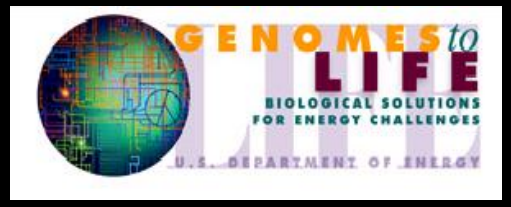
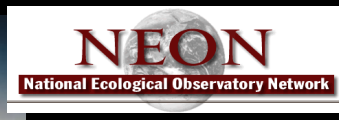
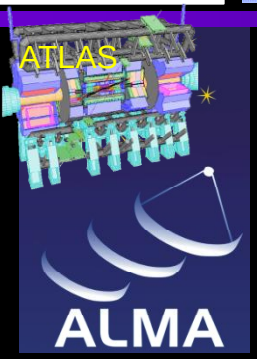
StarLight GOLE Update

Joe Mambretti, Linda Winkler, Alan Verlo

12th Annual Global LambdaGrid Workshop
& the StarLight International Consortium
Chicago, Illinois
11-12 October 2012



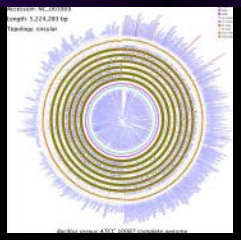




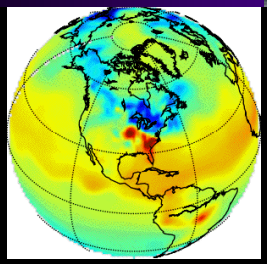
ALMA: Atacama Large Millimeter Array
www.alma.nrao.edu

ANDRILL: Antarctic Geological Drilling
www.andrill.org

BIRN: Biomedical Informatics Research Network
www.nbirn.net



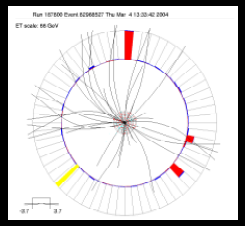
CAMERA metagenomics
camera.calit2.net



Carbon Tracker
www.esrl.noaa.gov/gmd/ccgg/carbontracker

CineGrid
www.cinegrid.org

LHCONE
www.lhcone.net



DØ (DZero)
www-d0.fnal.gov

GEON: Geosciences Network
www.geongrid.org

GLEON: Global Lake Ecological Observatory Network
www.gleon.org

OOI-CI
ci.oceanobservatories.org

ISS: International Space Station
www.nasa.gov/station

Comprehensive Large-Array Stewardship System
www.class.noaa.gov

LIGO
www.ligo.org

IVOA: International Virtual Observatory
www.ivoa.net

WLCG
lcg.web.cern.ch/LCG/public/

Pacific Rim Applications and Grid Middleware Assembly
www.pragma-grid.net

TeraGrid
www.teragrid.org

OSG
www.opensciencegrid.org

Globus Alliance
www.globus.org

SKA
www.skatelescope.org

Sloan Digital Sky Survey
www.sdss.org

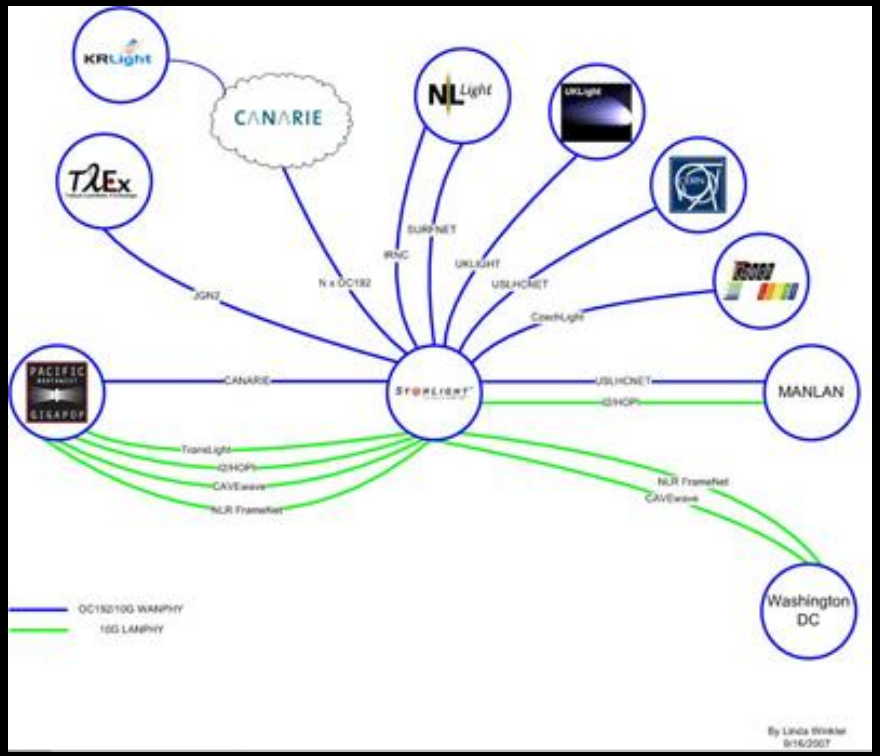
XSEDE
www.xsede.org

StarLight Supports All Major Data Intensive Science Projects

Compilation By Maxine Brown

Current StarLight Infrastructure

Ciena OME, 5410
Calient PXC (L1)
Juniper MX 960 (L2/L3)
Many Lambdas & Collaborators



http://wiki.glif.is/index.php/StarLight

Measurement Servers:
bwctl, owamp, ndt/npad, perfSONAR

IRNC:ProNet: TransLight/StarLight

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)

IRNC TL/SL 3-Year Deliverables

- Continue enabling multi-national application and middleware experiments 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 partnerships (e.g. MSC-CIEC*)
- Serve GLIF, NLR, and I2 as senior leaders, reviewers
- New services, including many with industrial partners
- Create opportunities for all the REUs we can get*

*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)

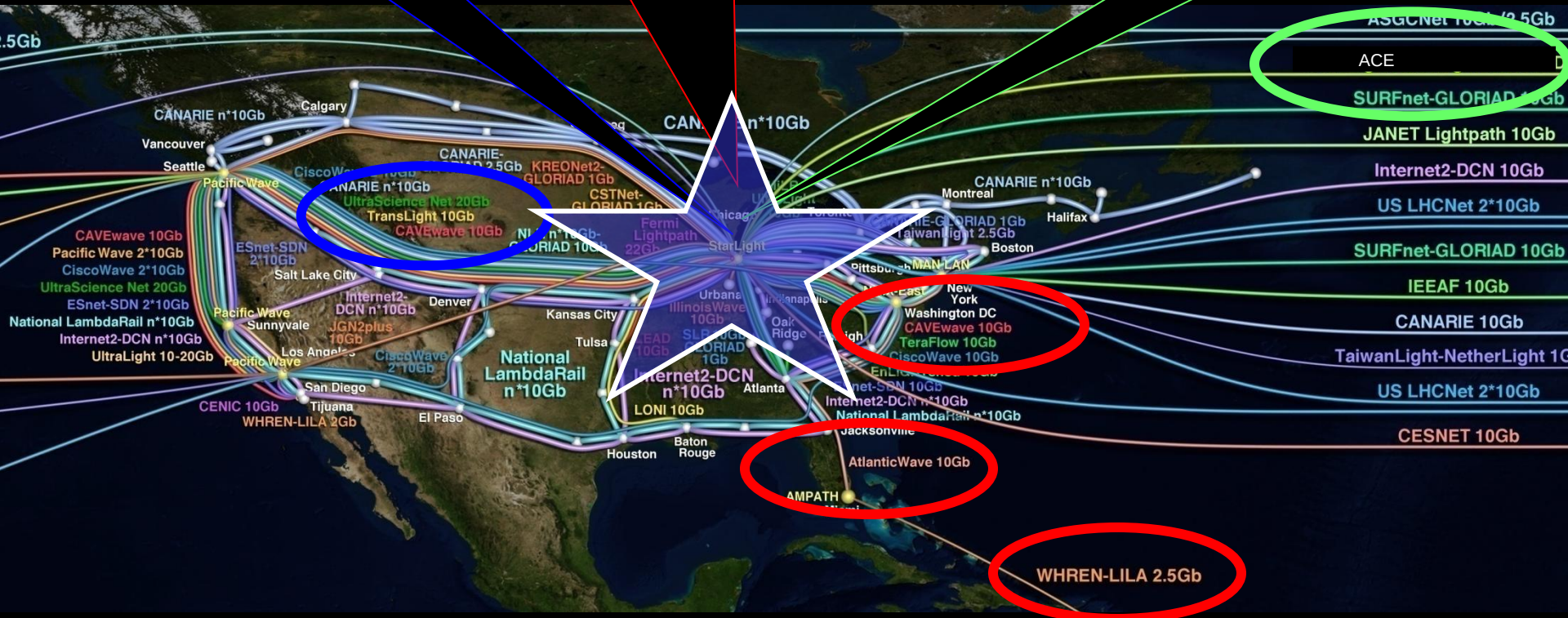
PACIFIC WAVE TRANS LIGHT

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 Miami; via AmLight-East to Brazil

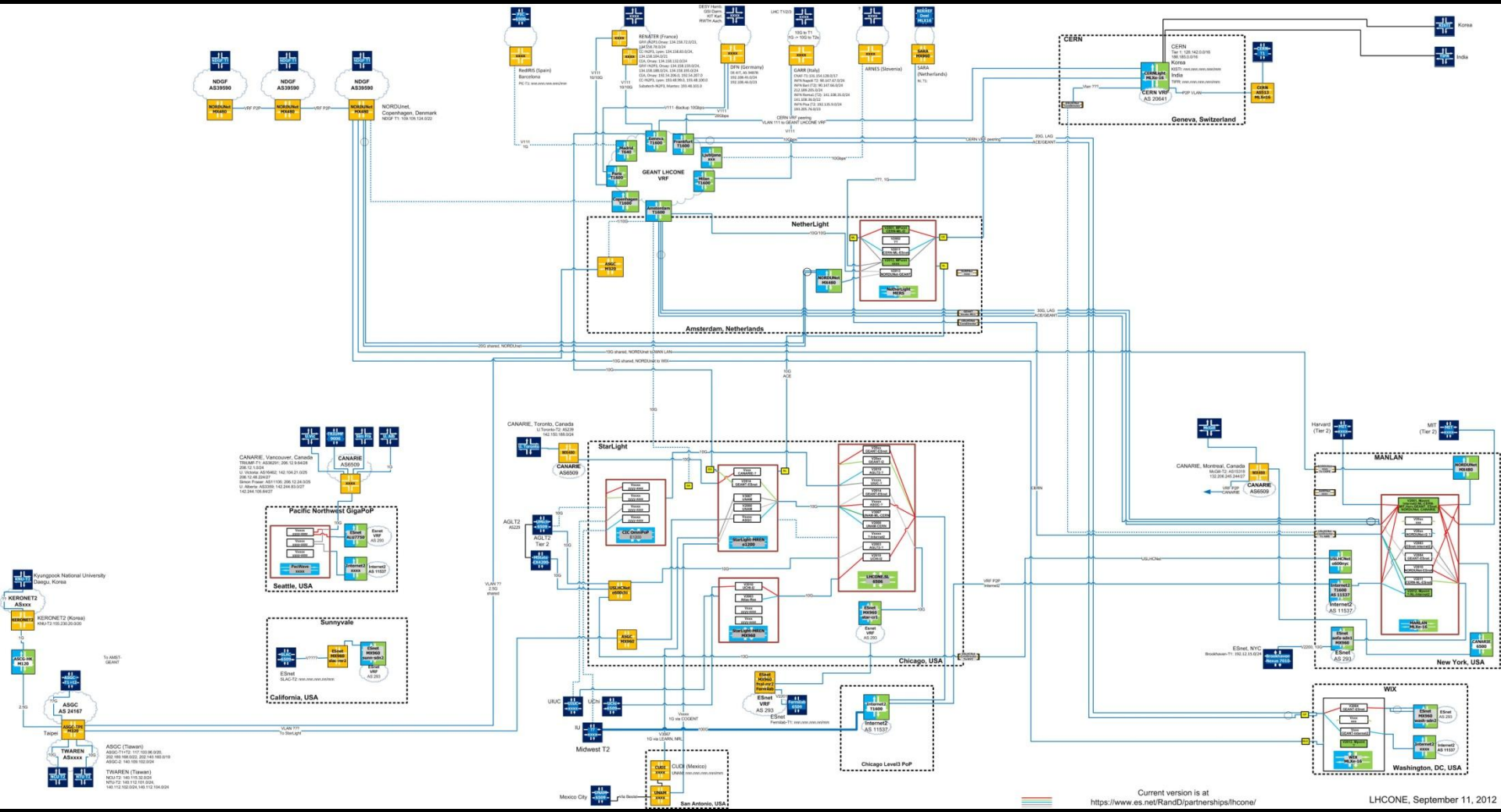
WHREN

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

GLORIAD



LHCONE


NDGF AS39590
NORDUNet MX480
NORDUNet, Copenhagen, Denmark
RENATER (France)
RedIRIS (Spain) Barcelona
DFN (Germany)
GARR (Italy)
ARNES (Slovenia)
SARA (Netherlands)
CERN
CERN VRF AS 20641
Geneva, Switzerland
Korea
India
GEANT LHCONE VRF
Geneva T1600
Frankfurt T1600
Paris T1600
Amsterdam T1600
NetherLight
Amsterdam, Netherlands
CANARIE, Vancouver, Canada
CANARIE AS6509
Pacific Northwest GigaPoP
Seattle, USA
CANARIE, Toronto, Canada
StarLight
Chicago, USA
CANARIE, Montreal, Canada
MANLAN
New York, USA
Harvard (Tier 2)
MIT (Tier 2)
Kyungpook National University Daegu, Korea
KERONET2 ASxxx
KERONET2 (Korea)
ASGC AS 24167
Taipei
TWAREN ASxxxx
ASGC (Taiwan)
TWAREN (Taiwan)
Sunnyvale
ESnet
California, USA
AGLT2 AS23
AGLT2 Tier 2
Midwest T2
UIUC
UChi
Chicago Level3 PoP
Internet2 T1600
Internet2 AS 11537
ESnet VRF AS 293
ESnet, NYC
WIX
Washington, DC, USA
CUDI (Mexico)
UNAM
San Antonio, USA
Mexico City
Current version is at https://www.es.net/RandD/partnerships/lhcone/
LHCONE, September 11, 2012

Multiple Network Research Testbeds

- Multiple Large Scale Network Research Testbeds
  - International
  - National
  - Regional
  - State-Wide
  - Metro
  - Local

iGENI: International Global Environment for Network Innovations

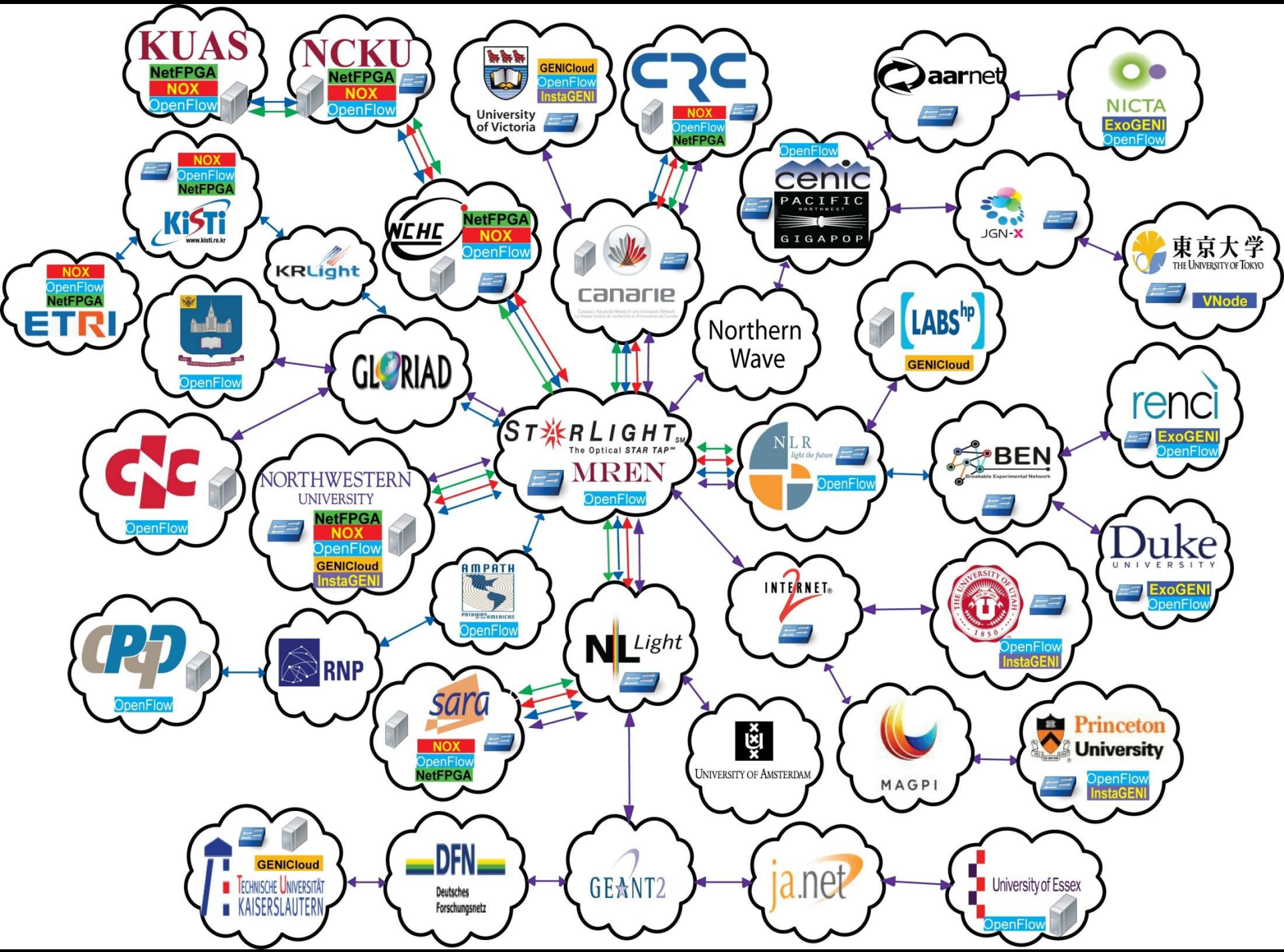
Joe Mambretti, Director, (j-mambretti@northwestern.edu)
International Center for Advanced Internet Research (www.icair.org)
Northwestern University
Director, Metropolitan Research and Education Network (www.mren.org)
Partner, StarLight/STAR TAP, PI-OMNINet (www.icair.org/omninet)

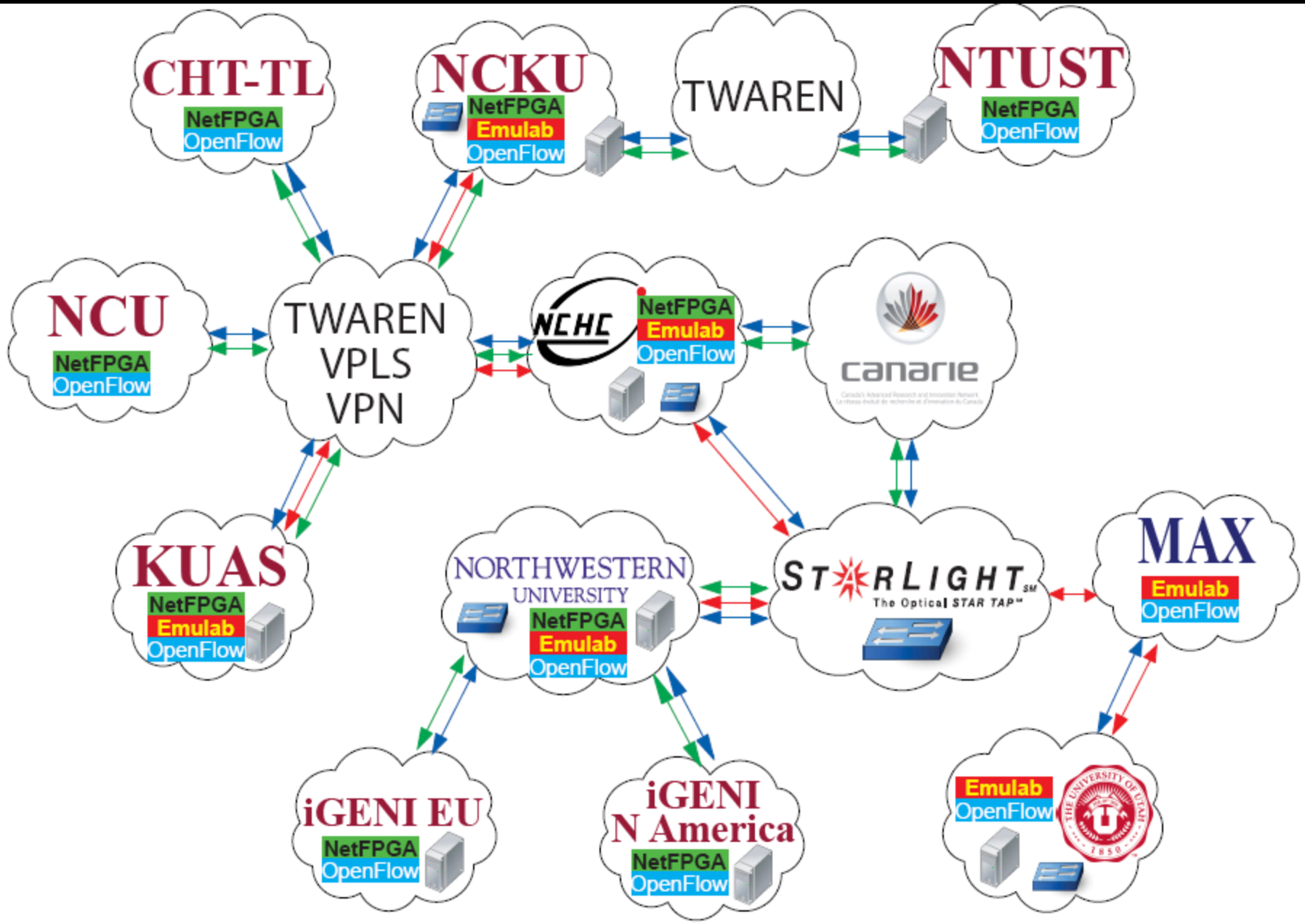
Maxine Brown, Associate Director (maxine@uic.edu)
Electronic Visualization Laboratory (www.evl.uic.edu)
University of Illinois at Chicago

Tom DeFanti, Research Scientist (tdefanti@ucsd.edu)
California Institute for Telecommunications and Information Technology (www.calit2.net),
University of California, San Diego

iGENI: The International GENI

- The iGENI Initiative Is Designing, Developing, Implementing, and Operating a Major New National and International Distributed Infrastructure.
- iGENI Is Placing the “G” in GENI Making GENI Truly Global.
- iGENI Is Creating a Unique Distributed Infrastructure To Support GLOBAL Research and Development for Next-Generation Network Communication Services and Technologies.
- This Infrastructure Is Being Integrated With Current and Planned GENI Resources.
- iGENI Infrastructure Is Interconnecting Its Resources With Current GENI National Backbone Transport Resources, With Current and Planned GENI Regional Transport Resources, and With International Research Networks and Projects
- iGENI Is Highly Leveraging Existing International Advanced Networking Facilities


KUAS
NetFPGA
NOX
OpenFlow
NCKU
NetFPGA
NOX
OpenFlow
University of Victoria
GENICloud
OpenFlow
InstaGENI
CRC
NOX
OpenFlow
NetFPGA
aarnet
NICTA
ExoGENI
OpenFlow
NOX
OpenFlow
NetFPGA
KiSTi
www.kisti.re.kr
NCHC
NetFPGA
NOX
OpenFlow
OpenFlow
cenic
PACIFIC NORTHWEST GIGAPOP
JGN-X
東京大学
THE UNIVERSITY OF TOKYO
VNode
NOX
OpenFlow
NetFPGA
ETRI
KRLight
canarie
OpenFlow
GLORIAD
Northern Wave
LABS hp
GENICloud
renci
ExoGENI
OpenFlow
CNC
OpenFlow
STARLIGHT
The Optical STAR TAP
MREN
OpenFlow
NLR
light the future
OpenFlow
BEN
Breakable Experimental Network
NORTHWESTERN UNIVERSITY
NetFPGA
NOX
OpenFlow
GENICloud
InstaGENI
AMPATH
PATHWAY TO THE AMERICAS
OpenFlow
Duke
UNIVERSITY
ExoGENI
OpenFlow
INTERNET2
THE UNIVERSITY OF UTAH
1850
OpenFlow
InstaGENI
CPqD
OpenFlow
RNP
NLLight
sara
NOX
OpenFlow
NetFPGA
UNIVERSITY OF AMSTERDAM
MAGPI
Princeton University
OpenFlow
InstaGENI
GENICloud
TECHNISCHE UNIVERSITÄT KAISERSLAUTERN
DFN
Deutsches Forschungsnetz
GÉANT2
ja.net
University of Essex
OpenFlow


CHT-TL
NetFPGA
OpenFlow
NCKU
NetFPGA
Emulab
OpenFlow
TWAREN
NTUST
NetFPGA
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NCU
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OpenFlow
TWAREN
VPLS
VPN
NCHC
NetFPGA
Emulab
OpenFlow
canarie
KUAS
NetFPGA
Emulab
OpenFlow
NORTHWESTERN
UNIVERSITY
NetFPGA
Emulab
OpenFlow
STARLIGHT
The Optical STAR TAP
MAX
Emulab
OpenFlow
iGENI EU
NetFPGA
OpenFlow
iGENI
N America
NetFPGA
OpenFlow
Emulab
OpenFlow

TransCloud

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

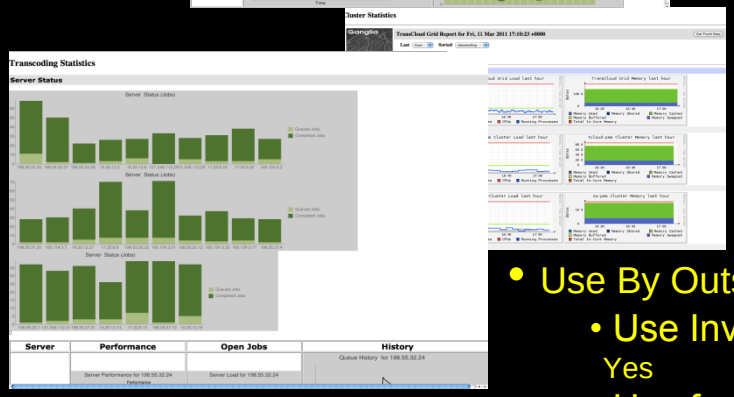
TransCloud Today

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:

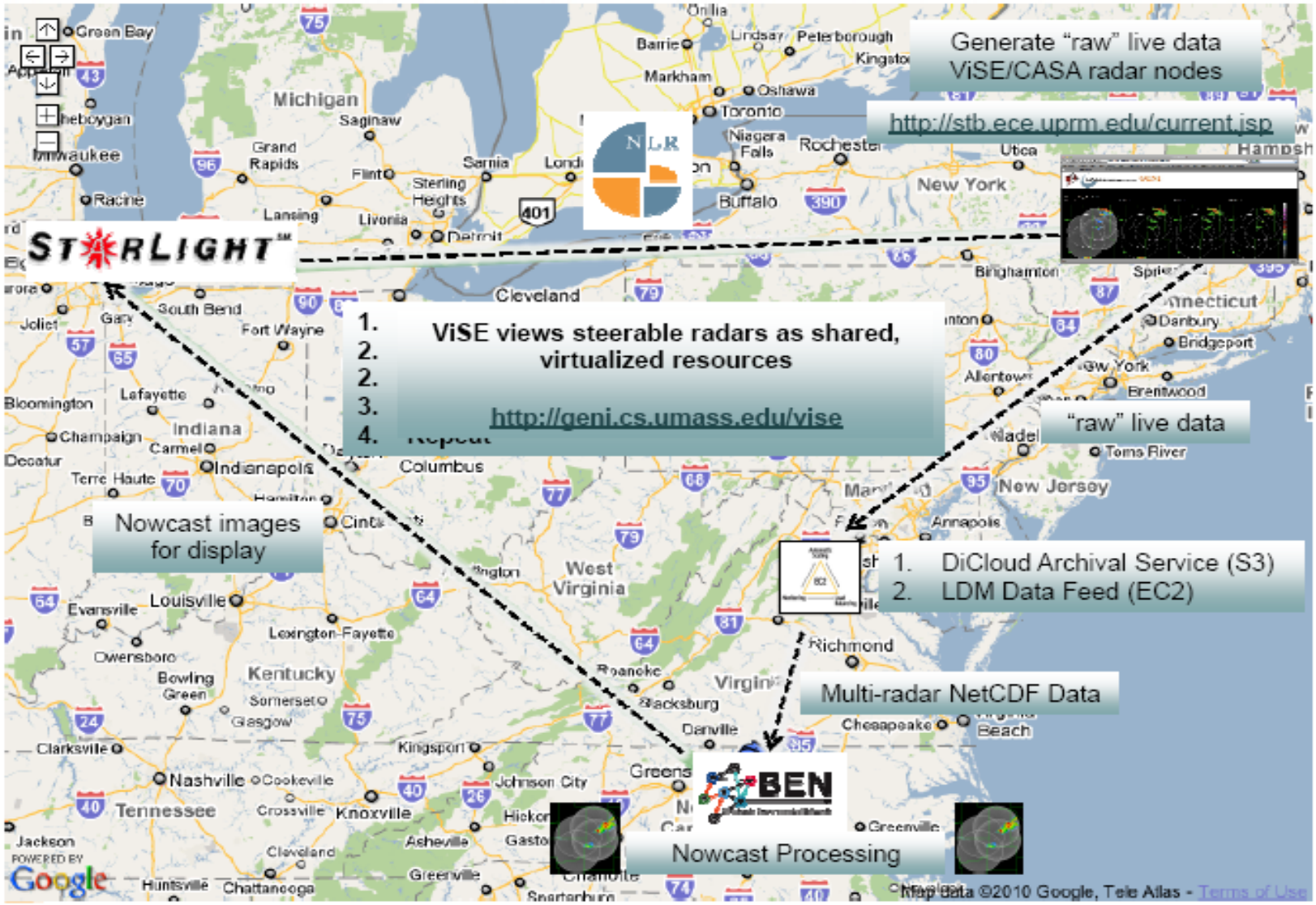
- HP OpenCirrus
- Northwestern OpenCloud
- UC San Diego
- Kaiserslautern

- Use By Outside Researchers? Yes
  - Use Involving Multiple Aggregates? Yes
  - Use for Research Experiments? Yes

Also Ref: Experiments in High Perf Transport at GEC 7

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

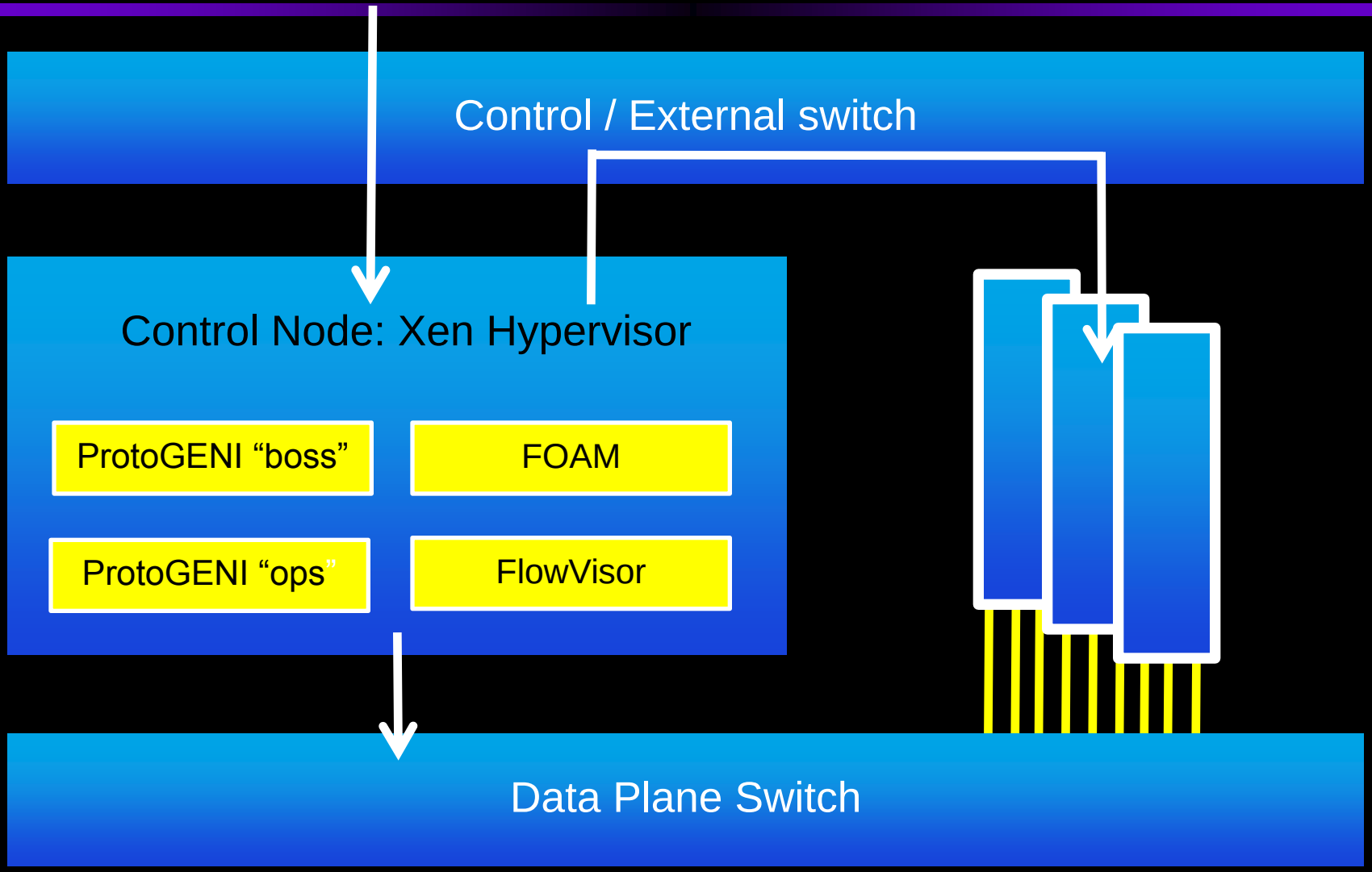
Mike Zink, Univ of Mass Amhurst – Next Gen Weather Radar



The InstaGENI Initiative

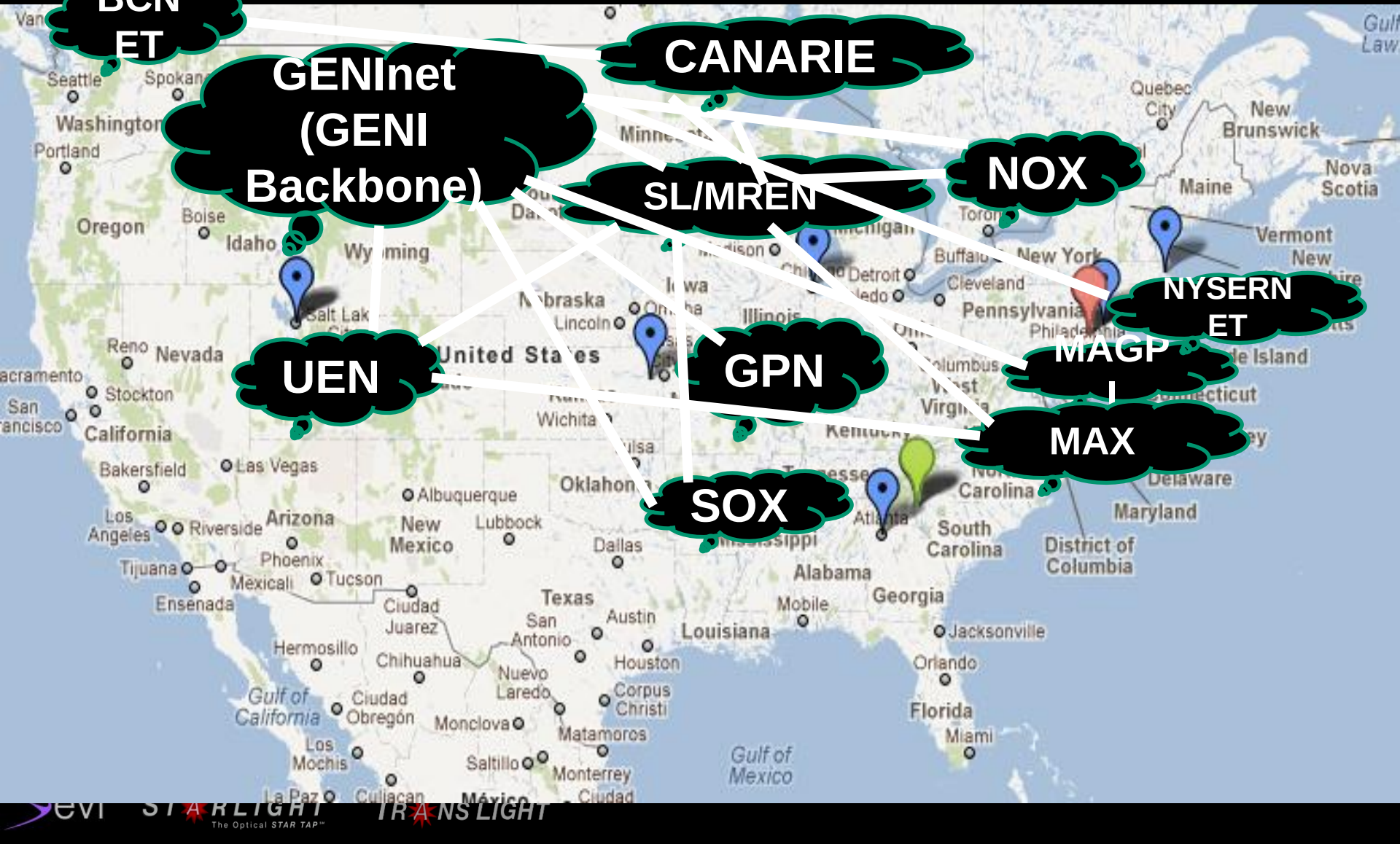
Nick Bastin, Andy Bavier, Jessica Blaine, Joe Mambretti, Rick McGeer, Rob Ricci, Nicki Watts, Jim Chen, Fei Yeh
PlanetWorks, HP, University of Utah, iCAIR Northwestern
March 13, 2012

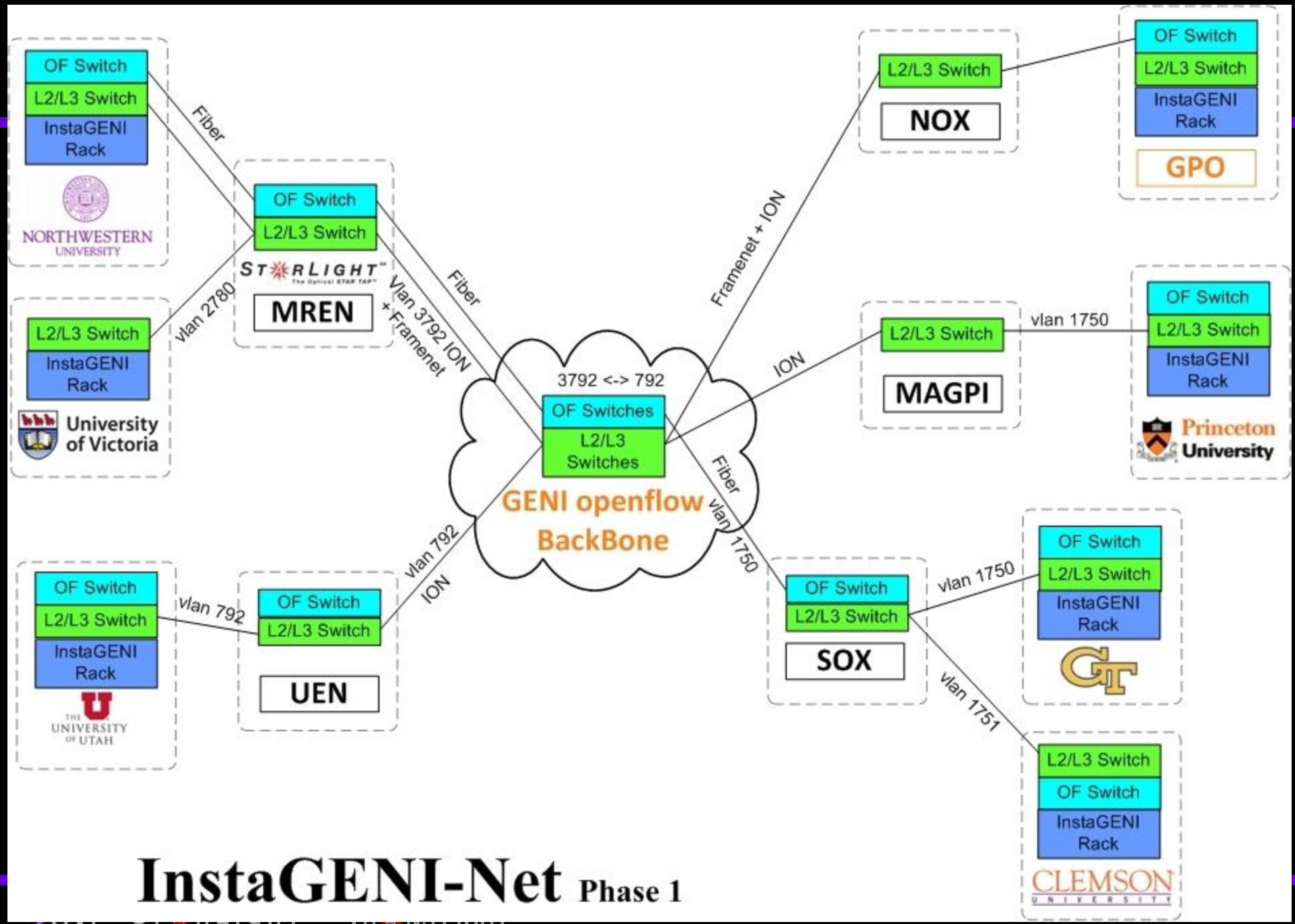
Control Infrastructure



InstaGENI Sites and Network: Y1

University of Utah, Princeton University, GPO, Northwestern University, Clemson University, Georgia Tech , University of Kansas , New York University University of Victoria



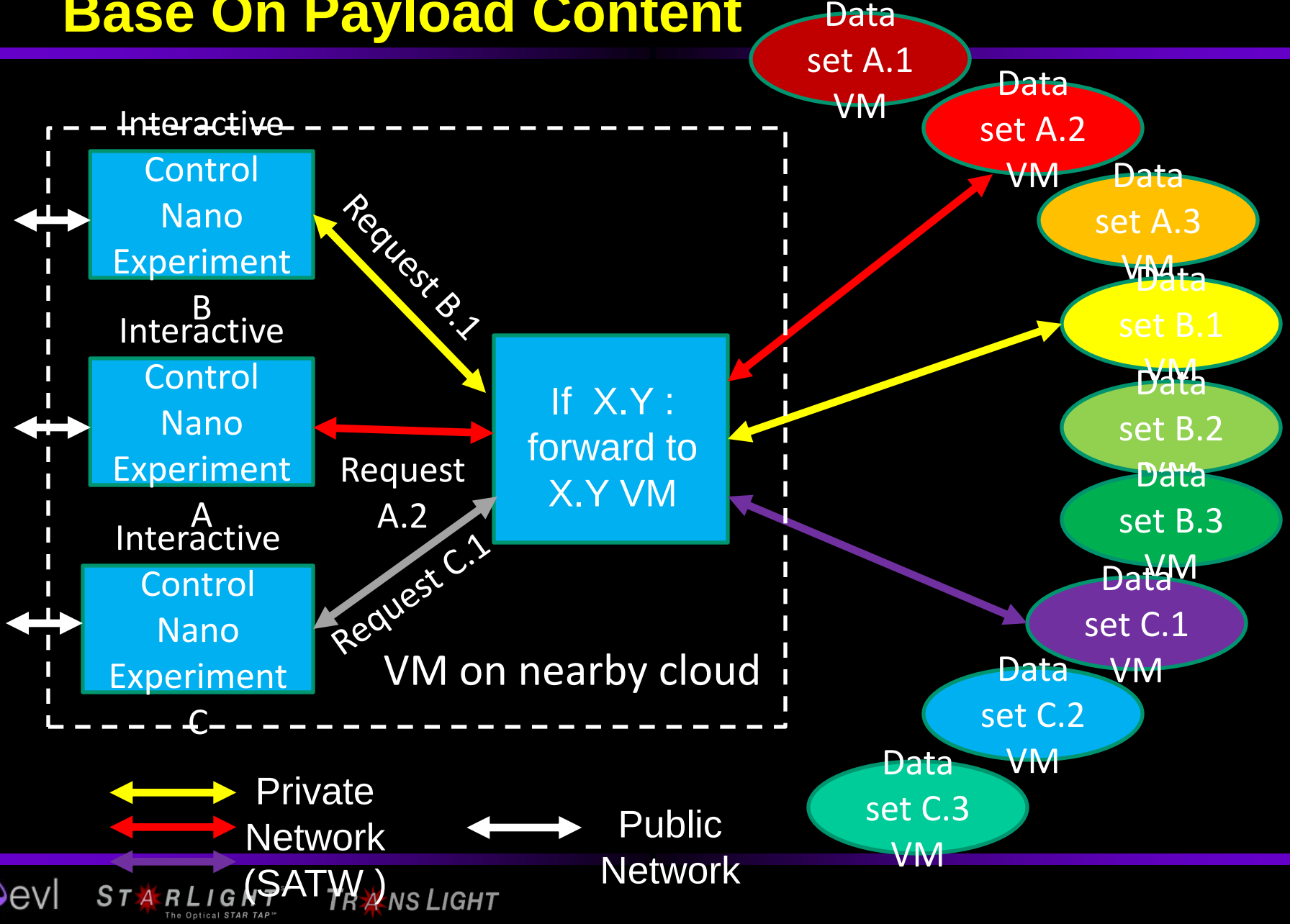

OF Switch
L2/L3 Switch
InstaGENI Rack
NORTHWESTERN UNIVERSITY
Fiber
OF Switch
L2/L3 Switch
STARLIGHT
MREN
vlan 2780
L2/L3 Switch
InstaGENI Rack
University of Victoria
Vlan 3792 ION + Framenet
Fiber
3792 <-> 792
OF Switches
L2/L3 Switches
GENI openflow BackBone
Framenet + ION
L2/L3 Switch
NOX
OF Switch
L2/L3 Switch
InstaGENI Rack
GPO
ION
L2/L3 Switch
MAGPI
vlan 1750
OF Switch
L2/L3 Switch
InstaGENI Rack
Princeton University
Fiber
vlan 1750
OF Switch
L2/L3 Switch
SOX
vlan 1750
OF Switch
L2/L3 Switch
InstaGENI Rack
vlan 1751
L2/L3 Switch
OF Switch
InstaGENI Rack
CLEMSON UNIVERSITY
vlan 792
ION
OF Switch
L2/L3 Switch
UEN
vlan 792
OF Switch
L2/L3 Switch
InstaGENI Rack
THE UNIVERSITY OF UTAH
InstaGENI-Net Phase 1

An Advanced International Distributed Programmable Environment for Experimental Network Research: "Slice Around the World" Demonstration

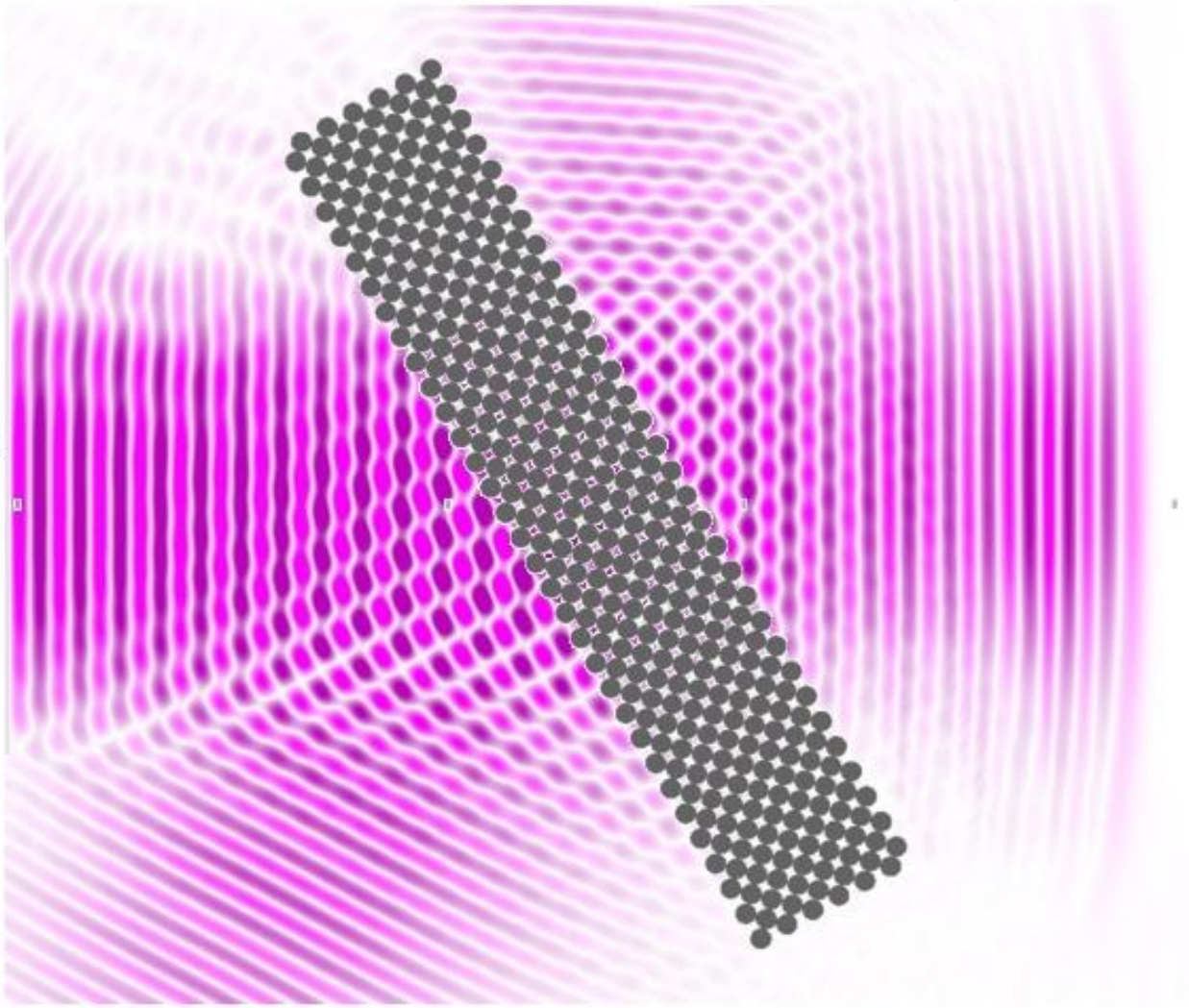
A Demonstration and Presentation By the
Consortium for International Advanced Network Research

Leads for Participating Organizations: Ilia Baldine, Andy Bavier, Scott Campbell, Jeff Chase, Jim Chen, Cees de Laat, Dongkyun Kim, Te-Lung Liu, Luis Fernandez Lopez, Mon-Yen Lou, Joe Mambretti, Rick McGeer, Paul Muller, Aki Nakao, Max Ott, Ronald van der Pol, Martin Reed, Rob Ricci, Ruslan Smeliansky, Marcos Rogerio Salvador, Myung-Ki Shin, Michael Stanton, Jungling Yu

Slice Using Forwarding Rules Base On Payload Content



Photonic Band Gap



← 11140 nanometers →

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

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

Violet (380 **nm)**

300 nm 980

Magnitude

\- 0 +

2. Choose particle size in nanometers

particle size is 200 **nm**

200 nm 380

3. Choose incident angle in degrees

Incident angle is 30 °

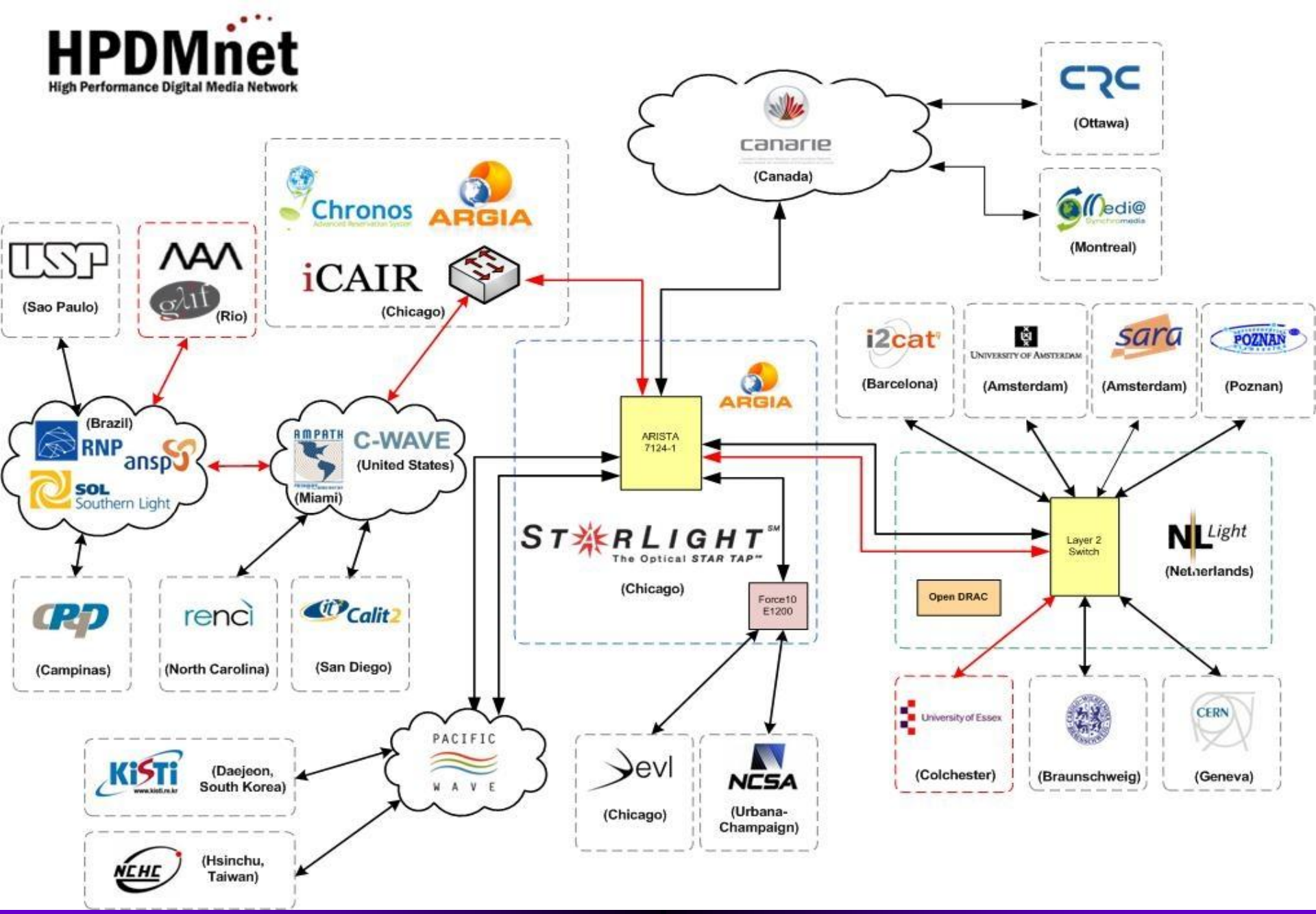
0 ° 45

Preview

4. Watch the animation

> ||

1 **Frame # 13 , time is 39 fs** 15


HPDMnet
High Performance Digital Media Network
canarie
(Canada)
CRC
(Ottawa)
Medi@
(Montreal)
Chronos
ARGIA
iCAIR
(Chicago)
USP
(Sao Paulo)
AAA
glif
(Rio)
(Brazil)
RNP
ansp
SOL
Southern Light
AMPATH
C-WAVE
(United States)
(Miami)
ARGIA
ARISTA
7124-1
STARLIGHT SM
The Optical STAR TAP™
(Chicago)
Force10
E1200
i2cat
(Barcelona)
University of Amsterdam
(Amsterdam)
sara
(Amsterdam)
POZNAN
(Poznan)
Layer 2
Switch
Open DRAC
NL Light
(Netherlands)
CPqD
(Campinas)
renci
(North Carolina)
Calit2
(San Diego)
PACIFIC
WAVE
KiSTi
(Daejeon,
South Korea)
NCHC
(Hsinchu,
Taiwan)
evl
(Chicago)
NCSA
(Urbana-
Champaign)
University of Essex
(Colchester)
(Braunschweig)
CERN
(Geneva)

8k Media Experiments At the Univ of Essex

StarLight 100 Gbps/Tbps Initiatives

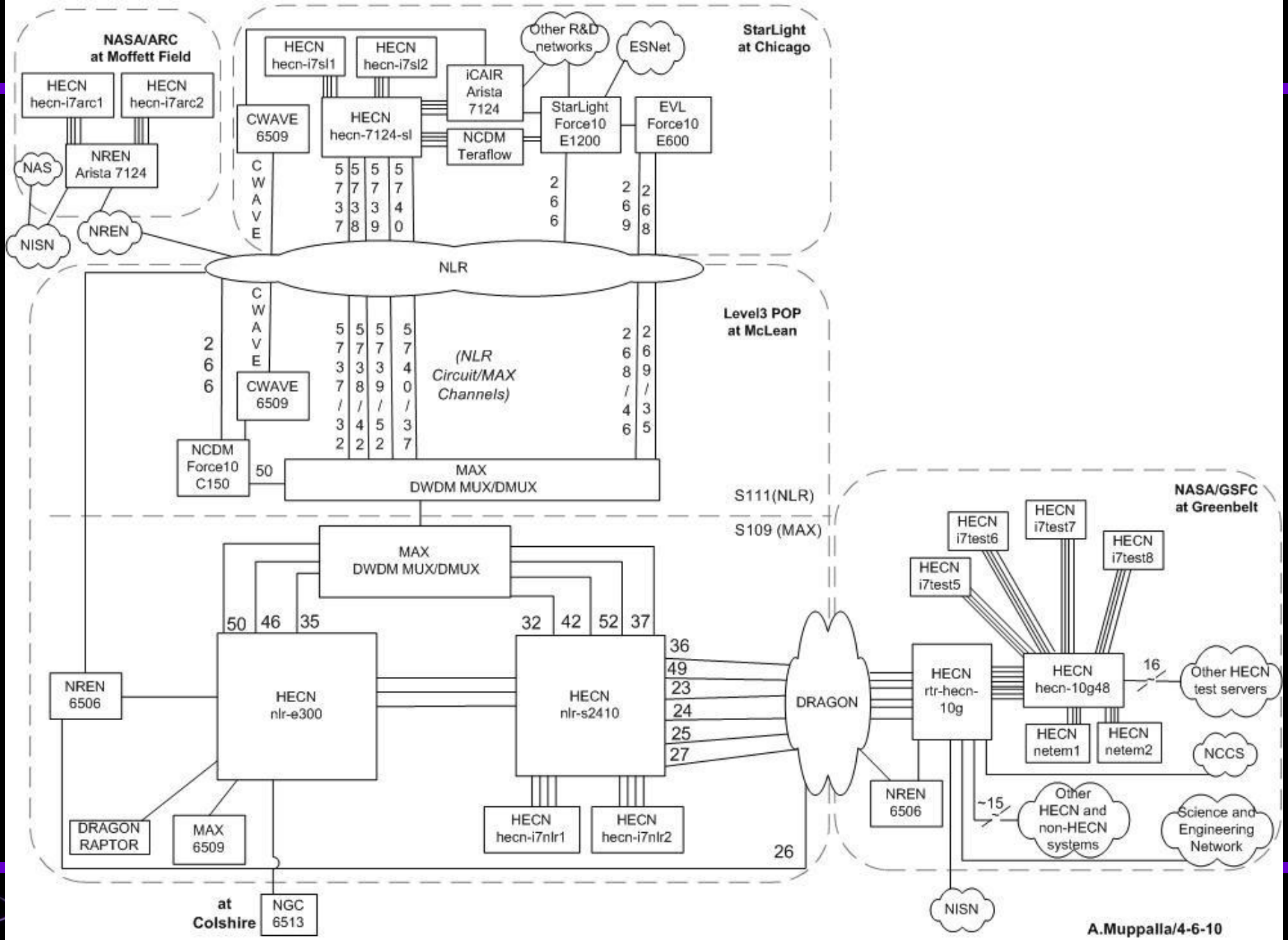
- StarLight Has Established Several Initiatives That Are Directed At Creating Networking Services, Architecture, Technology, and Networks Based on 100 Gbps and Higher Service, Including Tbps
- Foundation Research Is Based On Earlier Experience With Dynamic Lightpath Technologies
- 100 Gbps = More Than Capacity (e.g., Dynamic Control Over Channel Segments, Customization)

StarWave: A Multi-100 Gbps Exchange Facility

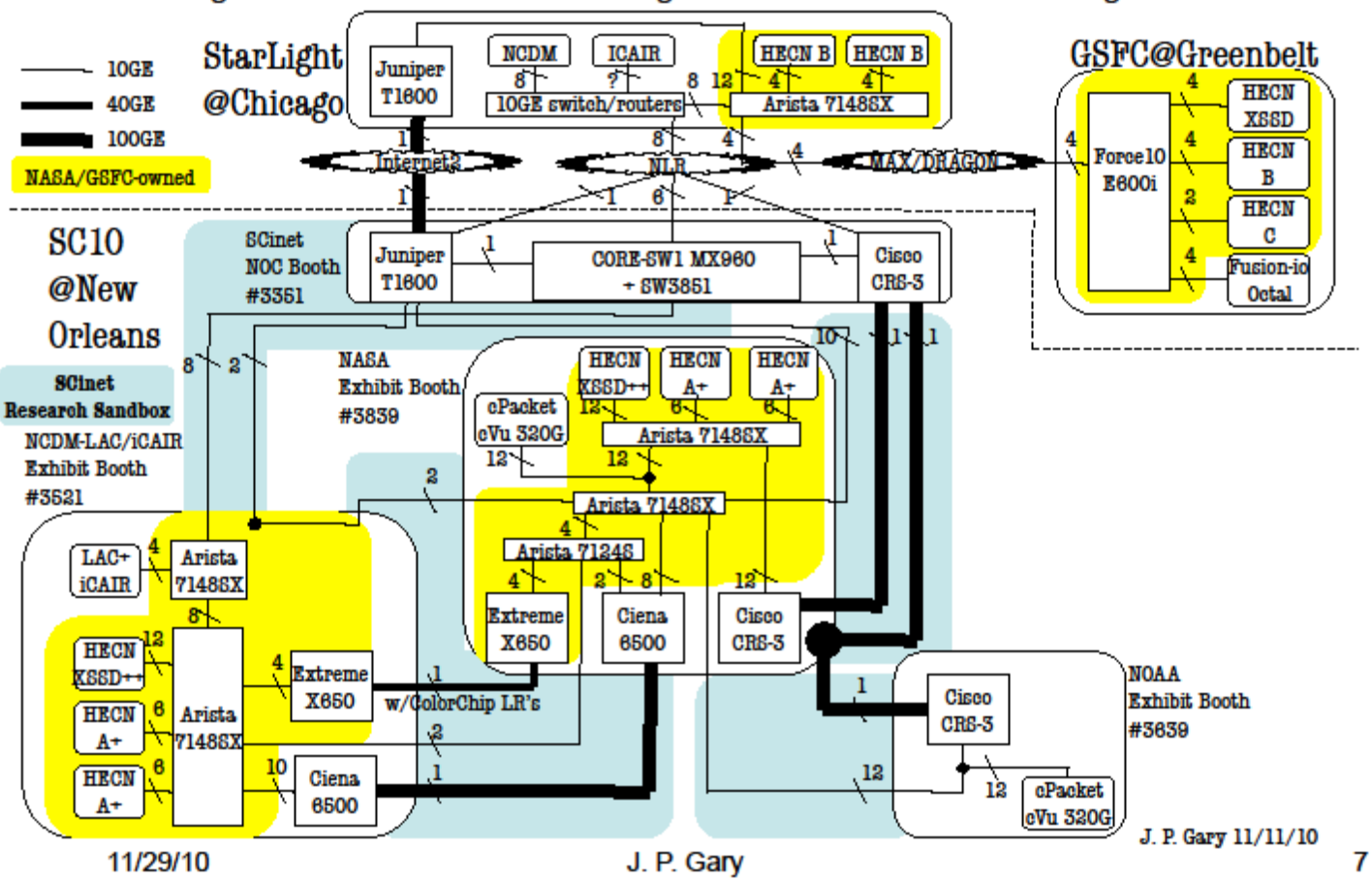
- StarWave, A New Advanced Multi-100 Gbps Exchange Facility and Services Implemented Within the StarLight International/National Communications Exchange Facility
- StarWave Was Implemented In 2011 To Provide Services To Support Large Scale Data Intensive Science Research Initiatives
- StarWave is Supporting Several GLIF Demonstrations

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



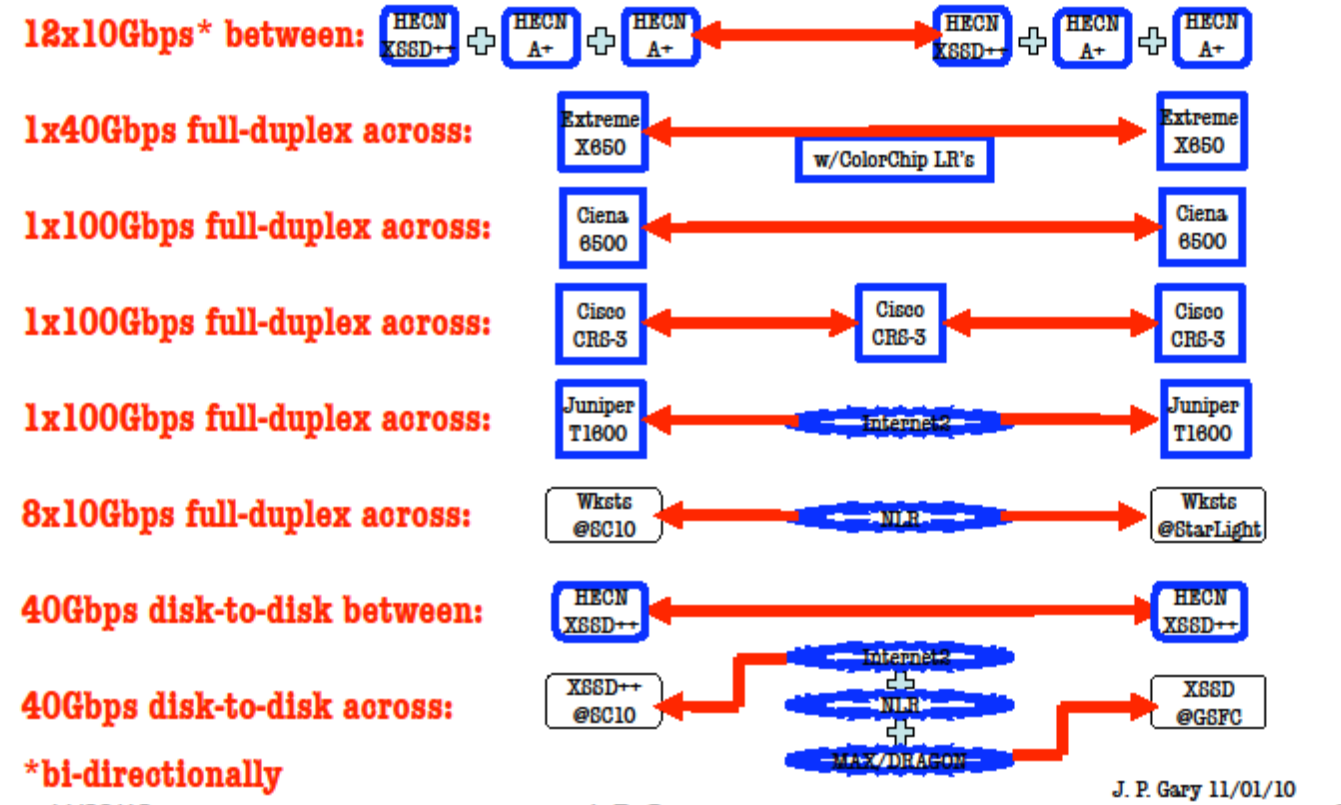
SC10 Demos


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
10GE
40GE
100GE
NASA/GSFC-owned
StarLight @Chicago
Juniper T1600
NCDM
iCAIR
10GE switch/routers
HECN B
HECN B
Arista 7148SX
GSFC@Greenbelt
Force10 E600i
HECN XS6D
HECN B
HECN C
Fusion-io Octal
Internet2
NLR
MAX/DRAGON
SC10 @New Orleans
SCinet NOC Booth #3351
Juniper T1600
CORE-SW1 MX960 + SW3851
Cisco CRS-3
SCinet Research Sandbox
NCDM-LAC/iCAIR Exhibit Booth #3521
NASA Exhibit Booth #3839
HECN XS6D++
HECN A+
HECN A+
cPacket cVu 320G
Arista 7148SX
Arista 7148SX
Arista 7124S
LAC+ iCAIR
Arista 7148SX
HECN XS6D++
HECN A+
HECN A+
Arista 7148SX
Extreme X650
Ciena 6500
Extreme X650
w/ColorChip LR's
Ciena 6500
Cisco CRS-3
Cisco CRS-3
NOAA Exhibit Booth #3839
cPacket cVu 320G
J. P. Gary 11/11/10
11/29/10
J. P. Gary
7

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

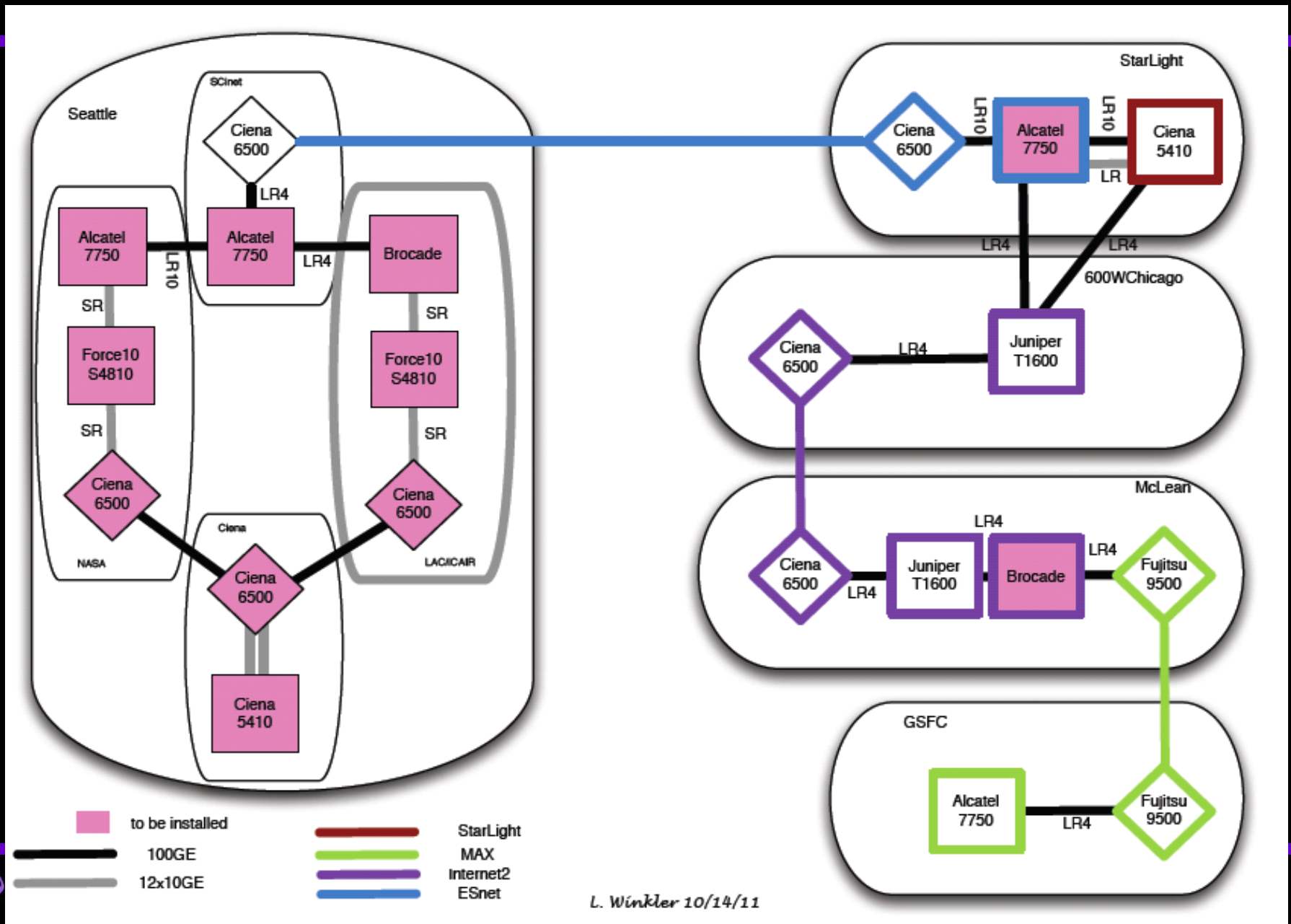
Demo Summary



*bi-directionally

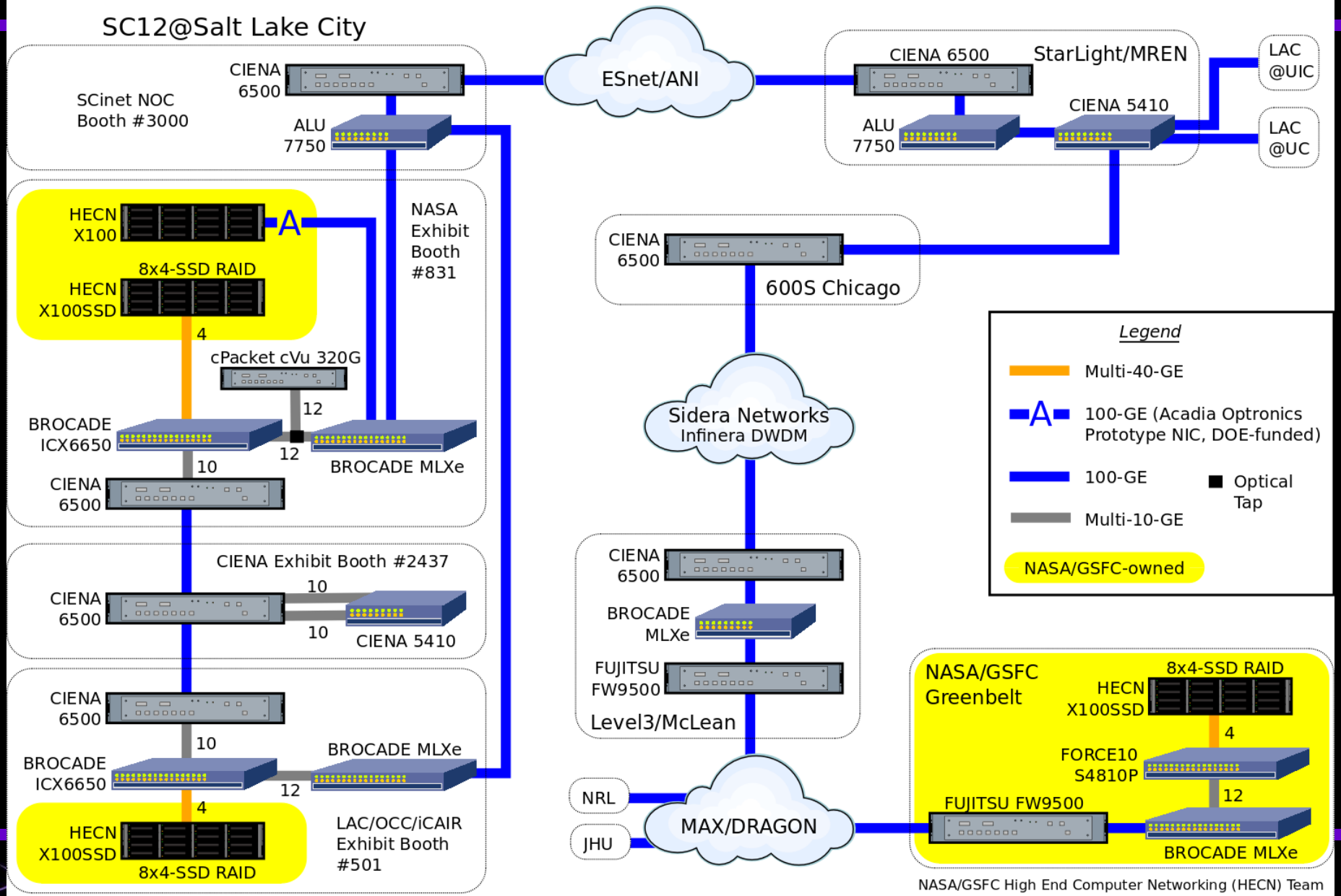
J. P. Gary 11/01/10

SCInet Research Sandbox Evaluations/Demonstrations of 40-100 Gbps IPv4/IPv6 Disk-to-Disk File Transfer Across WANs and LANs at SC11



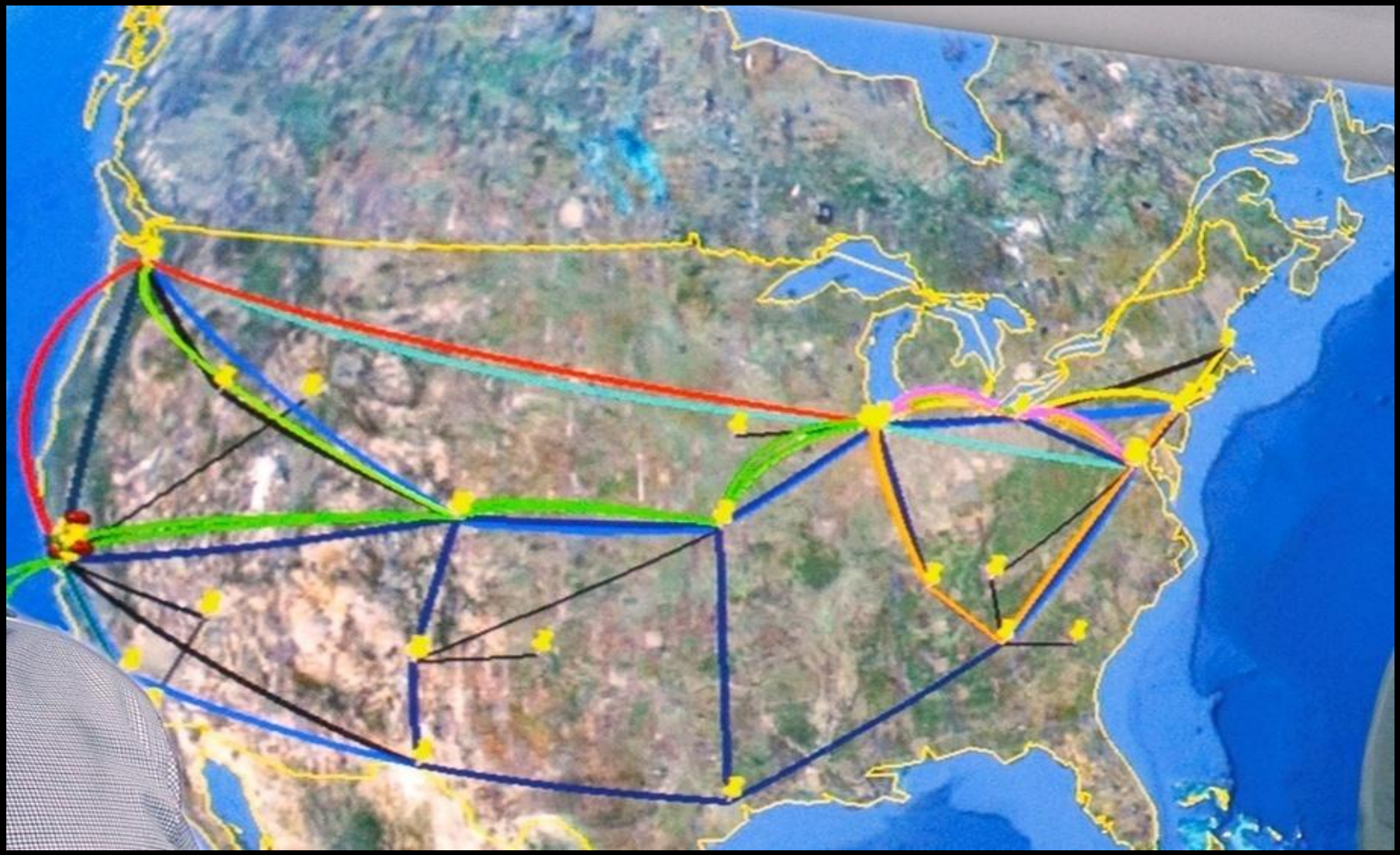
Evaluations/Demonstrations of 100 Gbps Disk-to-Disk File Transfer Performance using OpenFlow Across LANs & WANs

An SC12 Collaborative Initiative Among NASA and Several Partners



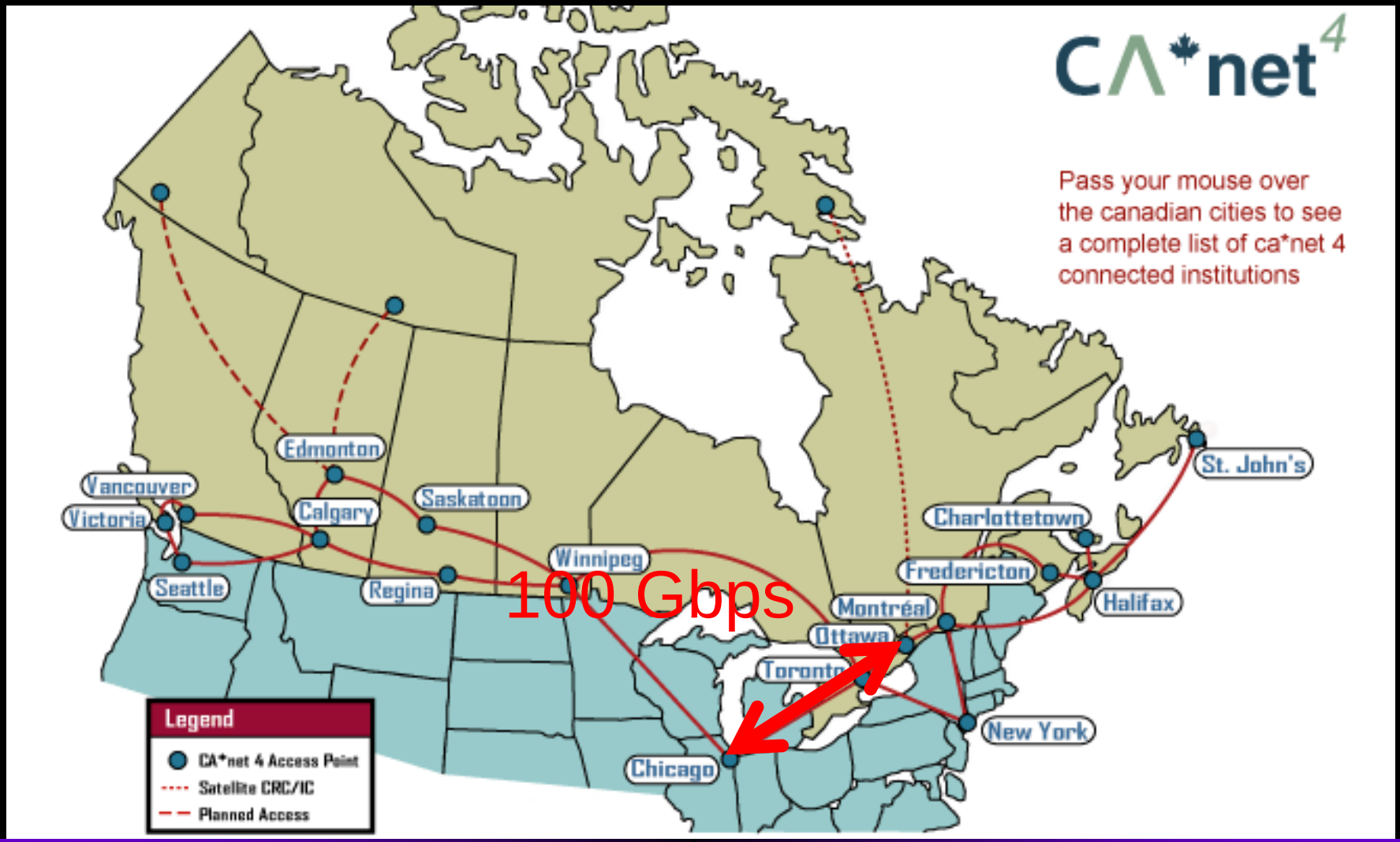
NASA/GSFC High End Computer Networking (HECN) Team
Diagram by Bill Fink / Paul Lang - 9/27/2012

DOE ESnet Advanced Networking Initiative: 100 Gbps

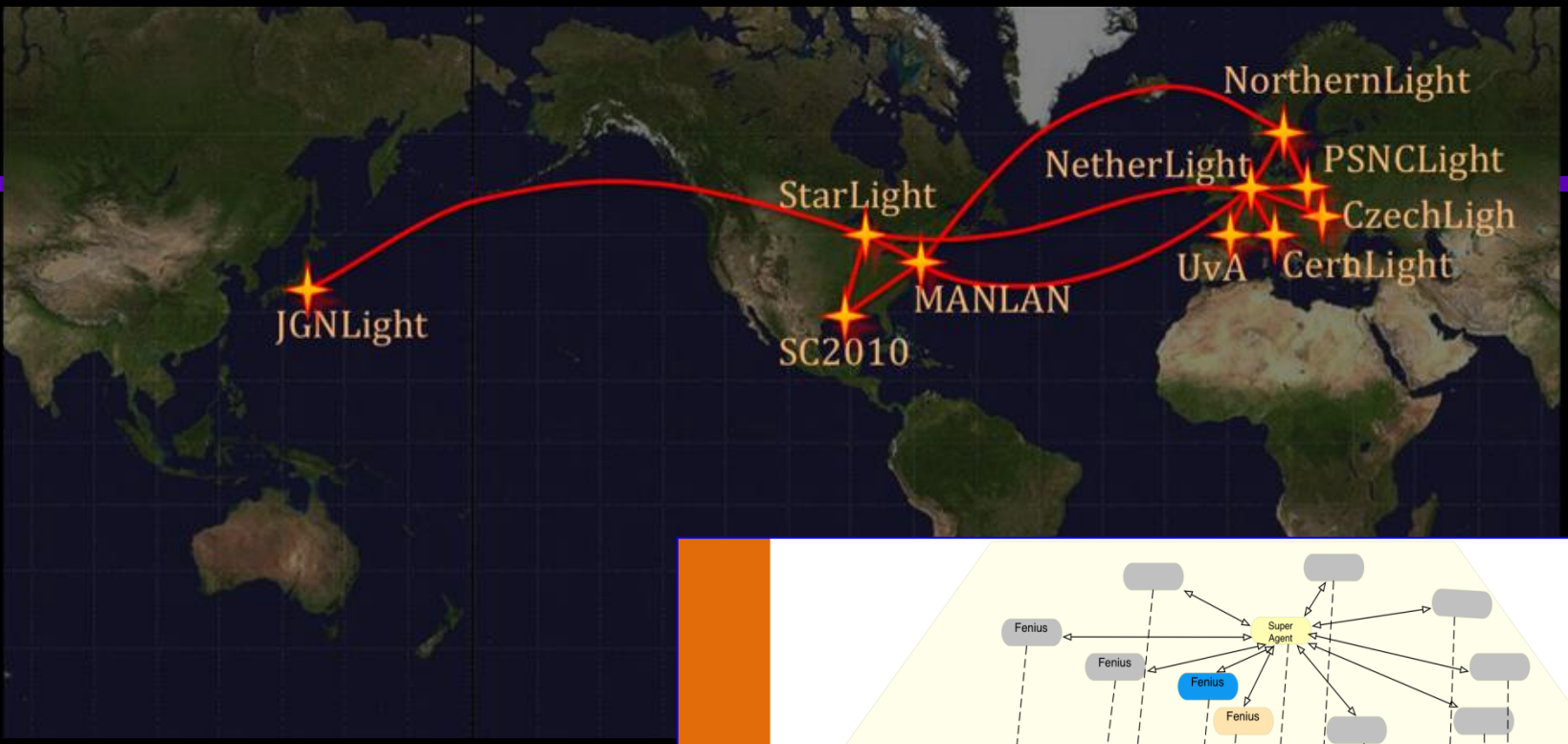


Source : ESnet

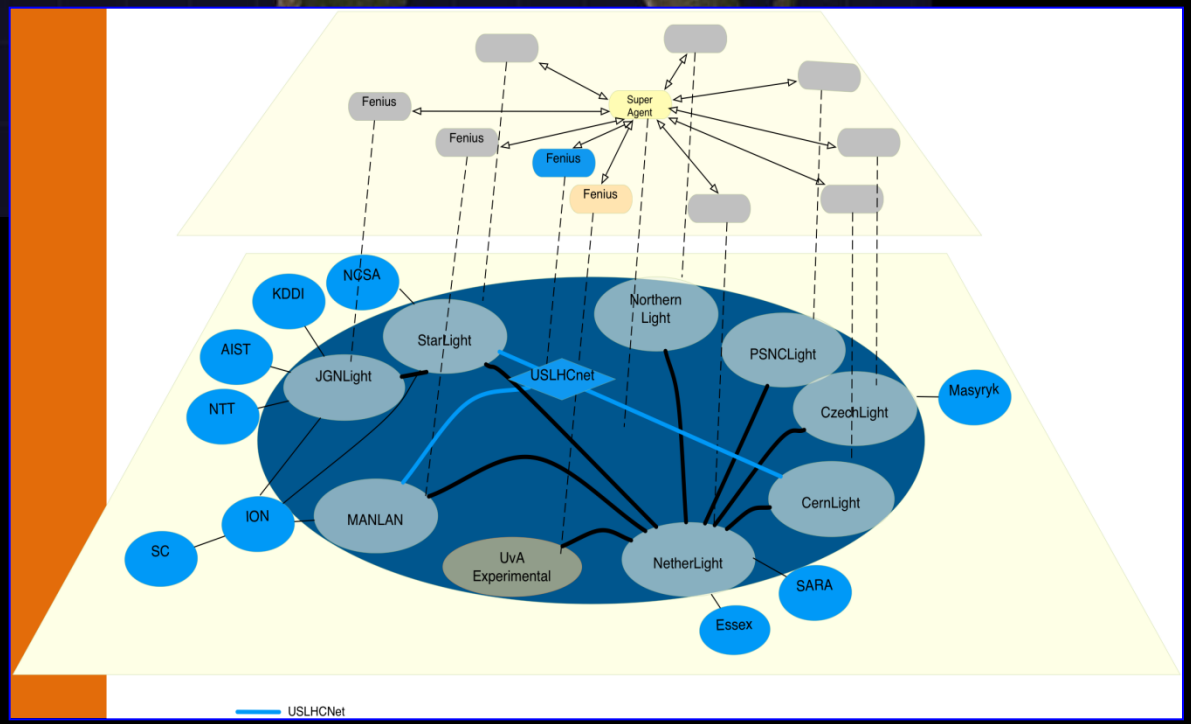
CA*net/Ciena/StarLight/iCAIR 100 Gbps Testbed 1st Implemented In Sept 2010, Scheduled Also for Sept-Oct 2011



Source: CANARIE



NSI Prototype



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