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First Annual Workshop
on
Energy Research Computing

The Future of Intersite Networking

October 27–28, 1986
Lawrence Berkeley Laboratory
Berkeley, California

November 1986

Information and Computing Sciences Division
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

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November 6, 1986

Dear Colleague,

Enclosed are copies of the viewgraphs that were presented at the recent LBL workshop on Intersite Networking. A copy of the agenda, written summaries of three of the four discussion groups, and an updated version of the attendance roster are also included.

Thank you for attending, and helping to identify strategies for for meeting the future networking needs of OER scientists.

Yours sincerely,

Leroy T. Kerth
Associate Director for Information and Computing Sciences
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Contents

1st ANNUAL WORKSHOP

on

ENERGY RESEARCH COMPUTING

THE FUTURE OF INTERSITE NETWORKING

October 27-28, 1986
Lawrence Berkeley Laboratory

Monday October 27

08:30	WELCOME	LT Kerth
	WORKSHOP GOALS	JS Cavallini
09:00	**ENERGY RESEARCH and COMPUTER NETWORKING**	
	Session Chairman	P Messina
09:00	BES, Chemistry	R Bair
09:30	BES, Materials	D Koelling
10:00	Break	
10:30	HENP	SC Loken
11:00	MFE	TA Casper
11:30	OHER	C Watson
12:00	Lunch	
1:00	**CURRENT AND FUTURE WIDE AREA NETWORKS**	
	Session Chairman	A Peskin
1:00	MFENET	J Leighton
1:30	HEPNET	H Montgomery
2:00	NASnet	A Ollikainen
2:30	Break	
3:00	NSFnet	S Wolff
3:30	DOE National Networks	DE Scott
4:00	**THE ER DISTRIBUTED COMPUTING ENVIRONMENT**	
	Session Chairman	C Quong
	FSU	K Hays
	ANL	L Amiot
	BNL	G Rabinowitz
	FNAL	G Chartrand
	LBL	LT Kerth
5:15	**Adjourn to LBL cafeteria**	
6:30	**Shuttle Buses Depart to Spengers Restaurant, Berkeley**	

Tuesday October 28

08:30	NEW TECHNOLOGIES	
	Session Chairman	K Hays
08:30	A View of European Networks	D Williams
09:00	Internet Workings and Science Research Networks	B Leiner
09:45	Fermi Networkshop Summary	G Brandenberg
10:15	Break	
10:30	BITNET	L Cottrell
11:00	Electronic Mail	V Jacobson
11:30	New LAN Technology	RL Fink
12:00	Group Discussion Briefing	DE Hall
12:15	Lunch	
1:30	**PARALLEL GROUP DISCUSSIONS**	
	Group A	H Montgomery
	Group B	A Ollikanian
	Group C	J Fitzgerald
	Group D	P Messina
3:00	Break	
3:30	Next ER Workshop	WA Lokke
3:45	**DISCUSSION SUMMARIES**	
	Session Chairman	DE Hall
	Group A	AX Merola
	Group B	J Leighton
	Group C	G Campbell
	Group D	FM Atchley
5:00	CLOSING REMARKS	LT Kerth
5:30	**Shuttle Buses depart to local hotels**	

Group A

Members of this discussion group will address the question: *What new network functionality and performance demands will be placed on ER network facilities by future energy research?*

Group B

Members of this discussion group will address the question: *How can existing ER networking facilities, both owned and subscribed, be consolidated to reduce communications costs and confustion?*

Group C

Members of this discussion group will address the question: *To what extent can commercial networks and products provide ER networking facilities?*

Group D

Members of this discussion group will address the question: *What new facilities are needed to meet the security problems surrounding increased networking within the ER community?*

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November 2, 1986

ENERGY RESEARCH COMPUTING WORKSHOP
THE FUTURE OF INTERSITE NETWORKING

Parallel Session A

Parallel Session A attendees were asked to address the question: "What new network functionality and performance demands will be placed on the E.R. Network Facilities by future energy research?"

Only 18 workshop attendees were asked to attend this session. The fact that over 30 workshop attendees were present at this session is indicative of the high level of interest concerning this subject.

Right from the start of this session it was clear that no scientist wanted networking to be in the way of his scientific computing. The closer a network was to being totally transparent, having infinite bandwidth, and being very cheap, the more appealling it would be to the E.R. Scientific Community.

It was apparent that almost all segments of our community have parochial views (perhaps appropriately) about use of computing and networking facilities. Should a network be forced to carry "phone" traffic? Should a CRAY be used for text editing? This type of activity impacts not only the way an individual computes, but also has an affect on the limited resource to the remainder of the community.

Summary:

There were two general statements made concerning the general performance and functionality requirements for E.R. Network Functionalities which are well worth quoting.

- "What we can do on LANs today is indicative of what we wish to be able to do on wide area networks."
- "Just as we expect a computer to perform as if we are the only user, we expect the network to give that same appearance."

Direct or Virtual Terminal Access:

Full screen editing and byte echoing must be supported such that remote terminal access appears as if it were local. A minimal number of "set hosts" should be required to access any given remote site. The data path should be fully transparent and support the full 8 bit character set. There is an intuitive point of view which requires a 56 KB line to interconnect any two sites supporting more than 20 distributed users.

File Transfer:

There should be both prioritization and interleaving of files such that long files do not leave short files waiting for their completion. Delayed scheduling of long file transfers should be permitted and encouraged for the same reason. As far as CRAY access is concerned, a network must be capable of delivering 20 megabytes every 10 minutes to give the feeling to the user that the CRAY is online.

Mail:

Mail systems must support name servers, mail forwarding, receipt confirmation, and ease of mail sorting. Some users would like to see mail delivery take place within minutes, while other users did not see that rapid mail delivery was a great advantage. Mail conferencing is seen as a useful facility in support of scientific collaborations.

RJE:

Network Remote Job Entry should require the users to access only a local queue. Typical management functions would include job inquiry and job purge ability.

Interprocess Communication:

The Scientific User Community is anticipating that networks would allow for process to process communications, permitting direct access to the network at the user level. Distributed editing and distributed computing would certainly allow more effective use of existing facilities.

Network Applications:

Members of this session recognize that many applications are so integrated into the network that they are seen as network services. A future network must not simply allow, but must indeed support, such facilities as: distributed code management, standardized distributed graphic systems, and a full range of printers, including laser printers. The bottom line is that the network must be very transparent, and that networking services be developed to fully support our distributed facilities.

Network Management:

Network management is important to insure the operability of all distributed resources. Those responsible for operating the network must be fully trained as to its total configuration, and must have tools at their fingertips to isolate problems and project future networking needs.

Futures:

It is a very reasonable observation, that this group is only beginning its work. It was recognized that a process needs to exist whereby the scientific user community can provide input and receive feedback from those responsible for our future E.R. Networking Services.

Summary of Recommendations of Network Cosolidation Discussion Group

J. Leighton

The group was asked to address the question: How can existing ER networking facilities, both owned and subscribed, be consolidated to reduce communications costs and confusion? Instead, the group chose to redefine the question. The question addressed was: *Should existing ER networking facilities, both owned and subscribed, be consolidated to reduce communications costs and confusion?*

Arguments in favor of consolidation were:

1. If a way to consolidate isn't found, one may be forced. This may be worse than voluntarily consolidating.
2. Future (but unknown) benefits may accrue.
3. The network overseer may be able to consolidate funding for small projects that could not be attempted separately.
4. Consolidation may result in performance enhancements and cost savings.
5. An overseer with a global viewpoint might recognize opportunities that are not apparent at "ground level" (i.e. to individual managers of small networks).

Arguments against consolidation were:

6. Voluntary sharing incurs too much overhead.
7. It is difficult for an overseer body to respond to short-term requirements.
8. Consolidation constrains everyone to the same technology. This could produce reliability problems.
9. The emphasis on optimizing facilities is misguided. Otimization should focus on people, not facilities.

The following observations were made:

10. The philosophy of sharing should be to consolidate facilities only where it makes sense to do so. A single sloution should not be insisted upon.
11. Users want functionality and connectivity. They don't really care about protocols.
12. Sharing nearly always causes some pain:
    - How much pain should be tolerated to provide for the common good.
    - What is the reward for sharing?
13. The question itself is unfair. HEPnet has paid for each of its link out of indiviual budgets. These links are actively used.
14. There is sharing already going on between HEPnet and MFEnet.

In response to the original question, the following techniques for consolidation of facilities were identified:

15. Circuit splitting, i.e. multiplexing techniques for sharing raw communications bandwidth.
16. Link level sharing, e.g. ethernet bridges.
17. Network level sharing, e.g. IP gateways.
18. Application level sharing, e.g. Argonne's multi-network file transfer and LBL's consolidated mail system.

Conclusions:

19. There is no real consensus on the value, implications, or limits of consolidation.

Graham Campbell

SUMMARY OF THE DISCUSSION GROUP ON

COMMERCIAL NETWORKS AND PRODUCTS FOR ENERGY RESEARCH NETWORKING

Participants:

George Rabinowitz - BNL
Mark Kaletka - MIT-LNS
John Fitzgerald - LLNL/MFECC - Discussion Chairman
John Wooten - ORNL
Harvey Newman - Cal Tech
William Wells - UCB
Jerry Johnson - PNL
Wayne Wood - ORNL
Tom Dunigan - ORNL
Graham Campbell - BNL - Summarizer

It should be understood that this summary represents the understanding of the summarizer, which is not necessarily the same as the understanding of the participants. Although I believe the contents of the discussions to be correctly reflected in the summary, the organization of the summary does not reflect the (dis-)organization of the discussions.

The task of the Energy Research Network was perceived to be:

1) The serving of existing requirements more effectively and for less cost.

2) To look to the future needs of the community.

Underlying this was the assumption that several communities of interest currently exit organized primarily along protocol lines (e.g. Bitnet, Decnet, MFEnet, etc.), and that there is no strong need for intercommunication at the present time. However such intercommunication will be an eventual requirement. The subject of discussion was defined to be: Are there commercial products that will reduce the cost and effort of constructing an ERnet?

The discussions can be divided into the three topics:

1) What is the role of commercial packet switching networks?

2) Is there commercial equipment that can be used to build and manage ERnet?

3) Are there commercial products to promote communication between protocol groups?

The pluses of commercial networks seem to be limited to providing good geographic coverage, while the minuses are that they are expensive, terminal oriented, and unable to supply high bandwidth. The terminal orientation and limited bandwidth would seem to be due to engineering choices made in design of these networks, not to inherent features of their architecture. Their primary market is in supplying terminal access to mainframes and where provision of high speed computer to computer links, such as required by ERnet; conflicting with that primary market, they are unwilling or unable to provide adequate service. As a result, the role foreseen for commercial networks is in providing additional geographic coverage for terminal access to computers on the network, which is a minor, but a valuable role.

The point was strongly made and generally agreed to in the discussion, that commercial equipment could be used to provide media level communication.

What was envisioned was a backbone of communication services supplied to the various protocol communities using commercially available equipment. The fact that this equipment does exist and can provide these capabilities, was demonstrated by a spec sheet from Telefile Computer Products about an X.25 switch that could handle more than 1100 packets/second and use up to 153 Kb links for a cost of about $14,000. It was generally felt that a network could be constructed rapidly using such equipment and would provide assurance that existing protocol communities could use the facilities with a minimum of effort. The discussion revealed no awareness of commercial products to enhance communication between protocol groups, however it was generally felt that these would be coming soon based on ISO protocols, and that the long term future lies in planning to convert to these protocols as they become well supported. Although not directly in the charter of this discussion group, the role of MFEnet II in ERnet was discussed. The point was made that the MFEnet II development was necessary even if it did not participate in ERnet. However the general viewpoint was that MFEnet II would present the various communities great difficulties in satisfying current needs. The basic problem that was foreseen is in conversion of current usage to adapt to MFEnet II.

Summary of Recommendations of Network Security Discussion Group

F. M. Atchley

> *" The safest policy in using networks is to assume that any network can be broken, that any transmission can be recorded, and that most can be forged. "*
>
> John Quarterman ACM 10/86

The group was to address the question: What new facilities are needed to meet the security problems surrounding increased networking within the ER community?

General consensus was reached upon the following new facilities:

1. In order to trace unauthorized entries and/or attempts, networks must provide information on the specific origin and path of remote sessions.
2. Networks must support encryption in a transparent or user invoked manner.
3. Sessions disconnects should disconnect the entire virtual circuit. Some modes of disconnect currently leave incoming ports enables for a vulnerable period.
4. Network managers should have the tools to logically cut off a node. Although it is unlikely that a site would not cooperate in preventing network access by a suspected hacker, such a tool would allow immediate action during off- hours.
5. Networks must provide the facility to timeout idle network circuits, similar to the facility offered by most computer systems that will timeout interactive users when their terminal is inactive for a period of time.
6. As it is now possible for one Ethernet host to masquerade as another, we recommend the technology be modified to prevent it.
7. On international circuits, do not allow files to be "pulled" from country to country. i.e. "proxy" access is not allowed. Sending or "pushing" of files is the only permissible technique of file transfer. This ensures that only U.S. validated users are accessing files.

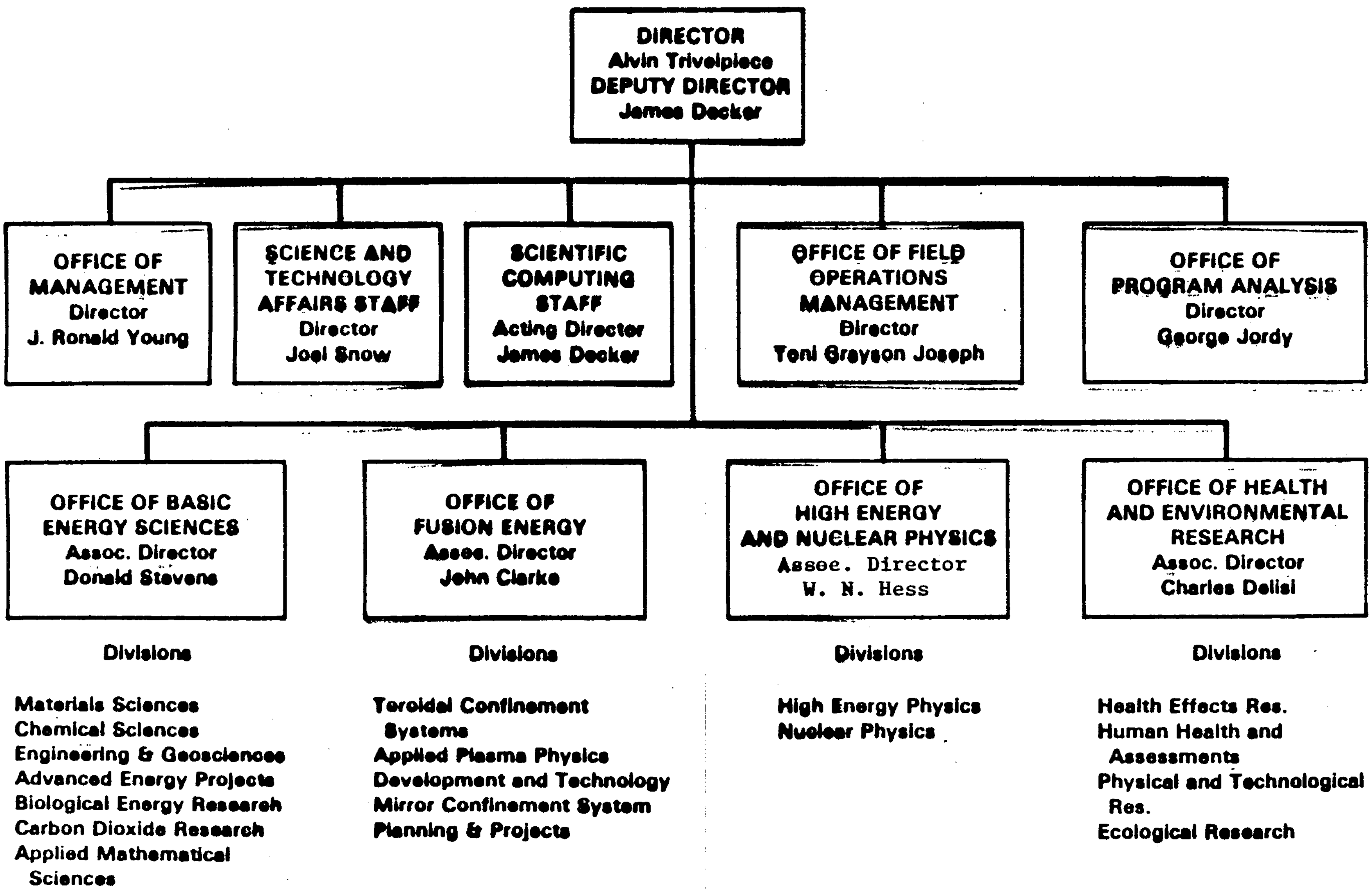
Much of the discussion focused on procedures and management issues rather than new facilities. The recommended procedures were:

8. Unauthorized users often go undetected because no one is looking for them. Management should assign specific responsibility for active intruder seeking in their organizations. This person would spend an appropriate amount of time looking both for breakin attempts, and for logins that have been compromised by an intruder.
9. Because of the difficulty in obtaining cooperation from out-of-state law enforcement officials for computer breakins, we should actively seek federal legislation. (Note: a federal computer crime law may have been passed this year by congress.)
10. Don't use electronic mail for security information - hackers have been observed reading mail.
11. Enforce good password management on your own computer system - the most important and most effective means of protection. While network security measures may filter out many potential intruders, the only secure barrier is at your own machine. Academic computer users who formerly regarded computer security as unnecessary bureaucracy are now supporting it for their own protection.

DEPARTMENT OF ENERGY

JOHN S. CAVALLINI
OFFICE OF ENERGY RESEARCH

DEPARTMENT OF ENERGY
OFFICE OF ENERGY RESEARCH



OFFICE OF ENERGY RESEARCH APPLIED MATHEMATICAL SCIENCES PROGRAM

- MATHEMATICAL SCIENCES RESEARCH ACTIVITY

  MISSION — TO CONDUCT FUNDAMENTAL RESEARCH IN THE MATHEMATICAL SCIENCES FOCUSING ON PROBLEMS AND COMPUTATIONAL ISSUES OF PARTICULAR INTEREST TO DOE

- ENERGY SCIENCES ADVANCED COMPUTATION ACTIVITY

  MISSION — TO PROVIDE STATE-OF-THE-ART SUPERCOMPUTING TO ALL ER PROGRAMS

- LAX REPORT
- CREATION OF SUPERCOMPUTER INITIATIVES
  - NSF - 5 CENTERS
  - DOE - EXPANSION OF ER PROGRAM
  - NASA - CREATION OF NAS CENTER
- HS&T COMMITTEE HEARING, JUNE 1985 HIGHLIGHTED IMPORTANCE OF NETWORK ACCESS
- FCCSET - NETWORK WORKING GROUP REPORT, FEBRUARY 1986 RECOMMENDATION FOR INTERAGENCY INTERNET CONCEPT
- NSF APPROPRIATIONS BILL - MANDATED COMPUTER NETWORK STUDY

IMPORTANCE OF NETWORKING TO SCIENTIFIC RESEARCH

- ENHANCES COLLABORATIVE RESEARCH EFFORTS ACROSS INSTITUTIONS
- PROVIDES ACCESS REMOTE RESEARCH FACILITIES
- PROVIDES ACCESS TO CENTRALIZED SCIENTIFIC INFORMATION BANKS
- PROVIDES ACCESS TO SUPERCOMPUTER SYSTEMS

APPROACH TO CONGRESSIONAL NETWORK STUDY

- o ACCESS REQUIREMENTS
  - SOLICIT PLANNING DOCUMENTS
  - ANALYZE CURRENT PLANS
  - WORKSHOP DISCUSSION OF ANALYSES

- o WHITE PAPERS TO ASSESS TECHNOLOGY
  - USER CAPABILITIES, ESPECIALLY FOR SUPERCOMPUTING
  - MEDIA AND COMMUNICATIONS
  - LOCAL AREA NETWORKS
  - GATEWAY TECHNOLOGY

- o SEEK CONSENSUS ON MANAGEMENT ISSUES
  - POSITION PAPERS ON IMPORTANT TOPICS
    - STANDARDS
    - INTERNET CONCEPTS
    - GOVERNMENT ROLE
  - SMALL WORKSHOPS SEEKING CONSENSUS
  - PANEL DISCUSSIONS

MILESTONES FOR CONGRESSIONAL NETWORK STUDY

- DECEMBER 1, 1986 - REQUIREMENTS AND PLANS RECEIVED
- JANUARY 15, 1987 - WHITE PAPERS AND REQUIREMENTS ANALYSIS
- FEBRUARY 17-19, 1987 - WORKSHOP AT SAN DIEGO SUPERCOMPUTER CENTER
- MARCH 15, 1987 - FIRST DRAFT
- APRIL 10, 1987 - FINAL REPORT

ENERGY SCIENCES NETWORK PLAN

- GOAL IS TO PROVIDE INTEROPERABILITY FOR ALL ENERGY RESEARCH PROGRAMS
- STANDARDIZE ON DOD ROUTING PROTOCOLS - TCP/IP - AS INTERIM TO ISO STANDARDS
- USE EXISTING MFENET BACKBONE FOR ER REQUIREMENTS WHERE POSSIBLE
- REDESIGN MFENET TO OPEN ARCHITECTURE, USING IP GATEWAY TECHNOLOGY
- MANAGE ESNET AS AN ER INTERNET THROUGH ER SCIENTIFIC COMPUTING STAFF
- COORDINATE REQUIREMENTS AND ACTIVITIES THROUGH AN ER-WIDE STEERING COMMITTEE

ESNET Steering Committee

Document, review and prioritize network requirements for all ER programs.

Advise NMFECC Network staff.

Ensure ESNET concept is workable.

Identify research needs for addressing network requirements.

Propose innovative techniques for enhancing ESNET capabilities.

Multi-Resource Computing

A User's Tour of Networking

Raymond A. Bair
Chemistry Division
Argonne National Laboratory

1st Annual Workshop on Energy Research Computing
The Future of Intersite Networking

October 27-28, 1986
Lawrence Berkeley Laboratory
Berkeley, California

Theoretical and Computational Chemistry Program

Program effort = 10.3 FTE

Fundamental studies of chemical reactivity

- elementary chemical reactions
- energetics, mechanisms & rates of reactions
- oxidation of simple hydrocarbon fuels

Ex: Oxidation of hydrocarbons and nitrogen

$$O + HCCH \leftrightarrow [OHCCH]^{\ddagger} \rightarrow H + HCCO$$
$$\rightarrow CO + CH_2$$
$$\rightarrow OH + CCH$$

$$CH + N_2 \leftrightarrow [HCNN]^{\ddagger} \rightarrow HCN + N$$

Quantum chemistry computations

- *ab initio* potential energy surfaces (ANL-QUEST)
- global surface representation
- reaction pathways
- classical trajectory & transition state theory
- quantum dynamics

Computational Chemistry Aspects

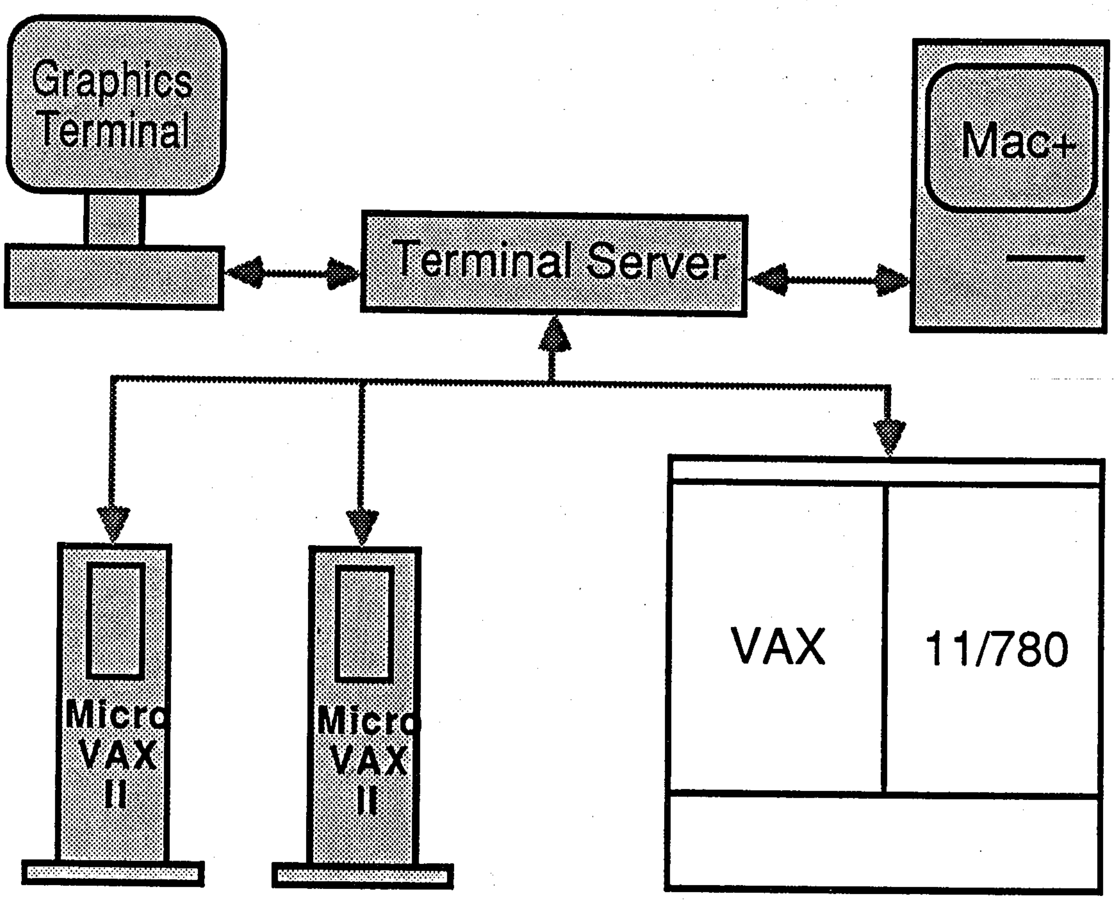
Quantum chemistry codes for supercomputers

- support theoretical studies
- develop new techniques and codes
- optimize for advanced computers
- researcher interfaces

Production calculation characteristics

- run times of 1–8 FPS-164 hours
- 100-1000 calculations per study
- major codes are vectorizable (lengths 10-1000)
- simple kernels: dot product, saxpy, M×V, M×M
- large memory (2-100 Mword)
- out-of-core methods are I/O intensive

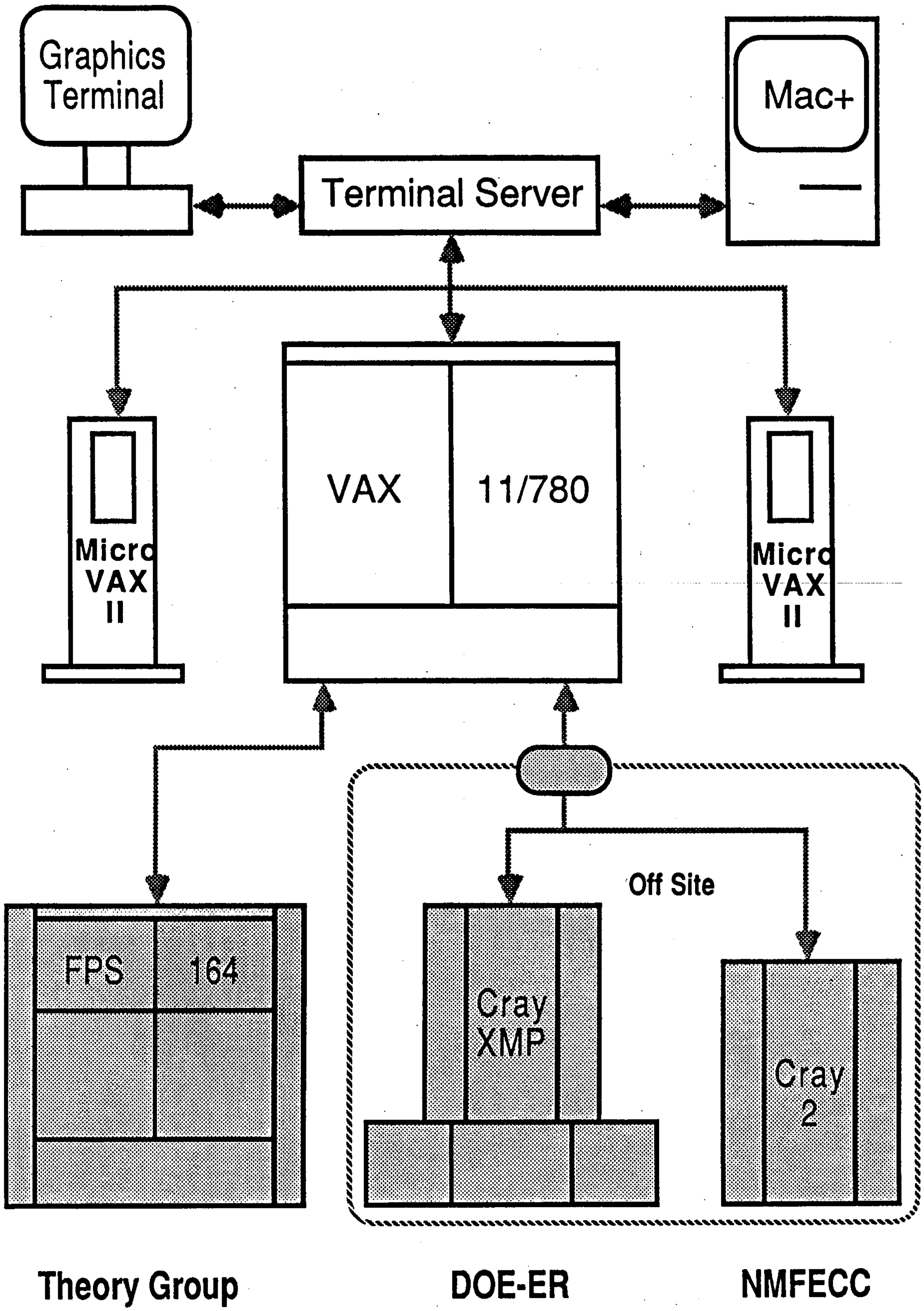
Front End Interactive Systems



Theory Group

Chemistry Division

TCG Large Scale Chemical Computations



TCG Networking Resources

Chemistry Divisional Network

- Ethernet with DECnet protocol
- 45 computational nodes (VAX, PDP, Nova)
- 5 DEC terminal servers

Sitewide Networks

- NJE star network to IBM 3033s
- DECnet router - 10 divisions

Intersite Networking

- MFEnet (56 Kbaud)
- Bitnet
- ARPAnet
- other private and commercial networks
- other networks and domains via gateways

TCG Utilization of MFEnet to Access ER Cray

Highly interactive chemical dynamics research

- Remote login from TCG MicroVAX or CHM VAX
- Transport of codes and input data to NMFECC
- Transport of final output to local microVAX or VAX
- Transport of intermediate results to local VAX for further analysis

Immediate Future

- Expand batch component of dynamics research
- Larger files transferred over network

Additional TCG Utilization of MFEnet

- Semi-interactive development of electronic structure codes for Cray-XMP and Cray-2
- Exchange of codes and data with colleagues
- Electronic mail
- Collaborate with off-site colleagues on common computer

Usage patterns restricted by resources at NMFECC

- Incompatible graphics software
- Rudimentary editors
- Non-networking problems

Critical Enhancements to MFEnet / NMFECC

- **All network services available over DECnet**
- **Suspend & resume remote interactive sessions**
- **Remote batch job submission & control**
- **User notification of data transmission problems**
- **Transmit multiple files simultaneously**
- **Default destinations and directories**

Important Enhancements to MFEnet

- Additional sites connected
- Greater network uptime
- NETTY able to run from VMS EMACS window
- File dispatch and arrival notices on any node
- Mail forwarding and VMS mail interface

```
%NETTY-E-SYS$INPUT, SYS$INPUT is NOT assigned to a terminal
%TERM-E-OUTBAND_ENABLE, Failed to enable out-of-band AST for SYS$INPUT
-SYSTEM-F-IVCHAN, invalid I/O channel
```

TCG Utilization of Future National Network

- **Remote login and full network data services**

  major university sites
  supercomputer resource centers
  national laboratories
  international links

- **Local tasks access remote files**
  (and *vice versa*)

- **Remote graphics generation**

  industry standard metafile
  exchange with colleagues
  display at any node with graphics hardware

- **Day to day intersite collaboration**

  research
  code development
  publications (manuscript metafiles)

National Network Characteristics

- High performance network backbone
- Local nodes have highly developed user interface
- Friendly interface for network operations
- Networks tie computer hierarchy together
- Computations are performed with resource which makes effective use of researcher and computer time

Networking and the Materials Scientist

D.D.Koelling
Staff Physicist
Materials Science Division
Argonne National Laboratory

(And a cast of...well, some.)

Why network?

1>Electronic Mail--this is an amazingly cost effective aid that is very important (and comparatively easy to achieve)

2>To connect the worker to a remote CPU--this makes the supercomputer an unusual user facility in that he need not travel to it.

3>MAYBE to connect CPU to CPU (may require too wide a bandwidth--tapes by Road Runner may remain the best bet for some)

Facilities Model

The Supercomputer **--this is the user facility that achieves number crunching. It should be optimized for that task alone!**

The front-end **--the data concentrator and manager for the supercomputer (final preparation/editing and even compiling is done here)**

The analysis machine(s) **-- proximity to the super only requied to ease data transmission difficulties.**

The workstation **-- this is the <u>tailorable</u> interface to the researcher. Major editing should be done here. Here is where master copies reside.**

The network should be-

Fast....

Accurate

Reliable

Transparent

Extensive

Flexible

Major Calculations--

Statistical Physics

Molecular Dynamics
Monte Carlo

Electronic Structure

Band Structure
Clusters
"Many-Body"

Combined!

Materials Science codes

*>are intermediate in size (500-10000 lines)

*>are constantly evolving

Materials Science data

*>Transmitted datasets are normally under 2000 lines.

*>Intermediate datasets are in the 1-100-1000 megaword range and growing.

*>Graphic analysis is needed, in its infancy, and growing.

HIGH ENERGY and NUCLEAR PHYSICS

RESEARCH PROGRAM

COMPUTER USAGE

NETWORK REQUIREMENTS

STEWART C. LOKEN

SENIOR STAFF SCIENTIST

PHYSICS DIVISION

LAWRENCE BERKELEY LABORATORY

UNIVERSITY OF CALIFORNIA

BERKELEY, CALIFORNIA 94720

NUCLEAR SCIENCE

ELEMENTARY EXCITATIONS

NUCLEAR SYMMETRIES

HIGH SPIN and EXOTIC NUCLEI

NUCLEONS and OTHER HADRONS IN NUCLEI

QUARKS and QCD IN NUCLEI

STRANGENESS IN NUCLEI

ELECTROWEAK INTERACTION AND BEYOND

MACROSCOPIC PHENOMENA

EXTREME STATES OF NUCLEAR MATTER

NUCLEI AND THE UNIVERSE

FACILITIES for NUCLEAR SCIENCE

Intermediate Energy Accelerators

- Los Alamos Meson Physics Facility (LAMPF)
- Bates Electron Accelerator Center at MIT
- Indiana University Cyclotron Facility

Heavy Ion Accelerators

- Double MP Tandem Accelerator at Brookhaven
- 88-Inch Cyclotron at LBL
- Holifield Heavy-Ion Research Facility (ORNL)
- Argonne Tandem-linac Accelerator System
- National Superconducting Cyclotron Lab (MSU)
- Bevatron Complex at LBL

Dedicated University Facilities

High Energy Physics Facilities

- Hypernuclear Spectrometer at the AGS (BNL)
- End Station A at SLAC

Some Examples:

Production of heavy elements in heavy ion interactions

Studies of nuclear structure at high angular momentum
using precise solid state detectors

Study of nuclear matter at high temperature
using heavy ion collisions

Search for muon decay to electron-gamma at LAMPF

Production of hypernuclei in K-nucleus collisions

Study of electron scattering from nuclei

Study of multiparticle states in heavy-ion collisions
nuclei, pions, leptons, ...

Search for neutrino oscillations at reactors

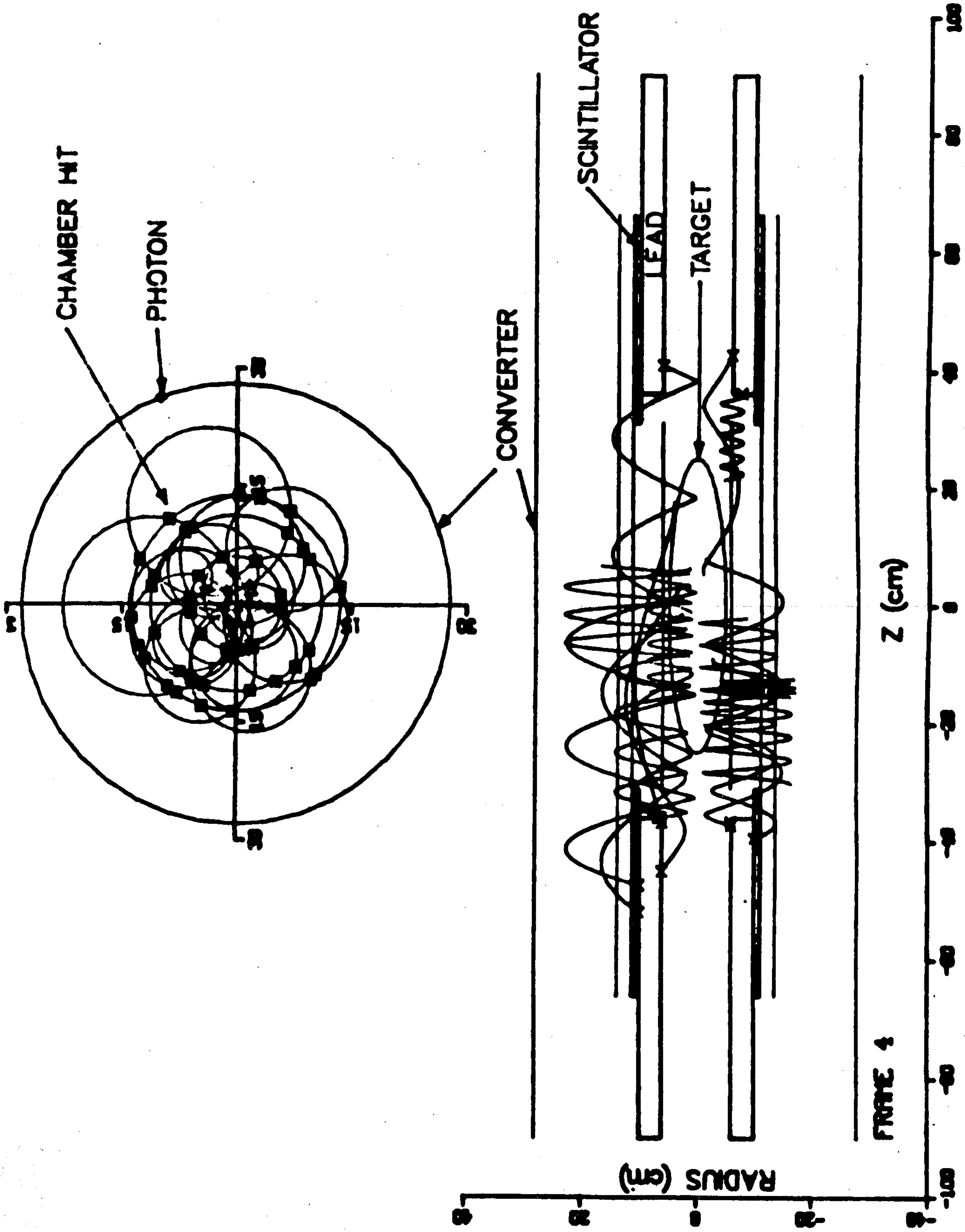


Fig. 15. **A typical positron event in the central chamber.**

NUCLEAR SCIENCE

FUTURE FACILITIES

CEBAF (Electron Accelerator)

RHIC (Relativistic Heavy Ions)

FACILITY UPGRADES

Bates Electron Accelerator

Bevatron

INTERNATIONAL PROGRAMS

CERN Heavy Ion Experiments

International collaborations in the US

RESEARCH IN HIGH ENERGY PHYSICS

Motivated by very successful theory

- **Electroweak interaction (W and Z)**
- **QCD (Quarks and Gluons)**

Tests of theory

- **eg. rare decays**
- **QCD tests in jets**

Spectroscopy

- **especially particles made with heavy quarks**

Searches for new particles

- **eg. Higgs particle**
- **eg. supersymmetry**

FACILITIES FOR HIGH ENERGY PHYSICS

COLLIDING BEAMS

Tevatron antiproton-proton collider

PEP

SLC

FIXED TARGET FACILITIES

Tevatron proton accelerator

Brookhaven AGS

SLAC

LAMPF

INTERNATIONAL FACILITIES

CERN Antiproton-proton Collider

LEP

Tristan

CERN Fixed Target Facility

TRIUMF

COMPUTING IN A LARGE EXPERIMENT

Very large collaborations (in many countries)

eg. 100-400 physicists

Software developed by 30-100 people

Some groups use formal design techniques (SA/SD)

Design documents distributed by network

Public code for analysis and Simulation (100-500K lines)

Software effort more than 100 man-years

Libraries maintained at one institution

and distributed to all collaborators by tape or network

Software evolves as more is learned about detector

One year's data fill 1000-10000 tapes at 6250 bpi

and 106 to 10**8 triggers**

Analysis time of 100-300 sec on "VAX 780"

Calibration databases of 100-500 Kbytes

monitored and updated daily or weekly

Experiment runs for many years

THE DØ COLLABORATION

S. Aronson, B. Gibbard, H. Gordon, W. Guryn,
S. Kahn, S. Prototopescu and P. Yamin
Brookhaven National Laboratory

D. Cutts, J. Hoftun, R. Lanou, D. Pilipovic and R. Zeller
Brown University

J. Anjos, A. Santoro and M. Souza
Centro Brasileiro de Pesquisas Fisicas (CBPF)

P. Franzini, P.M. Tuts and S. Youssef
Columbia University

F. Borcherding, A. Bross, C. Brown, W. Cooper, B. Cox,
G. Dugan, D. Eartly, H. Fenker, D. Finley, E. Fisk, D. Green,
H. Haggerty, S. Hansen, A. Ito, M. Johnson, A. Jonckheere,
H. Jostlein, P. Koehler, E. Malamud, P. Martin, P. Mazur,
J. McCarthy, T. Oshima, R. Raja, R. Smith and R. Yamada
Fermi National Accelerator Laboratory

H. Goldman, S. Hagopian, V. Hagopian,
S. Linn, D. Kaplan and H. Wahl
Florida State University

R. Crittendon, A. Dzierba, T. Marshall,
J. Martin, A. Zieminski and D. Zieminska
Indiana University

A. Clark, O. Dahl, W. Hofmann, L. Kerth,
C. Klopfenstein, S. Loken, R. Madaras, P. Oddone,
M.L. Stevenson, M. Strovink, T. Trippe, and W. Wenzel
Lawrence Berkeley Laboratory

S. Kunori and P. Rapp
University of Maryland

M. Abolins, D. Edmunds, J. Linnemann, D. Owen, B. Pi,
B. Pope, S. Stampke, M. Tartaglia and H. Weerts
Michigan State University

J. Christenson, P. Nemethy, D. Nesic, and J. Sculli
New York University

D. Buchholz, D. Claes, B. Gobbi and S. Park
Northwestern University

E. Gardella, W. Kononenko, W. Selove, G. Theodosiou,
R. Van Berg and W. Zajc
University of Pennsylvania

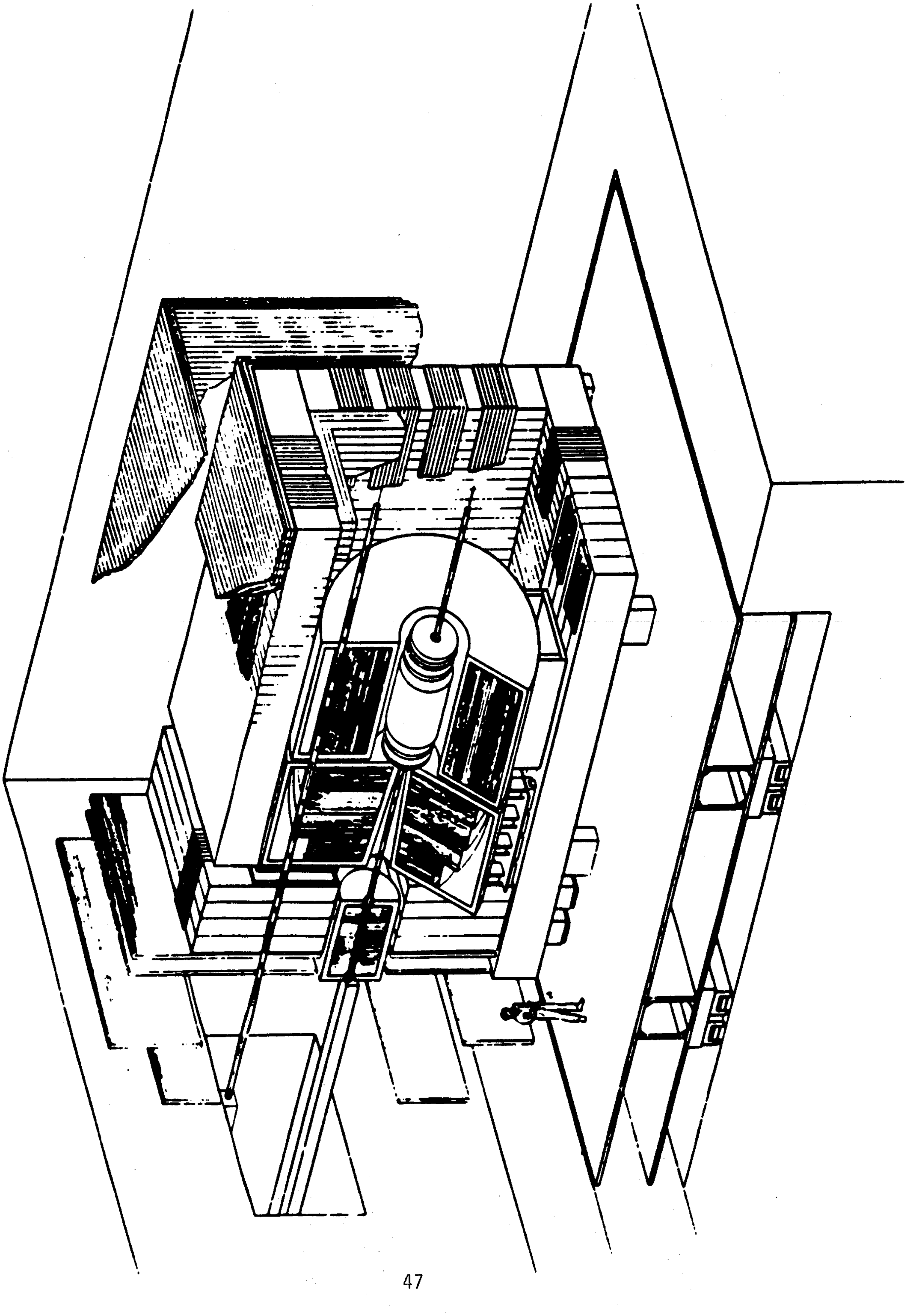
G. Fanourakis, T. Ferbel, F. Lobkowicz and P. Slattery
University of Rochester

Y. Ducros, R. Feinstein, R. Hubbard, P. Mangeot,
B. Mansoulié, J. Teiger, and A. Zylberstejn
CEN Saclay

E. Barasch, T. Behnke, R. Engelmann, G. Finocchiaro, M. Good,
P. Grannis, D. Hedin, J. Lee-Franzini, M. Marx, R. McCarthy,
K. Ng, K. Nishakawa, M. Rijssenbeek, and R. Schamberger
State University of New York

N. Hadley and M. Zeller
Yale University

Collaboration with Tata Institute of Fundamental Research (Bombay, India) has been approved in principle.



FUTURE FACILITY FOR HEP

SSC proposed for construction start in FY88

Operational in FY94 or 95

Detector effort much larger than current experiments

Very large international collaborations

on experiments and on accelerator

Software effort also much larger

ACTIVITIES

THEORY

Formal Theory eg. **Superstrings**

Computational eg. **Lattice Gauge Theory**

PHENOMENOLOGY

Compare data to experiment

Predict phenomena in new energy range

DATA COMPILATION

Compare experiments

Maintain databases

EXPERIMENT

Accelerator Experiments eg. **Electron-positron**

Non-accelerator Experiments eg. **Proton-decay**

DETECTOR DEVELOPMENT

Prototypes of new detectors

Design of new experiments

ACCELERATOR R&D

Development of new devices eg. **magnets**

Accelerator design eg. **beam dynamics**

COMPUTING ACTIVITIES

THEORY

Supercomputers

Specialized microprocessor arrays

PHENOMENOLOGY

General-purpose scalar computers

Vector supercomputers

DATA COMPILATION

General-purpose computers

EXPERIMENT

Data-acquisition computers

Large parallel arrays

DETECTOR DEVELOPMENT

Data-acquisition for testing detectors

Engineering calculations eg. Finite Element

ACCELERATOR R&D

CAD

Vector supercomputers for beam orbit

SOFTWARE USED

THEORY

Single large program

PHENOMENOLOGY

Small calculations

DATA COMPILATION

Commercial database products

EXPERIMENT

Commercial (SA/SD,CMS,Databases,Graphics)

Analysis program developed by many physicists

DETECTOR DEVELOPMENT

Small programs

Engineering programs

ACCELERATOR R&D

Engineering programs

Large tracking codes

NETWORKING ACTIVITIES

THEORY

Networking to supercomputers

International collaboration using mail

PHENOMENOLOGY

Remote computer access

Mail

DATA COMPILATION

Shared databases

File transfer

EXPERIMENT

Shared libraries or databases

Remote interactive graphics

DETECTOR DEVELOPMENT

File transfer to computer center for analysis

Remote access

ACCELERATOR R&D

Supercomputer access

Remote graphics

Existing Networks

Data Switches

DECNET

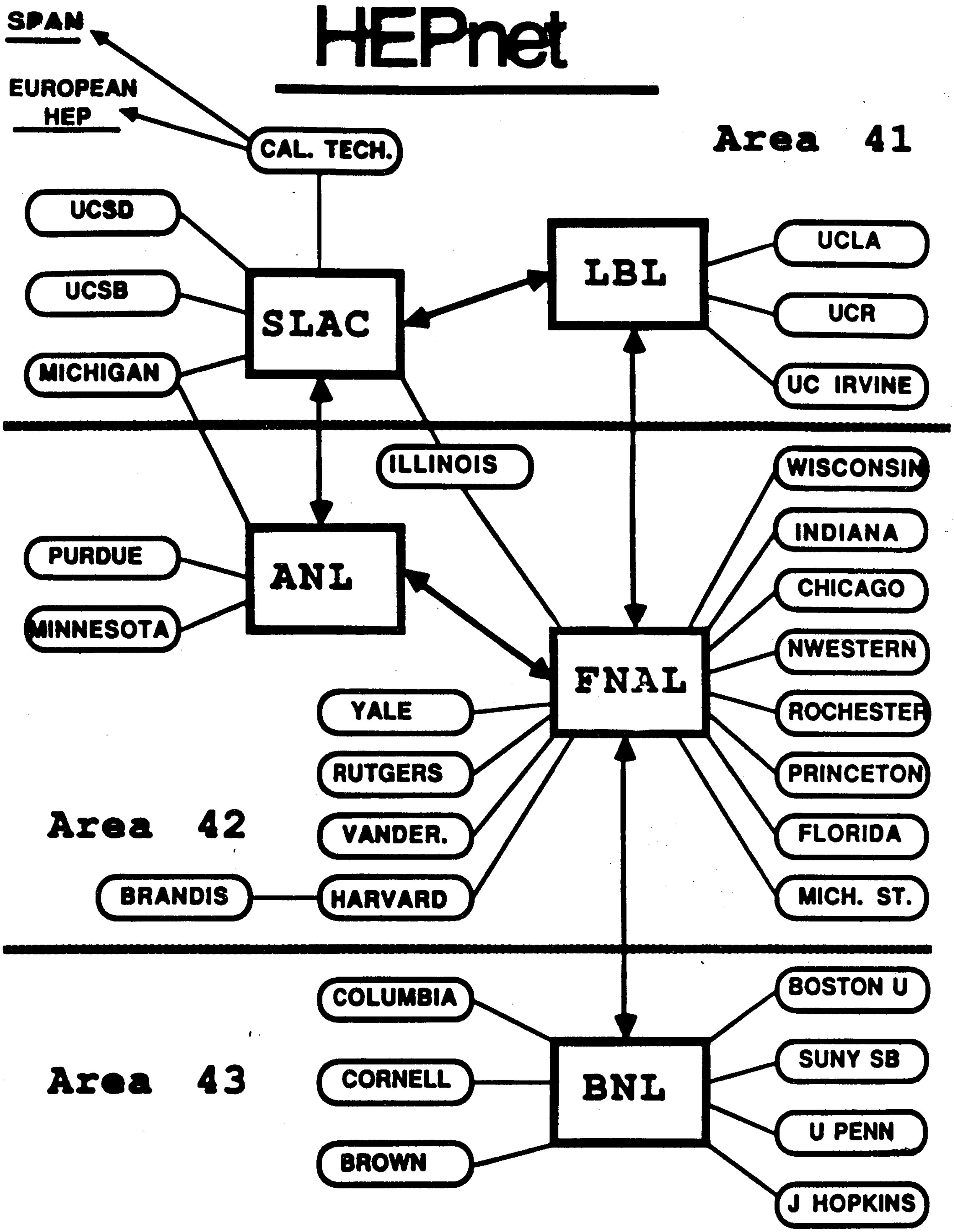
BITNET

Coloured Books / X.25

MFENET

MILNET (ARPANET)

ScienceNET


HEPnet
SPAN
EUROPEAN HEP
CAL. TECH.
Area 41
UCSD
UCSB
MICHIGAN
SLAC
LBL
UCLA
UCR
UC IRVINE
ILLINOIS
WISCONSIN
ANL
PURDUE
MINNESOTA
INDIANA
CHICAGO
NWESTERN
FNAL
YALE
ROCHESTER
RUTGERS
PRINCETON
Area 42
VANDER.
FLORIDA
BRANDIS
HARVARD
MICH. ST.
COLUMBIA
BOSTON U
SUNY SB
Area 43
CORNELL
BNL
U PENN
BROWN
J HOPKINS

Character of Network Use

Direct Terminal Access

Virtual Terminal Access

Mail

Phone

File Transfer

Remote Job Entry

Remote Printing and Graphics

Distributed Databases and Libraries

Process to Process Communication

Telefax

Video Conferencing

NETWORK NEEDS FOR HENP

Links to accelerator facilities, super computers,

and many universities

Emphasis on DEC computers and DECNET

Many international links needed (Europe & Japan)

Much overlap in needs between HEP and NS

eg. universities, accelerators

eg. DECNET, international community

THOMAS A. CASPER

M - DIVISION

LAWRENCE LIVERMORE NATIONAL LABORATORY

EXPERIMENTALIST'S VIEW OF NETWORKING - PRESENT AND FUTURE..........

LLNL-1
TAC 10/27/86

I will concentrate on one aspect of networking that we in M-division at LLNL are pursuing for use in the experimental environment (and therefore mostly useful within a given lab). Our next data acquisition and processing scheme will require high speed, reliable, and standardized networking.

Those people at LLNL who are participating with me in this effort are:

Physics	Elect. Eng.	Computations
W. Meyer	H. Bell	M. Brown
J. Moller	D. Butner	M. Drlik
D. Perkins	G. Preckshot	R. Hammon
	P. Siemens	M. Stewart

THERE ARE THREE AREAS WHERE NETWORKING DEVELOPMENTS HAVE A DIRECT PAYOFF IN SUPPORT OF LLNL'S M-DIVISION EXPERIMENTAL EFFORT..........

LLNL-2
TAC 10/27/86

1. We are able to acquire data on local computers that are dedicated to acquisition and instrument control and which also do some initial intershot processing of large quantities of data. The larger fusion experiments acquire volumes of data in the 10-20 Mbyte/shot range and may have a shot every 10 minutes.

2. Networking will enhance our ability to move the data to more powerful computers for additional on line (intershot) and off-line (post shot) data analysis and modeling with various plasma codes, such as MHD, TREQ-Tandem rate eqation, etc.

3. Collaboration (theory, experimental data analysis, diagnostic development, etc.) with other national laboratories and universities will be more readily available.

THE TANDEM MIRROR UPGRADE EXPERIMENT (TMX-U) COMPUTER SYSTEM HAS EVOLVED FROM A SINGLE, CENTRALIZED COMPUTER SYSTEM (5 HP-1000 COMPUTERS WITH 720 MBYTES OF SHARED DISK) TO ONE WHICH INCLUDES SEVERAL "NETWORKED" COMPUTERS DEDICATED TO DATA ACQUISITION AND ANALYSIS AND INSTRUMENT CONTROL..

LLNL-3
TAC 10/27/86

* Use of local computers allows us to continue to expand our plasma diagnostic effort and to make use of data intensive diagnostics.

* Parallel processing allows us to perform considerable intershot processing without sacrificing the repetition rate of the experiment, about 10 min./shot.

* Local computers create a data communication problem when attempting to do data comparisons or correlations. This has been solved by networking and additional data bases running on remote computers.

* Raw data is archived locally with highly processed data transferred. This creates the problem of a fragmented data archive. It would be preferrable to have sufficient networking bandwith to keep a single raw data archive with the local computers serving as workstations for diagnostic and systems control and data analysis.

* There is (and will always be?!) a problem with the "data hogs" such as imaging systems and cameras used on the experiments...a single fast video camera used on TMX-U records the equivalent of 120Mbytes of data per shot. The local computer digitizes and processes a fraction of that data (intershot) and passes physically meaningful results on to the central computer system via the network.

OUR INITIAL "NETWORK" WAS IMPLEMENTED USING A SHARED RESOURCE MANAGER (SRM) TO PROVIDE FILE TRANSFER (DATA). THIS IS A LOW-TO-MEDIUM THROUGHPUT SOLUTION WITH LIMITED CAPABILITIES........................

LLNL-4
TAC 10/27/86

* Througput of about 30kbytes/sec is fast enough to provide useful data transfer rates intershot; 15 instruments are presently connected.

* The network (SRM) is compatible with our HP computers but not with other computers on the network and therefore need an additional gateway.

* The system basically works and has allowed us to acquire and keep track of an additional 8 Mbytes (over the 6 Mbytes acquired into the original system) of data without sacrificing our experimental shot repetition rate. Data is processed locally with about 1 Mbyte actually transferred; we have not pushed the system throughput to date.

BASED ON OUR INITIAL RESULTS, WE HAVE EXPANDED OUR USE OF NETWORKING TO PROVIDE A GATEWAY TO OUR USER SERVICE CENTER (USC)................

LLNL-5
TAC 10/27/86

* We have added another computer to assemble a complete shot--the 6 Mbytes of data from our original system are transferred over a high speed link and combined with another 1-2Mbytes (approximate) of processed data from the satellite computers to create a combined data archive. Of the 15 instrumemts on the network, 8 are actively transferring processed data.

* Presently, this data is moved over to the USC by magnetic tape and used with two data bases for data searches and off-line analysis.

* The added computer also provides a gateway from the experimental computers (HP) to a local area network (LAN) which includes the USC VAX and thus to the CRAYs if desired. This link has just recently become available and has not been used extensively yet, since we are in an experimental operations cycle and thus lack personnel to do it now. It will replace the present scheme of transferring experimental data via magnetic tape and will improve the response time and thus allow near real time use of the USC computers for on-line experimental data analysis.

BLOCK DIAGRAM OF THE COMPUTER SYSTEM FOR THE TMX-U EXPERIMENT

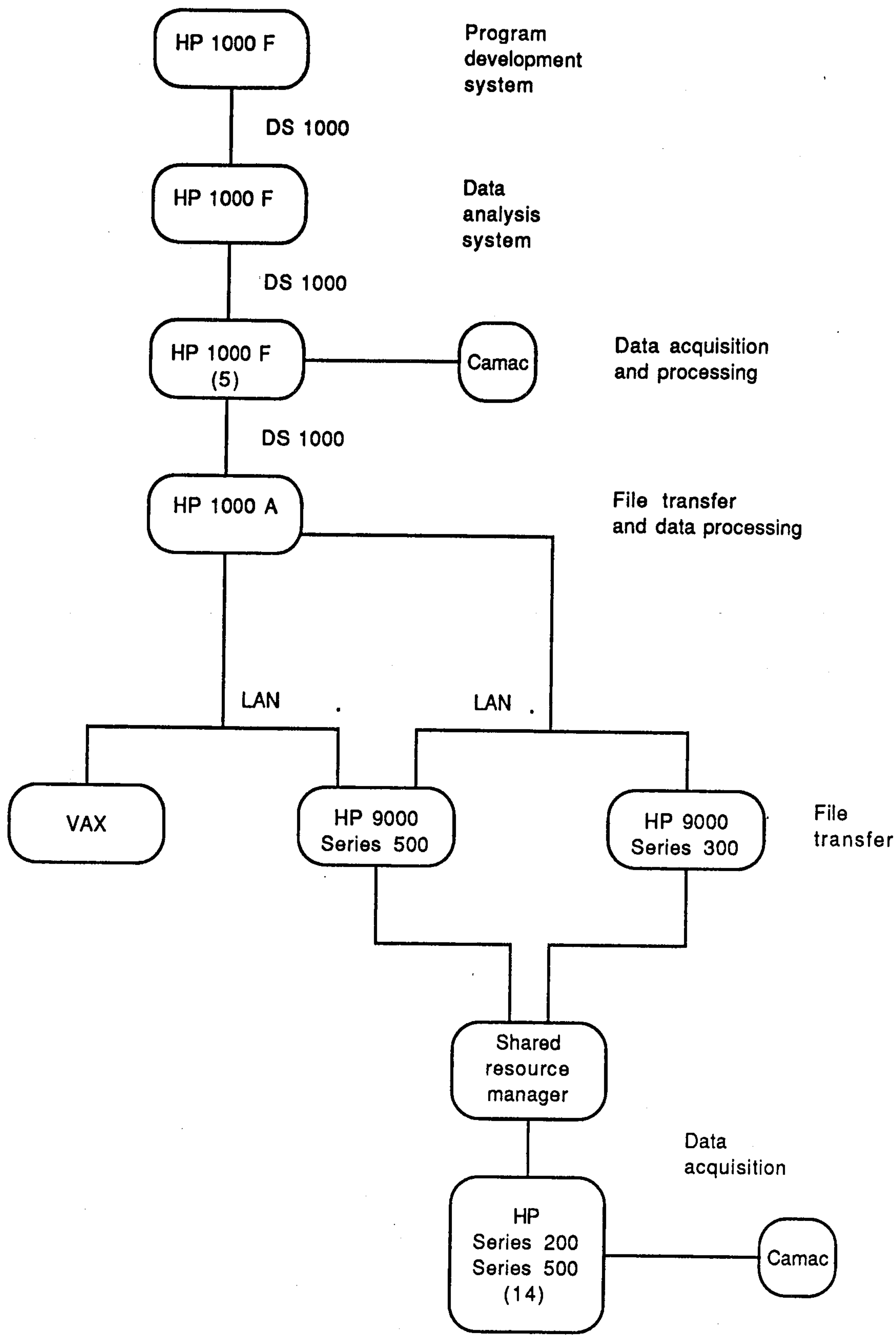


Table 1. Diagnostic systems using satellite computers for data acquisition, analysis, and archival.

Diagnostic	HP-computer	Data size	Channels/comments[a]
Plasma potential diagnostic	9836	32 K[b]	4
22-channel extreme UV	9920U	16 K	22
1024-channel EUV	9836	32 K	1024
Fast video camera	320	1 M[c]	Typically digitized
Video (or IR) camera	9920U	200 K	Many frames digitized
Secondary electron detectors	9920U	32 K	16
Fluctuation diagnostic	9920U	128 K	4
X rays	520	286 K	6
X-ray camera (under development)	9920U	4 M	Images
Ion gauges	9920U	1.7 M	9
	9816	64 K	4
End-loss ion spectrometer	9836	256 K	128
	9920U	256 K	128
Time of flight	520	500 K	1
	TOTAL	7.5 M	
HOT ELECTRON DETECTORS	320		
RADIAL ION ENERGY ANALYZER	9836		
MICROWAVE TOMOGRAPHY	320	500K	30

[a]Total data available on video tape is 120 megabytes of which about 6 megabytes include plasma data of interest. The value indicated corresponds to the volume of data typically digitized and analyzed.

[b]K = kilobytes.

[c]M = megabytes.

CURRENT EFFORTS INCLUDE AN OVERHAUL OF THE EXPERIMENTAL DATA ACQUISITION SYSTEM WITH AN EVEN GREATER RELIANCE ON THE NETWORKING CONCEPT...

LLNL-6
TAC 10/27/86

* The existing central computer system is old and the computers we are using are obsolete--going out of production--so we need to do the change.

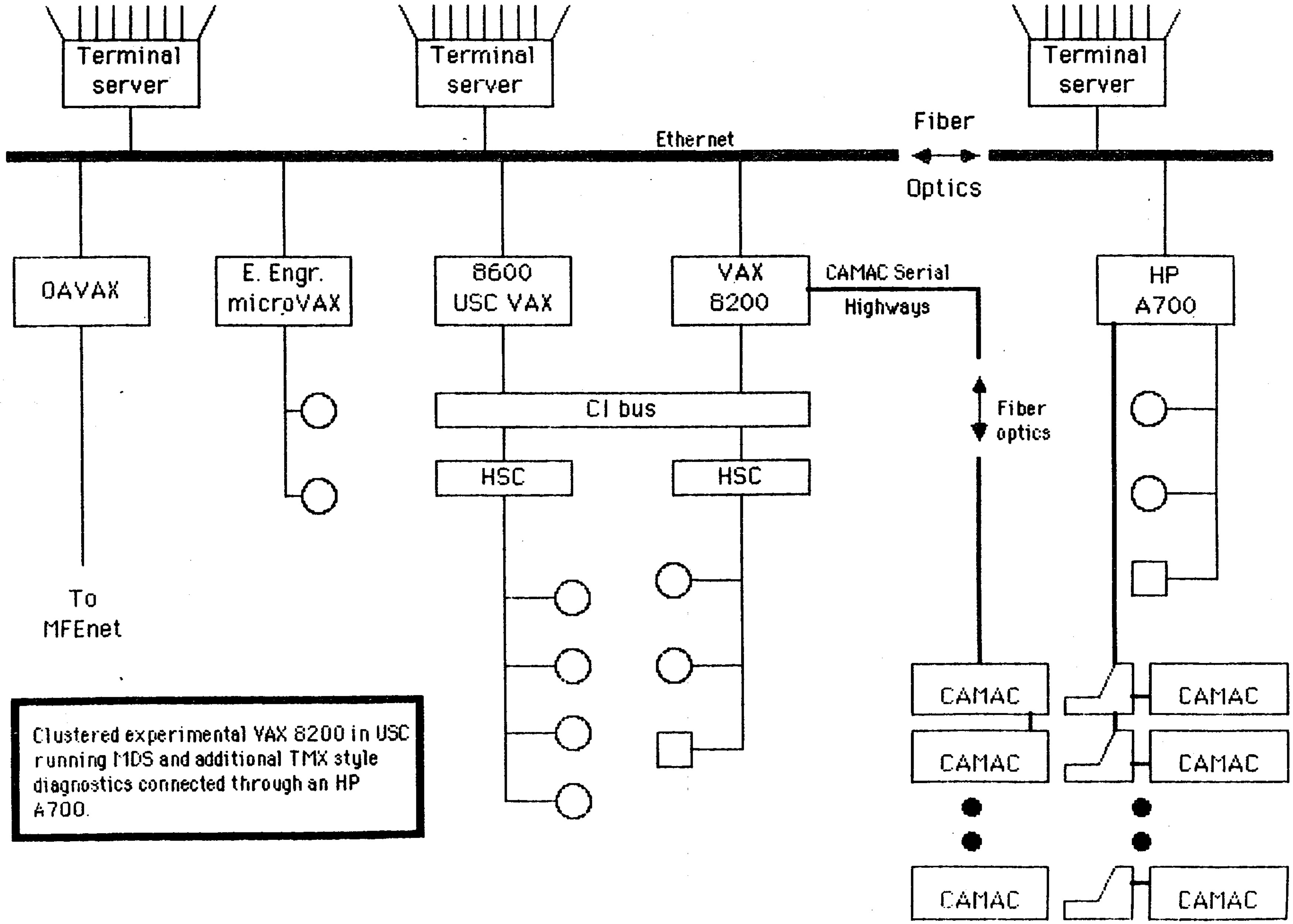
* Multiple computers, sized to the diagnostic control, data acquisition, and processing job at hand, will be networked along with the USC VAX's.

* This will be done utilizing standard protocols (TCP/IP) and possibly standardized graphics when available.

* The data acquisition computers serve as graphical workstations which control instruments and CAMAC (or other) data acquisition hardware as well as process data and display results in a near real time environment. Processed (or raw) data can then easily be moved to higher level systems for additional processing.

* The workstations presently in use on TMX-U have been readily accepted by the experimental physicists. The utility and flexibility of these workstations will be enhanced when fully networked.

Network Connections



CONCLUDING COMMENTS..

* Once the data acquisition system is fully networked, then possibilities are opened for easily moving data into the NMFECC system which will, by then, hopefully support the standard protocol. This should make the task of moving data much easier thus making the computing power of the CRAYs more readily accessible to another segment of the energy research community, namely, those performing data analysis, simulation, and experimental modeling.

* It becomes somewhat easier to support collaborative efforts between laboratories, universities, and foreign colleagues when the standard protocol for transfer of data and/or results is used. In addition, the flexibility for remote processing (with adequate controls) of experimental data is then only limited by the bandwidth of the data transfers...presumably future developments will increase the data transfer rates.

* One of the real and sometimes unnoticed benefits of a network connection is that we can easily move data to computers that have a much wider selection of software available. It is generally easier to move the data than to transport the software.

* The success depends critically upon the speed and reliability of the system. Standardization, especially of protocol; provides for flexibility and the ability to select computers specific to the given application.

Slide 1 ---

Current and Future uses of Computer Networking by OHER-supported projects

presented
October 27, 1986

at the
first annual workshop
on
Energy Research Computing

The Future of Intersite Networking

at
Lawrence Berkeley Laboratory

Chuck Watson
Battelle
Pacific Northwest Laboratories
FTS 233 4742

Slide 2 ---

WHAT MAKES A COMPUTER NETWORK SUCCESSFUL?

FIRST there must be a common mission or task

ONLY THEN does Network functionality become important

Historically, the projects supported by OHER have not needed computer networking because each project was independent. Although there was a common theme to the research, there was no need to coordinate it at the electronic level.

I will show that this situation is changing.

a. Past research being combined into my database

b. Human Genome project will use electronic communication

c. Future projects will emphasize modeling slide 3 --

WHAT IS OHER?

Office of Health and Environmental Research

$180 Million FY 86

Multi Disciplinary:

- biochemistry
- biophysics
- molecular biology
- cellular biology
- genetics
- toxicology
- radiation biology
- epidemiology
- preventative medicine
- health physics
- nuclear medicine
- physiology
- analytical chemistry
- atmospheric sciences
- ecology
- oceanography

etc. you name it

Historically, the projects funded by the OHER have little formal interaction with each other.

Communication is via publications, seminars, workshops, symposia, etc. For example, the journal Health Physics is essentially a creation of the office.

Synthesis is via scientific committee. For example, the NCRP and ICRP guidelines are essentially products of the office.

slide 4 --

THE DIVERSITY OF OHER PROJECTS

SOURCE AND DOSE DETERMINATION

ENVIRONMENTAL PROCESSES AND EFFECTS

NUCLEAR MEDICINE

HEALTH EFFECTS

Slide 5 --

SOURCE AND DOSE DETERMINATION

Analytical Studies
- Chemical nature of source term
- Radon daughters and lung dose

Dosimetry Research
- Neutron dosimetry
- Organ dose from internal emitters
- Human dose estimates:
  - Nevada environs
  - Hiroshima
  - Nagasaki
- Micro dosimetry

Measurement Science
- Semi-conductor radiation detectors
- Laser based mass spectrometry
- Portable fiber fluorometer

Slide 6 --

ENVIRONMENTAL PROCESSES AND EFFECTS

Atmospheric Transport
- Meteorology
- Chemistry
- Physics
- Computer models

Marine Transport and Transformation
- Radioactive fallout in ocean
- Chemicals - binding to sediments
- Mixing, flushing, freshwater influx

Terrestrial Transport and Fate
- DOE facility environs
- Subsurface movement
- Energy related organics

Ecosystem Functioning and Response
- Impact of energy production
- Population dynamics
- Re-vegetation

Slide 7 ---

NUCLEAR MEDICINE

Radionuclide Production
- BNL
- ORNL
- LASL

Radiopharmaceutical Agents
- production
- development of new agents
  - monoclonal antibodies

Instrumentation
- positron imaging devices

Radiation beam therapy
- High energy particles
- Neutron activation

Slide 8 ---

HEALTH EFFECTS

Long-term effects of Radiation Exposure and Energy-related Chemical Agents

Epidemiology
- Dial Painters
- Occupational cohorts
- Atomic Bomb survivors

Metabolic studies
- *in vitro*
  - membrane transport
  - organ perfusion
  - enzyme kinetics
- *in vivo*
  - ingestion
  - injection
  - inhalation

Dose effect studies
- Rodents
- Dogs

Generic and general life sciences research

Slide 9 --

NO FOCAL POINT
TO MOTIVATE
ELECTRONIC INTERACTION

There has been no motivation for computer networking in the OHER research community because:

The diverse projects supported

(which are often not quantitative)

are within the capability of

small, independent, research teams.

HOWEVER, this is rapidly changing.

Slide 10 --

INTERLABORATORY TOXICOLOGY DATABASE

I have been detailed to OHER at headquarters to design and implement a centralized database of toxicologic (dose-effects) data. Currently these values are fragmented at many research institutions. This database will be made available on a network, and future results will be entered into that database. A new generation of mathematically inclined researchers will access this database to develop and test models and to develop basic biological principles through analysis of the details.

INITIAL PROBLEM - to integrate results from:

	lab	computer
Dial Painters	ANL	IBM
Dogs:		
Injected	UTAH	PDP 11
Ingested	UC DAVIS	DATA GENERAL
External	UC DAVIS	DATA GENERAL
	ANL	IBM
Inhaled	ITRI	VAX
	PNL	VAX

NEED:
Network connections to currently isolated facilities
Access to/from heterogeneous hardware

Slide 11 --

HUMAN GENOME

Large multi-laboratory task involving:

Technology development for:
- robot flow cytometer
- automated sequencing of DNA
- automated data capture

Inter agency support for:
- chromosome-specific recombinant DNA libraries

Eventual plan:
- complete map of human genome
- on the order of 10^8 enzyme pairs

COMPUTATIONAL IMPACT:
- E-Mail within new research community
- Data file exchange
- Large central database
- Remote, interactive, query

Slide 12 --

FUTURE

Increased emphasis on

mathematical approach

in future OHER funding decisions.

RESULT:

Much greater computer usage, therefore

INCREASED NEED FOR COMPUTER NETWORKING

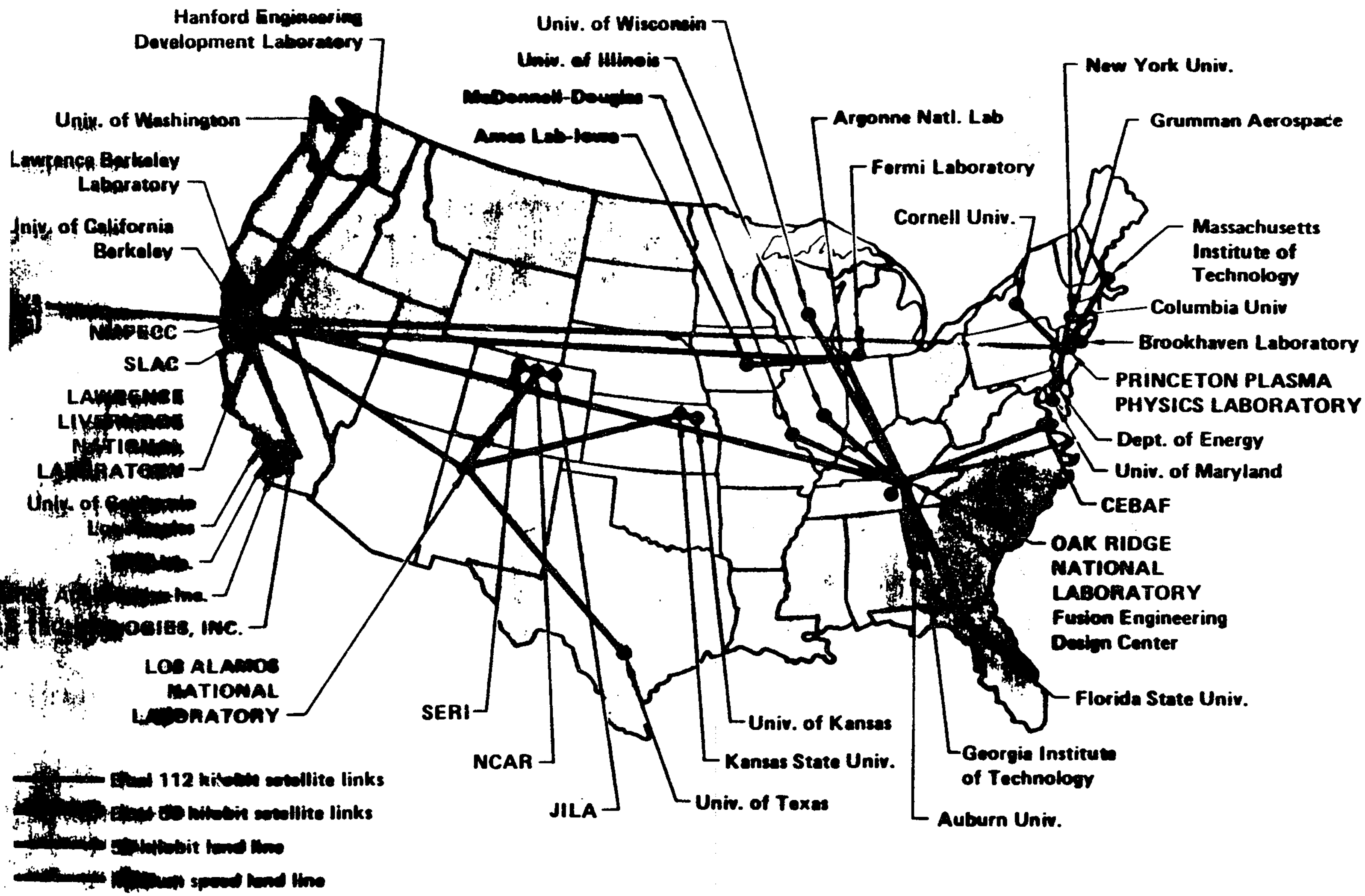
JAMES F. LEIGHTON, MANAGER

NATIONAL MAGNETIC FUSION ENERGY COMPUTER CENTER

LAWRENCE LIVERMORE NATIONAL LABORATORY

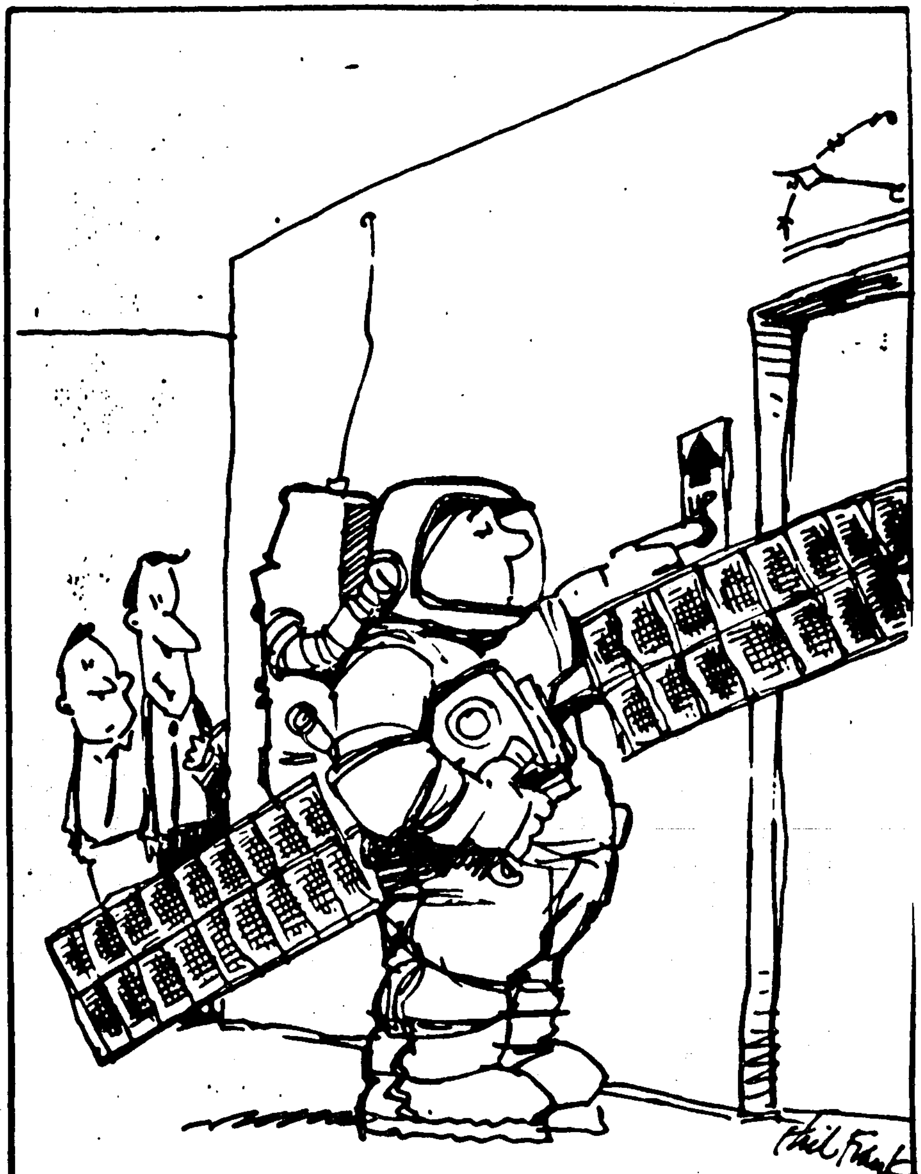
TITLE: NATIONAL MFE NETWORK 1986

MFE Network 1986



Networking Engineering

James F. Leighton
Manager– Networking and Engineering



Now that's what I like...
.. a network manager who knows how to take charge.

Project Definition

What is MFEnet II?

MFEnet II is a three year effort to make the transition from the current national network, MFEnet, to a completely revised data communications network, using new hardware, software, and protocols.

MFEnet II Requirements

What requirements are driving the project design?

- Internal
  - Transition plan for new hardware
  - Foundation for higher bandwidth
- External
  - More general role for network
    - Wider user access
    - International use
    - Interagency internetworking
  - User site local area network (LAN) support
  - Plan to incorporate ISO network standard protocols

Network hardware components

- 32 bit CPU
  - Micro VAX II
- Operating system
  - VAXeln
- Synchronous controllers
  - DMV-II (DDCMP up to 56 kbps)
  - ? (above 56 kbps)
- Asynchronous controllers
  - DHV-II (8 ports up to 38.4 kbps)
- Ethernet controller
  - DEQNA
- Printers
  - Versatec V-80 printer/plotter
  - LNO3+ laser printer + graphics

Network components (1/3)

- Gateway
  - Must sustain local service w/o gateway
  - Operate (degraded) w/o nameserver
  - Allow for dual redundant gateways
  - Subnet bridge
    - Hyperchannel/ethernet/device
- Host-name server
  - Maintains ASCII/IP/ETHERNET addresses
  - Allows for alias names and redirects
  - Maintains gateway/foreign net correspondance
  - Redundant name servers
    - Secondary at another site
  - Provides measure of access control
  - Maintain static hardware configuration tables

Network components (2/3)

- CCPs
  - Applicable code already converted and tested
  - Use same routing/loading/dumping algorithms
- HOSTs
  - NSP/IP installed
  - NSP minimally changed
- Network operations and statistics monitor
  - Maintain dynamic network configuration table
  - Virtual link capability
  - Statistics collected and saved
  - Alert on abnormal events
- Download server
  - Maintains software download images

MFEnet II Design Overview

Network components (3/3)

- Terminal server
  - New interface, more flexible
    - Compatible with circuit switches
    - Multiple simultaneous connections
    - Compatible with PC enhancements
    - Reviewing site configuration file
- Printer server
  - Versatec
  - Letter quality printer (LNO3+)
- GUSS + server
  - Will add video tape

MFEnet II Progress

What has been done so far?

- User design review completed
- Interagency design review completed
- "C" training completed
- Applicable existing code converted to "C" and tested
- Hardware procurement
  - IFP completed
  - Vendor selected
  - Contract negotiation underway
  - Financial RFQ in progress
- Design well underway
  - Functional specifications 75% complete
  - External reference document underway

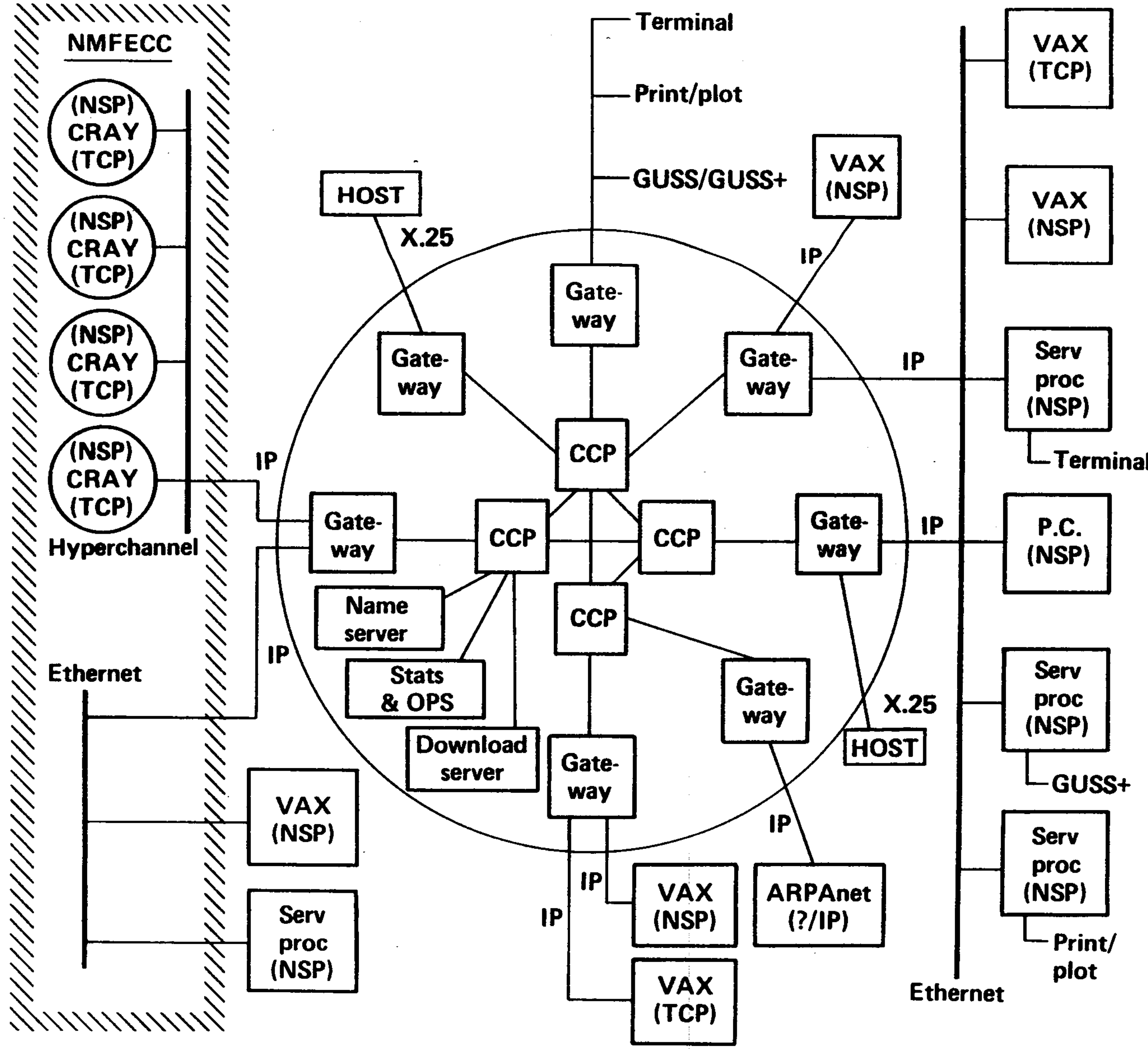
MFEnet II Schedule

How long is it going to take?

9-86

Sep 86	Complete technical evaluation Issue clearance document Wait for clearance document approval Issue financing RFQ Finalize vendor contract
Nov 86	Initial hardware delivery
2Q FY87	First quarterly hardware delivery
3Q FY87	First site installation
4Q FY89	Complete

MFEnet II
Block diagram



DOE/ER-0234

COMPUTING FOR PARTICLE PHYSICS

Report of the HEPAP Subpanel on Computer Needs for the Next Decade

August 1985

HUGH MONTGOMERY, HEAD

FERMI NATIONAL LABORATORY

U.S. Department of Energy
Office of Energy Research
Division of High Energy Physics
Washington, D.C. 20545

Character of Network Use

Direct Terminal Access

Virtual Terminal Access

Mail

Phone

File Transfer

Remote Job Entry

Remote Printing and Graphics

Distributed Databases and Libraries

Process to Process Communication

Telefax

Video Conferencing

Network growth ... an example:

TPC / PEP4 experiment at SLAC used microwave link between LBL and SLAC.

All VAX computers at SLAC connected.

LBL linked to UCLA and Riverside.

Two Gamma / PEP9 experiment linked to Davis Santa Barbara, and San Diego.

HRS experiment linked to ANL. Links to Michigan, Indiana, and Purdue.

CDF link from Fermilab to ANL as well as to Harvard, Brandeis, and Wisconsin.

DELCO link from SLAC to Caltech now used for MarkII.

- D0 link from BNL to Fermilab.

D0 links from BNL to Brown and Cornell.

- LBL to Fermilab for CDF and D0.

and so on ....

Existing Networks

Data Switches

DECNET

BITNET

Coloured Books / X.25

MFENET

MILNET (ARPANET)

ScienceNET

HEP LEASED LINES FOR TERMINALS

4-85

5067A3

FIGURE 4.2

BITNET

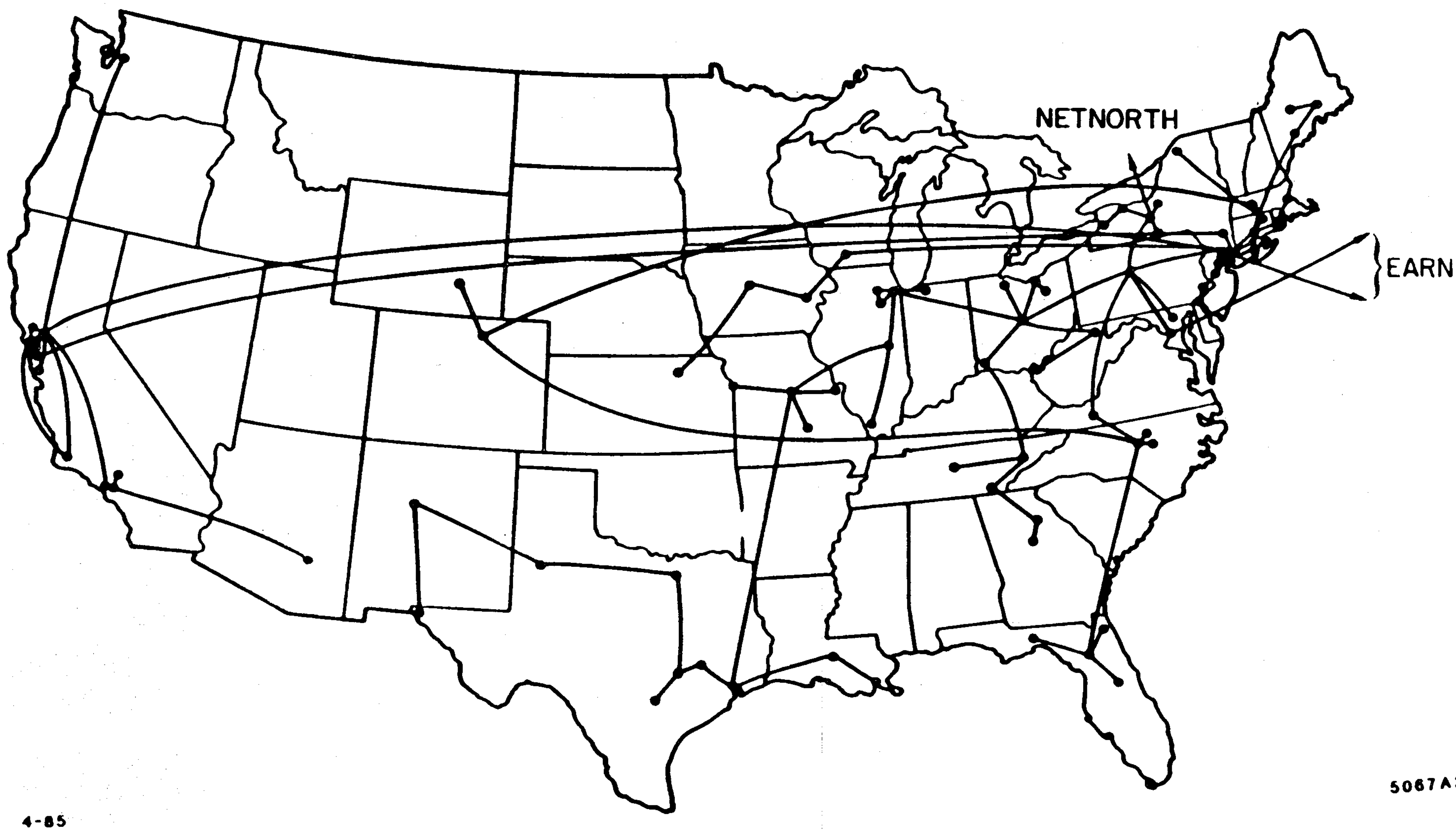
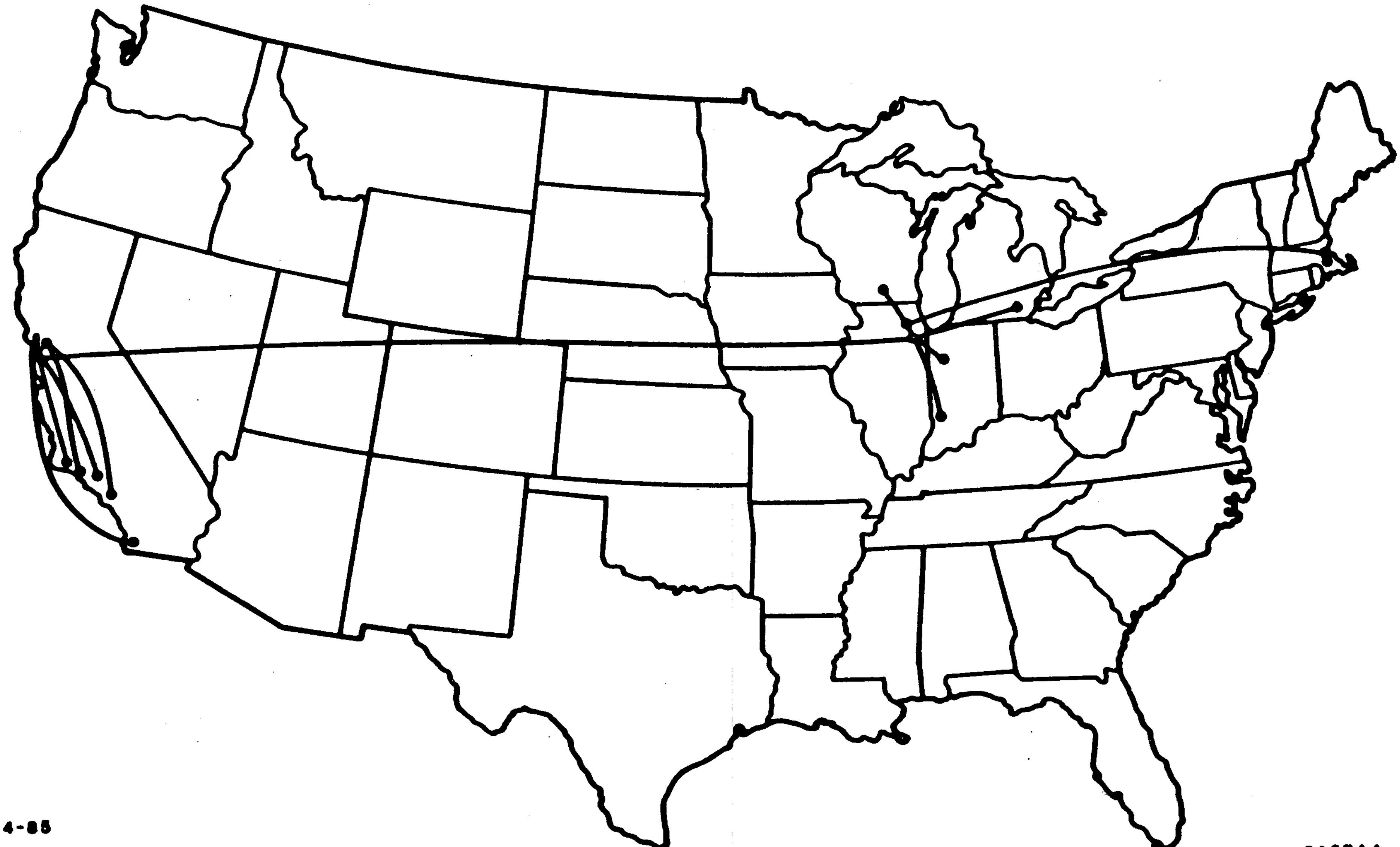


FIGURE 4.1

SLAC/LBL DECNET



4-85

5067A4

FIGURE 4.3

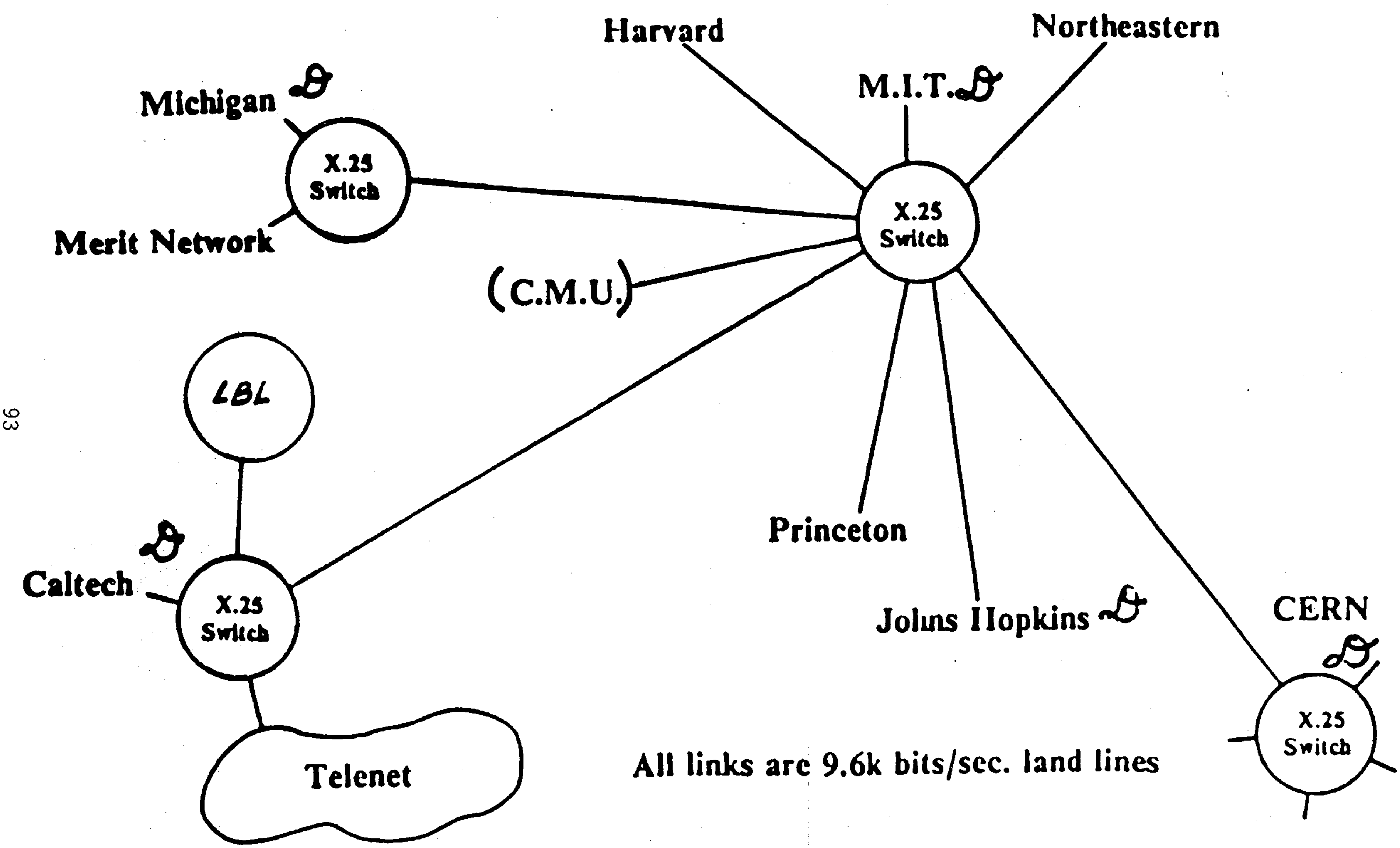

Harvard
Northeastern
M.I.T.
Michigan
X.25 Switch
Merit Network
(C.M.U.)
X.25 Switch
LBL
Caltech
X.25 Switch
Princeton
Johns Hopkins
CERN
X.25 Switch
Telenet
All links are 9.6k bits/sec. land lines

TABLE 4.1

COMPARISON OF NETWORK FEATURES

NETWORK	REMOTE LOG ON	MAIL	FILE TRANSFER	INTERACTIVE MESSAGES	INTERNATIONAL	VENDOR SUPPORT	INTERNETWORK SUPPORT	RELIABILITY
DECNET	YES	YES	TO and FROM	YES	YES X.25 or leased line	YES DEC	BITNET	Requires redundant links for reliable network
BITNET/ EARN	NO	YES	SEND TO only	YES	YES	YES various systems	DECNET	Uses store and forward
X.25/ COLOURED BOOKS	YES	YES	TO and FROM	YES	YES	YES various systems	DECNET one way	Uses retry
DATA SWITCHES	YES	NO	NO	NO	no direct connections	three vendors		Needs continuous links

MAY WELL BE NO SINGLE SOLUTION! CURRENTLY AVAILABE

Conclusions of HEPAP Subpanel

Networks are very important

Some experiments have used networks extensively; can use as foundation.

Cost savings can be realised by a more coordinated approach.

(More use for same total cost)

April 1985

HEPAP Subpanel Recommendations

A dedicated High Energy Physics Network
(HEPNET) should be established.

High-speed trunks between HEP Laboratories

University links to laboratories (DOE / NSF)

Link from BNL to Cornell / LNS

Leased line to CERN

Leased line to Japan when traffic justifies it

Technical working group to plan and implement

Permanent staff at one of the laboratories to coordinate installation and maintenance

Monitor use to assess need for upgrades

Until new links are working reliably, the existing links must be left intact.

April 1985

Model for HEPNET

The functionality and quality of all existing links must be maintained. New links must work at least as well.

Services:

- **Direct terminal access**
- **All DECNET functions**
- **All BITNET functions**
- **X.25 (Europe / Japan)**

Suggested Implementation

High-speed links between HEP laboratories

BNL to Fermilab / ANL to SLAC / LBL

University links to one laboratory

(choose site with highest traffic, not closest)

HEPNET PHASE I

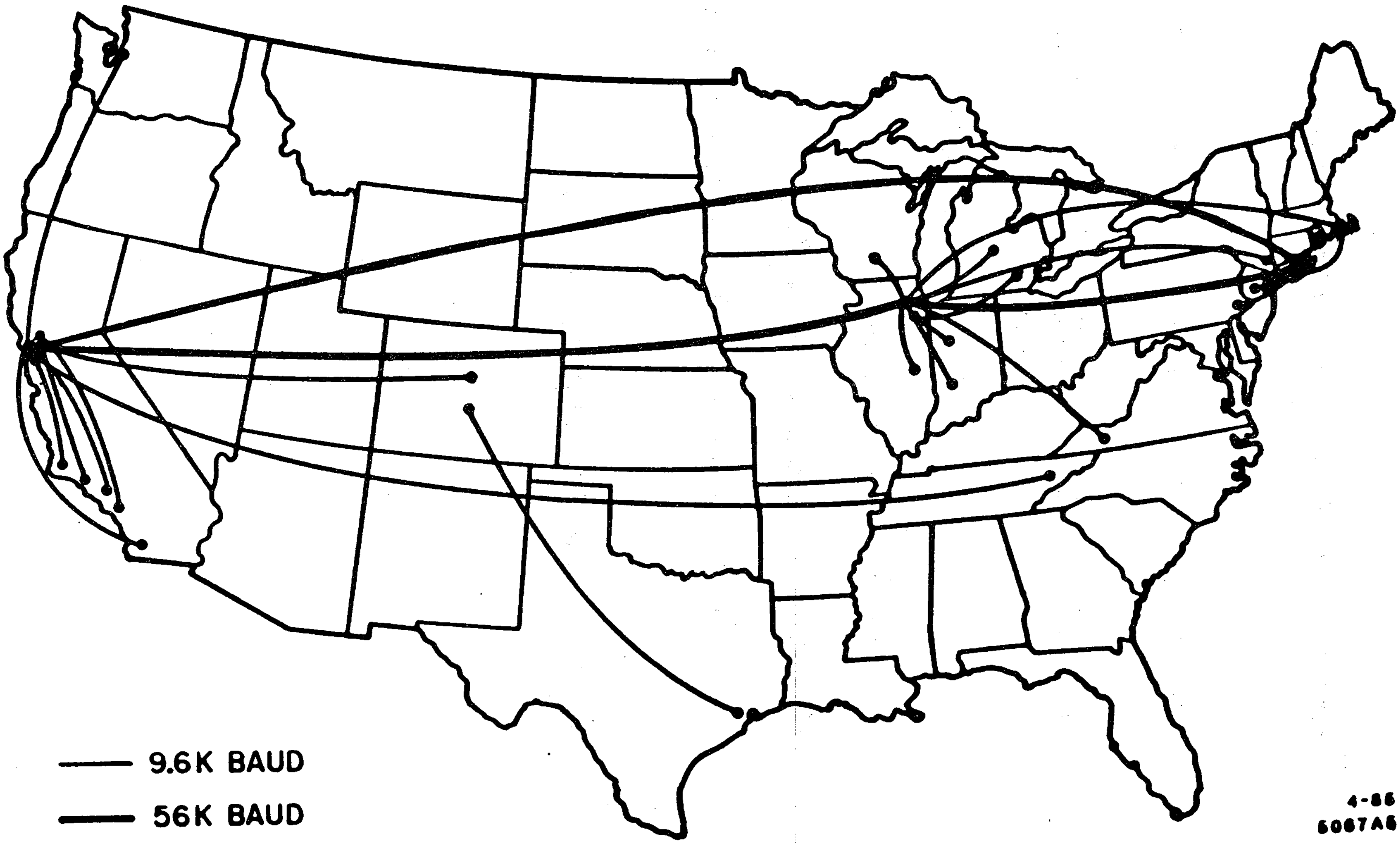


FIGURE 4.4

Where are we in October 1986 ?

Terminal links from Fermilab to SLAC/LBL

DECNET (BNL/Cornell to Fermilab/ANL to SLAC/LBL)

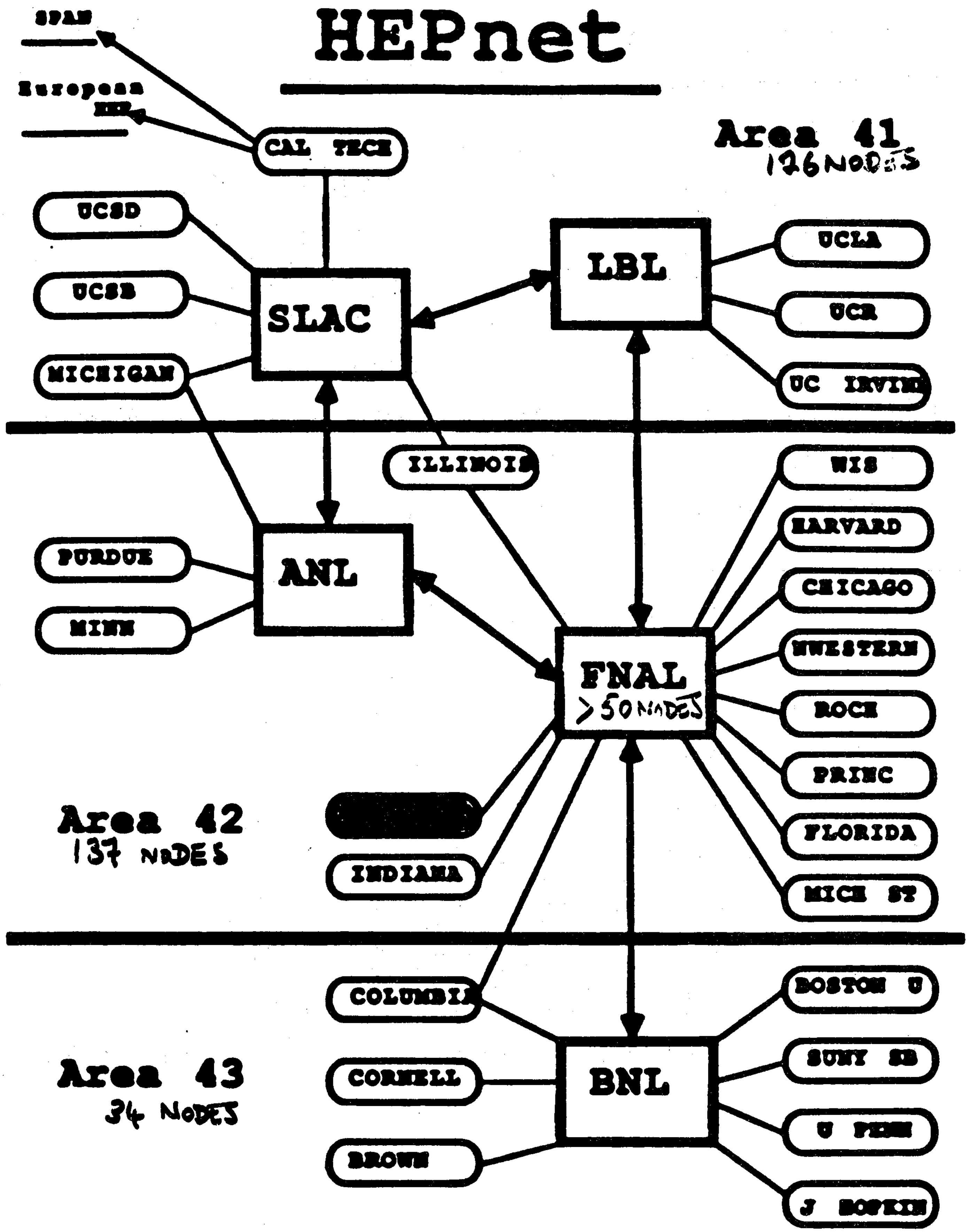
X.25 to CERN (Coloured books & DECNET)

Coexistence with BITNET

HTCC established in April 1986

HEPNET Technical Coordinating Committee

No direct funding support for links


HEPnet
SPAN
European
Area 41
126 NODES
CAL TECH
UCSD
UCSB
MICHIGAN
SLAC
LBL
UCLA
UCR
UC IRVINE
ILLINOIS
ANL
PURDUE
MINN
FNAL
>50 NODES
WIS
HARVARD
CHICAGO
NWESTERN
ROCH
PRINC
FLORIDA
MICH ST
Area 42
137 NODES
[redacted]
INDIANA
COLUMBIA
CORNELL
BROWN
BNL
BOSTON U
SUNY SB
U PENN
J HOPKIN
Area 43
34 NODES

BITNET USAGE

- Volume:

Site	Mbytes/day	<Baud-Rate>	Files/Day	US to Europe
CERN	50	6000	3000	27%
SLAC	16	1500	1000	25%
FNAL	2	200	100	23%

  - Equivalent Tymnet cost for SLAC would be ≈ $500/day.
- Gateways allow mail exchange with > 20,000 nodes, on >15 networks
  - ARPANET, CSNET, UUCP, MFENET, etc.
  - 6% of the files sent from SLAC go thru Gateways

ARPAnet: 2%
PHYSnet, Stanford, INFNet: 1%each

- Traffic Types (measured at SLAC)
  - Sent:Received = 60:40
  - 30% Mail, cost/mail item sent = $0.12
- Usage by Groups of Users at SLAC:

Experimental Physics	50%	Computer Sciences	11%
Computer Services	16%	Theoretical Physics	7.5%
Librarians	12%	Elec. Engineers	4%

- At SLAC > 40% of the 1300 users who logon in 1 month use BITNET

HEPNET Technical Coordinating Committee

ANL	Ed May
BNL	George Rabinowitz
Fermilab	Greg Chartrand
LBL	Sandy Merola
L.3-MIT	Ma k Kaletka
SLAC	Les Cottrell

+ UNIVERSITY REPS
WHEN REVIEW COMM. UNDERSTOOD.

HTCC Meetings

21 May 1986 at LBL

General organization

Interface to other networks (BITNET, SPAN)

Site reports

European networking (CERN, MFENET II)

ESNET and MFENET II

DECNET Areas

30 Sep - 2 Oct 1986 at MIT

Networking to Europe (CERN & Italy) — JAN 87

Networking to Japan

Five year networking plan

(needed for Interagency five year plan)

HEPNET Review Committee

Area Numbers and future of DECNET

BITNET (especially after IBM support ends)

Conclusions:

We have made a start on HEPNET

HTCC

Links between laboratories

Many questions remain

Review committee on cost/benefit,

funding, etc.

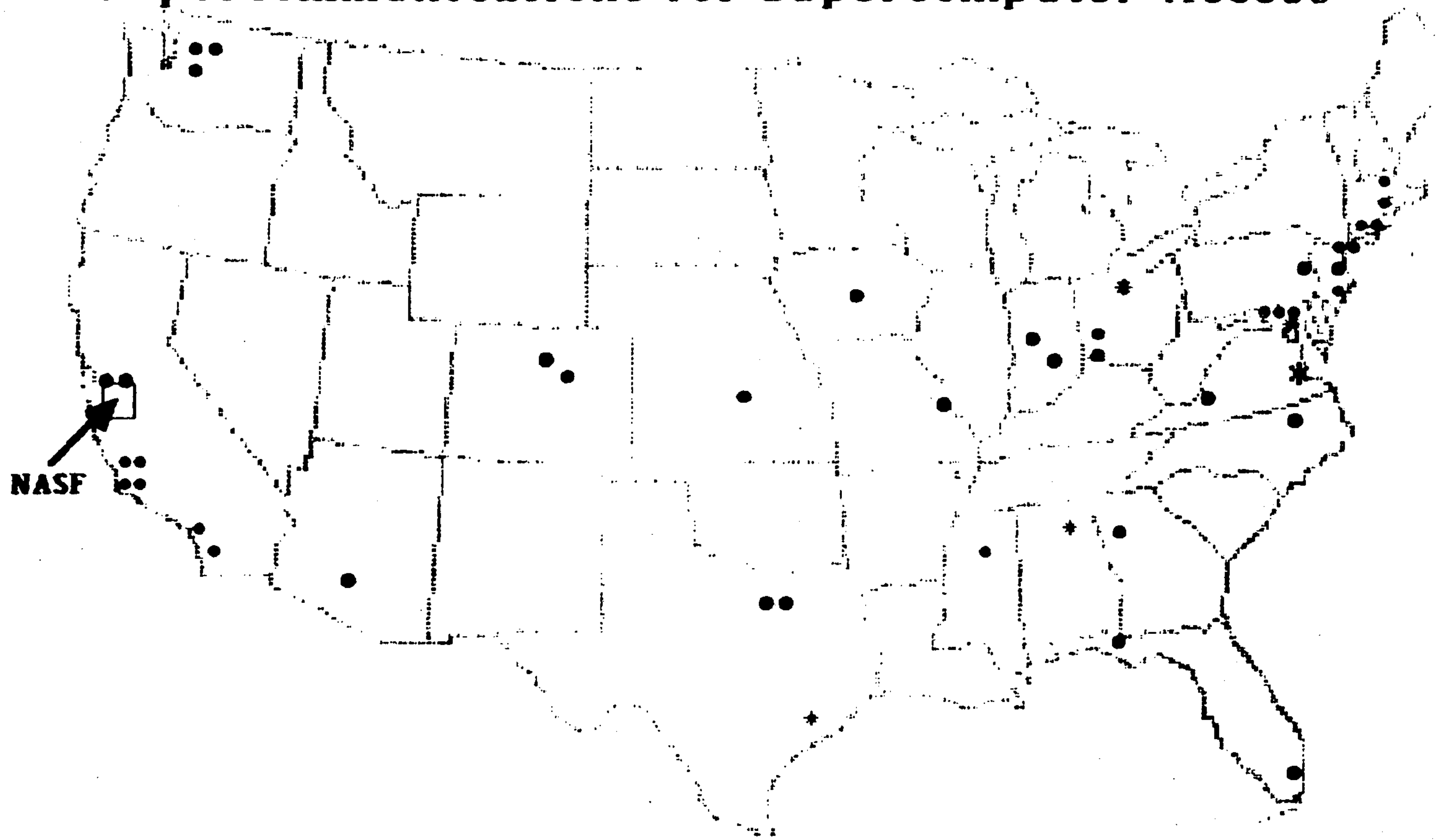
SCOPE OF ESNET ?

Evolution and ESNET

Interaction with other networks

NUMERICAL AERODYNAMIC SIMULATION NETWORK

" Supercommunications for Supercomputer Access"



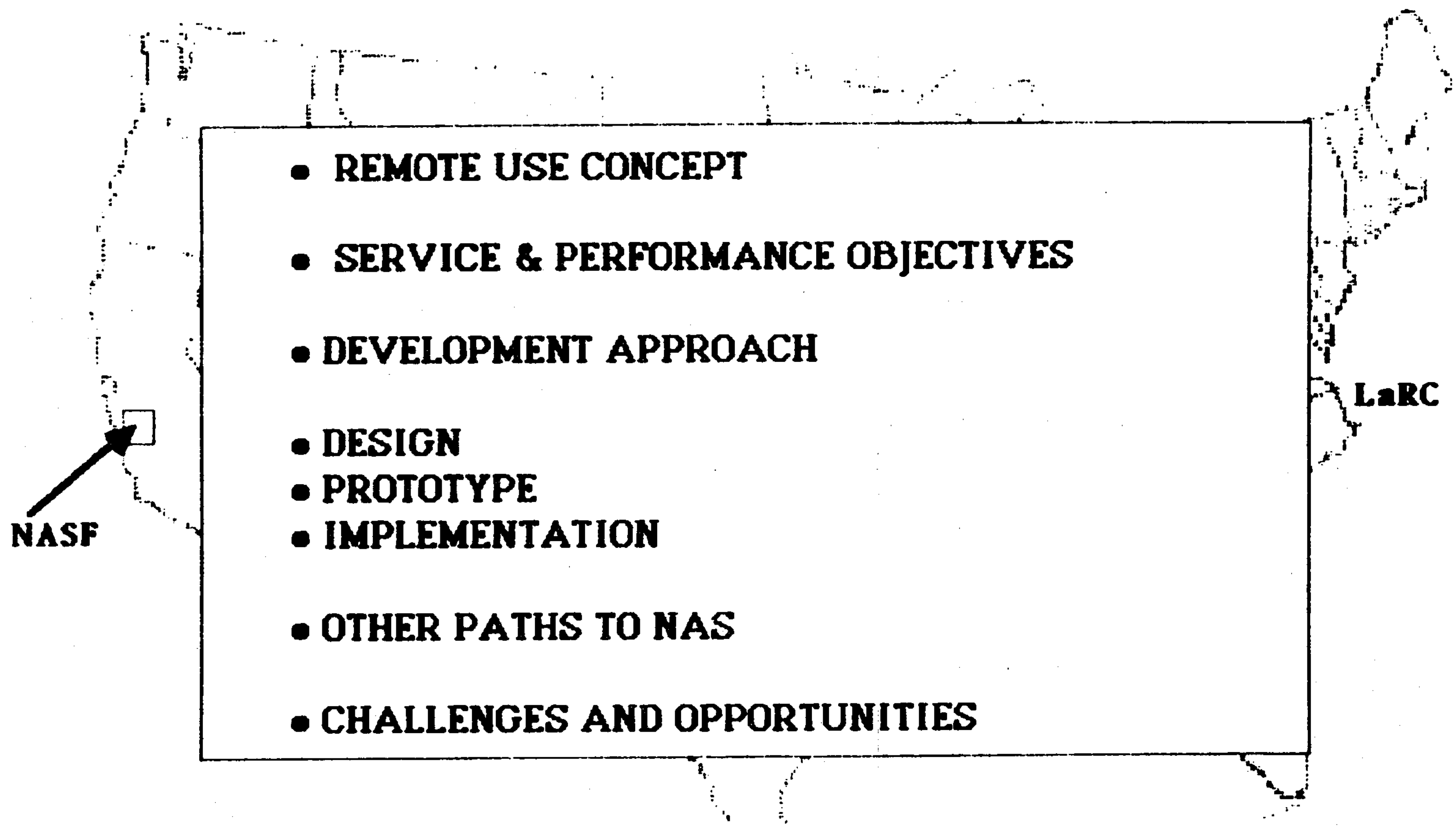
Ari Ollikainen
General Electric

(ari @ ames-nas)

WORKSHOP ON SUPERCOMPUTING ENVIRONMENTS
JUNE 24-26, 1986
NASA-AMES RESEARCH CENTER

NUMERICAL AERODYNAMIC SIMULATION NETWORK

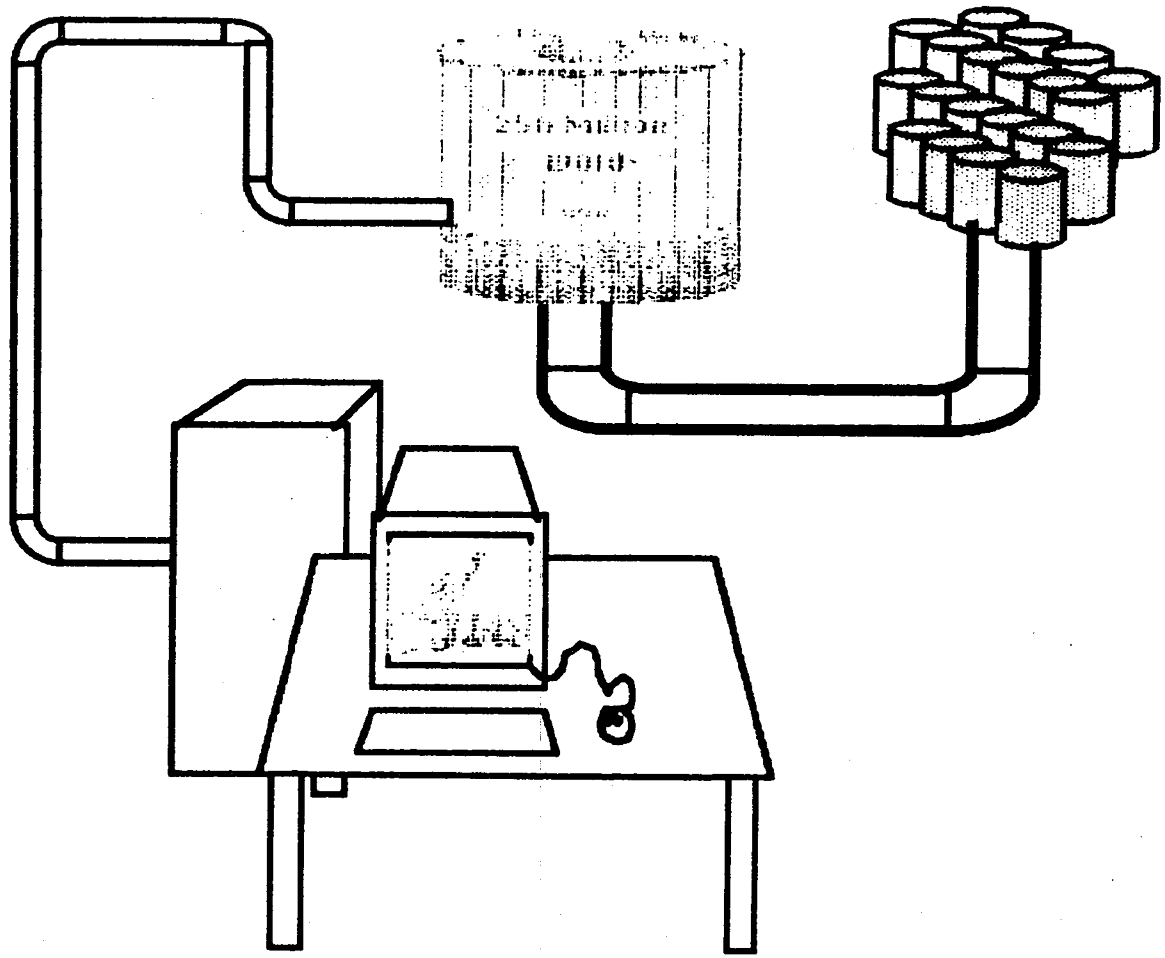
OVERVIEW



- REMOTE USE CONCEPT
- SERVICE & PERFORMANCE OBJECTIVES
- DEVELOPMENT APPROACH
- DESIGN
- PROTOTYPE
- IMPLEMENTATION
- OTHER PATHS TO NAS
- CHALLENGES AND OPPORTUNITIES

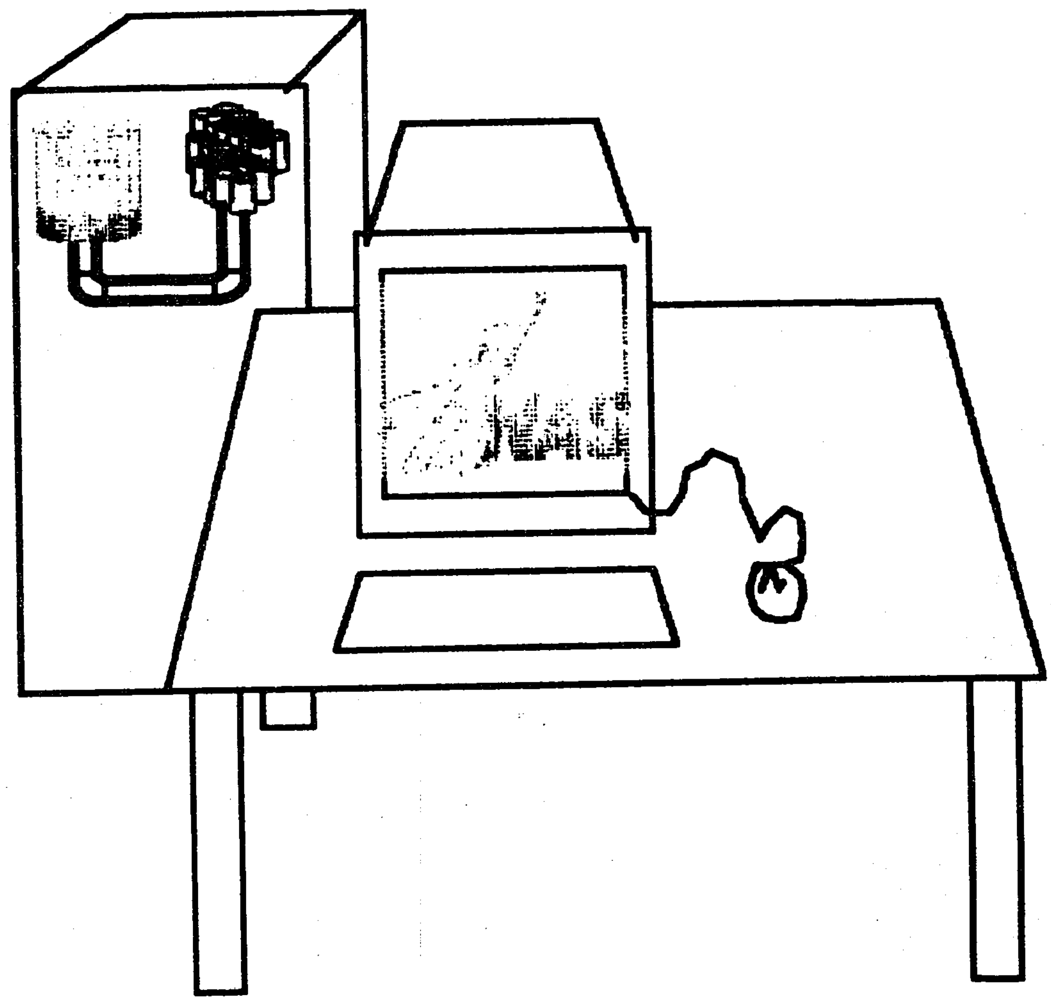
WSE
26JUN86
AO-

LOCAL USERS' VIEW



WSE
26JUN86
AO-

LOCAL USERS' VIEW

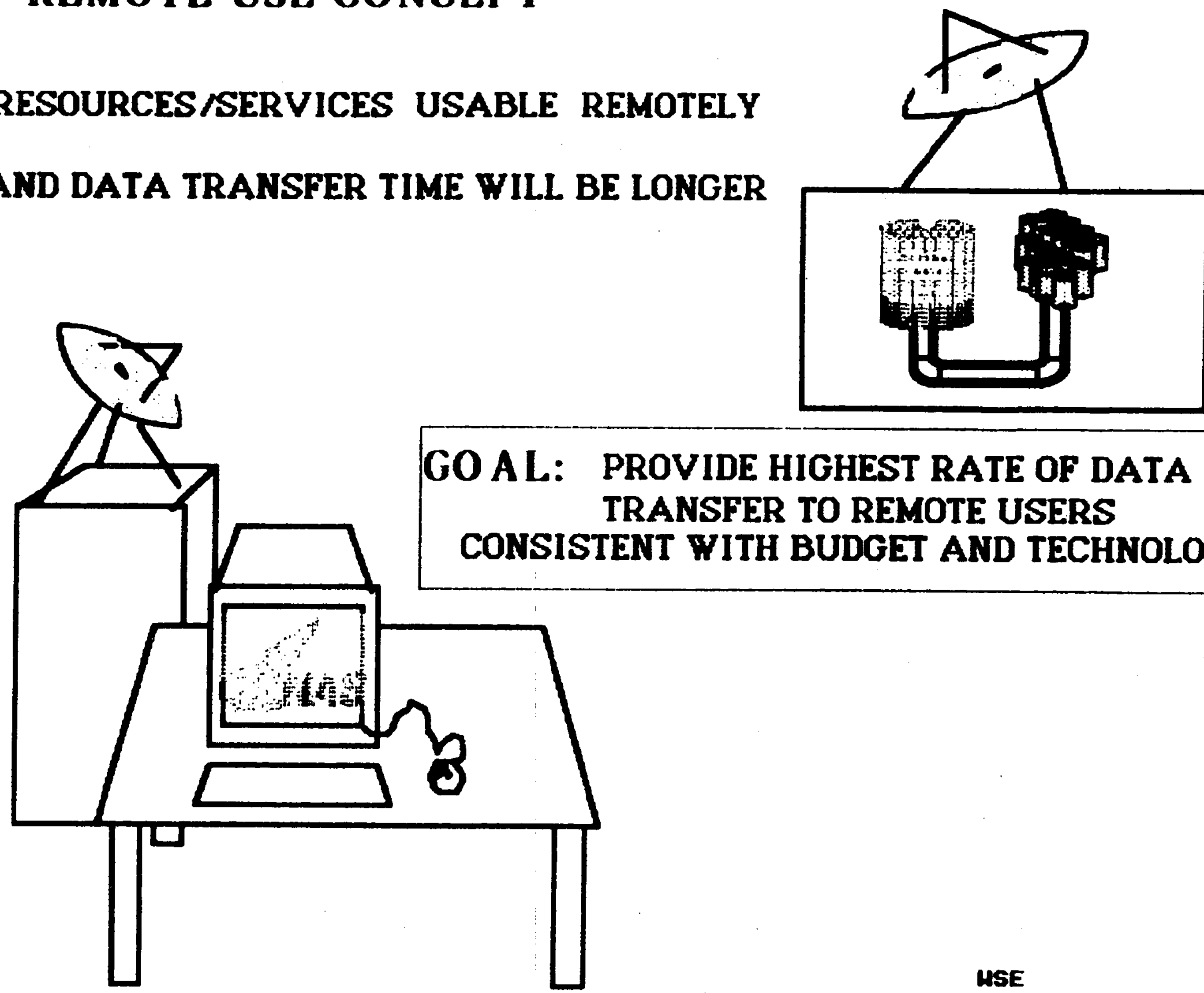


WSE
26JUN86
AO-

NUMERICAL AERODYNAMIC SIMULATION NETWORK

REMOTE USE CONCEPT

- o ALL NPSN RESOURCES/SERVICES USABLE REMOTELY
- o RESPONSE AND DATA TRANSFER TIME WILL BE LONGER



GOAL: PROVIDE HIGHEST RATE OF DATA TRANSFER TO REMOTE USERS CONSISTENT WITH BUDGET AND TECHNOLOGY

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NUMERICAL AERODYNAMIC SIMULATION NETWORK

SERVICE OBJECTIVES (1984)

- SUPPORT GEOGRAPHICALLY DISPERSED USER COMMUNITY
  - NASA Centers
  - Government R&D Centers
  - Industrial R&D Centers
  - Universities
  - 40 % remote use by IOC (1987)
  - 60 % remote use by EOC (1989)
- SUPPORT REMOTE ACCESS BY
  - 24 simultaneous low-speed (300-9600b/s) terminals/ workstations
  - 4 simultaneous workstations/computer systems @56kb/s
  - 1 workstation/computer systems @ 1.544Mb/s
  - 5 simultaneous MILnet/ARPAnet virtual terminal connections
  - 2 simultaneous MILnet/ARPAnet file transfers
  - (TBD) simultaneous CCF local network (ethernet) file transfers
  - (TBD) " " " " virtual terminal connections

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NUMERICAL AERODYNAMIC SIMULATION NETWORK

PERFORMANCE OBJECTIVES

- TRANSFER SOLUTION FILES (20-40 MEGABYTES) IN 10 MINUTES OR LESS
- TRANSFER GRAPHICS FILES (1 MEGABYTE) TO REMOTE NAS STANDARD WORKSTATION IN 10 SECONDS OR LESS

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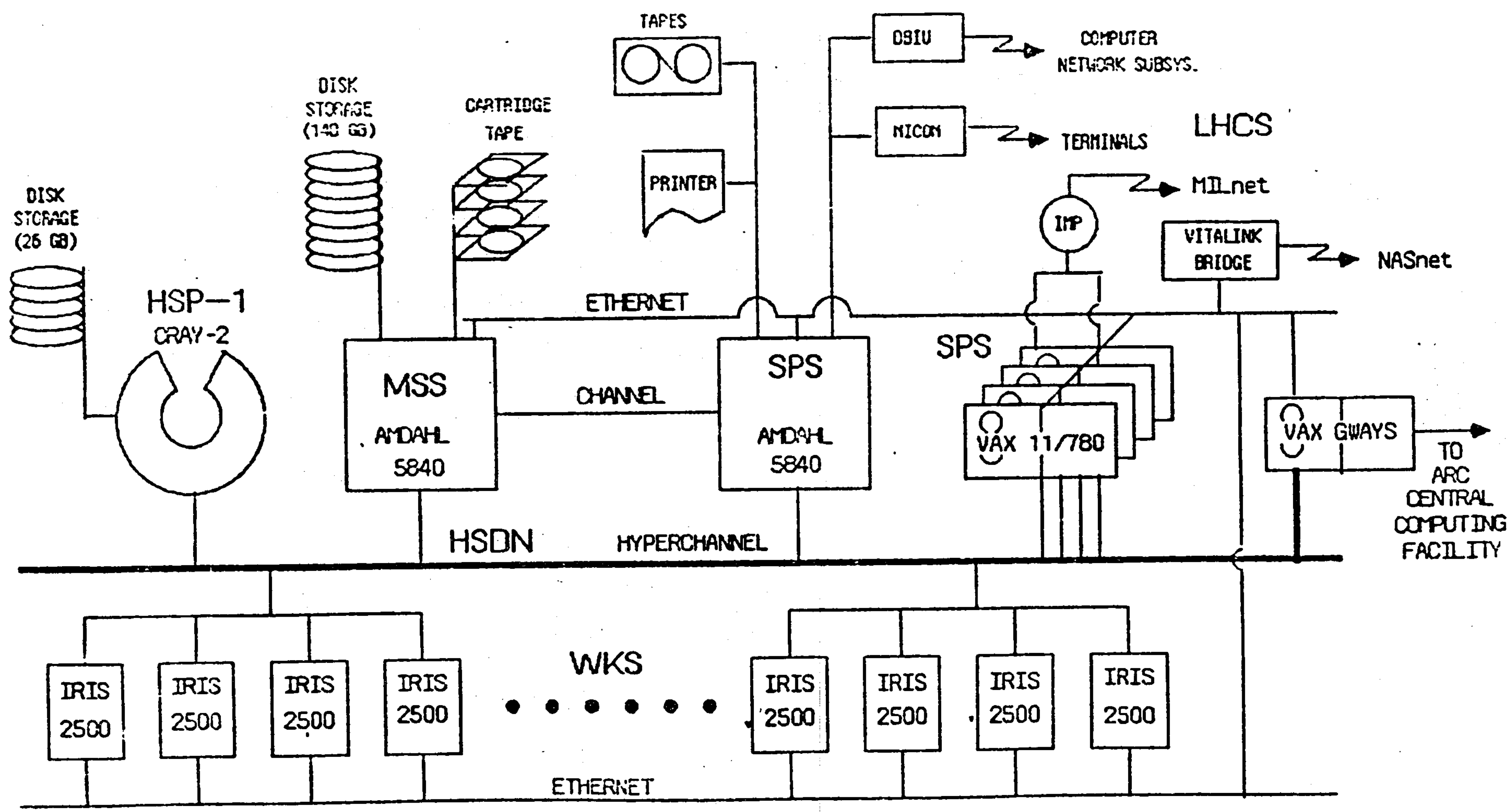
CURRENT NPSN INITIAL OPERATING CONFIGURATION



NUMERICAL AERODYNAMIC SIMULATION NETWORK

DEVELOPMENT APPROACH

- LEVERAGE EXISTING AND DEVELOPMENTAL NETWORKING TECHNOLOGY SUITED TO SUPPORT HETEROGENEOUS HOST-TO-HOST NETWORKING
  - MILnet/ARPAnet
  - ethernet
  - DARPA Internet protocols (TCP/IP, ICMP,FTP, TELNET, SMTP, UDP. . .)
- ADOPT DARPA INTERNET PROTOCOL FAMILY AS A STANDARD
  - matches NPSN internal protocol standard
  - implementations exist for MOST vendors' computer systems
  - migration path to future (ISO) multi-vendor standard(s)
- EXPLOIT CAPABILITIES OF NASA PROVIDED PROGRAM SUPPORT COMMUNICATIONS NETWORK (PSCN)
- RECOGNIZING EMERGENCE OF POWERFUL GRAPHICS WORKSTATIONS AS PRIMARY CFD USER TOOLS DEVELOP "PILOT" T1 BASED NETWORK TO SUPPORT ACCESS FROM REMOTE WORKSTATIONS TO THE NPSN
  - 224 kb/s to LaRC and LeRC (satellite); 56kb/s to CSU (terrestrial)
  - early user involvement/experience

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NUMERICAL AERODYNAMIC SIMULATION NETWORK

DESIGN

- ETHERNETS LINKED BY VITALINK VB/1 TRANSLAN BRIDGES
- USES WIDEBAND (56, 224, 448, and 1344kb/s) SWITCHED AND DEDICATED PSCN CIRCUITS
- REQUIRES USERS SITE ETHERNET
- NAS IS CENTER OF "STAR" OF ETHERNETS
- SUPPORTS DARPA INTERNET PROTOCOLS
- ADAPTABLE TO USE WITH ROUTERS/GATEWAYS
- CAN PROVIDE TERMINAL ACCESS THROUGH ETHERNET ATTACHED COMMUNICATIONS SERVERS
- PERFORMANCE ORIENTED (SINGLE HOP COMMUNICATION PATH)

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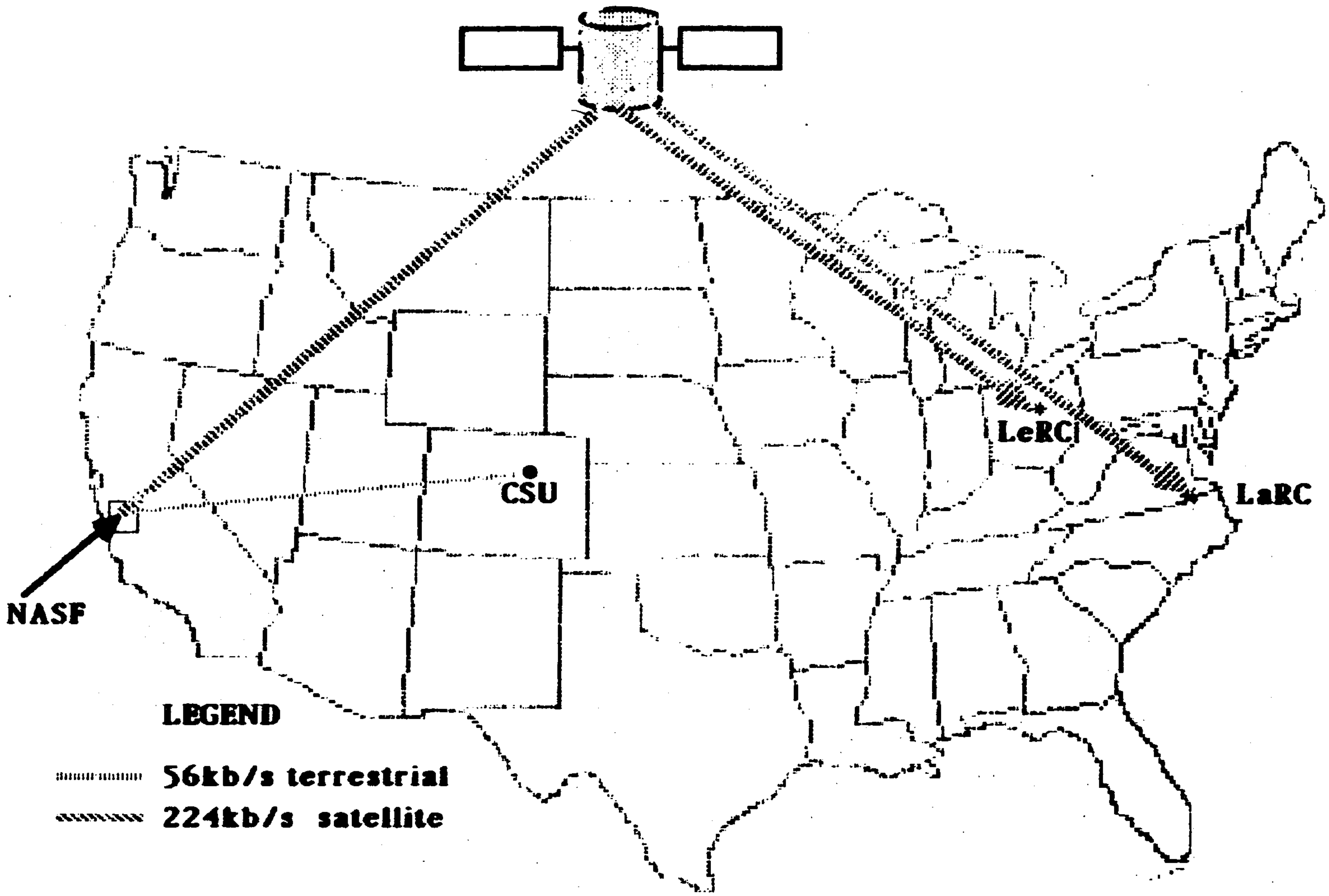
NUMERICAL AERODYNAMIC SIMULATION NETWORK



Prototype

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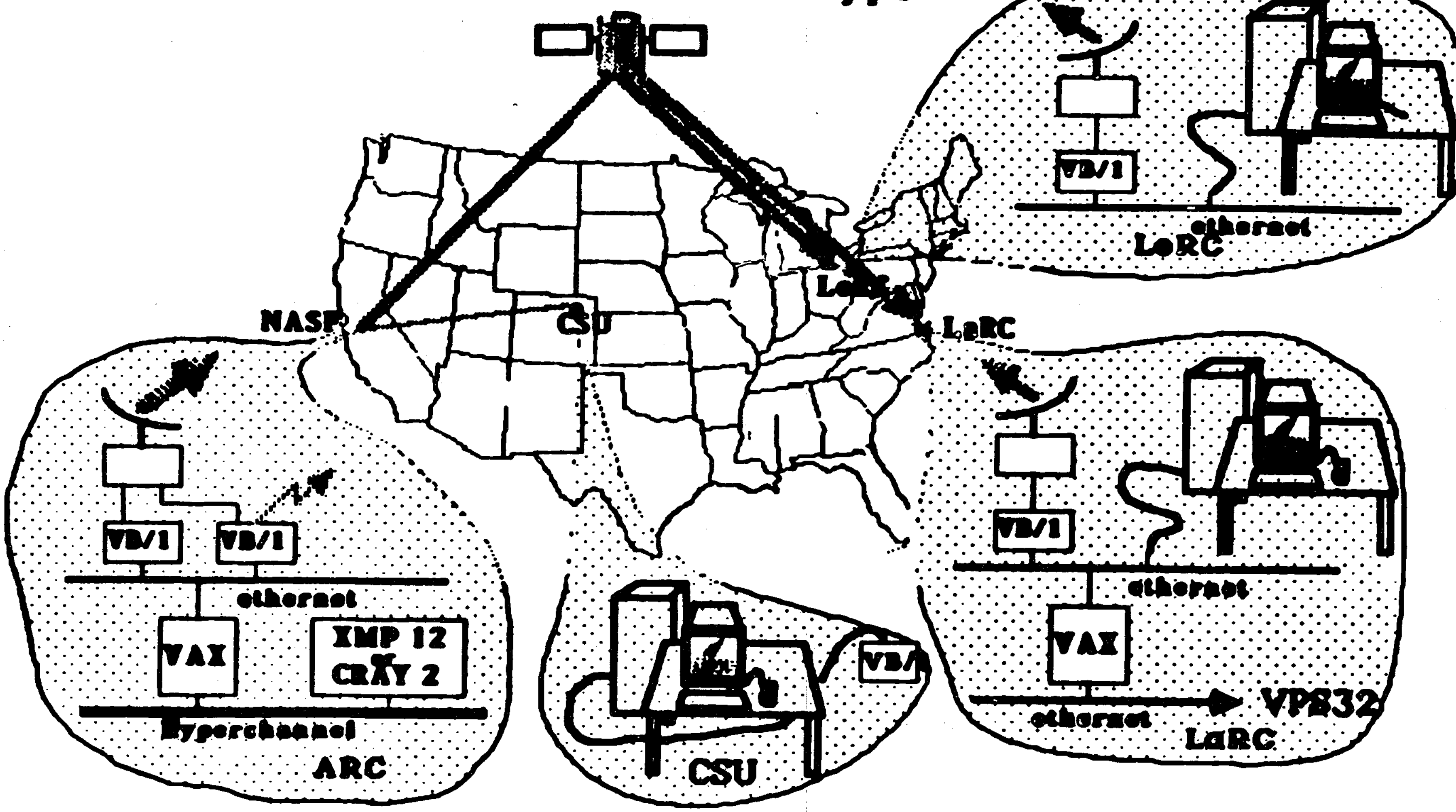
EOC System Requirements Review

NASnet Prototype



LEGEND

— 56kb/s terrestrial
— 224kb/s satellite

NUMERICAL AERODYNAMIC SIMULATION NETWORK

LESSONS LEARNED FROM PROTOTYPE

- EVERYTHING TAKES LONGER THAN PLANNED
- WORST CASES BECOME THE NORM
- T1 IS NOT CHEAP NOR ABUNDANT
- PROTOCOLS BUILT IN IGNORANCE OF SATELLITE DELAY PROVIDE POOR IMPEDANCE MATCH BETWEEN END-TO-END PERFORMANCE AND RAW TRANSMISSION BANDWIDTH OF SATELLITE CHANNEL
  - effective throughput 10% of raw transmission rate
  - "receive window" size arbitrarily set for LAN use
- INTERACTIVE (REMOTE ECHO CHARACTER MODE) USE IS DIFFICULT ON SATELLITE BASED CONNECTION
- REMOTE USER AND SOFTWARE SUPPORT IS A DIFFICULT TASK
- TERRESTRIAL WIDEBAND INTERCONNECTED ETHERNETS COUPLED WITH TCP/IP AND SERVICE PROTOCOLS CAN SUPPORT CLUSTERS OF SUPERCOMPUTER USERS

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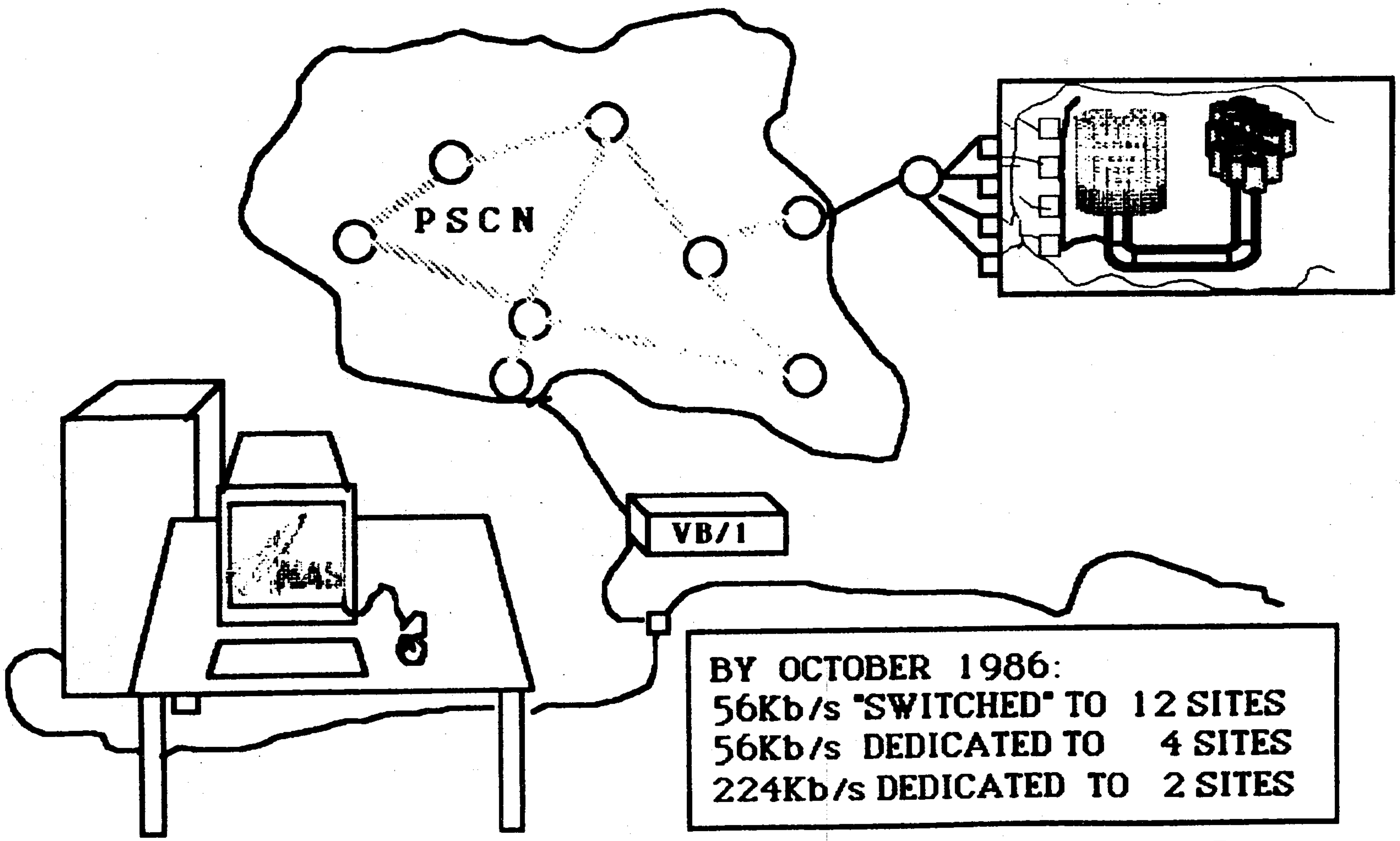
NUMERICAL AERODYNAMIC SIMULATION NETWORK

NASNET IMPLEMENTATION



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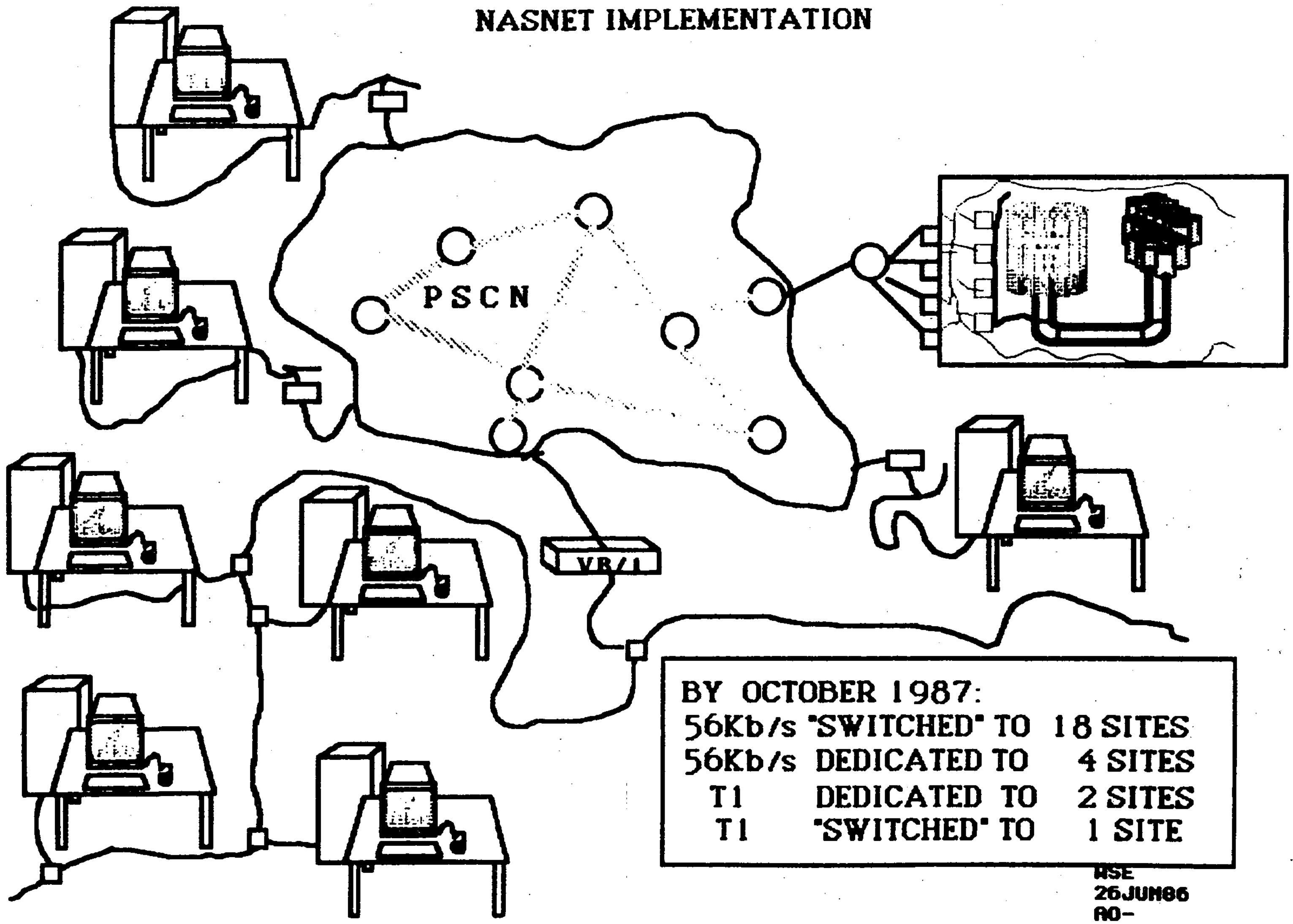
NUMERICAL AERODYNAMIC SIMULATION NETWORK

NASNET IMPLEMENTATION



BY OCTOBER 1987:

56Kb/s	"SWITCHED" TO	18 SITES
56Kb/s	DEDICATED TO	4 SITES
T1	DEDICATED TO	2 SITES
T1	"SWITCHED" TO	1 SITE

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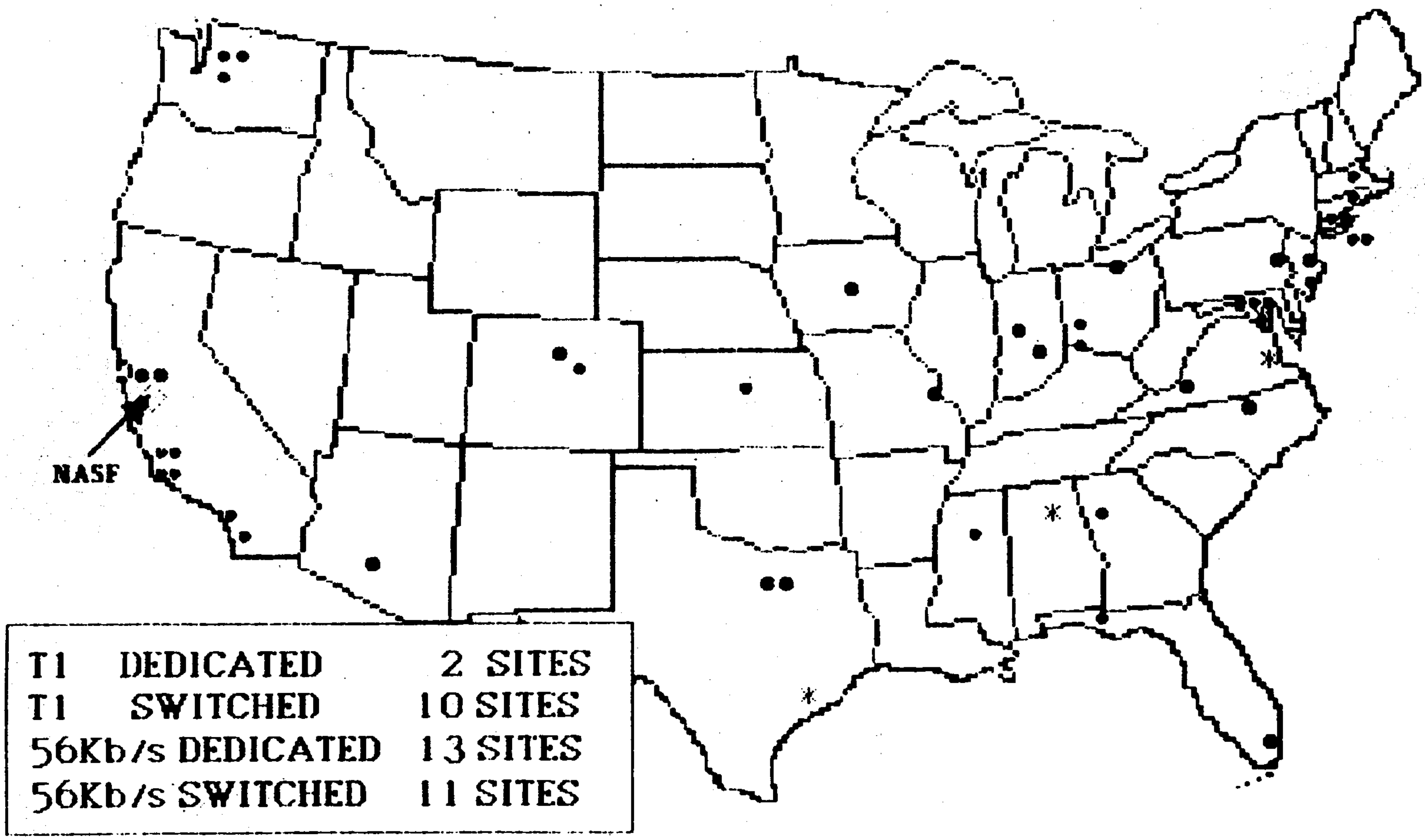
NUMERICAL AERODYNAMIC SIMULATION NETWORK

USER SITES SUPPORTED BY OCTOBER 1988



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NUMERICAL AERODYNAMIC SIMULATION NETWORK

REMOTE ACCESS ALTERNATIVES

- MILnet : DOD AND GOVERNMENT USERS
  - 7 out of 8 projected DoD user sites already connected
- ARPAnet : UNIVERSITY USERS (and Government sponsored R&D)
  - 9 out of 20 projected university user sites already connected; 6 more with NSF expansion
- PSCN : NASA AND NASA SPONSORED USERS
  - ramping up simultaneously with NASnet
- NSFnet : NSF SUPERCOMPUTING CENTERS/USERS
  - BARRN: Bay Area Regional Research Network
- OTHER : INDUSTRY USERS W/PROPRIETARY WORK

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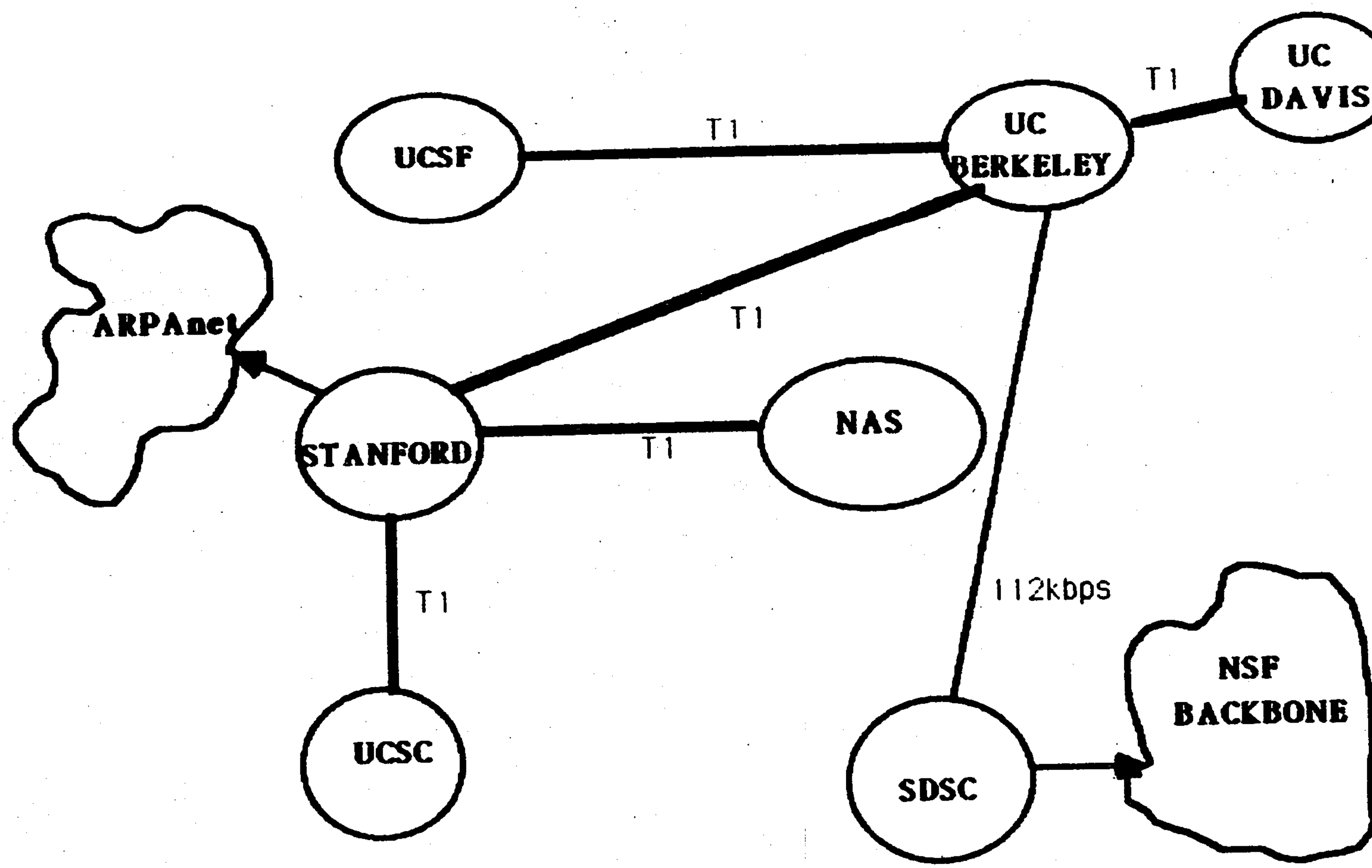
NUMERICAL AERODYNAMIC SIMULATION NETWORK



PROPOSED BAY AREA REGIONAL RESEARCH NETWORK - BARRN

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NUMERICAL AERODYNAMIC SIMULATION NETWORK

PSCN -- NASA PROGRAM SUPPORT COMMUNICATIONS NETWORK

- o CNS -- COMPUTER NETWORK SUBSYSTEM
  - bulk file transfer among OAST centers (ARC, DFRF, LaRC, LeRC)
- o NPSS -- NASA PACKET SWITCHING SYSTEM
  - 300/1200/2400 bps dial-in terminal access
  - 9600 bps with dedicated circuit for async/sync terminals
- o ACCUNET SWITCHED 56 -- AT&T PUBLIC OFFERING
  - digital 56Kbps circuit within 17 miles of AT&T C.O.
  - 40 cities in 1986
- o DEDICATED WIDEBAND CIRCUITS (56Kbps to 1.544Mbps)
  - terrestrial and satellite
  - NASnet (wideband linked ethernets)
- o EXISTING/EXPANDING NASA INTERCENTER "SPECIAL" INTEREST NETWORKS
  - SPAN (Space Physics Analysis Network)
    (8 of 20 projected university user sites already connected)

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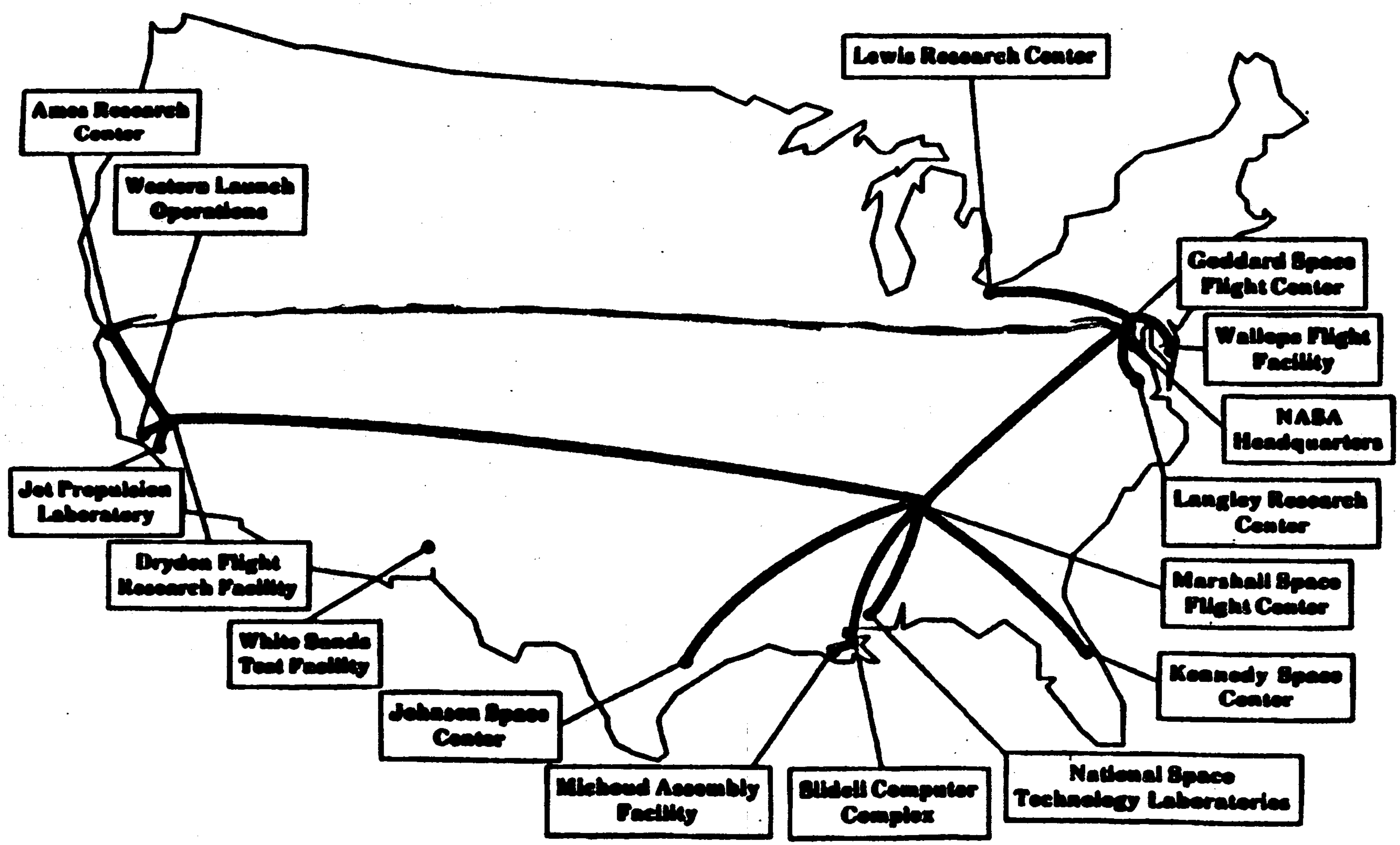
LONG HAUL COMMUNICATIONS

Program Support Communications - 1.5Mbps Terrestrial Backbone Network



NUMERICAL AERODYNAMIC SIMULATION NETWORK

CHALLENGES AND OPPORTUNITIES

- ACCOMMODATE UNFORSEEN ADDITIONAL SITES
- T1 SWITCHED SERVICE
- "TYPE/CLASS OF SERVICE" ROUTING
- HIGH-PERFORMANCE (HIGH THROUGHPUT) DATA TRANSFER PROTOCOL
  - reliable (NETBLT?)
  - unreliable
- ACCESS CONTROL(S)
- ADVANCED "MULTI-NETWORK" IP SWITCH
- NSFnet/ARPAnet/MILnet PERFORMANCE
- MIGRATION TO ISO PROTOCOL SUITE(S)
- "DISTRIBUTED" EDITOR(S)
- DISTRIBUTED GRAPHICS

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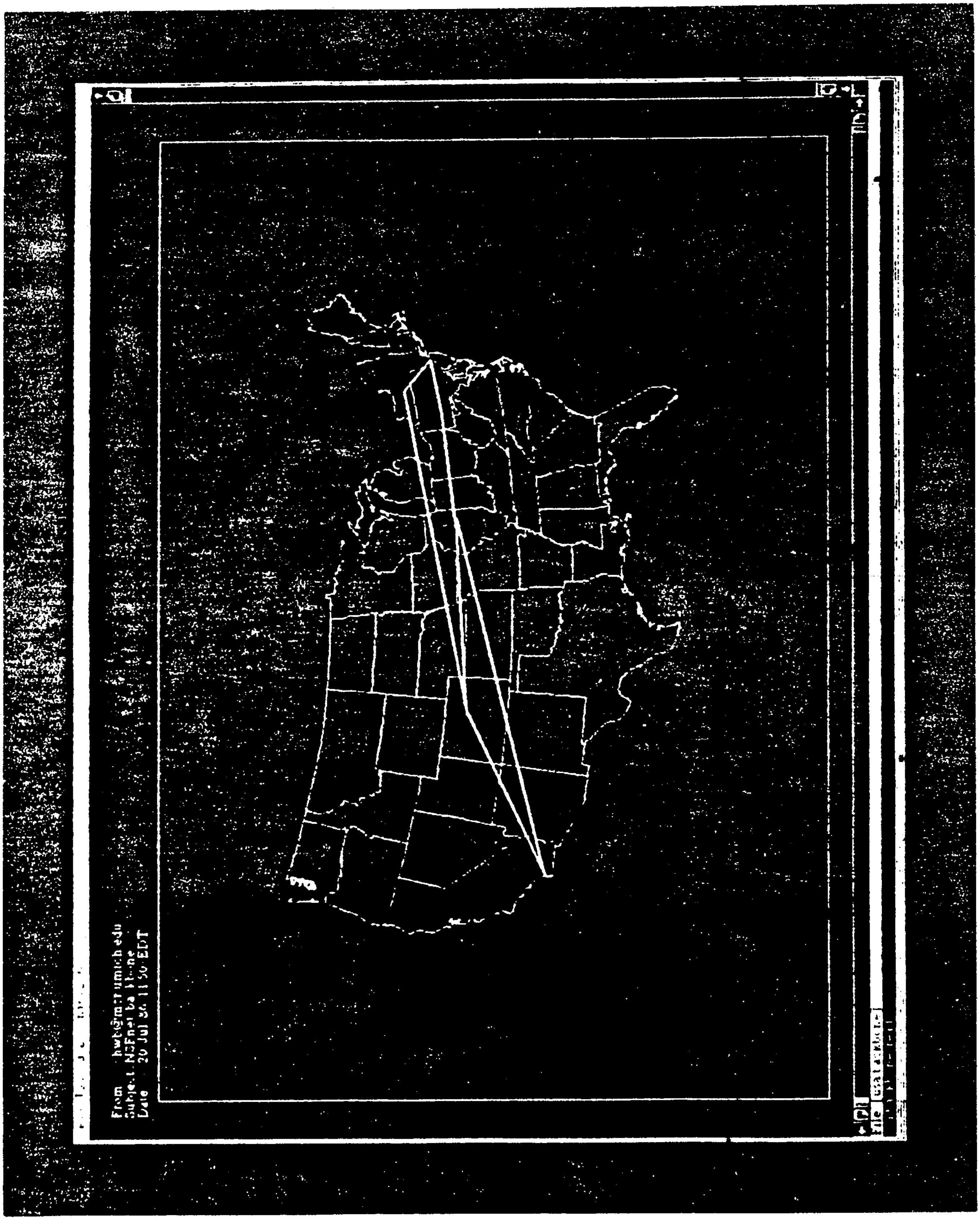
STEPHEN WOLFF, PROGRAM DIRECTOR FOR NETWORKING

NATIONAL SCIENCE FOUNDATION

TITLE: NSFNET STATUS AND PLANS

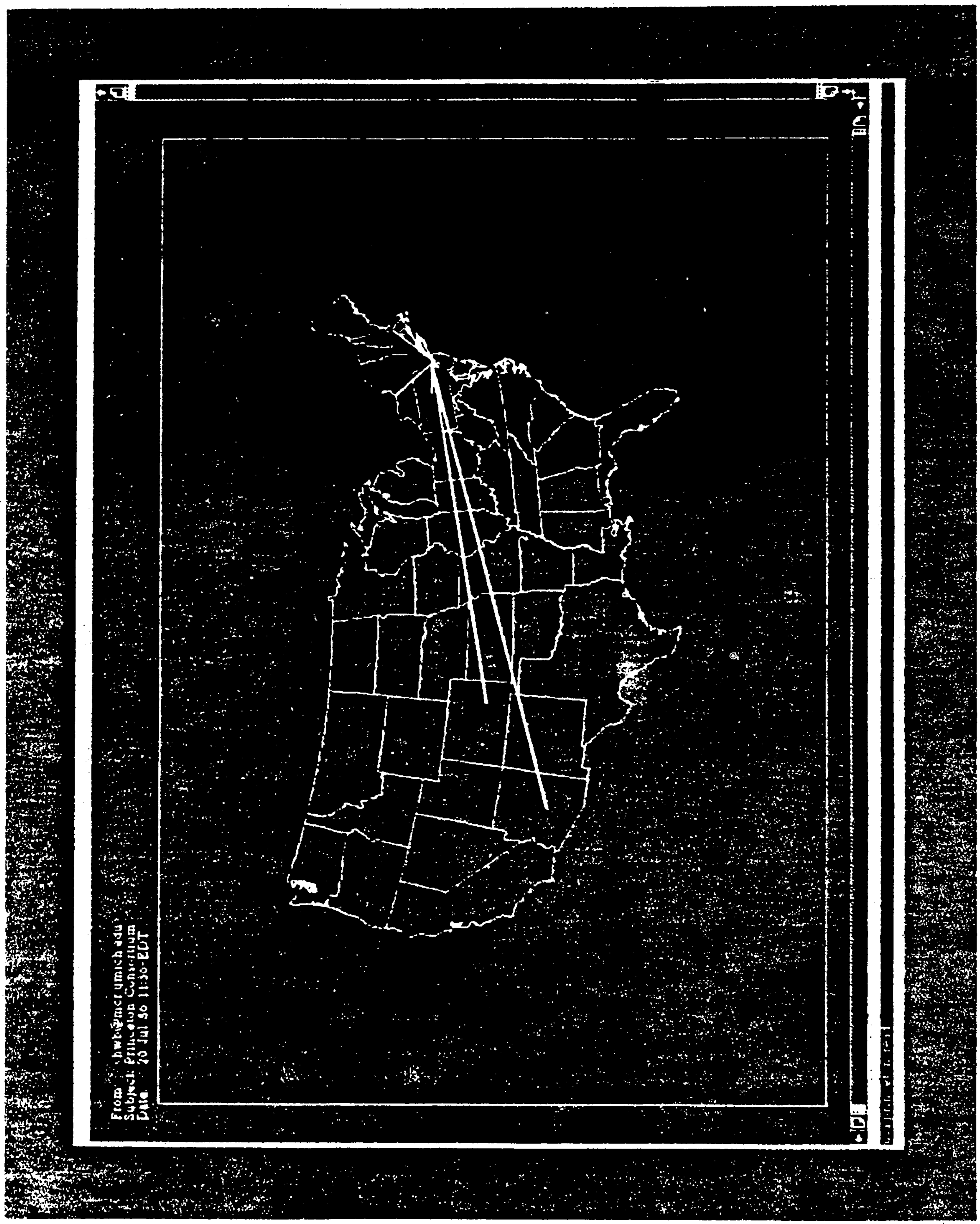
NSFNET

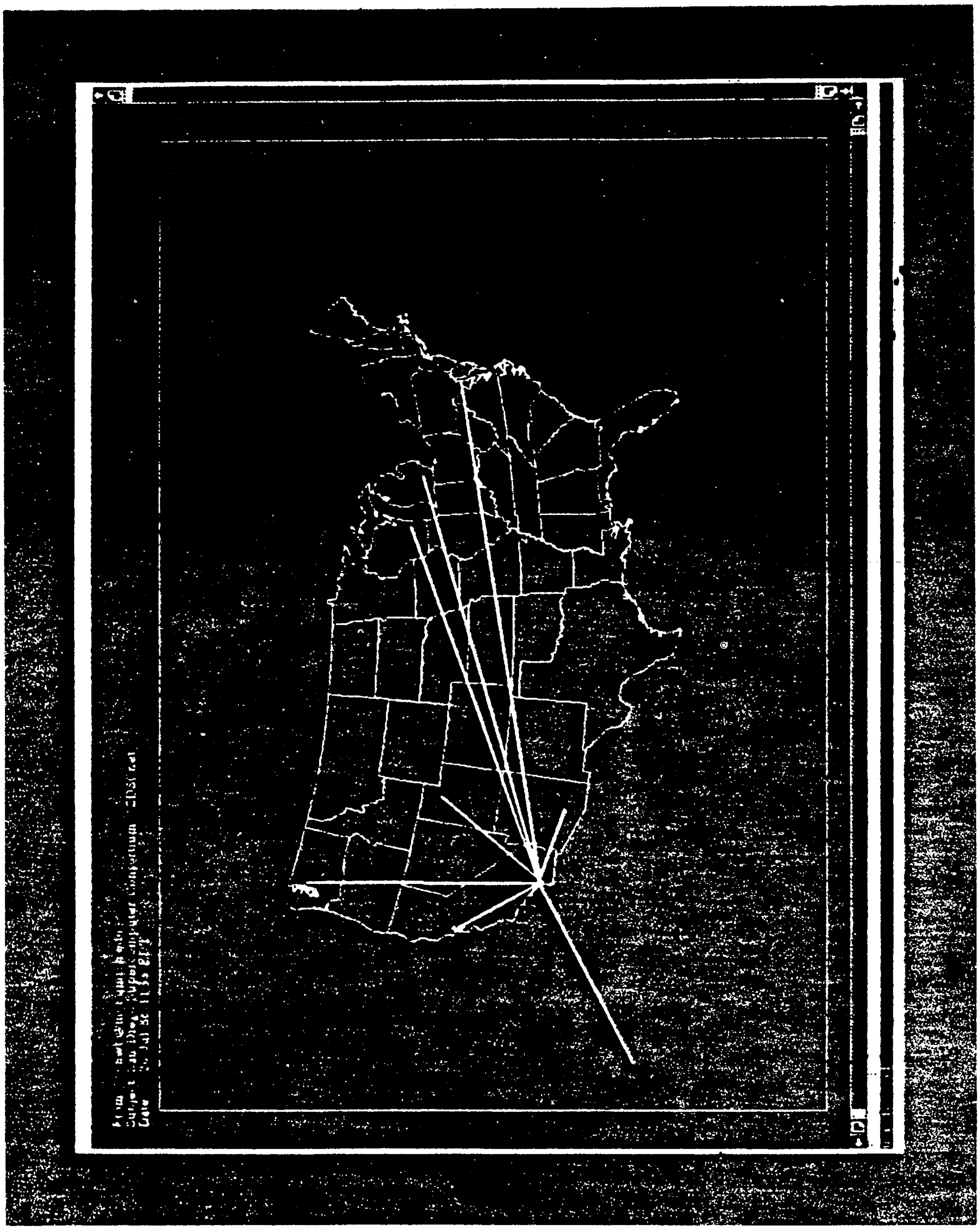
STATUS AND PLANS

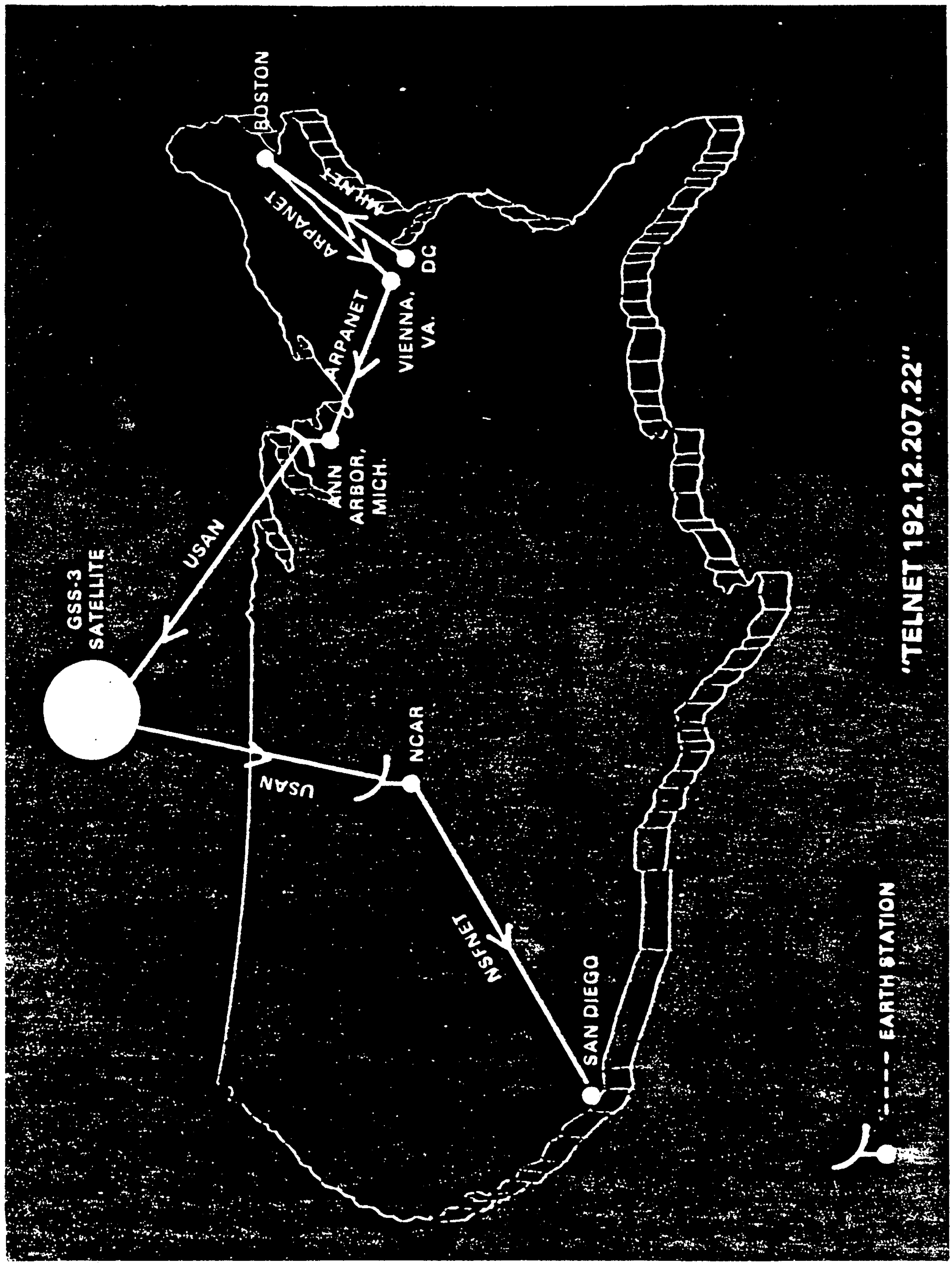


BACKBONE STATUS

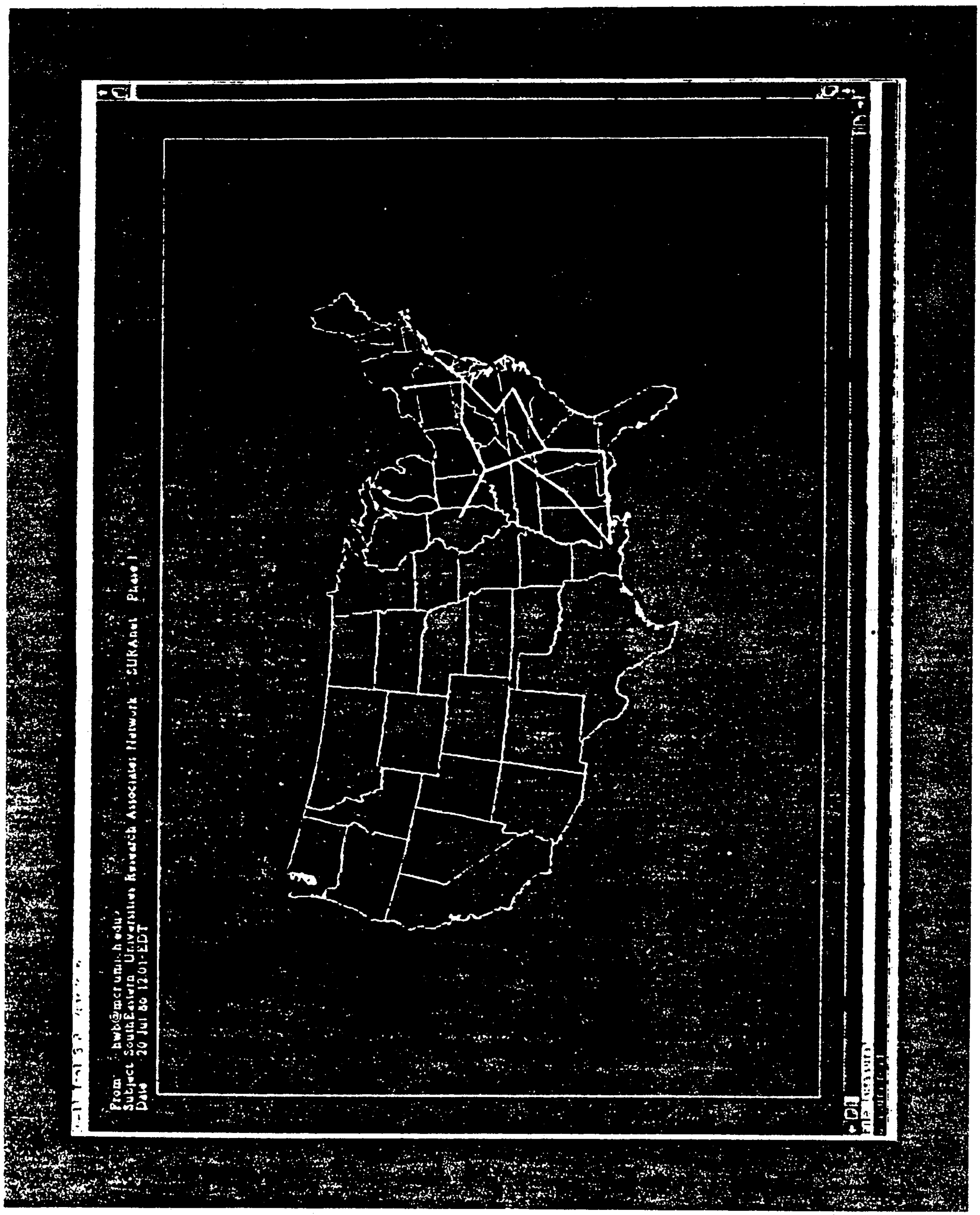
- running with networkers since july
- friendly users since september
- public announcement in october

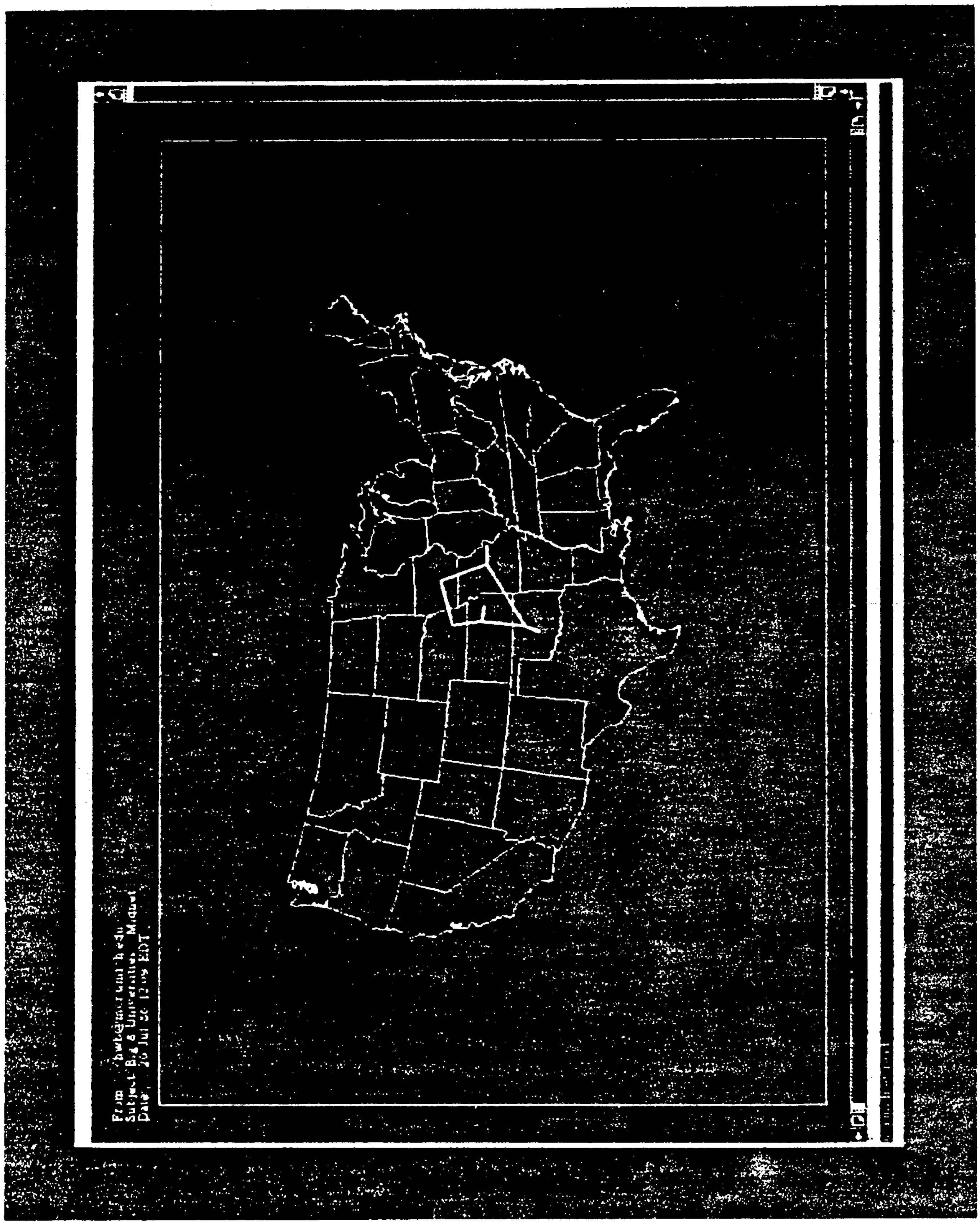

From
Subject
Date





BOSTON
MILNET
ARPANET
DC
VIENNA, VA.
ARPANET
ANN ARBOR, MICH.
USAN
GSS-3 SATELLITE
USAN
NCAR
USAN
NSFNET
SAN DIEGO
EARTH STATION
"TELNET 192.12.207.22"


From: hwb@mcr.umich.edu
Subject: SouthEastern Universities Research Association Network - SURAnet Phase I
Date: 20 Jul 88 12:01-EDT




Subject New York State Network   NYSERnet
Date : 20 Jul 86 12 38 EDT

BARRNET

uc berkeley   uc davis

uc san francisco   uc santa cruz

stanford   nasa ames

SESQUINET

baylor college of medicine

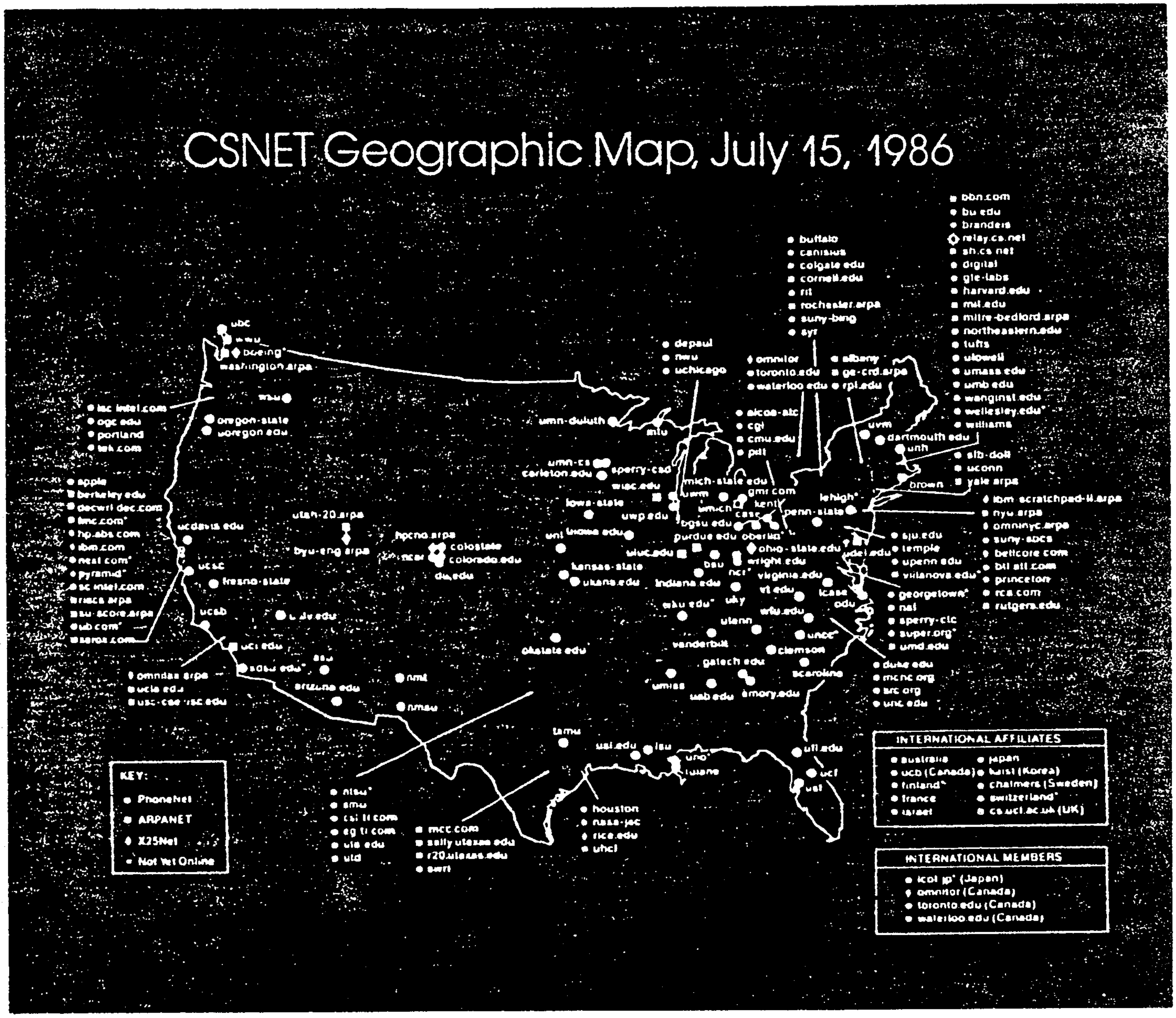
houston area research center

u houston   rice

texas a&m   texas southern u

**ut austin


Subject: University SAtellite Network Pilot Project: USAN
Date: 20 Jul 86 11:53-EDT



CSNET Geographic Map, July 15, 1986
ubc
boeing*
washington.arpa
isc intel.com
ogc edu
portland
tek.com
oregon-state
uoregon edu
apple
berkeley edu
decwrl dec.com
hp.abs.com
ibm.com
pyramid*
sc intel.com
riacs arpa
su-score.arpa
xerox.com
ucdavis edu
ucsc
fresno-state
ucsb
uci edu
omnidax arpa
ucla edu
sdsu edu*
arizona edu
nmt
nmsu
utah-20.arpa
byu-eng arpa
hpcno.arpa
colostate
colorado.edu
ncar
du.edu
umn-duluth
umn-cs
carleton.edu
sperry-csd
wisc.edu
iowa-state
uwp.edu
unl
kansas-state
ukans.edu
okstate edu
tamu
usl.edu
lsu
uno*
tulane
ntsu*
smu
csi ti com
eg ti com
uta edu
utd
mcc.com
sally utexas edu
r20.utexas.edu
swri
houston
nasa-jsc
rice.edu
uhcl
KEY:
PhoneNet
ARPANET
X25Net
Not Yet Online
depaul
nwu
uchicago
mtu
mich-state edu
gmr.com
kent
case
bgsu.edu
purdue edu
oberlin*
uiuc.edu
bsu
nci*
indiana.edu
ohio-state.edu
wright.edu
virginia.edu
vt.edu
icase
odu
uky
wfu.edu
utenn
vanderbilt
uncc*
clemson
galech edu
umiss
uab edu
emory.edu
scarolina
ufl.edu
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usf
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waterloo edu
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cmu.edu
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cornell.edu
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syr
albany
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rpi.edu
uvm
dartmouth edu
unh
lehigh*
penn-state
sju.edu
temple
upenn edu
villanova.edu*
udel.edu
georgetown*
nsf
sperry-ctc
super.org*
umd.edu
duke edu
mcnc org
src org
unc edu
bbn.com
bu edu
brandeis
relay.cs.net
sh.cs net
digital
gte-labs
harvard.edu
mit.edu
mitre-bedford.arpa
northeastern.edu
tufts
ulowell
umass.edu
umb edu
wanginst.edu
wellesley.edu*
williams
slb-doll
uconn
brown
yale arpa
ibm scratchpad-ii.arpa
nyu.arpa
omninyc.arpa
suny-sbcs
bellcore com
btl att.com
princeton
rca.com
rutgers.edu
INTERNATIONAL AFFILIATES
australia
ucb (Canada)
finland*
france
israel
japan
kaist (Korea)
chalmers (Sweden)
switzerland*
cs.ucl.ac.uk (UK)
INTERNATIONAL MEMBERS
icot jp* (Japan)
omnitor (Canada)
toronto.edu (Canada)
waterloo.edu (Canada)

NSF ARPANET CONNECTIONS

u wisconsin   u delaware

u minnesota   ohio state

uc santa barbara   u maryland

u michigan   ucla

cal tech   u indiana

northwestern   carnegie-mellon

u washington   colorado state

at&t bell labs   purdue

u illinois   cornell

sdsc   jvnc

princeton   suny stony brook

tucc   rice

u pennsylvania   u virginia

u colorado   ncar

we are witnessing the birth of the NATIONAL RESEARCH INTERNET

which will connect scientists to one another --

and to unique computing assets --

to enrich the national research enterprise in ways we are only beginning to understand, and have barely begun to exploit.

CURRENT ACTIVITIES

- » rfc985 - draft may '86
- » router meeting - july '86
- » queries and concerns to be sent out
- » update rfc985

The NSF is committed to international networking standards and to the timely migration of NSFNET to the full ISO protocol suite. In support of this commitment, the NSF will make available at each supercomputer center on the NSFNET backbone, software which presents an ISO TP4 environment to higher-level networking code, yet which uses the services of TCP and is transportable over IP networks such as NSFNET and the ARPANET.

This ISO Development Environment (ISODE) software will

(a) allow early deployment and use of existing high-level ISO networking software that requires a TP4 transport layer interface, and

(b) permit the development and testing of new ISO-style software with assurance that the development effort will not have been wasted when the actual underlying transport and network layers switch from TCP and IP to their ISO counterparts.

Thus with the ISODE at each NSF supercomputer center, NSFNET can serve as an early testbed for ISO-style high-level networking.

The ISODE package was developed by Marshall T. Rose and Dwight E. Cass of the Northrop Research and Technical Center and, while not in the public domain, is made available to the networking community without charge and without support. Comments on the package, including bug reports, will be gratefully received.

Stephen S. Wolff
Program Director for Networking
National Science Foundation

4 September 1986

PLANS

» move backbone to T1 asap

» high speeds would be nice, too

» collaborate in ISO migration

stephen wolff

program director
for
networking

national science foundation

(202) 357-9717

steve@brl.arpa

DONALD E. SCOTT, DIRECTOR

OFFICE OF COMPUTER SERVICES & TELECOMMUNICATIONS MANAGEMENT

U. S. DEPARTMENT OF ENERGY

TITLE:

DEPARTMENT OF ENERGY

TELECOMMUNICATIONS

DEPARTMENT OF ENERGY

TELECOMMUNICATIONS

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

IMPROVING TELECOMMUNICATIONS SERVICES AND REDUCING COSTS

PROPOSALS

SYSTEM COST	LOCAL DATA COMM.	INTERCITY DATA COMM.
< $50K/YR.	LOCAL APPROVAL	LOCAL APPROVAL DOE HQ APPROVAL NOTIFICATION TO GSA
> $50K/YR.	LOCAL APPROVAL DOE HQ APPROVAL	LOCAL APPROVAL DOE HQ APPROVAL GSA HQ APPROVAL

PROPOSAL REQUIRED ON

- PROGRAMS EXCEEDING $1 MILLION PER BUDGET YEAR
- PROGRAMS EXCEEDING $1 MILLION IN LIFE COST
- SERVICES INVOLVING A $50,000 OR MORE ANNUAL RECURRING COST OR TERMINATION LIABILITY
- PROGRAMS INVOLVING THE INTRODUCTION OF UNIQUE EQUIPMENT OR SERVICES
- MODIFICATIONS OR ADDITIONS TO DOE-WIDE SYSTEMS
- ALL INTERCITY CIRCUITS

TRANSPORT SYSTEMS

- OPMODEL SATELLITE SERVICE
- WIDE BAND TERRESTRIAL SERVICE
- FTS 2000
- NETWORK MANAGEMENT/TECHNICAL CONTROL

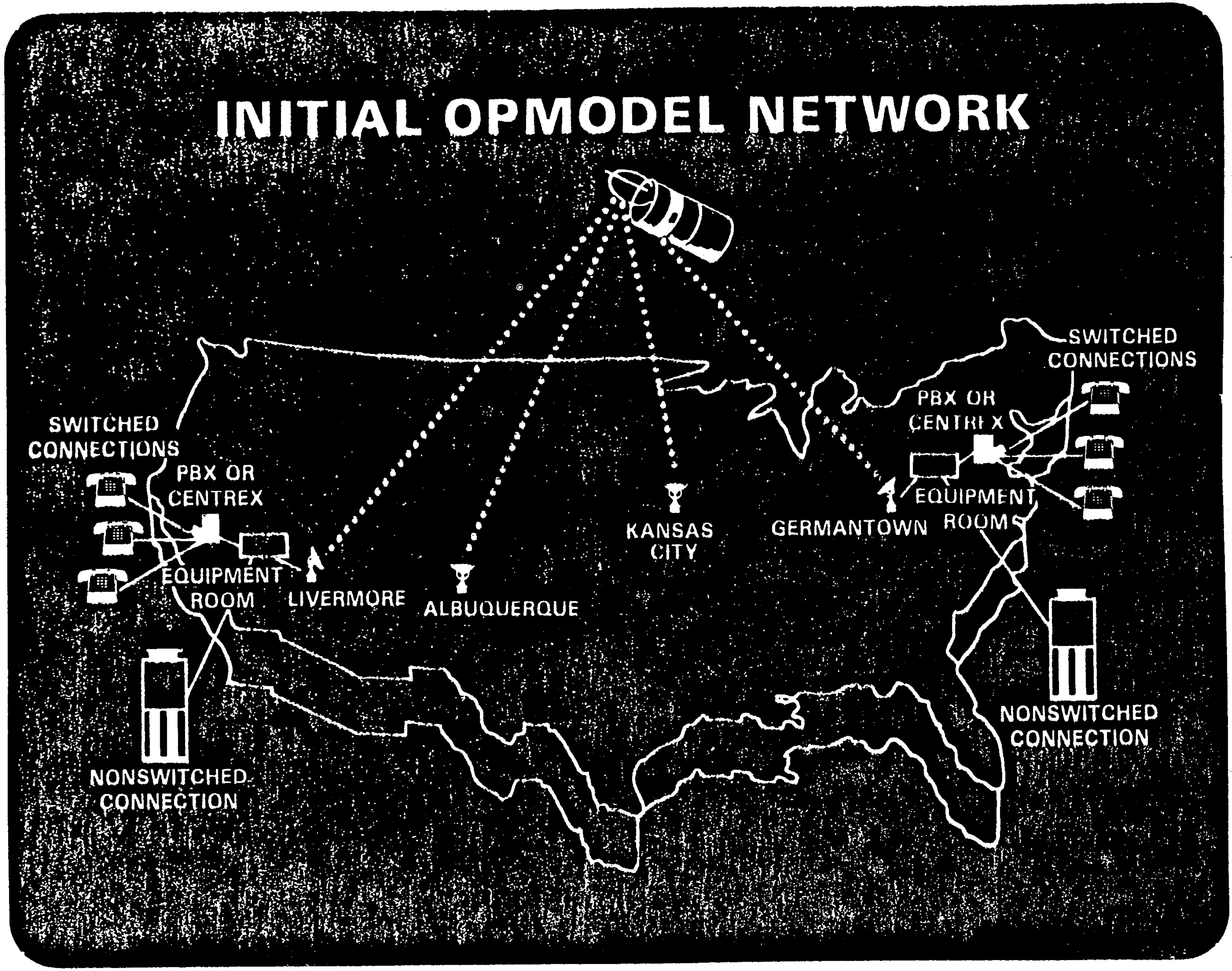
OPMODEL OBJECTIVE

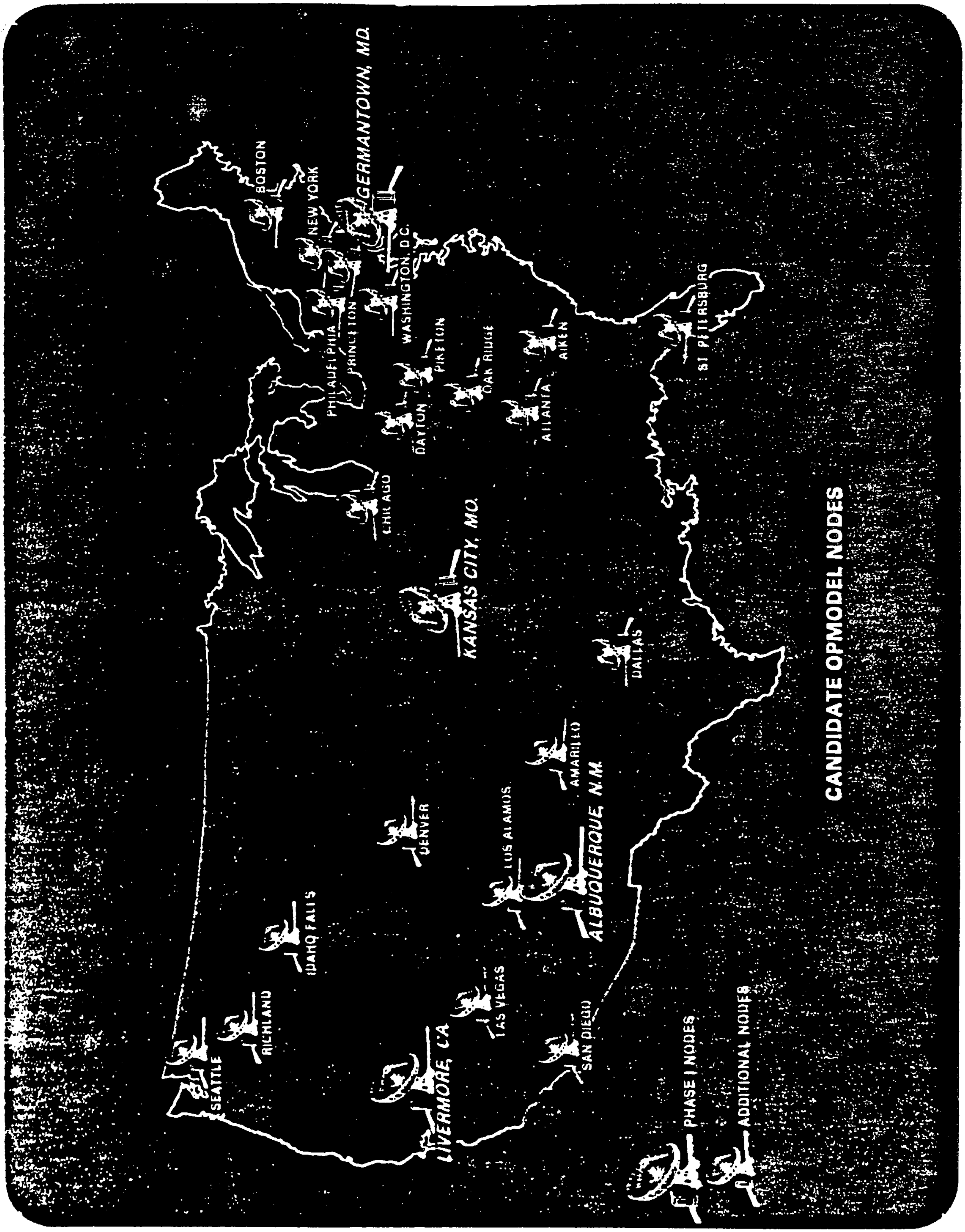
TO DEMONSTRATE THE FEASIBILITY, USEFULNESS, AND COST EFFECTIVENESS OF AN INTEGRATED TELECOMMUNICATIONS SYSTEM WHICH PROVIDES THE CAPABILITY FOR RELIABLE TRANSMISSION OF SECURE AND NONSECURE DATA, VOICE, AND SPECIALIZED SERVICES.

OPMODEL FEATURES

- SATELLITE BASED
- SECURE
- LONG HAUL BACKBONE
- CONFIGURATION FLEXIBILITY
- NETWORK CONTROL
- INTERFACE STANDARDS

- CAD/CAM
- SACNET
- COMPUTER TO COMPUTER
- GATEWAY
- DOCUMENT DISTRIBUTION
- VIDEO TELECONFERENCING


INITIAL OPMODEL NETWORK
SWITCHED CONNECTIONS
PBX OR CENTREX
EQUIPMENT ROOM
NONSWITCHED CONNECTION
LIVERMORE
ALBUQUERQUE
KANSAS CITY
GERMANTOWN
EQUIPMENT ROOM
PBX OR CENTREX
SWITCHED CONNECTIONS
NONSWITCHED CONNECTION



CANDIDATE OPMODEL NODES

OPMODEL DIGITAL PORT SPEEDS

LOW	2.4, 4.8, 9.6, 19.2 KBPS
MEDIUM	56, 112, 224, 448 KBPS
HIGH	386 KBPS, 772 KBPS, 1.544 MBPS

LOW SPEED DATA

GERMANTOWN	25
ALBUQUERQUE	26
KANSAS CITY	10
LIVERMORE	24

MEDIUM SPEED DATA

GERMANTOWN	2
ALBUQUERQUE	6
KANSAS CITY	4
LIVERMORE	8

HIGH SPEED DATA

GERMANTOWN	1
ALBUQUERQUE	2
KANSAS CITY	1
LIVERMORE	2

VOICE

	CARDS	PORTS AVAILABLE	PORTS IN USE
GERMANTOWN	3	12	9
ALBUQUERQUE	3	12	12
KANSAS CITY	3	12	10
LIVERMORE	4	16	16

DEDICATED CKT BUNDLING STUDY CONSIDERATIONS

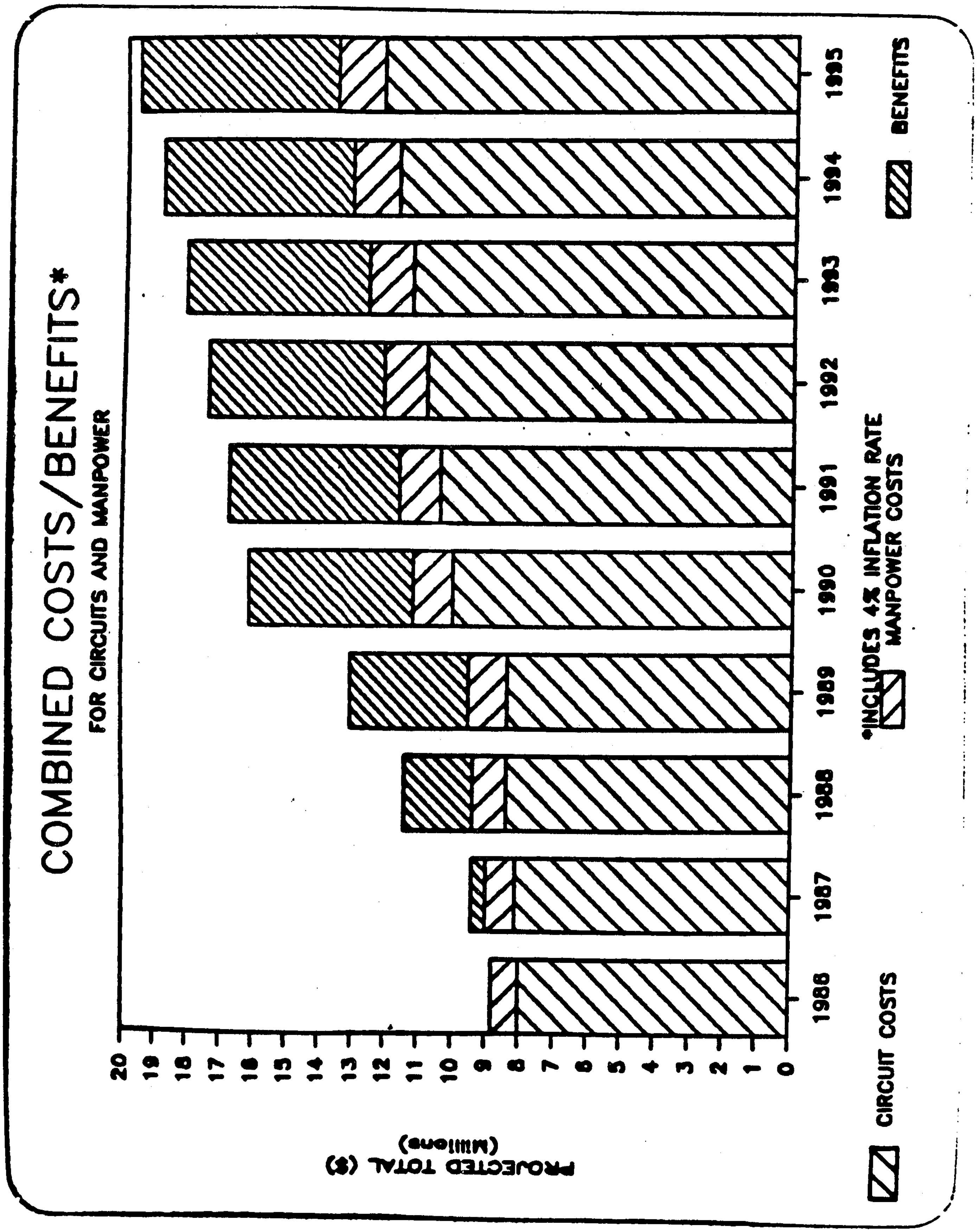
- 824 CKTs IDENTIFIED AND CONSIDERED
- 449 CKTs VIABLE CANDIDATES FOR BUNDLING
- OPMODEL CONSIDERATION
  - OPMODEL NODES
  - CKTs ON OPMODEL
- TERRESTRIAL WIDEBAND CKT ALTERNATIVES

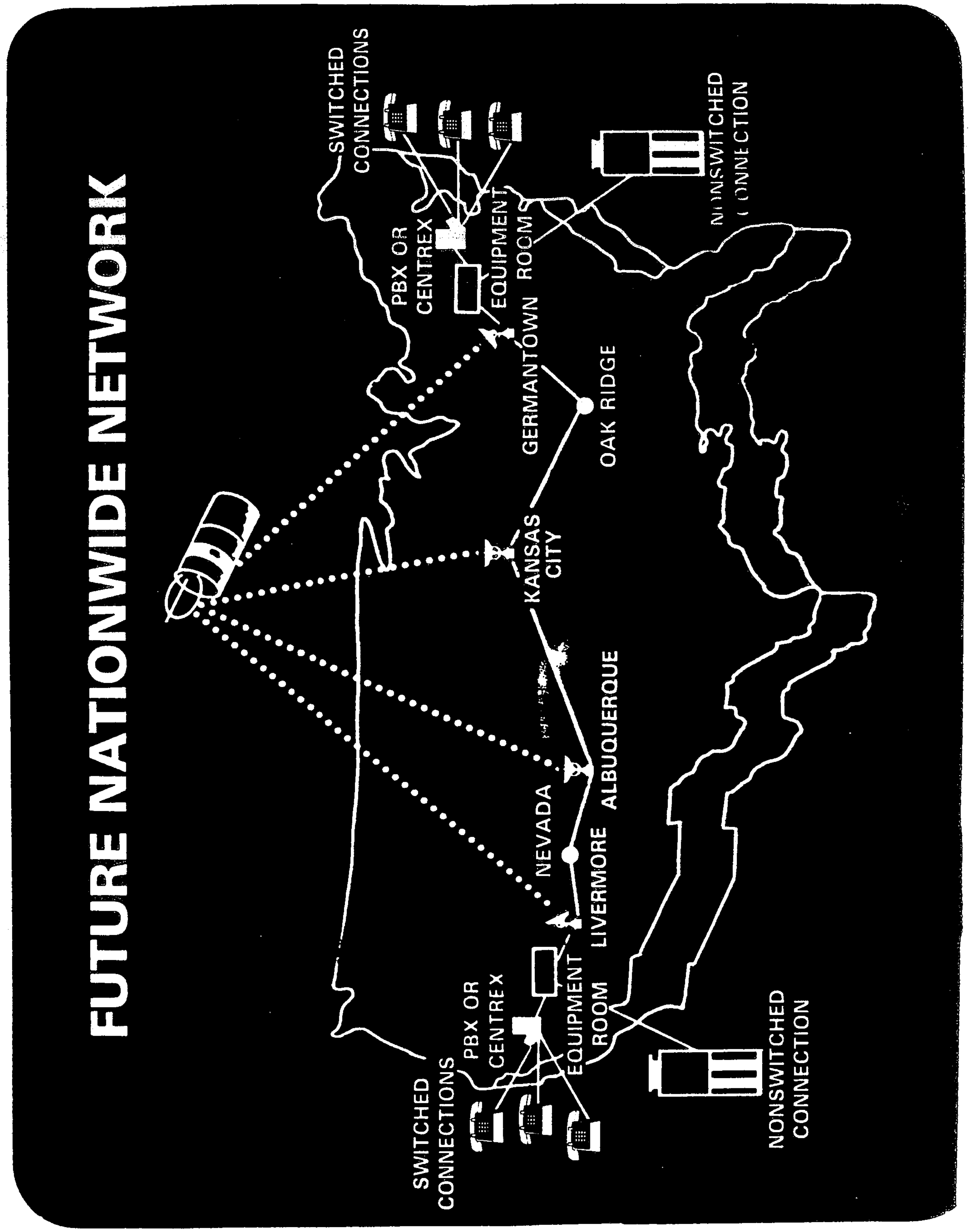
CKT BUNDLING PROJECT STATUS

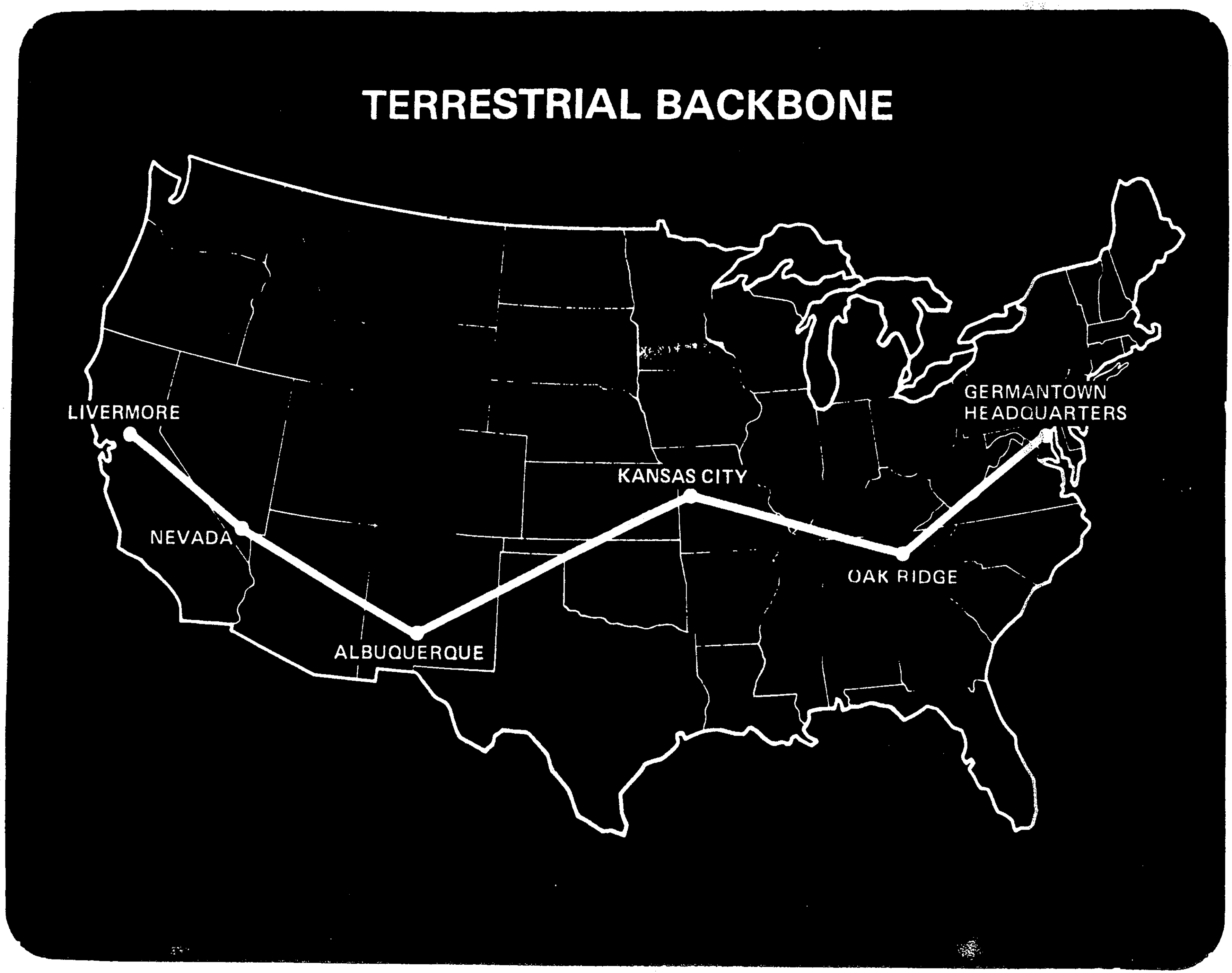
- DEDICATED CKT STUDY – COMPLETE
- DIAL UP CKT STUDY – ON HOLD
- DEDICATED CKT STUDY IMPLEMENTATION – IN PROCESS

OPMODEL NODES

- STUDY REVEALS ADDITIONAL OPMODEL COST BENEFITS AT:
  - OAK RIDGE
  - LAS VEGAS


COMBINED COSTS/BENEFITS*
FOR CIRCUITS AND MANPOWER
PROJECTED TOTAL ($)
(Millions)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
CIRCUIT COSTS
*INCLUDES 4% INFLATION RATE
MANPOWER COSTS
BENEFITS


FUTURE NATIONWIDE NETWORK
SWITCHED CONNECTIONS
PBX OR CENTREX
EQUIPMENT ROOM
NONSWITCHED CONNECTION
LIVERMORE
NEVADA
ALBUQUERQUE
KANSAS CITY
OAK RIDGE
GERMANTOWN
EQUIPMENT ROOMS
PBX OR CENTREX
SWITCHED CONNECTIONS
NONSWITCHED CONNECTION


TERRESTRIAL BACKBONE
LIVERMORE
NEVADA
ALBUQUERQUE
KANSAS CITY
OAK RIDGE
GERMANTOWN HEADQUARTERS

CONCEPTUAL PREVIEW OF DOENTS

FY 87 IMPLEMENTATION PLAN

- ACTIVATE 58 CKTs ON OPMODEL
- ACTIVATE TERRESTRIAL T–1 LINKS
  - ALB/LV/LIV
  - GTN/FORRESTAL
  - LIV/SAN RAMON
  - BROOKHAVEN/JAMAICA
  - SCHENECTADY/BALLSTON SPA
- ACTIVATE TERRESTRIAL 56 KB CKTs
  - OAKLAND/LIVERMORE
  - FT COLLINS/LOVELAND
  - KANSAS CITY/OMAHA
- INTERIM PTF AT OPMODEL NODES
- HQs NETWORK CONTROL CENTER

FY 88 IMPLEMENTATION PLAN

- ACTIVATE OPMODEL NODE AT OAK RIDGE
- ACTIVATE 48 CKTs ON OPMODEL
- ACTIVATE TERRESTRIAL T–1 LINKS
  - ALB/LOS ALAMOS
  - LIV/BERKELEY
  - SRP/OAK RIDGE
  - GTN/WILMINGTON
  - GTN/OAK RIDGE
- ACTIVATE TERRESTRIAL 56 KB CKTs
  - OAK RIDGE/MIAMISBURG
  - SRP/NEW ORLEANS

FY 89 IMPLEMENTATION PLAN

- ACTIVATE OPMODEL NODE AT LAS VEGAS
- MOVE CKTs FROM T-1'S TO OPMODEL
- ACTIVATE T-1 LINKS
  - ALB/KANSAS CITY
  - KANSAS CITY/OAK RIDGE

BENEFITS

- DOE NETWORK CONTROL
- IMPROVED SERVICE
- MAXIMUM NETWORK EFFICIENCY
- SIGNIFICANT ANNUAL SAVINGS

Computing Services
Argonne National Laboratory

ER Distributed Computing Environment

at

Argonne National Laboratory

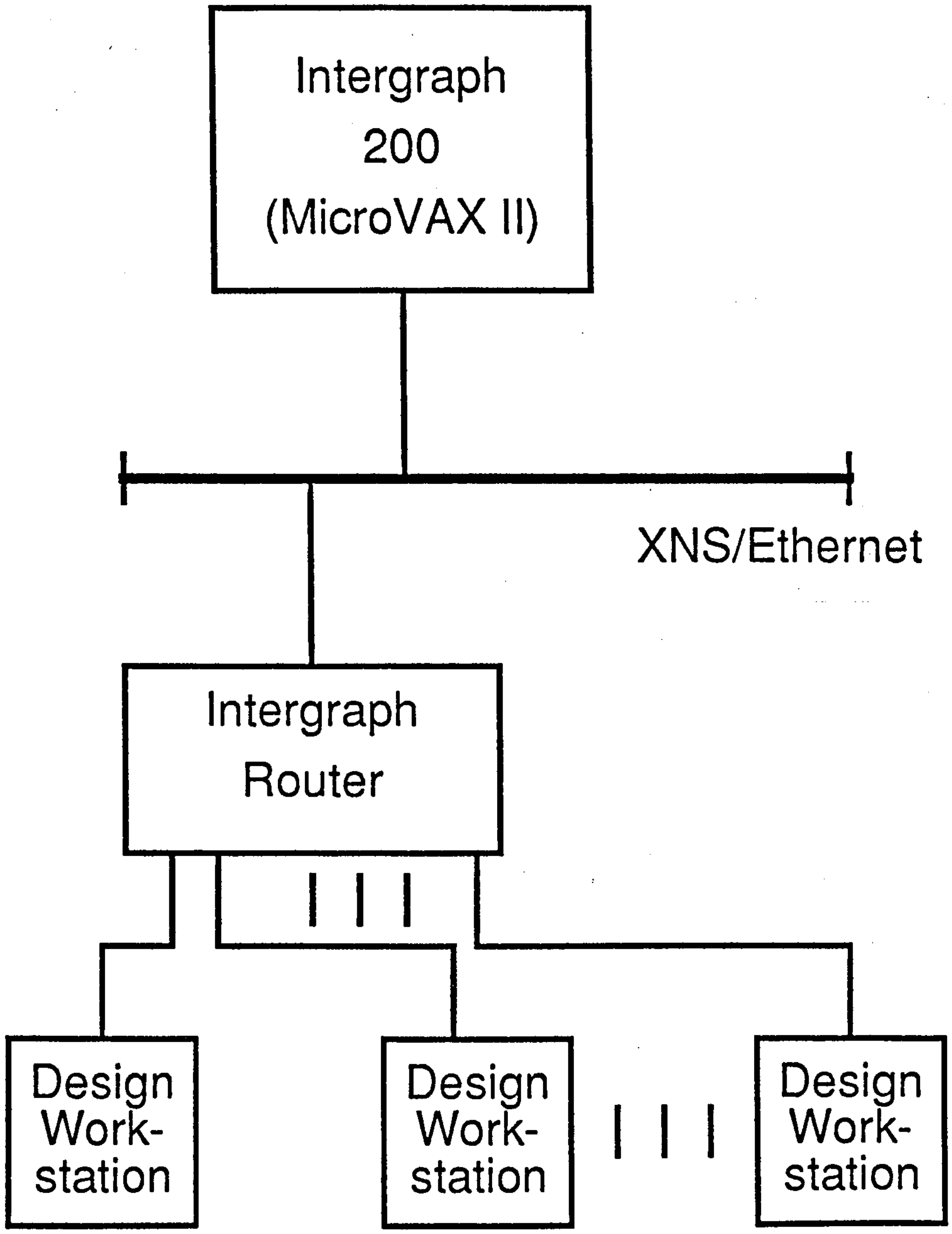
by

Larry Amiot
Acting Director of Computing Services

Principal ANL Networking Protocols

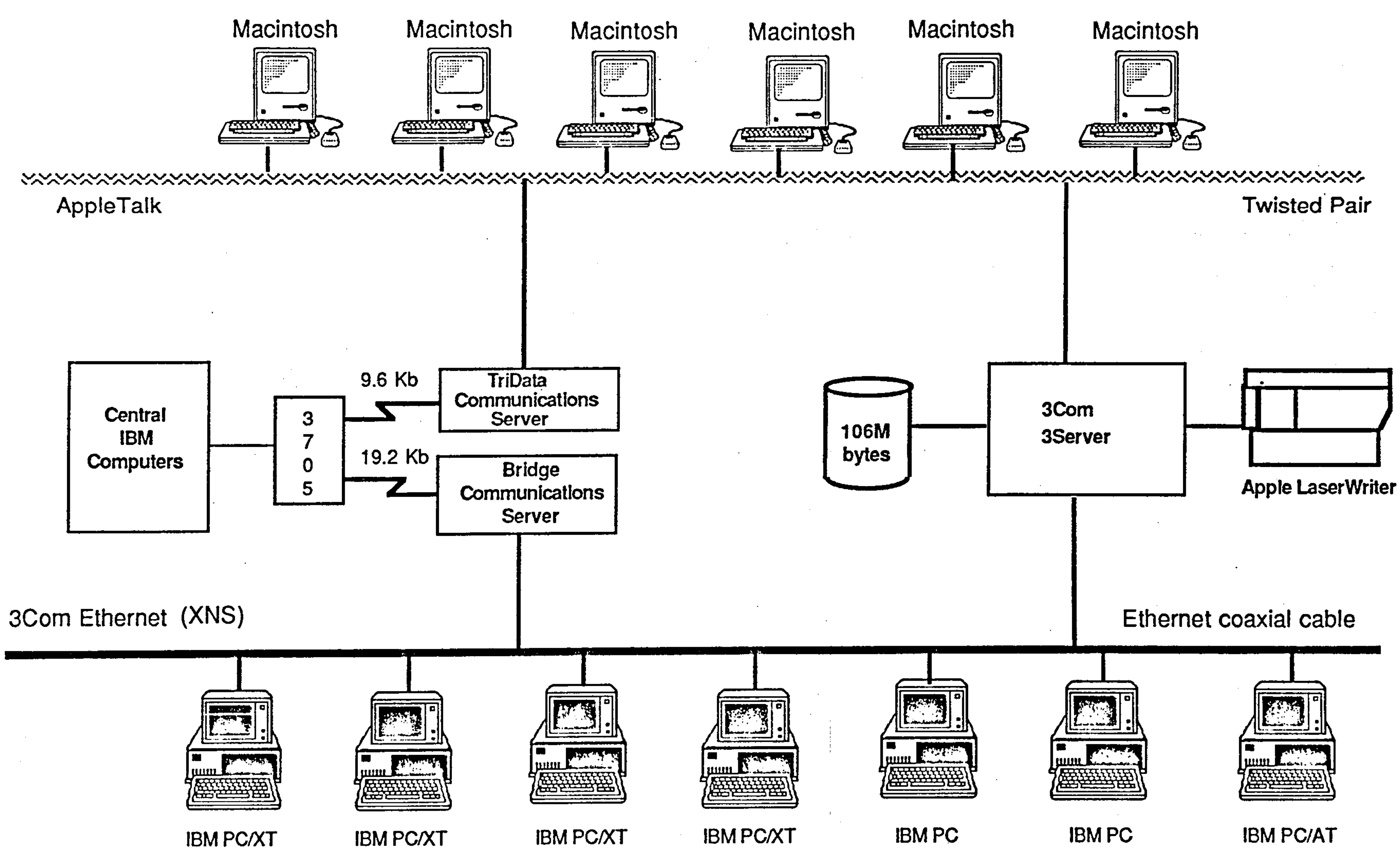
- *XNS*
  - *CAE*
  - *PC LANs*
- *TCP-IP*
- *DECnet*
- *NJE*

Computer Aided Engineering

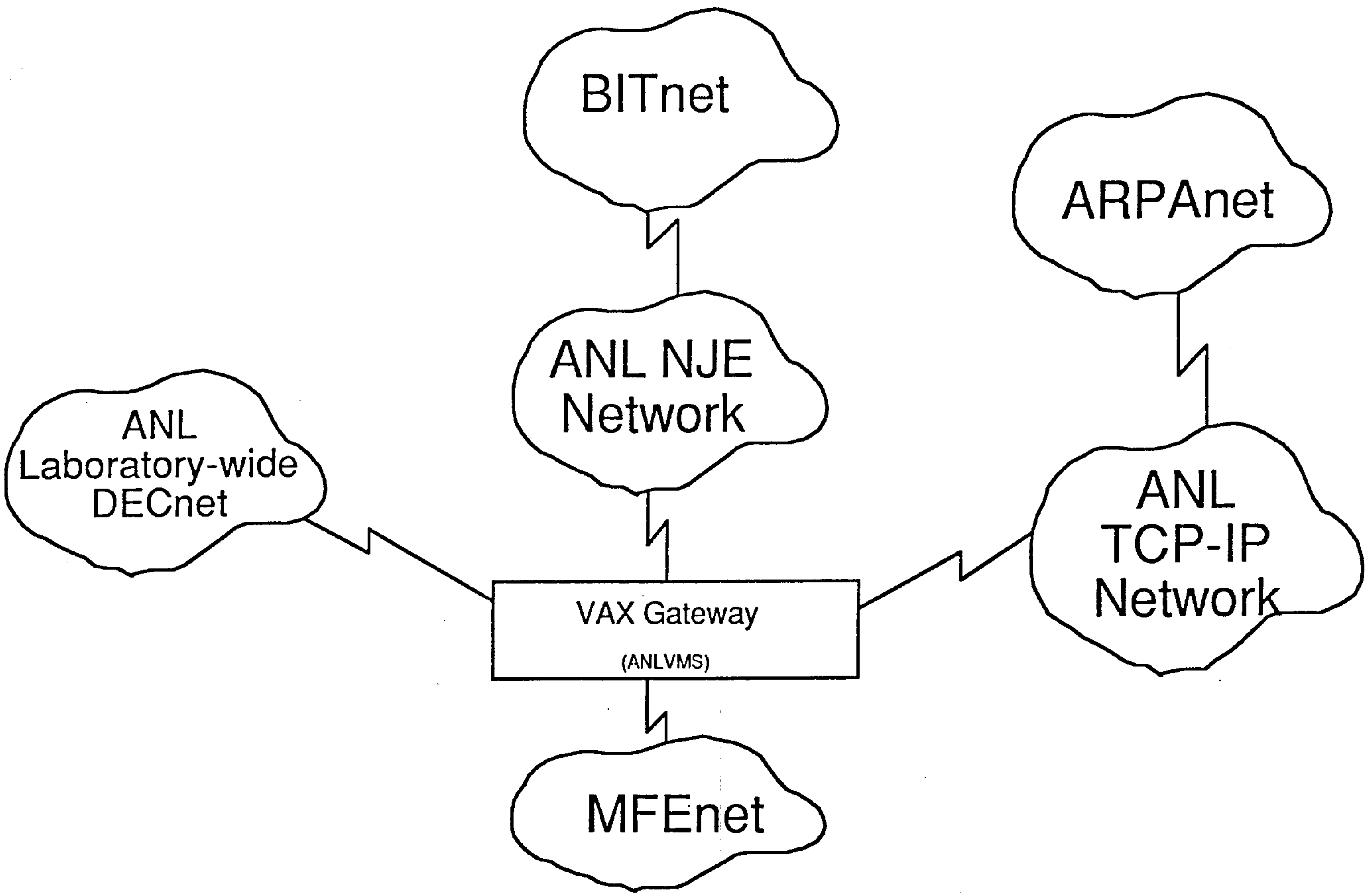


mdd/1RJM5/7/86jal-1

Personal Computer Local Area Network

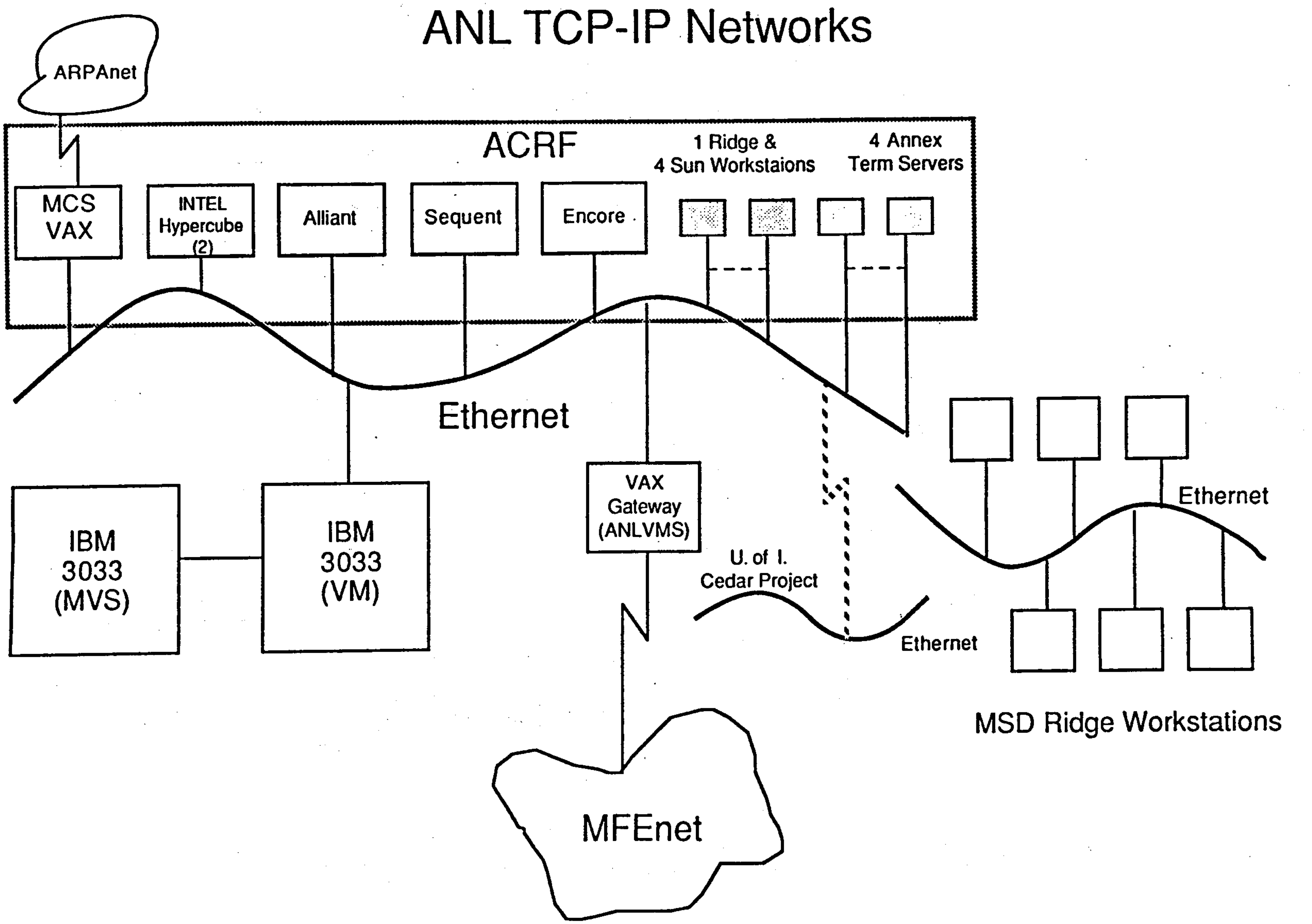


ANL ER Distributed Computing Environment



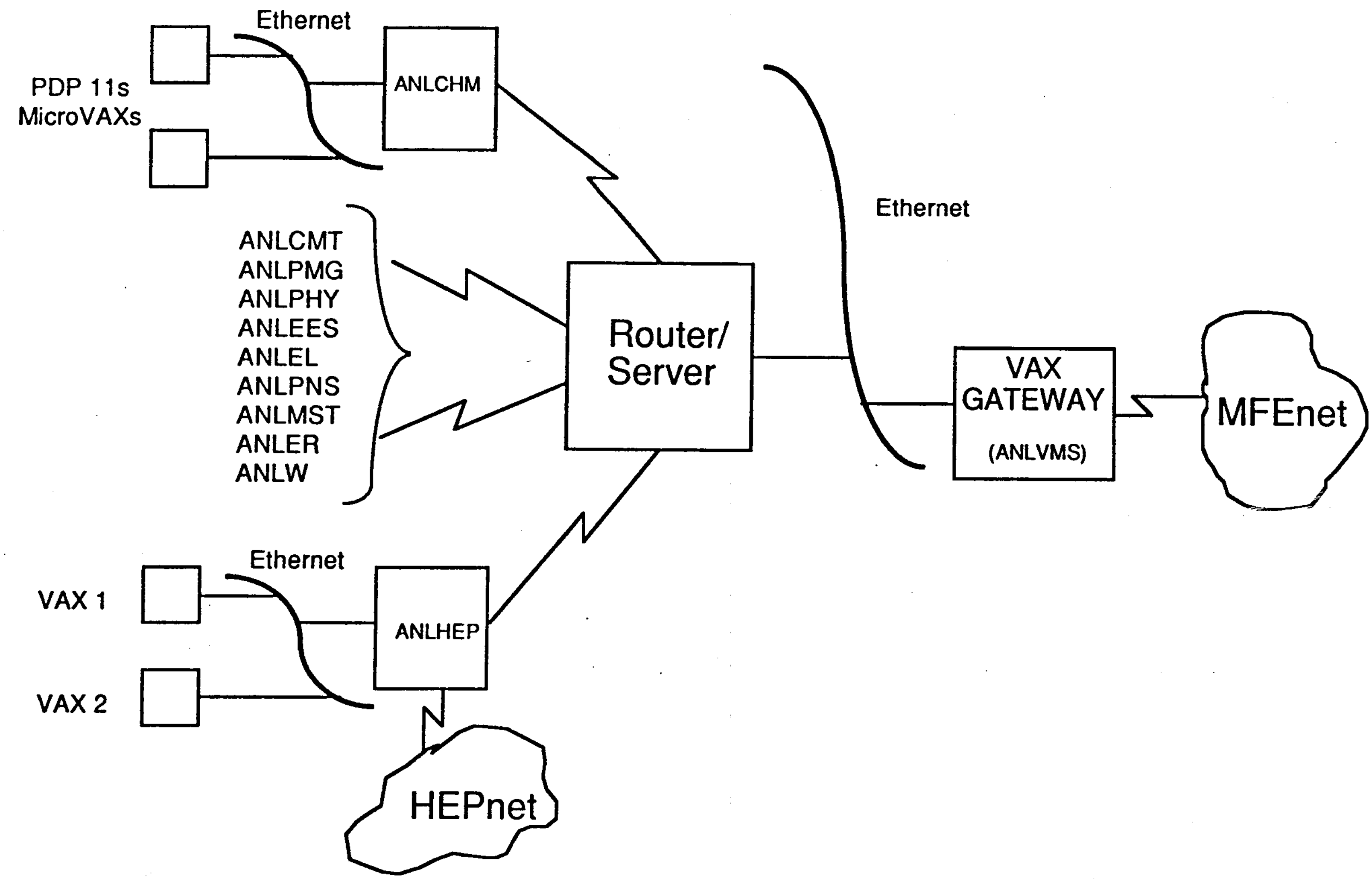
RJM10/17/86jal

ANL TCP-IP Networks



RJM10/20/86jal

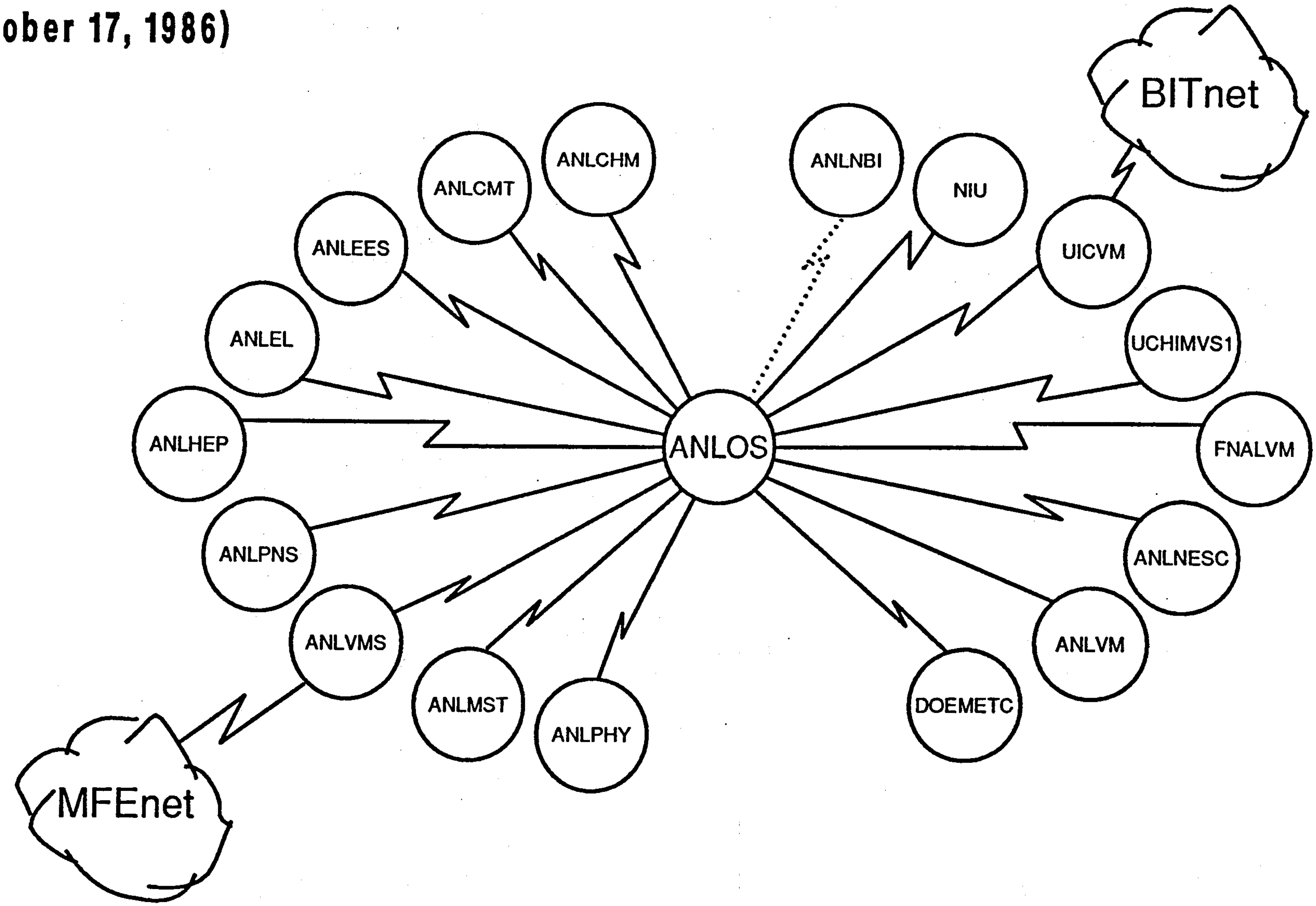
ANL Laboratory-Wide DECnet Netework



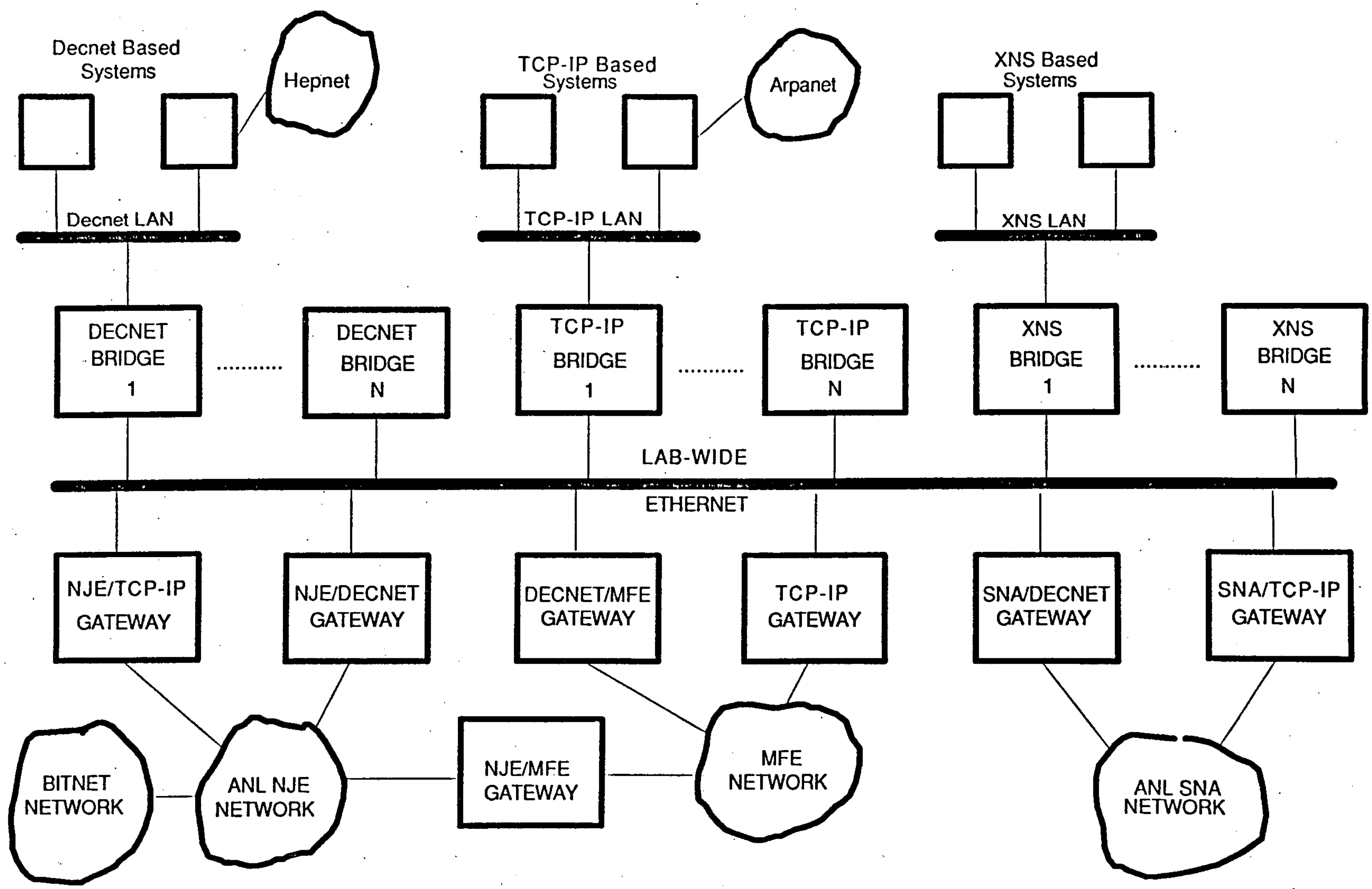
RJM10/20/86jal

Argonne NJE Network

(October 17, 1986)



LAB-WIDE ETHERNET-BASED LOCAL AREA NETWORK CONCEPTUAL VIEW



Computing Services

Argonne National Laboratory

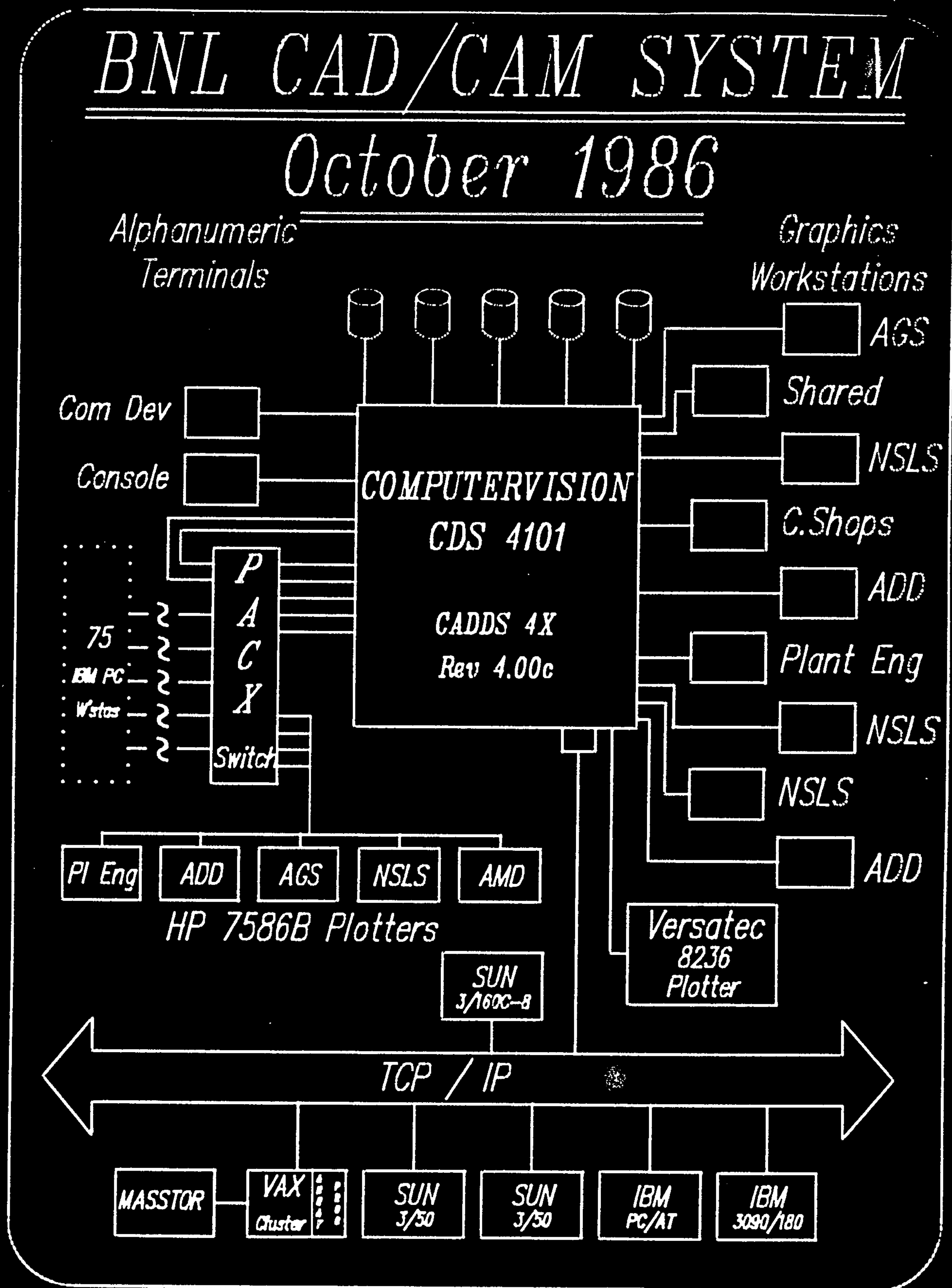
GEORGE RABINOWITZ, NETWORKING MANAGER

APPLIED MATHEMATICS DEPARTMENT

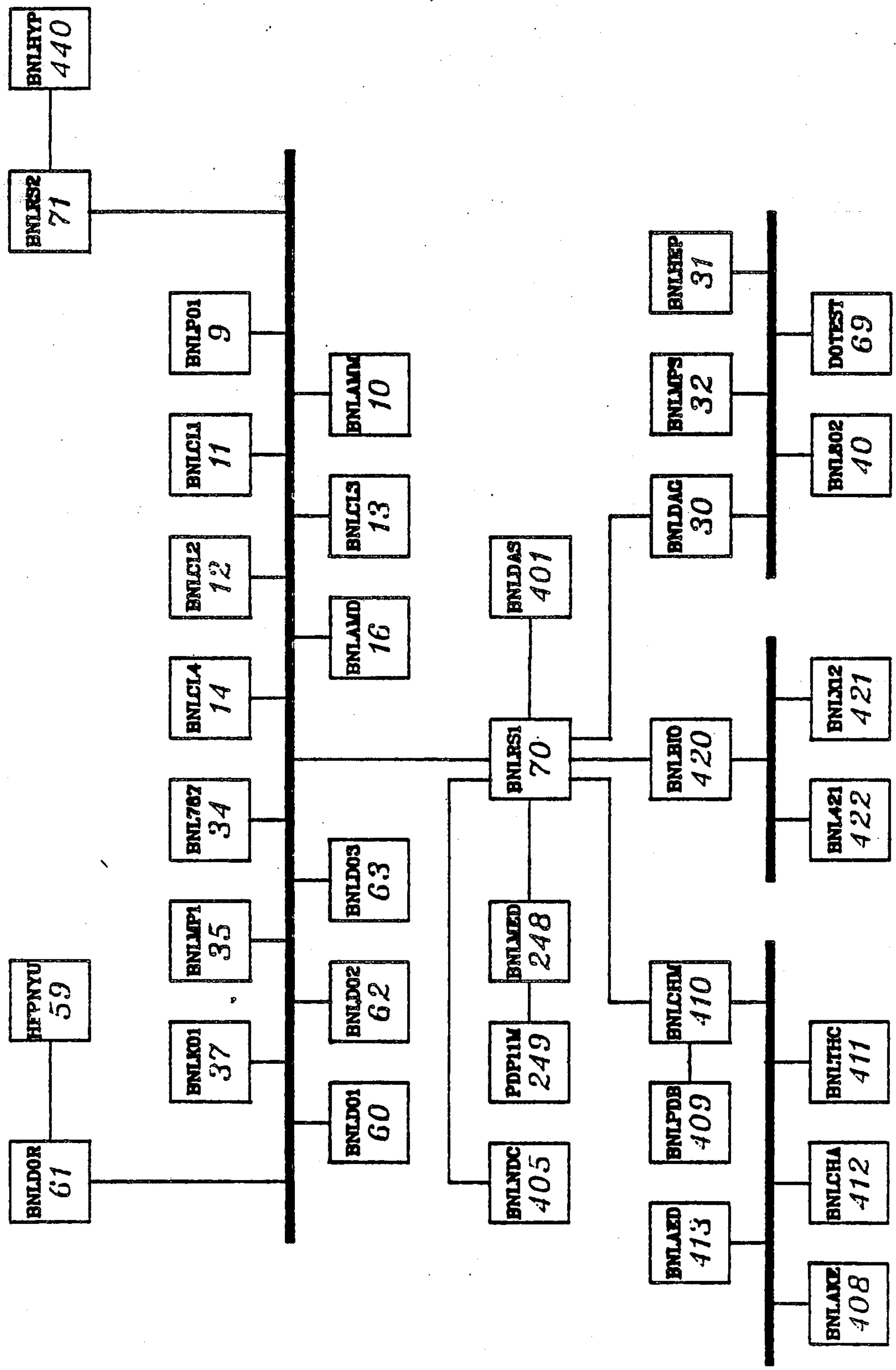
BROOKHAVEN NATIONAL LABORATORY

TITLE: BNL CAD/CAM SYSTEM

OCTOBER 1986

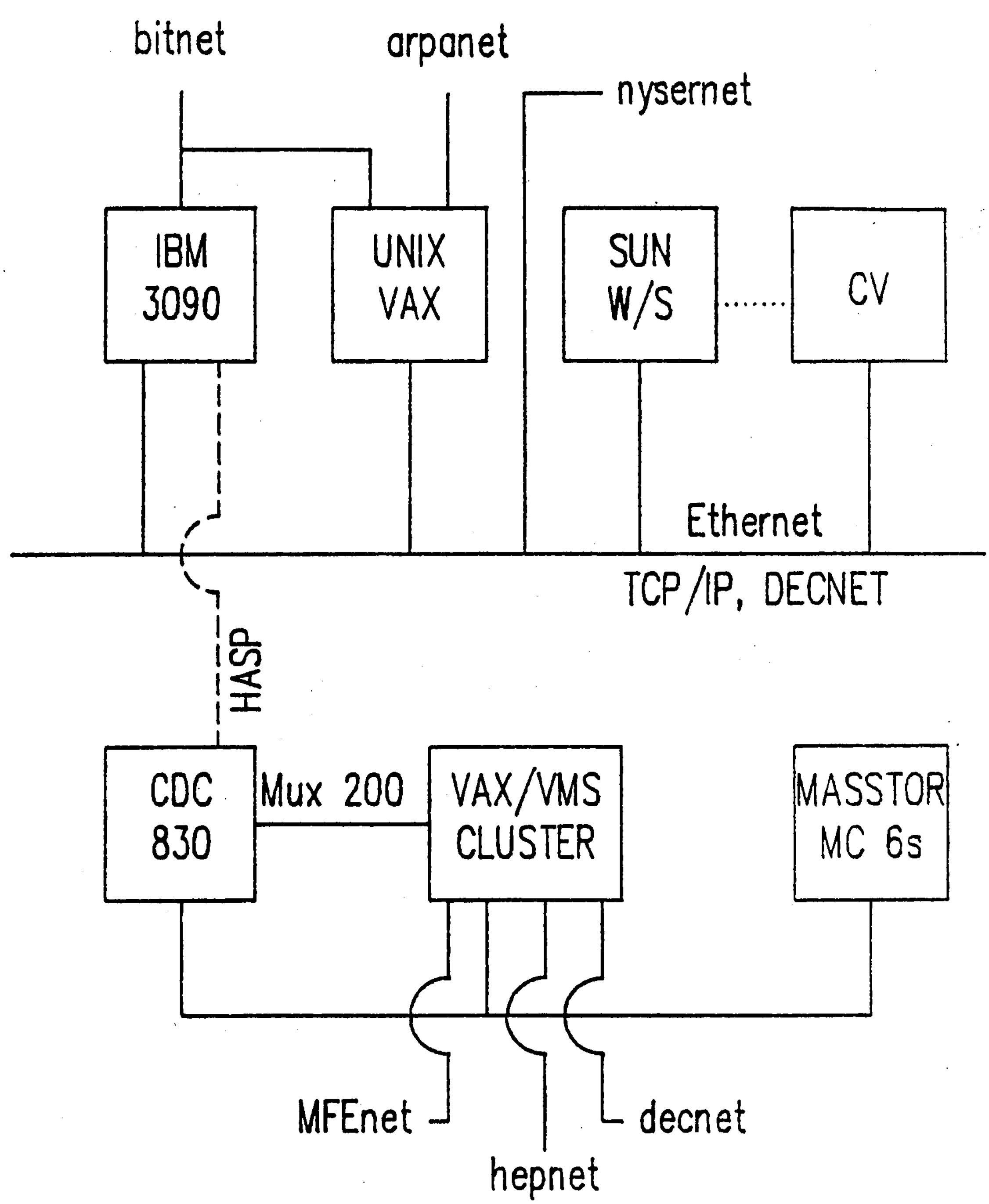


CAD GENERATED DRAWING – BNL


BNLHYP 440
BNLRS2 71
BNLP01 9
BNLAAM 10
BNLCL1 11
BNLCL3 13
BNLCL2 12
BNLAMD 16
BNLCL4 14
BNL782 34
BNLD03 63
BNLMP1 35
BNLD02 62
BNLK01 37
BNLD01 60
HEPNYU 59
BNLDOR 61
BNLDAS 401
BNLRS1 70
BNLMED 248
PDP11M 249
BNLNDC 405
BNLHEP 31
BNLMPS 32
DOTEST 69
BNLDAC 30
BNLS02 40
BNLBIO 420
BNLX12 421
BNLA21 422
BNLCHM 410
BNLPDB 409
BNLTHC 411
BNLCHA 412
BNLAED 413
BNLAKE 408

AREA 43

CSCF Local Network



CAD GENERATED DRAWING - BNL

LOCAL-AREA NETWORKS

1. FERMINET
2. DATA PBX NETWORK
3. ETHERNET (DECNET)

GREGORY CHARTRAND, NETWORK MANAGER
COMPUTER DEPARTMENT
FERMI NATIONAL LABORATORY

FERMINET

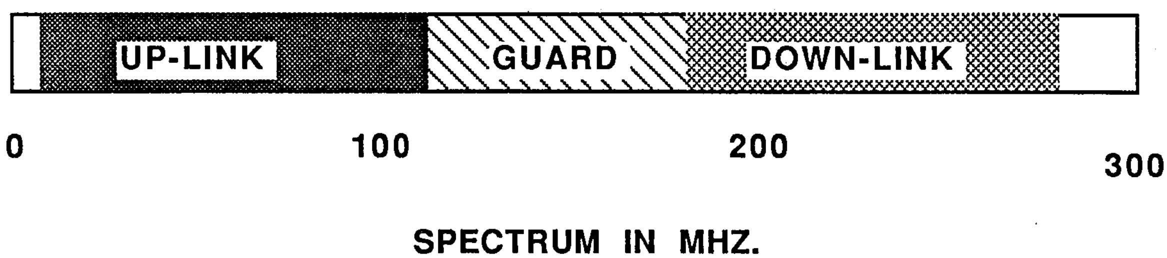
IS THE COMMUNICATIONS BACKBONE FOR FERMILAB'S LOCAL-AREA NETWORKING.

WHICH INCLUDES;

- DECNET
- DATA PBX INTERCONNECTIONS
- TERMINAL MULTIPLEXING
- REMOTE PRINTERS

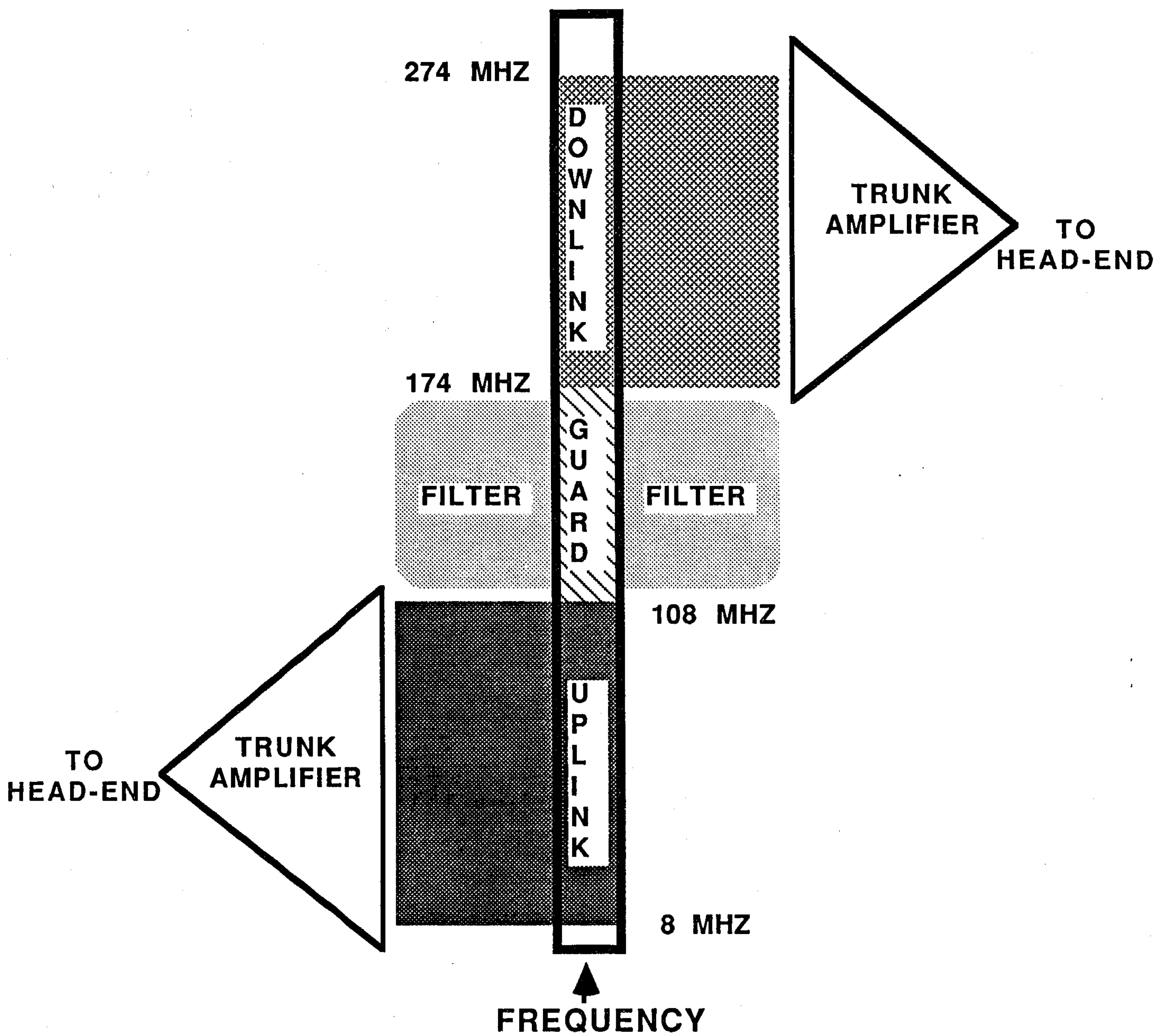
FERMINET

SPECTRUM USAGE



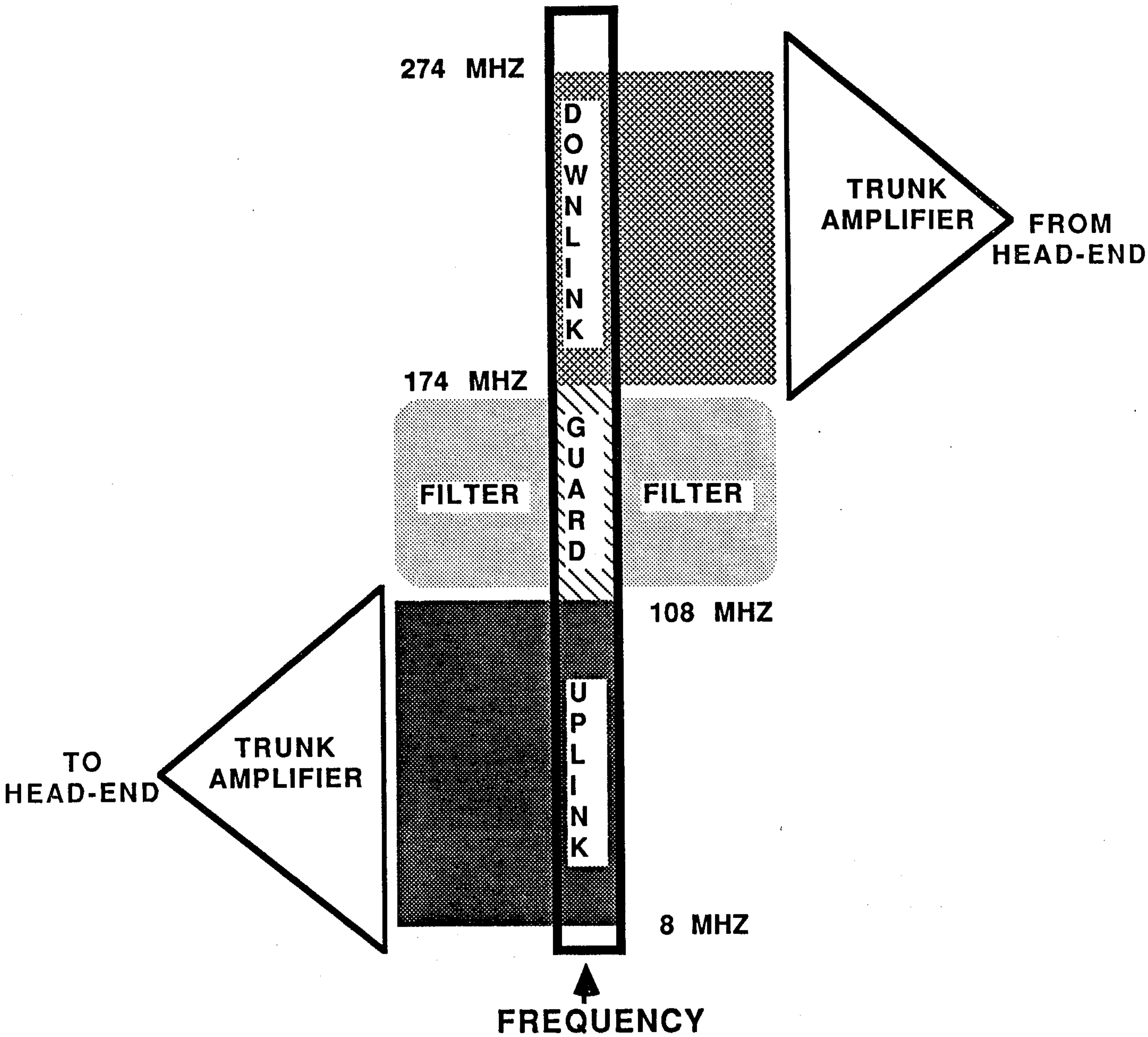
FERMINET

TRUNK AMPLIFLICATION

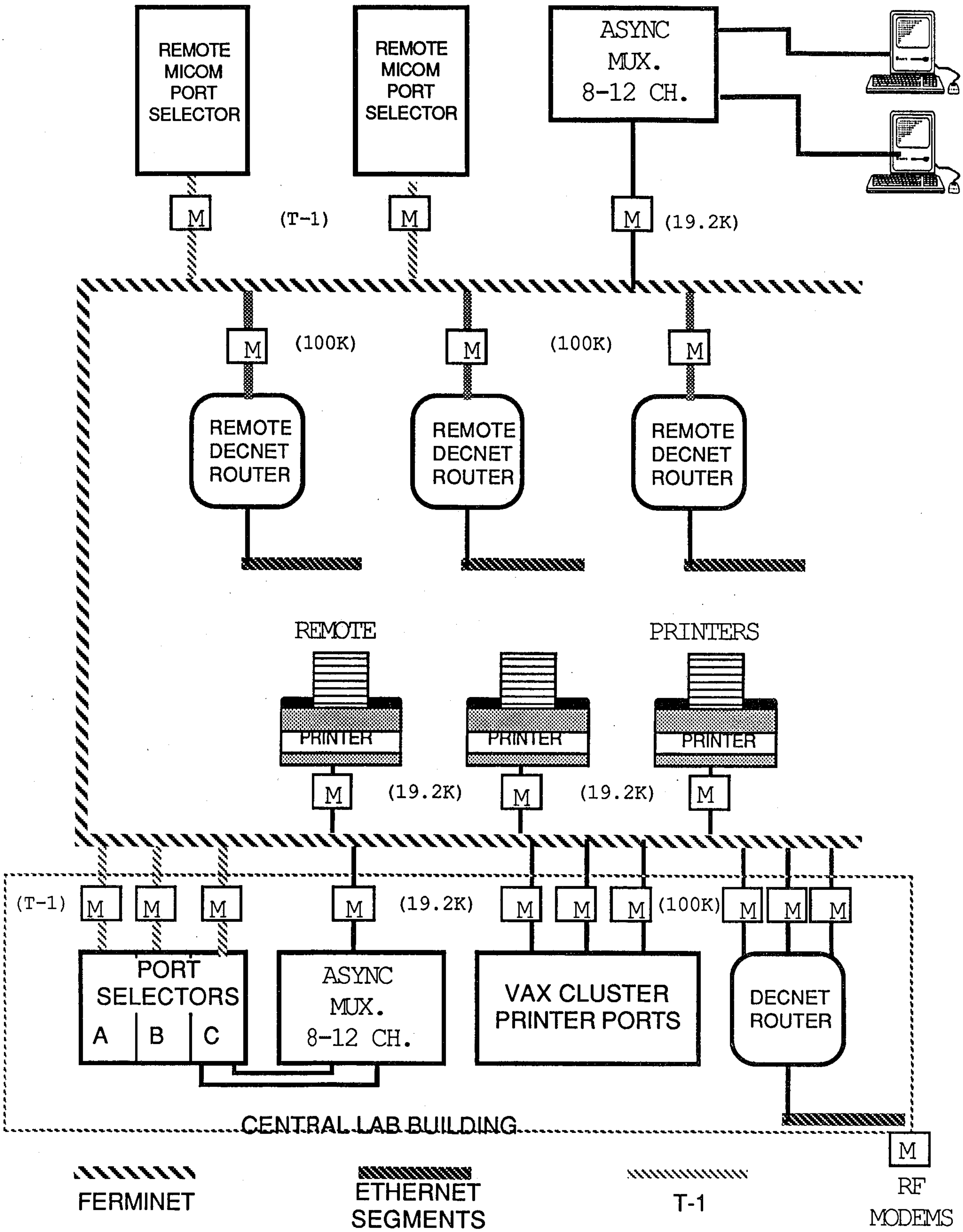


FERMINET

TRUNK AMPLIFLICATION

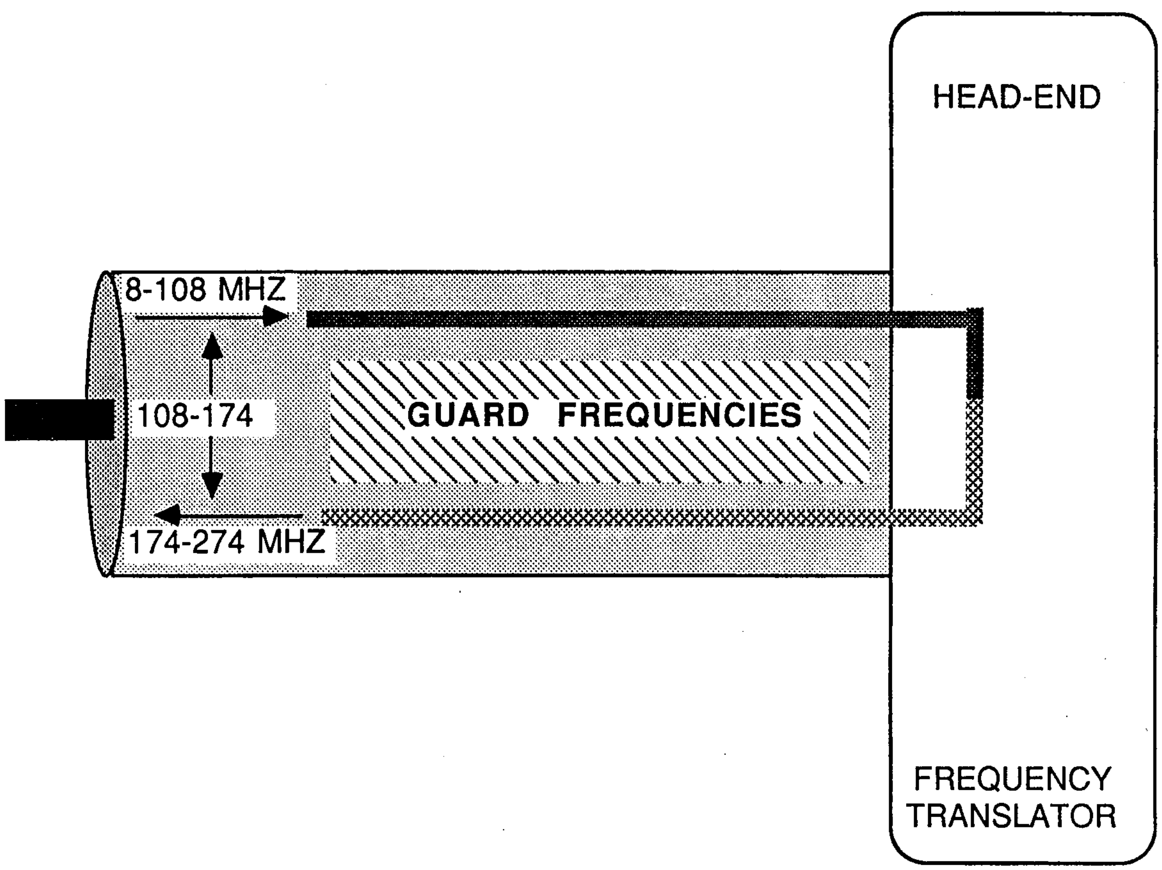


FERMINET'S CURRENT SERVICES

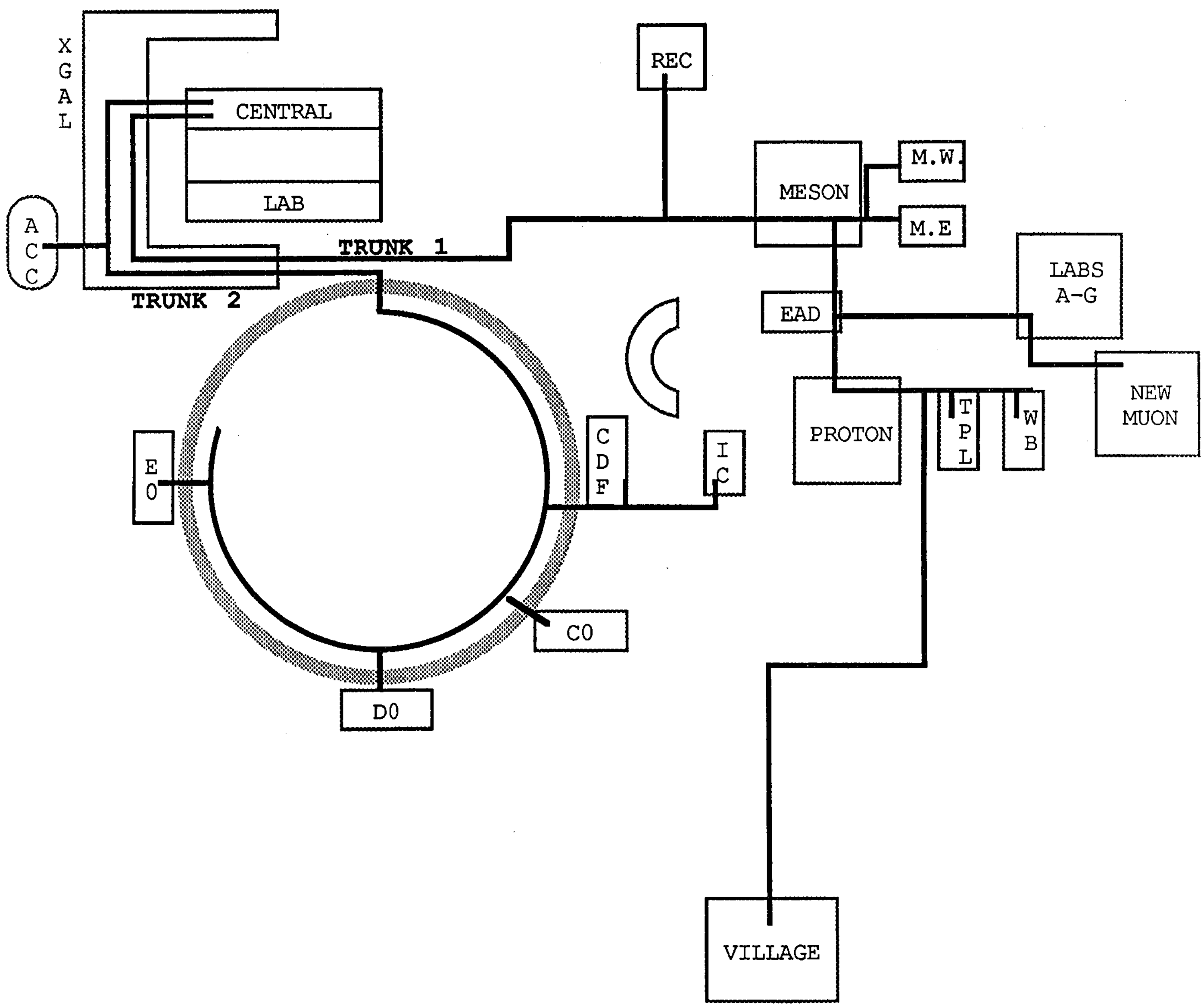


FERMINET

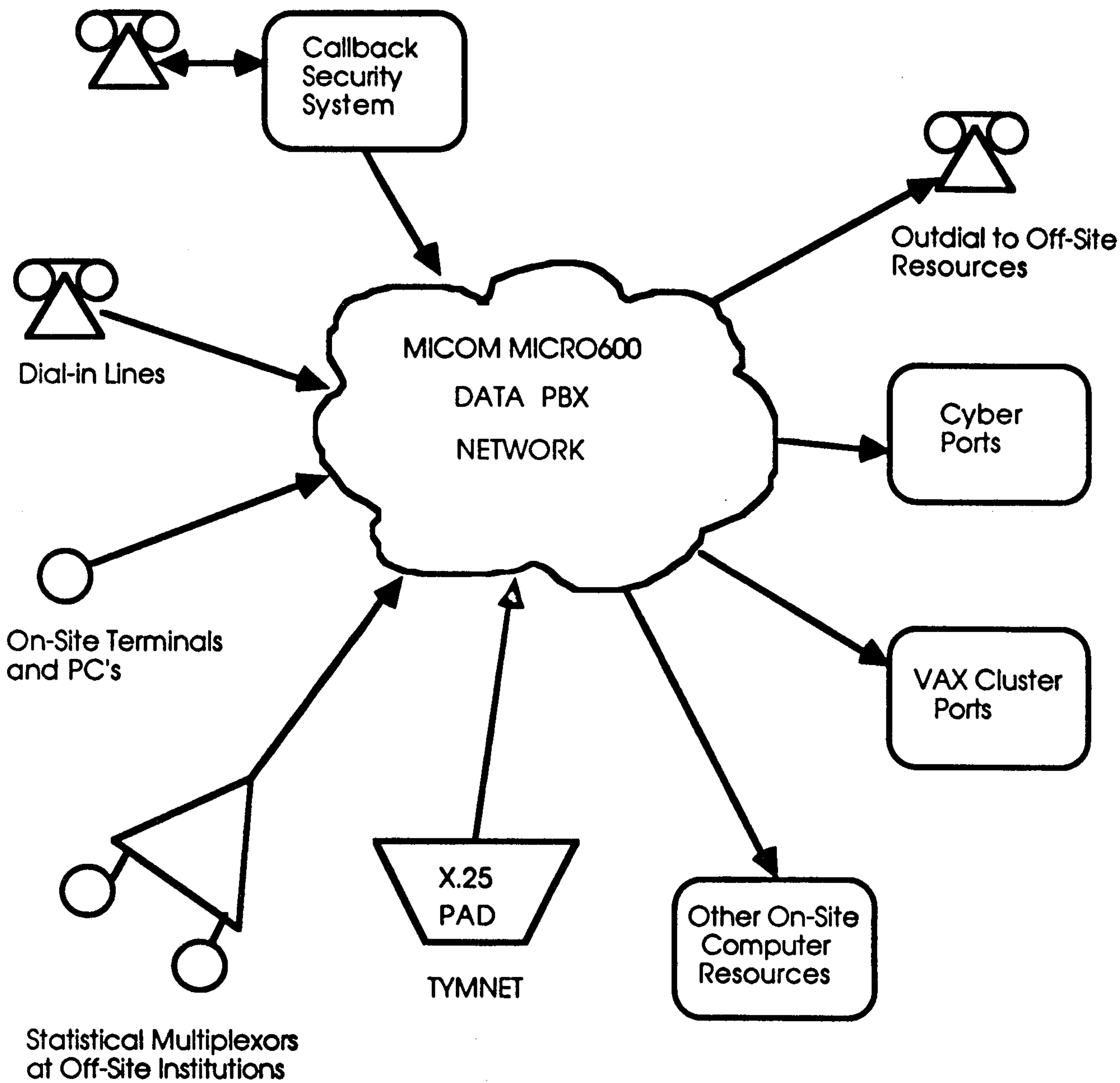
BROAD-BAND CABLE L.A.N.



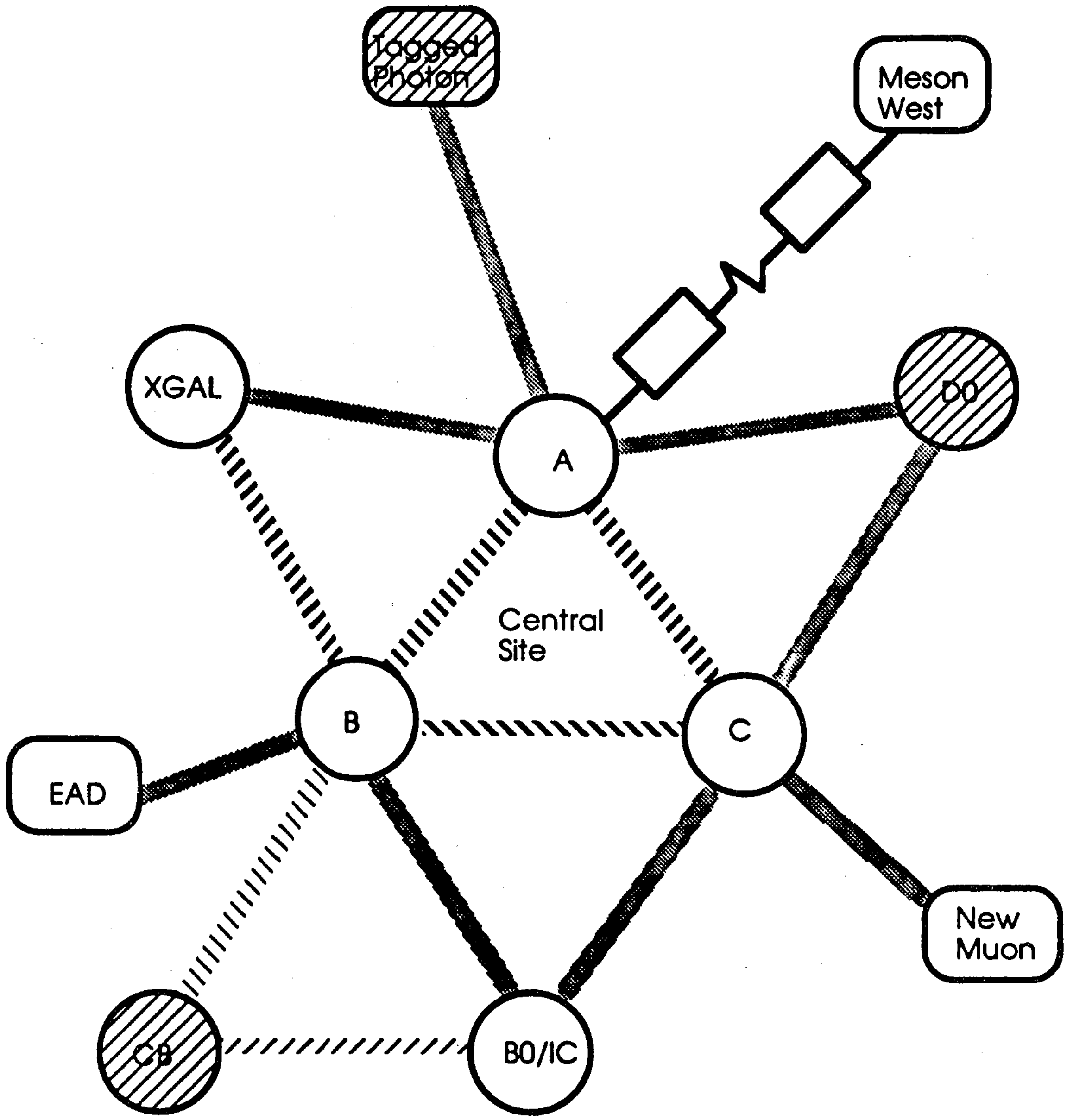
FERMINET DISTRIBUTION



DATA PBX OVERVIEW



DATA PBX NETWORK NODES
(Future)



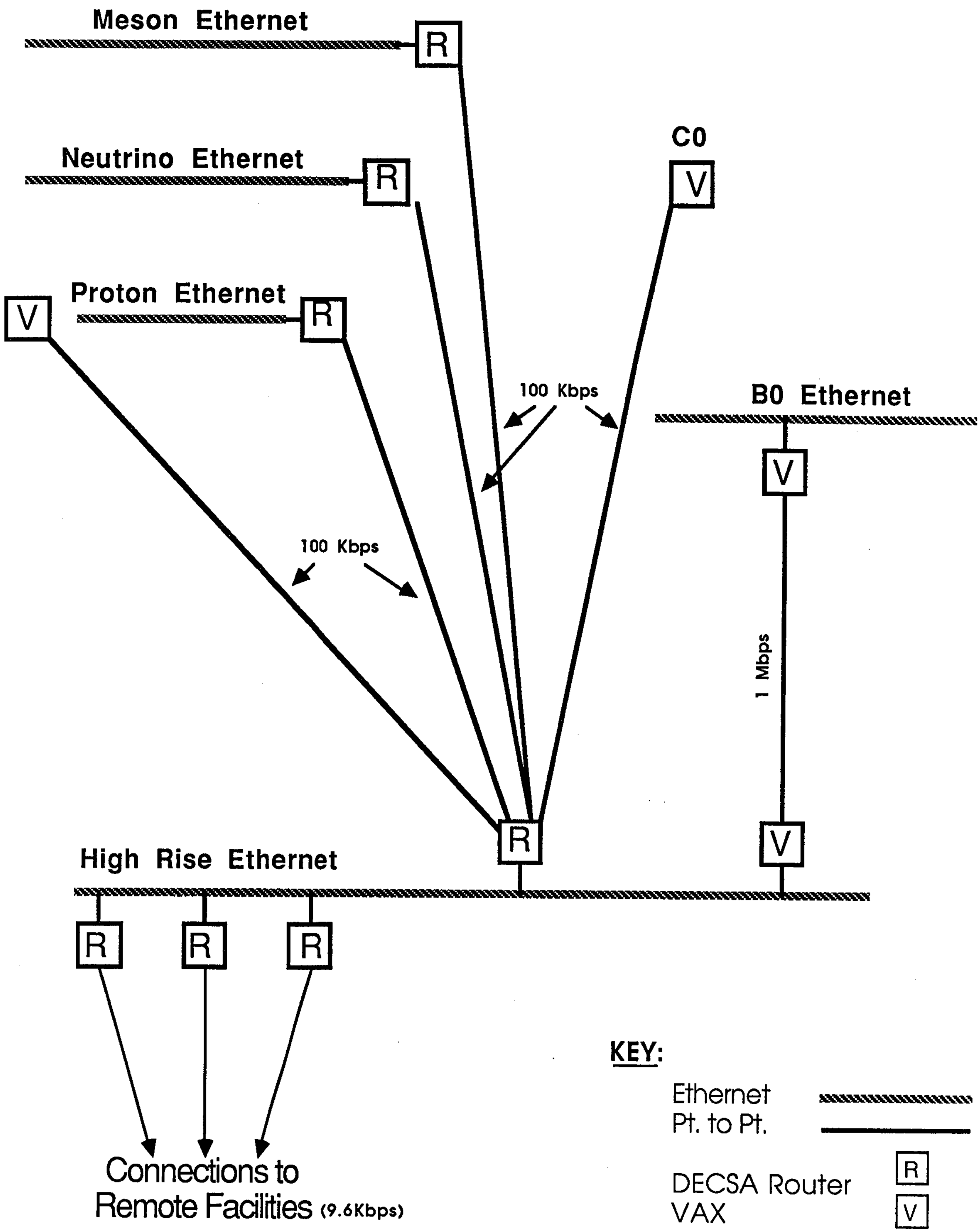
= Micro600/1 MINI Port Selector

= T1 over unspecified media

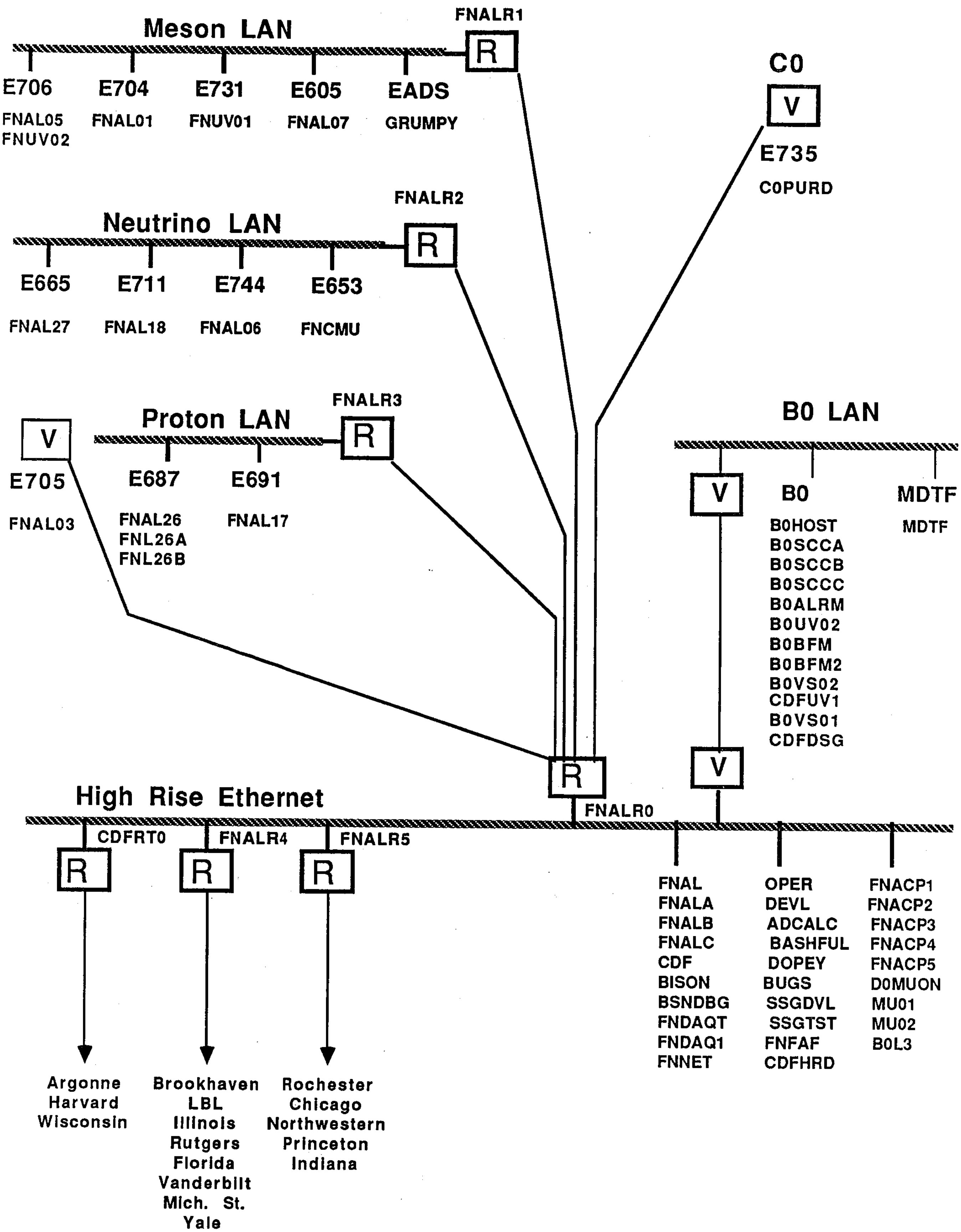
= T1 circuit over twisted pair

= T1 circuit over Ferminet

Fermilab DECnet Topology



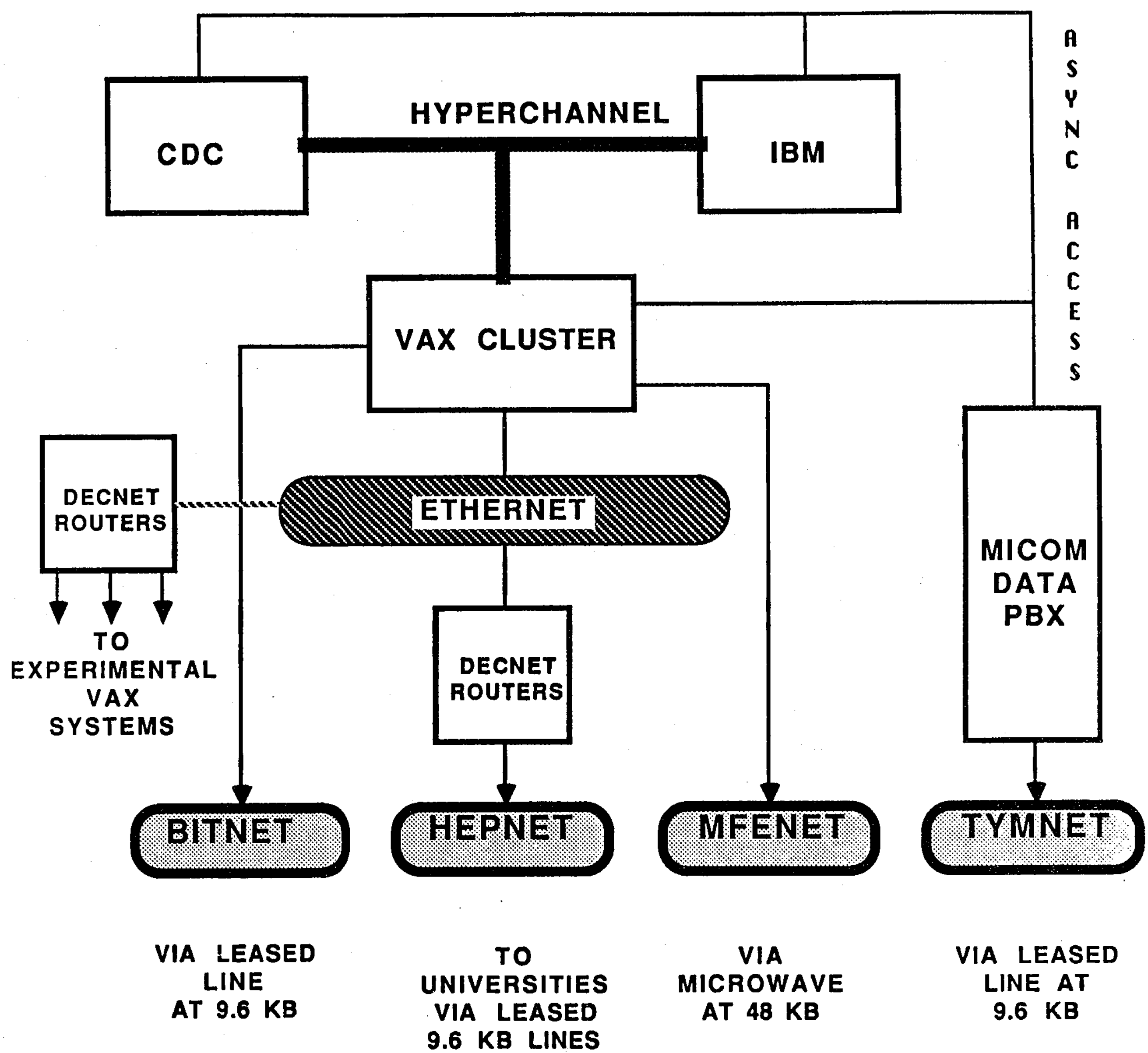
Fermilab DECnet Nodes



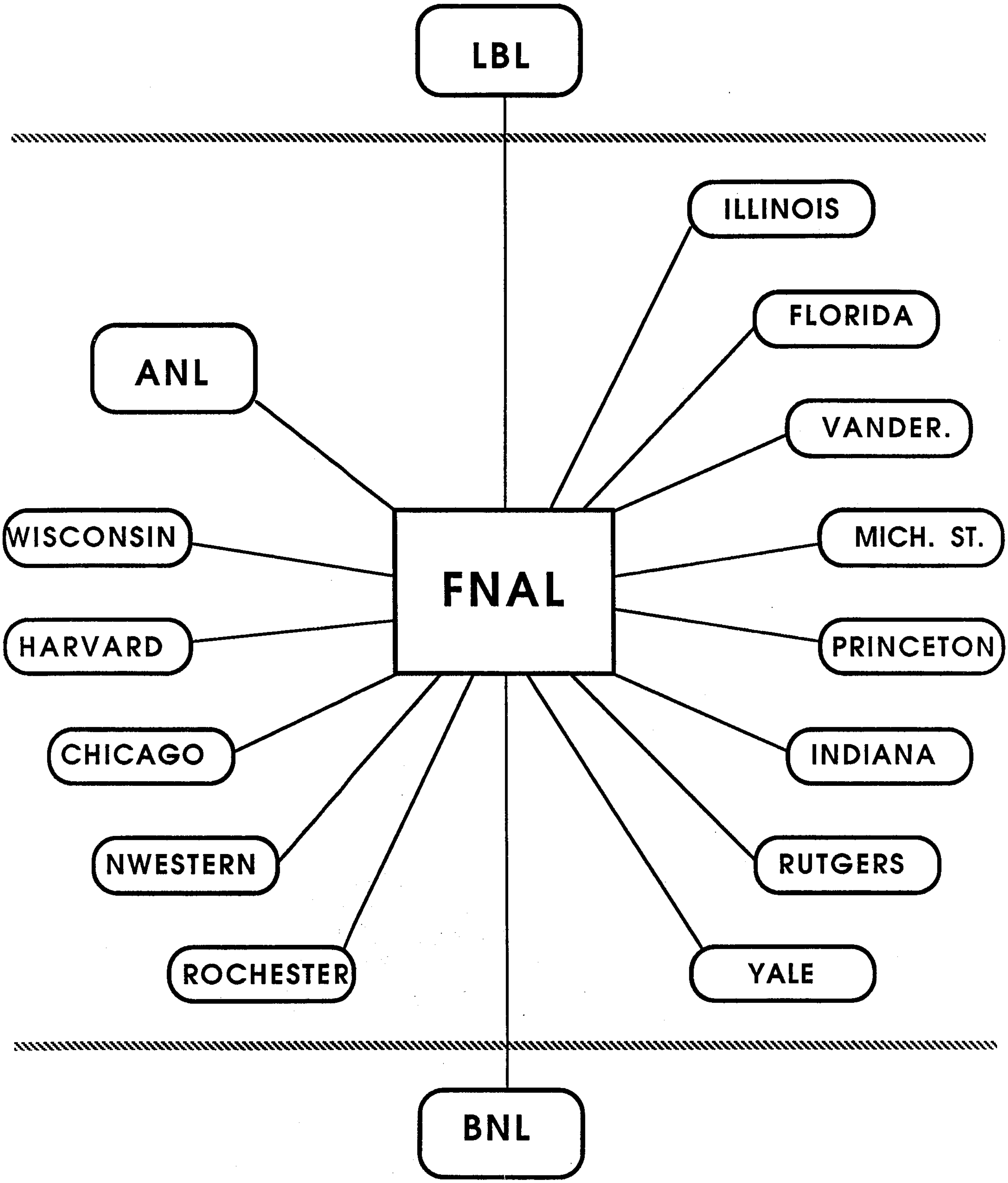
WIDE-AREA NETWORKING

1. MFENET
2. BITNET
3. TYMNET
4. DECNET (LOCAL AND WIDE-AREA)

WIDE-AREA NETWORK ACCESS



Remote Facility Connections to Fermilab



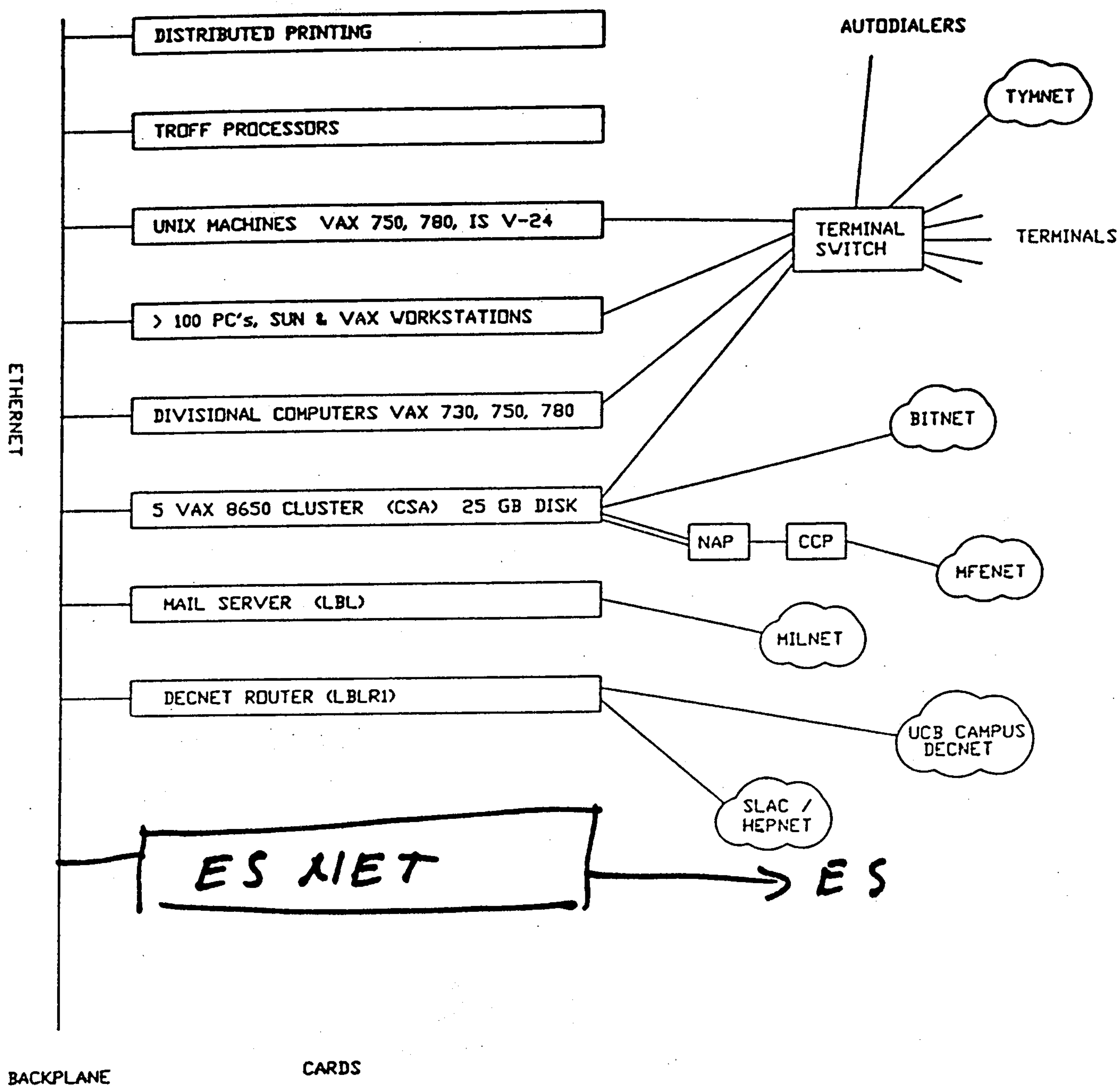
LEROY T. KERTH, ASSOCIATE DIRECTOR

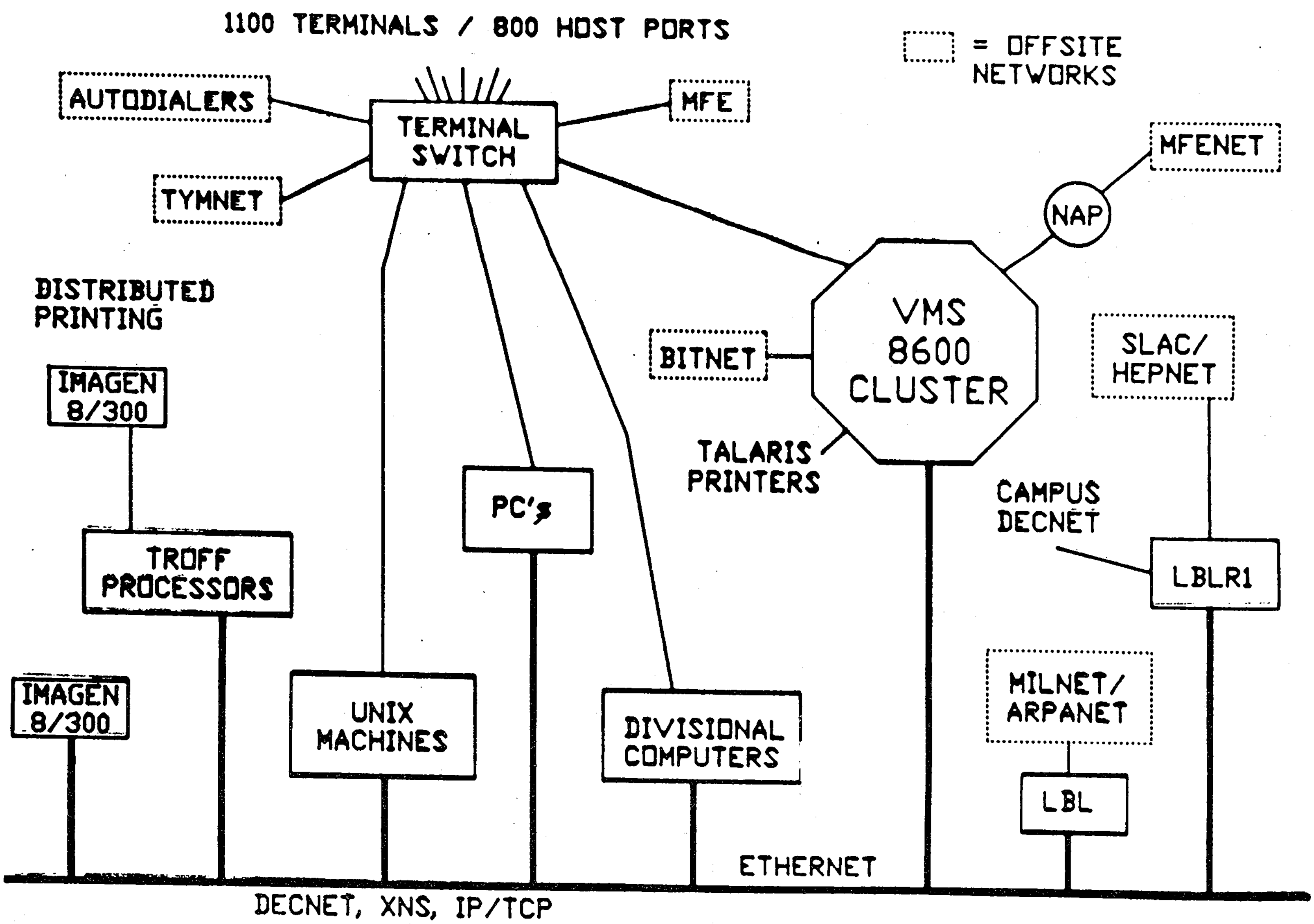
INFORMATION AND COMPUTING SCIENCES DIVISION

LAWRENCE BERKELEY LABORATORY

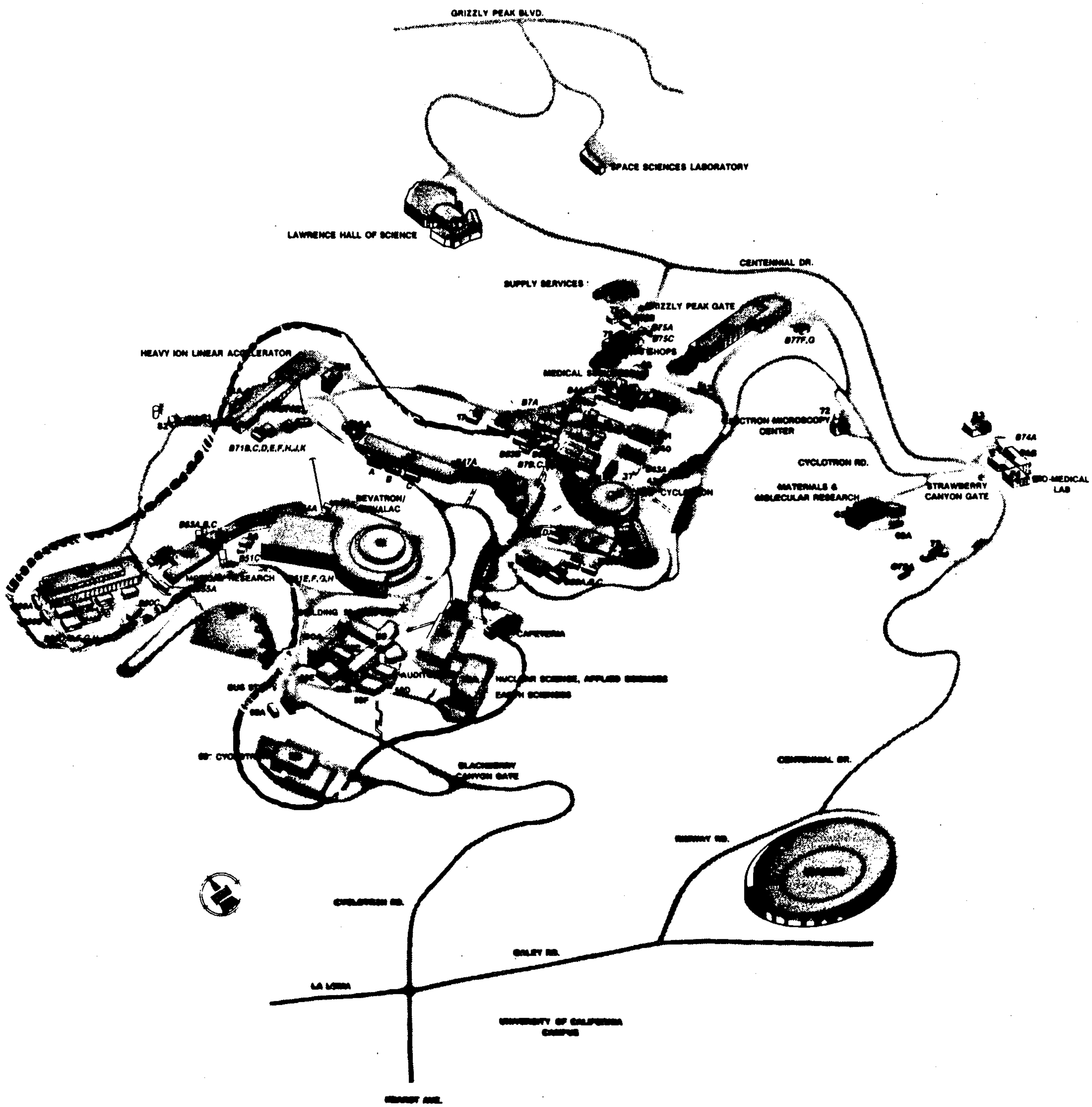
TITLE: THE LBL COMPUTER

THE LBL COMPUTER

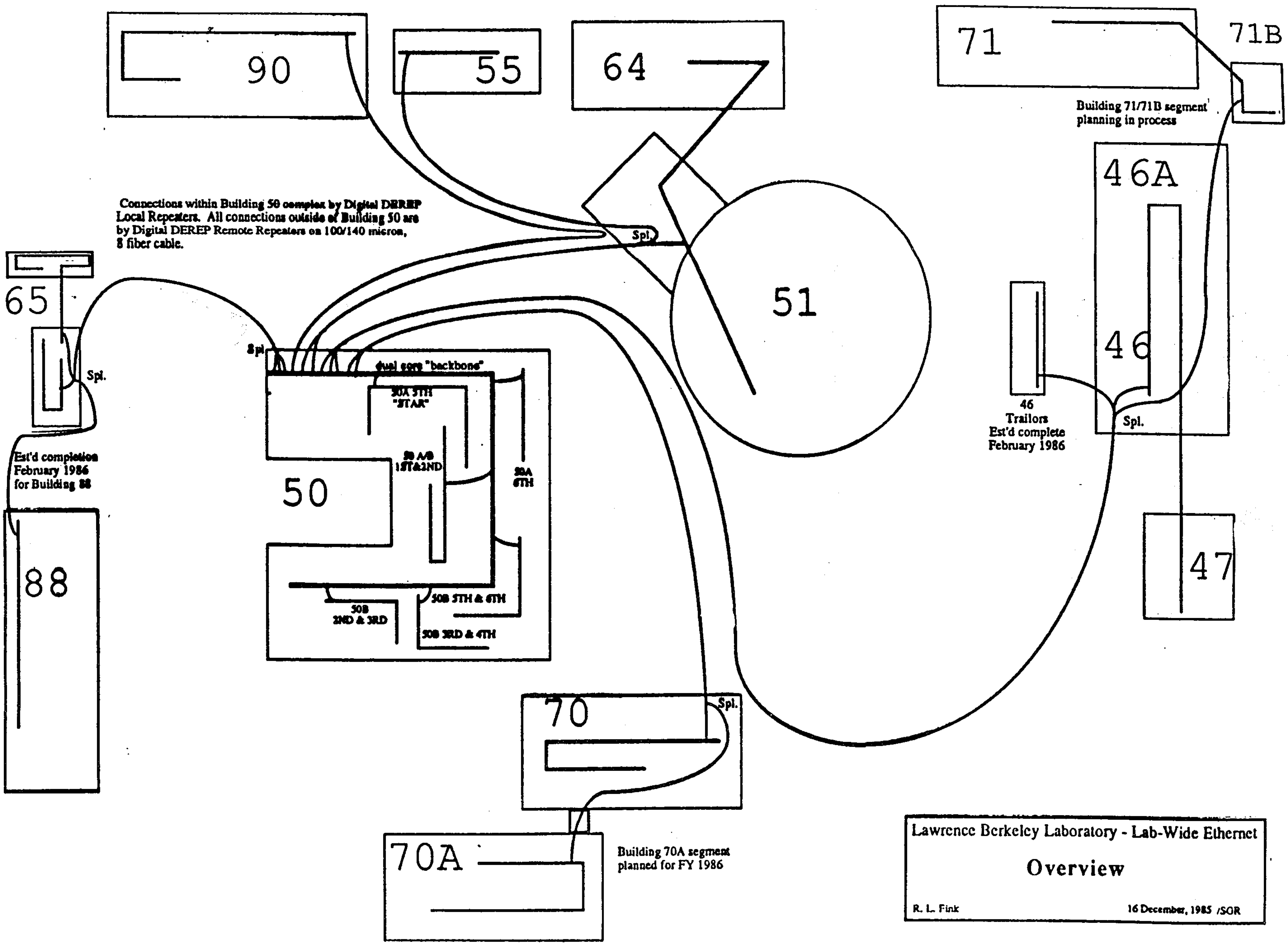




THE LBL COMPUTER



XBL 856- 9554A



Lawrence Berkeley Laboratory - Lab-Wide Ethernet

Overview

R. L. Fink 16 December, 1985 /SOR

DAVID WILLIAMS, DEPUTY DIVISION LEADER

DATA HANDLING

CERN

TITLE: A VIEW OF EUROPEAN NETWORKS

DAVID O. WILLIAMS
DATA HANDLING DIVISION
CERN.

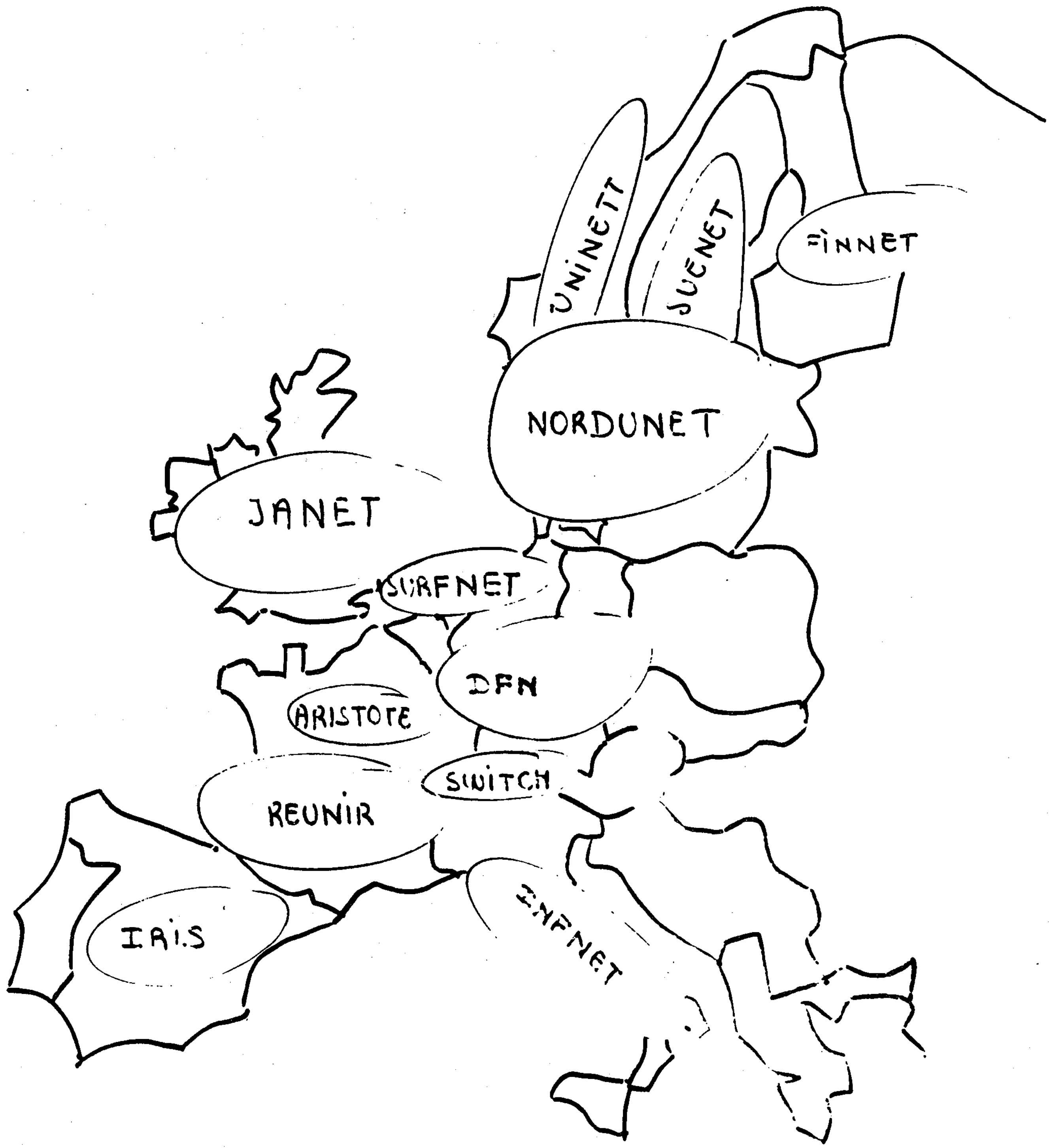
LBL
28 OCT 86

A VIEW OF EUROPEAN NETWORKS

ACK:
FLÜCKIGER
HEIMAN
CARPENTER

Wide Area Academic and Research Networking in Europe

- National A & R networks
- International A & R organizations for networking



European National
Academic and Research Networks

JANET : • based on a Private X25 subnetwork
>1000

• uses the "Coloured Book" Protocol Architecture which covers all the relevant A & R machines

DFN : • based on the Public X25 network
~100

• uses a collection of protocols
(e.g. : early X400 (EAN) for Mail
HMI-RDA for File Transfer)
(small variety of machines)

INFNET : • based on a Private DECnet network
~150 (using private leased lines)

SURFNET : • based on a "Public" DECNET network (using the Public X25 Network)

NORDUNET : • based on the use of Public X25 Networks

• a mixture of interim open-system and proprietary Protocols
(UNINETT, Coloured Books, X400-EAN, DECNET, ...)

others : • being established

- The most influencial : JANET (UK)
  and DFN (Germany)

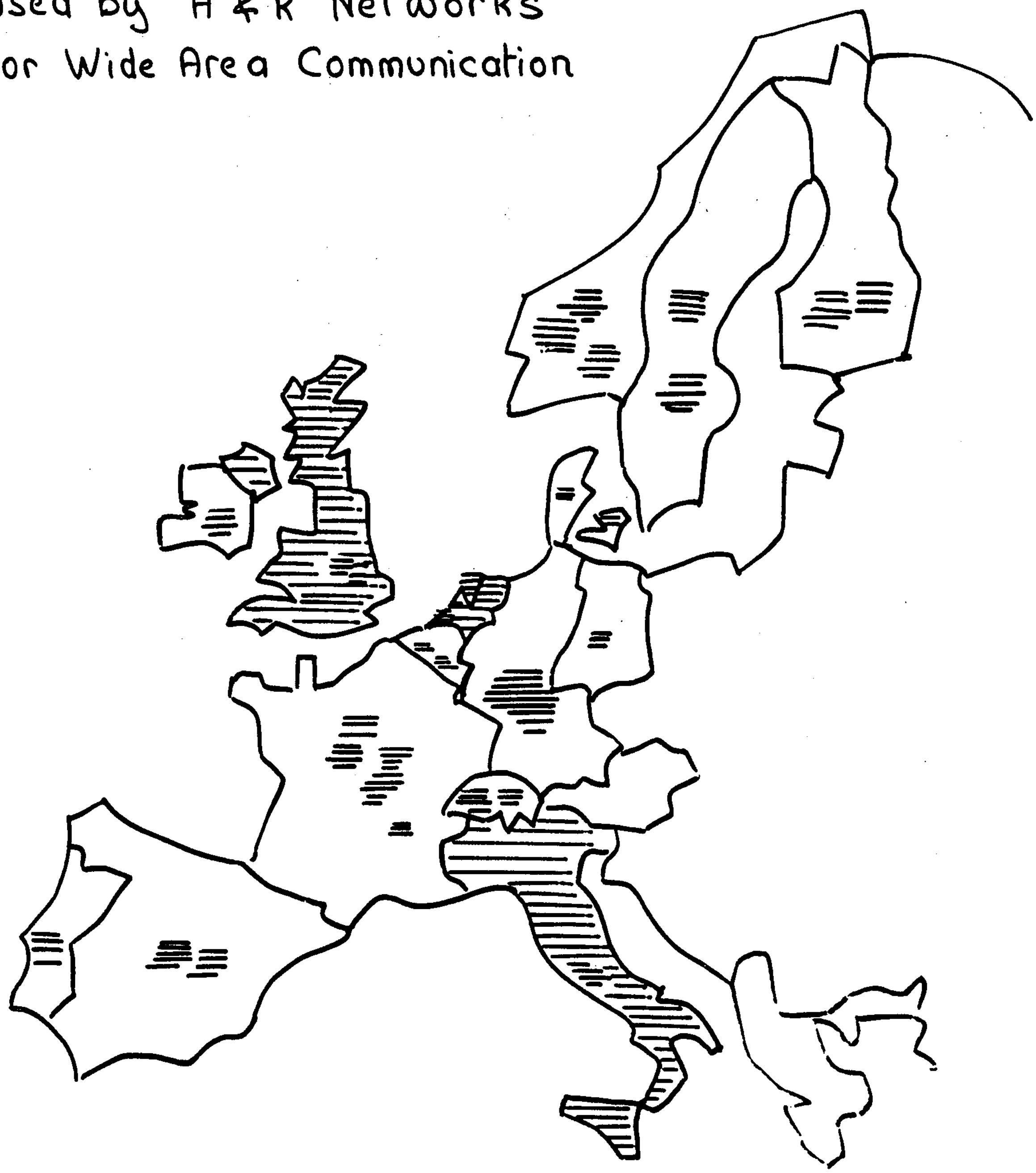
- They all use Public or Private (JANET) X25 Network:
  (Except INFNET (Italy))

- They all use an Interim Prot col Architecture
  The most famous : the "Coloured Books" (JANET)

- They are "open-systems"
  (i.e. interworking between heterogeneous machines)
  (except INFNET and SURFNET (Netherlands) : DECNET based)

- They are all committed to move to ISO-OSI Protocols

Some High Level Protocols Used by A & R Networks For Wide Area Communication



Coloured Books

DECNET

X400 (EAN)(or others)

Highlights on the European Situation

- Public (PTT) X25 networks are nationally cost effective, compared to Leased Lines

  However, concern about international X25 connections (too expensive for large scale File Transfers)

- X25 (public or private) is the favourit low level protocol in Europe

- TCP.IP Protocols are not used for wide area networking

- All the national networks have plans to move to full ISO-OSI Protocols

International A & R Networking Organizations

- EUNET (the European USENET)

- EARN (the European BITNET)

- RARE (the Federation of the European A & R Networks)

+

- Informal International DECNET

- ECFA SG5

EUNET

- 700 nodes in Europe

- Connection to USENET

EARN

- about 300 nodes in Europe (of which ~10 CERN)
- IBM Funds
  - the international links
  - most of the national links
  - the switching equipment
- End of IBM Funding (as announced by IBM): End 1987

Informal International DECNET

- around 300 nodes in Europe
  (of which ~150 INFNET, ~50 CERN)

- uses * Leased Lines
  (INFNET, CERN Leased Lines)
  * Public X25 Networks

- access to the US HEP DECnet

- no central organisation

ECFA SG5

- Data Harmonization Group Subgroup 5 (Links and Networks)
- Coordination of European Physics Networking. Institutes/CERN/ Academic + Res. Networks
- Chairman. J. Hutton

jsh@ib.rl.ac.uk

RARE

Réseaux Associés pour la Recherche Européenne

sécretariat: c/o JMA
de Boelelaan 873
1082 RW Amsterdam
PAYS-BAS

télex: 18934 jma nl
téléphone: +31 20 462243

Réseaux Associés pour la Recherche Européenne

RARE:

European organisation of national research networks and their users

full national members from

Austria	Germany	Luxembourg	Sweden
Belgium	Greece	Netherlands	Switzerland
Denmark	Iceland	Norway	Turkey
Finland	Ireland	Portugal	United Kingdom
France	Italy	Spain	Yugoslavia

associate national members

organisations from other countries

international members

CERN ECFA NORDUNET

liaison members

-for instance- CEPT

RARE promotes interworking and interoperability

RARE is motivated by getting jobs done

RARE is the voice of the user

RARE wants to establish

- **harmonized protocols**
- **information services**
- **rapid availability of products**
  by involvement in pilots
- **exchange of experience**
  in working groups
  in regular conferences

RARE does NOT intend

- to define its own standards
- to build a physical network
- to implement basic protocols
- to do leading edge research
- to operate a commercial service

RARE priorities

- Message Handling (X.400)
- File transfer (FTAM)
- Information services and directory services
- Full screen terminal working
- exchange of operational experiences
- X.25 (1984)
- liaisons with CEPT and national PTT's
- medium and high speed communications and ISDN
- liaisons with standardizing bodies in Europe (CEN/CENELEC)

RARE milestones

- preliminary meeting in Luxembourg, May 1985, initiated by European academic network providers
- initial funding from Dutch universities
- presentation to CEC officials
- presentation to European PTT's (CEPT)
- start of Working Groups
- Copenhagen Networkshop, May 1986
- start up funding from CEC
- formal establishment,June 1986
- EUREKA project COSINE
- Networkshop,May 1987

E U R E K A project COSINE

Cooperation for

Open

Systems

Interconnection

Networking in

Europe

- initiative of F.R.Germany
- supported by 18 European governments
- supported by RARE
- objectives:
  . rapid establishment of a European communications infrastructure for academic and research organisations
  . availability of services, based on functional standards
  . use of common carrier services for basic conveyance of wide area traffic
  . use of commercially available products

PROBLEMS with
Wide Area A & R networking in Europe

- Gap between EARN IBM's end funding (end 1987
  and first COSINE services (1989)
  (pure ISO-OSI solution)

- PTT offering not (yet) adapted to
  COSINE requirements (e.g. for File Transfers)
  (X25 tariffs, bandwith, r liability)

- ISDN probably the medium term solution
  (but available only in the 90')

- Gateways necessary for transatlantic communication:
  (to TCP/IP)

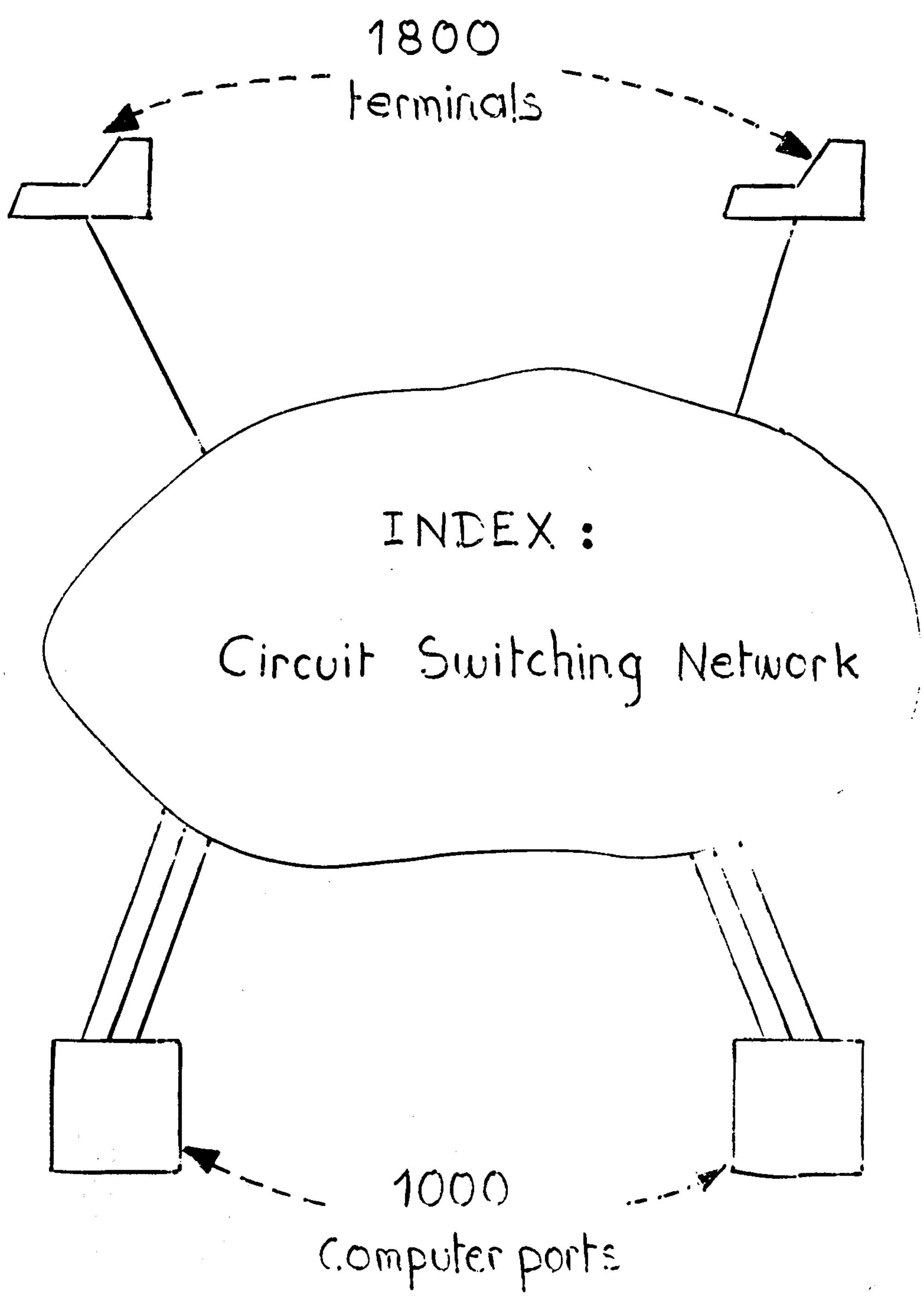
CONCLUSIONS on National A & R Networks

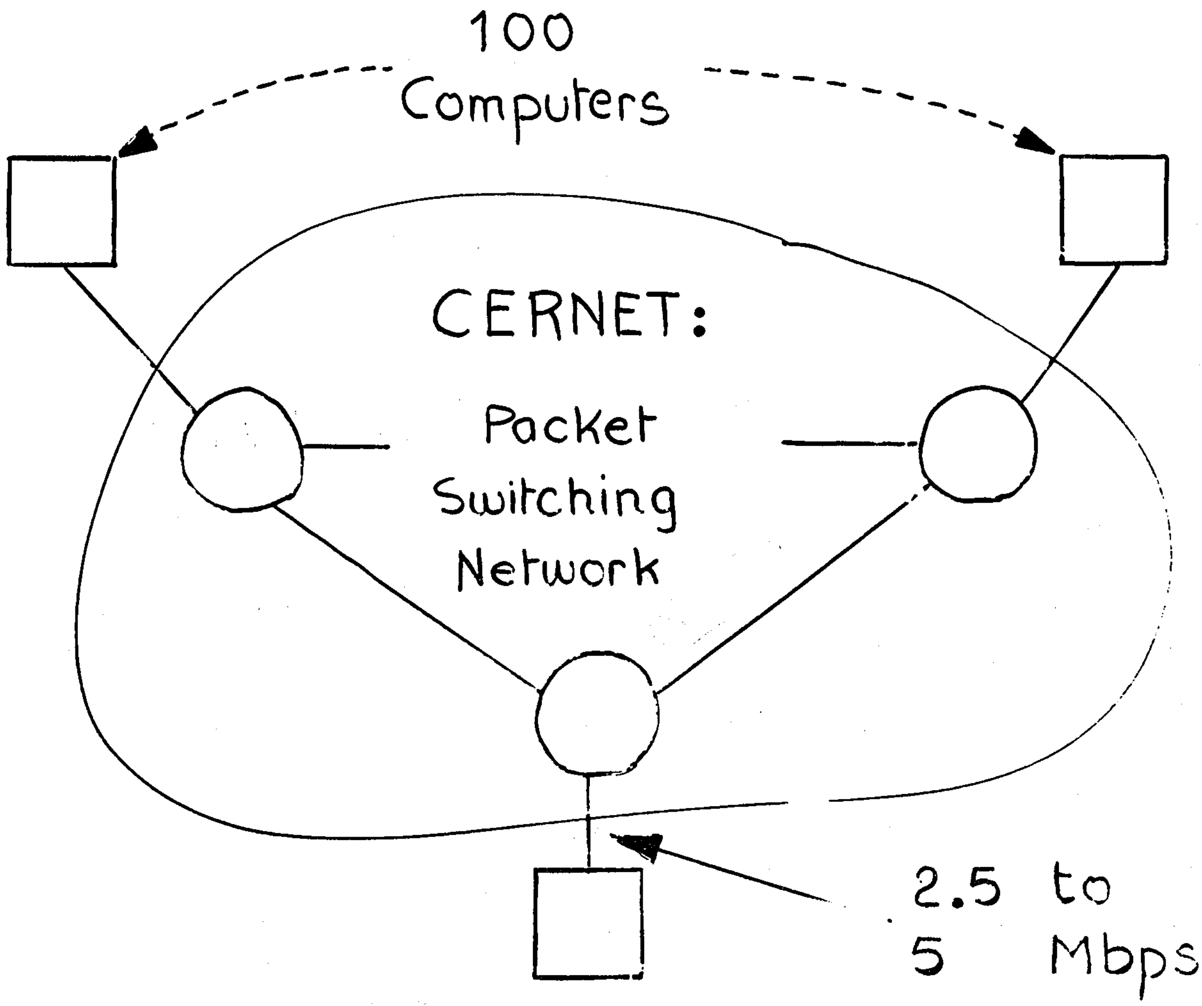
- Well established National Network : only in the UK
- Well established Physics ++ DECnet : Italy
- Countries starting Services : Germany
  Netherlands
  Nordic Countries
- In the definition phase : all the others

- Except in the UK, EARN is used everywhere also for national communications (as well as for international links)

NETWORKING at CERN

Terminal Switching at CERN

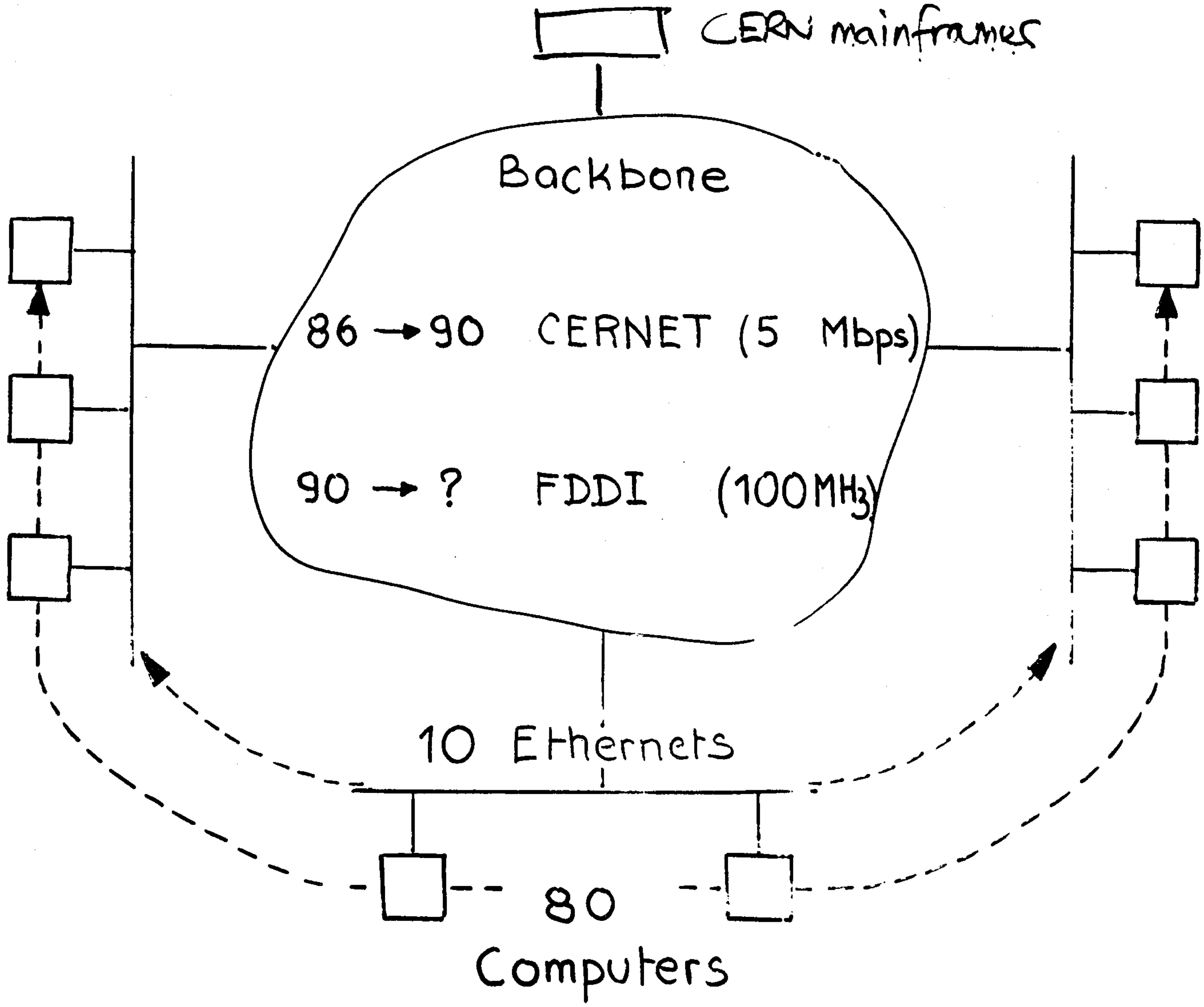




- designed (in 1976) and developed at CERN
- mesh of 18 nodes
- High Level Protocols for File Transfer

Local Area Networking Infrastructure at CERN

Ethernets and Backbone



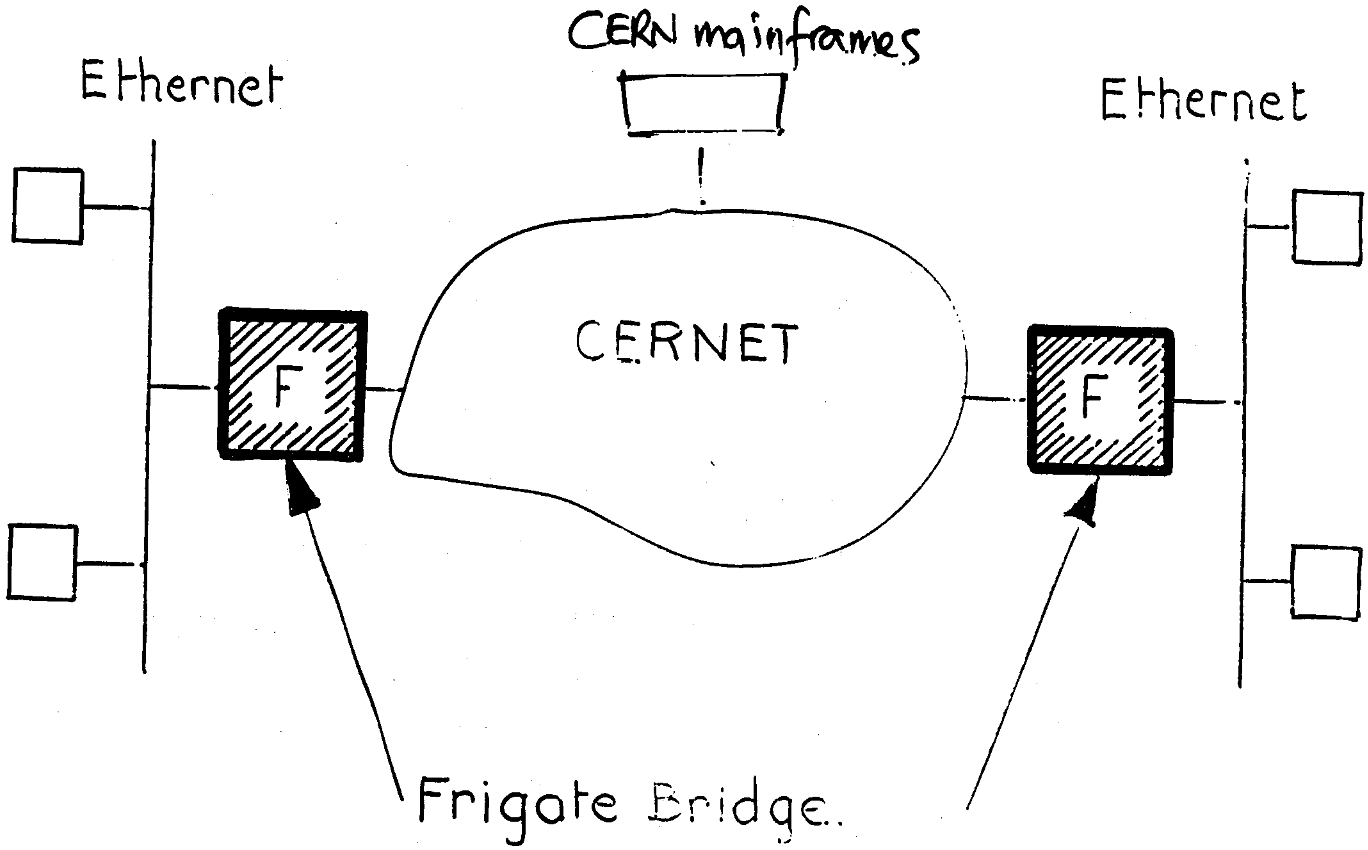
High level Protocols used :

today : DECnet
CERNET
TCP.IP
XNS

tomorow : ISO/OSI

Gateways at Low Level

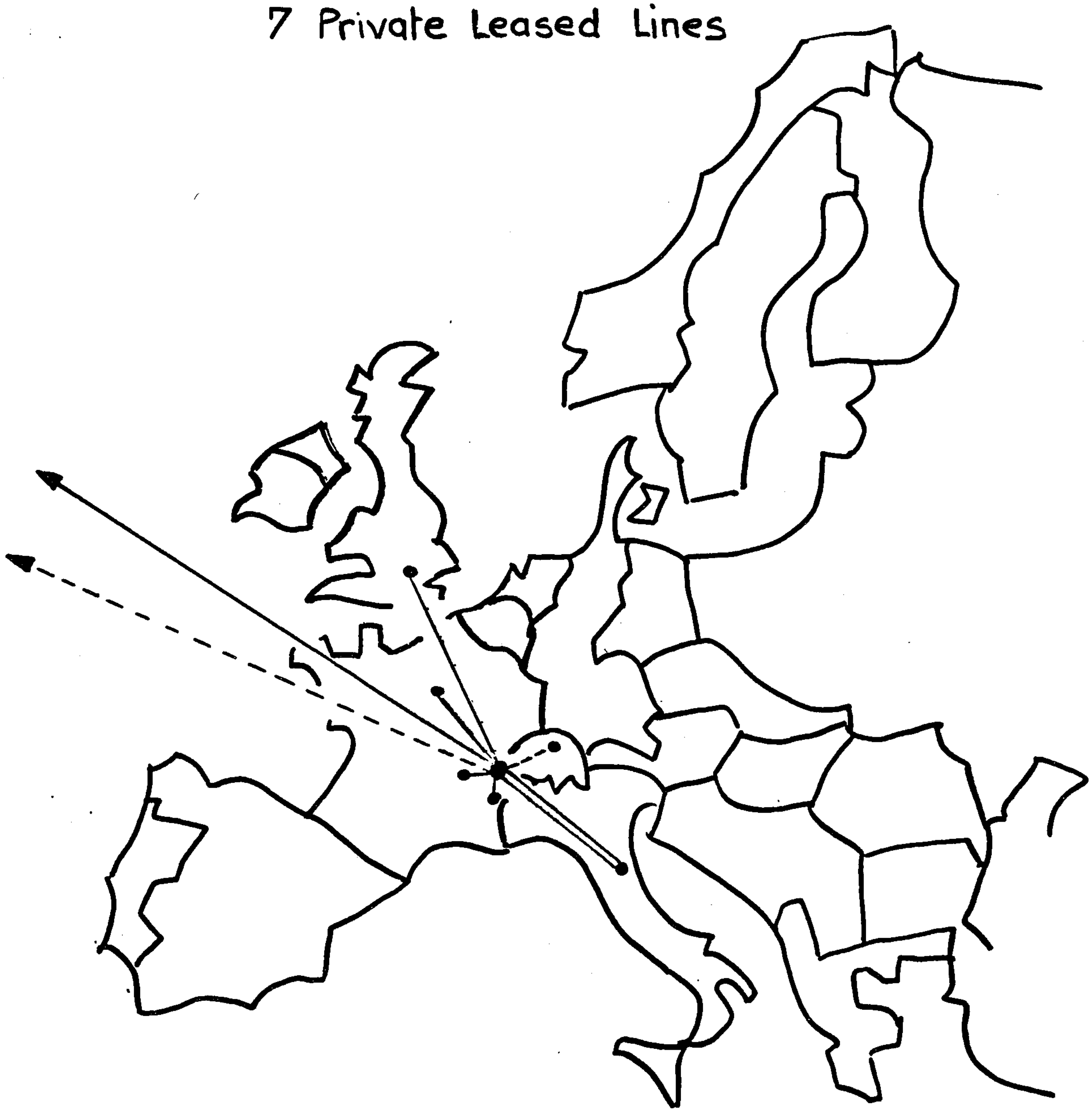
Frigates :
Bridges between Ethernets and CERNET



- designed and developed at CERN

Wide Area Networking Infrastructure at CERN

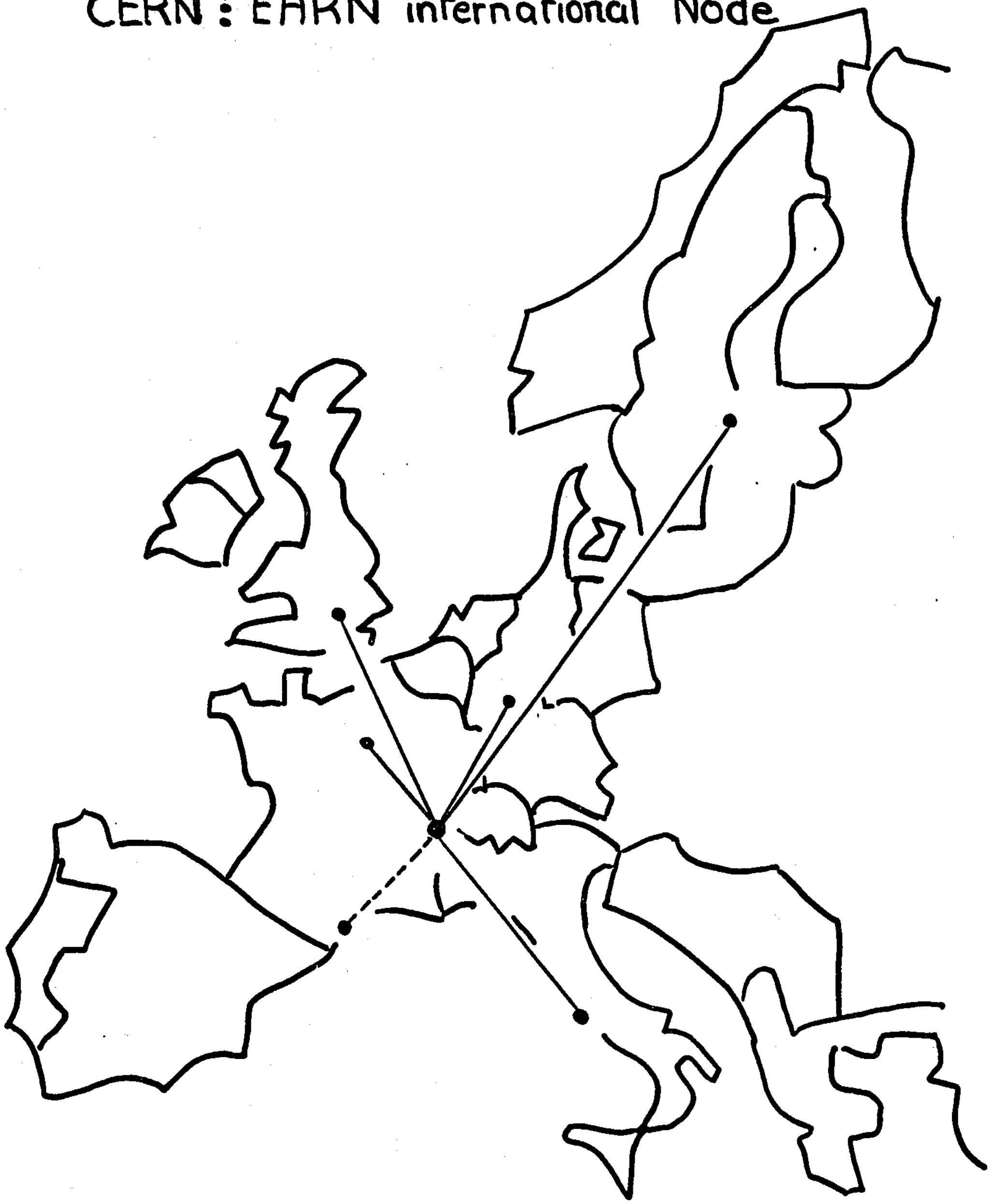
7 Private Leased Lines



___ today :	Annecy	(LAPP)	--- tomorow:	Zurich	(SIN
	Bologna	(INFN) (2)		Geneva	(Uni
	Lyon	(IN2P3)		Chicago	(FNA
	Oxford	(RAL)			
	Saclay	(DPhPE)			
	Boston	(MIT)			

Wide Area Networking Infrastructure at CERN

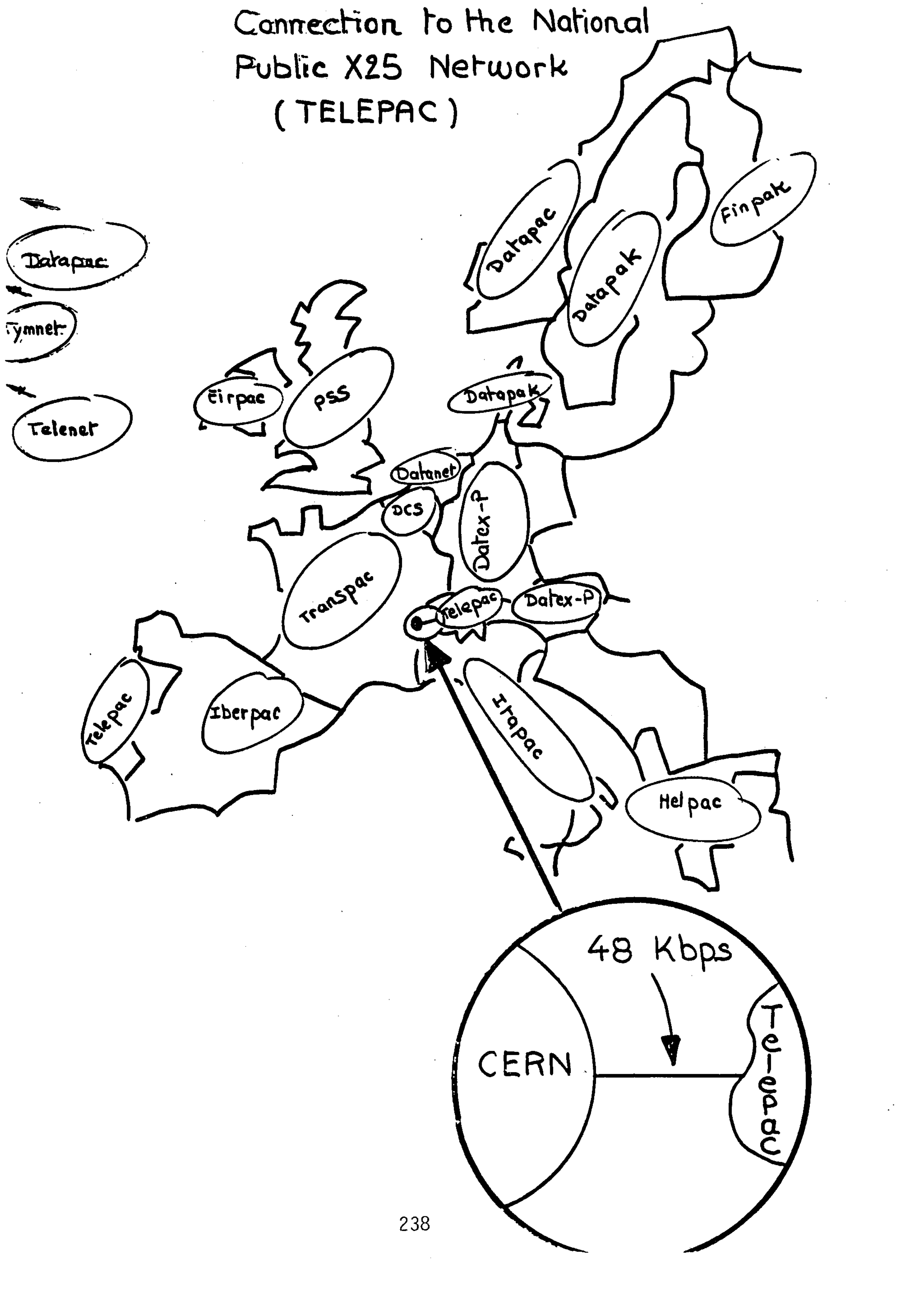
CERN : EARN international Node



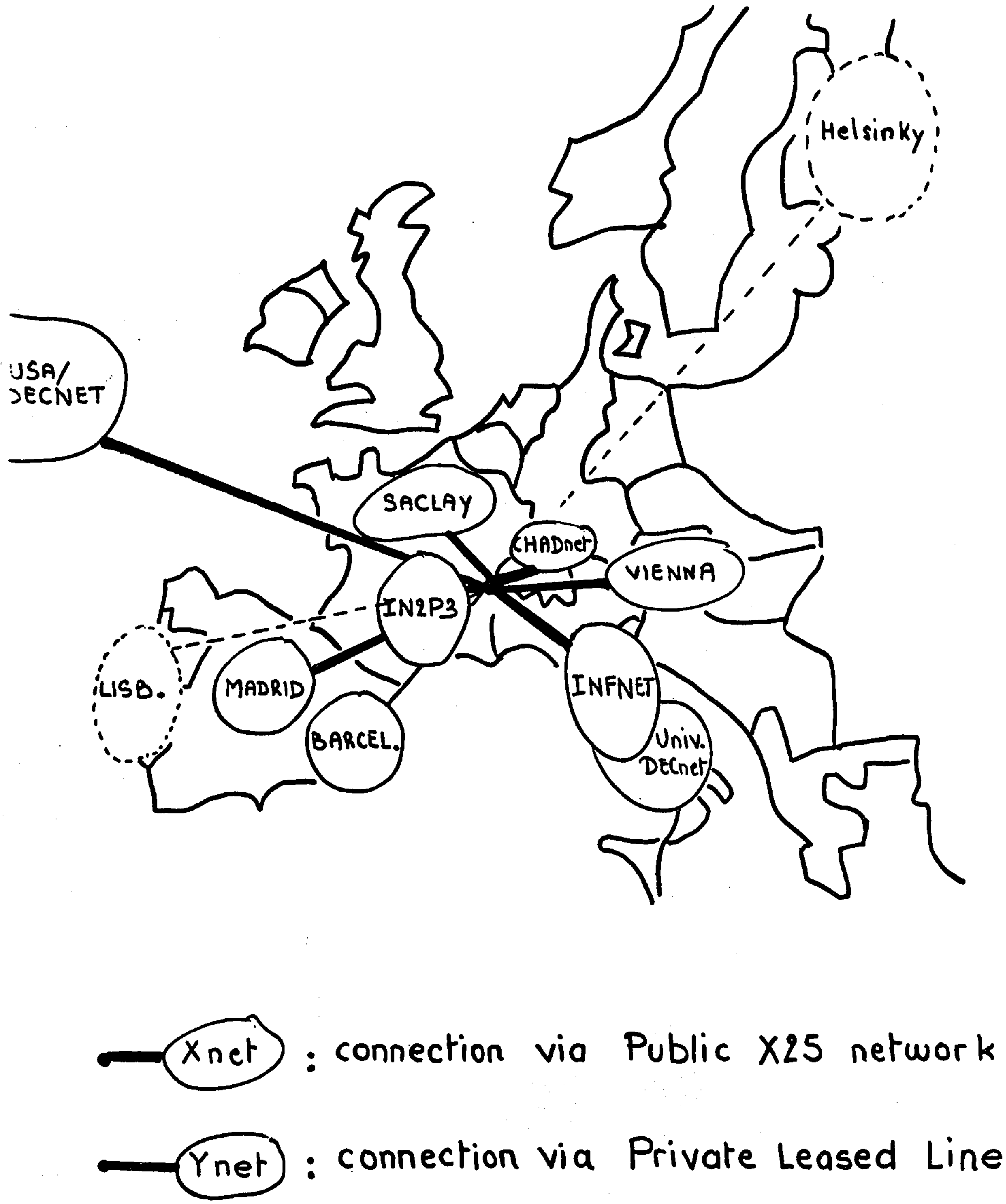
— today : Darmstadt
Oxford
Paris
Rome
Stockholm

--- soon : Montpelier

Wide Area Networking Infrastructure at CERN

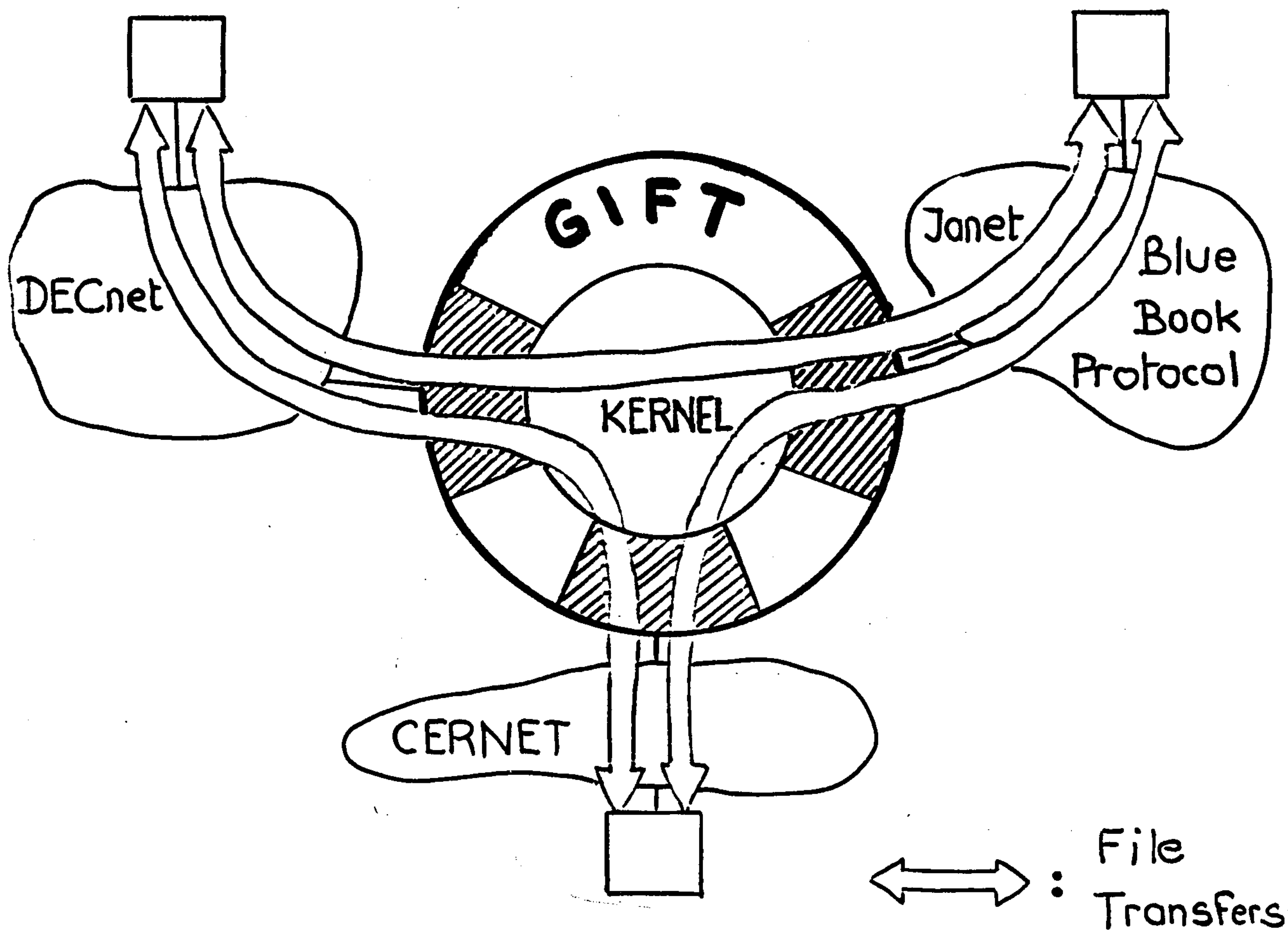


International Research DECNET
(700 - 1000 nodes)



Gateways at High Level

GIFT :
Multiple Protocol Converter for File Transfer



- Joint development between :

CERN	(CERNET	protocol)
INFN	(DECNET	protocol)
RAL - Oxford	(JANET	protocol)

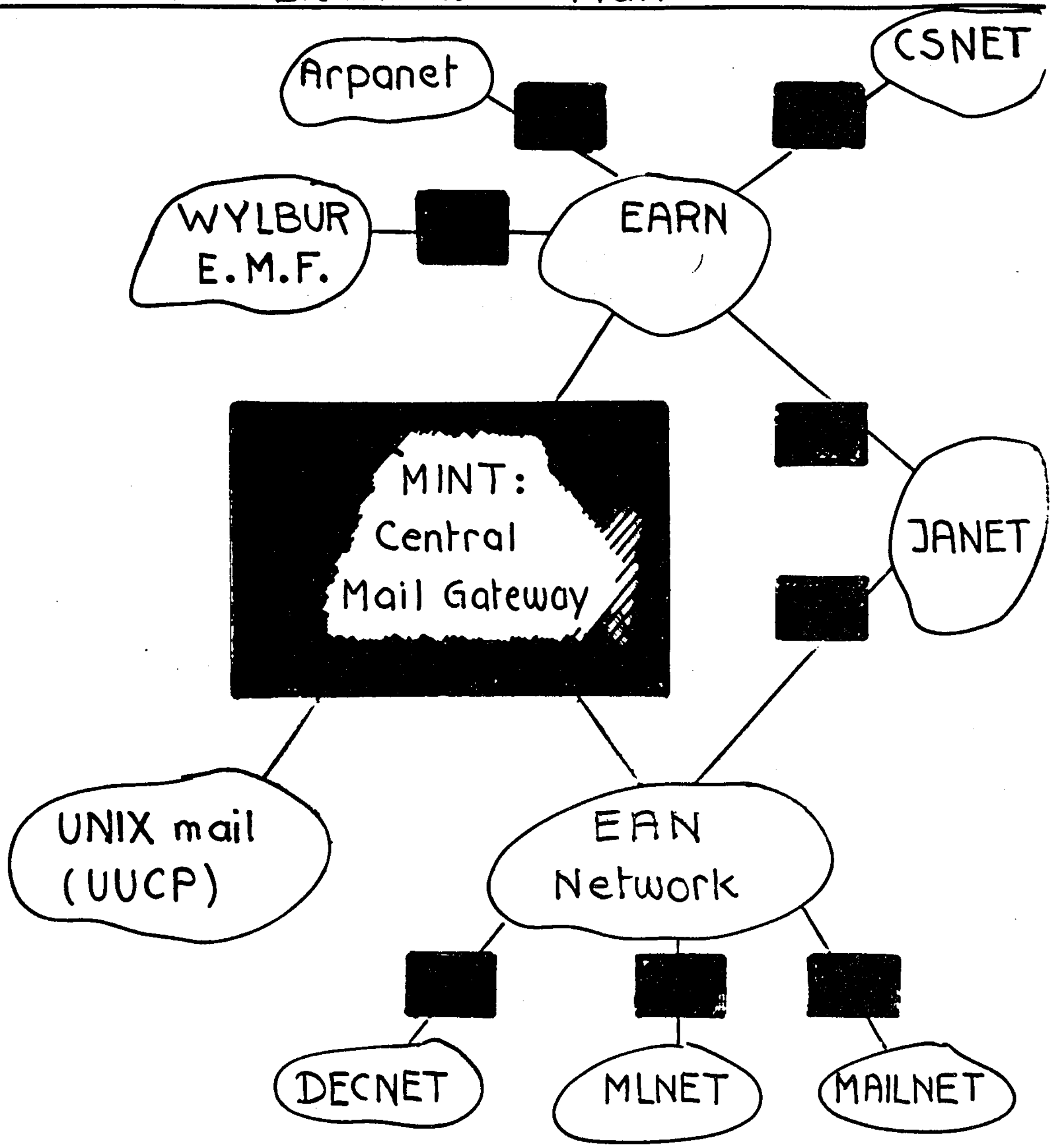
- Futur development with :

NIKHEF - SARA	(TCP.IP	protocol)
DFN - HMI	(HMI/RDA	protocol)

Gateways at High Level

MINT :

A Central Gateway and several Distributed Gateways for Electronic Mail



■ : Mail Gateways at CERN

■ : Mail Gateways outside CERN

Some KEY PERSONS at CERN
for Networking Questions

BITNET addresses

- **Brian CARPENTER** ------------ brian @ cernvax
  (Leader, Com. Systems Group)
  overall CERN Policy
  technical strategies

- **François FLUCKIGER** ----------- flu.dn @ gen
  technical strategies, GIFT, X25, FTAM
  RARE / COSINE

- **Denise HEAGERTY** ----------- denise @ cernvax
  E.mail, MINT, EAN

- **Giorgio HEIMAN** ----------- heiman @ vxgift.cern or heiman @ cernvax
  DECNET, GIFT, Transport Prot.

- **Olivier MARTIN** ------------ martin @ cearn
  EARN, Token Ring

- **Bob O'BRIEN** ----------- [illegible] @ vxgift.cern or [illegible] @ cernvax
  X25, XXX, Satellite connections

- **Crispin PINEY** --------------- [illegible] @ cernvax
  LANs, Ethernet, FRIGATE

- **Ben SEGAL** --------------- ben @ cernvax
  TCP/IP, UNIX Com.

CONCLUSIONS (?)

- I am not a fan of PTTs **BUT** we do not spend much time discussing infrastructure in Europe.

- Typically :-

  Local Area :- site wide Ethernet

  Wide Area :- PTT X.25 PPSN

- Leaves us time / energy to discuss the REAL PROBLEM — PROTOCOLS + SOFTWARE FOR TRANSPARENT, HETEROGENEOUS NETWORKING

CONCLUSIONS (?)

- We (CERN, The Users) cannot <u>possibly</u> solve the problem. We must persuade the manufacturers to do this.
- This is what the ISO protocols are all about. LEVERAGE.
- I am much more optimistic than all/most speakers here. (DECnet, X400, FTAM, TP4 ...)
- But the real service providers today are DECnet + EARN/BITNET. We cannot forget this!

TRANSITION STRATEGY. TODAY → ISO

CONCLUSIONS (?)

- New functionality needed :-
  - Remote conferencing (cf. VAXnotes)
  - Transparent symmetric remote file access (will reduce the pressure for remote logins — good for security issues)
  - Directory services for e-mail
  - Management of heterogeneous nets. (CERN project with ? manufacturers)

A physicist working at CERN
Found networking easy to learn
The mail on her Mac
Could be sent off to SLAC
Via Tymnet, or DECnet, or EARN.

INTERNETWORKING AND SCIENCE

DR. BARRY M. LEINER

RESEARCH INSTITUTE FOR ADVANCED COMPUTER SCIENCE

October 28, 1986

BACKGROUND

DARPA developed a number of packet switched networks:

- Arpanet - first packet switched network
- Packet Satellite Network - shared satellite channel
- Packet Radio Network - extension to mobile environment

In addition, local area networks becoming widespread

Early 1970's, DARPA began program to connect heterogeneous computers over heterogenous networks

INTERNET TECHNOLOGY

Permits connection of heterogenous computers over a wide variety of heterogeneous networks

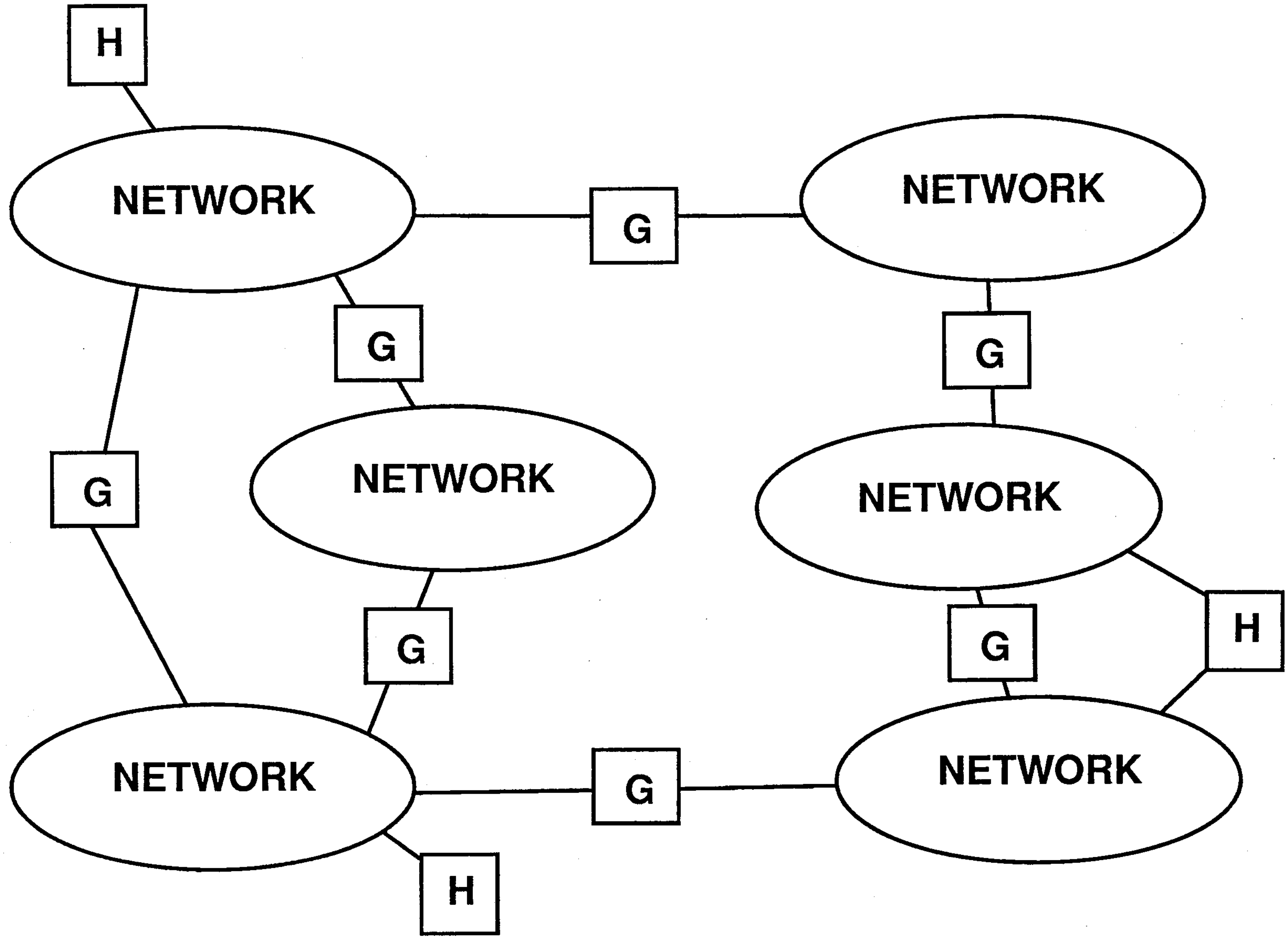
Only assumption about network is that it can transport packets (not necessarily totally reliably)

Provides 'virtual network' service through common naming and addressing mechanism

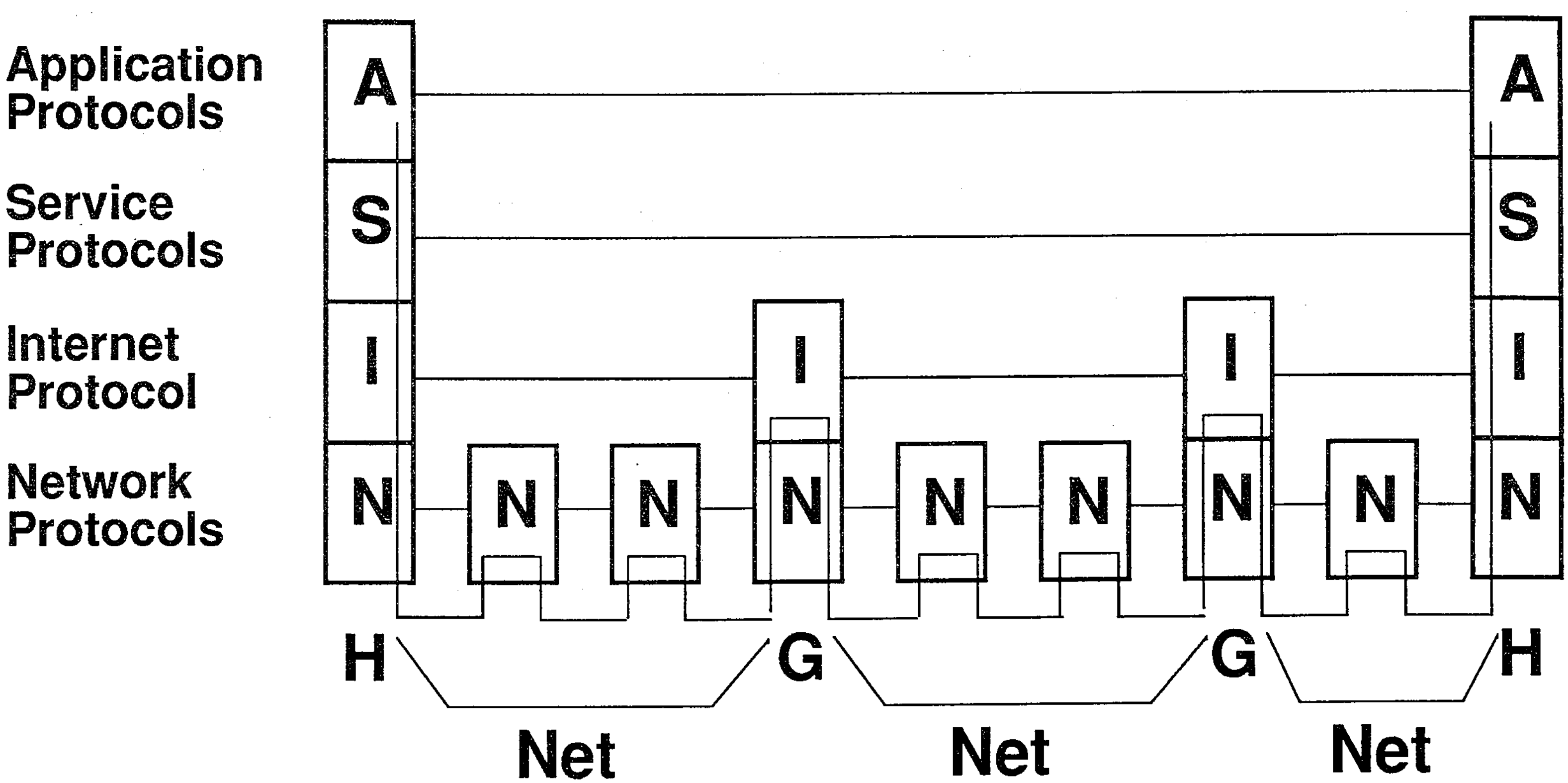
Automatically routes data according to available networks

In summary, basically uses networks as links and creates network of hosts and gateways

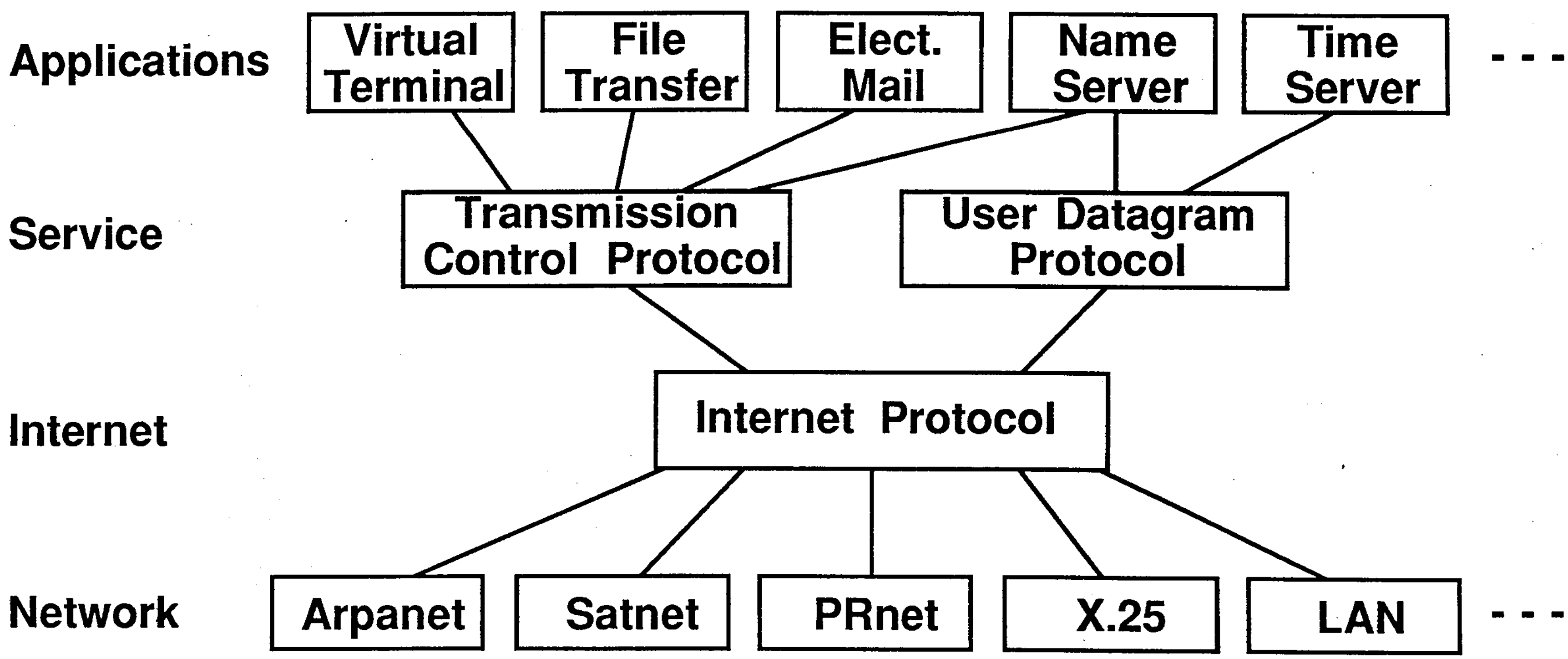
An Internet System



LAYERED ARCHITECTURE FOR INTERNETWORKING



THE INTERNET PROTOCOL SUITE



NETWORK PROTOCOLS

Network provides packet delivery service

Not necessary that total reliability provided

Internet system designed to support wide variety of networks

INTERNET PROTOCOL

- Lynch pin of internet system
  - Insulates applications programs from knowing specifics about networks
  - Unifies available network services into a uniform internet datagram service
- Provides several functions:
  - Global addressing structure
  - Provision for type of service requests
  - Provision for fragmentation of packets and reassembly at host
- Functions included in Internet Protocol => 'Do gateways need to know it?'
- Internet Control Message Protocol (ICMP) provided for control of internet 'virtual network'
  - Interaction of hosts, gateways, and monitoring and control centers
  - Provides for redirect messages, error reporting, etc.

SERVICE PROTOCOLS

Transmission Control Protocol (TCP)

- Reliable sequenced end-to-end data delivery
- Provides packetizing, sequence numbers, checksums, timers, acknowledgments and retransmission procedures

User Datagram Protocol (UDP)

- Basic datagram service
- Provides multiplexing and checksumming

Other protocols under development

- Transaction Protocol
- Multicast Protocol

(SOME) APPLICATION PROTOCOLS

Remote Terminal Protocol (TELNET)

- Network Virtual Terminal
- Negotiated options, symmetric processes
- Uses TCP

File Transfer Protocol (FTP)

- Uses TCP along with set of commands and replies

Simple Mail Transfer Protocol (SMTP)

- Uses TCP along with restricted set of file transfer options
- Negotiation of recipients, confirmed transfer of responsibility

Name Server

- Transaction service on UDP
- Provides for translation from name (e.g. ICARUS.RIACS.EDU) to internet address (128.102.8.1)

GATEWAY PROTOCOLS

Gateways provide:

- routing
- fragmentation
- other network control functions

Systems of gateways must interact with each other

- Autonomous Systems
- Exterior Gateway Protocol (EGP)

CURRENT STATUS OF INTERNET SYSTEM

160 Networks

- 450 Network numbers assigned
- 1800 Network numbers allocated
- Includes wide variety of networks internationally ranging from LANs through WAN's like Arpanet and X.25 networks and special networks like packet radio networks

Thousands of host computers

Tens of thousands of users

Basis for NSFnet

Conceptually similar in many ways to ISO OSI model

INTERNETWORKING FOR SCIENCE

Many agencies funding networks in support of scientific research:

- DARPA
  - Arpanet
  - WBnet
  - Internet
- NSF
  - NSFnet
  - CSNET
- NASA
  - PSCN
  - NASnet
  - SPAN
- DOE
  - MFEnet

Also, many other organizations funding networking activities (states, regional, campus, local)

INTERNETWORKING FOR SCIENCE (cont)

Several new directions needed:

1. New high performance services
2. Interconnection of various networks
3. Managment and operation of interconnected network

INTERAGENCY RESEARCH INTERNET

Intent is to achieve cost-effective high-performance ubiquitous network in support of scientific research

- Effective use of networks without unnecessary duplication
- Communication infrastructure to allow scientists to access resources independent of the network on which they are located
- Communication infrastructure to encourage collaborative research
- Cooperative research program to evolve and enhance the IRI

Spearheaded by Network Working Group of FCCSET Committee on Very High Performance Computing

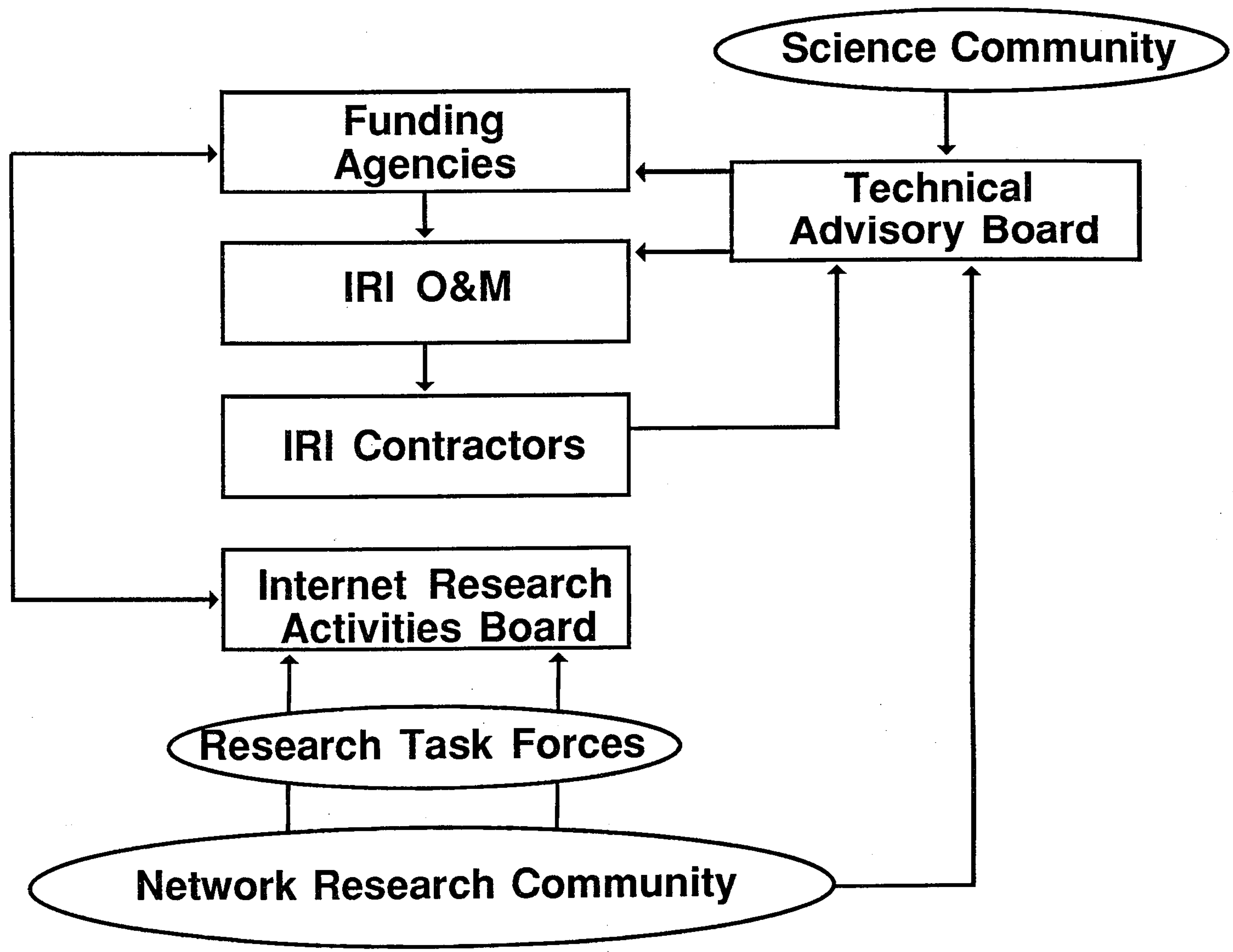
IRI CONCEPT

Interconnection of networks based on Internet Protocol Suite

Jointly funded operation and managment of 'glue' to interconnect agency and other networks

Collaborative research program (separately funded) to develop new networking technologies that enhance IRI

IRI MANAGEMENT STRUCTURE



IRI STATUS

Initial concept documented in February 1986 report from Network Working Group

Draft implementation plan documented in RIACS technical report

GEORGE W. BRANDENBURG, ASSOCIATE DIRECTOR

HIGH ENERGY PHYSICS LABORATORY

HARVARD UNIVERSITY

TITLE: FERMILAB NETWORKSHOP SUMMARY

Fermilab NETWORKSHOP
October 23-24

Day One

OSI Introduction

Fermilab Access Modes Chartrand

HEPNET Loken

MFENET Leighton

European Networks

International Links Montgomery, Merola

BITNET Cottrell

Day Two

Approach of the Funding Agencies

DOE Cavallini

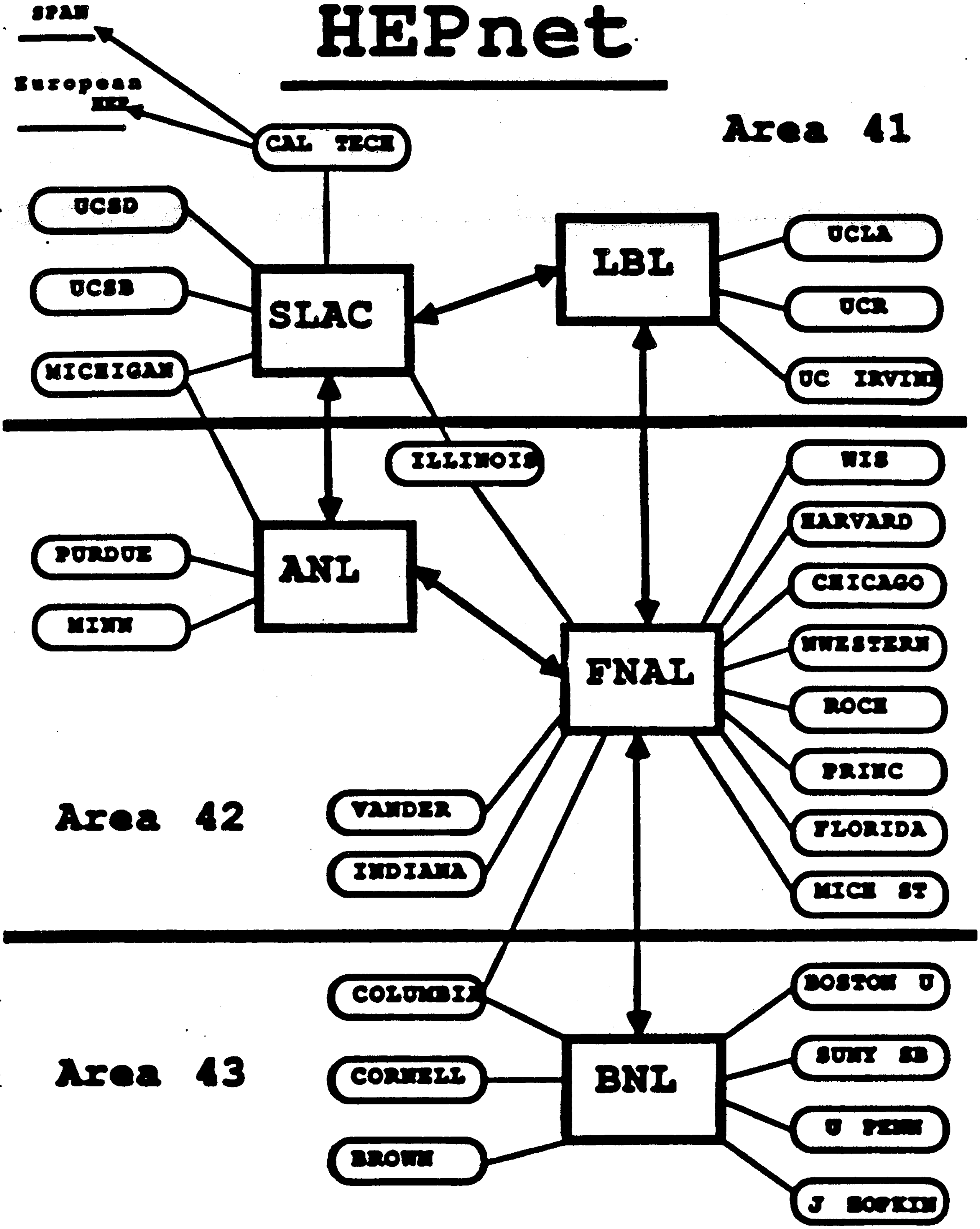
NSF

→ HEP Network Use Brandenburg, Newman, ...

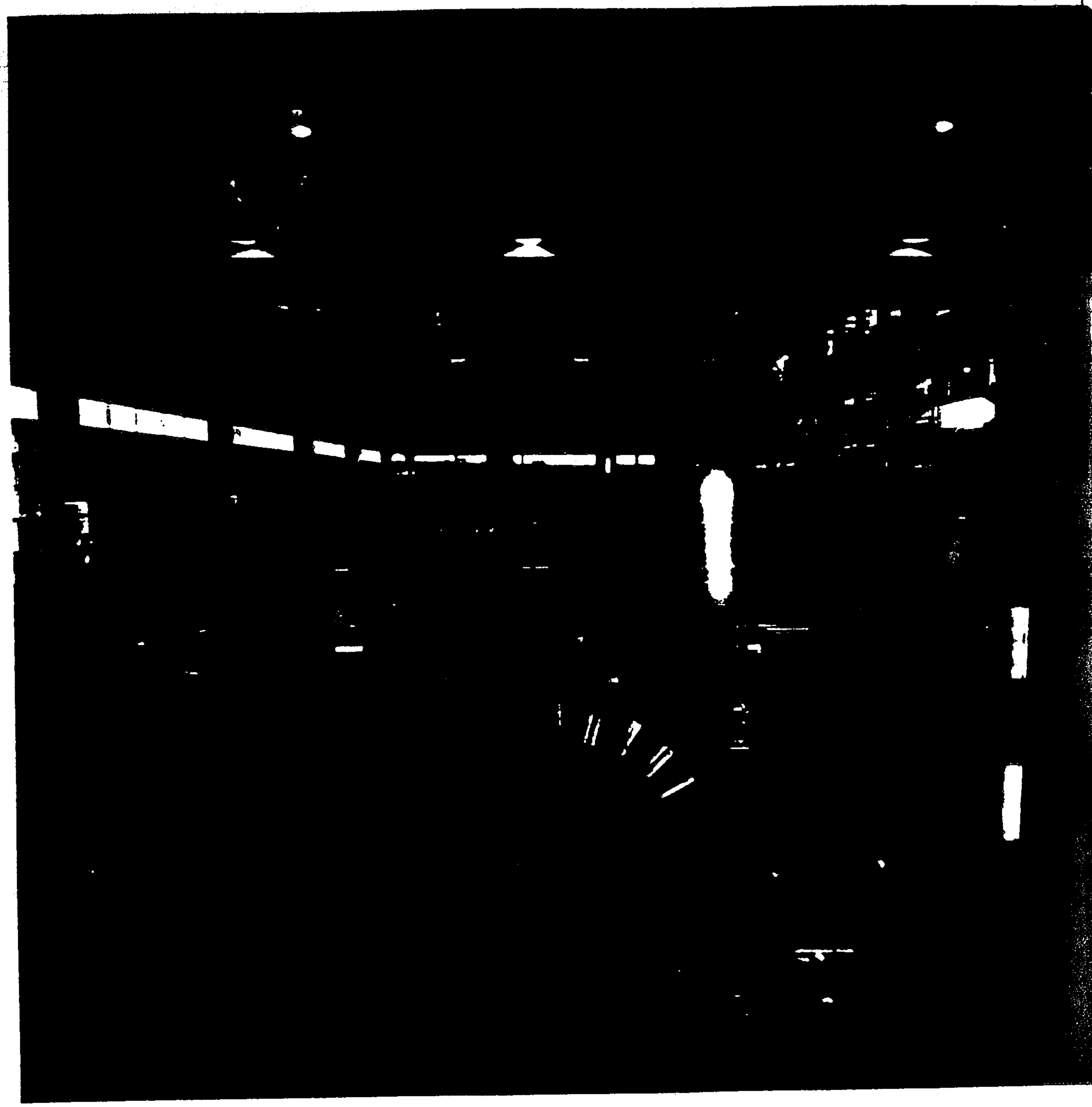
→ Panel Discussion
Woods, Loken, Montgomery, Newman, ...

Fly to California for next workshop!

HEPnet

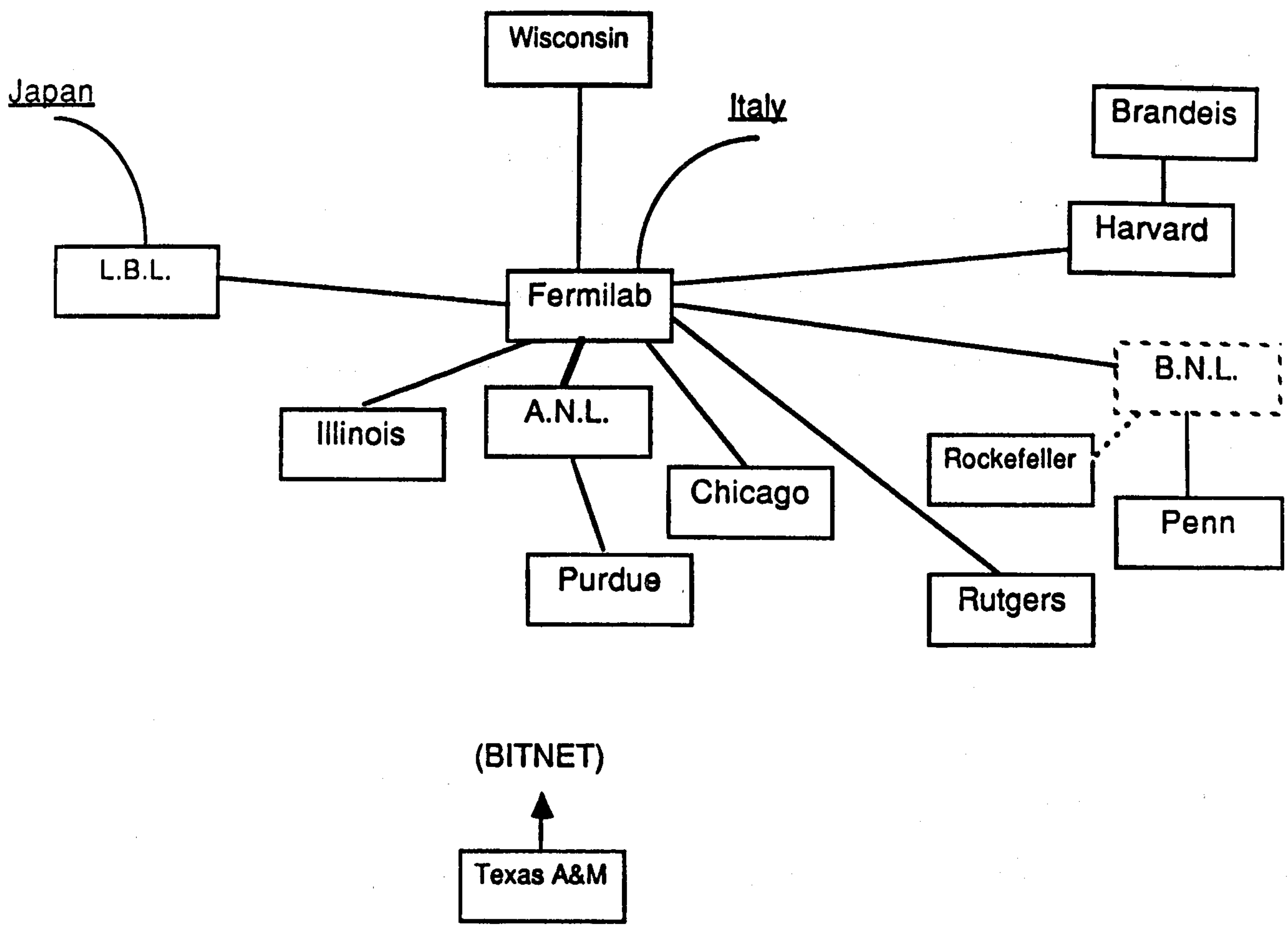


SPAN
European HEP
Area 41
CAL TECH
UCSD
UCSB
MICHIGAN
SLAC
LBL
UCLA
UCR
UC IRVINE
ILLINOIS
WIS
HARVARD
CHICAGO
NWESTERN
ROCH
PRINC
FLORIDA
MICH ST
ANL
PURDUE
MINN
FNAL
Area 42
VANDER
INDIANA
COLUMBIA
BOSTON U
Area 43
CORNELL
BNL
SUNY SB
U PENN
BROWN
J HOPKIN



85-521-9

CDF - NET



Note: all lines are 9600 kbps
except for FNAL-ANL

CDF Network Uses

Mail

—Memos and replies (and replies...)

—Leave messages (avoid FNAL phones!)

—Network address book on FNAL node *

—Mailing lists for different working groups

—Meeting minutes

—Junk mail!

Bulletin Board

—Announcements (machine status, meetings, etc.)

—Documentation (on-line and off-line software)

—Latest items visible on login

* More than 200 collaborators at seventeen institutions!

CDF Network...

Remote Computation

—Using SET HOST

—Pools resources that are available

—University VAXes may be free (and vice versa)

—Proxy logins allow long distance clustering

—Example: VAX workstation at Harvard logged on B0 cluster running event display with TEK graphics returned in 2nd window

Data Transfer

—One event ~ 50 kbytes

—B0 --> FNAL link 1 Mbps ~ 120 kbytes/sec (similar to tape speed — will improve)

—Write tapes at central facility?

—Remote links ~ 1 kbyte/sec ~1 event/min (display "occasional" events)

—Calibration data bases

CDF Network...

Remote Software Development

—Allows more University participation

—SET HOST to central machine, or... good

—Edit central files remotely, or... better

—Edit local files which are auto-updated best

Remote Software Updates

—Total software package ~ 100 Mbytes

—Install at remote sites

—Update command procedure runs while you sleep

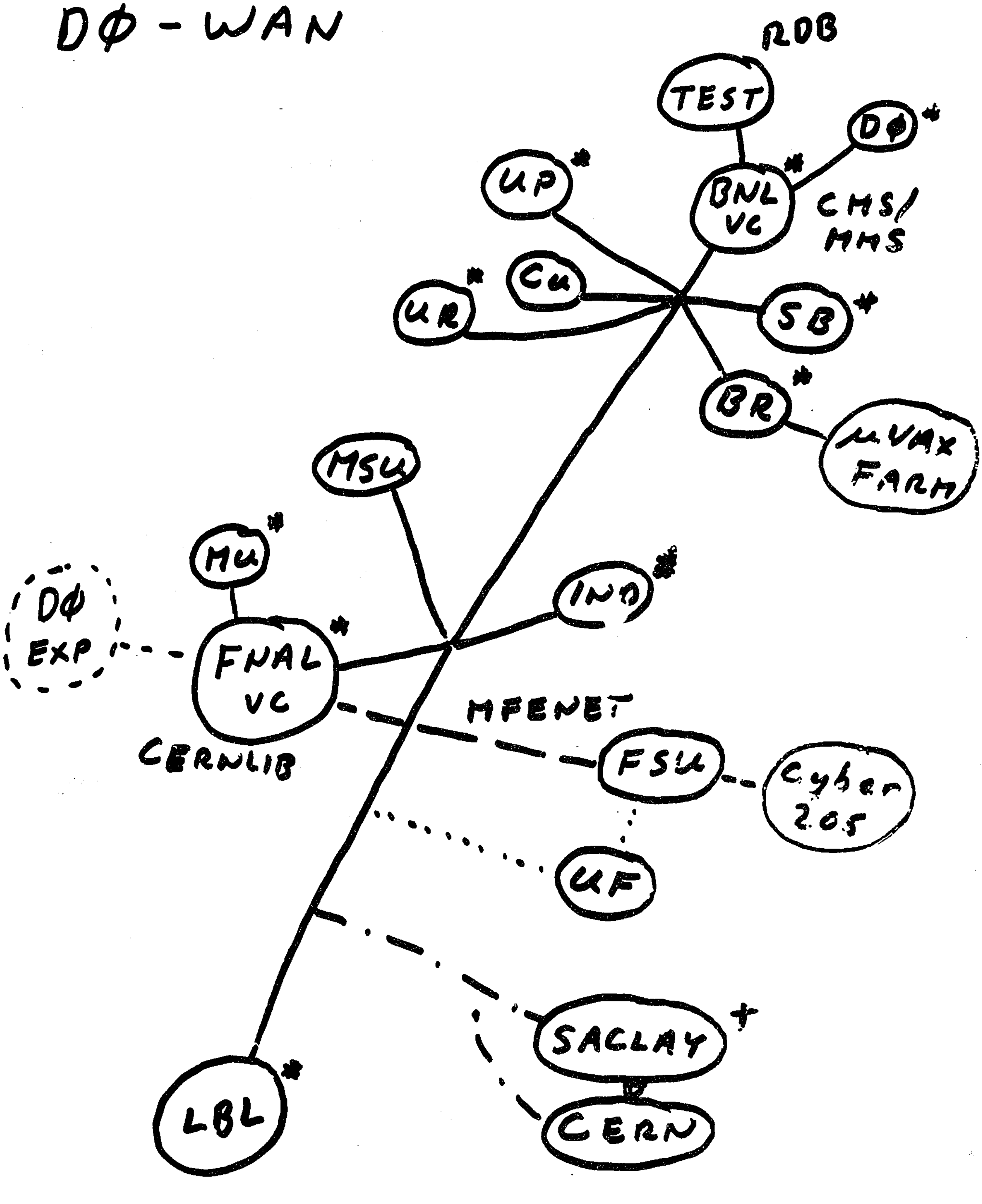
—Polls central site for changes

—Copies relevant files (modules)

—Recompiles for debug (if desired)

—If 1% changes per day — 1Mbyte or 15 minutes

DØ - WAN


ROB
TEST
DØ *
UP *
BNL VC *
CMS/ MMS
Cu
UR *
SB *
BR *
μVAX FARM
MSU
MU *
IND *
DØ EXP
FNAL VC *
CERNLIB
MFENET
FSU
Cyber 205
UF
SACLAY +
LBL *
CERN

NET USEAGE

INDIVIDUAL ACCOUNTS

+ DØLIBRARY

1) MOST DØ Products

2) DØLOCAL.COM

DEFINE NODE DEPENDENT

LOGICAL VARIABLES

CALLS

3) DØPROLOG

NODE INDEPENDENT

LOGICAL VARIABLES

+ Symbols

- GENERAL COMMUNICATION (MAIL - PHONE)
- LIBRARY REPOSITORIES
- DOCUMENTATION
- CODE MANAGEMENT

SOFTWARE DESIGN

D.D. (Data Dictionaries)

Maintained on: DØTEST @ BNL

- μVAX - 70 Mbyte disk
  "open" account

- Uses RDB + DØ written software

$

Structure Charts

BNLCLx

Direct Edit (EVE +)

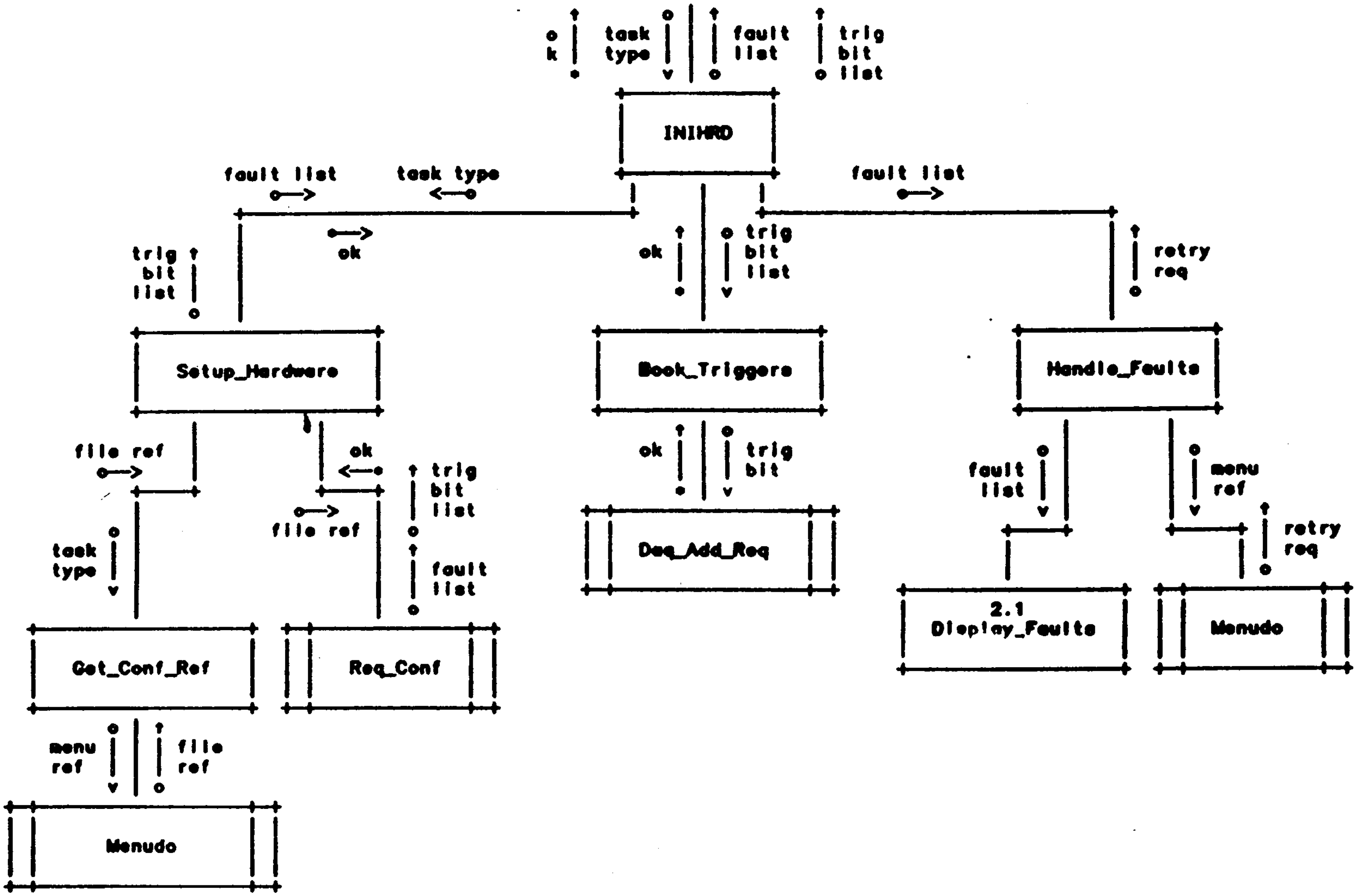
will go into CMS/MMS system

Lacking

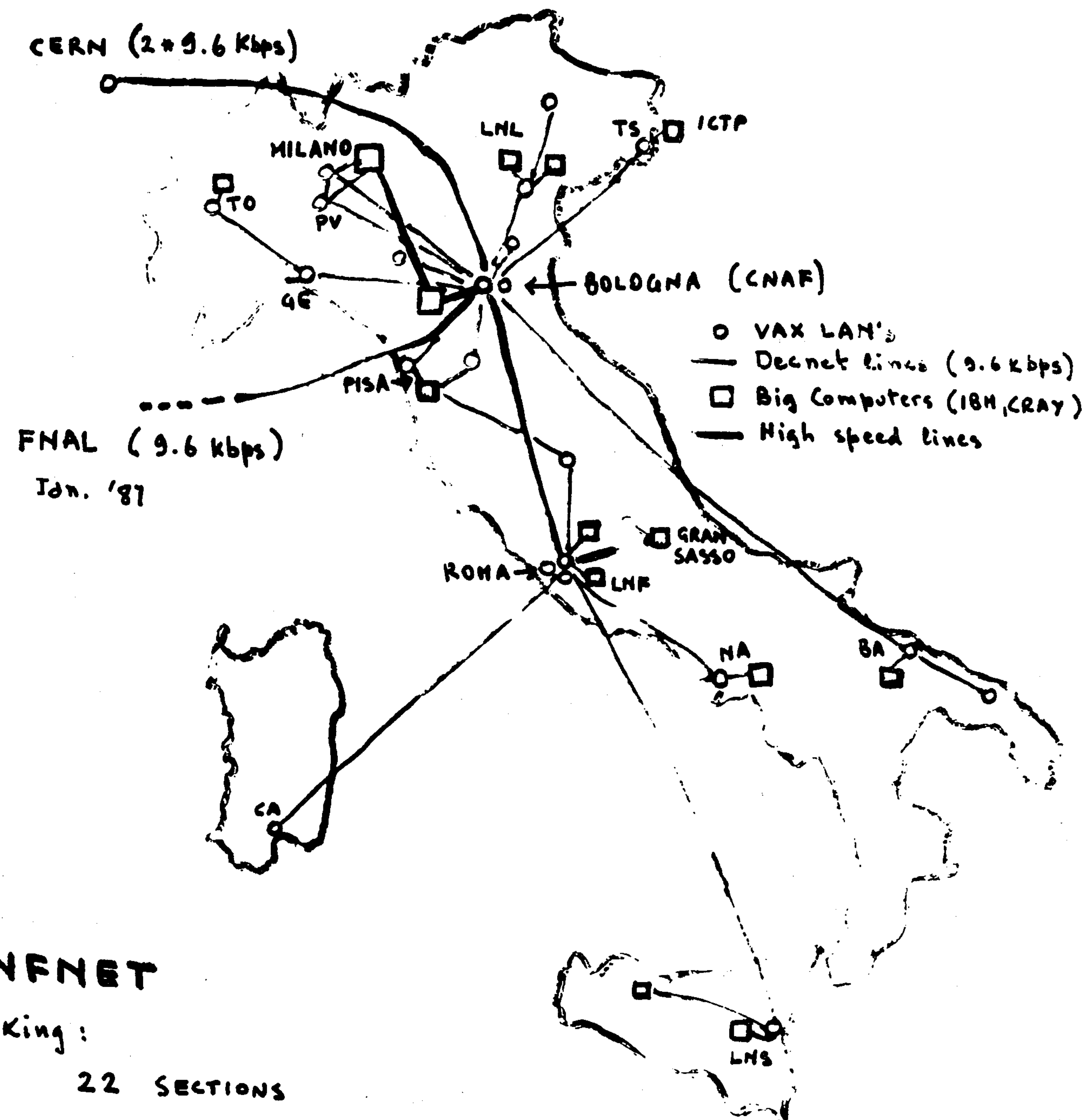
Graphics Transmission capability

Structure Chart for: CALIBRATE TASK
AUTHOR: BGG

Version 1.0 8 - Oct - 86
D0TASK.2



INFN - ITALY



INFNET

Linking:

22 SECTIONS

4 LABORATORIES

1 NATIONAL CENTER (CNAF)

~ 100 COMPUTERS

Experiments in American Laboratories

Experiment	Lab.	I.N.F.N. Section
CDF	FNAL	PI/LNF
JET-FNAL (E760)	FNAL	FE/GE/TO
FLATEV (E687)	FNAL	BO/LNF/MI/PV
BRD	FNAL	FI/BO
SEPTE (E581/E704)	FNAL	TS
PEP-6	SLAC	LNF
SLD	SLAC	BO/LNF/PD/PI PG/TS/FE

NETWORK links required for:

- Program development
- Detector studies
- DST analysis
- Access to data bases
- Hardware testing during data taking
- Data transfer: samples of events
  histograms
  etc ....
- Documents

L3

⇒ INTERNATIONAL COORDINATION

⇒ LARGE SOFTWARE and DATABASES

NEED to MAKE FULL USE

of

COMPUTER FACILITIES

and

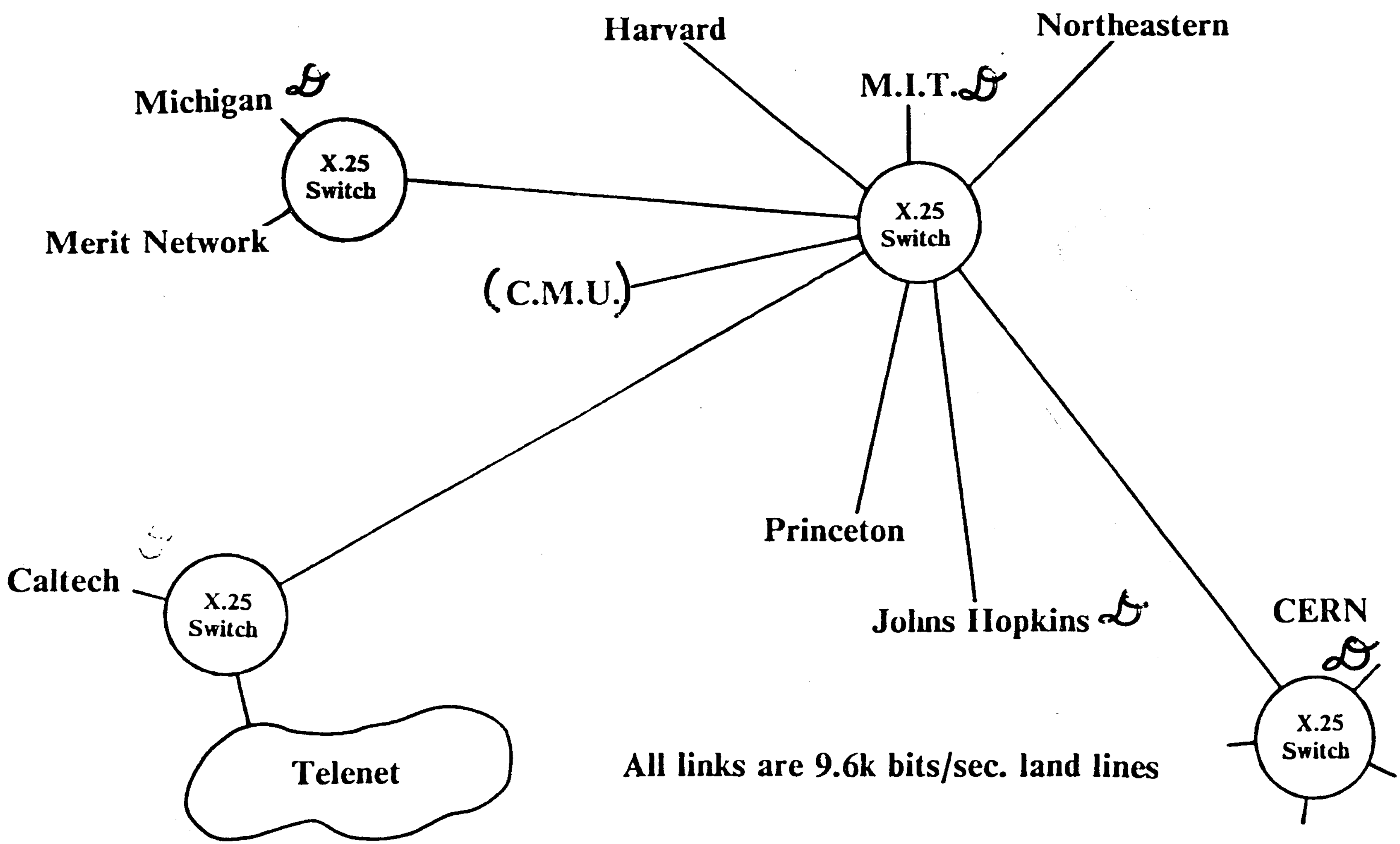
MANPOWER RESOURCES

⇓

LEP3NET

LEP3NET: START UP

PROPOSED to DOE:	1983
FUNDED (MAJOR COMPONENTS)	10/85
HARDWARE TESTS, PROGRAMMING	12/85 – 1/86
MIT – CALTECH NETWORK TRIALS	1/86
INSTALLATION AT MIT	1/26/86 – 1/30/86
MIT – CERN LINK UP	1/30/86
OFFICIAL LEP3NET START DATE	*1/30/86*
HARDWARE and SOFTWARE "SHAKEDOWN"	2/86
NETWORK STABLE and RELIABLE ➔ TWO INCIDENTS in FIRST 3 MONTHS	from 2/15/86
DECNET to CERN (and ITALY)	from 4/1/86


Harvard
Northeastern
M.I.T.
Michigan
X.25 Switch
Merit Network
(C.M.U.)
X.25 Switch
Princeton
Caltech
X.25 Switch
Johns Hopkins
CERN
X.25 Switch
Telenet
All links are 9.6k bits/sec. land lines

LEP3NET

FULL SET OF NETWORK SERVICES

- REMOTE LOGON (PAD)
- FILE TRANSFER (TRANSFER)
- ELECTRONIC MAIL (POST)

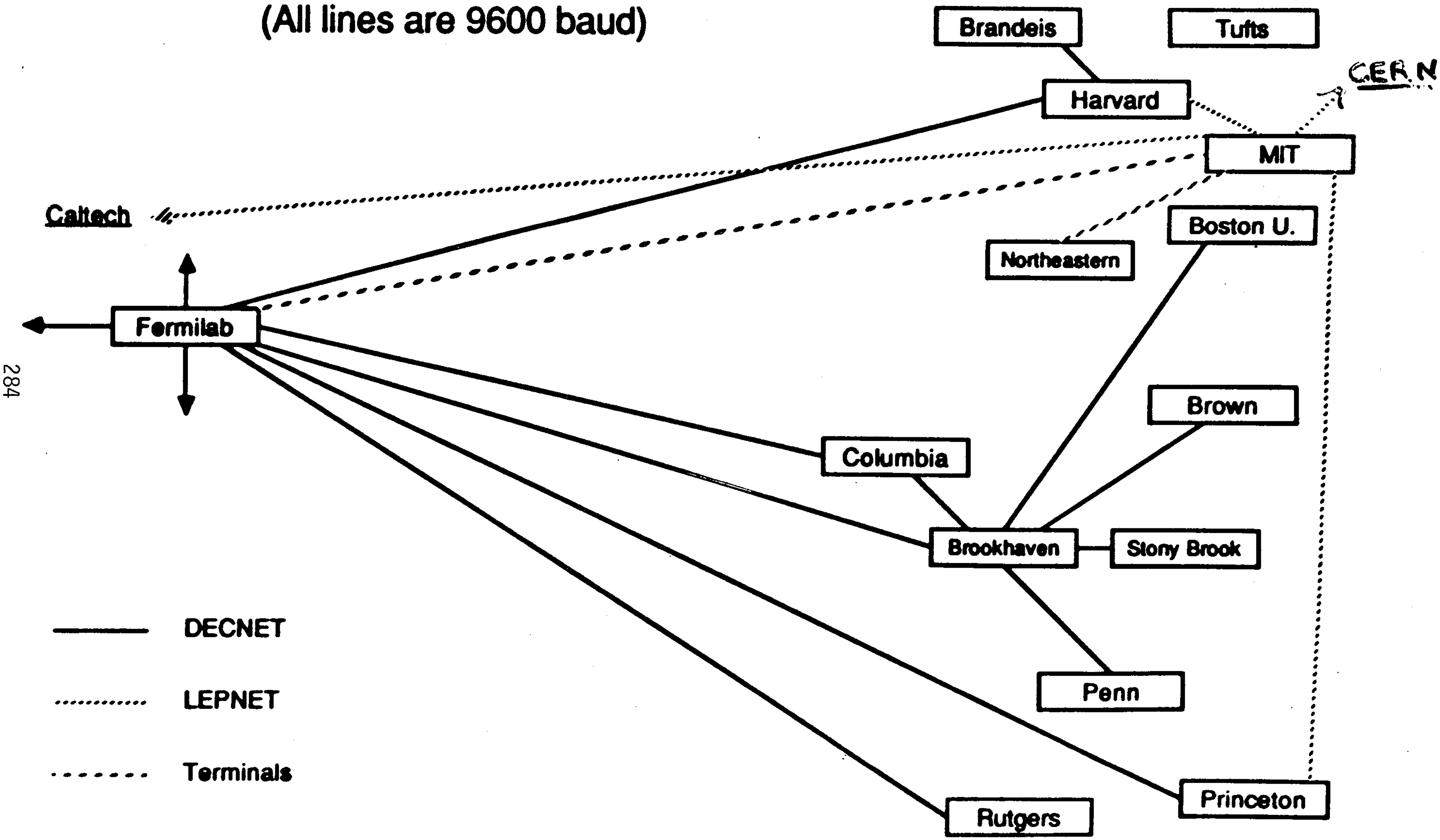
ALL TERRESTRIAL, 9.6 KBPS

- FAST RESPONSE
- IMMEDIATE TRANSFERS
- RELIABLE

⇛ AUTOMATIC QUEUEING, RETRY
⇛ MTBF: MONTHS

HEP East Coast Leased Lines

(All lines are 9600 baud)



Panel Discussion Highlights

Loken: We need to work on improving our European links...

Montgomery: HEP community needs to be aware of its needs and make itself felt. A HEPNET policy review comm. is needed...

Newman: Network infrastructure is available off the shelf...

Krol (NSF): HEP is in forefront of collaborative networking...

Woods (DOE): Write to me if you have ideas or needs. Two people will be appointed to ESNET steering committee.

Appel (FNAL): People have had to divert funds from their DOE contracts to do something that is absolutely necessary - lease lines.

Newman: Even with central funding you will always need to spend some money locally - there's no free ride...

Loken: We need to take some initiative on ESNET

Montgomery: What input would you like to give to ESNET?

Brandenburg: As physicists we are active network users — more active (and dependent) all the time. We want more (not less) functionality, more reliability, and more coordination. We don't want to start over from scratch!

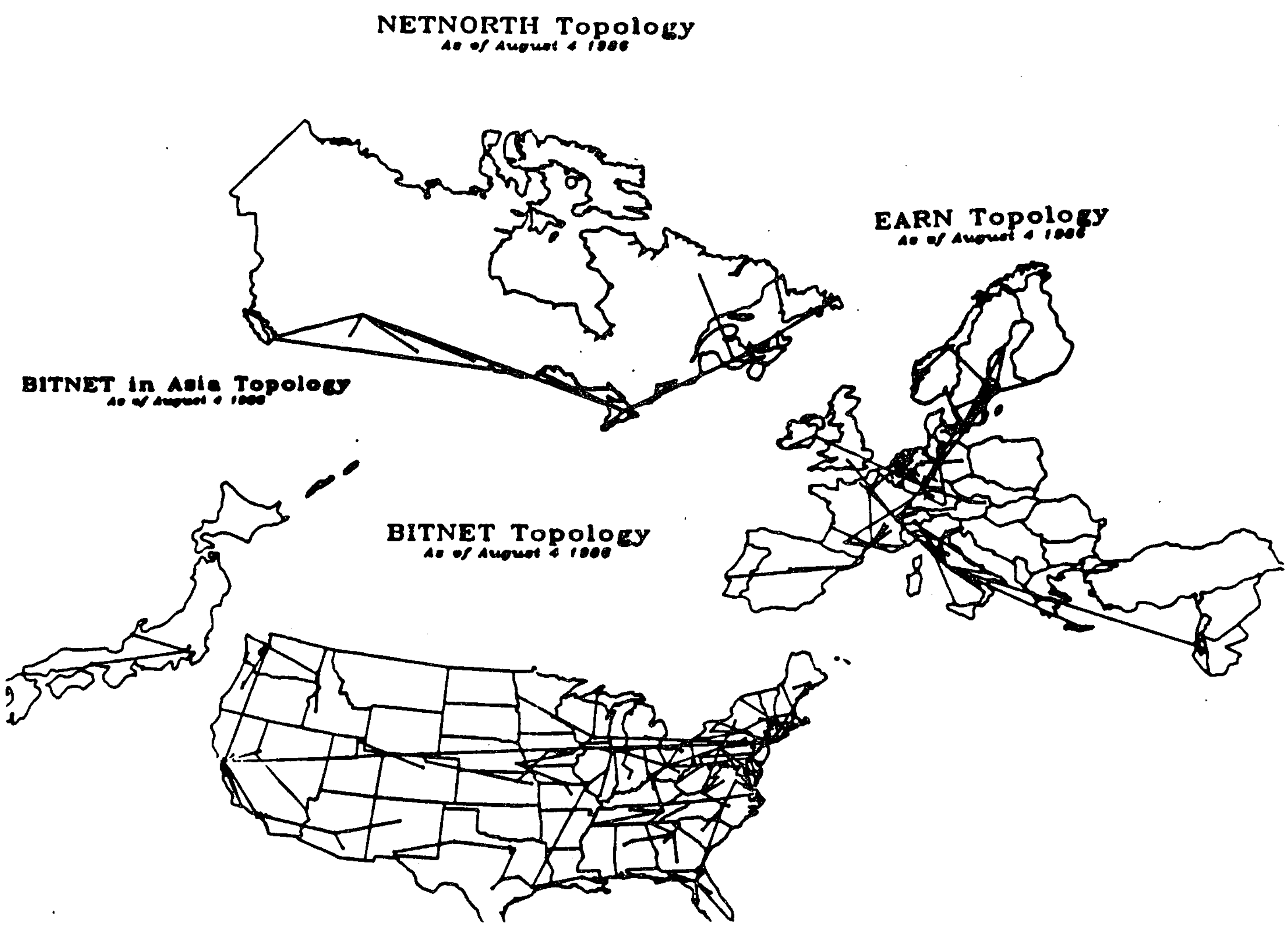
Merola: We need DECNET...

Chartrand: And we won't get it.

Newman: The means do exist.

BITNET (Because It's Time)
Dr. R. Les. A. Cottrell *Assistant Director,* *SLAC Computer Services* <COTTRELL@SLACVM.BITNET>

- Outline of Talk.
  - What is BITNET?
  - Where is BITNET?
  - History.
  - How to use BITNET.
  - What BITNET is used for.
  - Future.



What is BITNET

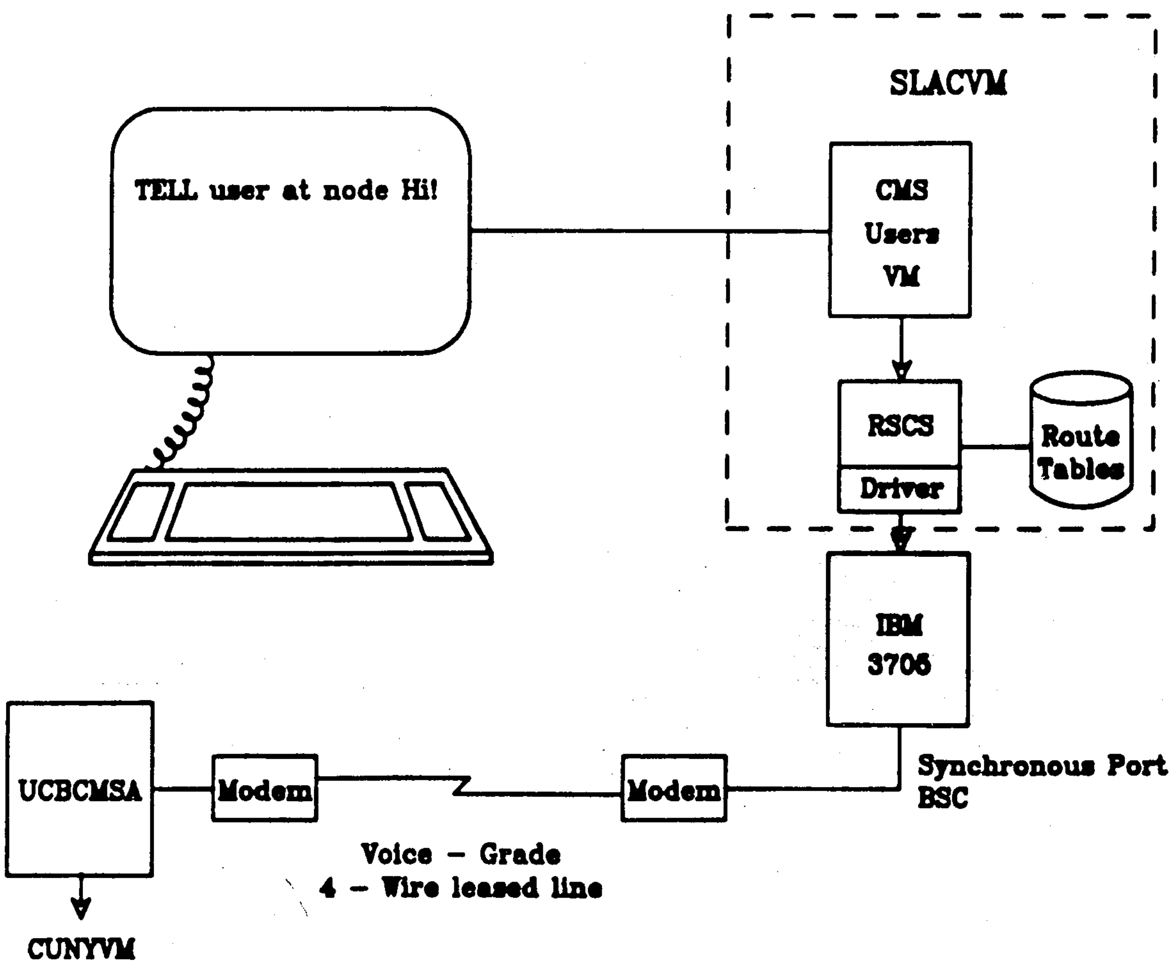
- Goals.
- Services.
- Implementation.
- Costs.

What is BITNET

- Goals.
  - Maximize connectivity for scholars of the world (keep fees low, make easy to use).
  - provide a reliable, dependable network.
  - Control is with the academic member institutions. Any organization, governance or service proposals must safeguard academia's controlling interest in BITNET.
- Services Supported
  - Electronic mail.
  - File transfer.
  - Interactive messages.
  - Limited remote command execution.
  - No remote: logon, procedure calls, file access etc.

What is BITNET

- Implementation
  - Based on IBM's VNET.
  - Store and forward computer-to-computer links.
  - Uses IBM's RSCS protocols (network & transport layers).
  - Bisynchronous Communications (BSC) protocol (link layer).
  - Point-to-point leased (i.e. not dial up) voice lines driven by 9600bps modems (physical layer).



What is BITNET

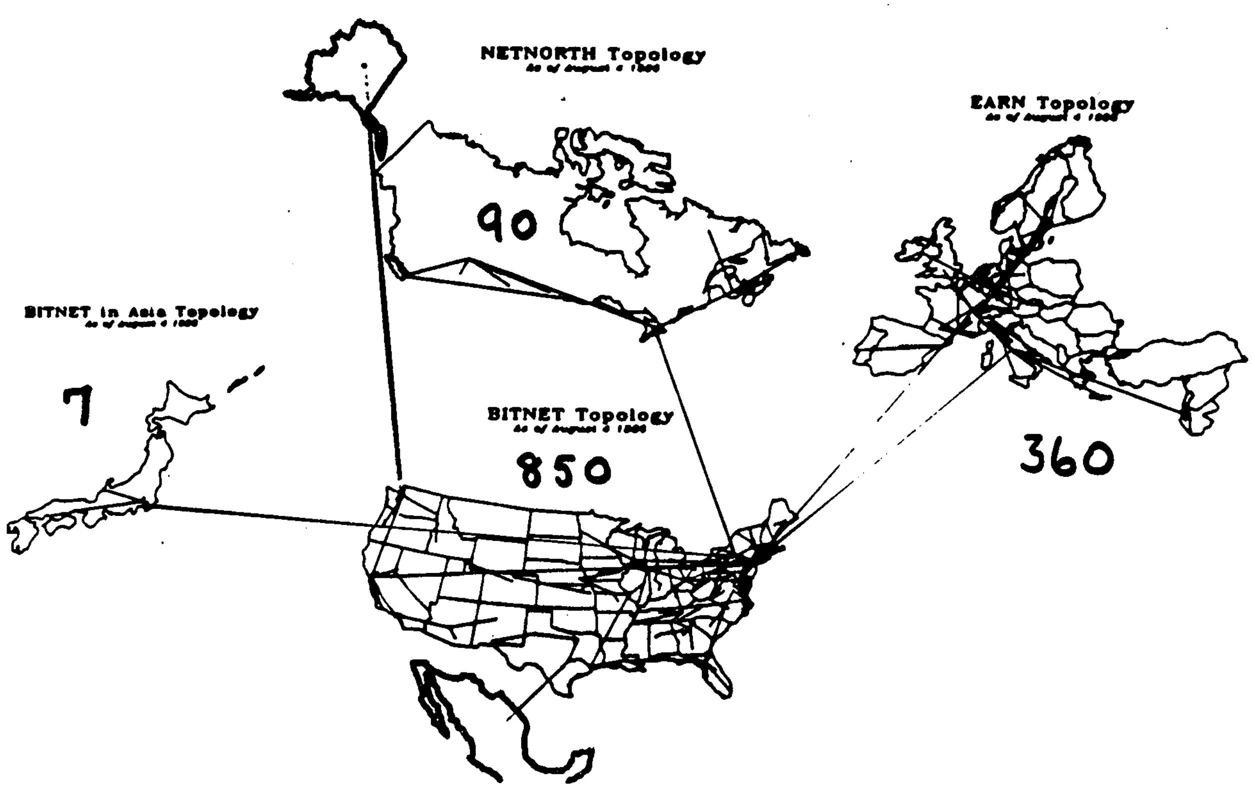
- Costs.
  - Each institution pays for its own connection to the network:

leased line	$200-800/month
modems	$3,000 one time
software licenses	
disk, storage, cpu cycles etc.	

  - Provide facilities for at least one new member to connect.
  - Handle pass-thru traffic without charge.

Where is BITNET?

- There are 4 major components to BITNET:
  - BITNET in U.S.
  - BITNET in Asia.
  - EARN (European Academic Research Network) in Europe & Israel.
  - NetNorth in Canada.
- These appear as a single network to the user, the separations are only administrative.
- Covers:
  - 43 U.S. states.
  - 21 Countries.
  - > 1300 nodes.
  - > 440 sites.
  - Largest number of hops between nodes = 21 (Texas to France).
  - Average number of hops between sites = 8.9.

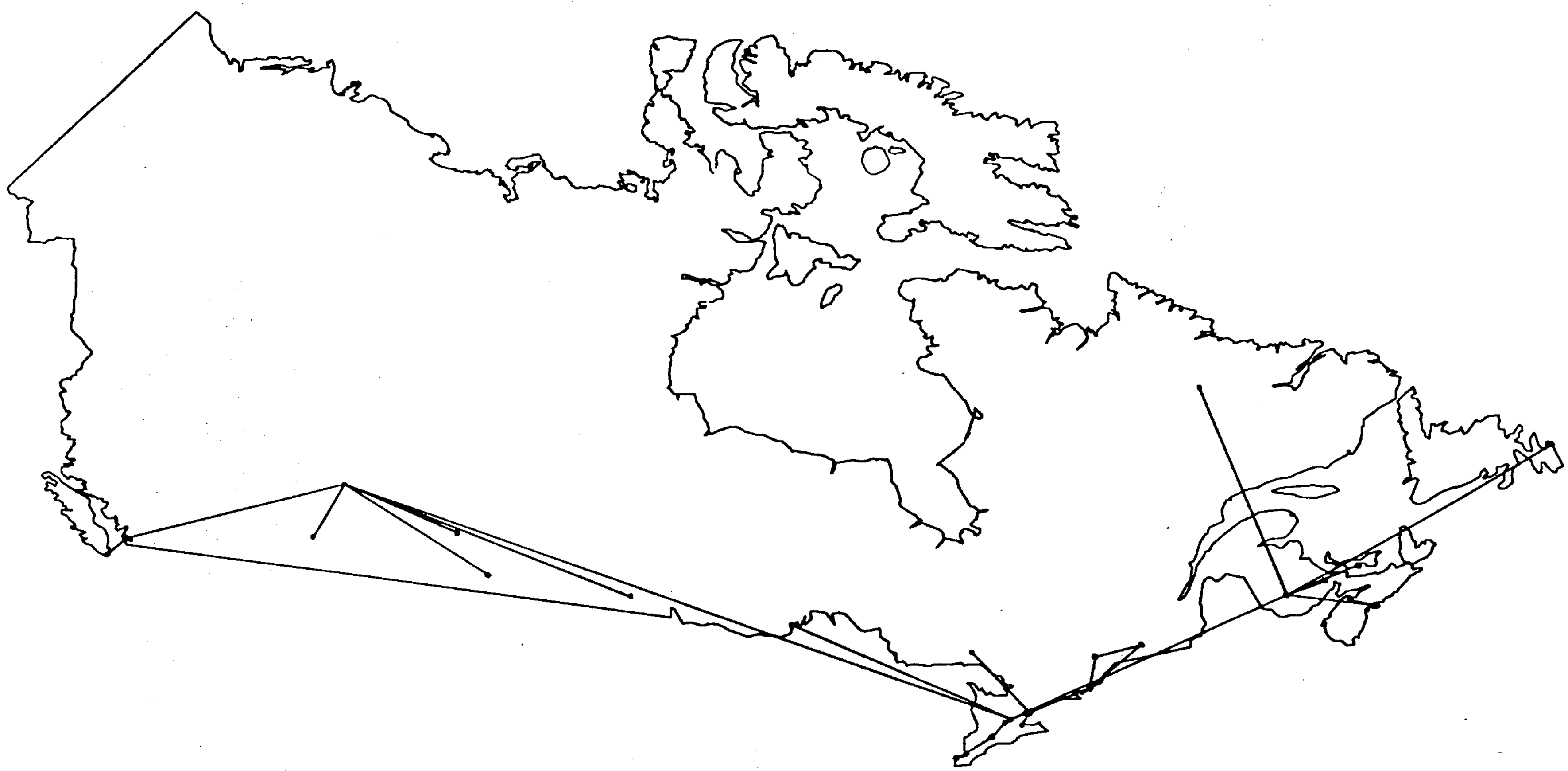


EARN Topology

As of August 4 1986

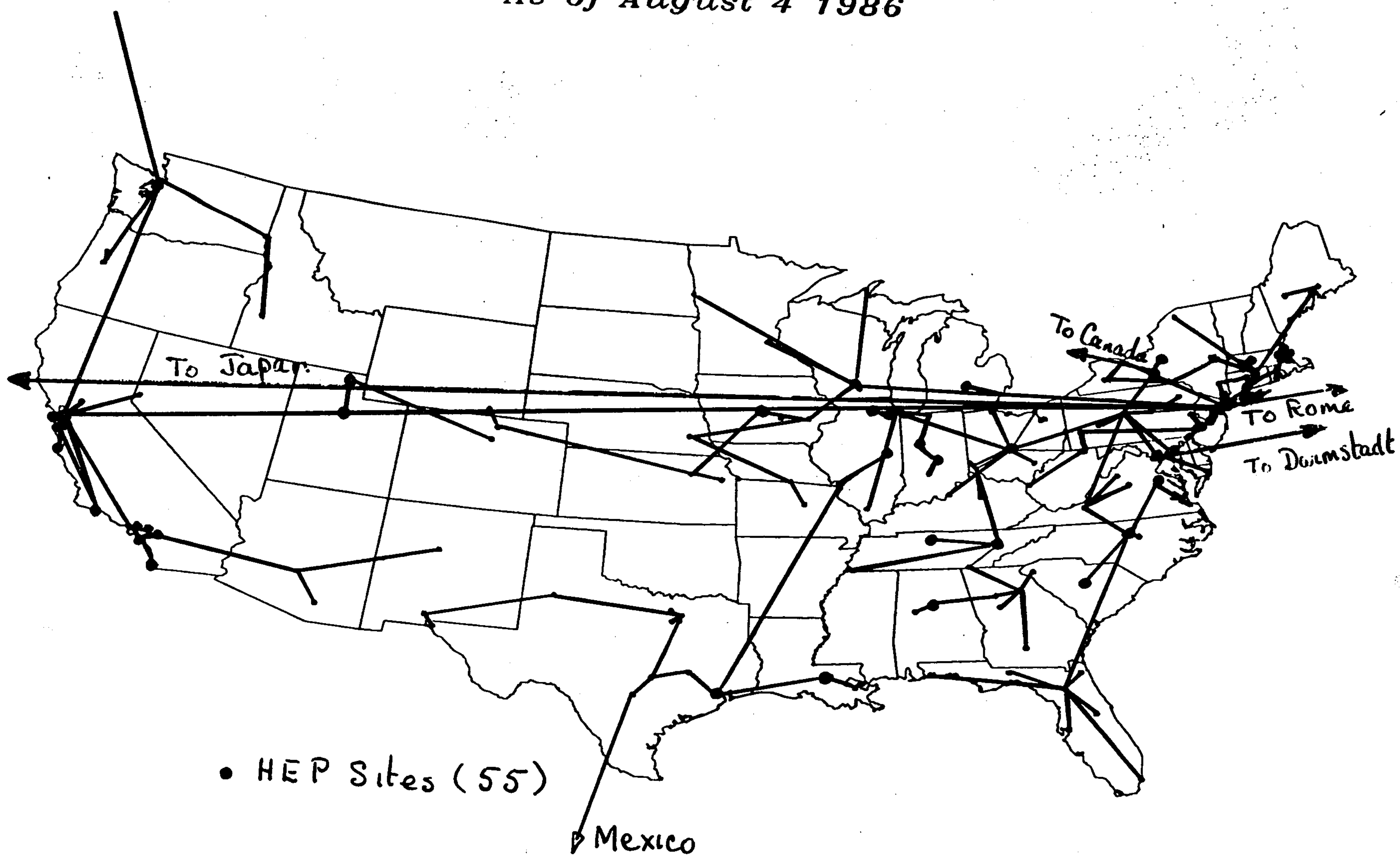
NETNORTH Topology

As of August 4 1986



BITNET Topology

As of August 4 1986



History of BITNET

1981 May 5, CUNY-Yale link.
Starts to grow (like crabgrass), Penn State emulates RSCS on UNIX

1982 Golden Spike connecting West coast (UCB-CUNY)
1st Systems programmers mtg to organize technical details
VAX/VMS emulation of RSCS from Craig Watkins of Penn State

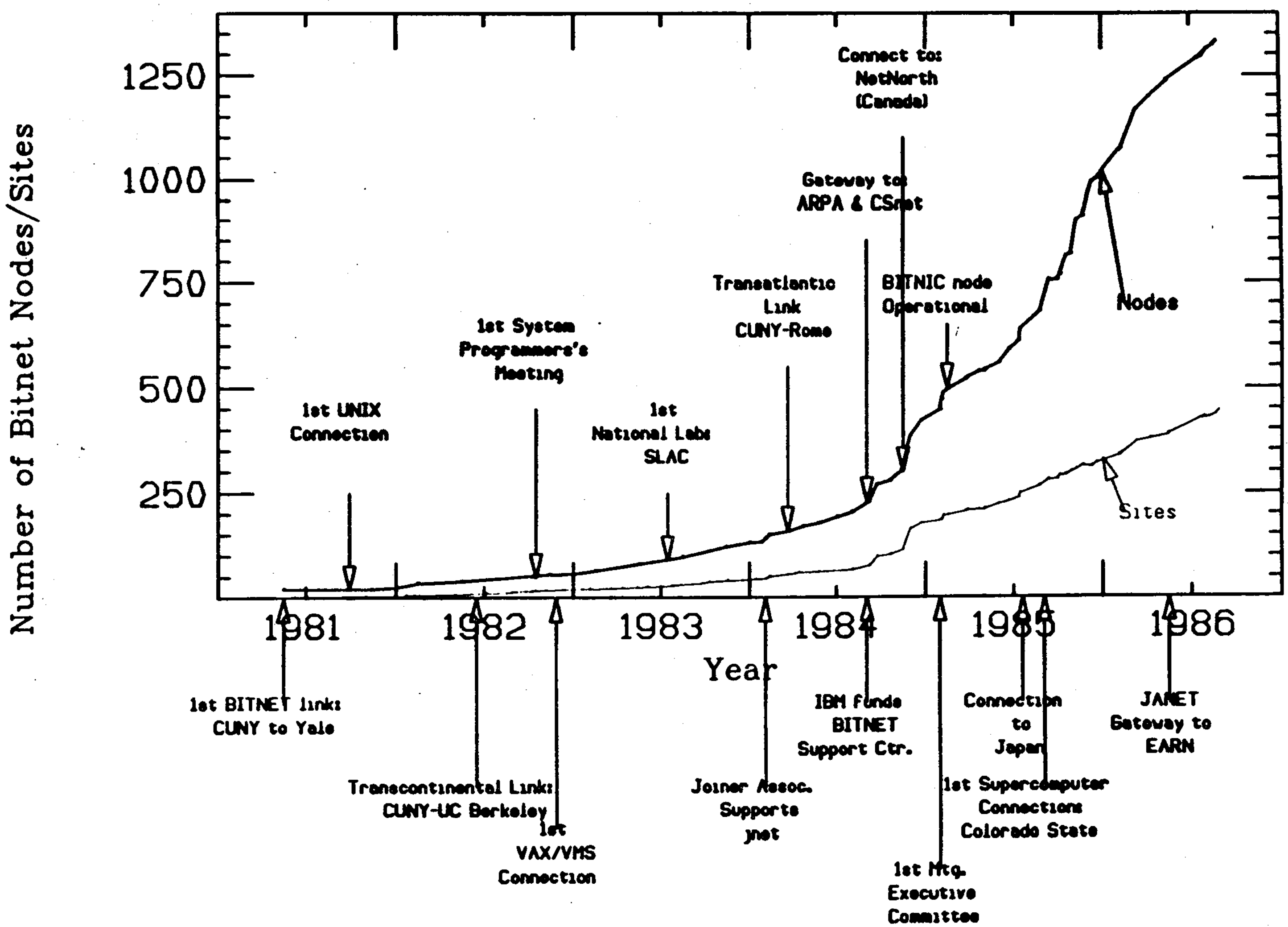
1983 1st National lab (SLAC) joins BITNET.

1984 Transatlantic link (CUNY-Rome)
Gateway to ARPAnet and CSnet.
EARN hubs get connected up.
IBM funds BITNET network support center (BITDOC & BITNIC)

1985 Executive Committee formed ($\geq$ 4 nodes)
BITNIC node operational
Japan Connected

1986 Creation of new BITNET charter & Fees
Prepare for end of IBM BITNIC grant

BITNET Timeline & Growth Chart



Using BITNET on VM and VMS

Mail:

VM : NOTE COTTRELL AT SLACVM

VMS MAIL

MAIL> SEND

To: BITNET%"COTTRELL@SLACVM"

Subj:

File Transfer:

VM : SENDFILE filename filetype TO userid AT node

VMS SEND/FILE filespec userid@node

n.b. One can only SEND files unless there is a server at the remote end. On large open networks this may be a useful security feature

Interactive Messages:

VM : TELL SCOTTY AT STARSHIP Beam me up.

VMS SEND WELLS@FARGO Did the mail get through?

Remote Commands:

VM : SMSG RSCS CMD node CPQ USER userid

VMS SEND/COMMAND node "CPQ TIME"

Can also interrogate a remote node to find out about: the LOGon message; logged on users; the load on the system; the queues on the links; the state of the links; routing tables etc.

Using BITNET

Servers:

- There are many servers on BITNET that provide:
  - Access to files of general interest, documentation, newsletters, e.g.
    TELL NICSERVE AT BITNIC SEND BITNET TOPOLOGY
    TELL NICSERVE AT BITNIC LIST
  - Access to directories and databases, e.g.
    TELL QSPIRES AT SLACVM WHOIS LES COTTRELL
    TELL NETSERV AT CEARN UDS FIND :NAME OLIVIER MARTIN
  - Conferencing: Mail list servers for exploding mail, e.g.
    NOTE LIAISON at BITNIC
    NOTE IBM7171 at TCSVM
  - Message relays (computerized Citizen's Band Radio)
  - Gateways to other networks, e.g.
    NOTE JOHNDOE AT LBL.ARPA
    NOTE COTTRELL AT E.MFE

BITNET USAGE

- Volume:

Site	Mbytes/day	<Baud-Rate>	Files/Day	US to Europe
CERN	50	6000	3000	27%
SLAC	16	1500	1000	25%
FNAL	2	200	100	23%

  - Equivalent Tymnet cost for SLAC would be ≈ $500/day.

- Gateways allow mail exchange with > 20,000 nodes, on >15 networks
  - ARPANET, CSNET, UUCP, MFENET, etc.
  - 6% of the files sent from SLAC go thru Gateways

ARPAnet:	2%
PHYSnet, Stanford, INFNet:	1%each

- Traffic Types (measured at SLAC)
  - Sent:Received = 60:40
  - 30% Mail, cost/mail item sent = $0.12

- Usage by Groups of Users at SLAC:

Experimental Physics	50%	Computer Sciences	11%
Computer Services	16%	Theoretical Physics	7.5%
Librarians	12%	Elec. Engineers	4%

- At SLAC > 40% of the 1300 users who logon in 1 month use BITNET

BITNET Usage

- Types of Computers on BITNET:
  - >1400 computers.
  - >120 models.
  - >27 manufacturers.
  - >28 operating systems.

Oper. Sys	Number	%
VM/SP	531	36%
VMS	509	35%
UNIX	184	13%
MVS	106	7%
NOS	53	4%

Manufacturer	Number
DEC	678 (664 VAX)
IBM	576 (645 IBM compatible)
CDC	57
Amdahl	25
Siemans	21

BITNET Future

- Centralized Management
  - IBM funding for BITNET support ctr. ends Dec 31 1986.
  - New Charter.
  - Executive Committee Elected.
  - Centralized support.
  - Fees.

Annual Budget Range	Annual Membership fee
Above $500M	$8,000
$420M to $500M	$7,000
$350M to $420M	$6,000
$280M to $350M	$5,000
$200M to $280M	$4,000
$130M to $200M	$3,000
$55M to $130M	$2,000
$20M to $55M	$1,000
Under $20M	$750

- Backbone (IBM funding of international links ends Dec. 1987).
- Migration to newer OSI standards, X.25, X.400 (mail).
- Continued growth:
  - Hawaii, South America.
  - Turkey, Iceland.
  - GulfNet (Saudi Arabia & Kuwait).

Summary

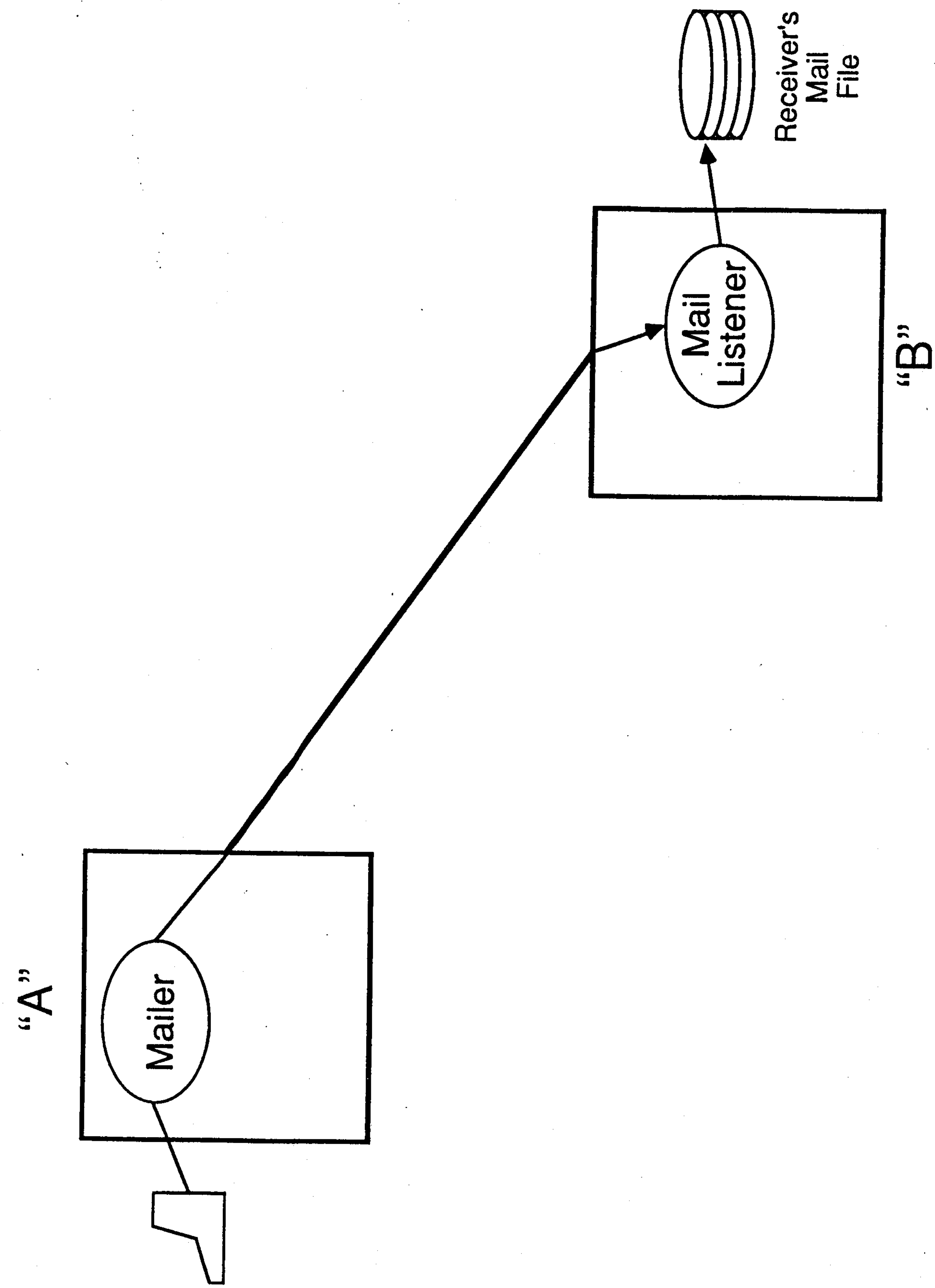
- BITNET is already a required tool for a large number of academics from numerous disciplines. The need for networking will not go away, it will evolve and grow.

VAN JACOBSON, STAFF SCIENTIST

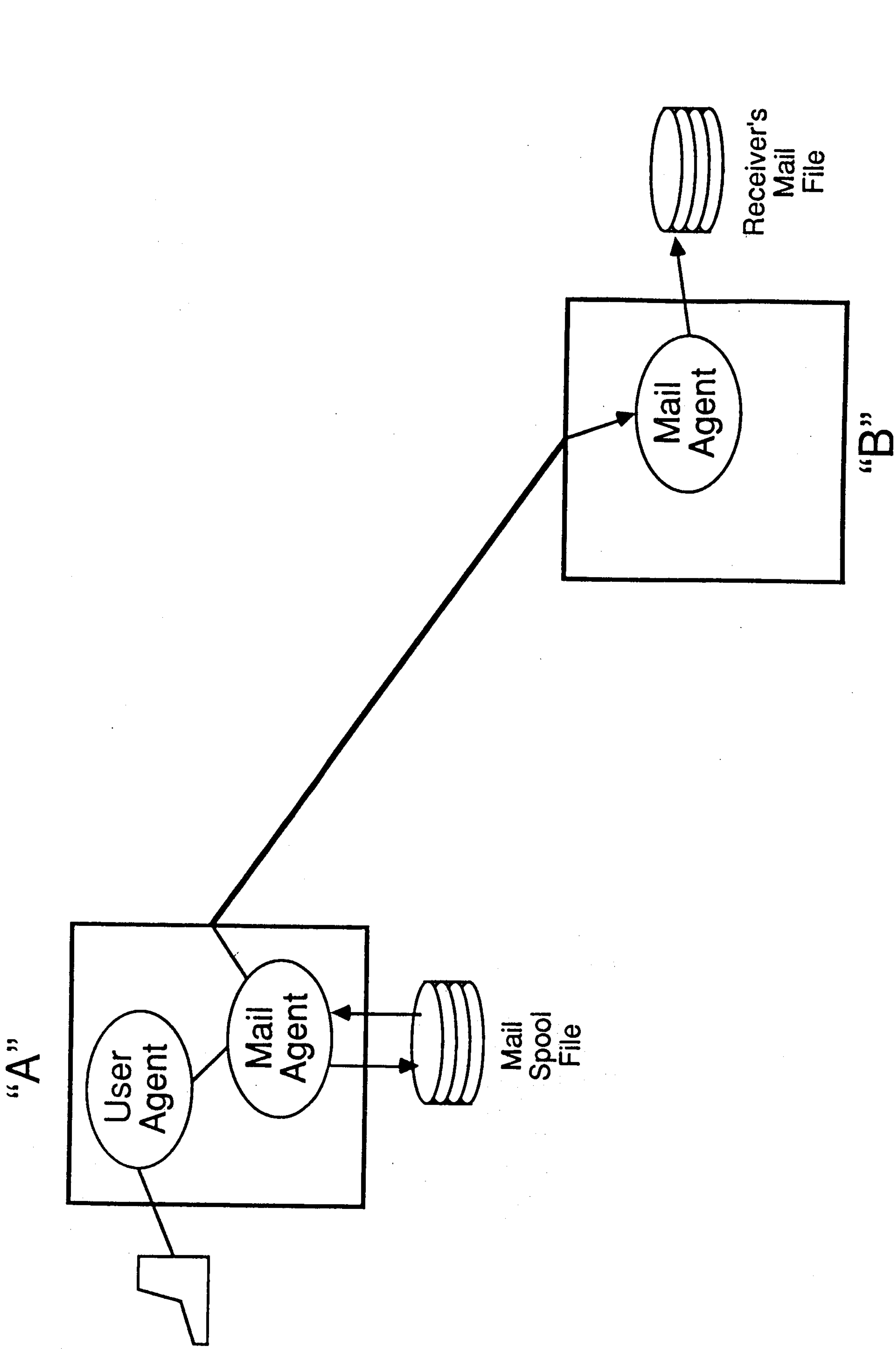
ENGINEERING DIVISION

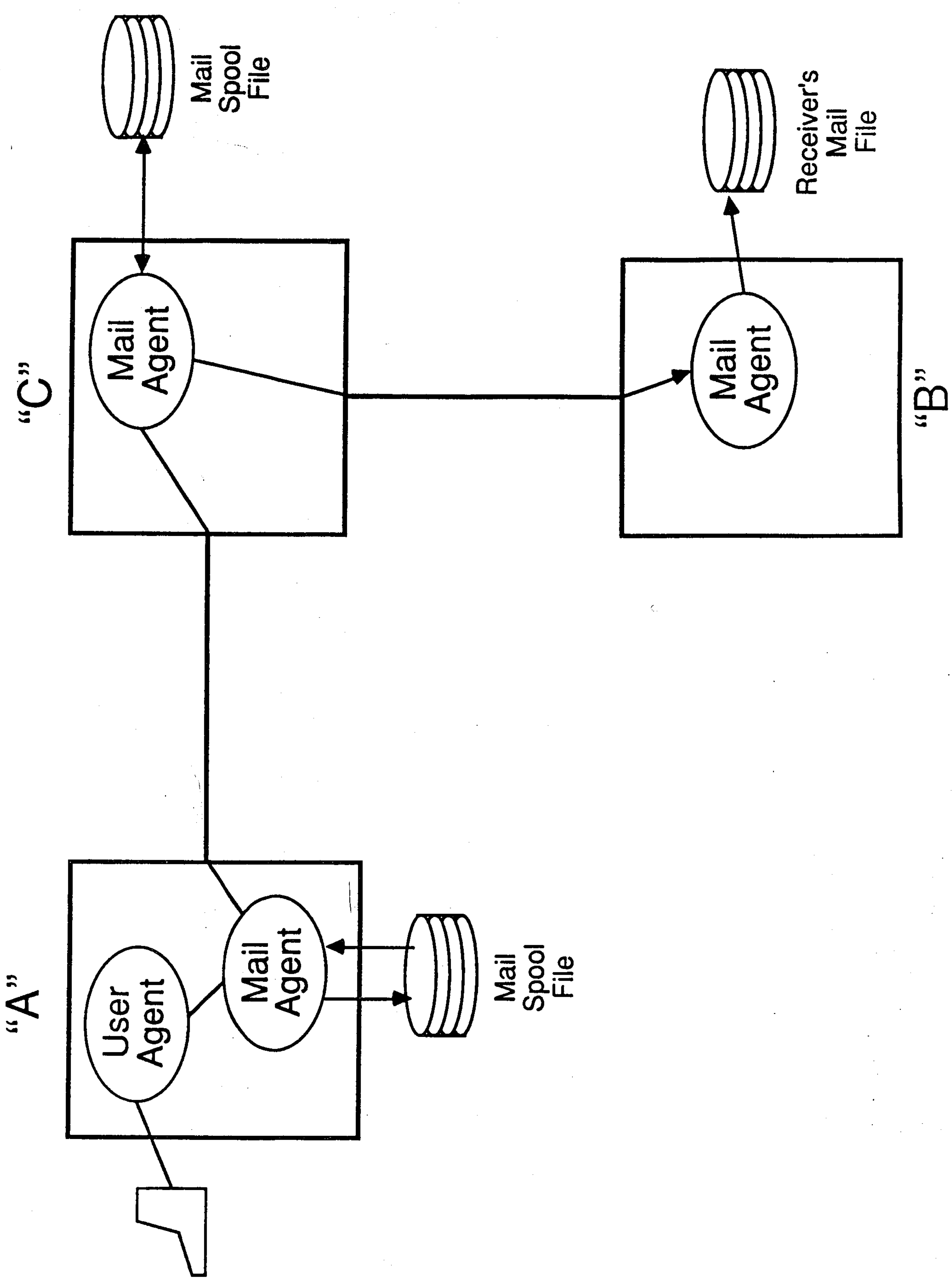
LAWRENCE BERKELEY LABORATORY

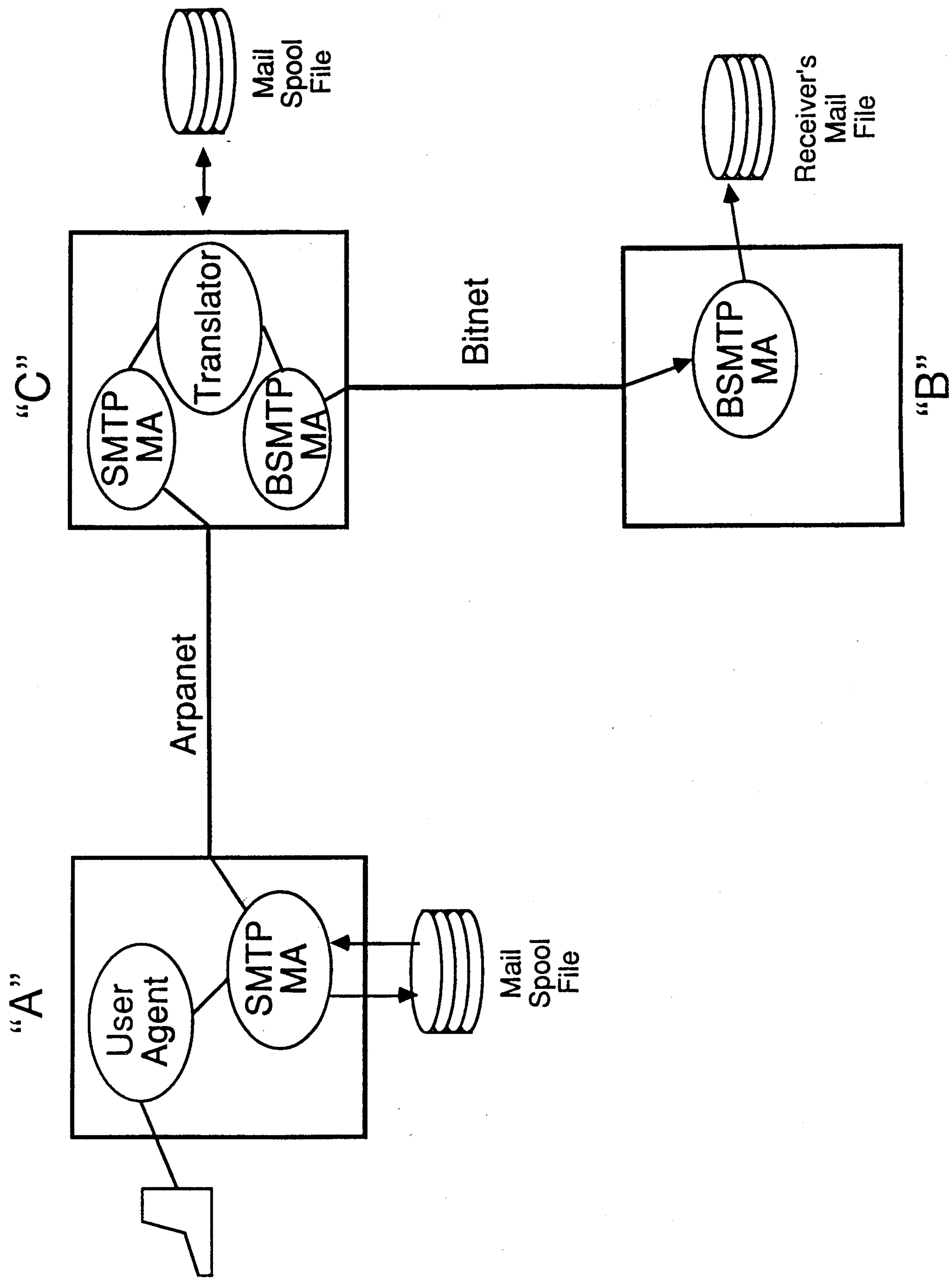
TITLE: ELECTRONIC MAIL



"A"
Mailer
"B"
Mail Listener
Receiver's Mail File


"A"
User Agent
Mail Agent
Mail Spool File
"B"
Mail Agent
Receiver's Mail File


"A"
User Agent
Mail Agent
Mail Spool File
"C"
Mail Agent
Mail Spool File
"B"
Mail Agent
Receiver's Mail File


"C"
SMTP MA
Translator
BSMTP MA
Mail Spool File
Bitnet
BSMTP MA
Receiver's Mail File
"B"
Arpanet
"A"
User Agent
SMTP MA
Mail Spool File

Variations

Protocols

- DEC Mail
- UUCP
- SMTP (Internet)
- BSMTP (Bitnet)
- X.411 (JANET, ISO/CCITT)

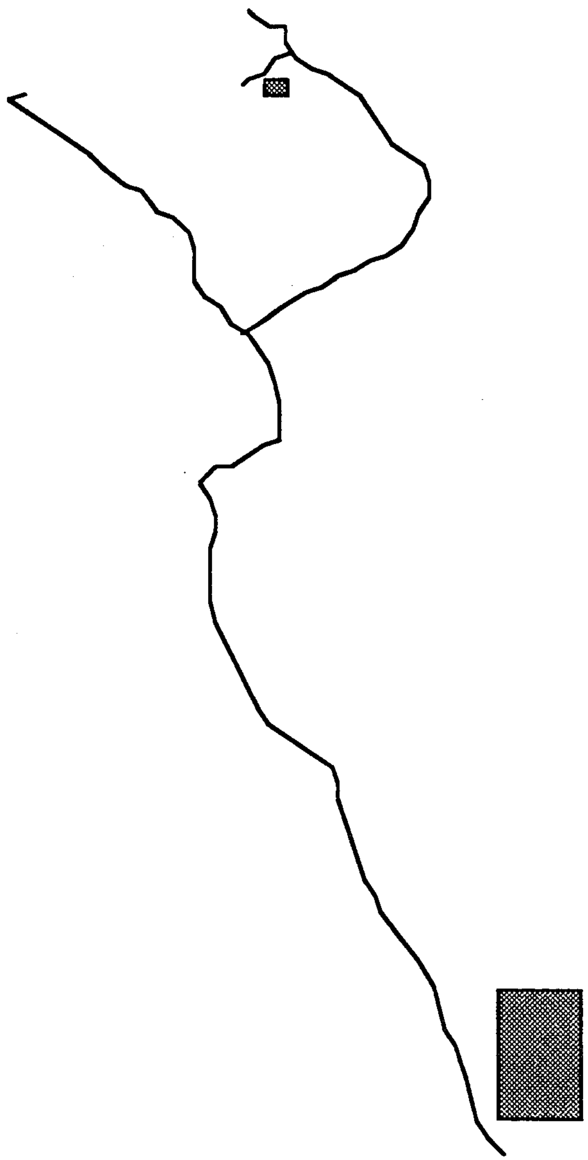
Message Formats

- DEC Mail
- UUCP
- RFC-822 (Internet)
- X.409 (JANET, ISO/CCITT)

Addresses

Internet:	van@lbl-vs.arpa
HEPNET:	rtsgvx::"van@lbl-vs"
BITNET:	van%lbl-vs.arpa@wiscvm
CSNET:	van%lbl-vs.arpa@relay.cs.net
UUCP:	inhp4!ucbvax!van@lbl-vs.arpa
JANET:	van%lbl-vs.arpa@uk.ac.ucl.cs

Domains: van@rtsg.lbl.doe.gov



Route: Have to know where you are, where you're going and everything in between.

Address: Have to know where you are and where you're going.

Name: Have to know where you're going.

The ISO / CCITT Standard (X.400)

INRIA	gb/bt/des/sventek(ucl/cs)
JANET/987	/C=GB/ADMD=BT/PRMD=DES/O=UCL/OU=CS/G=Sventek/
COSAC	<C=gb:A=bt:P=des;O=ucl;G=Sventek;OU=cs>
DFN	sventek!ucl!cs&des%bt&gb
EARN	sventek!ucl!cs#des&bt.gb

Future LAN Technology

28 October 1986

Robert L Fink

Office of Computing Resources
Information & Computing Sciences Division
Lawrence Berkeley Laboratory

New LAN Technology

- Fiber Optics
- Rings

FDDI

Fiber Distributed Data Interface

Pressures for a new I/O Interface Standard

- Technological Advances
- Higher Data Rates Needed
- Physical Size and Cost
- Open Systems Interconnection

Where Does FDDI Come From

- ANSC X3T9 Technical Committee for I/O Interfacing

    Storage Module Drive Interface
    Floppy Disk Drive Interface
    SCSI Interface
    IPI Interface

- X3T9.5 Task Group for LANs Over 50 M Bits per Second

FDDI

What is it?

- Fiber Optic Based Transmission Media
- Counter Rotating Ring Topology
- Distributed Token Access
- 100 M Bits per Second

Why a Ring for FDDI

- High Data Rates Achievable
- High Medium Utilization Realizable
- Minimum Arbitration Time
- Large Physical Extents Feasible
- Large Number of Stations Feasible
- Easy Allocation of Bandwidth
- Ease of Reconfiguration
- Failing Stations and Links Isolatable
- Simplicity of Point-to-Point Connections

FDDI Characteristics

- 100 M Bits per Second
  - Group Coding - 125 MegaBAUD
  - Practical Data Rates >80 M Bits per Second
- LED Based 1300 nm Transmission
- PIN Diode Receviers (APD not excluded)
- Up to 500 Stations per Ring
  - 1000 Connections Points
- Up to 100 km of Duplex Fiber
  - 200 km When Reconfigured
- Up to 2 km of Fiber Between Stations
  - 10 to 200 meters Typical

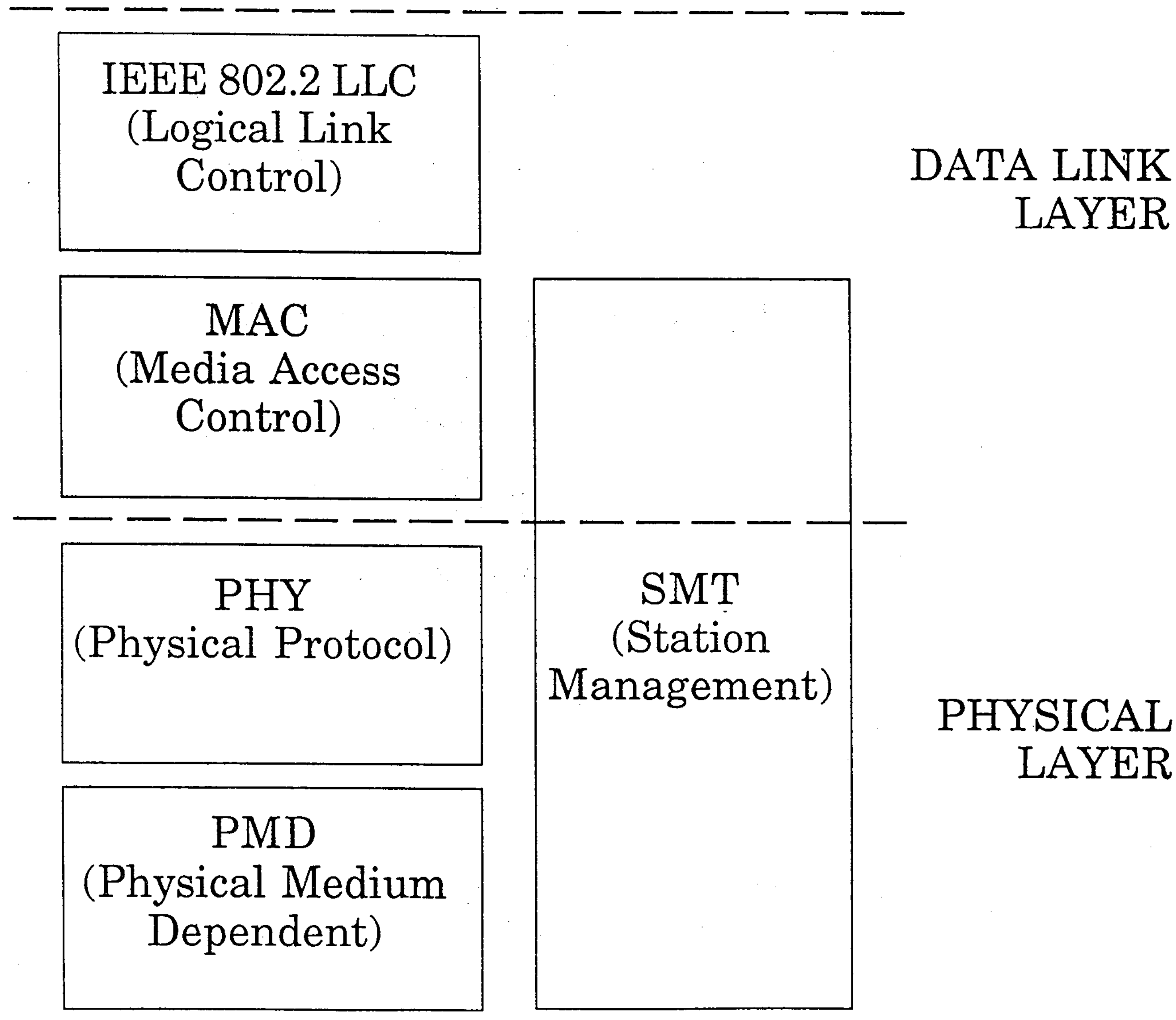
Reliability Features

- Powerful Reconfiguration Capability
- Fault Detection
  - Self-Monitoring of Point-to-Point Connections
  - Station Level Monitoring
- Resilience
  - Optical Station Bypass
  - Counter-Rotating Rings
- Availability
  - Concentrators Isolate Ring Trunk From Local Configuration Changes
  - Distributed Control Concept

FDDI Standards

- SMT - Station Management
- MAC - Media Access Control
- PHY - Physical Layer Protocol
- PMD - Physical Medium Dependent Protocol
- FDDI-II - Circuit Switching Enhancement Of FDDI-I

FDDI and The OSI Model



SMT - Station Management

- Monitors Activity and Exercises Overall Control
  - Initialization
  - Configuration
  - Activation
  - Bandwidth Allocation
  - Error Control
  - Maintenance
  - Performance Monitoring

MAC - Media Access Control

- Controls Access To The Media
  - Transmitting Frames
  - Receiving Frames
  - Timed Token Rotation Protocol
  - Token Control
  - Frame Stripping
  - Claim Token Process for Initialization
  - Frame Check Sequence

PHY - Physical Layer Protocol

- Specifies Control Of Physical Media

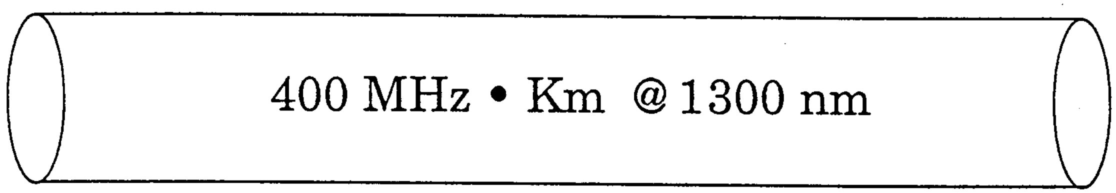
  - Line State Detection
  - Elasticity Buffer Function
  - Establishes Clock Sychronization
  - Decodes Incoming Symbol Stream
  - Defines Coding Of Symbols

PMD - Physical Medium Dependent

- Specifies Electrical and Mechanical Interface To Fiber Optic Media

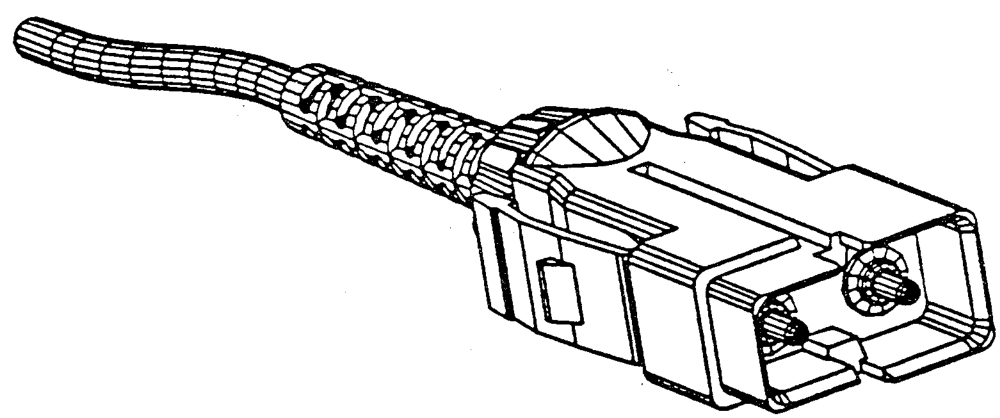
  - Connector Specification (4 keying types)
  - Media Signal Specification (In and Out)
  - Station Bypass Specification (Speed and Loss)
  - FiberPlant Specification (62.5 and 85 um)
  - Testing Methods
  - Alternate Fiber Spec (50 and 100 um)
  - Jitter Tolerance Specification

Fiber Optic Cable Specification

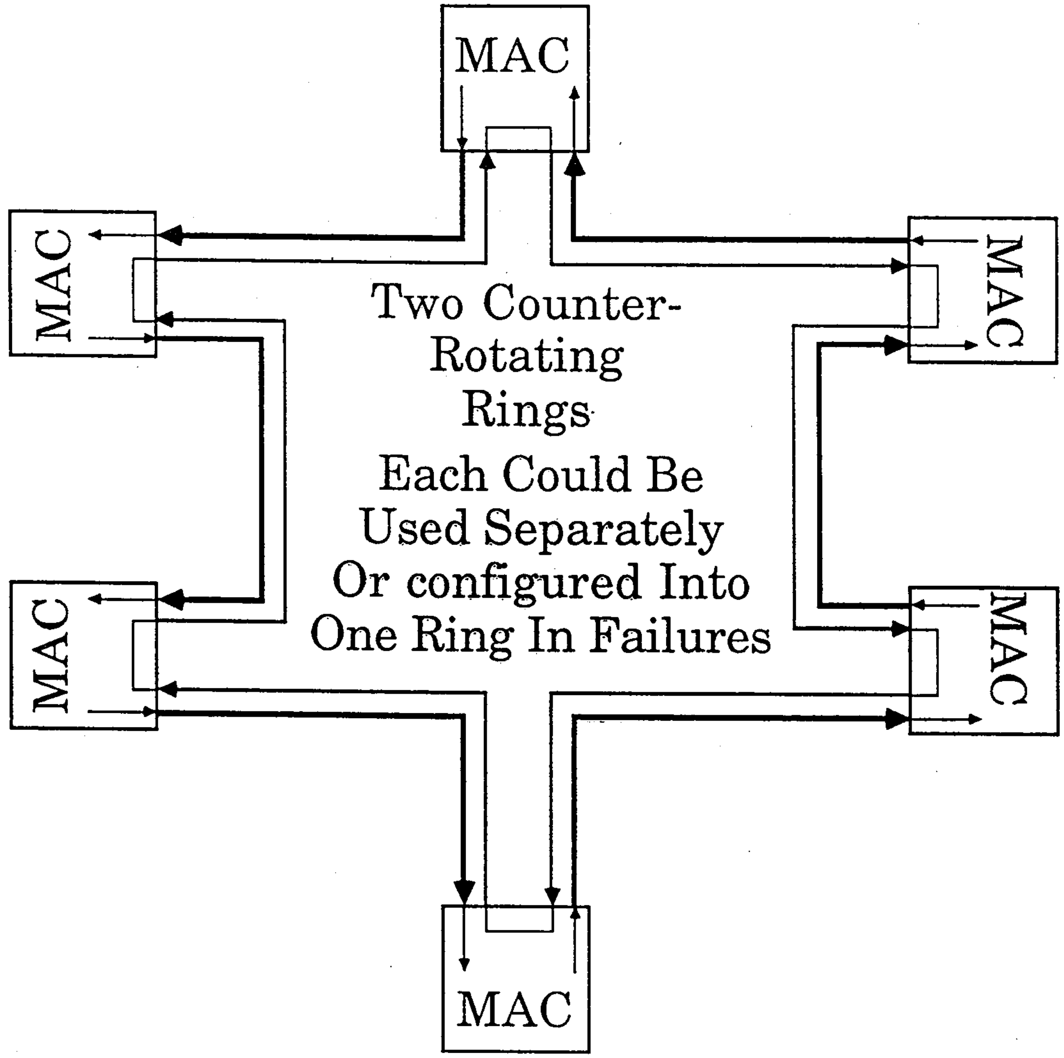


11 dB over all cable,
connectors and splices;
between bulkhead connectors

Example Of FDDI Connector

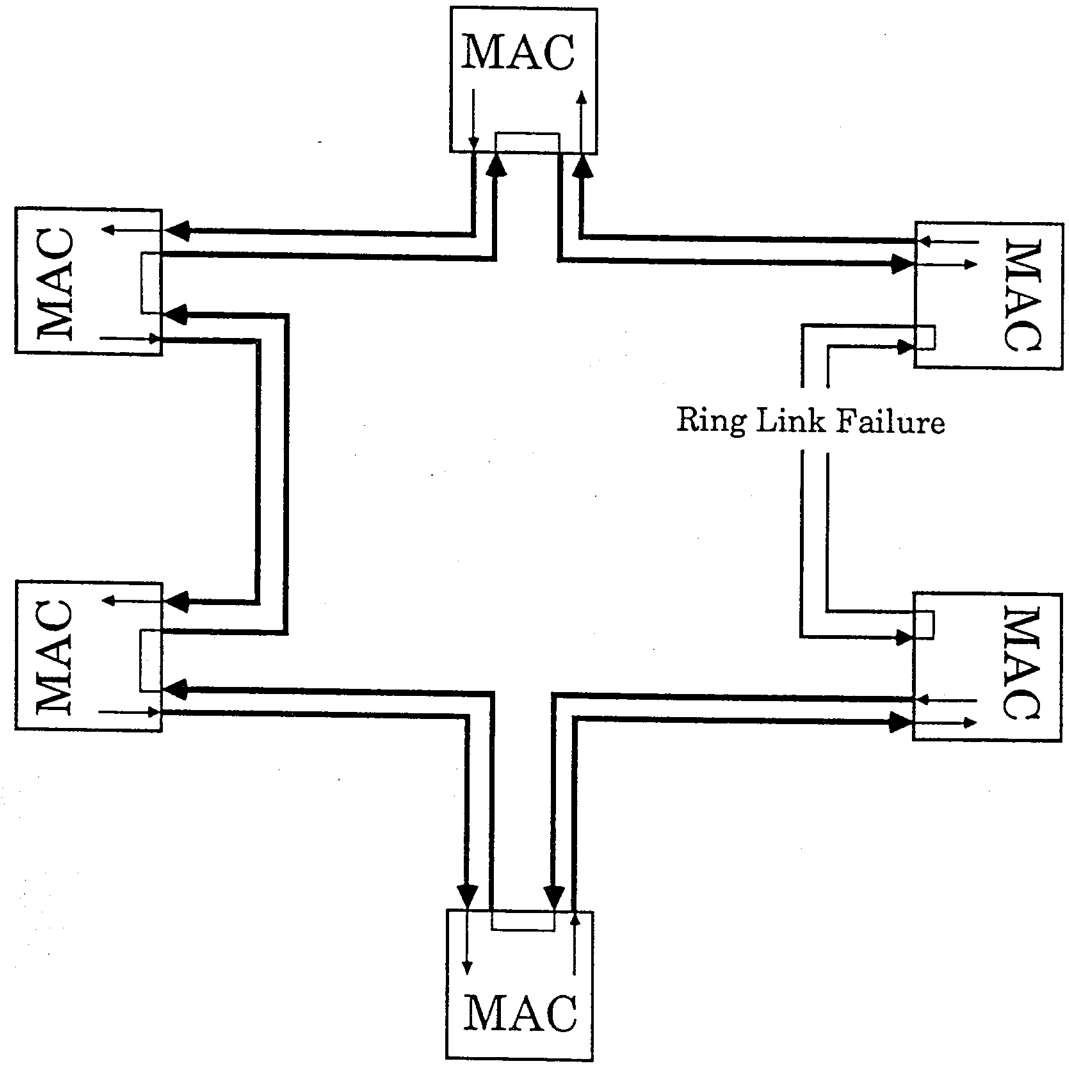


Example Of Class A Stations In A Ring



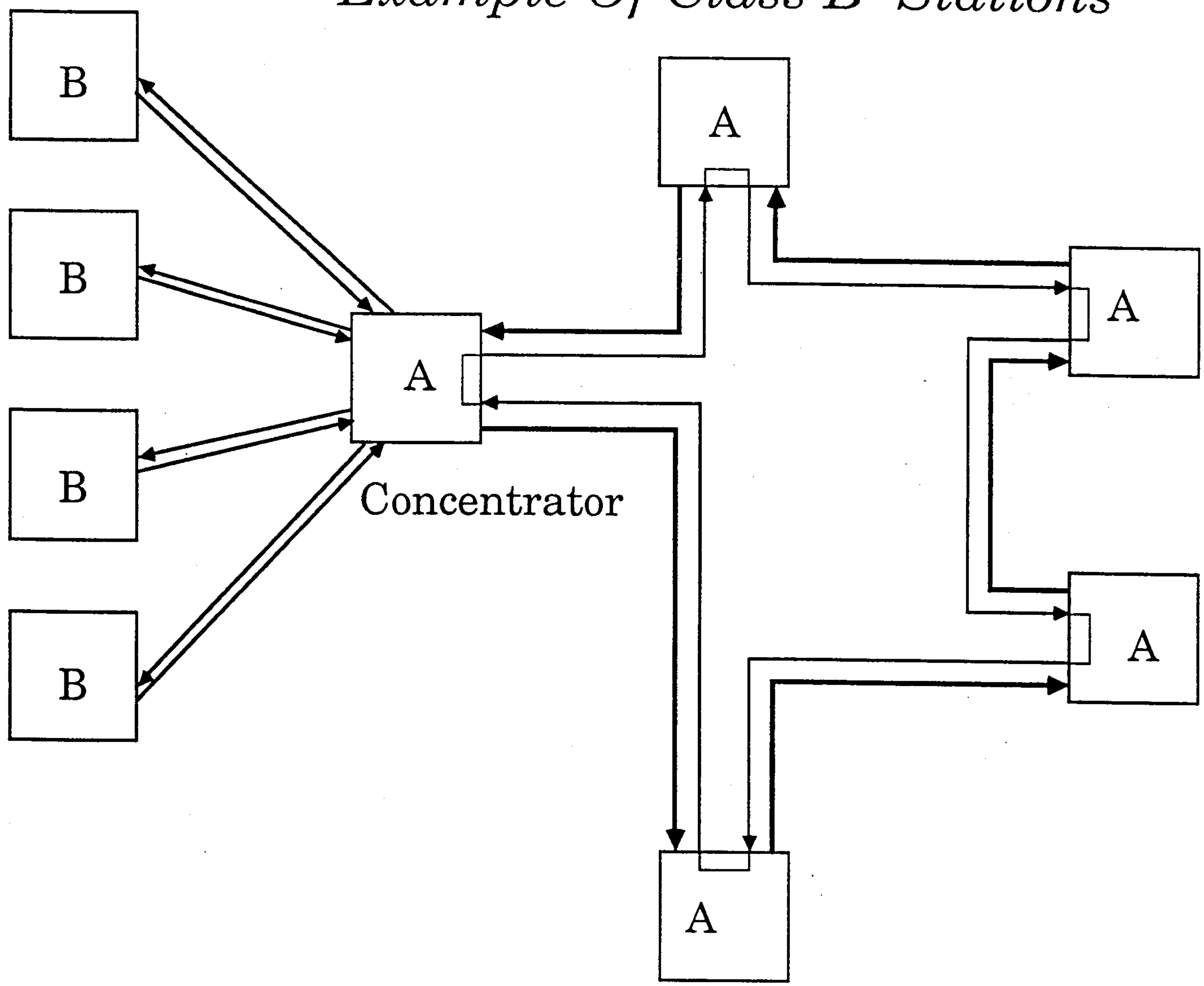
Class A Stations Have Two PHY/PMD Entities and
One or Two MAC Entities

Example Ring Reconfiguration



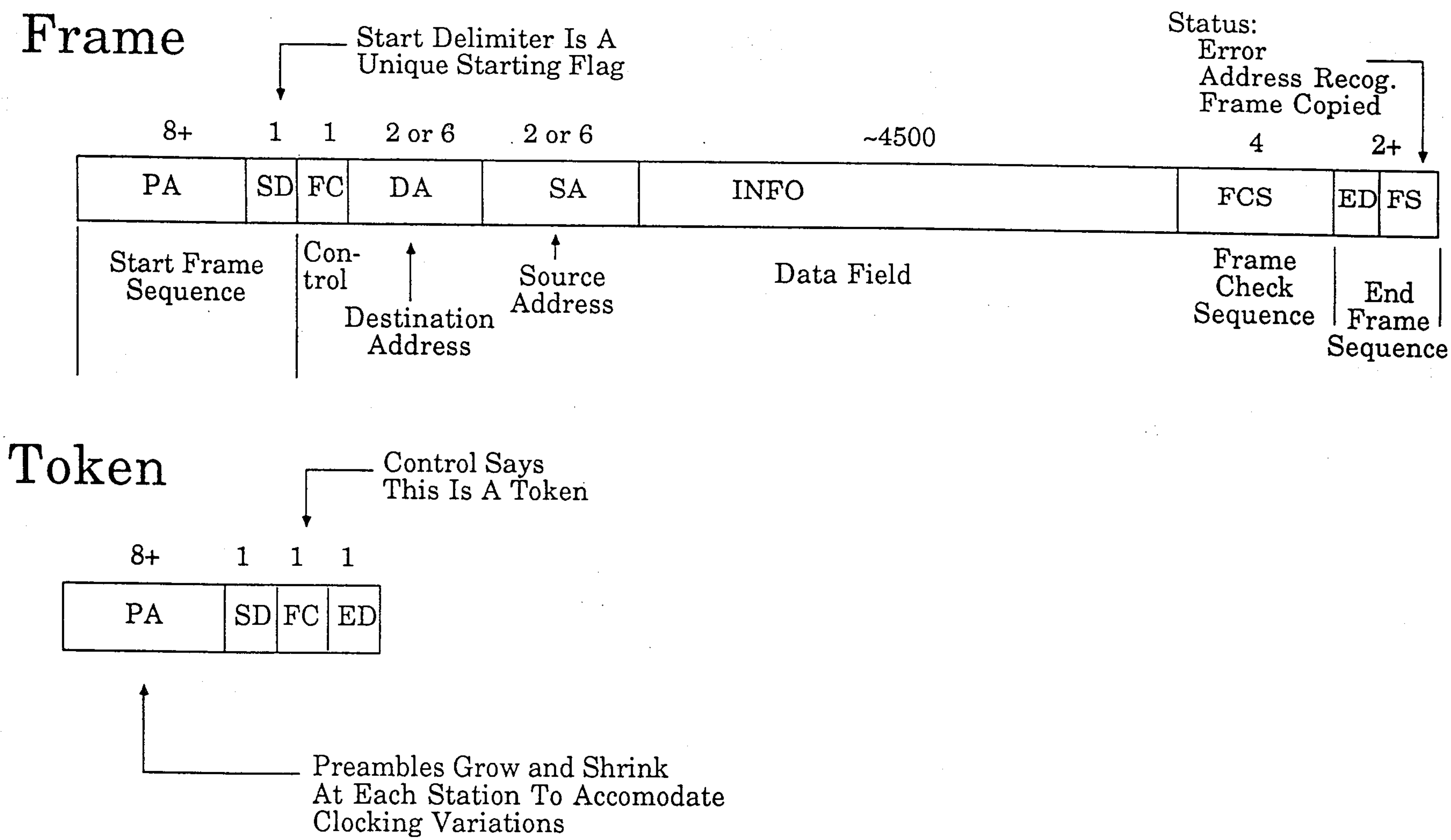
During Optical Link Failure The Bypass Function Can Utilize the Second Ring To Make One Larger Ring

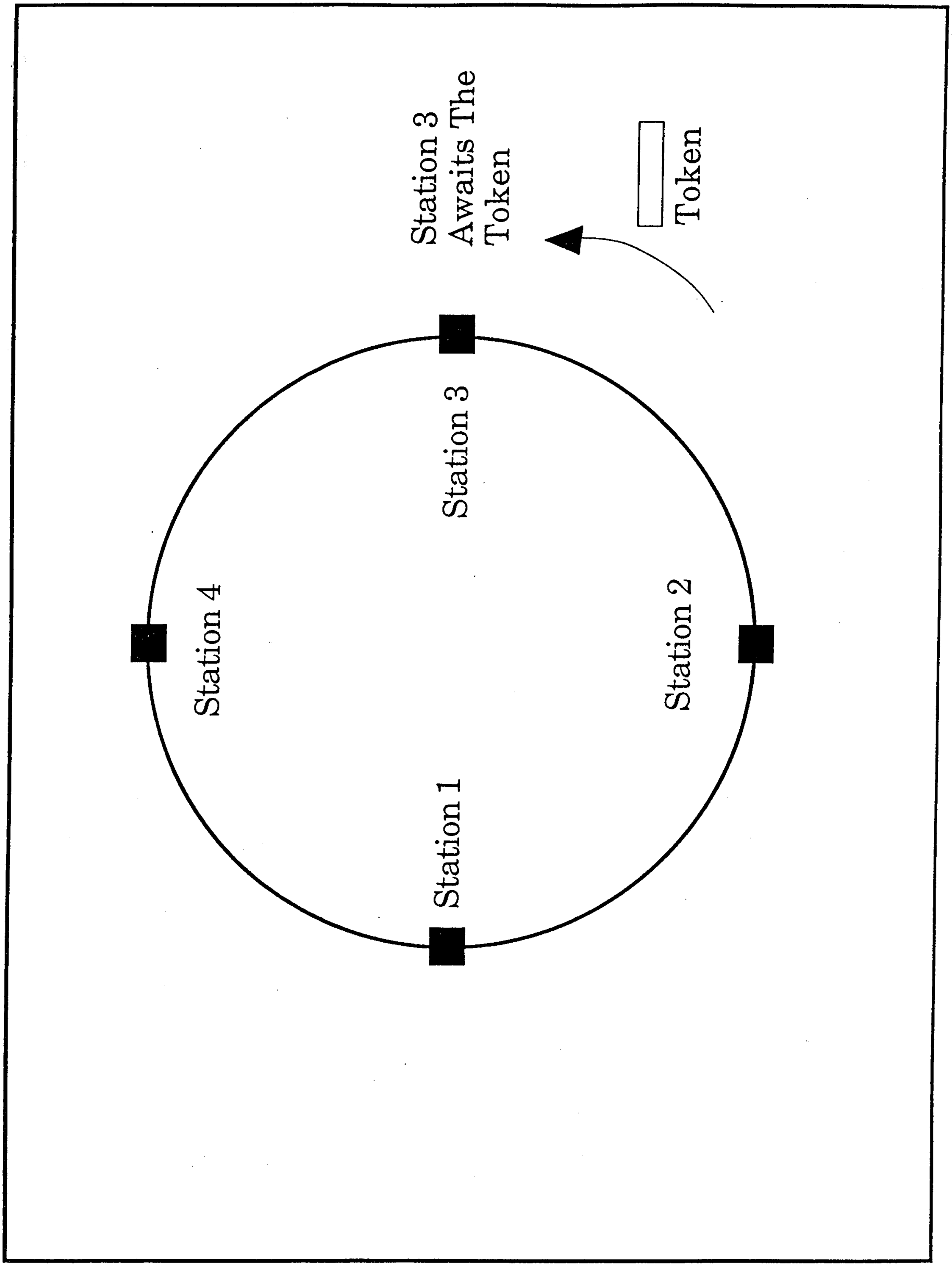
Example Of Class B Stations

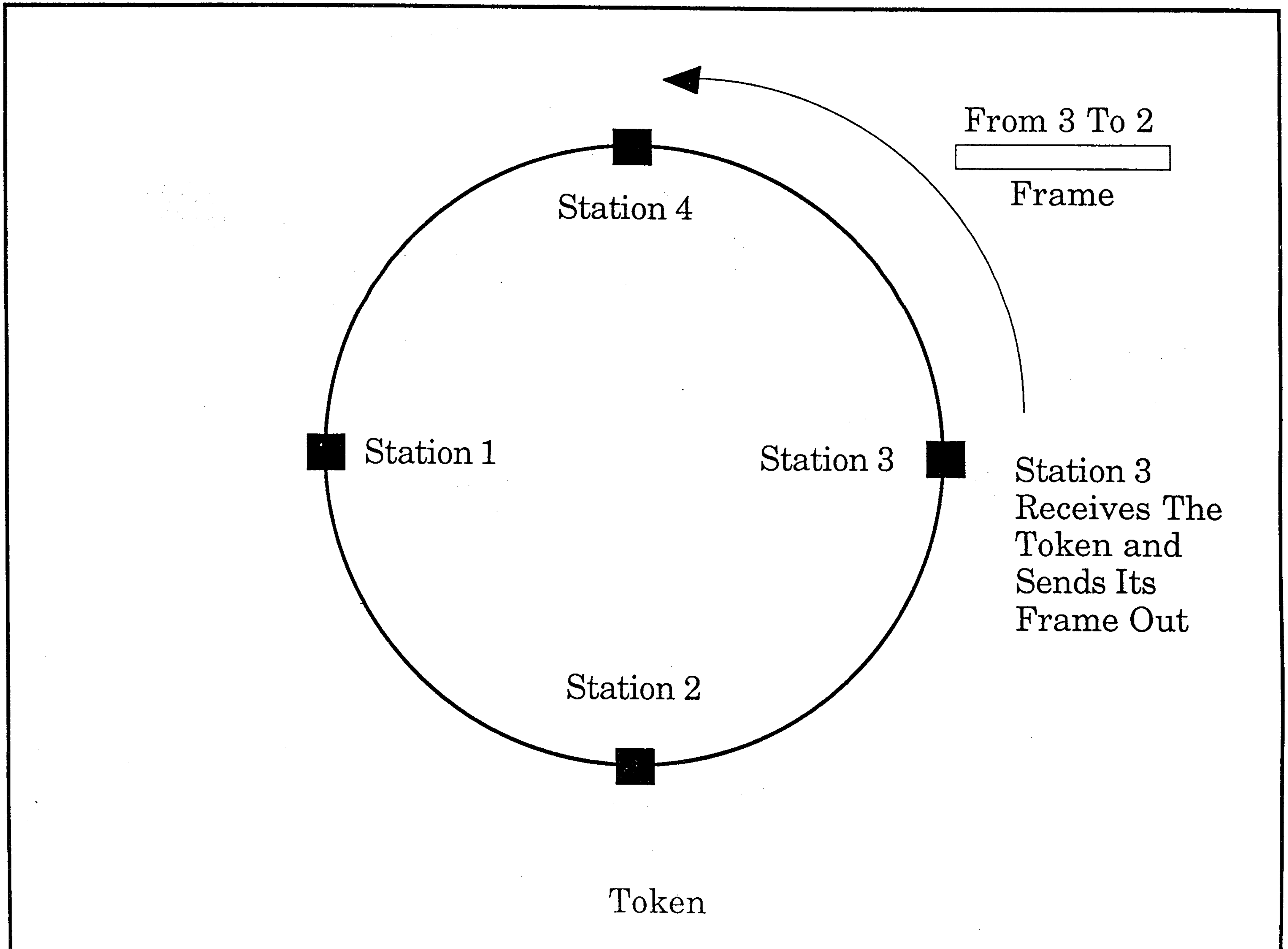


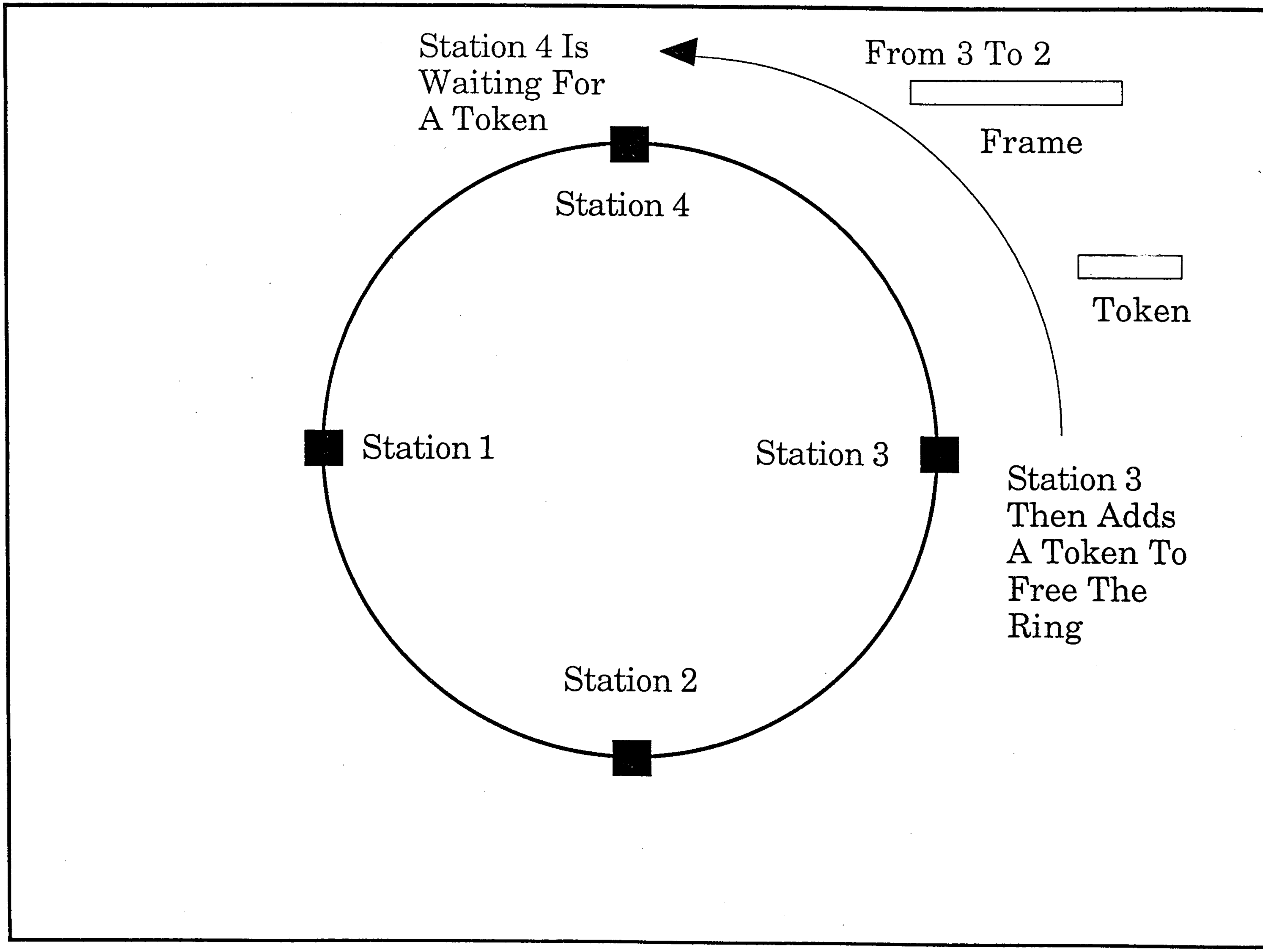
Class B Stations Have Only One PHY and MAC Entity, Can Only Be Attached To The Ring By A Concentrator and Have No Self Reconfigurability

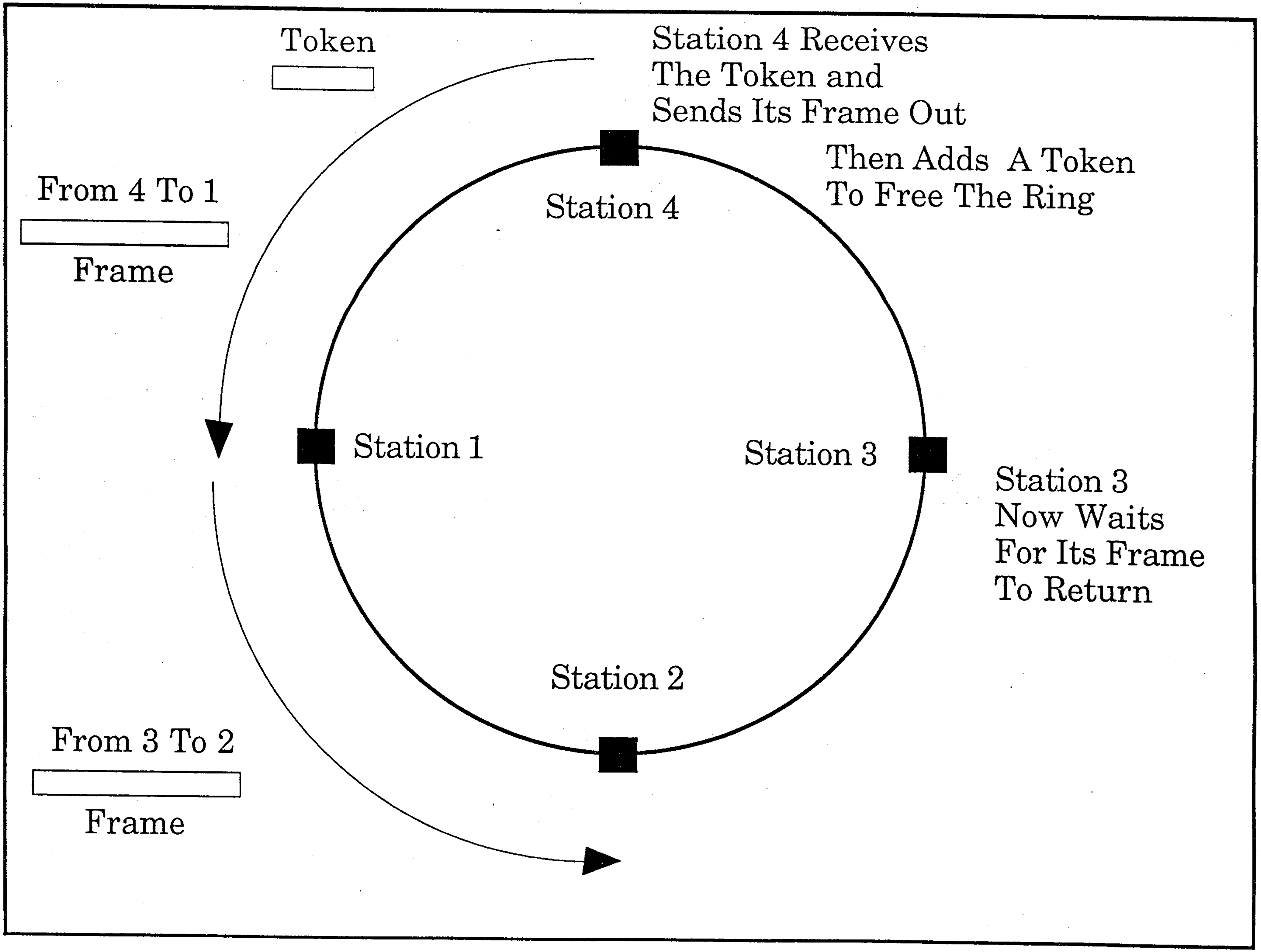
Frame and Token Formats

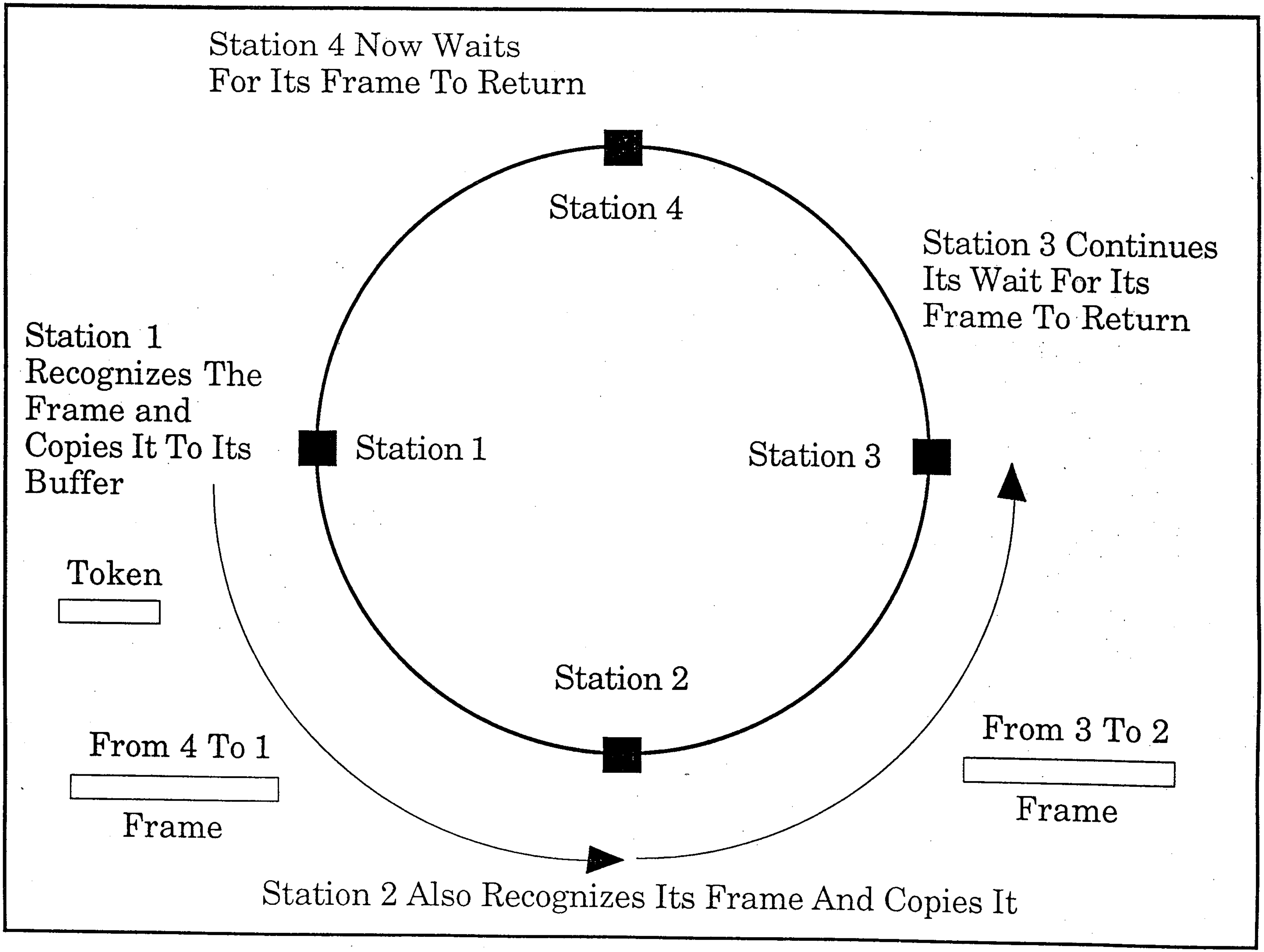



Station 3 Awaits The Token
Token
Station 3
Station 4
Station 2
Station 1

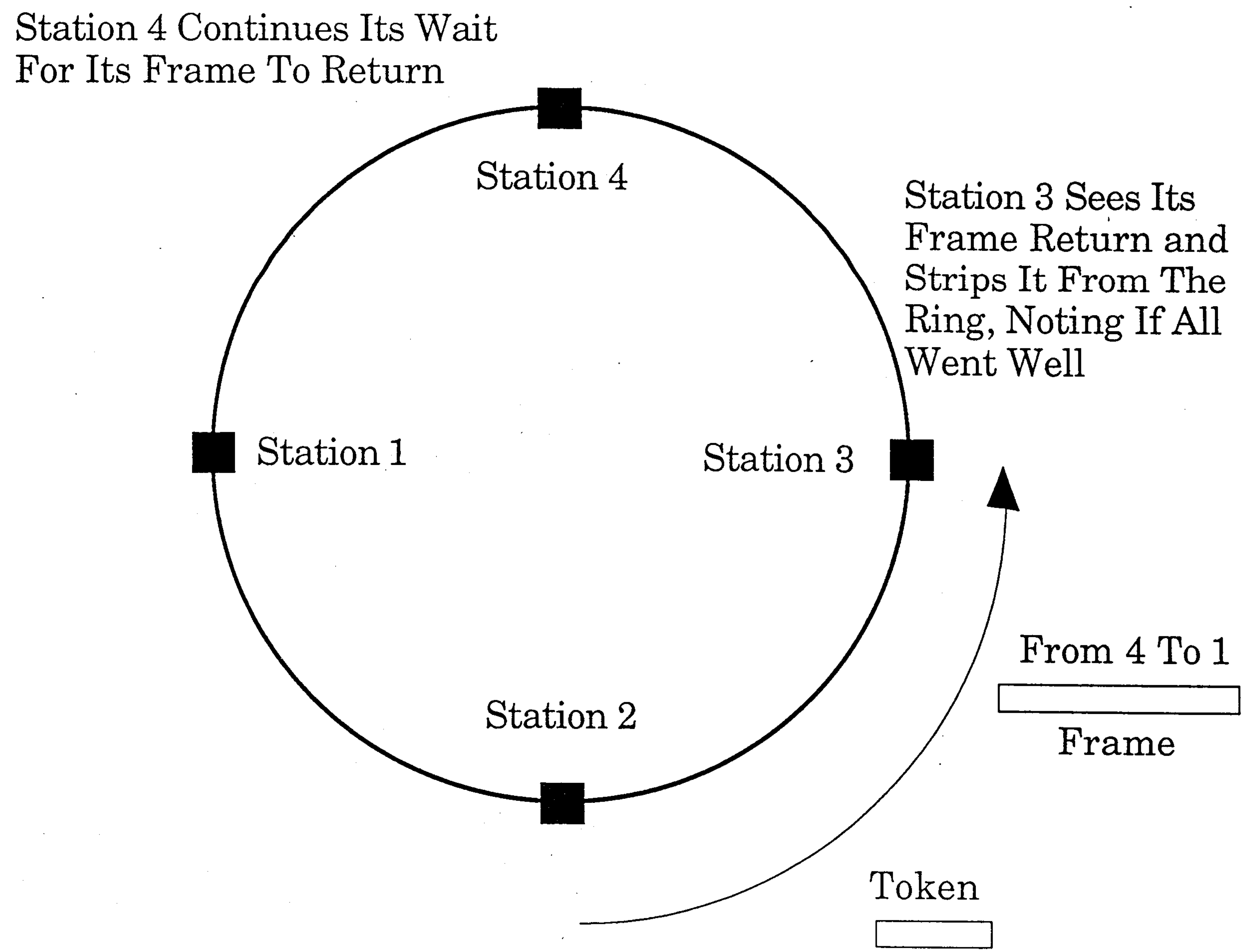

From 3 To 2
Frame
Station 4
Station 1
Station 3
Station 3
Receives The
Token and
Sends Its
Frame Out
Station 2
Token

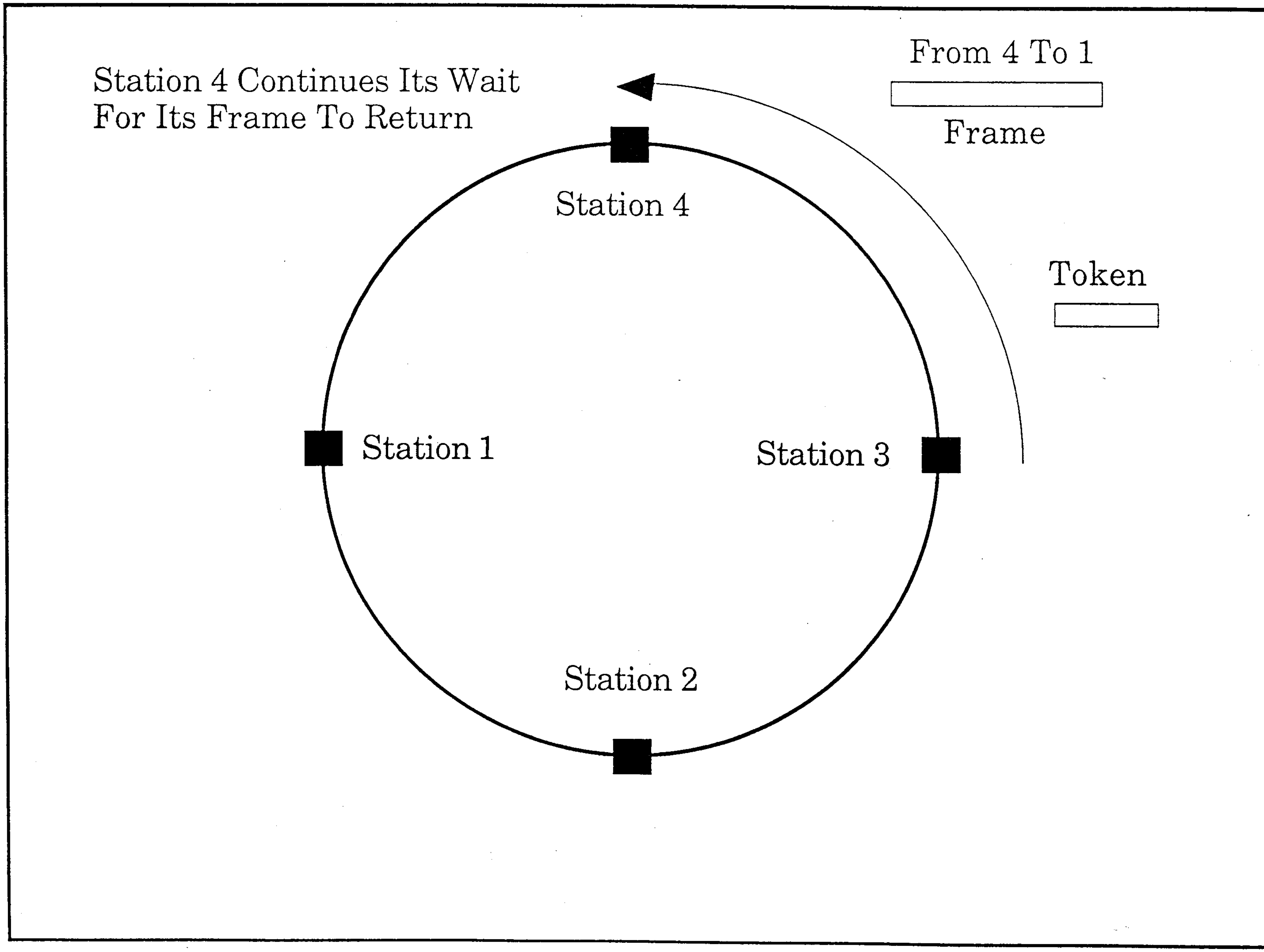

Station 4 Is
Waiting For
A Token
From 3 To 2
Frame
Token
Station 4
Station 1
Station 3
Station 3
Then Adds
A Token To
Free The
Ring
Station 2

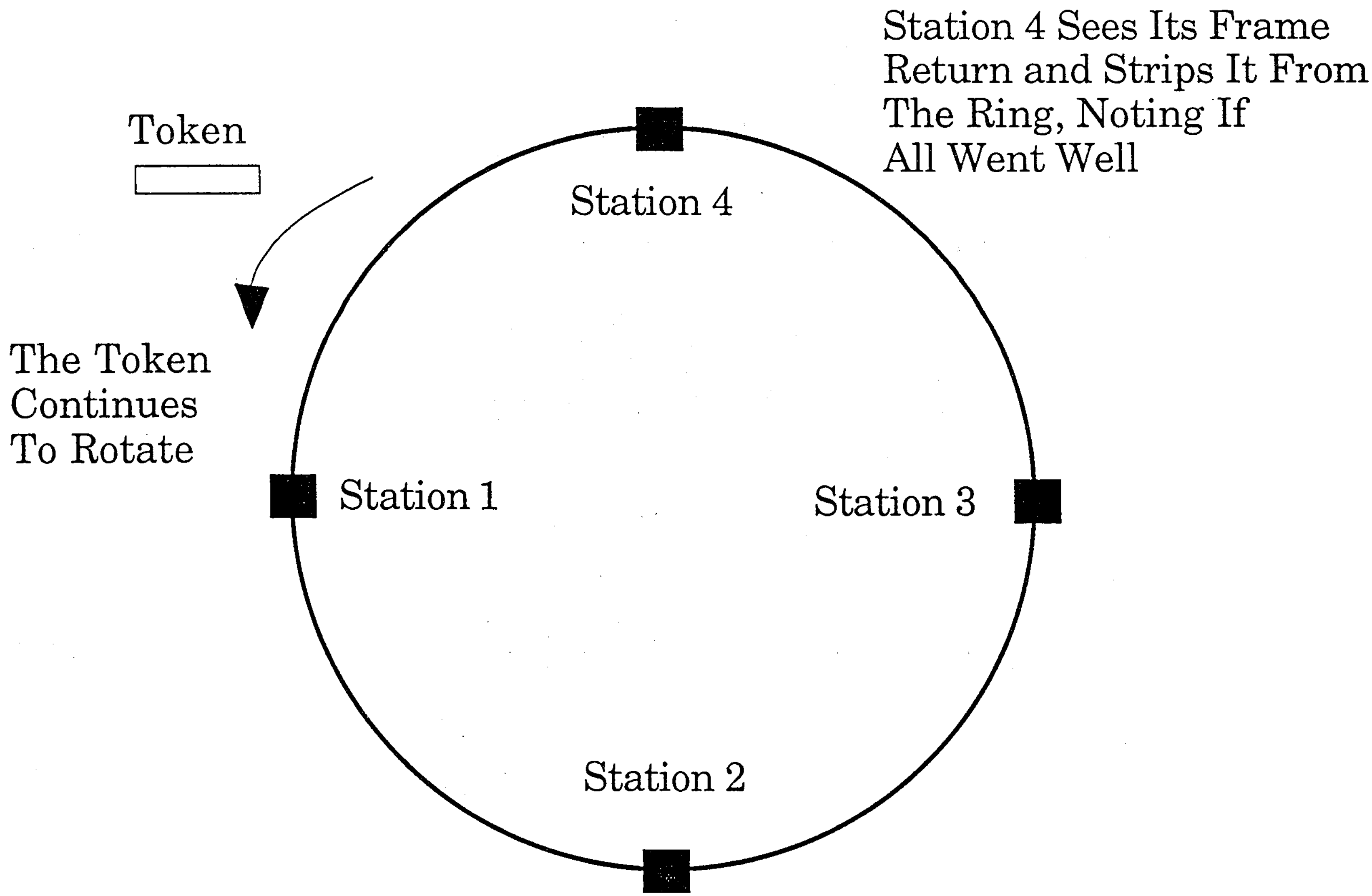

Token
Station 4 Receives
The Token and
Sends Its Frame Out
Then Adds A Token
To Free The Ring
From 4 To 1
Frame
Station 4
Station 1
Station 3
Station 3
Now Waits
For Its Frame
To Return
Station 2
From 3 To 2
Frame



Station 4 Now Waits
For Its Frame To Return
Station 4
Station 3 Continues
Its Wait For Its
Frame To Return
Station 1
Recognizes The
Frame and
Copies It To Its
Buffer
Station 1
Station 3
Token
Station 2
From 4 To 1
Frame
From 3 To 2
Frame
Station 2 Also Recognizes Its Frame And Copies It


Station 4 Continues Its Wait
For Its Frame To Return
Station 4
Station 1
Station 3
Station 2
Station 3 Sees Its
Frame Return and
Strips It From The
Ring, Noting If All
Went Well
From 4 To 1
Frame
Token


Station 4 Continues Its Wait
For Its Frame To Return
From 4 To 1
Frame
Token
Station 4
Station 1
Station 3
Station 2


Station 4 Sees Its Frame
Return and Strips It From
The Ring, Noting If
All Went Well
Token
The Token
Continues
To Rotate
Station 4
Station 1
Station 3
Station 2

FDDI Applications

- Backbone Network for Medium Performance LANs
  - IEEE 802.3, 802.4, 802.5
- Back End Networks
  - Processor to Processor
  - High Speed Peripherals
  - Servers
- High Peformance Work Stations
  - Medical Imaging
  - Engineering Graphics
  - etc.

FDDI - II

- Adds Circuit Switching To FDDI - I
- Dynamic Bandwidth Assignment
- Provides 16 Isochronous Channels
  - Each Is 6.144 M Bits per Second
  - Each Is Full Duplex
  - Incrementally Assignable
- Residual 1 M Bit per Second FDDI-I Service
- Bandwidth Not Assigned To FDDI-II Service Is Available For FDDI-I Service

History of FDDI at X3T9

- First Consideration - October 82
- Proposals Submitted - June 83
- Technical Direction Firmed - October 83
- MAC Technical Letter Ballot - October 84
  - Accepted as ISO Draft Proposal - November 85
  - X3 Letter Ballot Passed - September 86
  - ISO Draft Intnl Stndrd - November 86
- PHY Technical Letter Ballot - May 85
  - Accepted as ISO Draft Proposal - November 85
  - Put Out for 2nd X3 Public Review - August 85
- PMD Technical Letter Ballot - July 86
- SMT Revision 2 - September 86
- FDDI-II Project Approval - March 86

Support FDDI

The LAN You Save
May Be Your Own

WILLIAM A. LOKKE, DEPARTMENT HEAD

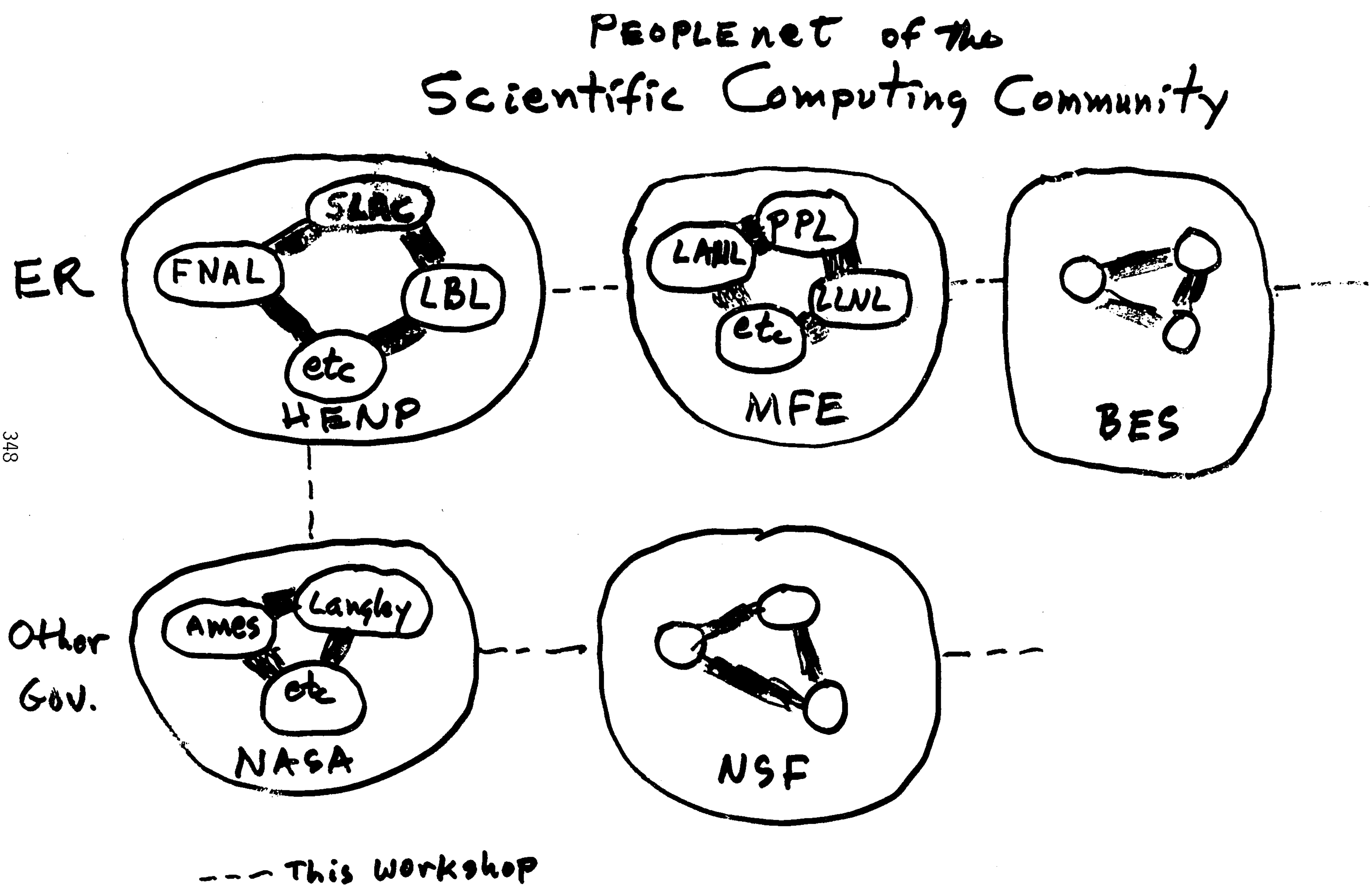
M - DIVISION

LAWRENCE LIVERMORE NATIONAL LABORATORY

TITLE: NEXT ENERGY RESEARCH WORKSHOP

Workshops serve as unique forum of users/developers to:

- Share current work & practices
  future needs
- Identify oppurtunities for collaboration
- Work issues:
  Standards
  Vendor Impact
- Develop (and renew) contacts


PEOPLEnet of the
Scientific Computing Community
ER
FNAL
SLAC
LBL
etc
HENP
LANL
PPL
LLNL
etc
MFE
BES
Other
Gov.
Ames
Langley
etc
NASA
NSF
--- This workshop

2nd ER Computing Workshop

Software Tools: Status and Impediments

- Current hot projects
- Future Needs
- Sharing Software
  - collaboration
  - distribution
- Vendor issues
  - schedules
  - functions

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