IPv6 and Internet2

Bill Cerveny
Network Services, Internet2

US IPv6 Summit
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- IPv6 Participation and Activities
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Background on Internet2 and Abilene

What's Internet2?

- An "Advanced Networking Environment" to use for research and education
  - Abilene backbone
  - Network research
  - IPv6, Multicast
  - End-to-End Performance Initiative
  - Applications and Services – e.g. Commons and InCommon
  - Middleware
  - Security

Internet2 Membership

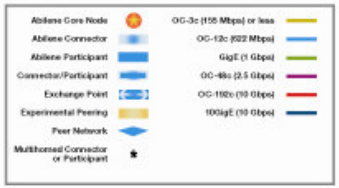
- University
  - United States institutions of higher education
- Corporate
  - For-profit companies
- Affiliate
  - Non-profit and other research or education organizations
- Association
  - Non-profit, higher education associations with national or international scope

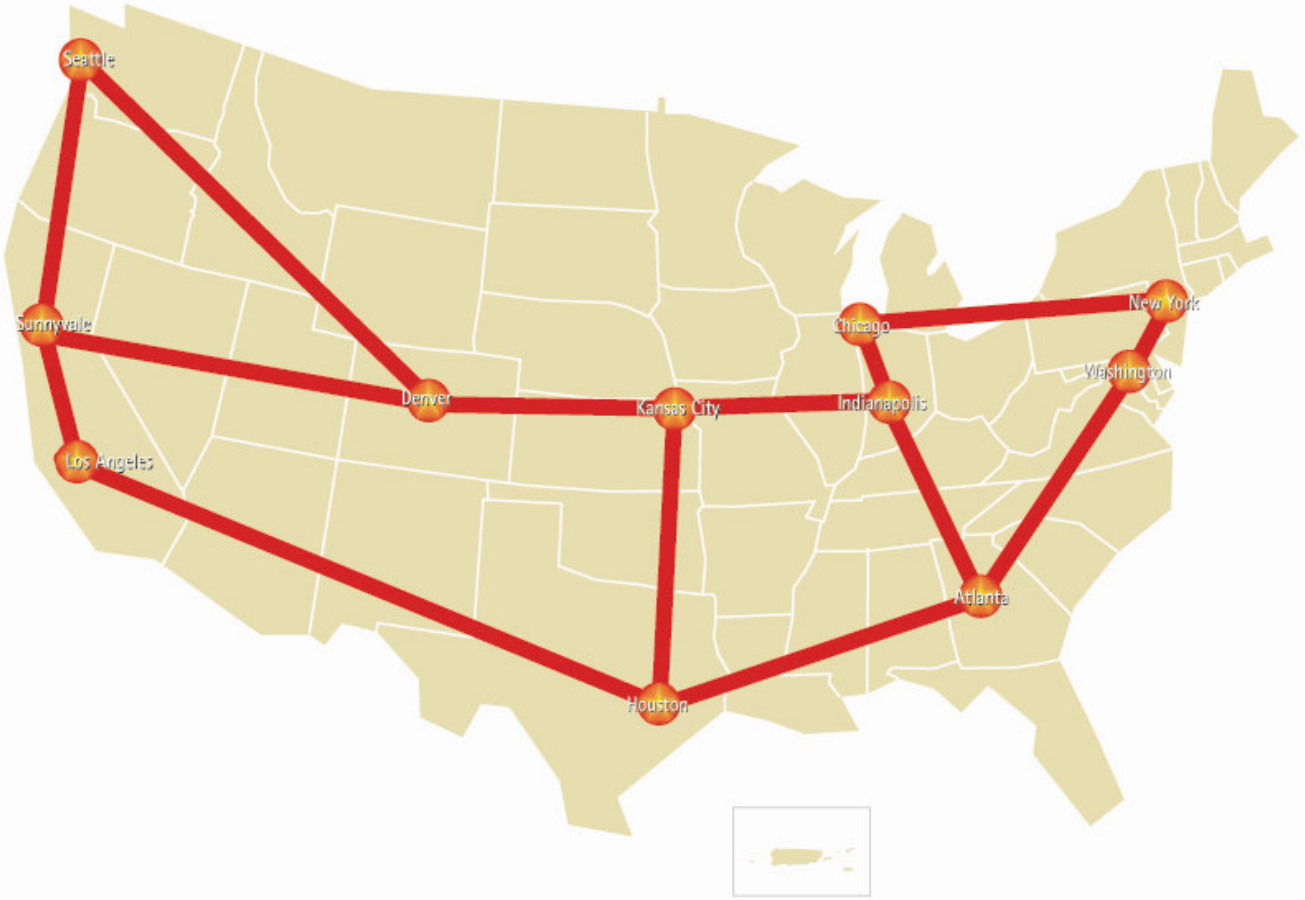
http://members.internet2.edu/

Abilene Network

Abilene is a high-performance backbone network that enables the development of advanced Internet applications and the deployment of leading-edge network services to Internet2 universities and research labs across the country.

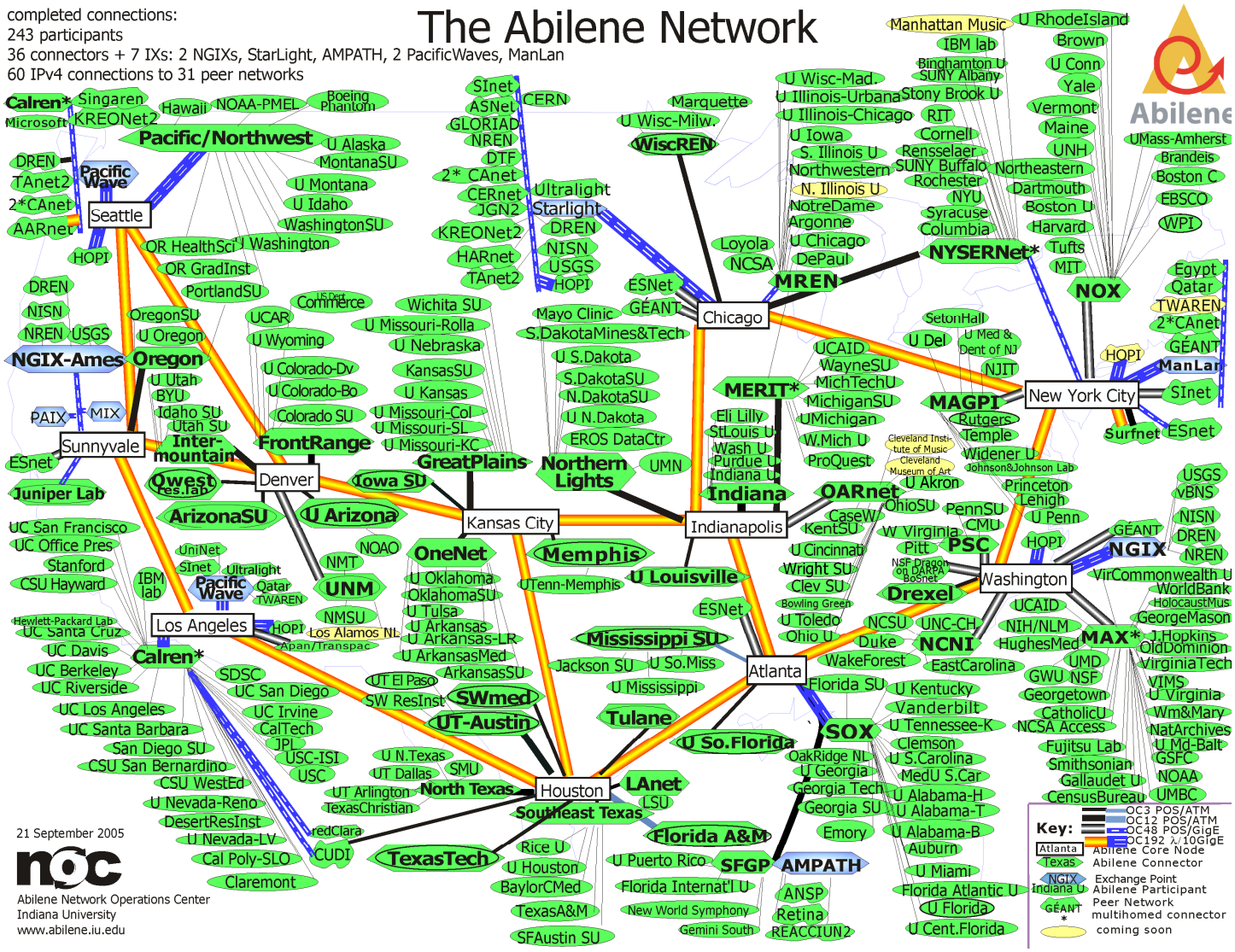
Abilene Network Topology





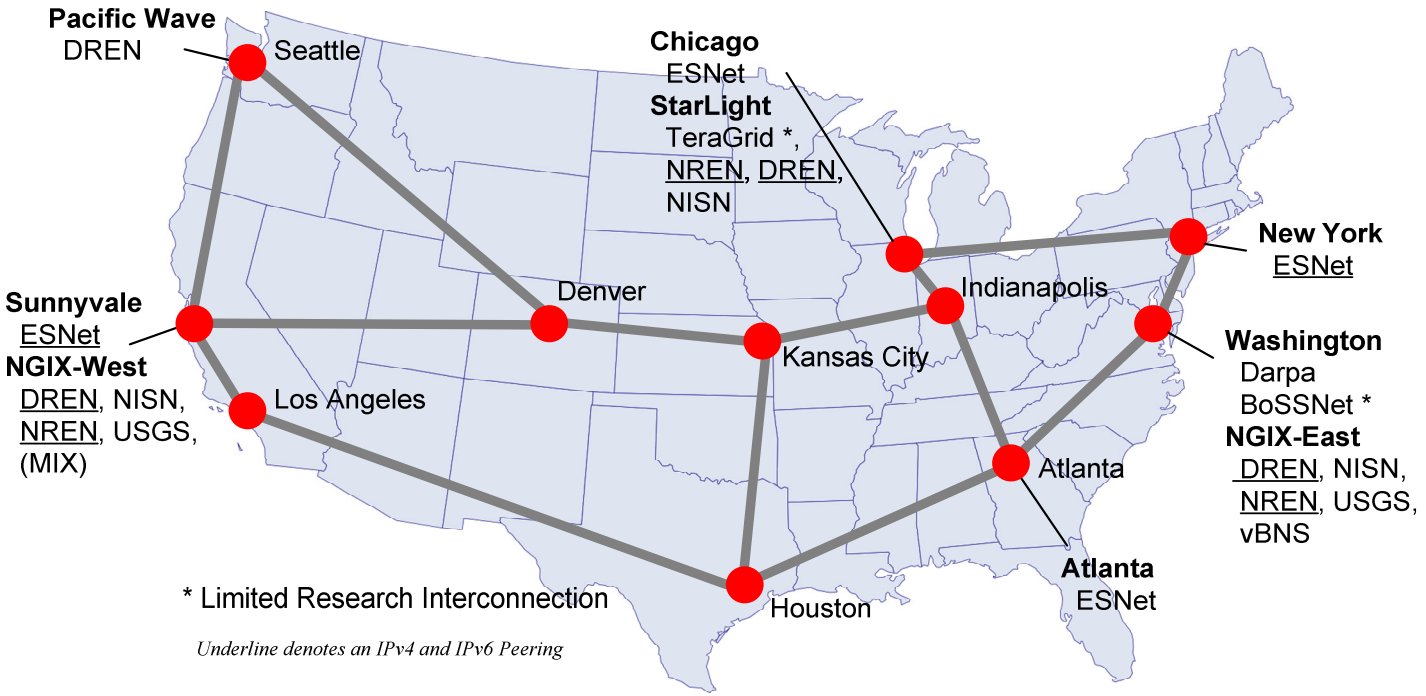
April 2005

Abilene Topology Map



Abilene Federal/Research Peering

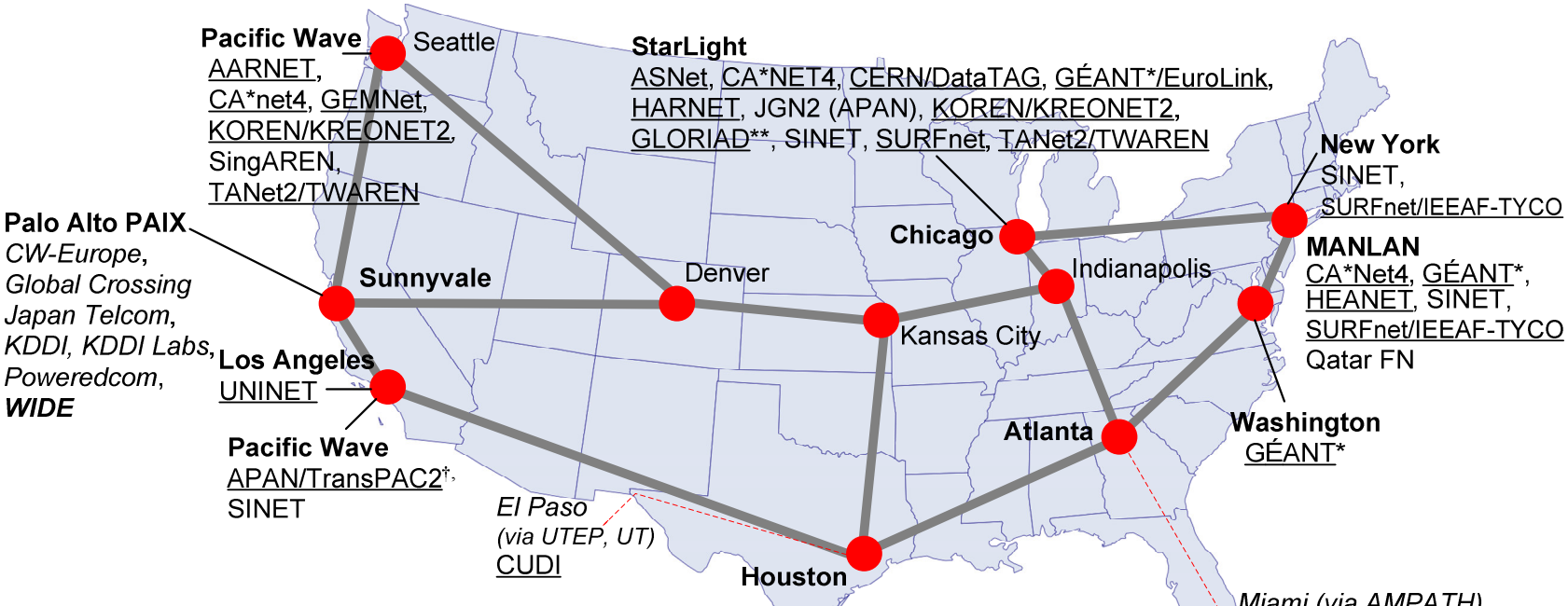
Abilene Federal/Research Network Peers



Last updated: May 2005

Abilene International Peering

Abilene International Network Peers



* *via GEANT:* ACOnet, ARNES, BELNET, CARNet, CERN, CESNET, CYNET, EENet, Forskningsnettet, Funet, G-WIN, GARR, GRNET, HEAnet, HUNGARNET, IUCC, JANET, LANET, LITNET, Univ. Malta, POL34, RBnet, RCTS2, RedIRIS, Renater, RESTENA, REUNA2, Rhnet, RNP2, RoEduNet, SANET, SUNET, SURFnet, SWITCH, ULAKBYM, UNINETT

† *via APAN/TransPAC2:* WIDE/JGN, IMnet, CERNet/CSTnet/NSFCNET, KOREN/KREONET2, PREGINET, SingAREN, TANET2, ThaiSARN, WIDE (v6)

** *via GLORIAD:* CSTNET, Rbnet

Underline denotes IPv4/IPv6 Peering

Italics indicates IPv6-only experimental non-production commercial peering

Bold italics indicates IPv6-only network peering

IPv6 in Internet2

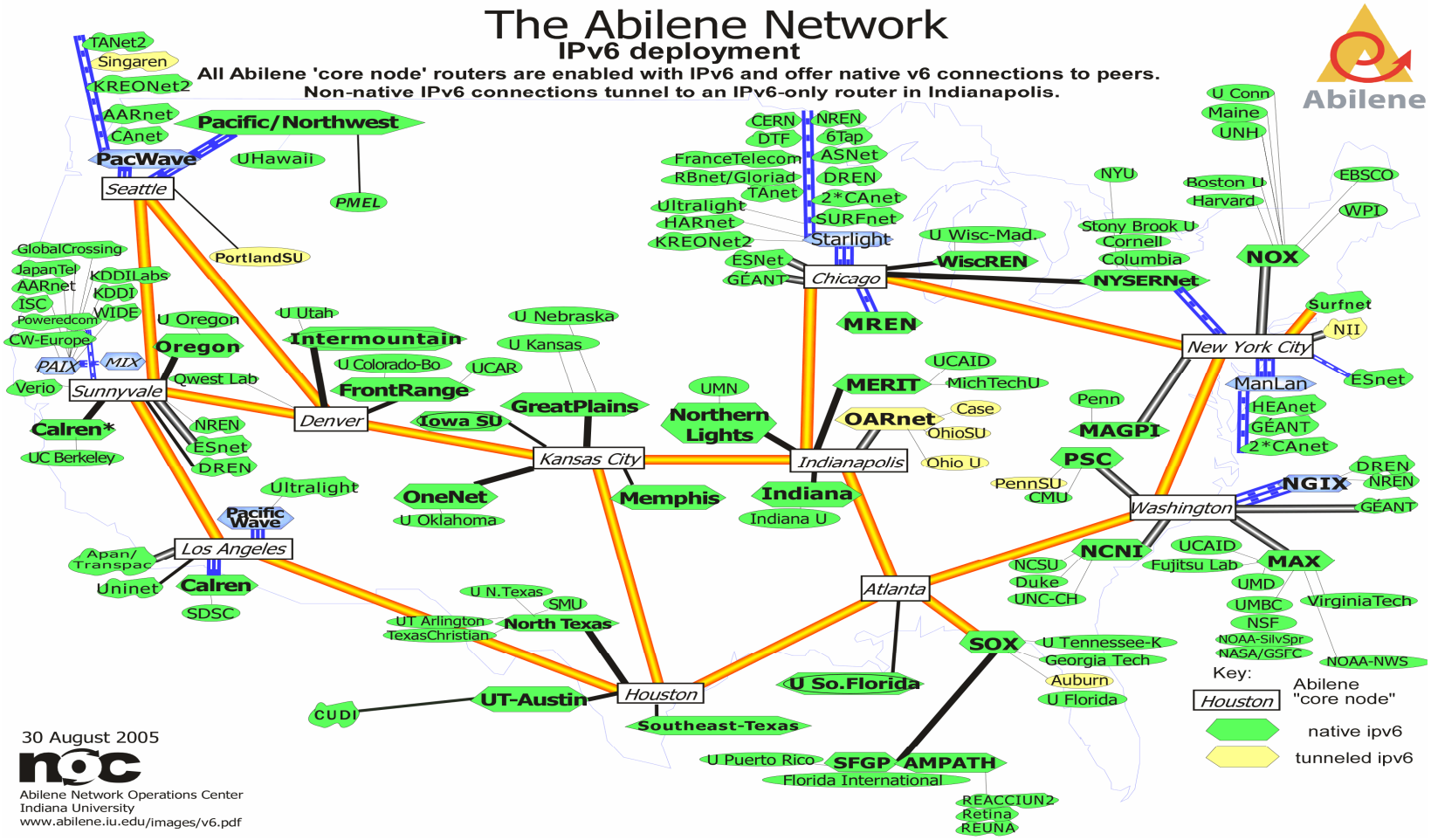
Abilene IPv6 History

- Substantial input from the Internet2 IPv6 working group
- Tunneled IPv6 network deployed 2000 across IPv4-based network
- Native, dual stack structure implemented at end of 2001
- Native dual stack was default for the upgrade
- Early testing

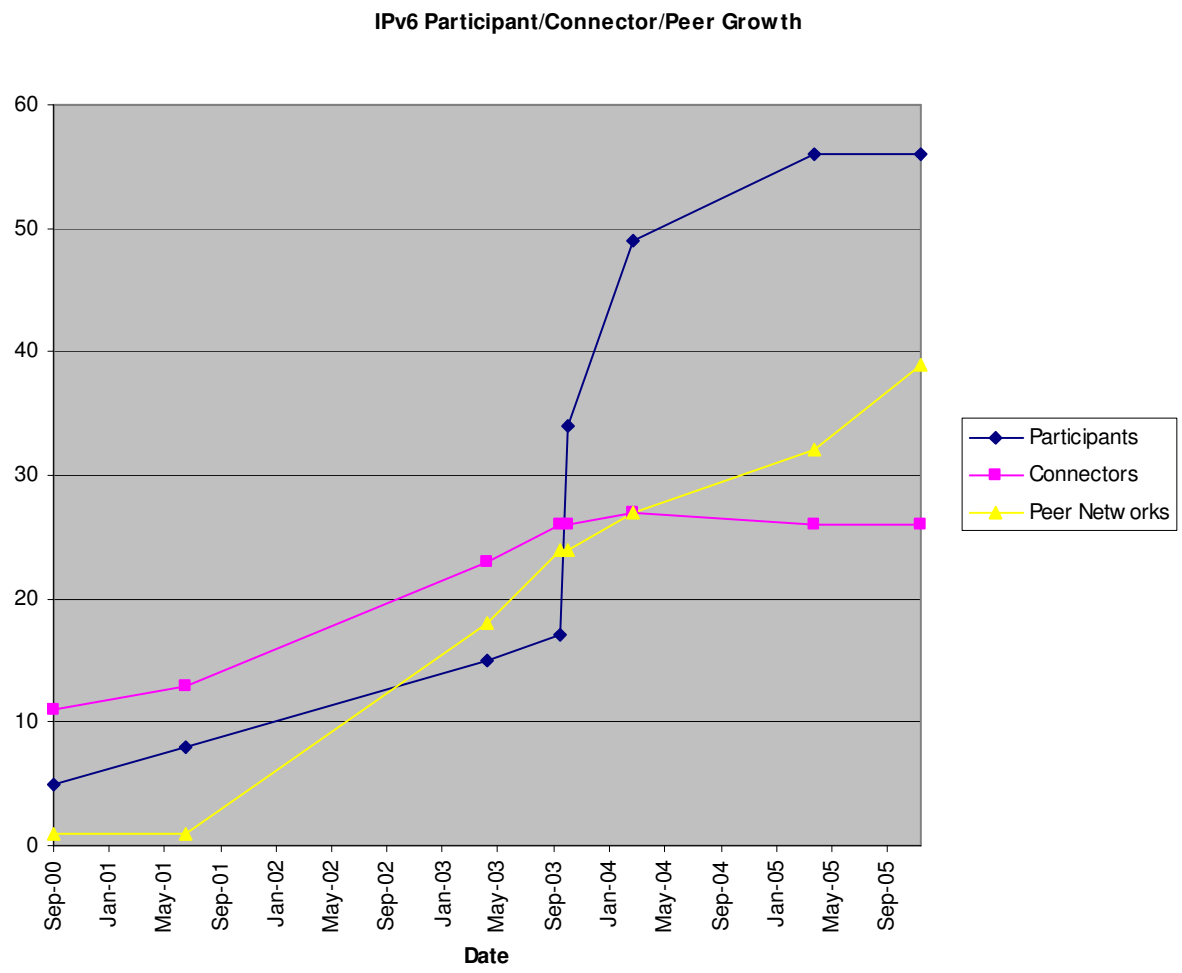
IPv6 Participants and Connectors

- Participants: 56
- Connectors: 26
- Peers: 40
  - 3 Federal
  - 27 International
  - 10 Experimental/Non-production

IPv6 Deployment Map



Abilene IPv6 Growth



Abilene IPv6 Peering

- IPv6 and IP Multicast Peering Policy – open peering policy, with transit if desired – different from IPv4
- Non-production, experimental peering with:
  - Verio
  - KDDI Labs
  - KDDI
  - Global Crossing
  - PoweredCom
  - CW-Europe
  - Japan Telecom
  - Speakeasy
- Peering Methods
  - Exchange point
  - Direct peering to backbone router
  - Peering through GigaPoPs, through tunnels or BGP multihop

Transit/Peering Problems

- Abilene NOC and Abilene staff addressing peering problems/issues
  - European-destined or even US-destined traffic routing via Asia-Pacific region
- Agreement for transit service imminent

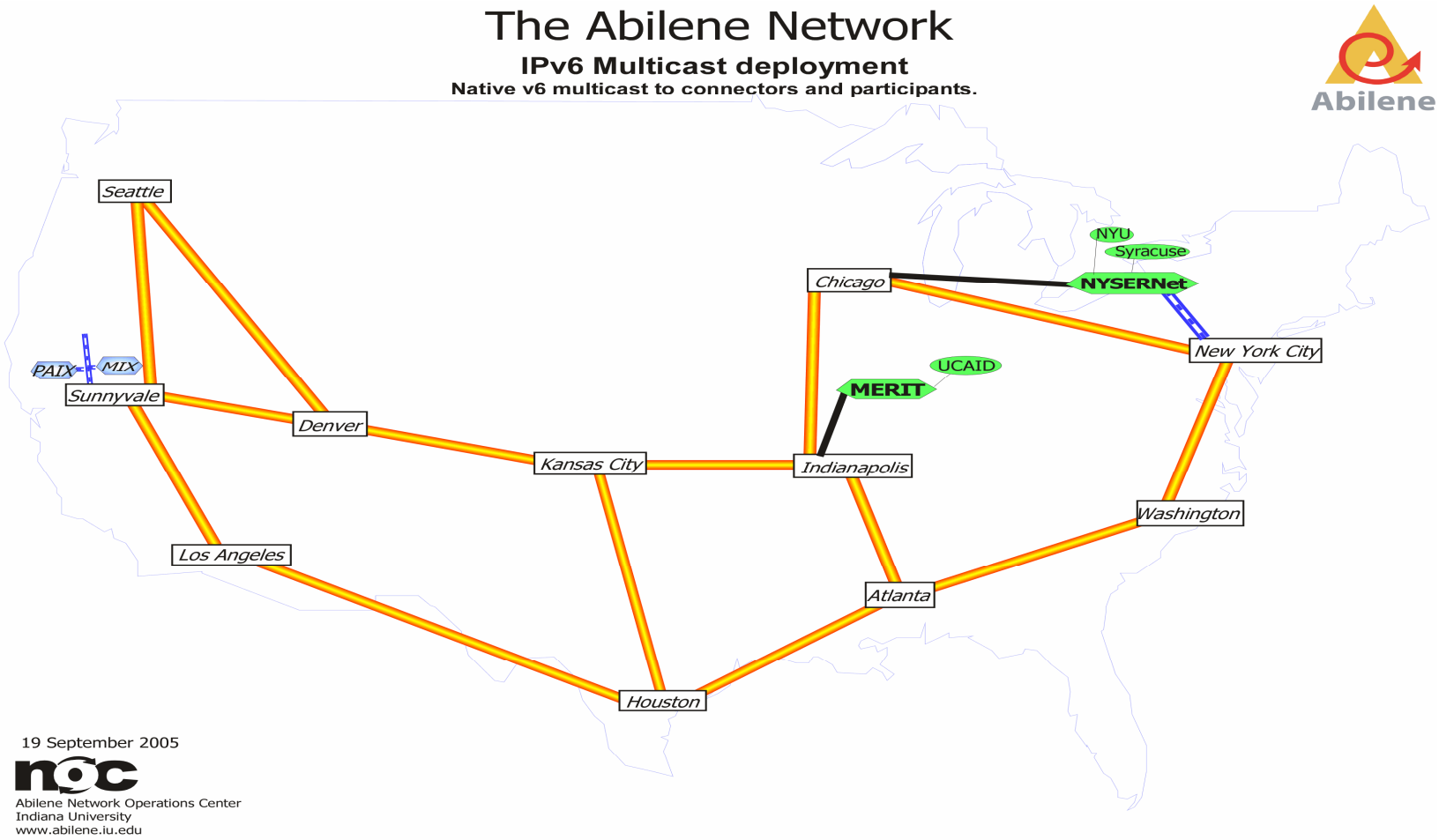
Additional IPv6 Deployment

- Backbone unicast and multicast enabled
  - Routing – BGP and IS-IS
- 6 to 4 tunnel relays:
  - Indiana University
  - Pittsburgh Supercomputer Center

Native IPv6 Multicast – Newest IPv6 Breakthrough

- Demonstrated native IPv6 multicast across Abilene in September 2005
  - 5 sites participated: Internet2-Ann Arbor office, NYSERnet-Syracuse, NYSERnet-Manhattan, NYU, Fall 2005 Internet2 member meeting site in Philadelphia
- Used Renater Rendezvous Point for demo, now using Embedded RP across Abilene

IPv6 Multicast Deployment Map



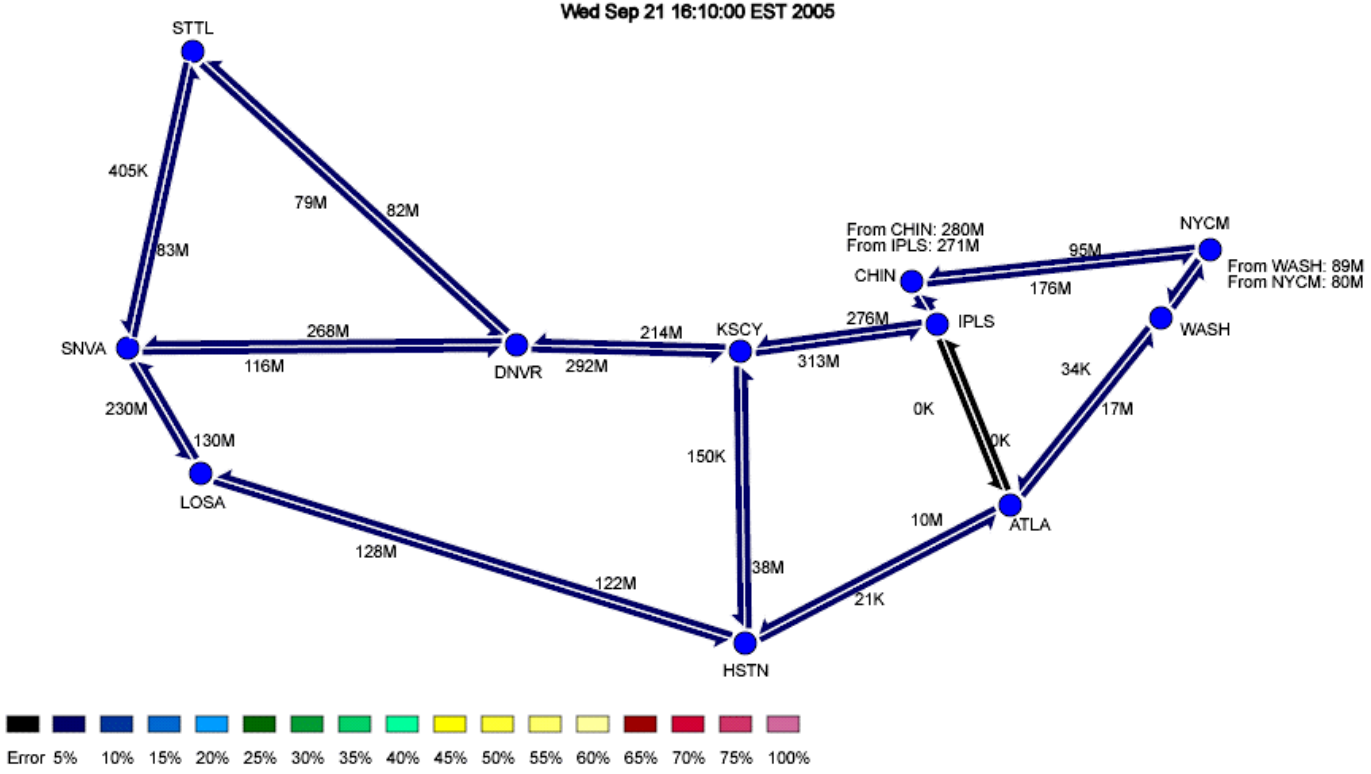
IPv6 Traffic Map

Abilene IPv6 Backbone Traffic Map

IPv6-Aggregate IPv6-TCP IPv6-UDP IPv6-Multicast IPv6-Other

Abilene IPv6 Aggregate Backbone Traffic

Wed Sep 21 16:10:00 EST 2005



Abilene IPv4/IPv6 Measurement

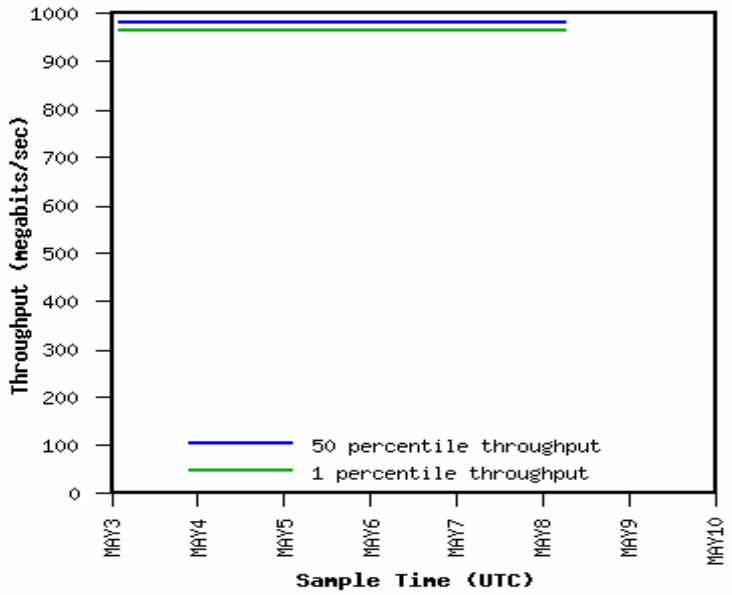
- Backbone measurements via IPv4 and IPv6:
  - BWCTL – Bandwidth Control
  - OWAMP – One Way Active Measurement Protocol
- Measurements to and from Abilene backbone
  - http://e2epi.internet2.edu/pipes/ami/pmp-info.html
- Difference between IPv6 and IPv4 performance on Abilene is indistinguishable

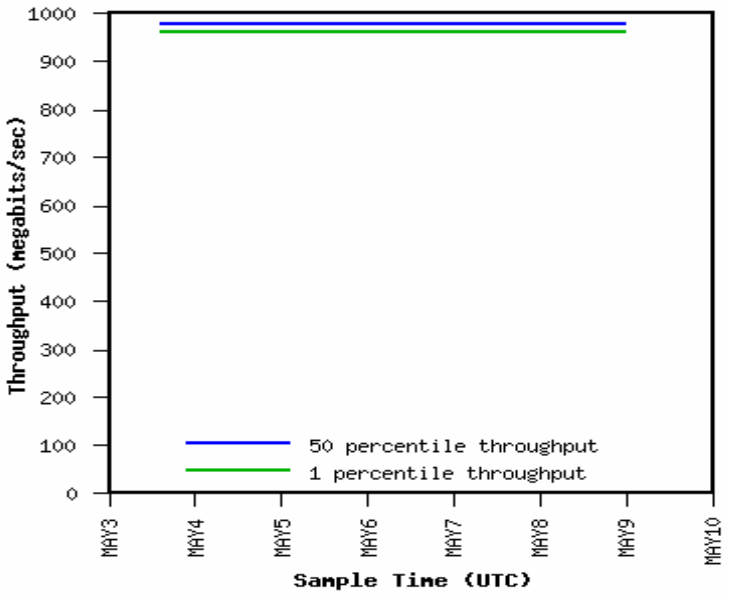
IPv4/IPv6 Comparative Performance

Tue May 3 16:25:40 UTC 2005 --- Tue May 10 16:25:40 UTC 2005

Select Timeframe

BWCTL TCP Status | BWCTL TCP Status Map | BWCTL Worst TCP Ten
BWCTL UDP Status | BWCTL UDP Status Map | BWCTL Worst UDP Ten
OWAMP Status | OWAMP Status Map | OWAMP Worst Ten





Internet2 Member IPv6 Activities

- North Carolina State University and Centaur Labs -- IPv6 streaming audio feeds from radio stations WCPE and WZYC
- Abilene IPv6-enabled hosts
  - http://ipv6.internet2.edu/ipv6hosts.shtml
- New York University introduced first IPv6-enabled supercomputer at a US university
- NYU and NYSERnet leaders in IPv6 Multicast

Applications of Note

- VRVS (CalREN)– IPv6 support in development
- Internet2 Detective
- DVTS (Wide)
- ConferenceXP (Microsoft Research)
- Multicast tools by Stig Venaas (Nordunet):
  - ssmping
  - asmping

IPv6 Tutorials

- 21 “hands-on” workshops since 2001
- Focused primarily on IPv6 router configuration
- Slides are available
  - http://ipv6.internet2.edu/presentations/
- First Internet2 hands-on IPv6 Multicast workshop in Albuquerque, NM February 2006 (led by Stig Venaas, NorduNet)

Challenges Ahead

Campus Deployment Challenges

- Getting IPv6 from the campus edge to departments interested in IPv6 is still a challenge on many campuses
- Tunneling not a popular option
- Need to appeal to desire for compatibility and maintaining competitiveness with international and government communities

Campus deployment Challenges (con't)

A "last mile" problem persists as it relates to IPv6. Theories:

- Hardware doesn't support IPv6
- Application server time-outs
- Difficulty convincing administrators of value
- Ensuring security isn't being compromised

Source: Joe Breen, University of Utah

IPv6 Security

- Issues:
  - Extension headers
  - Missing tools or limited tool support for IPv6
  - Firewalls
- Abilene NOC activities:
  - Limiting the v6 prefixes connectors sent to them (as they do for IPv4)
  - Limited filtering for peer networks
- Internet2 IPv6 Security e-mail list –
  - v6-security@internet2.edu

Possible Activities in 2006

- Encouraging purchase of IPv6-compliant hardware
- Propose methods (perhaps even using the “t” word) for getting from campus edge to interested segments of campus
- Revise IPv6 Workshops to address above issues
- Position IPv6 as future requirement for interoperating with the federal government and international research community

Outlook on IPv6

- At the backbone level, IPv6 is pretty easy
- It's a little harder at the campus level, but progress is being made.
- There will be subtle problems that occur with any new technology:
  - New code, new bugs
  - Unforeseen security issues
  - Inexperience
- Internet2 is committed to IPv6

For Further Information …

- References
  - http://www.internet2.edu
  - http://abilene.internet2.edu
  - http://www.abilene.iu.edu
  - http://ipv6.internet2.edu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www.internet2.edu