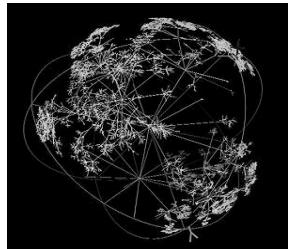


# Overview of Grid Networks

**Joe Mambretti, Director, ([j-mambretti@northwestern.edu](mailto:j-mambretti@northwestern.edu))**  
**International Center for Advanced Internet Research ([www.icair.org](http://www.icair.org))**  
**Director, Metropolitan Research and Education Network ([www.mren.org](http://www.mren.org))**  
**Partner, StarLight, PI-OMNINet ([www.icair.org/omninet](http://www.icair.org/omninet))**



## Midwest Grid Workshop 2007 March 24, 2007



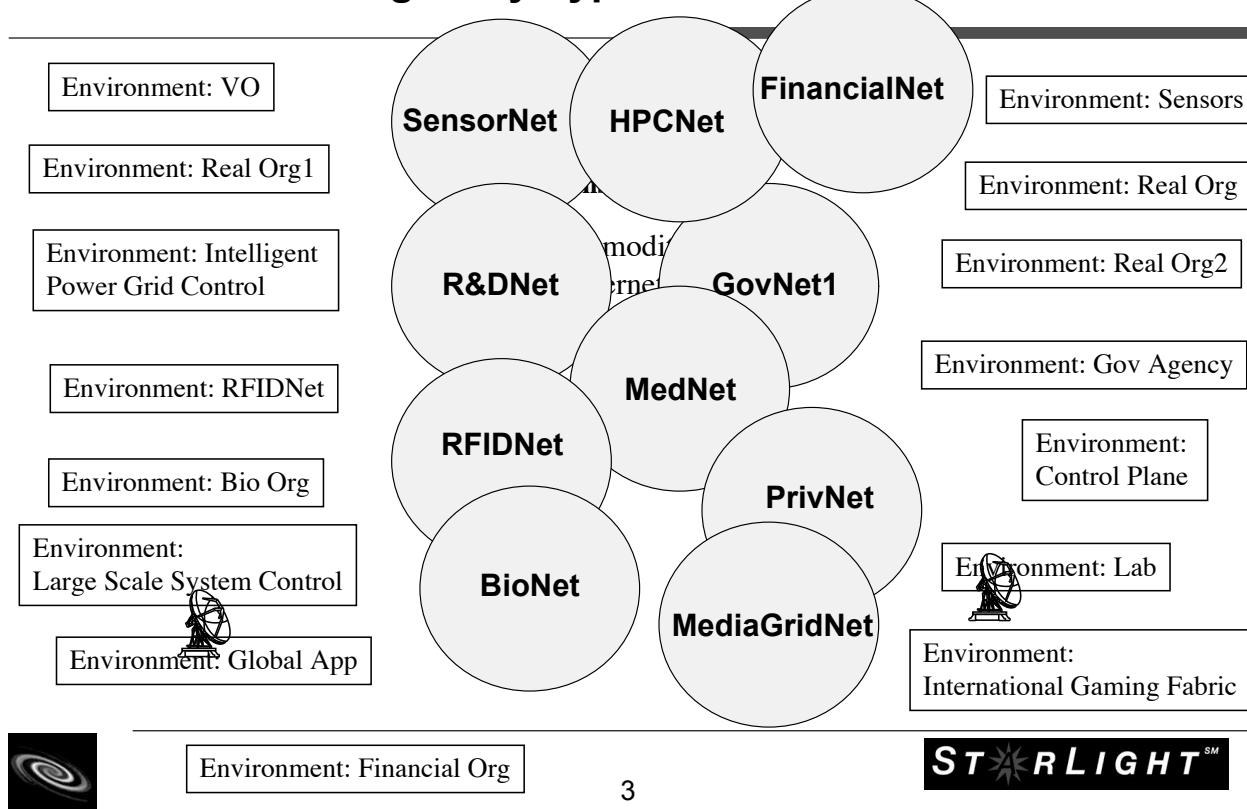
## Introduction to iCAIR:

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



3

## 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



4



# 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)**

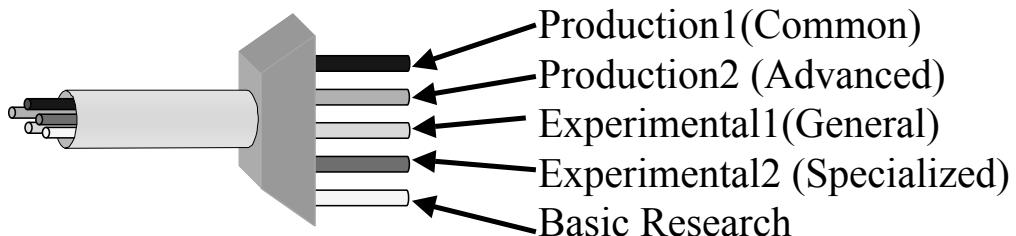


5

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## Lightwave Networking

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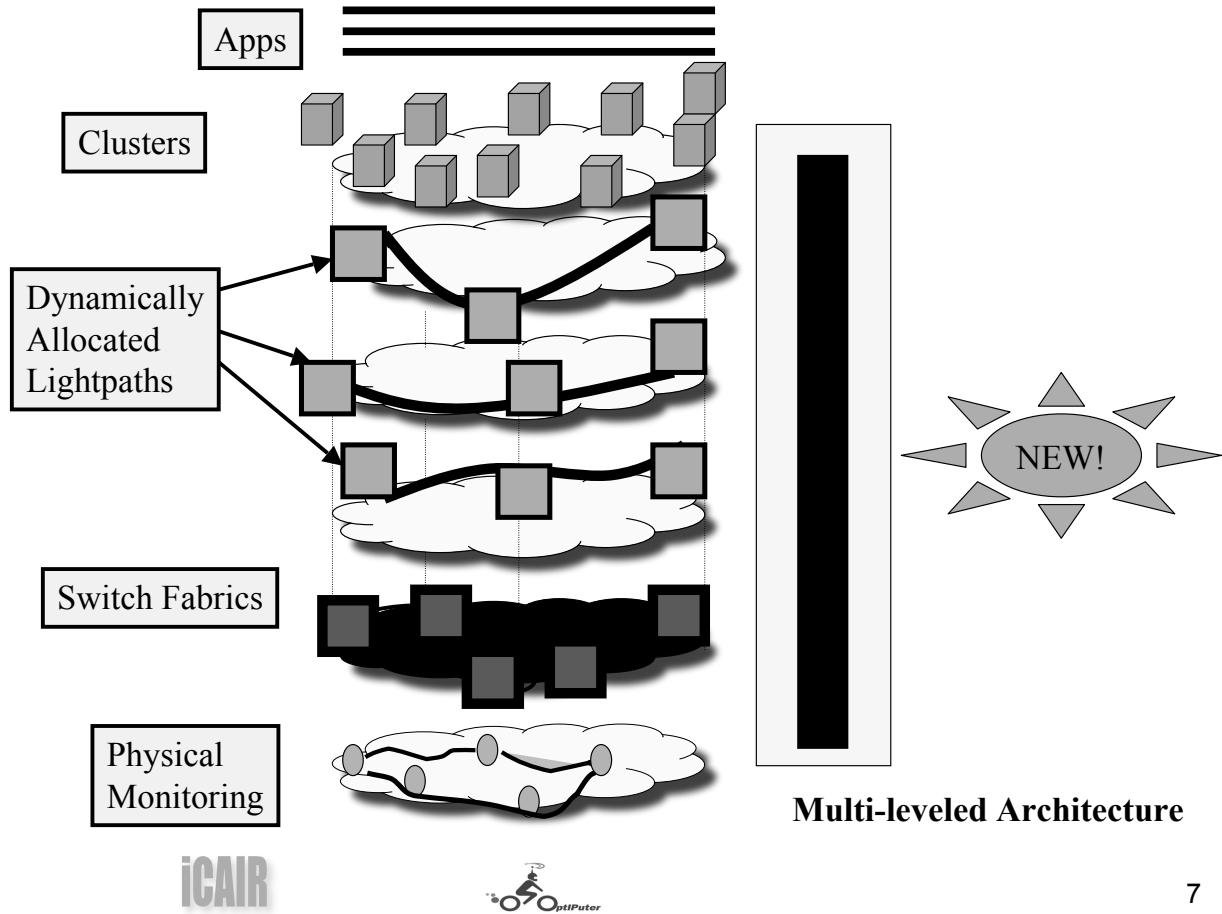


**Separate Networks On the Same Infrastructure**  
**Multiple Drivers, Including Many New Services,**  
**(Scalable to Many 1,000s of Services)**  
**Deterministic Requirements, New Technology,**  
**New Infrastructure, e.g, Distributed All Optical**  
**Facilities, and FTTP Investments,**

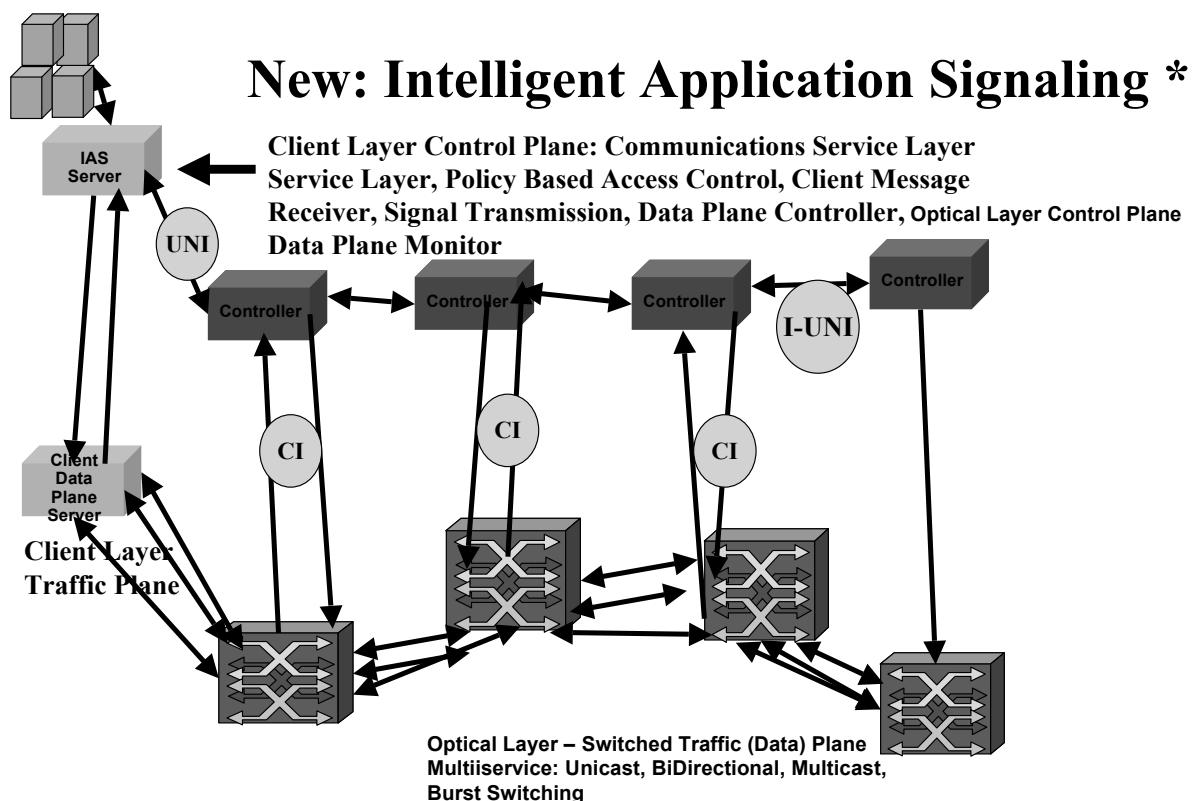


6

 STARLIGHT<sup>SM</sup>

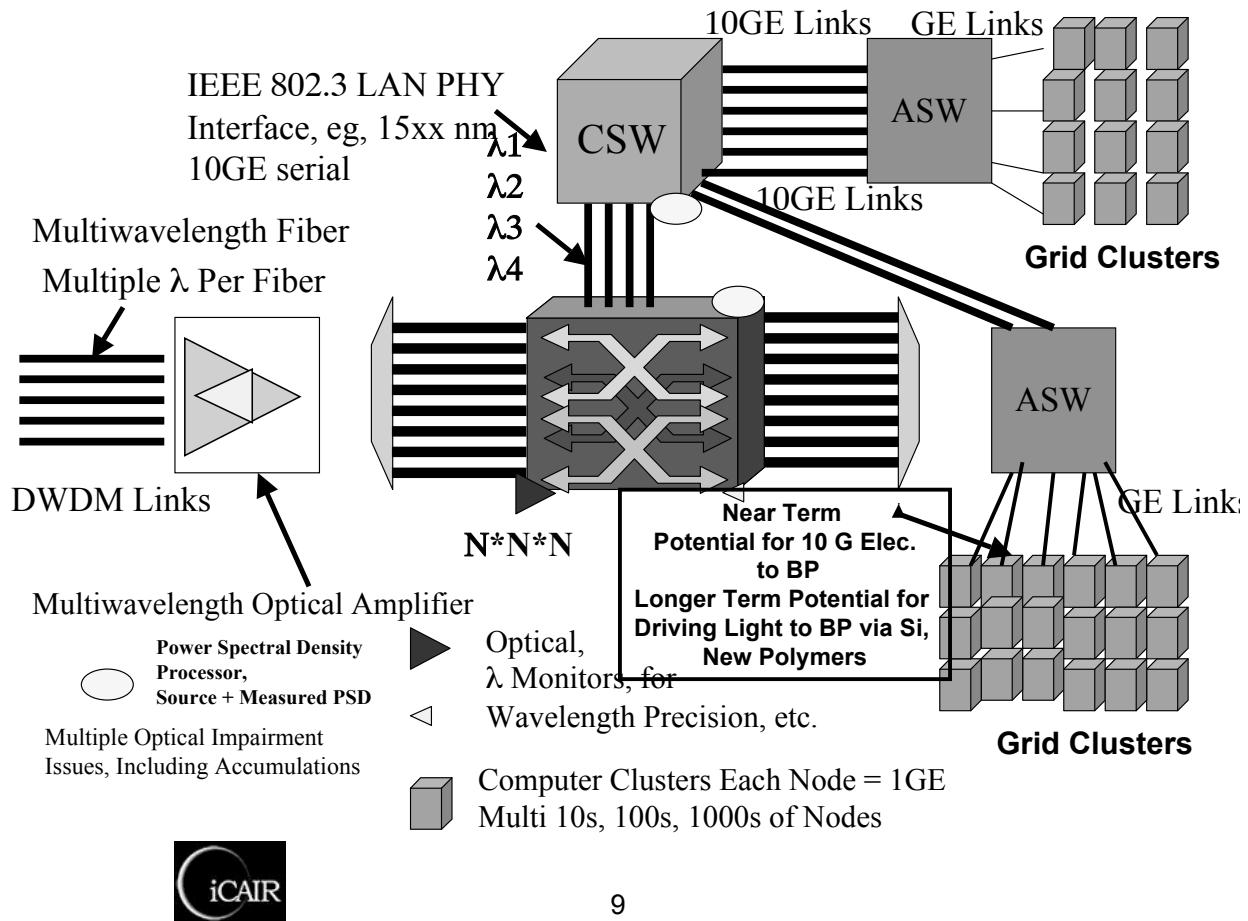


7

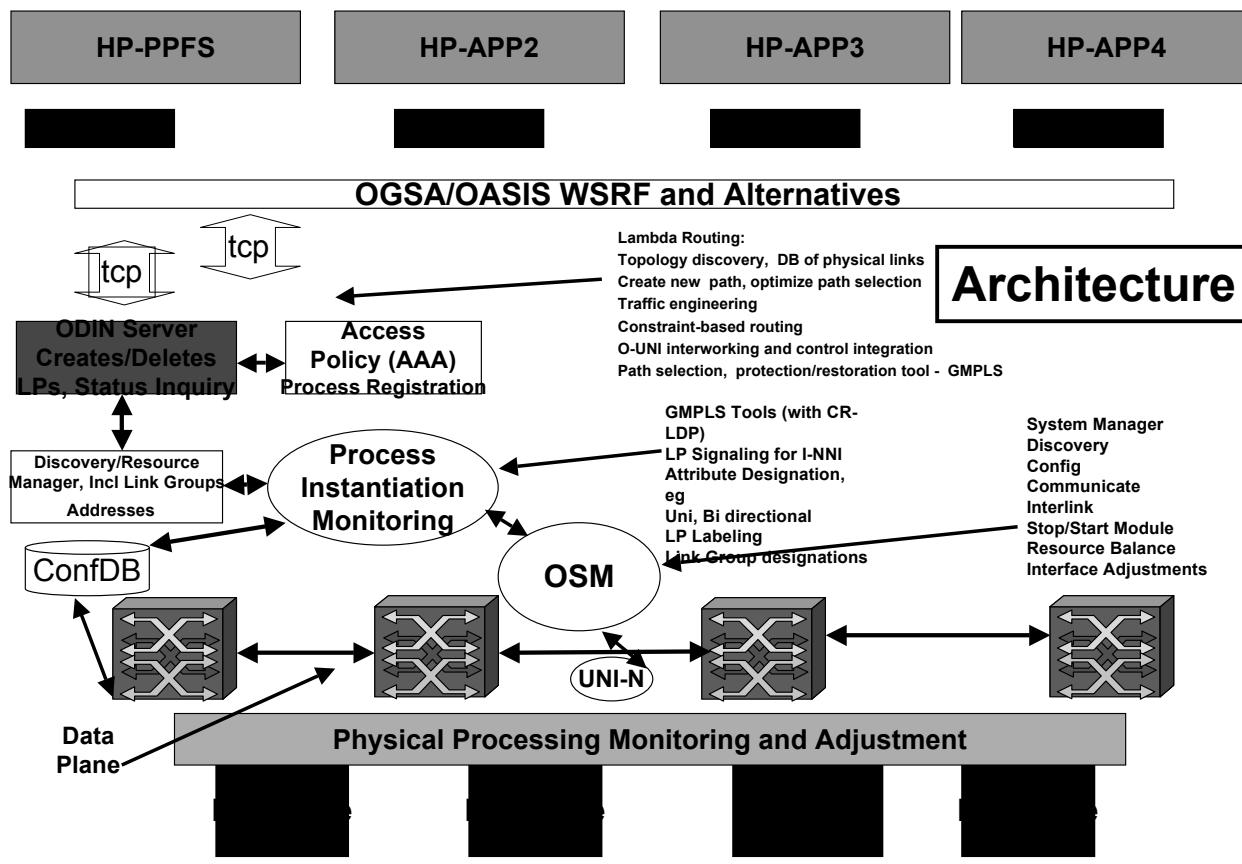


\* Also Control Signaling, et al





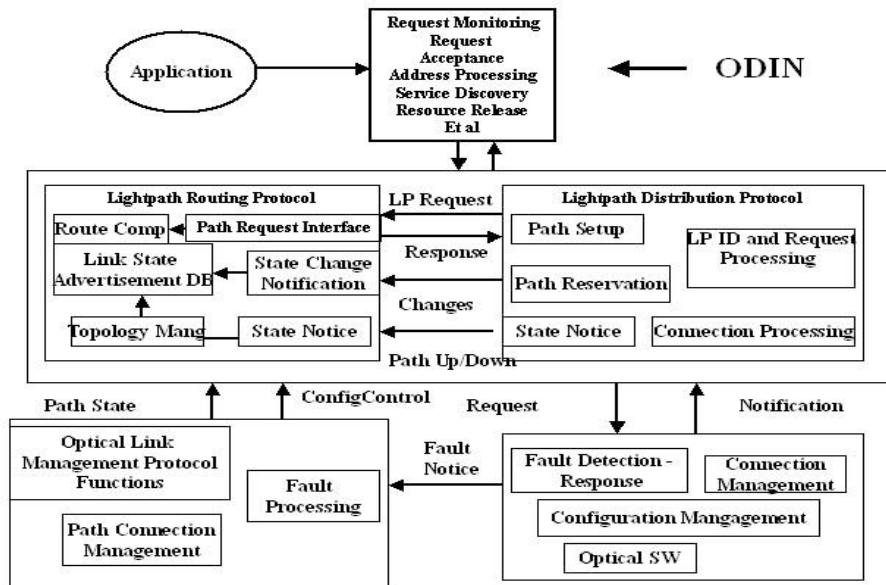
9



Control Channel monitoring, physical fault detection, isolation, adjustment, connection validation etc

10

# Optical Dynamic Intelligent Network (ODIN)



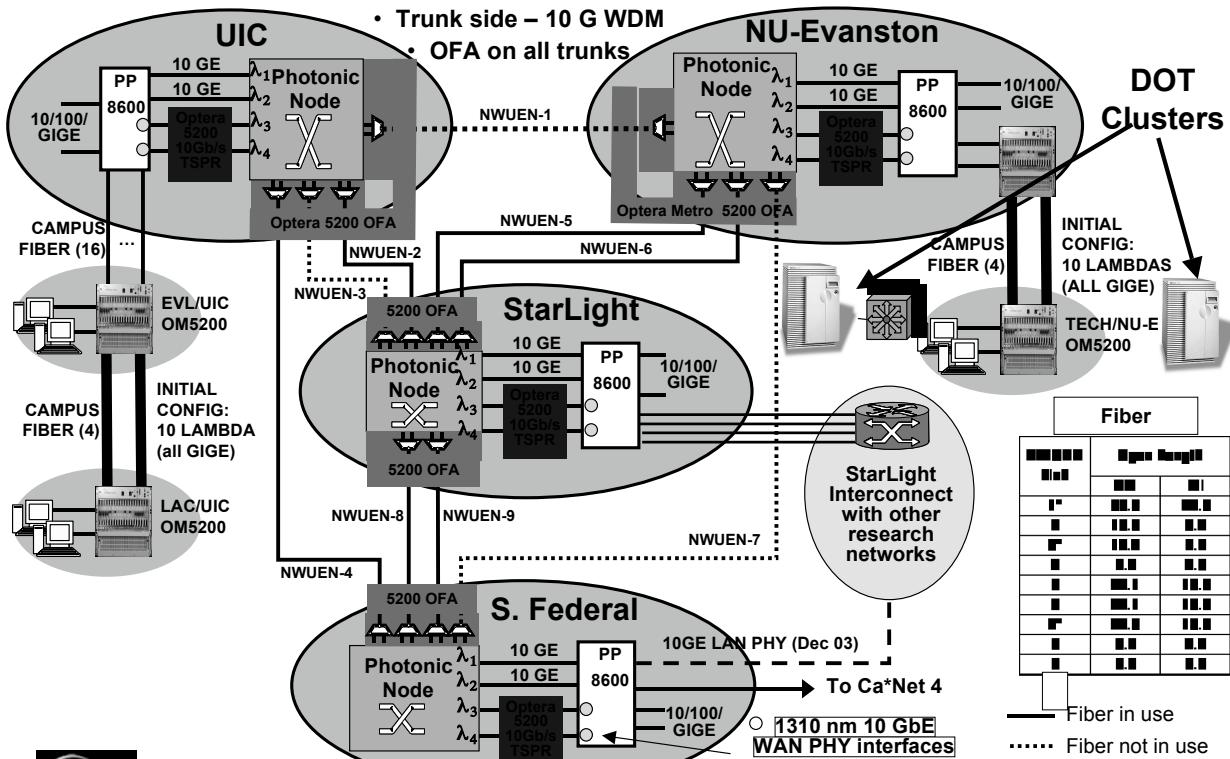
Ref: IEEE Communications Magazine, March 2006, Vol 44, Issue 3 **STARLIGHT™**

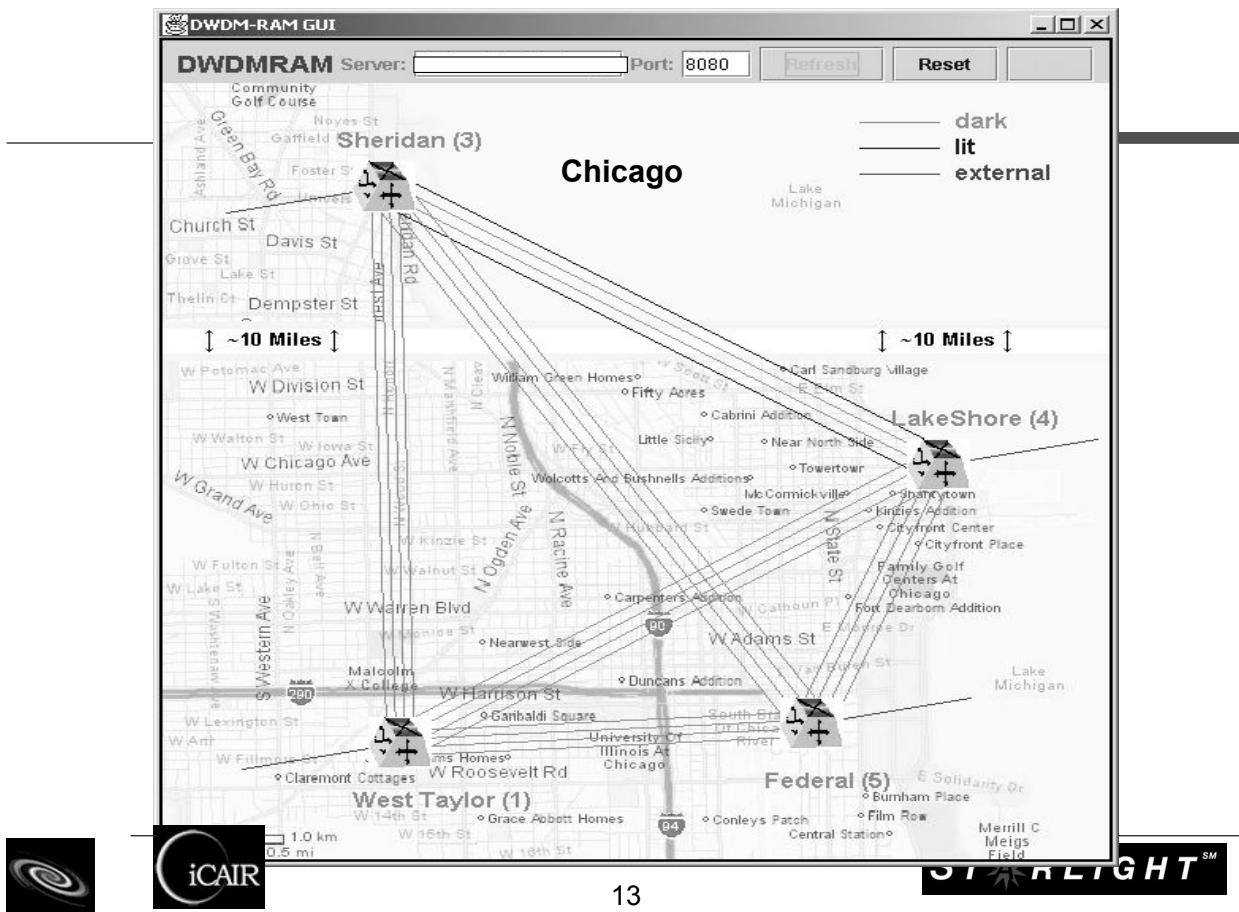
## OMNInet Network Configuration Phase 2 (Extended Via Demonstrations Nationally and Internationally)

- 8x8x8λ Scalable photonic switch

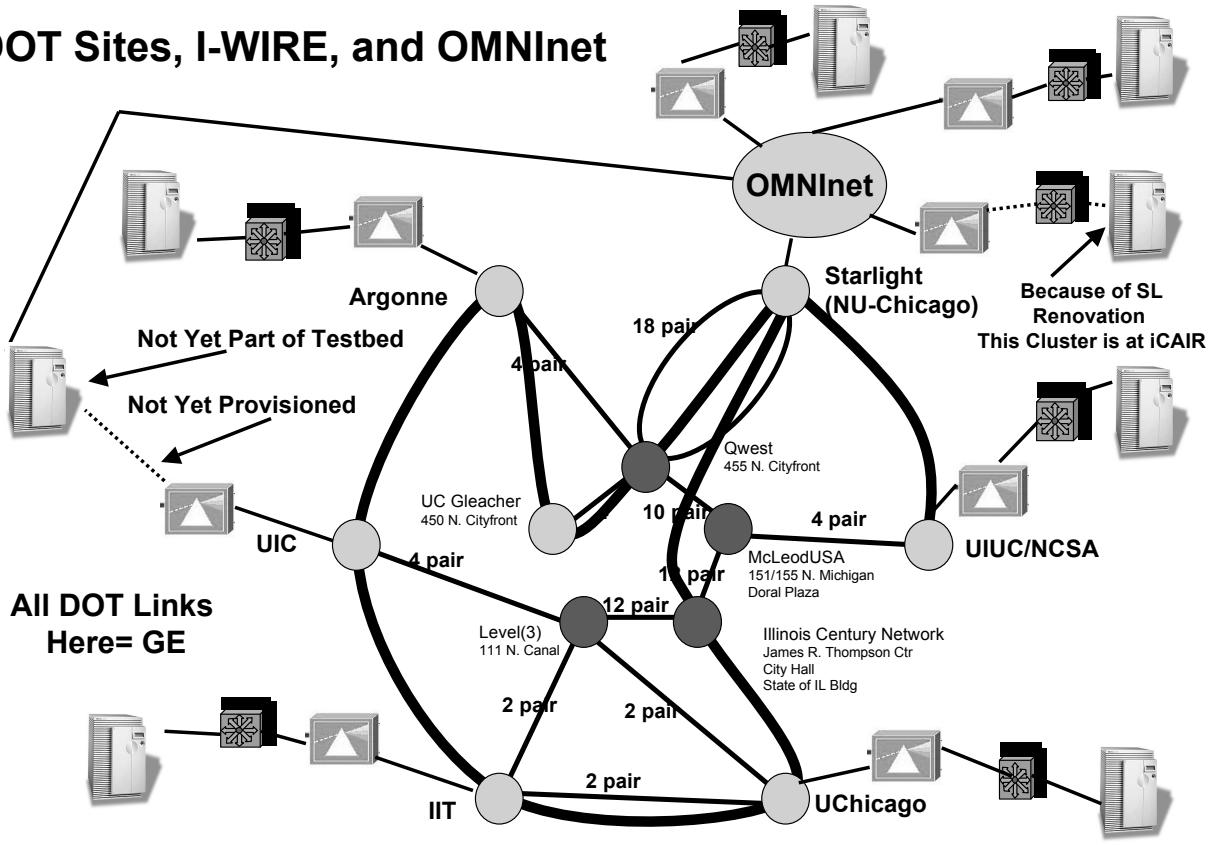
- Trunk side – 10 G WDM

- OFA on all trunks

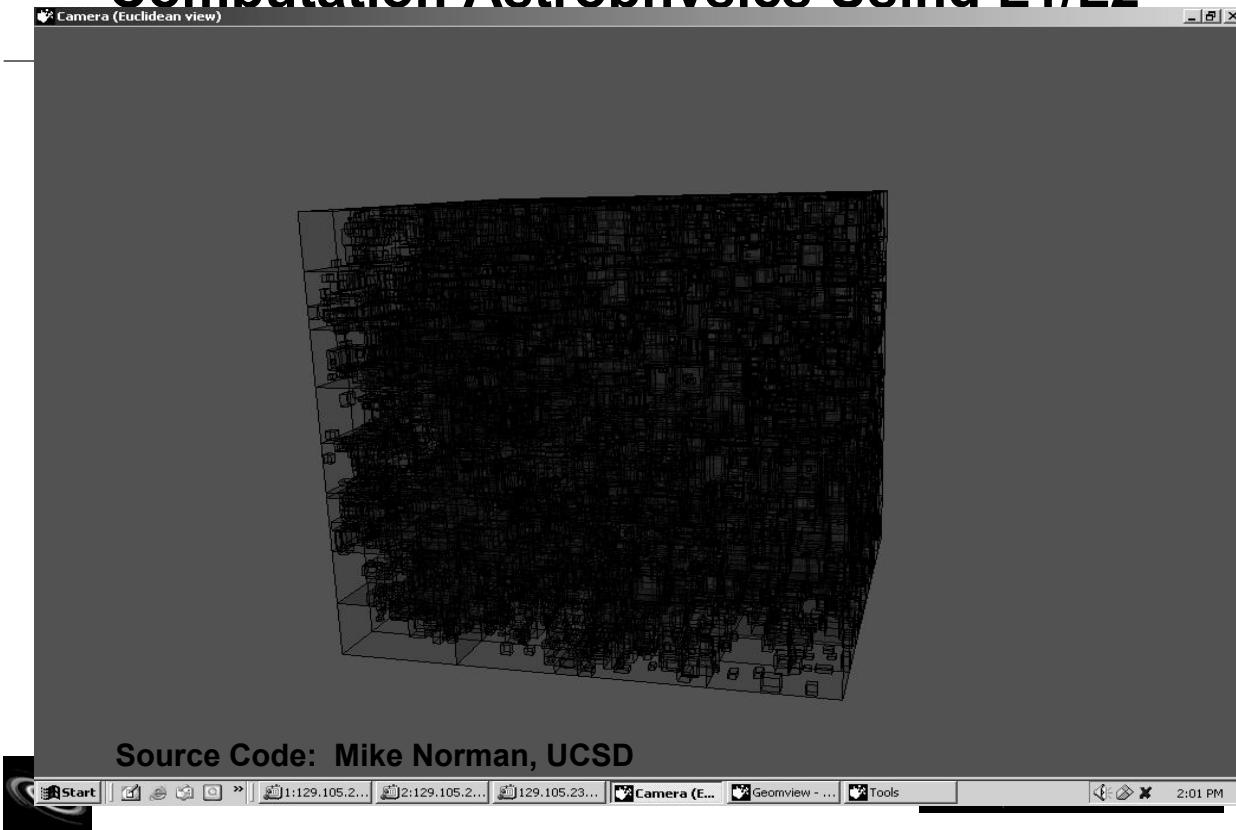




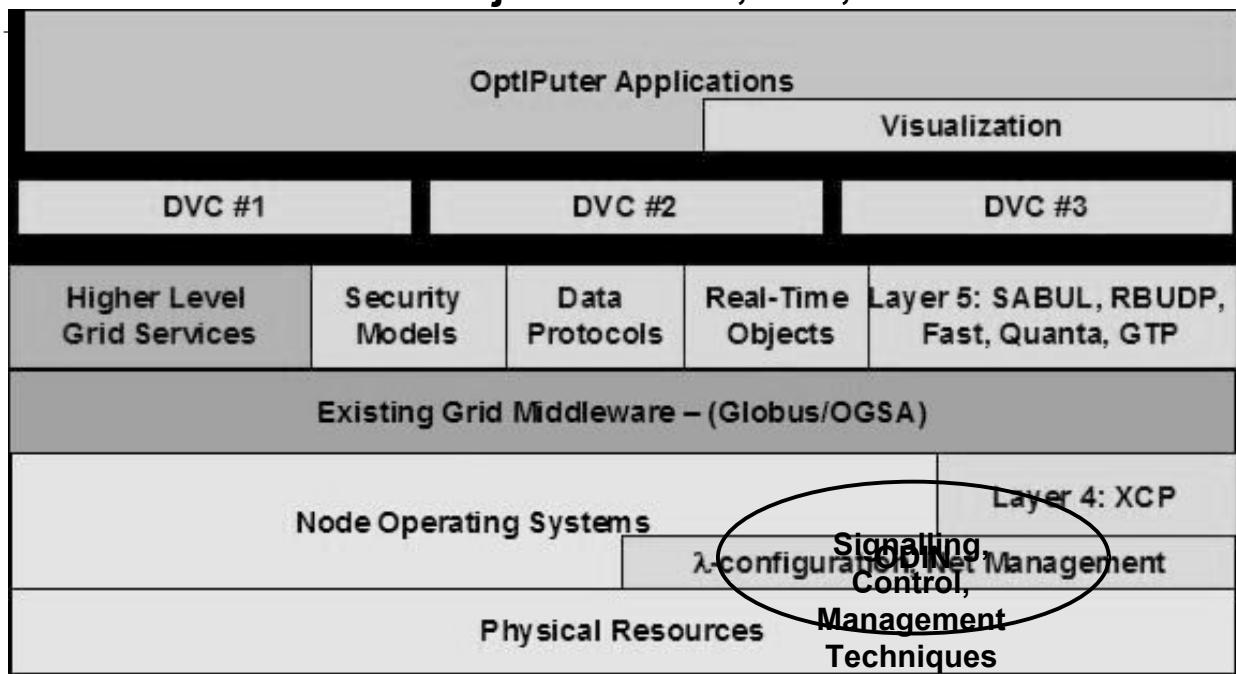
## DOT Sites, I-WIRE, and OMNInet



# 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**



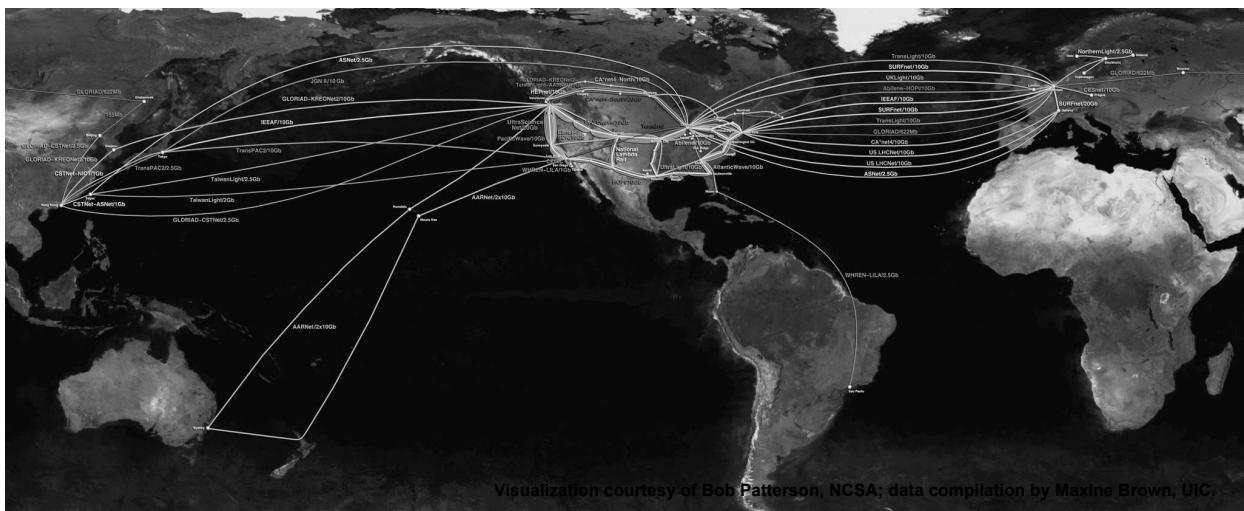
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# Global Lambda Integrated Facility

## 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



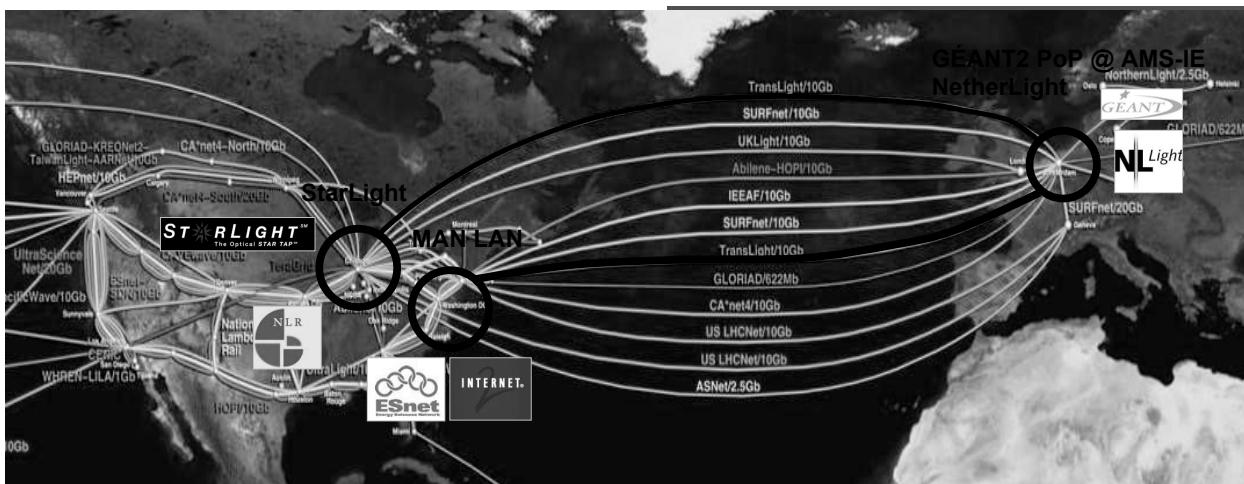
[www.glif.is](http://www.glif.is)

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# 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



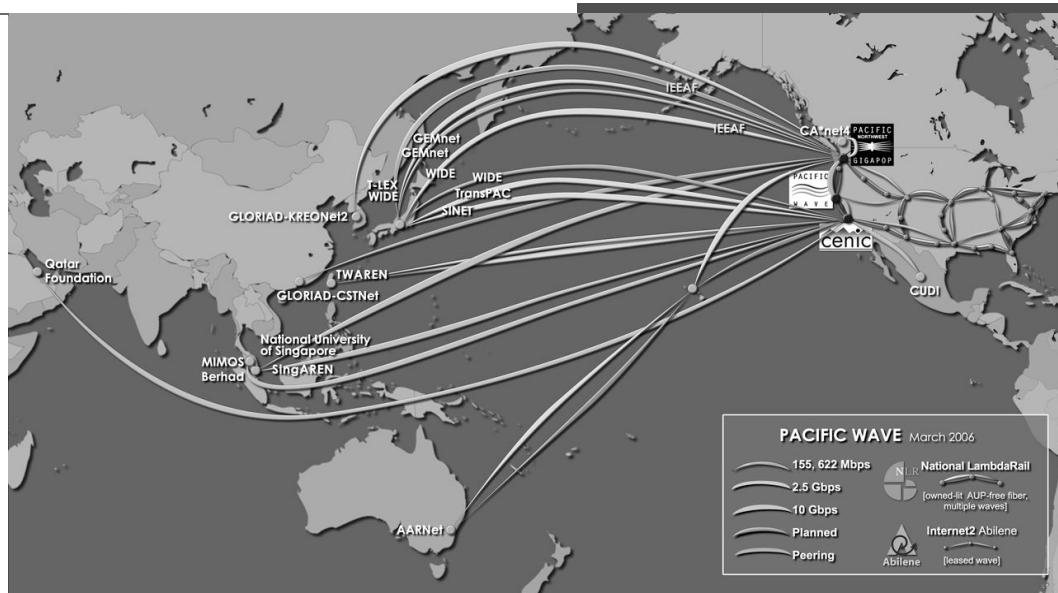
[www.startap.net/translight](http://www.startap.net/translight)

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# TransLight/Pacific Wave

## 10GE Wave Facilitates US West Coast Connectivity



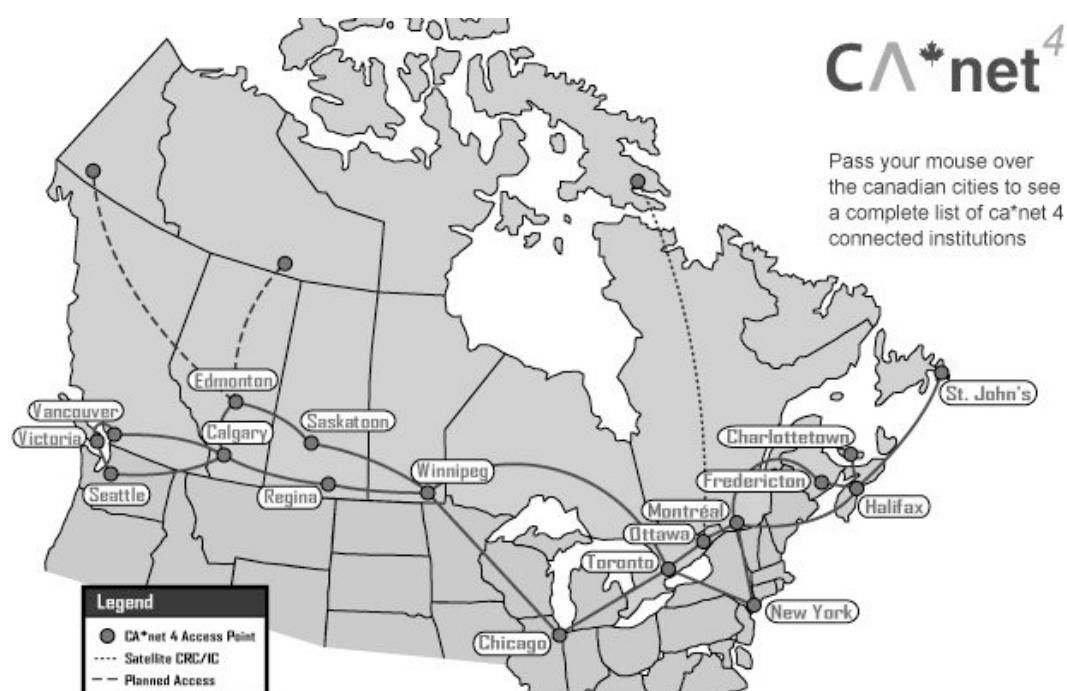
Developing a distributed exchange facility on the US West Coast (currently Seattle, Sunnyvale and Los Angeles) to interconnect international and US research and education networks



[www.pacificwave.net/participants/irnc/](http://www.pacificwave.net/participants/irnc/) 21

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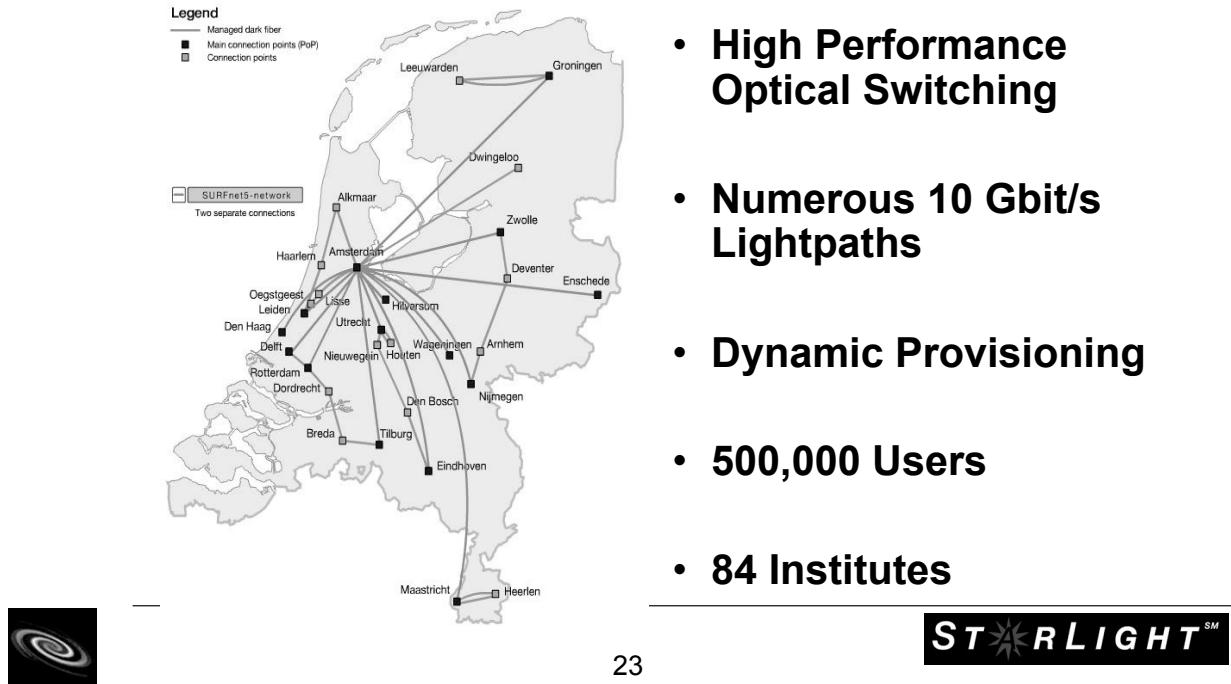
## CA\*net4 has 2x10Gb and Equipment at StarLight



Source: CANARIE

**STARLIGHT<sup>SM</sup>**

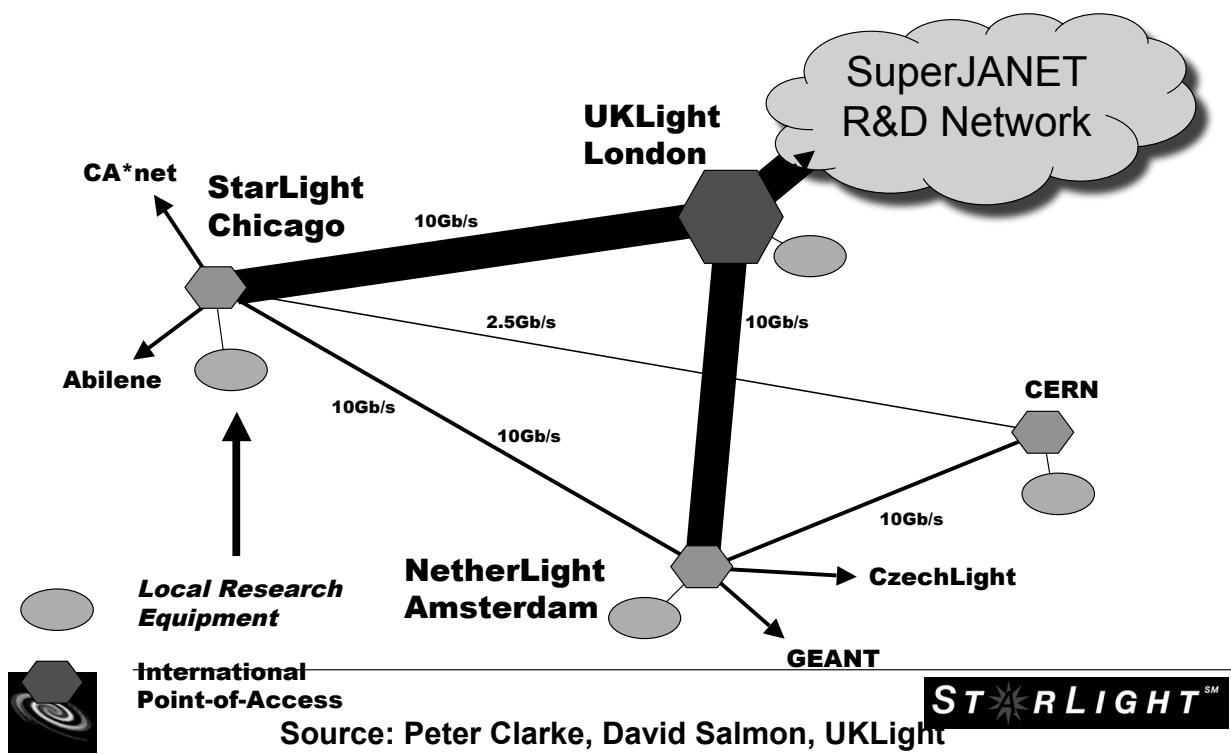
# SURFnet6 National Optical R&E Network



- 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



# SPICE: Part of UK e-Science Initiative

Interactive  
Molecular Dynamics  
Simulation

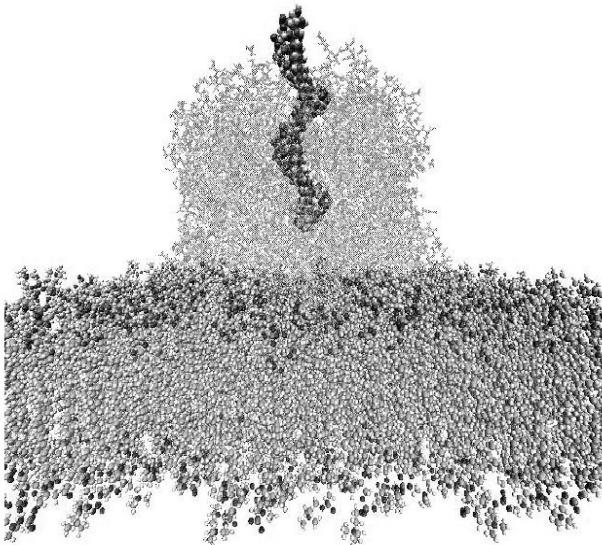
SC05 HPC  
Analytics Challenge  
Award  
ISC

Life Sciences Award  
2005

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

Uses steered molecular  
dynamics to pull DNA  
strand through hemolysin,  
a channel protein

Problem size = ~250,000 atoms  
Run time on normal servers  
=25 years

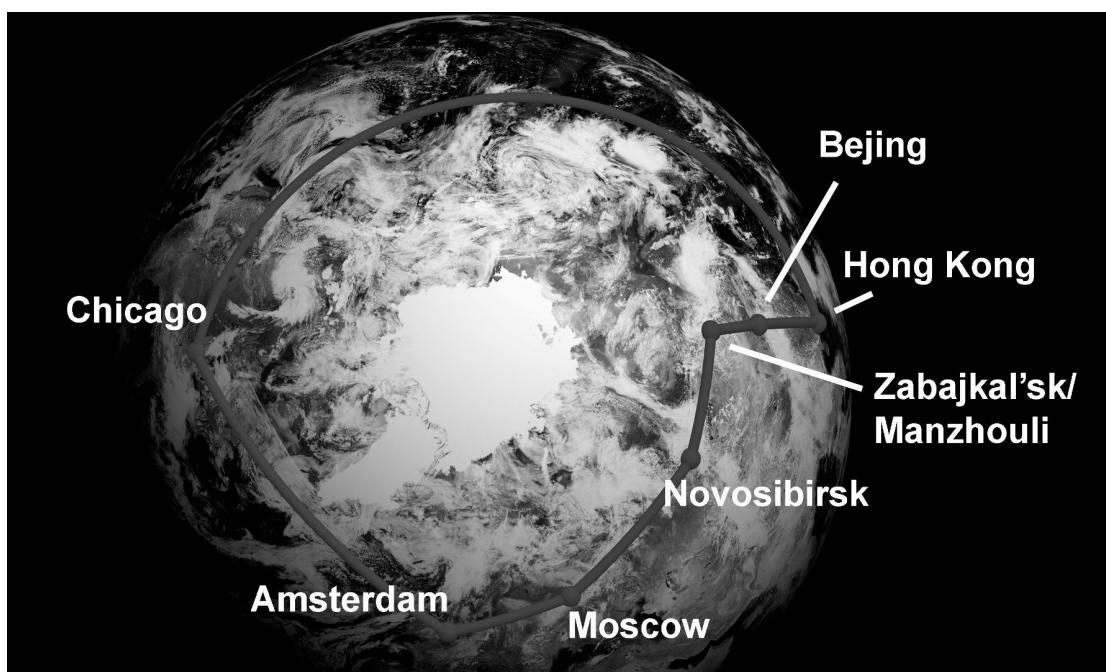


Source: UCL

25

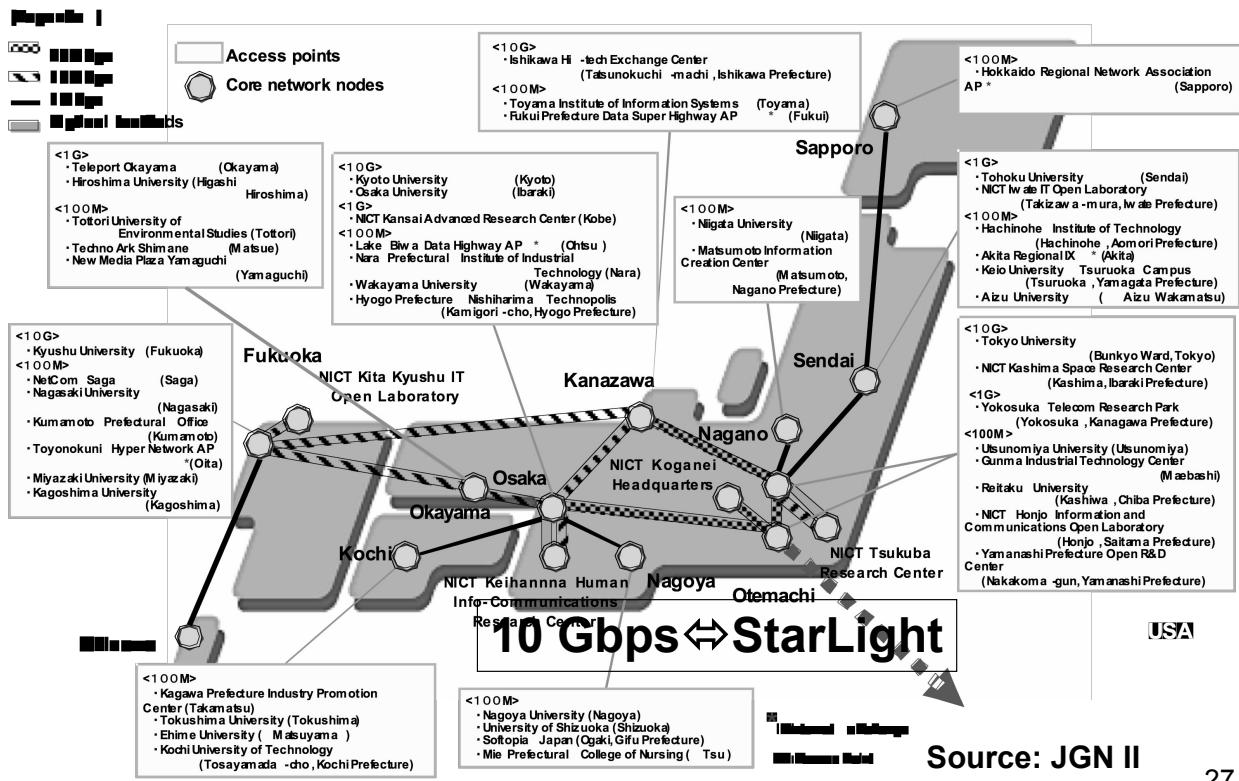
STARLIGHT<sup>SM</sup>

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



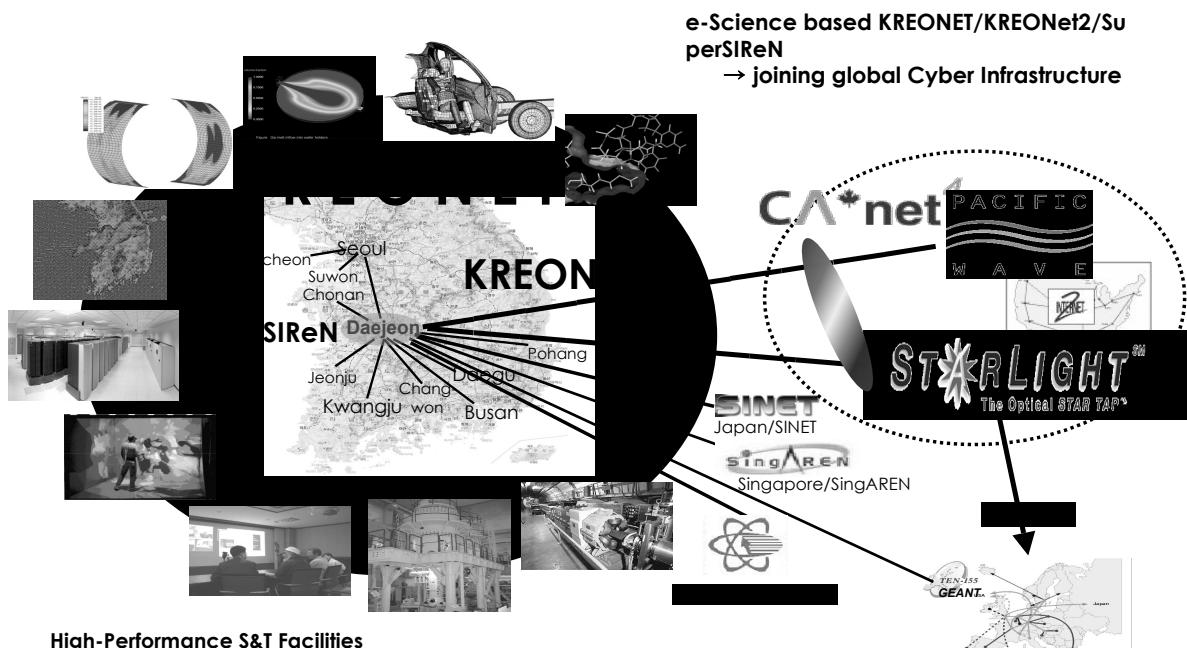
T. Schindler / National Science Foundation

# JGN II Network Topology Map



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## Kreonet



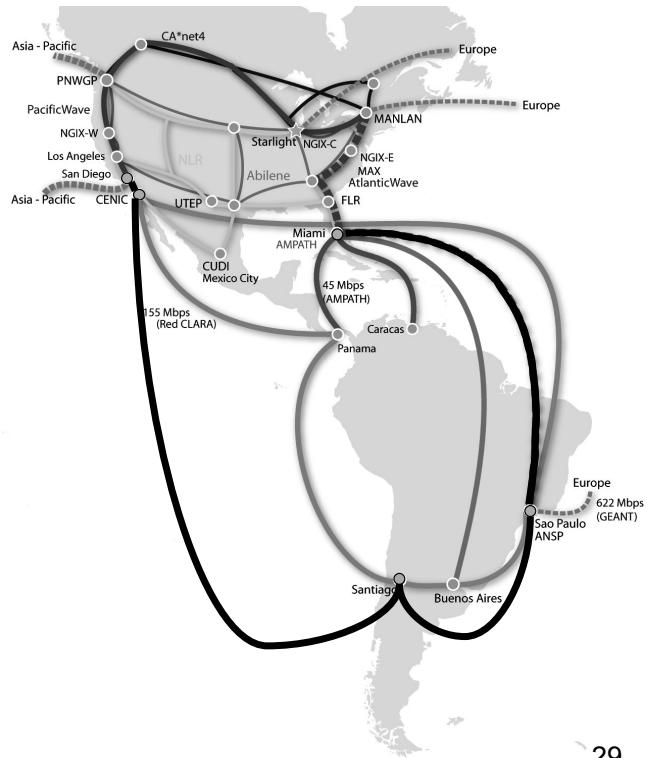
High-Performance S&T Facilities  
(High-Performance Cluster/Supercomputers, Storage, Experimental Facilities, Visualization, Access Grid, DB Servers, etc.)

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

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© 2005 National LambdaRail

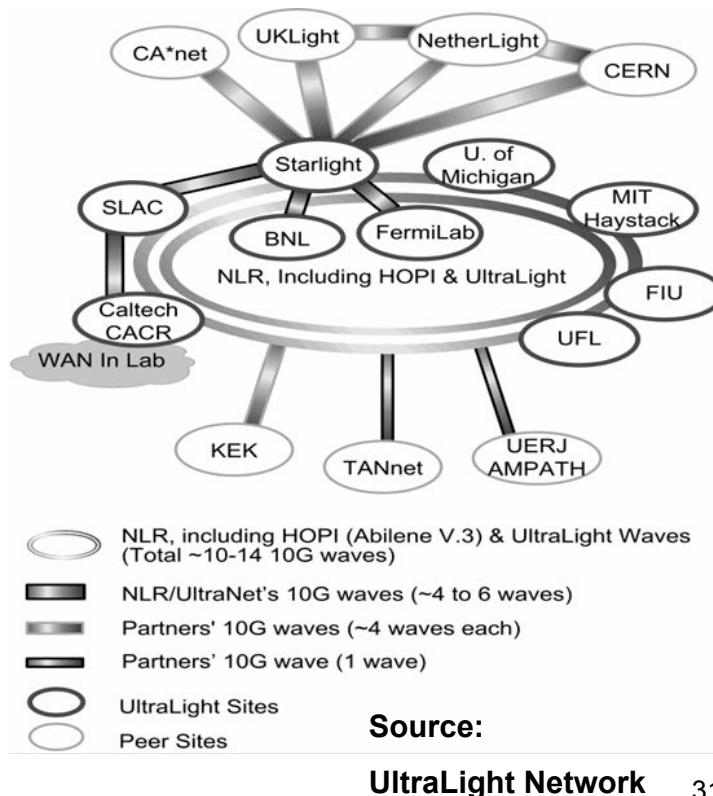
For more information regarding NLR see <http://www.nir.net> or contact [info@nir.net](mailto:info@nir.net)

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

30

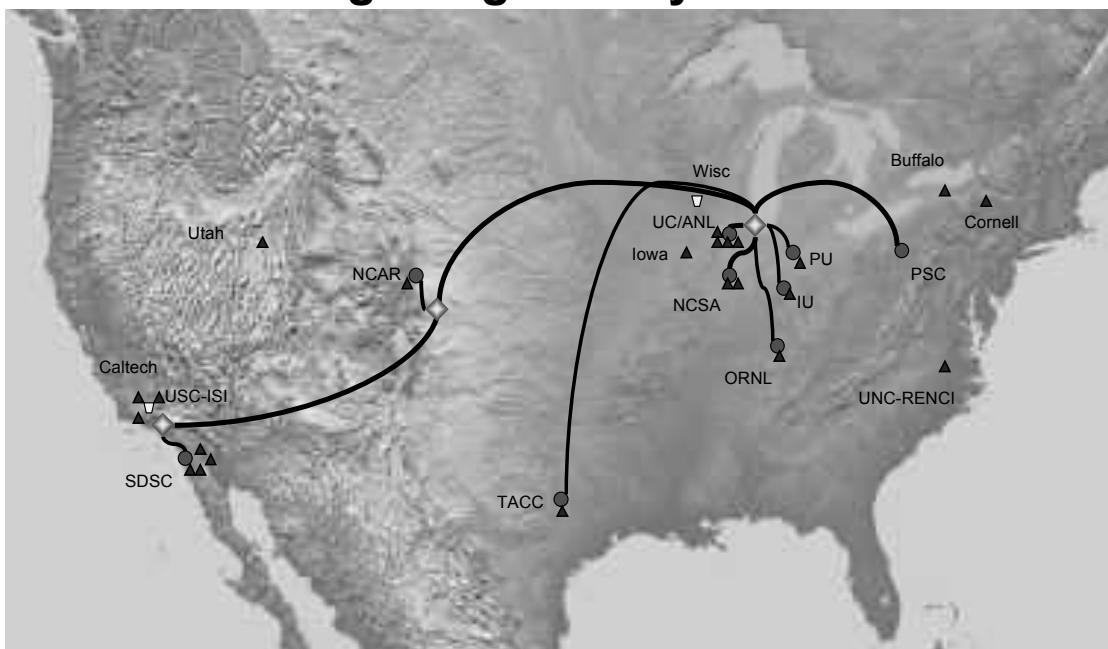
# UltraLight Network: PHASE III

- Move into production
- Optical switching fully enabled amongst primary sites
- Integrated international infrastructure



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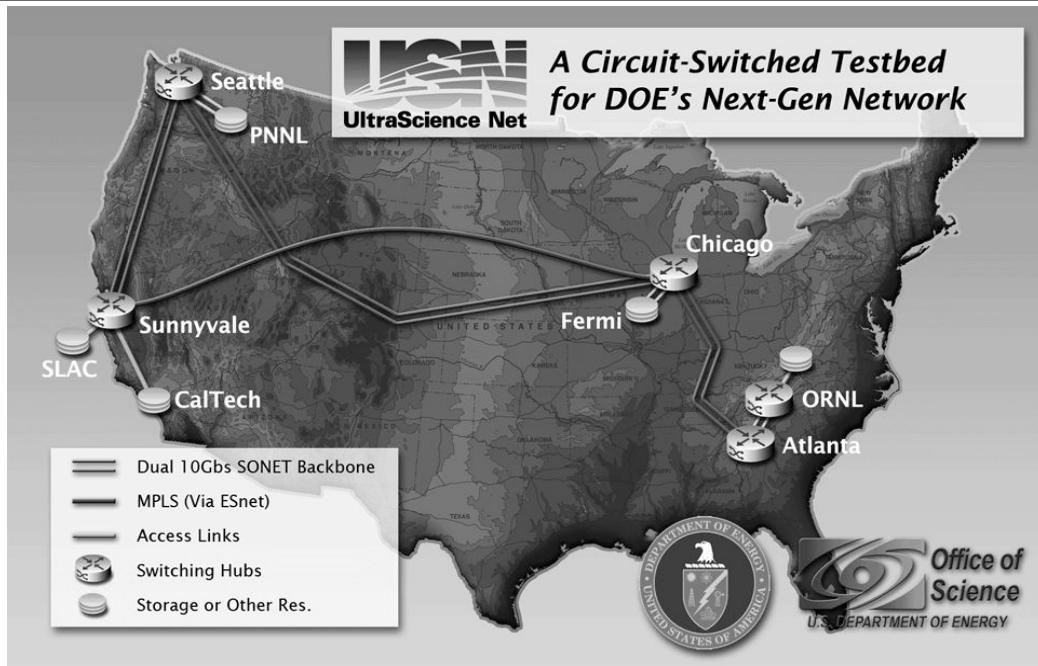
## TeraGrid: Integrating NSF Cyberinfrastructure



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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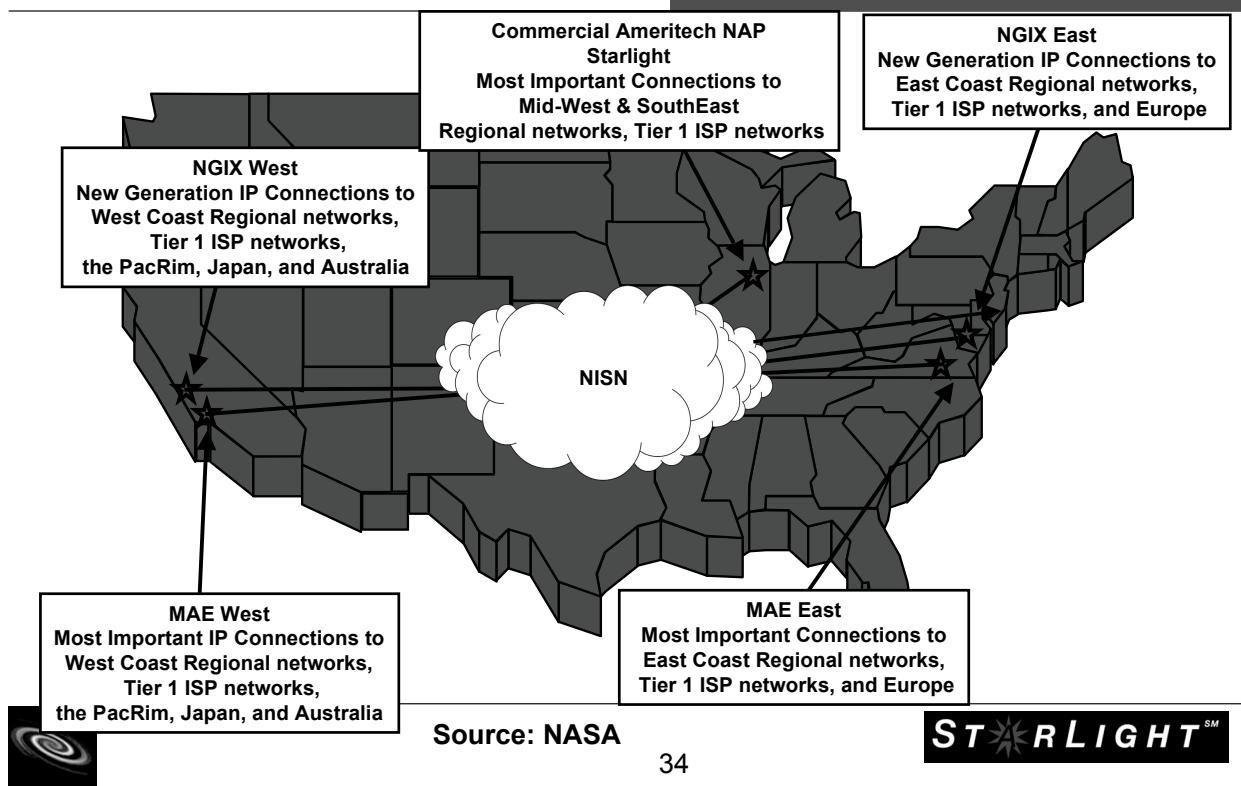
# DOE's UltraScience Net is at StarLight



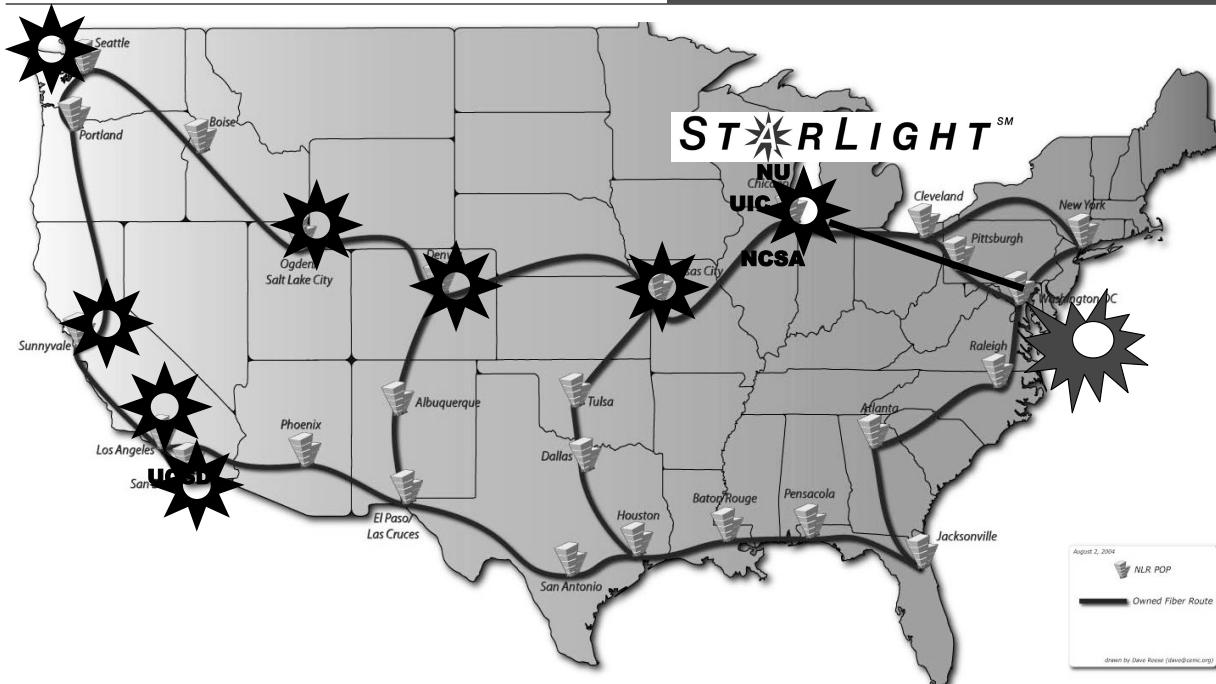
33

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# NASA's NISN is at StarLight



# 10GE CAVEwave on the National LambdaRail



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## 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](http://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!

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

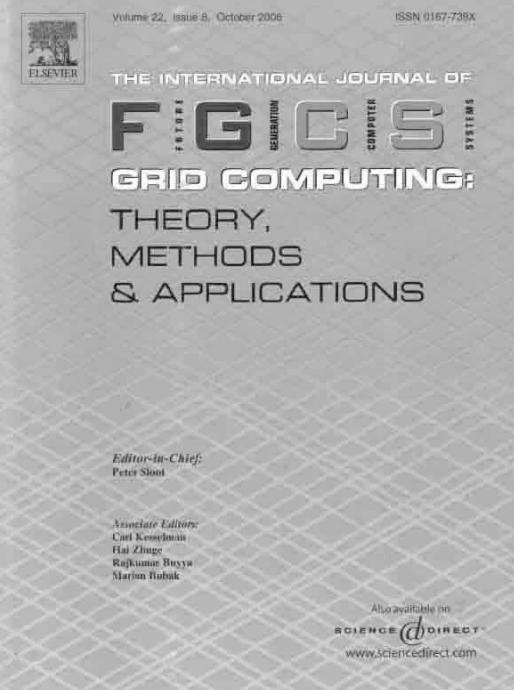
Future Generation Computer Systems,  
Volume 22, Issue 8, Elsevier, October 2006, pp. 849-1054

"Computational Astrophysics Enabled By Dynamic Lambda Switching," iCAIR

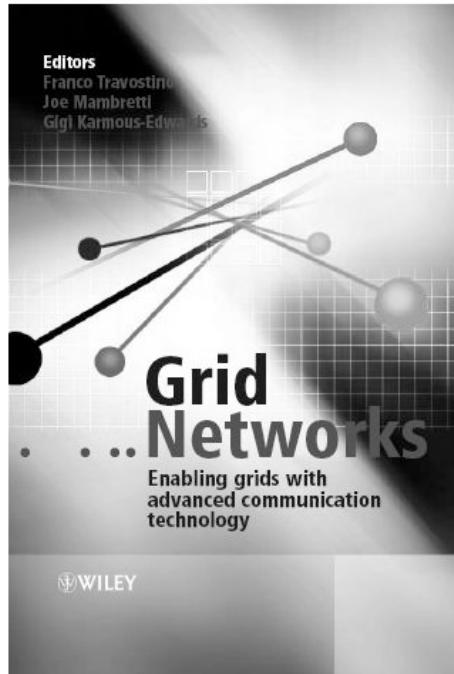


[www.elsevier.com/locate/future](http://www.elsevier.com/locate/future)

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**[www.startap.net/starlight](http://www.startap.net/starlight)**

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**Thanks to the NSF and Other Supporters**



Open Science Grid



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