
Reality and the “next generation” projects

NGI, Internet 2 and the real world

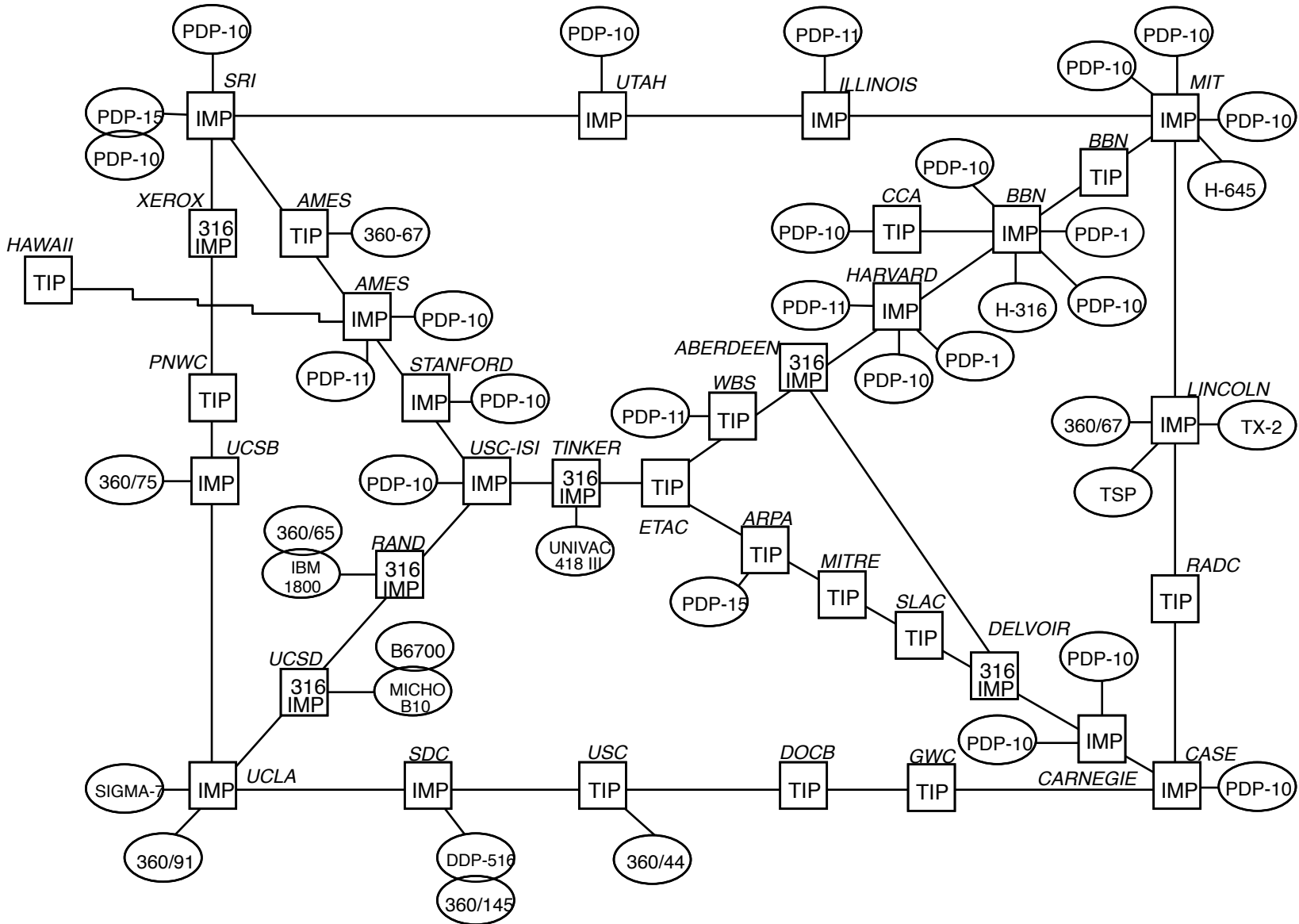
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Historical Picture

- ◆ US government has been key to development of the Internet
- ◆ basic research
- ◆ advance state of the art
- ◆ proof of concept
- ◆ seed funding
- ◆ but total US funding “small”

ARPANET

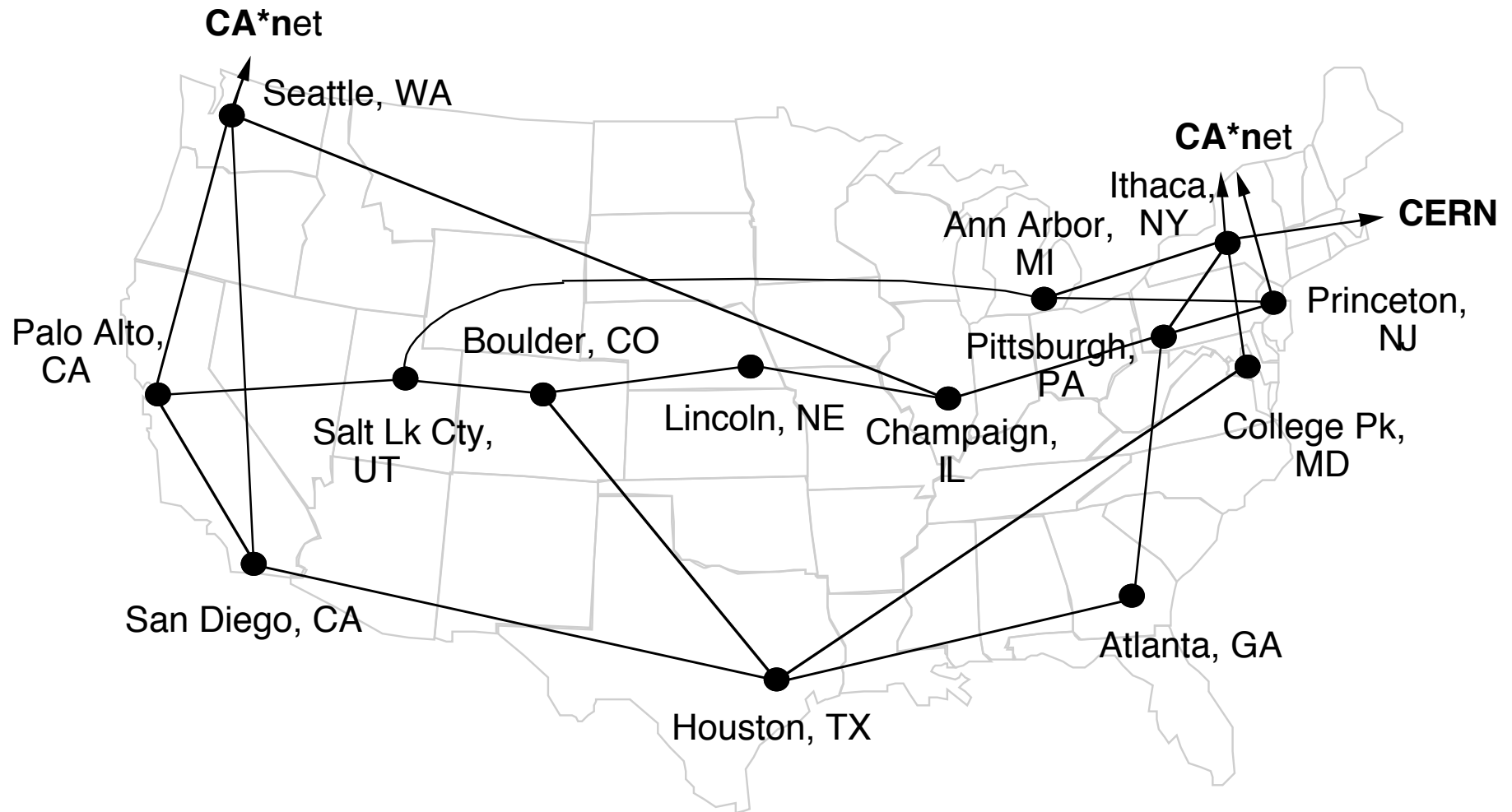


ARPANET, contd.

- ◆ followed basic datagram decision
QoS impact
- ◆ routers / routing
IMPs, link-state routing
- ◆ transport protocols
NCP - TCP/IP
- ◆ applications
FTP, TELNET, SMTP ...
- ◆ i.e. everything

NSFnet

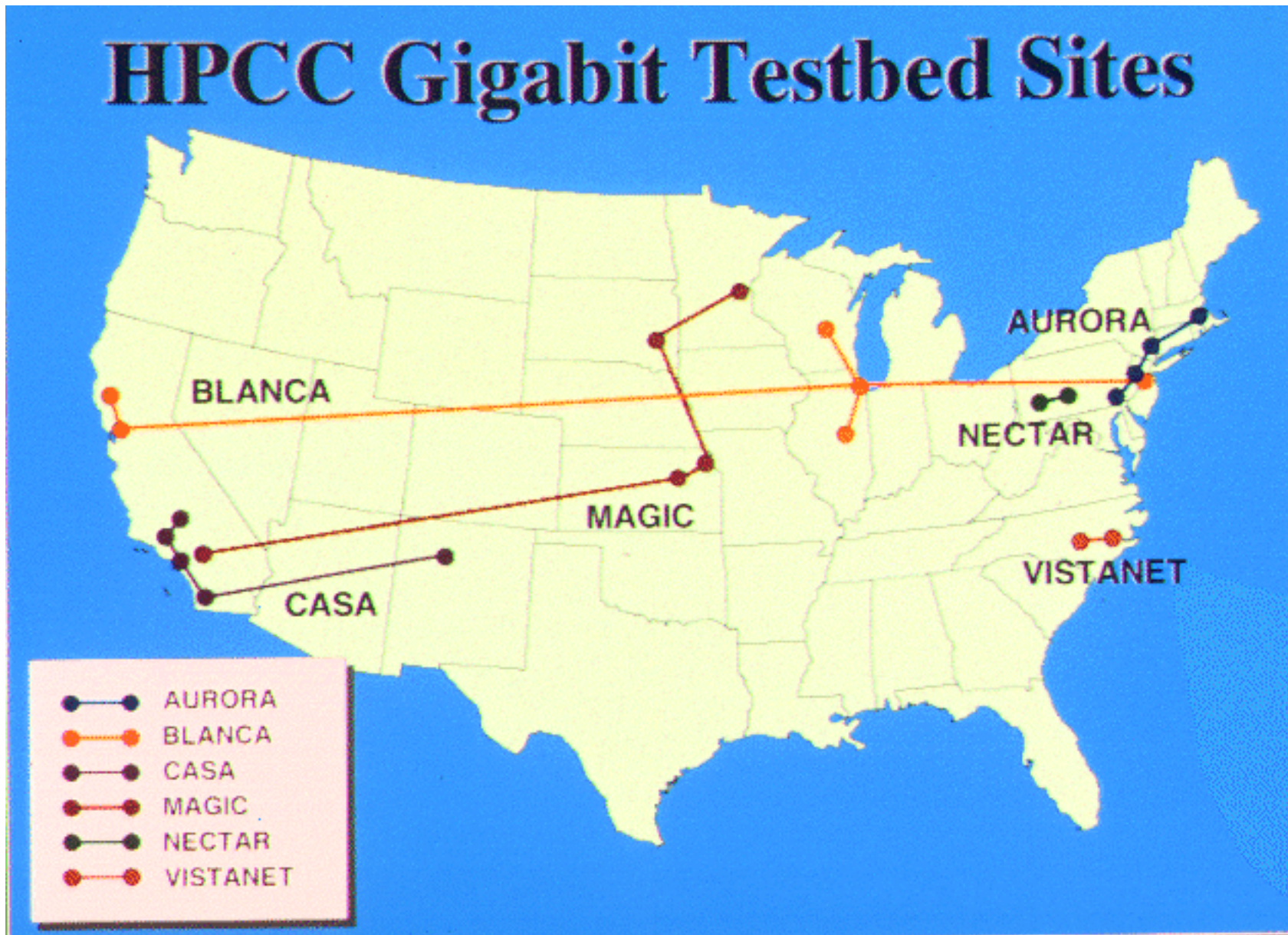
NSFNET T1 Backbone 1990



NSFnet, contd.

- ◆ also everything
- ◆ plus proof of concept for high-speed networks
 - no, the commercial world was not ready
 - in spite of AT&T offer to Congress
- ◆ kick start for general use
- ◆ AUP forced commercial net development

Gigabit Test Networks



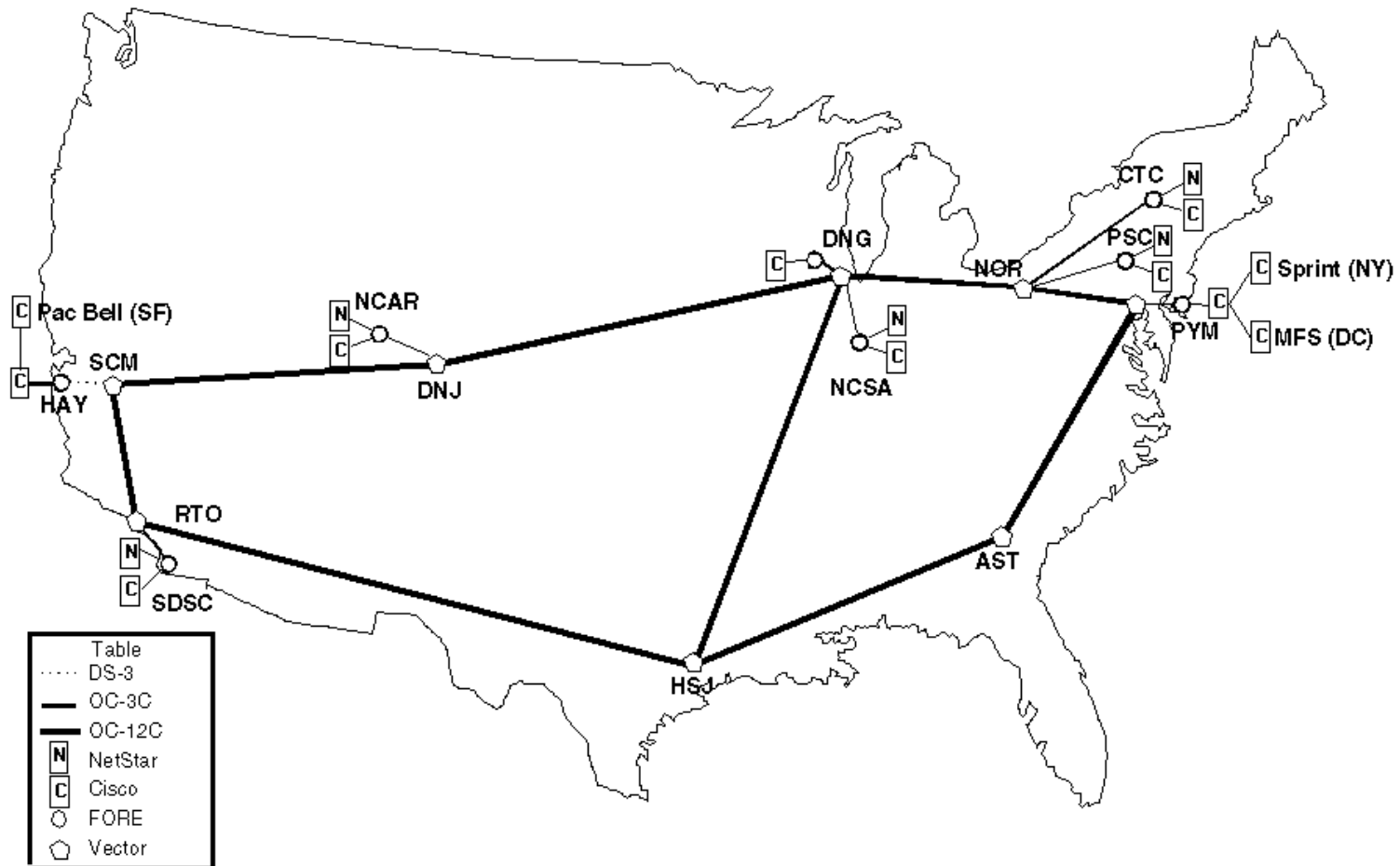
Gigabit Test Networks

- ◆ HPCC - 12 US government agencies
- ◆ Government funds long term, high risk research
- ◆ 6 test nets - 24 sites
- ◆ ATM @ 155mb & 622 Mb
- ◆ SONET @ 2.4 Gb
- ◆ look at problems involved with very high speed networking - seemed to focus on ATM

vBNS

◆ very High-Speed Backbone Network Service

vBNS - Today
03-19-97



vBNS

- ◆ NSF funded, MCI contractor
- ◆ “to connect supercomputer centers”
- ◆ “platform for developing and testing Broadband Internet Services and equipment for the future”
- ◆ increase to gigabit speeds “in 1990s”
- ◆ now expanding to ~100 sites
connections program

Internet 2

- ◆ high-ed initiative
- ◆ some confusion over goals
- ◆ some confusion with NGI

I2 History

- ◆ first there was lamentations
and then there were lamentations
- ◆ Monterey Futures Group (Mfug)
needs (& solutions)
- ◆ enter Educom
collected Internet I geeks, university pols, ...
meetings at FARNET, in Ann Arbor, in Colorado
Springs leading up to Oct meeting in Chicago
- ◆ 40ish “R1” universities said OK
\$25K now for organization, “up to” \$500K later for
net
- ◆ then the prez talked about NGI & I2
- ◆ since then more confusion

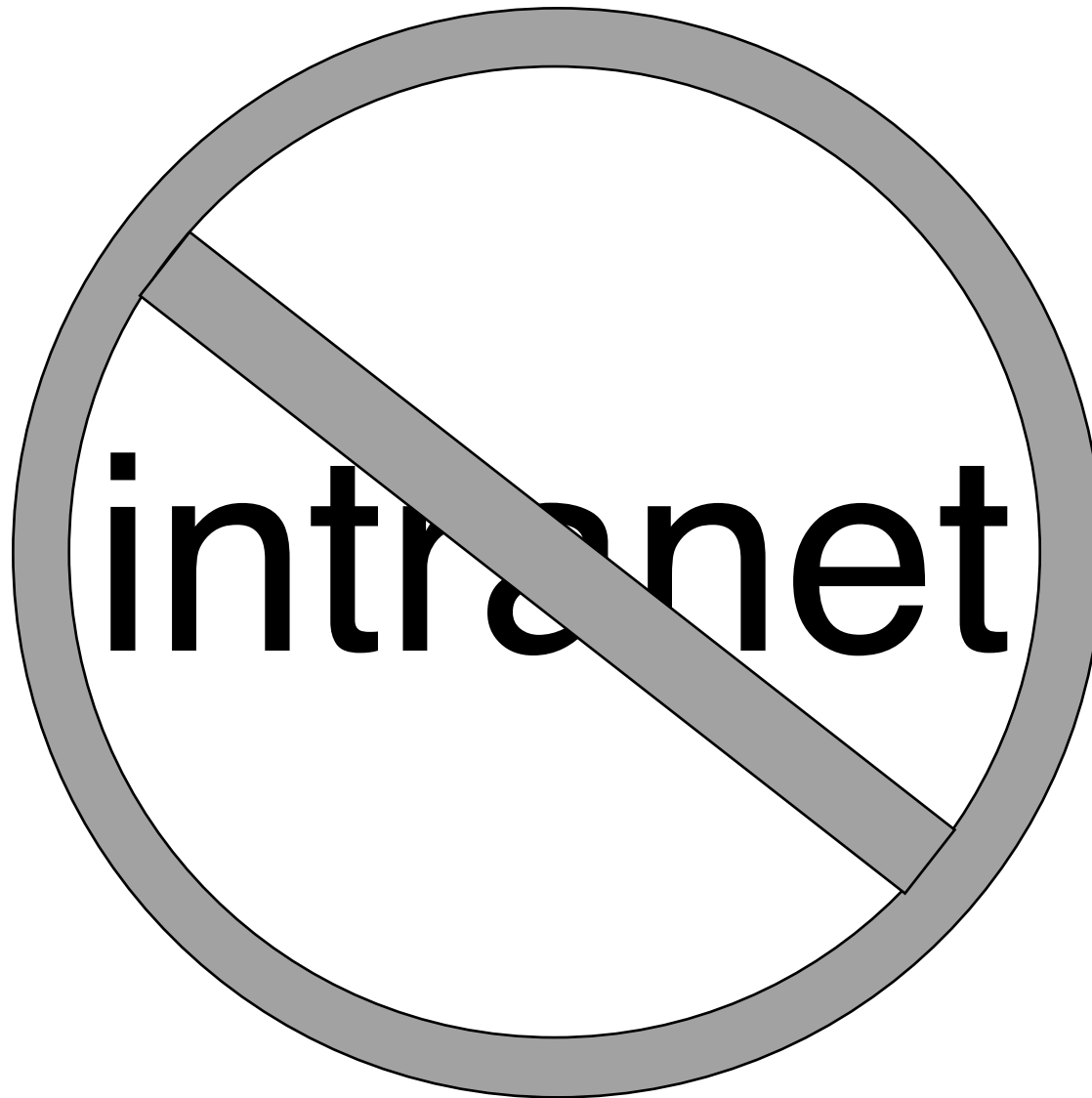
I2 Members

Arizona State	New York	Univ Cincinnati	Univ Washington
Boston	North Carolina State	Univ Colorado	Univ Wisconsin Madison
Brown	North Dakota State	Univ Delaware	Univ Wisconsin Milwaukee
California Inst of Tech	Northeastern	Univ Florida	Univ Wyoming
Carnegie Mellon	Northwestern	Univ Georgia	Utah State
Case Western Reserve	Ohio	Univ Hawaii	Vanderbilt
Clemson	Ohio State	Univ Houston	Virginia Commonwealth
Colorado State	Oklahoma State	Univ Illinois Urbana-Champaign	Virginia Tech
Columbia	Old Dominion	Univ Iowa	Washington State
Cornell University	Oregon State	Univ Kansas	Yale
Dartmouth College	Pennsylvania State	Univ Kentucky	
Duke	Princeton	Univ Michigan	
Emory	Purdue	Univ Minnesota	
Florida A&M	Rensselaer Polytechnic Inst	Univ Maryland	
Florida Atlantic	Rice	Univ Massachusetts	
Florida International	Rutgers	Univ Missouri	
Florida State	Stanford	Univ Nebraska	
George Mason	Syracuse	Univ New Hampshire	
George Washington	Texas A&M	Univ New Mexico	
Georgetown	Texas Tech	Univ North Carolina	
Georgia Inst of Tech	Tulane	Univ Notre Dame	
Georgia State	Univ Alabama	Univ Oklahoma	
Harvard	Univ Alabama Birmingham	Univ Oregon	
Indiana	Univ Alaska	Univ Pennsylvania	
Iowa State	Univ Arizona	Univ South Florida	
Johns Hopkins	Univ Arkansas	Univ Southern California	
Kansas State	Univ California Berkeley	Univ Tennessee	
Lehigh	Univ California Davis	Univ Texas	
Massachusetts Inst Tech	Univ California Los Angeles	Univ Utah	
Michigan State	Univ Central Florida	Univ Vermont	
Mississippi State	Univ Chicago	Univ Virginia	

So What Is It Not?



What Else Is It Not?



Basic Mission

- ◆ pre-competitive technology development environment
- ◆ high-speed
- ◆ QoS enabled
- ◆ next generation applications

GiGaPoP!?

- ◆ part of the given
- ◆ definition followed term
- ◆ current definition
 - service connection point
 - multiple universities
 - multiple services
 - ISP(s)
 - inter-GP connectivity
 - telephone?

Inter-GigaPop Connections

- ◆ vBNS is a candidate initial connectivity service
- ◆ need QoS hooks
- ◆ like to have alternatives

Strategic Objectives

- ◆ enable advanced applications
 - add functionality to existing apps
 - create new apps
- ◆ strengthen the Universities in their research and education mission
- ◆ pioneer the introduction of:
 - Quality of Service
 - Advanced Multicast Support
 - IPv6
- ◆ establish the gigaPoPs as effective service points

So Why?

- ◆ “Quality of Service” control
 - believed to be a key enabler for advanced applications
 - particularly for “real-time” applications
- ◆ multicast support
 - one-to-many
 - few-to-few
- ◆ IPv6
 - an answer without a question?
 - or a key enabler for growth and for other advanced features?

More on gigaPoPs

- ◆ concentrate demand by local universities
 - bottom up not top down GP setup
- ◆ attract competitive providers
 - multiple ISPs - VC connection to each customers
- ◆ diversity of technical and organizational styles

Emerging GigaPoPs

- ◆ Alabama, Florida, Georgia, Tennessee
- ◆ New England
- ◆ Ohio
- ◆ DC, Maryland, Virginia
- ◆ Westnet states
- ◆ Michigan
- ◆ Texas
- ◆ Southern California
- ◆ Metro NYC area
- ◆ Chicago region
- ◆ Oregon
- ◆ Western Pennsylvania
- ◆ North Carolina
- ◆ Alaska, Washington
- ◆ Northern California
- ◆ Upstate New York

Diversity of GigaPoPs

- ◆ geographic scope
 - campus, metro area, state
- ◆ technology
 - ATM, SONET, IP
- ◆ what needs to be the same despite differences?
 - inter-gigaPoP routing policy and design
 - measurement policy, design, and implementation
 - admissions control for QoS
 - inter-NOC trouble tickets
 - security coordination

QoS Issues

- ◆ what are the needs each application has?
 - bandwidth
 - packet loss
 - delay and jitter
- ◆ what basis
 - per-flow?
 - per-path?

1997 Technical Aspirations

- ◆ high-speed uncongested best-efforts IPv4 service
- ◆ T3 and OC3 rates will be typical
- ◆ OC12 to some sites
- ◆ about 12 vBNS connect points
- ◆ about 36 universities connected
- ◆ figure how to measure utilization, performance, flows . . .
 - info to provide fodder to figure how-to “do” accounting

1997 Applications Aspirations

- ◆ application requirements documented
- ◆ network services assumptions forecast
- ◆ identifying “Internet 2” applications
 - demos in Oct & intercampus application trials
- ◆ establishing QoS requirements
 - note IP is the bearer service
 - IP QoS requirements & experiments
- ◆ application-level network models

1998 Technical Aspirations

- ◆ growing number of gigaPoPs
- ◆ growing number of institutions connected
- ◆ introduction of Quality of Service support
- ◆ advanced multicast support
- ◆ introduction of IPv6 support

1998 Applications Aspirations

- ◆ initial applications in production
- ◆ advanced apps in trial
- ◆ QoS “toolkits” available
- ◆ large scale demos
- ◆ I2 instrumented to provide input for network modeling efforts

I2 Issues

- ◆ why (in the context of the campus)
- ◆ with what money
- ◆ production vs. developmental net
- ◆ IP vs ATM
- ◆ QoS granularity
- ◆ role vs NGI

Next Generation Internet

- ◆ research in applications, services and infrastructure
- ◆ \$100M/yr - 5 year program
- ◆ accelerate introduction of new networking services
 - builds on current “very strong agency programs”
- ◆ keep US ‘in the lead’
- ◆ 3 sets of goals

NGI Goal 1

- ◆ high-performance network fabric
- ◆ 2 subgoals
 - a/ ~100 sites at 100x current speed (~155Mb)
work with vBNS & Internet 2
NSF connections program + ESnet
must be “highly reliable”
 - b/ ~10 sites at 1000x current speed (~1Gb)
Gb end-to-end
advanced network management + negotiated QoS
can “break periodically”

NGI Goal 2

- ◆ advanced network service technologies
- ◆ promote experimentation with next generation networking technologies
 - QoS, security, robustness, network management (including bandwidth sharing), system operations, new routing, security, multicast & mobility protocols, computer operating systems, distributed application environments
- ◆ define qualitative metrics for above
- ◆ move technologies to commercial net

NGI Coal 3

- ◆ revolutionary applications
- ◆ demonstrate applications that can not be done over “today’ s Internet”
- ◆ e.g. distributed computing & collaborative apps
- ◆ others that “may be approved”
 - national security response & crisis response
 - distance education
 - teleoperation (extreme reliability & guaranteed delay bounds)
- ◆ identify a small number of demo apps for each agency + apps from industry and academia

The Real World

- ◆ what is QoS?
 - instance of application vs McDonalds?
 - more than one ISP “product”
 - CBR?
- ◆ policy/authentication/settlements
 - needed to apply QoS to real world
- ◆ confusion in I2 / NGI roles
- ◆ NSF / MCI relationship
 - NSF pay vBNS user fees
- ◆ resource split between NGI goals
 - how important is Fed development of ultra-speed nets
 - vs NGI goal 2 projects?