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)

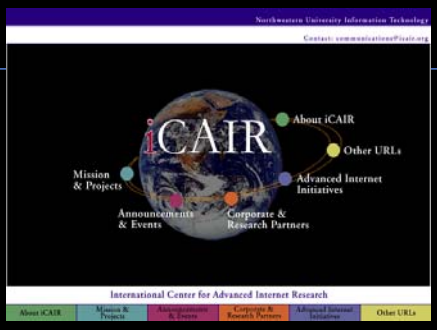
Summer Grid Workshop 2007

March 24, 2007

iCAIR

STARLIGHT

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**

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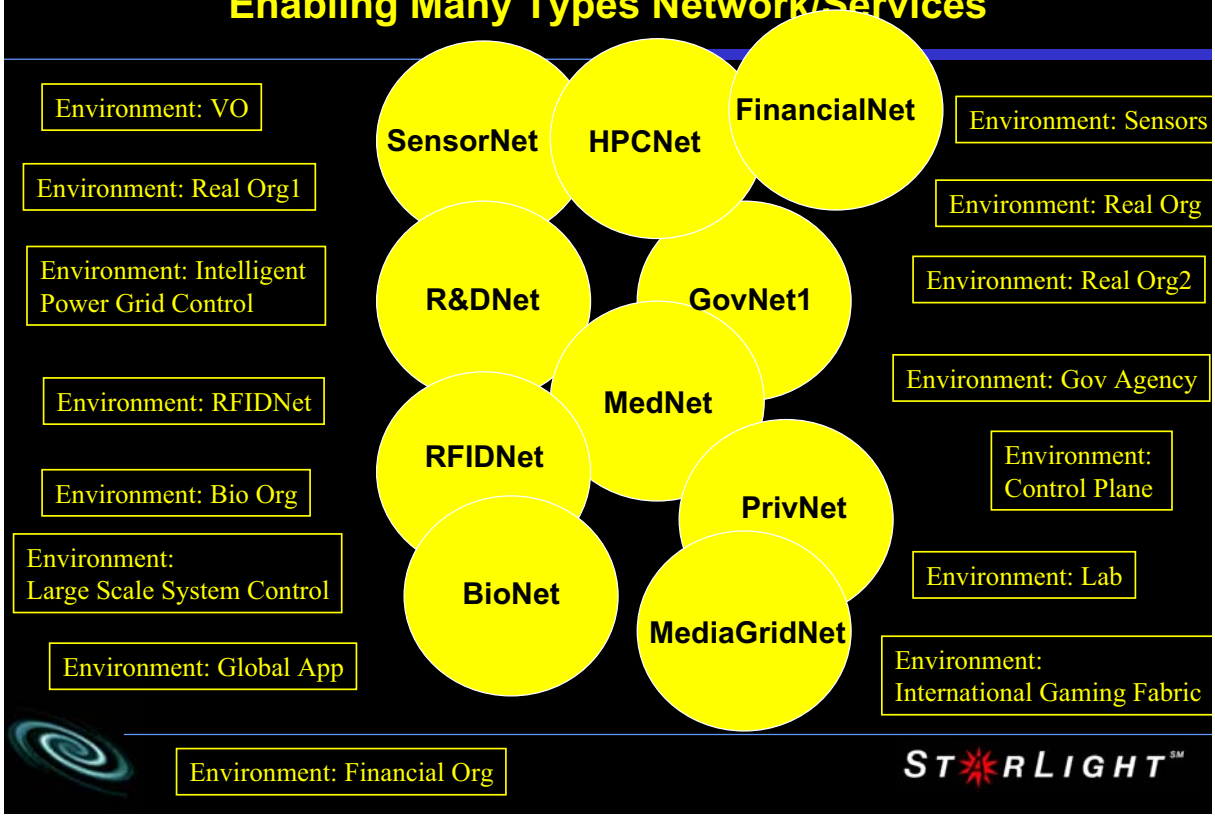
A Next Generation Architecture: *Distributed Facility*
Enabling Many Types Network/Services



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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

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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)

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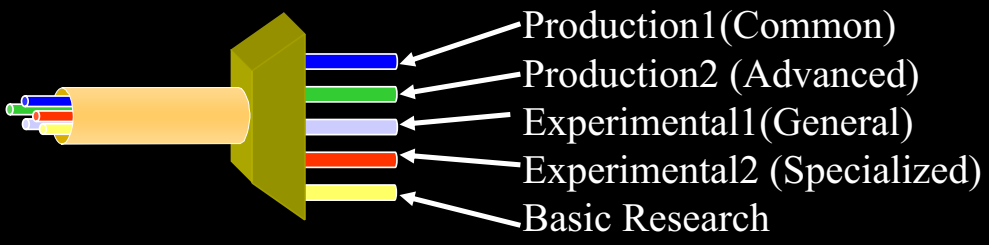
Lightwave Networking



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,

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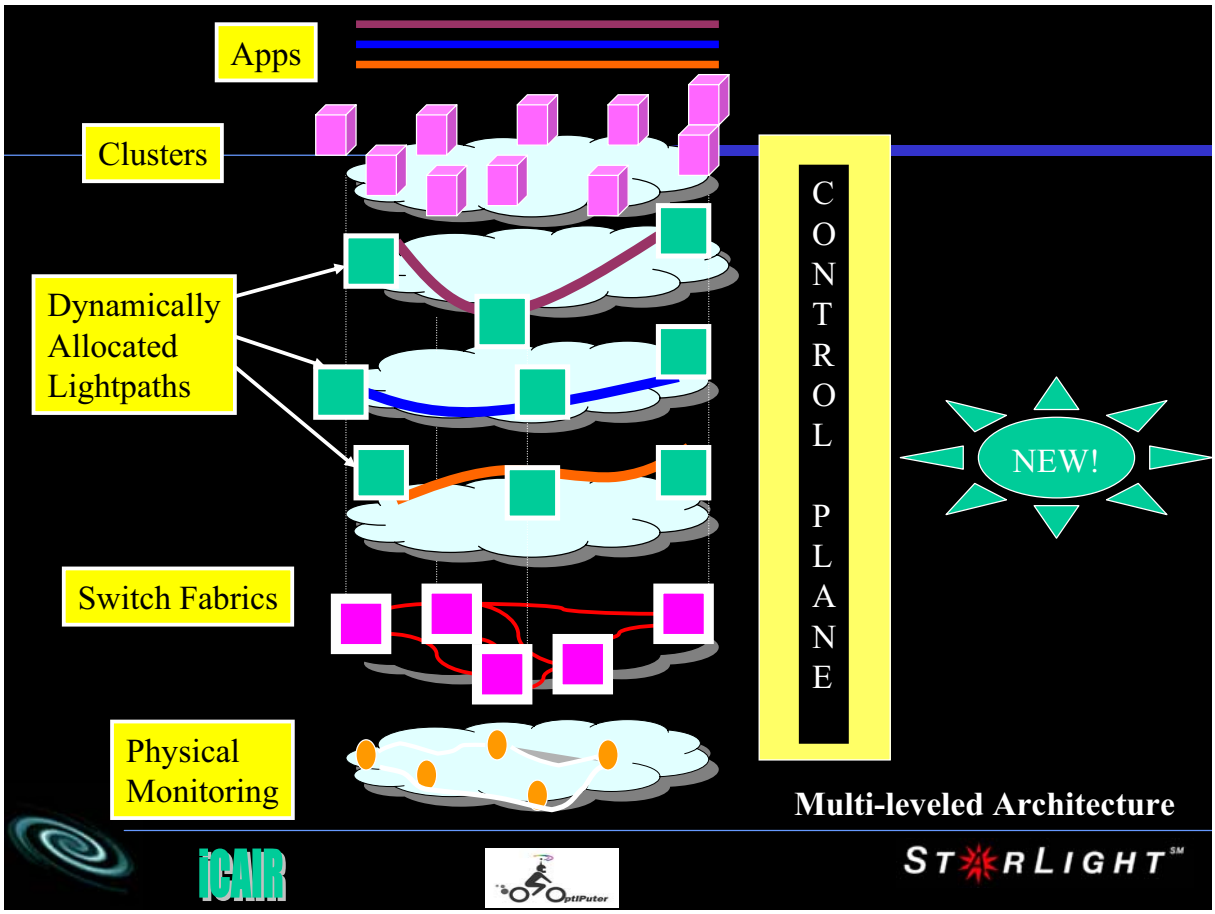
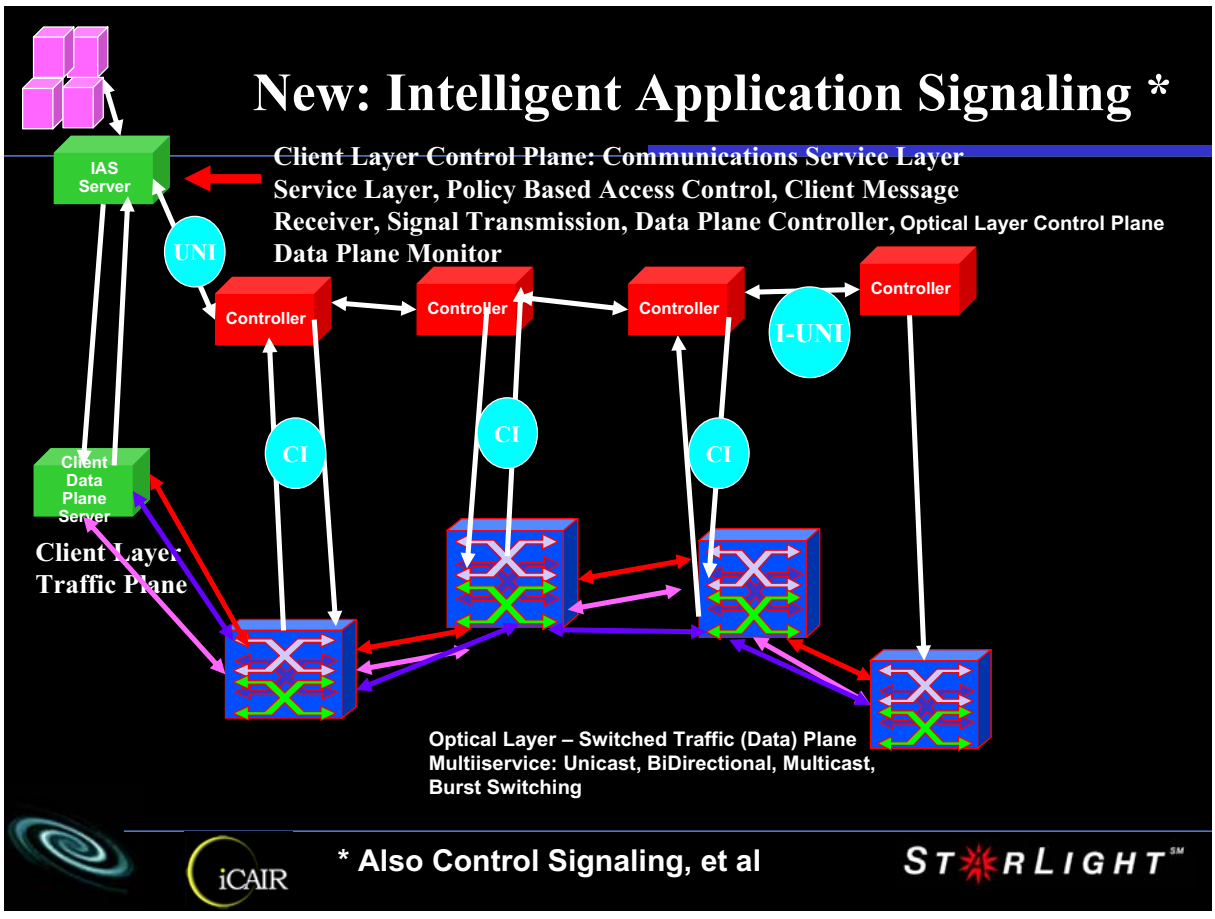

Apps
Clusters
Dynamically Allocated Lightpaths
Switch Fabrics
Physical Monitoring
CONTROL PLANE
NEW!
Multi-leveled Architecture
iCAIR
OptIPuter
STARLIGHT


New: Intelligent Application Signaling *
IAS Server
UNI
Client Layer Control Plane: Communications Service Layer
Service Layer, Policy Based Access Control, Client Message
Receiver, Signal Transmission, Data Plane Controller, Optical Layer Control Plane
Data Plane Monitor
Controller
Controller
Controller
I-UNI
Controller
CI
CI
CI
Client Data Plane Server
Client Layer Traffic Plane
Optical Layer – Switched Traffic (Data) Plane
Multiiservice: Unicast, BiDirectional, Multicast,
Burst Switching
* Also Control Signaling, et al
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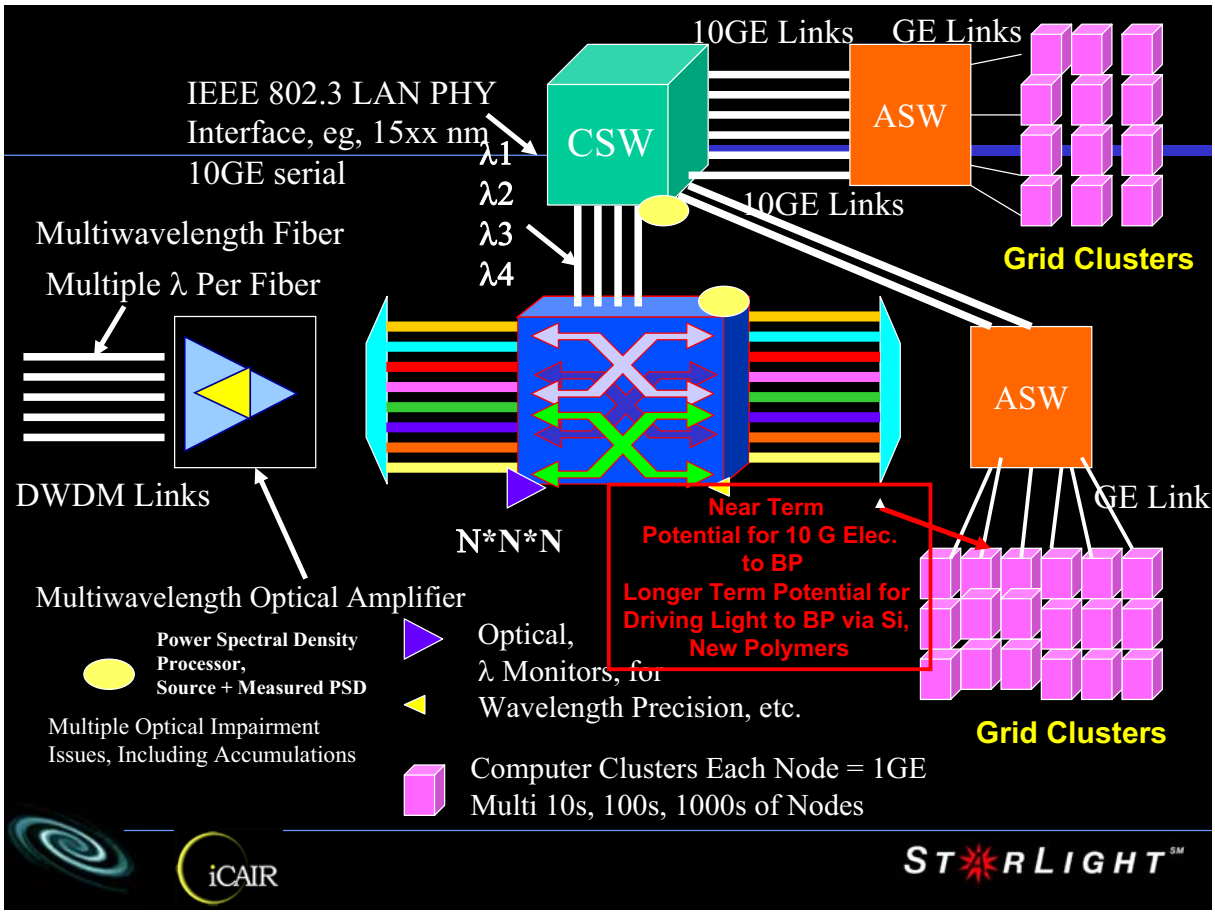
10GE Links
GE Links
IEEE 802.3 LAN PHY
Interface, eg, 15xx nm
10GE serial
CSW
ASW
λ1
λ2
λ3
λ4
10GE Links
Grid Clusters
Multiwavelength Fiber
Multiple λ Per Fiber
ASW
DWDM Links
GE Link
N*N*N
Near Term
Potential for 10 G Elec.
to BP
Longer Term Potential for
Driving Light to BP via Si,
New Polymers
Multiwavelength 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
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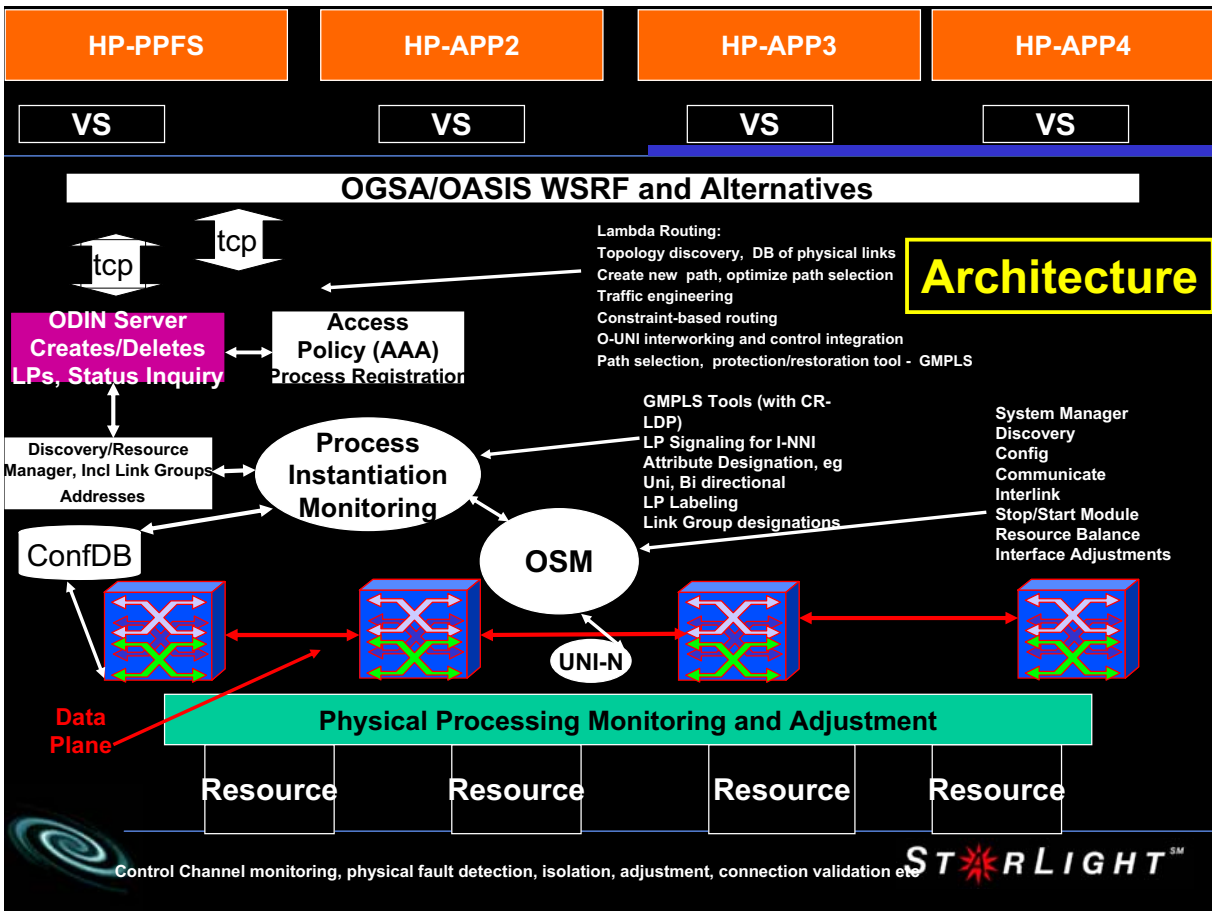
HP-PPFS
HP-APP2
HP-APP3
HP-APP4
VS
VS
VS
VS
OGSA/OASIS WSRF and Alternatives
tcp
tcp
Lambda Routing:
Topology discovery, DB of physical links
Create new path, optimize path selection
Traffic engineering
Constraint-based routing
O-UNI interworking and control integration
Path selection, protection/restoration 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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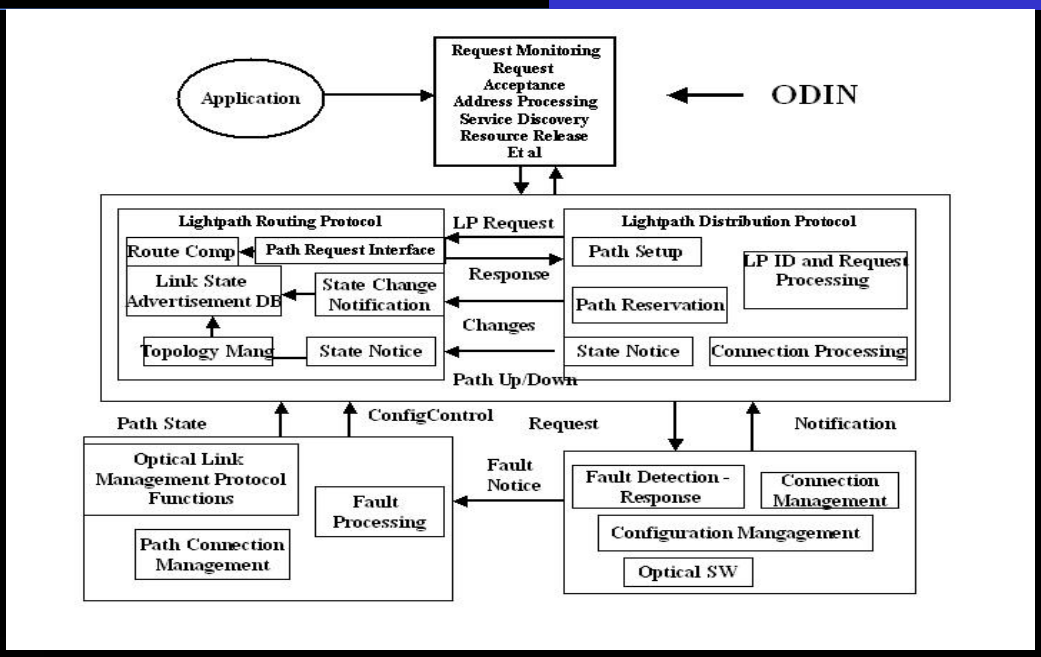
Optical Dynamic Intelligent Network (ODIN)



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

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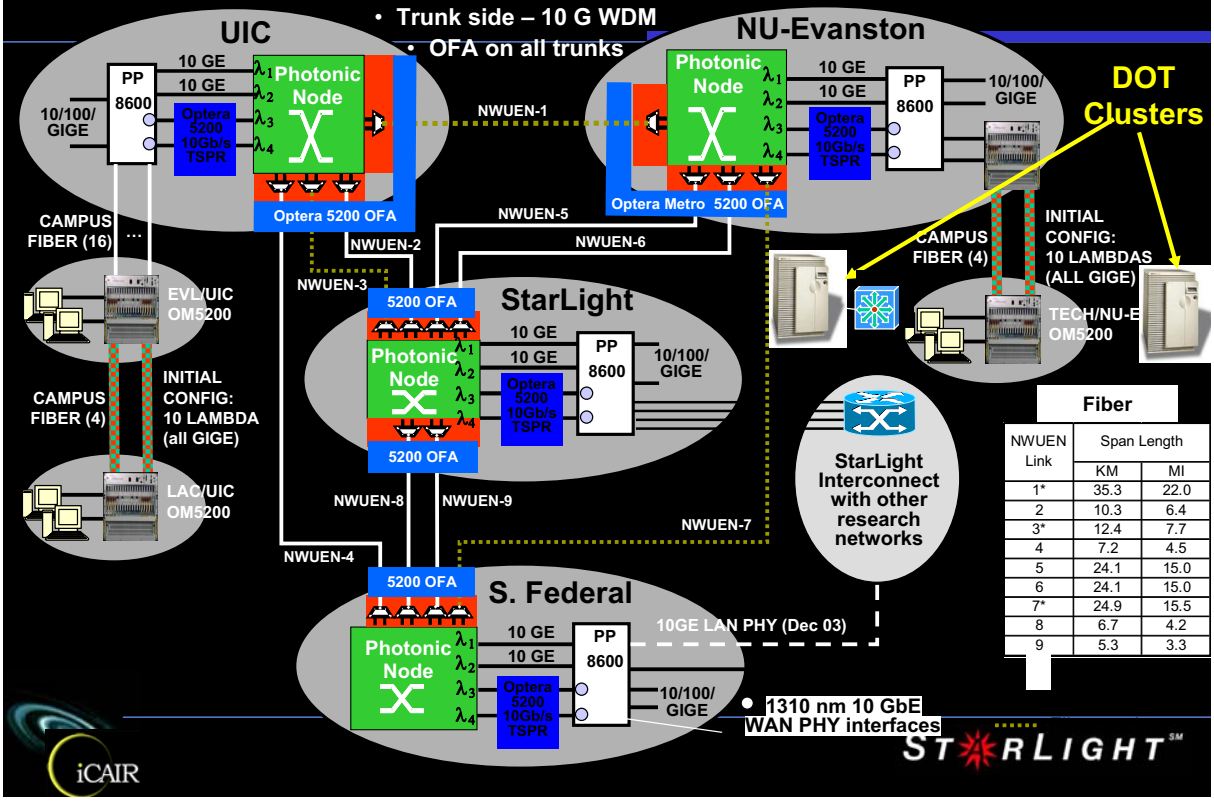
OMNInet Network Configuration Phase 2 (Extended Via Demonstrations Nationally and Internationally)

- 8x8x8λ Scalable photonic switch
- Trunk side – 10 G WDM
- OFA on all trunks



Fiber

NWUEN Link	Span Length	
	KM	MI
1*	35.3	22.0
2	10.3	6.4
3*	12.4	7.7
4	7.2	4.5
5	24.1	15.0
6	24.1	15.0
7*	24.9	15.5
8	6.7	4.2
9	5.3	3.3

iCAIR

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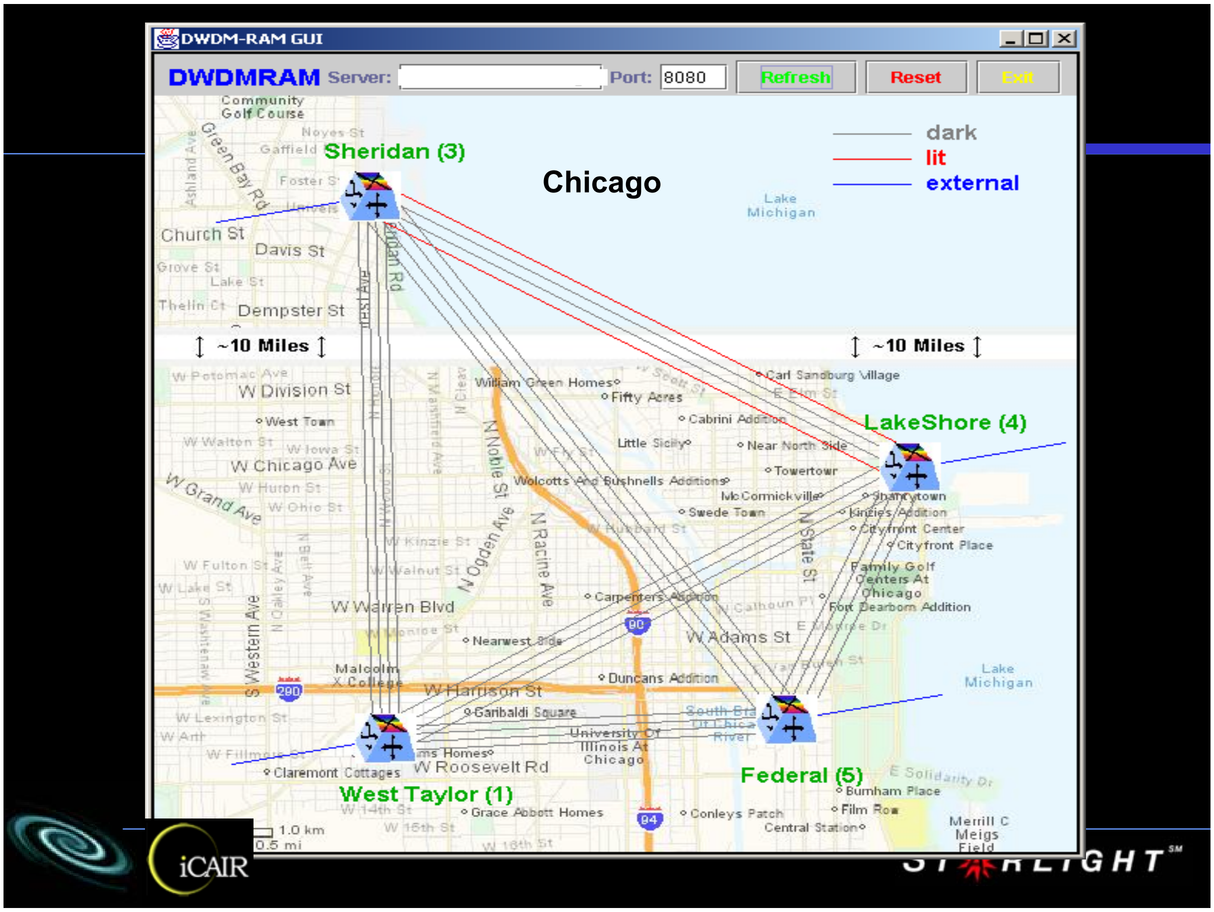
DWDM-RAM GUI
DWDMRAM Server: Port: 8080 Refresh Reset Exit
Chicago
dark
lit
external
Sheridan (3)
LakeShore (4)
Federal (5)
West Taylor (1)
~10 Miles
~10 Miles
Lake Michigan
Church St
Davis St
Dempster St
W Division St
W Chicago Ave
W Warren Blvd
W Adams St
W Harrison St
W Roosevelt Rd
1.0 km
0.5 mi
iCAIR
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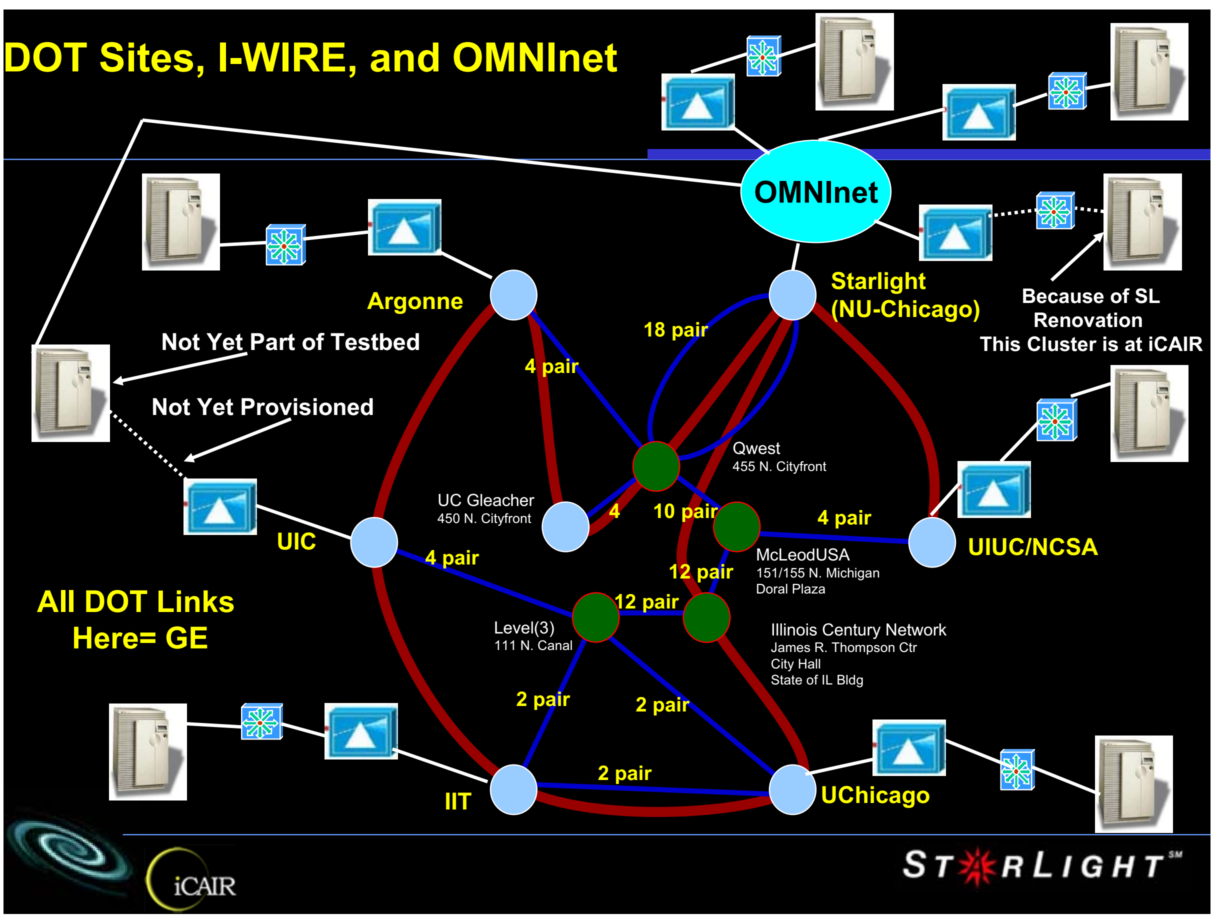
DOT Sites, I-WIRE, and OMNInet
OMNInet
Argonne
Starlight
(NU-Chicago)
Because of SL
Renovation
This Cluster is at iCAIR
Not Yet Part of Testbed
Not Yet Provisioned
18 pair
4 pair
Qwest
455 N. Cityfront
UC Gleacher
450 N. Cityfront
4
10 pair
4 pair
UIC
4 pair
McLeodUSA
151/155 N. Michigan
Doral Plaza
12 pair
UIUC/NCSA
12 pair
All DOT Links
Here= GE
Level(3)
111 N. Canal
Illinois Century Network
James R. Thompson Ctr
City Hall
State of IL Bldg
2 pair
2 pair
2 pair
IIT
UChicago
iCAIR
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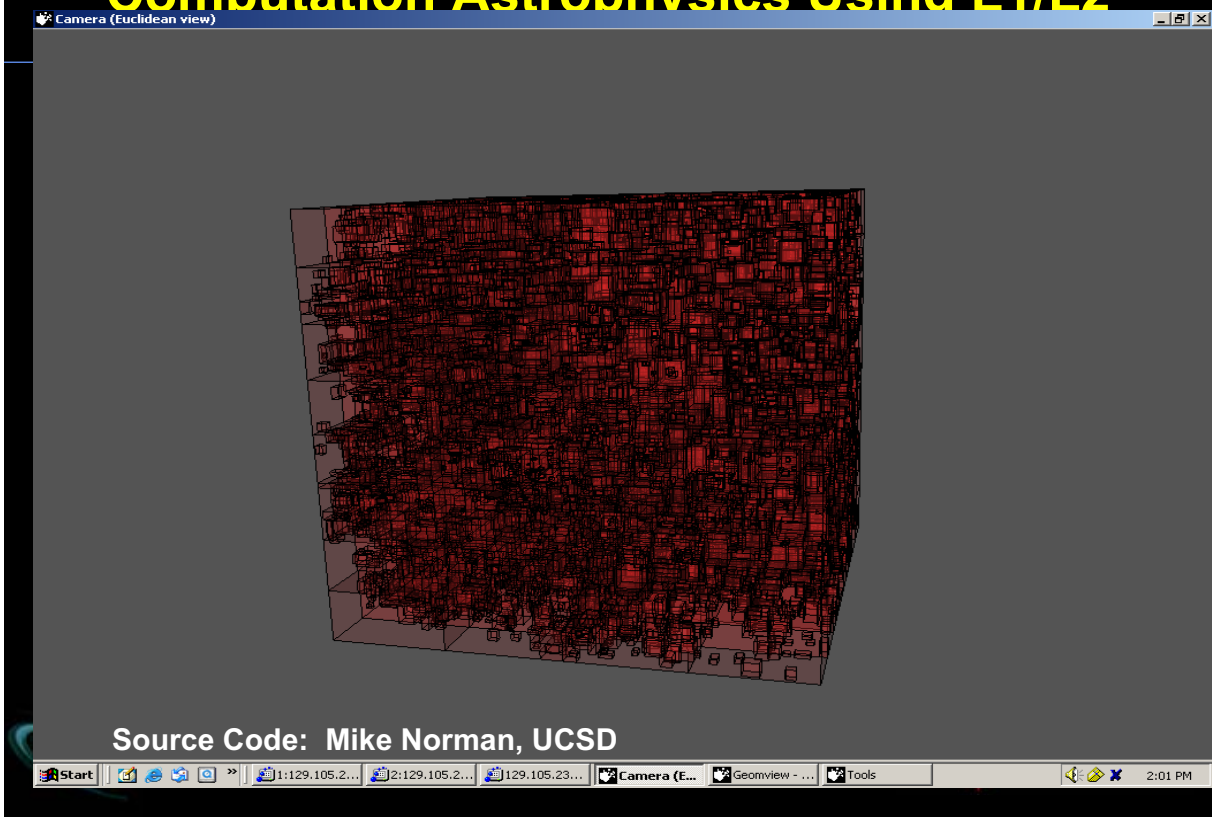
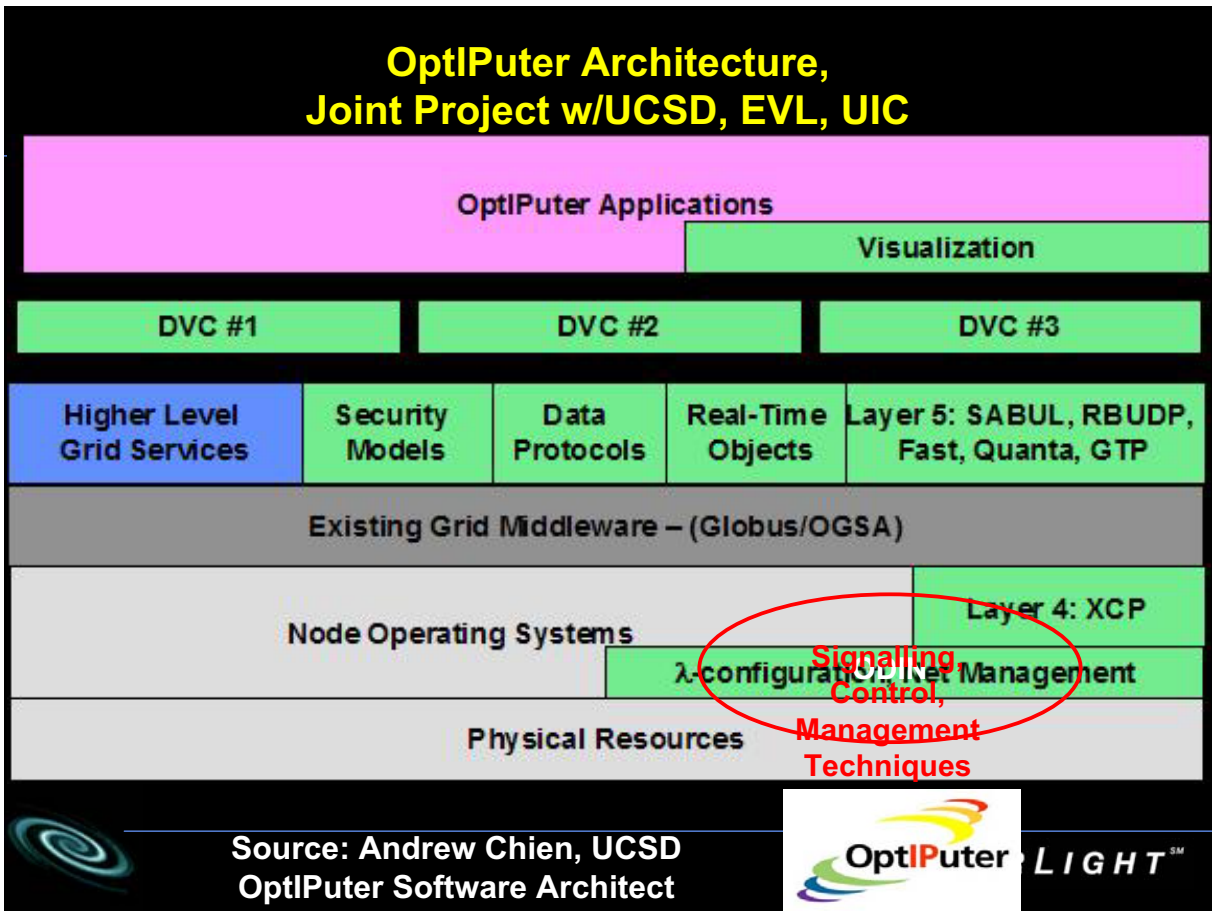
Computation Astrophysics Using L1/L2



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



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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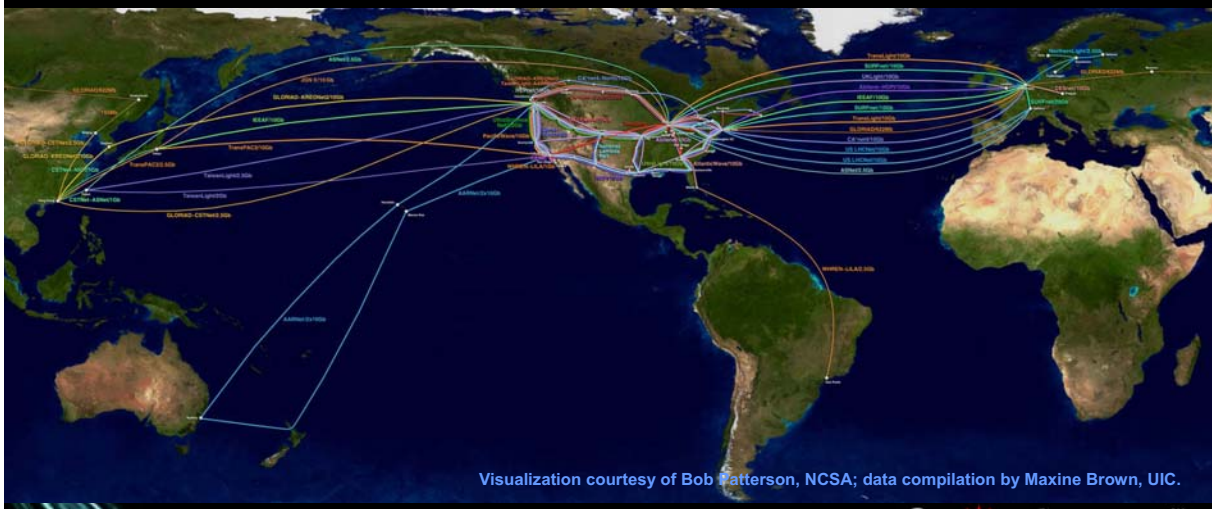
Global Lambda Integrated Facility

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



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

www.glif.is

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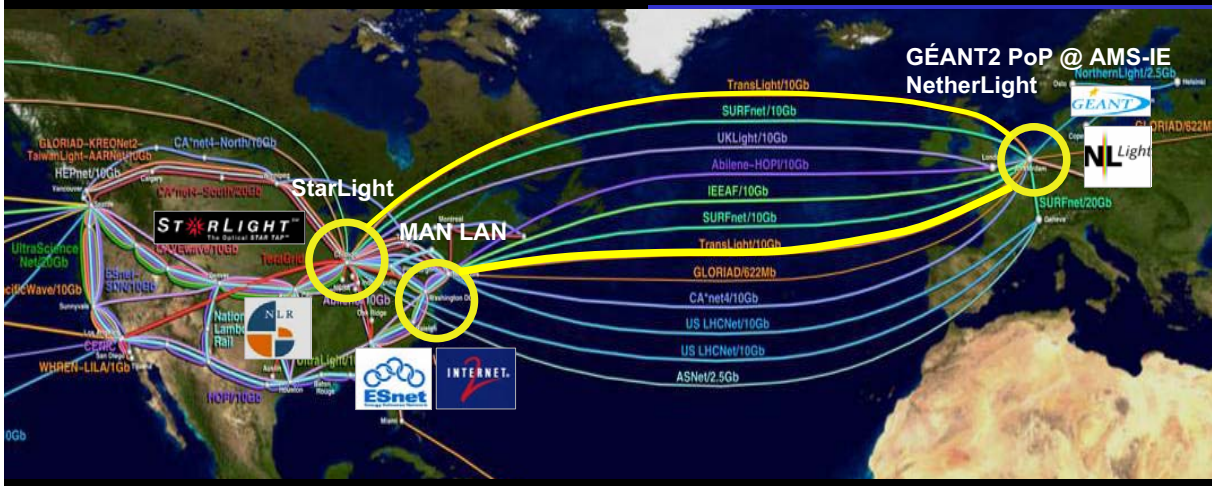
TransLight/StarLight

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

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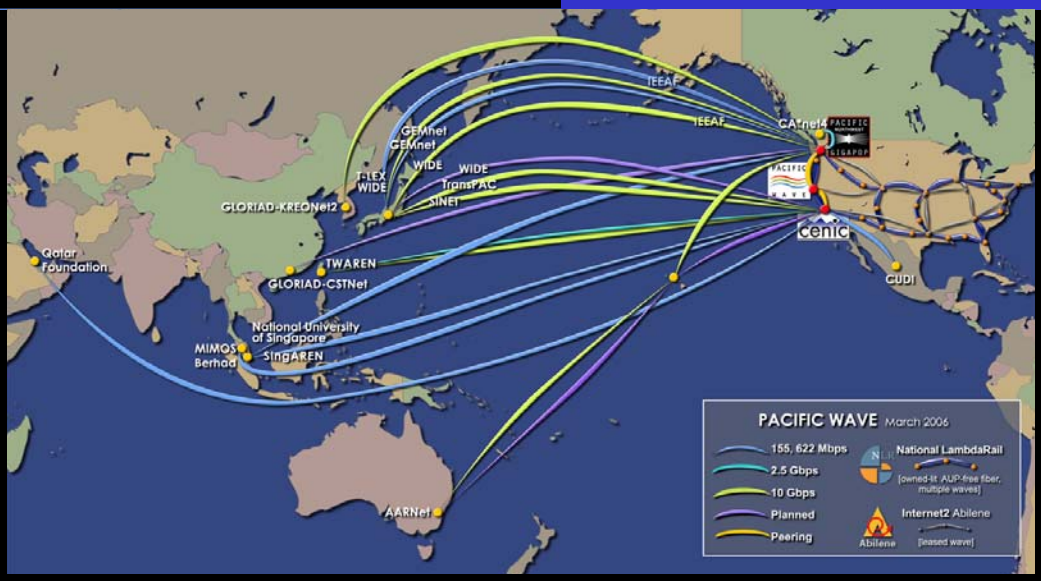
TransLight/Pacific Wave

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/

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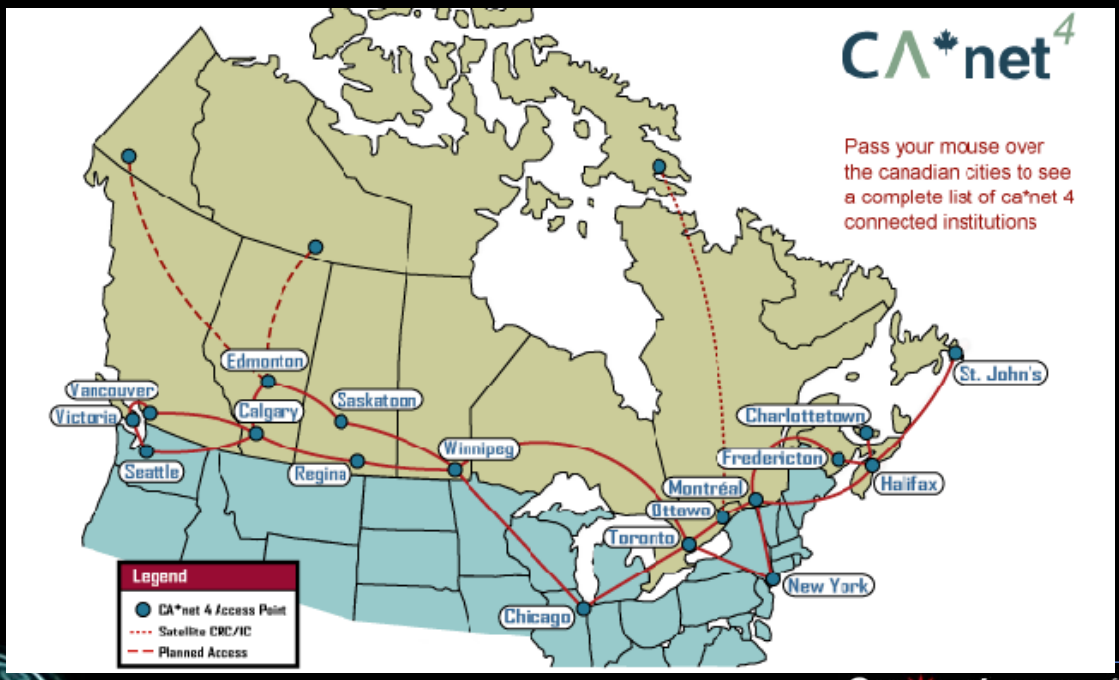
CA*net4 has 2x10Gb and Equipment at StarLight



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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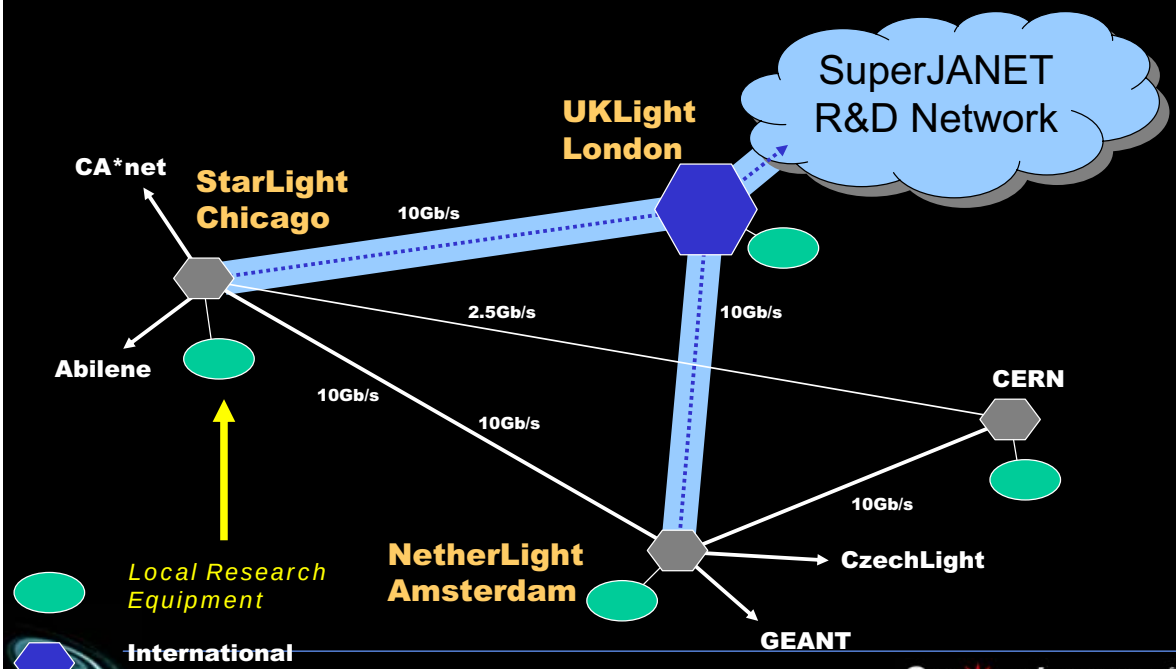
UKLight is Connected to StarLight with 10Gb and Equipment



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Source: Peter Clarke, David Salmon, UKLight

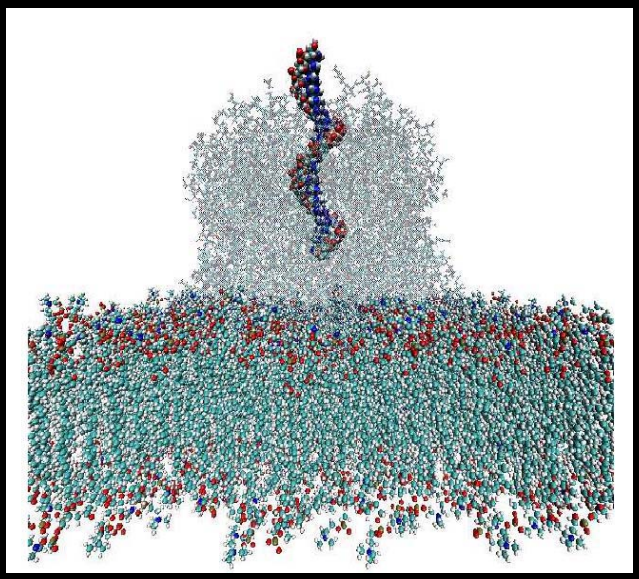
SPICE: Part of UK e-Science Initiative

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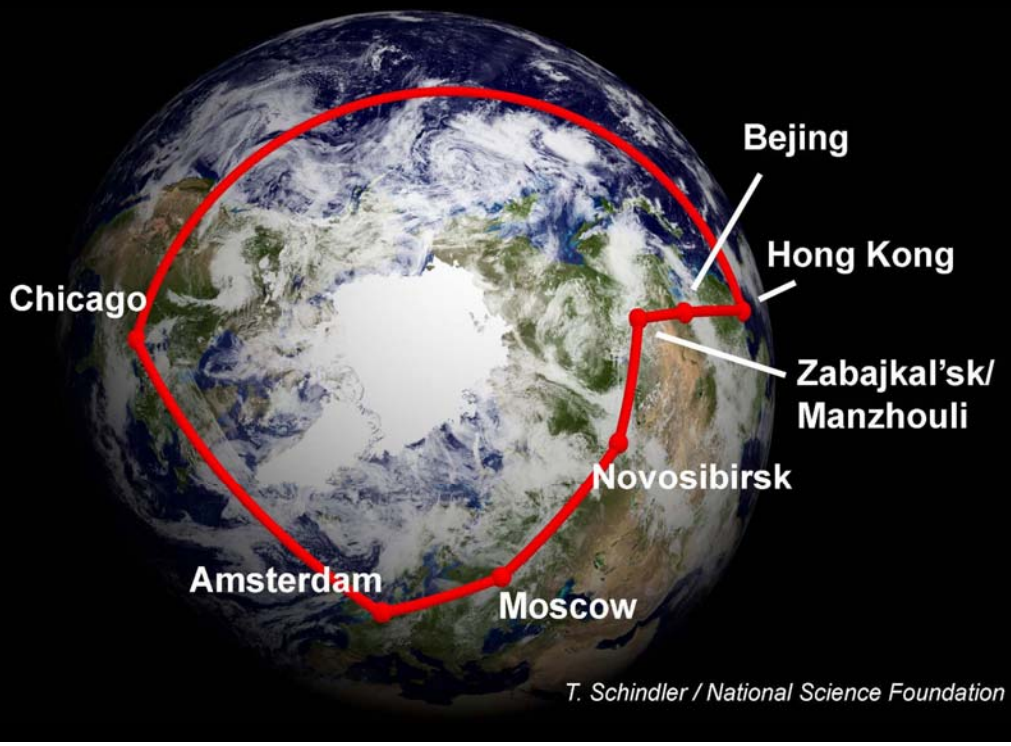
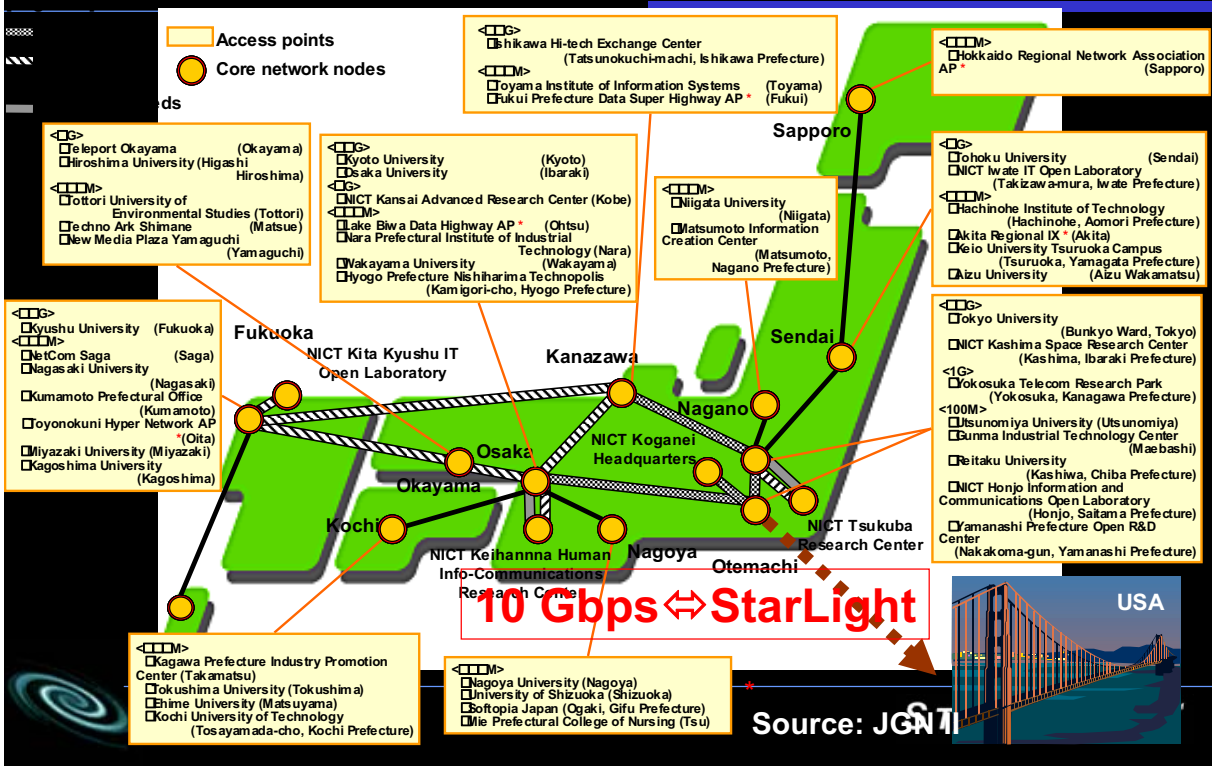
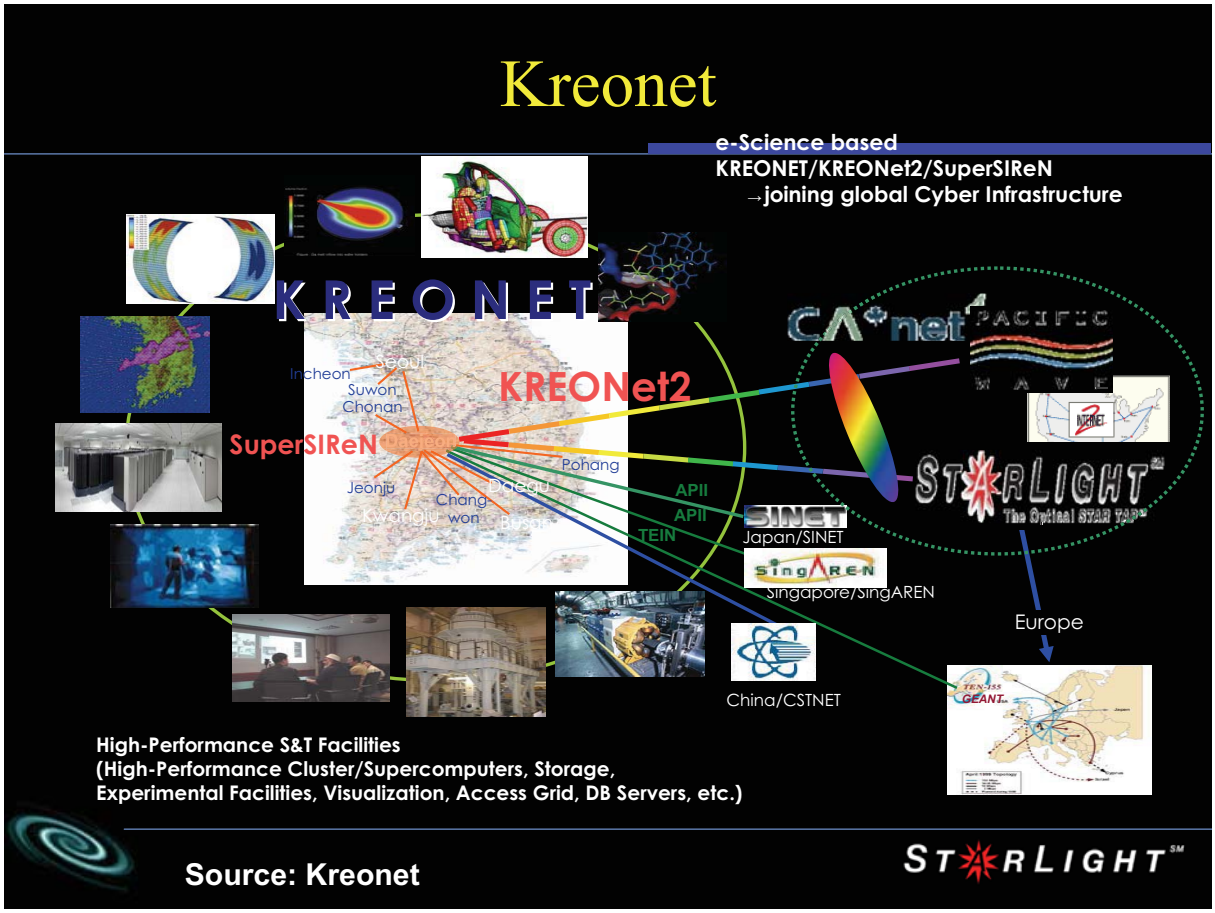
GLORIAD: Worldwide Ring
Now 10 G StarLight to Moscow, 100% 10Gb Soon



JGN II Network Topology Map

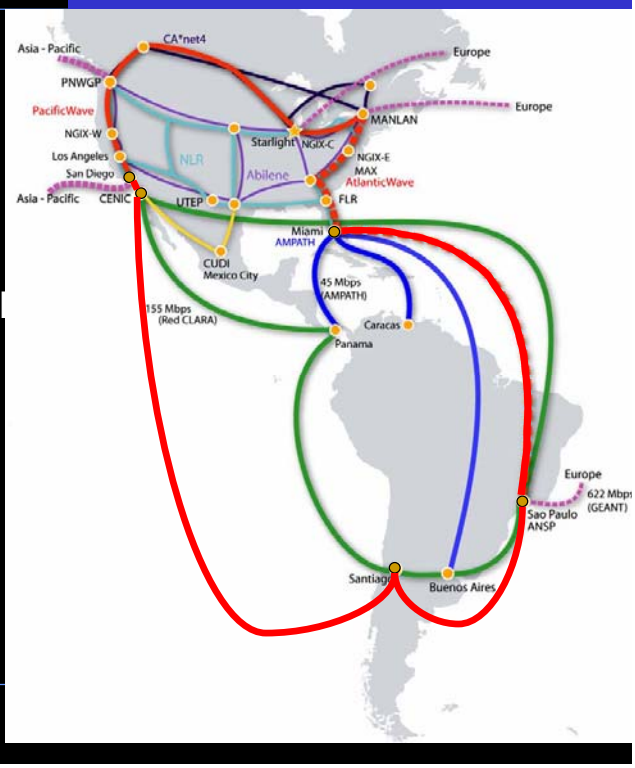


Kreonet

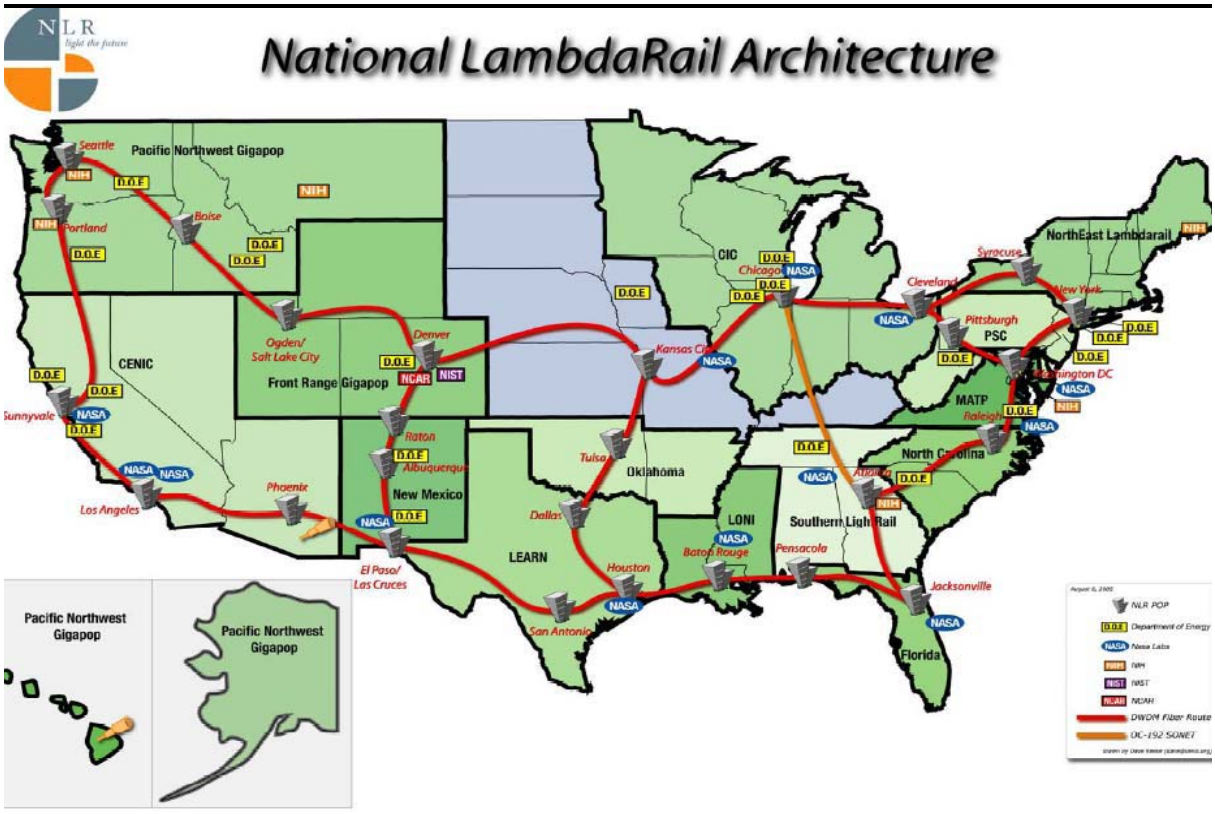


WHREN - LILA Proposal

- 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



 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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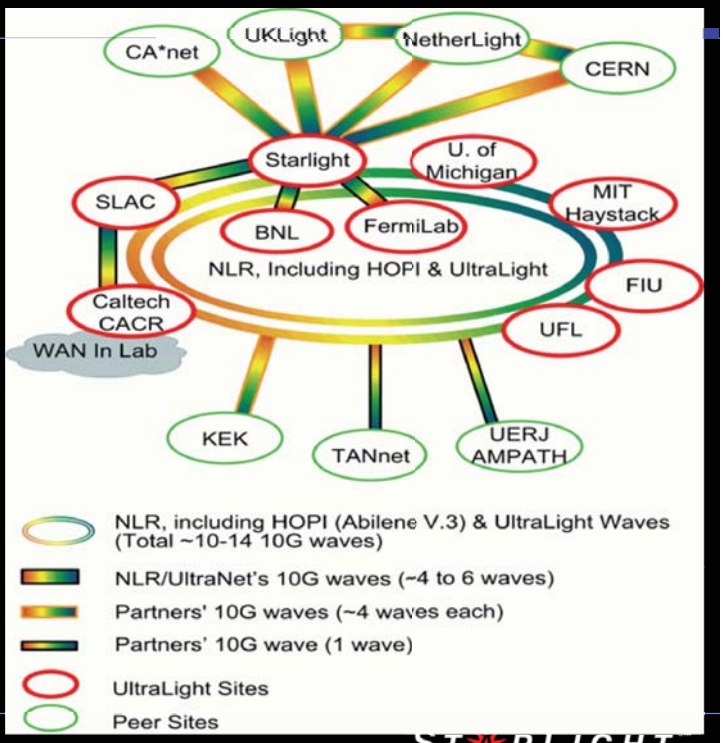
UltraLight Network: PHASE III

- Move into production
- Optical switching fully enabled amongst primary sites

Source:

UltraLight Network

- 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

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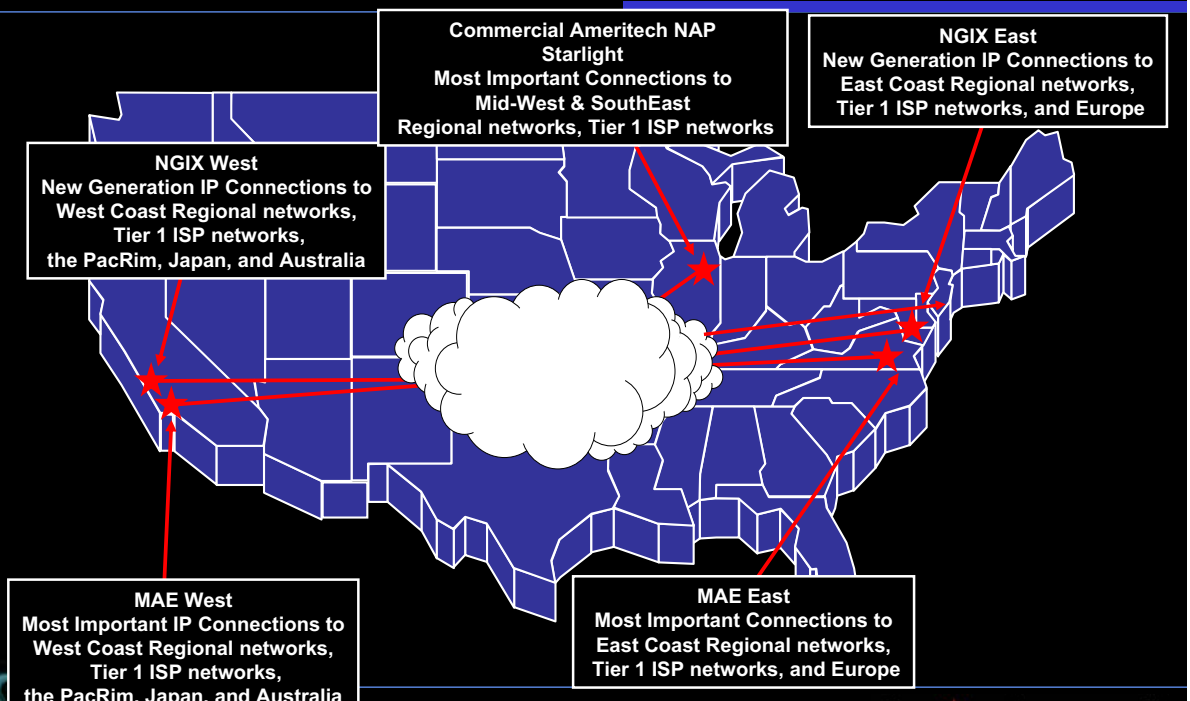
NASA's NISN is at StarLight



Source: NASA

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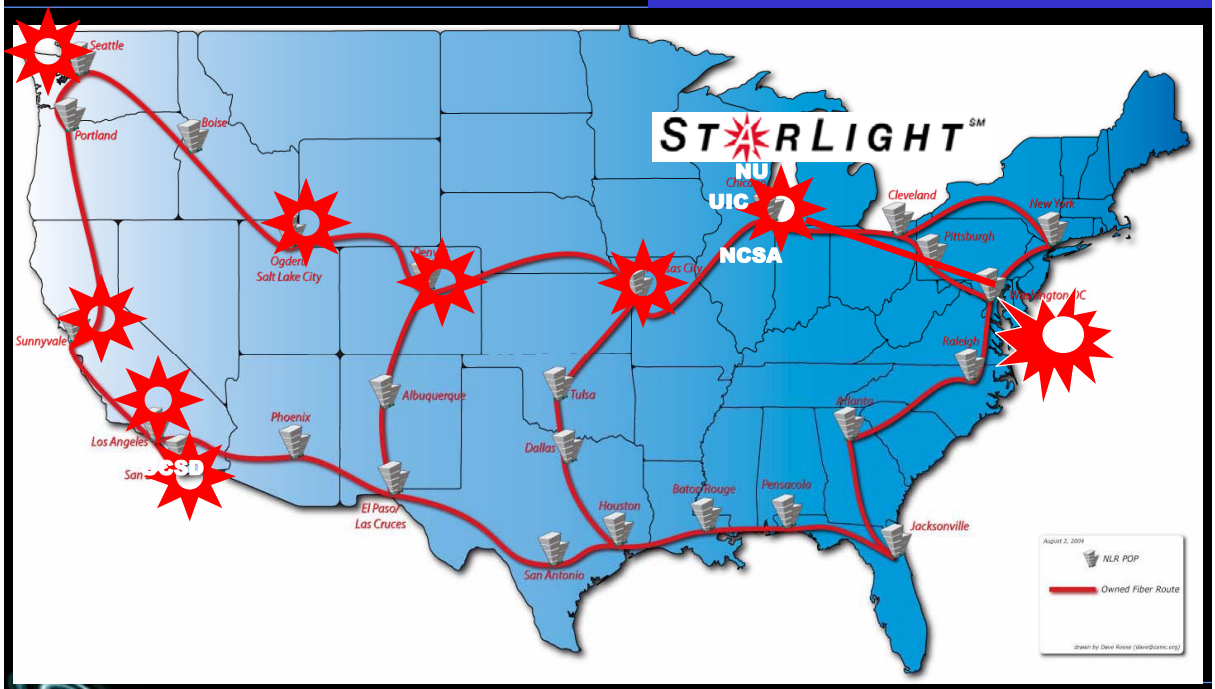
10GE *CAVEwave* on the National LambdaRail



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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

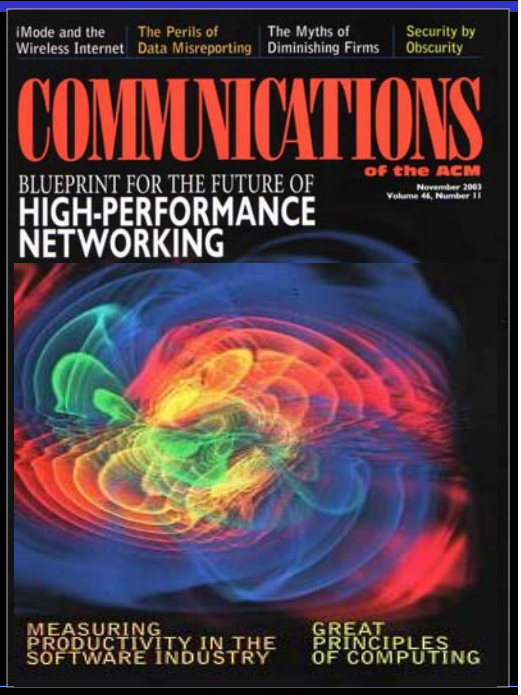
STARLIGHT SM

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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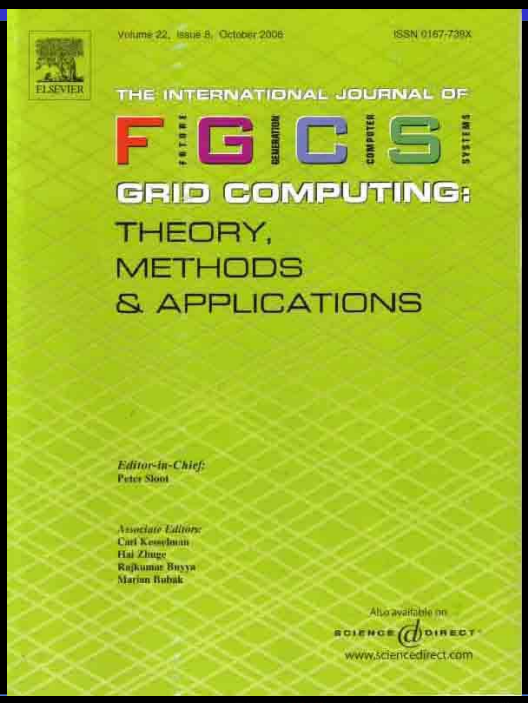
iGrid 2005 Proceedings Available!

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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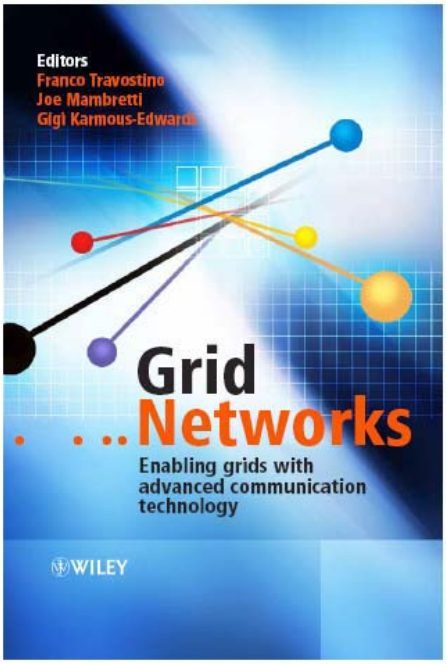

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www.startap.net/starlight

Thanks to the NSF and Other Supporters

STARLIGHT℠