

# Creating Environments for International Advanced Network Research: Motivation, Communities, Distributed Facilities, and The Global Environment for Network Innovations (GENI)

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Director, Metropolitan Research and Education Network ([www.mren.org](http://www.mren.org))

Co-Director, StarLight International/National Communications

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

Pi- International Global Environment for Network Innovations (iGENI)

GENI CIO Workshop  
Boston, Massachusetts

July 12, 2012



# Introduction to iCAIR:



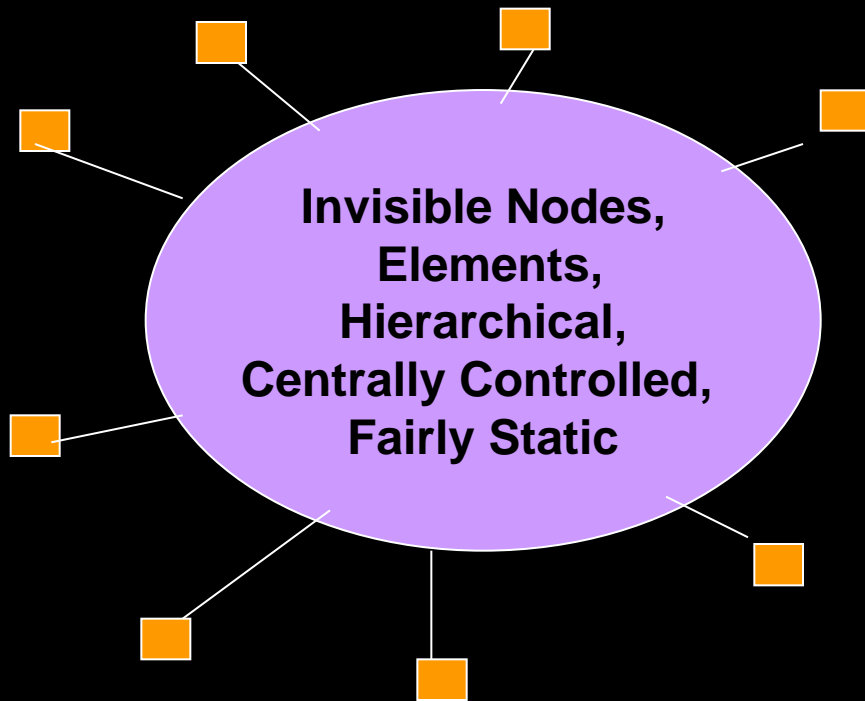
Accelerating Leading Edge Innovation and Enhanced Global Communications through Advanced Internet Technologies, in Partnership with the Global Community

- **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)**



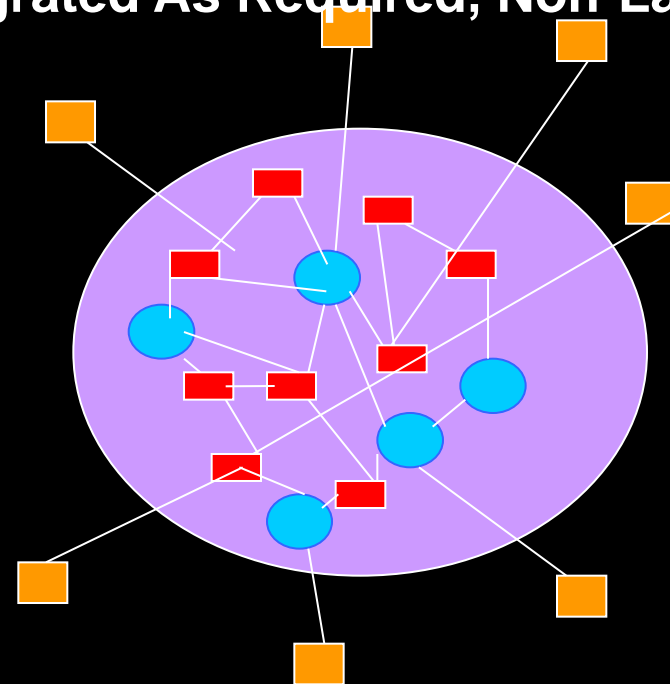
# Paradigm Shift – Ubiquitous Services Based on Large Scale Distributed Facility vs Isolated Services Based on Separate Component Resources

**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**

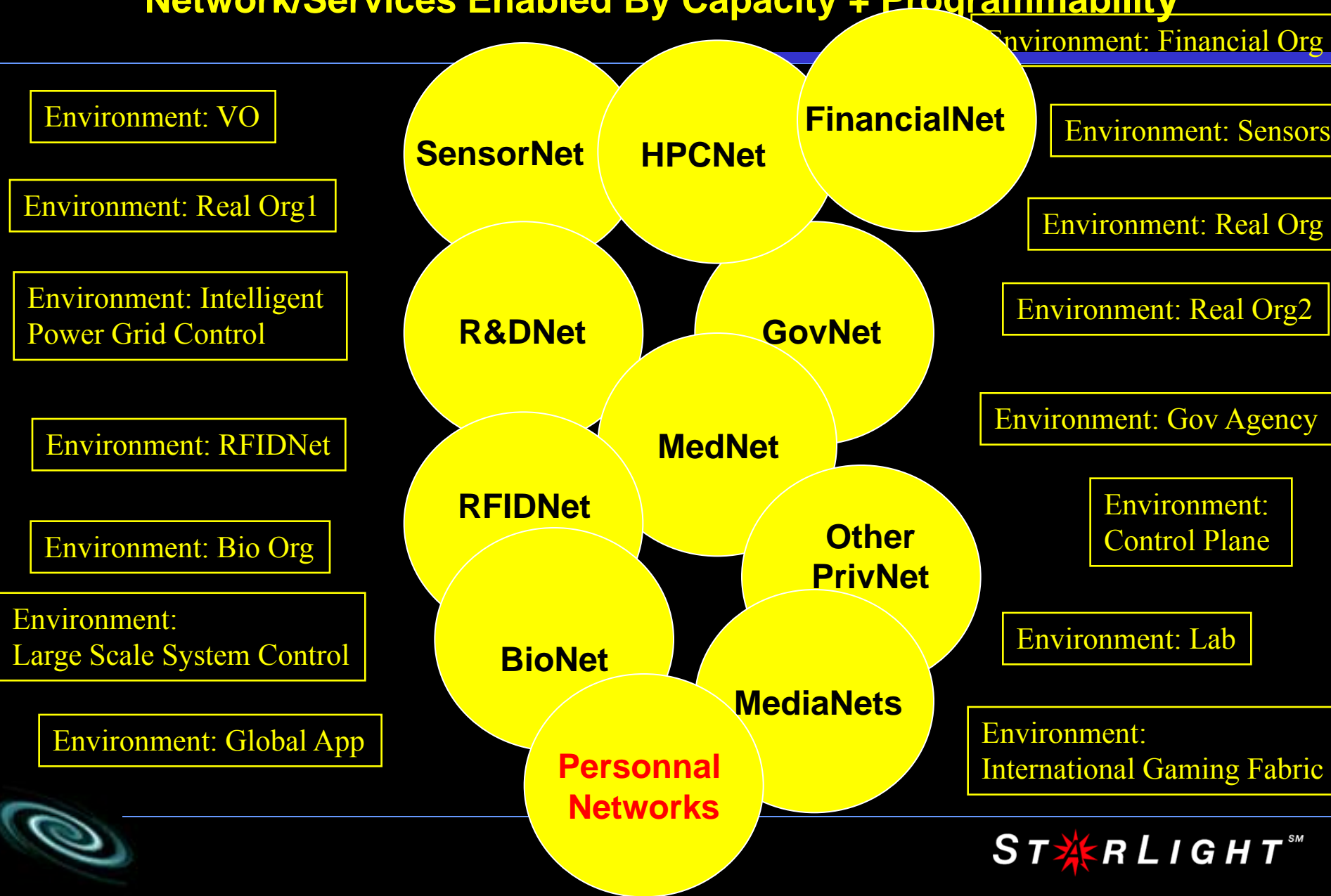


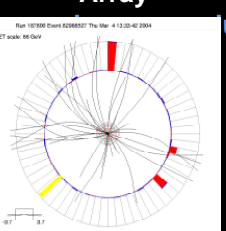
**Unlimited Services, Functionality,  
Flexibility, Expandability**

**Releasing the Fully Potential of Digital Technologies**

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

# A Next Generation Architecture: *Distributed Facility* Enabling Many Types Network/Services Enabled By Capacity + Programmability





**DØ (DZero)**  
[www.d0.fnal.gov](http://www.d0.fnal.gov)



**IVOA:**  
 International Virtual Observatory  
[www.ivoa.net](http://www.ivoa.net)



**OSG**  
[www.opensciencegrid.org](http://www.opensciencegrid.org)



**ANDRILL:**  
 Antarctic Geological Drilling  
[www.andrill.org](http://www.andrill.org)



**BIRN:** Biomedical Informatics Research Network  
[www.nbirn.net](http://www.nbirn.net)



**GLEON:** Global Lake Ecological Observatory Network



**WLCG**  
[lcg.web.cern.ch/LCG/public/](http://lcg.web.cern.ch/LCG/public/)



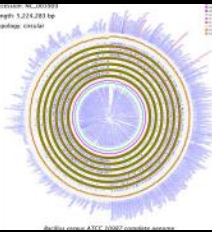
**LIGO**  
[www.ligo.org](http://www.ligo.org)



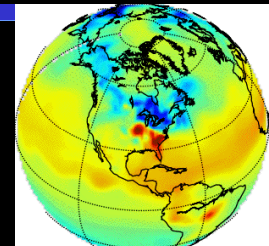
**OSG**  
[www.opensciencegrid.org](http://www.opensciencegrid.org)



**Globus Alliance**  
[www.globus.org](http://www.globus.org)



**CAMERA**  
 metagenomics  
[camera.calit2.net](http://camera.calit2.net)



**Carbon Tracker**  
[www.esrl.noaa.gov/gmd/ccgg/carbontrack](http://www.esrl.noaa.gov/gmd/ccgg/carbontrack)



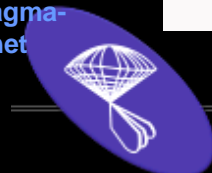
**OOI-CI**  
[ci.oceanobservatories.org](http://ci.oceanobservatories.org)



**PRAGMA**  
 Pacific Rim Applications and Grid Middleware Assembly  
[www.pragma-grid.net](http://www.pragma-grid.net)



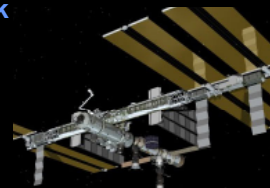
**SKA**  
[www.skatelescope.org](http://www.skatelescope.org)



**Sloan Digital Sky Survey**  
[www.sdss.org](http://www.sdss.org)



**CineGrid**  
[www.cinegrid.org](http://www.cinegrid.org)



**ISS:** International Space Station  
[www.nasa.gov/station](http://www.nasa.gov/station)



**TeraGrid**  
[www.teragrid.org](http://www.teragrid.org)



**XSEDE**  
[www.xsede.org](http://www.xsede.org)



**LHCONE**  
[www.lhcone.net](http://www.lhcone.net)



**CLASS**  
 Comprehensive Large-Array Stewardship System  
[www.class.noaa.gov](http://www.class.noaa.gov)



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



# 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



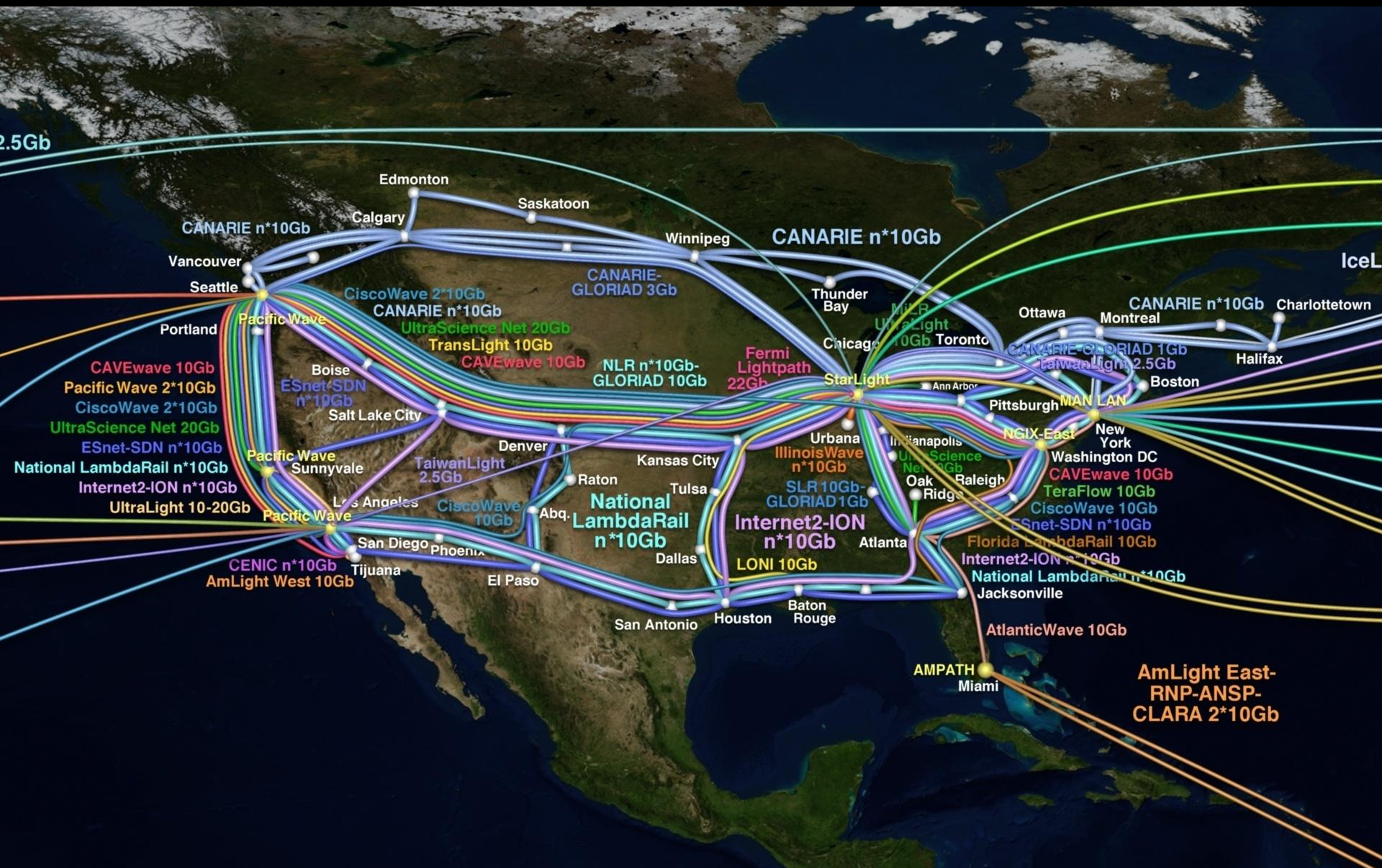
Abbott Hall, Northwestern University's Chicago Campus



STARLIGHT<sup>SM</sup>

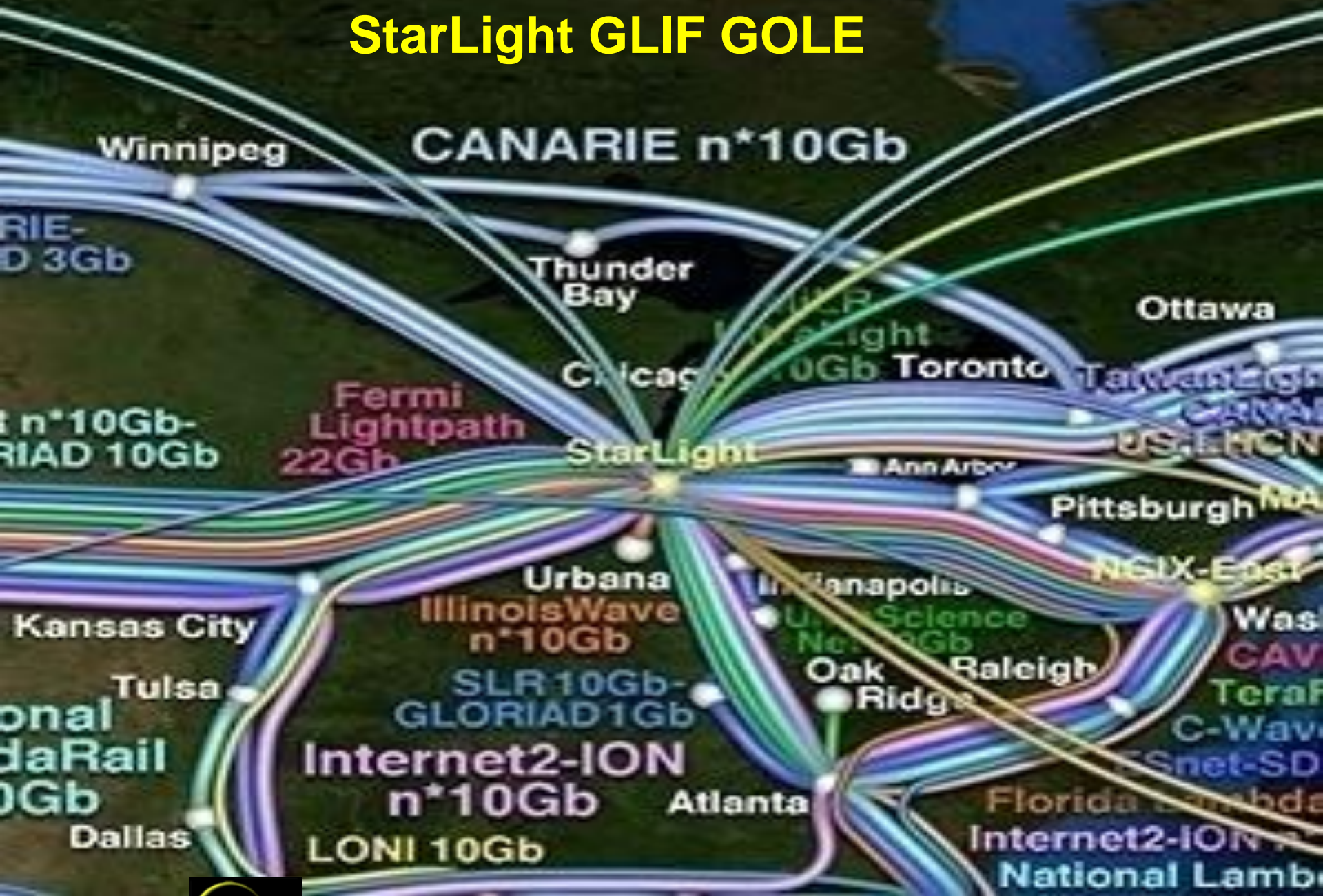








# StarLight GLIF GOLE







## Projected (minimal) Network Topology 2014

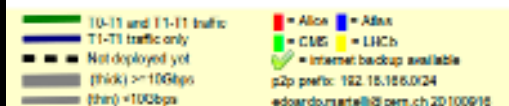


Africa R&E Network Development  
Planned by Egyptian GLORIAD  
Partners under Chairmanship of  
African Ministerial Conference on  
Science and Technology (AMCOST)



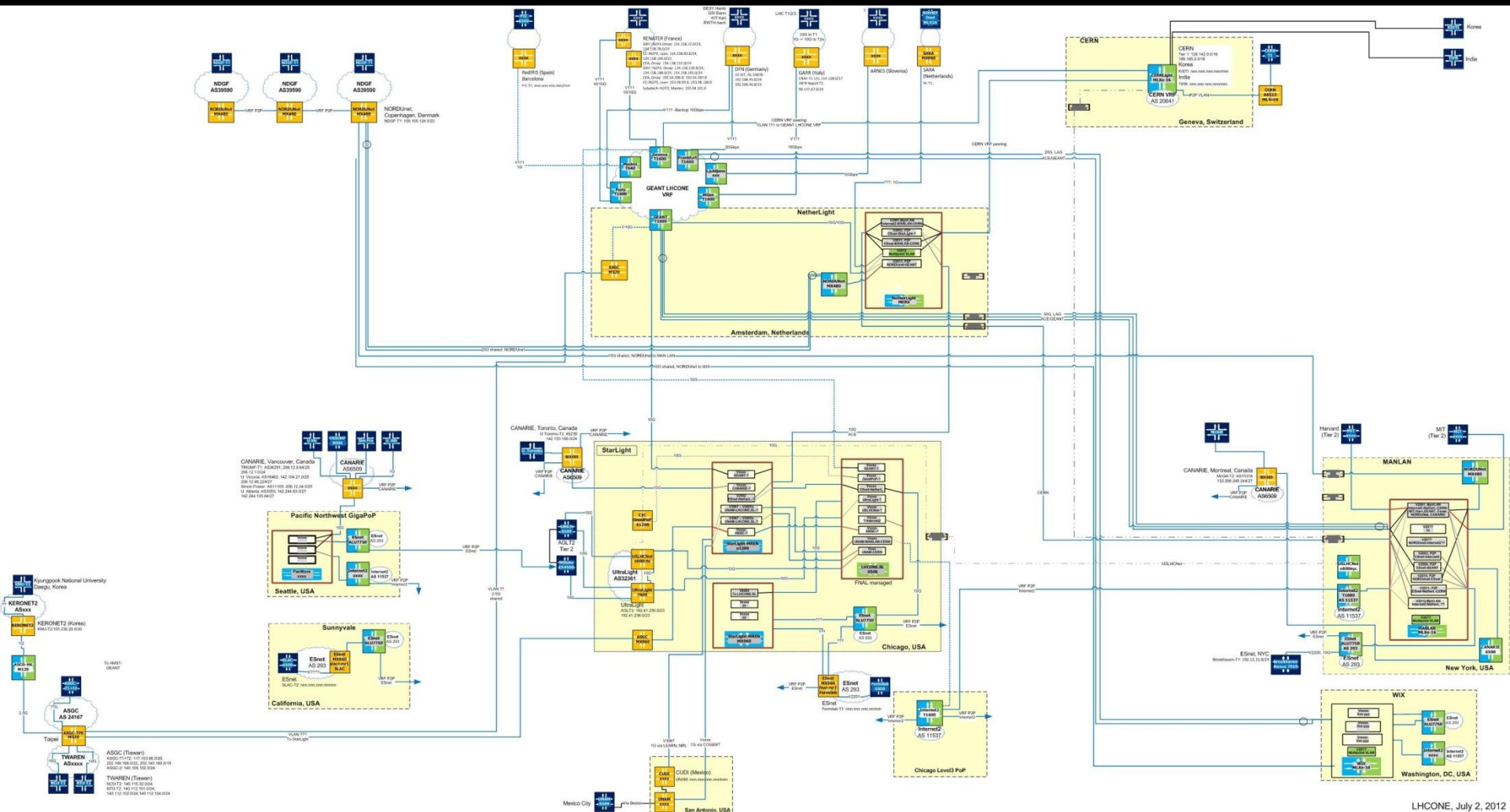
Open Exchange Points (GLIF GOLEs)

## 39. A. 5000





# TransLight/StarLight Example: LHCONE

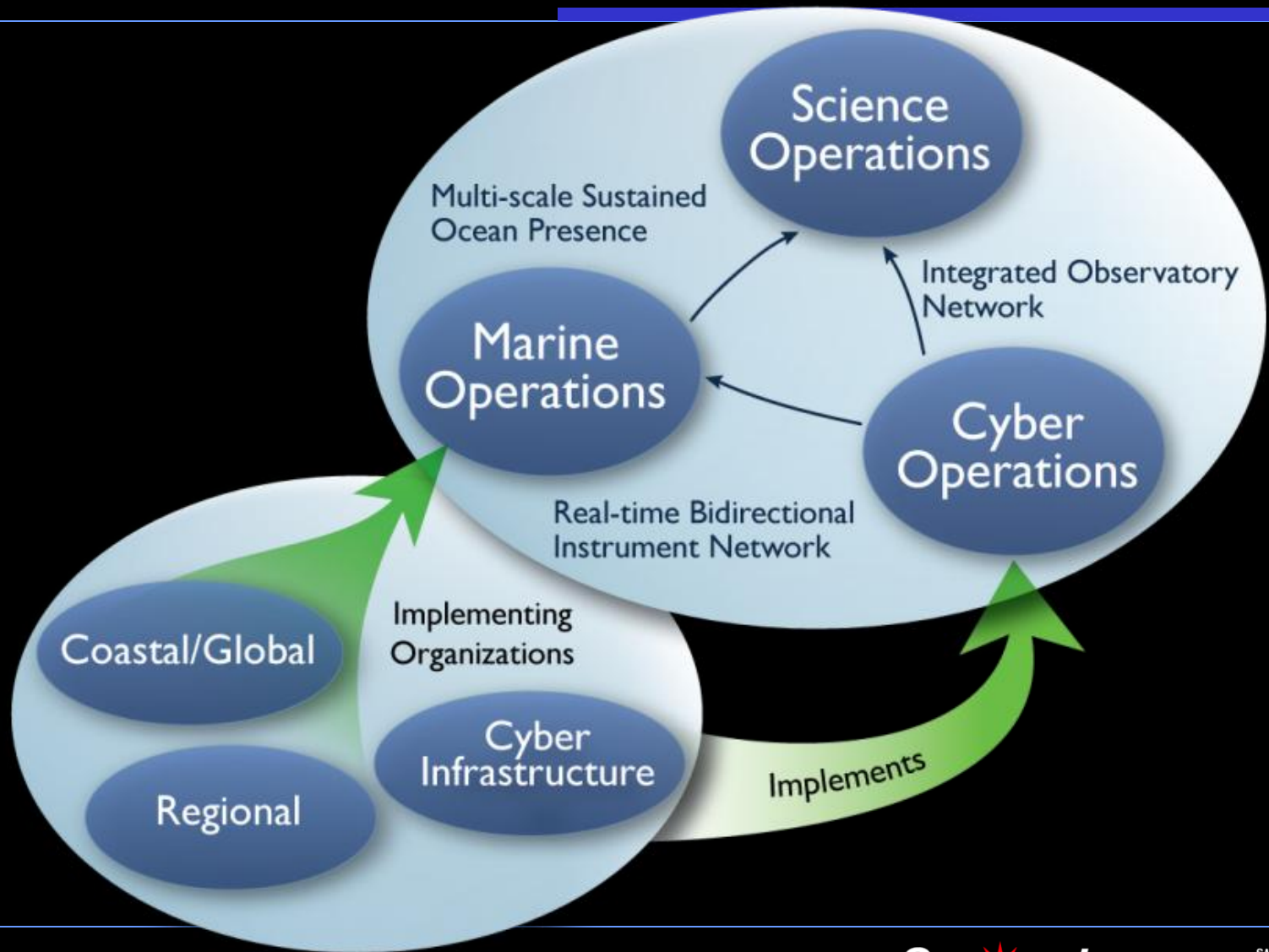


LHCONE, July 2, 2012

## Example 2: Astrophysics Networks



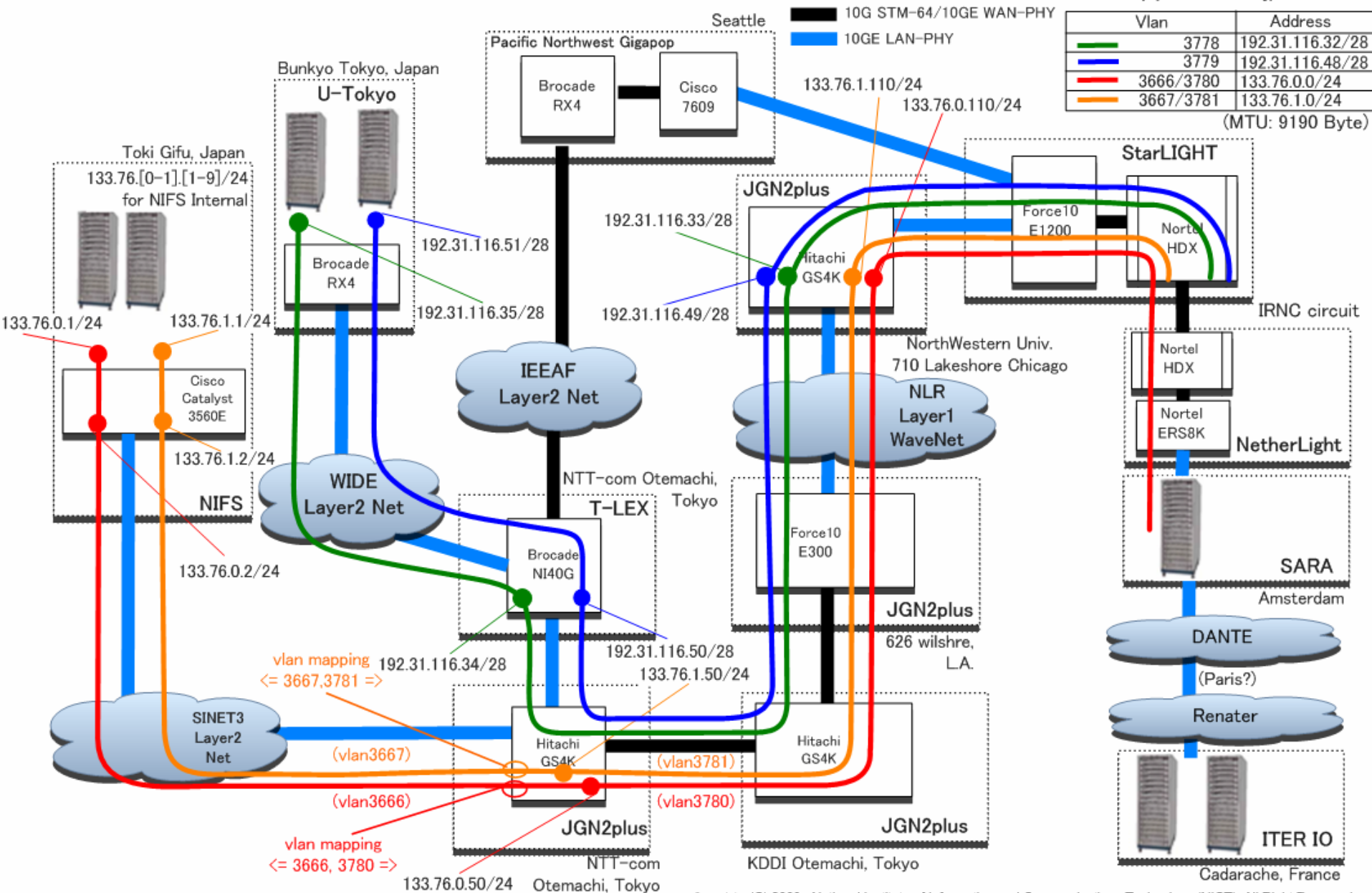
## Example 3a: NSF OOI





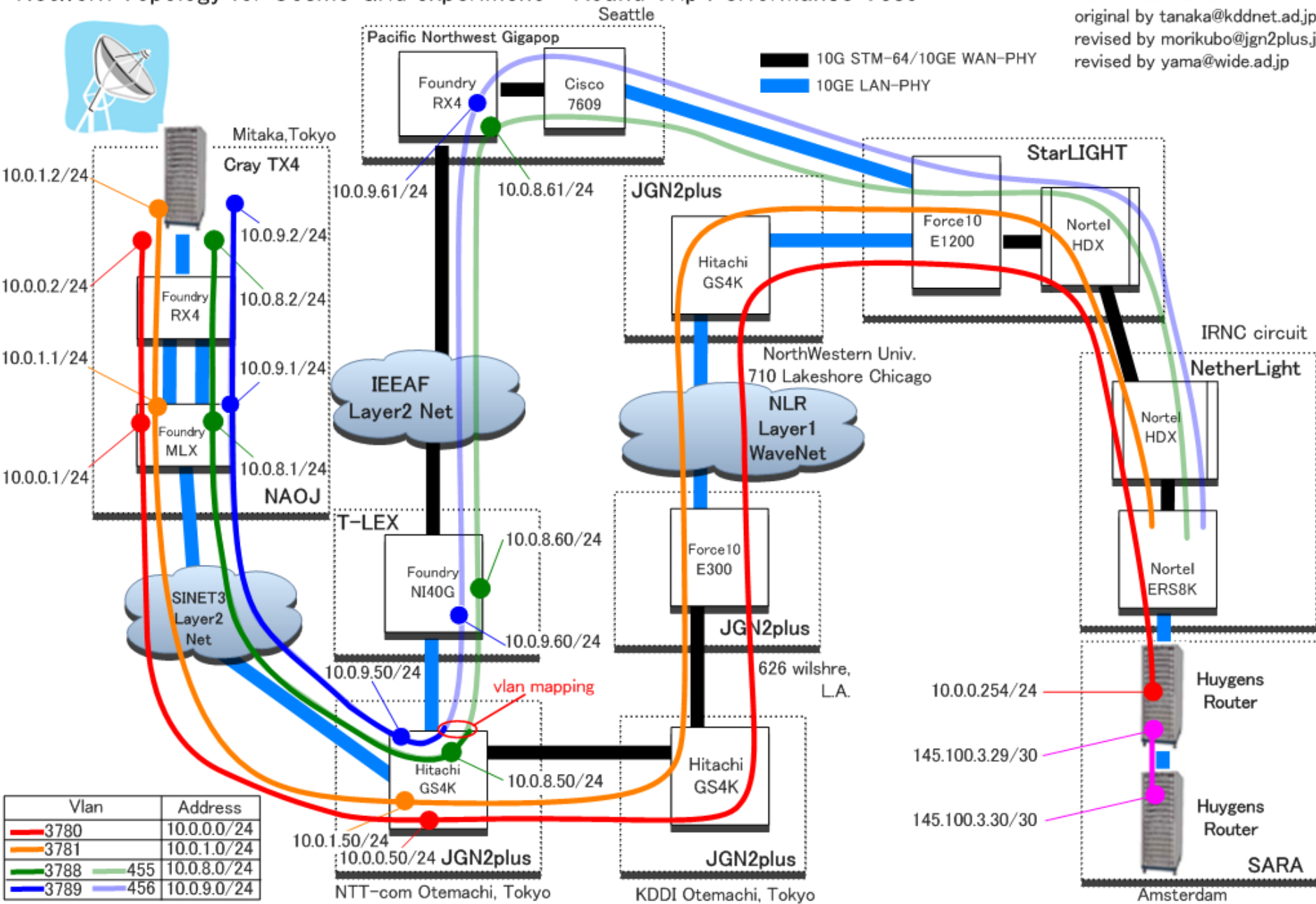
# Network Topology for Japan-France High-Speed Data Transfer Experiment

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



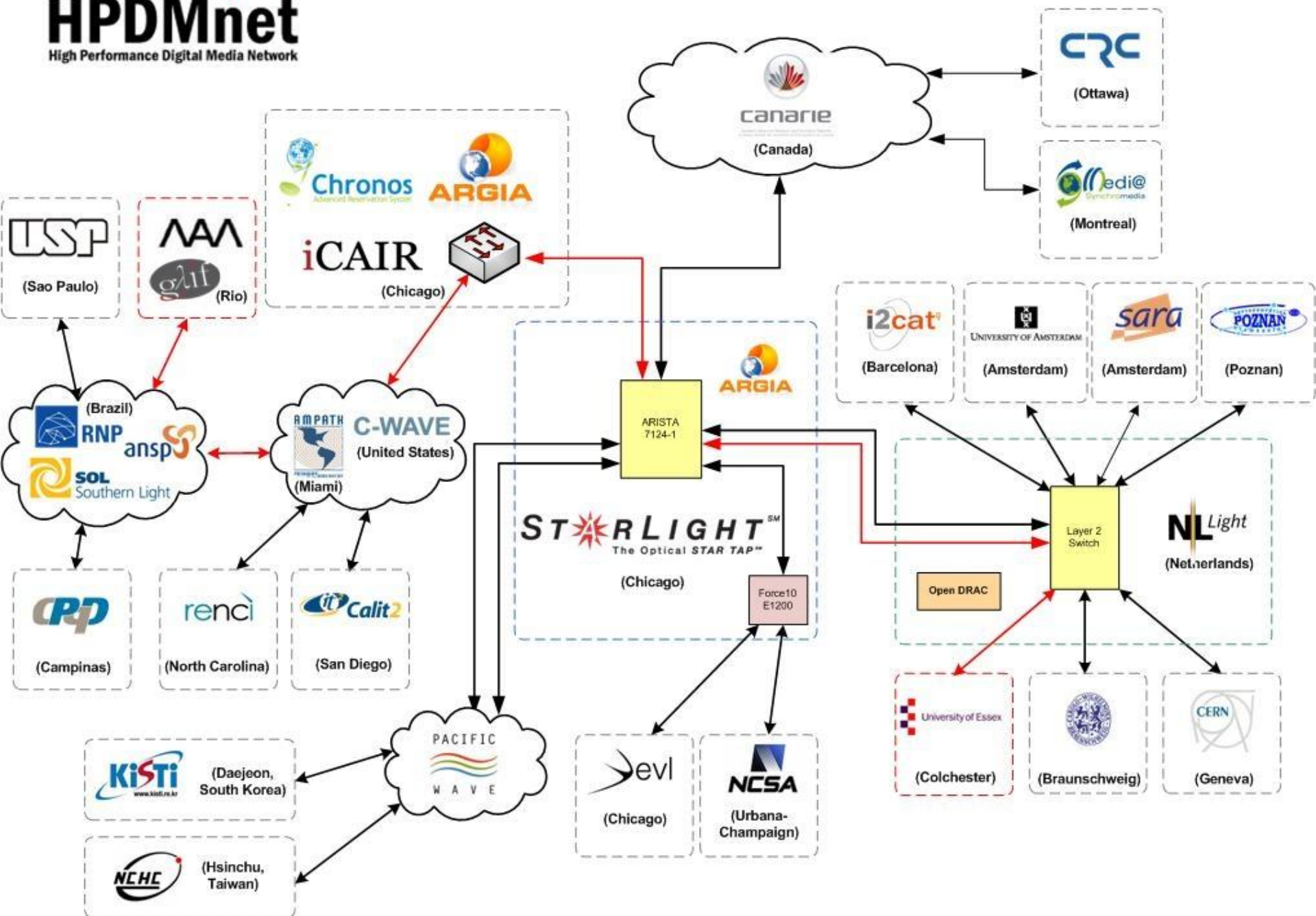
Network Topology for Cosmo Grid experiment – Round Trip Performance Test –

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



# HPDMnet

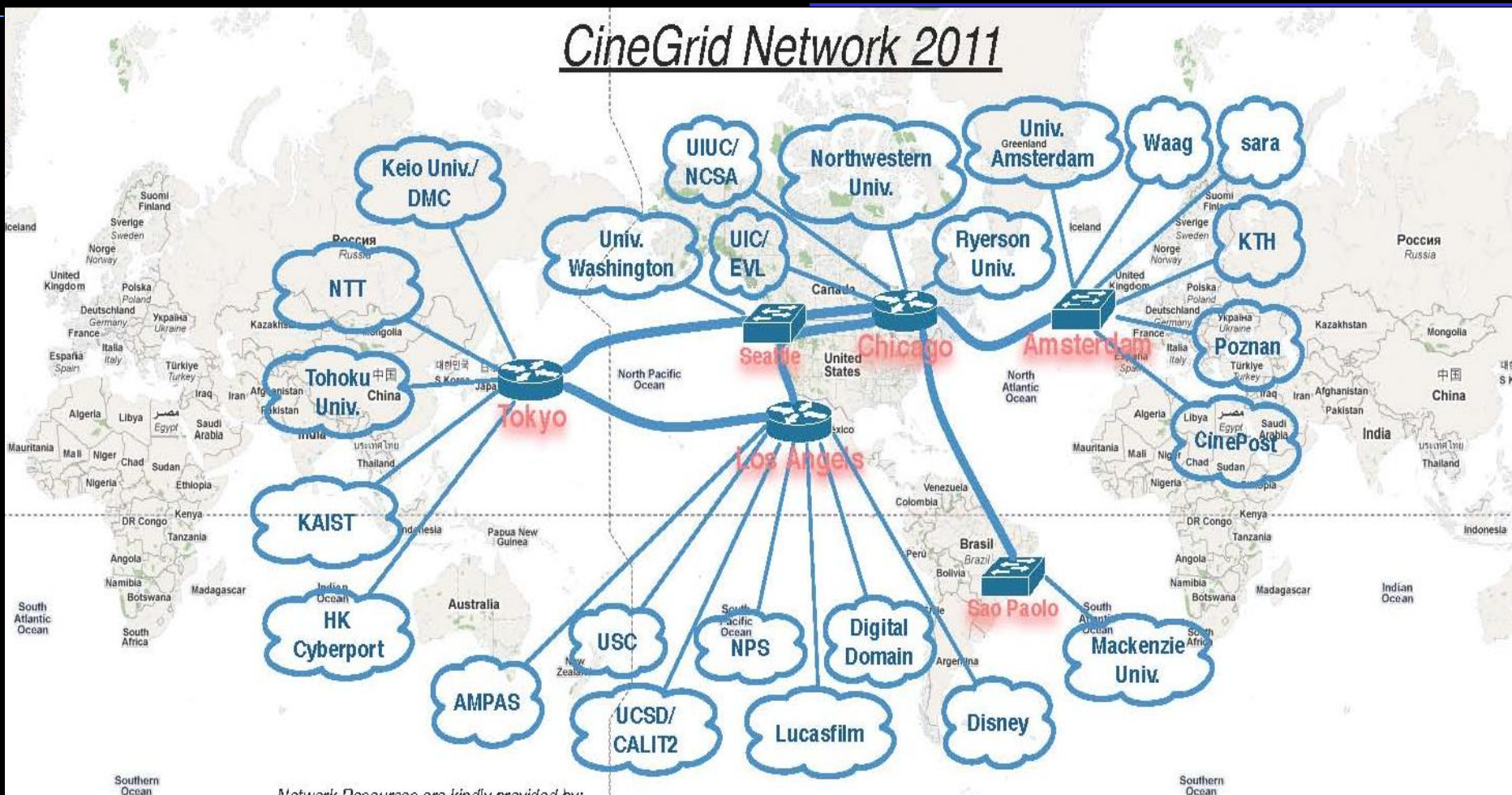
High Performance Digital Media Network





# CineGrid

## CineGrid Network 2011



Network Resources are kindly provided by:

AMPATH, C-Wave, CANARIE, CaveWave, CENIC, CESNET, CzechLight, GEMNET, Internet2, JANET, JGN2plus, NetherLight, NLR, NORDUnet, PacificWave, PNWGP, RNP, StarLight, SOL, SURFnet, TransLight/StarLight, T-LEX, WIDE

kaneko@dmc.keio.ac.jp, as of 2011/02/14

# SAGE

## Scalable Adaptive Graphics Environment

74 sites worldwide, plus 3 new sites in South America!





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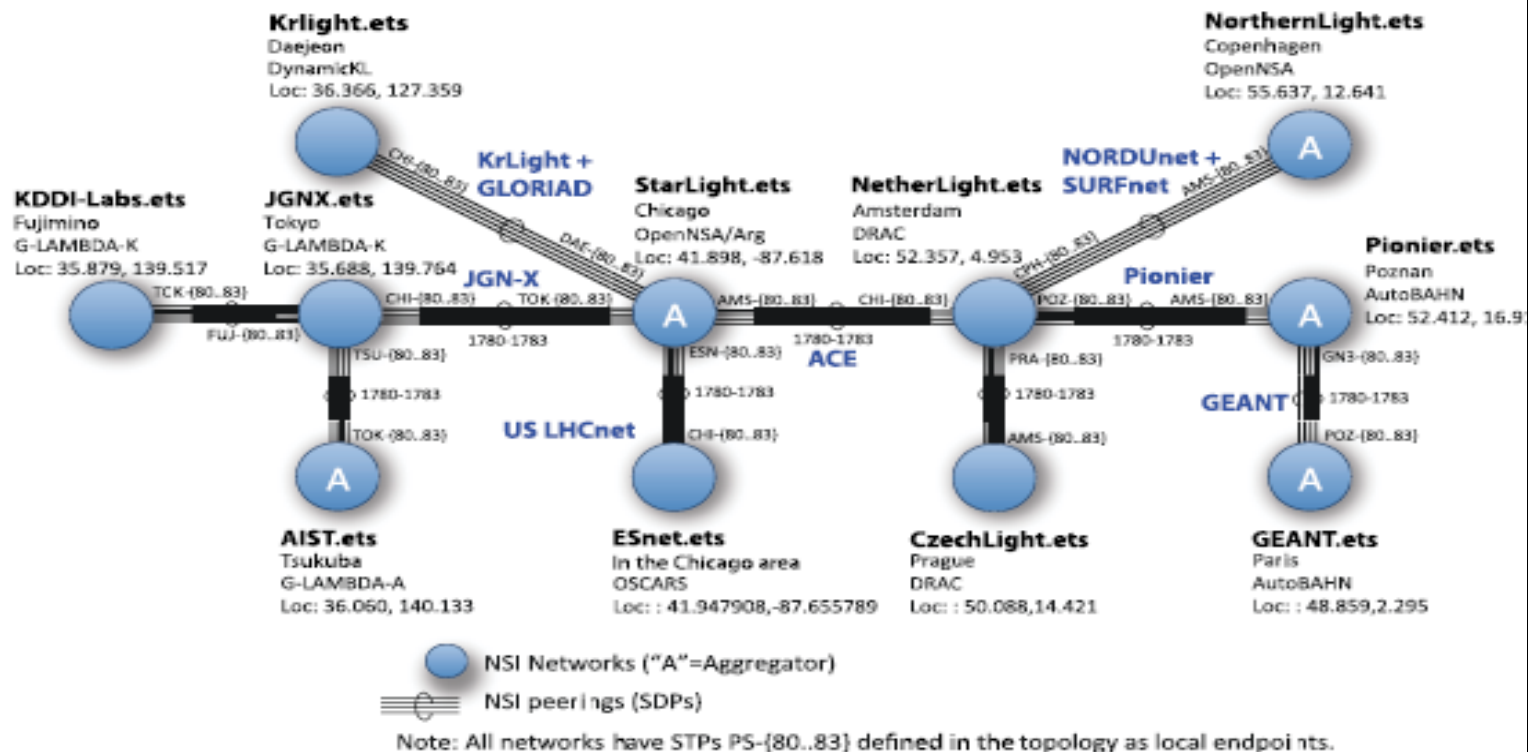




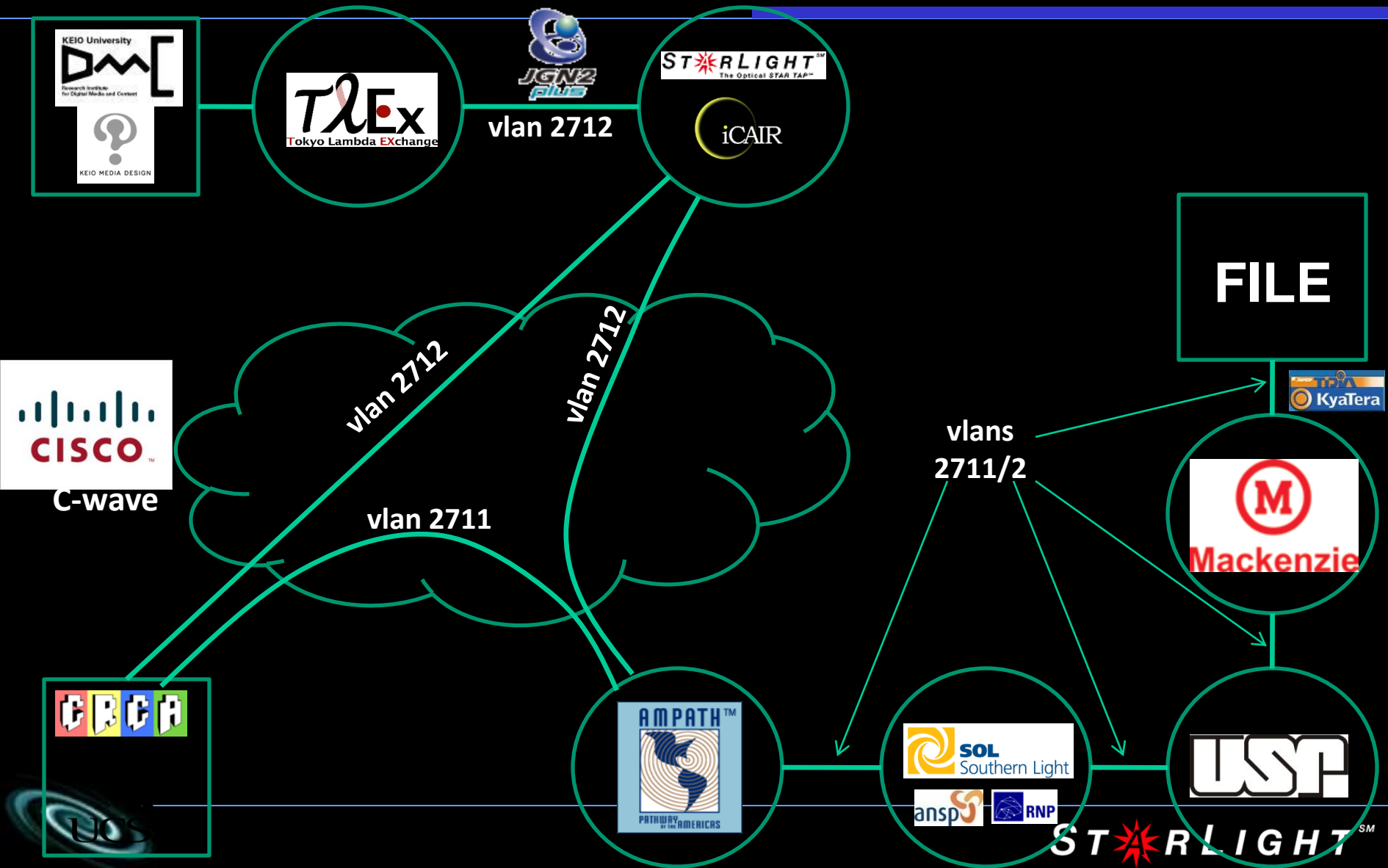
# Automated GLIF Open Lambda Exchange Demonstration at SC11

## Automated GOLE / NSI Demo Network Supercomputing 2011

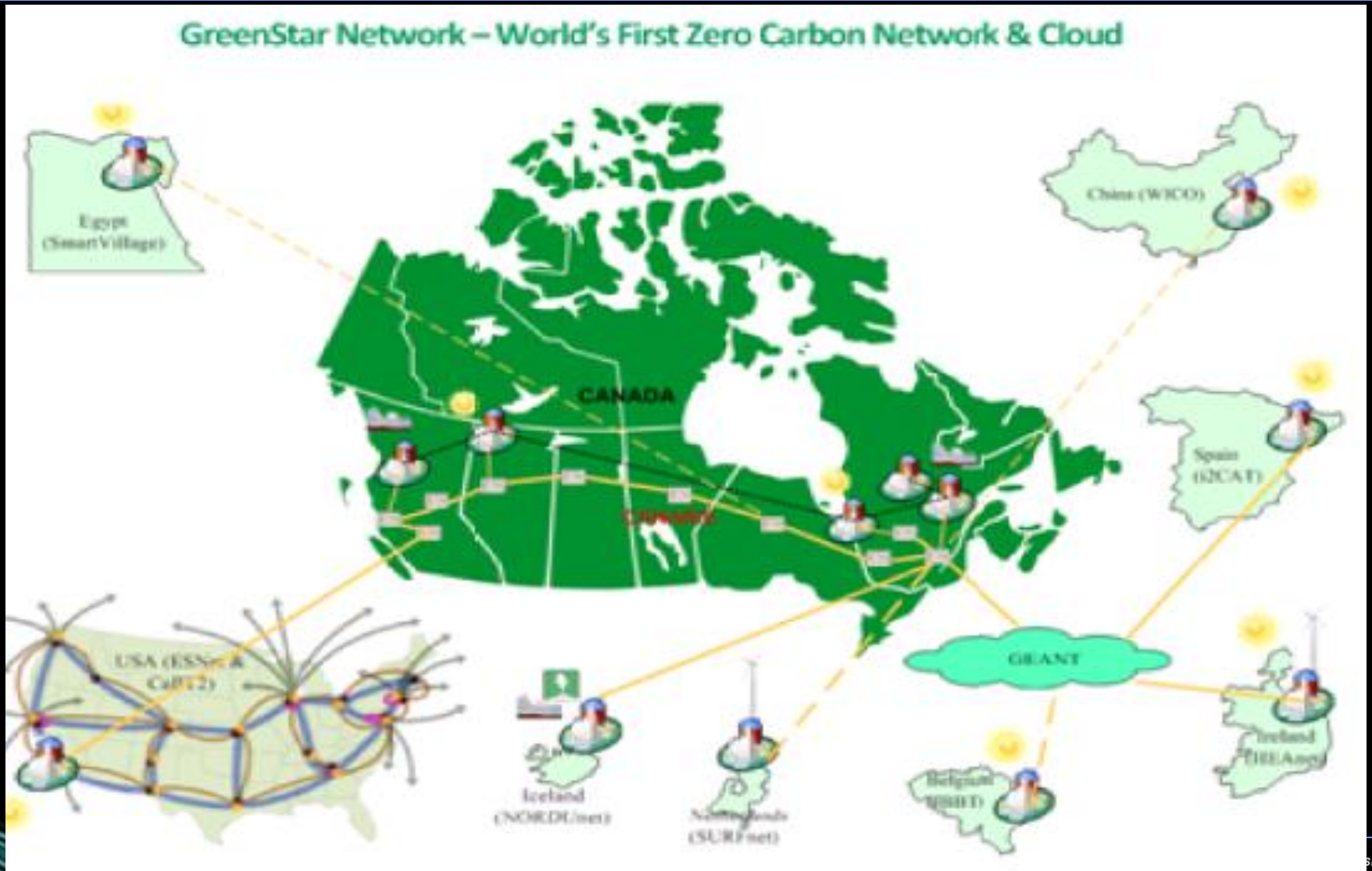
Nov 14-17, 2011  
Seattle, US



# FILE

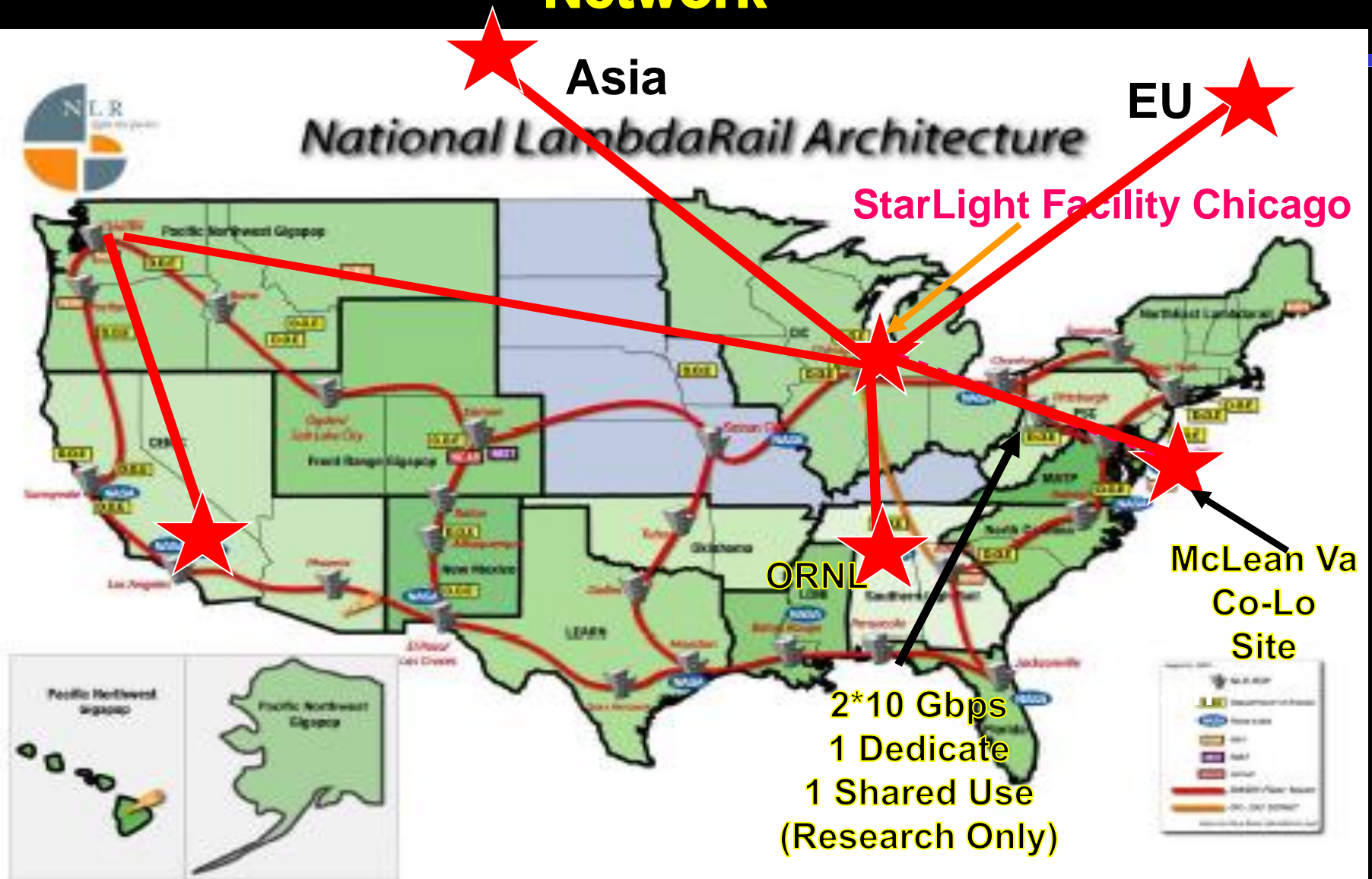


# Green Star Network: World's 1<sup>st</sup> Zero Carbon Network





# TeraFlow Network and Open Data Cloud Network



# Next Phase = A \*Global\* Platform For Customized Networks

- **Migration**
  - From Designing, Creating, Implementing, Operating Private Networks As Individual Projects
  - To Designing, Creating, Implementing, Operating Distributed Environment (Platform) Within Which Such Individual Networks Can Be Readily Created
  - Highly Distributed, Highly Programmable Communications Environment
  - National Science Foundation's Global Environment for Network Innovations (GENI)!
- ***GENI Is Both***
  - A Distributed Instrument for Network Research and
  - A Prototype of Future Network Platforms



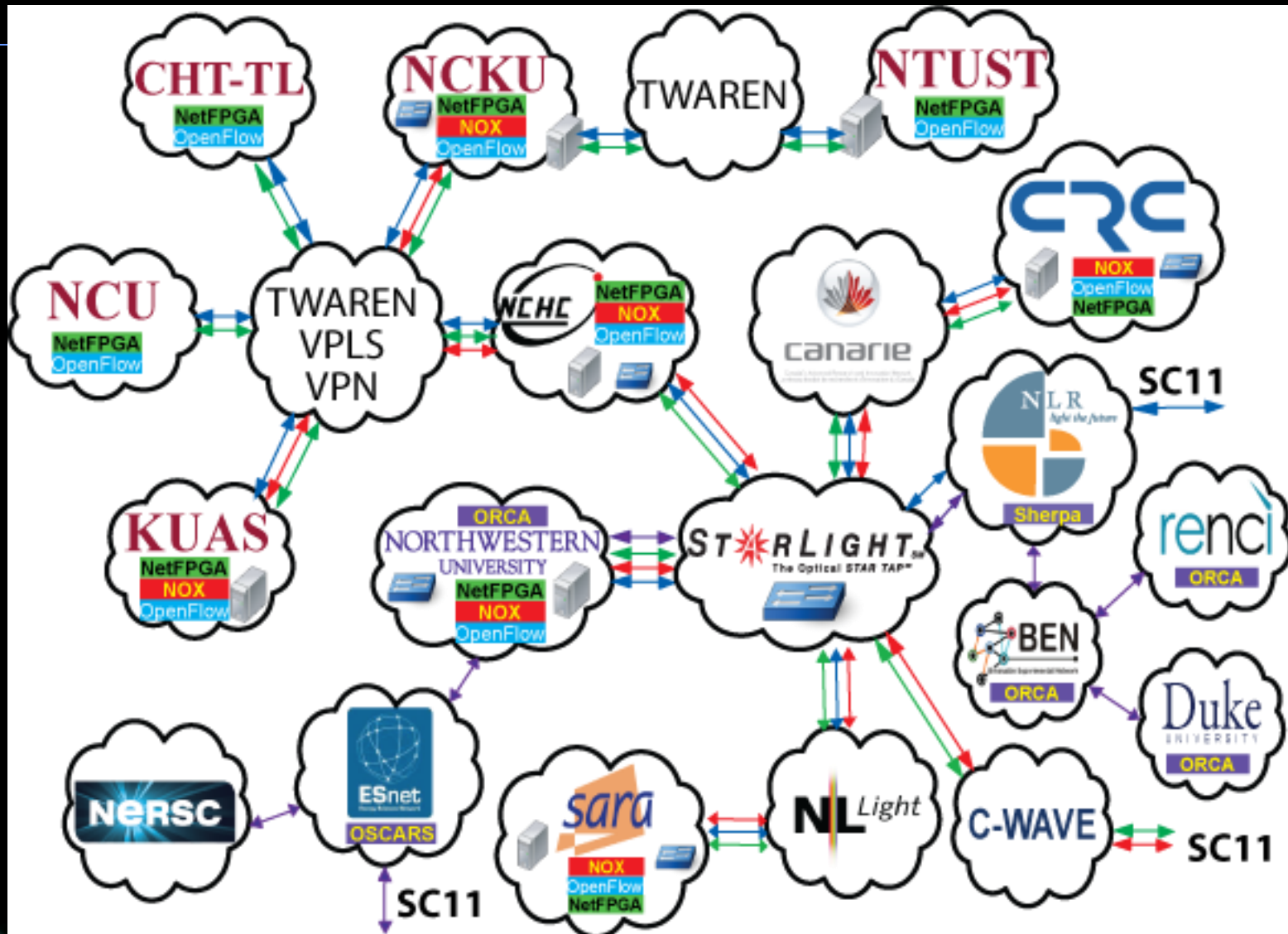
# **GENI and International Initiatives**

- **Multiple Innovative Network Research Initiatives Have Been Established Around the World**
  - The National Science Foundation Funded Global Environment for Network Innovations (GENI)
  - The European Union Future Internet Research Environment (FIRE)
  - The Japanese New Generation Network (NGN)
  - The Korean Future Internet Initiatives
  - G-Lab At Kaiserslautern
  - And Many Others.



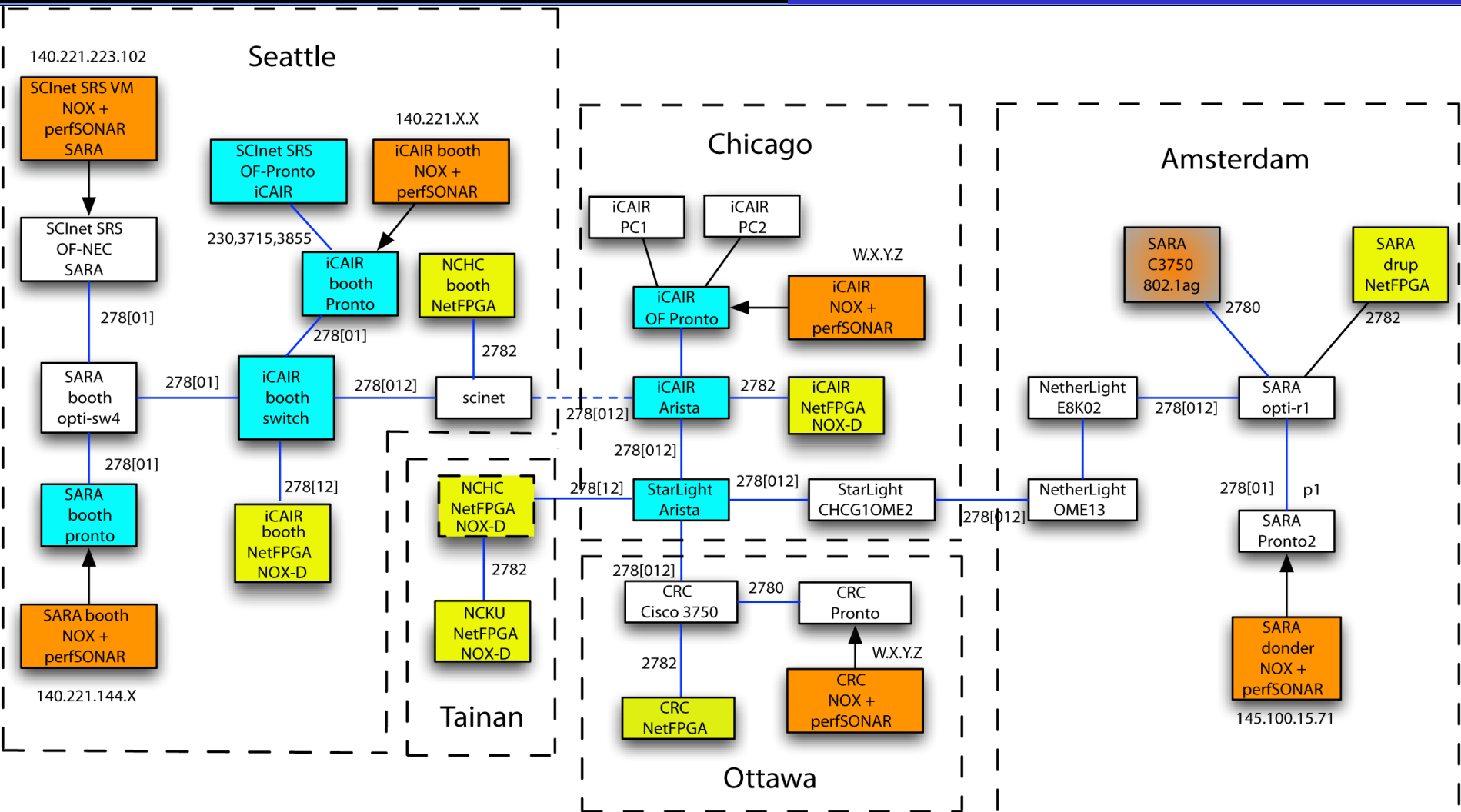


# iGENI Initiative & International OpenFlow Testbeds

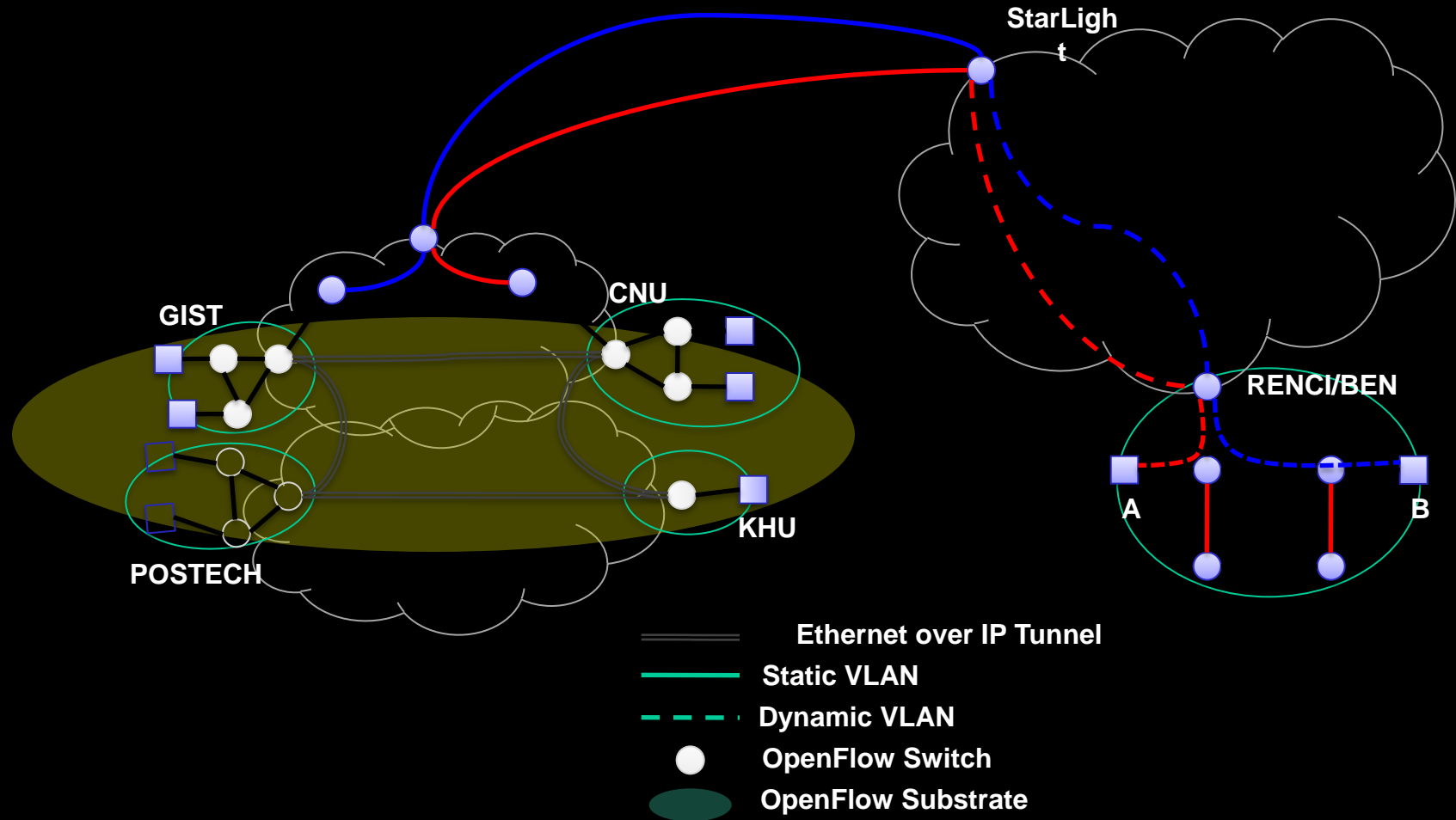


# SC11 SCinet Research Sandbox OpenFlow Demonstrations

## Seattle, Wash November 2011



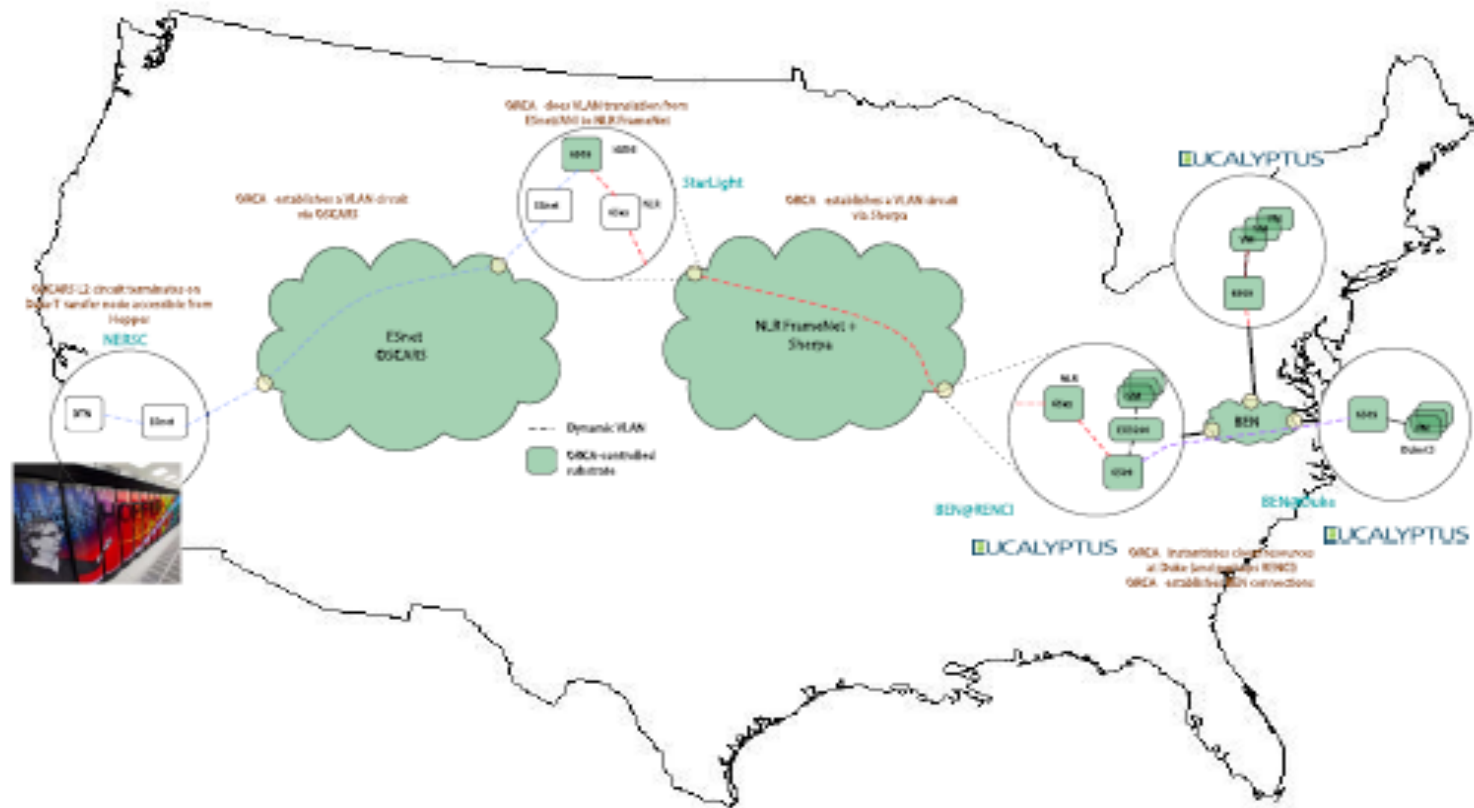
# iGENI GIST-BEN-KREONET Testbed





# Open Resource Control Architecture/ OSCARS (DOE)/ iCAIR Testbed

## ORCA / OSCARS / iGENI



# TransCloud Experiments

Alvin AuYoung, Andy Bavier, Jessica Blaine, Jim Chen, Yvonne Coady, Paul Muller, Joe Mambretti, Chris Matthews, Rick McGeer, Chris Pearson, Alex Snoeren, Fei Yeh, Marco Yuen

## TransCloud Today



## TransCloud: Based on iGENI and GENICloud

- Transcontinental Federation of Cloud Systems
- Slice-Based Federation Architecture for sign on and trans-cluster slice management
- SFA cluster manager at each site
  - Currently, enhanced Eucalyptus
- Private 10 Gb/s transcontinental network linking sites
  - Thanks to GLIF, NLR, NetherLight, CAVEWave, StarLight, DFN

## Roadmap

- Accept experimenters **now**
- Federation expansion
  - TU Amsterdam immediately
  - Brazil, Asia by July
  - All interested parties at any time
- Full integration with PlanetLab Control Framework (July)
- High-level programming environment based on RePy and NaCl
- High-level distributed query environment

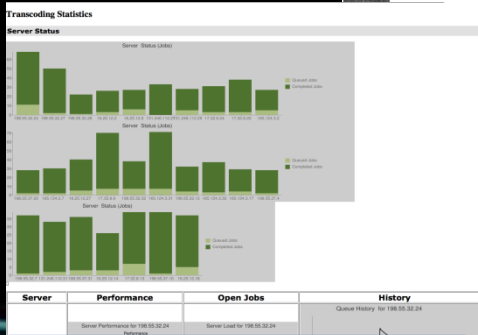
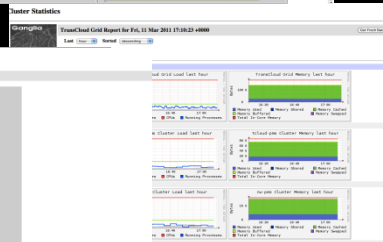
## Example of working in the TransCloud

### [1] Build trans-continental applications spanning clouds:

- Distributed query application based on Hadoop/Pig
- Store archived Network trace data using HDFS
- Query data using Pig over Hadoop clusters

### [2] Perform distributed query on TransCloud, which currently spans the following sites:

- HP OpenCirrus
- Northwestern OpenCloud
- UC San Diego
- Kaiser



- Use By Outside Researchers? Yes
- Use Involving Multiple Aggregates? Yes

- Use for Research Experiments? Yes

Demo: <http://tcdemo.dyndns.org/>



STARLIGHT<sup>SM</sup>

# VirtuLab Tile Display: Directly Connected To National 10 Gbps Testbed With Core at the StarLight Facility





# **“Slice Around the World” Initiative**

- **A Basic Goal of The International Consortium Is To Create A Large Scale Distributed Environment for Basic Network Science Research, Experiments, and Demonstrations.**
- **This Initiative Is Designing and Implementing An International Highly Distributed Environment (at Global Scale) That Can Be Used for To Advance Next Generation Communications and Networking.**
- **This Environment Is Much More Than “A Network” – Other Resources Include Programmable Clouds, Sensors, Instruments, Specialized Devices, and Other Resources.**
- **This Environment Will Be Based On Interconnects Among Major Network Research Centers Around the World**
- ***=> The Initial Concept for the “Slice Around the World” Demonstration Was Suggested By Chip Elliott!***



# Current Organizational Participants and Leads

- *ANSP, São Paulo, Luis Fernandez Lopez*
- *Applied Research Center for Computer Network at Skolkovo, Moscow, Ruslan Smeliansky*
- *Centro de Pesquisa e Desenvolvimento de Telabras, São Paulo, Marcos Rogerio Salvador*
- *Canadian Communications Research Centre, Ottawa, Scott Campbell\**
- *Computer Network Information Center, Chinese Academy of Sciences, Beijing, Jungling You\**
- *Duke University, Durham, Jeff Chase*
- *Electronic and Telecommunications Institute, Daejeon, Myung-Ki Shin*
- *HP Research Labs, Palo Alto, Rick McGeer\**
- *International Center for Advanced Internet Research, Northwestern University, Chicago, Joe Mambretti, Jim Chen\**
- *Korea Institute of Science and Technology Information, Daejeon, Dongkyun Kim*
- *National Center for High-Performance Computing of Taiwan, Tainan, Te-Lung Liu\**
- *National Cheng-Kung University, Tainan, Chu-Sing Yang\**

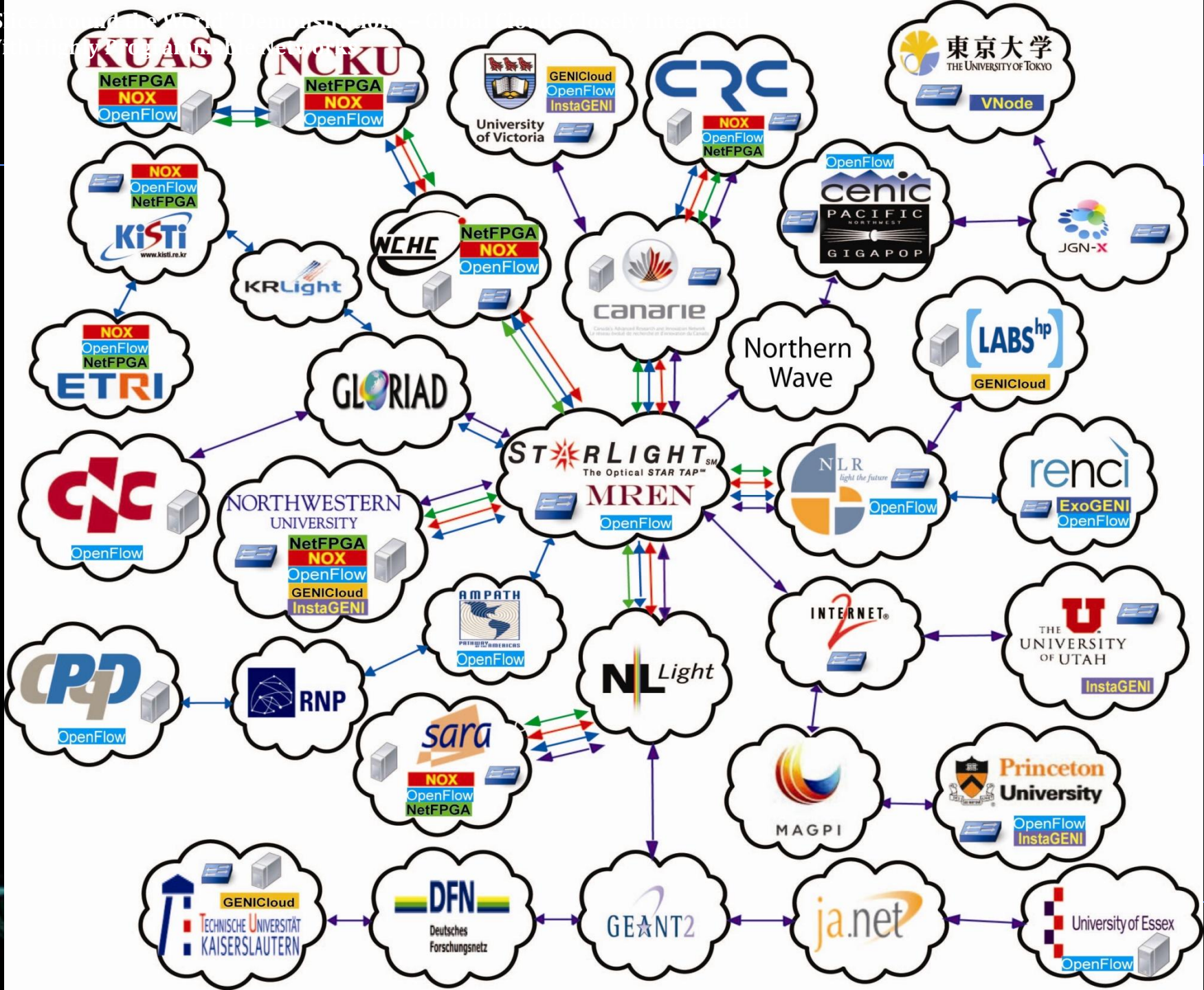


# Current Participants

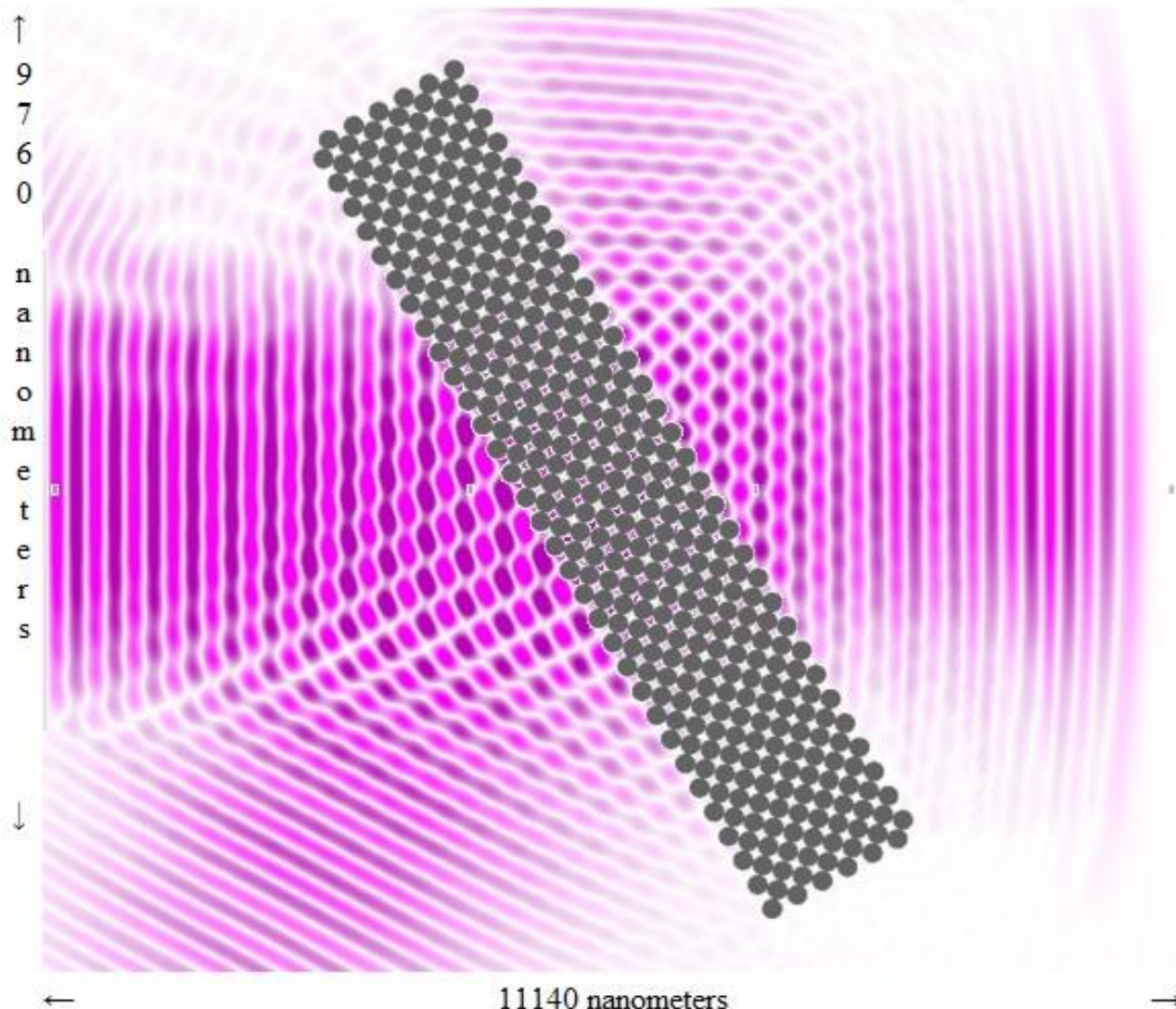
- *National Institute of Information and Communications Technology, Tokyo, Aki Nakao \**
- *National Kao Hsiung University of Applied Science, Kaohsiung, Mon-Yen Lou\**
- *NICTA, Australia, Max Ott*
- *Princeton University, Princeton, Andy Bavier*
- *Rede Nacional de Ensino e Pesquisa, Brazil, Michael Stanton*
- *Renaissance Computing Institute (RENCI), Chapel Hill, Ilia Baldine*
- *SARA, Amsterdam, Ronald van der Pol\**
- *Technische Universitat Kaiserslautern, Kaiserslautern, Paul Muller\**
- *University of Amsterdam, Cees de Laat*
- *University of Essex, Colchester, Martin Reed\**
- *University of Tokyo, Tokyo, Aki Nakao \**
- *University of Utah, Salt Lake City, Rob Ricci\**
  
- **\* Indicates Participants in the First Demonstrations**





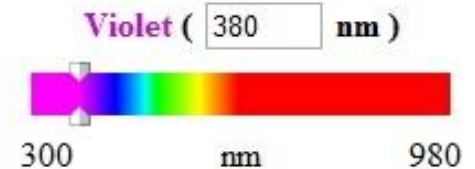


# Photonic Band Gap



Click the picture to zoom in (picture will appear in a new window)

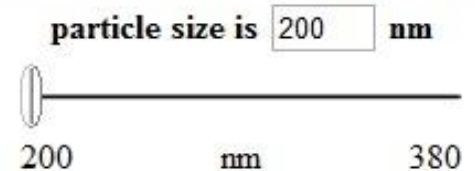
1. Choose the color of light source.  
Wavelength appears in nm



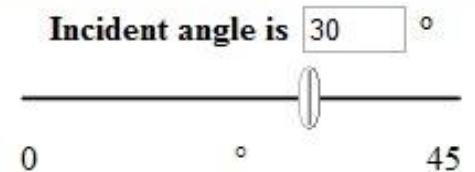
Magnitude



2. Choose particle size in nanometers



3. Choose incident angle in degrees



4. Watch the animation



1

Frame # 13 , time is 39 fs

15



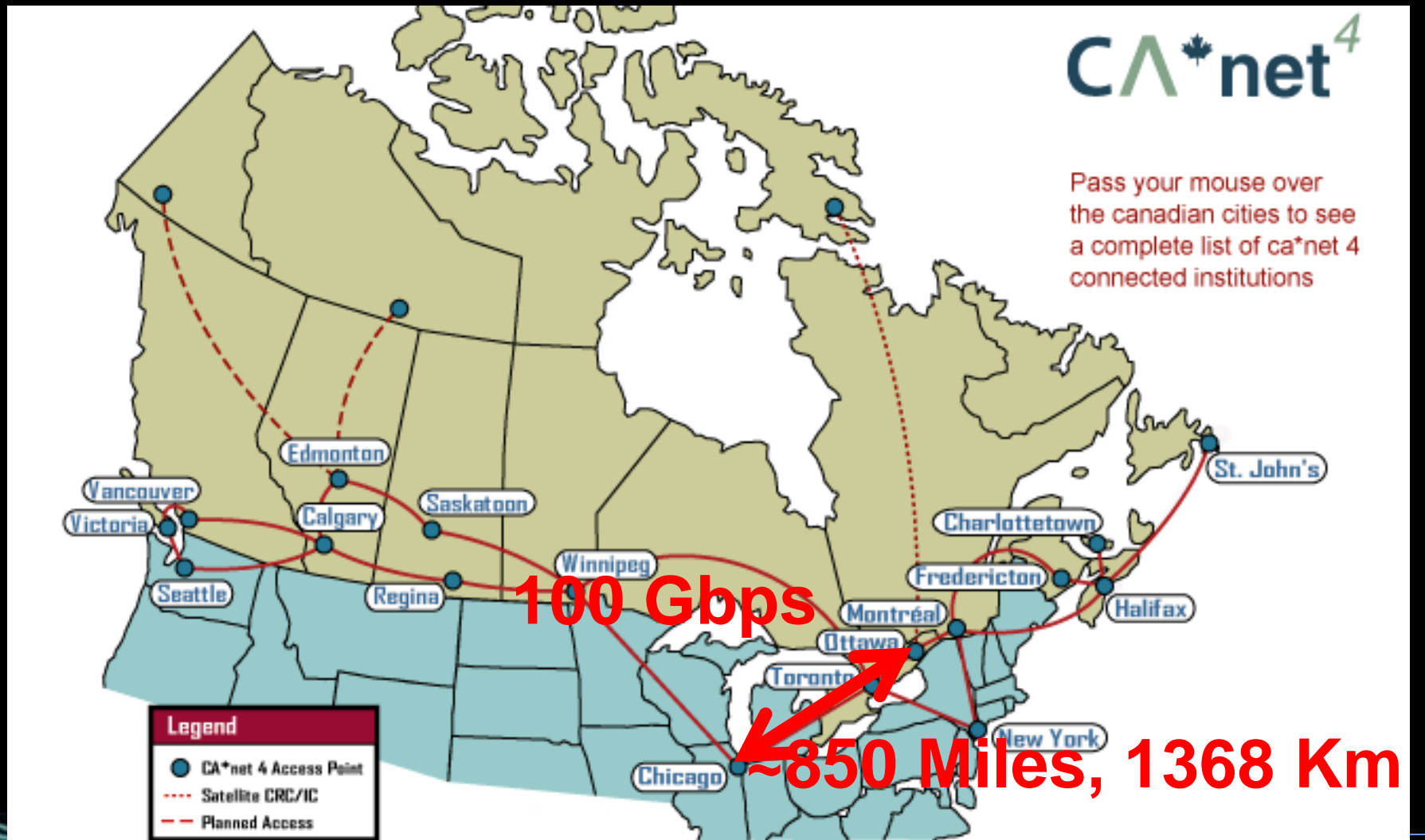
# StarWave: A Multi-100 Gbps Facility

- **StarWave, A New Advanced Multi-100 Gbps Facility and Services Will Be Implemented Within the StarLight International/National Communications Exchange Facility**
- **StarWave Is Being Funded To Provide Services To Support Large Scale Data Intensive Science Research Initiatives**
- **Facilities Components Will Include:**
  - **An ITU G. 709 v3 Standards Based Optical Switch for WAN Services, Supporting Multiple 100 G Connections**
  - **An IEEE 802.3ba Standards Based Client Side Switch, Supporting Multiple 100 G Connections, Multiple 10 G Connections**
  - **Multiple Other Components (e.g., Optical Fiber Interfaces, Measurement Servers, Test Servers)**



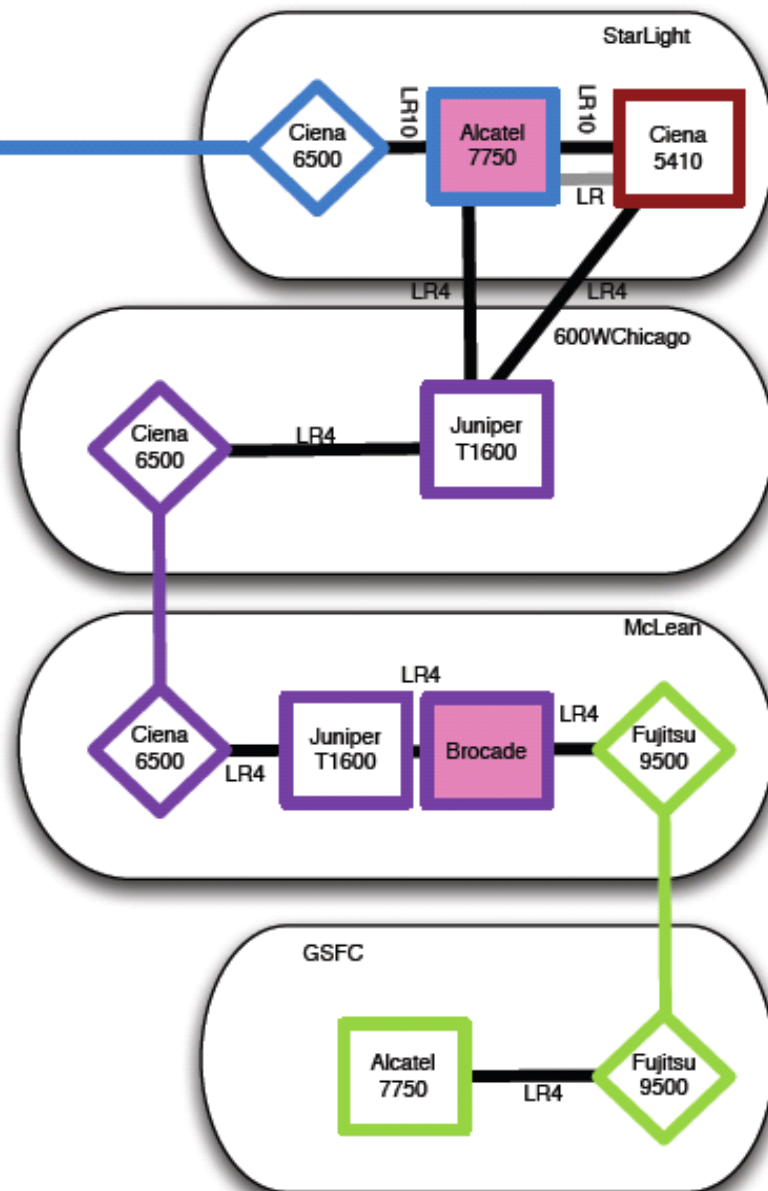
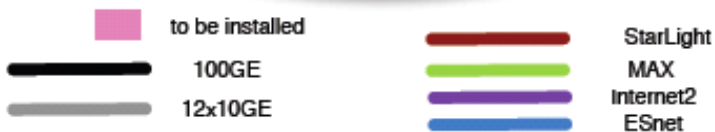
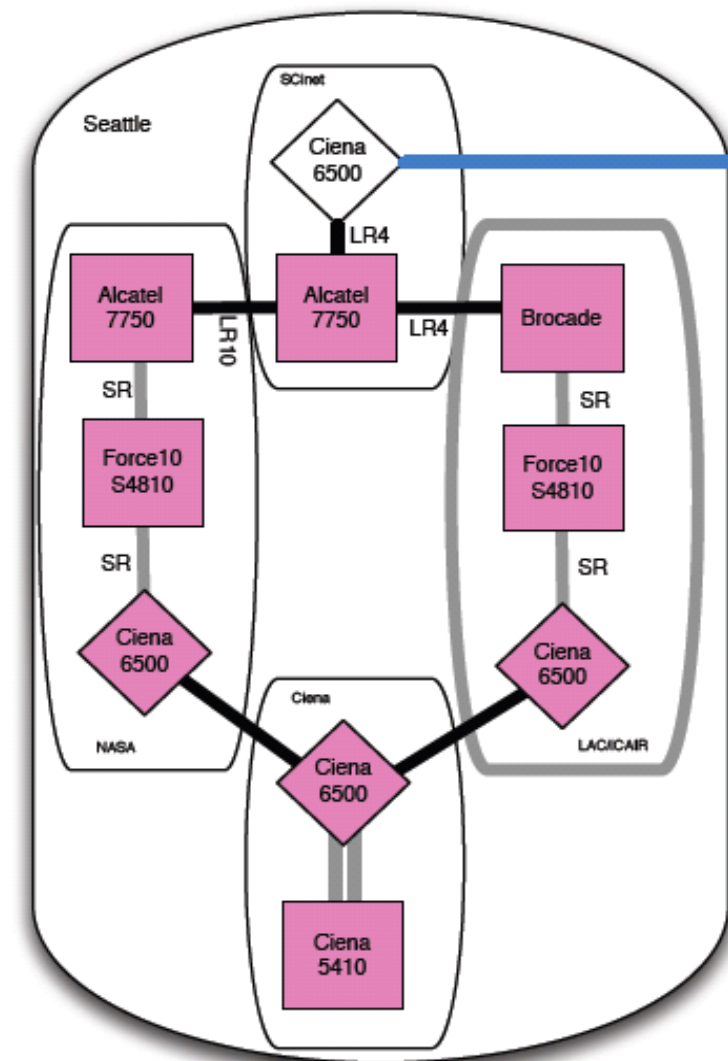


# CA\*net/Ciena/StarLight/iCAIR 100 Gbps Testbed Sept-Oct 2010, Oct 2011



Source: CANARIE

STARLIGHT<sup>SM</sup>



L. Winkler 10/14/11

# Conclusion: GENI = The Future!

- Thanks!!
- Questions?
- Comments?



Boston Harbor

