

NLR Update: Facilitating Learning and Discovery on a Global Scale

International ICFA Workshop on HEP Networking,
Grid and Digital Divide Issues for Global e-Science
Daegu, Korea
May 24, 2005

Dr. Don Riley
Univ. of Maryland, SURA IT Fellow
Member, NLR Board
drriley@umd.edu



nlr.net

© 2004 National LambdaRail, Inc

Institutional, Regional, National and International Network Infrastructures

Owned by
the Research and Education Community:
A Key Pillar



Key Words of the Specific Messages

- Ownership and Control
- Leadership and Partnership
- Network Research Laboratory
- Big Science - Big Pipes, New Capabilities
- Teaching-Learning - Big Pipes
- Collaboration and Cost Efficiencies
- Worldwide Connectivity



Sea Change in R&E Impacting Networking Needs

- Increased collaboration worldwide on “Big” Science projects
- Exponential growth in size of data sets being accessed
- Grids - Shared, Distributed Resources
- Growing urgency for new network technologies
- Need for multiple dedicated/private research networks



Demands of Top Computing and Network-Intensive Research Applications

- Astronomy
- Biotechnology
- Drug Research
- Healthcare Delivery
- High Energy and Nuclear Physics
- Weather Research -- Monitoring & Prediction
 Tsunami.....
- Wearable Sensors & Sensor Nets, Sensor Grids
- Etc

Advanced applications will become routine.



Emerging Optical Networking Fundamentals

Dark Fiber + DWDM =

Multiple networks on same fiber pair

Networks versus Infrastructure



Access to Dark Fiber and DWDM Changes Networking Dynamics

- Support new “Big Science” applications with dedicated or “on demand” connections/bandwidth
- Realize cost effectiveness
- Enable large-scale network research
- Ensure flexibility in adopting new technologies
- Support many dedicated research networks on same network infrastructure



U.S. R&E Optical Network Development

- 1995: Individual Institutions deploy fiber campus-wide
- 2000: Regional Optical Networks Emerge in USA
- 2003: National LambdaRail formed in May
- 2003: First NLR segment lit in November
- 2004: Phase 1 of NLR completed and operational in August
- 2004: Regional optical networking explodes

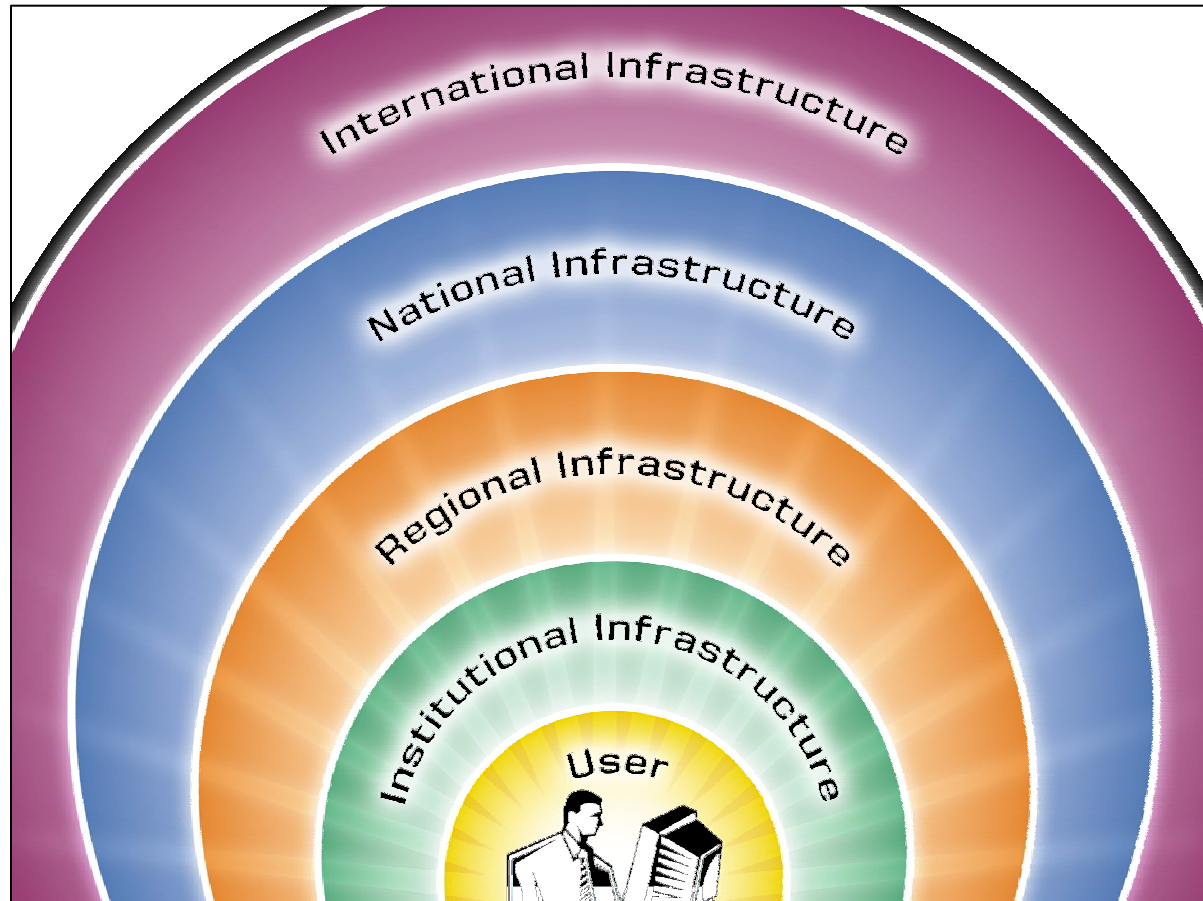


Optical Network Infrastructure Framework

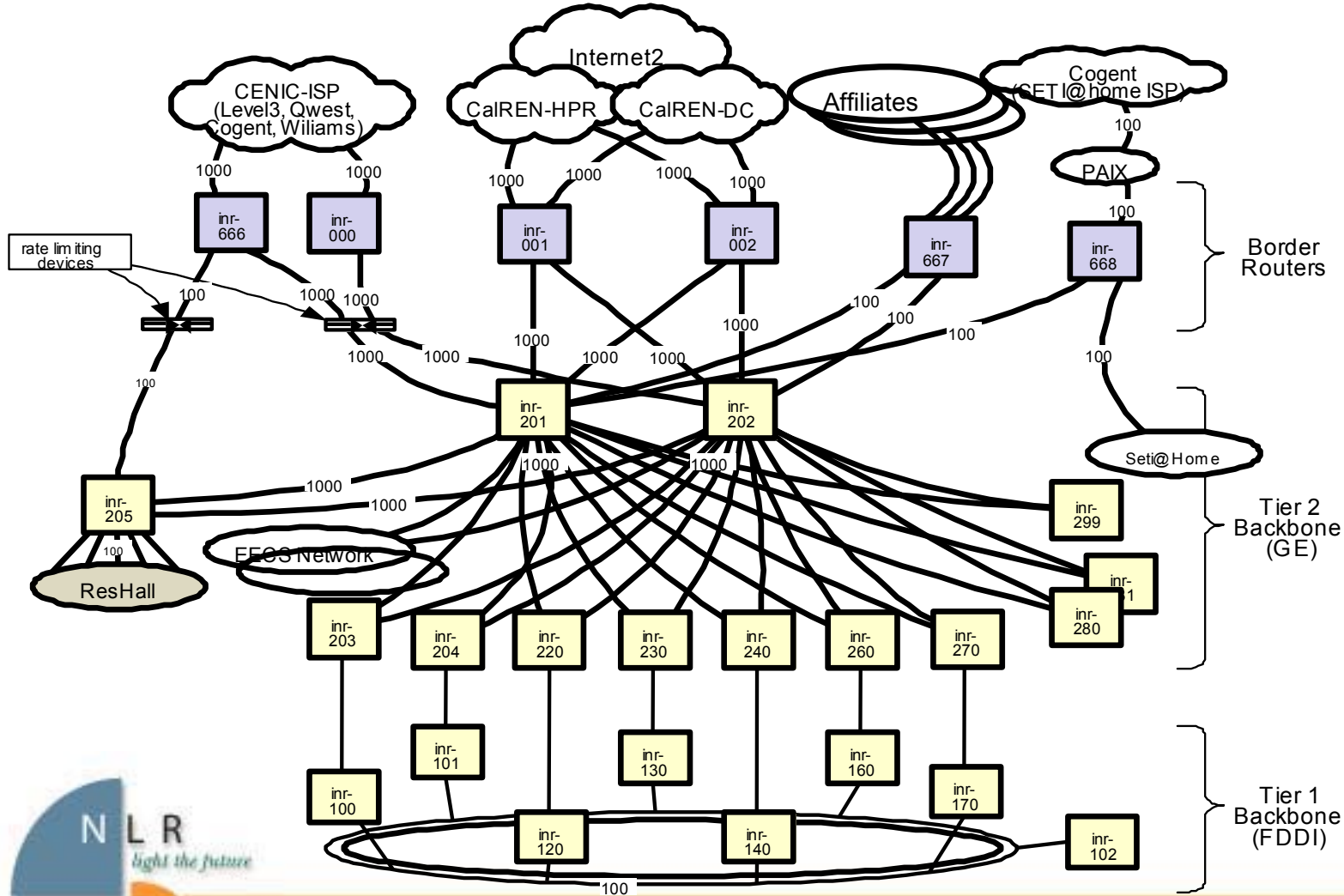
Efforts to deploy optical networking are being led by groups that might be called **Network Infrastructure Plumbing Persons for Education and Research**

(The NIPPERS)

Tom West



University of California Berkeley Example



Regional Response in the United States

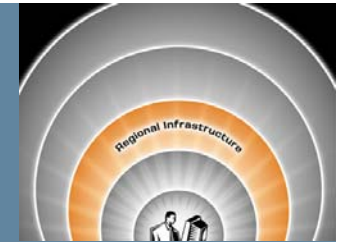


2000-2004: Regional Optical Networks Emerge in USA

2004-2005: Regional Optical Networking Explodes



Leading & Emerging Regional Optical Networks



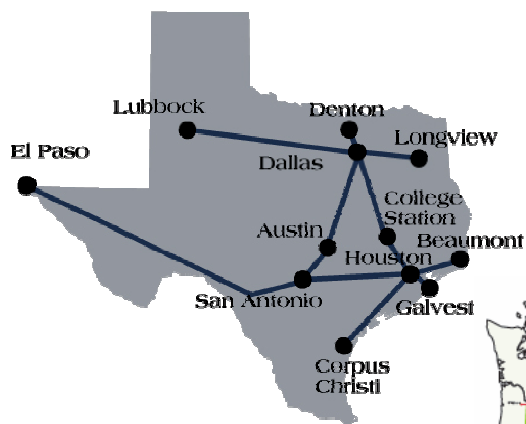
- Arkansas
- California (CALREN)
- Colorado (FRGP/BRAN)
- Connecticut (Conn. Education Network)
- Florida (Florida LambdaRail)
- Georgia (Southern Light Rail)
- Indiana (I-LIGHT)
- Illinois (I-WIRE)
- Louisiana (LONI)
- Maryland, D.C. & northern Virginia (MAX)
- Michigan
- Minnesota
- New York + New England region (NEREN)
- North Carolina (NCLambdaRail)
- Ohio (Third Frontier Network)
- Oklahoma (OneNet)
- Oregon Pacific Northwest (Lariat – supported by NIH)
- Rhode Island (OSHEAN)
- SURA Crossroads & Atlantic Wave (Southeastern U.S.)
- Tennessee (OneTN)
- Texas (LEARN)
- Utah
- Virginia (MATP)



RONs - Regional Optical Networks



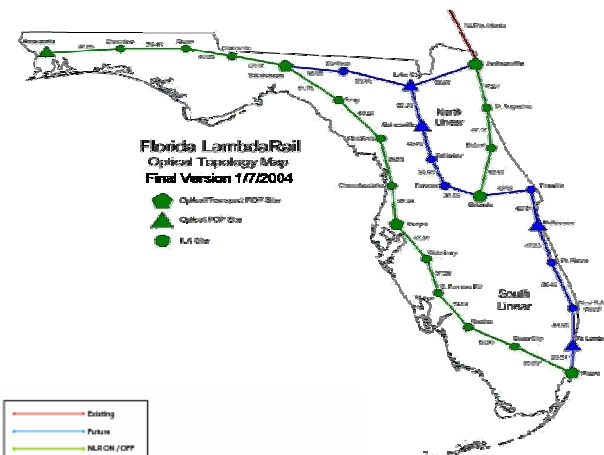
Texas - Lonestar Education and Research Network (LEARN)



Louisiana Optical Network Initiative (LONI)



Florida LambdaRail (FLR)

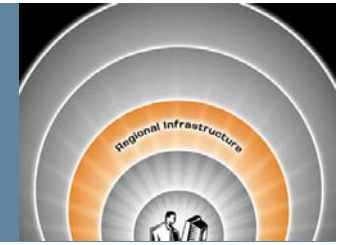


Facilities-based Regional Optical Networks

Rev: 04/14/04 May 2003
(Please send updates to sw@indiana.edu)

www.neron.edu
Advanced Network Management
Laboratory
<http://www.neron.edu>

Aggregate Dark Fiber Assets Acquired by U.S. R&E Optical Network Initiatives



| <u>Organization</u> | <u>Route-Miles</u> |
|--|--------------------|
| • CENIC (for CalREN & NLR) | 6,200 |
| • FiberCo (via Level 3 for NLR & RONS) | 5,700 |
| • SURA (via AT&T) | 6,000 |
| • Plus 2,000 route-miles for research | |
| • NLR Phase 2 (Wiltel & Qwest) | 4,000 |
| • OARnet Third Frontier Network | 1,500 |
| • ORNL (via Qwest) | 900 |
| • Other projects (IN,IL,MI,OR,CT,NEREN...) | 2,900+ |

Total (conservative estimate) 27,200+



National-Scale Opportunity in the United States



- Leverage, and provide leverage to, regional efforts
- Unprecedented opportunity to support network research on a national scale
- Continued ability to collaborate with international partners in advanced networking



National LambdaRail Mission

To advance the research, clinical and educational goals of members and other institutions by establishing and maintaining a nationwide advanced network infrastructure.



National LambdaRail Goals

- Support **experimental and production** networks
- Foster **networking** research
- Promote and enable next-generation **applications**
- Facilitate **interconnectivity** among high-performance research and education networks



National LambdaRail Members and Associates

- CENIC
- Pacific Northwest Gigapop
- Pittsburgh Supercomputing Center/University of Pittsburgh
- Duke University, representing a coalition of NC universities
- Mid-Atlantic Terascale Partnership
- Cisco Systems
- Internet2
- Florida LambdaRail
- Georgia Institute of Technology
- Committee on Institutional Cooperation (CIC)
- Cornell University
- Louisiana Board of Regents
- Oklahoma State Board of Regents
- Lonestar Education and Research Network (LEARN)
- University of New Mexico (on behalf of the State of New Mexico)
- UCAR/FRGP



National LambdaRail Class C Members

- Southeastern Universities Research Association (SURA)
- Oak Ridge National Lab (ORNL)
- Case Western Reserve University



Strategic Corporate Participants

- **Cisco Systems**
- Level 3 Communications
- WilTel Communications



NLR Infrastructure

- Owned fiber (20 years) nationwide
- Layer 1: DWDM supporting up to ~40 10 Gbps lambdas
- Layer 2: Gigabit Ethernet
- Layer 3: IP Network
- Wavelengths to support additional Layer 2 and 3 experimental or production networks
- Possible additional experimental Layer 1 infrastructure

As Layer 1 through Layer 3 transport becomes more dynamic and flexible, these services will overlap with Internet2's



Recent NLR Progress

- Phase 1 complete; Phase 2 committed
- Network Research Council established; Science Research Council being formed
- Internet2 & NLR research collaboration through Research Councils
- Cisco funding for network research
- Services supporting a wide range of research projects
 - Teragrid, DOE ESNEAT, NASA, Optiputer, SC200x
 - HOPI experimentation over NLR
- Already committed uses of 20% of total network capacity (i.e., wave segments)



Phase 1 (complete)



For more information regarding NLR see <http://www.nlr.net> or contact info@nlr.net

Phase 1 + Phase 2 (Complete Sept. '05)



For more information regarding NLR see <http://www.nlr.net> or contact info@nlr.net

Communities Served by NLR

- Network Researchers
- Science Researchers—Big Applications
- Educators---Teaching-Learning Applications

Supercomputing continues to be a key driver

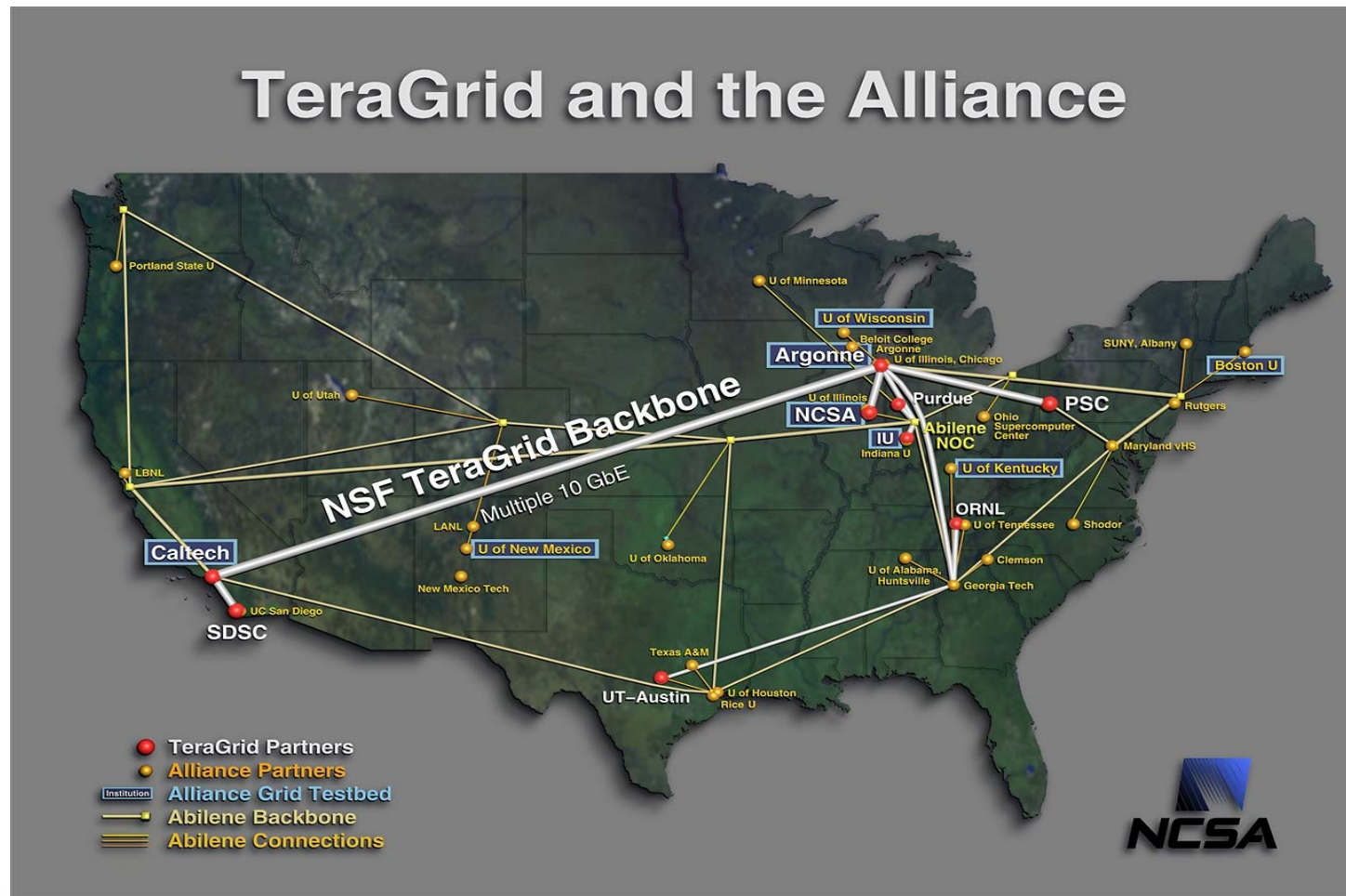


Special Commitment to Network Research

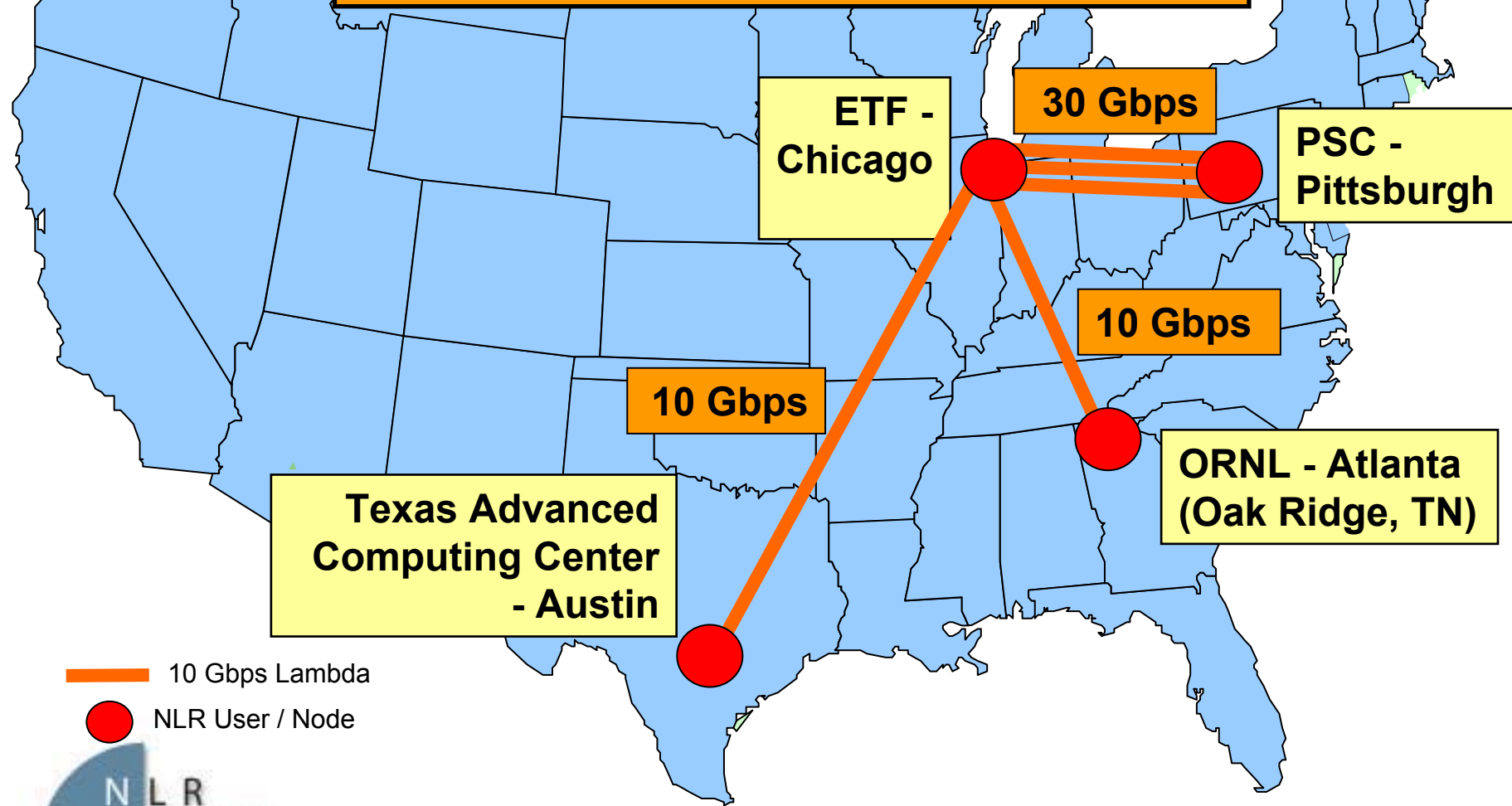
- Devoting up to 50% of NLR capacity to support network research projects
- Advisory council of leading network researchers sets the agenda



Current Projects Served: TeraGrid Extensible Terascale Facility (ETF)



NLR Lambdas Supporting *ETF*

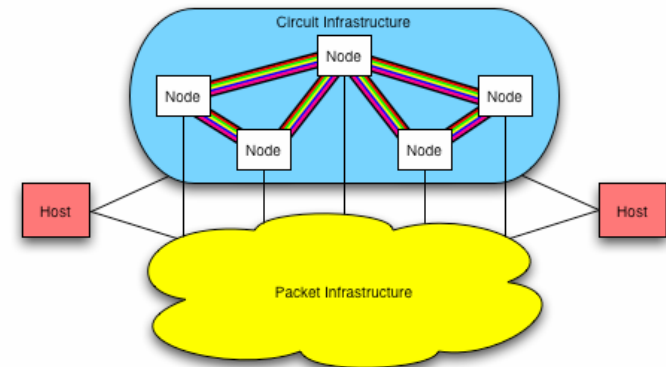


— 10 Gbps Lambda
● NLR User / Node

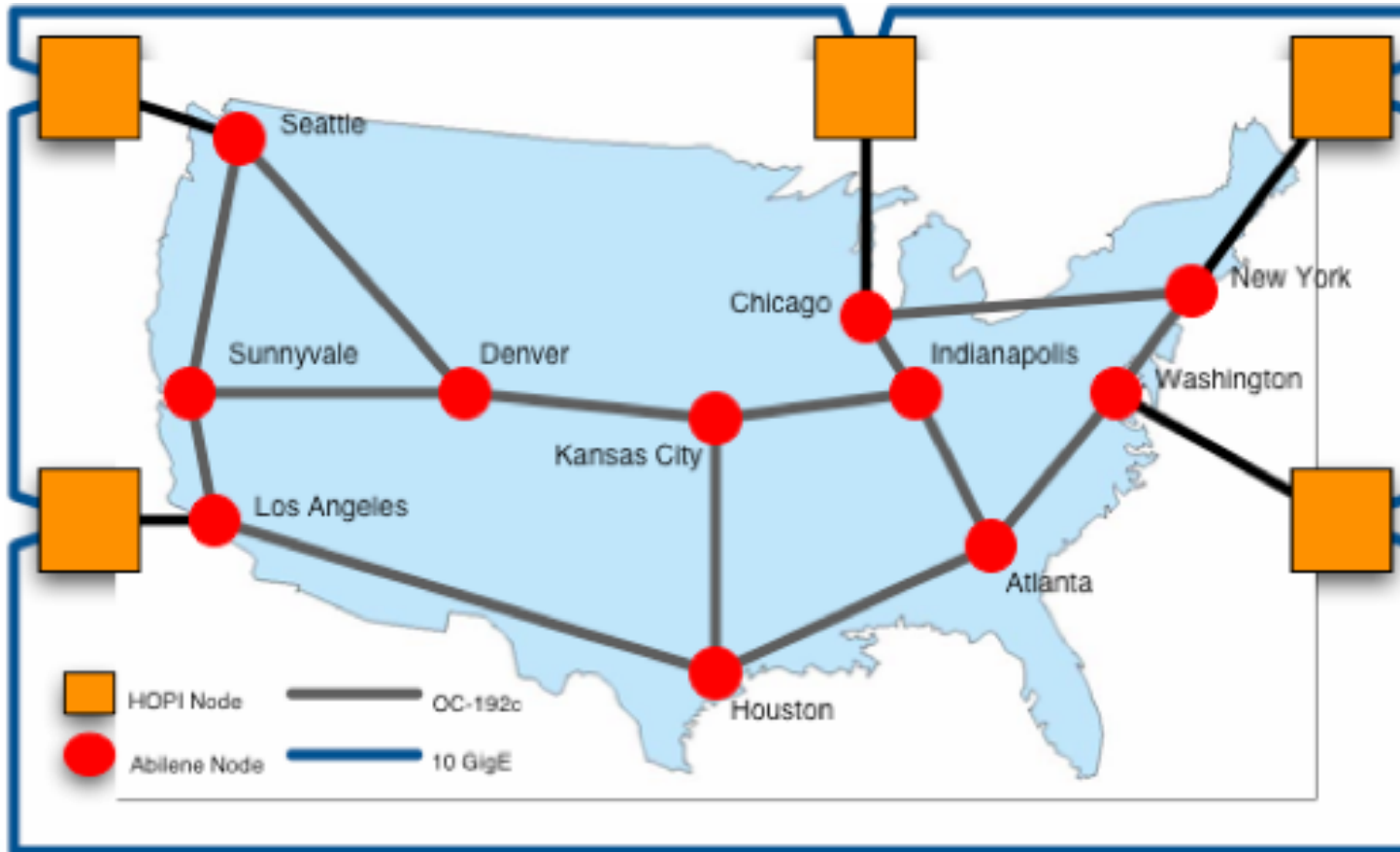


Current Projects Served: Internet2 Hybrid Optical Packet Infrastructure (HOPI)

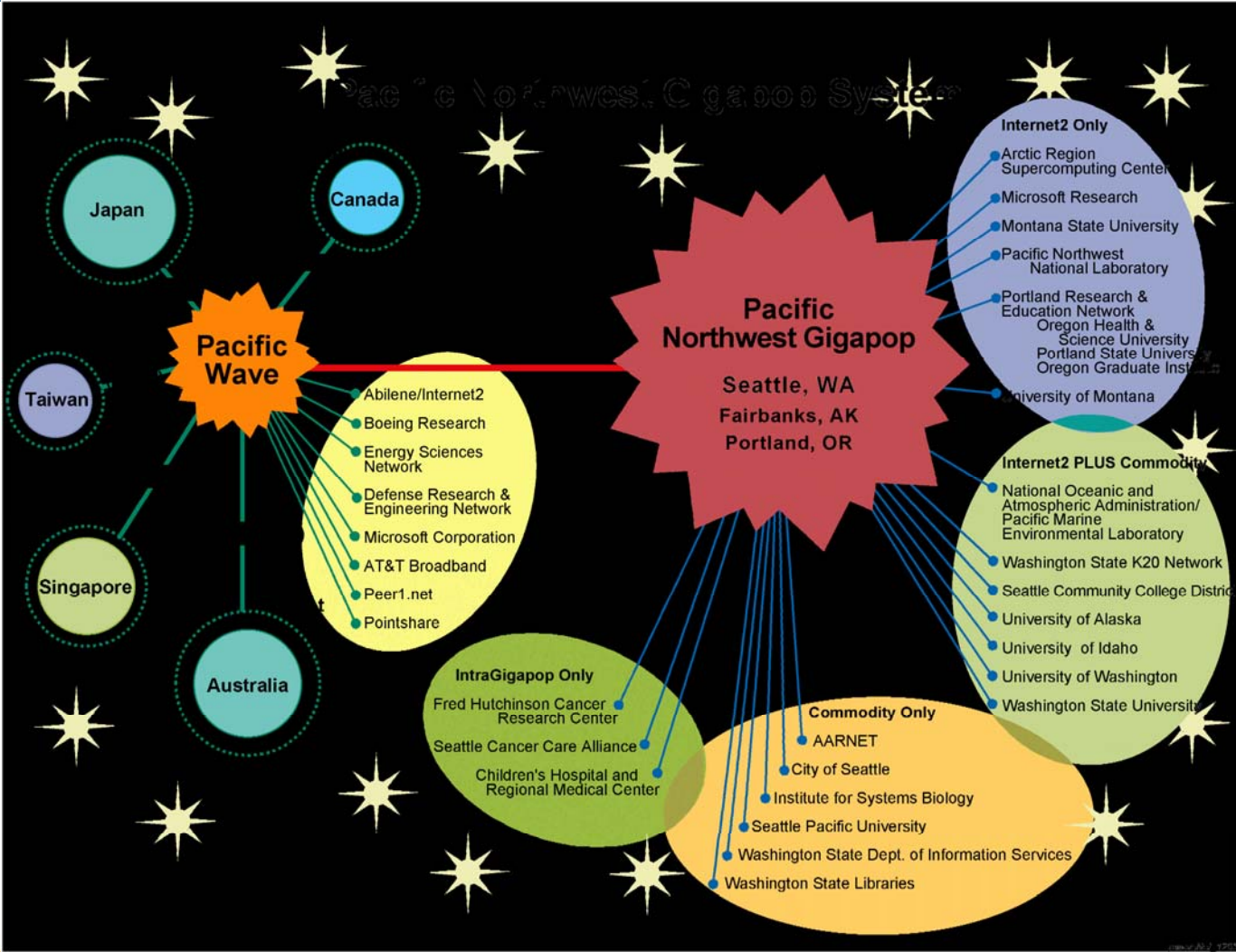
- Exploring the evolution of the Internet's core architecture
- Examining a hybrid of packet switching and dynamically provisioned lambdas
- Engaging industry, regional, and international partners
- Deploying a testbed based on design team's white paper
- Just Announced: DC to LA wave for HOPI

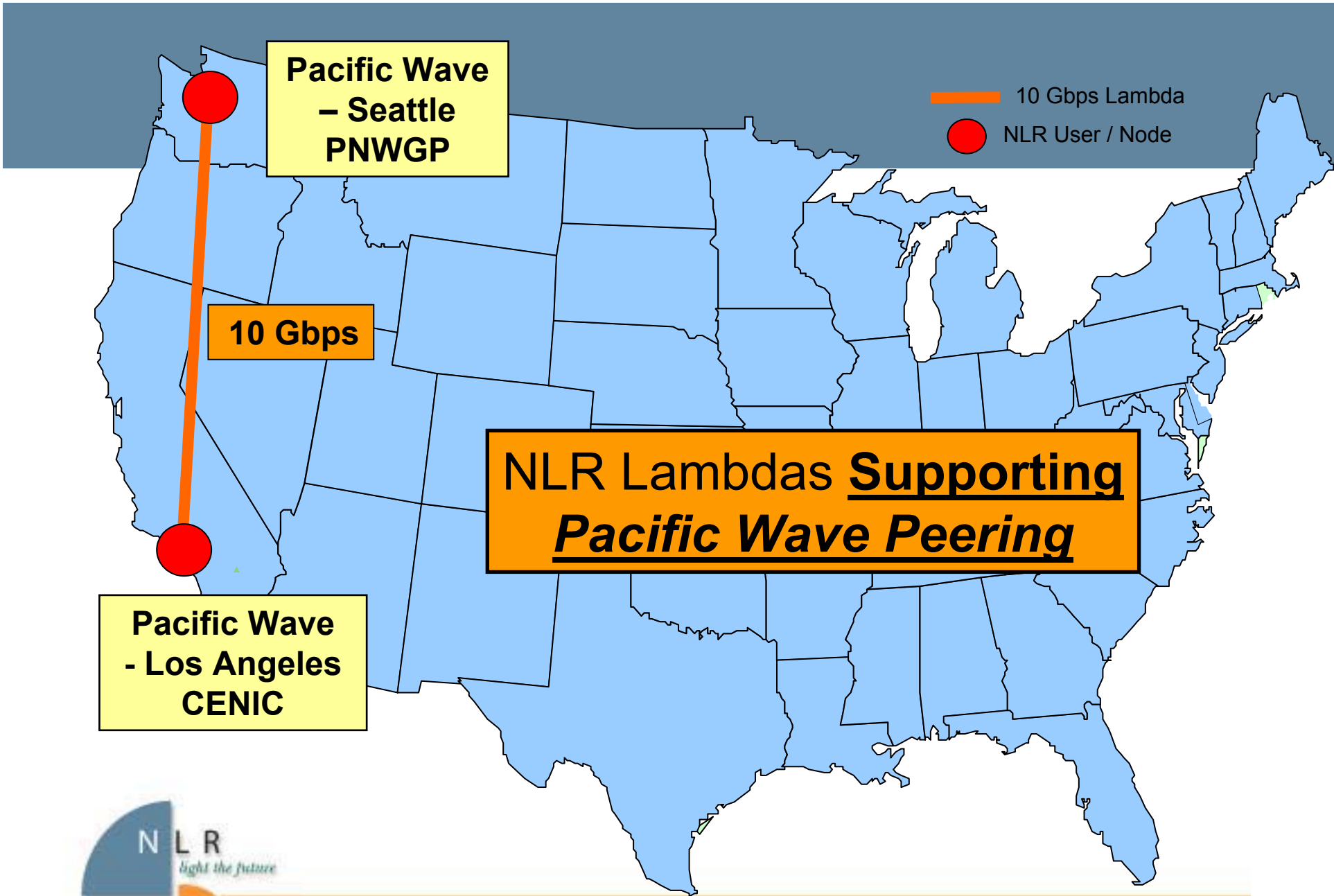


HOP1 Topology via NLR

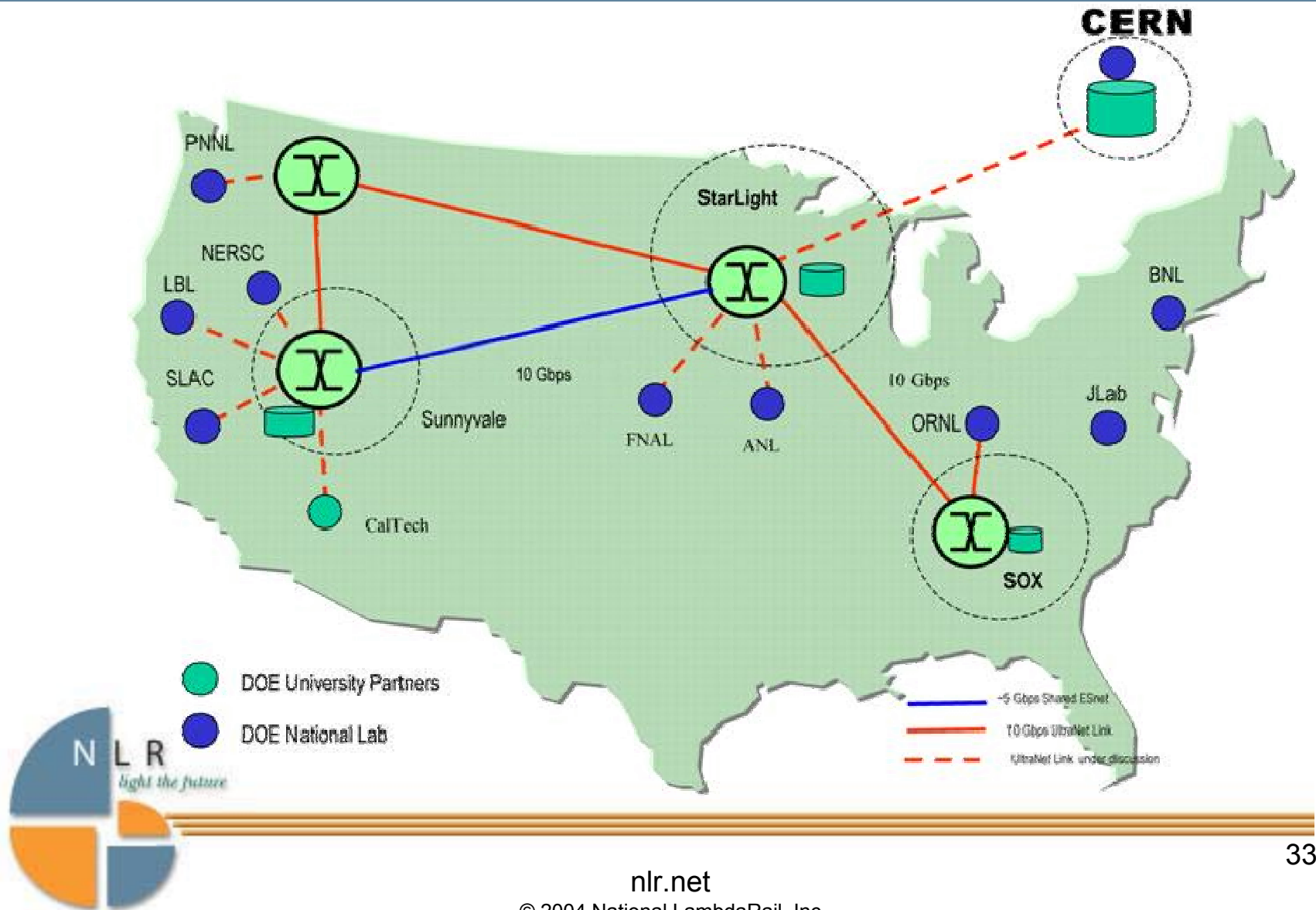


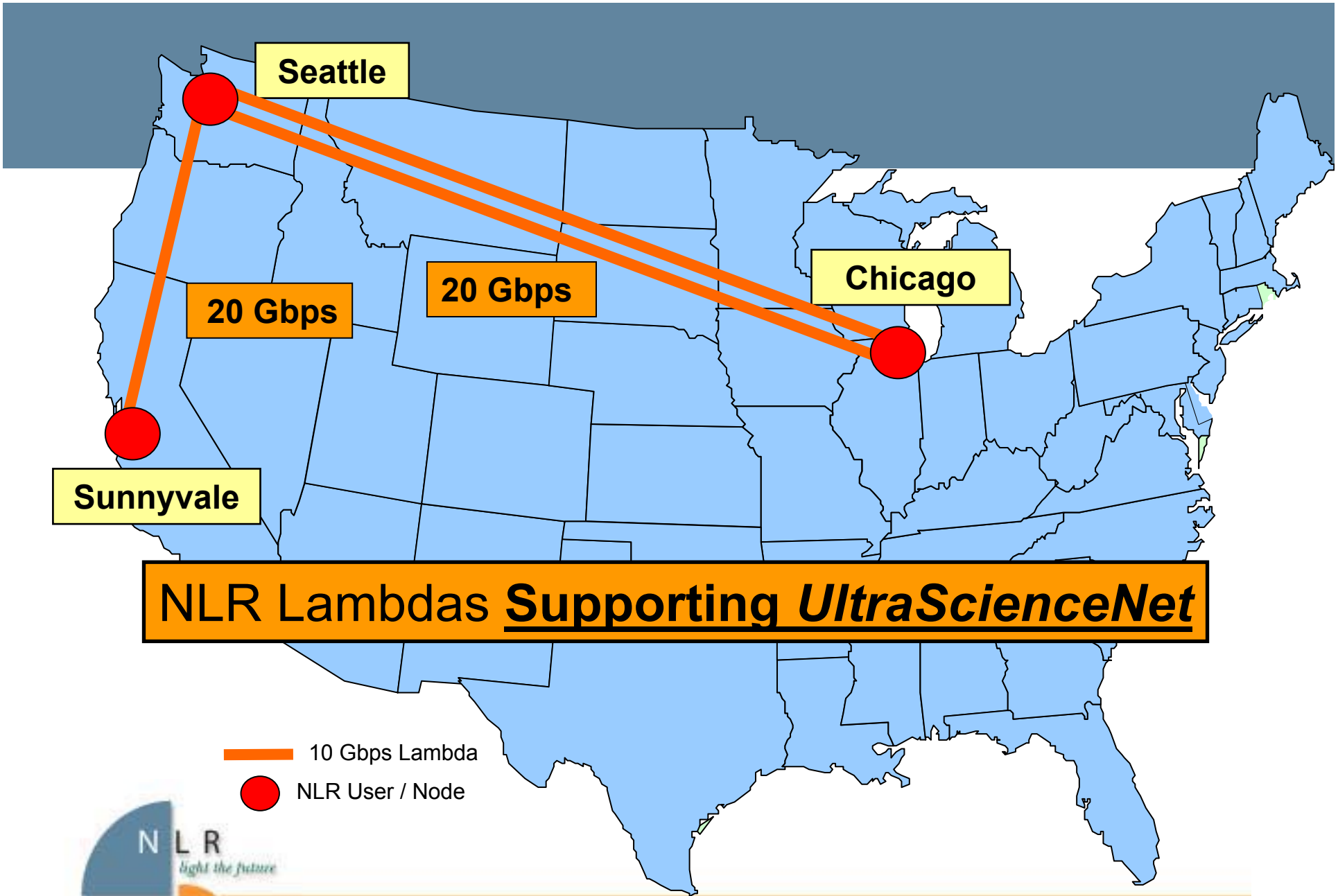
Current Projects Served: Pacific Wave





Current Projects Served: UltraScience Net



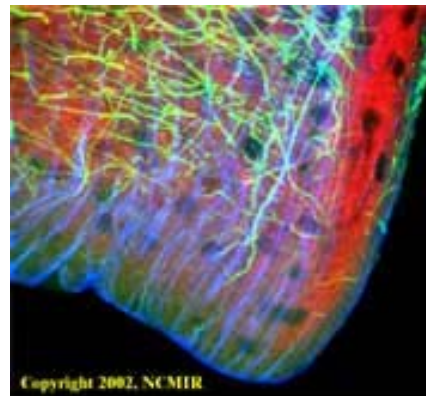
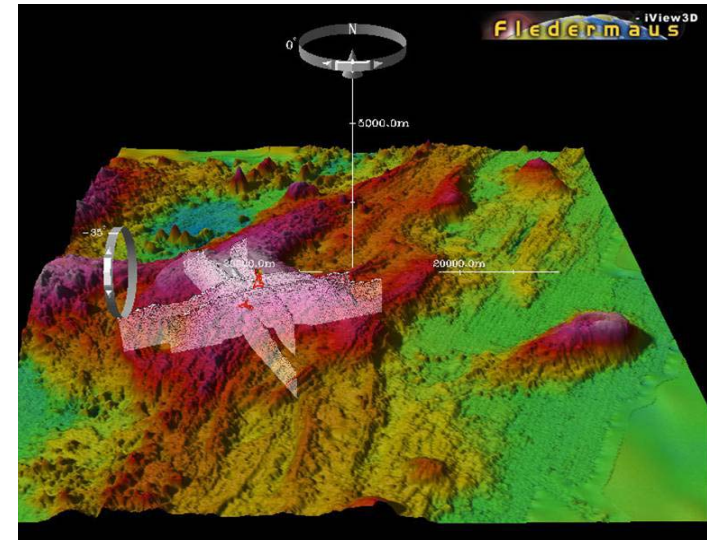
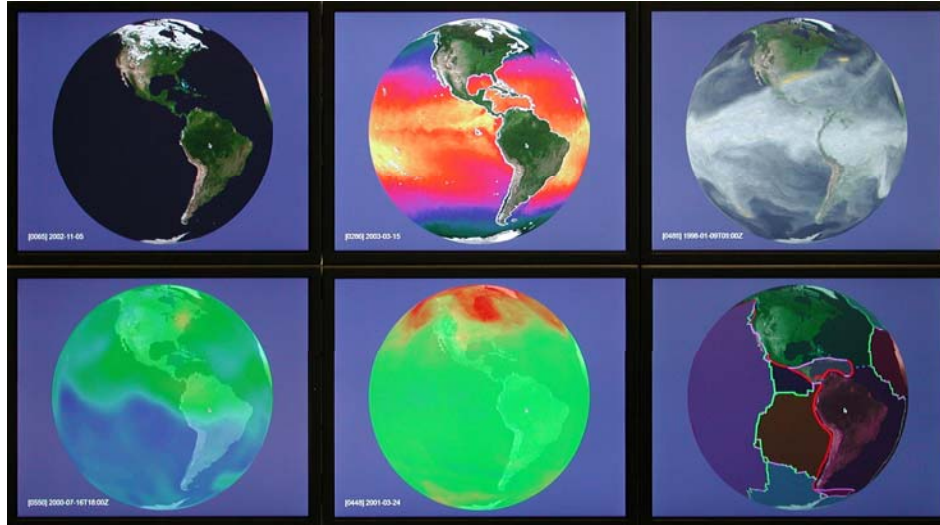


NLR Lambdas Supporting *UltraScienceNet*

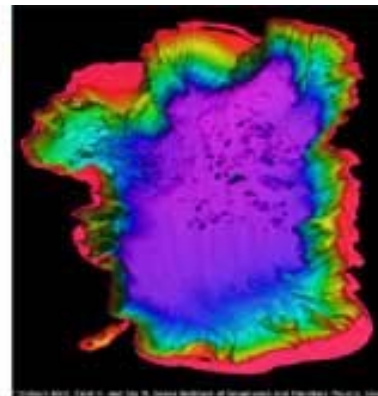
- 10 Gbps Lambda
- NLR User / Node



Current Projects Served: OptIPuter



Marketta Bobik

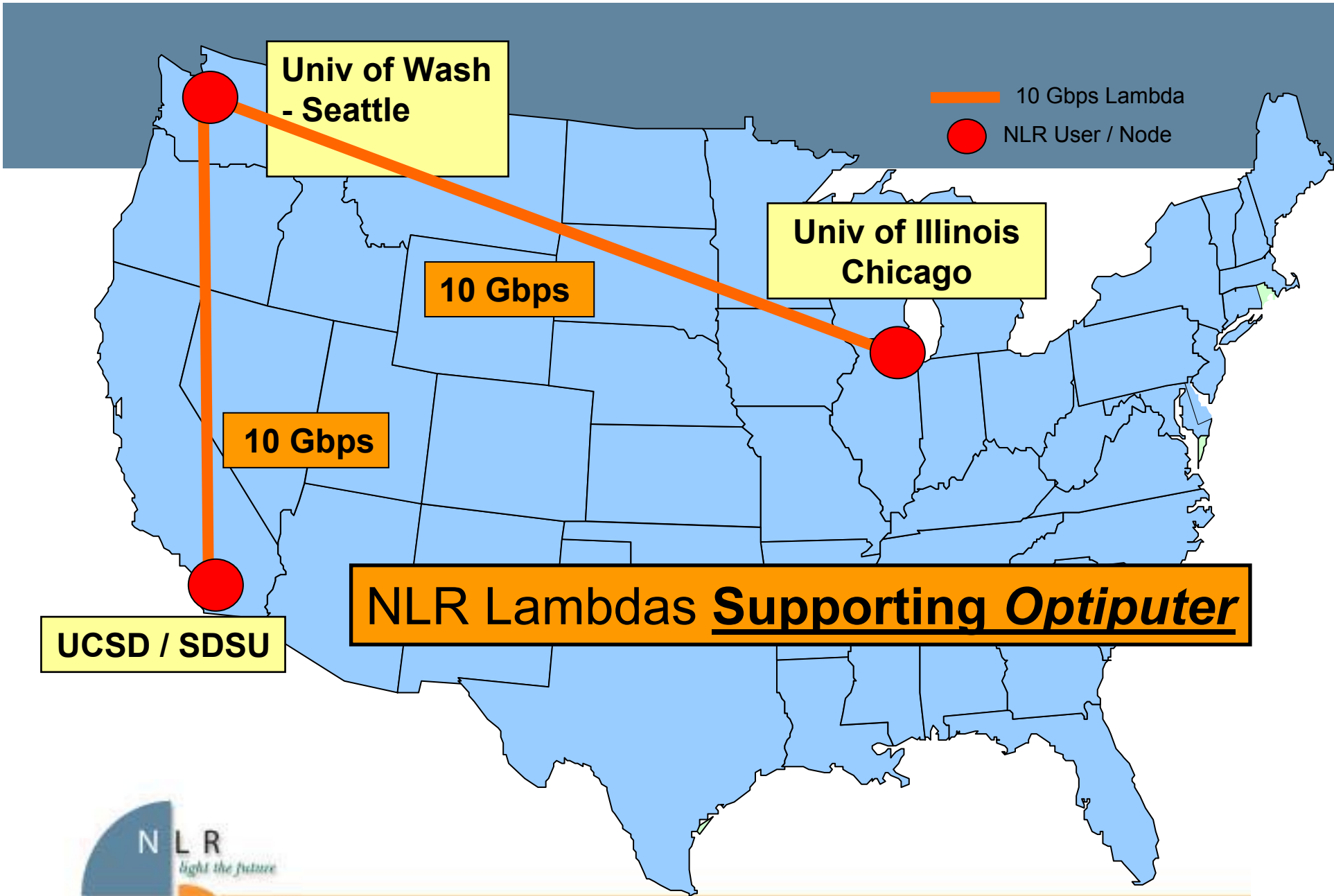


Graham Kent



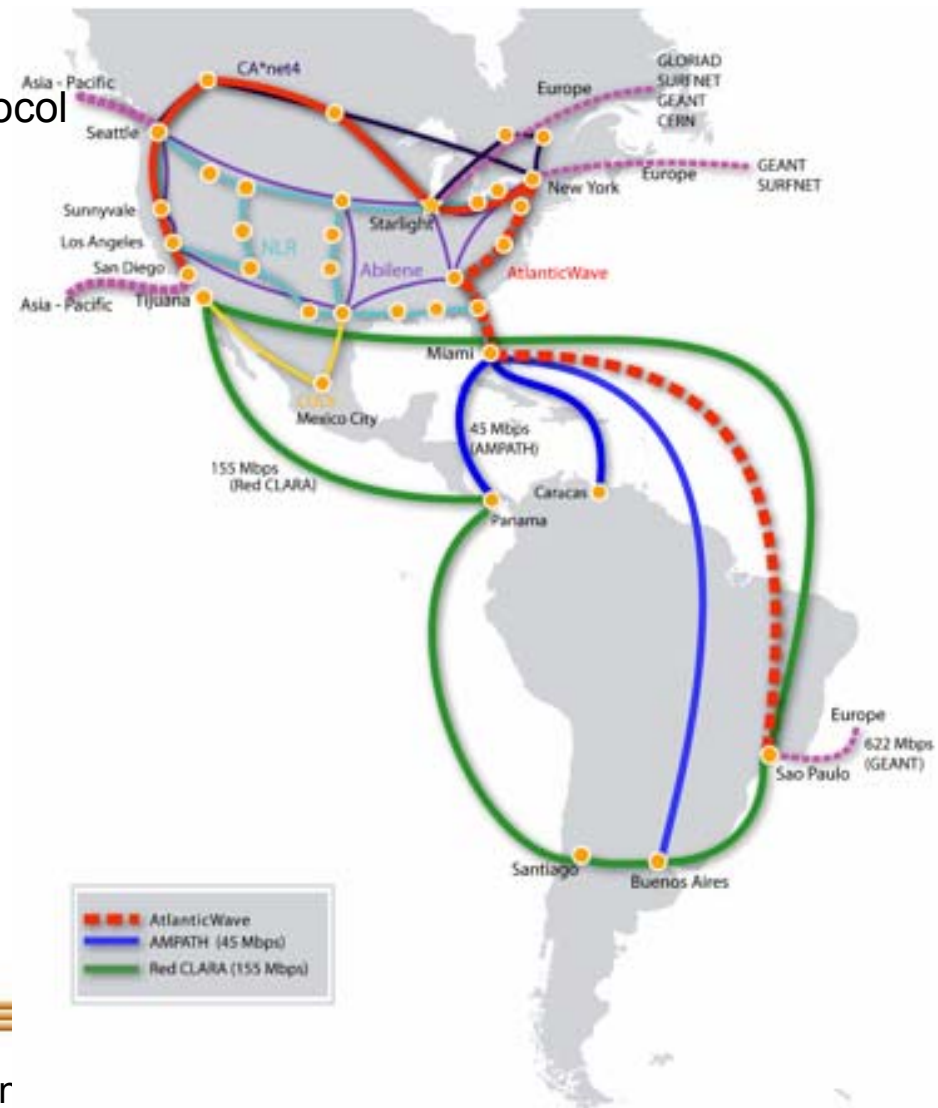
Francisco Capani & Eric Bushong





AtlanticWave - coming Fall '05

- Provisioned 10G wave over NLR & FLR
- A-Wave will provide multi-layer/multi-protocol services between participating networks
 - Layer 3 peering services over ethernet
 - GLIF “light path” services
 - Others TBD
- A-Wave will provide a Layer 3 distributed exchange capability
 - Ethernet based
 - Best effort packet exchange
 - Linear topology – unprotected (NLR based)
 - 1 GE, 10GE LAN, 10GE WAN client access
 - Jumbo frame support

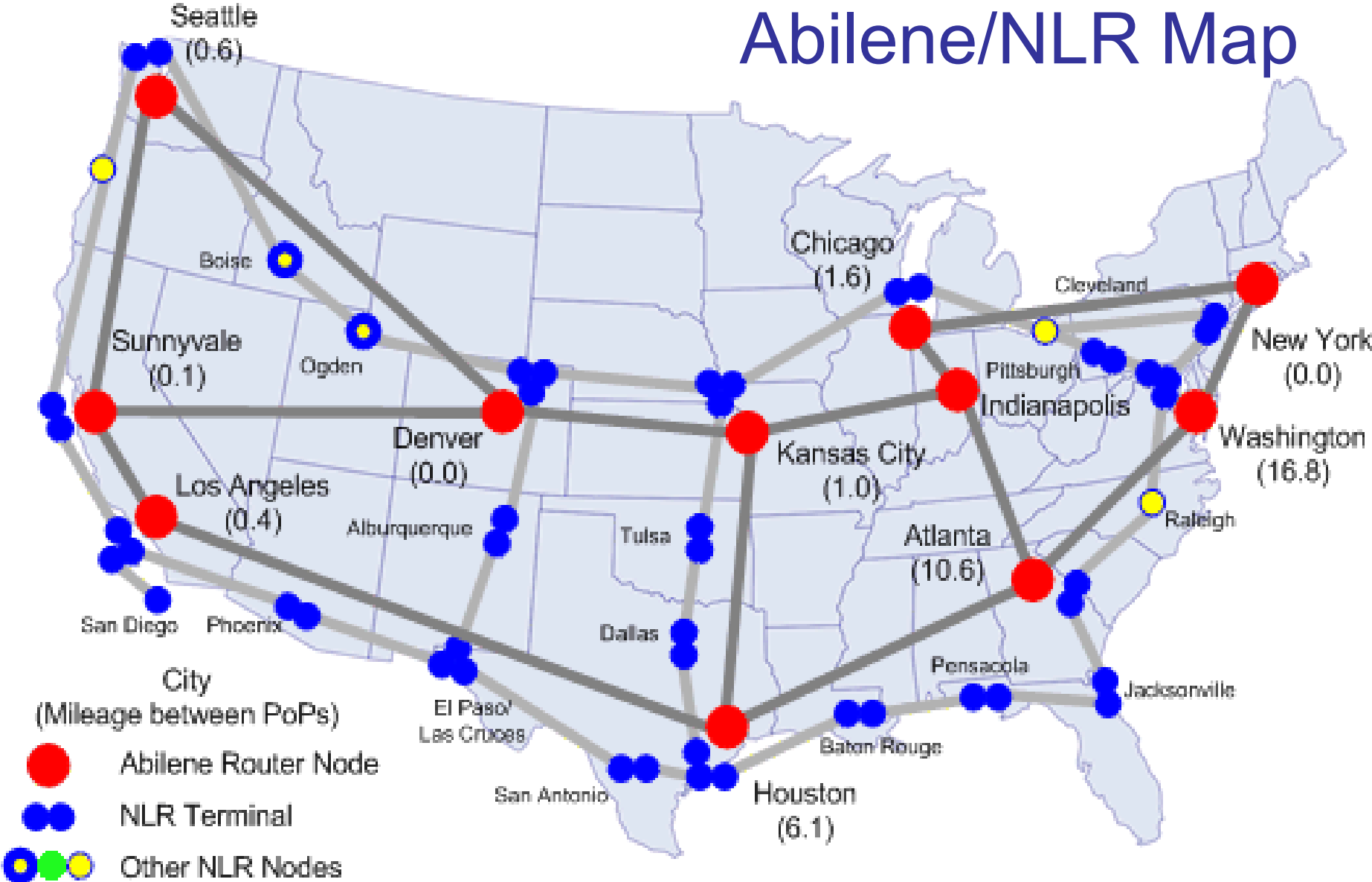


National LambdaRail and Internet2



Internet2 Abilene Network: Future State?

Abilene/NLR Map



Vision

- Global network that might one day serve research and education while leveraging the importance of regional networks
- Evolving a pervasive communications fabric that fosters innovation and services
- Sharing and integrating resources, technology transfer and commercialization in research and education



Needs of End-Users and Sites

- Needs of End-Users and Sites not tied to a specific backbone or network
 - Internet2 + NLR + ?
- Needs of the R&E Community
 - Wide range of services and facilities: commodity service, local & regional peering, nearby co-location, access to R&E backbones, access to on-demand switchable waves
- Regional aggregation points
 - GigaPOPs or RONS currently provide a wide range of network services and capabilities not found on the backbones



Network and Technical Environment

- Environment built to accommodate as many services and capabilities as possible
- Importance of a common interconnection and service development module
- Broad range of attributes critical to the new network environment



Organizational Environment

- Common Services and Interconnection model
 - Standardize service delivery and support mechanisms
- Financial Considerations
 - Current and long-term issues associated with competing and complementary financial strategies among NLR, Internet2, and RONS



Expected Services and Capabilities

- Current and Near Term Examples
 - Core Waves - high reliability waves that support a range of applications
 - Examples: IP Network or Grid Application
 - Flexible Waves - less stringent reliability requirements, low cost, flexible duration
 - Examples: Network Research, IP Network Overflow
- Long Term Perspective
 - Fundamental shift in the way we think about and provision networks
 - Need to move towards the notion of a “virtual network”



NLR Network Research Project: Virtualized Testbed for Network Research

- Provide multiple heterogeneous virtual networks on a common substrate
- Engage broad networking research community
- Bridge gap between cutting-edge research and production usage
- Proposed by:
 - Tom Anderson, University of Washington
 - Larry Peterson, Princeton University
 - Scott Shenker, UC Berkeley
 - Jon Turner, Washington University in St. Louis



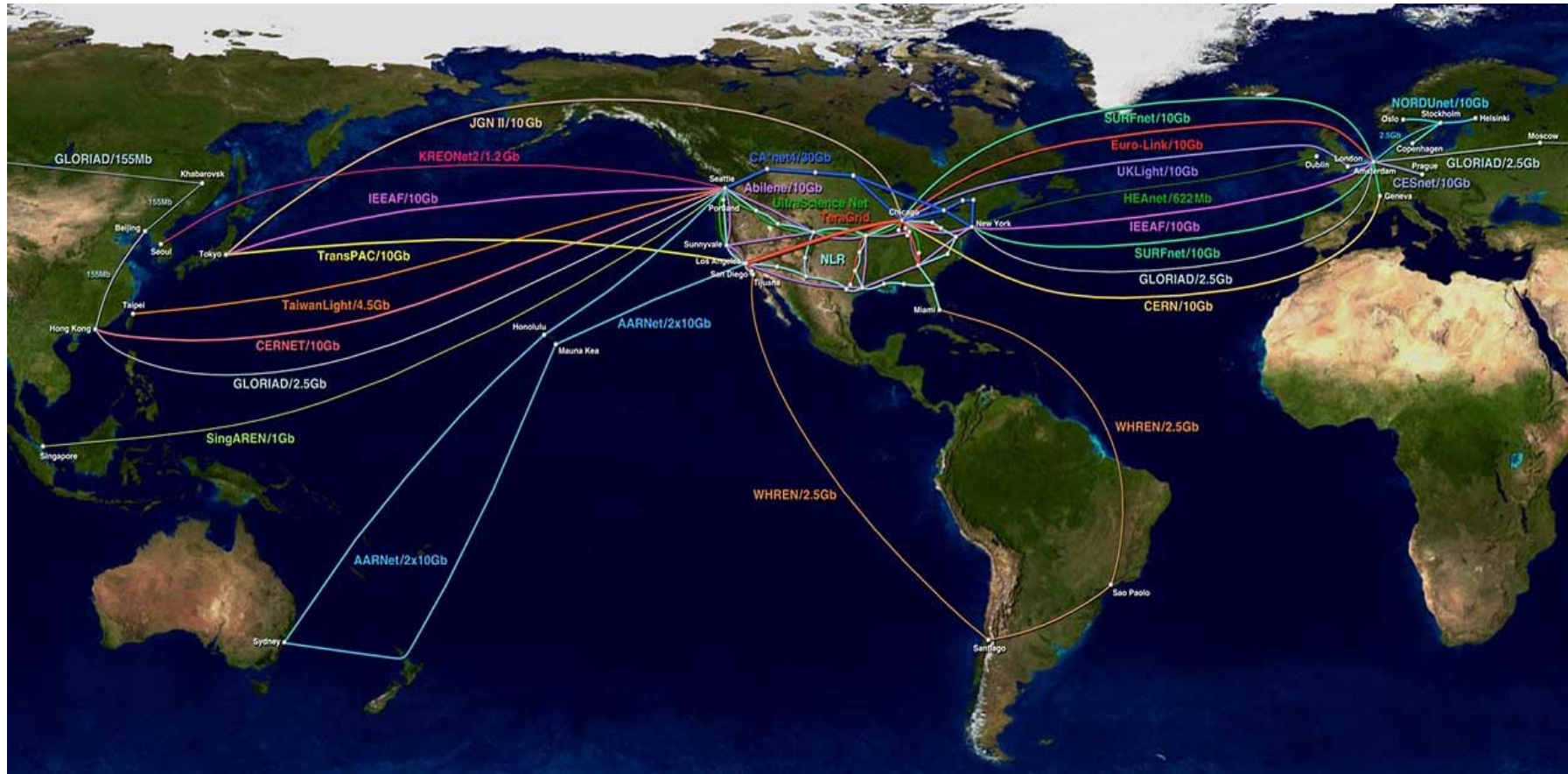
Connecting Researchers Worldwide



- GLIF
- TRANSLIGHT & NETHERLIGHT
- IEEAF
- WIDE
- PACIFIC WAVE + TRANSPAC2 + AARNET +....
- WHREN/LILA, AMPATH, RED CLARA
- ATLANTIC WAVE
- GLORIAD



Global Lambda Integrated Facility



Visualization courtesy of Bob Patterson, NCSA.

www.glif.is



nlr.net

© 2004 National LambdaRail, Inc

Think Globally – Act Locally



More Information

www.nlr.net
info@nlr.net

