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Network Development and Grid Requirements

E-IRG
May 13th, 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

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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 Grid 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
- Deterministic end-to-end connections – low jitter, low latency
- Applications 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

Current Problem Space

- **Grid Applications requiring network determinism, interactive - computational steering**
  - **Routed networks cannot provide determinism**
    - **Queues**
    - **Fairness**
    - **load changes**
  - **Solution - dedicated connection**
- **Large File transfer over Long distances**
  - **Transport protocol Behavior – result in very slow transfer for large data sets**
  - **Routed networks are expensive**
  - **Solution – dedicated connection and modified TPs**
    - **Lots of work in this area (FAST, GTP, etc.)**
- **Grid Applications requiring near-real-time reaction to events and changing environments**
  - **GridLAB Apps**
  - **Creation of a virtual Compute system**
  - **Solution - fast connection set-up**

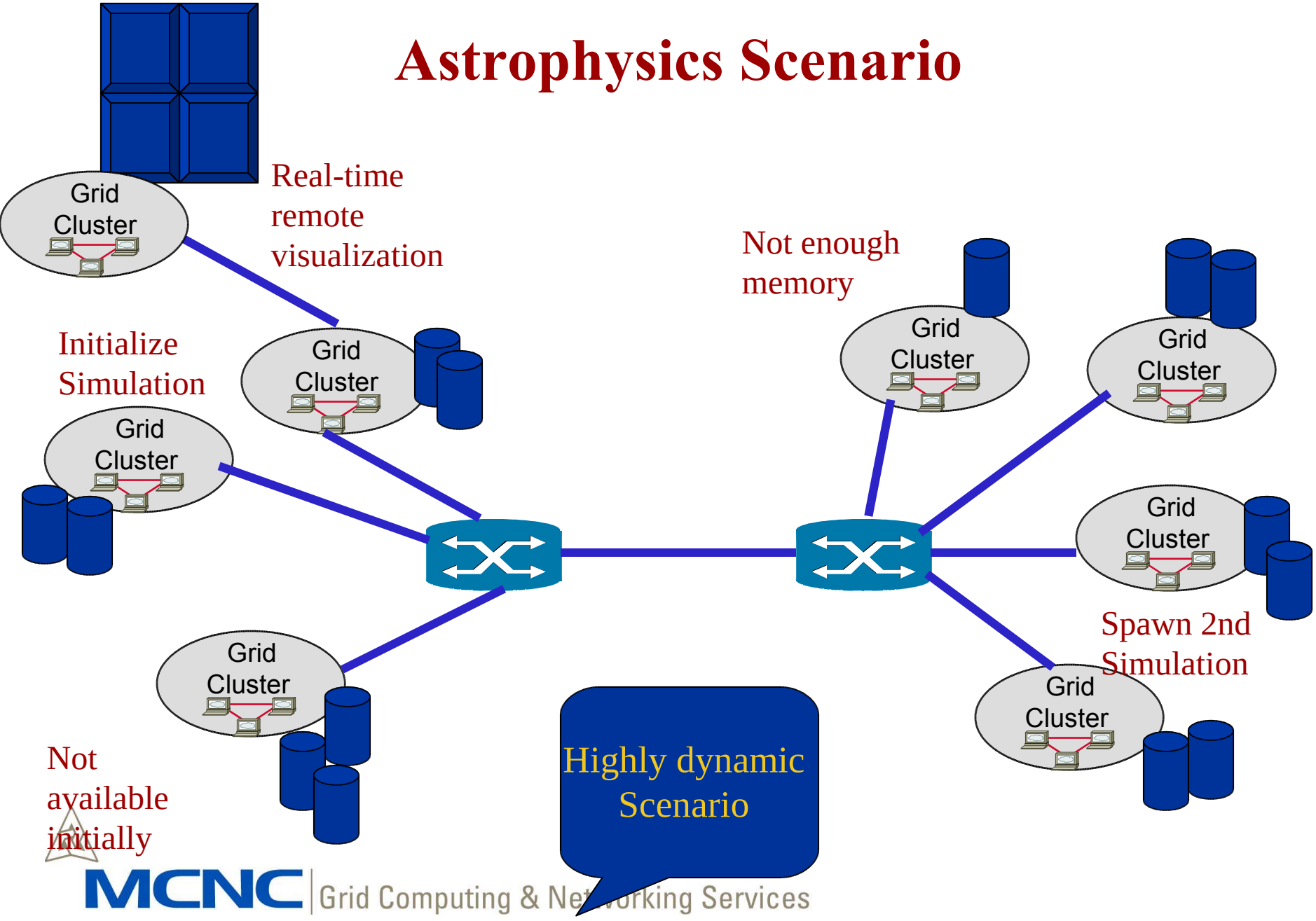
Is Connection Oriented technology the only solution?

Challenges of Next-gen E-science

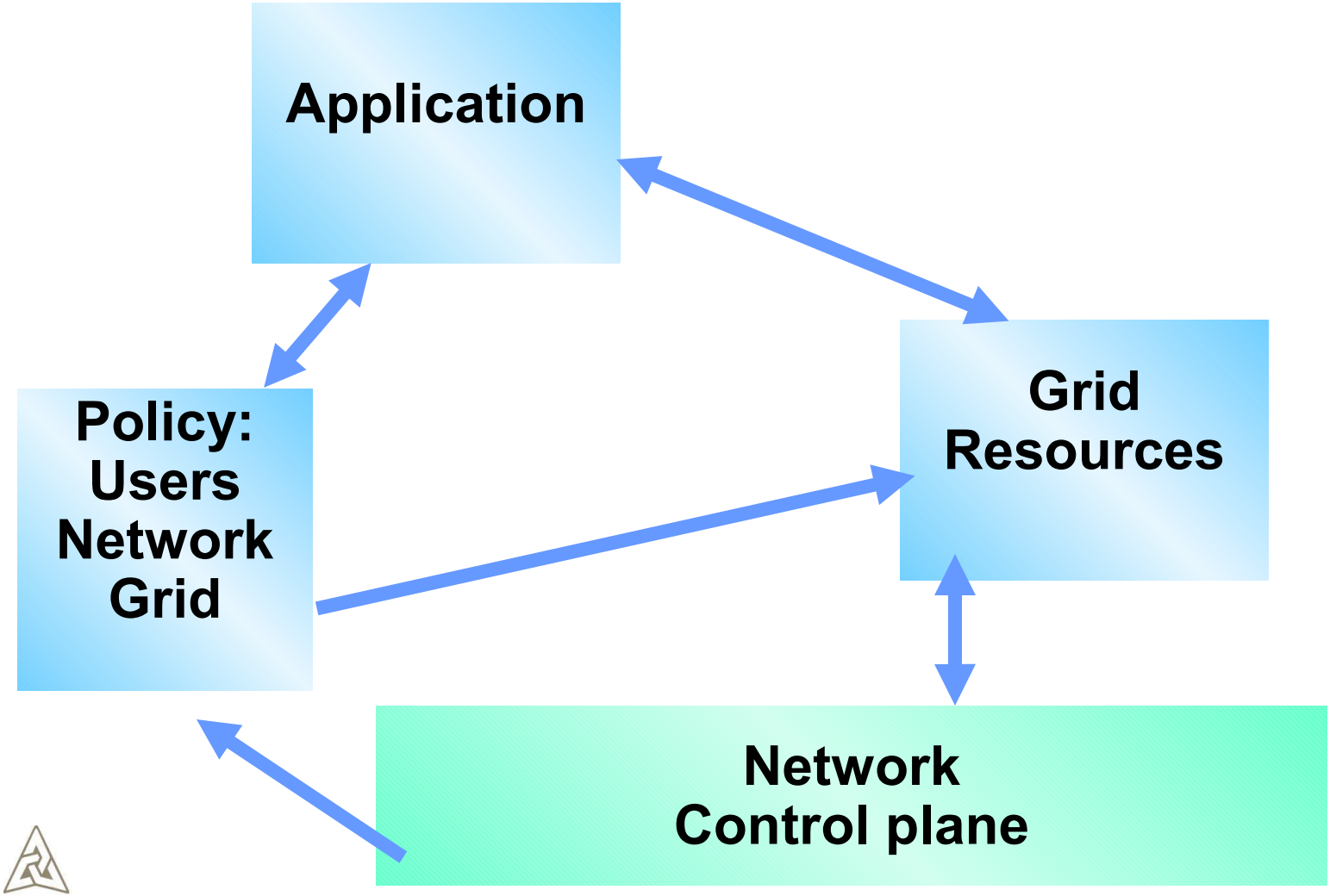
Highly Dynamic Astrophysics Simulations

- 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

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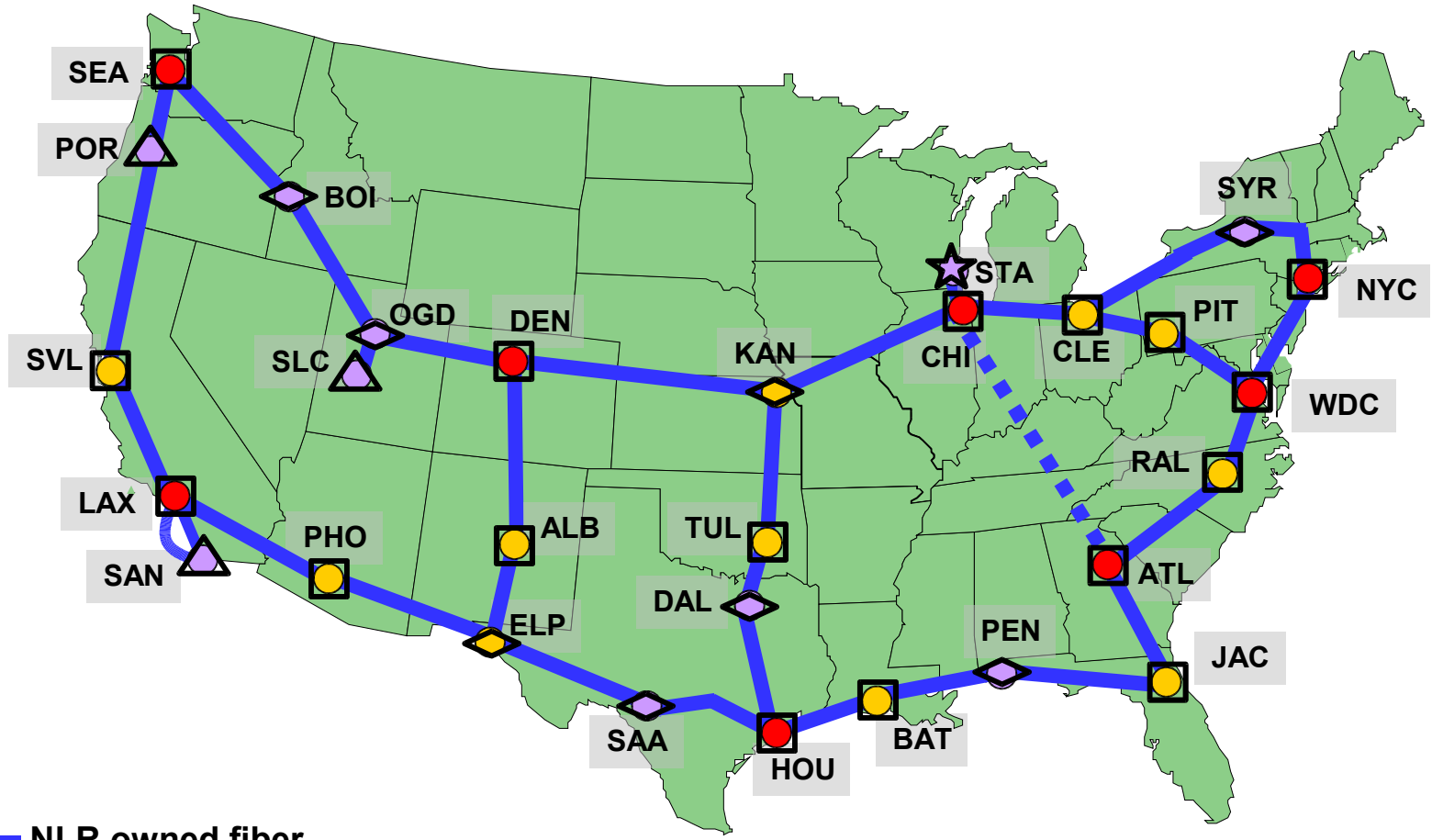
NLR Footprint & PoP Types – Phase 1 and 2



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

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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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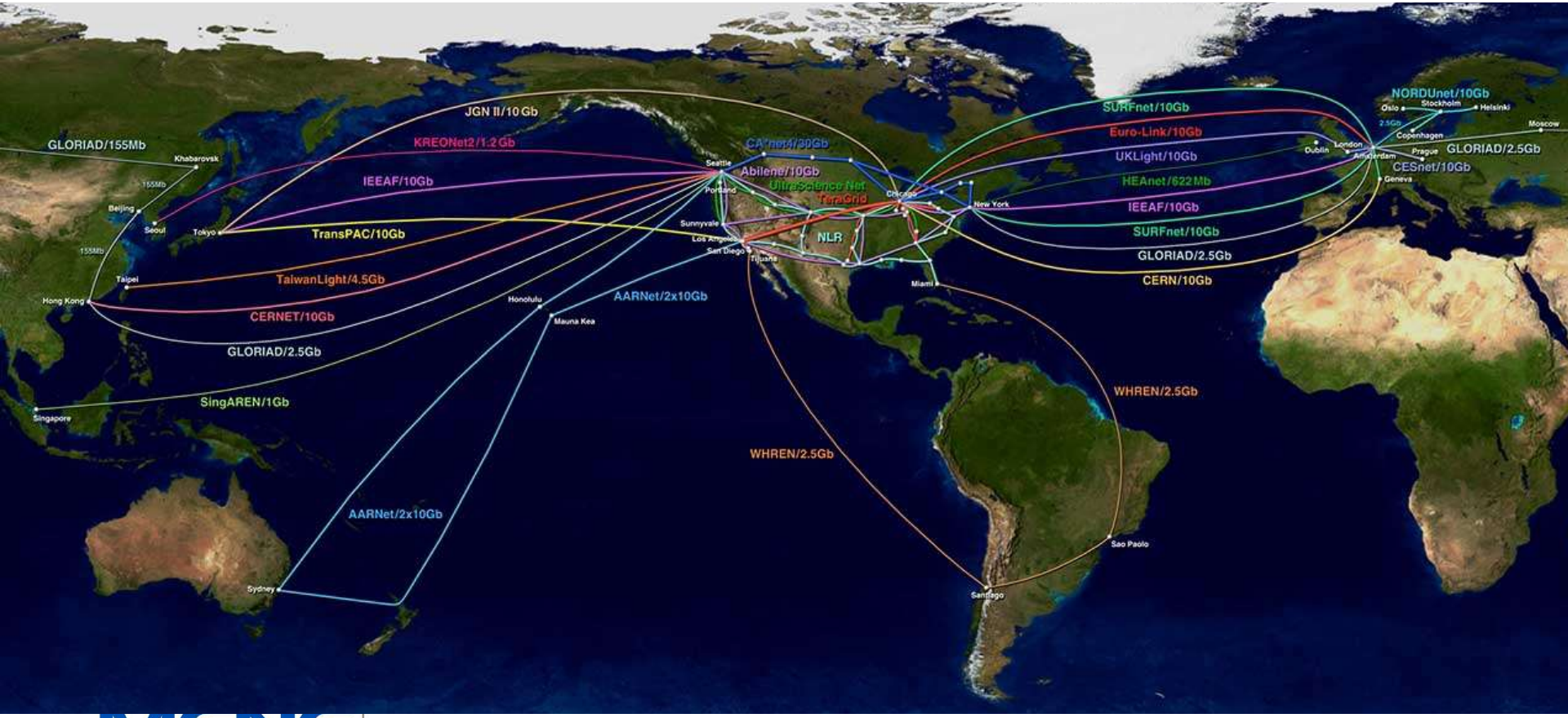
Global Lambda Integrated Facility
World Map – December 2004

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

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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**

Topic

Grid Computing Optical Control Plane Research

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Where does the Network 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

Optical Control Plane Research Areas

- Advanced Optical technology architectures -OPS, OBS
- Optical connection signaling and provisioning
- Optical layer Recovery (protection and Restoration)
- Layer interactions - optical interacting w/ transport protocol layer
- Optical network performance monitoring, metrics and analysis
- Resource availability monitoring (network, CPU, storage)
- Security - AAA -
- Resource discovery
- Topology state information dissemination
- Intra-domain and Inter-domain Routing
- Centralized vs. Distributed control functionality
- OGSA integration and WEB services
- Interaction and coordination with other Grid resources - CPU, Storage
- Advanced resource reservation

Optical Control Plane initiatives

- **Integration of advanced optical technologies**
  - **Introduction of all-photonic architectures - OBS, OPS**
  - **Experimentation of with advanced photonics:**
    - **High speed all- optical switches**
    - **Optical 3R**
    - **Optical header recognition**
    - **New fiber technologies**
    - **Etc.**

A well designed optical control plane architecture should accommodate advancing optical technologies

Topic

Conclusions

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Conclusion

2. **Network research is vital to meeting future generation Grid computing - with a strong focus on "vertical integration"**
3. **Reconfigurability is essential top bring down cost.**
4. **Funding Policy for joint infrastructure is critical**
5. **Accounting and billing needs to be developed for this community.**
6. **Interdisciplinary research is vital from application to the network - vertical integration.**
7. **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.**
8. **Next generation networks could be vastly different than today's mode of operation - should not constrain research to today's model**
9. **Cost should be part of the equation but NOT the highest priority for Federal funded research - industry will do that anyway**
10. **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.**
11.