



Internet2 and IPv6: A Status Update

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Outline

- **Internet2 Goals**
- **Participation**
 - **IPv6 Deployment**
- **Peering**
- **Focus Areas**
- **Performance**
- **Observatory**
- **History**
- **Applications**
- **Deployment Issues**
- **Support**

Internet2 Goals

- Create a leading edge network capability for the national research community
 - The Abilene Network – IPv4/IPv6
- Enable revolutionary Internet applications
 - Encourage IPv4/IPv6 Applications
 - Internet2 is a member organization – enables an environment for application development
- Ensure the rapid transfer of new network services and applications to the broader Internet community.
 - Again, both IPv4 and IPv6

Abilene Backbone

- Abilene backbone – OC-192c over unprotected DWDM waves with SONET framing
- Original design of current upgrade was as a dual stack IPv4/IPv6 network

Abilene Backbone



Abilene Partners

- Internet2
- Indiana University
- Juniper Networks
- Nortel Networks
- Qwest Communications
- North Carolina, Ohio, San Diego ITECs

Abilene Participation

April 2004

- 44 direct connections (OC-3c → 10 GigE)
 - 2 10-GigE connections (10 Gbps)
 - 6 OC-48c connections (2.5 Gbps)
 - 2 Gigabit Ethernet connections (1 Gbps)
 - 23 connections at OC-12c (622 Mbps) or higher
- 228 participants – research universities & laboratories
 - All 50 states, District of Columbia & Puerto Rico
 - Johns Hopkins as of last Friday!
- Expanded access
 - 104 sponsored participants
 - 33 state education networks
- Active IPv6 participation at all levels



Abilene Connections

Connection Technologies

Network	Router	Speed	Type	Shared	AS	IP	Address	MTU	Multicast
Connectors									
Arizona GigaPoP	Denver	OC-3	SONET	NO	1706	IPv4	192.80.43.21	9000	YES
						IPv6			
Arizona State University	Denver	OC-3	SONET	NO	2900	IPv4	209.147.191.133	9180	YES
						IPv6			
CalREN-2 North	Sunnyvale	OC-12	SONET	NO	11423	IPv4	198.32.249.161	4470	YES
						IPv6			
CalREN-2 South	Los Angeles	10 gbps	Ethernet	NO	2153	IPv4	137.164.25.2	9178	YES
						IPv6	2001:468:ff:144e::2	9000	NO

See <http://abilene.internet2.edu/observatory/connection-technologies.html>

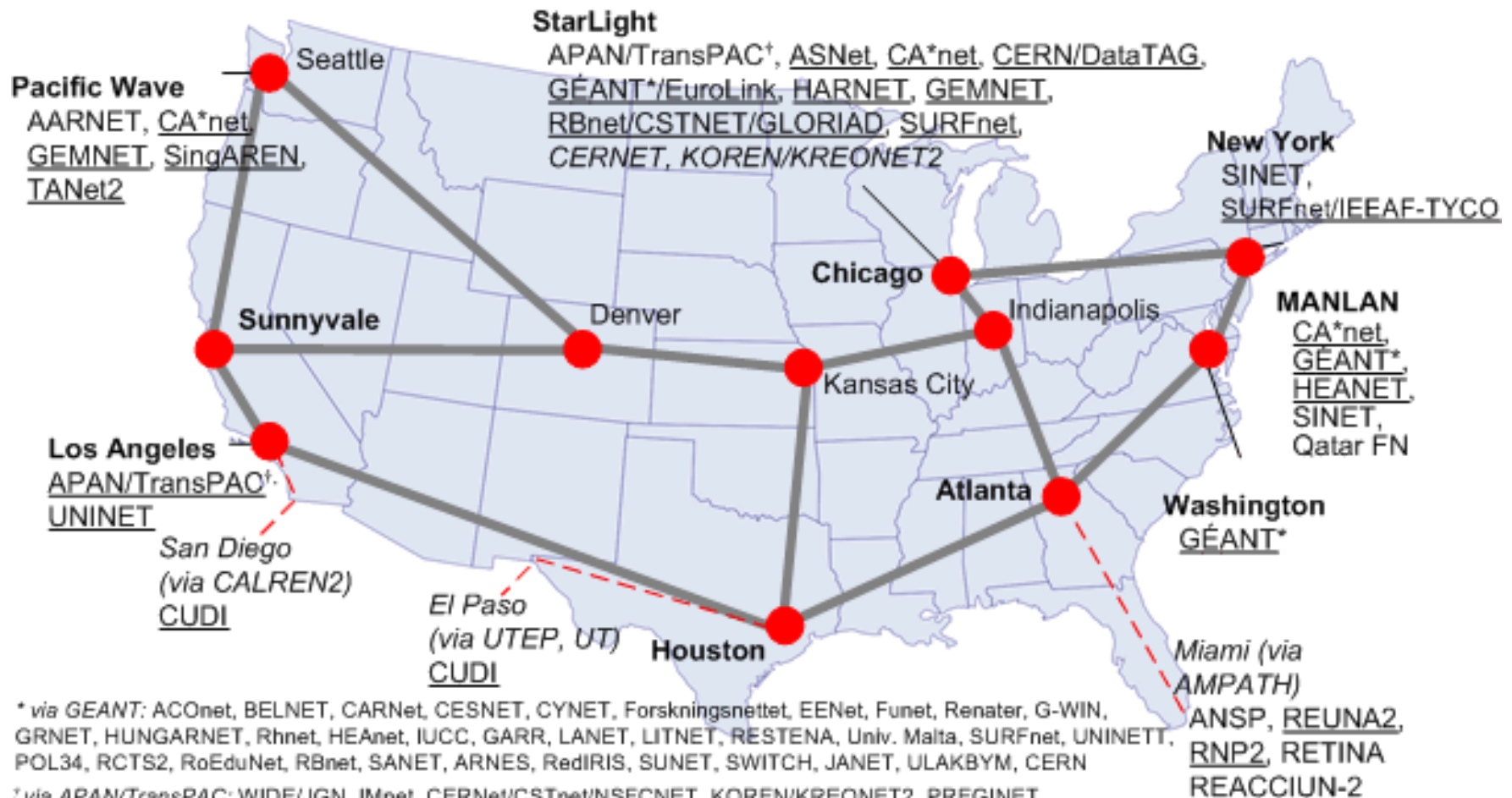


Abilene Federal/Research Peering





Abilene International Peering



Underline denotes an IPv4 and IPv6 Peering

Abilene Peering

■ Peering Methods

- Preferred is through an exchange point: For example, PacWave, Starlight, MAN LAN, and AMPATH
- Direct peering to backbone router in some cases
- Peering through GigaPoPs, through tunnels or BGP multihop (for example, AMPATH, CUDI peerings)

■ Connectivity to Exchange Points

- MANLAN (Internet2/NYSERnet partnership) – 10 GigE
- PacWave-Seattle – 10 GigE
- PacWave-LA – 10 GigE in very near future
- Starlight – 2 x 10 GigE
- NGIX East – 10 GigE
- NGIX West – 1 GigE in very near future

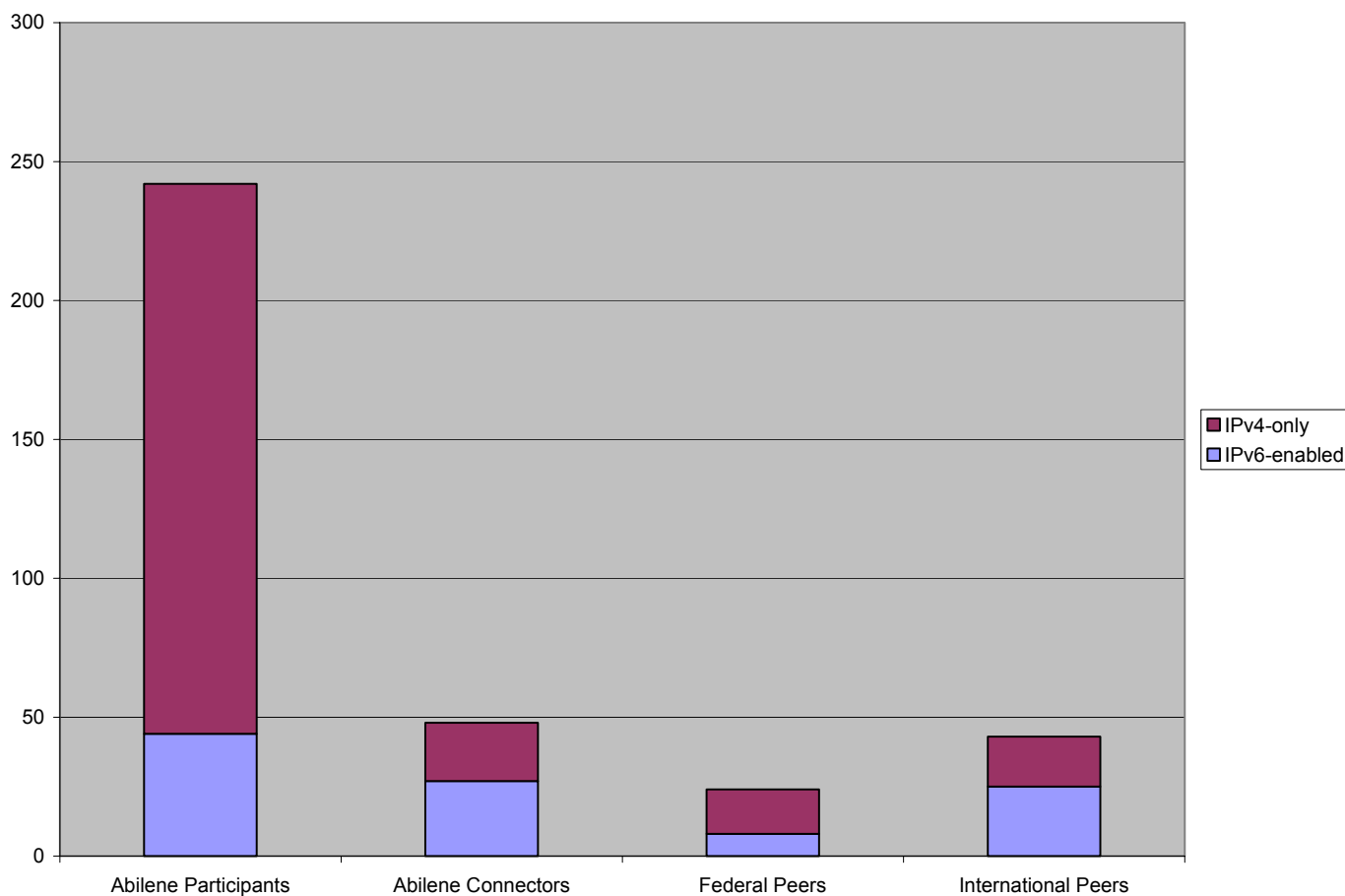
■ IPv6 Peering Policy – open peering policy, with transit if desired – different from IPv4

■ Will soon be available through the PAIX

IPv6 Participants and Connectors

- Participants: 44
 - 9 new since October 2003
- Connectors: 17
 - 3 new since October 2003
- Peers: 34
 - 1 Corporate (1 new)
 - 8 Federal (4 new)
 - 25 International (5 new)

Abilene Participants and Connectors



Additional IPv6 Deployment

- Backbone unicast enabled
 - Routing – BGP and IS-IS
 - Experimenting with IPv6 multicast as standards and technology evolve
- Three 6 to 4 tunnel relays:
 - Deployed at Indiana University and Pittsburgh Supercomputer Center
 - University of Utah in the near future
- Tunnel broker/server and Teredo are under consideration
- Significant experimentation and support effort
 - DNS testbeds using IPv6 transport servers
 - Tutorials at the GigaPoP or University level

Abilene Focus Areas – 2004

- Support for high-throughput flows (multi-Gbps)
 - Collaboration with End-to-End Performance Initiative
 - Ensuring that large flows are the standard across the Internet2 infrastructure – both IPv4 and IPv6
- Security
 - Collaboration with REN-ISAC and the pending Cyber Trust effort
 - Understanding IPv6 problems
- IPv6
- Abilene Observatory – Supporting Network Research and an Open Measurement Platform
 - Including IPv6 in all measurements, whenever possible
- Provisioning dedicated capabilities and the Hybrid Optical and Packet Infrastructure (HOPI) Project.

Abilene Performance

■ Performance

- 6.25 Gbps flows across Abilene
 - Recent LSR from Caltech to CERN
 - Comparable performance using IPv6
 - See <http://lsr.internet2.edu>
- Consistent 9.5 gbps traffic volumes during SC2003 from Phoenix
- MPLS L2VPN experiments with prioritized service have shown excellent performance on tunnels and with little effect on normal traffic
- We're currently looking to the future and at potential next generation architectures

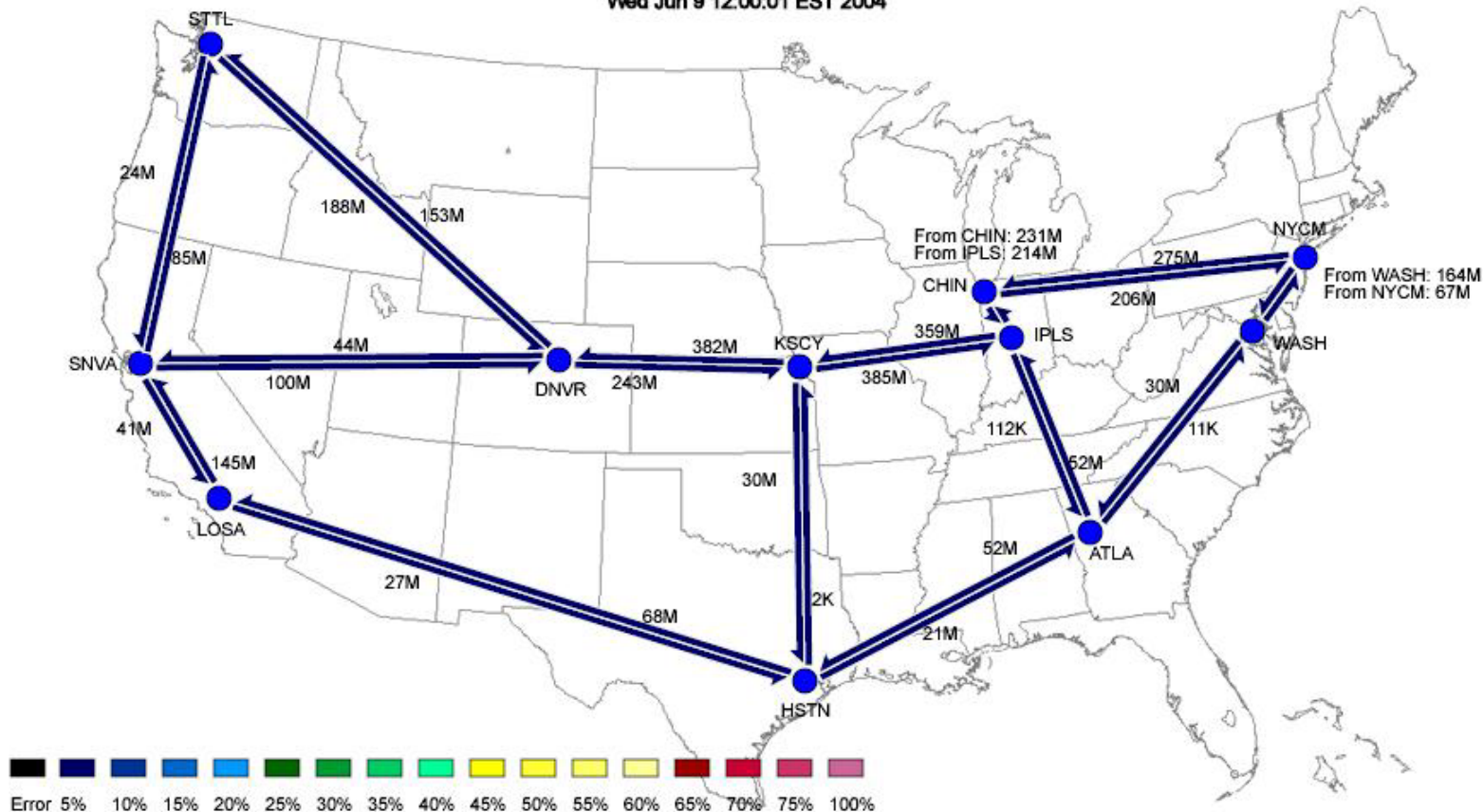
IPv6 Traffic Map

Abilene IPv6 Backbone Traffic Map

[IPv6-Aggregate](#) [IPv6-TCP](#) [IPv6-UDP](#) [IPv6-Multicast](#) [IPv6-Other](#)

Abilene IPv6 Aggregate Backbone Traffic

Wed Jun 9 12:00:01 EST 2004

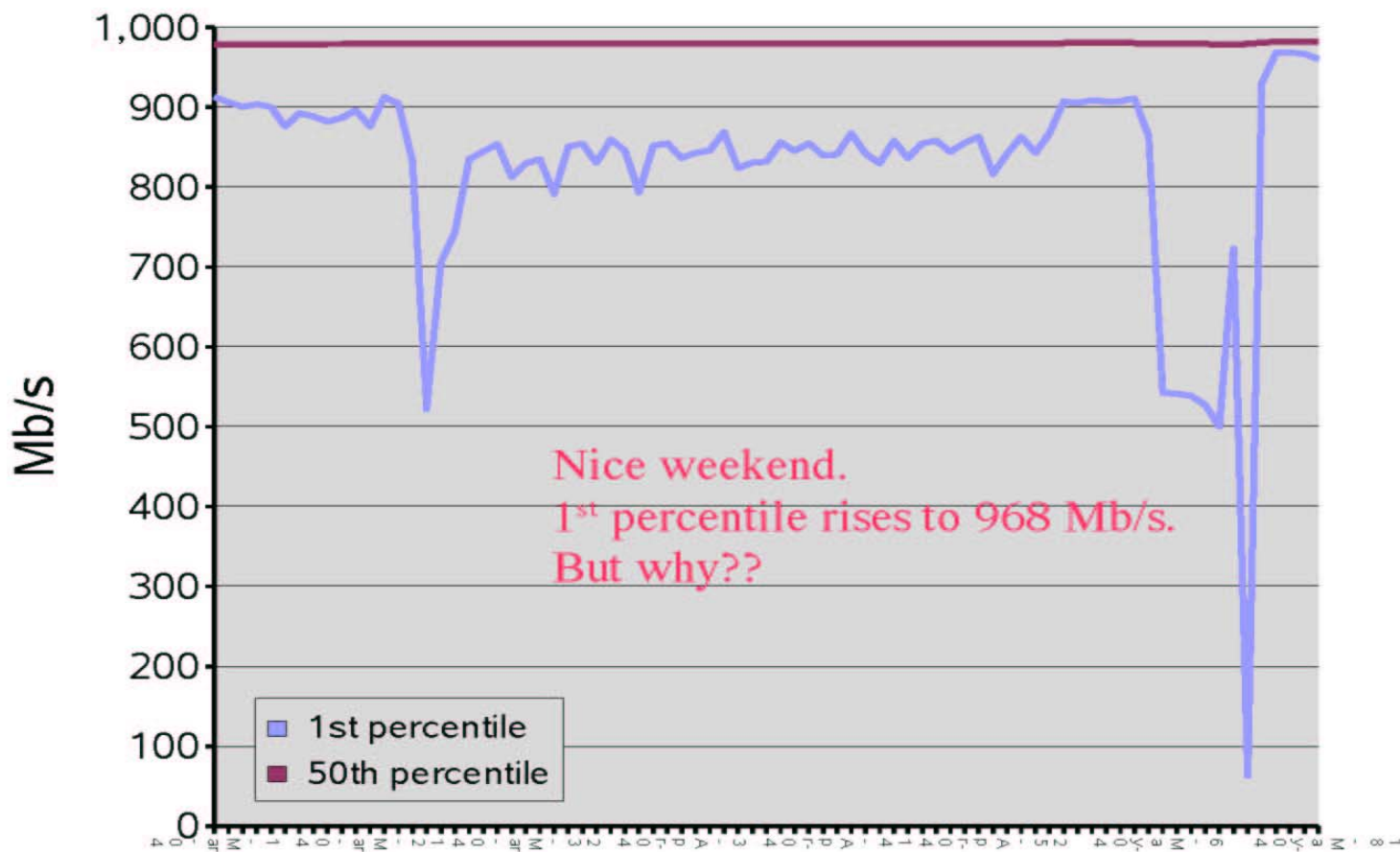


Abilene Worst 10 Lists

- Full mesh of TCP tests across the backbone, both IPv4 and IPv6, every hour at 1 Gbps
- Keep the worst 10 over a days time
 - June 9, 2004
 - IPv4: 96.1 % (that is, .961 Gbps)
 - IPv6: 95.8 % (that is, .958 Gbps)
- Essentially no performance difference between v4 and v6

Abilene Performance

Abilene IPv4 TCP performance



Abilene Observatory

- A program to provide enhanced support of computer science research over Abilene
 - Include IPv6 data whenever possible
 - Create network data archive
 - Consists of distributed database located on servers in Ohio, Indiana, and Michigan
 - Forms a large correlated database
 - Tools to access the database
 - Support from and for graduate programs
 - Collocation Component - provision for direct network measurement and experimentation
 - Resources reserved for additional servers
 - Power (DC), rack space (2RU), router uplink ports (GigE)
 - PlanetLab and AMP are current projects

Abilene Observatory

- Research groups involved in the project
 - Boston University
 - Carnegie Mellon University
 - Case Western Reserve University
 - Kent State University
 - University of Massachusetts Amherst
 - University of Minnesota
 - University of Wisconsin
 - University of Wisconsin / Oregon Health & Science University
- Collocation projects
 - PlanetLab, AMP
- See
 - <http://abilene.internet2.edu/observatory/research-projects.html>

Abilene IPv6 History

- Substantial input from the Internet2 IPv6 working group
- Tunnel network deployed 2001
 - First IPv6 tutorial at Lincoln joint-techs meeting
- Migration to native, dual stack implementation at end of 2001
 - Before upgrade began
 - Using Cisco GSR routers
 - Began migration of connectors
- Native dual stack was default for the upgrade
- Early testing
 - 8 gig tests from Sunnyvale to Washington DC
 - IPv4, IPv6, and mixed IPv4/IPv6
 - No distinguishable difference in performance

Applications

- Most standard public software now IPv6 enabled
 - Examples include bind, sendmail, apache, news, etc.
 - Some reluctance to upgrade stable servers to new versions – need to educate server administrators
 - For software that is IPv6 enabled, the use of IPv4/IPv6 is almost always transparent. It just works!
 - List of standard IPv6 hosts on Abilene
 - <http://ipv6.internet2.edu/ipv6hosts.shtml>
- Growing list of commercial software availability
 - Moonv6 tests are very valuable – what is ready, and what is not.
 - Many new applications to come
- Some universities are trying to move significant applications to IPv6
- Having an application where there is a significant advantage in using IPv6 would hasten deployment

Applications

- Currently monitoring applications like
 - VRVS (CalREN)– IPv6 support expected this summer
 - Internet2 detective – detecting IPv6
 - Georgia Tech experimenting with OpenH323 via IPv6
 - Discussion about deploying OpenMCU with IPv6 support
 - DVTS (Wide)

Deployment Issues

- Many monitoring tools are missing, impacting security
 - Schools are reluctant to deploy fully because of potential for attacks
 - For example, difficulty in supporting access lists that monitor address/port number – extended header implementation problem
- The multihoming problem.
 - Internet2 could not implement IPv6 with the same policy as IPv4 because of this problem
 - Policy based networks may be of growing importance

IPv6 Everywhere by 2006?

- Is it realistic that by 2006, these issues will be resolved?
 - We believe the answer is “yes”, and need to encourage support from vendors and research and education networks!
- Note that dual-stack IPv4/IPv6 architectures are likely to endure for a long time after IPv6 deployment
- There is significant activity on the international scene to deploy IPv6 networks, and some may be IPv6 only.
 - Deployment will likely continue world wide and reach a point where it is crucial to be IPv6 enabled.

Internet2 Commitment

- Internet2 is committed to deploying an IPv6 native dual stack network for the research community.
- Internet2 is committed to encouraging connectors, peers, and members to fully deploy IPv6 on their networks by 2006.
- Internet2 will monitor IPv6 penetration in the future to provide guidance to the community.
 - Network penetration.
 - Availability of software and tools
 - Security Issues

Support for IPv6

■ Tutorials

- Two day workshops, hands-on experience
- Descriptions and planning guides
 - <http://ipv6.internet2.edu/workshops/index.shtml>
- Alternate discussion/lecture with hands-on work
- Slides are available
 - <http://ipv6.internet2.edu/presentations/>
- Very popular events

Support for IPv6

■ Topics

- Addressing
- Allocation Schemes
- Router Configuration
- Basic Functionality
- Multi-homing
- Multi-homing Lab
- Provider Independent Addressing
- Provider Independent Addressing Lab
- Under the Hood
- Stateless Autoconfiguration
- Neighbor Solicitation
- Transition and Tunnels
- DNS
- Unix Hosts
- Microsoft Windows
- DVTS
- ISIS
- GigaPoP Implementations

Internet2 IPv6 Deployment Issues

■ References

- <http://www.internet2.edu>
- <http://abilene.internet2.edu>
- <http://ipv6.internet2.edu>

■ Questions?

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www.internet2.edu