Overview of Grid Networks

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International Center for Advanced Internet Research (www.icair.org)
Director, Metropolitan Research and Education Network (www.mren.org)
Partner, StarLight, PI-OMNINet (www.icair.org/omninet)

Summer Grid Workshop 2007

March 24, 2007

iCAIR

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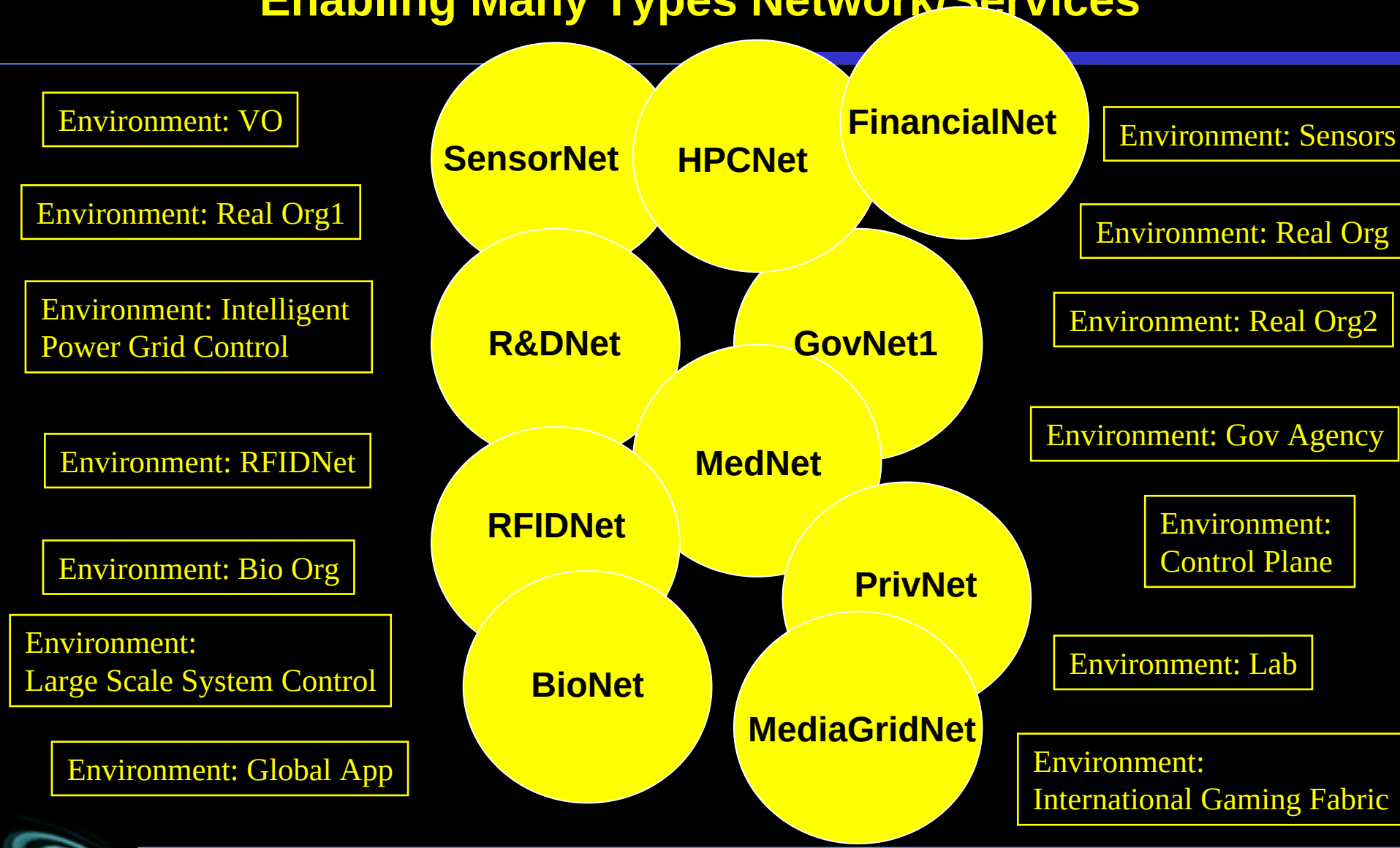
Introduction to iCAIR:

Accelerating Leading Edge Innovation and Enhanced Global Communications through Advanced Internet Technologies, in Partnership with the Global Community

- **Creation and Early Implementation of Advanced Networking Technologies - The Next Generation Internet All Optical Networks, Terascale Networks**
- **Advanced Applications, Middleware, Large-Scale Infrastructure, NG Optical Networks and Testbeds, Public Policy Studies and Forums Related to NG Networks**

A Next Generation Architecture: *Distributed Facility*
Enabling Many Types Network/Services



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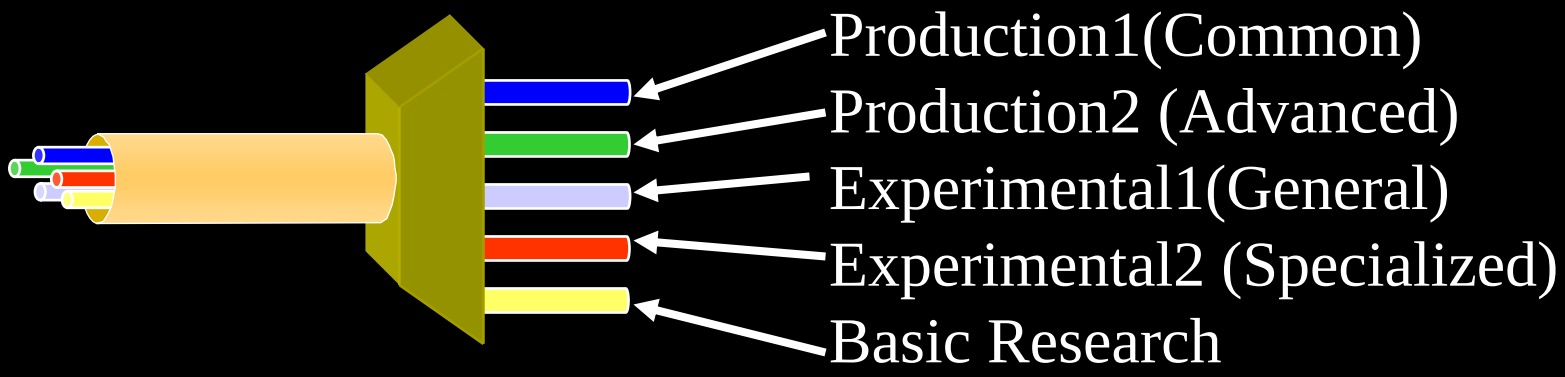
IEEE L2 Scaling Enhancements

- Current Lack of Hierarchy
- IEEE Developing Hierarchical Architecture
- Network Partitioning (802.1q, vLAN tagging)
- Multiple Spanning Trees (802.1s)
- Segmentation (802.1ad, “Provider Bridges”)
- Enables Subnets To be Characterized Differently Than Core
- IETF – Architecture for Closer Integration With Ethernet
  - GMPLS As Uniform Control Plane
  - Generalized UNI for Subnets
  - Link State Routing In Control Plane
  - TTL Capability to Data Plane
  - Pseudo – Wire Capabilities

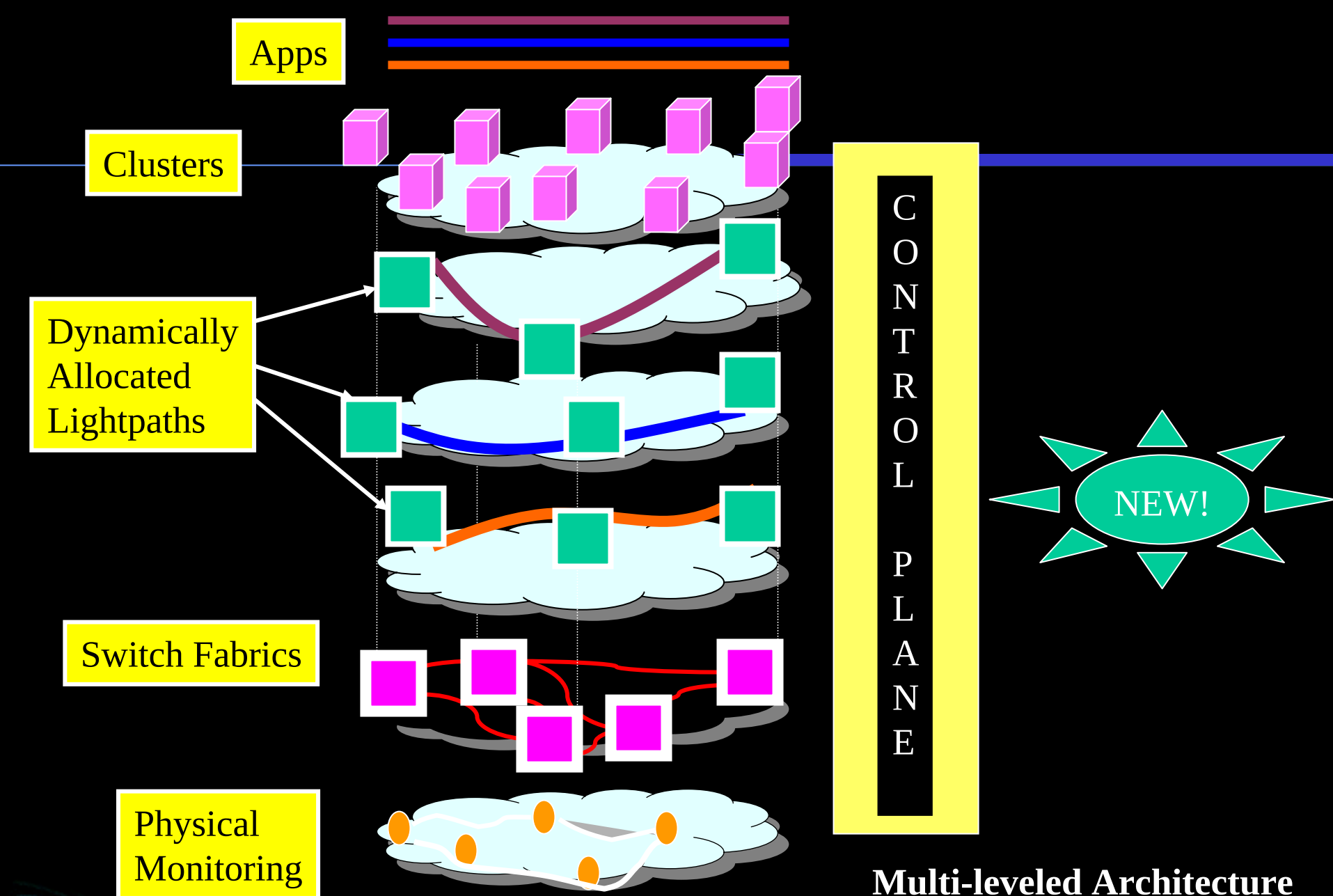
L1 10 Gbps

- 10 GE Node Compute Clusters
- APIs
- Automated Switch Panels
- GMPLS
- IETF GMPLS UNI (vs ONI UNI, Implications for Restoration Reliability)
- 10 G Ports
- MEMs Based
  - Services
    - Lightpaths with Attributes, Uni-directional, Bi-directional
    - Highly Secure Paths
    - OVPN
    - Optical Multicast
    - Protected Through Associated Groups
- ITU-T SG Generic VPN Architecture (Y.1311), Service Requirements (Y.1312), L1 VPN Architecture (Y.1313)

Lightwave Networking

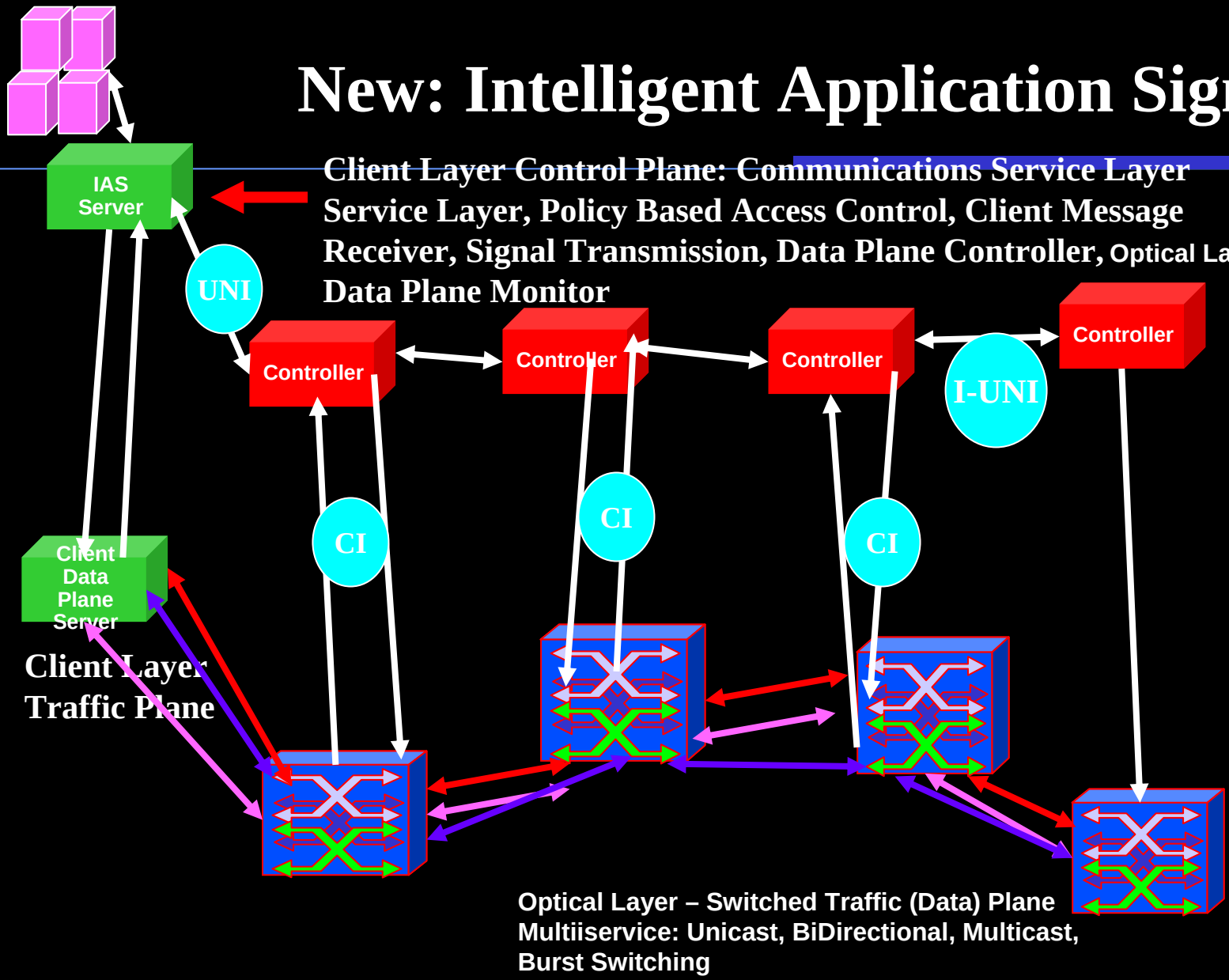


Separate Networks On the Same Infrastructure
Multiple Drivers, Including Many New Services, (Scalable to Many 1,000s of Services)
Deterministic Requirements, New Technology, New Infrastructure, e.g, Distributed All Optical Facilities, and FTTP Investments,

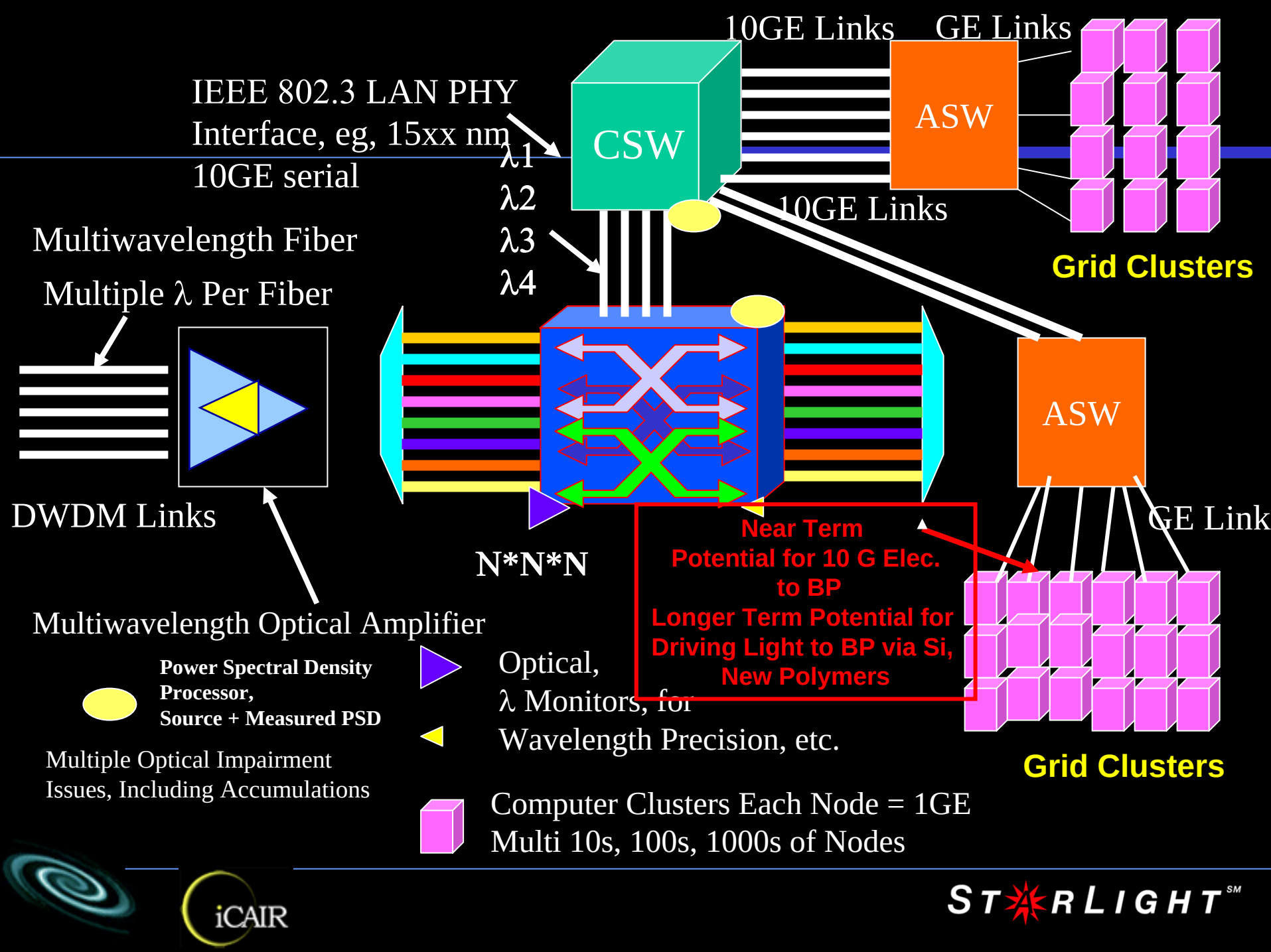


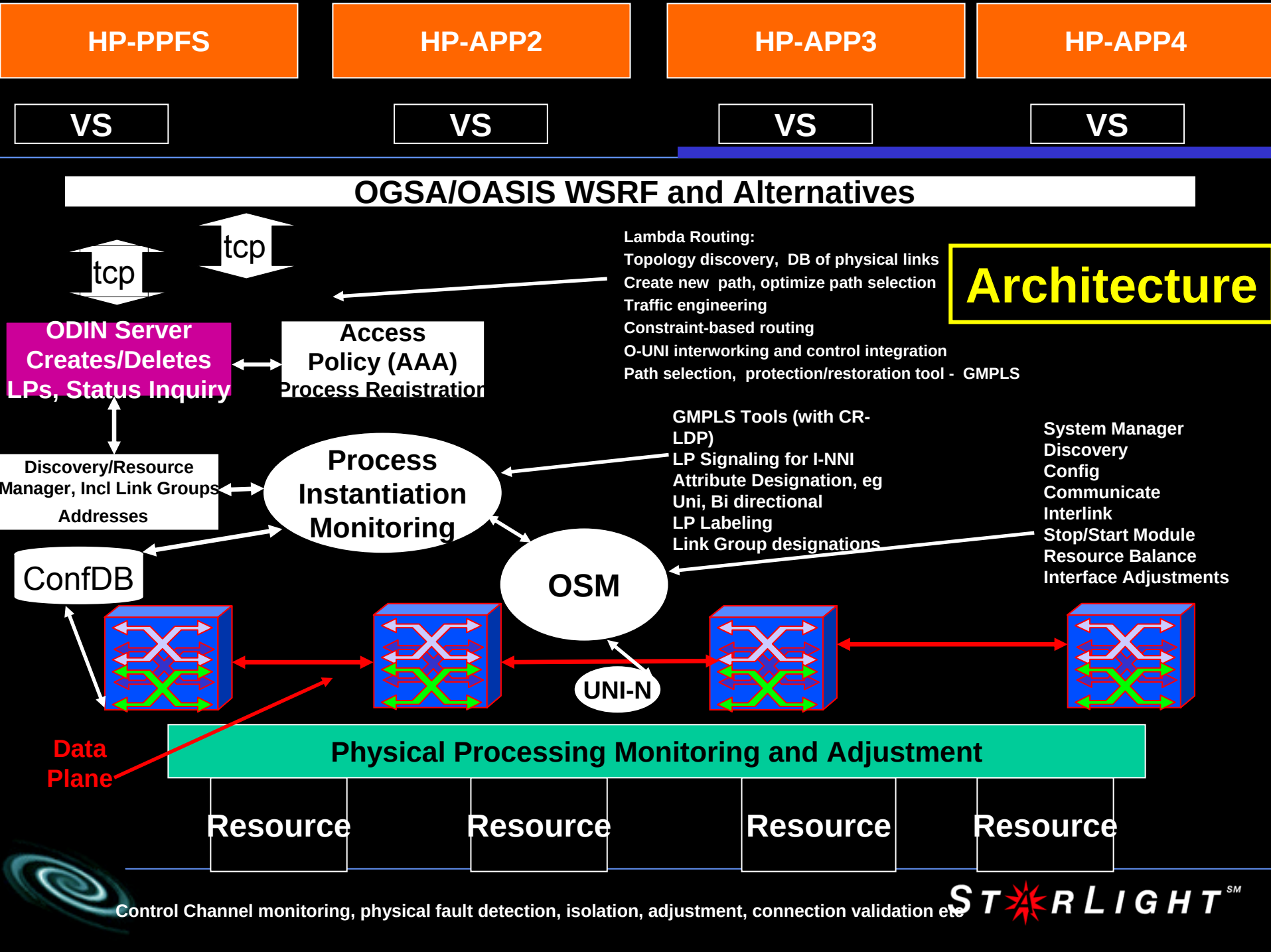
Multi-leveled Architecture

New: Intelligent Application Signaling *



* Also Control Signaling, et al


10GE Links
GE Links
IEEE 802.3 LAN PHY
Interface, eg, 15xx nm
10GE serial
λ1
λ2
λ3
λ4
CSW
ASW
10GE Links
Grid Clusters
Multiwavelength Fiber
Multiple λ Per Fiber
DWDM Links
N*N*N
ASW
GE Link
Near Term
Potential for 10 G Elec.
to BP
Longer Term Potential for
Driving Light to BP via Si,
New Polymers
Multiwavelength Optical Amplifier
Power Spectral Density
Processor,
Source + Measured PSD
Optical,
λ Monitors, for
Wavelength Precision, etc.
Multiple Optical Impairment
Issues, Including Accumulations
Grid Clusters
Computer Clusters Each Node = 1GE
Multi 10s, 100s, 1000s of Nodes


HP-PPFS
HP-APP2
HP-APP3
HP-APP4
VS
VS
VS
VS
OGSA/OASIS WSRF and Alternatives
tcp
tcp
Lambda Routing:
Topology discovery, DB of physical links
Create new path, optimize path selection
Traffic engineering
Constraint-based routing
O-UNI interworking and control integration
Path selection, protection/restoration tool - GMPLS
Architecture
ODIN Server
Creates/Deletes
LPs, Status Inquiry
Access
Policy (AAA)
Process Registration
GMPLS Tools (with CR-LDP)
LP Signaling for I-NNI
Attribute Designation, eg
Uni, Bi directional
LP Labeling
Link Group designations
System Manager
Discovery
Config
Communicate
Interlink
Stop/Start Module
Resource Balance
Interface Adjustments
Discovery/Resource Manager, Incl Link Groups
Addresses
Process
Instantiation
Monitoring
ConfDB
OSM
UNI-N
Data Plane
Physical Processing Monitoring and Adjustment
Resource
Resource
Resource
Resource
Control Channel monitoring, physical fault detection, isolation, adjustment, connection validation etc
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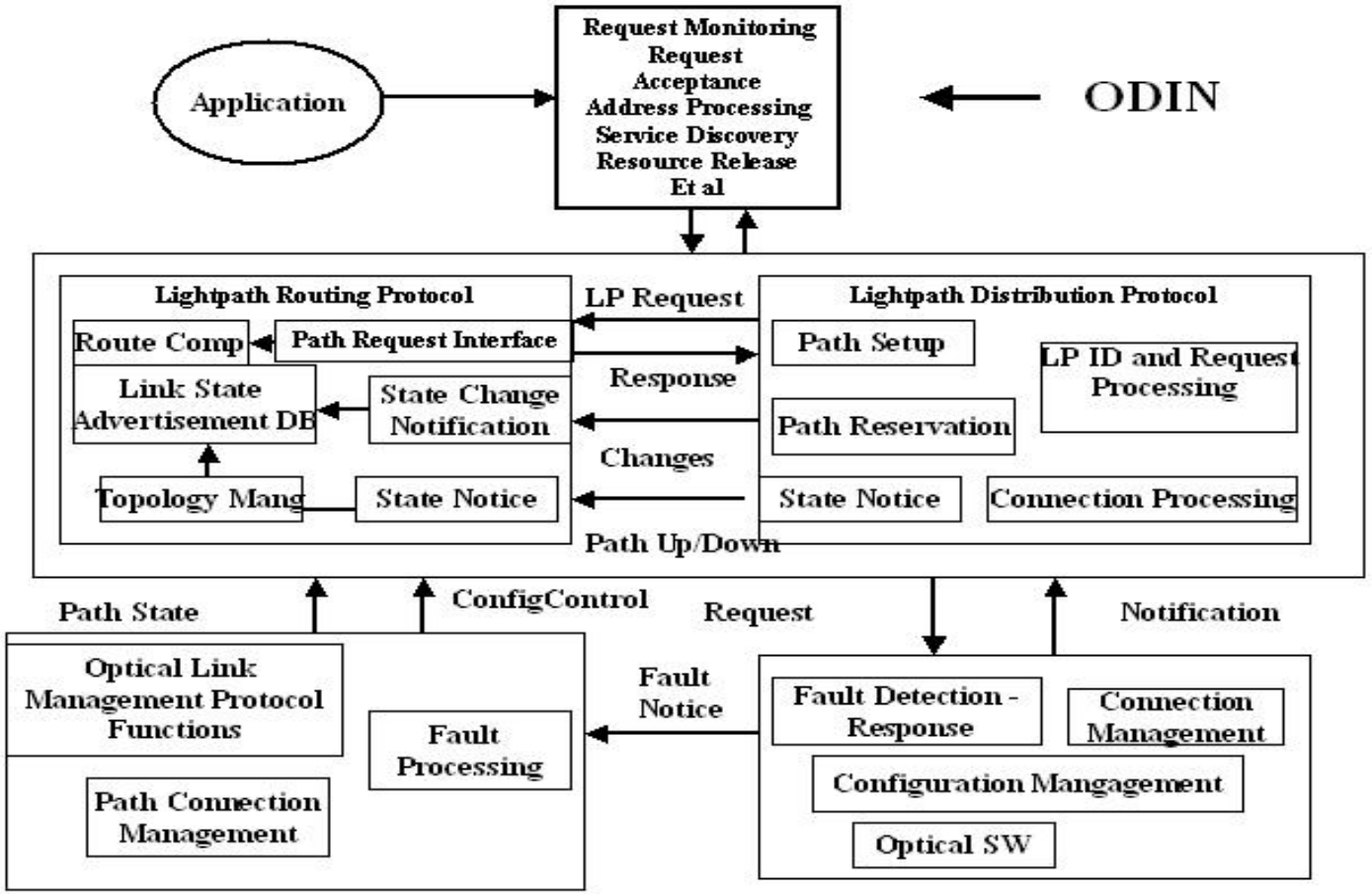
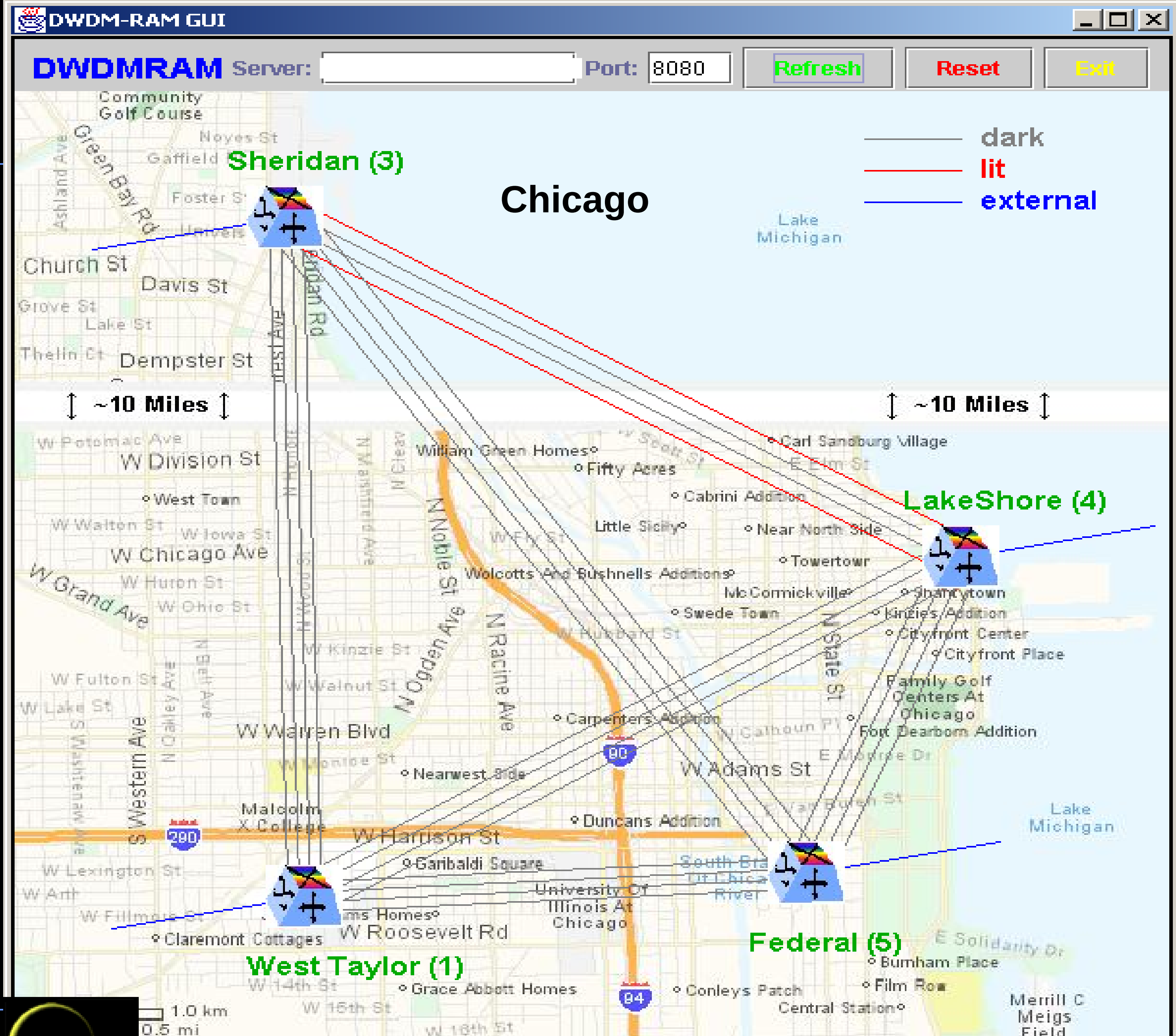
Optical Dynamic Intelligent Network (ODIN)





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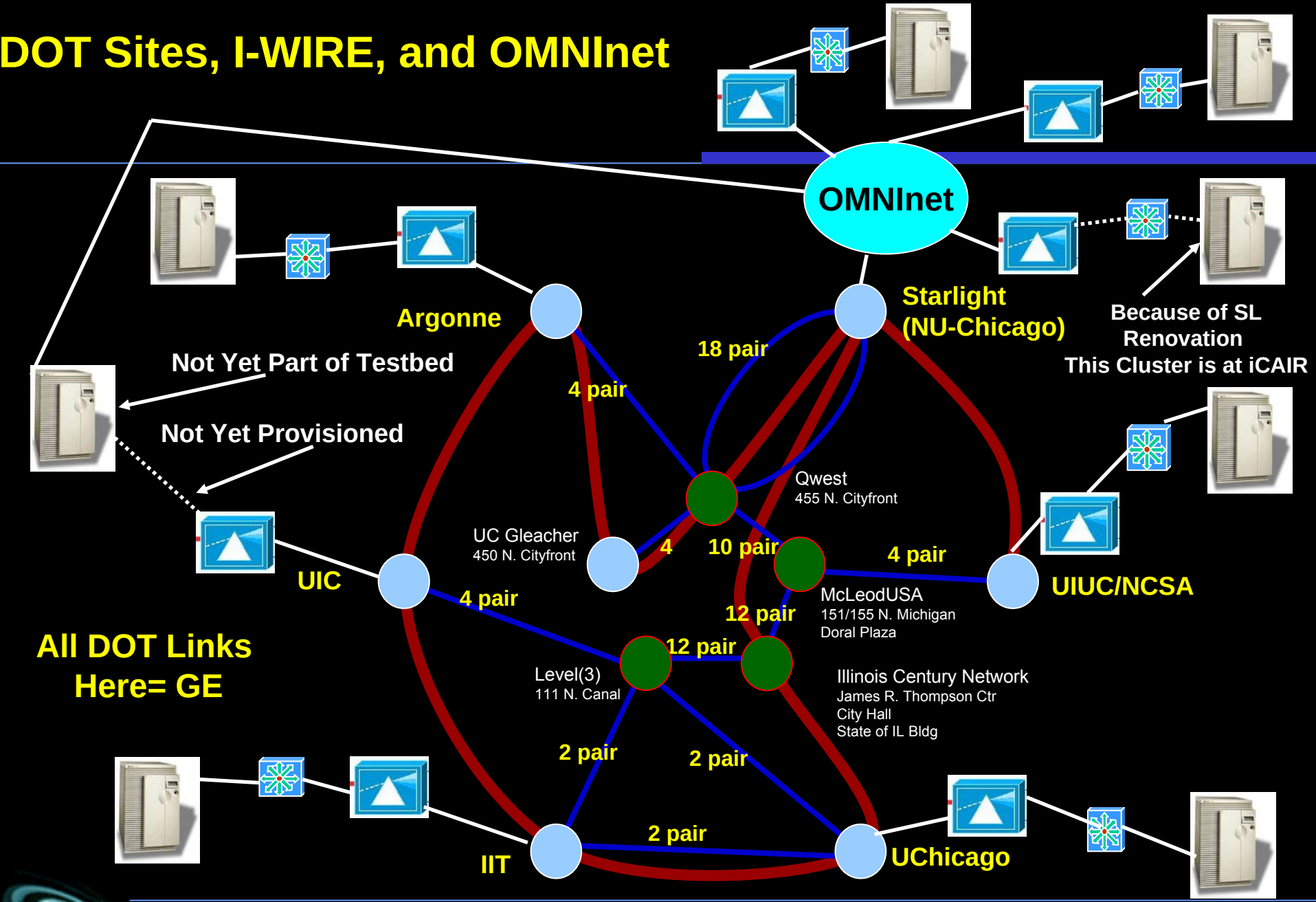
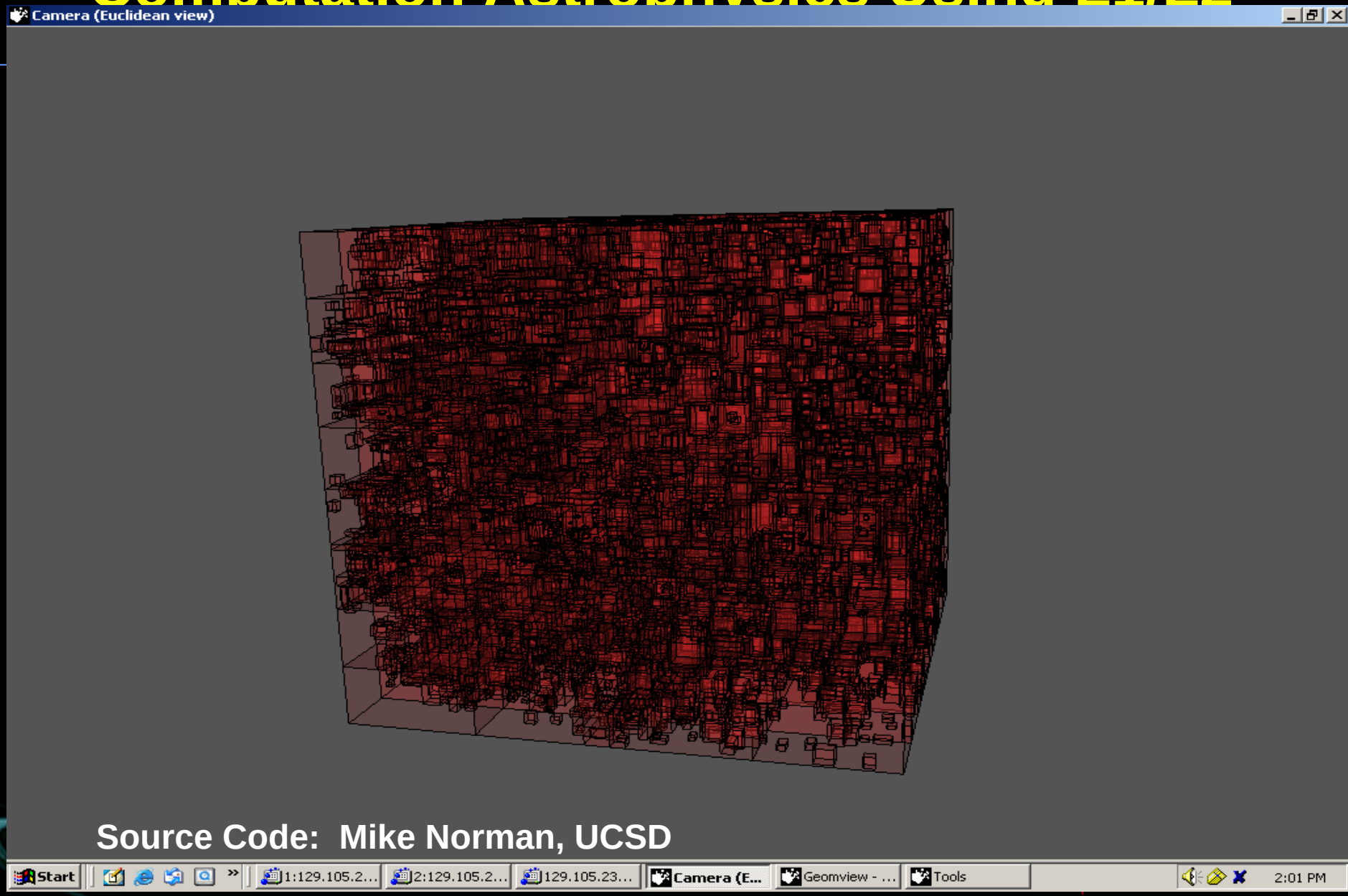
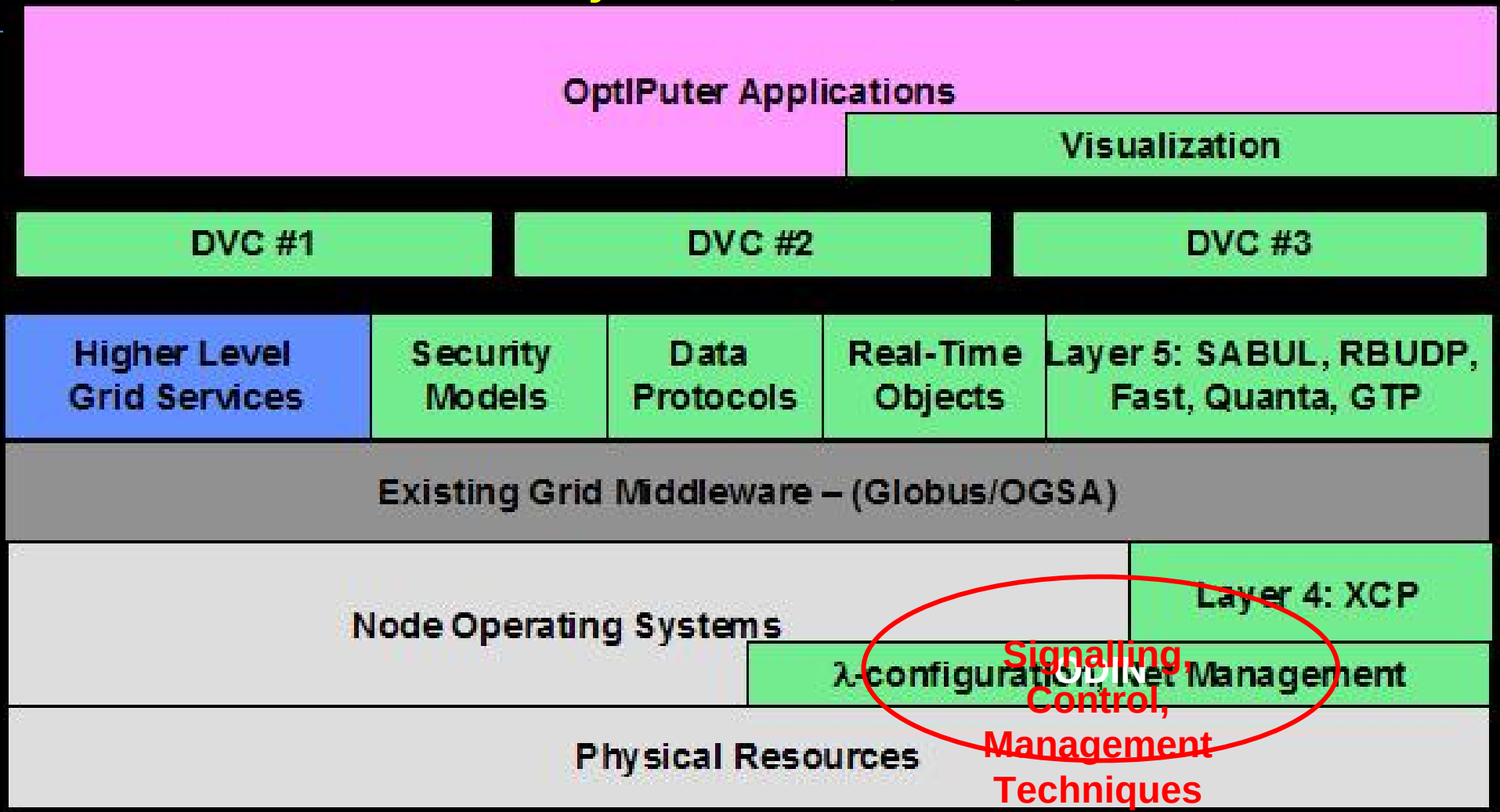
DOT Sites, I-WIRE, and OMNInet



Computation Astrophysics Using L1/L2



OptIPuter Architecture, Joint Project w/UCSD, EVL, UIC



Source: Andrew Chien, UCSD
OptIPuter Software Architect

StarLight – "By Researchers For Researchers"

StarLight is an experimental optical infrastructure and proving ground for network services optimized for high-performance applications

GE+2.5+10GE Exchange

Soon: Multiple 10GEs Over Optics – World's "Largest" 10GE Exchange!

View from StarLight

Abbott Hall, Northwestern University's Chicago downtown campus

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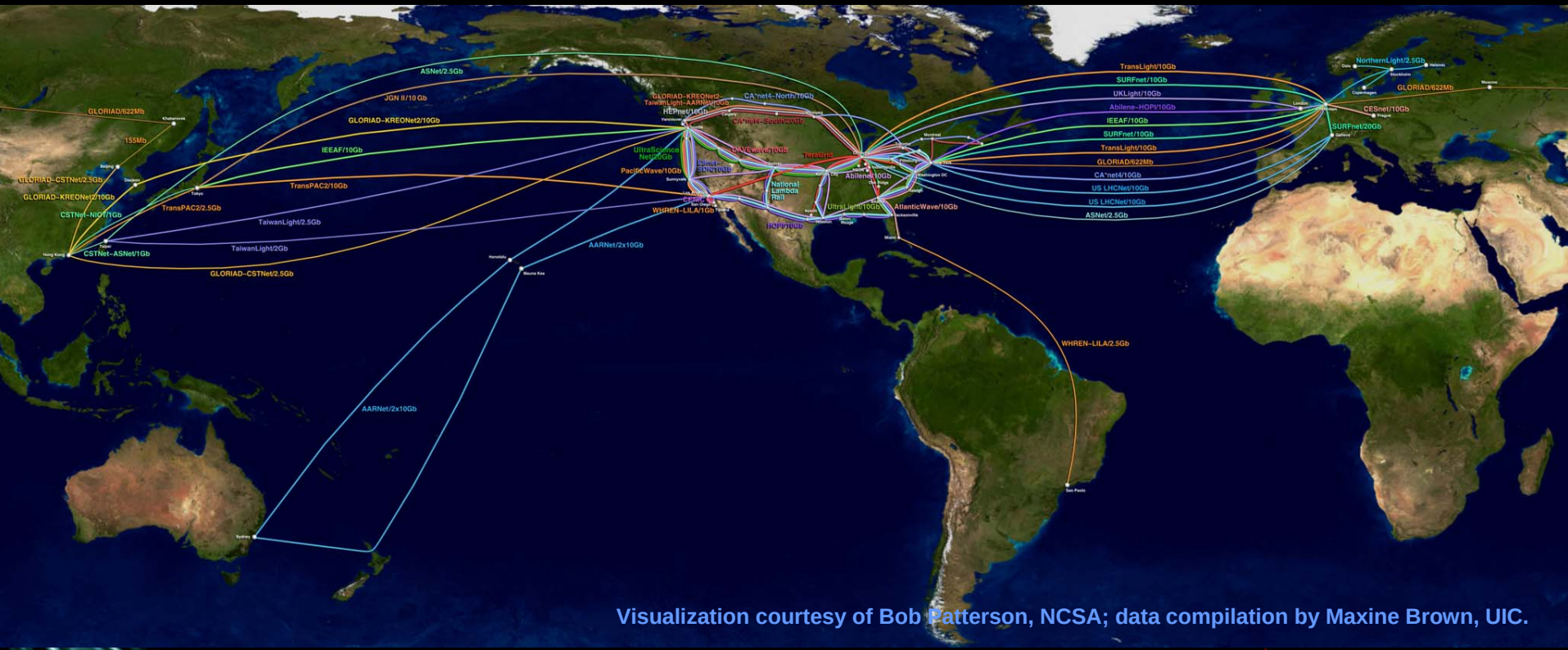
StarLight Infrastructure

StarLight is *a large research-friendly co-location facility* with space, power and fiber that is being made available to university and national/international network collaborators as a *point* of presence in Chicago

Global Lambda Integrated Facility

Available Advanced Network Resources – September 2005

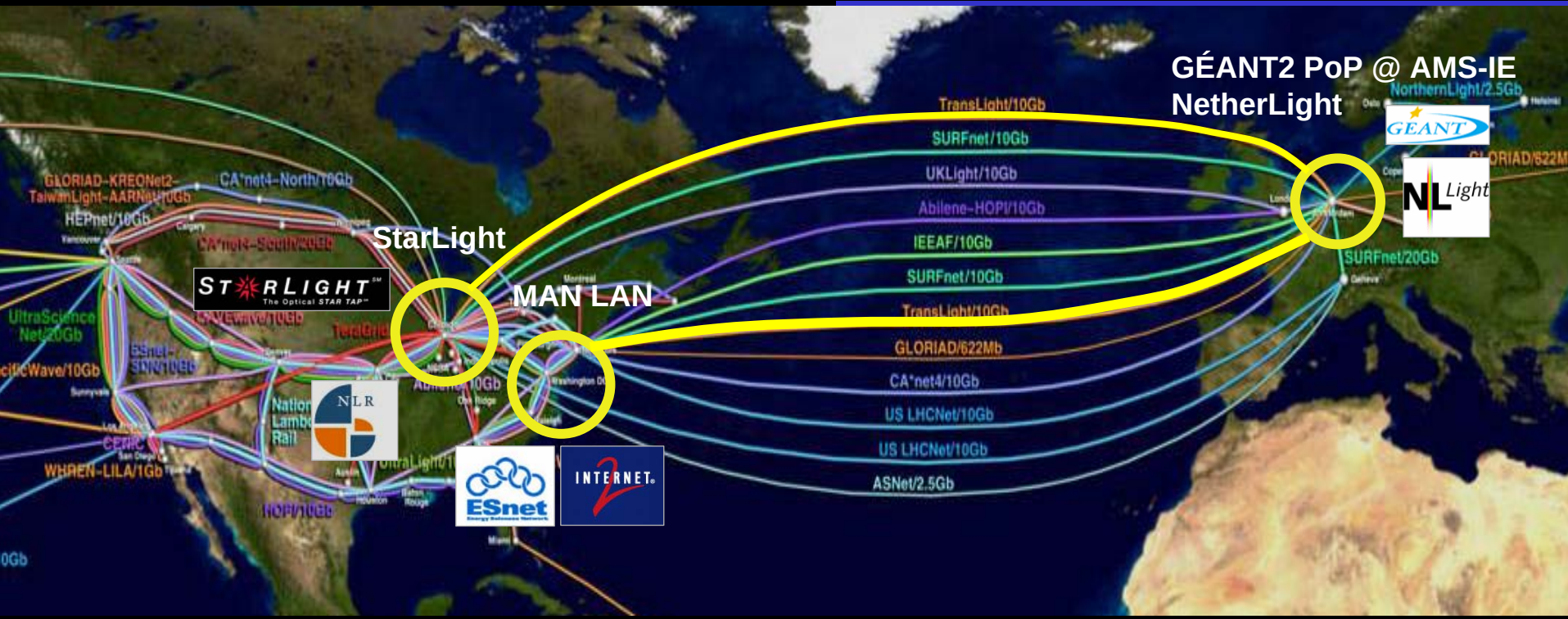
GLIF is a consortium of institutions, organizations, consortia and country National Research & Education Networks who voluntarily share optical networking resources and expertise to develop the *Global LambdaGrid* for the advancement of scientific collaboration and discovery



Visualization courtesy of Bob Patterson, NCSA; data compilation by Maxine Brown, UIC.

TransLight/StarLight

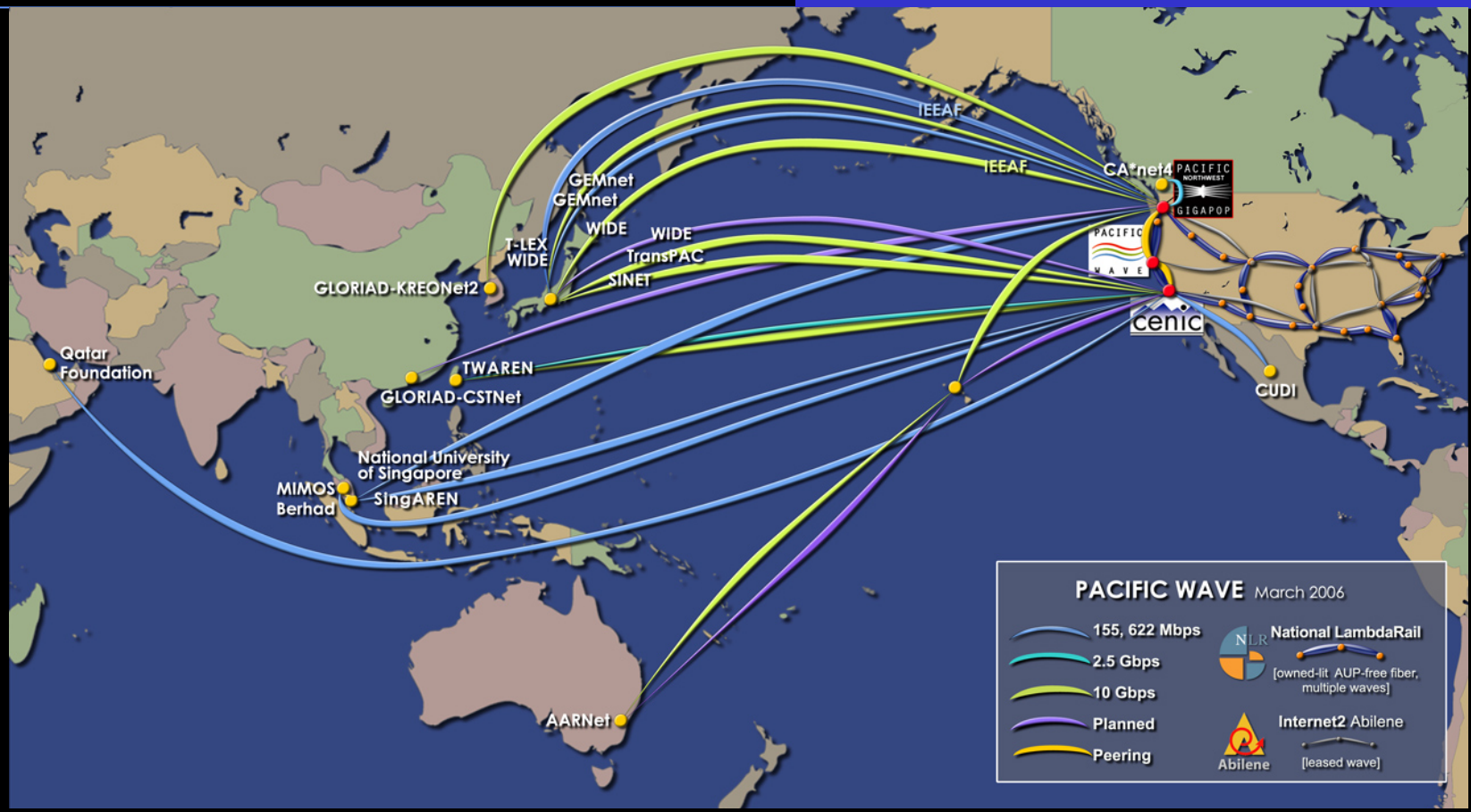
Funds Two Trans-Atlantic Links



- OC-192 routed connection between MAN LAN in New York City and the Amsterdam Internet Exchange that connects the USA Abilene and ESnet networks to the pan-European GÉANT2 network
- OC-192 switched connection between NLR and RONs at StarLight and optical connections at NetherLight; part of the GLIF LambdaGrid fabric

TransLight/Pacific Wave

10GE Wave Facilitates US West Coast Connectivity



Developing a distributed exchange facility on the US West Coast (currently Seattle, Sunnyvale and Los Angeles) to interconnect international and US research and education networks

www.pacificwave.net/participants/irnc/

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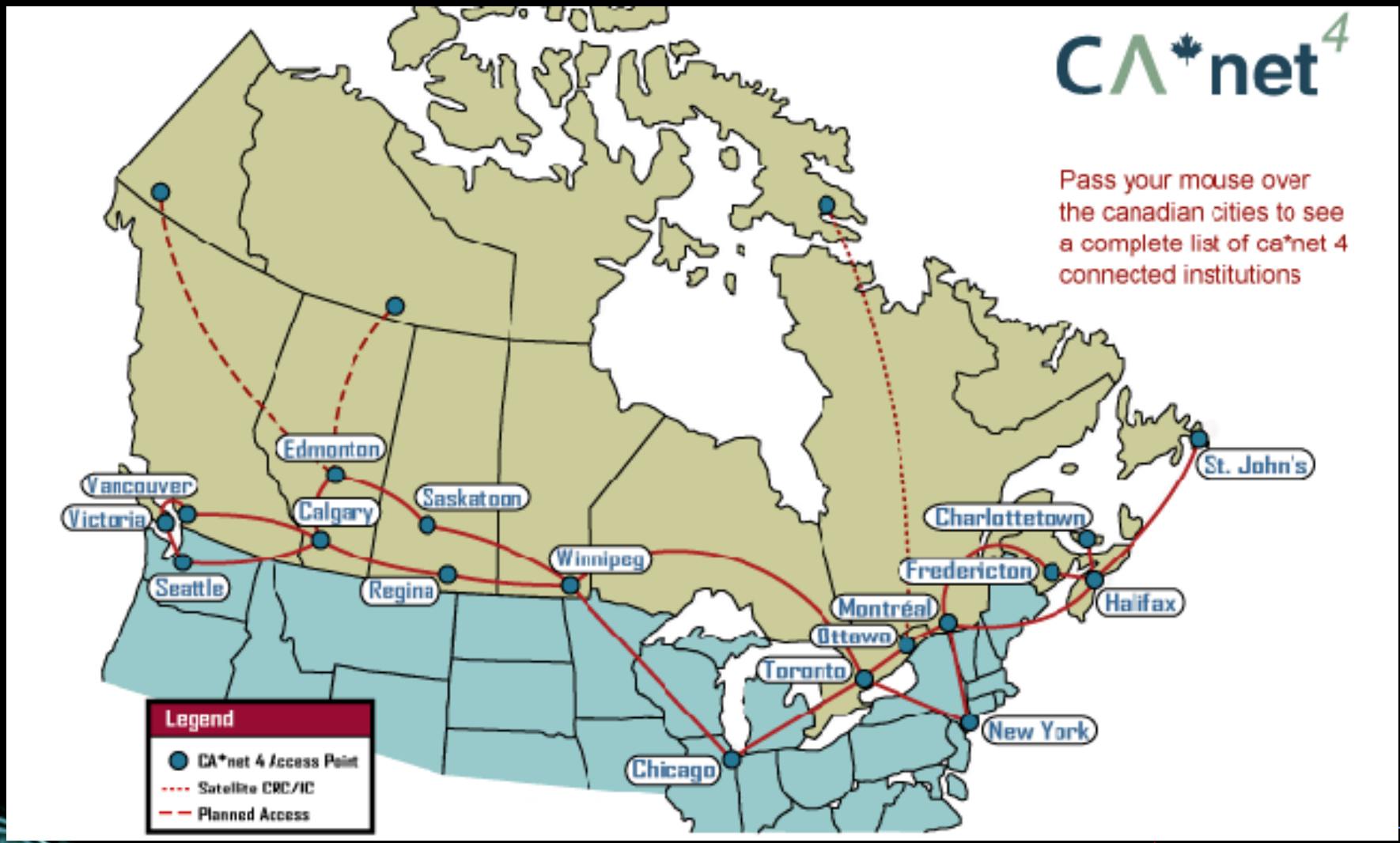
CA*net4 has 2x10Gb and Equipment at StarLight



Source: CANARIE

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SURFnet6 National Optical R&E Network

- High Performance Optical Switching
- Numerous 10 Gbit/s Lightpaths
- Dynamic Provisioning
- 500,000 Users
- 84 Institutes

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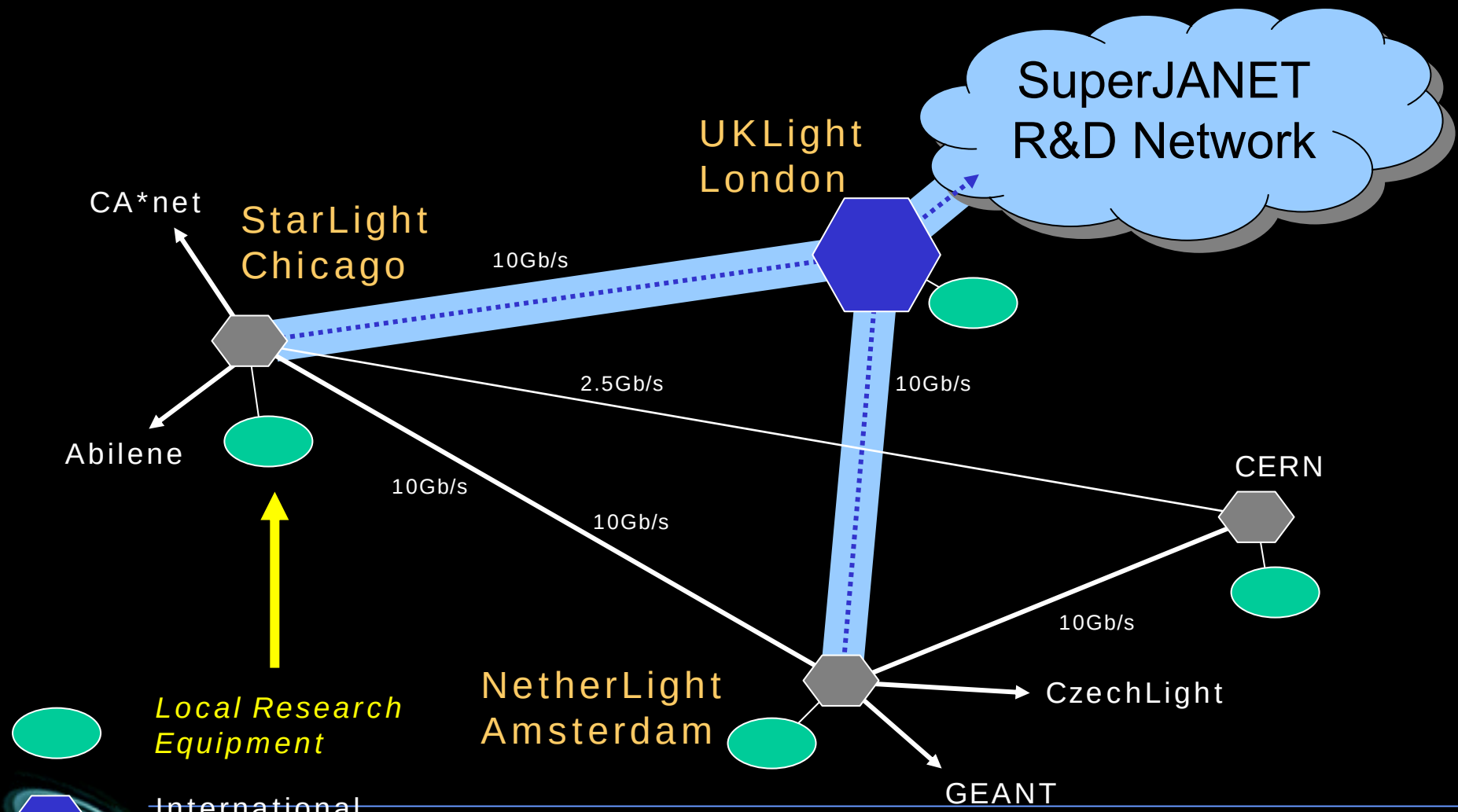
UKLight is Connected to StarLight with 10Gb and Equipment



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Source: Peter Clarke, David Salmon, UKLight

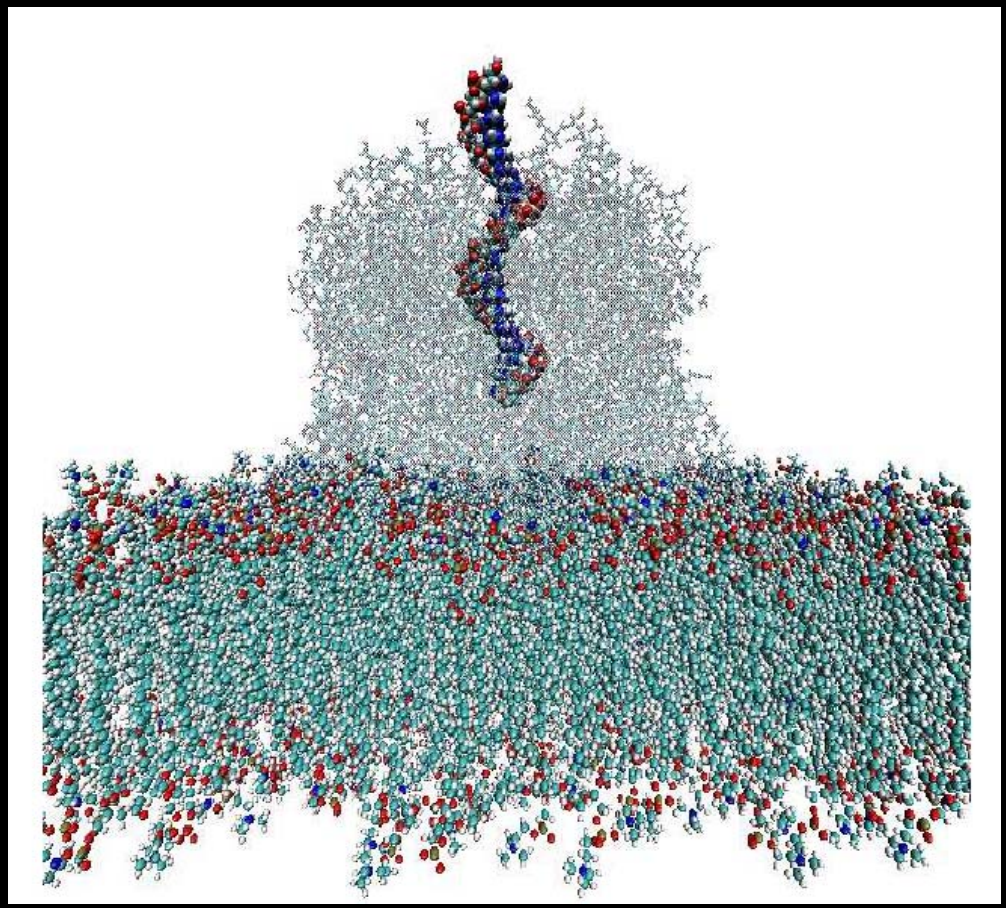
SPICE: Part of UK e-Science Initiative

Interactive
Molecular Dynamics
Simulation

SC05 HPC Analytics Challenge Award
ISC Life Sciences Award 2005

TeraGrid + UK e-Science Grid
Over UKLight at StarLight:

Uses steered molecular dynamics to pull DNA strand through hemolysim, a channel protein
Problem size = ~250,000 atoms
Run time on normal servers =25 years



Source: UCL

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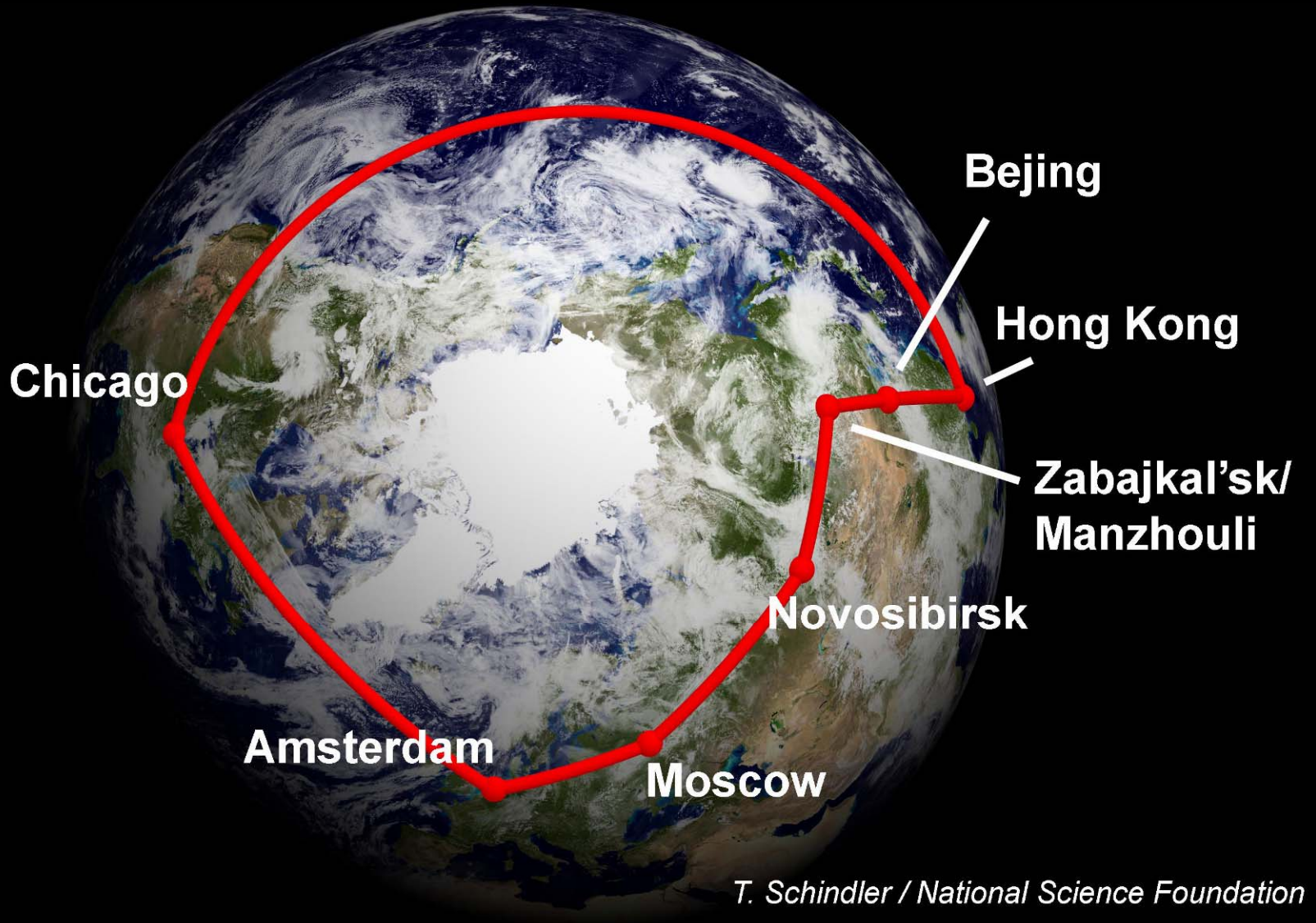
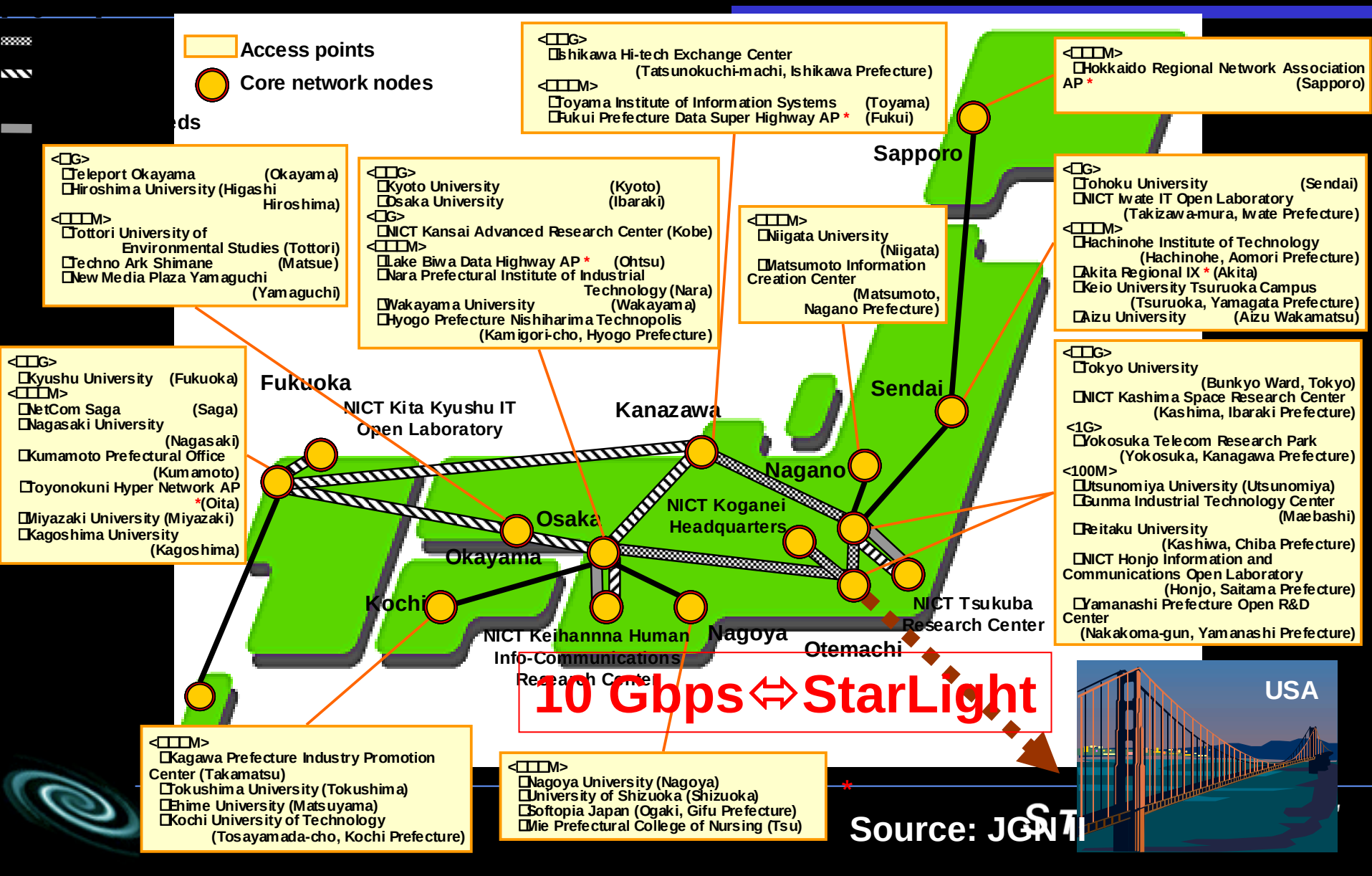
GLORIAD: Worldwide Ring
Now 10 G StarLight to Moscow, 100% 10Gb Soon

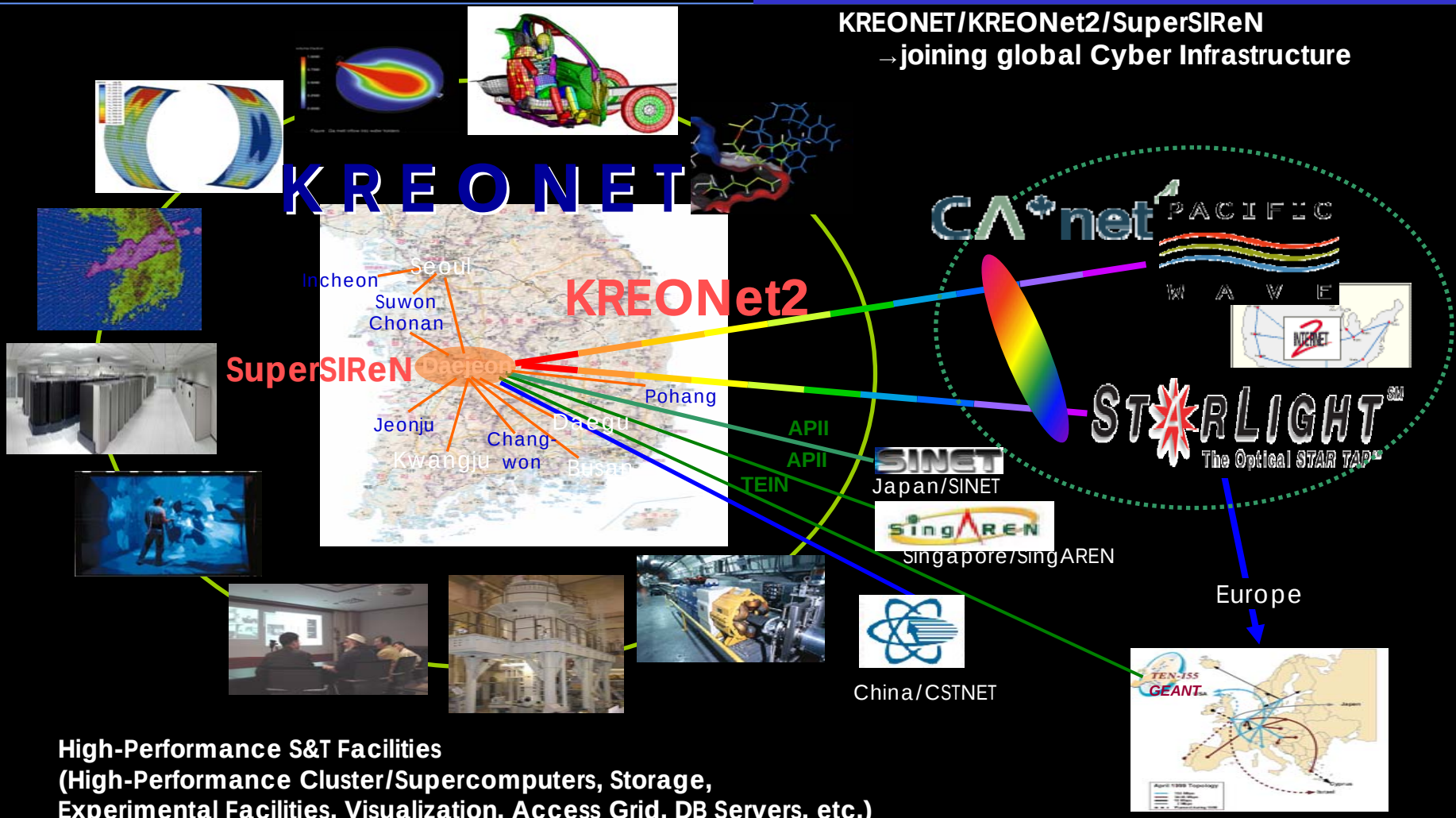


JGN II Network Topology Map



Kreonet

e-Science based
KREONET/KREONet2/SuperSIReN
→joining global Cyber Infrastructure



High-Performance S&T Facilities
(High-Performance Cluster/Supercomputers, Storage, Experimental Facilities, Visualization, Access Grid, DB Servers, etc.)

Source: Kreonet

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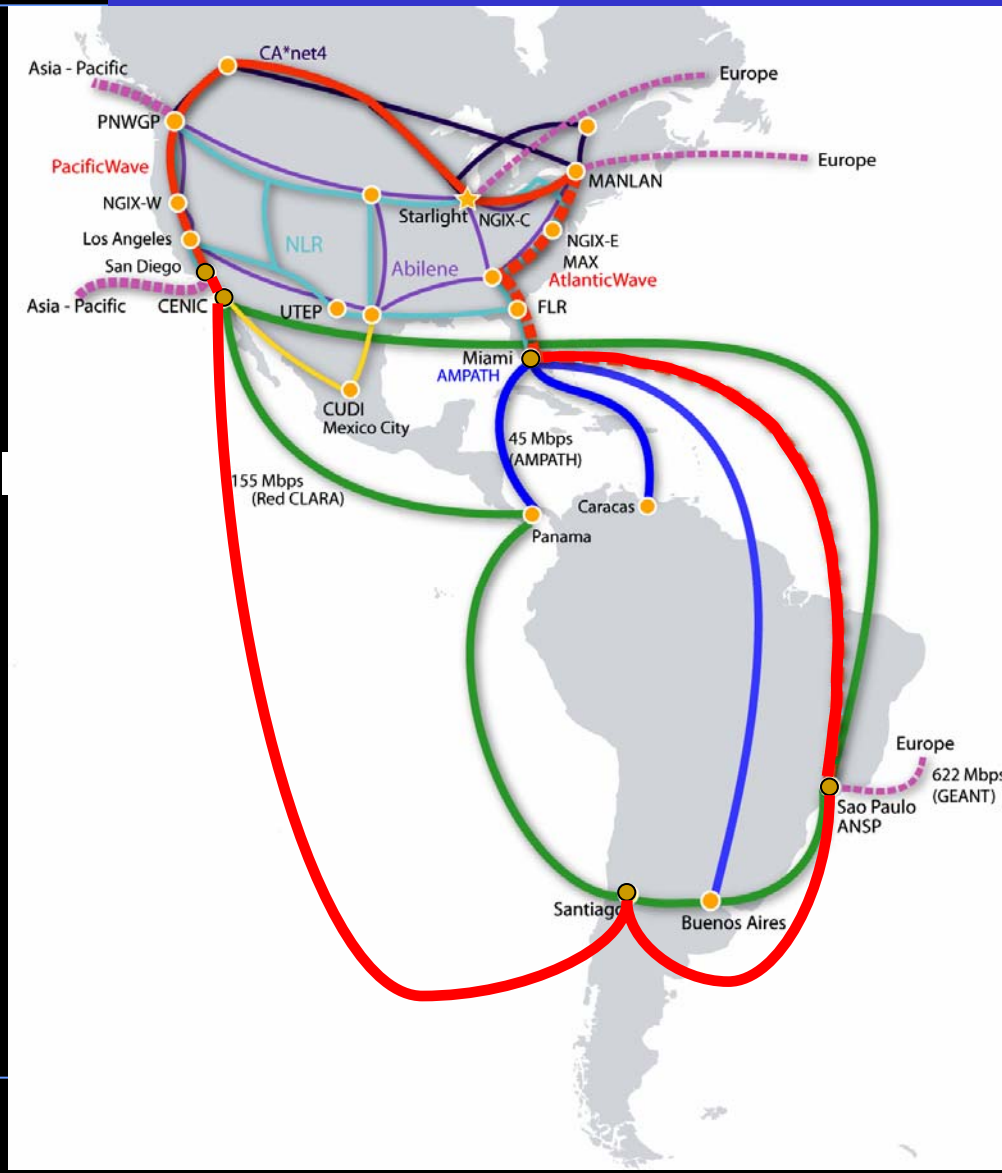
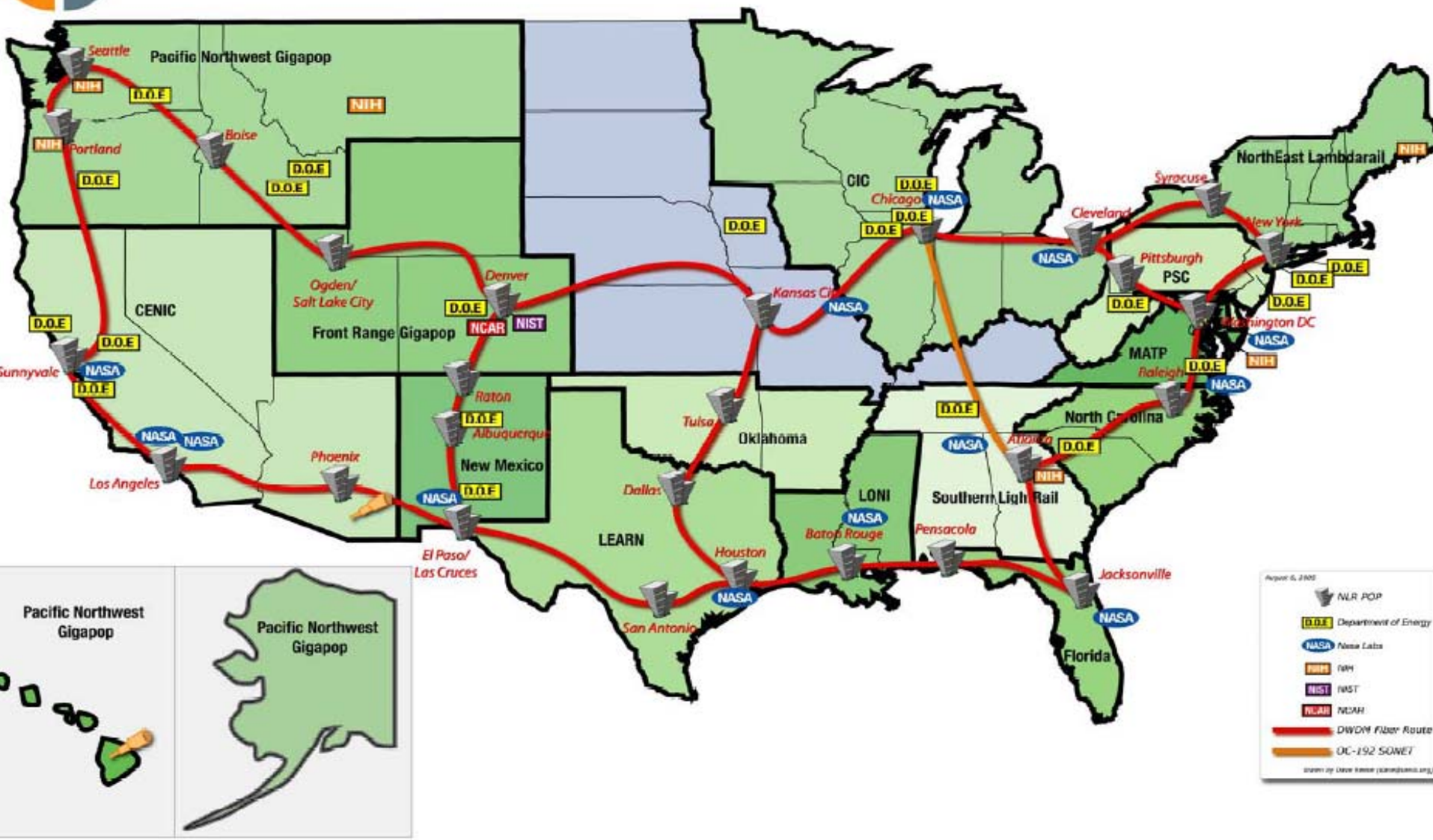
WHREN - LILA Proposal

- Joint response by FIU and CENIC to NSF IRNC solicitation
- 2.5Gbps persistent high-performance research network for South America to support U.S. and international science and engineering research and education communities
- Collaboration with research network operators and exchanges in the Americas
- Phased implementation over 5 years



Source: AMPATH

National LambdaRail Architecture



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

Source: John Silvester, Dave Reese, Tom West, CENIC

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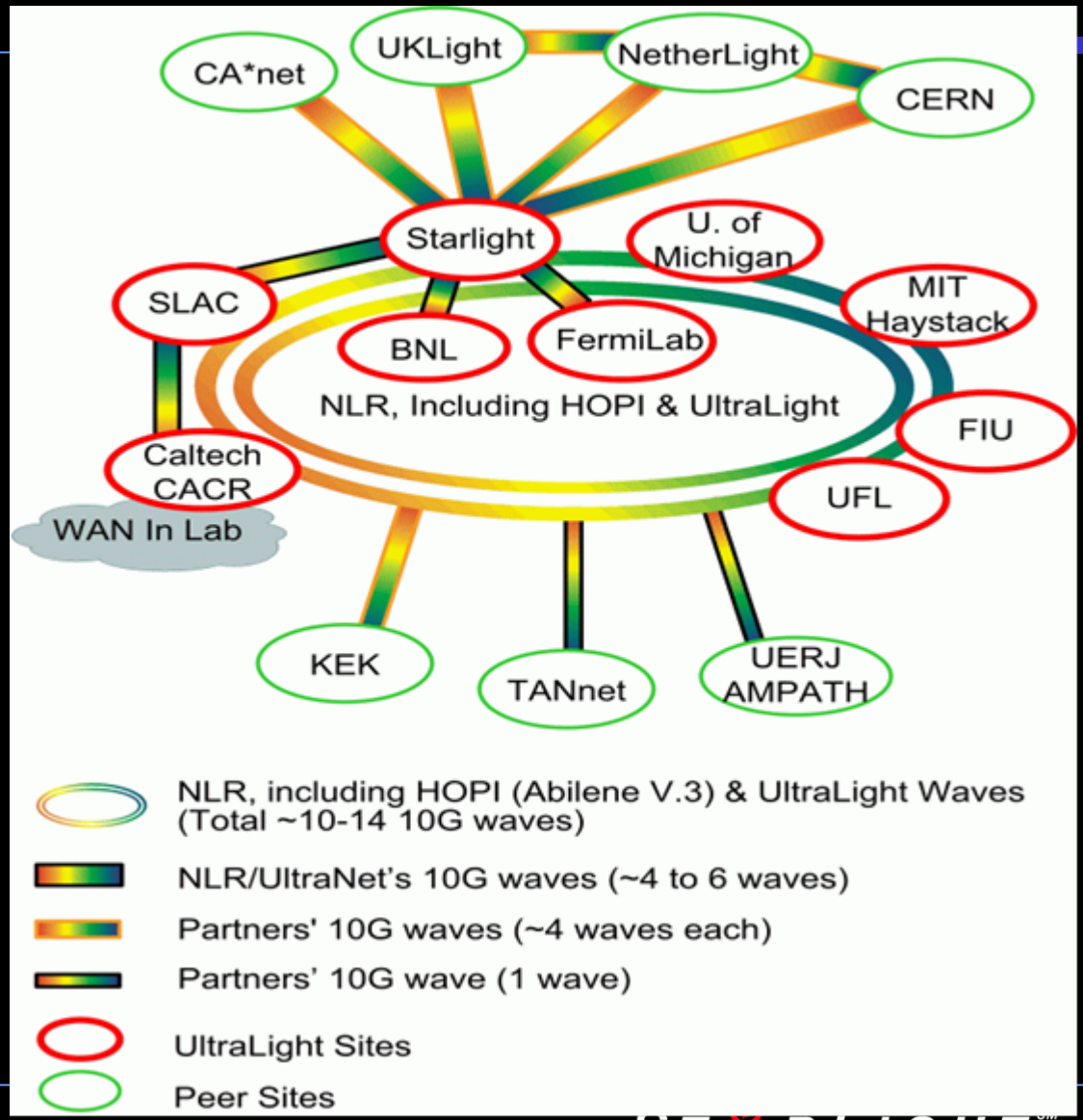
UltraLight Network: PHASE III

Source:

UltraLight Network



TeraGrid: Integrating NSF Cyberinfrastructure

TeraGrid is a facility that integrates computational, information, and analysis resources at the San Diego Supercomputer Center, the Texas Advanced Computing Center, the University of Chicago / Argonne National Laboratory, the National Center for Supercomputing Applications, Purdue University, Indiana University, Oak Ridge National Laboratory, the Pittsburgh Supercomputing Center, and the National Center for Atmospheric Research. ***SOURCE TeraGrid***

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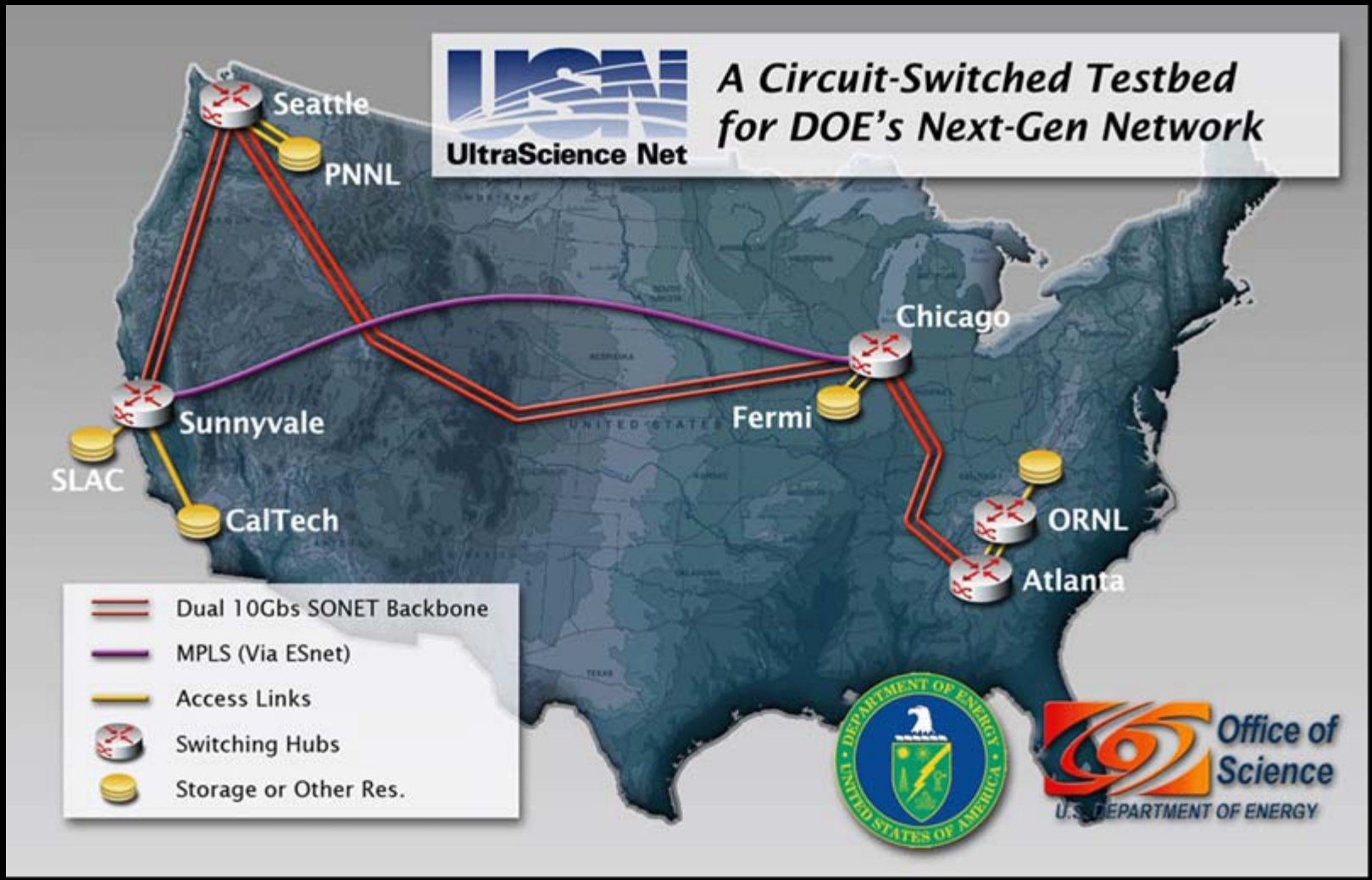
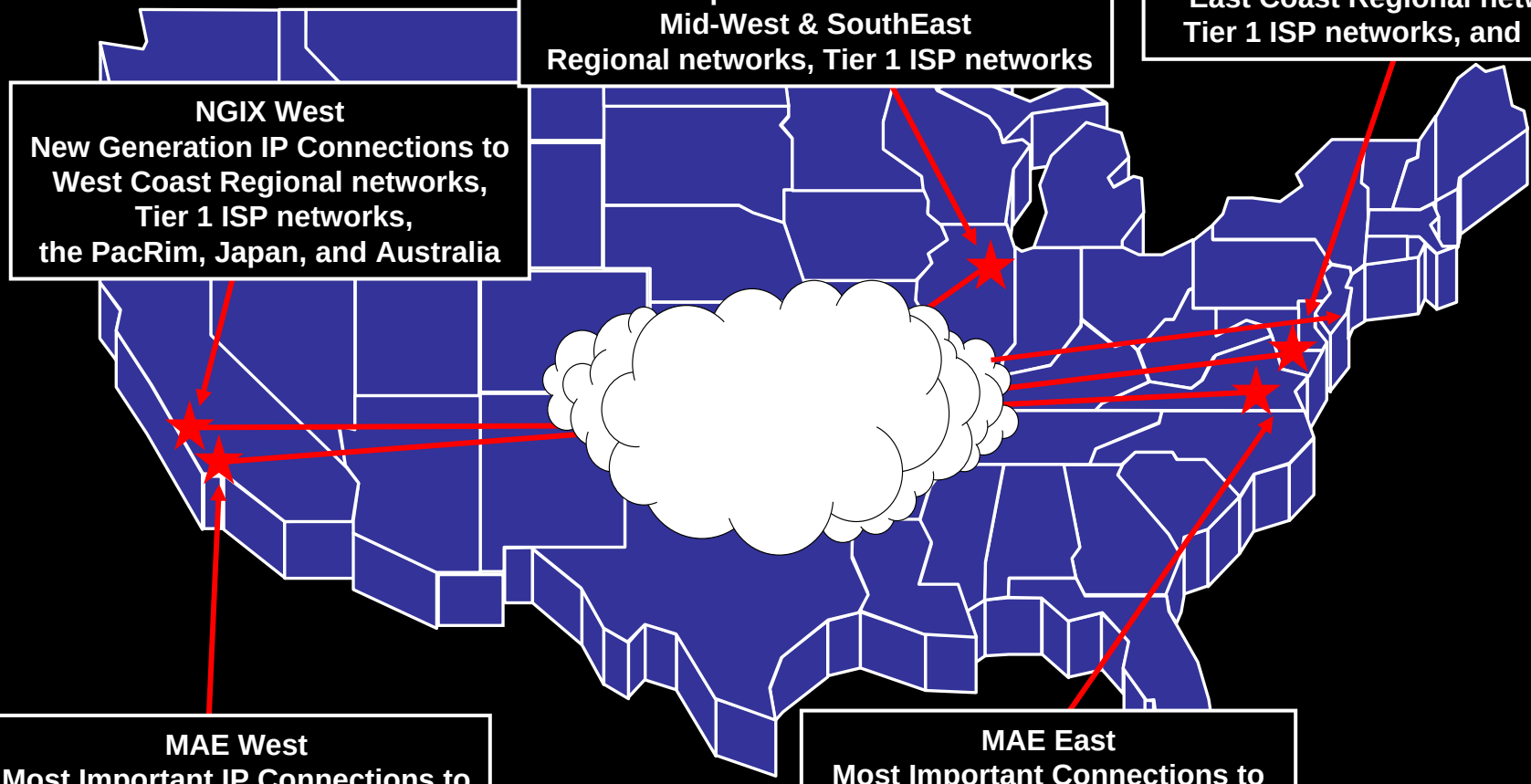
DOE's UltraScience Net is at StarLight



NASA's NISN is at StarLight



Commercial Ameritech NAP
Starlight
Most Important Connections to
Mid-West & SouthEast
Regional networks, Tier 1 ISP networks

NGIX East
New Generation IP Connections to
East Coast Regional networks,
Tier 1 ISP networks, and Europe

NGIX West
New Generation IP Connections to
West Coast Regional networks,
Tier 1 ISP networks,
the PacRim, Japan, and Australia

MAE West
Most Important IP Connections to
West Coast Regional networks,
Tier 1 ISP networks,
the PacRim, Japan, and Australia

MAE East
Most Important Connections to
East Coast Regional networks,
Tier 1 ISP networks, and Europe

Source: NASA

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10GE *CAVEwave* on the National LambdaRail

MREN

Metropolitan Research & Education Network

- An Advanced Network for Advanced Applications
- Designed in 1993; Initial Production in 1994, Managed at L2 & L3
- Created by Consortium of Research Organizations -- over 20
- Partner to STAR TAP/StarLight, I-WIRE, NGI and R&E Net Initiatives, Grid and Globus Initiatives etc.
- Model for Next Generation Internets
- Developed World's First GigaPOP
- Next – the "Optical MREN"
- Soon - Optical 'TeraPOP' Services

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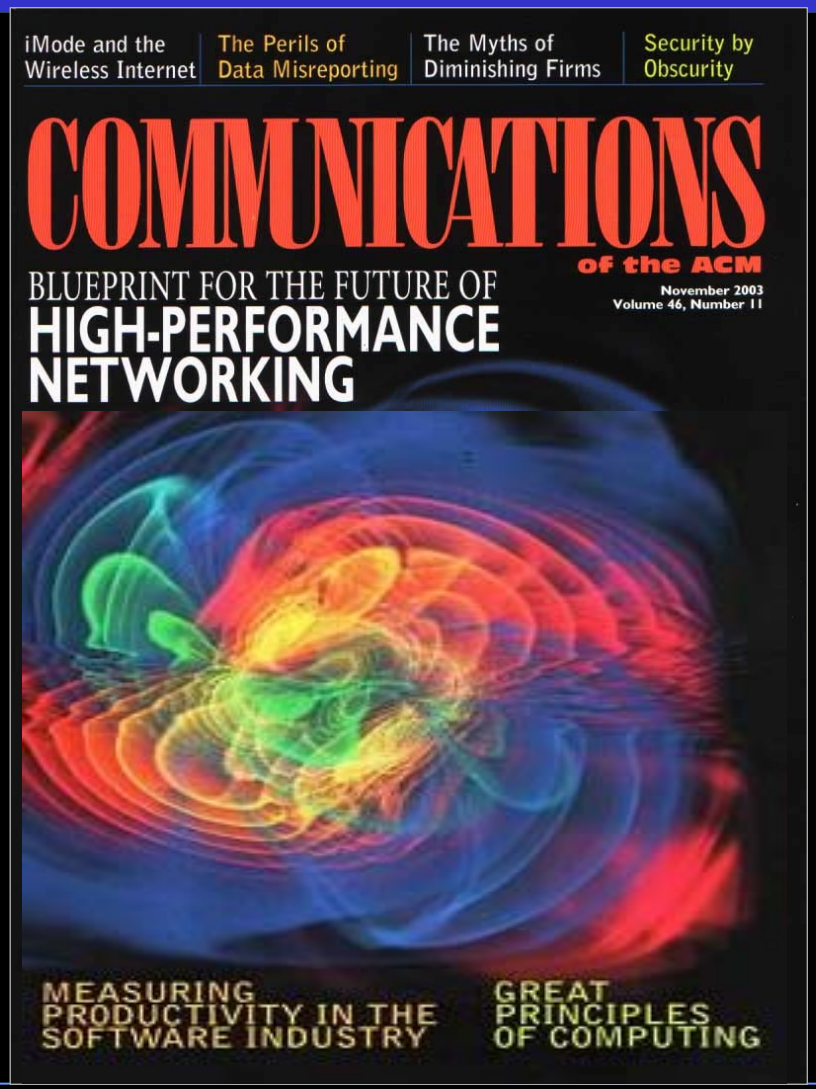
Communications of the ACM (CACM)

Volume 46, Number 11
November 2003

Special issue: Blueprint for the Future of High-Performance Networking

- *Introduction,* Maxine Brown (guest editor)
- *TransLight: a global-scale LambdaGrid for e-science,* Tom DeFanti, Cees de Laat, Joe Mambretti, Kees Neggers, Bill St. Arnaud
- *Transport protocols for high performance,* Aaron Falk, Ted Faber, Joseph Bannister, Andrew Chien, Bob Grossman, Jason Leigh
- *Data integration in a bandwidth-rich world,* Ian Foster, Robert Grossman
- *The OptIPuter,* Larry Smarr, Andrew Chien, Tom DeFanti, Jason Leigh, Philip Papadopoulos
- *Data-intensive e-science frontier research,* Harvey Newman, Mark Ellisman, John Orcutt



www.acm.org/cacm

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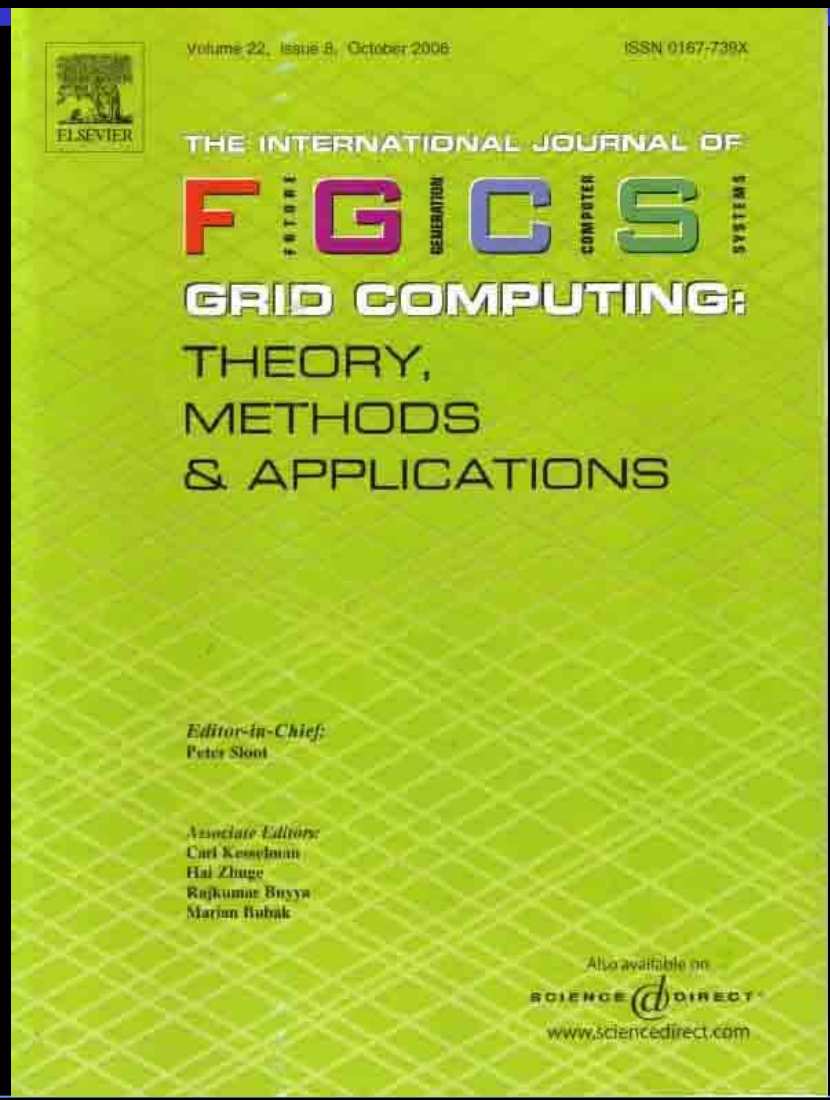
iGrid 2005 Proceedings Available!

Special issue on iGrid 2005: The Global Lambda Integrated Facility
27 referred papers!

Smarr, Larry, Maxine Brown, Tom DeFanti and Cees de Laat (guest editors)

Future Generation Computer Systems, Volume 22, Issue 8, Elsevier, October 2006, pp. 849-1054

“Computational Astrophysics Enabled By Dynamic Lambda Switching,” iCAIR



www.elsevier.com/locate/future

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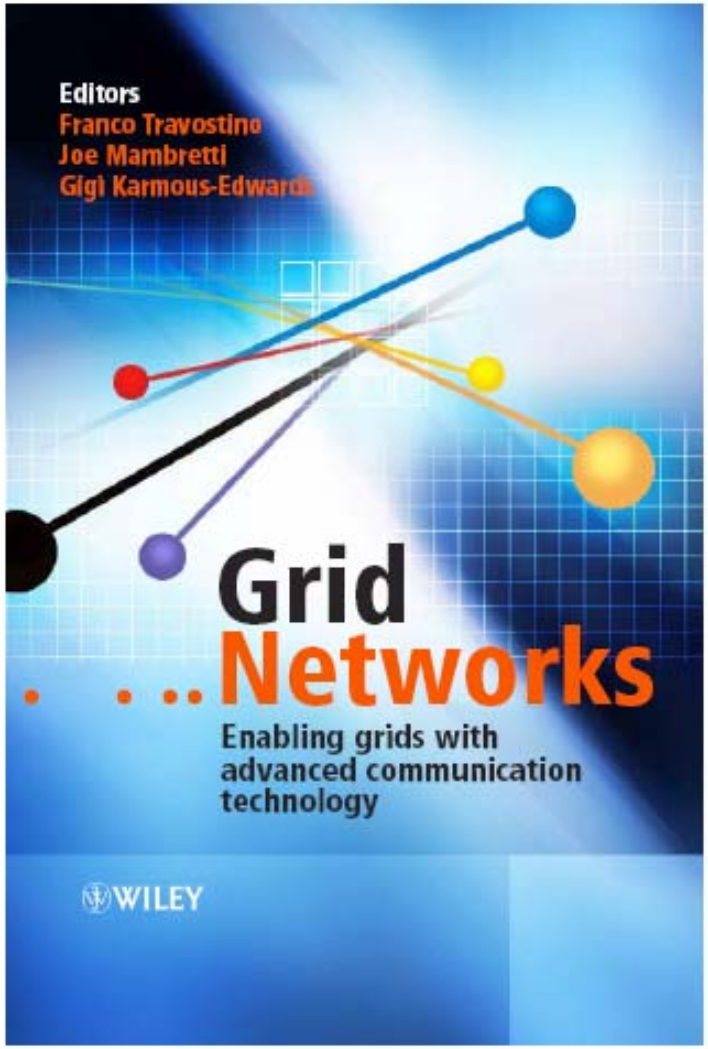
Editors
Franco Travostino
Joe Mambretti
Gigi Karmous-Edwards
Grid
Networks
Enabling grids with
advanced communication
technology
WILEY

www.startap.net/starlight

Thanks to the NSF and Other Supporters