StarLight GOLE Update

Joe Mambretti, Linda Winkler, Alan Verlo

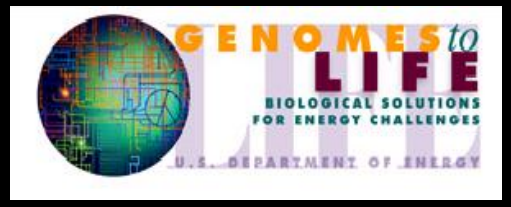
13th Annual Global LambdaGrid Workshop

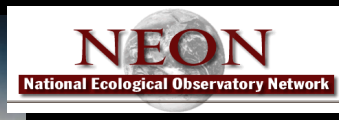
& the StarLight International Consortium

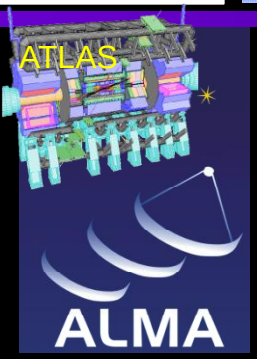
Global LambdaGrid Workshop

Singapore

October 2-4 2013



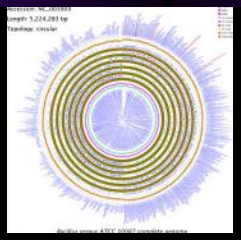




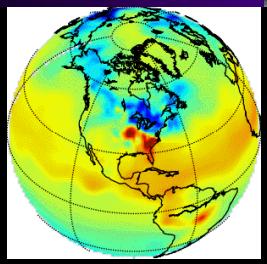
ALMA: Atacama Large Millimeter Array
www.alma.nrao.edu

ANDRILL: Antarctic Geological Drilling
www.andrill.org

BIRN: Biomedical Informatics Research Network
www.nbirn.net



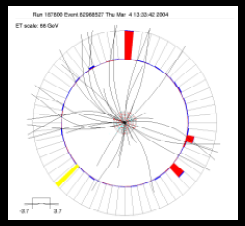
CAMERA metagenomics
camera.calit2.net



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

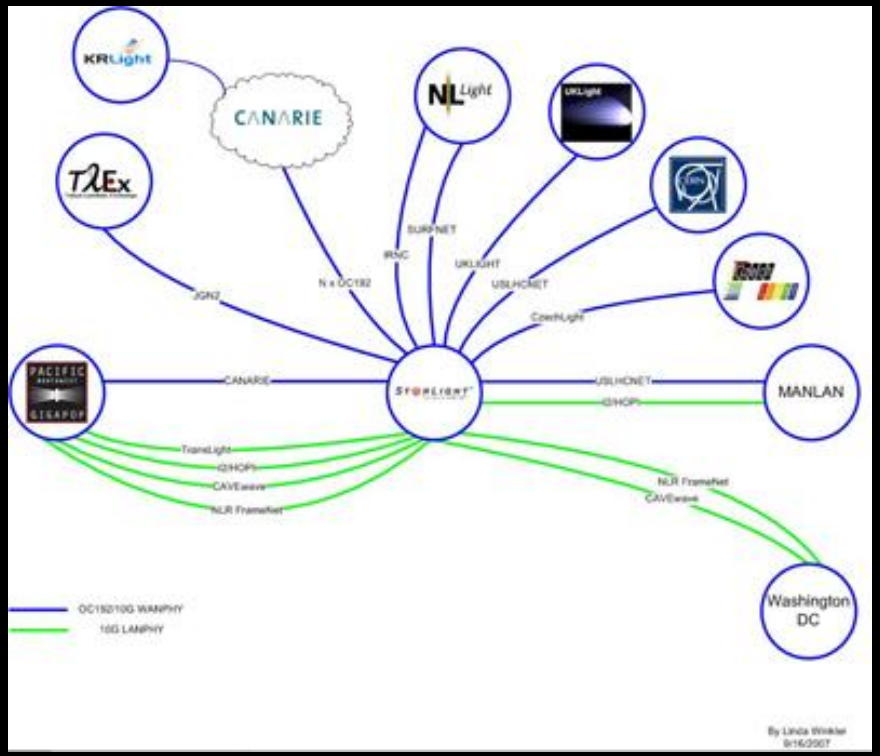
XSEDE
www.xsede.org

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

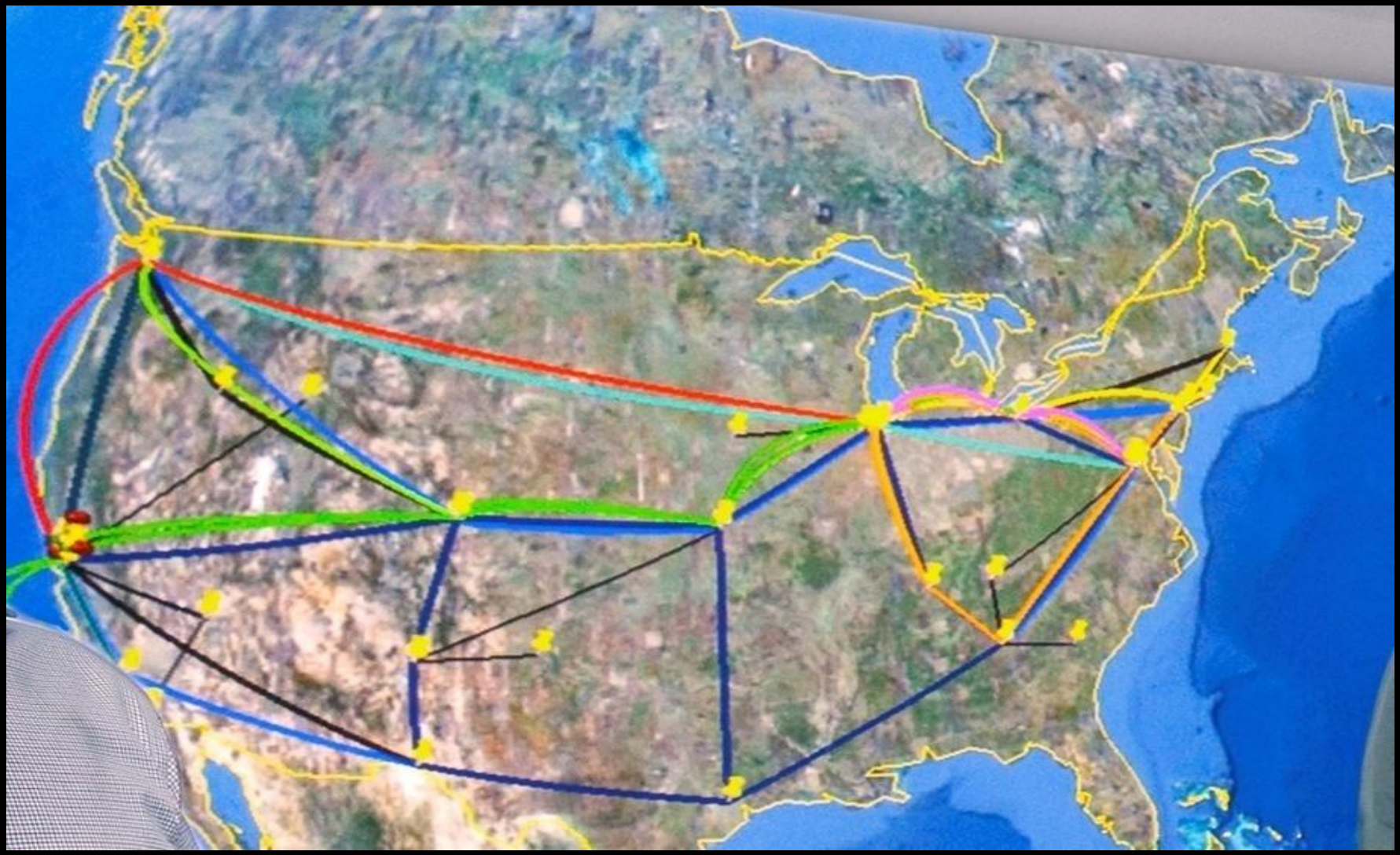
Multiple Network Research Testbeds

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

StarLight 100 Gbps/Tbps Initiatives

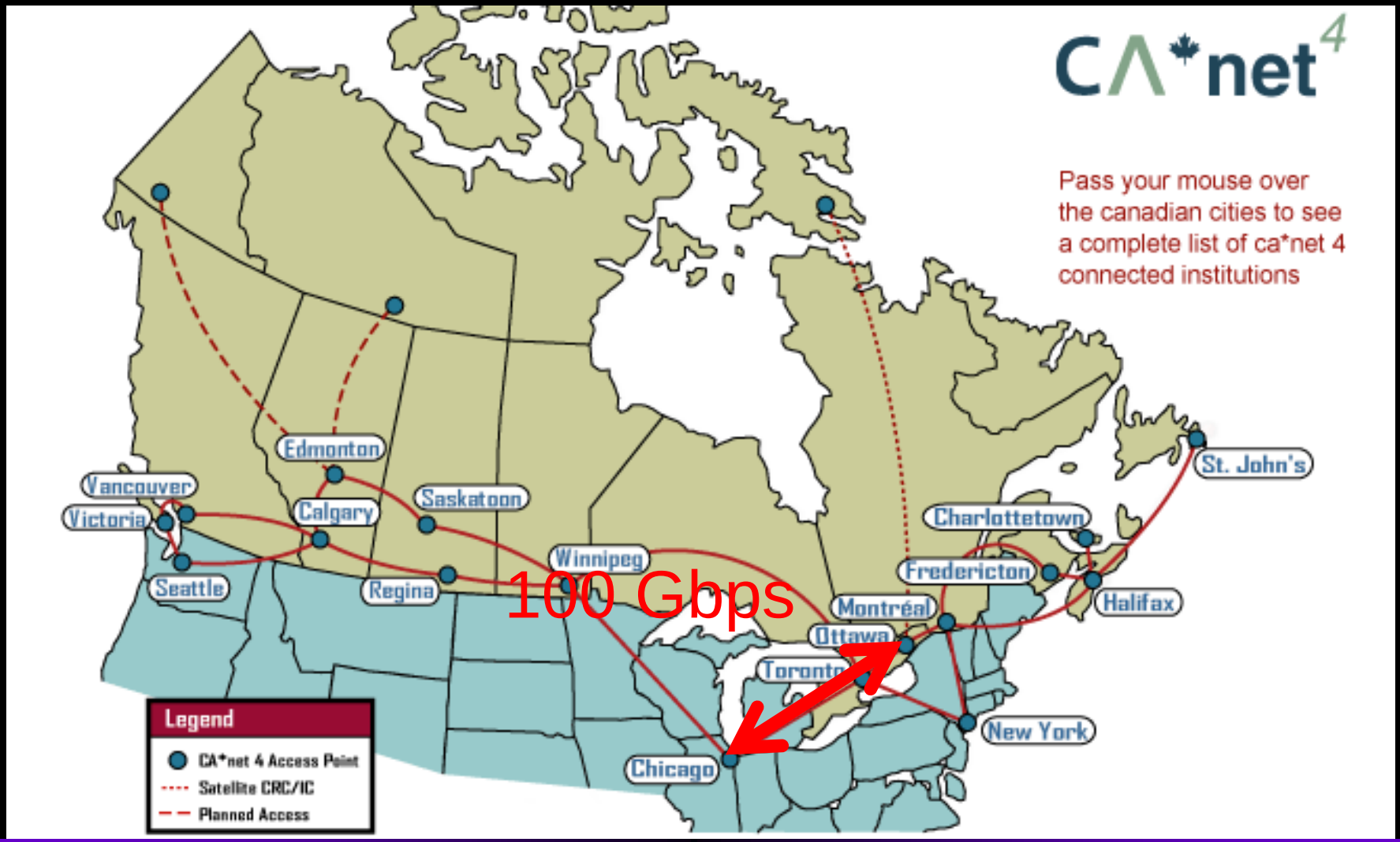
- StarLight Has Established Several Initiatives That Are Directed At Creating Networking Services, Architecture, Technology, and Networks Based on 100 Gbps and Higher Service, Including Tbps
- Foundation Research Is Based On Earlier Experience With Dynamic Lightpath Technologies
- 100 Gbps = More Than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

DOE ESnet Advanced Networking Initiative: 100 Gbps



Source : ESnet

CA*net/Ciena/StarLight/iCAIR 100 Gbps Testbed 1st Implemented In Sept 2010, Implemented Periodically Since



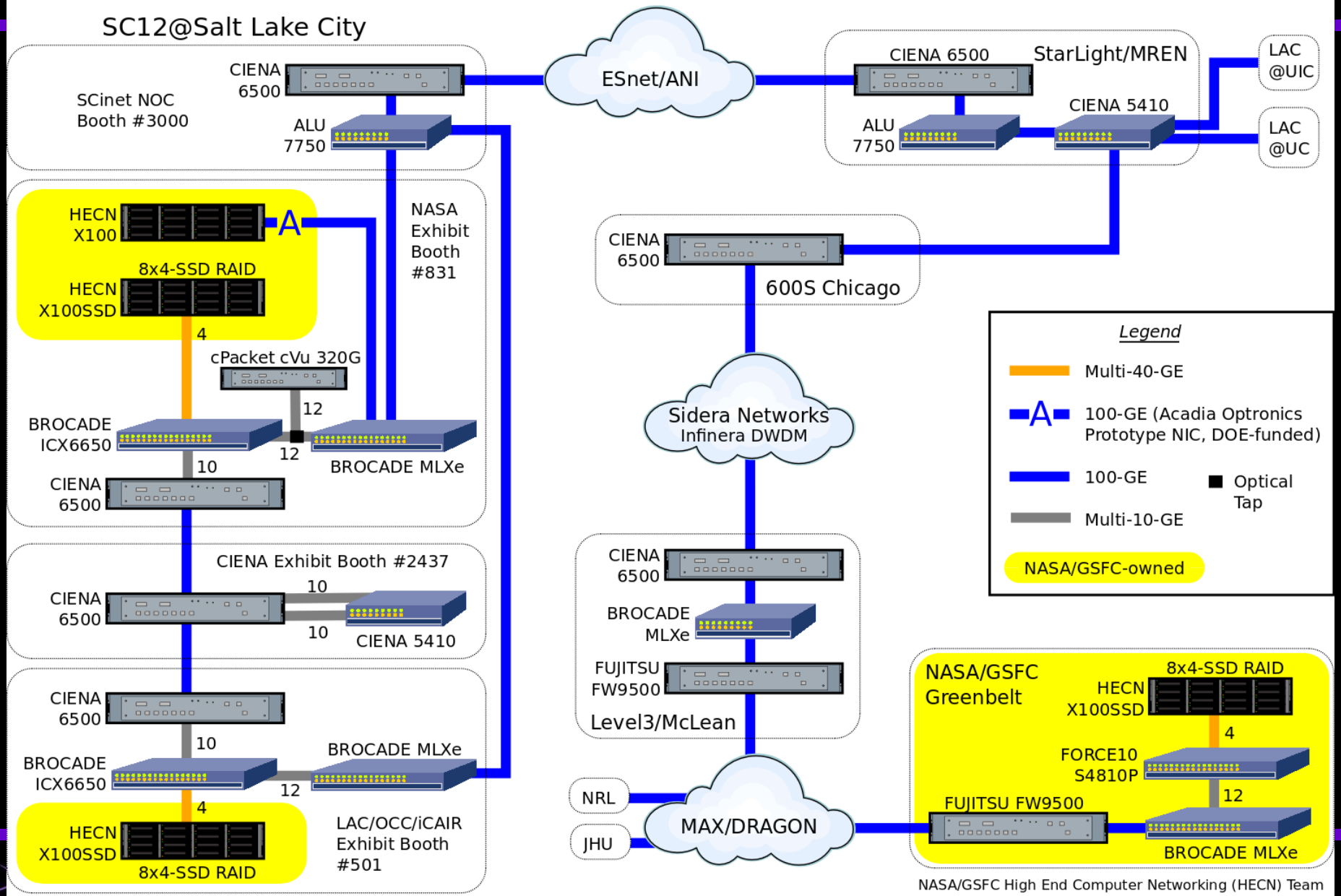
Source: CANARIE

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

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

IRNC:ProNet: TransLight/StarLight

July 2010- August 2014

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)

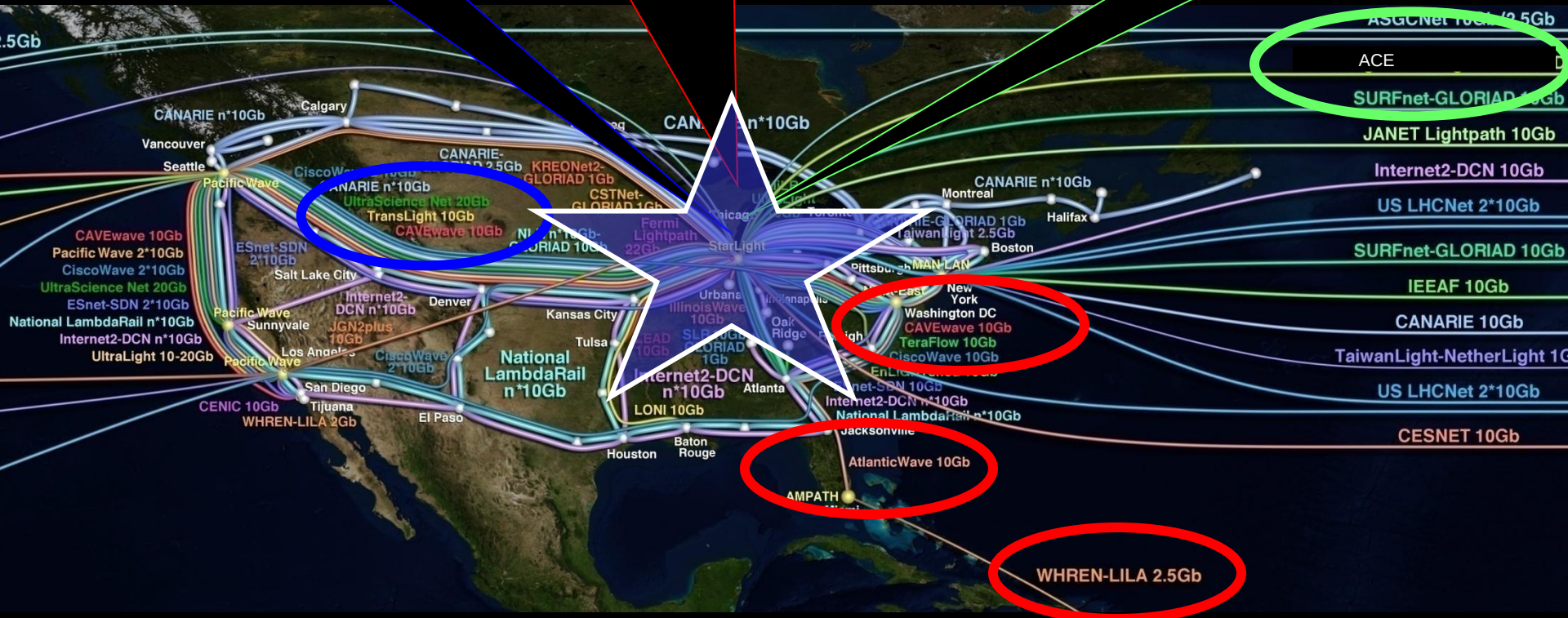
PACIFIC WAVE TRANS LIGHT

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



TransLight/StarLight
Petascale Science Prototype Services Facility

- **Goal: Prototyping Trans-Atlantic 100 Gbps Architectures, Services, and Emerging Technologies Among Institutions Connected to NetherLight, StarLight, and Other Participating GOLEs in North America and Europe**
- **The TransLight/StarLight Consortium Has Been Awarded a National Science Foundation (NSF) Grant To Establish An Initiative To Design and Implement Network Architectures, Services, Technologies, and Core Capabilities In Support of Big Data Science Over 100 Gbps Trans-Atlantic Paths, Enabling Large-Scale Global Scientific Research Experiments, Instrumentation Access, Collaborations, Data Sharing and High-Resolution Visualization.**

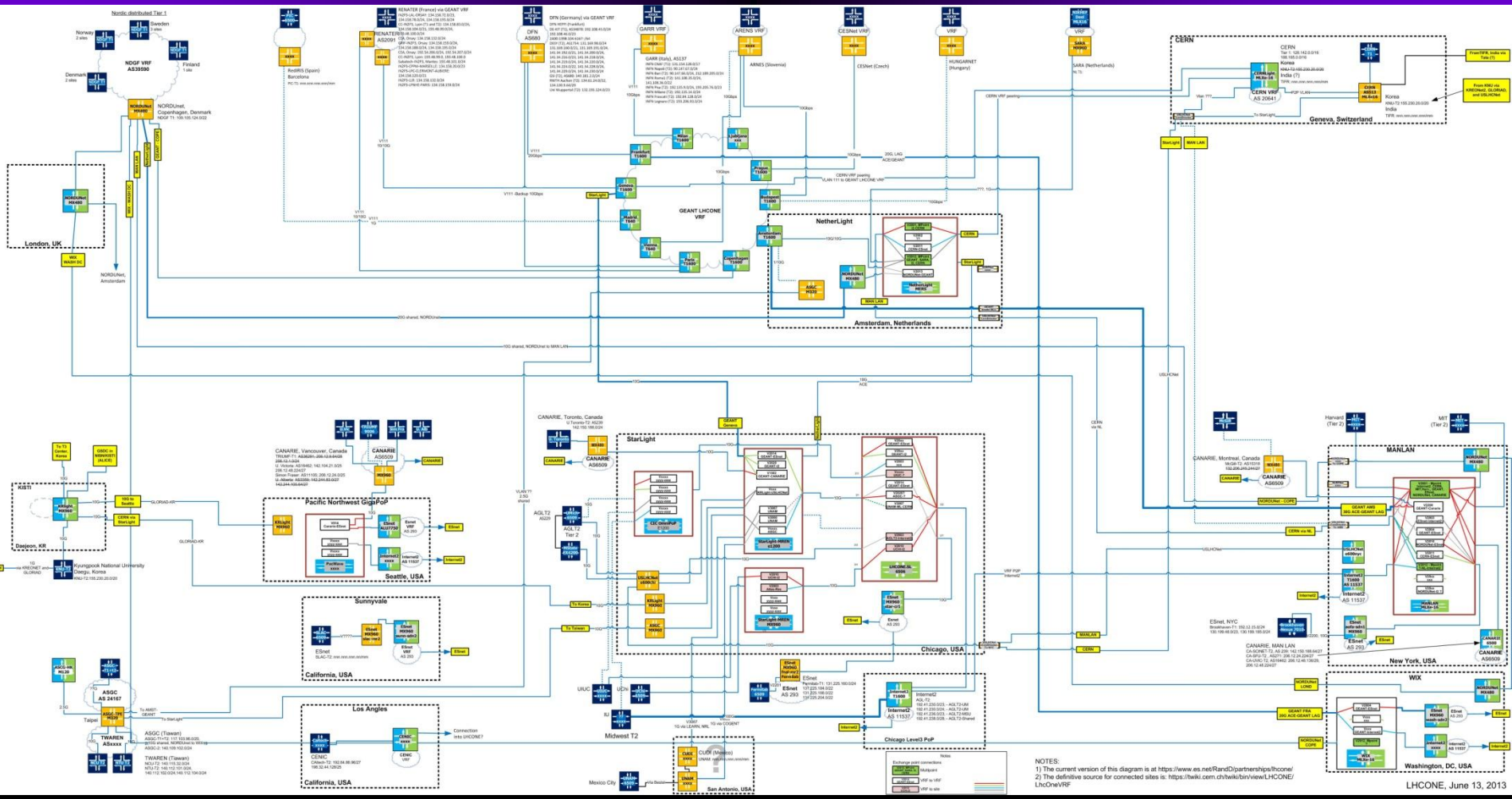
TransLight/StarLight
Petascale Science Prototype Services Facility

- **This Project Will Implement and Experiment With Prototype Services and Capabilities That Have the Potential to Optimize Advanced Networks for Production Science Research, Particularly for Large-Scale Data Transport, Including Persistent, Ultra-Large-Capacity, Real-Time, Long-Duration Streams. These Experiments Will Be Conducted With Multiple National and International Partners.**
- ***Four Major Themes of This Initiative Are To Provide: (a) Large-Scale Network Capacity, Including Support For Extremely High-Volume Individual Data Streams, (b) Network Services and Resource Programmability For This Capacity, (c) Edge Access To These Capabilities, and (d) Exchange Facilities That Can Support These Services and Capabilities.***

Initial Project Workshops

- Workshop Themes: 100 Gbps Services for Global Data Intensive Science
- Chicago, Aug, Sept, Oct: Project Planning
- Amsterdam, Sept 16-17: SURFnet, SURFsara, University of Amsterdam
- Singapore, Oct 2-4: Side Meetings at Global LambdaGrid Workshop
- Denver, Nov 17-22: Planning Joint IRNC 100 Gbps Workshop At SC13

LHCONE


Nordic distributed Tier 1
Norway
Sweden
Denmark
Finland
NDGF VRF
AS39590
NORDUNet
NORDUNet, Copenhagen, Denmark
London, UK
NORDUNet, Amsterdam
RENATER (France) via GEANT VRF
RENATER
AS2091
RedIRIS (Spain)
Barcelona
DFN (Germany) via GEANT VRF
DFN
AS680
GARR VRF
GARR (Italy), AS137
ARENS VRF
ARENS (Slovenia)
CESNet VRF
CESNet (Czech)
VRF
HUNGARNET (Hungary)
SARA VRF
SARA (Netherlands)
CERN
CERN, Tier 1, 128.142.0.0/16, 188.185.0.0/16
CERN VRF
AS 20641
Geneva, Switzerland
GEANT LHCONE VRF
NetherLight
Amsterdam, Netherlands
StarLight
Chicago, USA
CANARIE, Toronto, Canada
CANARIE, Vancouver, Canada
CANARIE
AS6509
Pacific Northwest GigaPoP
Seattle, USA
KISTI
Daejeon, KR
Kyungpook National University
Daegu, Korea
Sunnyvale
California, USA
ESnet
AS 293
Internet2
AS 11537
Los Angles
CENIC
ASGC
AS 24167
Taipei
TWAREN
ASxxxx
ASGC (Tiawan)
TWAREN (Tiawan)
Midwest T2
UIUC
Mexico City
CUDI (Mexico)
UNAM
San Antonio, USA
Chicago Level3 PoP
Harvard (Tier 2)
MIT (Tier 2)
MANLAN
CANARIE, Montreal, Canada
New York, USA
CANARIE, MAN LAN
WIX
Washington, DC, USA
NOTES:
1) The current version of this diagram is at https://www.es.net/RandD/partnerships/lhcone/
2) The definitive source for connected sites is: https://twiki.cern.ch/twiki/bin/view/LHCONE/LhcOneVRF
LHCONE, June 13, 2013

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

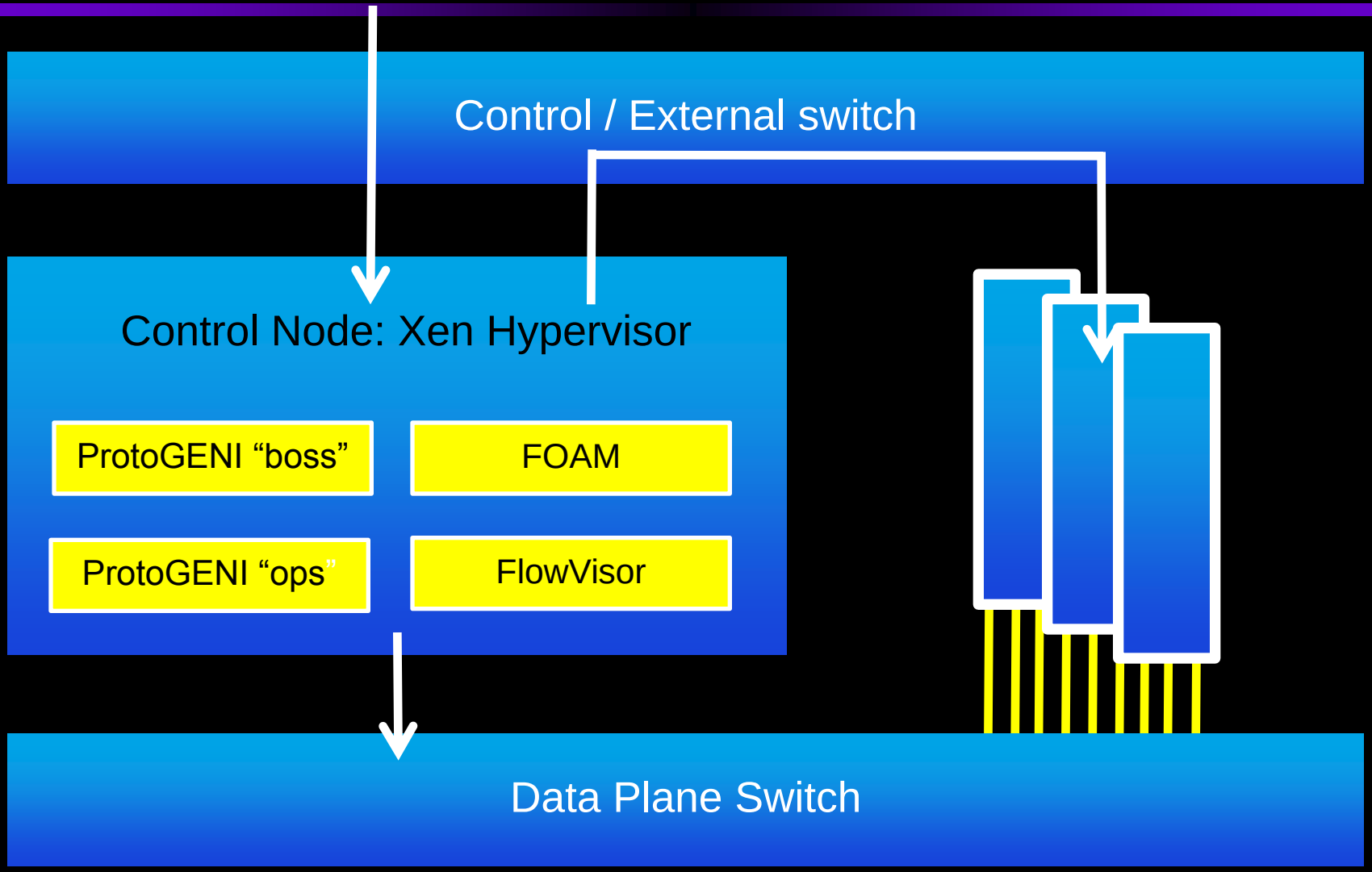
- The iGENI Initiative Is Designing, Developing, Implementing, and Operating a Major New National and International Distributed Infrastructure.
- iGENI Is Placing the “G” in GENI Making GENI Truly Global.
- iGENI Is Creating a Unique Distributed Infrastructure To Support GLOBAL Research and Development 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

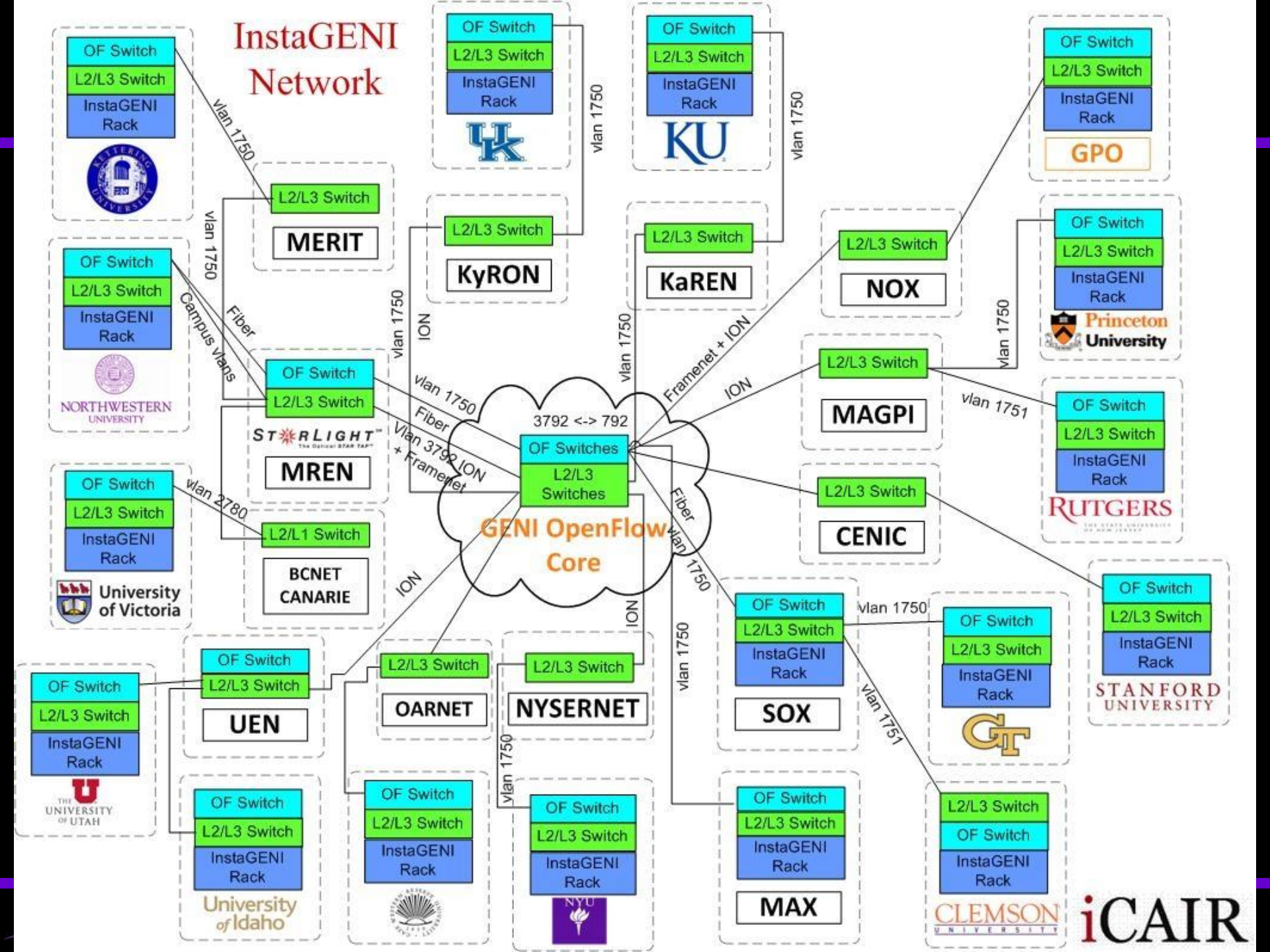

KUAS
NetFPGA
NOX
OpenFlow
NCKU
NetFPGA
NOX
OpenFlow
ETRI
NOX
OpenFlow
NetFPGA
KiSTi
University of Victoria
GENICloud
OpenFlow
InstaGENI
CRC
NOX
OpenFlow
NetFPGA
NLR
light the future
OpenFlow
JGN-X
東京大学
THE UNIVERSITY OF TOKYO
VNode
OpenFlow
cenic
PACIFIC NORTHWEST GIGAPOP
aarnet
NICTA
ExoGENI
OpenFlow
NCHC
NetFPGA
NOX
OpenFlow
KRLight
canarie
APPLIED RESEARCH CENTER FOR COMPUTER NETWORKS
OpenFlow
GLORIAD
Northern Wave
hp
GENICloud
SingLight
SingAREN
OpenFlow
renci
ExoGENI
OpenFlow
STARLIGHT
The Optical STAR TAP
MREN
OpenFlow
NLR
light the future
OpenFlow
BEN
Breakable Experimental Network
Duke
UNIVERSITY
ExoGENI
OpenFlow
CNC
OpenFlow
NORTHWESTERN UNIVERSITY
NetFPGA
NOX
OpenFlow
GENICloud
InstaGENI
AMPATH
OpenFlow
INTERNET2
uen
UTAH EDUCATION NETWORK
OpenFlow
CPqD
OpenFlow
RNP
NL Light
NOX
OpenFlow
NetFPGA
THE UNIVERSITY OF UTAH
OpenFlow
InstaGENI
UNIVERSITY OF AMSTERDAM
ExoGENI
MAGPI
Princeton University
OpenFlow
InstaGENI
USP
InstaGENI
GENICloud
TECHNISCHE UNIVERSITÄT KAISERSLAUTERN
DFN
Deutsches Forschungsnetz
GEANT2
ja.net
University of BRISTOL
OpenFlow
University of Essex
OpenFlow
grnet
Belnet
dedicated connectivity
iMinds
CONNECT.INNOVATE.CREATE
InstaGENI

The InstaGENI Initiative

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

Control Infrastructure



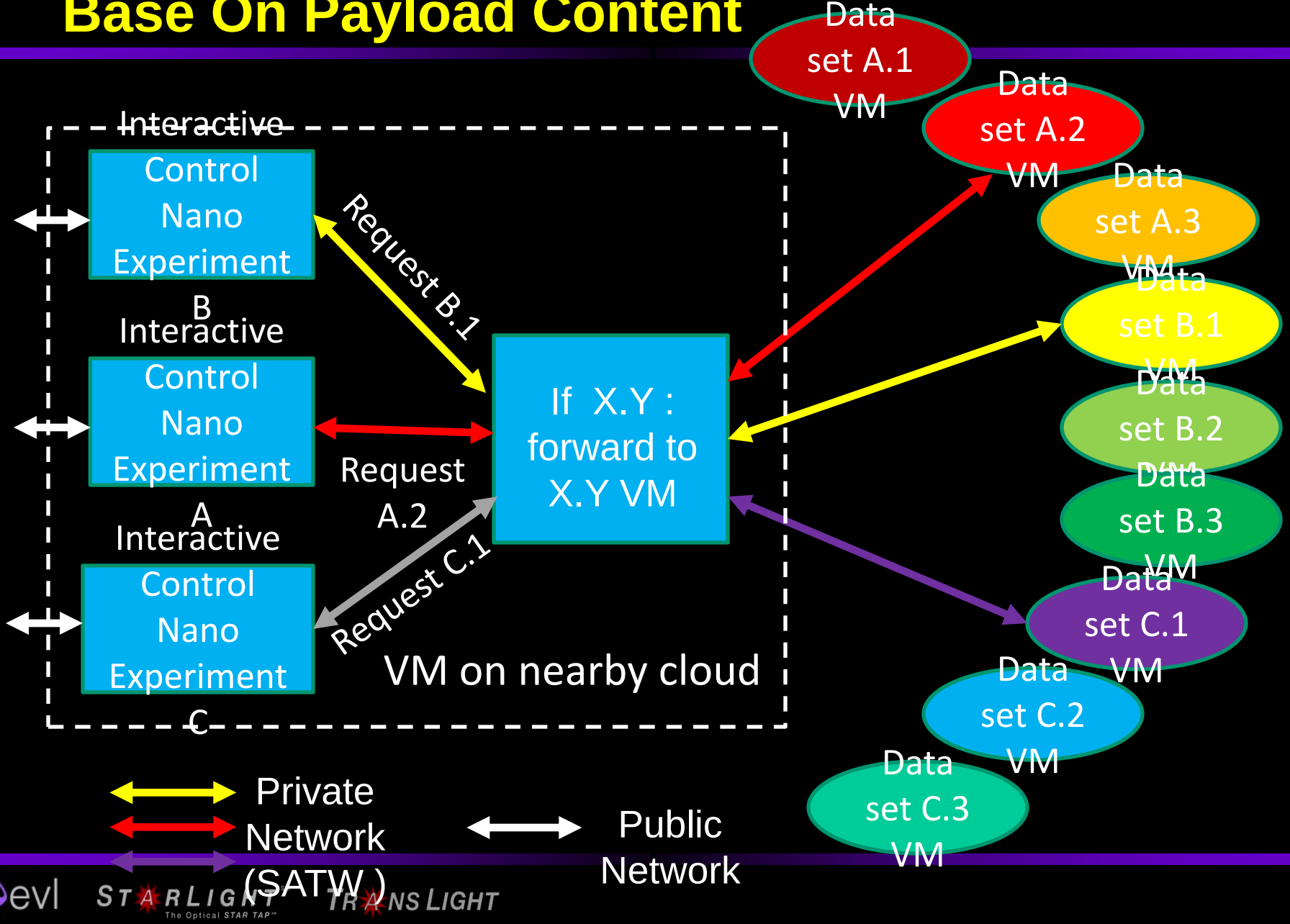

InstaGENI Network
OF Switch
L2/L3 Switch
InstaGENI Rack
MERIT
KyRON
KaREN
NOX
GPO
Princeton University
NORTHWESTERN UNIVERSITY
STARLIGHT
MREN
MAGPI
RUTGERS
CENIC
University of Victoria
L2/L1 Switch
BCNET CANARIE
3792 <-> 792
OF Switches
L2/L3 Switches
GENI OpenFlow Core
UEN
OARNET
NYSERNET
SOX
STANFORD UNIVERSITY
THE UNIVERSITY OF UTAH
University of Idaho
MAX
CLEMSON UNIVERSITY
iCAIR
vlan 1750
vlan 1751
vlan 2780
Campus vlans
Fiber
ION
Frameнet + ION
Vlan 3792 ION + Frameнet

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

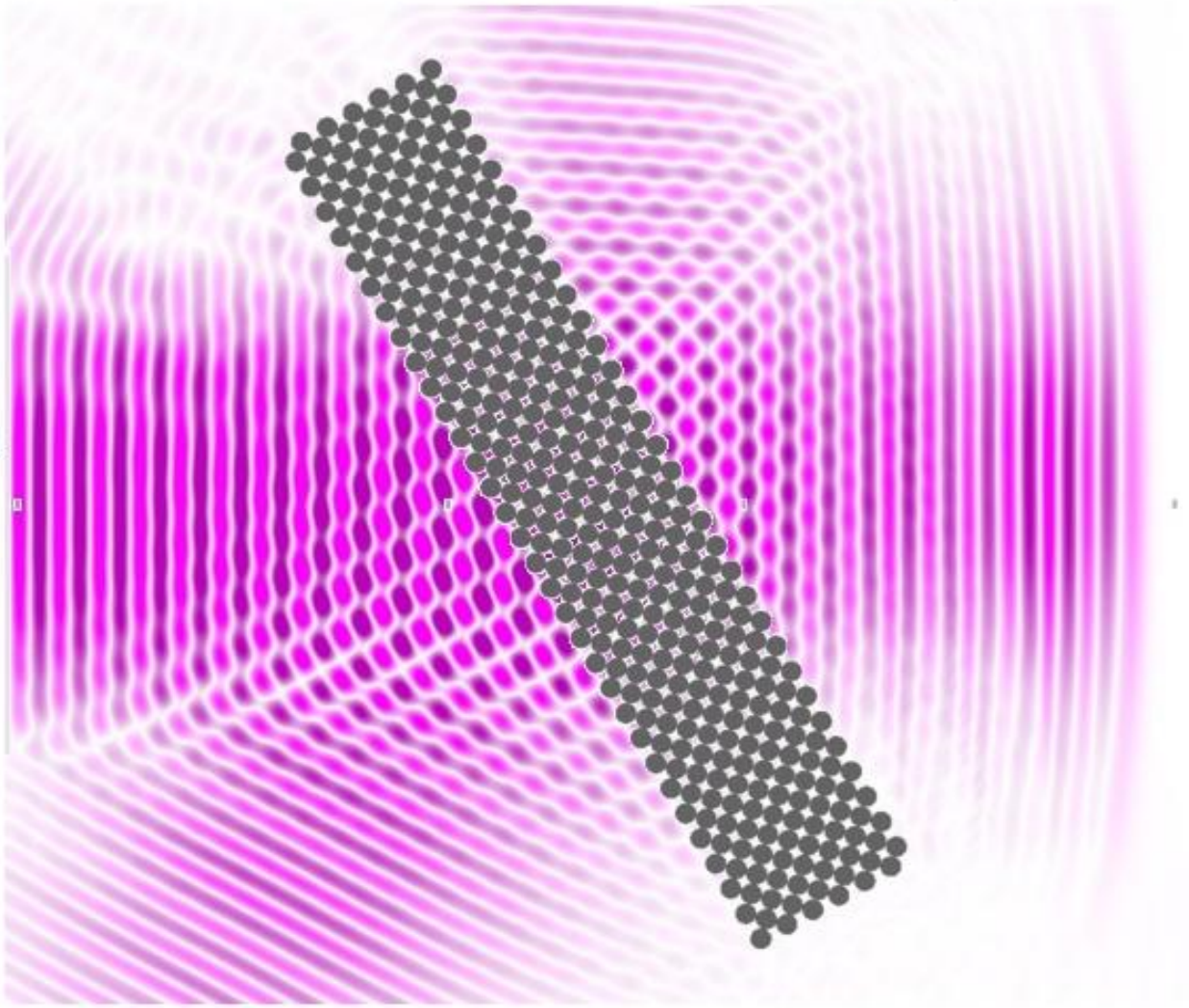
A Demonstration and Presentation By the
Consortium for International Advanced Network Research

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 °

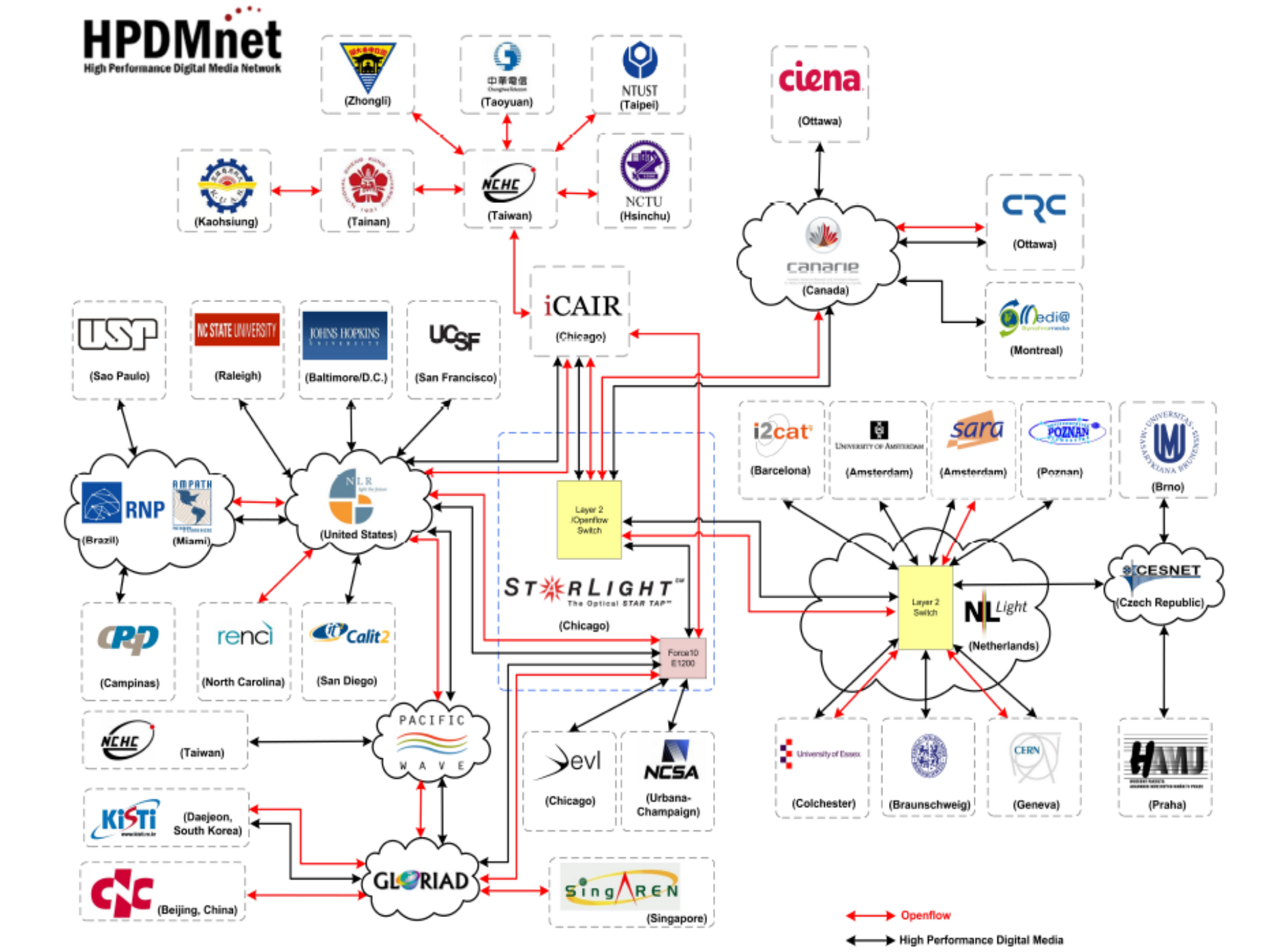
0 ° 45

Preview

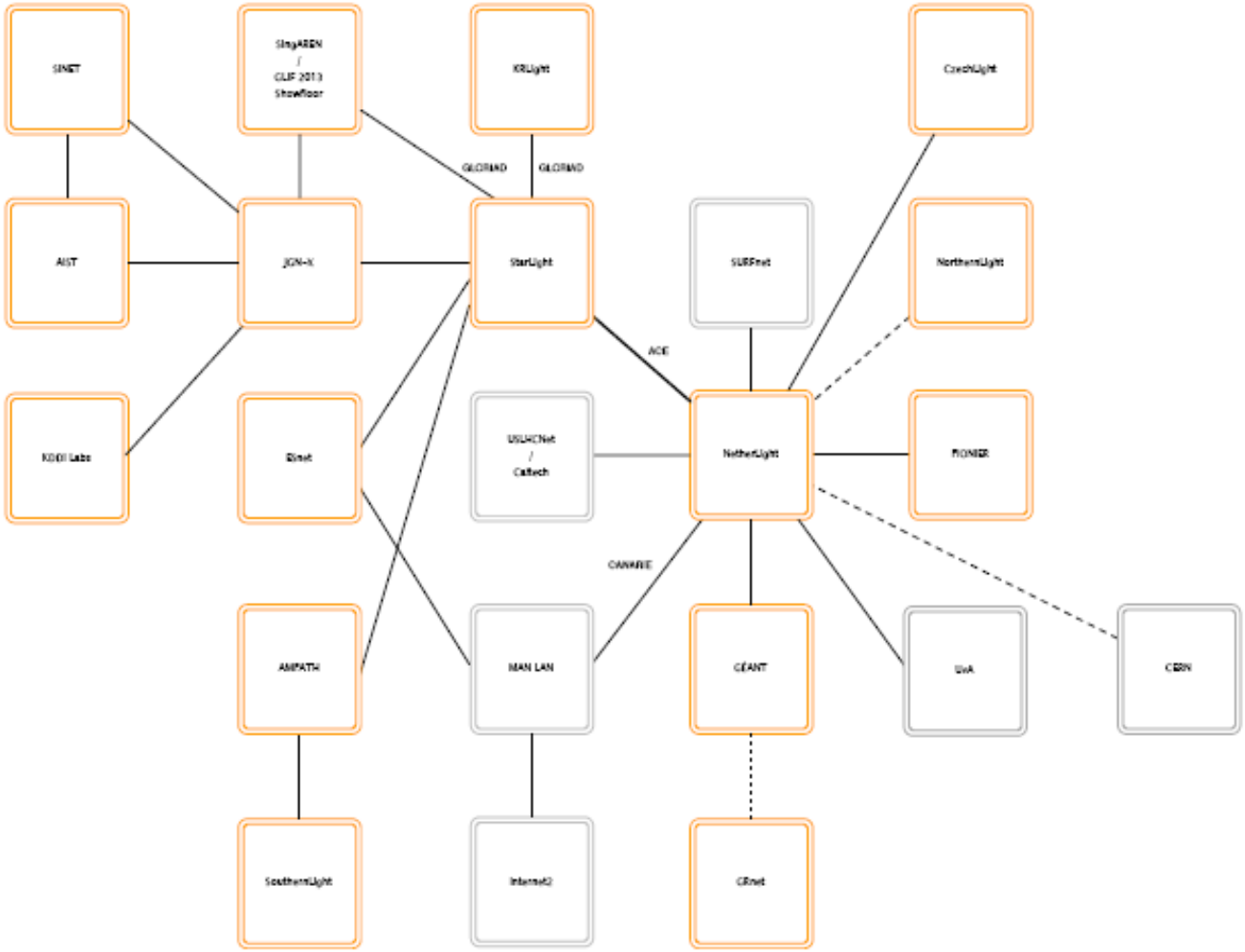
4. Watch the animation

> ||

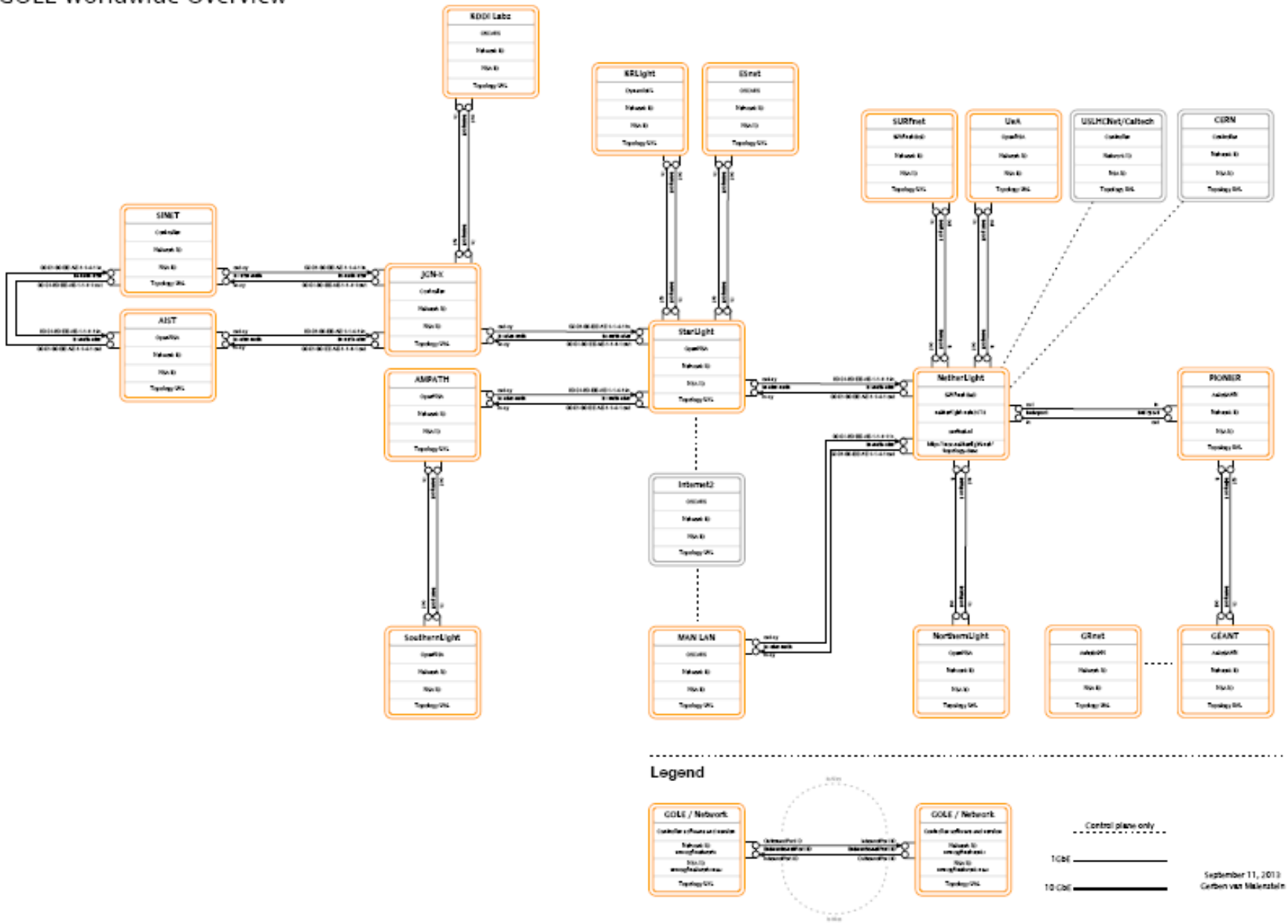
1 **Frame # 13 , time is 39 fs** 15


HPDMnet
High Performance Digital Media Network
(Zhongli)
(Taoyuan)
NTUST
(Taipei)
(Kaohsiung)
(Tainan)
NCHC
(Taiwan)
NCTU
(Hsinchu)
ciena
(Ottawa)
canarie
(Canada)
CRC
(Ottawa)
Medi@
(Montreal)
iCAIR
(Chicago)
USP
(Sao Paulo)
NC STATE UNIVERSITY
(Raleigh)
JOHNS HOPKINS
(Baltimore/D.C.)
UCSF
(San Francisco)
RNP
(Brazil)
AMPATH
(Miami)
NLR
(United States)
Layer 2
/Openflow
Switch
STARLIGHT
The Optical STAR TAP
(Chicago)
Force10
E1200
i2cat
(Barcelona)
University of Amsterdam
(Amsterdam)
sara
(Amsterdam)
POZNAN
(Poznan)
(Brno)
Layer 2
Switch
NL Light
(Netherlands)
CESNET
(Czech Republic)
(Campinas)
renci
(North Carolina)
Calit2
(San Diego)
NCHC
(Taiwan)
PACIFIC
WAVE
evl
(Chicago)
NCSA
(Urbana-
Champaign)
University of Essex
(Colchester)
(Braunschweig)
CERN
(Geneva)
(Praha)
KISTI
(Daejeon,
South Korea)
GLORIAD
(Beijing, China)
SingAREN
(Singapore)
Openflow
High Performance Digital Media

Automated GOLE Worldwide Overview – Schematic



Automated GOLE Worldwide Overview



Contact Us

Joe Mambretti (iCAIR/NU)
Alan Verlo (EVL/UIC)
Linda Winkler (MCS/ANL)

‘710engineers (at) startap (dot) net’
www.startap.net/starlight