IPv6 in Internet2

Rick Summerhill
Associate Director, Backbone Network Infrastructure, Internet2

North American IPv6 Global Summit
Arlington, VA
8 December 2003

Outline

- General Internet2 Infrastructure
  - Internet2 Goals
  - Abilene Partners
  - Abilene Backbone
  - Connectors
  - Peers
  - Focus
- IPv6 Deployment
  - Goals
  - History
  - Current Status
  - Issues
  - Applications
  - Future

Internet2 Goals

- Create a leading edge network capability for the national research community
- Enable revolutionary Internet applications
- Ensure the rapid transfer of new network services and applications to the broader Internet community.

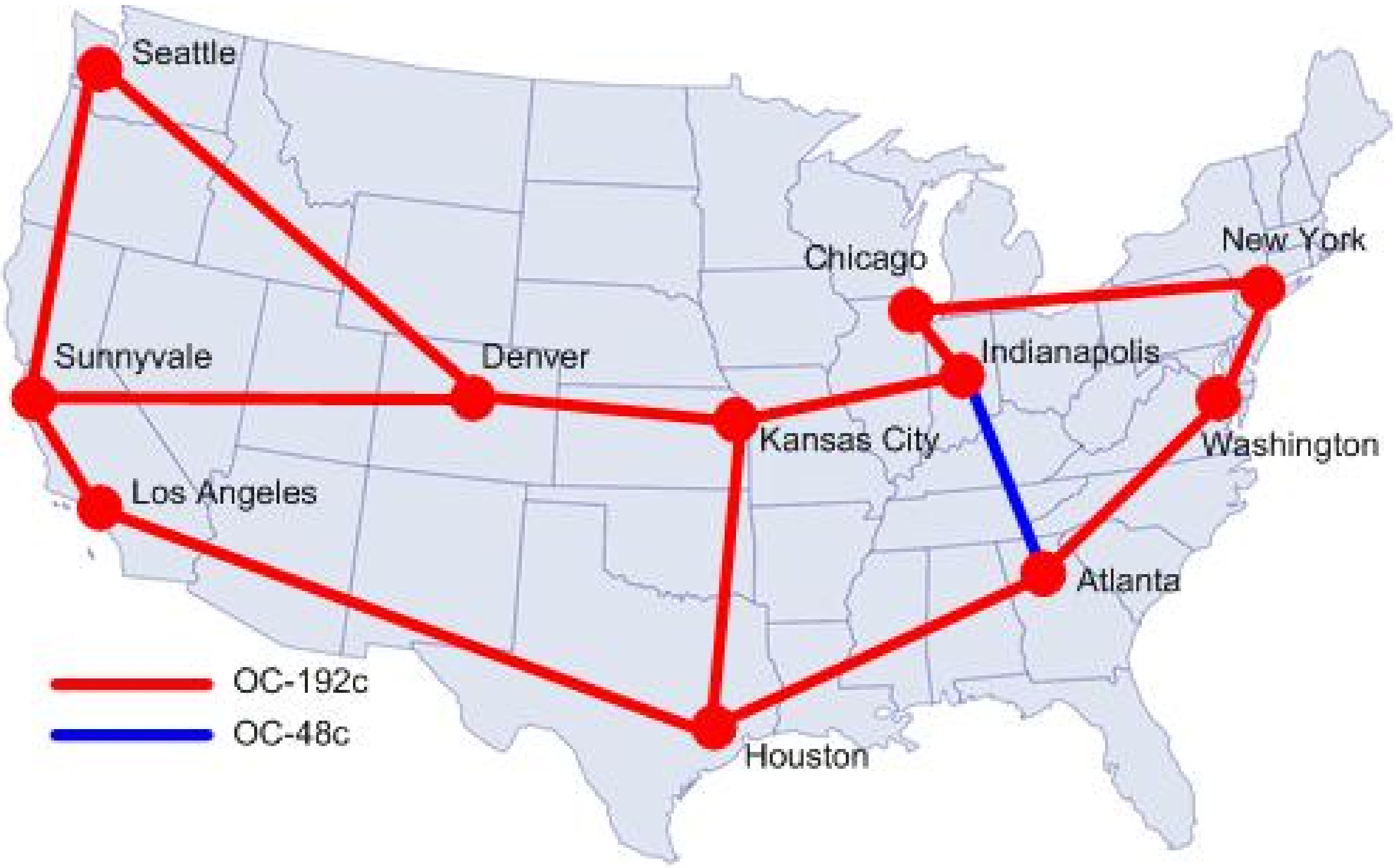
Partners

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

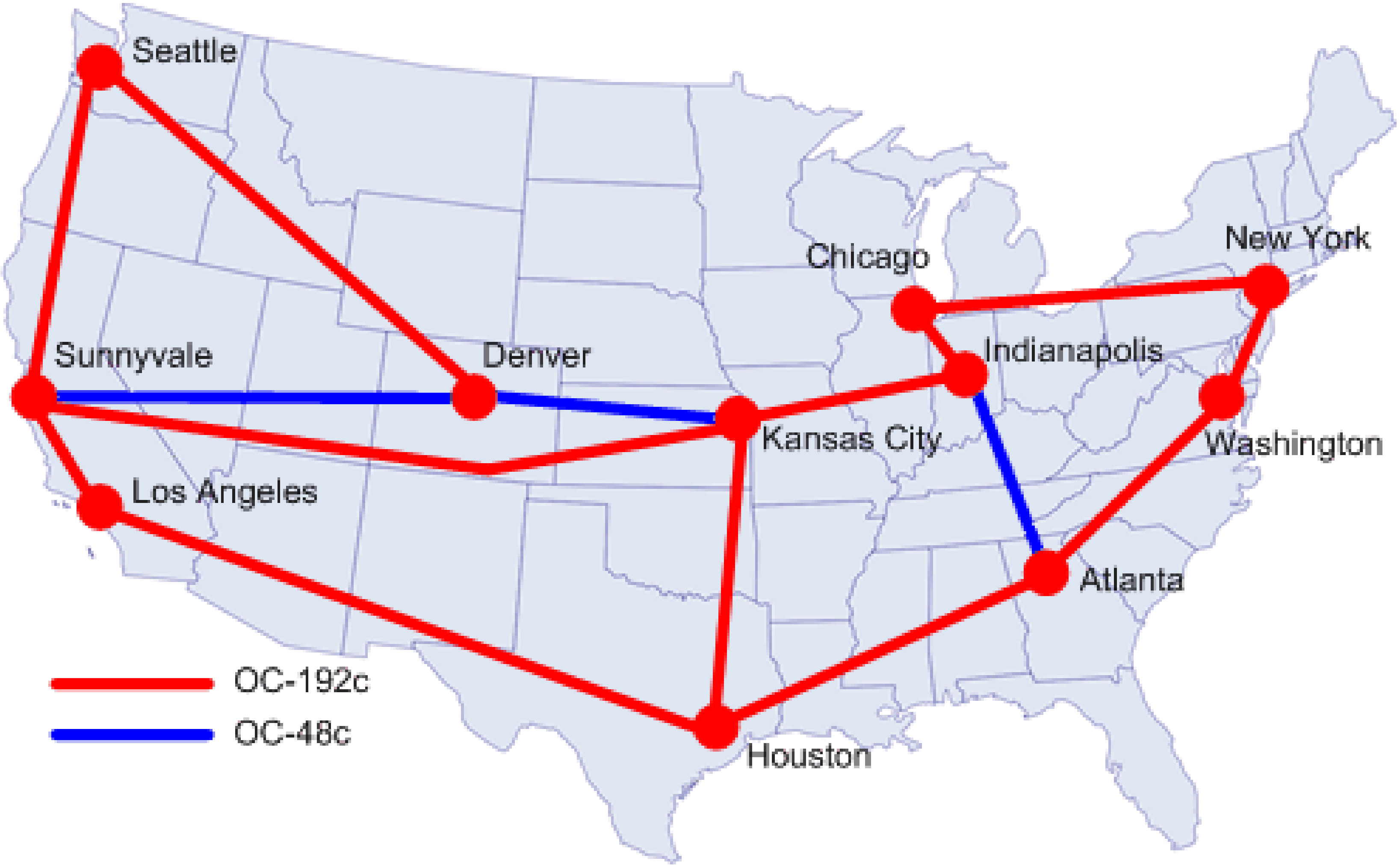
Abilene Backbone

- Abilene backbone – OC-192c over unprotected DWDM waves with SONET framing
- In final stages of an upgrade to OC-192c
- Often easier to deploy advanced services on a backbone network than at the edges
  - Multicast
  - IPv6
- Topology

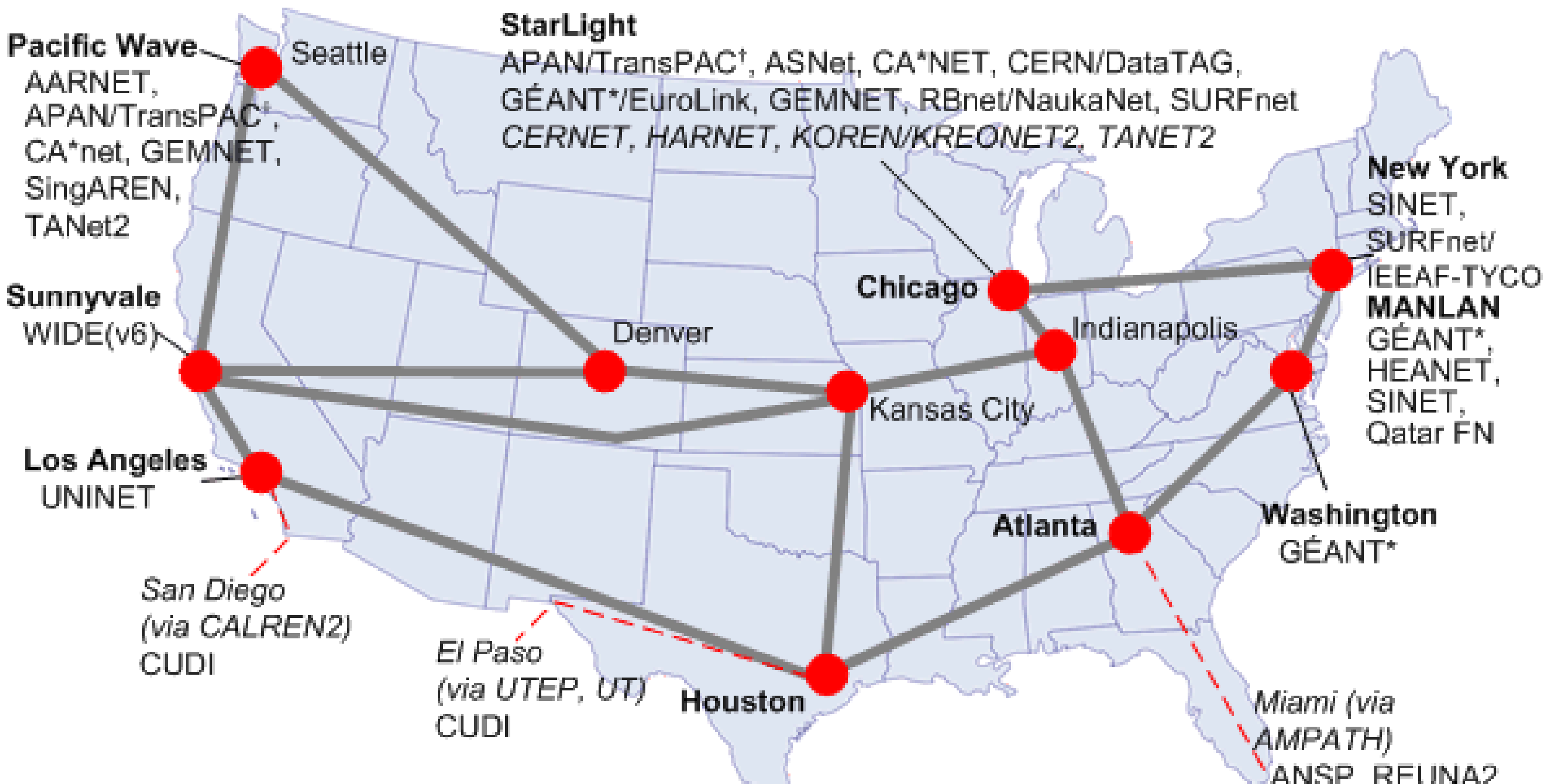
Abilene Backbone – Design



Abilene Upgrade – Current



Abilene International Peering



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

† *via APAN/TransPAC:* WIDE/JGN, IMnet, CERNet/CSTnet/NSFCNET, KOREN/KREONET2, PREGINET, SingAREN, TANET2, ThaiSARN

Last updated: 03 October 2003

Abilene Federal/Research Peering

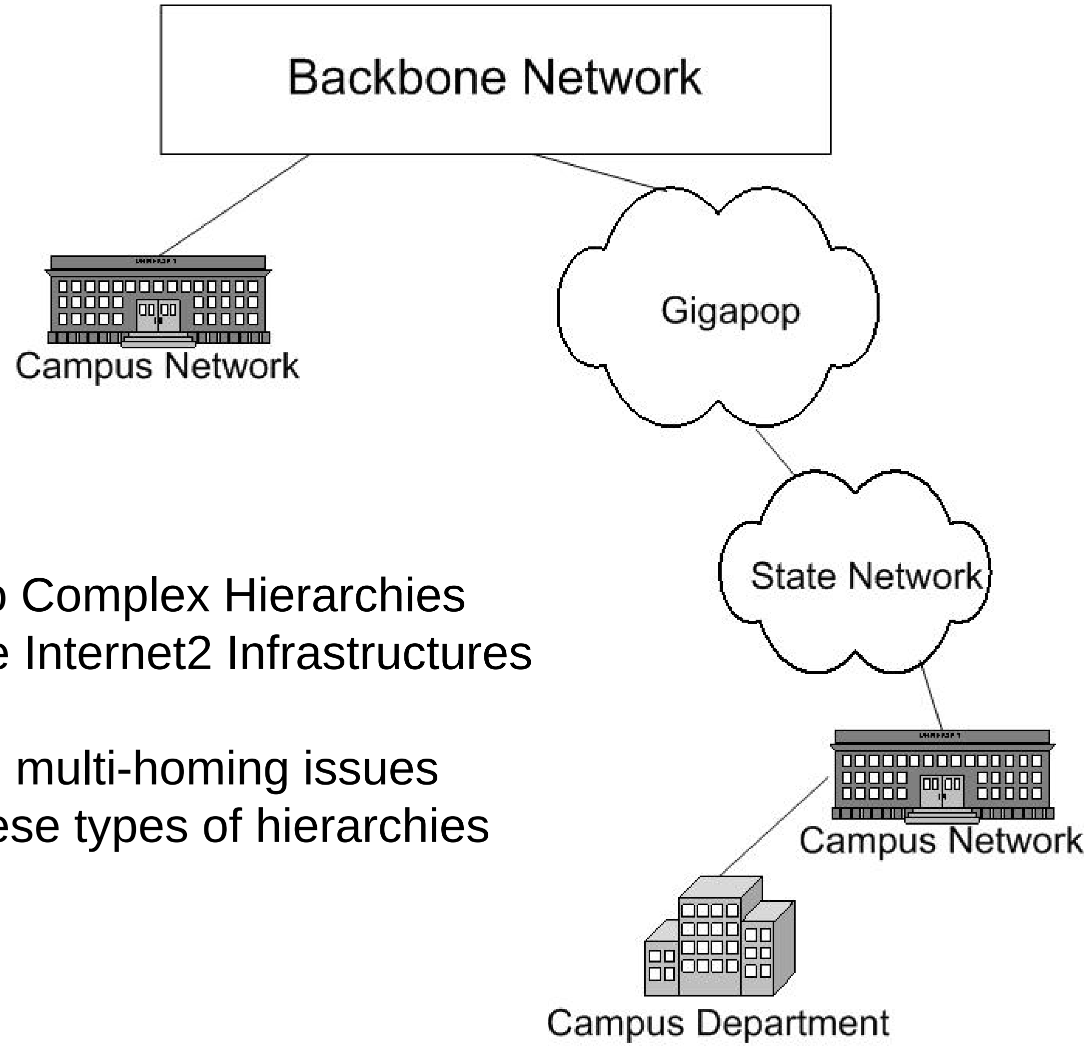
Abilene Scale
October 2003

- IP-over-DWDM (OC-192c) and IP-over-SONET OC-48c Backbone
- 48 Connectors (OC-3c $\rightarrow$ 10 GigE)
  - 2 10 GigE connections
  - 6 OC-48c
  - 24 OC-12c or higher
- 222 participants – research universities & labs
  - All 50 states, District of Columbia, & Puerto Rico
  - Aggregation on the rise!
- Expanded access
  - 92 sponsored participants, expected to increase
  - 30 State networks, expected to increase

Internet2 Infrastructure

- The Full Internet2 infrastructure is diverse and complex
  - Backbone is relatively simple
    - Management provided by Indiana Global NOC
    - Testing by Internet2 Test and Evaluation Centers (ITECs)
  - Connectors often exhibit a complicated hierarchy
    - Some research institutions connected directly
    - Some are connected through regional networks, state networks, and some have complex campus networks
    - Land Grant institutions often have county extension offices
    - Diversity/Complexity increases as one gets closer to the edges of the network
- Influences the way IPv6 is implemented
  - Consider the classic IPv6 addressing/routing plan, with potentially multiple connections, in this diverse infrastructure

Internet2 Infrastructure



Simple to Complex Hierarchies within the Internet2 Infrastructures

DNS and multi-homing issues within these types of hierarchies

Abilene Focus Areas - 2003

- Advanced Services
  - IPv6 and Multicast (and IPv6 Multicast)
  - All the following include both IPv4 and IPv6 – the common bearer service for Abilene is both IPv4 and IPv6
- Facilitating end-to-end performance
- Supporting network research – Abilene Observatory
- Experimenting with MPLS/VPN on backbone
- Supporting large MTUs
- Security and the REN-ISAC

Internet2 IPv6 Goals

- Support and encourage development of advanced applications using IPv6
- Create a national infrastructure to support IPv6 for the Research and Education Community
  - Implement IPv6 on Abilene Backbone
  - Encourage deployment of IPv6 throughout the Internet2 infrastructure
  - Support end-2-end transparency for IPv6 advanced applications
    - Important issue for high performance applications
    - High performance applications often have trouble with NATs
    - Provide a more robust infrastructure to provide security
- Educating the Internet2 IPv6 user base
- Support interconnectivity and transit during the initial stages of IPv6 deployment

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

Current Status

- Backbone unicast enabled
  - Experimenting with IPv6 multicast as standards and technology evolve
- Connectors and Peers
  - Significant number of peers and connectors now have connections, almost all native:
    - 26 connectors
    - 19 international peers
    - 4 research/federal peers
  - See http://abilene.internet2.edu/observatory/connection-technologies.html
  - See http://www.abilene.iu.edu/images/v6.pdf

Current Status

- Campus penetration
  - More than 24 member campuses with native connections
  - More than 10 member campuses with tunneled connections
- Several 6 to 4 tunnel relays expected in some GigaPoPs
- Significant experimentation and support effort
  - Abilene Observatory and IPv6
  - DNS experiments, IPv6 transport servers
  - Tutorials at the GigaPoP or University level

Current Status

- Addressing Plan
  - Currently have /32, originally was a /35
  - Allocate a /40 to a gigapop or a /48 to a university
    - Some gigapops have 12 member universities and had to allocate their /40 to those universities plus state networks
  - Universities immediately felt constrained by this
    - Recall that some universities have locations in potentially 200 counties within a state (i.e. Land Grant Institutions)
- WiscREN and Pittsburgh gigapops have obtained their own space
- Some universities attempting to obtain space – could satisfy current ARIN guidelines

Current Status

- Provisioning an IPv6 Measurement Infrastructure
  - Attempt to perform measurements using IPv4 and IPv6
  - Need for MIBs for basic measurements via SNMP
  - Types of data collected
    - One way latency tests
    - Throughput measurements
    - Netflow measurements
    - Routing
    - End-2-end performance testing

Deployment Issues

- Many campuses unable to deploy IPv6 due to lack of support for IPv6 in router and switch production software code
  - Reluctance to upgrade stable code
- Most standard public software now IPv6 enabled
  - Examples include sendmail, apache, news, etc.
    - Reluctance to upgrade stable servers to new versions
  - For software that is IPv6 enabled, the use of IPv4/IPv6 is almost always transparent. It just works!
- Some software is not available yet
  - Will compile list in the near future of the status of common software

Deployment Issues

- Many monitoring tools are missing impacting security
  - For example, full support for basic IPv6 mib, limiting ability to monitor usage easily.
  - IPv6 netflow is missing on Abilene routers
    - It is difficult to debug DoS attacks, for example
  - Must encourage vendors to support standard tools

Deployment Issues

- Addressing and routing – multi-homing
  - Abilene currently has a /32, allocates /40 prefixes to large connectors, /48 prefixes to universities
  - The classic model for IPv6 is PA addressing, to contain the size/stability of the global routing table – potentially very large if using PI addressing.
  - Recall the complicated hierarchy within our infrastructure
  - Within the next 6 months, we expect member institutions to inherit multiple prefixes, potentially from 2 or more research networks and 2 or more commodity networks
  - Policy requirements complicate the multi-homing problem

Deployment Issues

- Applications
  - Many applications currently available
  - Some reluctance to deploy for fear of breaking v4 availability – gradually decreasing
  - Considering a review process for application deployment. For example,
    - Web servers
    - DNS servers
    - Mail servers
  - Ability to run IPv6 only machines

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
  - Create future web page outlining the deployment

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/fiu/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
  - abilene@internet2.edu
- Questions?

INTERNET2®

www.internet2.edu