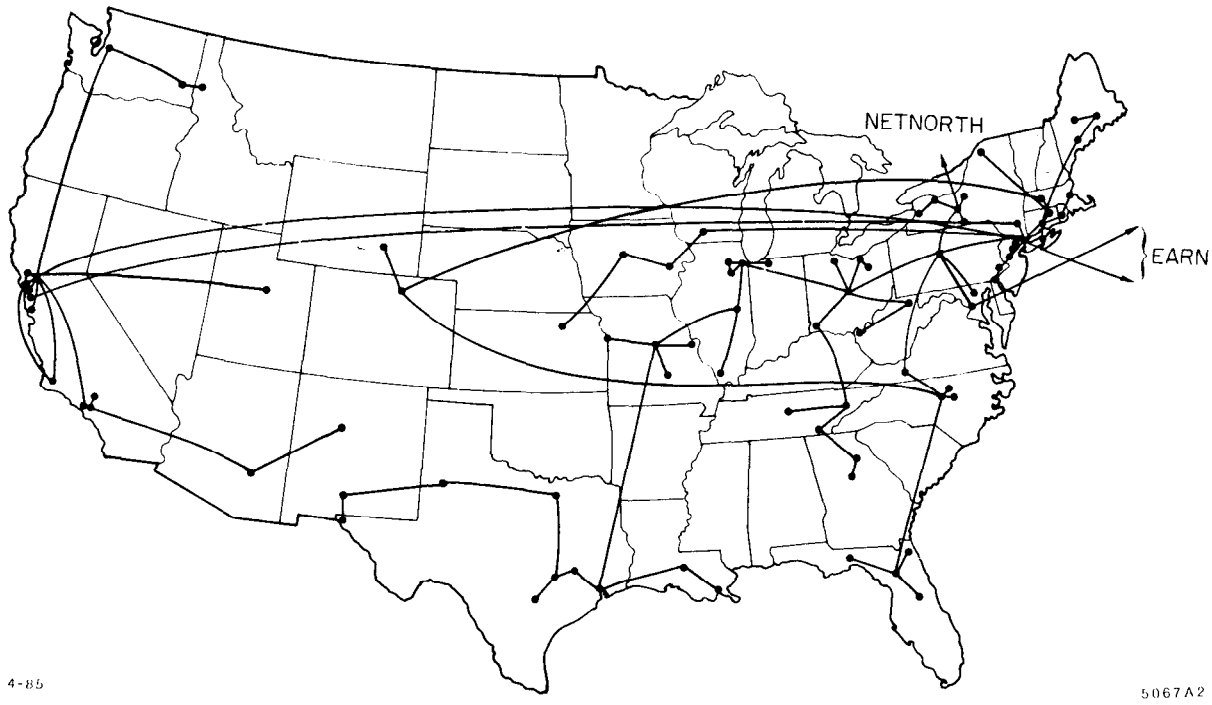

Figure 1. BITNET Topology, June 1985.

are typically measured in minutes during times of peak network load and in seconds at other times.

BITNET also has the feature of interactive messages between users on different computers, which may seem frivolous (some people say annoying), but is actually a very useful feature. It permits the implementation of interactive conferencing and interactive network file servers besides allowing one to send short messages interactively instead of sending mail. The interactive feature also gives one the impression that a remote user is as close to you as a user on your own machine, which has the effect of encouraging information exchange.

The difficulties with BITNET is that large file transfer is done by store-and-forward at each node, thus needlessly extending the elapsed time to transfer a large file and tieing up a link while it is being transferred (the later is supposed to be fixed with the next release of RSCS this fall). Also BITNET only allows a user to send a file but not to 'fetch' a file unless additional remote software is provided (such as an interactive file server). However, on such a heterogeneous network, the send-only nature becomes a feature because of the potential of 'hackers' stealing software.

DECNET

DECnet is a product from DEC which allows linking VAX VMS and PDP-11 computers together with a variety of line protocols. There are about 80 HEP computers at 20 sites on the SLAC/LBL DECnet. Although the network was originally for California sites, it has been extended to the midwest and east coast via 9600 baud leased land and satellite lines. At 8 sites, there are VAXes on this network that are on BITNET as well. The current topology of the DECnet is show in Figure 2.

DECnet is clearly the choice of most collaborations based on distributed computing with DEC computers. It allows all the services expected from a network and it integrates very well with the VMS operating system. In particular, file transfer in either direction is very natural within DECnet as well as process to process communication. This allows centralized data bases for a collaboration as well as the automatic updating programs throughout the network; features that are used heavily by the collaborations based on DECnet. It is harder to get usage statistics

Figure 2. SLAC/LBL DECNET Topology, June 1985.

from DECnet so exactly how much the network is used is unknown, however, it is known that the 9600 baud line between SLAC and Argonne saturates during peak periods.

The difficulty with DECnet is that needed network links must be working to proceed with communications. For this reason using DECnet for electronic mail does not work too well over wide area where it is possible for a needed link to be down. Using DECnet for logon to remote nodes also does not work very well as the effective baud rate is frequently very low (this is should be fixed, however, with Release 4.0 of VMS). DECnet also does not provide a connection to non-DEC computers such as the mainframes located at the laboratories.

Data Switches/Terminal Multiplexors

Remote logon via statistical multiplexors are extensively used in the States. These are mainly lines from university sites to the HEP laboratories. There are 12 lines to Fermilab and 10 to SLAC, for example. The current topology of leased lines with multiplexors is shown in Figure 3.

One can understand this extensive network if one considers the alternatives which are still being used by some:

1. Public phone lines. Some sites use public phone lines to connect to a remote site with 1200 baud modems. For low usage, such as accessing SPIRES at SLAC, this service is adequate. Long distance telephone costs in the States are only about US$ 30 per hour during the weekday and up to 60% discount at other hours. However, for large usage this method becomes very expensive and 1200 baud is too slow for serious use of a remote computer.
2. Dial in to Public Packet Switching Networks (PPSN). The PPSNs in the States have dial in ports available in over 500 cities so they are almost always only a local phone call away. At a certain level of usage, this method is less expensive than public phone lines and, of course, the only way to Europe (due to modem incompatibilities). The costs are about US$ 5.50 per hour plus the packet or byte charges. However, one is limited to 1200 baud.

Figure 3. HEP network for terminal multiplexors, June 1985.

3. Direct connection to PPSN. For higher baud rates, one needs a leased line connection to PPSN. This costs about US$ 1,200 per month plus connect time and packet or byte charges. When used for remote logon the quality of the service is not too good, there are large echo delays which make use of full screen editors frustrating and the real throughput seems to be about 2000 baud instead of the 9600 baud one is paying for.

On the other hand, the quality of remote logon service via leased lines with statistical multiplexors is very high and the costs are quite reasonable. For example, the land line from Tennessee to SLAC is about US$ 1,300 per month from MCI (one of the 3 telephone companies that could supply the line). A 9600 baud satellite circuit costs about US$ 600/month (independent of distance) plus the land line cost to the nearest earth station at each end. Fortunately, there are earth stations near SLAC and Fermilab, but some university sites need such a long line to an earth station that is less expensive to lease a land line all the way to the laboratory.

Most sites run a number of terminals at 9600 baud in full duplex mode, so that full screen editors can be used as easily as at the laboratory site. Some of these leased lines are via satellite links which does cause an echo delay of 1/2 second. Users of these links say that they get used to this delay and don't notice it after a while except when positioning the cursor with a full screen editor.

Many of these leased lines also run some channels in the opposite direction for printers. From SLAC the printers are driven by the same RSCS that drives BITNET and from Fermilab an equivalent system on the Cybers drives the printers. Also DECnet shares the bandwidth on some of the leased lines. One site runs all three protocols on the same 9600 baud line.

COLOURED BOOKS

There are six university groups using Coloured Books protocols in the States (all of them in the LEP3 collaboration). They are all the UWIST implementation under VAX VMS. Since the protocol is based on X.25 standards which is available from the PPSNs on an international scale, they have easily made connections between their computers in the States and those in Europe. Some of their computers are on BITNET and/or the SLAC/LBL DECnet as well.

Their experience so far has been with using PPSN X.25 service and has been good and improving. They use heavily the services for file transfer, electronic mail, and remote logon. Their problems are in the area of costs and real throughput. Since they estimate needing to transmit over 20 Gigibytes per year for transatlantic traffic alone, they are planning a backbone of leased lines, where possible, on which to run X.25. Thus they can reduce their costs and still connect to their European computers with PPSNs. One leased satellite line is already installed in the States and a leased satellite line to CERN is being planned.

MFENET

MFENET was setup by the plasma physics community so remote users could gain access to the supercomputers at the Magnetic Fusion Energy center at Livermore, California. As the DOE's Energy Research computer is also there, MFENET is starting to be used by HEP to gain access to the supercomputer time allocated to HEP. Use is mostly by theorists for lattice guage calculations and accelerator physicists for modeling.

MFENET supports terminal logon to the MFE computers as well as remote job entry/retrieval from a VAX. Within the HEP community there has been little experience with this network so far. It is a non-standard protocol and there has been mixed reviews about its performance. Soon there will be a 56K baud link to BNL and the 56K baud link to Argonne will be extended to Fermilab.

OTHER PROTOCOLS

Other well known network protocols are almost non-existent as far as HEP is concerned. Mostly, other networks are used via gateways from BITNET to reach HEP sites not reachable otherwise. ARPANET is used as a somewhat dubious path between BITNET and JANET. USENET is not used much because most HEP VAXes run VMS. However, two UNIX machines used by theorist are reachable via USENET. MAILNET is used as a path to MTSNET which includes one HEP site in Canada. CDNnet has two HEP computers in Canada running the EAN implementation of X.400. In almost every case, however, the HEP sites currently only reachable via other networks are planning to connect to BITNET soon.

FUTURE U.S. HEPNET

As a result of the recent HEPAP Subpanel on Computing, it has been realized that a coordinated approach to networking within HEP might be better than the ad hoc growth being experienced so far. It would allow sharing and central funding of much higher speed lines and avoid the duplication of effort and apparent waste in having so many transcontinental leased lines. It would also provide the needed coordination for eventual leased lines to Europe and Japan.

An example of what a U.S. HEPNET might look like is the following. 56K baud trunk lines would run between SLAC, Fermilab, and Brookhaven. LBL and Argonne would use their existing microwave links to SLAC and Fermilab, respectively. University sites would have 9600 baud feeders to one of the laboratories, but not necessarily the nearest one. This is because the costs don't vary with distance that much, so university groups will want to connect to the laboratory of their prime interest.

There are a number of issues that need to be resolved before a U.S. HEPNET comes into existence. The choice of protocol or protocols needs to be made. A management structure needs to be setup with appropriate funding mechanisms. Equipment choices may need to be made at a national level instead of locally. One will also need to make choices on an international scale for the connection to Europe and Japan.

CONCLUSION

Networks are playing an important role in the HEP program in the States. They have become the foundation for many collaborations and will be even more so in the future. They are also rapidly reducing the number of telephone calls and displacing telex and postal mail as the means of communication within the HEP community.

Like the computer industry as a whole, networking technology is rapidly changing, costs are coming down, and speeds are going up. It will be interesting to compare the status of U.S. HEP network today with what the community will have 5 years from now.

APPENDIX A. LIST OF HIGH ENERGY PHYSICS SITES ON NETWORKS

This compilation is a list of high energy physics sites whose computers are on one of the networks described in this paper. Although there are undoubtly some errors in the list, it is believed to be mostly accurate. For completeness, European and Japanese sites have been included in the list since these sites are reachable from the U.S. either directly or via gateways.

The designations used for the networks are:

BITNET	—	has a computer on BITNET, EARN, or NETNORTH.
DECNET	—	has a computer on SLAC/LBL DECnet.
INFNET	—	has a computer on INFN DECnet.
C.B.	—	has a computer with Coloured Books and X.25 connection.
JANET	—	has a computer on JANET.
USENET	—	has a computer running UNIX and registered in USENET.
MFENET	—	has MFENET connection.
MTSNET	—	has a computer on the MTSNET.
CDNnet	—	has a computer on the CDNnet.
Statmux	—	has line with statistical multiplexors to a laboratory.
TYMNET	—	has X.25 connection for logon only (used for U.S. sites only).

United States sites.

Argonne National Lab.	BITNET	DECNET			TYMNET	MFENET
Lawerence Berkeley Lab.		DECNET		Statmux		
Brandeis University		DECNET				
Brookhaven National Lab.	BITNET			Statmux		
Brown University	BITNET			Statmux		
California Inst. of Tech.	BITNET	DECNET	C.B.	Statmux	USENET	
Cal. St. U. - Northridge				Statmux		
Carneige-Mellon Univ.		DECNET				
University of Chicago				Statmux		
University of Cincinnati	BITNET					
University of Colorado				Statmux		
Colorado State Univ.	BITNET			Statmux		
Columbia Univ. (Nevis)				Statmux		
Cornell University	BITNET					
U. C. at Davis				Statmux		
Fermilab	BITNET	DECNET		Statmux	TYMNET	
University of Houston	BITNET			Statmux		
Harvard University	BITNET	DECNET				
Johns Hopkins University	BITNET	DECNET	C.B.			
Univ. Illinois-Urbana	BITNET	DECNET		Statmux		
Indiana University		DECNET				
Louisiana State Univ.	BITNET					

U. C. - Los Angles		DECNET			
University of Maryland	BITNET				
Mass. Inst. of Tech.	BITNET		C.B.	Statmux	
University of Michigan		DECNET	C.B.		
Michigan State Univ.				Statmux	
Northeastern University	BITNET				
University of Oregon				Statmux	
Univ. of Pennsylvania	BITNET				
Penn. State University	BITNET				
Princeton University			C.B.		USENET
Purdue University		DECNET			
U. C. at Riverside		DECNET			
Rockefeller University	BITNET				
Rutgers University	BITNET			Statmux	
U. C. at San Diego		DECNET			
U. C. at Santa Barbara	BITNET	DECNET		Statmux	
U. C. at Santa Cruz				Statmux	
Stanford University	BITNET				
SLAC	BITNET	DECNET		Statmux	TYMNET
SUNY at Stony Brook				Statmux	
Syracuse University	BITNET				
University of Tennessee	BITNET			Statmux	
Texas A&M	BITNET				
Vanderbilt University	BITNET				
Virginia Polytech. Inst.	BITNET			Statmux	
University of Washington				Statmux	
University of Wisconsin	BITNET	DECNET			
Yale University	BITNET				

Sites outside the United States.

Belgium					
Brussels University			C.B.		
Canada					
Un. British Columbia					MTSNET
McGill University	BITNET				
NRC - Ottawa	BITNET				
Univ. of Toronto			C.B.		
TRIUMF			C.B.		CDNnet
Univ. of Victoria					CDNnet
Denmark					
Niels Bohr Inst.	BITNET				
Univ. Copenhagen	BITNET				
France					
Un. of Montpellier	BITNET				
Saclay		INFNET			
Germany					
University of Bonn	BITNET		C.B.		
DESY	BITNET	INFNET	C.B.		
Heidelberg	BITNET				
MPI-Munich	BITNET				
Siegen University			C.B.		

Israel				
Tel Aviv University	BITNET			
Technion University	BITNET			
Weizmann Institute	BITNET			
Italy				
INFN & CSATA - Bari	BITNET	INFNET		
INFN & CINECA - Bologna	BITNET	INFNET		
INFN Sez. di Ferrara		INFNET		
Lab. Naz. di Frascati		INFNET		
INFN Sez. di Genova		INFNET		
Lab. Naz. Legnaro		INFNET		
INFN Sez. di Milano		INFNET		
INFN Sez. di Napoli		INFNET		
INFN Sez. di Padova		INFNET		
INFN Sez. di Pavia		INFNET		
Universita' di Perugia	BITNET			
INFN & CNUCE - Pisa	BITNET	INFNET		
INFN Sez. di Roma		INFNET		
Ist. Sup della Sanita'		INFNET		
INFN Sez. di Torino		INFNET		
INFN Sez. di Trieste		INFNET		
Japan				
KEK			C.B.	
Netherlands				
Kath. Uni Nijmegen	BITNET			
Univ. Utrecht	BITNET			
Switzerland				
CERN	BITNET	INFNET	C.B.	USENET
United Kingdom				
Birmingham University			JANET	
Bristol University			JANET	
Cambridge University			JANET	
Daresbury Laboratory			JANET	
Edinburgh University			JANET	
Glasgow University			JANET	
Imperial College			JANET	
Lancaster University			JANET	
Liverpool University			JANET	
Manchester University			JANET	
Oxford University			JANET	
Queen Mary College			JANET	
Rutherford laboratory			JANET	
Sheffield University			JANET	
Southampton University			JANET	
Surrey University			JANET	
Sussex University			JANET	
University Coll. London			JANET	