Abilene Update

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Outline

- Partners
- Performance
- Participants
- Peering
- Focus Areas
- Futures
Abilene Partnerships

- Indiana University
- Juniper Networks
- Nortel Networks
- Qwest Communications
- Internet2
- ITECs
Abilene Backbone
Performance

- 6.25 Gbps flows across Abilene
  - Recent LSR from Caltech to CERN
- 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
Abilene Timeline

- Apr 1998  Network announced
- Jan 1999  Network went into production
- Second generation network upgrade
  - Oct 2001 Qwest MoU (DWDM+SONET) extension (5 years)
    - Oct 2001 NLR initiative commenced
  - Apr 2002 Juniper router selection
  - Dec 2003 2nd generation upgrade complete
- Oct 2006 Transport MoU with Qwest ends
  - Past experience suggests that the time frame for both next generation architecture finalization & decision on transport partner(s) would occur ~12 months from now – Spring 2005.
IPv4/v6-over-DWDM (OC-192c) backbone

44 direct connections (OC-3c → 10 GigE)
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  • 6 OC-48c connections (2.5 Gbps)
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228 participants – research universities & laboratories
  • All 50 states, District of Columbia & Puerto Rico
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Expanded access
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Abilene Participation - Upgrades

- Connection fees lowered in 2004 to facilitate upgrades

- Upgrades – please contact us to start the process
  - Facilitate the process with Qwest from the national side
  - Insure that there is coordination between the national and local teams working the upgrade
  - We attempt to solve problems that occur, for example dark fiber builds into a Qwest PoP

- We will put up a web page on the Abilene site that describes the process and indicates current status of various upgrades
Abilene Participation - Upgrades

- Current status
  - Connectors well along in the process
    - University of Oregon
    - University of Arizona
  - Connectors looking at upgrades
    - Connectors in Florida (Florida Lambda Rail)
    - Louisiana
    - New Mexico GigaPoP
    - University of Minnesota (Northern Lights)
Abilene International Peering

* via GEANT: ACoNet, BELNet, CARNet, CESNET, CYNET, Forskningsnettet, EENet, Funet, Renater, G-WIN, GRNET, HUNGARNET, Rhenet, HEAnet, IUCN, GARR, LANET, Litnet, RESTENA, Univ. Malta, SURFnet, UNINETT, POL34, RCTS2, RoEduNet, RBnet, SANET, ARNES, RedIRIS, SUNET, SWITCH, JANET, ULAKBIM, CERN

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

- Security
  - Collaboration with REN-ISAC and the pending Cyber Trust effort

- Network resiliency
  - Fast network restoration in the face of outages

- IPv6

- Abilene Observatory – Supporting Network Research and an Open Measurement Platform

- Provisioning dedicated capabilities (with the HOPI project)
Abilene and IPv6

**IPv6 Deployment**

- Significant number of peers and connectors now have native connections:
  - 28 connectors (roughly 2/3 of the connectors)
  - 21 peers
- Abilene is a native backbone participating in the Moonv6 project
  - Provides rich IPv6 connectivity for the research and education community
- Significant experimentation and support effort
  - Looking at multicast deployment
  - DNS and tunnel server support
  - Tutorials at the GigaPoP or university level
- See [http://abilene.internet2.edu/observatory/connection-technologies.html](http://abilene.internet2.edu/observatory/connection-technologies.html)
A program to provide enhanced support of computer science research over Abilene

- 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
- **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](http://abilene.internet2.edu/observatory/research-projects.html)
Abilene Observatory

**Measurement capabilities**

- Four dedicated servers at each node
  - Local data collection to capture data at times of network instability
  - CDMA device provides GPS-synchronized time signals
  - Provision for additional servers in the future
- Datasets
  - Usage Data – the amount of traffic on network links
  - Netflow Data – data that examines individual flows across the network
  - Routing Data – where packets are directed within the network
  - Latency Data – how long it takes packets to reach their destinations
  - Throughput Data – the capability of the network to support flows of information.
  - Router Data – how the routers view the network
  - Syslog Data – what the routers are reporting about the network
Abilene Observatory

- Recent additions
  - IGP (IS-IS) Data collections
  - The worst ten lists

- Concerted effort to coordinate activities with the research communities
Dedicated Capabilities on Abilene

Recent MPLS/VPN Experiments
- MPLS tunnel to support the PSC connection to the TeraGrid
- Permanent MPLS L2VPN between Abilene NOC and North Carolina ITEC
- Lightpath experiment from LA to CERN – MPLS L2VPN across Abilene from LA to Starlight
- MPLS L2VPN to support the Texas connection to the TeraGrid

Future Experiments
- Expand ITEC/NOC tunnel by creating MPLS L2VPN capability between the Abilene NOC and all the ITECs
- Will support MPLS L2VPNs for research groups
- Will pursue other opportunities over next year, especially related to the HOPI project
HOPI – The Hybrid Optical and Packet Infrastructure Project

- Project of Internet2
- Creating a HOPI testbed
- Testbed will use resources from Abilene, the Internet2 wave on NLR, the MAN LAN Experimental facility, and the Regional Optical Networks

Goal is to look at future architectures involving a hybrid of shared packet switched networks like Abilene and an infrastructure consisting of dynamically provisioned optical waves

- In particular, to examine next generation Internet2 architectures

MPLS L2VPN tunnels across Abilene will provide access to the HOPI testbed
Abilene and the HOPI Project

- HOPI Design Team (consisting of many Internet2/Abilene participants) has created a HOPI Testbed Whitepaper
  - Now available on the HOPI web site at
    - http://hopi.internet2.edu

- Will coordinate activities with other groups and testbeds
  - Surfnet
  - CA*net
  - Research projects such as DRAGON and CHEETAH
More information

- http://abilene.internet2.edu
- http://abilene.internet2.edu/observatory
  - Additional pointers off this page
- http://hopi.internet2.edu
- abilene@internet2.edu
- hopi@internet2.edu
Internet2, NLR, and the RONs

• Internet2 is one of the strongest collaborators/contributors within NLR and for the Regional Optical Networks (RONs)
• We believe it is essential that NLR is successful, and we are committing resources accordingly
  – Internet2 is contributing $10M directly to NLR in unrestricted cash and dark fiber – largest R&E contributor
  – Significant personnel engagement:
    • Doug Van Houweling (board member)
    • Steve Corbató (board officer)
    • Steve Cotter (implementation)
    • Michelle Pollak (communications)
  – Internet2 is planning to use its NLR λ capability in a visible fashion through the HOPI testbed
• We believe that RON development is absolutely critical for the future architecture
  – FiberCo is facilitating both NLR and RON development
  – Quilt Fiber project is focusing on RON optical equipment
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32 connections utilize provided SONET backhaul
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- **Time is now for architecture evaluation and planning**
  - HOPI design team and testbed is a first step in this direction
The fundamental nature of *regional networking* is changing

- The *GigaPoP* model based on *provisioned, high-capacity services* is being replaced steadily – on the *metro and regional scales*

- A model of *facility-based networking often built with owned assets* – Regional Optical Networks (RONs) – has emerged

- Notably, this change *increases* the importance of regional networks in the traditional *three-level hierarchy* of U.S. R&E advanced networking
  - The Quilt Project is a critical component in facilitating these ongoing metamorphoses
### Gauging community-wide progress with dark fiber

- **Aggregate dark fiber held for and assigned by U.S. R&E optical initiatives (segment-miles):**
  - CENIC (for NLR and CalREN via L3, WilTel) 6,200
  - FiberCo (for NLR and RONs via Level 3) 4,900
  - SURA (via AT&T) 6,000
    - (plus 2,000 route-miles for research usage)
  - Oak Ridge National Lab. (via Qwest) 900
  - Ohio 1,600
  - Other state projects (IN, IL, MI, OR, etc.) 1,500+

- **Total (conservative estimate)** 21,000+

- **Pending procurements (TX, NY, NE)** 1,700+
HOPI’s raw materials

- **Abilene Network**
  - 10-Gbps IPv4/IPv6 + MPLS tunnels

- **Internet2’s 10-Gbps λ over NLR**

- **MAN LAN exchange point – New York City**
  - Ethernet Switch – layer 2 switching
  - TDM Switch – layer 1 switching
  - Venue for international collaboration
    - SURFnet, CANARIE, ESnet, SINET, Abilene

- **IEEAF/Tyco 10-Gbps λ - NYC-Amsterdam**

- **Collaborations with Regional Optical Networks (RONs) and other related efforts (e.g., GLIF, DRAGON)**
SURFnet6 Network Architecture
Conclusions

- Abilene is now halfway into its 2\textsuperscript{nd} generation
  - Established platform for network and application innovation for the U.S. R&E community
  - Strong community and established business plan
  - We have a very strong partnership – Qwest, Juniper, and IU

- The logical starting point for evaluation process for next generation architecture is now…
  - We are at an inflection point in network architecture
  - HOPI design team and testbed underway
  - Read the design team report: \texttt{http://hopi.internet2.edu}
  - Coordinating with the RON buildouts and NLR time table will be a critical task

- Good news: lots to evaluate, ponder & discuss
  - We need your input: \texttt{abilene@internet2.edu}
  - Phone (Steve): 734-352-7006