



Developing a national R&E optical networking capability in the United States

Steve Corbató

Director, Backbone Network Infrastructure

AMPATH Workshop

Miami

30 January 2003

Emerging requirements may not met by a high-performance, yet best-effort IP network

- DWDM: 10-Gbps channels now; 40-Gbps hard, but coming
- Computational science grids
 - Applications with deterministic network requirements
- Infrastructure for basic and applied network research

Period of unprecedented contrarian economic opportunity

- Distressed fiber assets available on national scale
- Optronics industry severely impacted by carrier woes

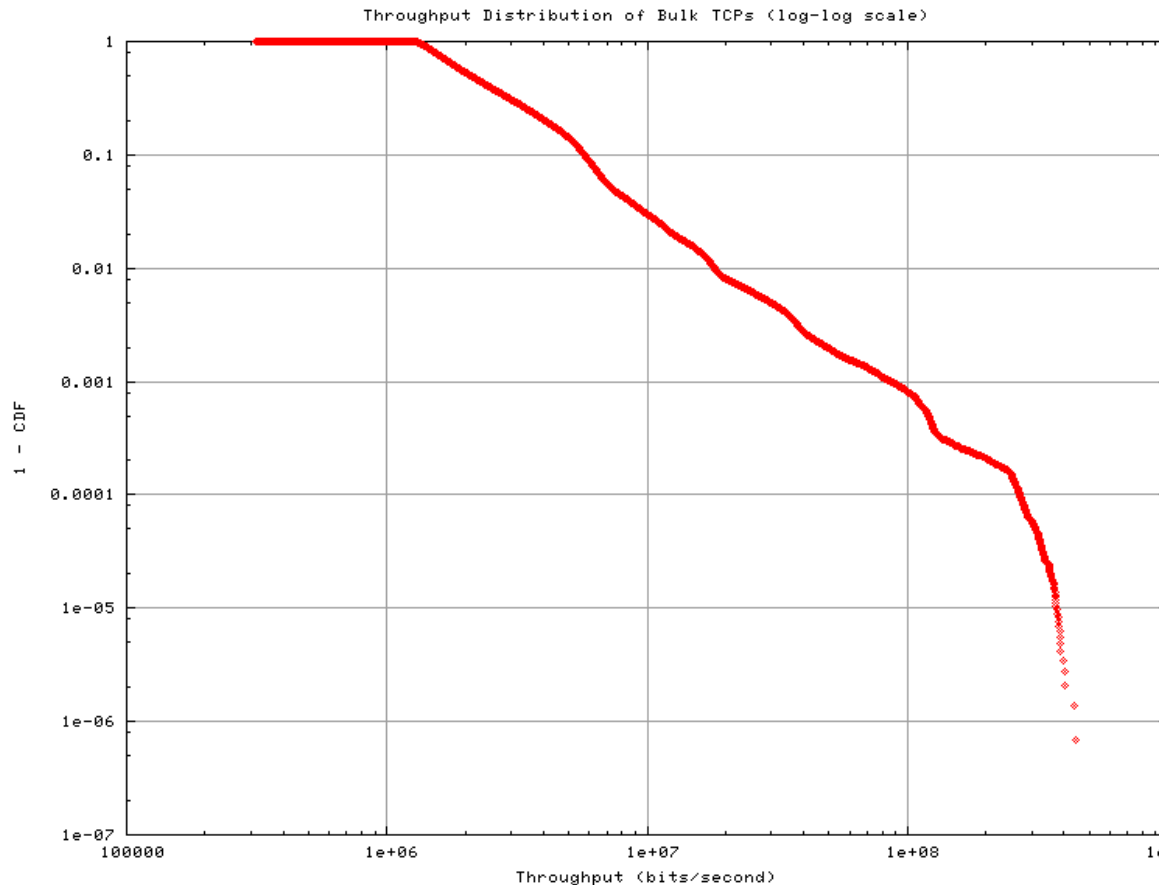
However, optical networking alone does not solve the end-to-end performance problem

- Host configuration (Web100)
- Local networking capability (DAST, Internet2 E2EPI)

End-to-End Performance: ‘High bandwidth is not enough’

Bulk TCP flows (payloads > 10 MBytes)

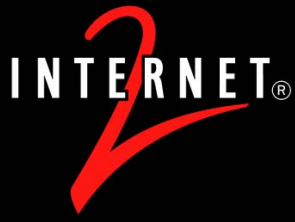
Median flow rate over Abilene: 2.1 Mbps





Optical network project differentiation

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



Unique optical requirements in Higher Education Community (HEC)

10-Gbps: 10 Gigabit Ethernet preferred over OC-192c SONET

HPC could need 40-Gbps λ 's prior to the carriers

Integrated view of network management

- Transport & IP engineering/operational approaches are not intrinsically different
- SNMP preferable for network polling

HEC can provide experimental environment for development of 'rational', customer-focused optical switching

- Switching tightly integrated with optical transport
- Capacity for IP backbone expansion and p2p λ 's

Three current projects

- Fiberco
- USA Waves
- National Light Rail

Common factors

- National fiber footprint represents a strategic asset for HEC
- All leverage the much lower *incremental* cost of λ 's in an existing DWDM system (vs. the cost of the first λ)

Differentiating factors

- Scope
- Buy vs. build
- Production vs. research capabilities
- Participation cost

National fiber assets

- CENIC: \$5M minimum commitment for Level 3 fiber

Fiberco as fiber holding company

Can hold national/regional fiber assets with capability to assign to other organizations

- Intent is for CENIC and UCAID to assign fiber here
- Can support national initiatives such as National Light Rail
 - **Unlit** national fiber is a strategic asset for HEC
- Can support regional fiber acquisition outside NLR
- Not an operational entity (i.e., cannot light the fiber)

Limited scope simplifies governance issues

- UCAID assumed responsibility for LLC formation
 - Partners: CENIC, Pacific Northwest, Virginia Tech
- Level 3 has been very supportive of the concept

SURA initiative

- Outgrowth of SURA National Buyers Consortium
- UCAID and many U.S. Gigapops are collaborators

Proposed cooperative agreement with AT&T

- Ability for HEC to provision 2.5 and 10 Gbps λ IRUs at carrier's *incremental cost*
 - Anywhere on existing DWDM deployment and on future DWDM network
- Dark fiber & network equipment donation
 - Fiber available for network research
- Ability for HEC to procure additional dark fiber

Organization

- Non-profit, cooperative membership approach
- No entry fee for participation
- Very much in early stages of development

National facilities-based approach for optical networking and network research

- 15,000+ miles of fiber footprint
- HEC owned/managed fiber and optronics for p2p λ 's
- Shared experimental services: IP and GigE

Enabling innovative network research is key goal

Leadership: CENIC, Pacific Northwest Gigapop

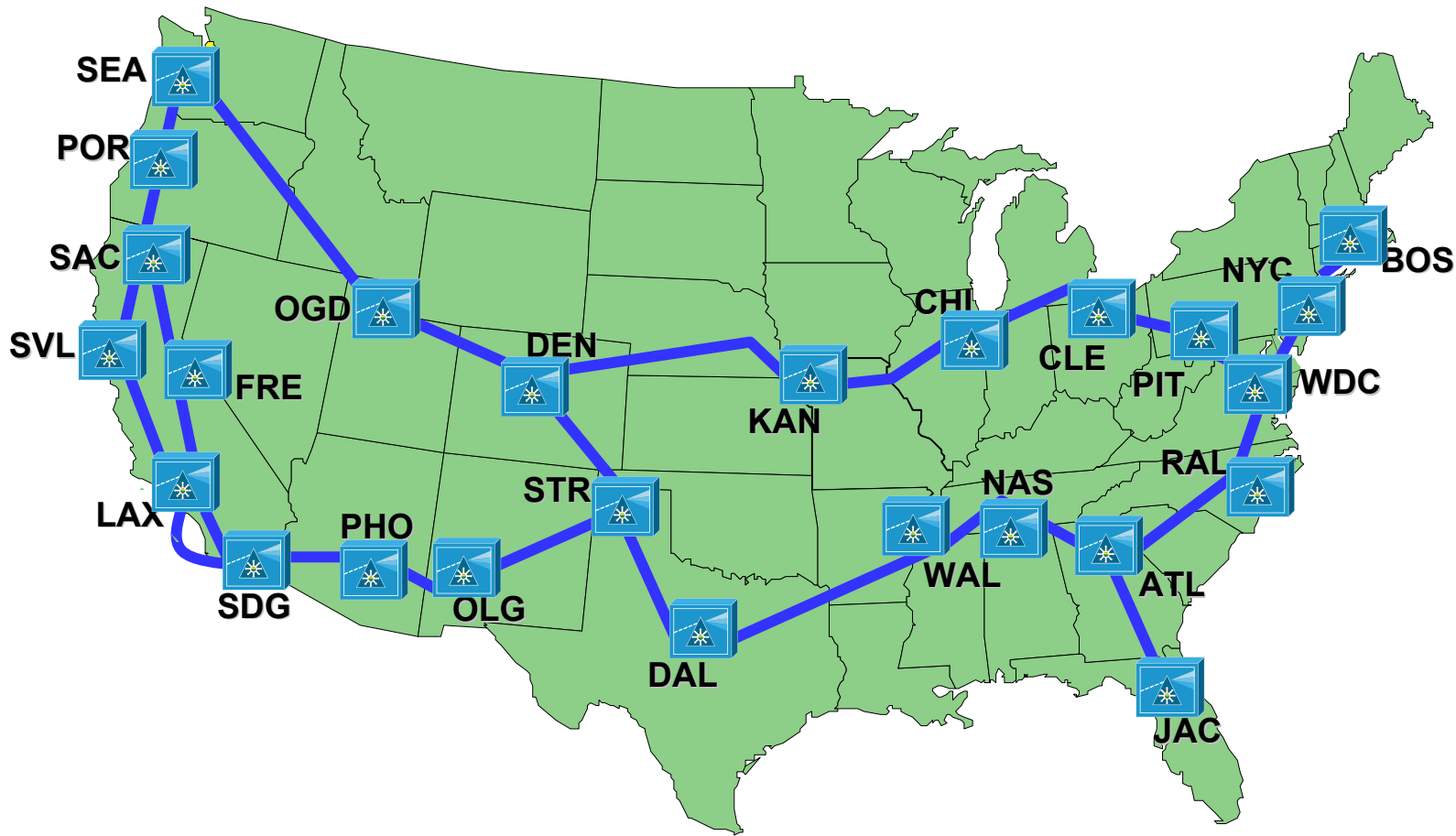
- Outgrowth of CENIC ONI regional project
- UCAID and multiple research universities collaborating

Corporate partners: Cisco, Level 3

Economics

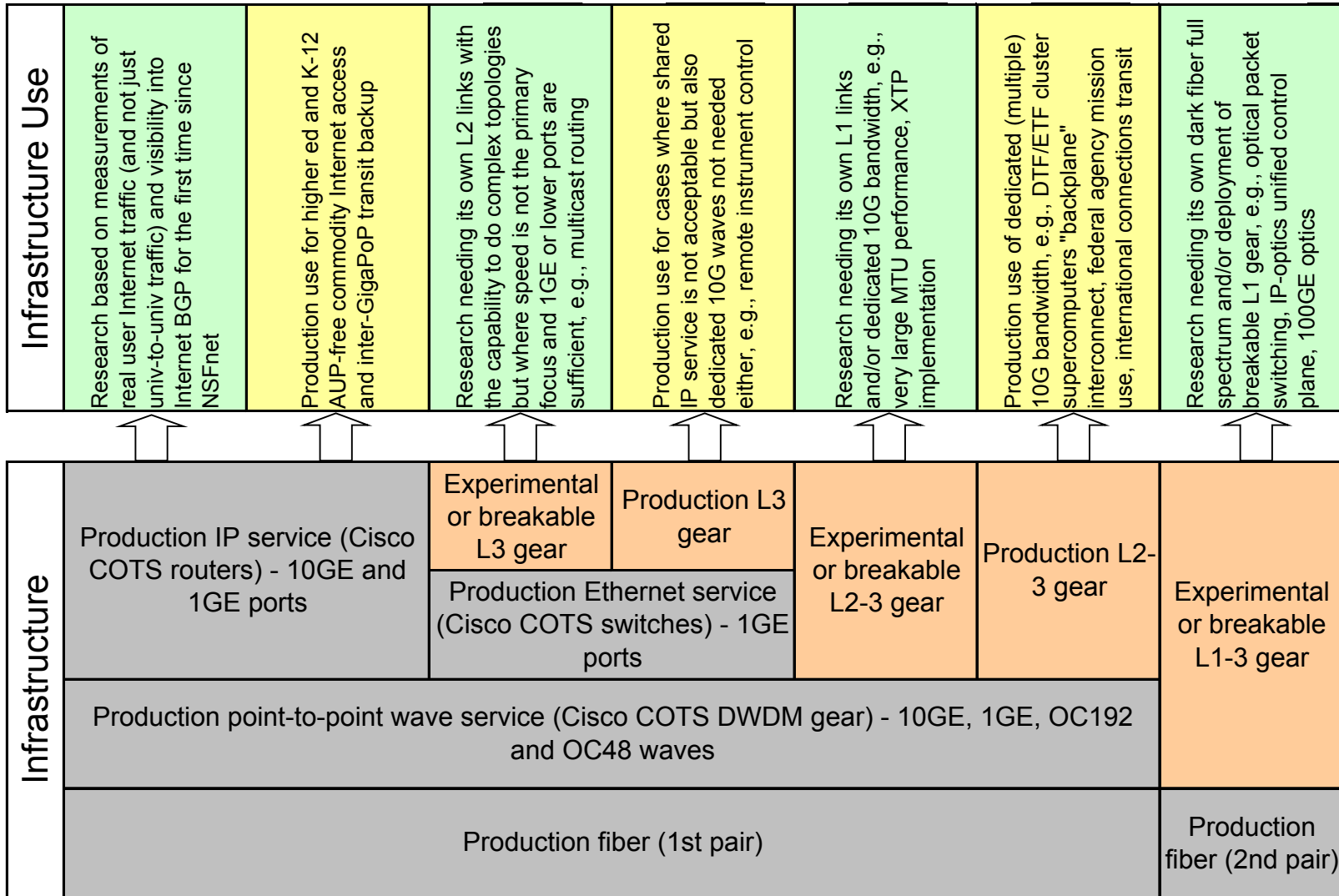
- 5-year cost for national footprint: \$83M (for 4 10-Gbps λ 's)
- Significant participation fee: \$5M over 5 years

NLR Footprint and Layer 1 Topology



 15808 Terminal, Regen or OADM site (OpAmp sites not shown)
 Fiber route

NLR networking research use vs. production (including science research) use



- NLR operated
- NLR or its production customer or researcher operated
- Research use
- Production use

- 3 significant national optical networking initiatives underway in the U.S.
 - Fiberco, USA Waves, National Light Rail
- Higher education community will continue to acquire dark fiber assets on the national and regional scales in 2003
- Regional optical networks will be deployed
- Whether a national optical networking capability will be '*built or bought*' is an open issue
 - Possibility of hybrid approach
- In either case, expanding requirements of the computational science and network research communities must be addressed