
INTERNET2®
Next Generation Abilene
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Abilene – April, 2002

- IP-over-SONET backbone - OC-48c, 2.5 Gbps
- 53 direct connections
  - 4 OC-48c connections
  - *1 Gigabit Ethernet trial*
  - 23 will connect via at least OC-12c (622 Mbps) by 1Q02
  - Number of ATM connections *decreasing*
- 212 participants – research universities & labs
  - All 50 states, District of Columbia, & Puerto Rico
  - 15 regional GigaPoPs support ~70% of participants
- Expanded access
  - 48 sponsored participants
  - *21 state education networks*

Abilene international connectivity

Transoceanic R&E bandwidths growing!

- GÉANT – 5 Gbps between Europe and New York City

Key international exchange points in U.S.

- Gigabit Ethernet ($\rightarrow$ 10 GE) exchange points
  - STAR LIGHT – Chicago
  - Pacific Wave – Seattle
  - Manhattan Landing – New York City (under development)
- Americas interconnectivity
  - AMPATH – Miami (OC-3c $\rightarrow$ OC-12c)
  - CA*NET3 (Canada) – Seattle, Chicago, and New York
  - CUDI (Mexico) – CENIC and Univ. of Texas at El Paso

International transit service

- Collaboration with CA*NET3 and STARTAP

Packetized raw High Definition Television (HDTV)

Raw HDTV/IP – single UDP flow of **1.5 Gbps**

- Project of USC/ISIe, Tektronix, & UWash (DARPA support)
- 6 Jan 2002: Seattle to Washington DC via Abilene
  - Single flow consumed 60% of backbone bandwidth
- 18 hours: **no packets lost**, 15 resequencing episodes
- End-to-end network performance (includes P/NW & MAX GigaPoPs)
  - Loss: <0.8 ppb (90% c.l.)
  - Reordering: 5 ppb
- *Transcontinental* 1-Gbps TCP requires loss of
  - <30 ppb (1.5 KB frames)
  - <1 ppm (9KB jumbo)

Future of Abilene

Original UCAID/Qwest agreement amended on October 1, 2001

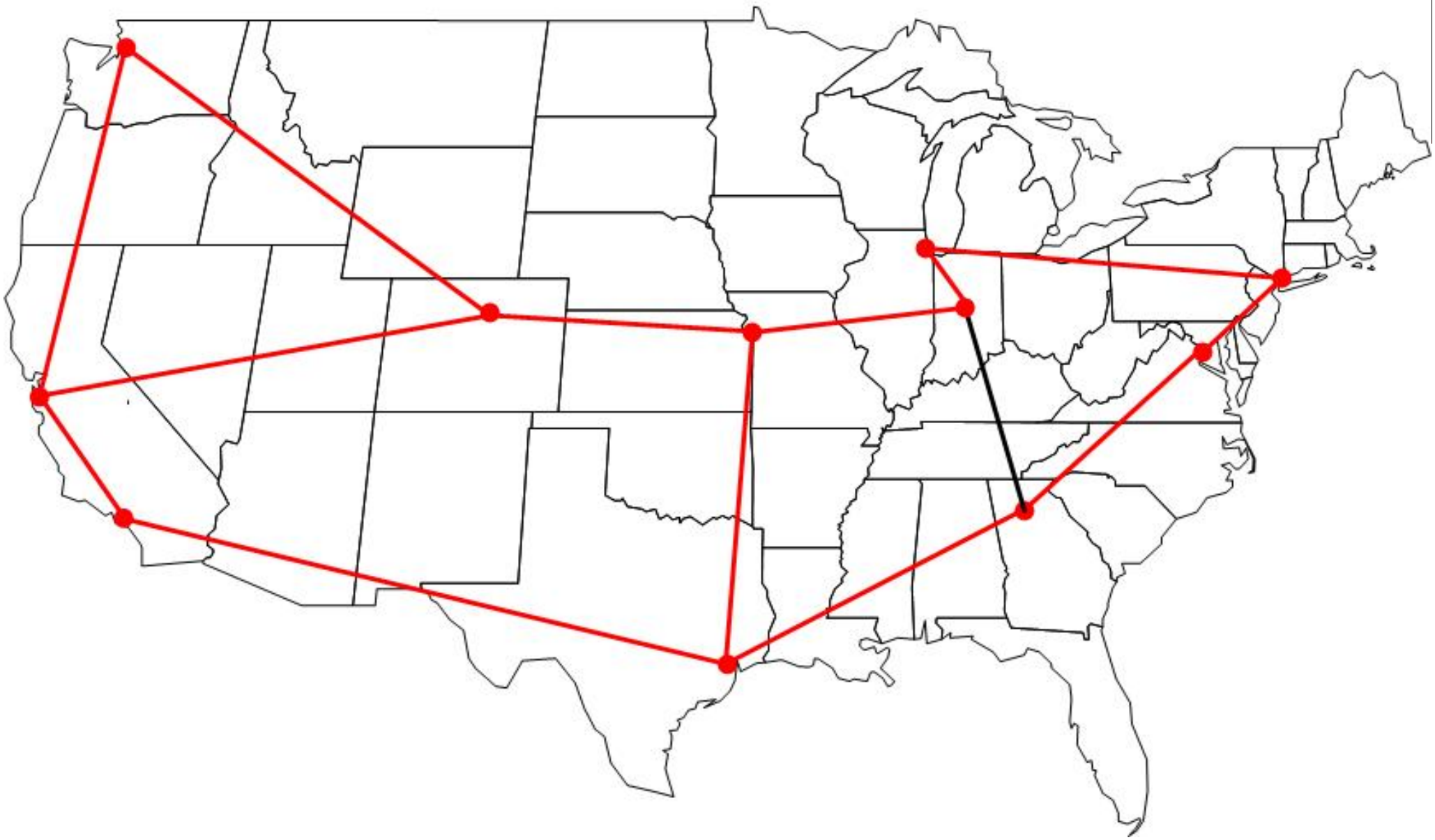
Extension of for another 5 years – until October, 2006

- Originally expired March, 2003

Upgrade of Abilene backbone to optical transport capability - λ's (unprotected)

- x4 increase in the core backbone bandwidth
  - –OC-48c SONET (2.5 Gbps) to 10-Gbps DWDM

ABILENE NETWORK 10-Gbps OPTICAL UPGRADE - 2002-2003 (DRAFT)



Two leading national initiatives in the U.S.

Next Generation Abilene

- Advanced Internet **backbone**
  - connects entire campus network of the research universities
- 10 Gbps nationally

TeraGrid

- Distributed computing (Grid) **backplane**
  - connects high performance computing (HPC) machine rooms
- Illinois: NCSA, Argonne
- California: SDSC, Caltech
- 4x10 Gbps: Chicago ↔ Los Angeles

Ongoing collaboration between both projects

Key aspects of next generation Abilene backbone

Native IPv6

- Run natively - concurrent with IPv4
- Replicate multicast deployment strategy
- Close collaboration with Internet2 IPv6 WG

Network resiliency

- Abilene λ's will not be *protected* circuits as with SONET
- Need restoral times under 100 ms – VoIP and videoconf

Enhanced, differentiated measurement capabilities

- Active measurement, traffic matrices, routing information
- Computer science research via Abilene Observatory
- End-to-End Performance beacons

Regional optical fanout

Next generation architecture: Regional & state based optical networking projects are critical

- Three-level hierarchy: backbone, GigaPoPs/ARNs, campuses
- Leading examples
  - CENIC ONI (California), I-WIRE (Illinois), I-LIGHT (Indiana)

Close collaboration with the Quilt Project

- Regional Optical Networking effort

U.S. carrier DWDM access is now not nearly as widespread as with SONET circa 1998

- 30-60 cities for DWDM
- ~120 cities for SONET

Optical network project differentiation

	Distance scale (km)	*Examples*	*Equipment*
Metro	< 60	UW(SEA), USC/ISI(LA)	Dark fiber & end terminals
State/ Regional	< 500 (ULH: < 2500)	I-WIRE (IL), CENIC ONI, I-LIGHT (IN)	Add OO amplifiers
Extended Regional/ National	> 500	Pacific LR, TeraGrid NG Abilene	Add OEO regenerators & O&M $'s

Future of Abilene

- UCAID's partnership with Qwest extended through 2006
- Upgrading to 10-Gbps λ's in three phases starting this summer
- Emphasizing native IPv6, enhanced measurement, and increased resiliency
- Planning for an incremental, non-disruptive transition
- Collaborating with the NSF supported TeraGrid project