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Optical Control Plane

International ICFA workshop
Daegu Korea
May 25th 2005

Agenda

- **E-science and their requirements on the Network**
- **Today's Research Network Infrastructure**
- **Optical Control Plane**
- **Grid Computing Optical Control Plane Research**
- **Conclusions**

Topic

E-science and their requirements on the Network

E-Science Community

- Migration of the E-science community towards Grid Computing emerged from three converging trends which also promotes reducing the digital divide;

  i)Advances in optical networking technologies. Widespread deployment of the fiber infrastructure has led to low-cost, high-capacity optical connections.

  ii)Affordability of the required computational resources through sharing. The increasing demand of computational power and bandwidth by the new e-science applications is proving to be a financially difficult and nearly impossible task unless resources are shared across research institutions on a global basis.

  iii)Need for interdisciplinary research. The growing complexity of scientific problems is driving the need for increasing numbers of scientists from diverse disciplines and locations to work together in order to achieve breakthrough results.

What do we mean when we say E-science application

- **Big e-science applications - new generation of applications combines scientific instruments, distributed data archives, sensors, and computing resources to solve complex scientific problems.**

- **Characteristics:**

  i) very large data sets, terabytes, petabytes, etc.

  ii) high-end computing resources, teraflops, super computers, cluster computing, etc.

  iii) remote instrumentation and sensors for data collection

  iv) powerful visualization tools for analysis

  V) sometimes highly dynamic

Advances in Optical technologies

- Dark Fiber every where ….
- Fiber is much cheaper…US Headlines: companies giving away dark fiber!
  - RONS buy their own and operate it with out the big bell companies
  - AT&T made available at no-cost to SURA 8,000 miles of dark fiber
- All-optical switches are getting faster and smaller (ns switch reconfiguration)
- Layer one Optical switches relatively cheaper than other technologies
- Fiber, optical impairments control, and transceiver technology continue to advance while reducing prices!

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10Gig Capacity

Global E-science Network Requirements

- High bandwidth pipes along very long distances – terabyte transfers, petabyte, etc
- Network resources coordinated with other vital Grid resources – CPU, and Storage
- Advanced reservation of networking resources
- End-to-end network resources for short periods of time
- Deterministic end-to-end connections – low jitter, low latency

Global E-science Network Requirements

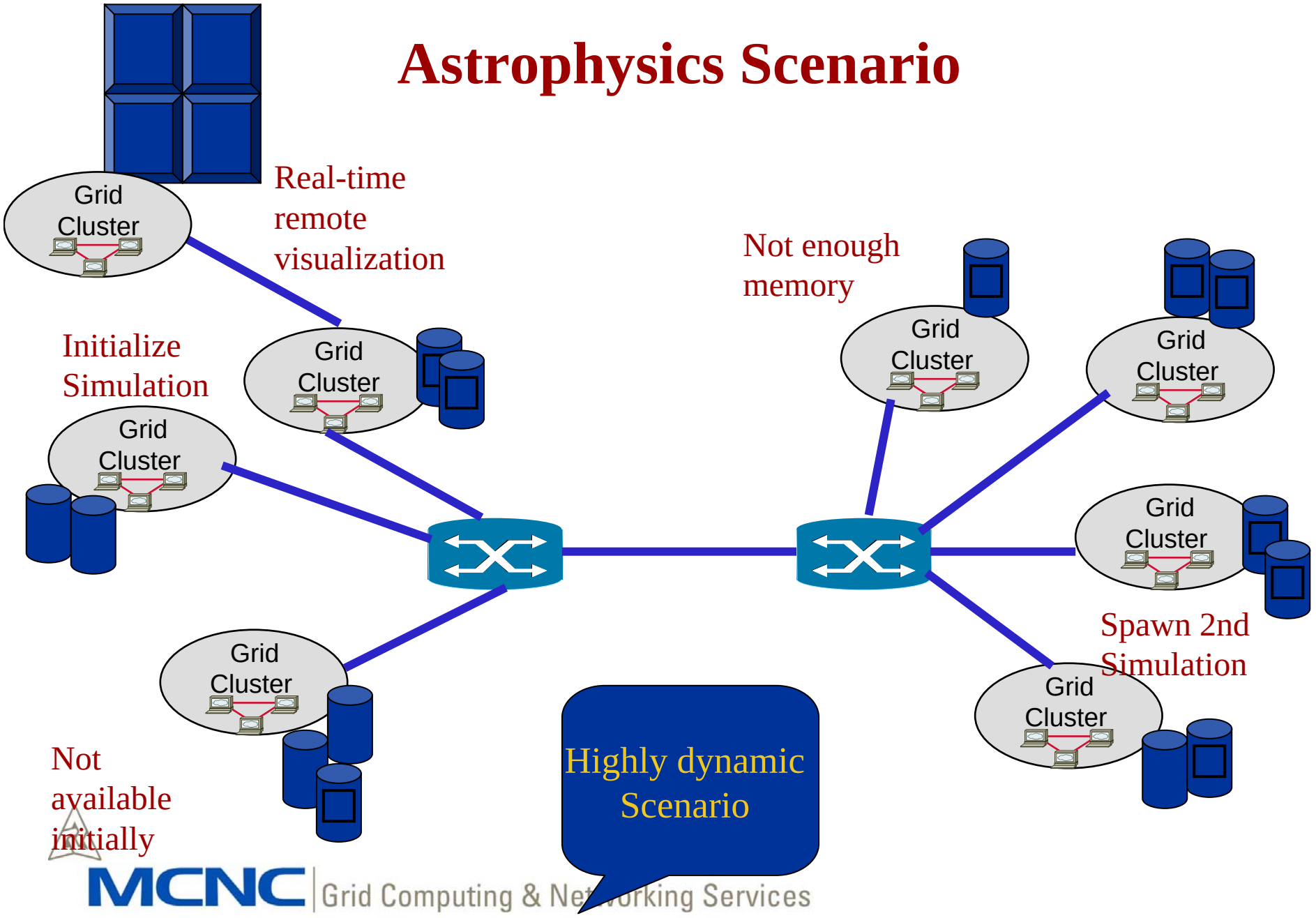
- Applications / end-users / sensors / instruments requesting optical networking resources host-to-host connections - on demand
- Near-real-time feedback of network performance measurements to the applications and middleware
- Exchange data with sensors via potentially other physical resources
- Destination may not be known initially rather only a service is requested from source

Challenges of Next-gen E-science

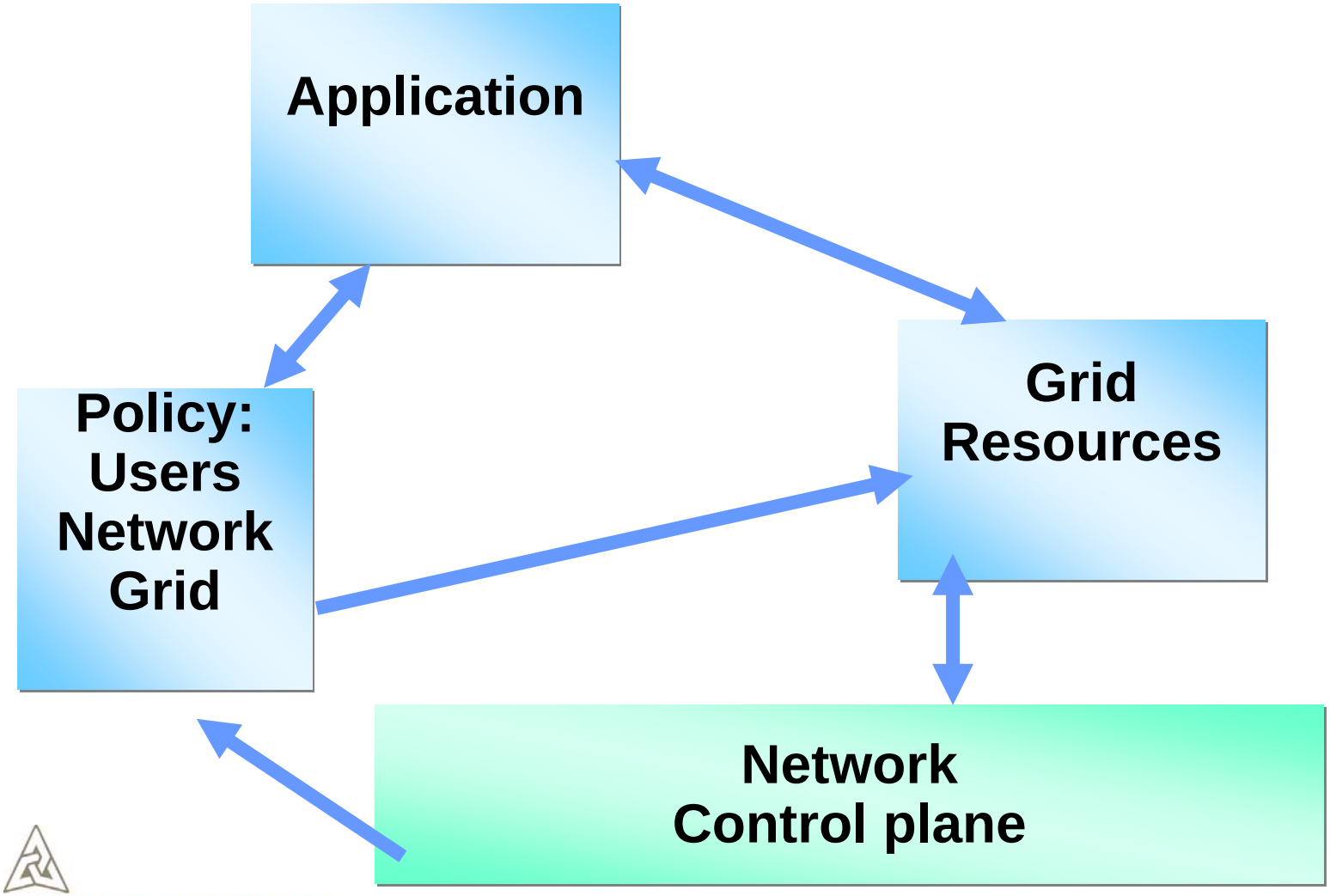
Highly Dynamic Astrophysics Simulations

- Coordination of all three (CPU, Storage, Network) resources based on near-real-time availability
- Near-real-time simulation results requires spawning of more simultaneous simulations running on other clusters
- Large amounts of data needed to be transferred to available Grid resources (namely clusters with enough storage capacity as well)
- Re-adjusting resource usage based on near-real-time monitoring information

Astrophysics Scenario



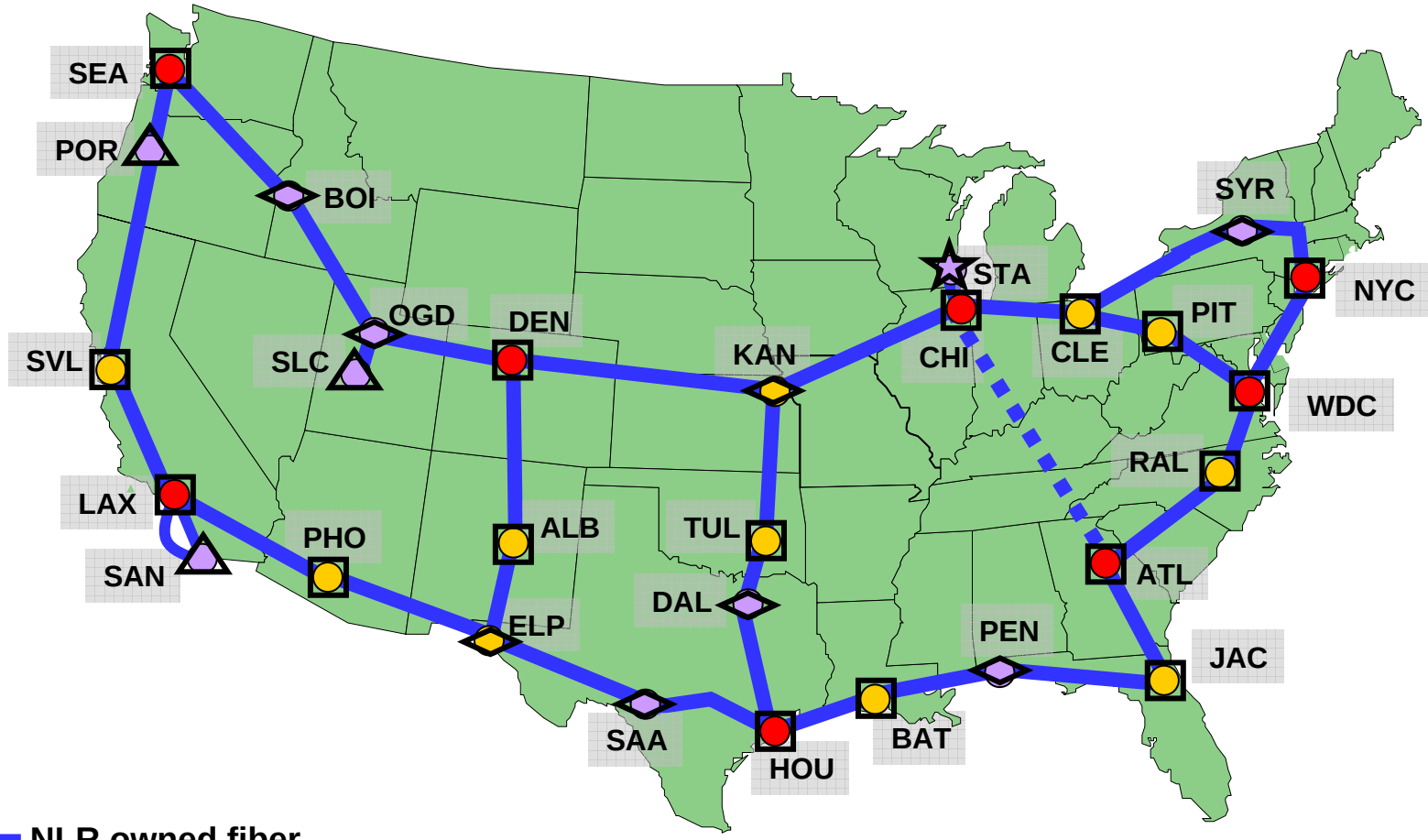
Feedback Loop



Topic

Today's Research Network Infrastructure

NLR Footprint & PoP Types – Phase 1 and 2



NLR owned fiber
Managed waves

NLR WaveNet, FrameNet & PacketNet PoP
NLR WaveNet & FrameNet PoP
NLR WaveNet PoP

PoP for primary connection point by a member ("MetaPoP")
PoP needed because of signal regeneration requirements but can also be used for secondary connection by a member
PoP established by NLR for members regional needs
PoP established at exchange points

How will we as a community use these networks?

Two categories of users:

(1) **Black box user - Application and Middleware researchers needing high-speed network to transfer data to and from different parts of the Nation**

- **At SC2004 - all point-to-point connections GigE**

(2) **Gray (combination of black and white parts) Box user- Network Researcher**

- **part of the box will be black (or none)**
- **The rest will be white - experiment with network protocols and control plane**
  - **Different layers in the stack**

GLIF Control Plane and Grid Integration working group

Mission

To agree on the interfaces and protocols that talk to each other on the control planes of the contributed Lambda resources. People working in this field already meet regularly in conjunction with other projects, notably the NSF-funded OptIPuter and MCNC Controlplane initiatives.

several key areas we need to focus on.

-Define and understand real operational scenarios
-Defining a set of basic services:
  *precise definitions
  *developing semantics the whole community agrees to
-Interdomain exchange of information
  *determine what information needs to be monitored
  *how to abstract monitored information to share
-Determine what existing standards are useful vs. where Grid requirements are unique and new services and concepts.
  * how do we standardize mechanisms and protocols that are unique to the
-Grid community
  *Define a Grid control plane architecture
  *Work closely with E-science applications to provide vertical integration

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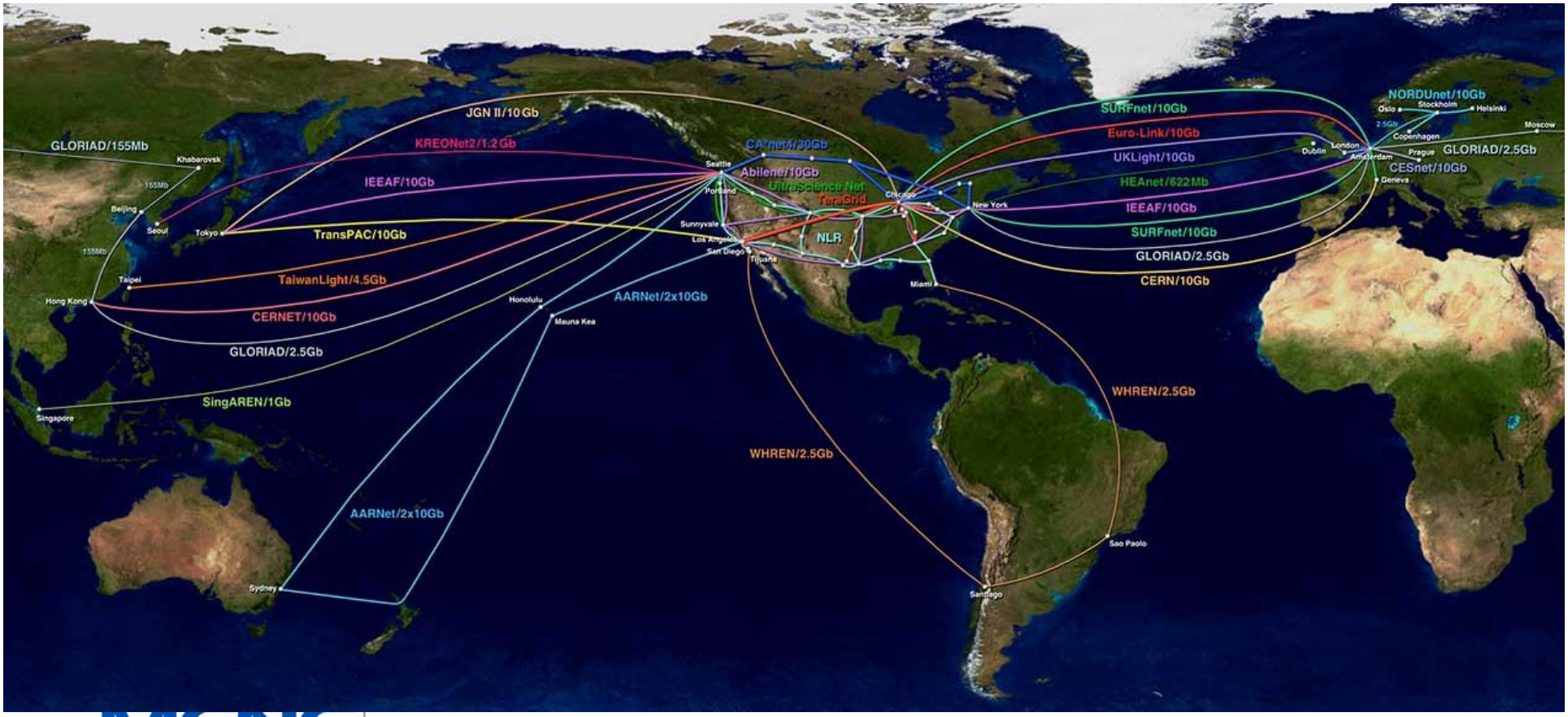
Global Lambda Integrated Facility

World Map – December 2004

Predicted international Research & Education Network bandwidth, to be made available for scheduled application and middleware research experiments by December 2004.



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www.glif.is

Visualization courtesy of
Bob Patterson, NCSA.

Topic

Optical Control Plane

One Definition of Control Plane

"Infrastructure and distributed intelligence that controls the establishment and maintenance of connections in the network, including protocols and mechanisms to disseminate this information; and algorithms for engineering an optimal path between end points."

Draft-ggf-ghpn-opticalnets-1

Another definition of Optical Control plane

- **Moving centralized Network management functions (FCAPS) down to the network elements in a distributed manner…**
  - **This speeds up reaction time for most functions**
  - **Reduces operational time and costs**
  - **Allows the optical network to be more agile**
  - **Interacts with Grid middleware**

Optical
Control plane

- **Migrating functionality from centralized control to distributed at optical layer**
  - **Distributed Fault management**
    - **Self-healing opportunities at the optical layer**
  - **Distributed Performance management**
    - **Dynamically adjust the information to be collected to match context and near-real-time usability**
  - **Distributed Configuration Management**
    - **Autodiscovery**
    - **Provisioning using signaling - GMPLS, OBS, OPS etc**

- **Determine what functionality makes sense from a centralized management plane vs. a distributed control plane**

Control plane Functional Areas

- **Routing - Intra-domain and Inter-domain**
  - **1) automatic topology and resource discovery**
  - **2) path computation**
- **Signaling - standard communications protocols between network elements for the establishment and maintenance of connections**
- **Neighbor discovery - Network elements sharing of details of connectivity to all its neighbors**
- **Local resource management - accounting of local available resources**

Industry vs. Grid Community

Industry Standards - a unified IP control plane,
IETF - GMPLS
OIF - UNI and NNI
Motivation- reduce operation cost from manual provisioning

Grid networking community - borrow from standards when we can, rethink concepts when we must!

- **Motivation for Grid computing:**
  - **Vertical Integration - Application down to the optical resources**

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Topic

Grid Computing Optical Control Plane Research

Where does the Optical Control Plane fit in?

- Application accesses the control plane to initiate/ delete connections
- Network resources coordinated with other vital Grid resources – CPU, and Storage - control plane monitoring exchange information with Grid middleware
- Advanced reservation of networking resources - Grid Scheduler (middleware) interacts with control plane
- Applications requesting optical networking resources – host-to-host connections (applications interacting w/ control plane (this is not done today)
- Very dynamic use of end-to-end networking resources - feedback loop between control plane and Application
- Near-real-time feedback of network performance measurements to the applications and middleware - to be used by the control plane
- Interoperation across Global Grid networks - network interdomain protocols for Grid infrastructure rather than between operators

Why is the Control Plane important to GLIF?

- Today to set up an End-to-end connection between two laboratories across national borders:
  - 1) takes “lots of phone calls”
  - 2)takes “lots of emails”
  - 3)tens of people
  - 4) connection becomes relatively static
  - 4) over three weeks!!!!
- Failed link results in days of out-of service

- What do we want?
- We want :
- applications/sensors/end-users/instruments to initiate an end-to-end connection
- Resources for short periods of time
- We want automatic recovery - restoration/protection

- How do we as a community go from where we are today to what we really want?
- We need to use the Morphnet concept in the GLIF community…. Part of the infrastructure for vertical integration research and others as production

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Optical Control Plane initiatives

- **Many Global initiatives have been discussed at**
- **“International Optical Control Plane for the Grid Community” Workshops:**

www.mcnc.org/mcncopticalworkshop/nov04/

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GridNets 2005

www.gridnets.org

Co-located with BroadNets

Boston October 6th and 7th, 2005

The Thursday and Friday before GGF in Boston!

CALL FOR PAPERS

IEEE Communications Magazine
Feature Topic

Optical Control Plane for Grid Networks: Opportunities, Challenges and the Vision

http://www.comsoc.org/pubs/commag/cfpcommag306.htm

Guest Editors: Gigi Karmous-Edwards and Admela Jukan

Manuscripts due: June 20, 2005

Topic

Conclusions

Conclusion

1. Control Plane research is vital to meeting future generation Grid computing - with a strong focus on “vertical integration”
2. Reconfigurability is essential top bring down cost and meet application requirements.
3. Understanding what infrastructure exists for GLIF and for how long
4. Accounting and billing needs to be understood/developed for this community.
5. Currently, we have a view of the behavior of potential future enterprise applications by focusing on the needs of Big E-science applications, but it is also important to understand the requirements of Industry.
6. Next generation networks could be vastly different than today’s mode of operation - should not constrain research to today’s model
7. The Research networks are the ones that will take these bold steps not the carriers… apply lessons learned to production quickly.
8. International Collaboration is a very Key ingredient for the future of Scientific discovery - The Optical network plays the most critical role in achieving this! International collaborative funding is necessary.