FutureNets: Designing Architecture, Technology, and Facilities for Multi-Service, Deterministic, Differentiated-Attribute Networks

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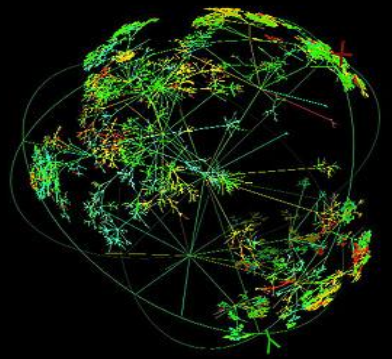
Director, Metropolitan Research and Education Network (www.mren.org)
Co-Director, StarLight, PI-iGENI, PI-OMNINet (www.startap.net/starlight)

Conducting Research on LEARN Workshop
University of Houston
February 18, 2011



iCAIR

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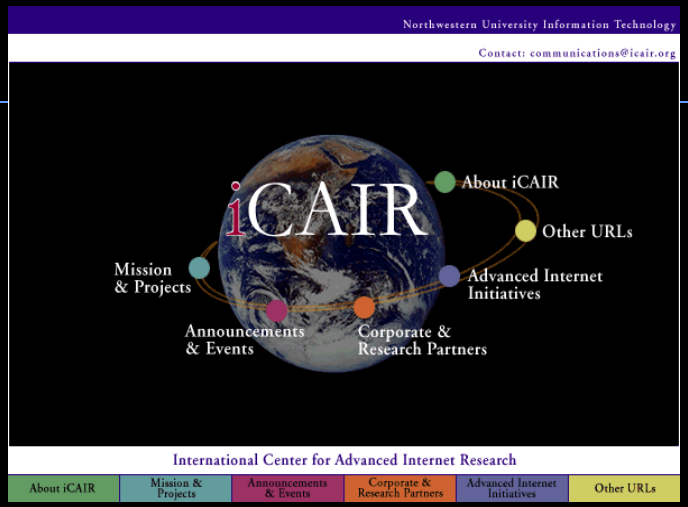
Introduction to iCAIR:



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, Networks for Petascale Science**
- **Advanced Applications, Middleware, Large-Scale Infrastructure, NG Optical Networks and Testbeds, Public Policy Studies and Forums Related to NG Networks**
- **Three Major Areas of Activity: a) Basic Research b) Design and Implementation of Prototypes c) Operations of Specialized Communication Facilities (e.g., StarLight)**

Advanced Communications Research Topics

- Many Current Topics Could Be Considered "Grand Challenges" In Communications
- Scaling the Internet from A Service For 1-2 Billion Individuals (Current) to 4-6 Billion (Future) and Beyond
- Improving the Current Internet (Creating a "Better Internet," Removing Limitations, Adding Capabilities, Increasing Security, Reliability, etc.)
- Migrating Services from Layer 3 Only to Multi-Layer Services, Including L2.5, L2, L1, e.g., Lightpaths
- Empowering *Edge* Processes, Applications, and Users
- *Creating a Fundamentally New Architecture That Allows for Accomplishing All of These Goals*

Motivation for New Communications Architecture

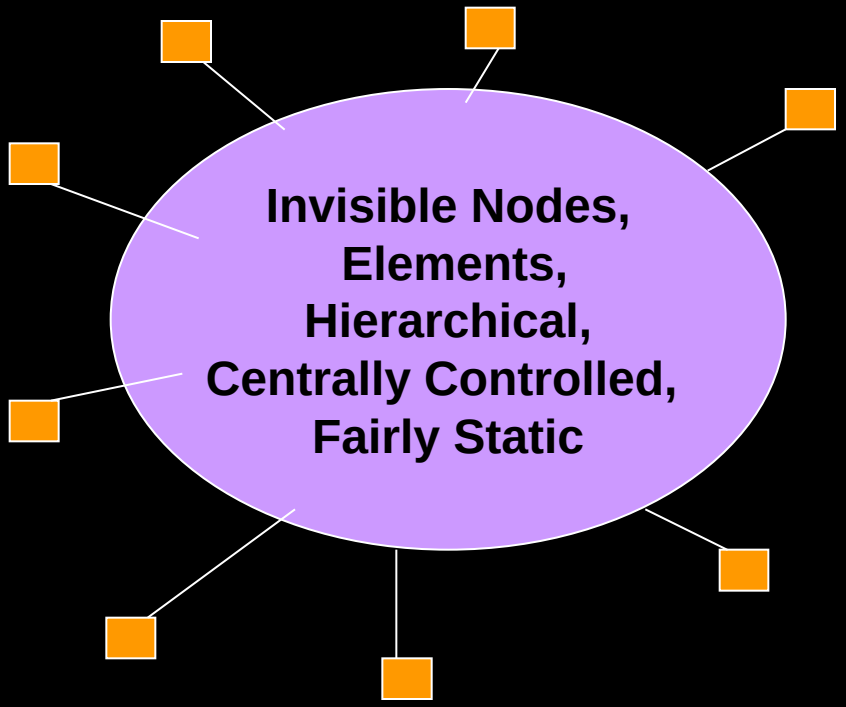
- **Traditional Networking Architecture and Technology Are Oriented to Supporting A Relatively Few Communications Modalities e.g., Voice, Video, Common Data, for a Very Long Time (Many Years...).**
- **Traditional Networking Infrastructure Is Too Rigid To Accommodate Changes Quickly**
- **Traditional Services Are Essentially Based on 19th Century Utility Models of Service and Infrastructure, Which --**
  - ***Severely Restrict the Inherent Potential of Digital Technology***
  - ***Cannot Meet Many Emerging Requirements for 21st Century Services***
- **A Fundamentally New Architectural Model is Required**
- **A New Architecture Replaces The Traditional Network With a New Communication Services Foundation – a Highly Distributed Facility That Can Support Multiple Networks With Different Characteristics Each Supporting Multiple Highly Differentiated Services**

Selected Macro Network Research Themes

- Transition From Legacy Networks To Networks That Take Full Advantage of IT Architecture and Technology
- Extremely Large Capacity Networks (Multi-Tbps Streams)
- High Degrees of Communication Services Customization
- Highly Programmable Networks
- Network Facilities As Enabling Platforms for Any Type of Services
- Extremely High Levels of Network Virtualization
- Highly Distributed Processes
- Open Communication Exchanges
- Service Exchanges at All Layers (vs Only Traditional L3)
- Innovations Based On New Extended Environments

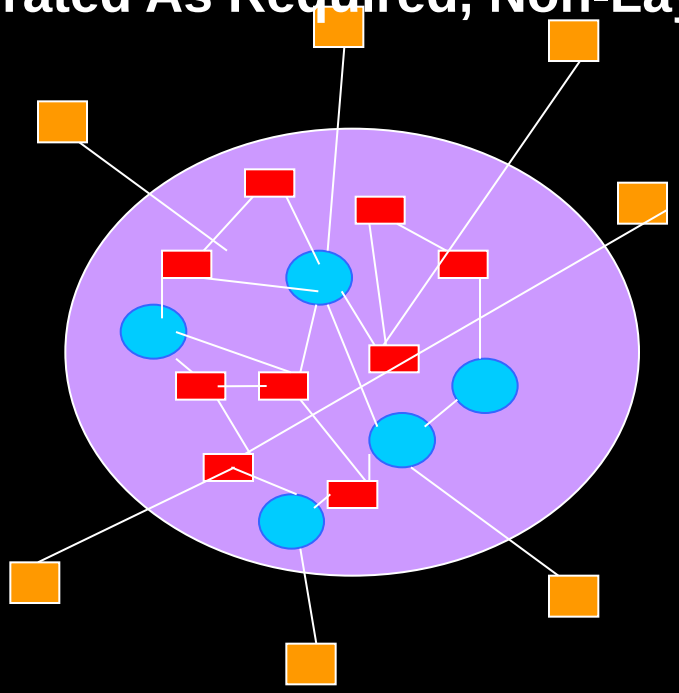
Paradigm Shift – Ubiquitous Services Based on Large Scale Distributed Facility vs Isolated Services Based on Separate Component Resources

Traditional Provider Services:
Invisible, Static Resources,
Centralized Management,
Highly Layered



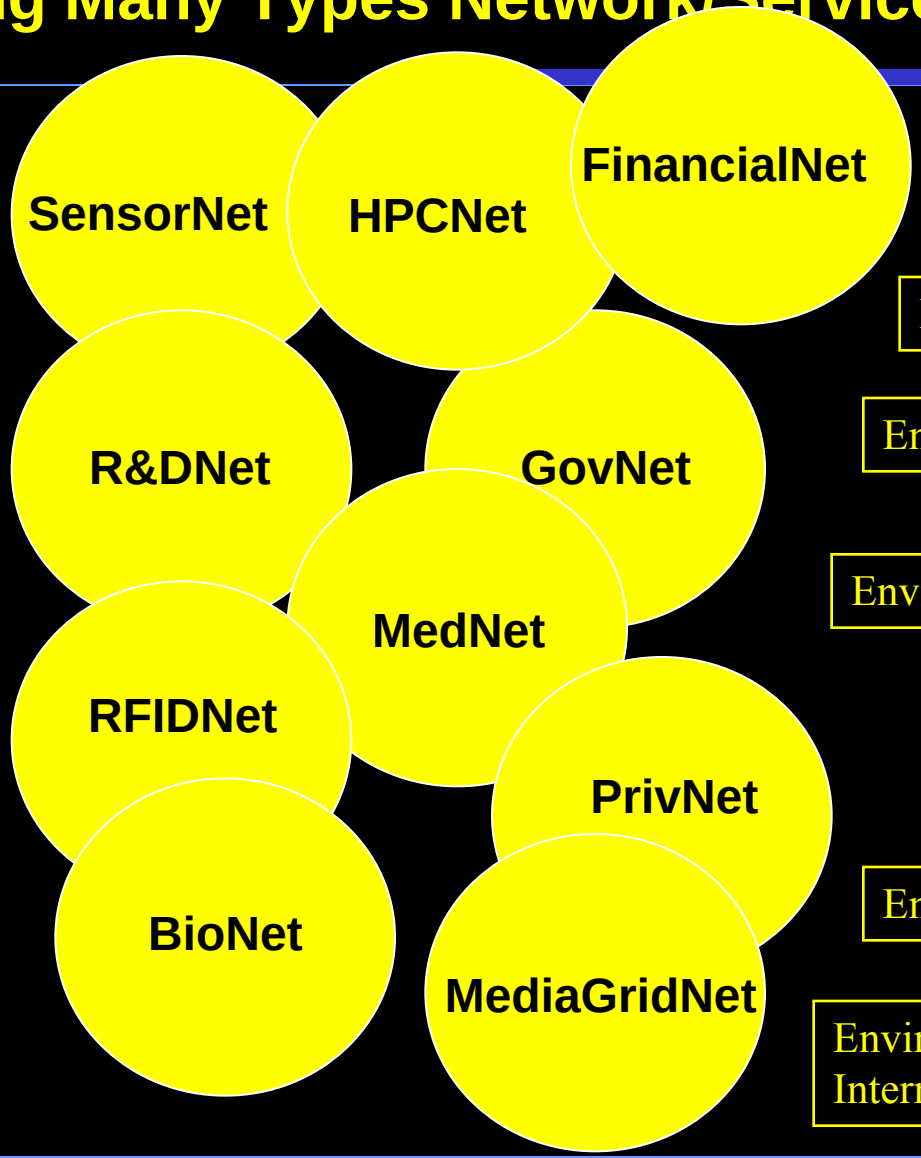
Limited Services, Functionality,
Flexibility, Expandability

Distributed Programmable Resources,
Dynamic Services,
Visible & Accessible Resources,
Integrated As Required, Non-Layered



Unlimited Services, Functionality,
Flexibility, Expandability

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



Environment: VO

Environment: Real Org1

Environment: Intelligent Power Grid Control

Environment: RFIDNet

Environment: Bio Org

Environment: Large Scale System Control

Environment: Global App

Environment: Financial Org

Environment: Sensors

Environment: Real Org

Environment: Real Org2

Environment: Gov Agency

Environment: Control Plane

Environment: Lab

Environment: International Gaming Fabric

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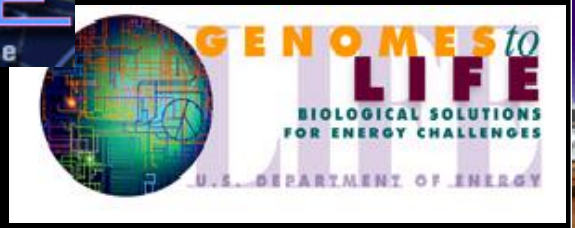
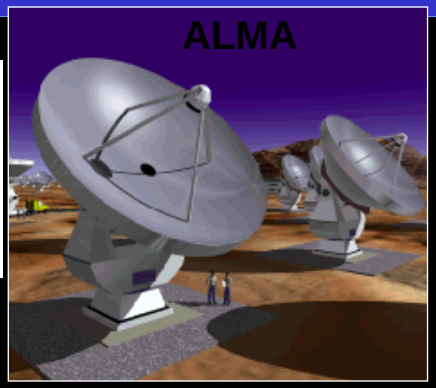
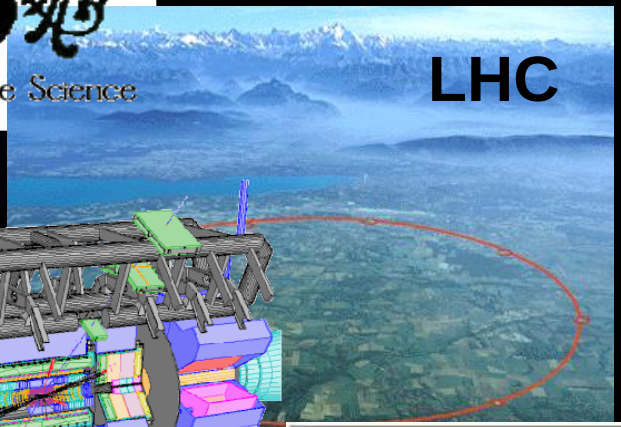
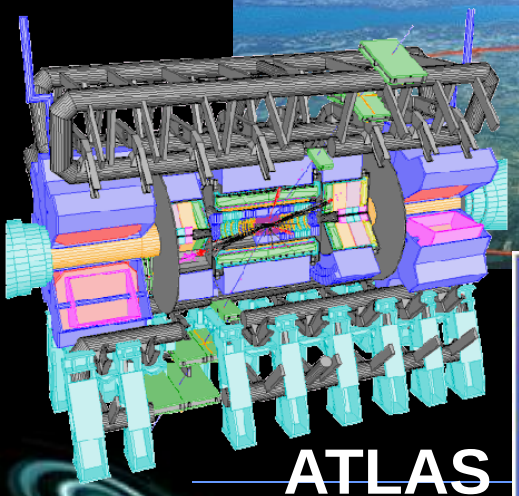
Creating Data-Intensive Science & Engineering e-Science Community Resources









HEP = Staggering Amounts of Data

BaBar 0.3 PetaByte/year (2001)

CDF or D0 Run II

0.5 PetaByte/year (2003)

LHC Mock Data Challenge
1 PetaByte/year (~2005)

CMS or ATLAS

2 PetaBytes/year (~2008)

KTeV 50 TeraBytes /year (1999)

SLD 3 TB /year (1998)

Run I (CDF or D0) 20 TB /year (1995)

L3 5 TB /year (1993)

E791 50 TB /year (1991)

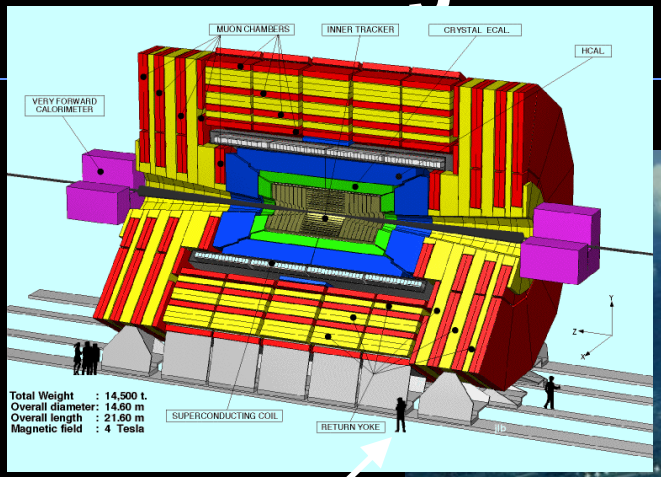
EMC 400GB /year (1981)

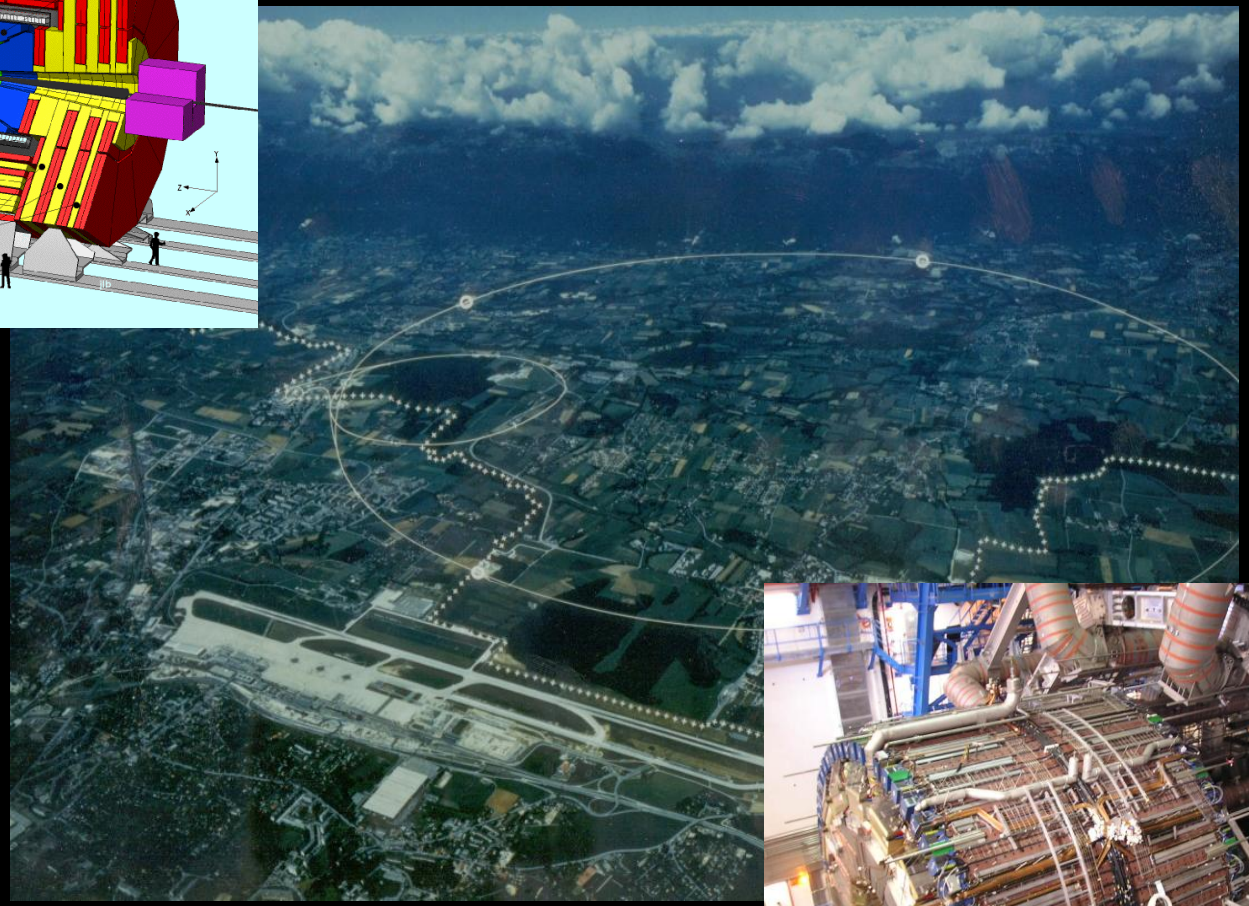
In 1977 the Upsilon (bottom quark) was discovered at Fermilab by experiment E288 led by now Nobel laureate Leon Lederman

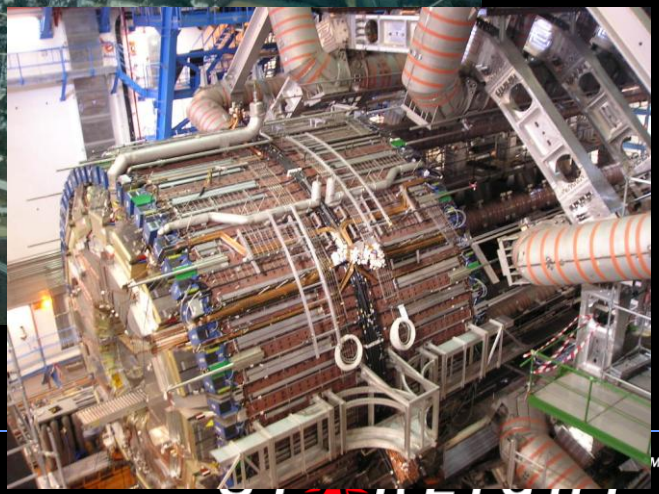
The experiment took about 1 million events and recorded the raw data on ~ 300 magnetic tapes for about 6 GB of raw data

Source: Fermi Lab

Large Hadron Collider at CERN



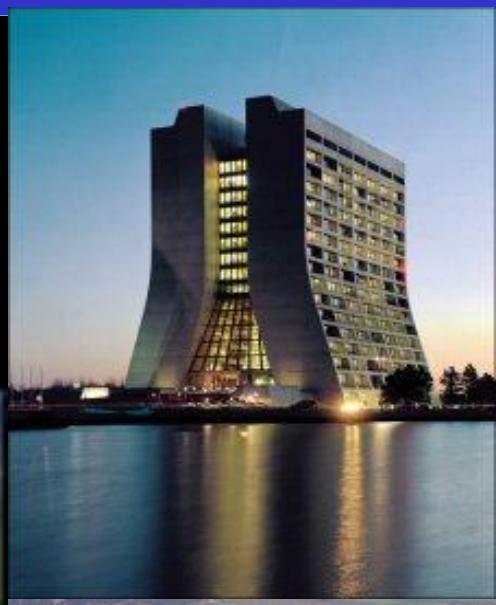


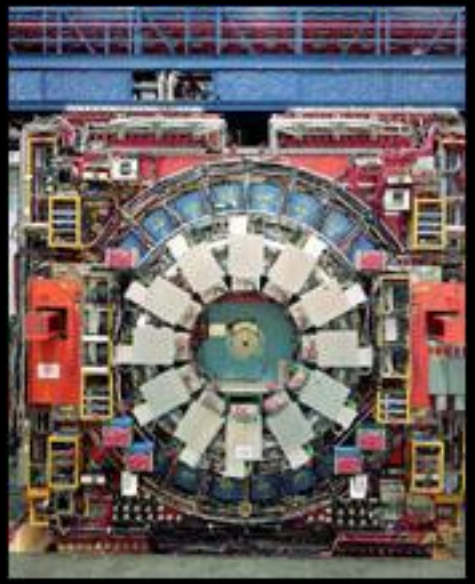


Fermi National Accelerator Laboratory

Fermi LightPath

35 Mile LAN PHY to StarLight





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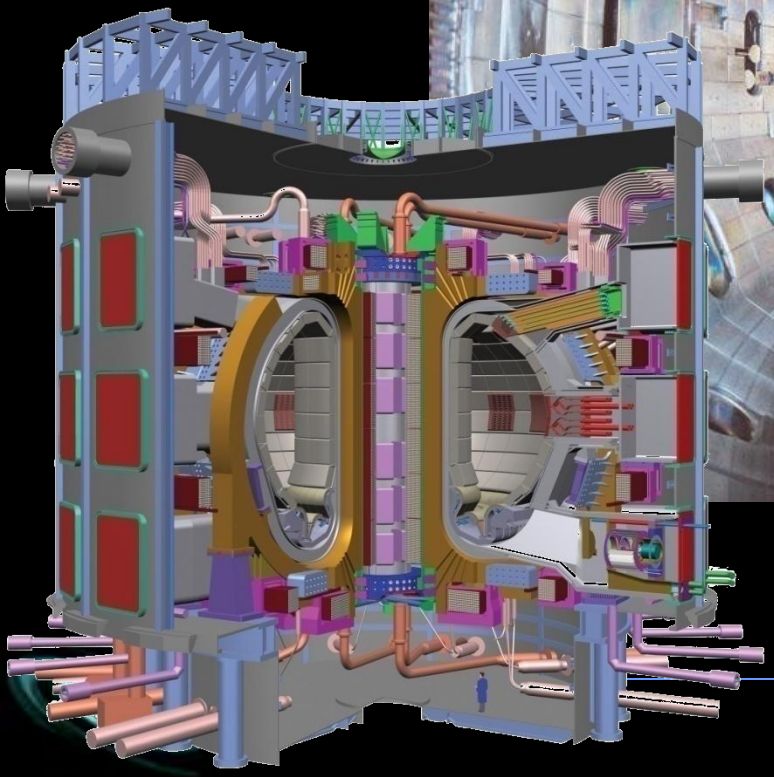
Magnetic Fusion Energy

New Sources
Of Power



Source: DOE

Source: DOE

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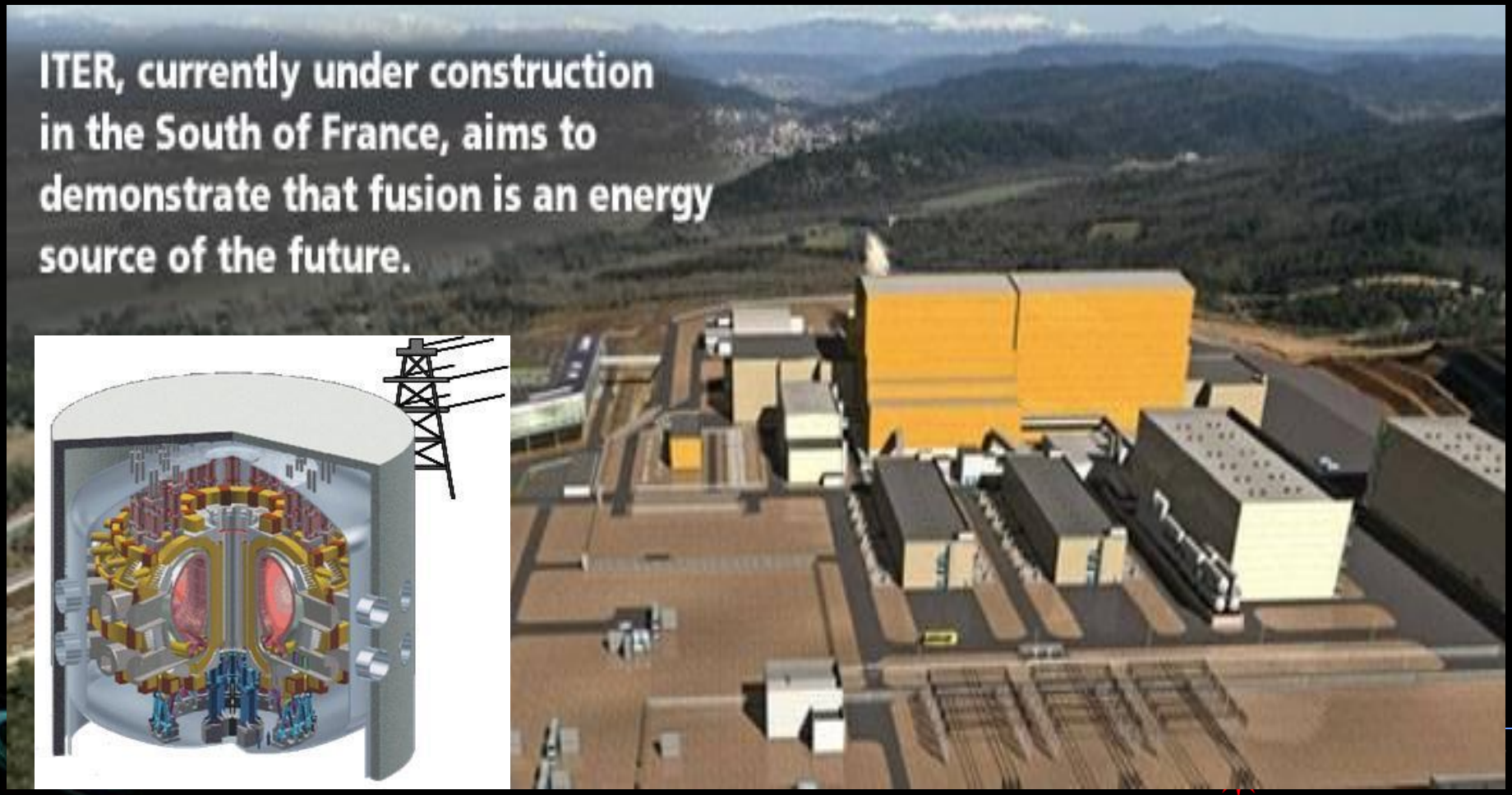
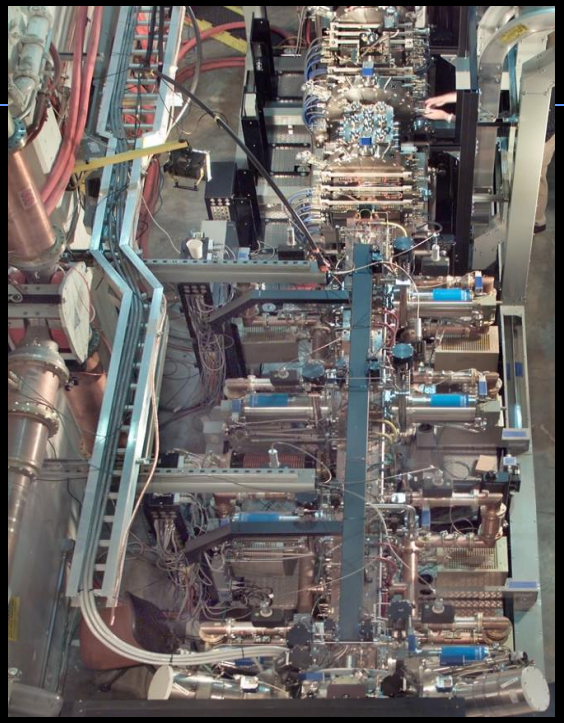
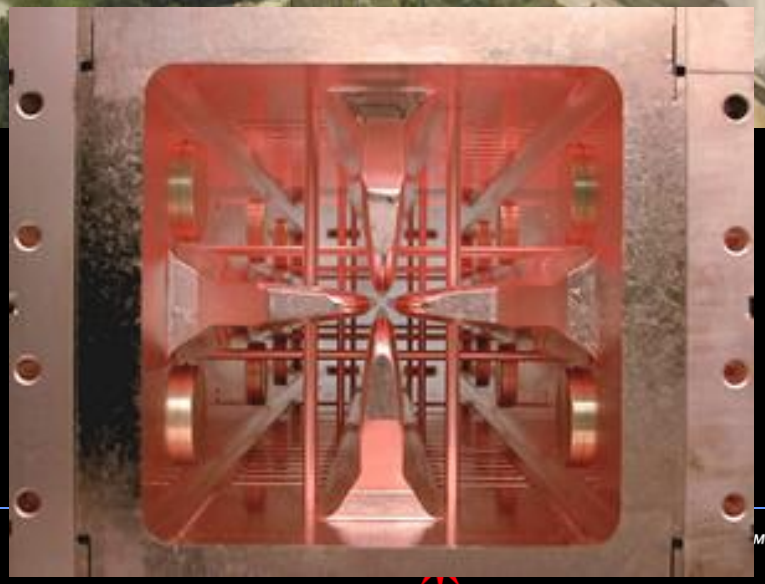
ITER (Formally- International Thermonuclear Experimental Reactor)

- **ITER Is One of the World's Largest and Most Ambitious International Science Project Extremely Data Intensive**



Spallation Neutron Source (SNS) at ORNL





Neutron Beams Are Directed At Different Types of Materials To Investigate Their Atomic Properties, Including Structures

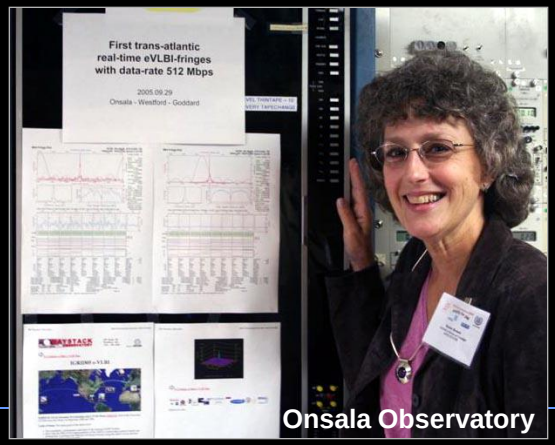
Source: DOE

Real-Time Global e-Very Long Baseline Interferometry

DRAGON (Dynamic Resource Allocation via GMPLS Optical Networks)

- Mid Atlantic Crossroads (MAX) GigaPoP, USA
- Information Sciences Institute, USA
- Westford Observatory, MIT Haystack, USA
- Goddard Geophysical and Atmospheric Observatory, NASA, USA
- Kashima, NiCT, Japan
- Onsala, Sweden
- Jodrell Bank, UK
- JIVE, The Netherlands
- Westerbork, Observatory/ ASTRON, The Netherlands

Real-time e-VLBI data correlation from telescopes in USA, Sweden, the Netherlands, UK and Japan



Onsala Observatory

http://dragon.maxgigapop.net

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eVLBI JIVE-Arecibo Project

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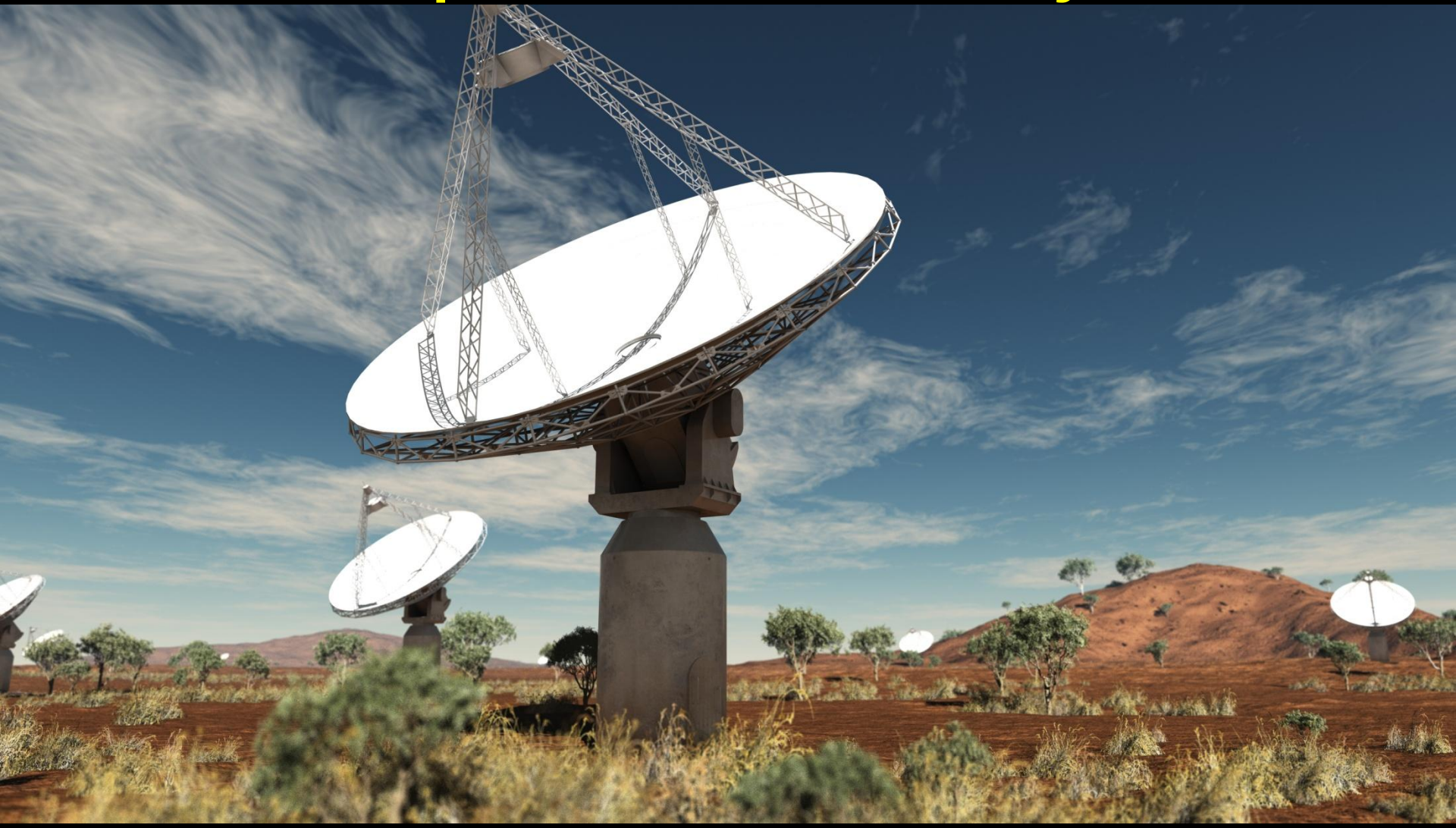
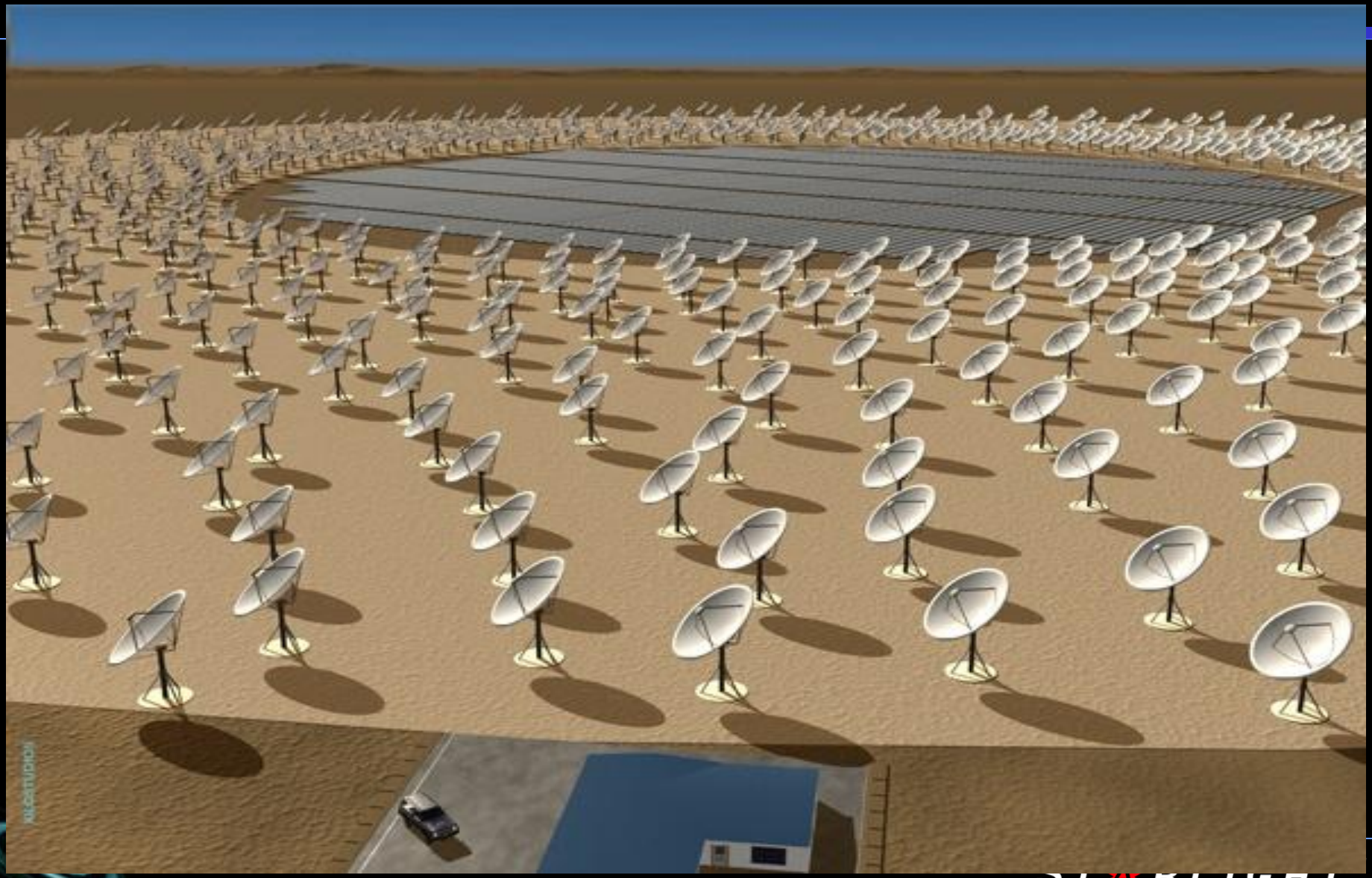
Square Kilometer Array



Today: Prototypes – Future: Austrialia or South Africa

Square Kilometer Array



Increasing Accuracy in Hurricane Forecasts
Ensemble Runs With Increased Resolution

5.75 Day Forecast of Hurricane Isidore

NASA fvGCM — 0.625x0.5 degrees

Precip [inches/hr] : Sea Level Pressure [mb] : 1000 MB Winds [m/s]

2002 SEP 26 18:00Z

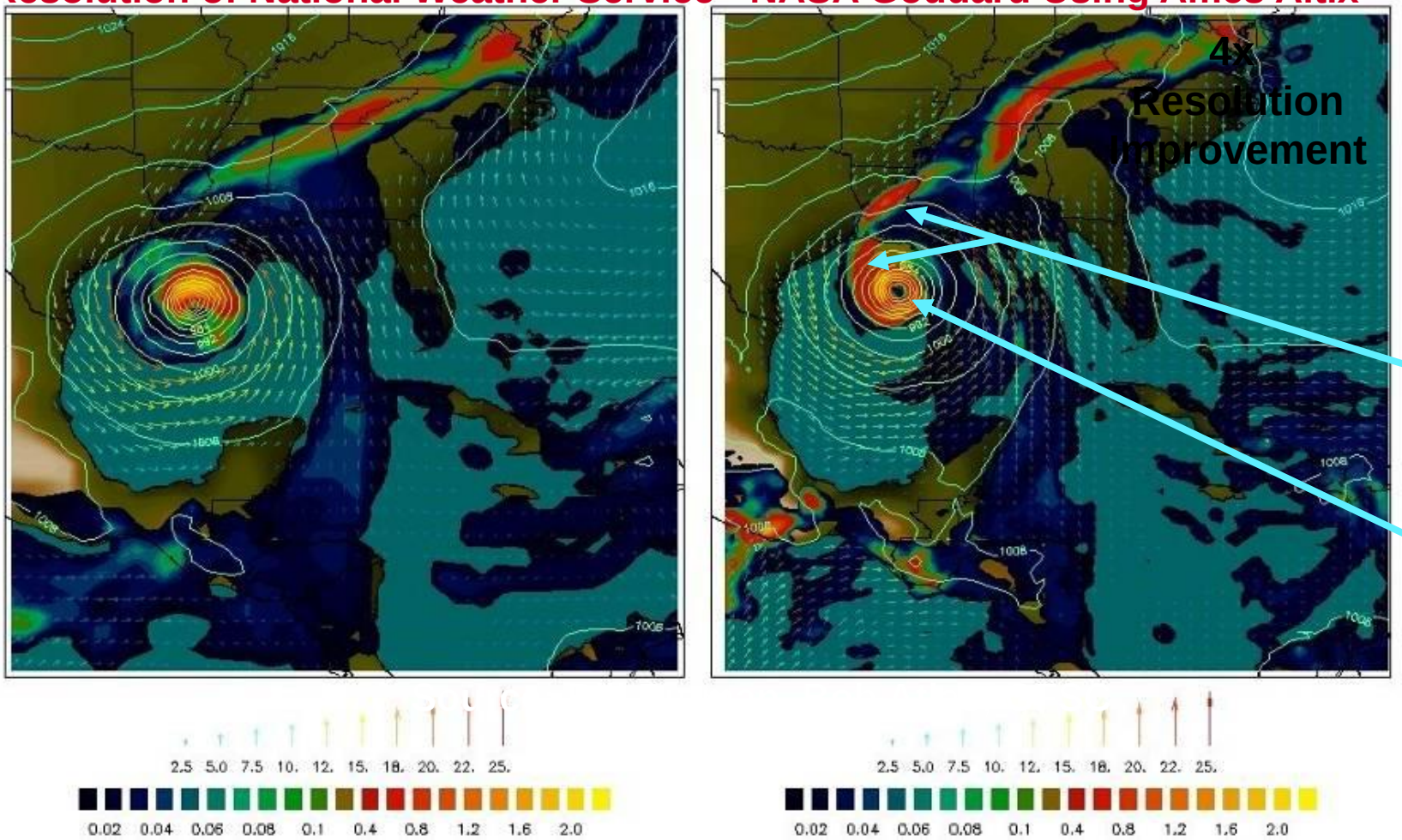
Operational Forecast Resolution of National Weather Service

NASA fvGCM — 0.36x0.25 degrees

Precip [inches/hr] : Sea Level Pressure [mb] : 1000 MB Winds [m/s]

2002 SEP 26 18:00Z

Higher Resolution Research Forecast NASA Goddard Using Ames Altix



Source: Smarr

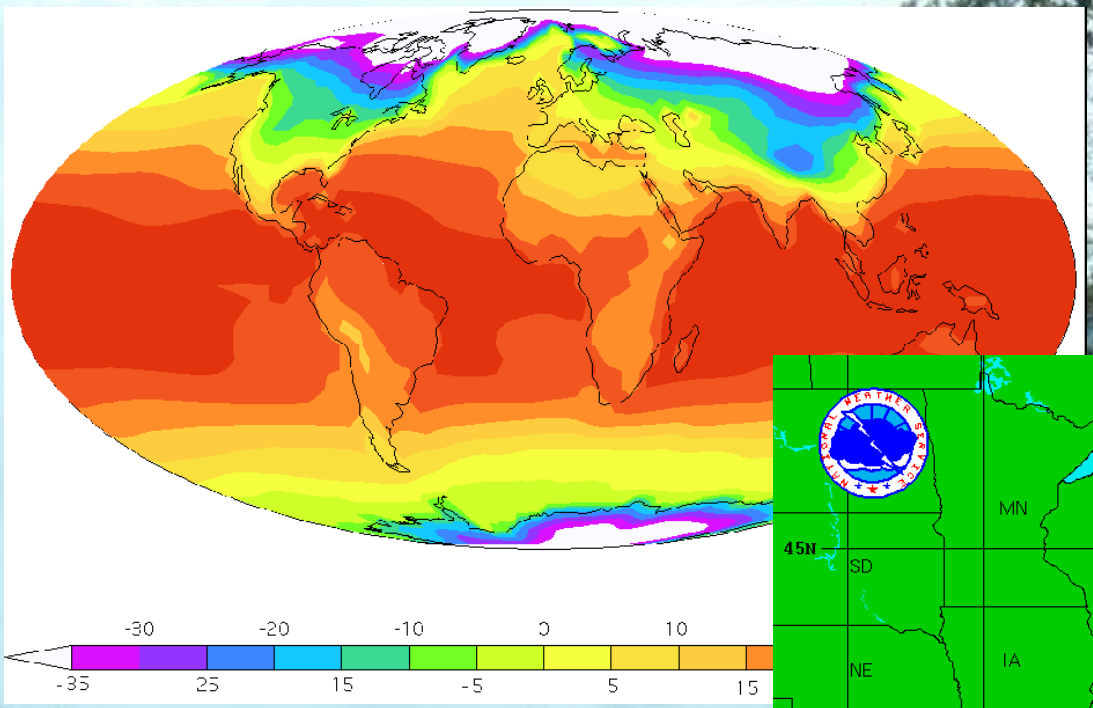
InterCenter Networking is Bottleneck

Intense Rain-Bands

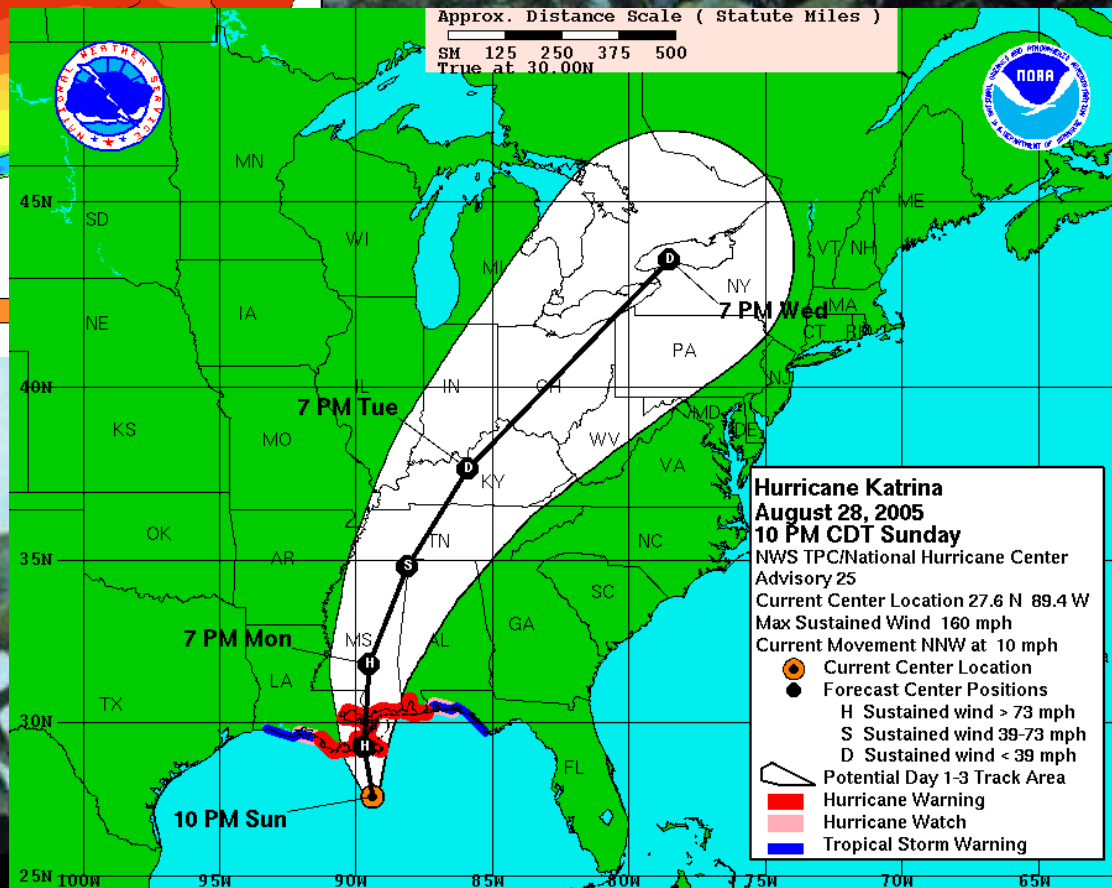
Resolved Eye Wall

LIGHT SM

Climate Modeling

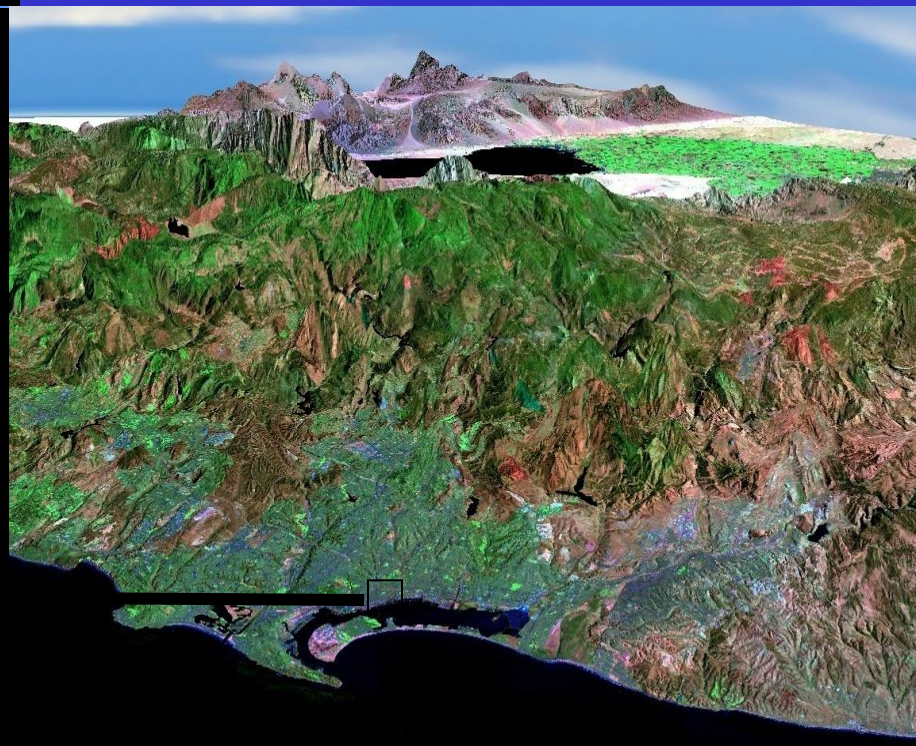


Source: DOE



USGS Images 10,000 Times More Data than Landsat7

Landsat7 Imagery
100 Foot Resolution
Draped on elevation data



New USGS Aerial Imagery
At 6-inch Resolution

Source: EVL, UIC

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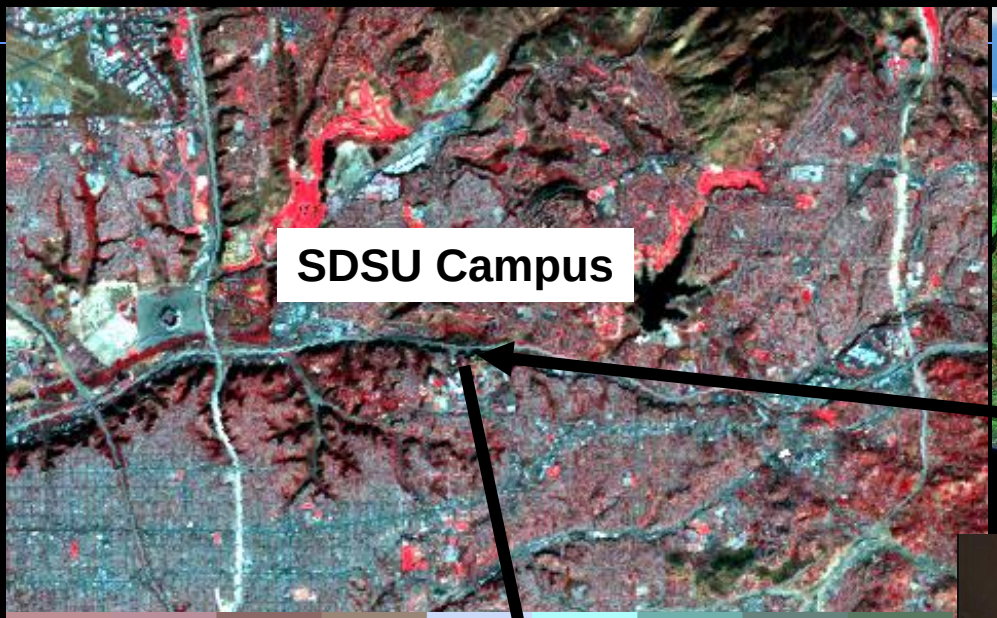
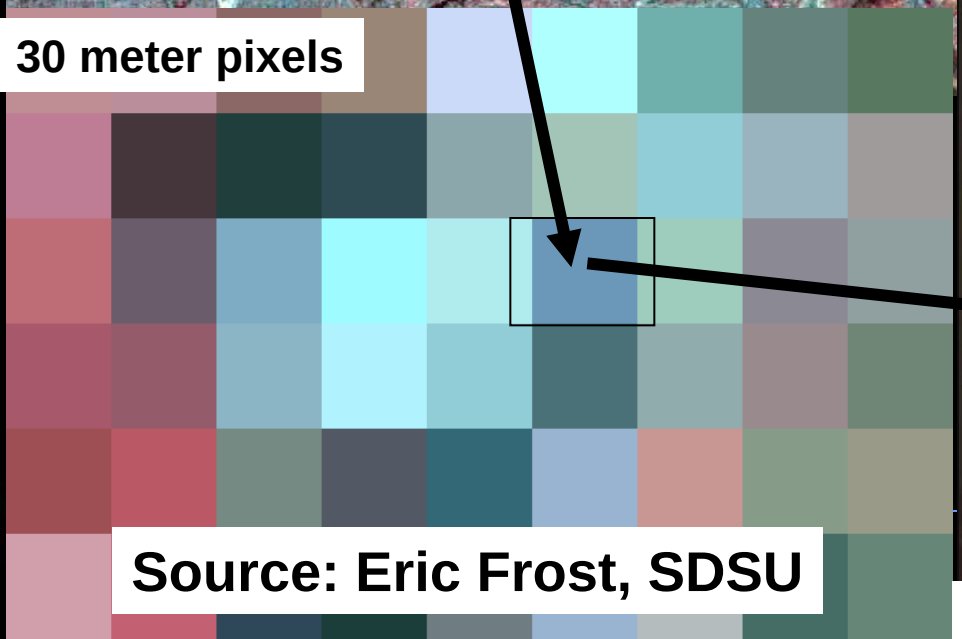
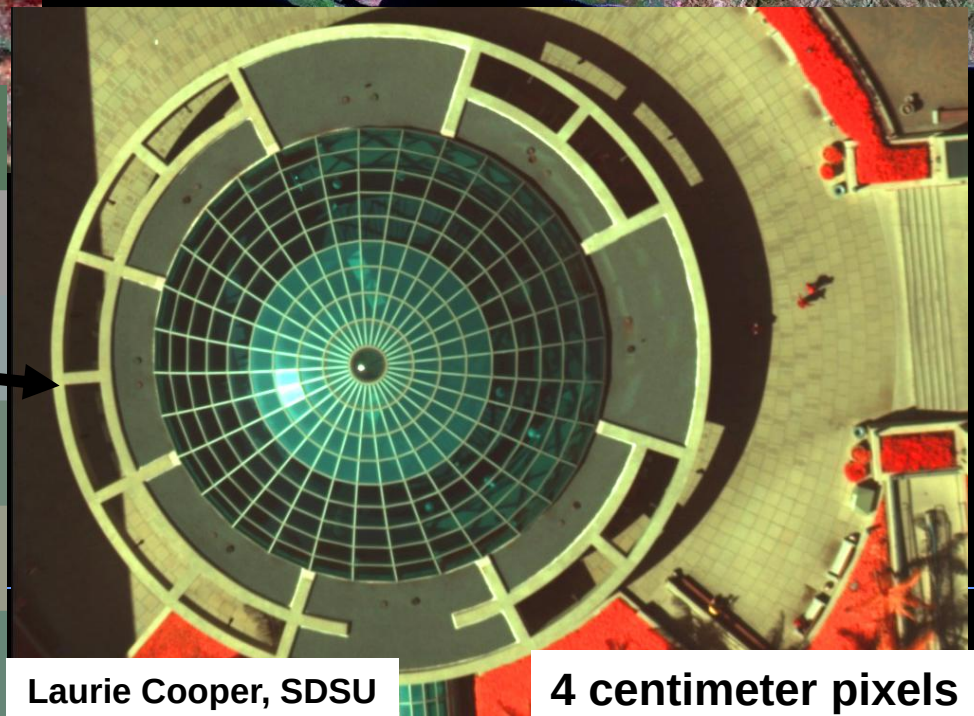
Today's Aerial Imaging is >500,000 Times More Detailed than Landsat7



30 meter pixels





The Crisis Response Room of the Future

SHD Streaming TV -- Immersive Virtual Reality – 100 Megapixel Displays

Source: EVL, UIC

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Brain Imaging Collaboration -- UCSD & Osaka Univ. Using Real-Time Instrument Steering and HDTV

Most Powerful Electron Microscope in the World - - Osaka, Japan

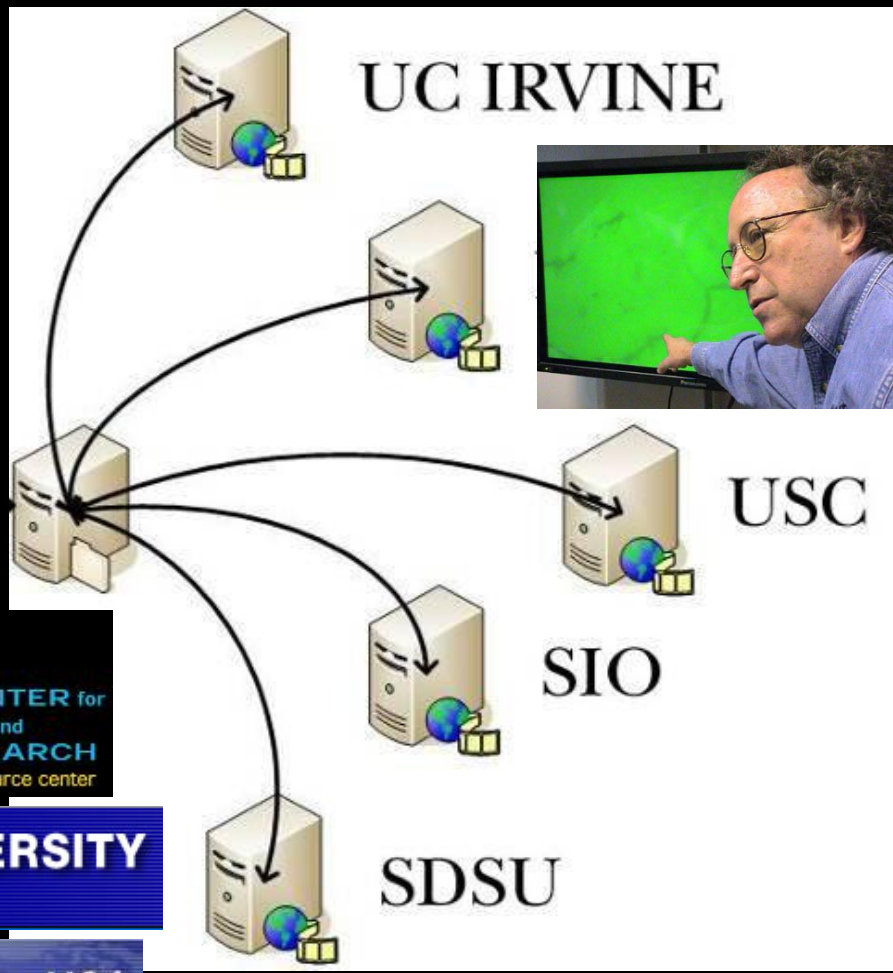
HDTV

NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

OSAKA UNIVERSITY

KDDI Labs USA

Southern California OptIPuter



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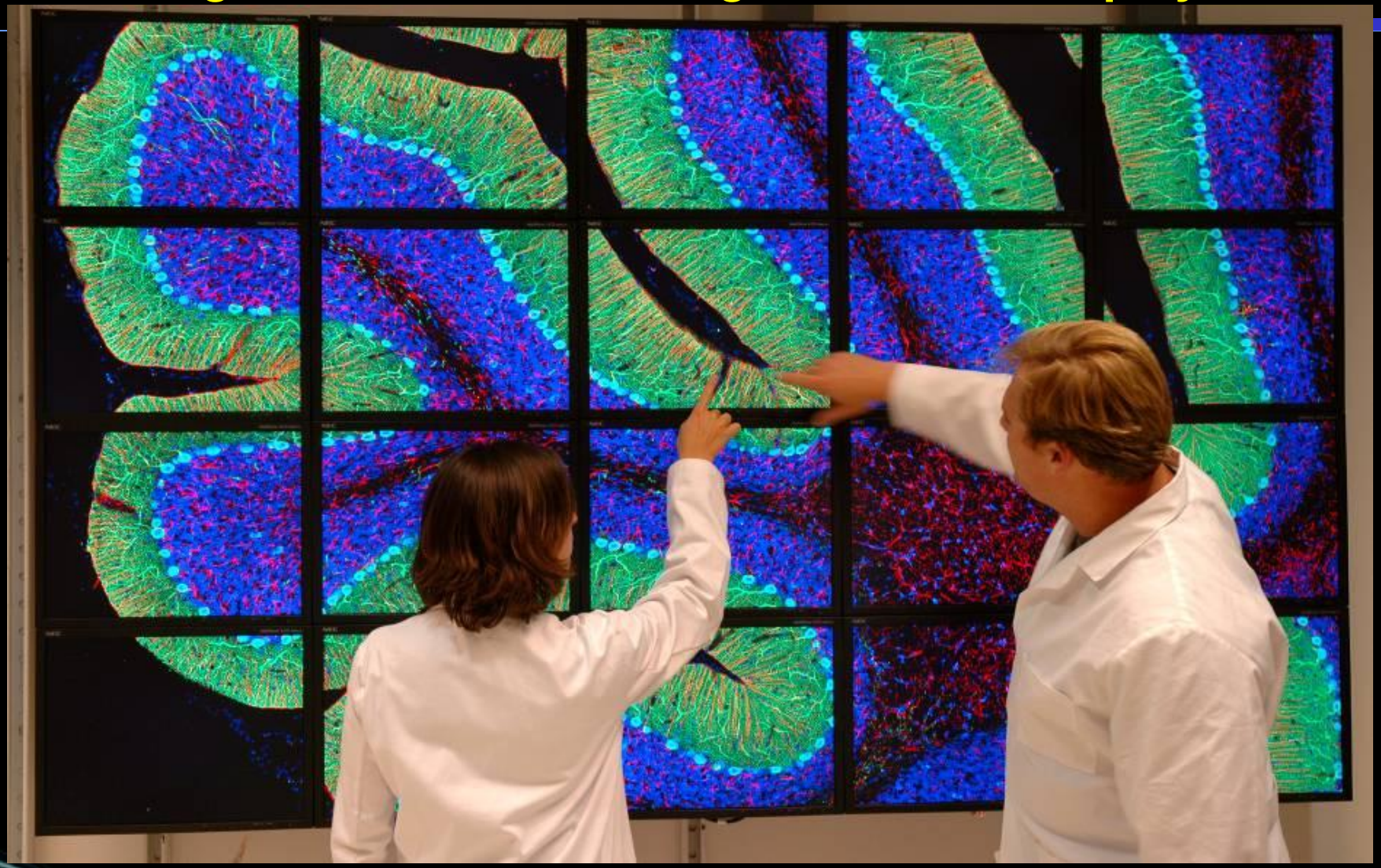
Source: Mark Ellisman, UCSD

OptIPuter JuxtaView Software for Viewing High Resolution BioImages on Tiled Displays



30 Million Pixel Display
NCMIR Lab UCSD

Source: David Lee, Jason Leigh, EVL, UIC

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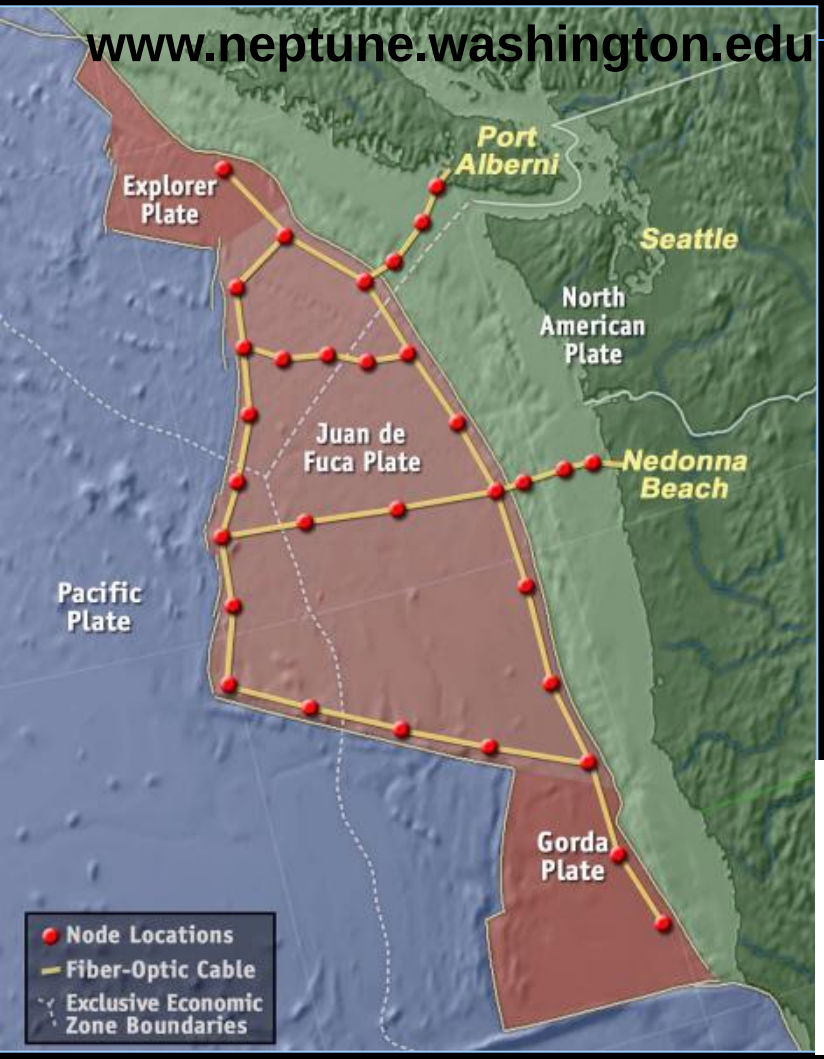
New OptIPuter Driver: Gigabit Fibers on the Ocean Floor
A Working Prototype Cyberinfrastructure for NSF's ORION



- NSF ITR with Principal Investigators
  - John Orcutt & Larry Smarr - UCSD
  - John Delaney & Ed Lazowska –UW
  - Mark Abbott – OSU
- Collaborators at:
  - MBARI, WHOI, NCSA, UIC, CalPoly, UVic, CANARIE, Microsoft, N[illegible]E

LOOKING (Laboratory for the Ocean Observatory Knowledge Integration Grid) –
Adding Web Services to LambdaGrids

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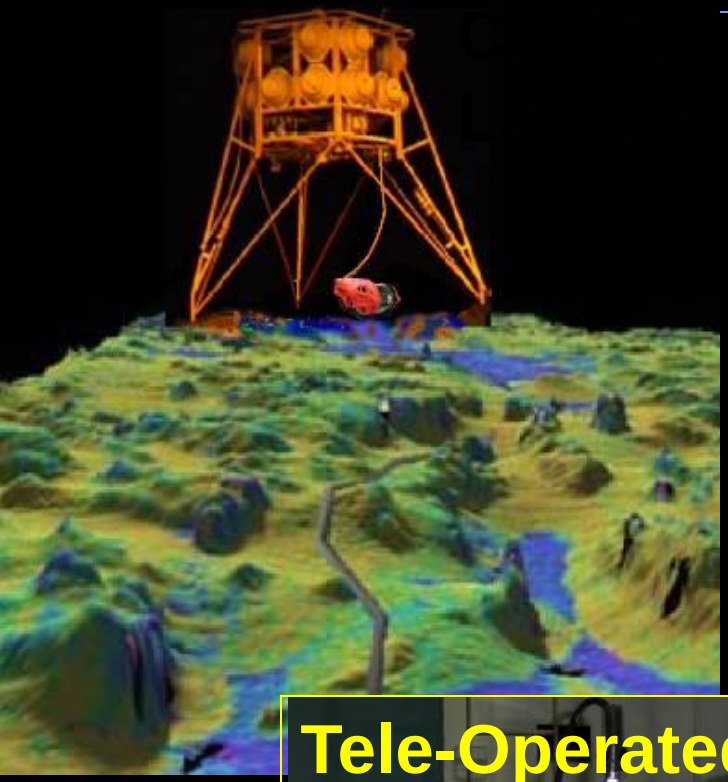
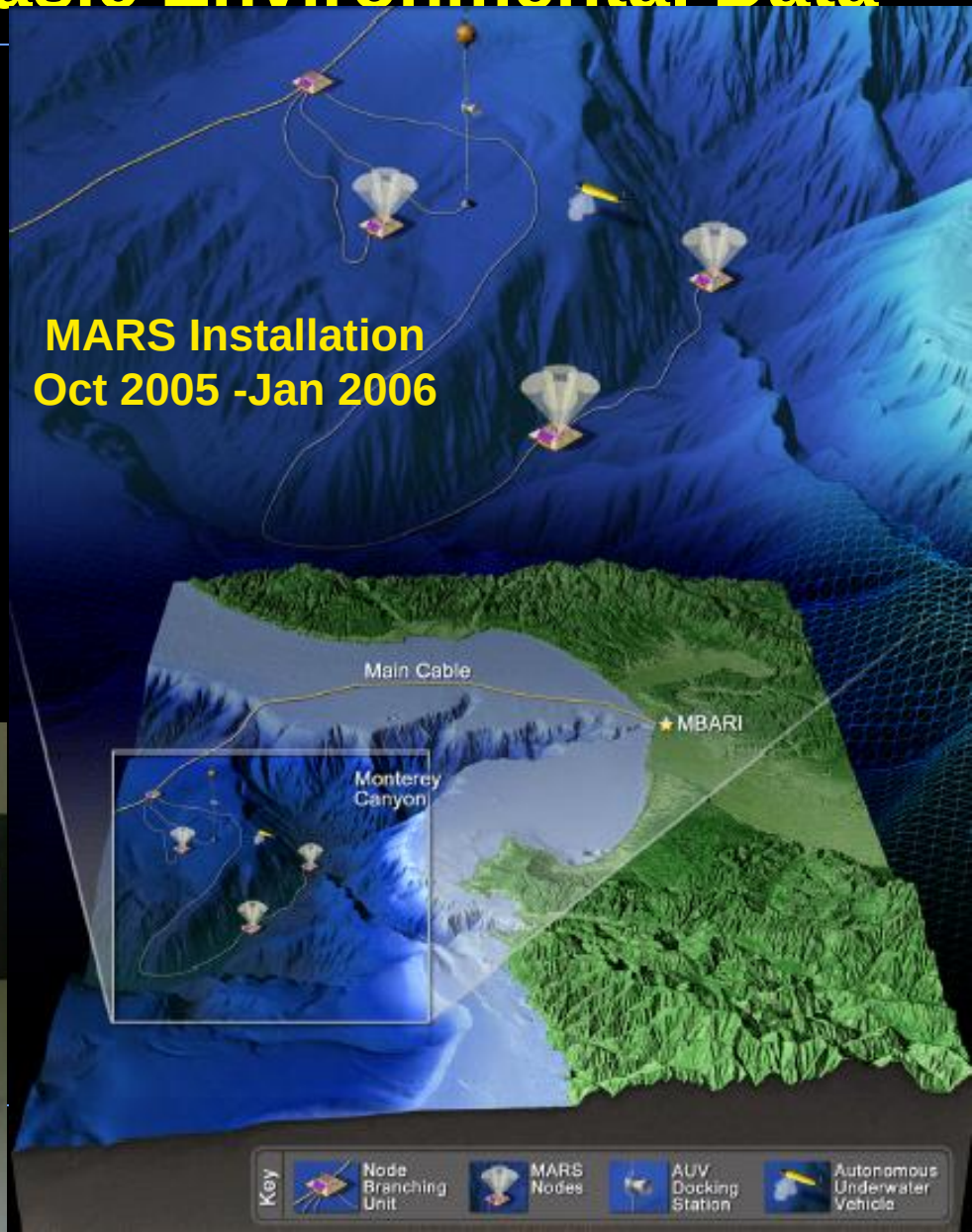
MARS New Gen Cable Observatory Testbed - Capturing Real-Time Basic Environmental Data



MARS Installation
Oct 2005 -Jan 2006



Tele-Operated Crawlers

Source: Jim Bellingham, MBARI

CAMERA: Community Cyberinfrastructure for Advanced Marine Microbial Ecology Research and Analysis

National LambdaRail
Direct Connect
Computation and Storage Complex

Funded by: Gordon and Betty Moore Foundation

Joint Partnership of:

PI Larry Smarr

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Marine Genome Sequencing Project
Measuring the Genetic Diversity of Ocean Microbes

MARINE MICROBIOLOGY INITIATIVE

Gordon and Betty MOORE FOUNDATION

CAMERA will include
All Sorcerer II Metagenomic Data

J. Craig Venter INSTITUTE

Source: Larry Smarr, C. Venter

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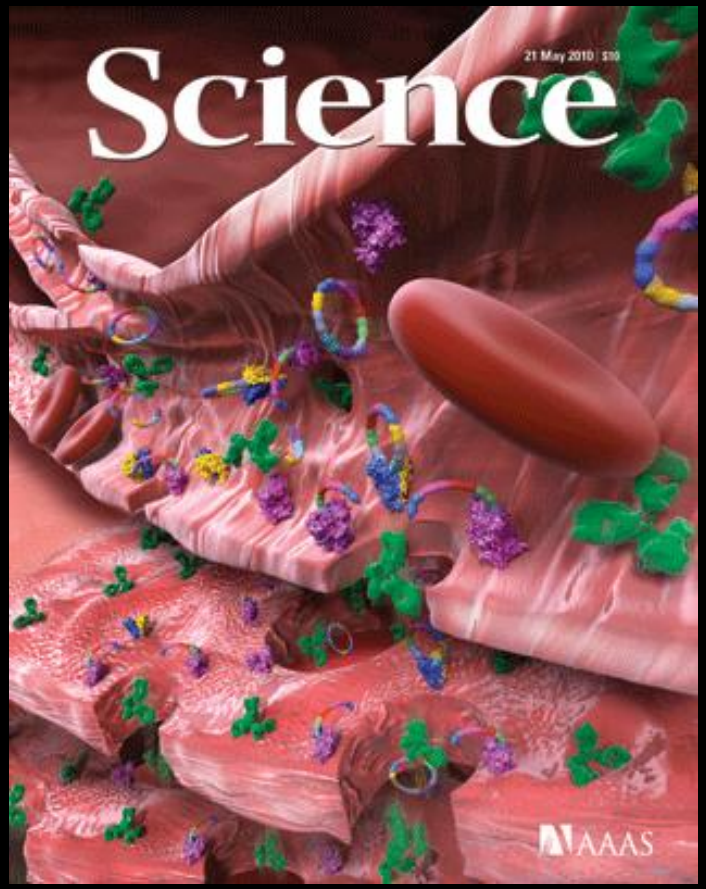
Craig Venter Announces Creation of the First Synthetic Life Form

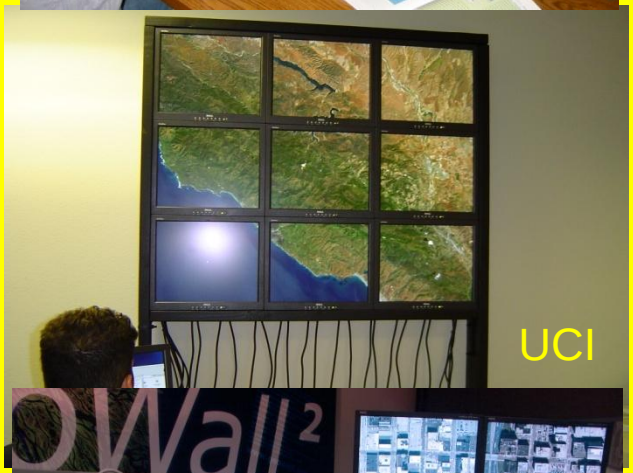


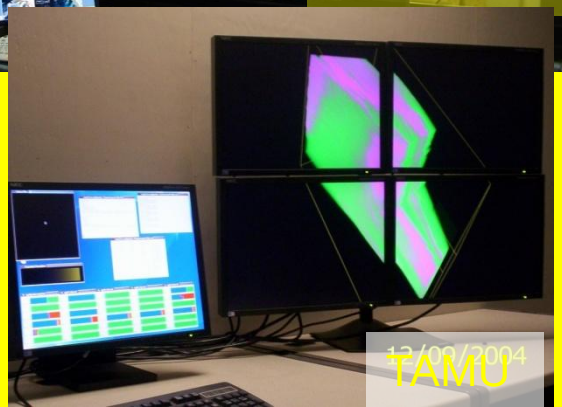
Creation of a Bacterial Cell Controlled by a Chemically Synthesized Genome

Daniel G. Gibson,1 John I. Glass,1 Carole Lartigue,1 Vladimir N. Noskov,1 Ray-Yuan Chuang,1 Mikkel A. Algire,1 Gwynedd A. Benders,2 Michael G. Montague,1 Li Ma,1 Monzia M. Moodie,1 Chuck Merryman,1 Sanjay Vashee,1 Radha Krishnakumar,1 Nacyra Assad-Garcia,1 Cynthia Andrews-Pfannkoch,1 Evgeniya A. Denisova,1 Lei Young,1 Zhi-Qing Qi,1 Thomas H. Segall-Shapiro,1 Christopher H. Calvey,1 Prashanth P. Parmar,1 Clyde A. Hutchison, III,2 Hamilton O. Smith,2 J. Craig Venter1,2,*

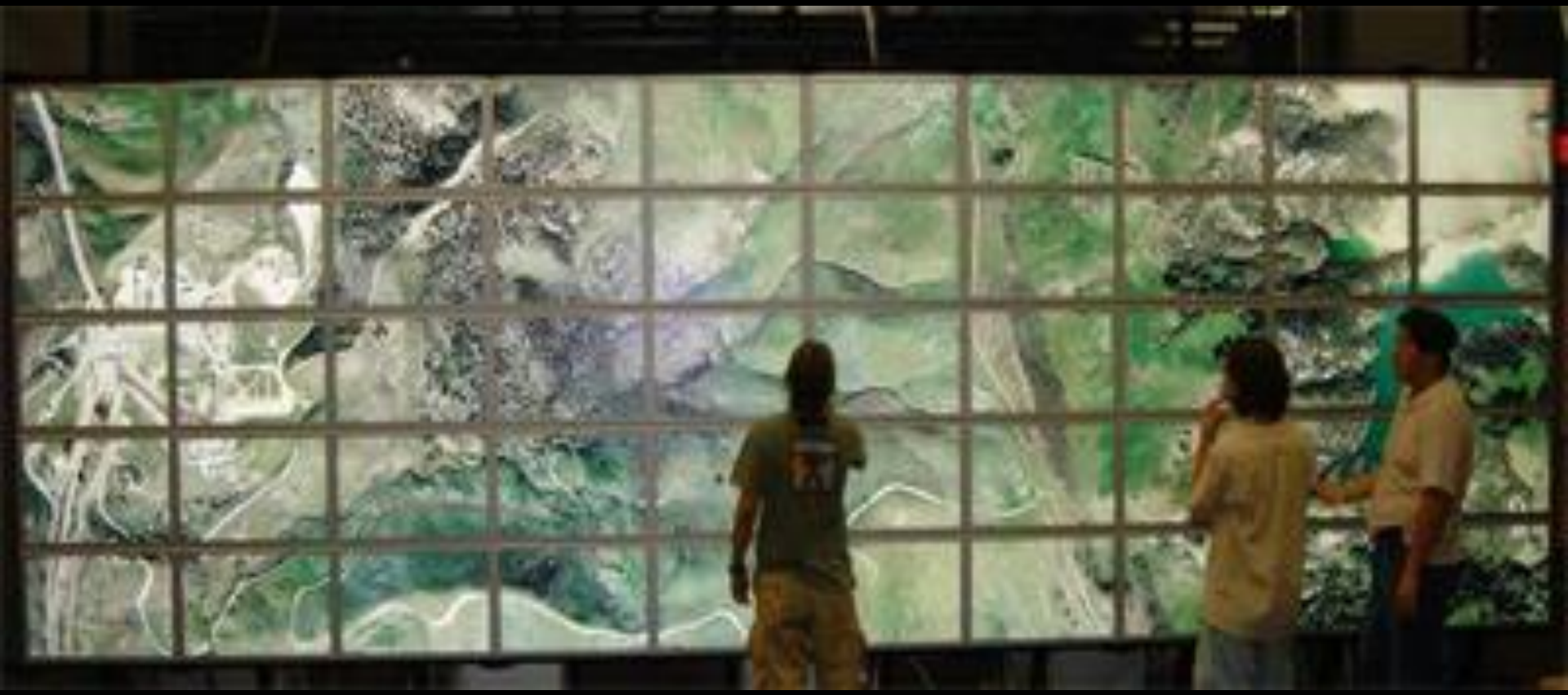
Published in Science, May 20, 2010
***Science* DOI: 10.1126/science.1190719**

OptIPortal Scalable Display Systems
(Source: Smarr, DeFanti OptIPuter)





Advanced Visualization Enabled By Optical Lightpaths



The 200-million-pixel HIPerWall at Calit2 on the UC Irvine campus is now part of the OptIPortal Collaboratory.

Source: UCSD

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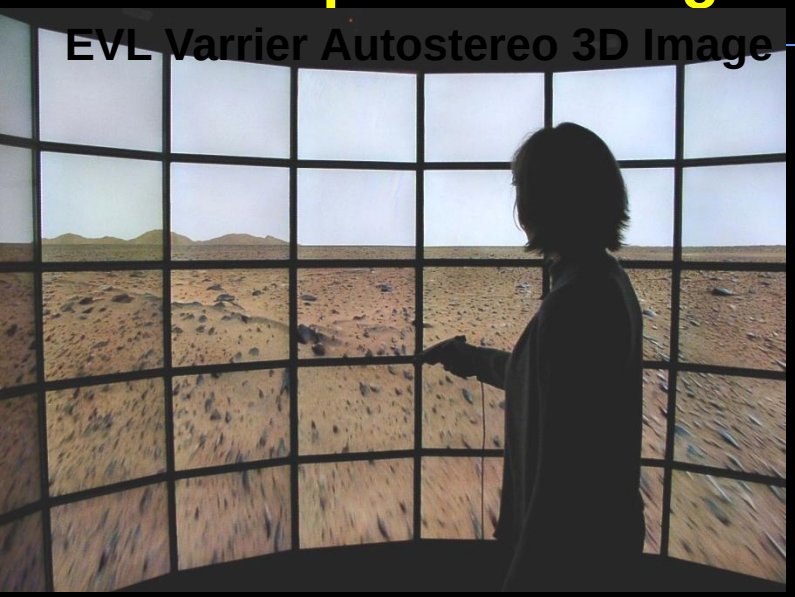
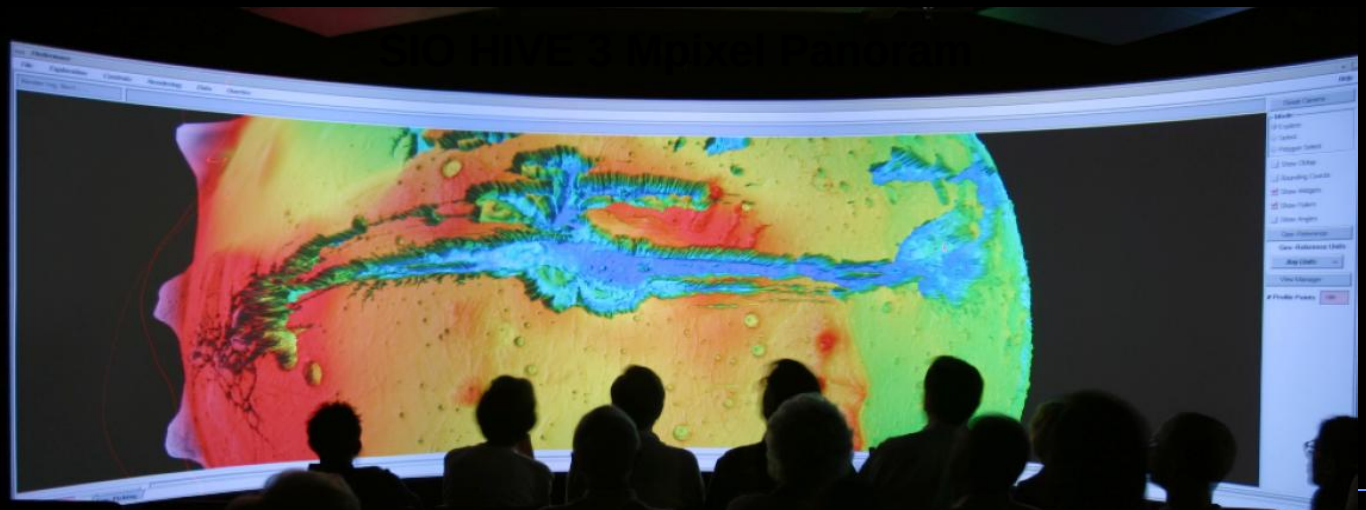
Harry Ammons Photography©


WHREN-ULA LSOB
wttw.tt

Earth and Planetary Sciences are an OptIPuter Large Data Object Visualization Driver





Source: Smarr, Defanti: OptIPuter

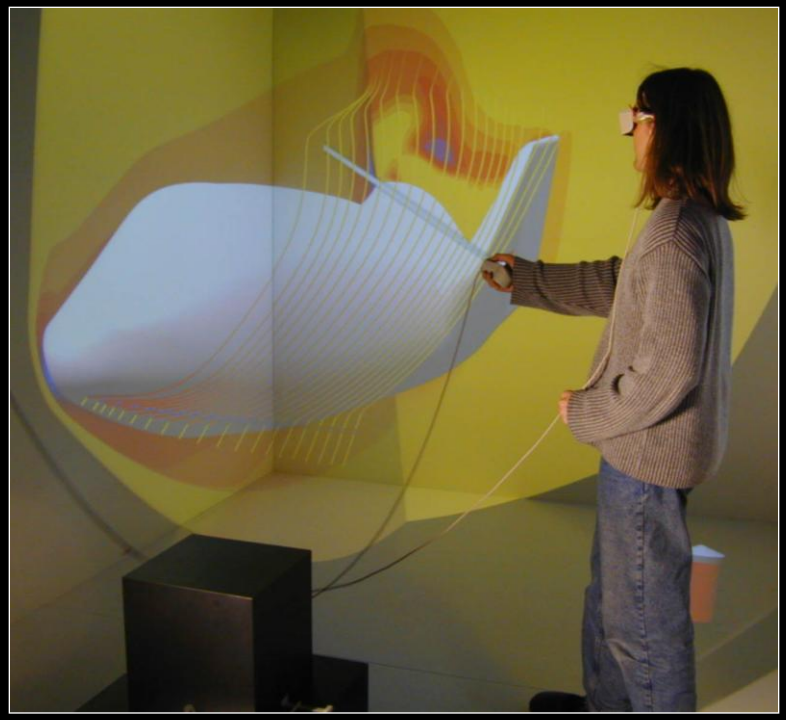
LIGHT SM

3D Modeling and Simulation

Distributed Simulation Analysis

- Sandia National Laboratories, USA
- High Performance Computing Center Stuttgart
- (HLRS), Germany

Thanks to the Computer Services for Academic Research Centre (Manchester, UK), the Centre of Virtual Environments at University of Salford (UK), Tsukuba Advanced Computing Center (Japan) and Pittsburgh Supercomputing Center (USA) for additional supercomputing resources.

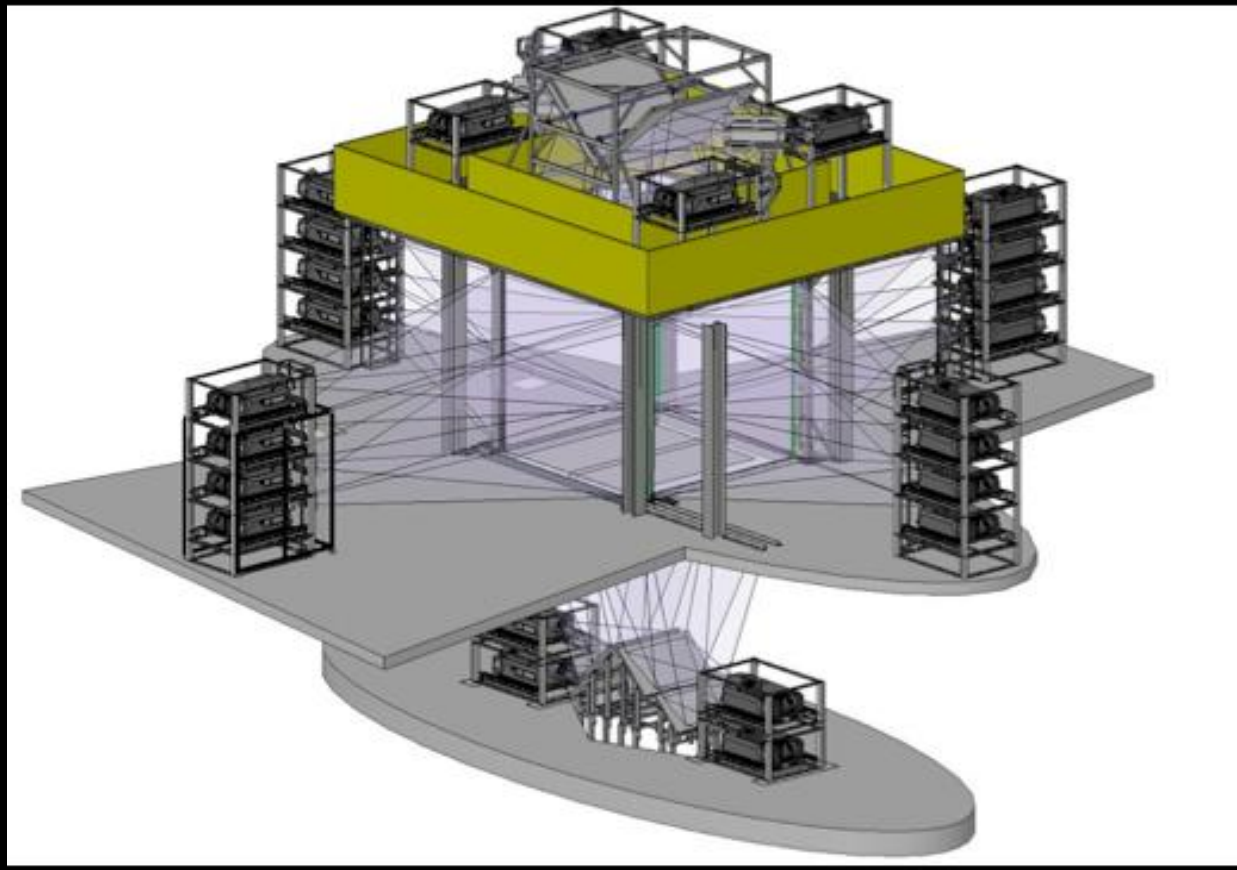


This application emphasizes distributed parallel supercomputing and a collaborative virtual-reality computation steering environment applied to Grand Challenge problems.

Source: Tom Defanti Dan Sandia, EVL

CORNEA

- Next step up in res/power: KAUST-Saudi Arabia
- 24 Sony 4K projectors 100 Million Pixels/eye
- 240,000 lumens!
- Mechdyne/Iowa State Design based on original 1991 EVL CAVE



Source: Tom DeFanti, UCSD, KAUST

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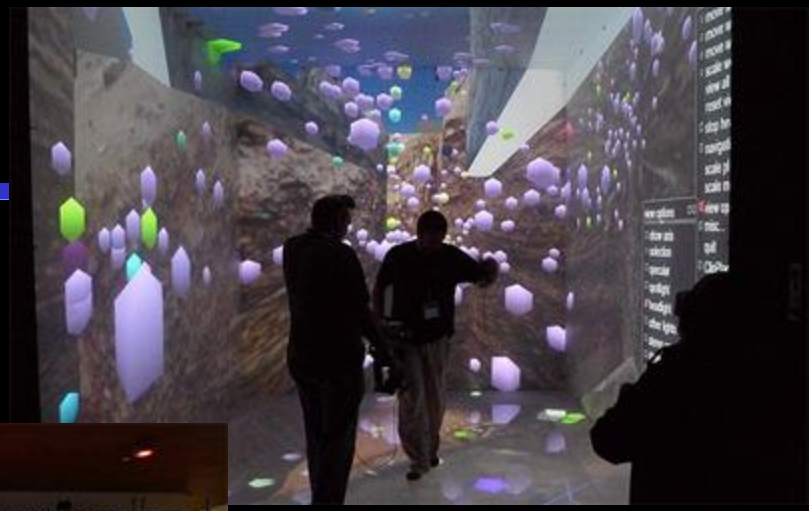
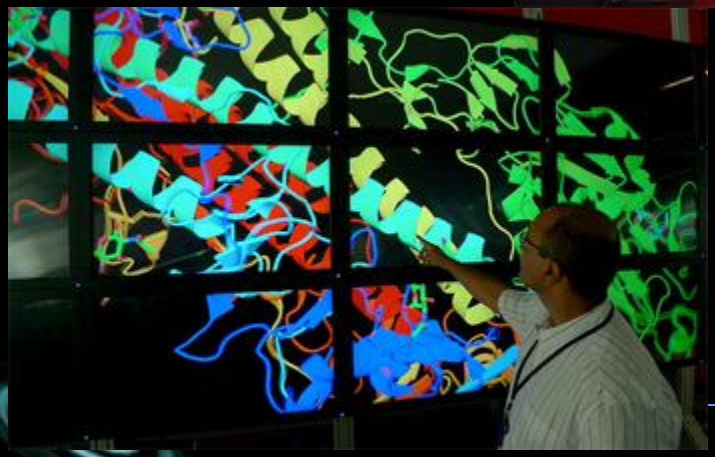


KAUST
CORNEA



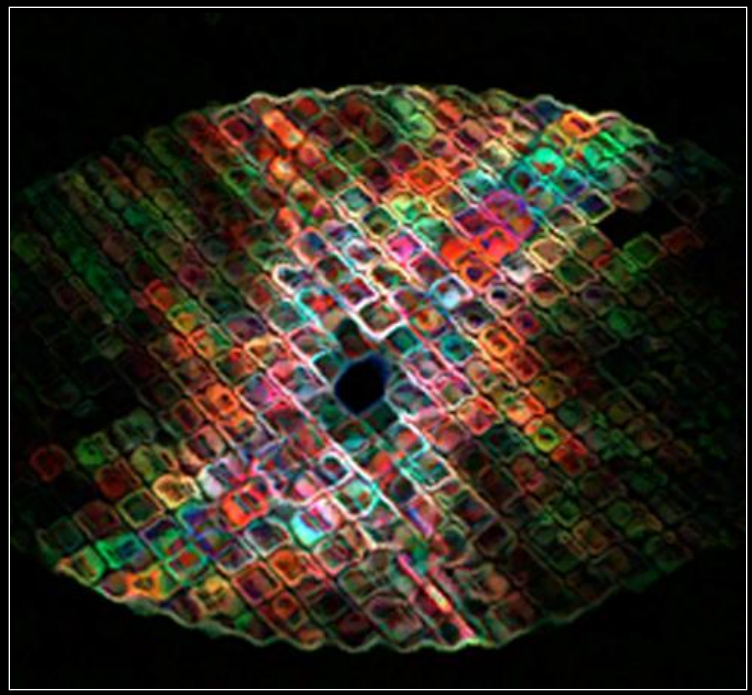
STARLIGHT SM

Digital Media (iGrid 2000, Yokohama Japan

USA, Canada, Japan, Singapore, Netherlands, Sweden, CERN, Spain, Mexico, Korea)

GiDVN: Global Internet Digital Video Network

- Digital Video Working Group, Coordinating Committee for International Research Networks
- CERN, Switzerland
- APAN, Japan; KDD, Japan
- APAN-KR, Korea; Seoul National University, Korea
- SURFnet, The Netherlands
- DFSCA-UNAM, Mexico
- SingAREN, Singapore
- Universitat Politecnica de Catalunya, Spain
- Royal Institute of Technology, Sweden
- Int'l Center for Advanced Internet Research (iCAIR), Northwestern, USA



GiDVN projects have enhanced media capabilities for the next-generation Internet, enabling new applications to interoperate throughout the world.

www.icair.org/inet2000

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4K Media

4K Digital Media
Ultra High Definition
Digital
Communications

Digital communications using SHD transmits extra-high-quality, digital, full-color, full motion images.

4k pixels horizontal, 2k vertical

4 * HDTV – 24 * DVD

4K Video is approximately 4X standard HD

HD = 720x1280 or 1080x1920 pixels

4K = 3840x2160 pixels

www.onlab.ntt.co.jp/en/mn/shd

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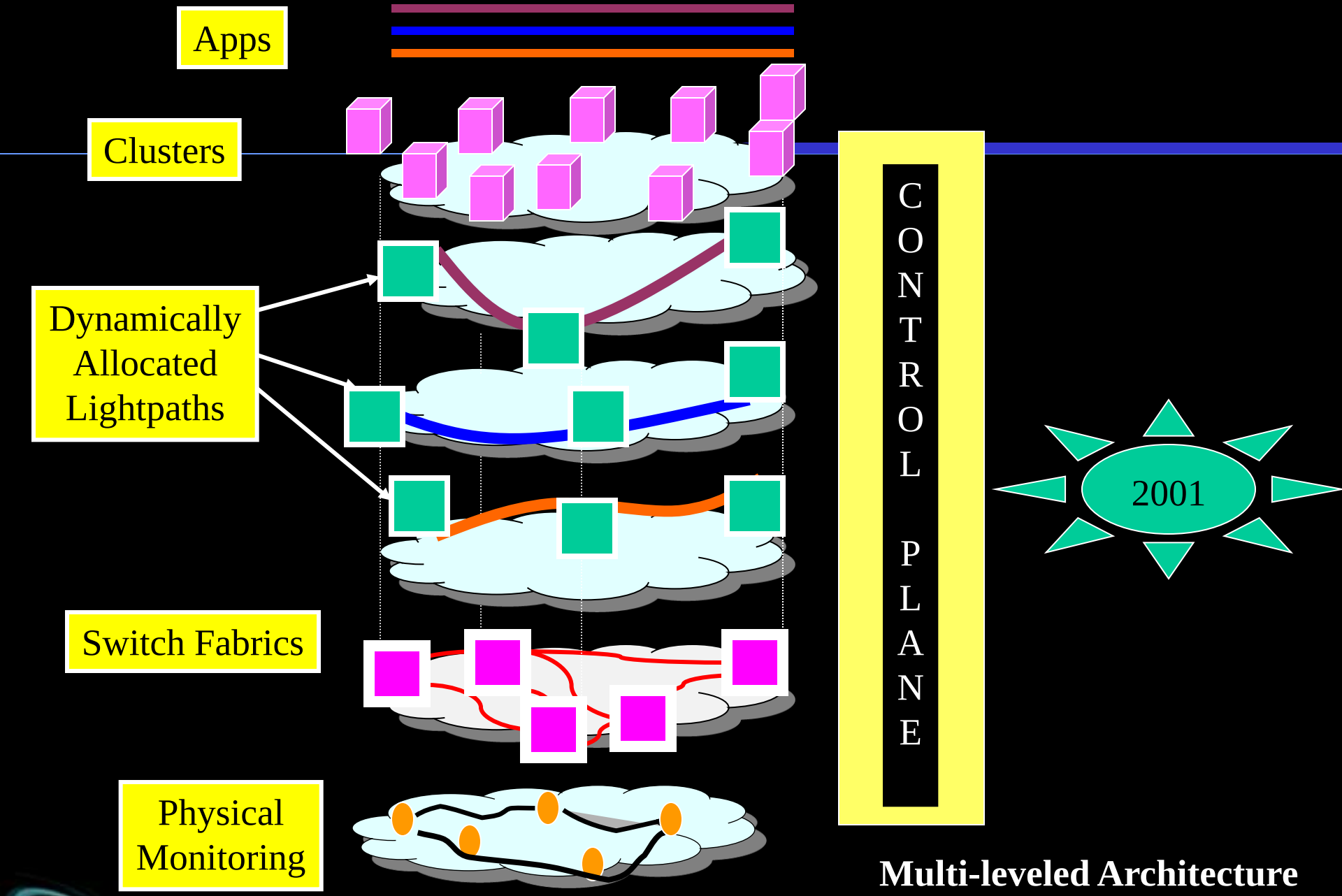

Multi-leveled Architecture

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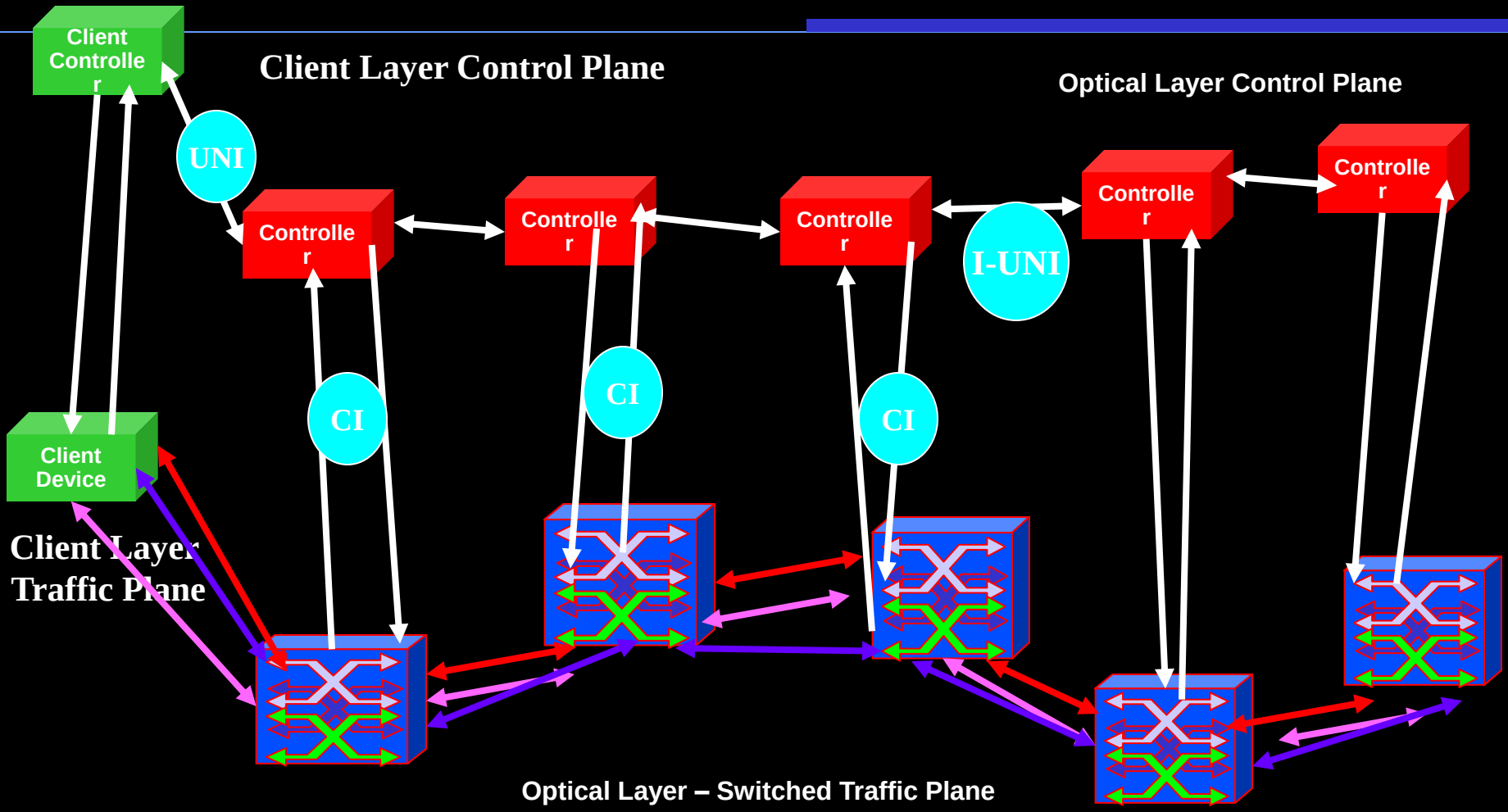
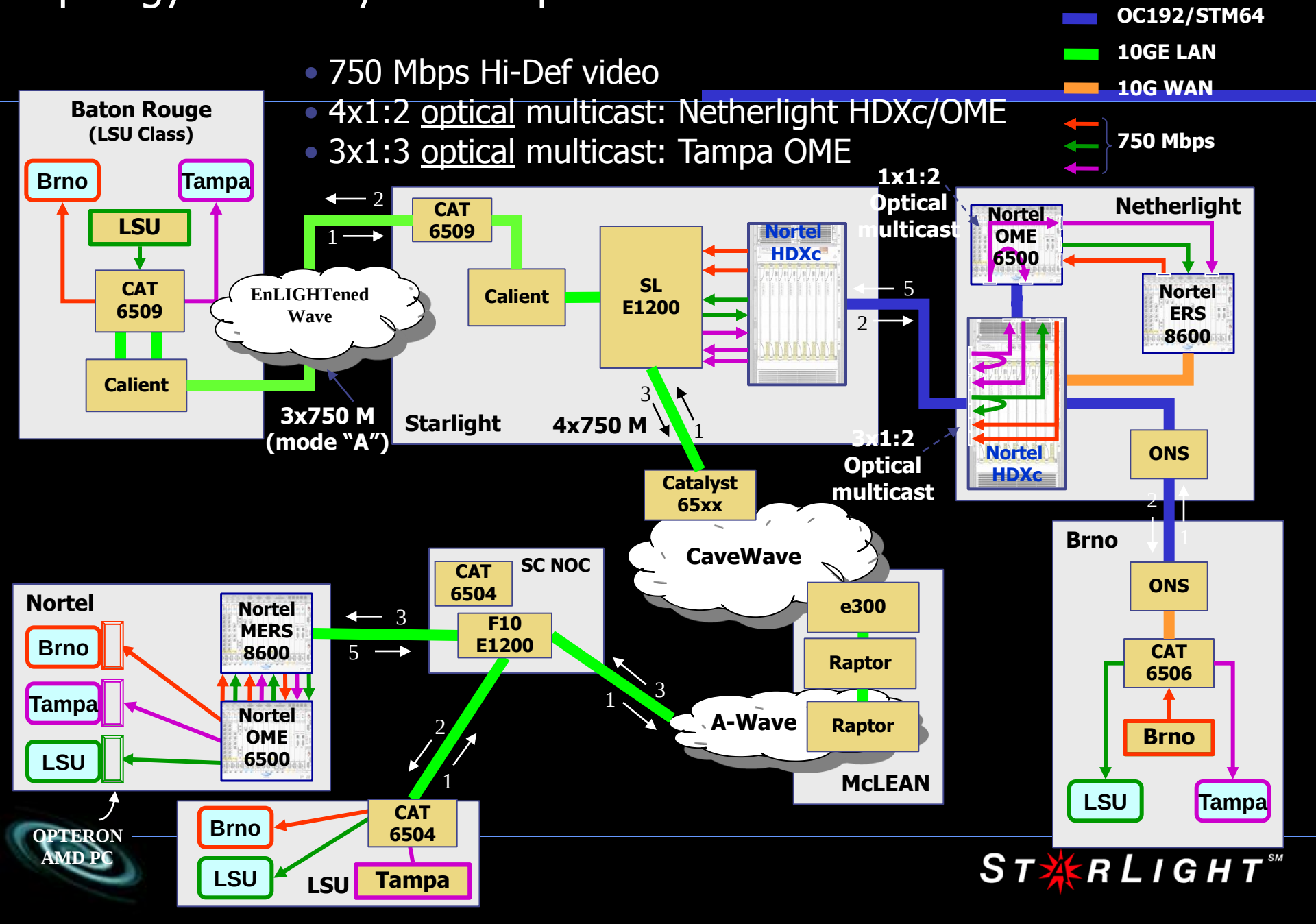
Optical Layer Control Plane



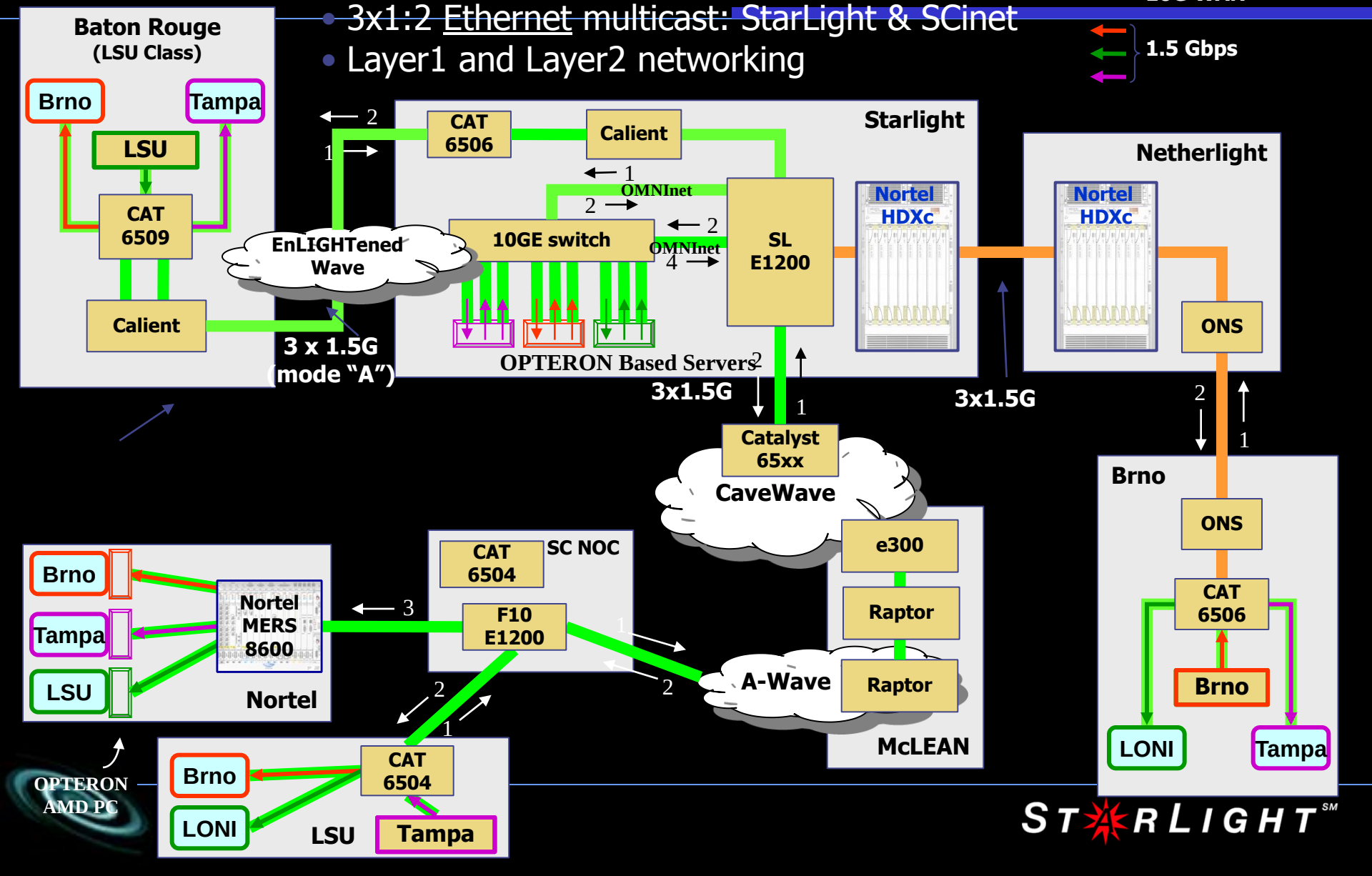
Topology for L1 Dynamic Optical Multicast SC06 Demo

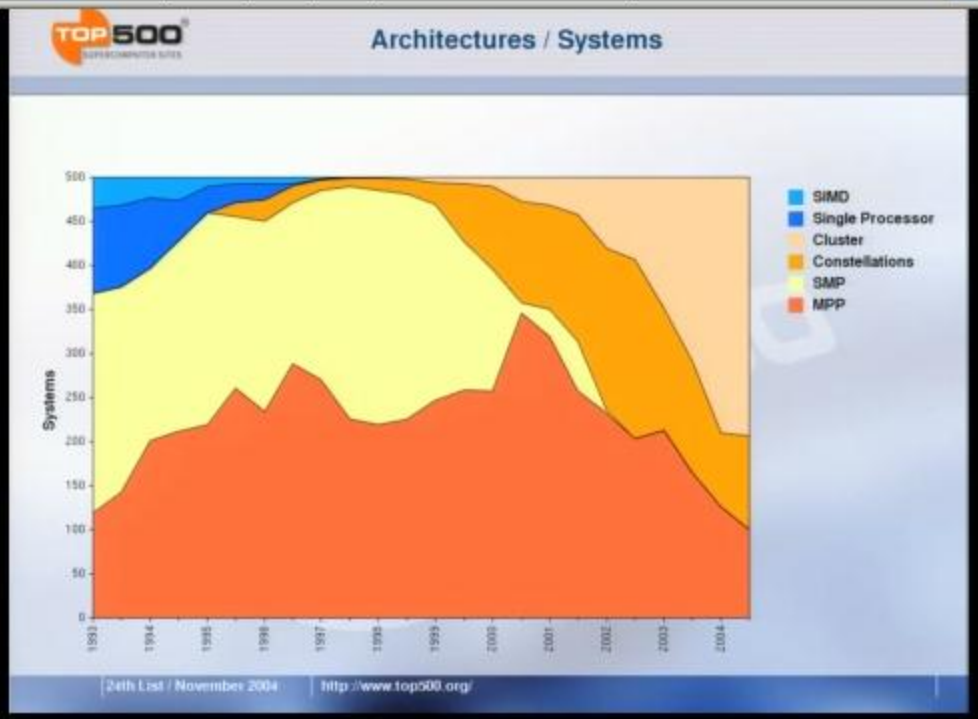
- 750 Mbps Hi-Def video
- 4x1:2 optical multicast: Netherlight HDXc/OME
- 3x1:3 optical multicast: Tampa OME



Topology for L2 Multicast SC06 Demo (L2 Stream Duplication)

- 1.5 Gbps Hi-Def video
- 3x1:2 Ethernet multicast: StarLight & SCinet
- Layer1 and Layer2 networking





Introduction to High Performance Computing

Dr. Thomas Sterling
January 16, 2007

Week One: Class One Introduction

LSU Center for Computation & Technology
http://www.cct.lsu.edu/

The First Public Demonstration Of HPDMnet GDOM Was Staged At GLIF 2007 in Prague, Czech Republic Sept 17-18, 2007

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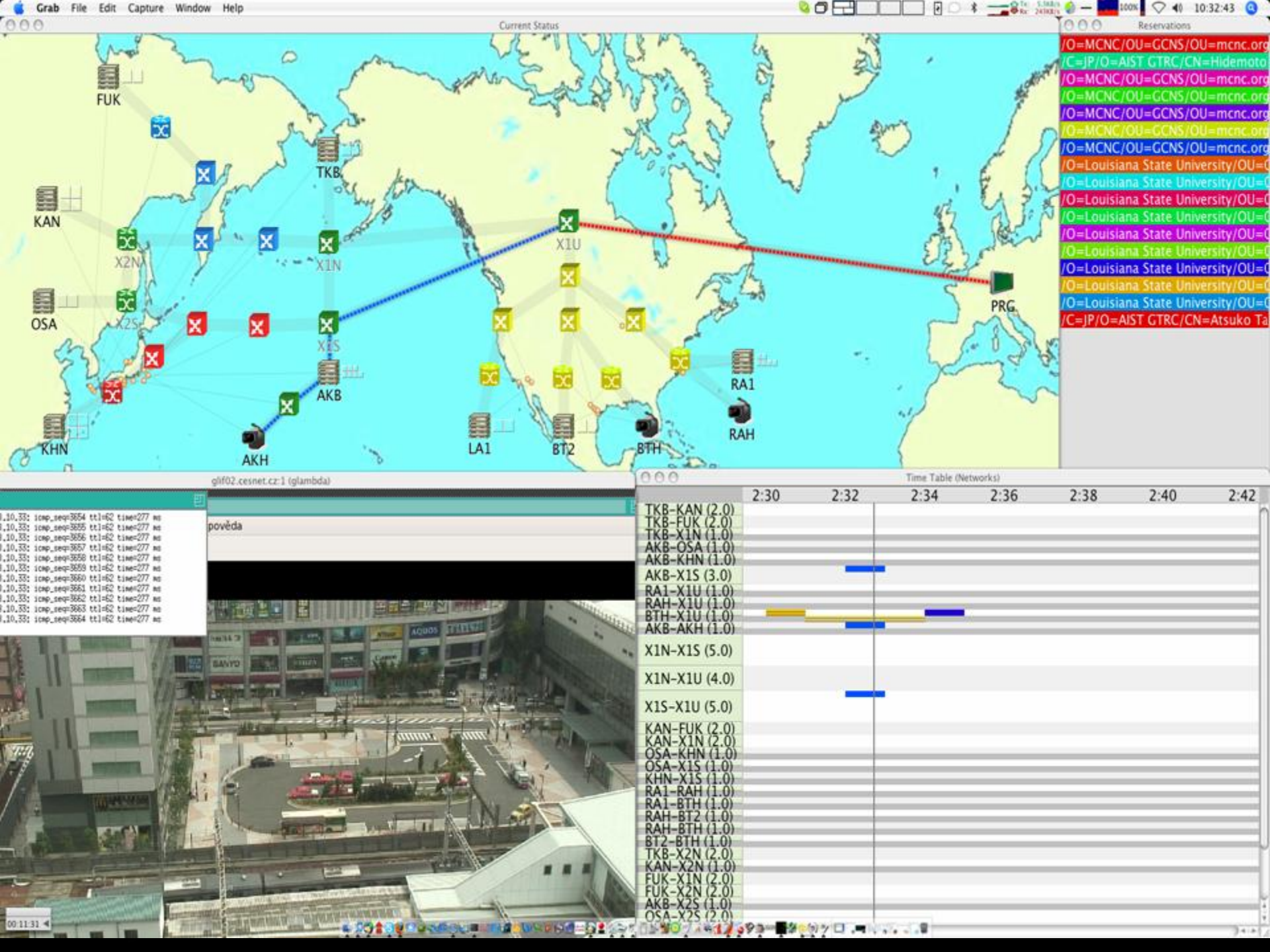
High Performance Digital Media GLIF

- A Consortium of Research Centers From Around the World Has Formed a Cooperative Partnership To Explore the Key Issues Related to the Challenges and Opportunities Related to Using Lightpaths for High Performance Digital Media (HPDM)
- At the Annual Global LambdaGrid Workshop in Prague, Demonstrations Have Been Designed to Show the Current Project Status
- Multiple Sites Require High Performance/High Volume/High Definition Digital Media Streaming Simultaneously Among All Locations (Multi-Point to Multi-Point)

Music Grid Canada - Prague


Grab File Edit Capture Window Help
10:32:43
Current Status
Reservations
/O=MCNC/OU=GCNS/OU=mcnc.org
/C=JP/O=AIST GTRC/CN=Hidemoto
/O=MCNC/OU=GCNS/OU=mcnc.org
/O=MCNC/OU=GCNS/OU=mcnc.org
/O=MCNC/OU=GCNS/OU=mcnc.org
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/O=Louisiana State University/OU=
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/O=Louisiana State University/OU=
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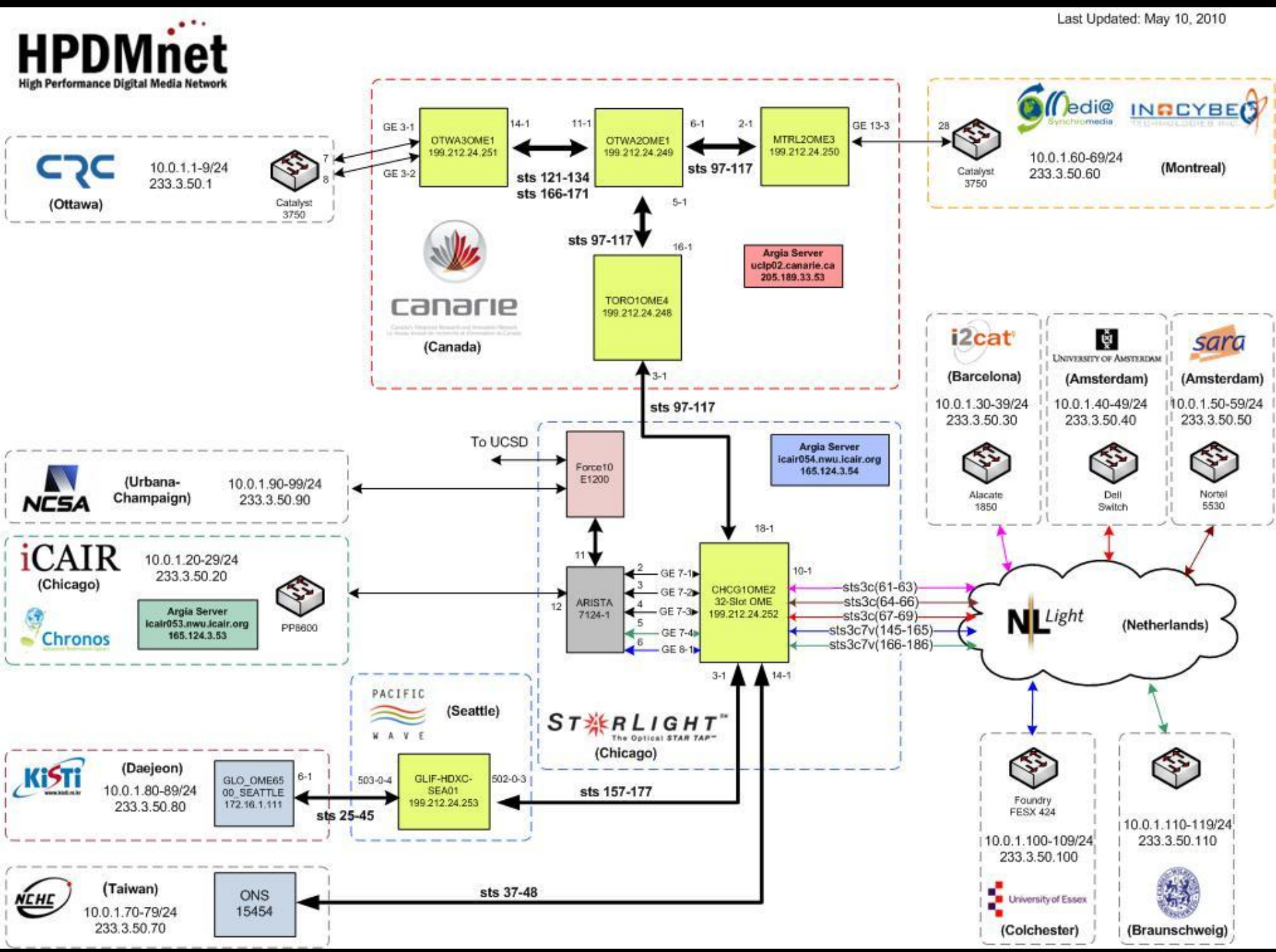
/O=Louisiana State University/OU=
/C=JP/O=AIST GTRC/CN=Atsuko Ta
FUK
TKB
KAN
X2N
X1N
X1U
PRG
OSA
X2S
X1S
AKB
RA1
RAH
KHN
AKH
LA1
BT2
BTH
glif02.cesnet.cz:1 (glambda)
pověda
Time Table (Networks)
2:30
2:32
2:34
2:36
2:38
2:40
2:42
TKB-KAN (2.0)
TKB-FUK (2.0)
TKB-X1N (1.0)
AKB-OSA (1.0)
AKB-KHN (1.0)
AKB-X1S (3.0)
RA1-X1U (1.0)
RAH-X1U (1.0)
BTH-X1U (1.0)
AKB-AKH (1.0)
X1N-X1S (5.0)
X1N-X1U (4.0)
X1S-X1U (5.0)
KAN-FUK (2.0)
KAN-X1N (2.0)
OSA-KHN (1.0)
OSA-X1S (1.0)
KHN-X1S (1.0)
RA1-RAH (1.0)
RA1-BTH (1.0)
RAH-BT2 (1.0)
RAH-BTH (1.0)
BT2-BTH (1.0)
TKB-X2N (2.0)
KAN-X2N (1.0)
FUK-X1N (2.0)
FUK-X2N (2.0)
AKB-X2S (1.0)
OSA-X2S (2.0)

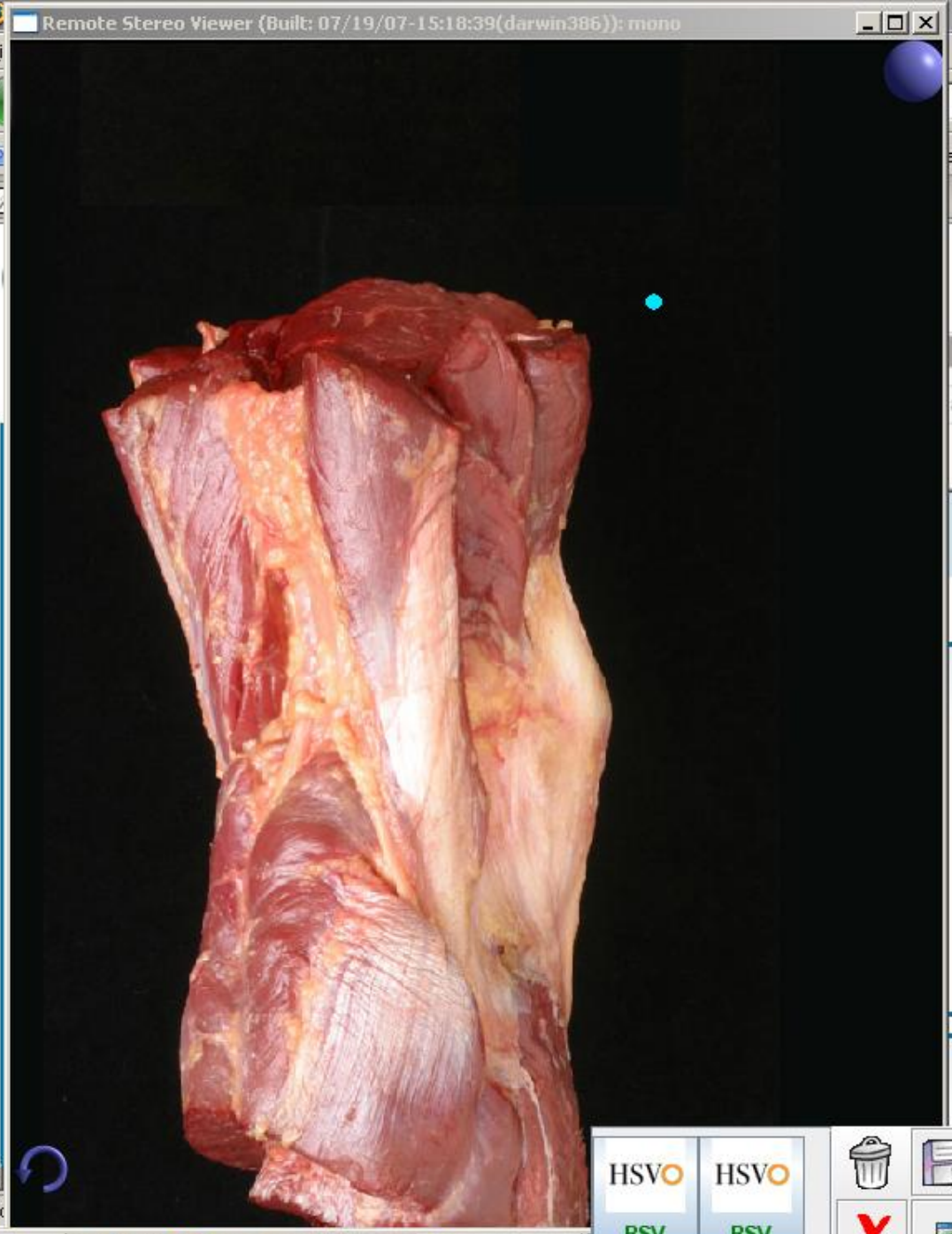
Last Updated: May 10, 2010

HPDMnet

High Performance Digital Media Network



iCAIR 3D HD HPDMnet Demonstration At GLIF Deajong, South Korea Oct 2009



Command Prompt - ping -t 10.20.200.91

```
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=79ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
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Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
```

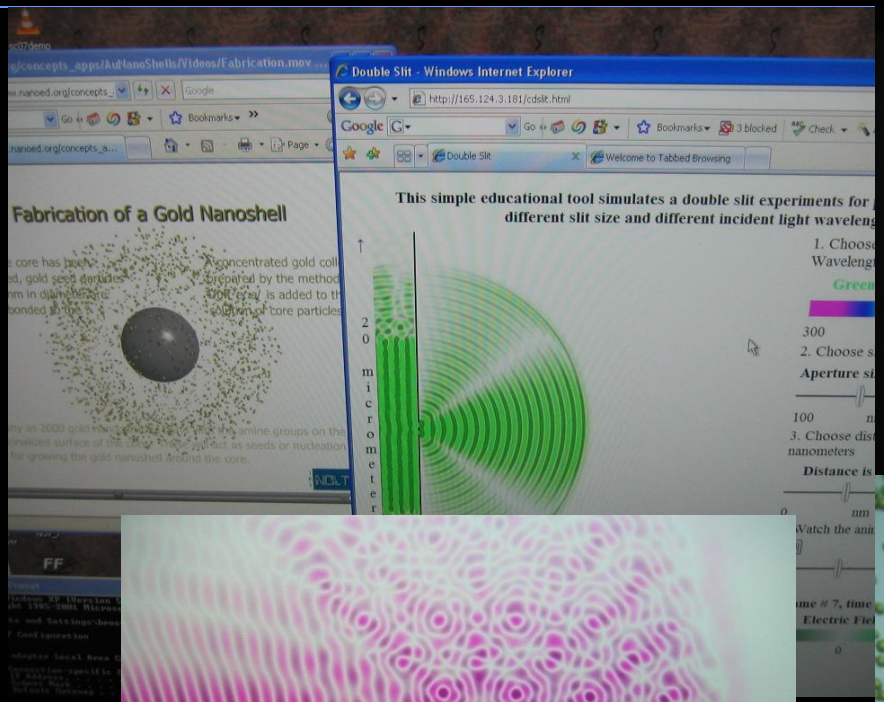
Testbed Demonstrations With National Science Foundation at the Annual Conference of The American Association for the Advancement of Science February 2009

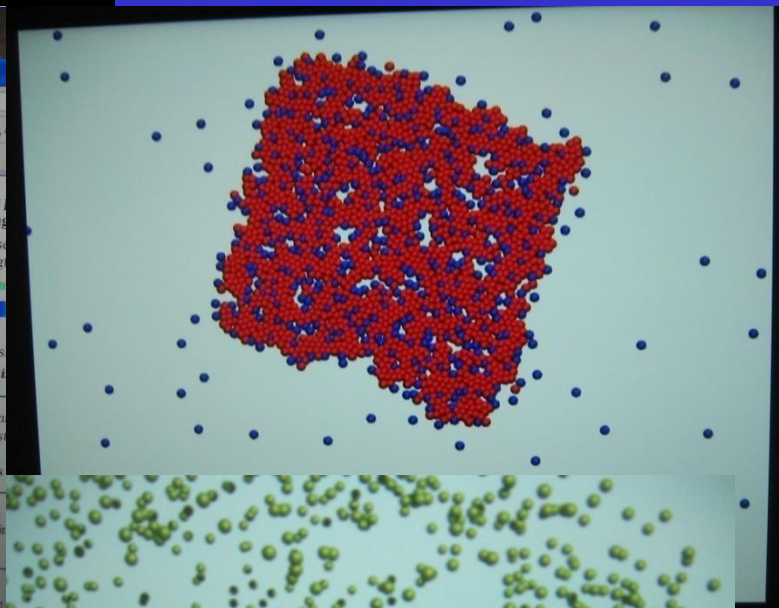
Using An Optical Fiber Extension from StarLight/GLIF

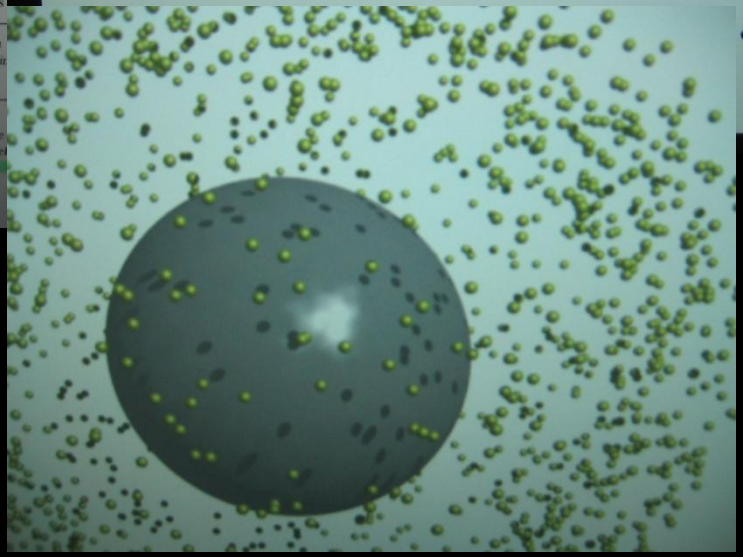
STARLIGHT℠

Virtual Instruments for Science

Cooperative Project iCAIR, NCLT

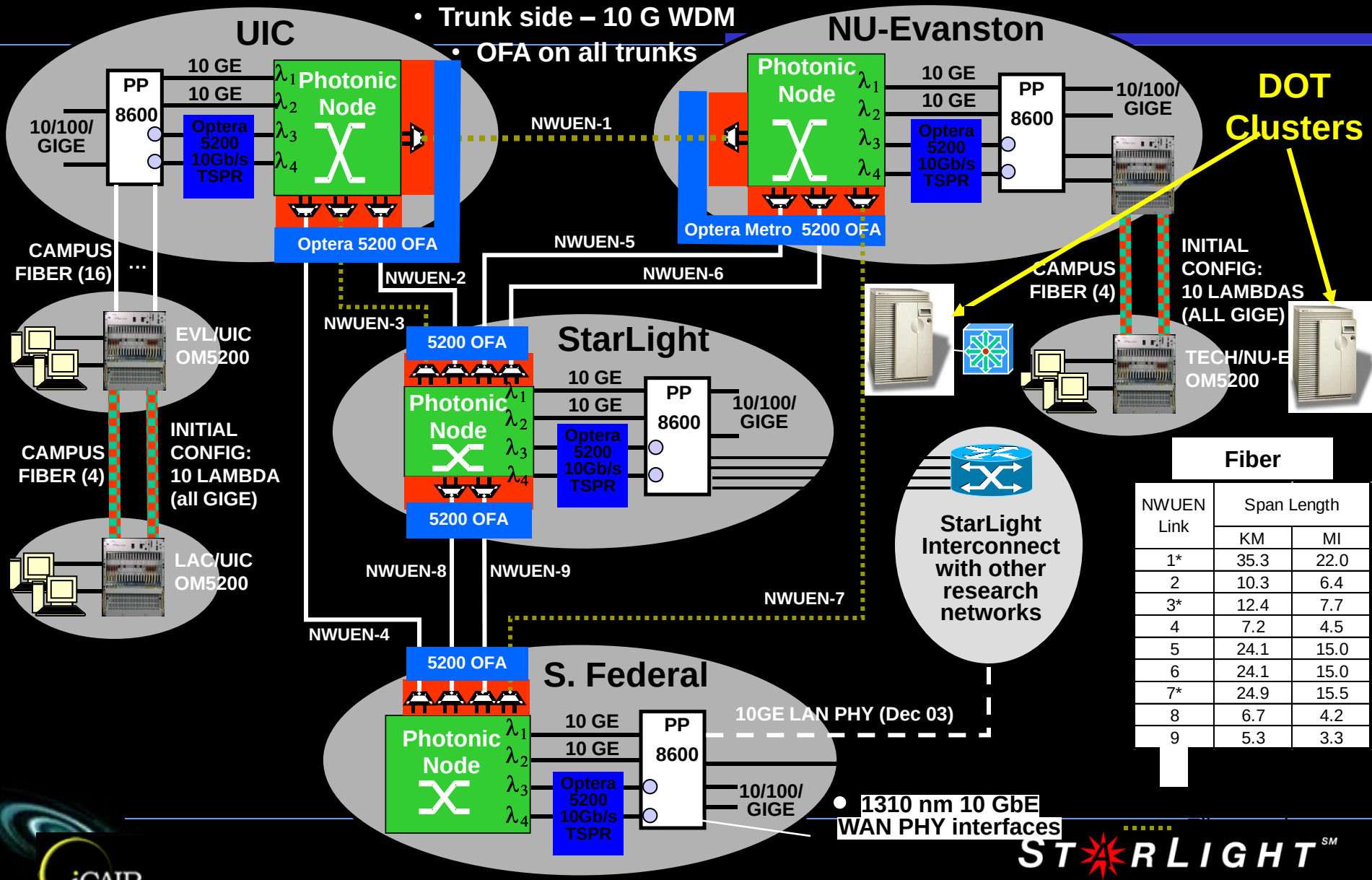






OMNInet Network Configuration Phase 2 (Extended Via Demonstrations Nationally and Internationally)

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



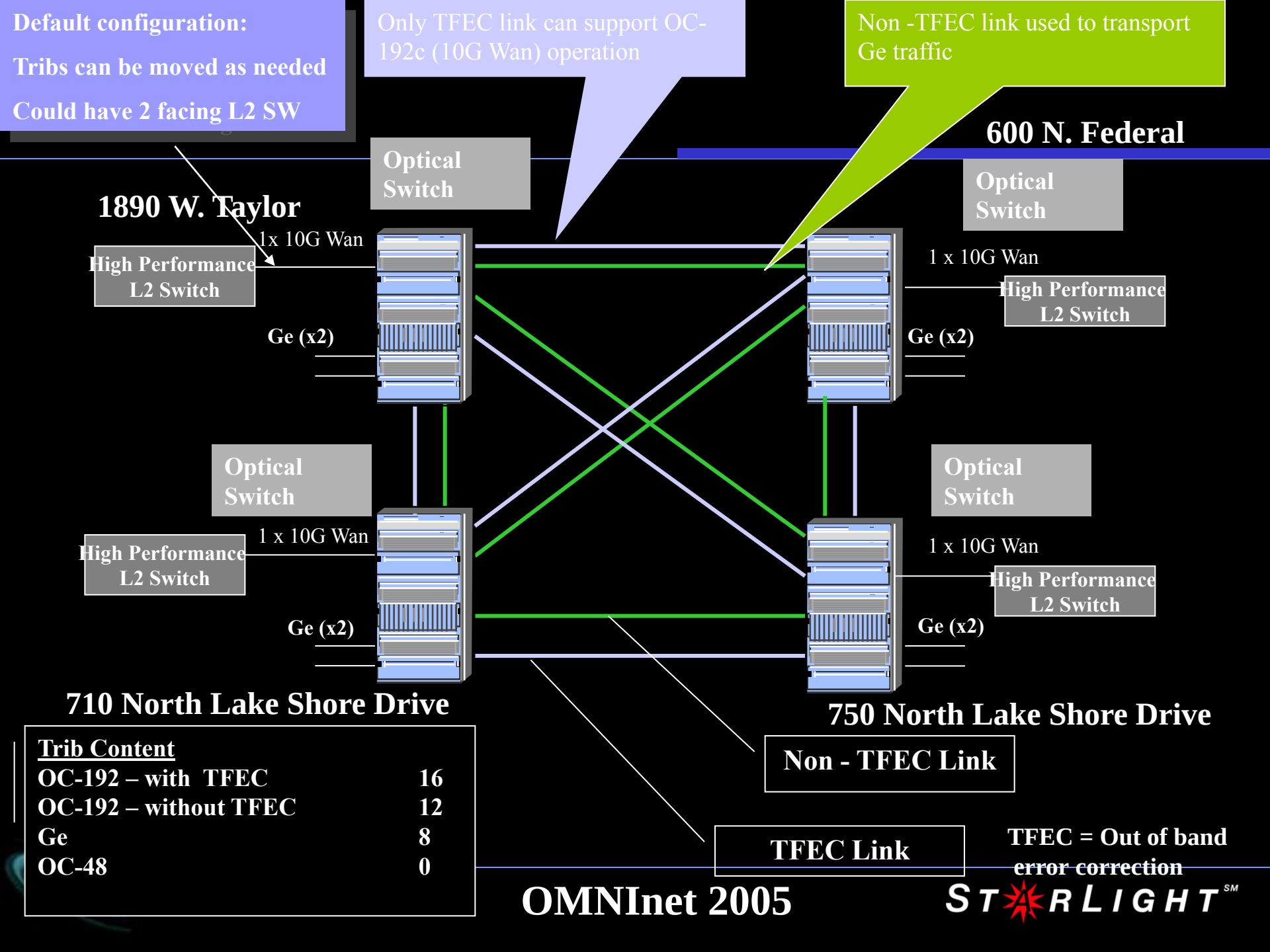
Fiber

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

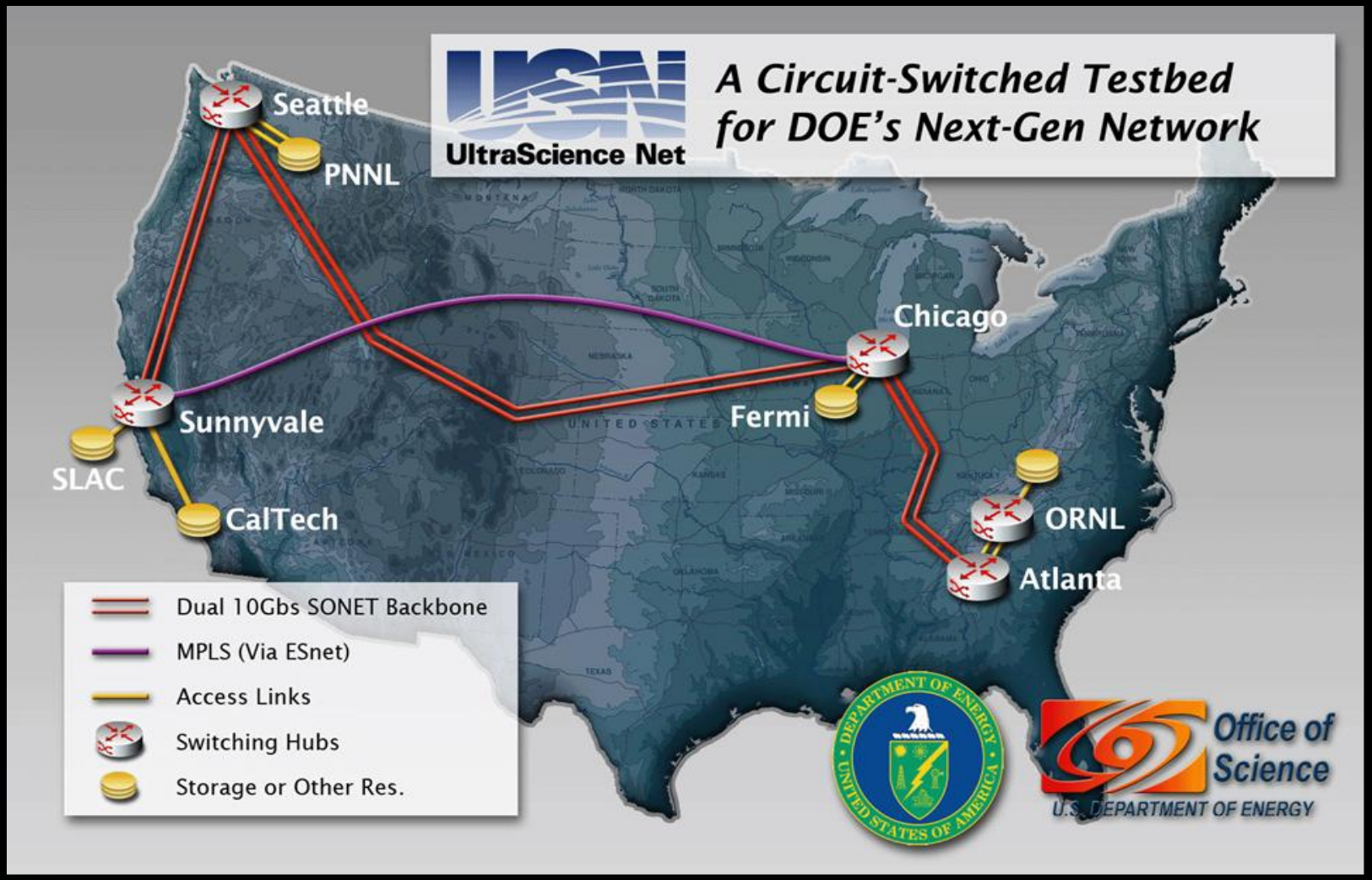
iCAIR

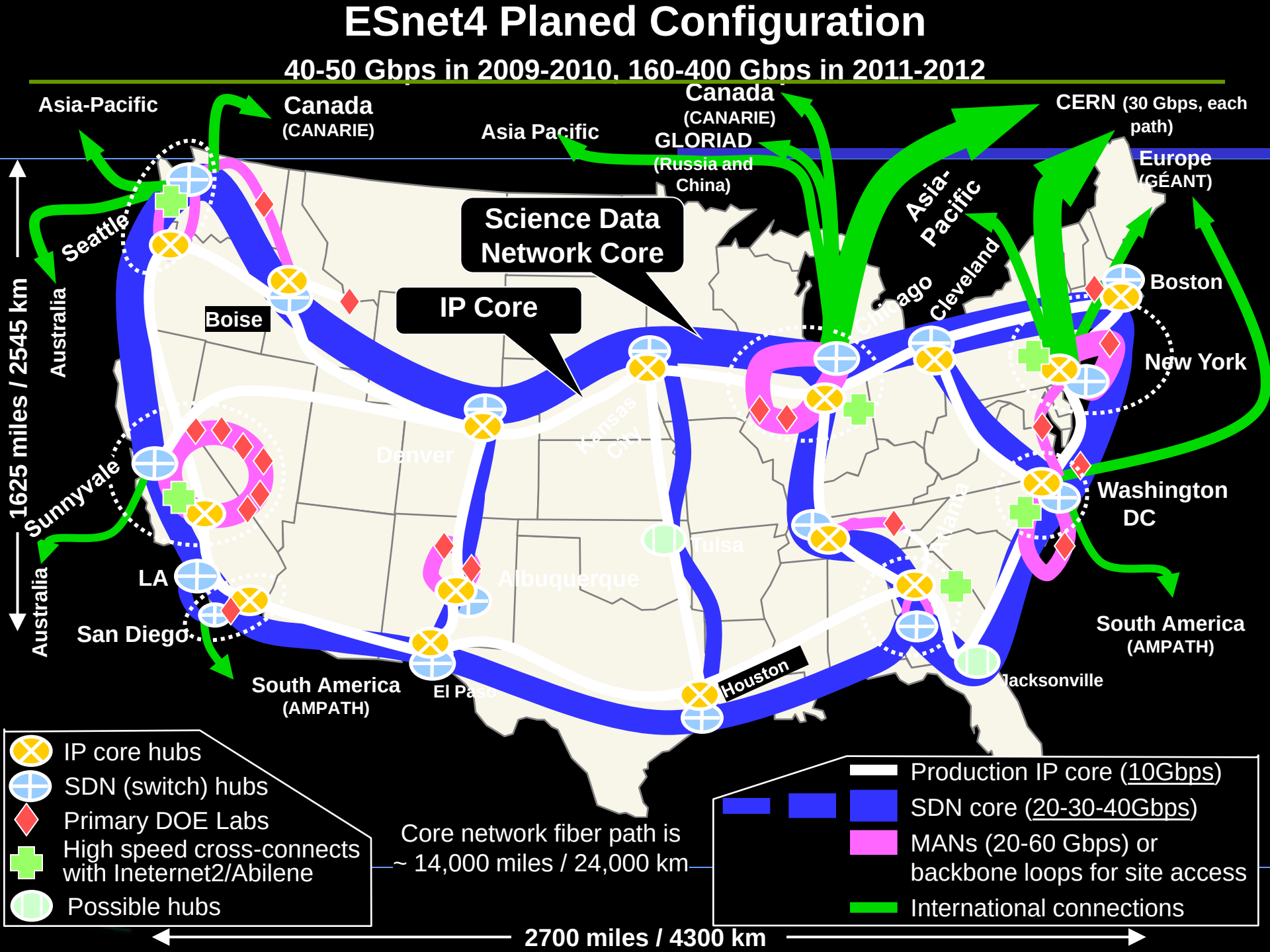
STARLIGHT SM


DWDM-RAM GUI
DWDMRAM Server:
Port: 8080
Refresh
Reset
Exit
dark
lit
external
Chicago
Sheridan (3)
LakeShore (4)
West Taylor (1)
Federal (5)
~10 Miles
~10 Miles
Lake Michigan
Community Golf Course
Church St
Davis St
Dempster St
W Division St
W Chicago Ave
W Grand Ave
W Warren Blvd
W Adams St
W Harrison St
W Roosevelt Rd
N Noble St
N Ogden Ave
N Racine Ave
N State St
Western Ave
Green Bay Rd
Ridge Ave
Sheridan Rd
West Town
Near North Side
Little Sicily
Cabrini Addition
Fifty Acres
William Green Homes
Carl Sandburg Village
Towertown
Wolcotts And Bushnells Additions
McCormickville
Swede Town
Linzie's Addition
Cityfront Center
Cityfront Place
Family Golf Centers At Chicago
Fort Dearborn Addition
Carpenters Addition
Nearwest Side
Duncans Addition
Garibaldi Square
University Of Illinois At Chicago
Malcolm X College
Claremont Cottages
Grace Abbott Homes
Conleys Patch
Central Station
Burnham Place
Film Row
Merrill C Meigs Field
1.0 km
0.5 mi


Default configuration:
Tribs can be moved as needed
Could have 2 facing L2 SW
Only TFEC link can support OC-192c (10G Wan) operation
Non -TFEC link used to transport Ge traffic
600 N. Federal
Optical Switch
1890 W. Taylor
1x 10G Wan
High Performance L2 Switch
Ge (x2)
Optical Switch
1 x 10G Wan
High Performance L2 Switch
Ge (x2)
Optical Switch
1 x 10G Wan
High Performance L2 Switch
Ge (x2)
Optical Switch
1 x 10G Wan
High Performance L2 Switch
Ge (x2)
710 North Lake Shore Drive
750 North Lake Shore Drive
Non - TFEC Link
TFEC Link
Trib Content
OC-192 – with TFEC 16
OC-192 – without TFEC 12
Ge 8
OC-48 0
TFEC = Out of band error correction
OMNInet 2005
STARLIGHT SM

DOE's UltraScience Net at StarLight




ESnet4 Planed Configuration
40-50 Gbps in 2009-2010, 160-400 Gbps in 2011-2012
Asia-Pacific
Canada (CANARIE)
Asia Pacific
Canada (CANARIE)
GLORIAD (Russia and China)
CERN (30 Gbps, each path)
Europe (GÉANT)
Science Data Network Core
IP Core
Seattle
Boise
Asia-Pacific
Cleveland
Boston
New York
Washington DC
Sunnyvale
Denver
Kansas City
Tulsa
Albuquerque
LA
San Diego
South America (AMPATH)
El Paso
Houston
Jacksonville
South America (AMPATH)
Australia
1625 miles / 2545 km
Australia
IP core hubs
SDN (switch) hubs
Primary DOE Labs
High speed cross-connects with Ineternet2/Abilene
Possible hubs
Core network fiber path is ~ 14,000 miles / 24,000 km
Production IP core (10Gbps)
SDN core (20-30-40Gbps)
MANs (20-60 Gbps) or backbone loops for site access
International connections
2700 miles / 4300 km

Network Topology for Cosmo Grid experiment – Round Trip Performance Test –

Rev 0.8 Jan. 21 2008
original by tanaka@kddnet.ad.jp
revised by morikubo@jgn2plus.jp
revised by yama@wide.ad.jp

Seattle
Pacific Northwest Gigapop
Foundry RX4
Cisco 7609
10.0.9.61/24
10.0.8.61/24

10G STM-64/10GE WAN-PHY
10GE LAN-PHY

Mitaka,Tokyo
Cray TX4
10.0.1.2/24
10.0.9.2/24
10.0.0.2/24
Foundry RX4
10.0.8.2/24
10.0.1.1/24
10.0.9.1/24
Foundry MLX
10.0.0.1/24
10.0.8.1/24
NAOJ

IEEAF Layer2 Net

JGN2plus
Hitachi GS4K
Force10 E1200
Nortel HDX
StarLIGHT
IRNC circuit
NorthWestern Univ.
710 Lakeshore Chicago
NLR Layer1 WaveNet
NetherLight
Nortel HDX
Nortel ERS8K

T-LEX
Foundry NI40G
10.0.8.60/24
10.0.9.60/24
10.0.9.50/24
SINET3 Layer2 Net

Force10 E300
JGN2plus
626 wilshre, L.A.

vlan mapping
Hitachi GS4K
10.0.8.50/24
10.0.1.50/24
10.0.0.50/24 JGN2plus
NTT-com Otemachi, Tokyo

Hitachi GS4K
JGN2plus
KDDI Otemachi, Tokyo

10.0.0.254/24
Huygens Router
145.100.3.29/30
145.100.3.30/30
Huygens Router
SARA
Amsterdam

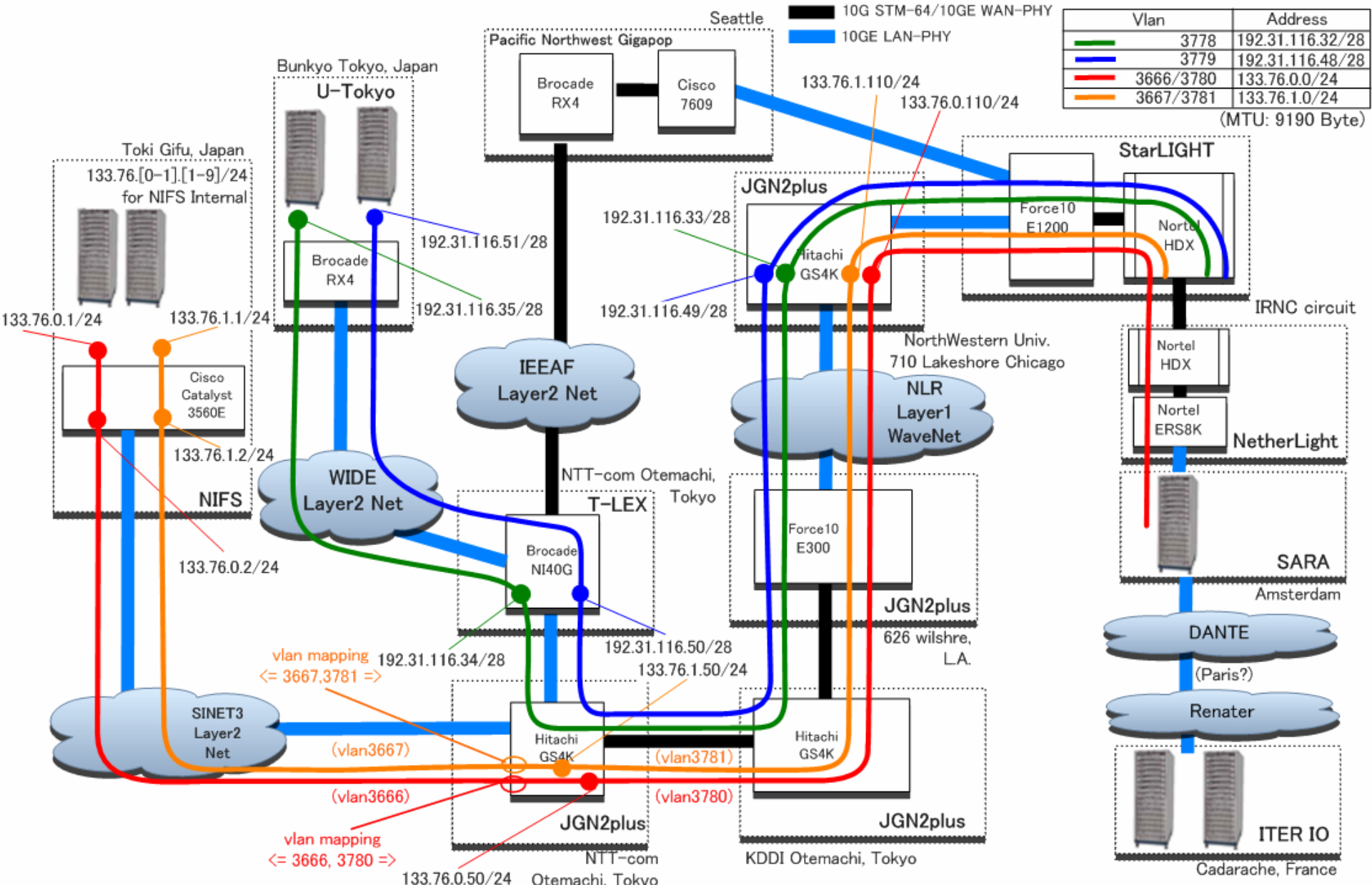
Vlan	Address
3780	10.0.0.0/24
3781	10.0.1.0/24
3788 455	10.0.8.0/24
3789 456	10.0.9.0/24

Network Topology for Japan-France High-Speed Data Transfer Experiment

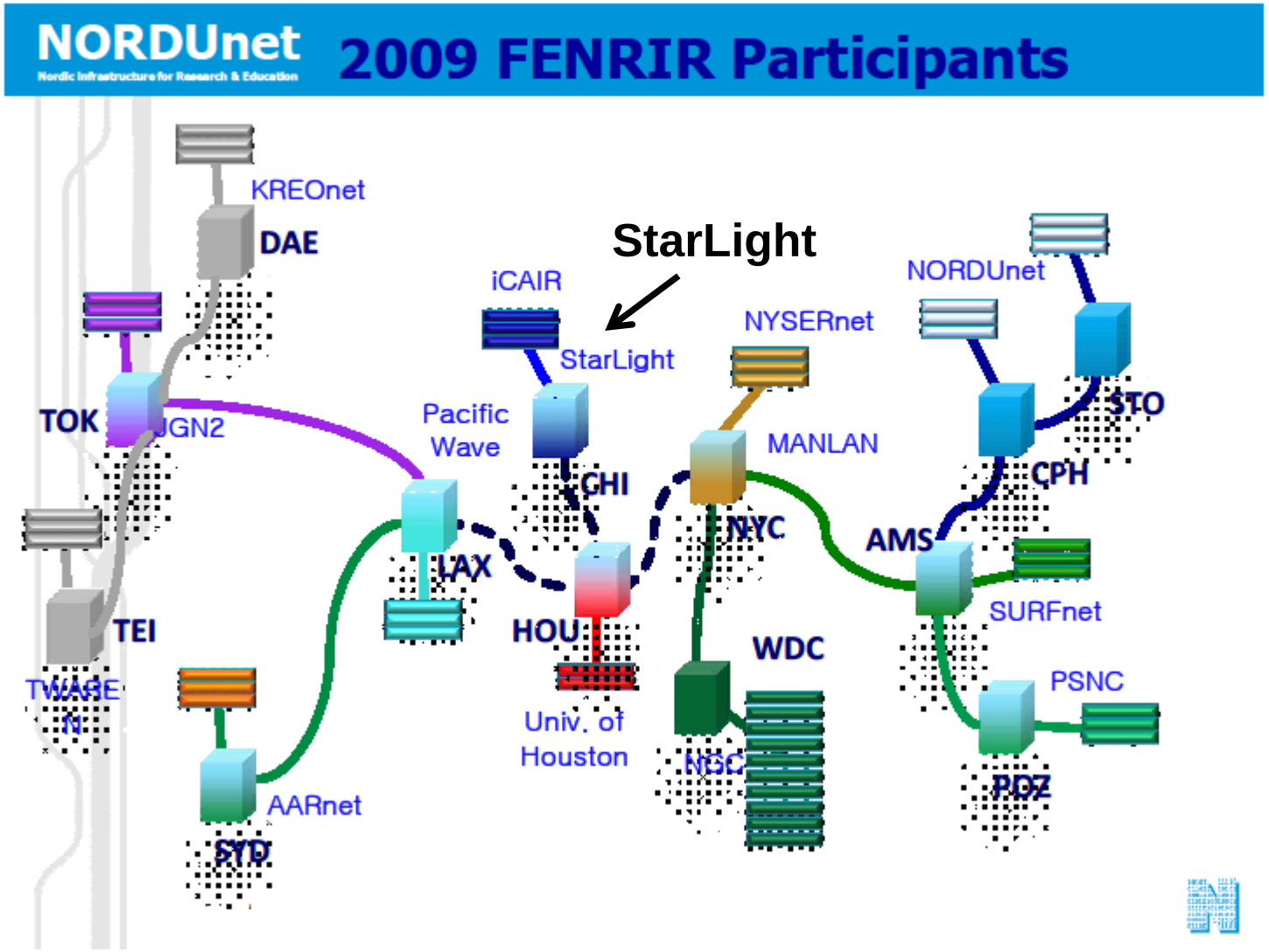
Rev 0.4 Sep. 21 2009
original format by tanaka@kddnet.ad.jp
revised by yama@wide.ad.jp

Vlan	Address
3778	192.31.116.32/28
3779	192.31.116.48/28
3666/3780	133.76.0.0/24
3667/3781	133.76.1.0/24

(MTU: 9190 Byte)



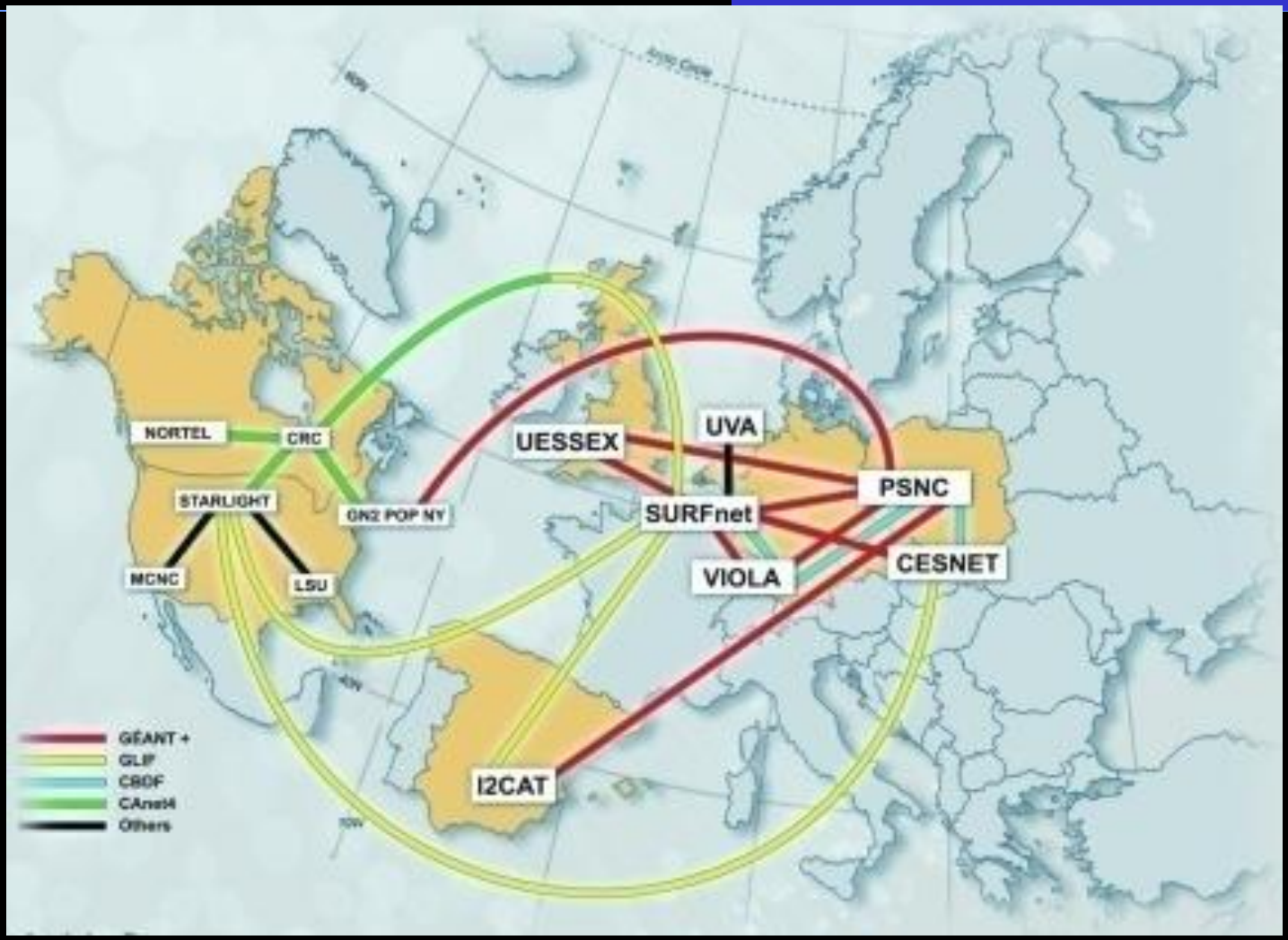
FENRIR - Federated Experimental Network Resources for International Research



VINI Testbed: Virtual Network Infrastructure

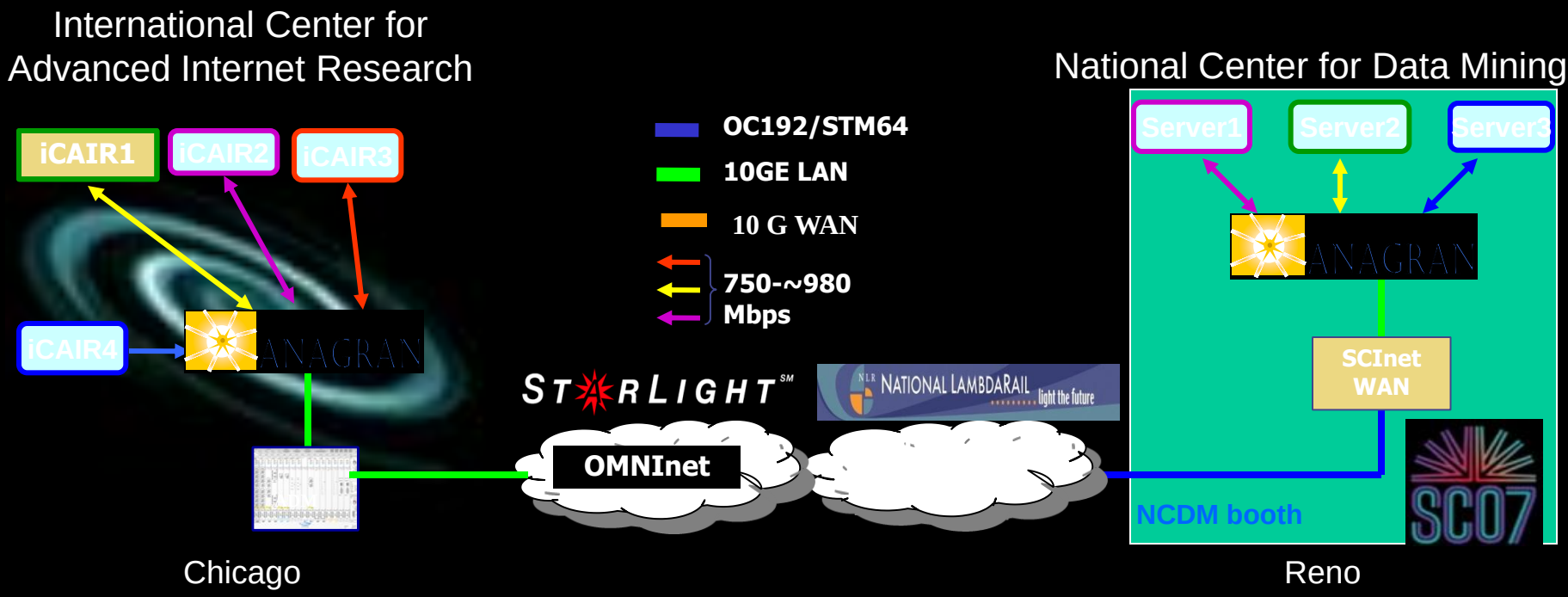
STARLIGHT SM

Phospherous



STARLIGHT SM

High Performance Flow Switching Network (HPFSnet) Demonstration – ANAGRAN enabled, using the National TeraFlow Network and the National Lambda Rail (NLR)



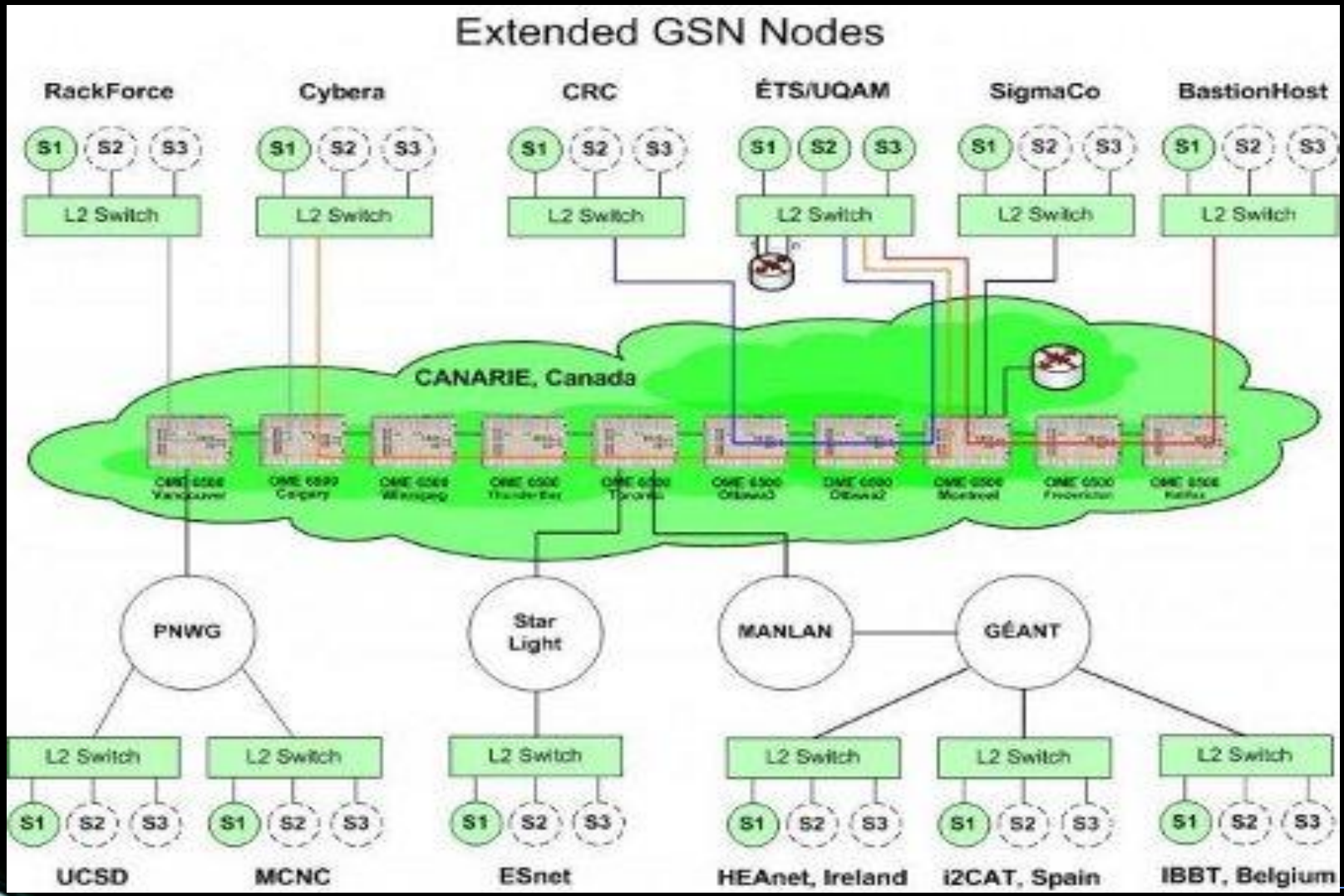
Showcasing high performance services and capabilities made possible on national networks using sophisticated flow control engineering techniques enabled by Anagran.

- Providing fine-grained control over all network traffic end-to-end
- Allowing targeted delivery of quality of service to support all types of applications, including digital media

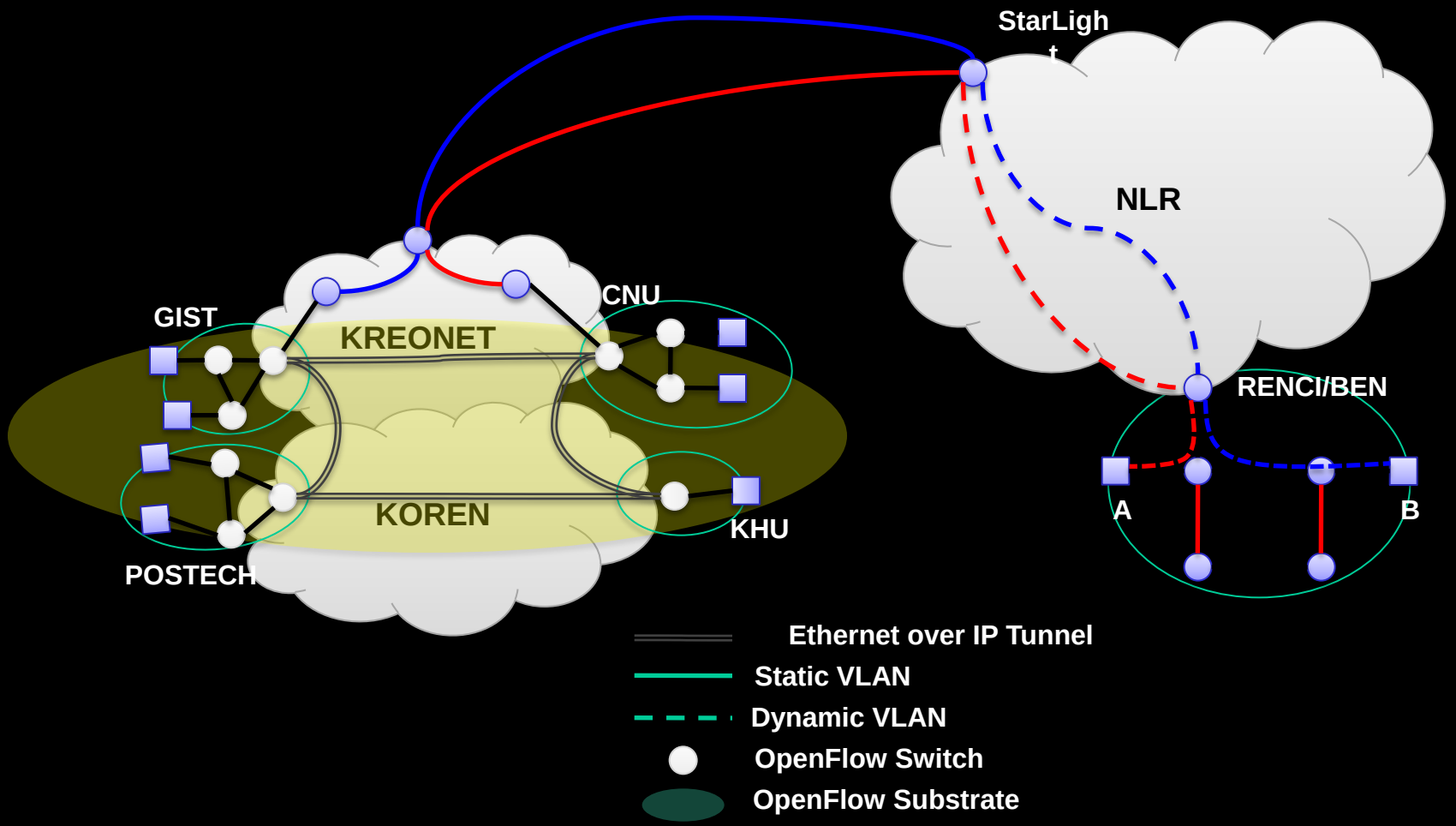
- Demonstration Partners: Anagran, International Center for Advanced Internet Research, National Center for Data Mining, National LamdaRail, StarLight International Communications Exchange

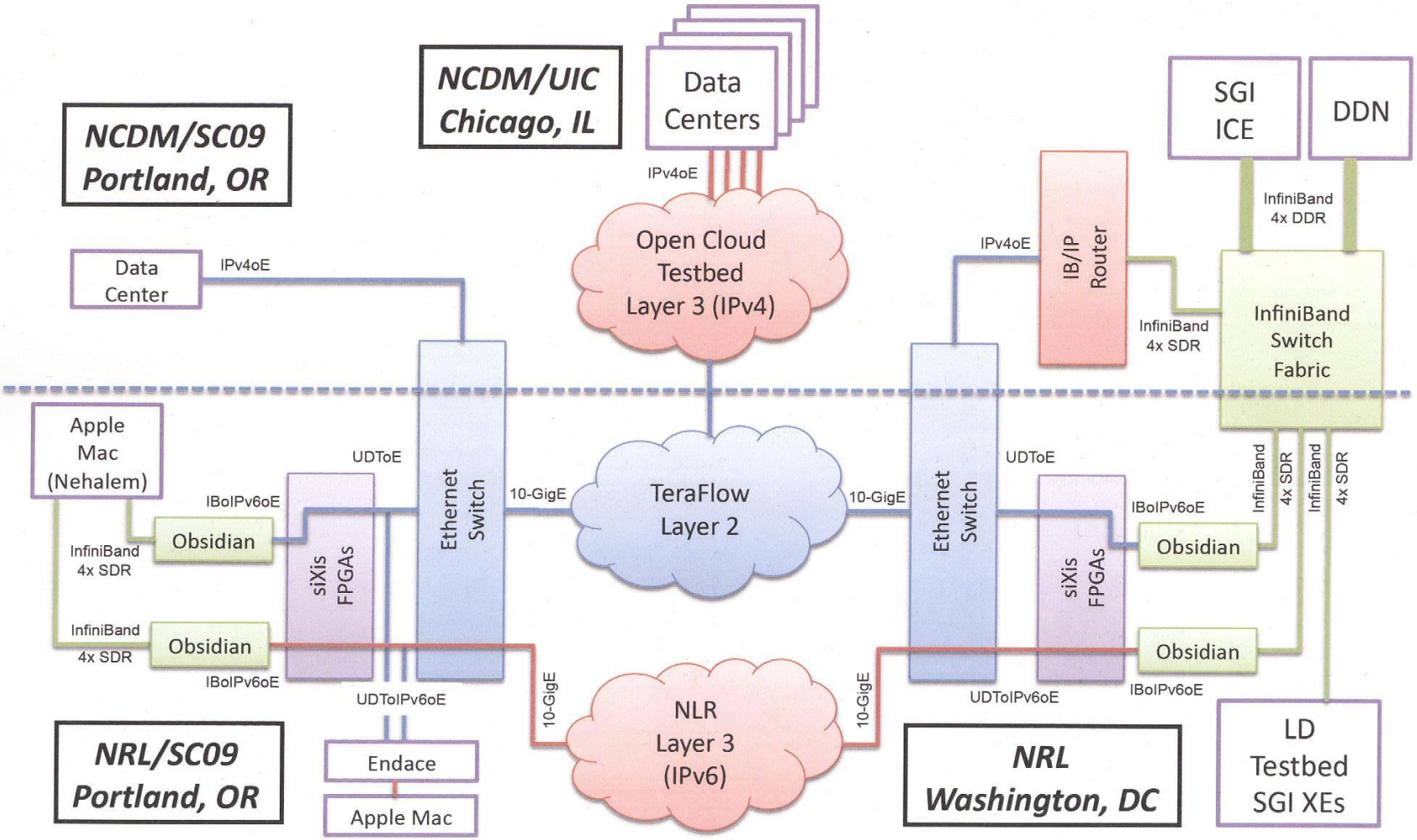
STARLIGHT SM

Green Star Network



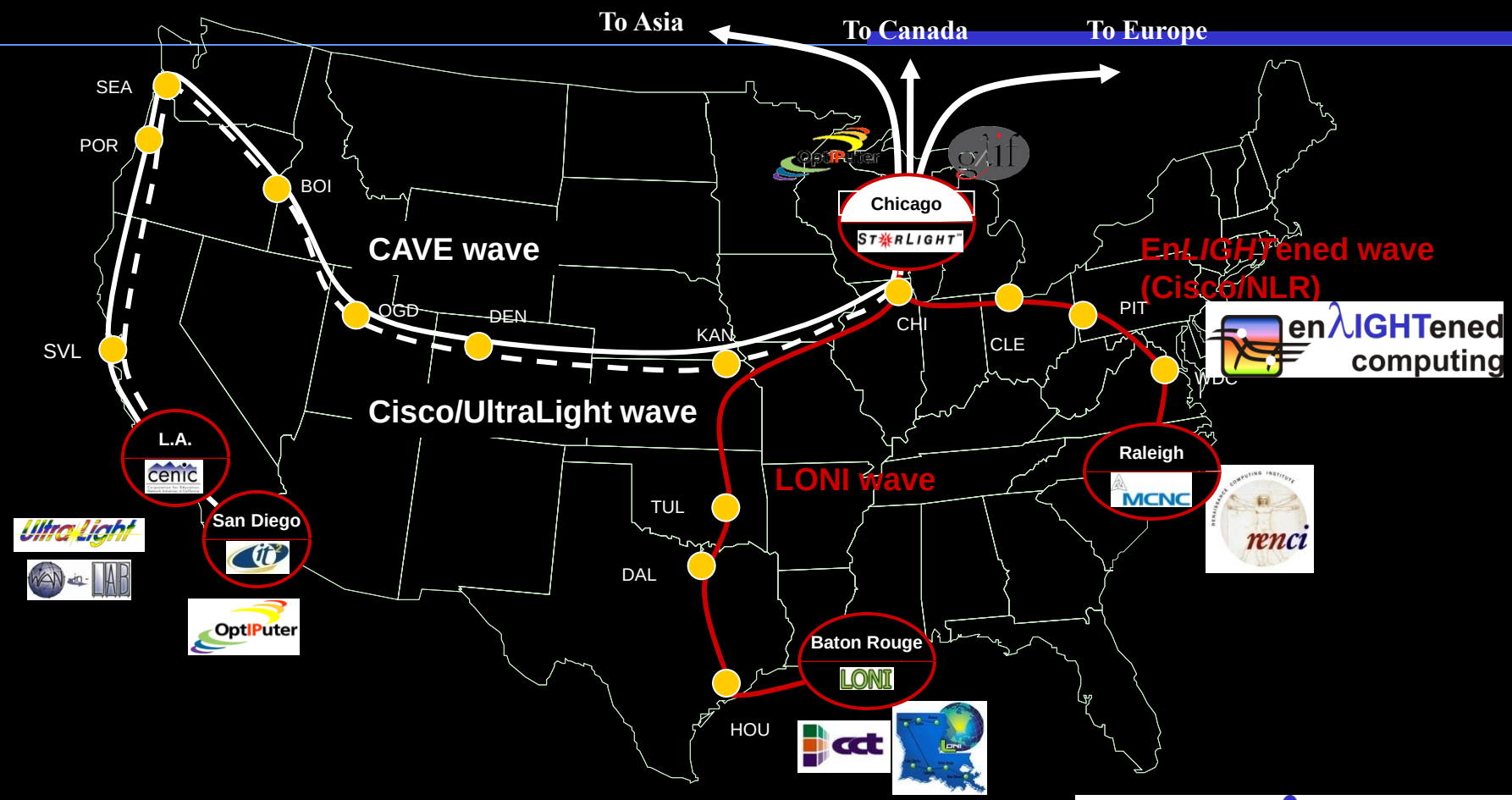
iGENI GIST-BEN-KREONET Testbed



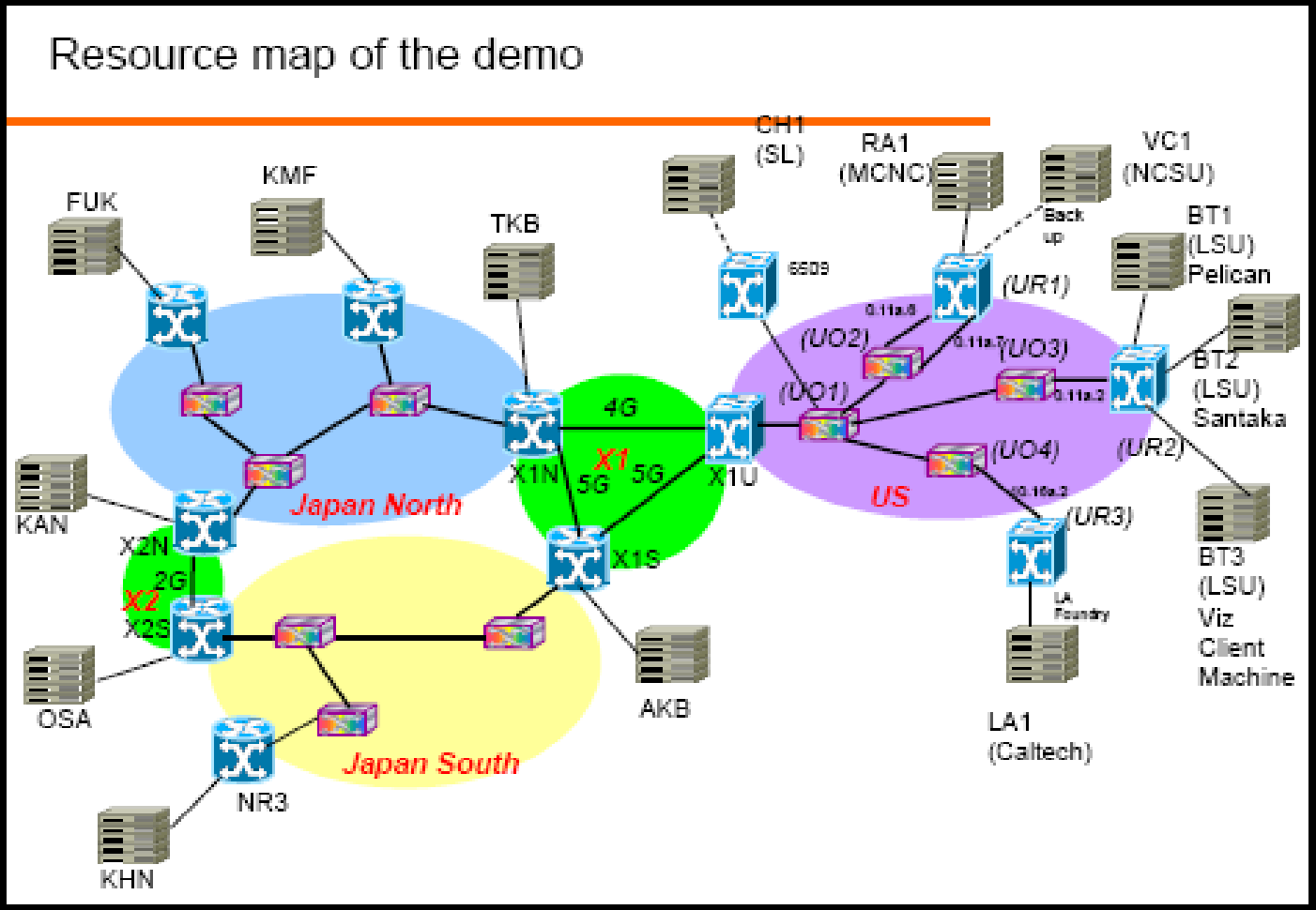


15 November 2009

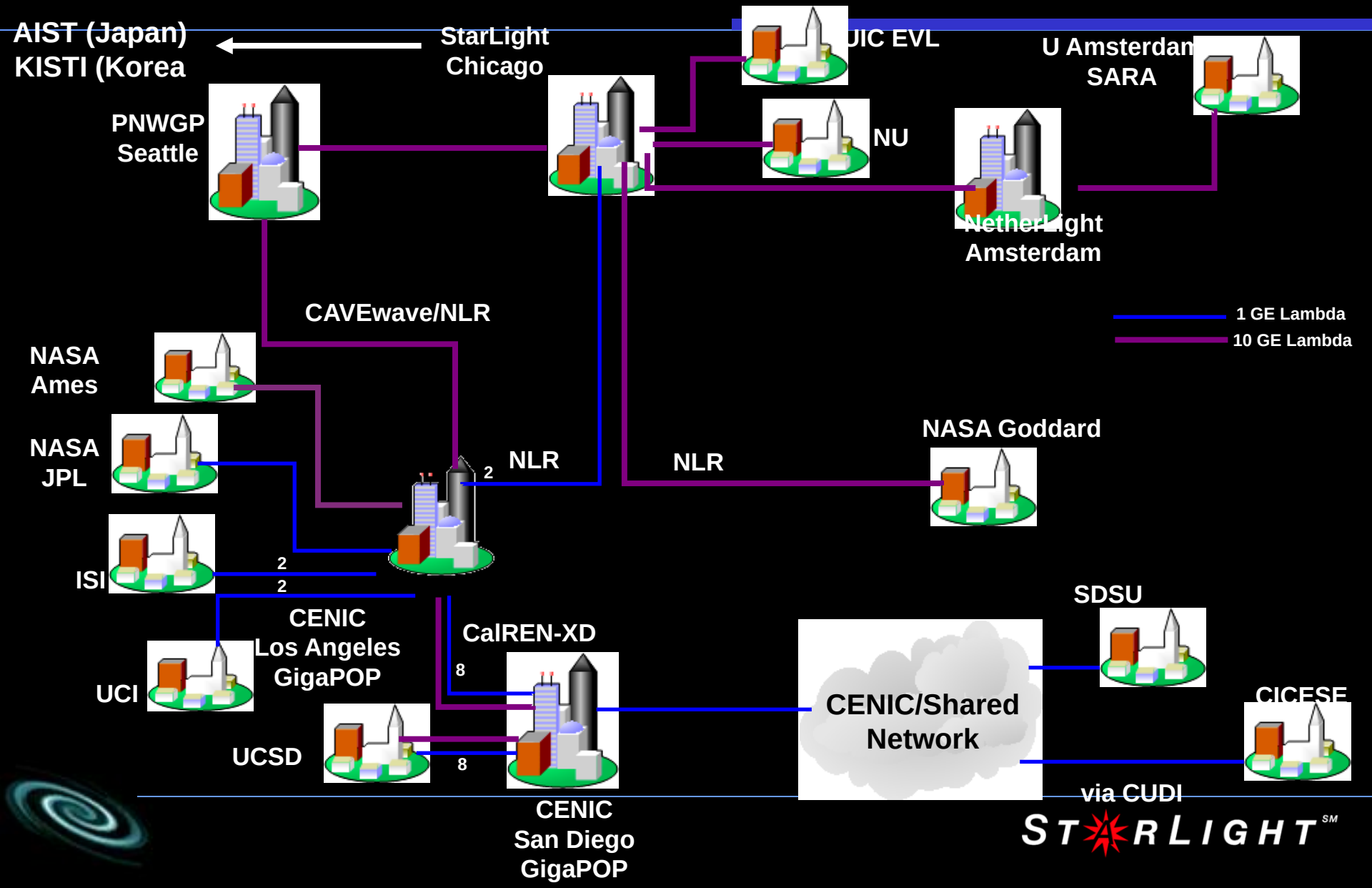
Early Testbed Diagram



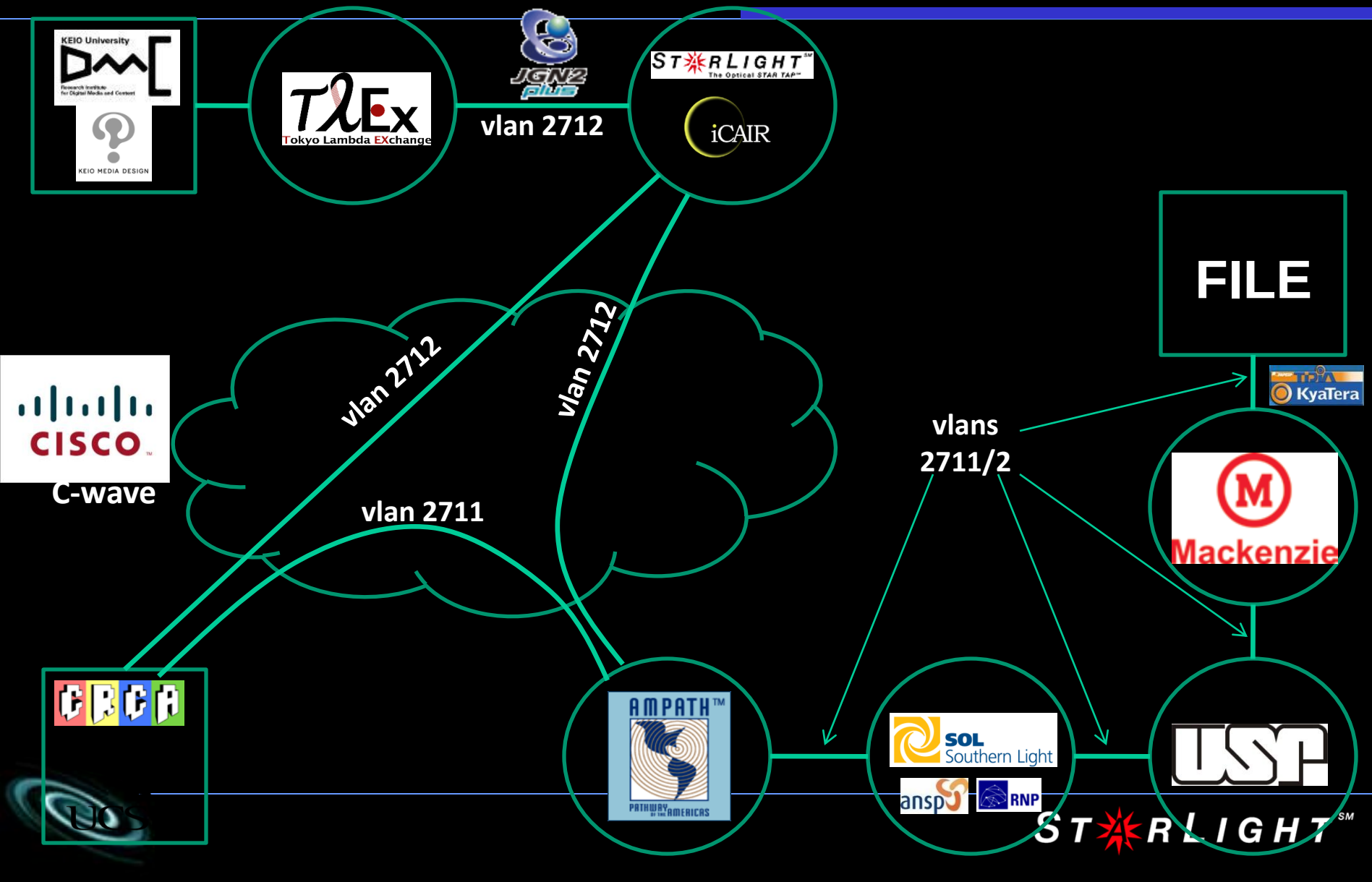
EnLIGHTened – G-Lambda Demo at GLIF Conference Tokyo 2006



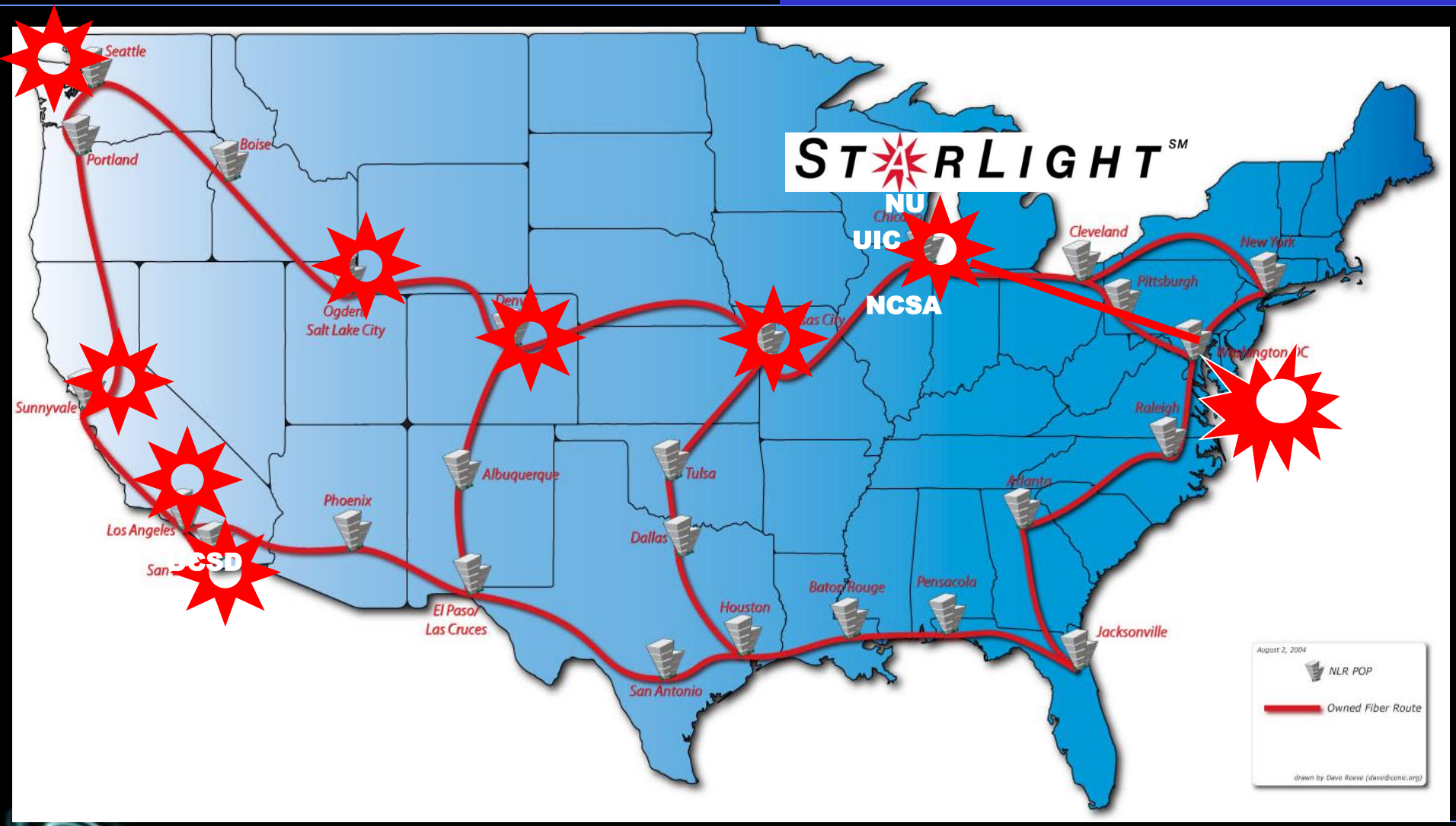
The OptIPuter LambdaGrid



FILE


KEIO University
KEIO MEDIA DESIGN
TLEx
Tokyo Lambda EXchange
JGN2 plus
vlan 2712
STARLIGHT
The Optical STAR TAP
iCAIR
FILE
vlan 2712
vlan 2712
vlans
2711/2
CISCO
C-wave
vlan 2711
KyaTera
Mackenzie
CRCA
AMPATH
PATHWAY OF THE AMERICAS
SOL
Southern Light
ansp
RNP
USP
STARLIGHT

10GE *CAVEwave* on the National LambdaRail



Global Environment for Network Innovations (GENI)

- GENI
  - Supports At-Scale Experimentation on Shared, Heterogeneous, Highly Instrumented Infrastructure
  - Enables Deep Programmability Throughout the Network,
  - Promotes innovations in Network Science, Security, Technologies, Services and Applications
  - Provides Collaborative and Exploratory Environments for Academia, Industry and the Public to Catalyze Groundbreaking Discoveries and Innovation.

National Science Foundation's Global Environment for Network Innovations (GENI)

- GENI Is Funded By The National Science Foundation's Directorate for Computer and Information Science and Engineering (CISE)
- GENI Is a Virtual Laboratory For Exploring Future Internets At Scale.
- GENI Is Similar To Instruments Used By Other Science Disciplines, e.g., Astronomers – Telescopes, HEP - Synchrotrons
- GENI Creates Major Opportunities To Understand, Innovate and Transform Global Networks and Their Interactions with Society.
- GENI Is Dynamic and Adaptive.
- GENI Opens Up New Areas of Research at the Frontiers of Network Science and Engineering, and Increases the Opportunity for Significant Socio-Economic Impact.

iGENI: The International GENI

- The iGENI Initiative Will Design, Develop, Implement, and Operate a Major New National and International Distributed Infrastructure.
- iGENI Will Place the “G” in GENI Making GENI Truly Global.
- iGENI Will Be a Unique Distributed Infrastructure Supporting Research and Development for Next-Generation Network Communication Services and Technologies.
- This Infrastructure Will Be Integrated With Current and Planned GENI Resources, and Operated for Use by GENI Researchers Conducting Experiments that Involve Multiple Aggregates At Multiple Sites.
- iGENI Infrastructure Will Connect Its Resources With Current GENI National Backbone Transport Resources, With Current and Planned GENI Regional Transport Resources, and With International Research Networks and Projects,
-

Initial iGENI Consortium

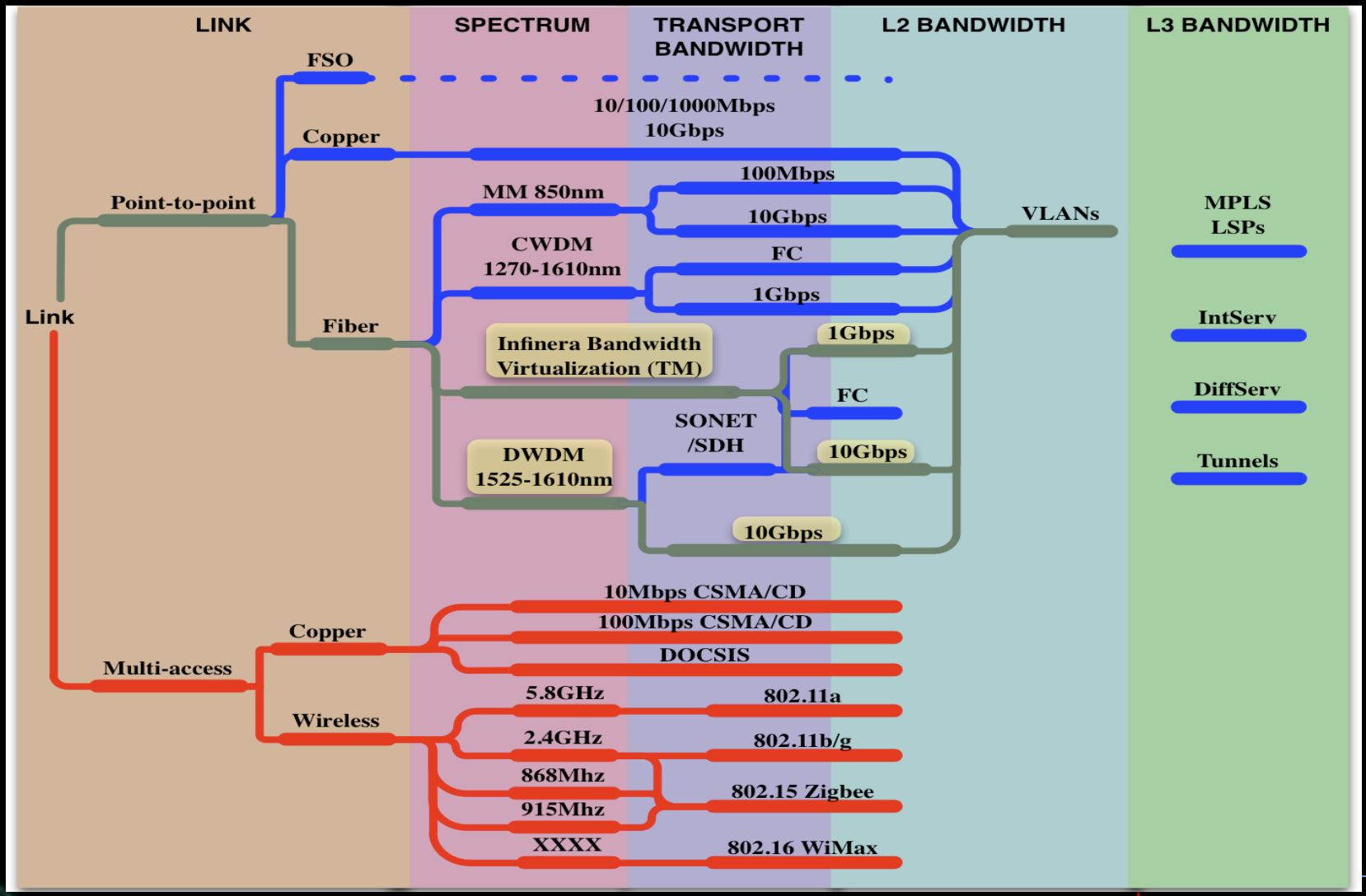
- **Consortium Partners Include Several Major Network Research Organizations:**
  - **International Center for Advanced Internet Research (iCAIR) at Northwestern University,**
  - **Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago**
  - **The California Institute for Telecommunications and Information Technology (Calit2) at the University of California, San Diego**
  - **Cisco Systems, Inc. Research**
  - **BBN Technologies GENI Program Office (GPO).**
  - **The StarLight Consortium**
  - **RENCI and North Carolina University Partners, e.g. Duke, North Carolina State**
  - **Other Cluster D Participants (Univ of Mass - Amherst, Columbia, Ohio State, Wayne State, Univ of Houston, Rice, Texas A&M, UT Austin, Oklahoma State)**

  - **iGENI Initiatives Also Extend To Activities In Other GENI Clusters**
  - ***iGENI Research Initiatives Have Multiple International Partners***

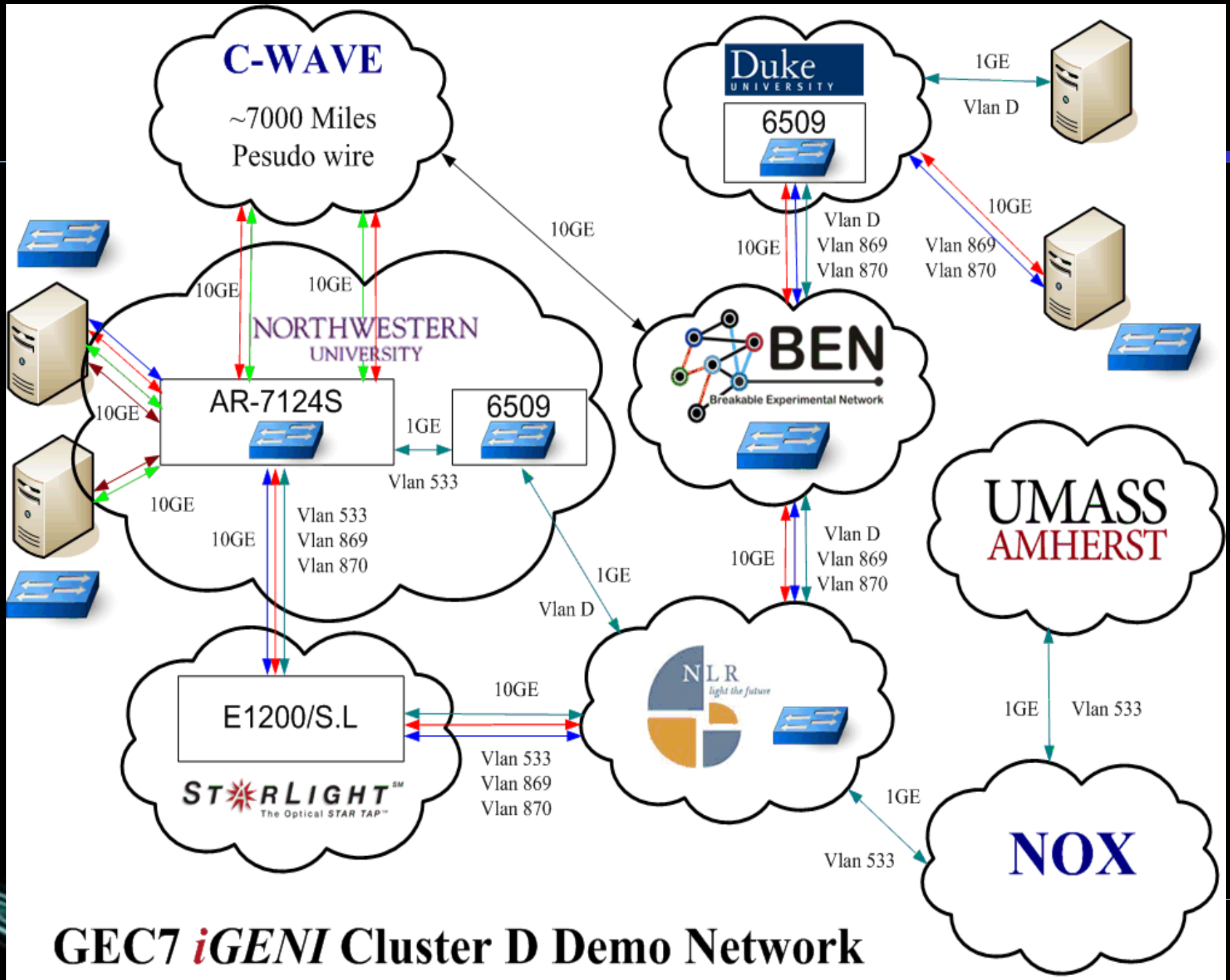
Cluster D Initiatives

- ORCA/BEN -- Primary Distinction Among Other Control Frames = A Unique Comprehensive Strategy Cross-Layer Provisioning and Experimentation
- DOME -- Diverse Outdoor Mobile Environment
- ViSE -- Sensor Virtualization and Slivering in an Outdoor Wide-Area Wireless -- GENI Sensor/Actuator Network Testbed
- ERM -- Embedded Real-Time Measurements
- KANSAI – KanseiSensorNet
- DICLOUD – Data Intensive Cloud Control
- OKGEMS – Cyber-Physical System
- IMF – Integrated Measurement Network
- LEARN – Measurement Handler and Network Integration (Programmable Measurements)
- BBN ORCA Xen Cluster
- iGENI

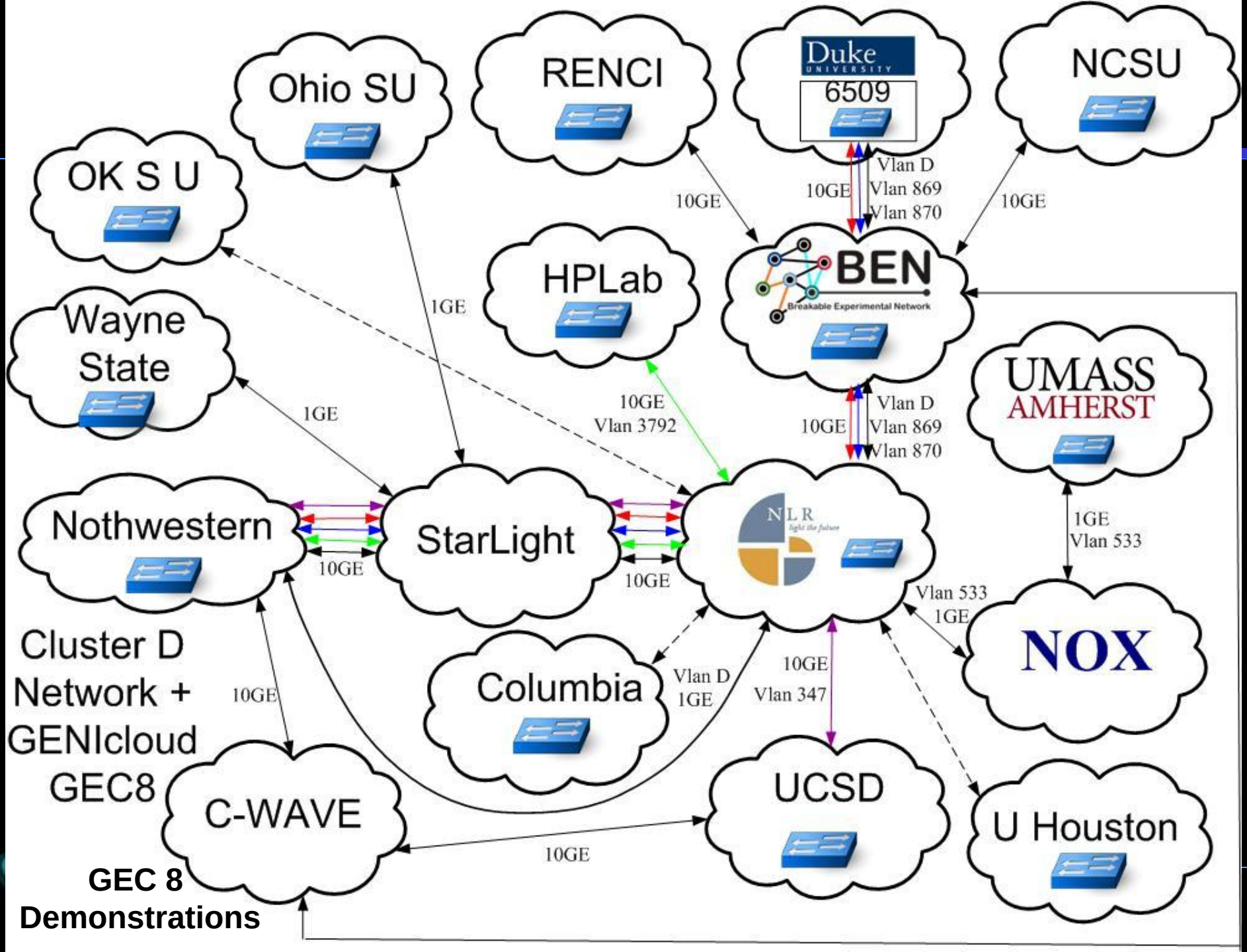
ORCA "Link" Slivering



STARLIGHT SM

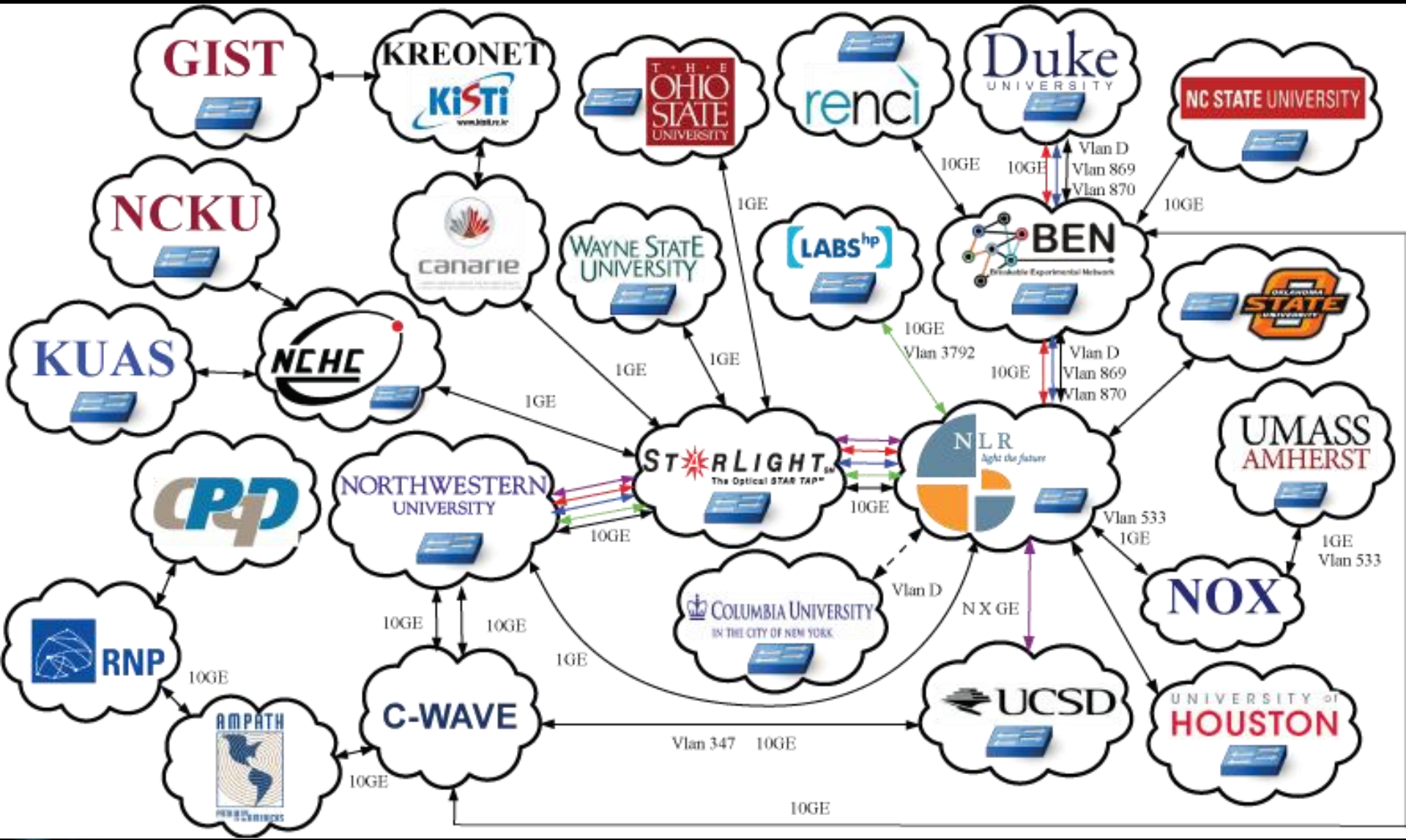


GEC7 *iGENI* Cluster D Demo Network

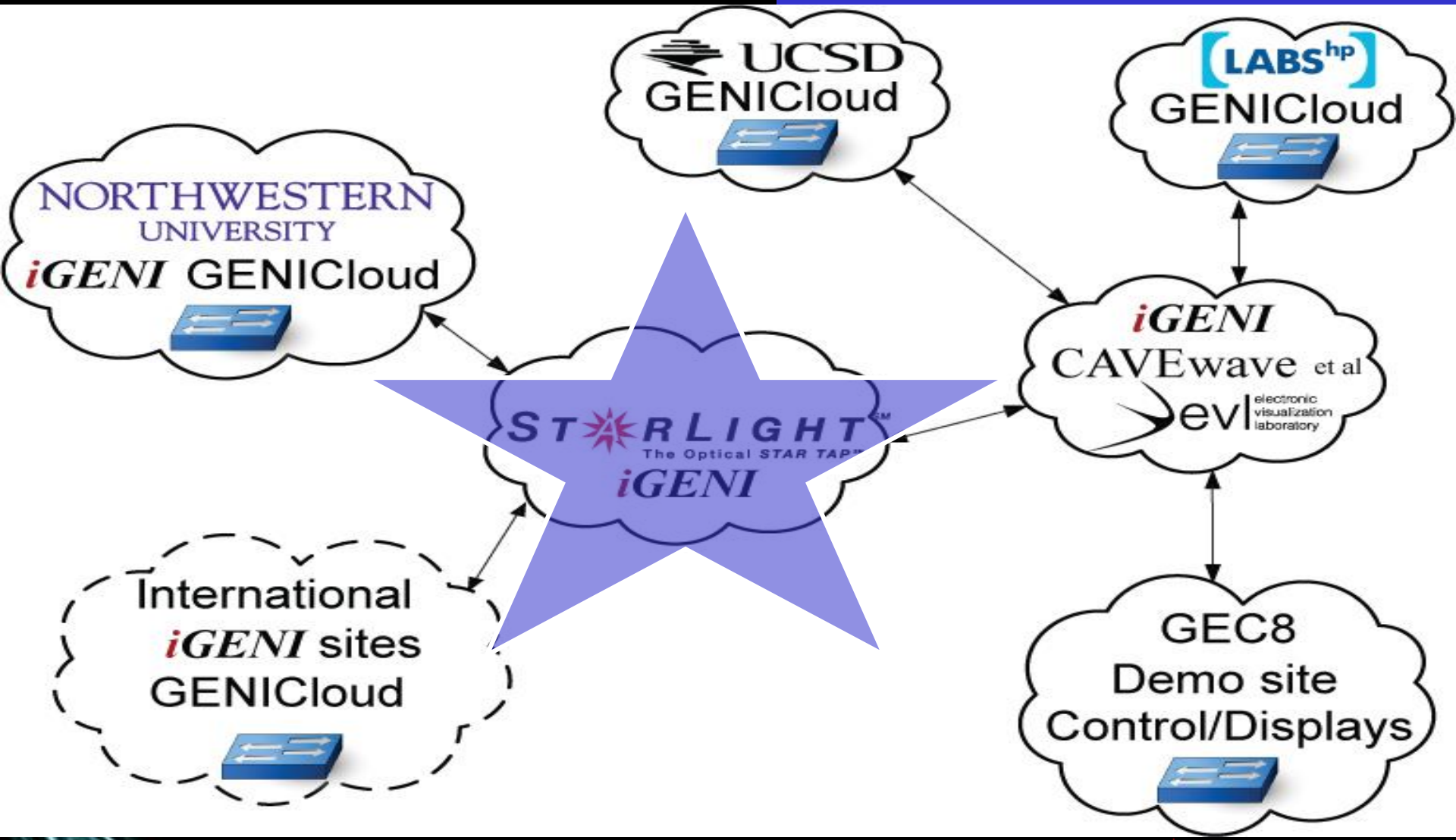


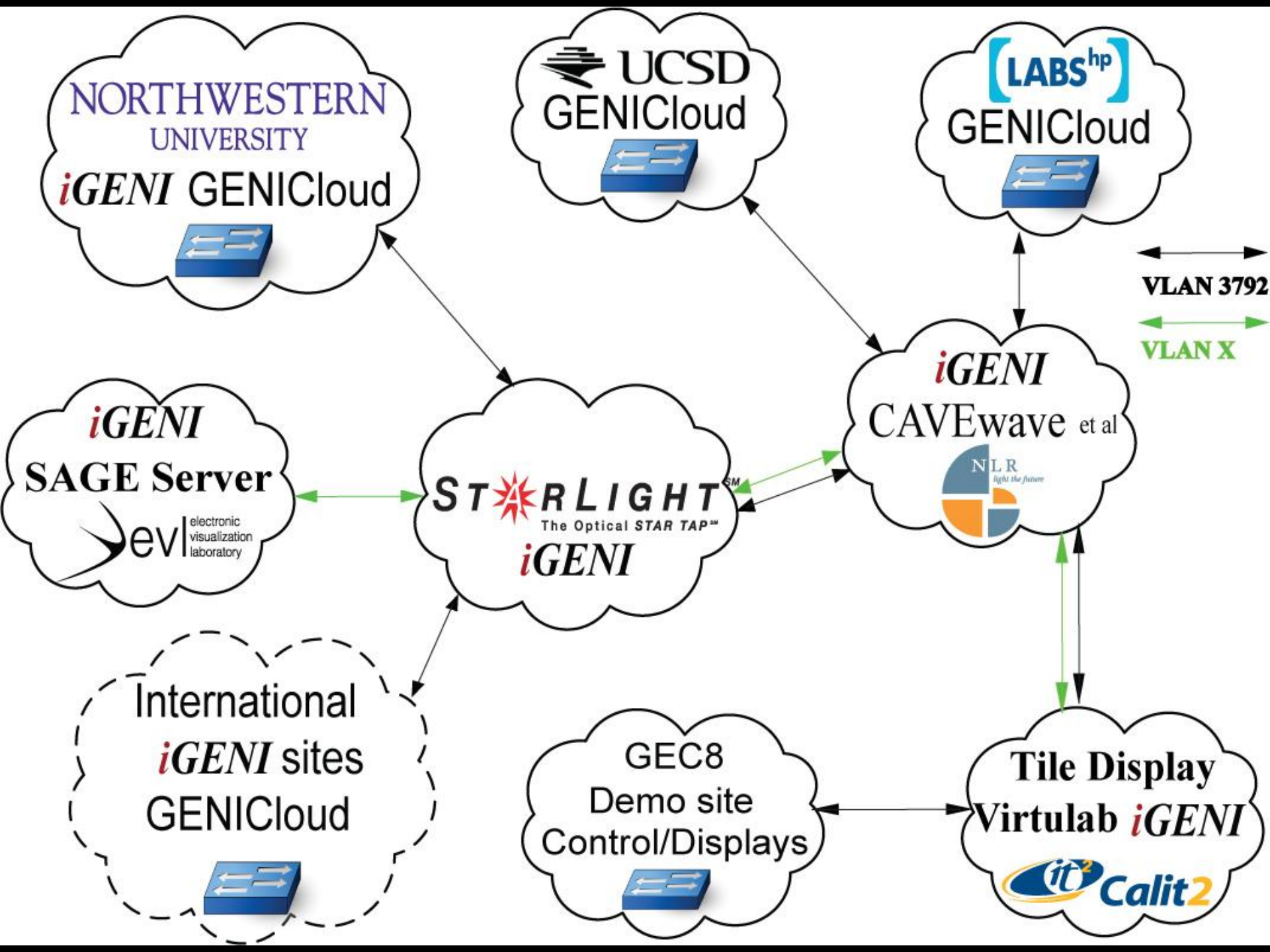
GEC 8 Demonstrations

GENI Engineering Conference 9



iGENI Demonstrations at GEC 8




NORTHWESTERN UNIVERSITY
iGENI GENICloud
UCSD GENICloud
LABS hp GENICloud
VLAN 3792
VLAN X
iGENI CAVEwave et al
NLR light the future
iGENI SAGE Server
evl electronic visualization laboratory
STARLIGHT The Optical STAR TAP℠
iGENI
International iGENI sites GENICloud
GEC8 Demo site Control/Displays
Tile Display Virtulab iGENI
it² Calit2





GEC 10 Demonstrations
TransCloud: A Distributed Environment Based On Dynamic Networking

Rick McGeer, HP Labs
Joe Mambretti, Northwestern
Paul Müller , TU Kaiserslautern
Chris Matthews, Chris Pearson, Yvonne Coady, Victoria
Jim Chen, Feh Yeh, Northwestern
Andy Bavier, PlanetWorks
Marco Yuen, Princeton
Jessica Blaine, Alvin Au Young, HP Labs
Alex Snoeren, UC San Diego

March 16, 2010

http://www.icair.org

http://www.geni.net

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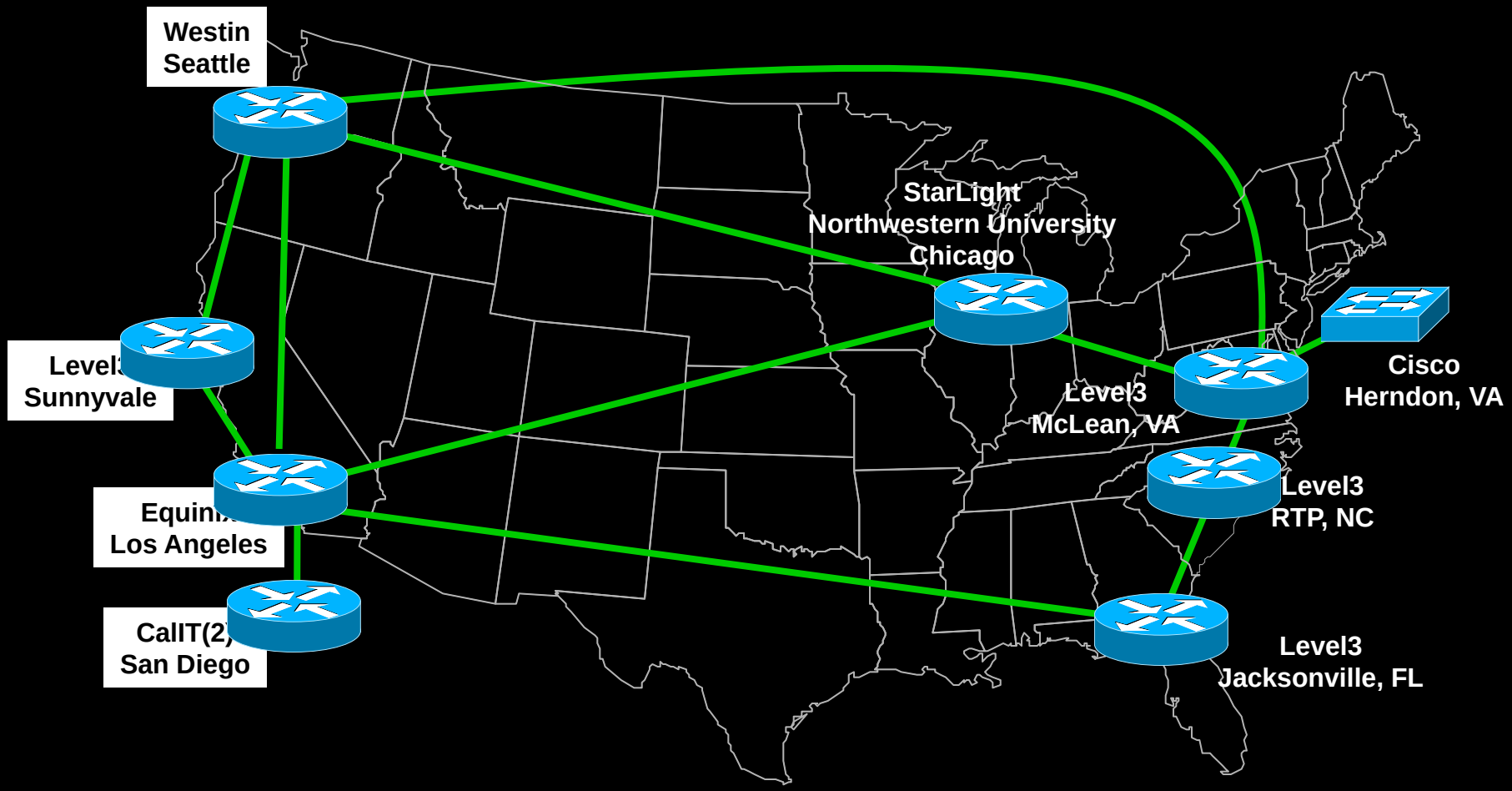
TransCloud

- **TransCloud = A Cloud Where Services Migrate, Anytime, Anywhere In a World Where Distance Is Eliminated**
  - **Joint Project Between GENICloud, iGENI, et al**
  - **GENICloud Provides Seamless Interoperation of Cloud Resources Across N-Sites, N-Administrative Domains**
  - **iGENI Optimizes Private Networks of Intelligent Devices Capable of Dynamically Provisioned Low-Latency, High-Performance Communications Among Multiple Physically-Distributed Infrastructures and Facilities**

C-Wave Summer 2010



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Issues Related To Federated Processes Across Multiple Sites

- Topics Revolve Around Policy Issues Related To Resource Utilization
- Macro APIs
- Fenius Example
- An Experimental Architecture
- Based on a Super Agent That Can Be Used As an API That Can Interact With Individual GLIF GOLE Control Planes
- Edge Processes Can Interact With One API Yet Utilize Multiple Different Control Frameworks

Building On Existing Partnerships, Current & Future International Partners Include Researchers From Many Countries

- Australia
- Brazil
- Canada
- China
- Egypt
- Germany
- India
- Japan
- Korea
- Taiwan
- Spain
- Singapore
- Netherlands
- Spain
- New Zealand
- Sweden
- UK
- Et Al

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

First of a Kind Enabling Interoperability At L1, L2, L3

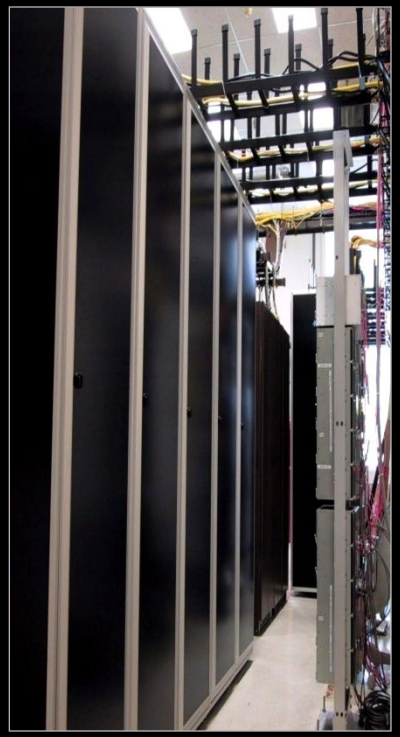
View from StarLight

Abbott Hall, Northwestern University's Chicago downtown campus

STARLIGHT℠

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



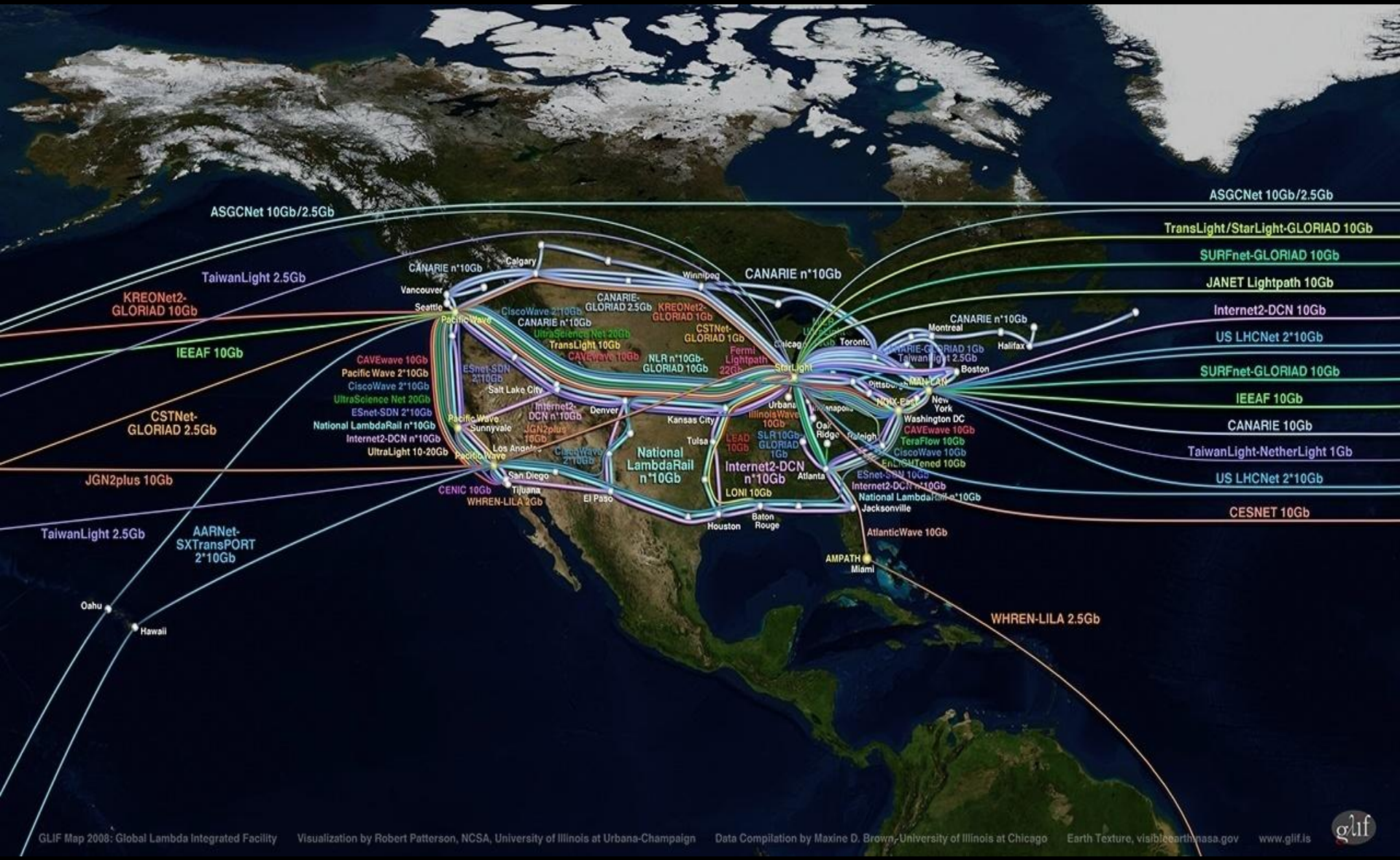
MREN

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

iCAIR: Founding Partner of the Global Lambda Integrated Facility
Available Advanced Network Resources

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.


ASGCNet 10Gb/2.5Gb
TaiwanLight 2.5Gb
KREONet2-GLORIAD 10Gb
IEEAF 10Gb
CSTNet-GLORIAD 2.5Gb
JGN2plus 10Gb
TaiwanLight 2.5Gb
AARNet-SXTransPORT 2*10Gb
Oahu
Hawaii
CANARIE n*10Gb
Calgary
Vancouver
Seattle
Pacific Wave
CiscoWave 2*10Gb
CANARIE n*10Gb
UltraScience Net 20Gb
TransLight 10Gb
CAVEwave 10Gb
Pacific Wave 2*10Gb
CiscoWave 2*10Gb
UltraScience Net 20Gb
ESnet-SDN 2*10Gb
National LambdaRail n*10Gb
Internet2-DCN n*10Gb
UltraLight 10-20Gb
ESnet-SDN 2*10Gb
Salt Lake City
Pacific Wave
Sunnyvale
Los Angeles
Pacific Wave
San Diego
Tijuana
CENIC 10Gb
WHREN-LILA 2Gb
Internet2-DCN n*10Gb
Denver
JGN2plus 10Gb
CiscoWave 2*10Gb
El Paso
CANARIE-GLORIAD 2.5Gb
KREONet2-GLORIAD 1Gb
CSTNet-GLORIAD 1Gb
NLR n*10Gb-GLORIAD 10Gb
Fermi Lightpath 22Gb
Kansas City
Tulsa
National LambdaRail n*10Gb
Houston
Baton Rouge
Winnipeg
CANARIE n*10Gb
Chicago
StarLight
Toronto
Urbana
IllinoisWave 10Gb
LEAD 10Gb
SLR10Gb-GLORIAD 1Gb
Internet2-DCN n*10Gb
LONI 10Gb
Atlanta
Oak Ridge
Raleigh
CANARIE n*10Gb
Montreal
Halifax
Boston
MAN LAN
New York
Washington DC
CAVEwave 10Gb
TeraFlow 10Gb
CiscoWave 10Gb
ESnet-SDN 10Gb
Internet2-DCN n*10Gb
National LambdaRail n*10Gb
Jacksonville
AtlanticWave 10Gb
AMPATH
Miami
ASGCNet 10Gb/2.5Gb
TransLight/StarLight-GLORIAD 10Gb
SURFnet-GLORIAD 10Gb
JANET Lightpath 10Gb
Internet2-DCN 10Gb
US LHCNet 2*10Gb
SURFnet-GLORIAD 10Gb
IEEAF 10Gb
CANARIE 10Gb
TaiwanLight-NetherLight 1Gb
US LHCNet 2*10Gb
CESNET 10Gb
WHREN-LILA 2.5Gb
GLIF Map 2008: Global Lambda Integrated Facility
Visualization by Robert Patterson, NCSA, University of Illinois at Urbana-Champaign
Data Compilation by Maxine D. Brown, University of Illinois at Chicago
Earth Texture, visibleearth.nasa.gov
www.glif.is
glif

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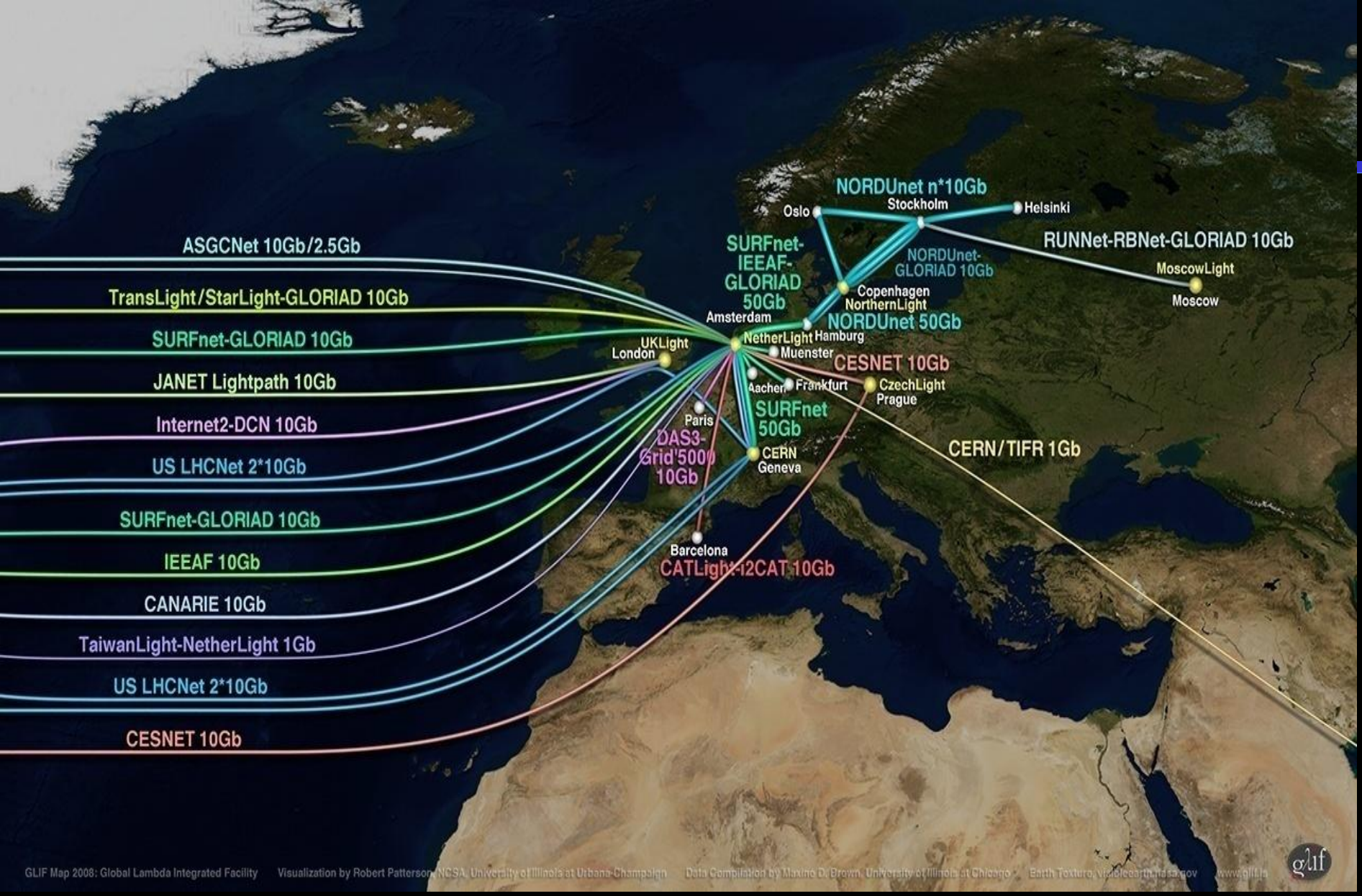
ASGCNet 10Gb/2.5Gb
TransLight/StarLight-GLORIAD 10Gb
SURFnet-GLORIAD 10Gb
JANET Lightpath 10Gb
Internet2-DCN 10Gb
US LHCNet 2*10Gb
SURFnet-GLORIAD 10Gb
IEEAF 10Gb
CANARIE 10Gb
TaiwanLight-NetherLight 1Gb
US LHCNet 2*10Gb
CESNET 10Gb
NORDUnet n*10Gb
Oslo
Stockholm
Helsinki
SURFnet-IEEAF-GLORIAD 50Gb
NORDUnet-GLORIAD 10Gb
RUNNet-RBNet-GLORIAD 10Gb
MoscowLight
Moscow
Copenhagen NorthernLight
Amsterdam
NetherLight
NORDUnet 50Gb
Hamburg
UKLight
London
Muenster
CESNET 10Gb
Aachen
Frankfurt
CzechLight Prague
Paris
SURFnet 50Gb
DAS3-Grid'5000 10Gb
CERN Geneva
CERN/TIFR 1Gb
Barcelona
CATLight-I2CAT 10Gb
GLIF Map 2008: Global Lambda Integrated Facility
Visualization by Robert Patterson, NCSA, University of Illinois at Urbana-Champaign
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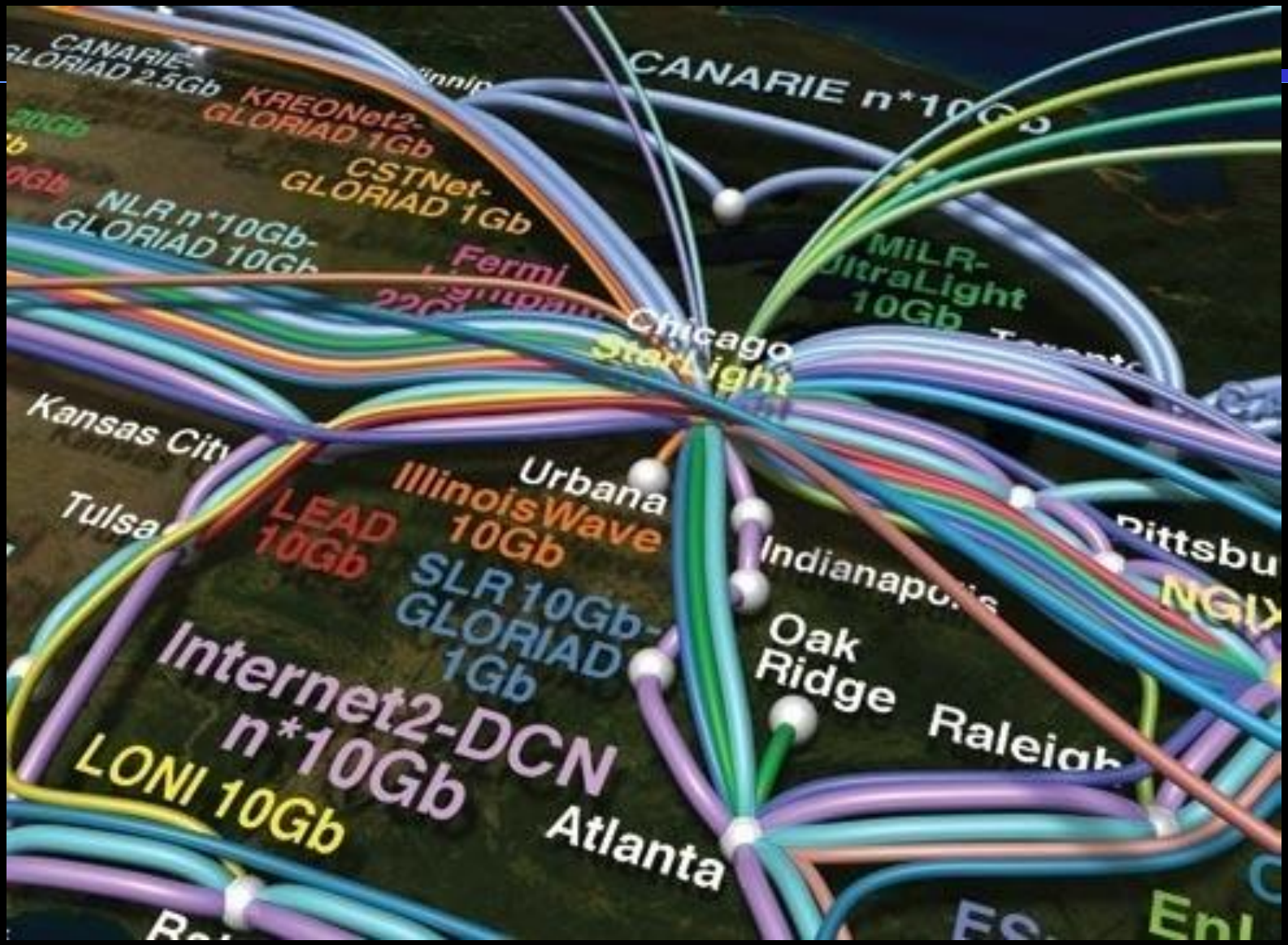
glif


CANARIE
GLORIAD 2.5Gb
KREONet2-
GLORIAD 1Gb
CSTNet-
GLORIAD 1Gb
NLR n*10Gb-
GLORIAD 10Gb
Fermi
CANARIE n*10Gb
MiLR-
UltraLight
10Gb
Chicago
StarLight
Kansas City
Tulsa
Urbana
IllinoisWave
10Gb
LEAD
10Gb
SLR 10Gb-
GLORIAD
1Gb
Internet2-DCN
n*10Gb
LONI 10Gb
Atlanta
Indianapolis
Oak
Ridge
Raleigh
Pittsbu
NGIX

IRNC ProNet: TransLight/StarLight

Announced: July 13, 2010

Tom DeFanti, Maxine Brown, Joe Mambretti, Tajana Rosing

Calit2, University of California, San Diego
Electronic Visualization Lab, University of Illinois at Chicago
International Center for Advanced Internet Research, Northwestern University

20 years of NSF-Funded High-Performance International Networking for Advanced Applications (1995-2014)

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IRNC TL/SL Deliverables

- Continue Enabling Multi-National Application and Middleware Experiments Through Innovative Services and Technologies On International Networks:
  - High-Performance Digital Media Network (HPDMnet)
  - iGENI: the GENI-funded international GENI project* ##
  - SAGE: connecting people and their data at high-res*
  - CineGrid: it's all about visual communications
  - GreenLight International: less watts/terabyte*
  - Science Cloud Communication Services Network (SCCSnet)*: the impending disruption
- Build Cooperative National and International Partnerships*
- Provide New Services, Including Many with Industrial Partners
- Capitalize On Other Emerging Opportunities*

Now, In Part, A CISE/OCI Partnership!!

*Currently also funded by various NSF awards to UCSD/UIC/NU

TransLight/StarLight Collaborates with All IRNC/GLIF Initiatives

Connect to TransLight/PacificWave in Seattle via TransLight (Cisco Research Wave deployed on NLR)

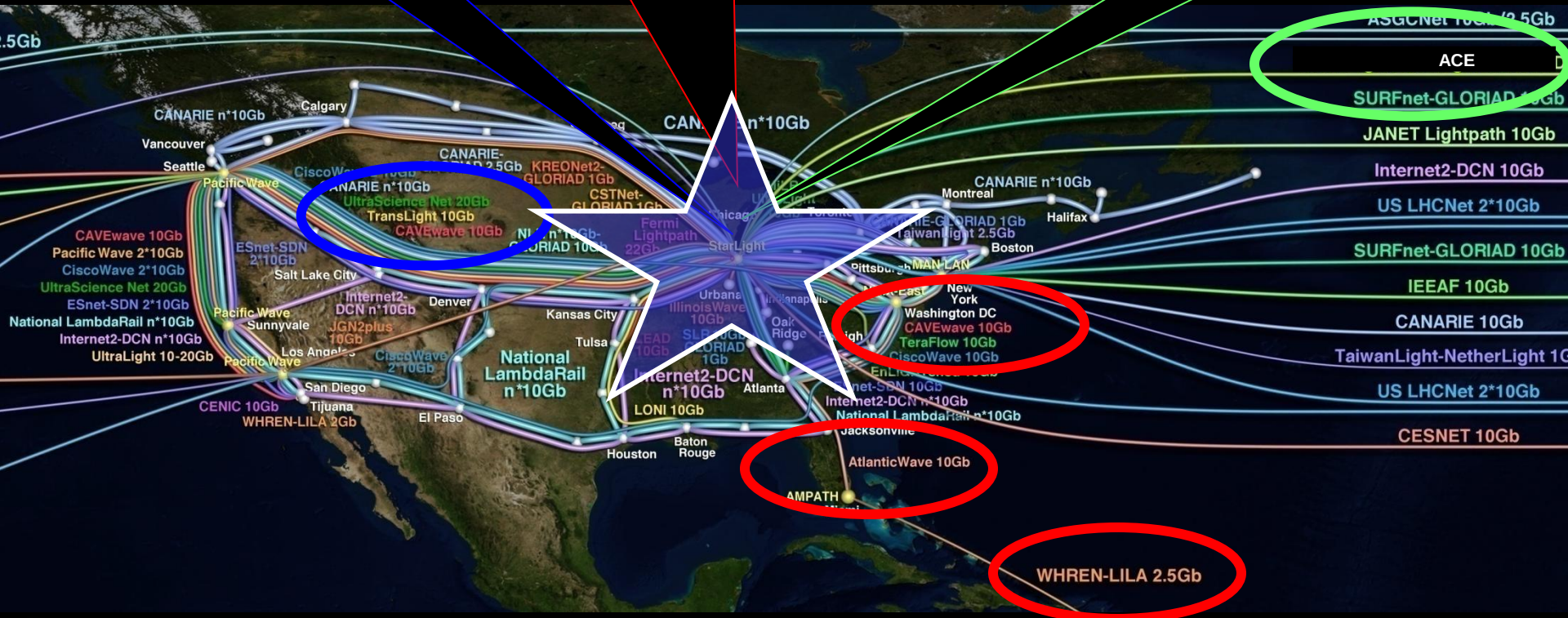
PACIFIC WAVE TRANS LIGHT

With US HEP/LHC researchers, do trials to move multi-gigabit traffic between CERN and Brazil (Geneva to Amsterdam; via LHCnet to Chicago; via CAVEwave to DC; via AtlanticWave to I via AmLight-East to Br

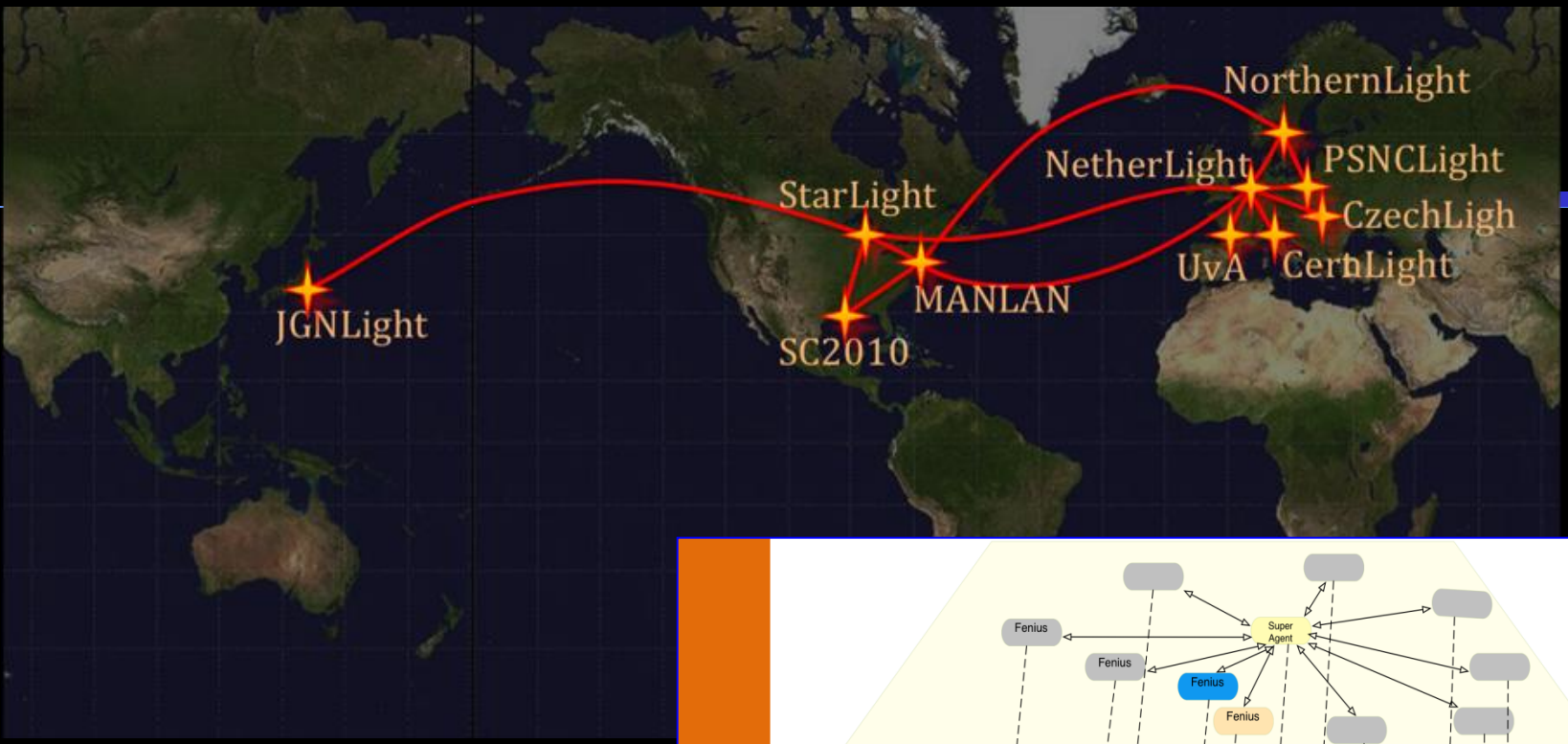
WHREN

Provide GLORIAD via StarLight with services to support multi-gigabit US traffic to partners in Russia, Netherlands, Nordic countries, Asia

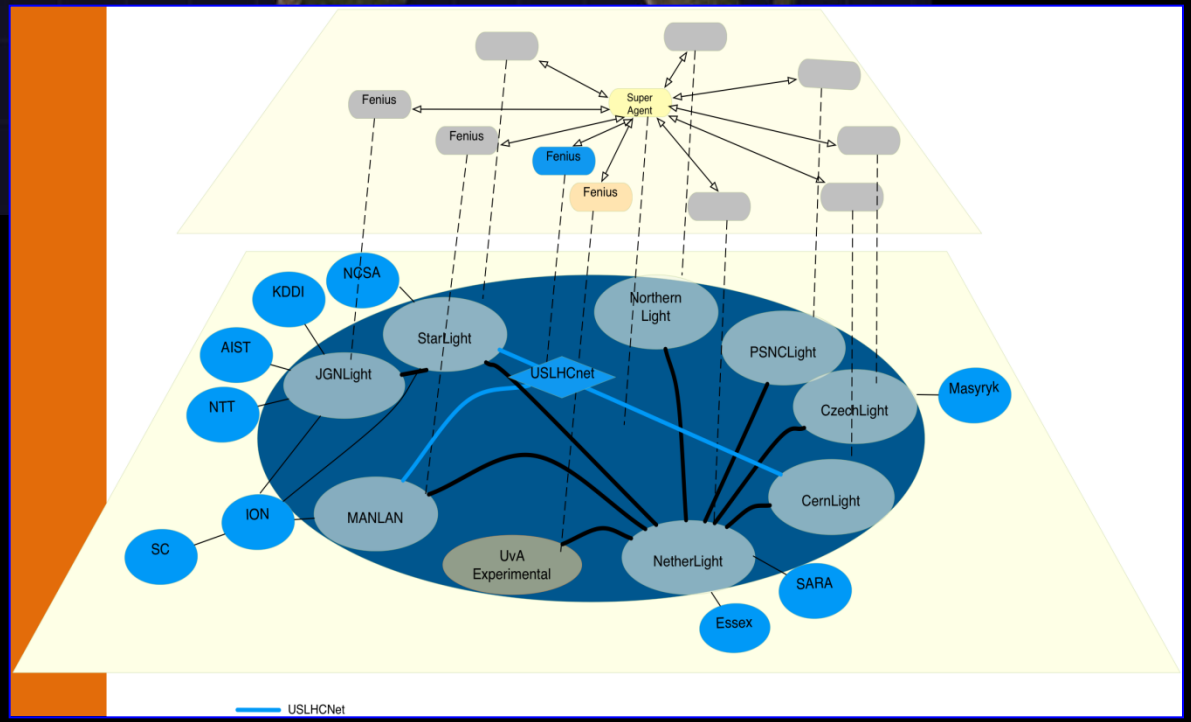
GLORIAD

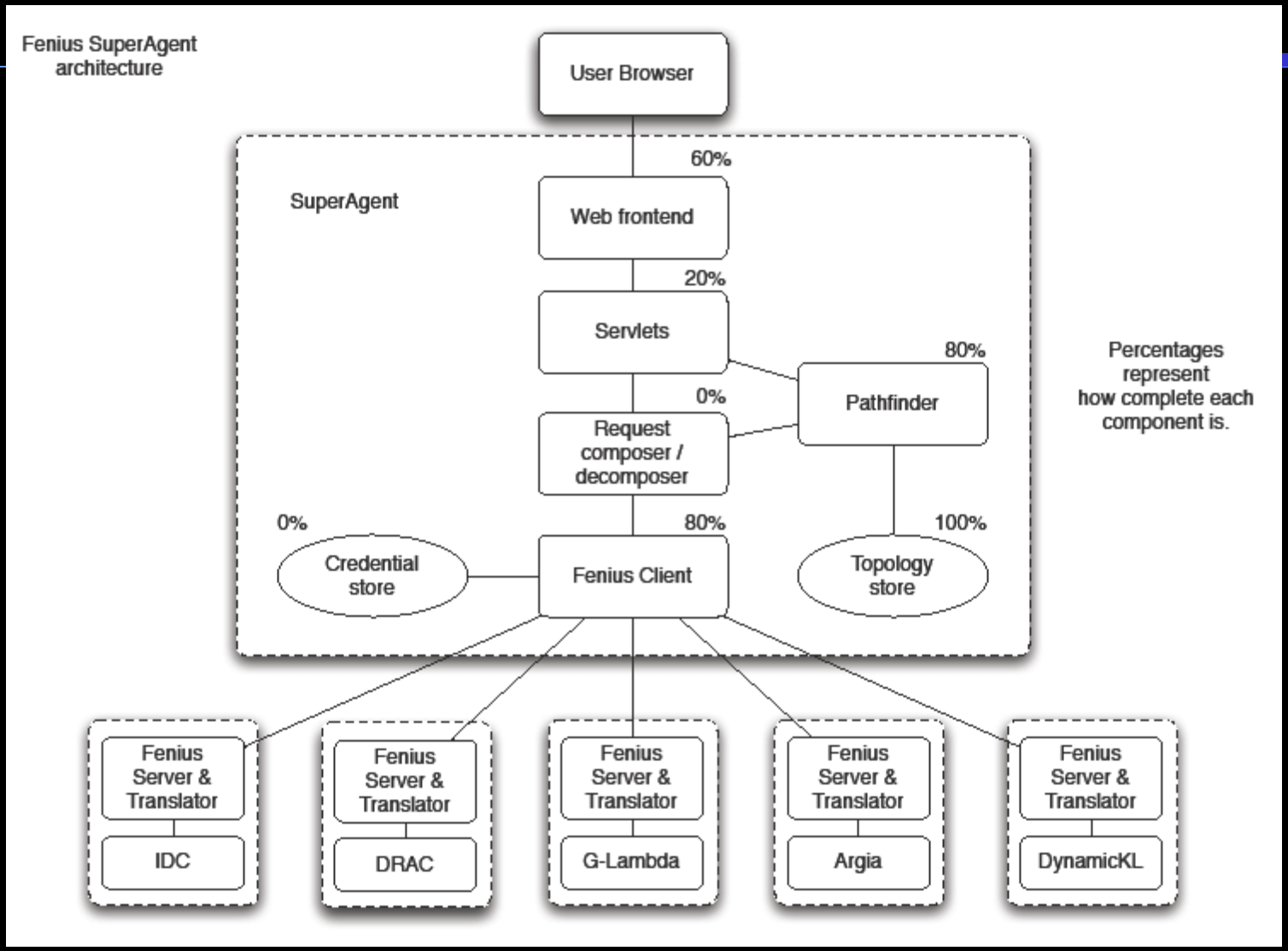


STARLIGHT SM



Fenius GLIF Demonstrations Global Lambda Grid Workshop SC10

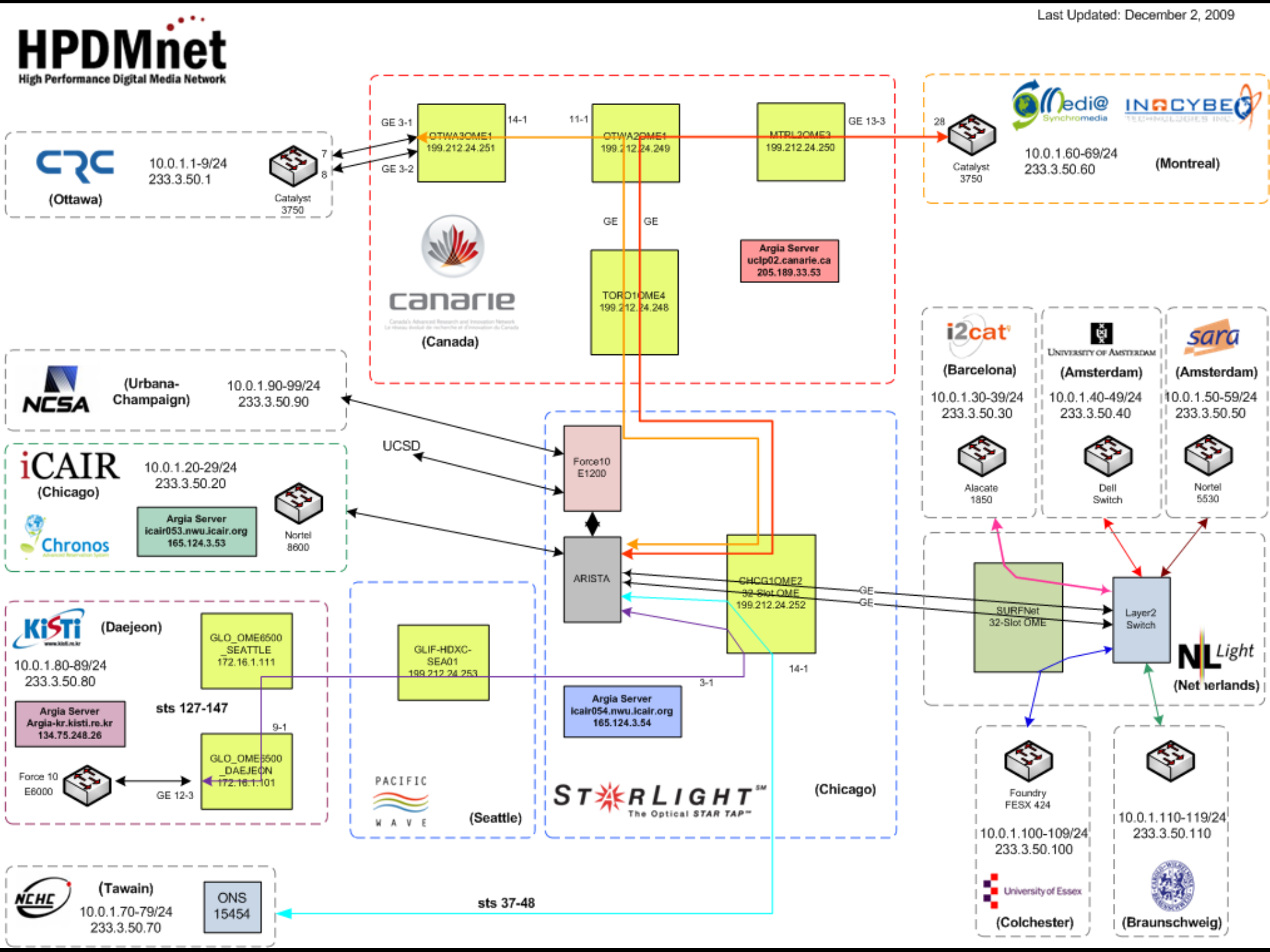


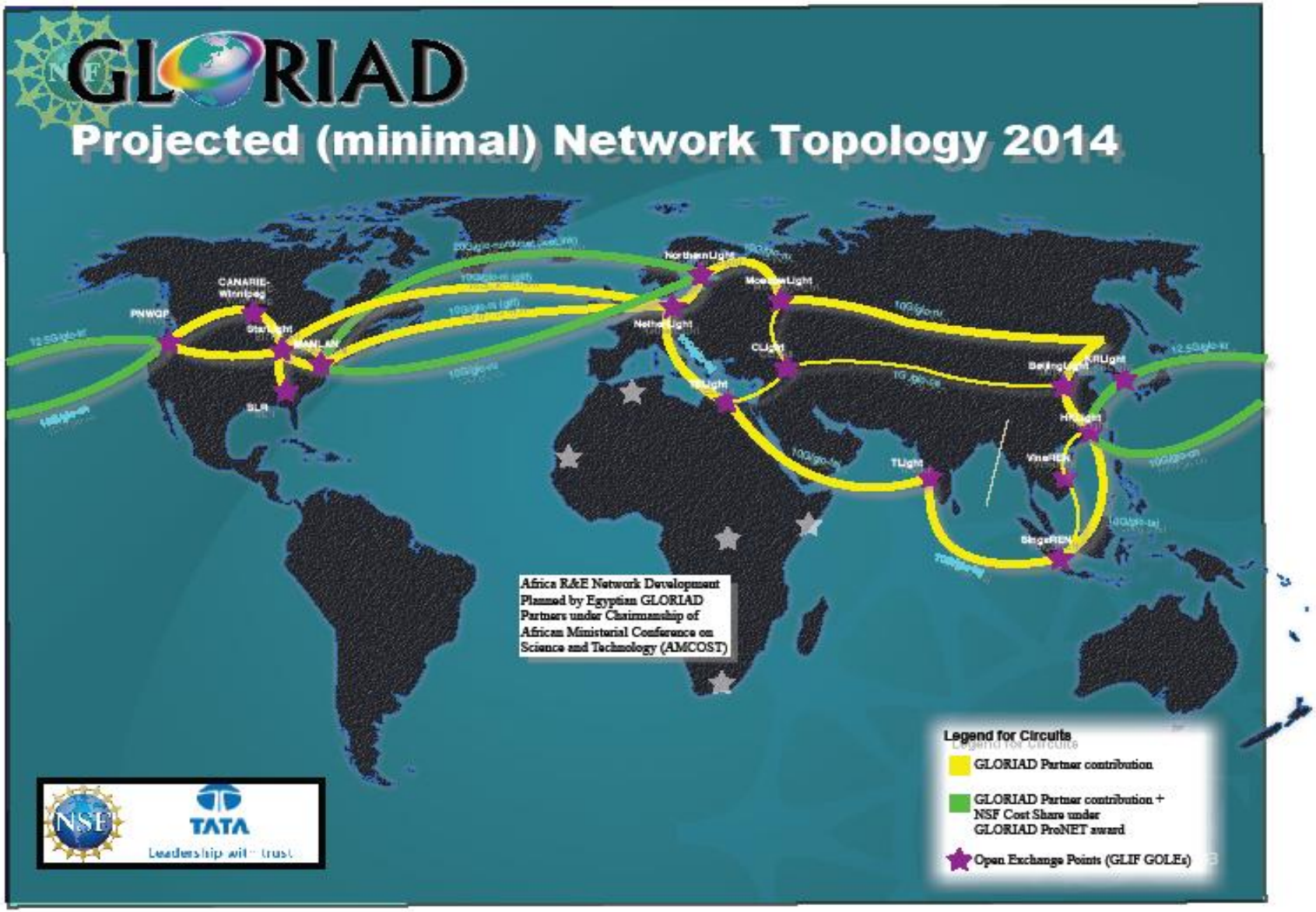

Fenius SuperAgent architecture
User Browser
SuperAgent
60%
Web frontend
20%
Servlets
80%
Pathfinder
0%
Request composer / decomposer
0%
Credential store
80%
Fenius Client
100%
Topology store
Percentages represent how complete each component is.
Fenius Server & Translator
IDC
Fenius Server & Translator
DRAC
Fenius Server & Translator
G-Lambda
Fenius Server & Translator
Argia
Fenius Server & Translator
DynamicKL

Last Updated: December 2, 2009

HPDMnet

High Performance Digital Media Network




GLORIAD
Projected (minimal) Network Topology 2014
CANARIE-Winnipeg
PNWGP
StarLight
MANLAN
SLR
NetherLight
CLight
TLight
TLight
Africa R&E Network Development Planned by Egyptian GLORIAD Partners under Chairmanship of African Ministerial Conference on Science and Technology (AMCOST)
NSF
TATA
Legend for Circuits
GLORIAD Partner contribution
GLORIAD Partner contribution + NSF Cost Share under GLORIAD ProNET award
Open Exchange Points (GLIF GOLEs)

USA-RUSSIA-CHINA-KOREA-NETHERLANDS-CANADA-
DENMARK-FINLAND-ICELAND-NORWAY-SWEDEN

INDIA-EGYPT-SINGAPORE-VIETNAM-GREENLAND

GLORIAD-Taj Expansion

The new Taj expansion is highlighted in orange on this map

Global Ring Network for Advanced Applications Development

Based on Map created (2007) by Natasha Bulashova

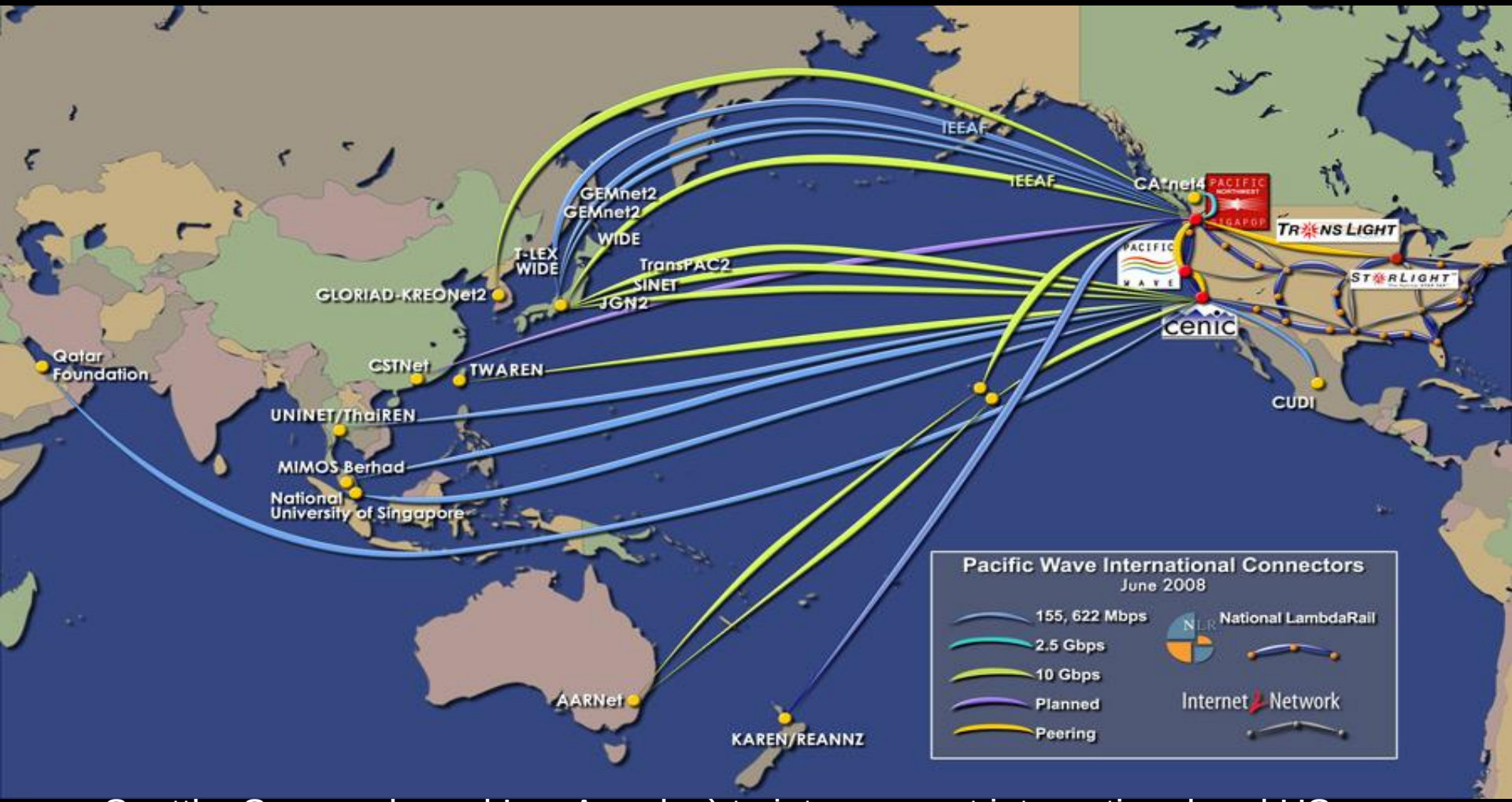
NSF TATA Leadership with trust


GLORIAD
App. Categories
GLORIAD
App. Categories
GLORIAD
App. Categories

STARLIGHT℠

TransLight/Pacific Wave

10GE Wave Facilitates US West Coast Connectivity



Seattle, Sunnyvale and Los Angeles) to interconnect international and US research and education networks

www.pacificwave.net/participants/irnc/

STARLIGHT SM

Testbeds Preparing for Transition To 100 Gbps Services

- Capacity
  - Support for Capacity Much Beyond Aggregation of Millions of Small Flows
  - Support for Extremely Large Individual Stream (Including End-To-End)
- Communications for Data Intensive Petascale Science
- Communications for Specialized Distributed Environments
- Environments Directly Controlled By Edge Processes (Application Specific Network Services)
- Highly Controllable Science Workflows
- Science Clouds (vs Consumer and Enterprise)
- Many New Applications and Services That Cannot Be Supported Today

100 Gbps Services: Routing

- 100 Gbps Routing
- Available Today Based on Proprietary Technology
- Optimal Network Designs Place Such Devices At the Network Edge vs Network Core

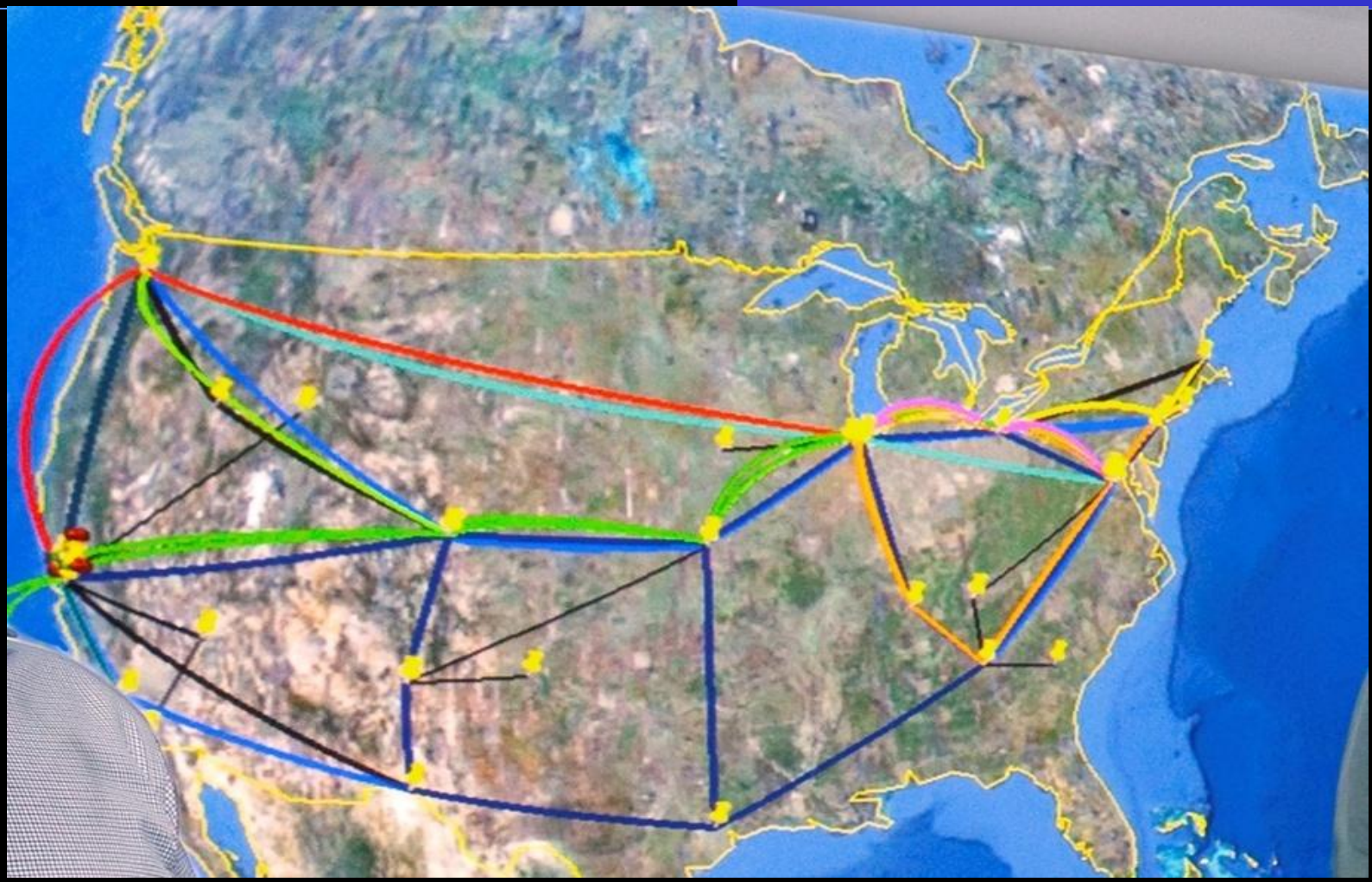
100 Gbps Services: Client Side (b)

- 100 GigE Physical Layer Standard (PHY) Objectives
  - Preserve 802.3 / Ethernet Frame Format Based On 802.3 MAC
  - Preserve Min/Max Frame Size of 802.3 Standard
  - Provide PHY Specifications For Single-Mode Optical Fiber, Multi-Mode Optical Fiber (MMF), Copper Cables, Backplanes.
  - Support Bit Error Ratio (BER) Better Than or Equal to 10 − 12 at the MAC/PLS Service Interface
  - Provide Appropriate Support for Optical Transport Network (OTN) Standard

100 Gbps Services: WAN Side/Line Side (a)

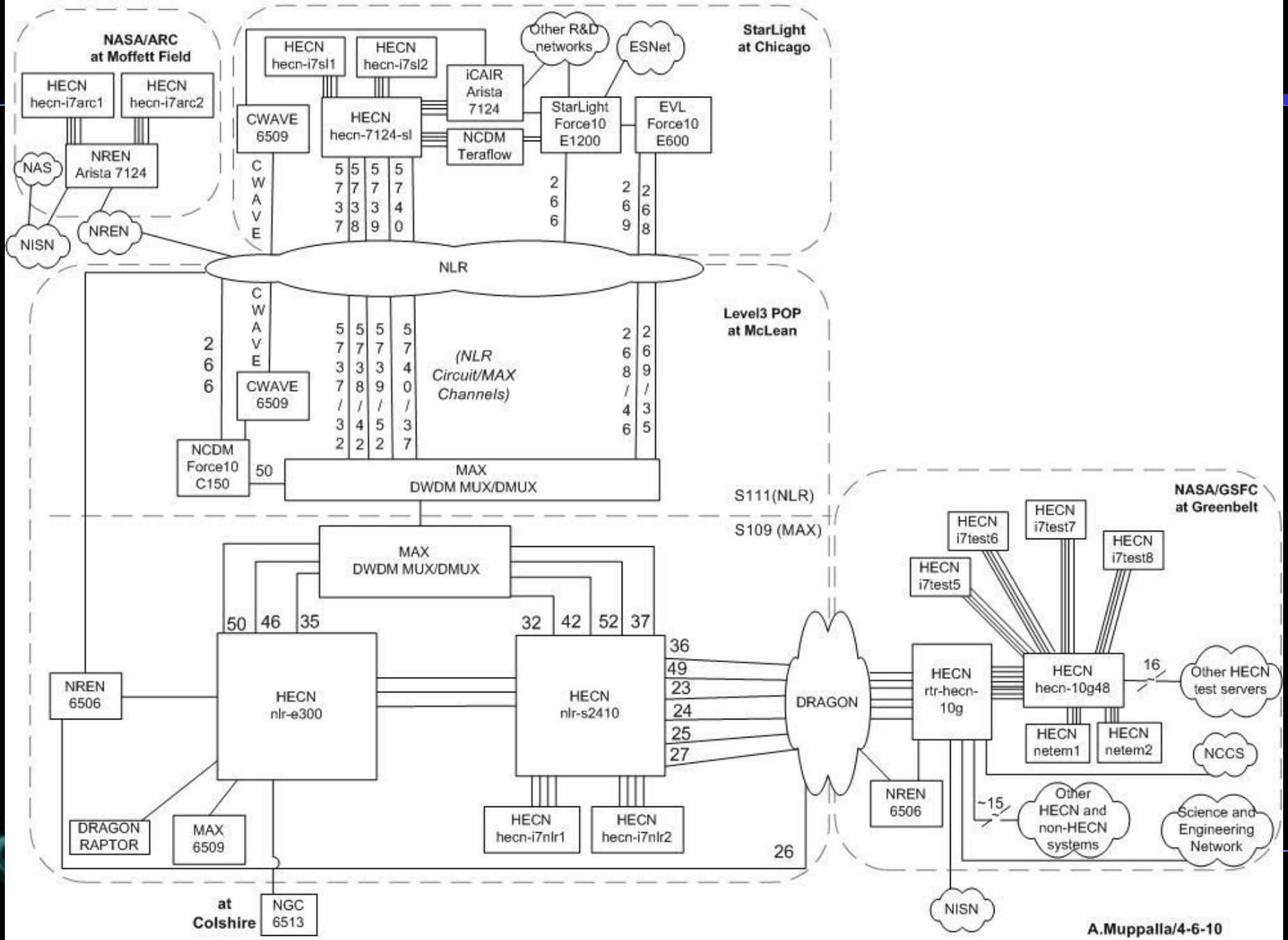
- 100 Gbps Optical Switching
  - Standard: ITU G.709 v3 (ODU4 100G)
  - ODU4/OTU4 Format -- Designed to Transport 100GbE (OTU4 = the ODU4 With FEC Included
  - Formal Final Approval Took Place In Dec 2009
  - Beta Products Available Today
  - Ref: Demonstrations at SC10
  - 1st Commercial Products Available End of Q2- Beginning Q3 2011

DOE ESnet Advanced Networking Initiative: 100 Gbps

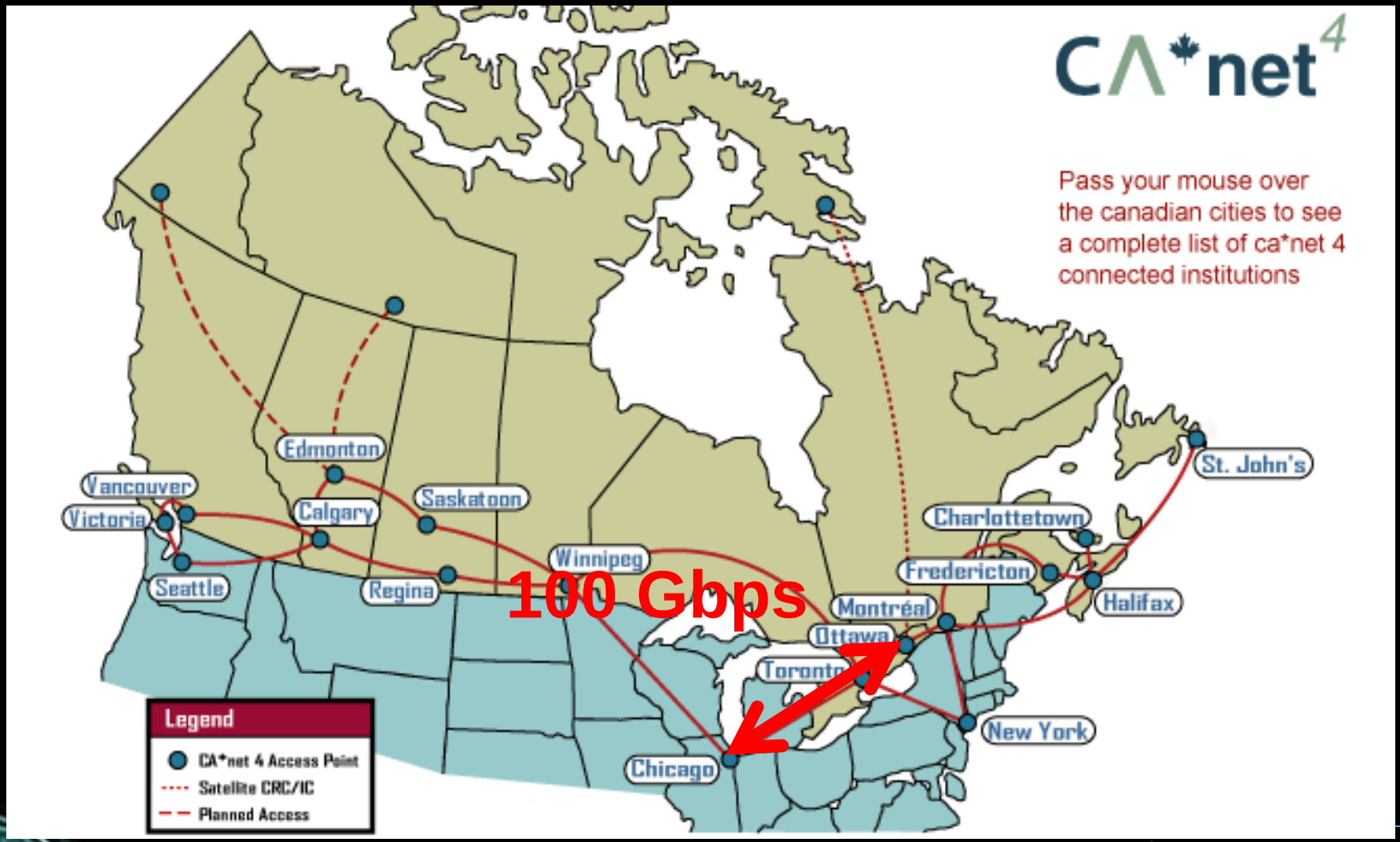


GSFC/High End Computer Network (HECN) and Partners 10GE and 10G Lambda Connections Through McLean

Note: The non-GSFC/HECN systems shown typically have other connections that are not shown in this diagram, as the focus is primarily GSFC/HECN connections



CA*net/Ciena/StarLight/iCAIR 100 Gbps Testbed



Source: CANARIE

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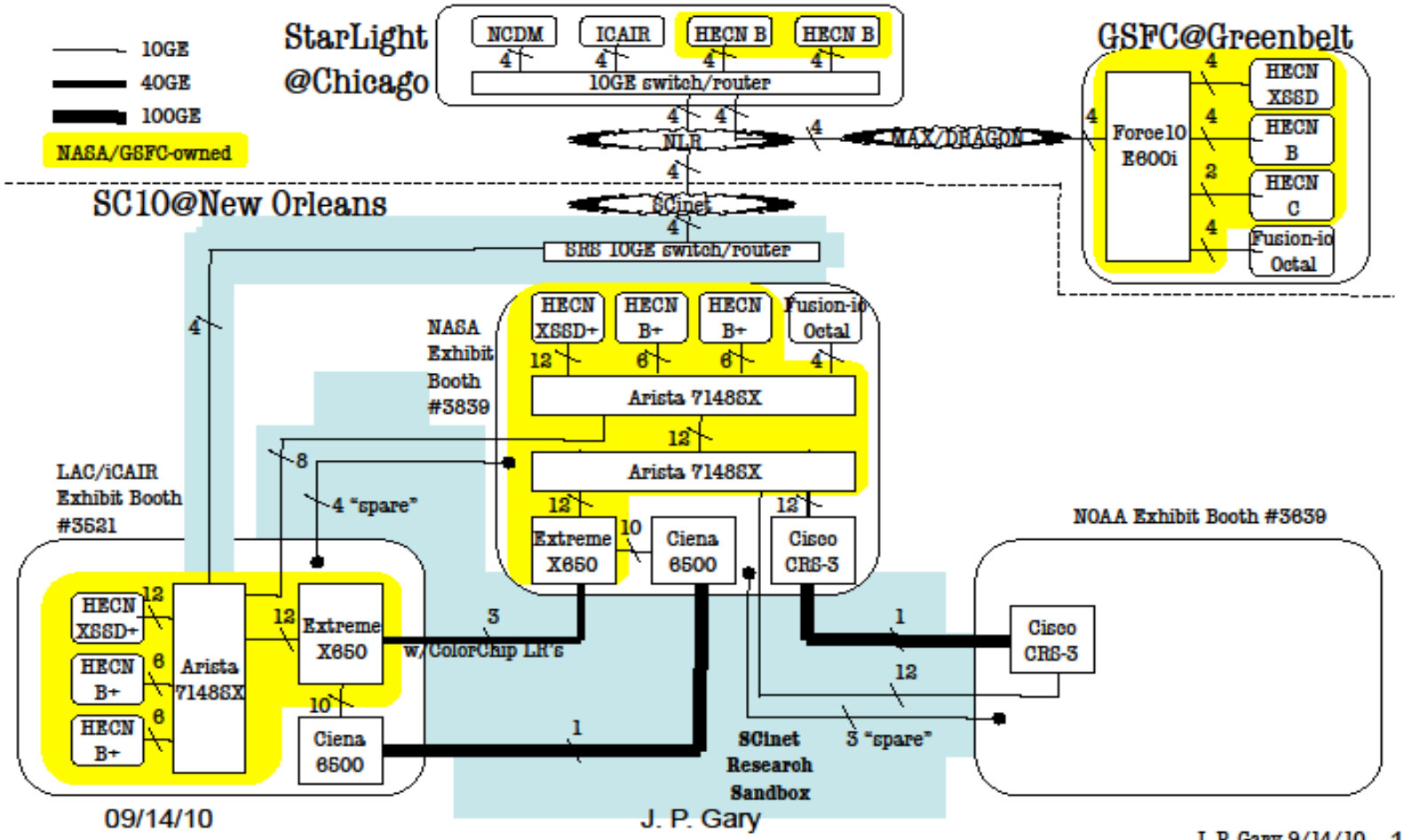
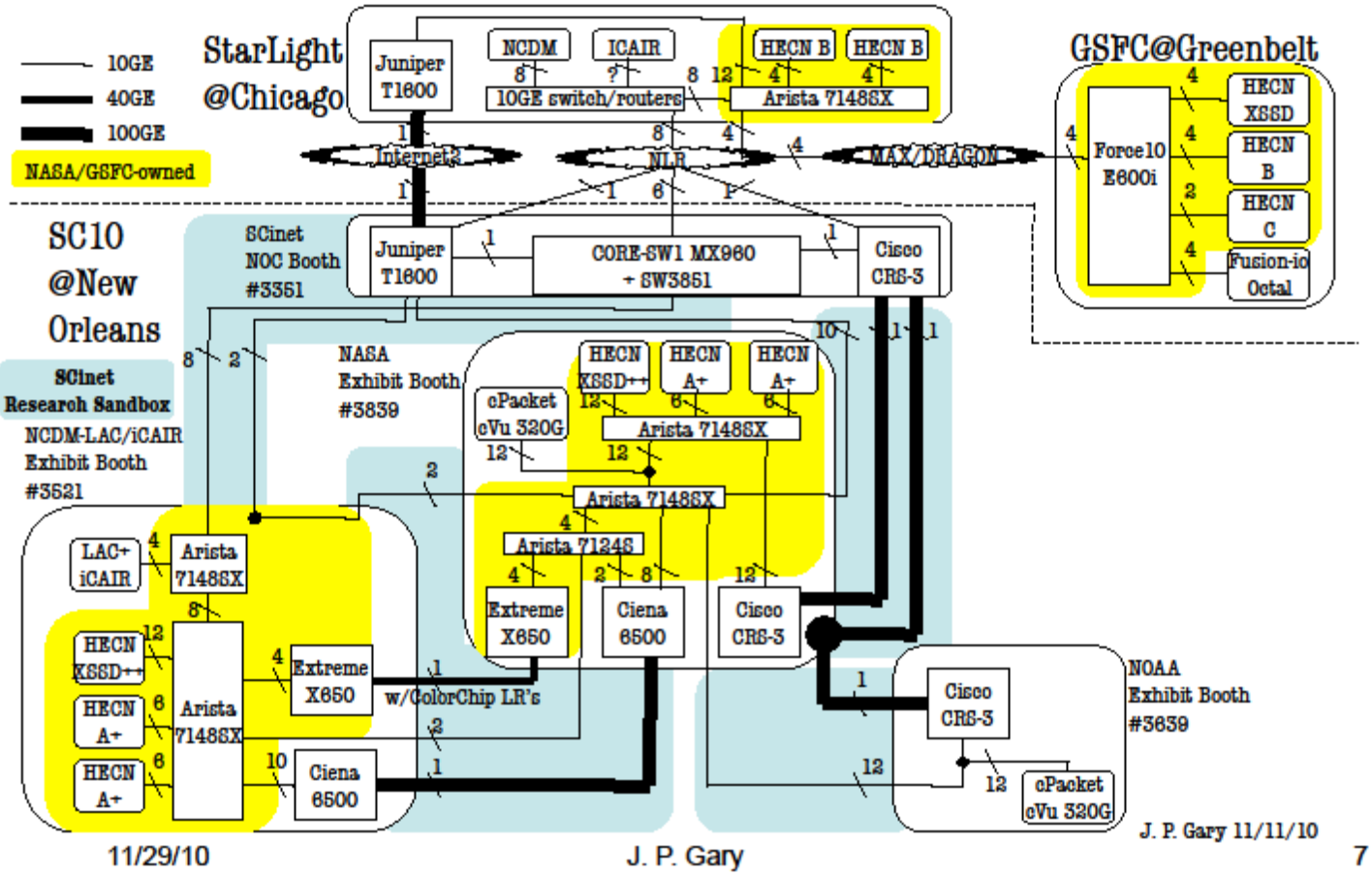
Using 100G Network Technology in Support of Petascale Science

A Collaborative Initiative Among NASA, NLR, NOAA, Northwestern/iCAIR, SCinet & UIC/LAC



Using 100G Network Technology in Support of Petascale Science

A Collaborative Initiative Among NASA, NLR, NOAA, Northwestern/iCAIR, SCinet & UIC/LAC
Also Using Internet2's Multi-Vendor 100GigE Infrastructure Between StarLight and SC10



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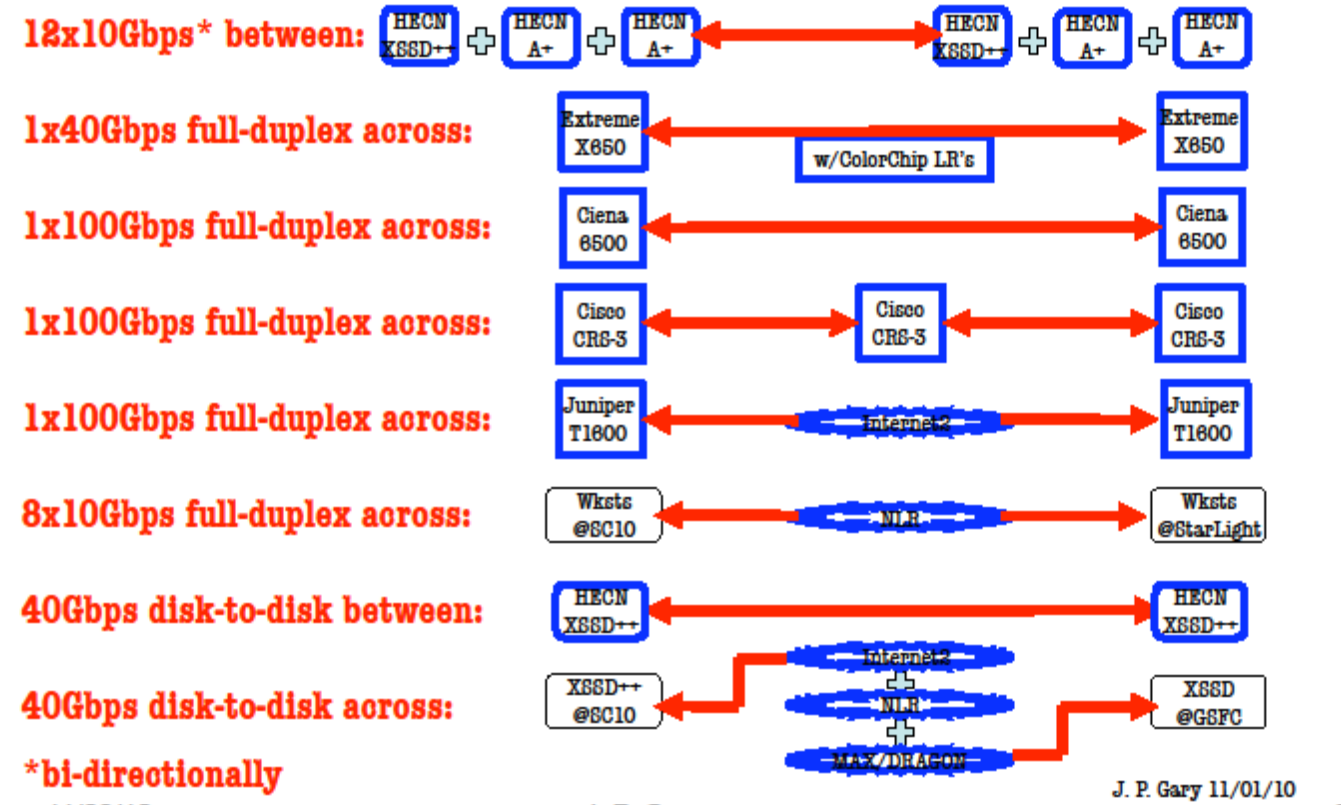
Demo Summary



*bi-directionally

J. P. Gary 11/01/10

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StarWave Facility With StarLight

- A National Science Foundation Funded Initiative
- Led by iCAIR
- Currently In Design Phase
- Scheduled for Summer 2011
- StarWave Will Provide Multi-100 Gbps Services for Data Intensive Science
- StarWave Will Integrated State-of-the-Art Architecture and Technology
- More Than Mere “Additional Capacity”
- Ref: Subsequent iCAIR Presentation on Multi-100 Gbps Services

Terabit Networks for Extreme Scale Science

- Workshop - February 16-17, 2011
  Rockville, MD
- Sponsored by Advanced Scientific Computing Research
- Department of Energy Office of Science
- Requirements for Significantly More Capacity
- New Architecture At All Levels
- New Technologies

Open Cloud Consortium

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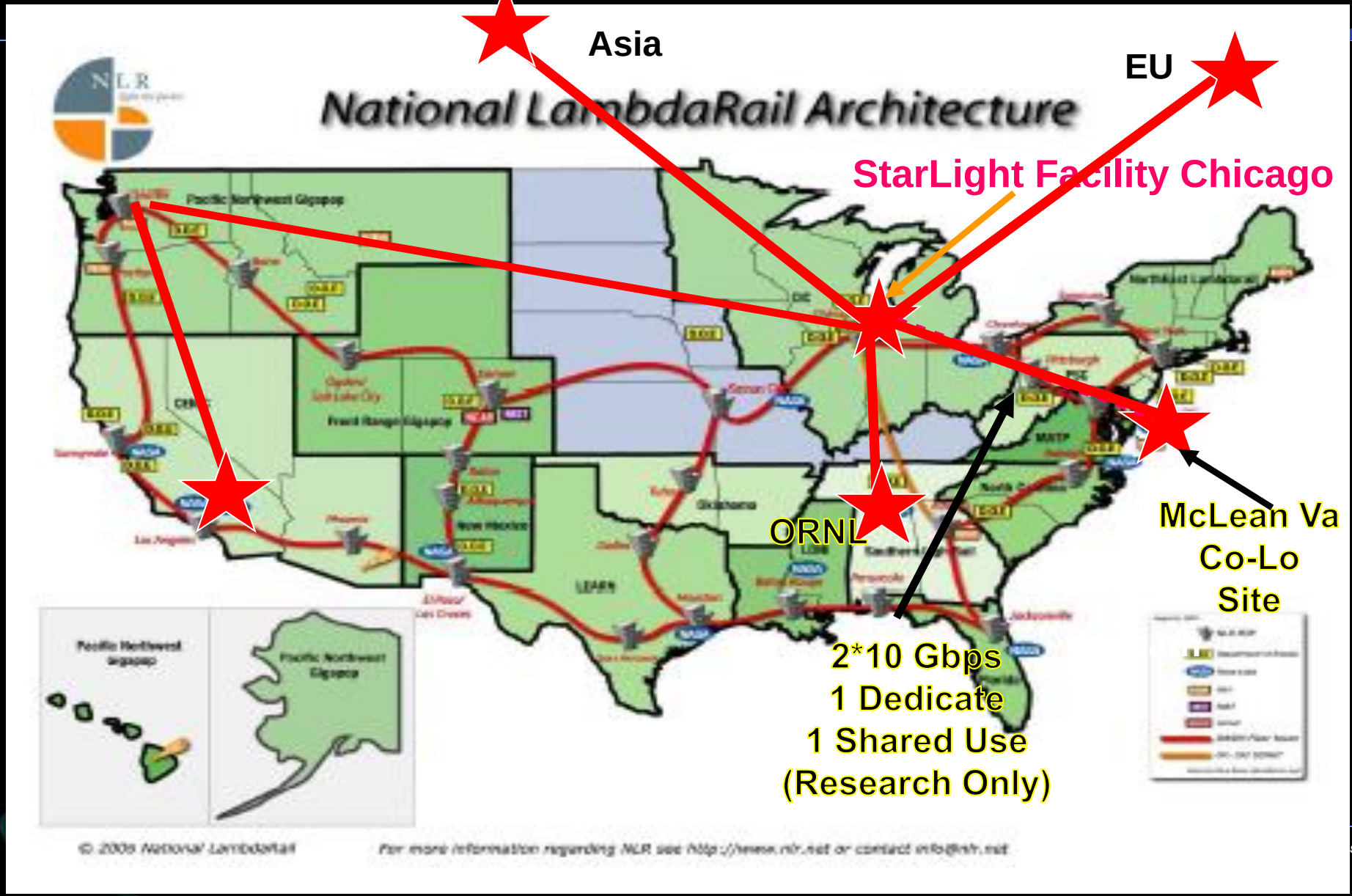
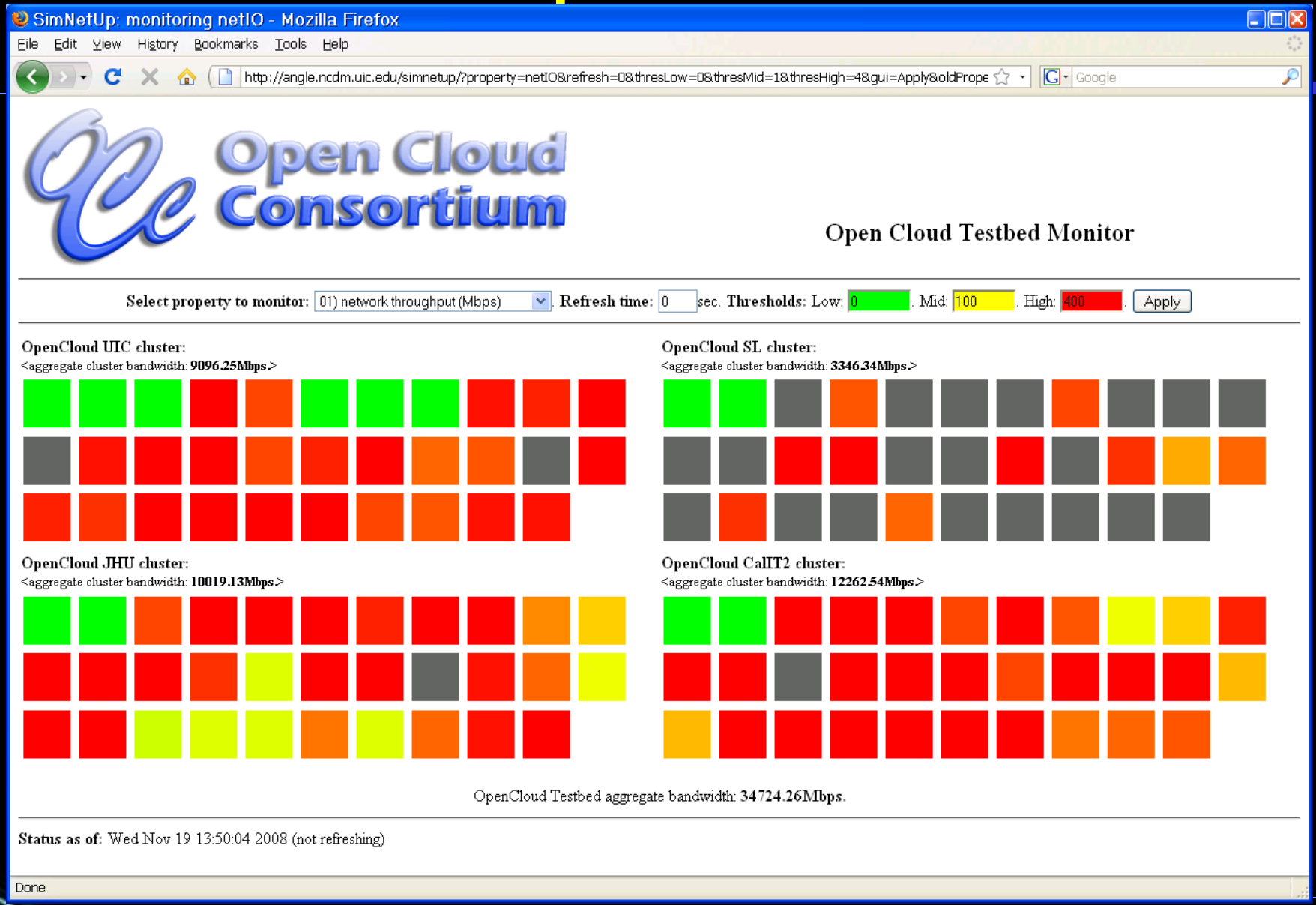
TeraFlow Network and NLR National View



Terasort on Open Cloud Testbed



Source: NCDM, UIC

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IEEE Communications March 2006 Special Issue on "An Optical Control Plane for the Grid Community"
Ref: iCAIR Article on ODIN – Optical Dynamic Intelligent Networking

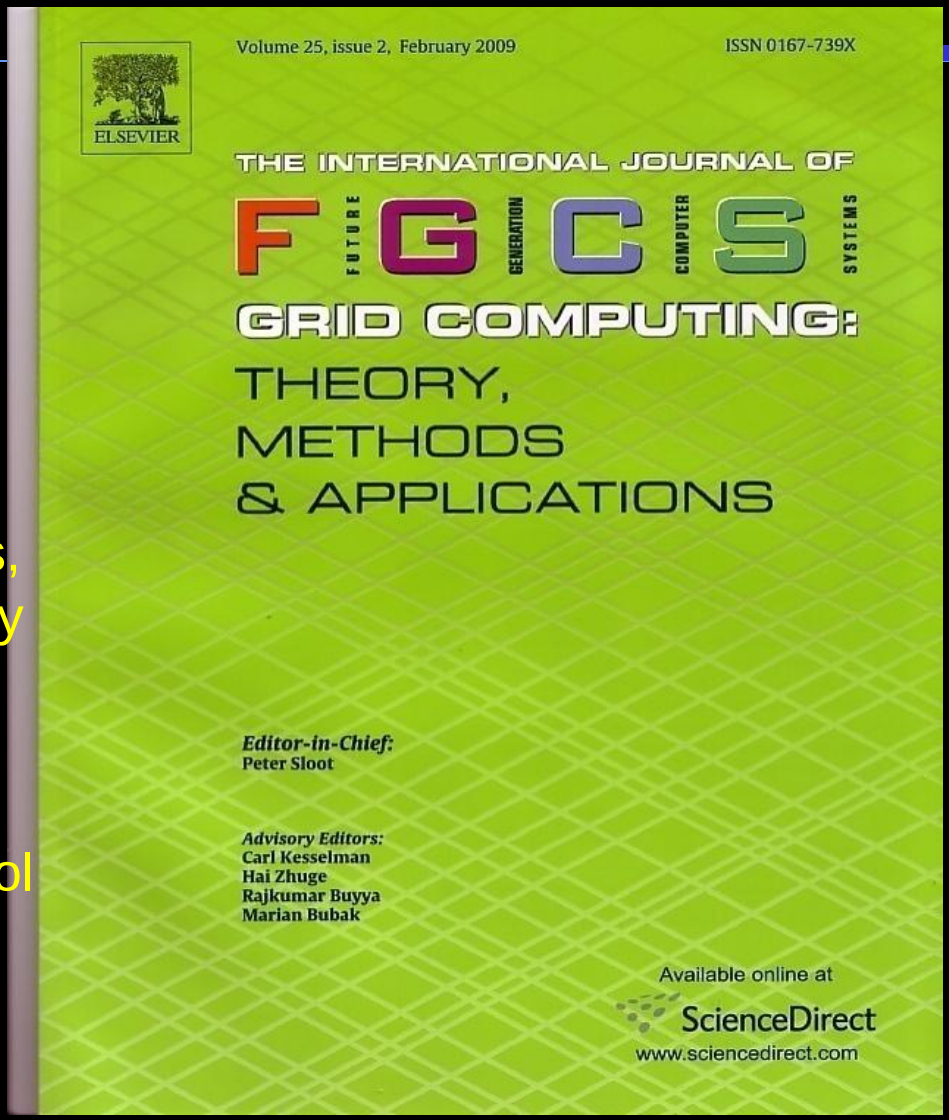
Future Generation Computer Systems 2009

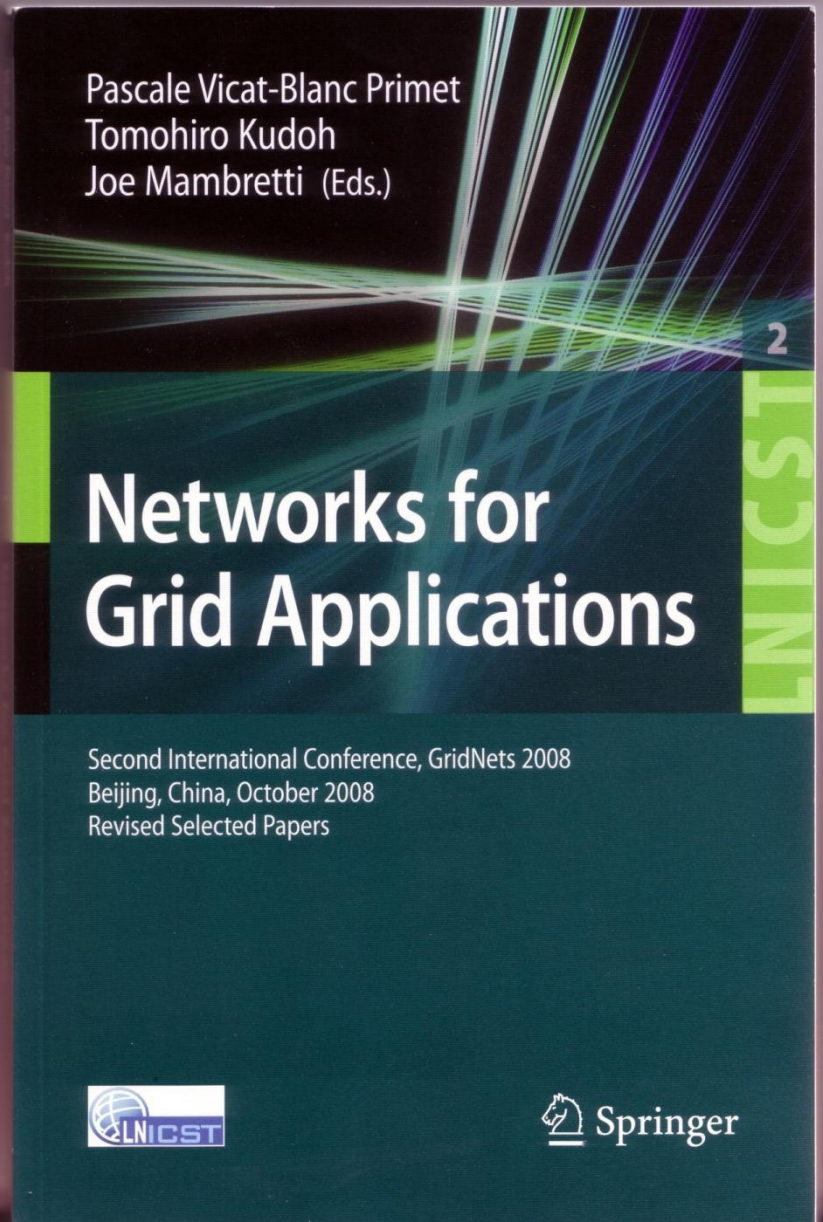
Special Issue Enabling Science With Optical Communications: The Global Lambda Integrated Facility

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

Future Generation Computer Systems, Volume 25, Issue 2, Elsevier, February 2009, pp. 137-141

"OptIPuter: Enabling Advanced Applications With Novel Optical Control Planes and Backplanes," iCAIR




Pascale Vicat-Blanc Primet
Tomohiro Kudoh
Joe Mambretti (Eds.)
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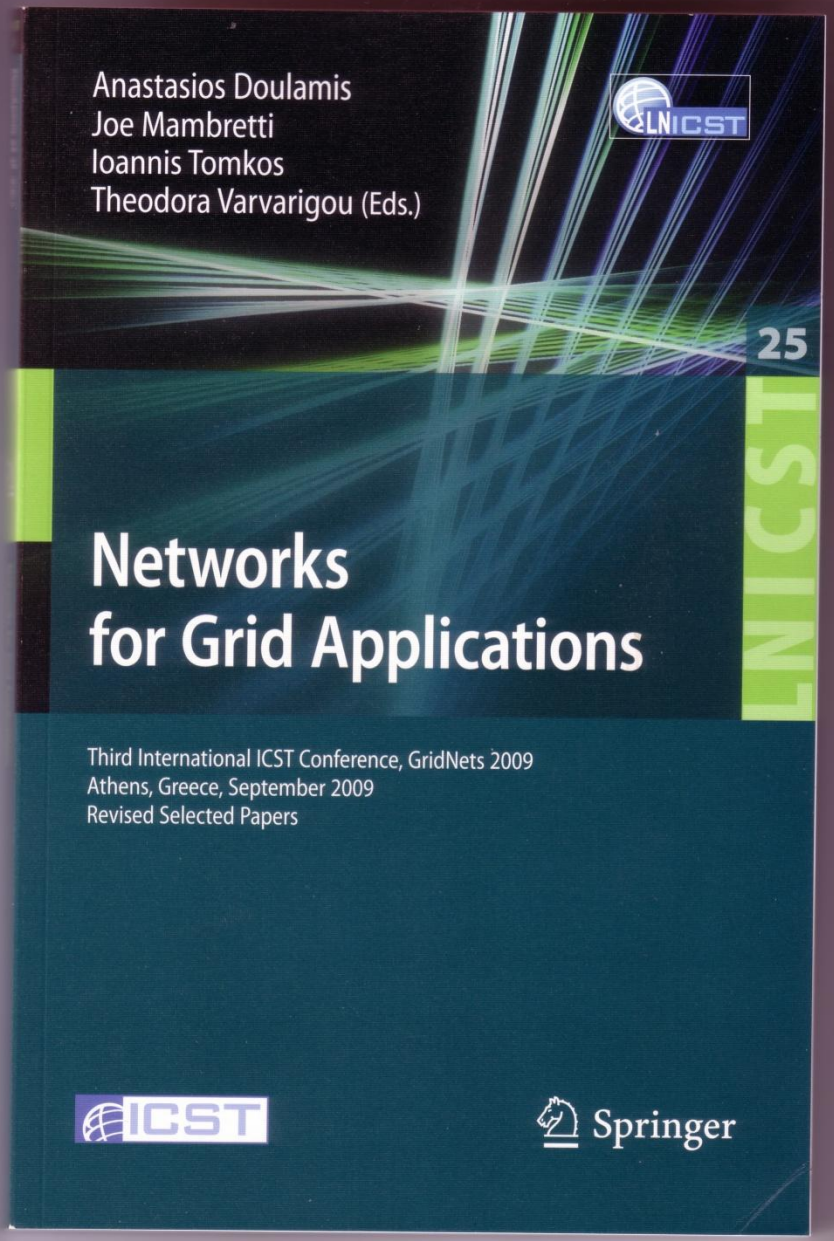
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Theodora Varvarigou (Eds.)
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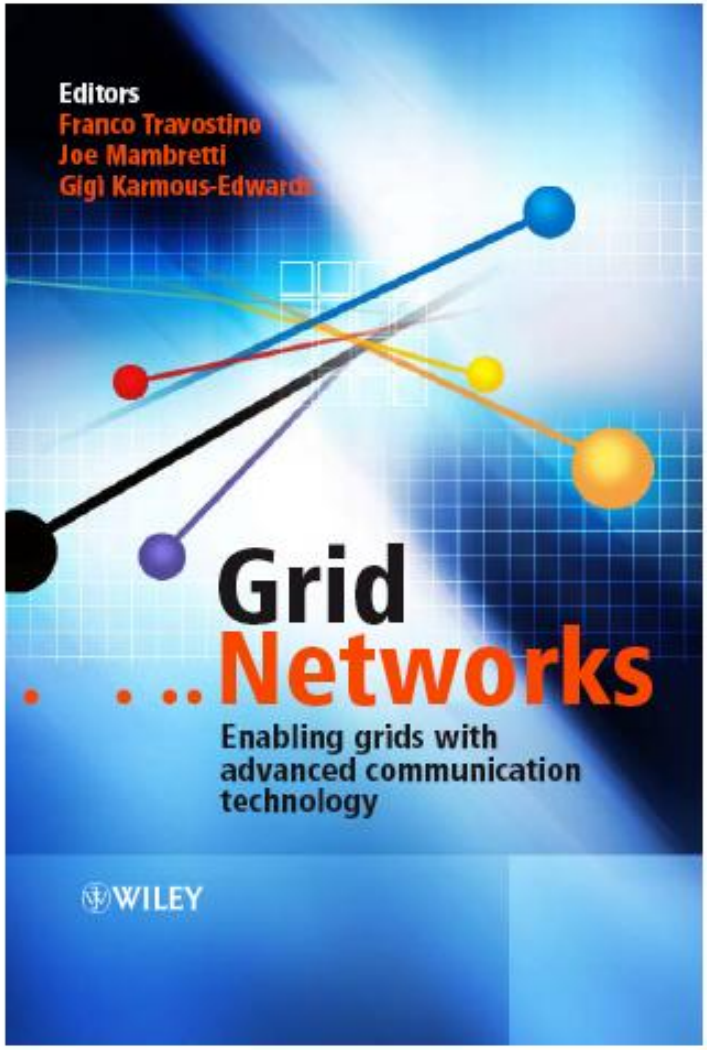
Editors
Franco Travostino
Joe Mambretti
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