IGS

SESSION 9

NEW COMMUNICATION TECHNOLOGY

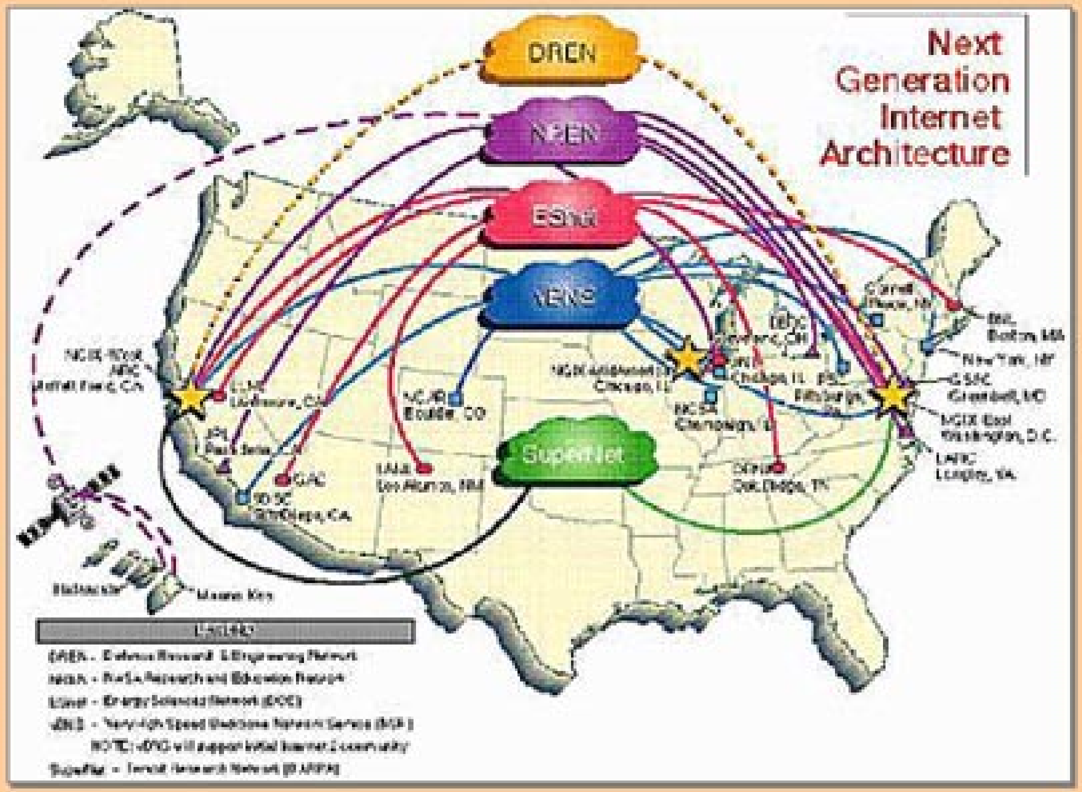
International High-Performance Networking

November, 1998

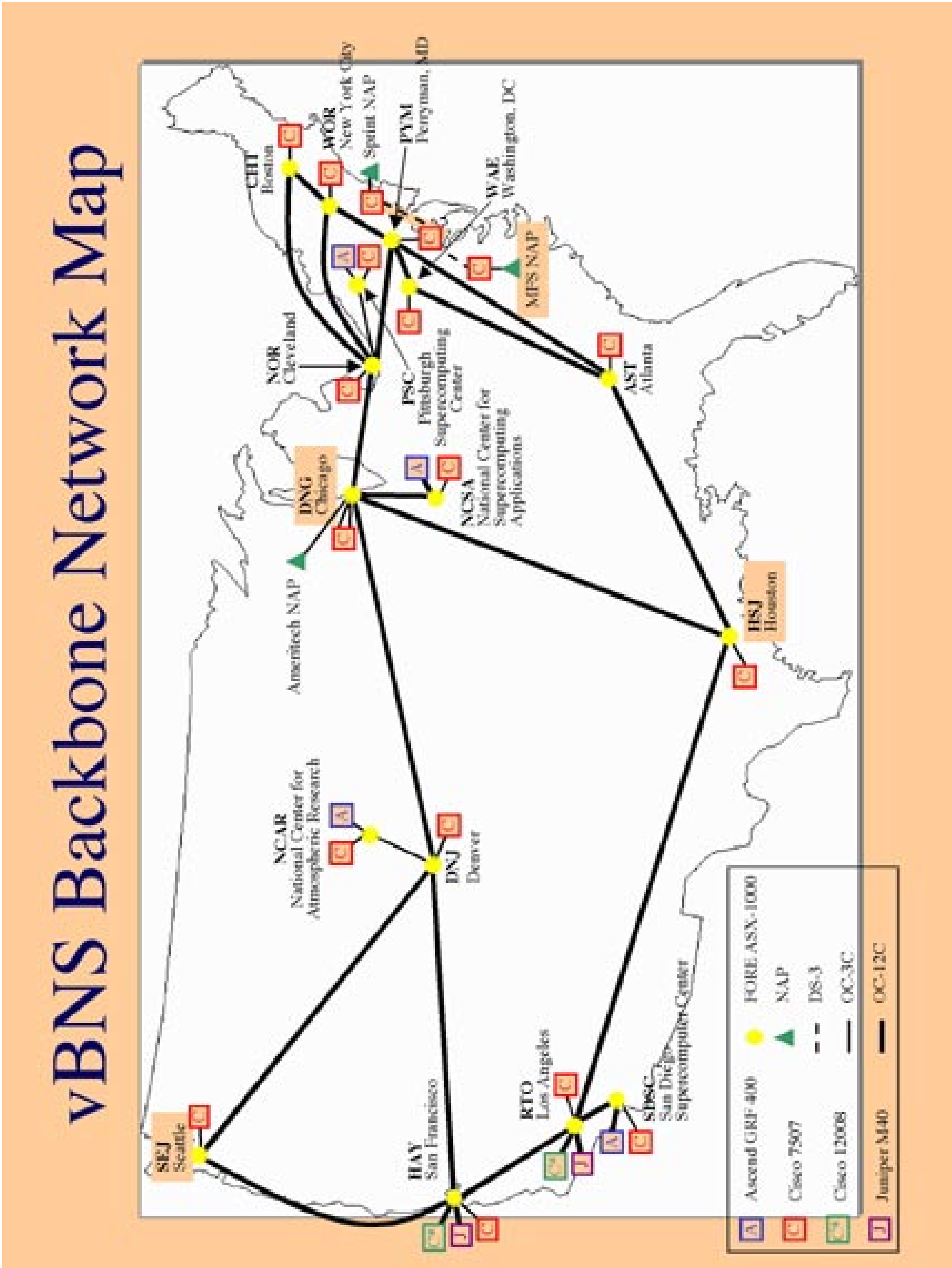
by

Steven N. Goldstein

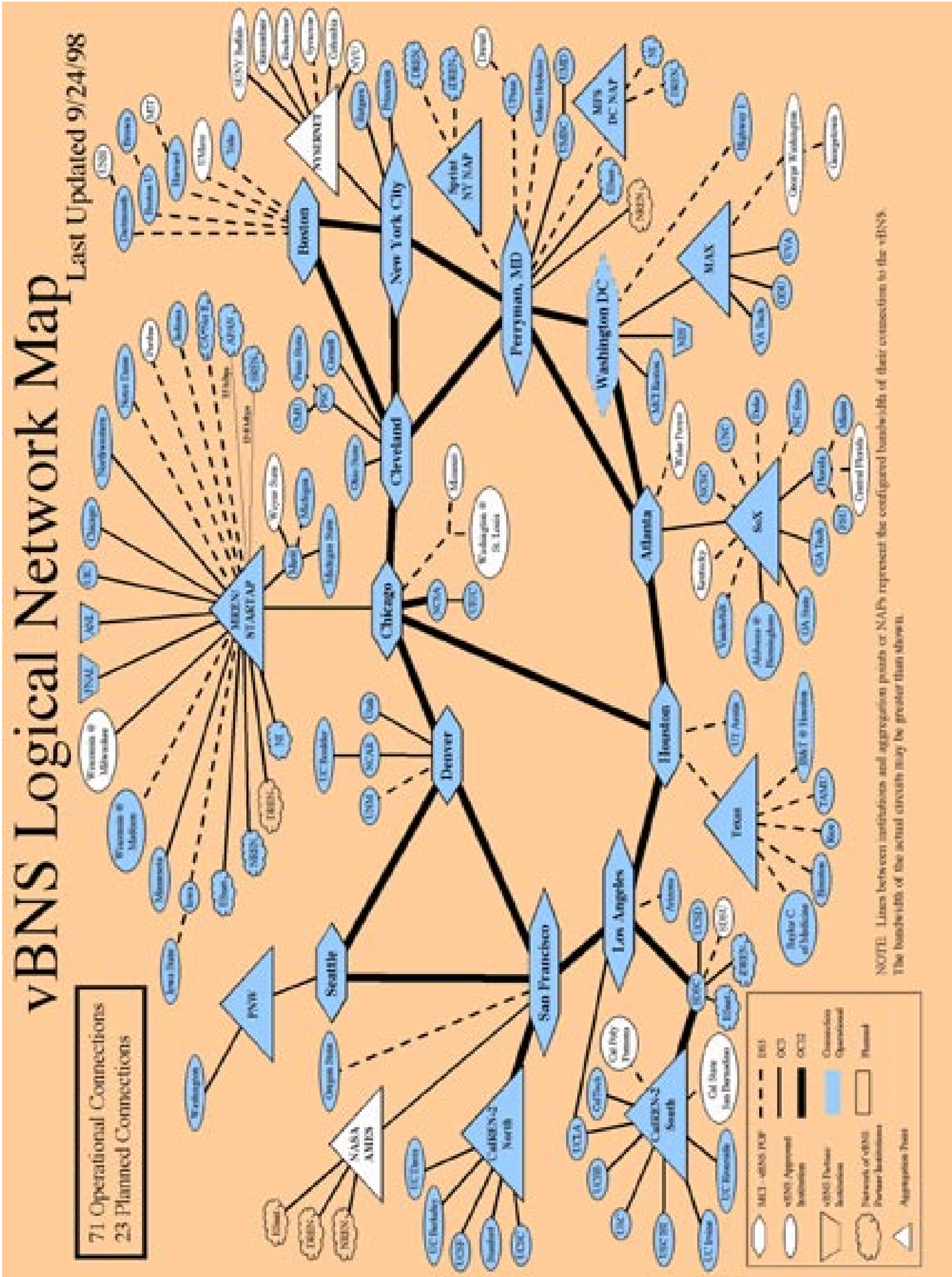
Proposed NGI Architecture

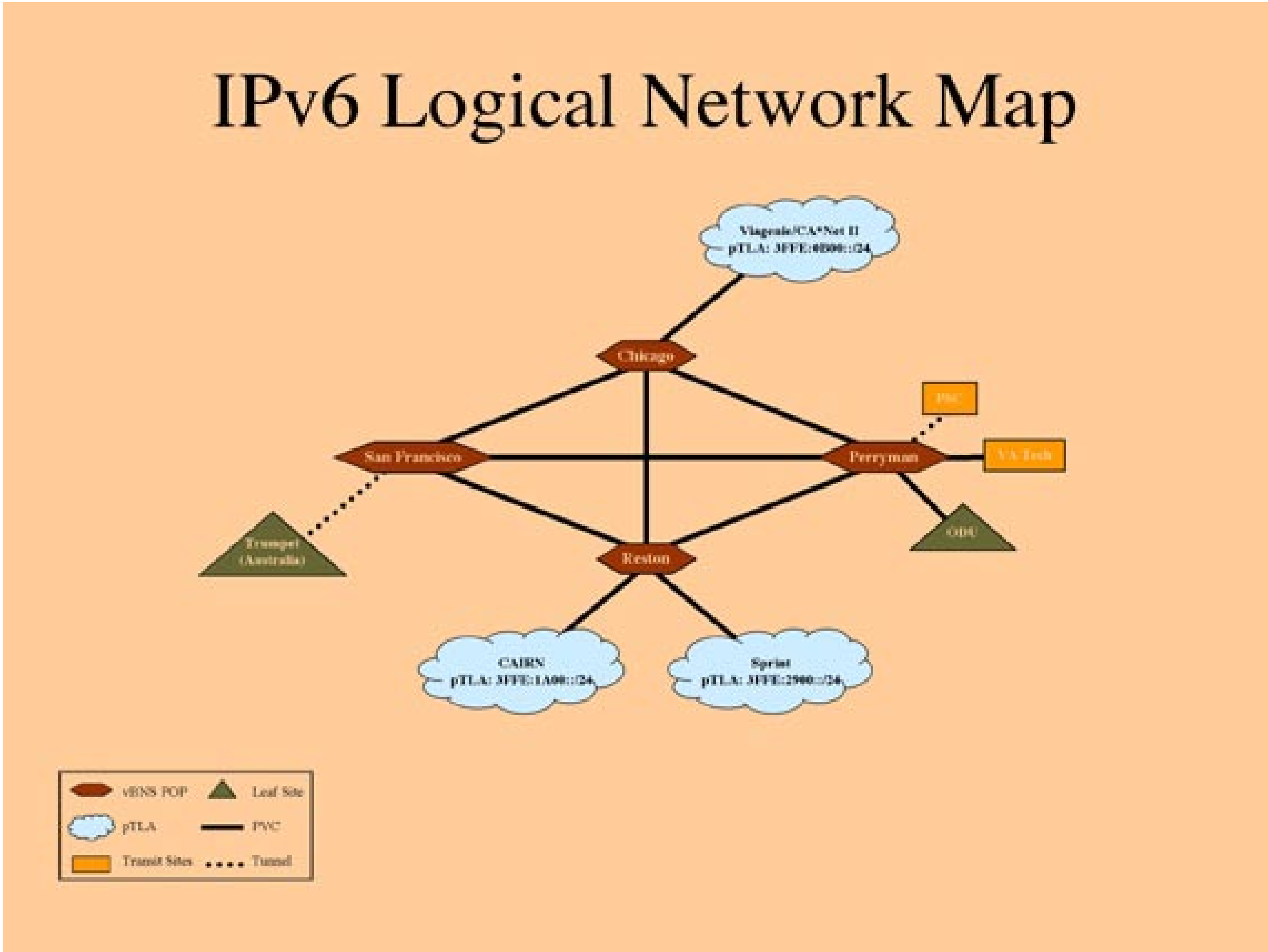


Source: http://www.ccic.gov/ngi/implementation-Jul97/g2_hp_conn_spec.html

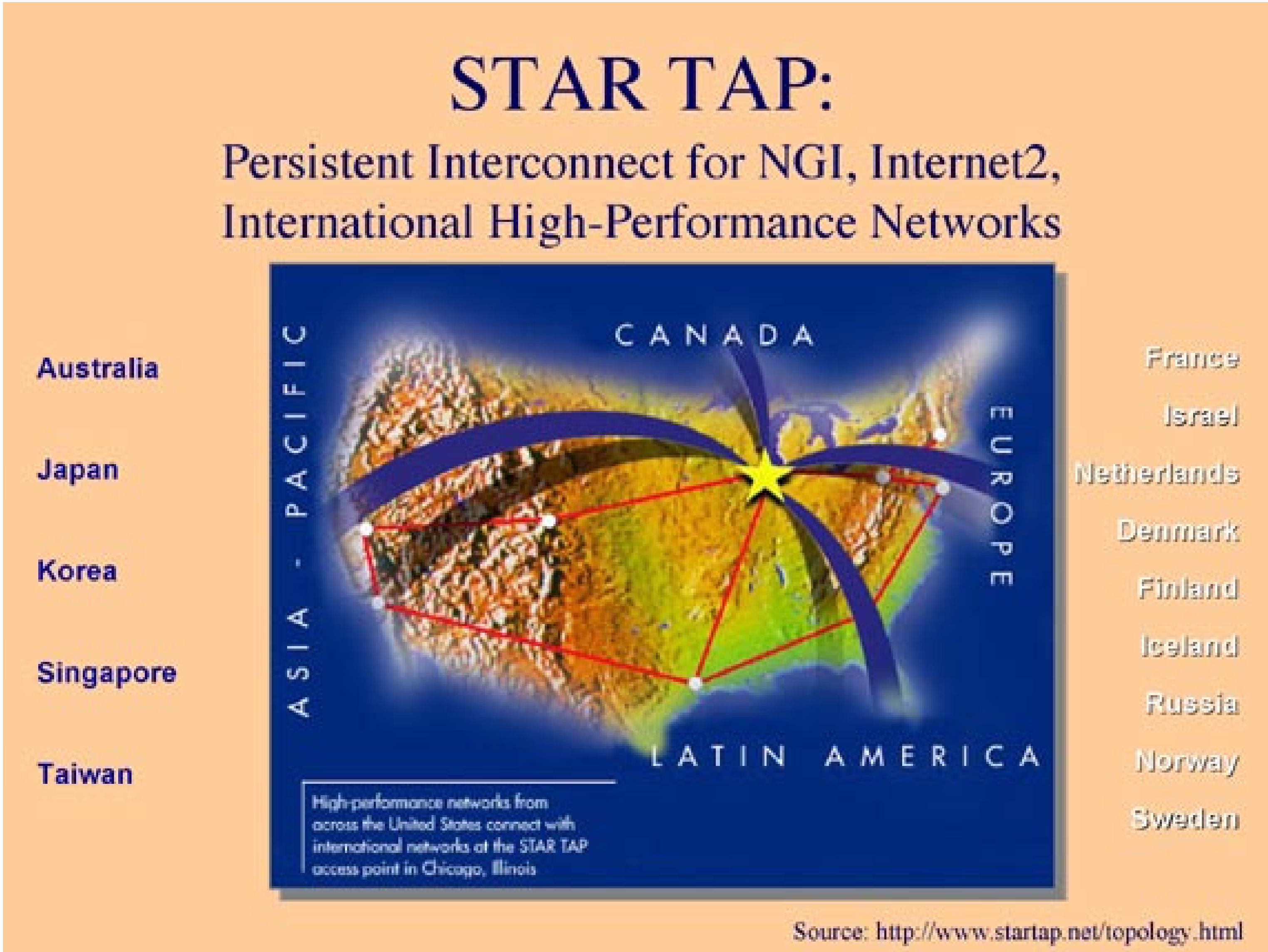


vBNS Backbone Network Map
CHT
Boston
WOR
New York City
Sprint NAP
PYM
Perryman, MD
WAE
Washington, DC
MFS NAP
NOR
Cleveland
PSC
Pittsburgh
Supercomputing
Center
AST
Atlanta
DNG
Chicago
NCSA
National Center for
Supercomputing
Applications
Ameritech NAP
HSJ
Houston
NCAR
National Center for
Atmospheric Research
DNJ
Denver
SEJ
Seattle
HAY
San Francisco
RTO
Los Angeles
SDSC
San Diego
Supercomputer Center
Ascend GRF 400
Cisco 7507
Cisco 12008
Juniper M40
FORE ASX-1000
NAP
DS-3
OC-3C
OC-12C

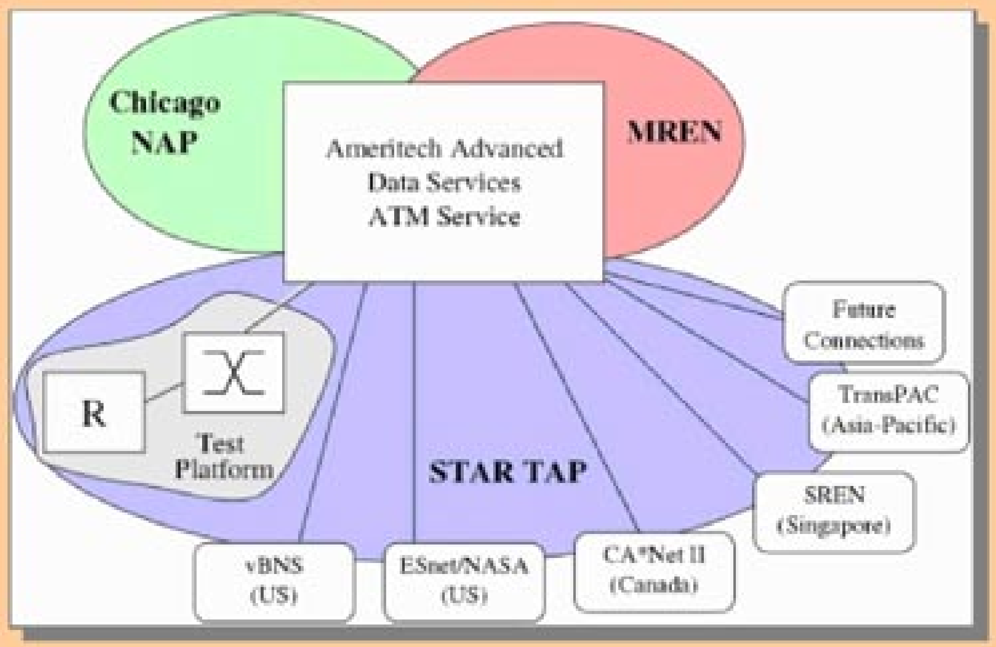

vBNS Logical Network Map
Last Updated 9/24/98
71 Operational Connections
23 Planned Connections
Seattle
San Francisco
Los Angeles
Denver
Chicago
Cleveland
Boston
New York City
Perryman, MD
Washington DC
Atlanta
Houston


IPv6 Logical Network Map
Viagenie/CA*Net II
pTLA: 3FFE:0B00::/24
Chicago
San Francisco
Perryman
VA Tech
ODU
Trumpet
(Australia)
Reston
CAIRN
pTLA: 3FFE:1A00::/24
Sprint
pTLA: 3FFE:2900::/24
vBNS POP
Leaf Site
pTLA
PVC
Transit Sites
Tunnel


Internet2 Abilene Network
University Corporation for Advanced Internet Development
Qwest


STAR TAP:
Persistent Interconnect for NGI, Internet2,
International High-Performance Networks
Australia
Japan
Korea
Singapore
Taiwan
ASIA - PACIFIC
CANADA
EUROPE
LATIN AMERICA
High-performance networks from across the United States connect with international networks at the STAR TAP access point in Chicago, Illinois
France
Israel
Netherlands
Denmark
Finland
Iceland
Russia
Norway
Sweden
Source: http://www.startap.net/topology.html

The Many "Faces" of STAR TAP*



* Courtesy Paul Zawada

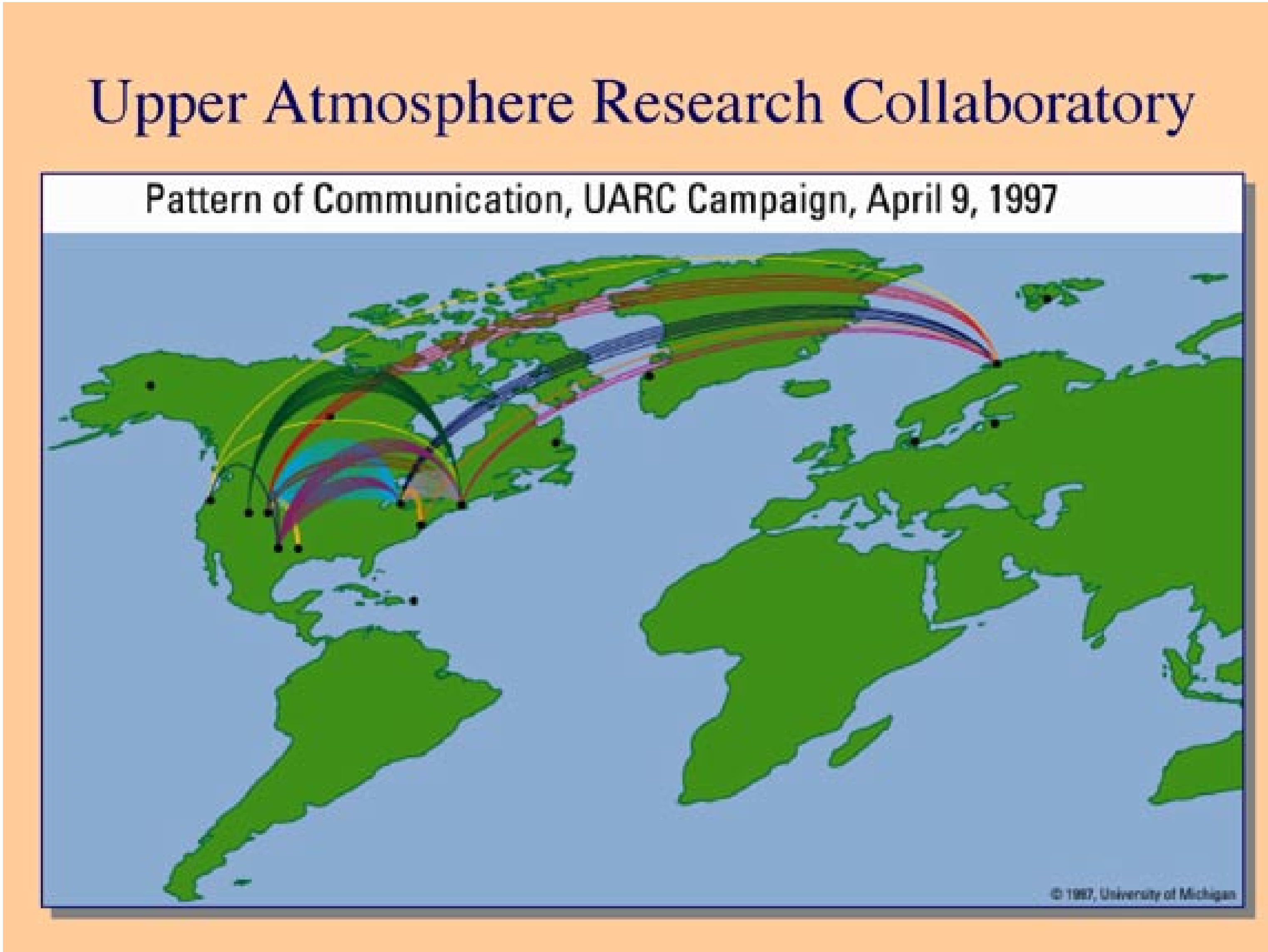
STAR TAP CONNECTIONS

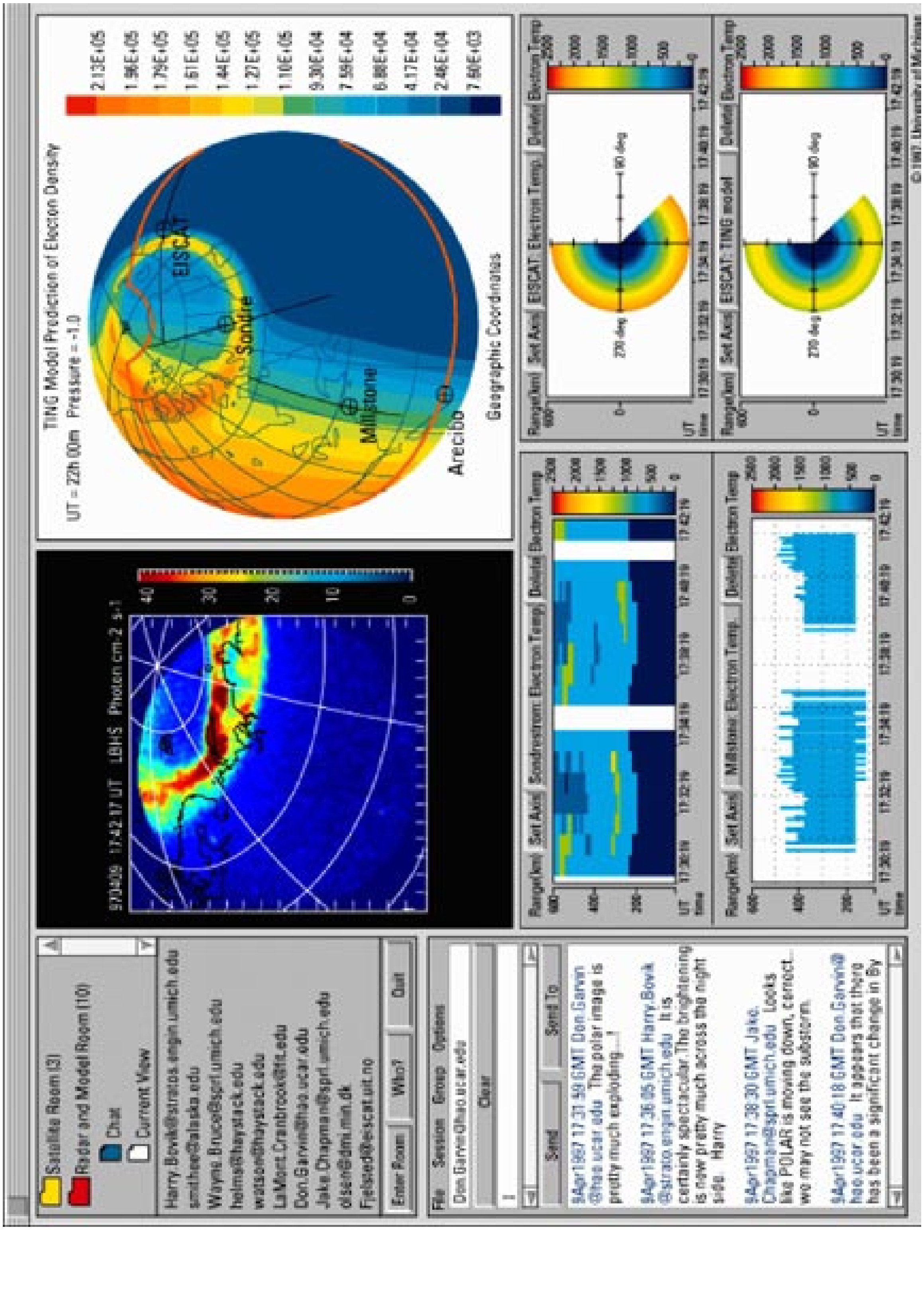
Already Connected:

- CA*Net (Canada) 155 Mbps (http://www.canarie.ca)
- vBNS (NSF/MCI) 155 Mbps (http://www.vbns.net)
- DoE (ESnet) and NASA (NREN and NISN) share 155 Mbps connection TAP (http://www.es.net)
- Abilene (UCAID/Internet2) (http://www.ucaid.org)
- SINGAREN (Singapore) 14 Mbps (http://www.singaren.net.sg)
- TransPAC (35 Mbps from Tokyo-- Japan, Korea, Singapore, Australia...); potential for doubling capacity in '99 (http://www.transpac.org);
- TAnet II (Taiwan, ~15 Mbps of a 45 Mbps link)

Pending:

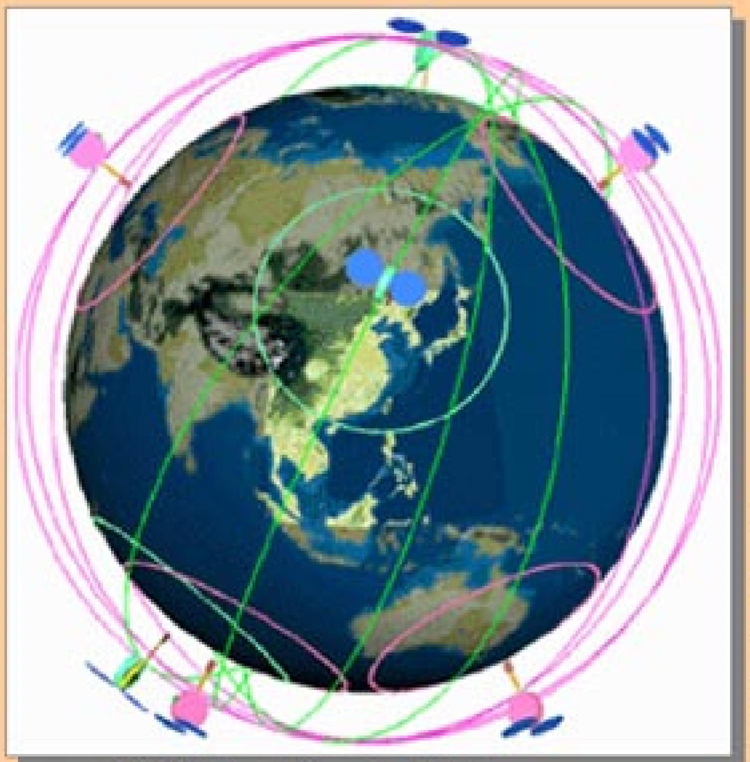
- NORDUnet (backbone connects IS, NO, SE, FI, DK) expected Nov 98; ~45 Mbps will be split off from 155 Mbps to New York (http://www.nordu.net)
- MirNET (6 Mbps link from Moscow) planned install date is 15 Nov 98; (http://www.mirnet.org)
- SURFnet (Netherlands) 155 Mbps to New York, and 45 Mbps split off to STAR TAP
- Israel (~45 Mbps Inter-University Computation Center) delivery expected at end '98/January '99;
- Renater (~45 Mbps, France) is tendering for 45 Mbps, or greater, link to the U.S., portion to STAR TAP


Upper Atmosphere Research Collaboratory
Pattern of Communication, UARC Campaign, April 9, 1997
© 1997, University of Michigan



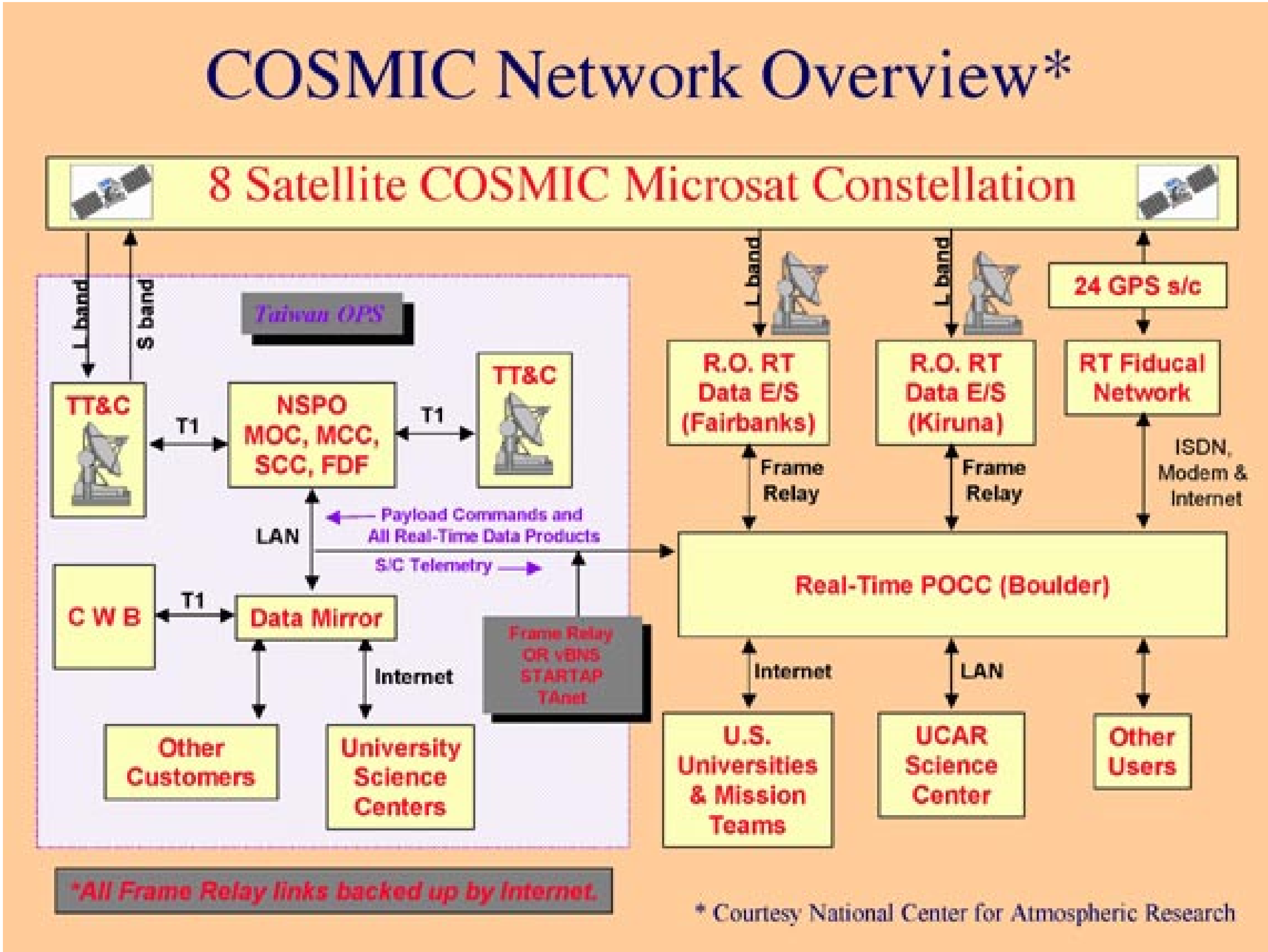
TING Model Prediction of Electron Density
Geographic Coordinates
EISCAT
Sondre
Millstone
Arecibo

Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC)



COSMIC is a collaborative science project – between the United States and Taiwan – for launching a constellation of eight micro-satellites to collect atmospheric remote sensing data for weather prediction, climate, ionospheric and gravity research.

NCAR Scientific Computing Division
Supercomputing | Communications | Data


COSMIC Network Overview*
8 Satellite COSMIC Microsat Constellation
L band
S band
Taiwan OPS
TT&C
T1
NSPO MOC, MCC, SCC, FDF
T1
TT&C
LAN
Payload Commands and All Real-Time Data Products
S/C Telemetry
C W B
T1
Data Mirror
Internet
Other Customers
University Science Centers
Frame Relay OR vBNS STARTAP TAnet
L band
R.O. RT Data E/S (Fairbanks)
L band
R.O. RT Data E/S (Kiruna)
24 GPS s/c
RT Fiducal Network
Frame Relay
Frame Relay
ISDN, Modem & Internet
Real-Time POCC (Boulder)
Internet
LAN
U.S. Universities & Mission Teams
UCAR Science Center
Other Users
*All Frame Relay links backed up by Internet.
* Courtesy National Center for Atmospheric Research

REAL TIME GLOBAL WADGPS DATA COLLECTION NETWORK

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Study to Investigate Techniques for the Real Time Transmission of GPS Receiver Data to Network Control Centers

Principal Data Collection Techniques

Today

- Global frame relay
- Internet virtual private networks (VPN)
- Very small aperture satellite terminal (VSAT)

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Near Future

- Low earth orbit (LEO) systems
- Medium earth orbit (MEO) systems
- High frequency broadband systems (K_a and V-band)
- "Internet in the sky" systems like Teledesic

Redundancy, Reliability, and Network Design

Reliability

- The only practical method of obtaining network reliability is through redundancy.
- Implement extra reference stations.
- Implement two separate NCCs to eliminate single point failures from taking down the entire network.

Network Design

- Compress data to save bandwidth.
- Design robust WADGPS algorithms that will tolerate dropped packets.
- Spend more on capital equipment if it will reduce monthly transmission costs.

Frame Relay Service

Frame relay cost elements

- Local access charge
- Port charge
- Committed information rate (CIR)

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Global frame relay

- Costs are higher than in U.S. and quality of service is lower.
- Local tariffs and regulations vary widely from country to country.

Internet Virtual Private Networks

- A VPN is a secure communications channel, called a tunnel, across an existing network that has an IP infrastructure.
- Internet VPNs allow the Internet to be used to exchange proprietary data instead of more costly frame relay or leased lines.
- Large Internet VPN providers use private peering to avoid Internet congestion at public network access points.
- The best Internet VPN performance will be obtained if all or most of the remote locations are connected to a major service provider's network.

VSATs

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- VSATs use small 1 to 3 meter diameter antennas to implement two-way communications through a geostationary satellite.
- Traditional users are point-of-sales applications and retail stores.
- Global monthly service costs can vary widely primarily due to landing right fees levied by the country in which the VSAT terminal is located.
- The use of large antennas lowers monthly bandwidth costs.
- Time division multiple access (TDMA) systems allow multiple remote locations to share a common space segment channel bandwidth.

Global Transmission Costs

- Varies widely due to local regulations.
- New systems, alliances between providers, and changing international regulations make it impossible to select the best specific implementation today for service required six months from now.

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- Accurate installation and service quotes are impossible to obtain until you are ready to install a network.
- Final contract prices are often designated confidential by the service providers.

Representative Monthly Frame Relay Service Costs

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Within the U.S.

- 56K local access - $100 to $400
- 56K port - $200
- 32K CIR - $40

U.S. to Europe (Infonet)

- 64K local access (50 mile line) - $1,500 in Germany
- 64K port & 16K CIR - $2,600

U.S. to Asia (Infonet)

- Local access - ?
- 64K port & 16K CIR - $4,400

Representative Monthly Internet VPN Service Costs

U.S. to Europe (Infonet)

- 64K local access (50 mile line) - $1,500 in Germany
- 64K port - $1,310

U.S. to Asia (Infonet)

- Local access - ?
- 64K port - $1,750

Representative Monthly VSAT Service Costs

Point-of-sale within the U.S.

- Equipment - $5000 per site
- Shared 256K bandwidth - $100 to $200 per site

U.S. to Europe (Orion)

- Equipment - $14,000 to $25,000 per site
- 128K bandwidth - $15,000 to $20,000

Regional TDMA (Interstate Electronics)

- Equipment - $40,000 per site
- Shared 128K bandwidth - $7,000
- Landing rights - $200 to $1000 per site

Representative Monthly VSAT Service Costs

Regional (Comsat)

- 64Kb/s - $975

South America (GE American)

- 16Kb/s - $375
- 256Kb/s - $2,625

Europe, Russia, Middle East, North Africa (GE American)

- 256Kb/s - $2,917

Representative LEO Service Costs

Iridium

- Equipment - $3000
- 2.4Kb/s - $3 per minute

Globalstar

- Equipment - $2,000
- 9.6Kb/s - $0.50 per minute

Orbcomm

- Equipment - $1,000
- $0.01 per byte

Network Implementation

- Establish network reliability goals.
- Determine required WADGPS algorithm data collection rates, latencies, and dropped packet tolerance.
- Compress raw data if possible to save bandwidth.
- Prepare a RFP for each region and submit it to each potential service provider.
- Ask for service level agreements for the type of service being quoted.
- Select provider based on cost and performance.