



# The Network Technology Spiral

an R&E Perspective

Net2002

University of New Brunswick

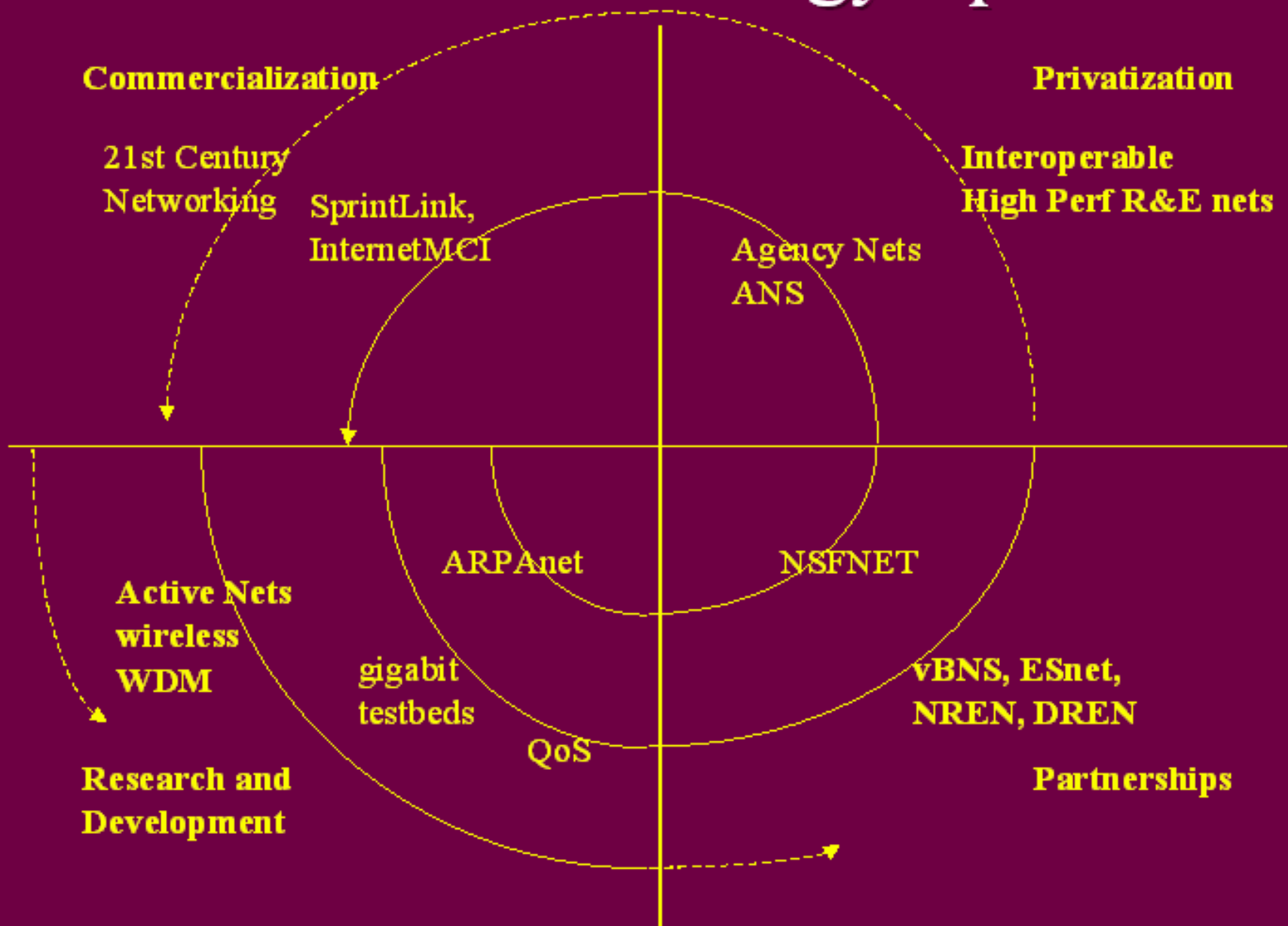
JJ Jamison



# Keynote – Discuss “Big Ideas”

- ◆ **2 Big Ideas for the price of one:**
  - ❖ **The Network Technology Spiral - a different perspective**
  - ❖ **And Canadian R&E Networking effort’s influence on R&E Networking in the US**

# Network Technology Spiral





# Network Technology Spiral

## ◆ Standard Interpretation

- ❖ Technology is developed in the academic community for transfer to the commercial Internet
- ❖ Projects are declared a success and shut down when their offerings can be provided with out NSF support

## ◆ A Different Interpretation

- ❖ R&E Networking advancements do not necessarily map to commercially marketable services
- ❖ Focusing on providing cutting edge networking to advance the capabilities of academic researchers is critical independent of marketability
- ❖ It's the NSF's job to push the edge of the envelop but there are scaling factors that limit how big these projects can grow



# What Doesn't Scale?

## ◆ Money

- ❖ The cutting edge is expensive

## ◆ Wizards

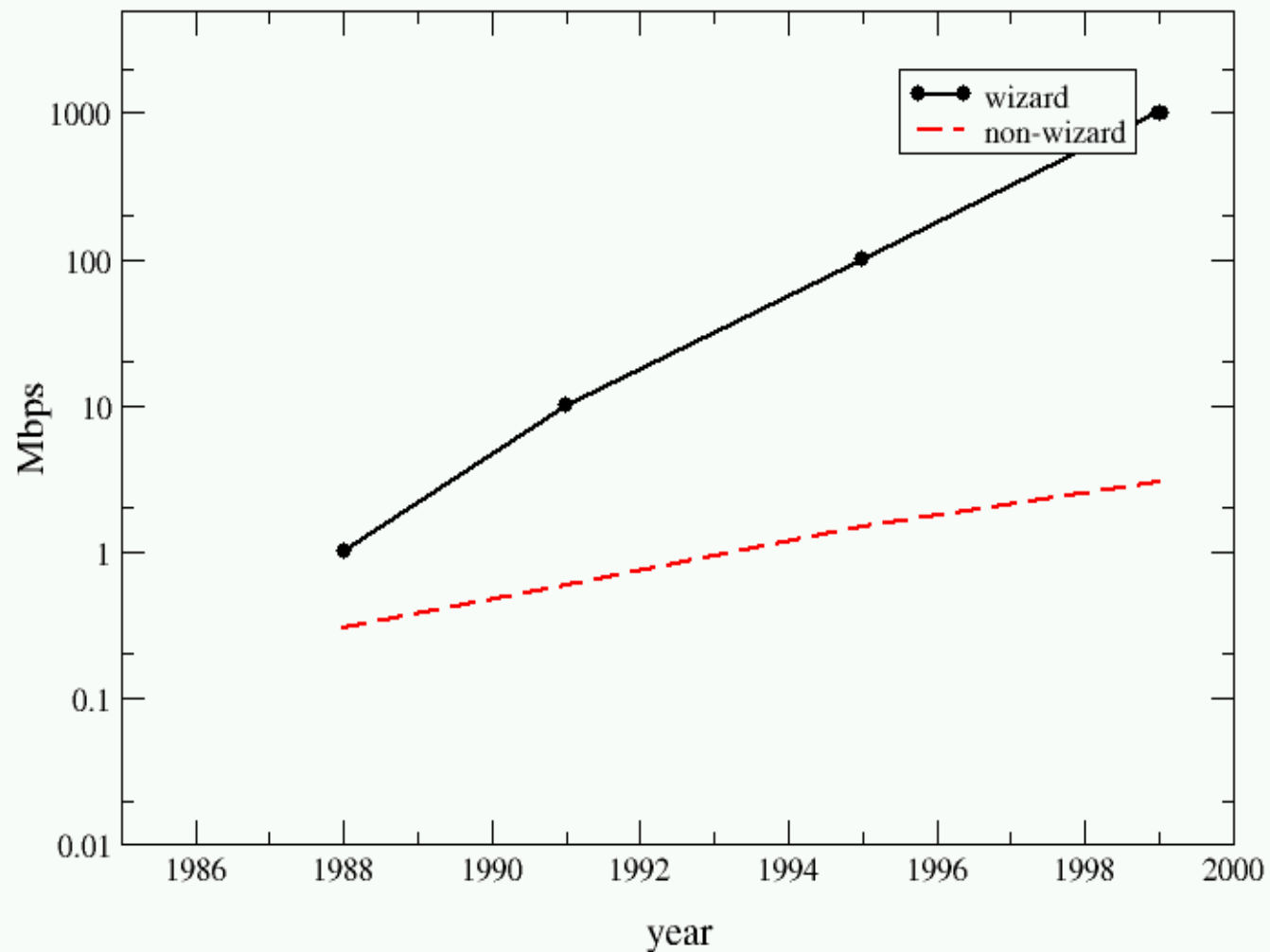
- ❖ What Matt Mathis, of PSC, calls the Wizard Gap is growing

## ◆ Support Resources

- ❖ As networks grow technical and logistical support organizations have to grow with them

# The Wizard Gap

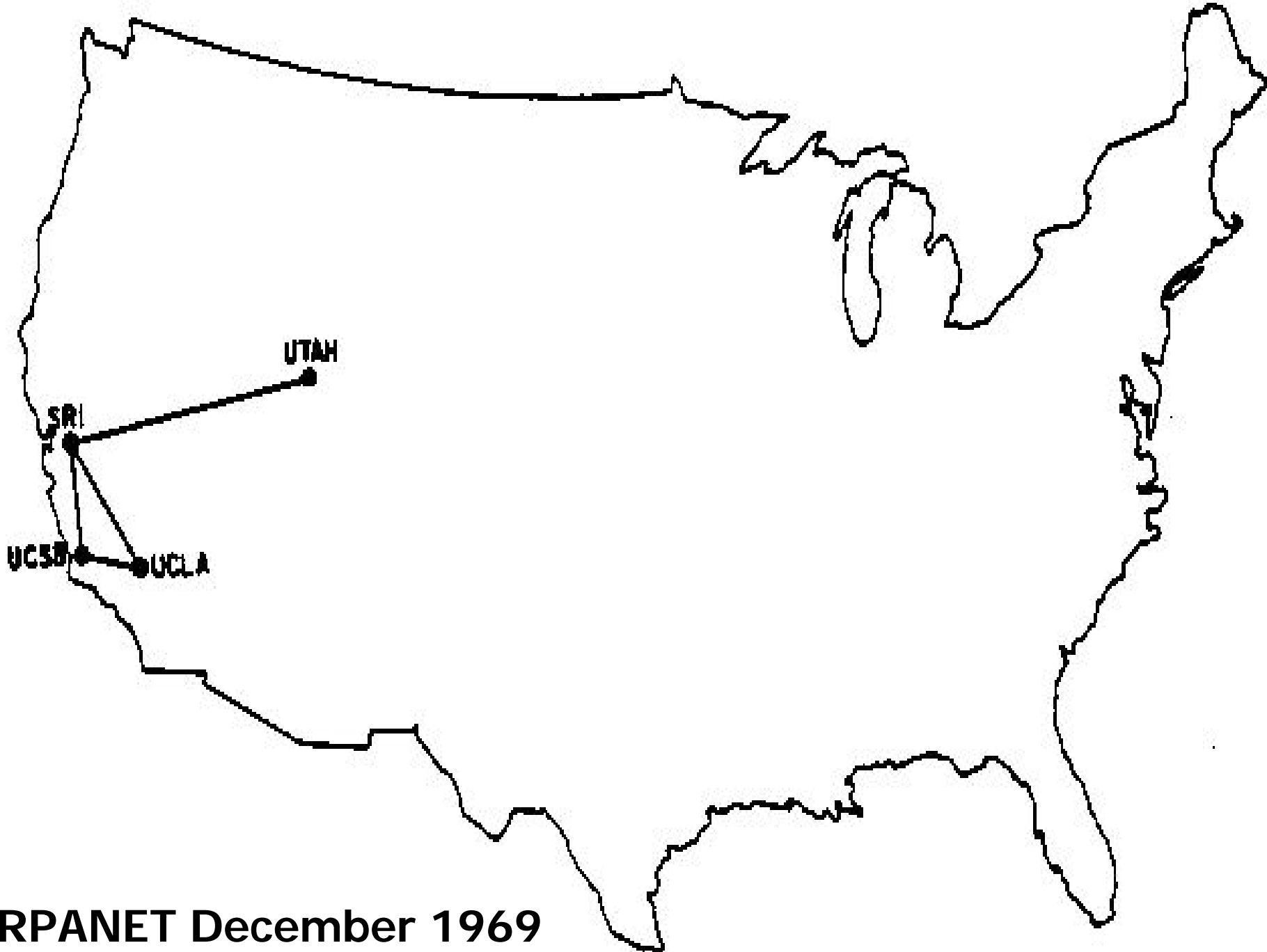
(ratio has gone from 3:1 to 300:1 in last decade)





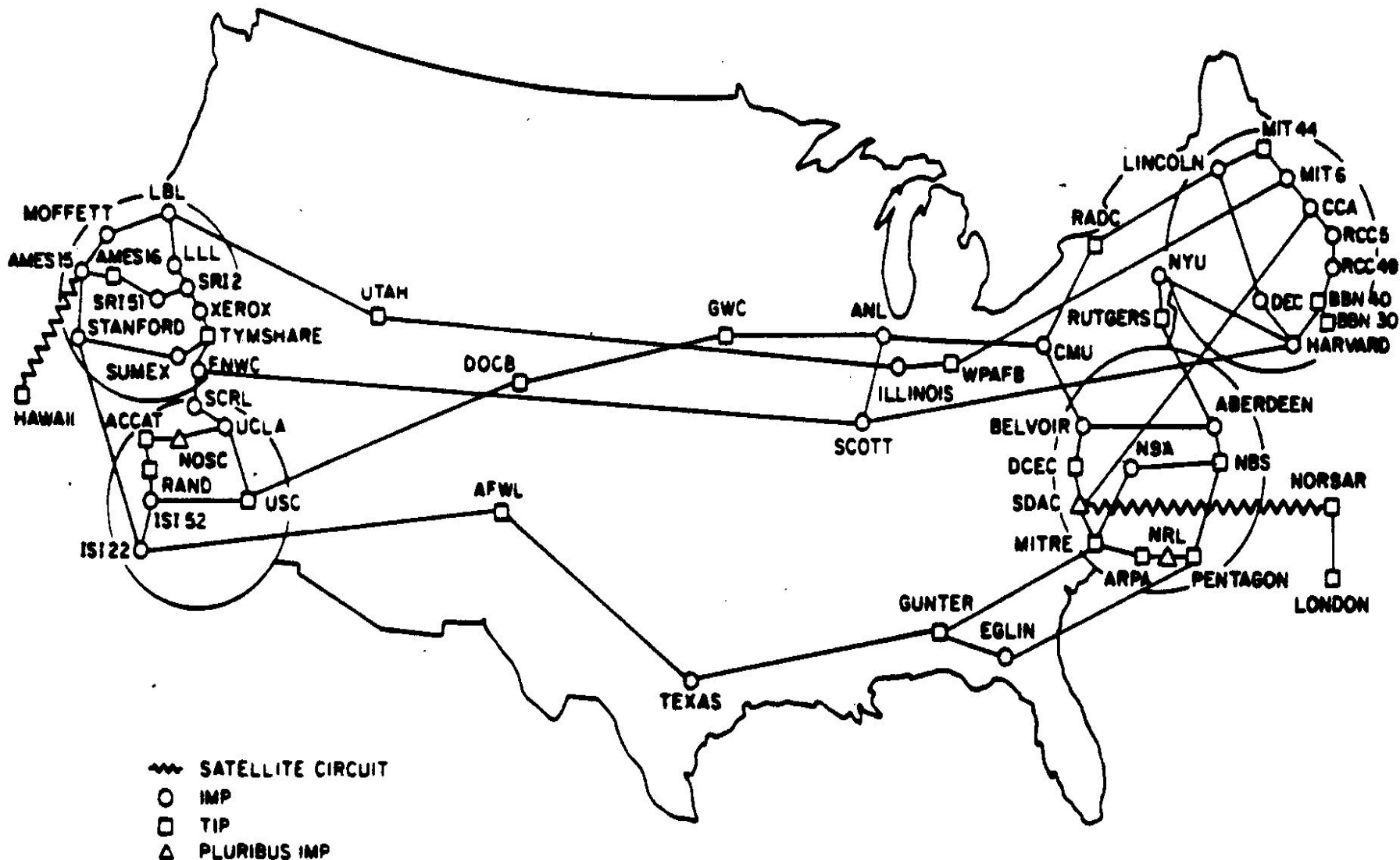
# ARPANET (1969 – 1990)

- ◆ **Funded by ARPA**
  
- ◆ **Connected Universities, Federally Funded and Private Research Labs, and DoD Labs and other Facilities**
  
- ◆ **1983**
  - ❖ **Cutover from NCP to TCP/IP**
  - ❖ **ARPANET split into ARPANET and MILNET**



## ARPANET December 1969

From *ARPANET Completion Report, BBN, 1978*



~ SATELLITE CIRCUIT

○ IMP

□ TIP

△ PLURIBUS IMP

(NOTE THIS MAP DOES NOT SHOW ARPA'S EXPERIMENTAL SATELLITE CONNECTIONS)

NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES

# ARPANET July 1977

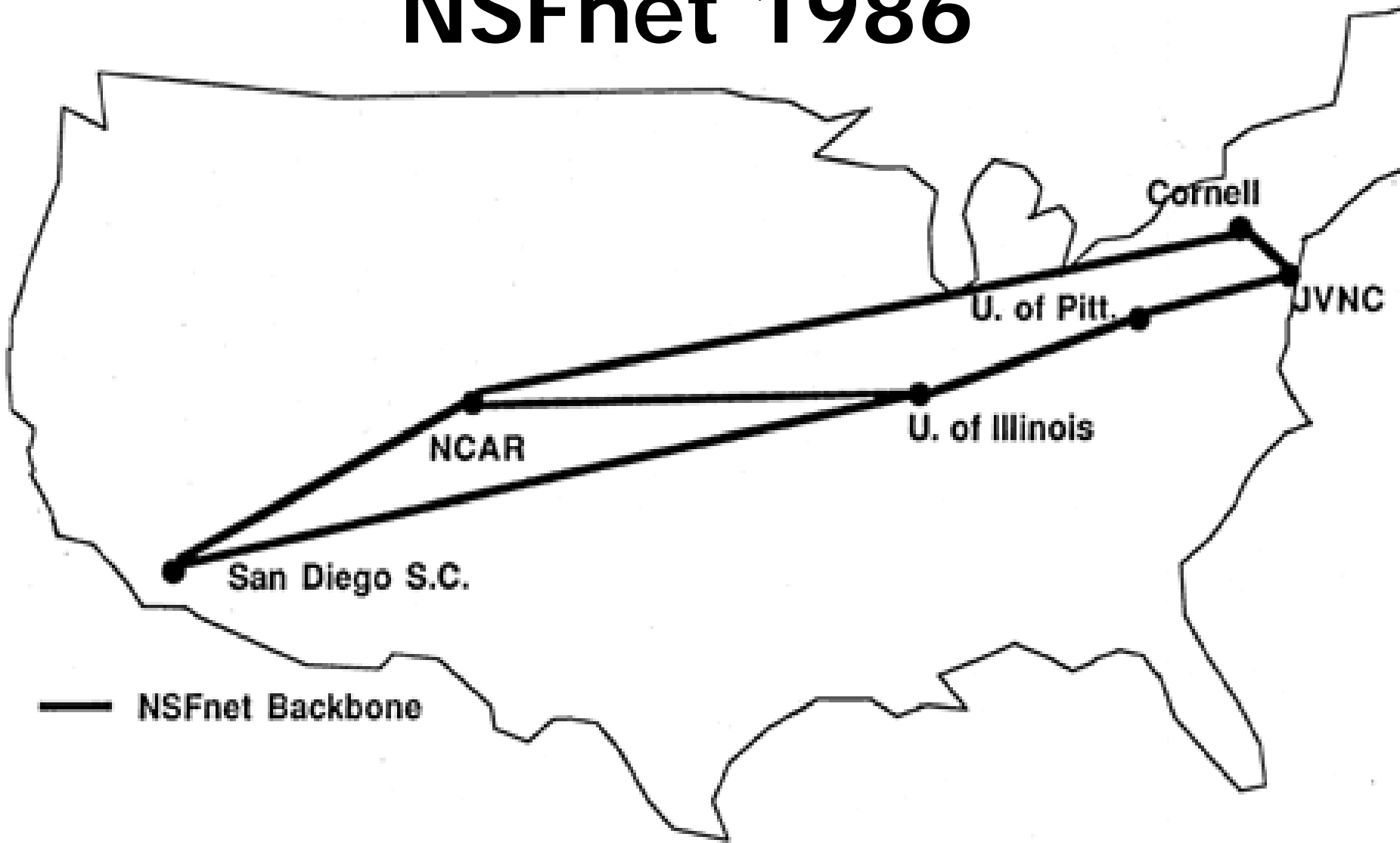
From *ARPANET Completion Report*, BBN, 1978



# NSFnet (1985 – 1995)

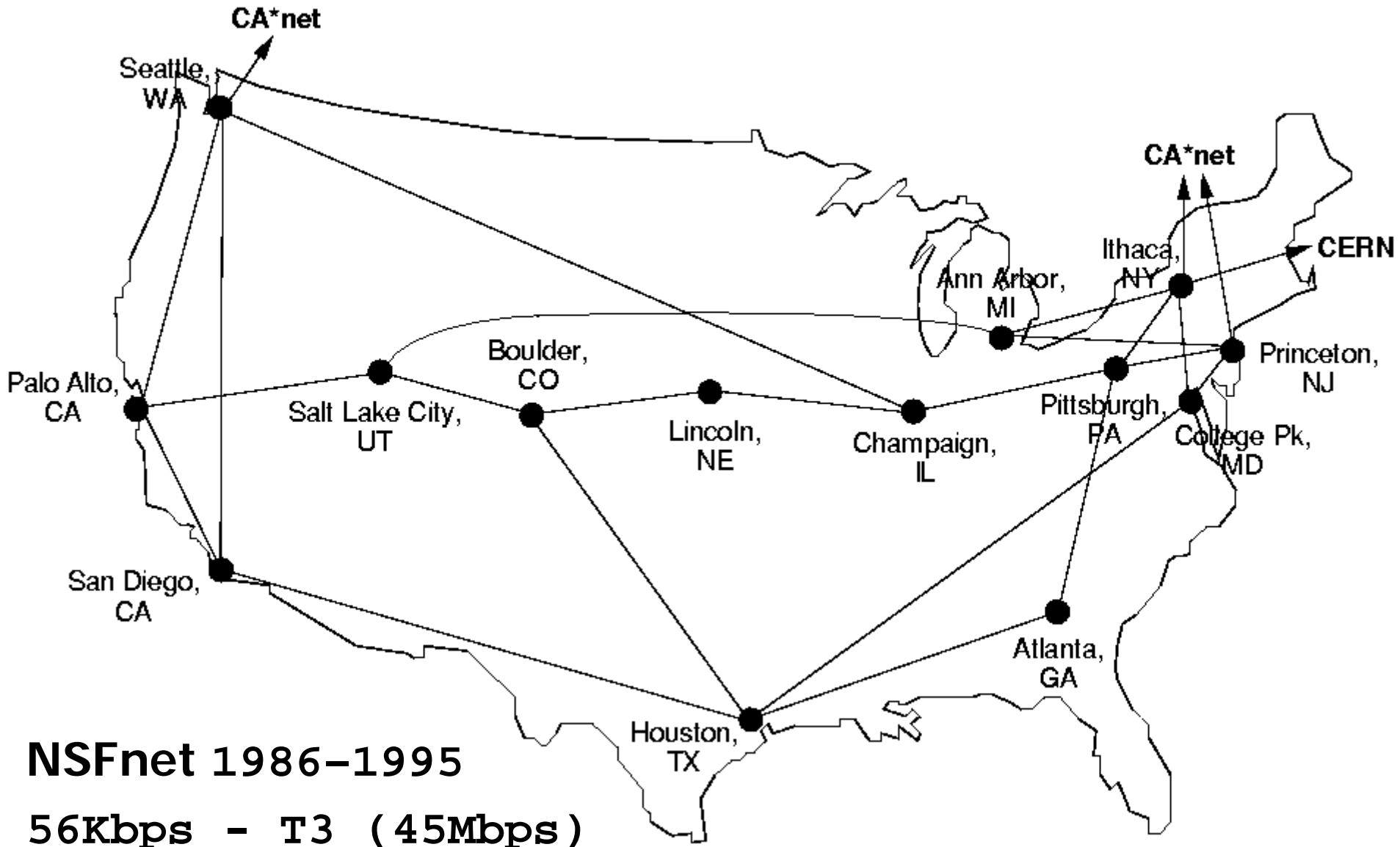
- ◆ **Started off connecting 5 Supercomputer Centers**
  - ❖ JvNSC, SDSC, NCSA, CTC, PSC
  
- ◆ **Grew to connect Universities and Regional Nets**
  
- ◆ **Served as the Internet's backbone**
  - ❖ grew even further and faster as the Internet grew
  
- ◆ **1995**
  - ❖ Internet is served by multiple commercial backbones
  - ❖ NSF shuts the NSFnet down

# NSFnet 1986



**NSFnet Backbone Network**

# NSFNET T1 Network 1991



**NSFnet 1986-1995**

**56Kbps - T3 (45Mbps)**



## vBNS (1995 – 2000)

- ◆ **vBNS comes up as the NSFnet goes offline**
  - ❖ **Connects 5 Supercomputer Centers**
    - ◆ **CTC, NCAR, NCSA, PSC, SDSC**
  - ❖ **And 4 NAPS: Ameritech, MFS, PacBell, Sprint**
  
- ◆ **1997**
  - ❖ **vBNS' role expanded to include service to the Top 100 US Research Universities**
  
- ◆ **2000**
  - ❖ **vBNS morphs into vBNS+**
    - ◆ **NSF grants a 3 year extension of the vBNS project on a no cost (to NSF) basis**

# vBNS Production Network

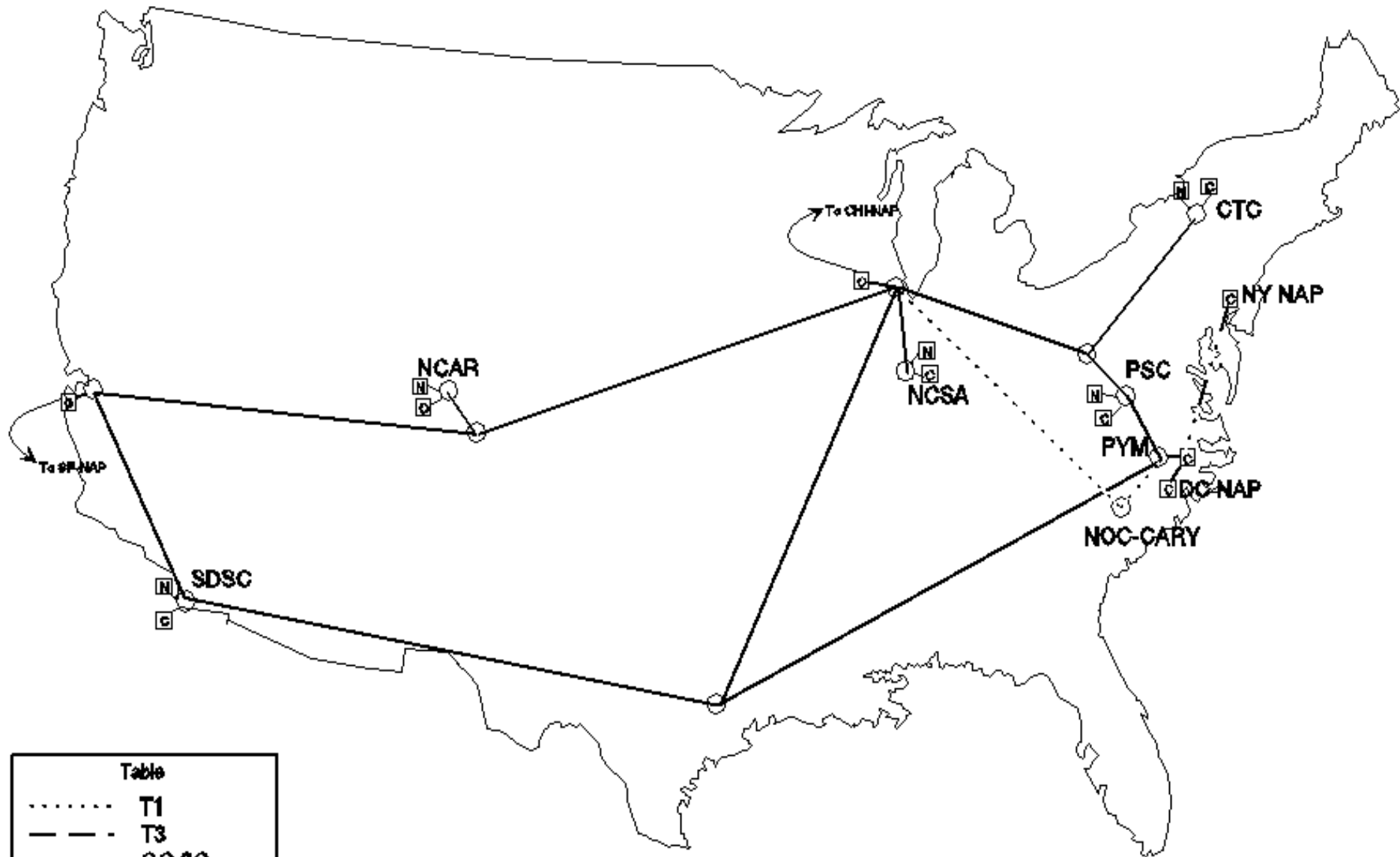


Table	
-----	T1
- - - - -	T3
—————	OC-3C
Ⓝ	NetStar
Ⓢ	Cisco
○	Lightstream

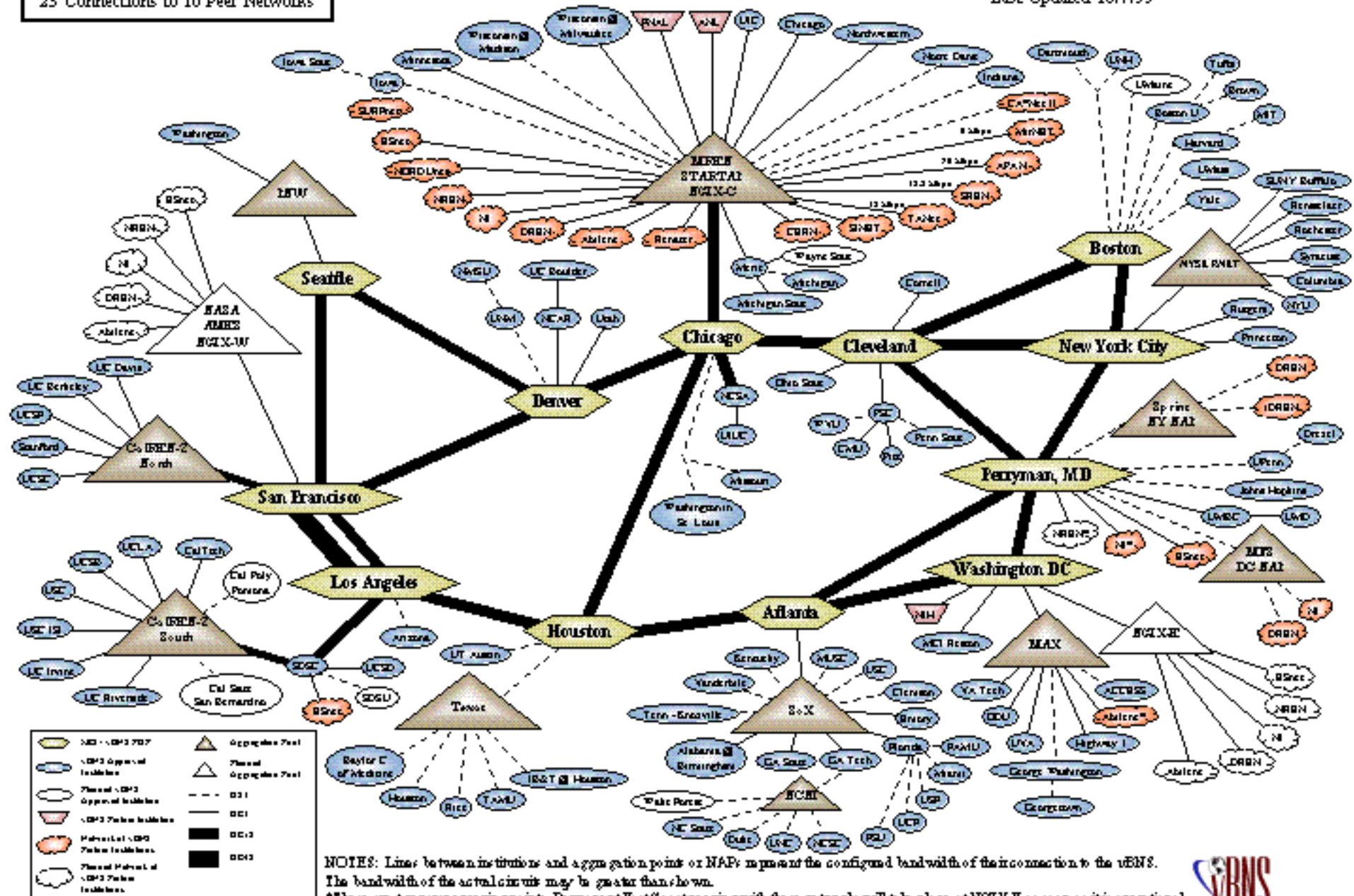
## vBNS 1995

Served only Supercomputer Centers

104 Institutions Connected  
23 Connections to 16 Peer Networks

# vBNS Logical Network Map

Last Updated 10/7/99

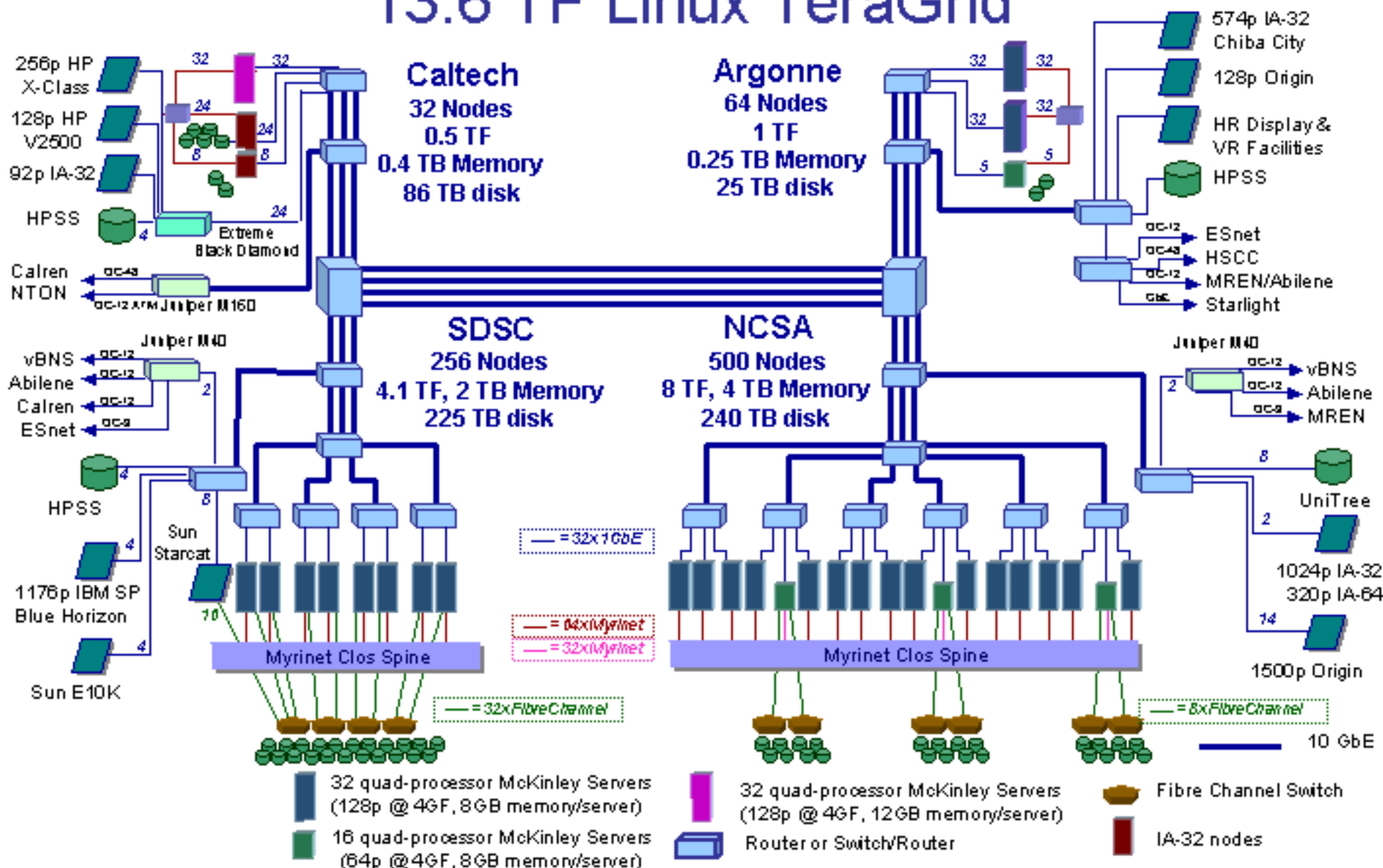




## DTF (2002 – ?)

- ◆ **Distributed TeraGrid Facility**
- ◆ **Embedded IP Network that serves as the backplane of the TeraGrid (a distributed Supercomputer)**
- ◆ **The TeraGrid is distributed across 4 facilities**
  - ❖ **NCSA, ANL, SDSC, CalTech**
- ◆ **There is talk of expanding the TeraGrid to include additional Supercomputer Centers**

# 13.6 TF Linux TeraGrid





## Is there a problem here? No

- ◆ **When big projects end networks like the Commercial ISPs (for NSFnet) and vBNS+ and Abilene (for vBNS) pick up the slack and in many ways do a better job**
- ◆ **Regional Networks (AKA GigaPoPs) help scale money, wizards, and support across their user bases**
- ◆ **Resources get reapplied to new projects**



# Canadian R&E Networking

## Has a Big Impact on R&E Networking in the US

- ◆ North American peering
  - ❖ ITN
    - ◆ Transit between Europe and Asia
    - ◆ Transit for US Federal Networks
    - ◆ Transit for Latin America (AMPATH)
  - ❖ North American International Meet Points
    - ◆ Sites CA\*net3/4 peers at (Seattle, Chicago, NYC) becoming main international peering points
  - ❖ GTRN
  
- ◆ Lambda Networking Efforts
  - ❖ STAR LIGHT

# International Peering

**SEA**

Abilene	TAnet2
CA*net3	APAN
ESnet	DREN
	AARnet

**SNV**

Abilene	ESnet
SINET	Singaren
GEMNET	WIDE

**LA**

UNINET
Abilene

**SD**

CUDI
Abilene

**EIPaso**

CUDI
Abilene

**Miami**

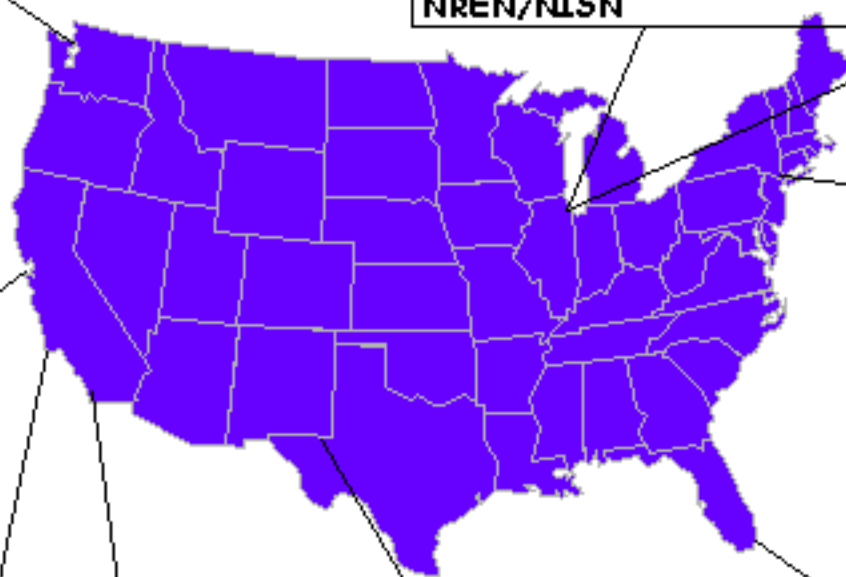
Argentina	
Brazil	
Chile	
Colombia	Sao Paulo

**NGIX-CH/STARTAP**

Abilene	BELnet	CA*net3
ESnet	CERNET	FASTnet
DREN	Singaren	Renater
vBNS+	TAnet2	CERN
	GEMNET	IUCC
		HEANET
	KOREN/KREONET2	
	NREN/NISN	

**STARLIGHT**

Abilene	CA*net4
SURFnet	CERN
NORDUnet	ESnet
APAN	NREN/NISN
	Renater
	FASTnet



**NYC**

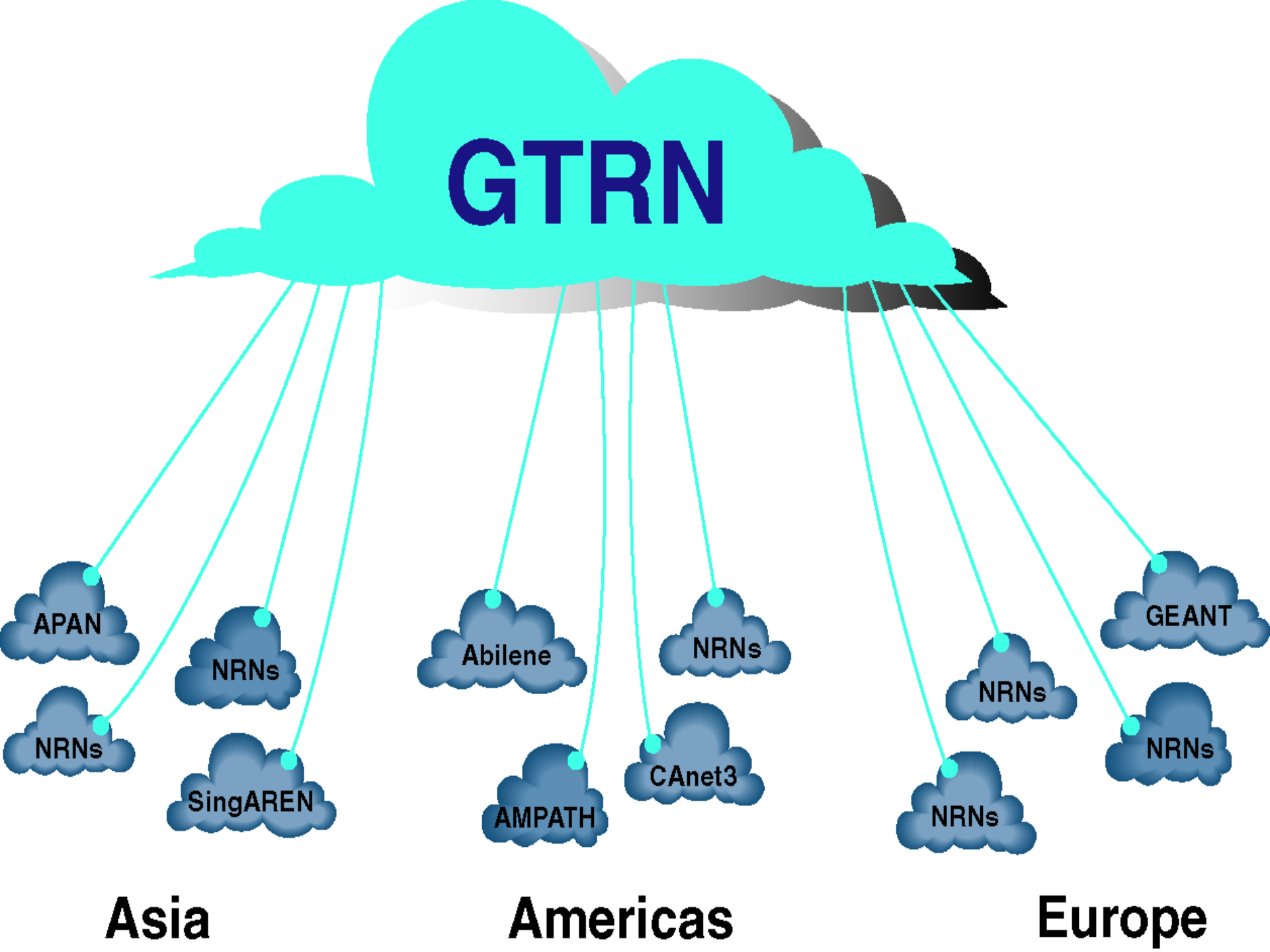
Abilene	JAnet
ESnet	BELnet
	HEAnet
	NORDUnet
GEANT	CA*net3



# GTRN

## Global Terabit Research Network

- ◆ A collaborative effort between Asian, North American, and European R&E Networks
- ◆ Spearheaded by Michael McRobbie & Steven Wallace of Indiana University
- ◆ Goal is to create a Global R&E Backbone connecting GNAP (Global Network Access Points)
- ◆ In place today:
  - ❖ Two OC-48 circuits between London and Frankfurt and NYC
  - ❖ A router in NYC
  - ❖ A tunnel across Abilene to Chicago
  - ❖ A router in Chicago
  - ❖ A tunnel across Abilene to a router in Seattle ( Routers in NYC
- ◆ Working on 2 OC-12s from Seattle to Japan



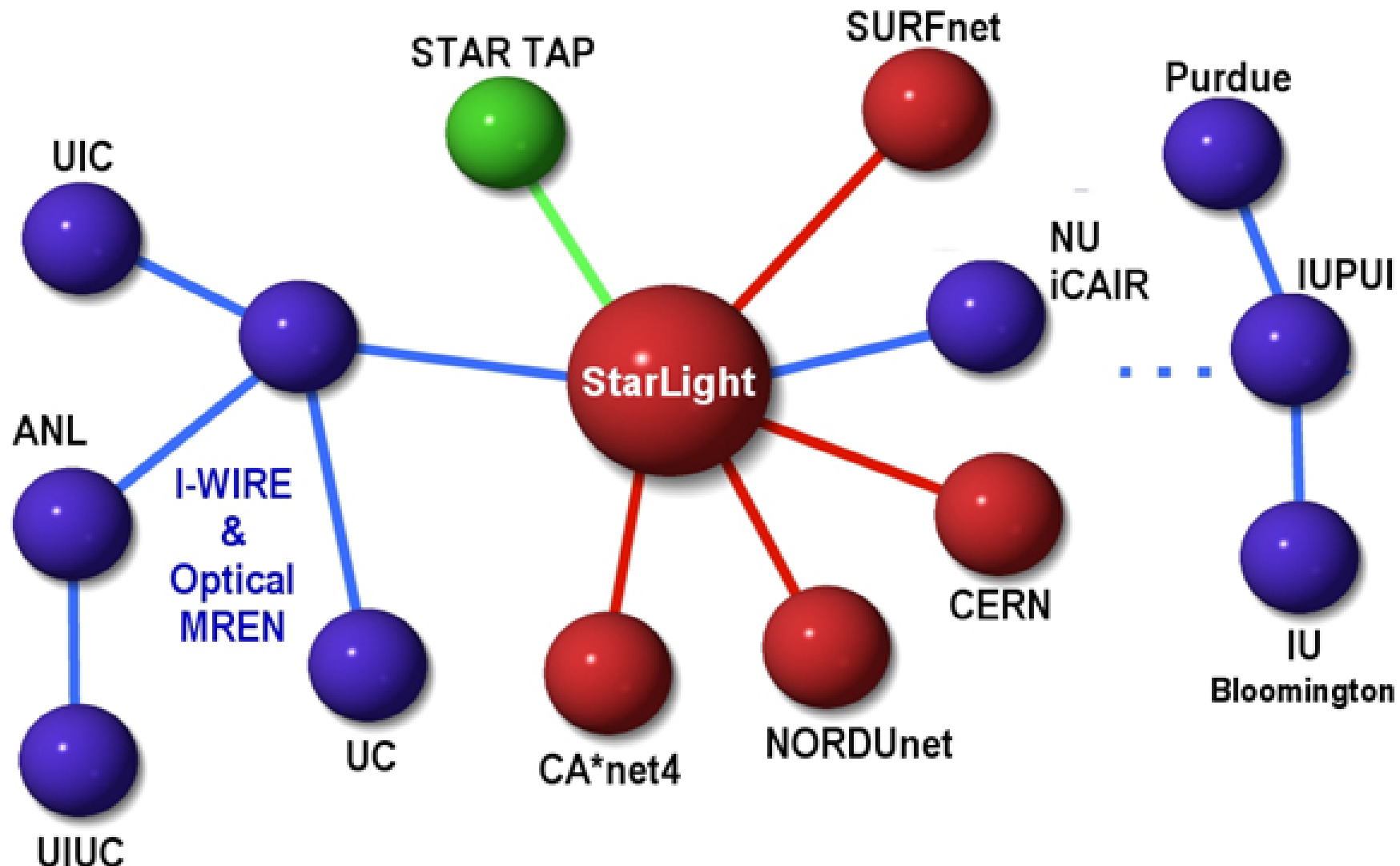


# STAR LIGHT

- ◆ **Bring Us Your Lambdas**
- ◆ **Optical International Connection Point for Research and Education Networks at Northwestern University in Chicago**
- ◆ **UIC, NWU, ANL, in partnership with Canada's CANARIE and Holland's SURFnet**
- ◆ **[www.startup.net/starlight](http://www.startup.net/starlight)**

# STARLIGHT<sup>SM</sup>

The Optical STAR TAP<sup>SM</sup>





# A few words about Bill St. Arnaud



# A few words about Bill St. Arnaud

- ◆ **A Tireless Ambassador of Canadian R&E Networking**
- ◆ **Does an outstanding job representing Canadian R&E Networking to the US and the rest of the world**
- ◆ **Is a true visionary and has influenced and made contributions to R&E Networking Projects far beyond Canada**
- ◆ **And in his "spare" time edits one hell of an news list (CANet-3-NEWS)**





# Thank You

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