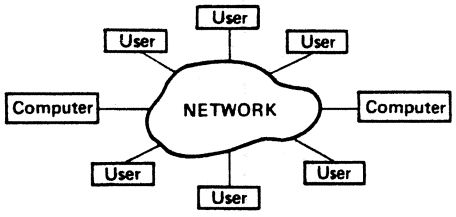
INTRODUCTION TO THE ADVANCED RESEARCH PROJECTS AGENCY NETWORK –ARPANET– AND THE MILITARY NETWORK –MILNET–

- Introduction to Data Networks
- Introduction to ARPANET and MILNET
- Components of the Network
- ARPANET and MILNET

INTRODUCTION TO DATA NETWORKS

- Provide Data Flow Services to Users
- Fast, Low-Delay Communications Between

  People – People
  People – Computers
  Computers – Computers



– Speedily
– Reliably
– Securely
– Economically

INTRODUCTION TO ARPANET AND MILNET

ARPANET – Research and Development

Since Late 1960s

MILNET	ARPANET
Military Network	Network Research Network

OBJECTIVES OF ARPANET

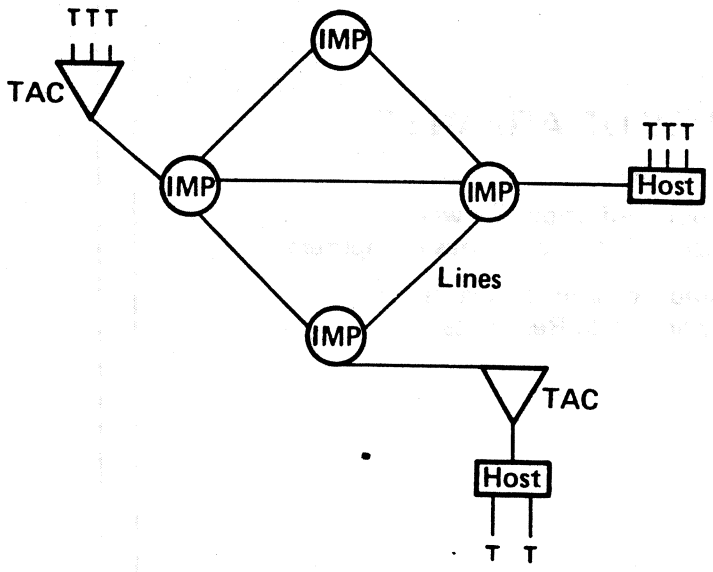
- Provide Efficient Communications Between Geographically Separated Heterogeneous Computers
- Allow Convenient and Economical Sharing of Hardware, Software and Data Resources

COMPONENTS OF THE NETWORK

- Terminals
- Host Computers
- Lines
- Nodes (Switches)
- TACs
- Network Management

Notes

A MODEL OF A NETWORK



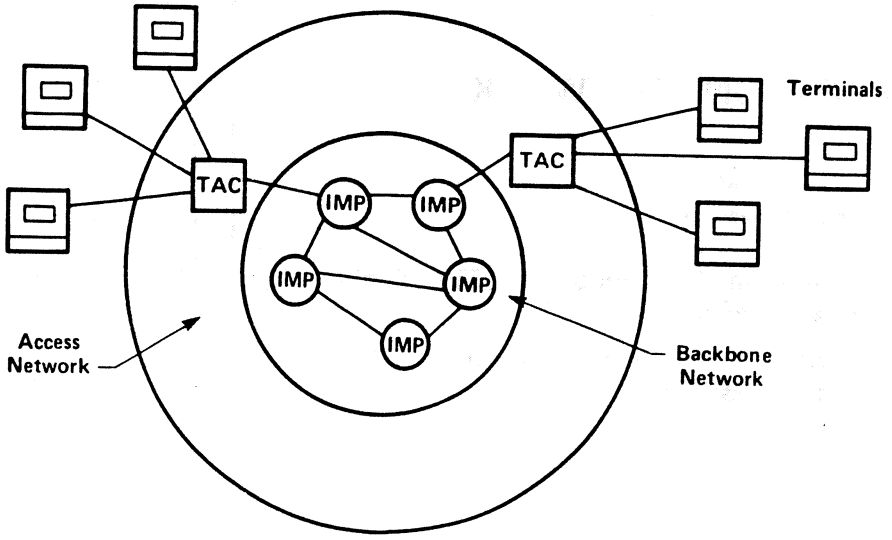
NETWORK FUNCTIONS

- Communicate
- Correct Faults
- Insure Security
- Collect Data
- Configure Network

PACKET SWITCHING NETWORKS

- Common Network Serves Many Hosts and Users
- Computers Talk in Bursts and Want Fast Transfer, Low Delay
- Packets Allow Efficient Sharing of Common Circuits
- Store-and-Forward

THE ACCESS AND BACKBONE NETWORKS



THE BACKBONE NETWORK

- NODES
- TRANSMISSION LINKS

THE BACKBONE NETWORK

IMP
Interface Message Processor

- Interface Hosts to Backbone Network So That They Can Send and Receive Data Traffic
- Act as a Tandem Switch So That Intransit Traffic Can Be Properly Directed to Its Destination IMP

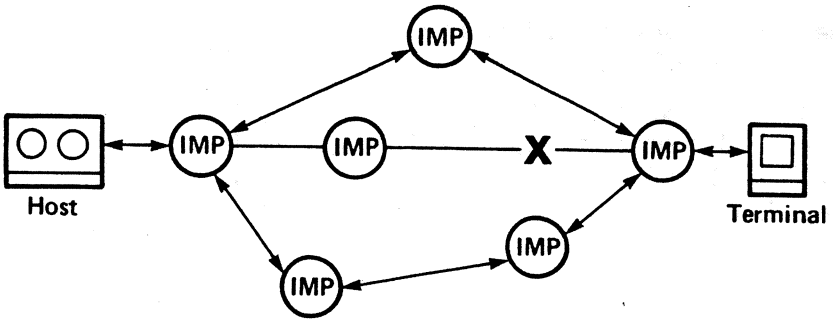
Notes

IMP

- Dynamic Adaptive Routing
- Automatic Line Monitoring
- End-to-End Error Control
- Response to Failures/Congestion
- Restart Procedures

DYNAMIC ROUTING

- Route Around Outage or Congestion
  — vs. Predetermined or Fixed Route



Notes

TRANSMISSION LINKS

- Land-Analog (50 Kb; 9.6 Kb Europe)
- Land-Digital (56 Kb)
- Satellite and Submarine Cable
- Microwave

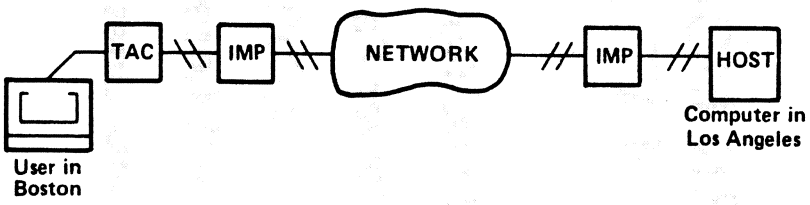
THE ACCESS NETWORK

- Terminals That Use and Are Located at a Single Host Access Network Through Host Systems
- Terminals That Use Several Hosts or Are Not Located Near Primary Host Access Network Through a TAC
  - Through Dedicated Circuit
  - Dial-Up a TAC Port

TAC
Terminal Access Controller

- BBNCC C/30 With 64 K Memory
- Acts Like Telephone Switchboard
  - Connects Users to Any Authorized Host Computer
- Controls Access to the Network (via IMP)
- Support Many Users on "1 Circuit" to IMP
- Network-Terminal Connection is Transparent

CONNECTING TO THE REMOTE HOST



User's Procedures:

- Prepares His Terminal
- Alerts the TAC
- Logs on Host as User, When Connected
- Continues Session as if Directly Connected to Host

NETWORK MONITORING AND CONTROL: WHAT COULD GO WRONG?

- Lines Go Down or Have Errors
- Power Failure at the Node
- Node Software or Hardware Fails
- Host Loses Connection With Network
- TAC Goes Down

Notes

NETWORK MONITORING AND CONTROL: WHAT COULD GO WRONG?

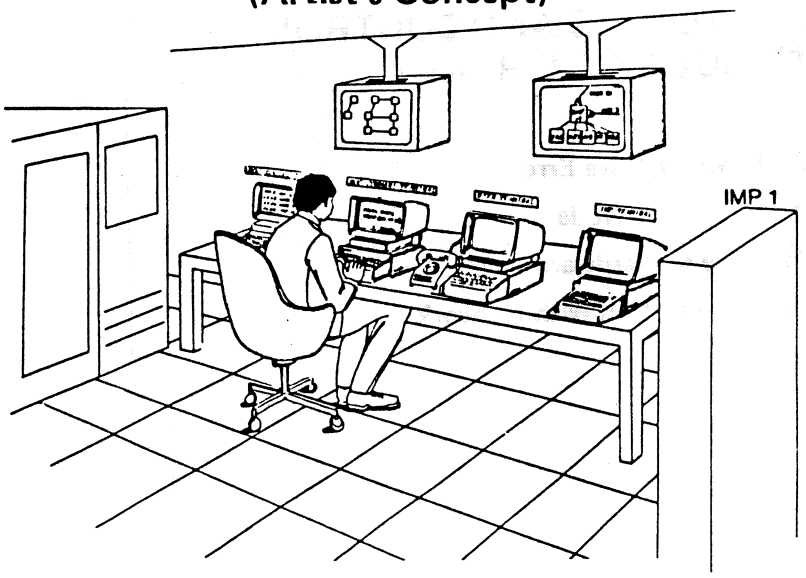
- Lines Go Down or Have Errors
- Power Failure at the Node
- Node Software or Hardware Fails
- Host Loses Connection With Network
- TAC Goes Down

MC RESPONSIBILITIES

- User Assistance
  - Hotline for Questions and Problems
- Isolating, Diagnosing and Correcting Problems
  - Verifying the IMP Program
  - Reloading IMPs
  - Looping Lines
- Coordinating Overall Network Performance
  - Conducting Network Tests
  - Releasing New Software
  - Scheduling Preventative Maintenance
- Measuring Network Performance
  - Monitoring Status Throughput Summaries
  - Compiling Reports
- Maintaining the Network Controller's Log

Notes

NETWORK MONITORING CENTER
(Artist's Concept)



Located at BBN, Cambridge MA

ARPANET AND MILNET
HISTORY OF ARPANET

- 1960s ARPA (Advanced Research Projects Agency) Sponsored Computer Time-Sharing Research at Leading Universities and Research Labs
- These Projects and Their Computers Provided an Ideal Environment for a Pilot Network Project
- 1967 An Experimental R&D Network (ARPANET) Planned to Link These Computers
  - To Provide Efficient Communications Between Heterogeneous Computers, so That Hardware, Software and Data Resources Could Be Economically and Efficiently Shared by a Wide Community of Users

Notes

HISTORY OF ARPANET (Cont)

- 1969 4 Nodes Installed and Operating
- Mid 1970s ARPANET Operational as Well as Experimental
  - – Operational Responsibility Transferred to Defense Communications Agency (DCA)
- 1983 DCA Divided ARPANET Into Two Separate Networks
  - – MILNET – Unclassified Military Network
  - –ARPANET – Continuing as a Facility for Network Research

PROBLEMS FACED IN DEVELOPING ARPANET

- Reliability
- Allow Communication Between Computers of Varying Makes
- Control Errors
- Provide High Performance
- Control Switching Remotely

Notes

MILNET

- Worldwide, Unclassified Network Providing Data Communications Between Military and Other Selected Users
  - Services and Agencies Operational ADP Systems Split From ARPANET to Become Baseline for MILNET
  - To Be Divided Into Open and Closed Communities of Interest
- 65 Nodes in Europe, the U.S. and the Pacific
  - Plans for Growth to 120 Nodes

ARPANET

- Experimental Network – Utilized for Computer Network Research and to Test New Concepts to be Employed by the DDN
- Over 100 Computers and 10,000 Users Make Use of the ARPANET
  - Carries an Average of Over 20 Million Packets Per Day

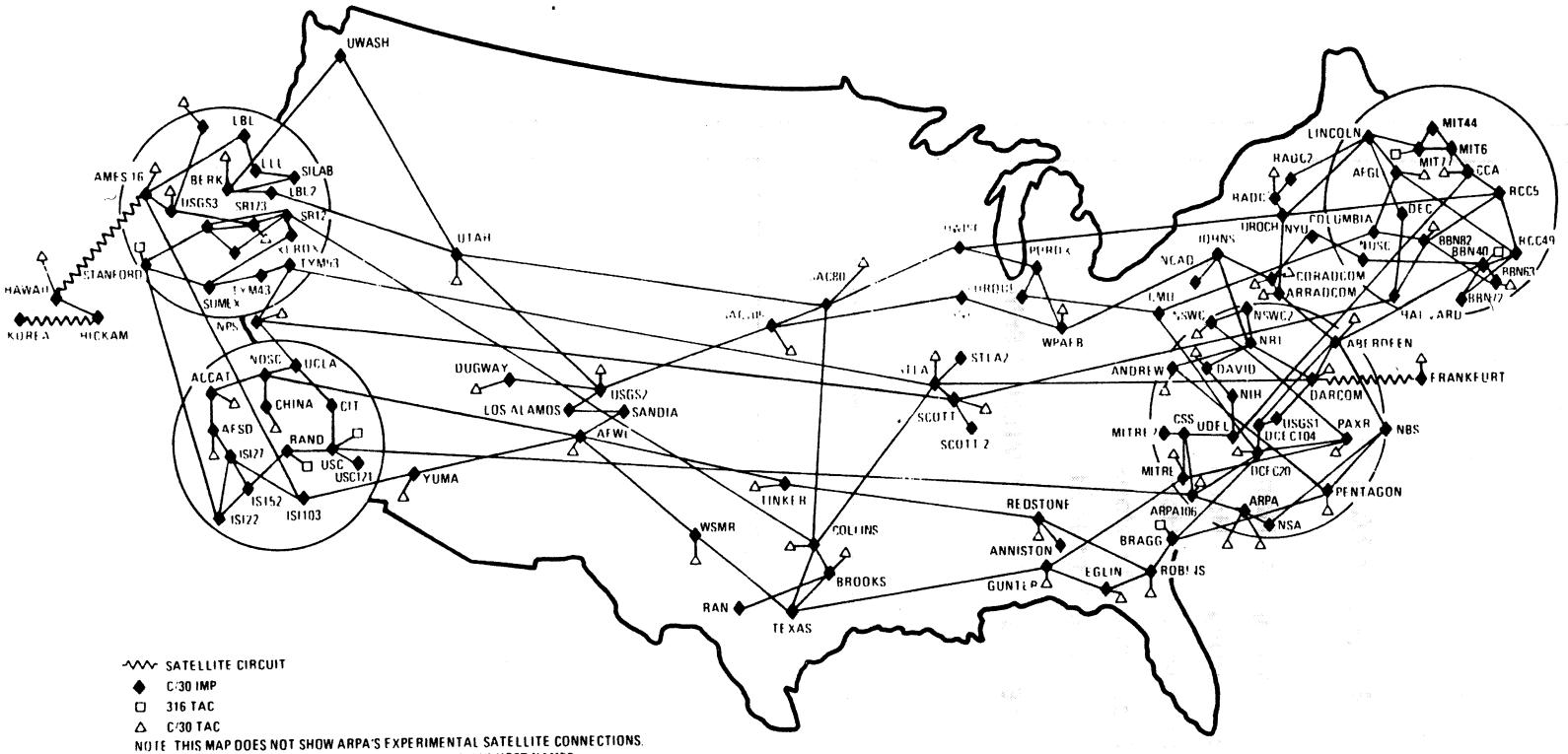
Notes

GROWTH OF ARPANET

1969 Supporting 4 Hosts
1971 Supporting 23 Hosts
1974 Supporting 62 Hosts
1977 Supporting 111 Hosts
1984 Supporting 350* Hosts

*Before ARPANET/MILNET Split

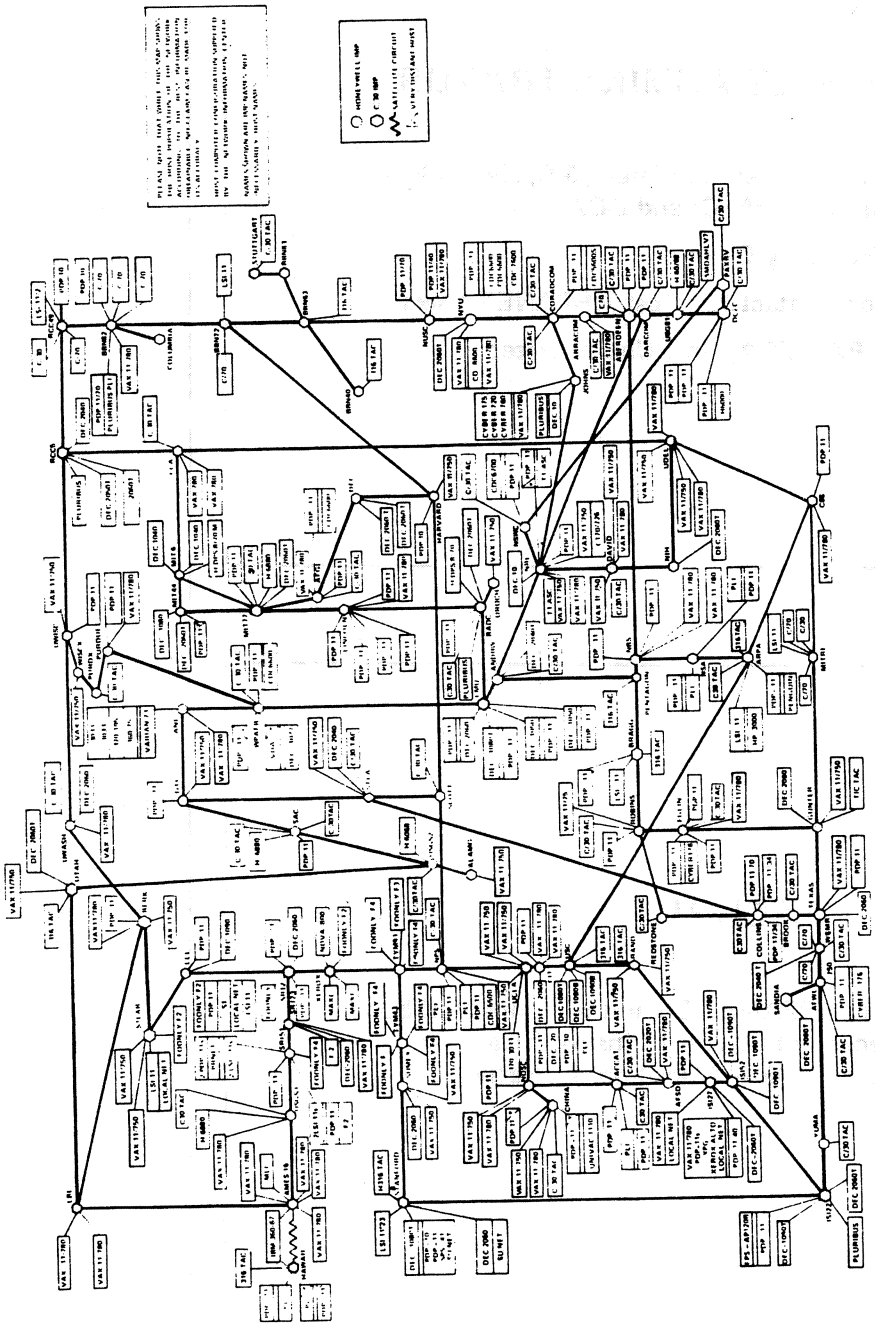
ARPANET GEOGRAPHIC MAP, SEPTEMBER 1982



NOTE: THIS MAP DOES NOT SHOW ARPA'S EXPERIMENTAL SATELLITE CONNECTIONS.
NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES
TINKER: OKLAHOMA CITY

Notes

ARPANET LOGICAL MAP
SEPTEMBER 1982

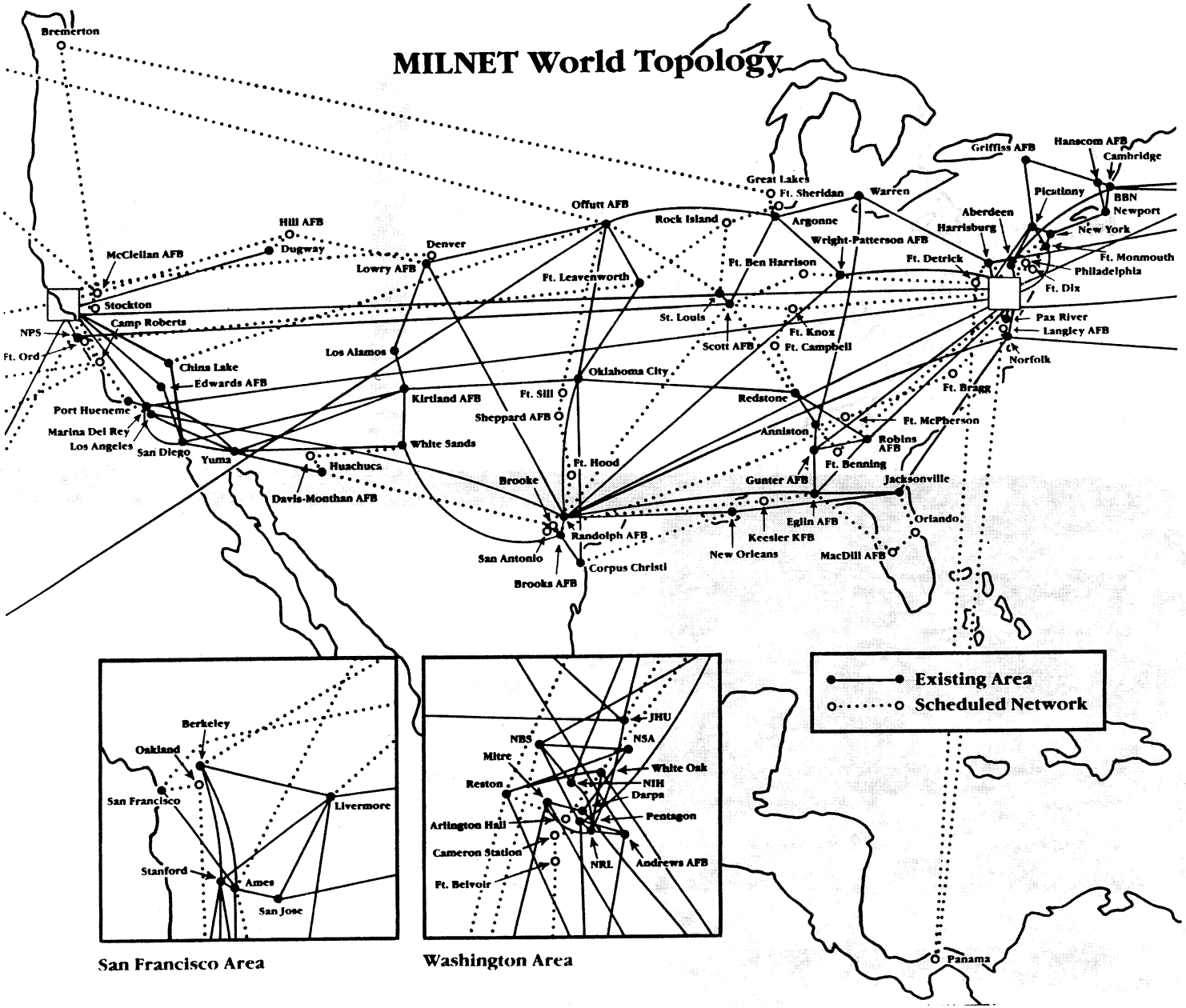


ARPANET HOST ADMINISTRATOR

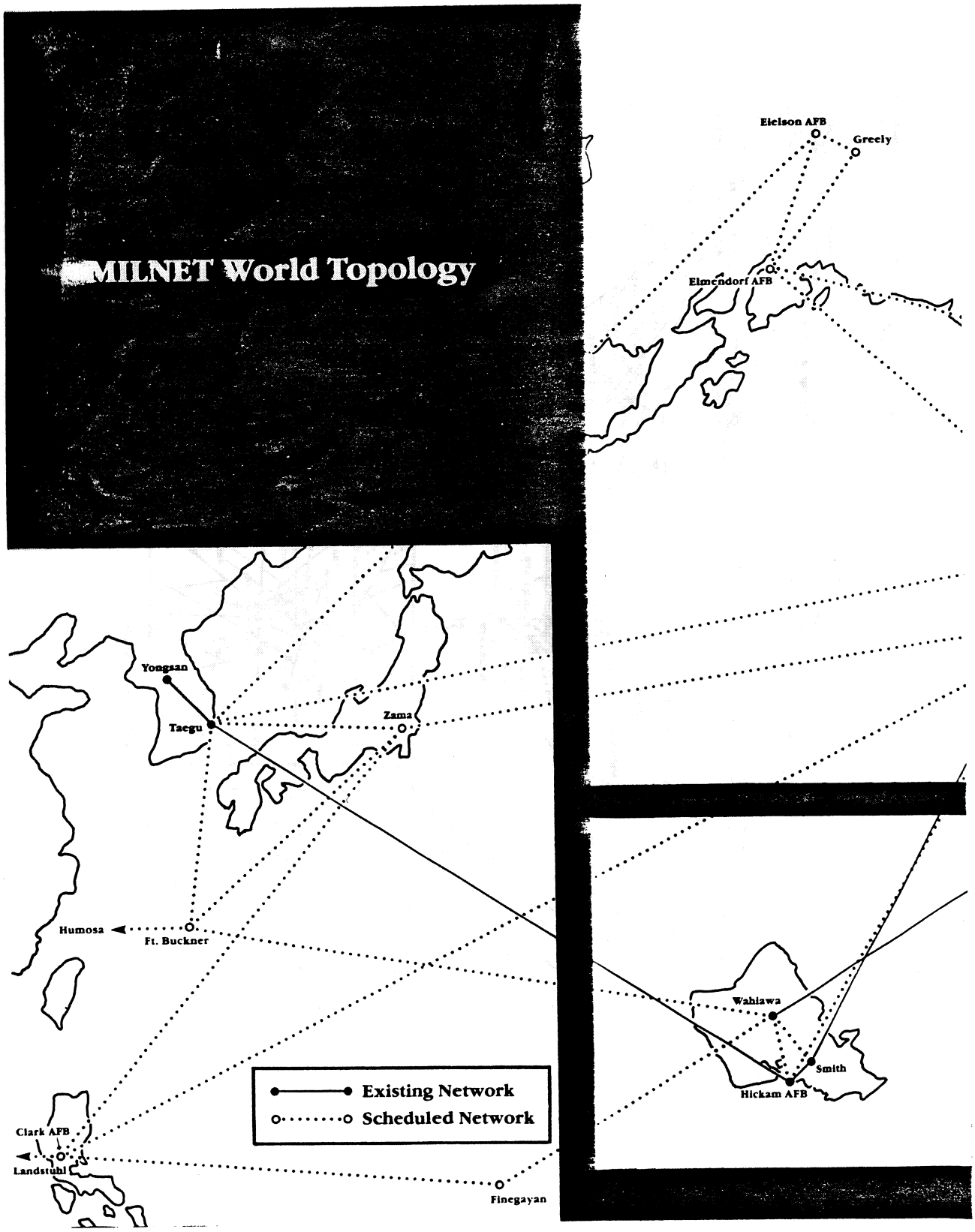
- Act as Advisors to Network Users, MC, Network Information Center (NIC) and DCA
- Each Host Has Only One
- First Point of Contact for Most ARPANET Users
- Monitor ARPANET Against Unauthorized Use

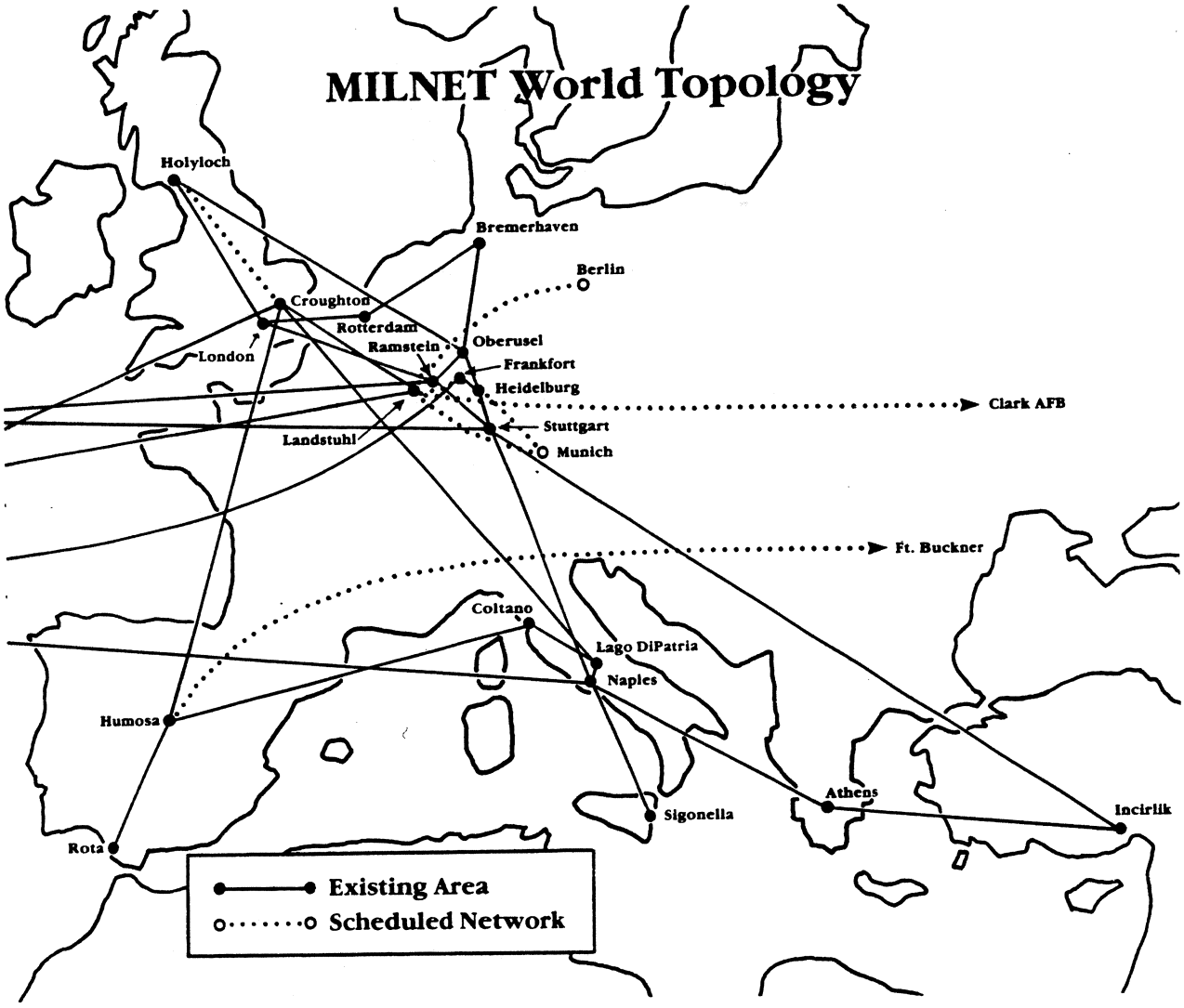
SECURITY

- Unlike MILNET, ARPANET Communications Backbone Contains No Security Features to Insure Privacy or Protection of Information Transiting the Network


MILNET World Topology
Bremerton
McClellan AFB
Hill AFB
Dugway
Denver
Lowry AFB
Offutt AFB
Rock Island
Great Lakes
Ft. Sheridan
Warren
Argonne
Griffiss AFB
Hanscom AFB
Cambridge
Picatinny
BBN
Newport
Aberdeen
Harrisburg
New York
Wright-Patterson AFB
Ft. Detrick
Ft. Monmouth
Philadelphia
Ft. Dix
Ft. Ben Harrison
Ft. Leavenworth
Stockton
Camp Roberts
NPS
Ft. Ord
St. Louis
Ft. Knox
Ft. Campbell
Scott AFB
Pax River
Langley AFB
Norfolk
Los Alamos
China Lake
Edwards AFB
Oklahoma City
Ft. Sill
Kirtland AFB
Sheppard AFB
Redstone
Ft. Bragg
Port Hueneme
Marina Del Rey
Los Angeles
San Diego
Yuma
White Sands
Huachuca
Davis-Monthan AFB
Ft. Hood
Brooke
Anniston
Ft. McPherson
Robins AFB
Ft. Benning
Gunter AFB
Jacksonville
Orlando
Eglin AFB
Keesler KFB
Randolph AFB
San Antonio
Brooks AFB
Corpus Christi
New Orleans
MacDill AFB
Panama
Existing Area
Scheduled Network
Berkeley
Oakland
San Francisco
Livermore
Stanford
Ames
San Jose
San Francisco Area
JHU
NBS
NSA
Mitre
White Oak
Reston
NIH
Darpa
Pentagon
Arlington Hall
Cameron Station
NRL
Andrews AFB
Ft. Belvoir
Washington Area

Notes


MILNET World Topology
Eielson AFB
Greely
Elmendorf AFB
Yongsan
Taegu
Zama
Humosa
Ft. Buckner
Wahiawa
Smith
Hickam AFB
Existing Network
Scheduled Network
Clark AFB
Landstuhl
Finegayan


MILNET World Topology
Holyloch
Bremerhaven
Berlin
Croughton
Rotterdam
Ramstein
Oberusel
London
Frankfort
Heidelburg
Clark AFB
Stuttgart
Landstuhl
Munich
Ft. Buckner
Coltano
Lago DiPatria
Naples
Humosa
Athens
Incirlik
Sigonella
Rota
Existing Area
Scheduled Network