Software-Defined Network Exchanges (SDXs) and Software-Defined Infrastructure (SDI)

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)
Co-Director, StarLight, PI-iGENI, PI-OMNINet (www.startap.net/starlight)

Workshop on Prototyping and Deploying
Experimental Software Defined Exchanges (SDXs)

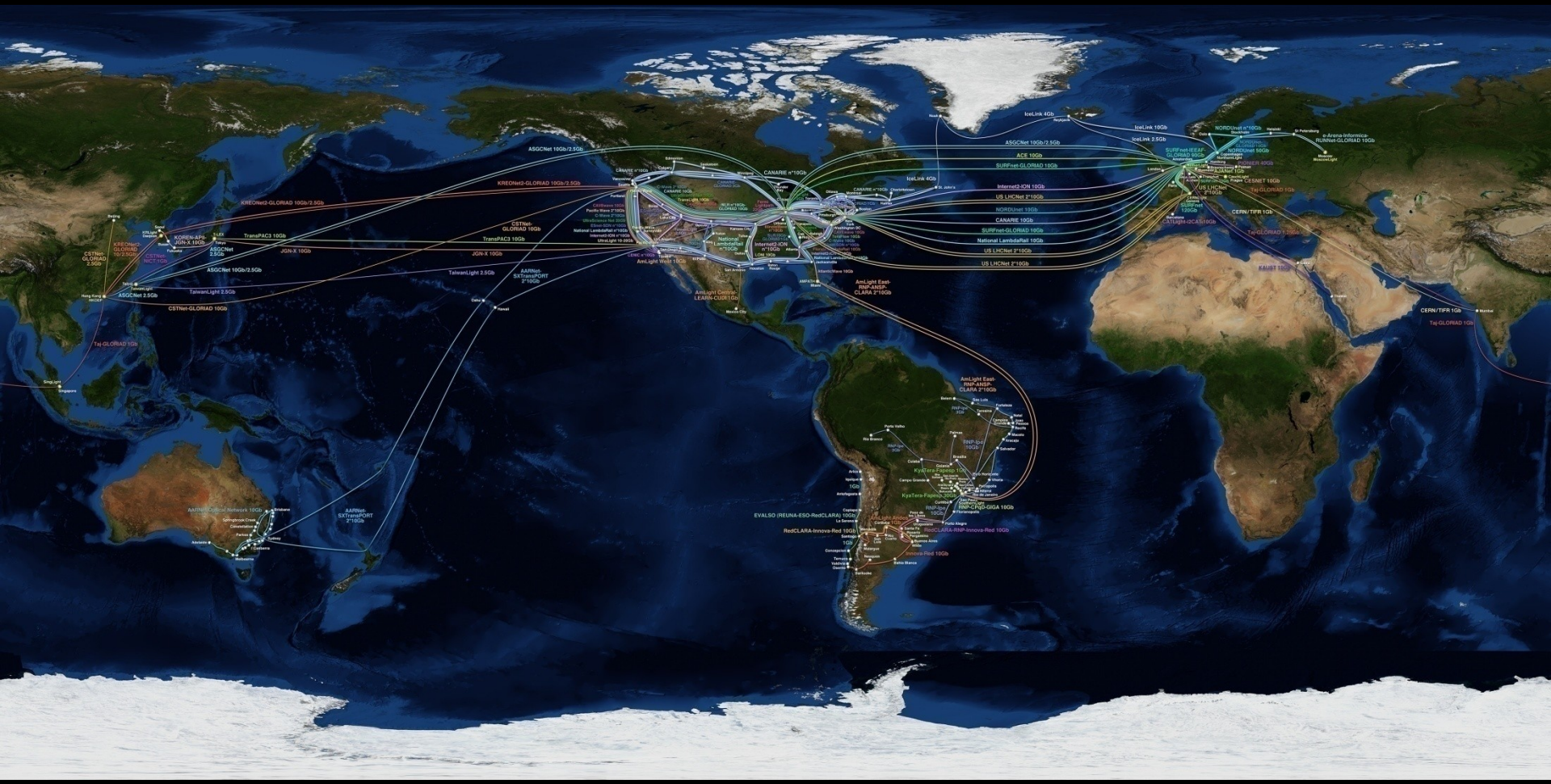
Washington DC

June 5-6, 2014

iCAIR

STARLIGHT℠

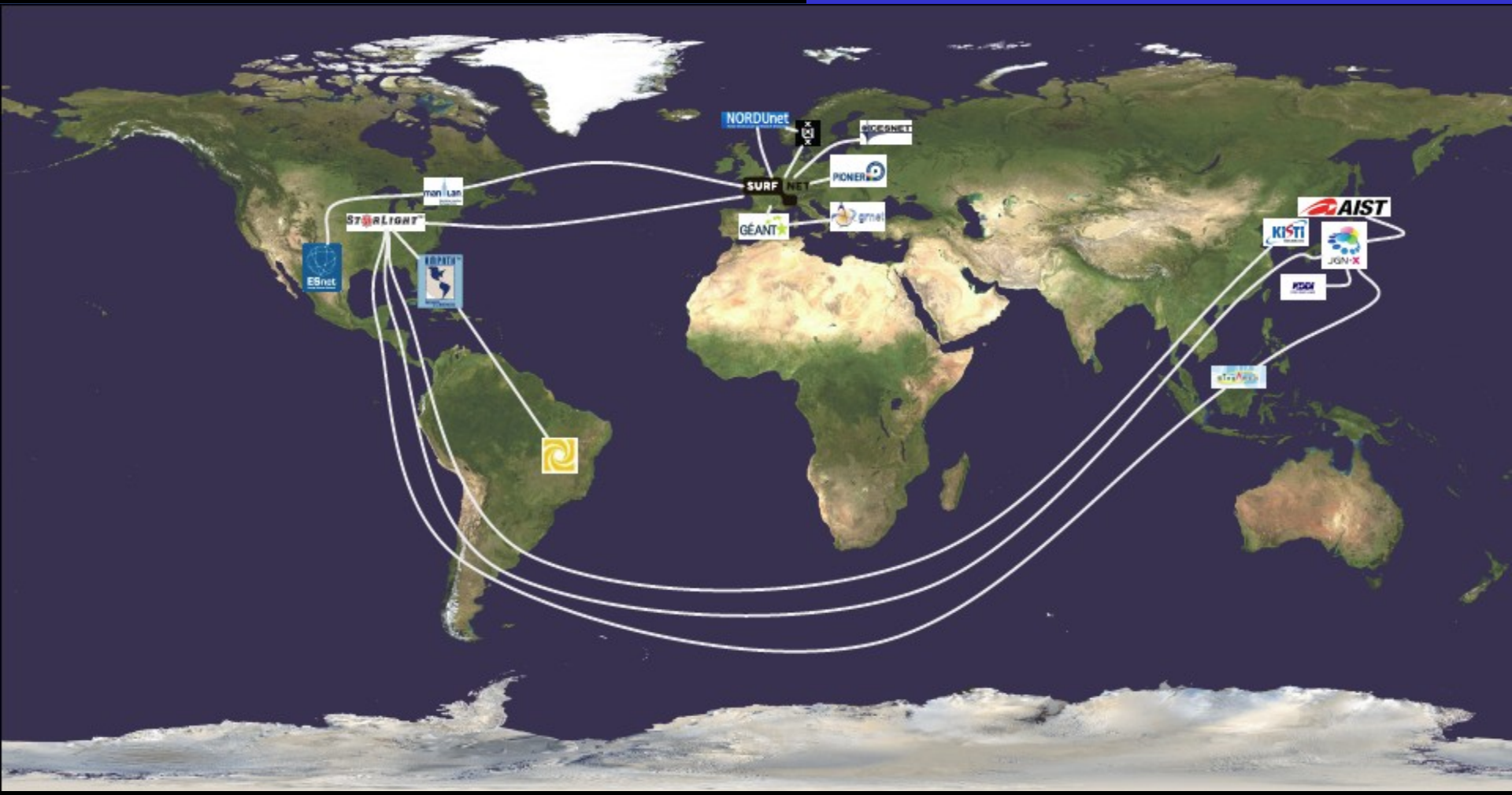
Next Generation SDXs and SDIs Must Be International -- The Global Lambda Integrated Facility



Automated GOLE Fabric

Source: GLIF Auto GOLE Group

GLIF AutoGOLE Initiative Oct 2013

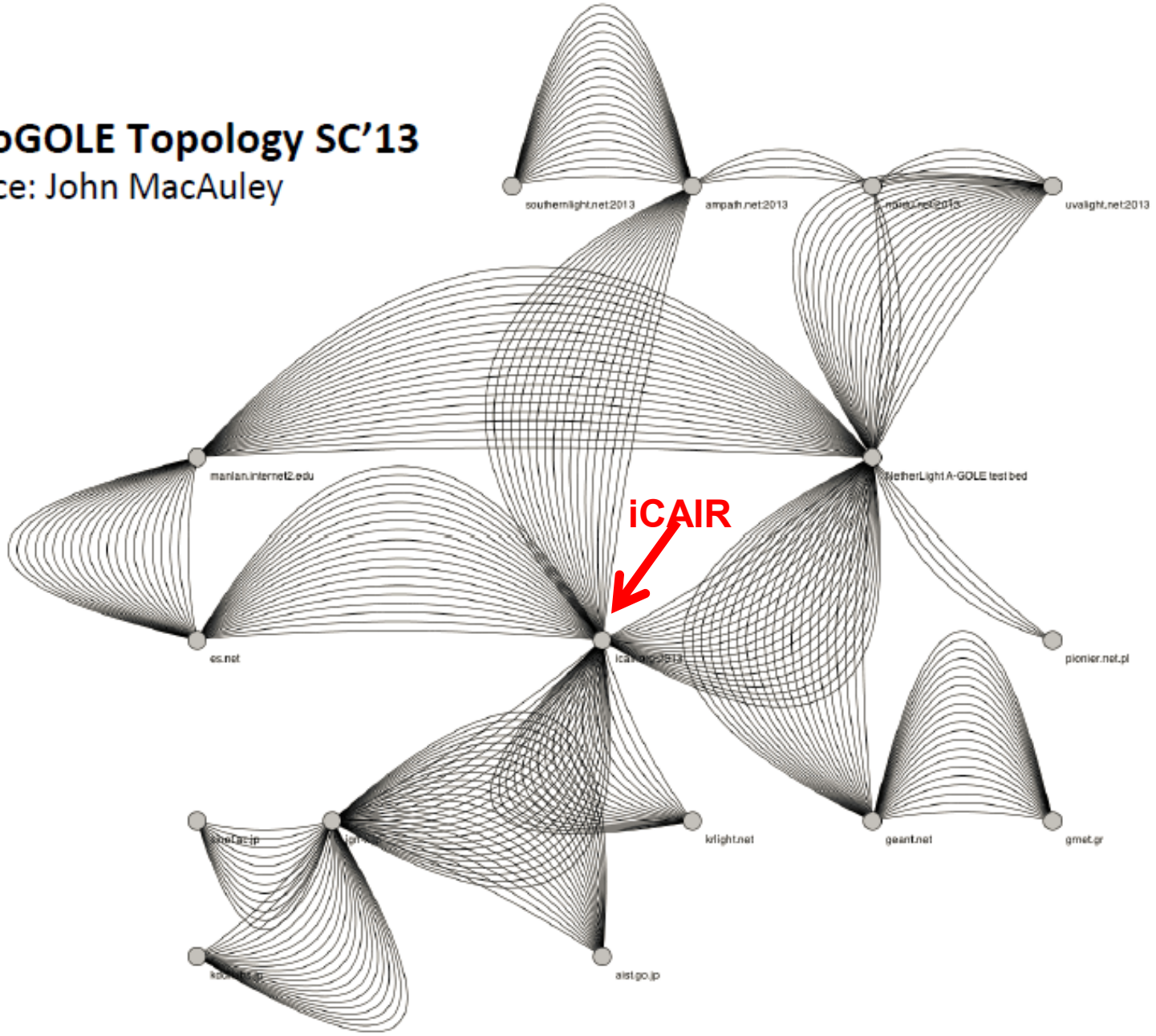


Source: GLIF Auto GOLE Group

STARLIGHT℠

AutoGOLE Topology SC'13

Source: John MacAuley

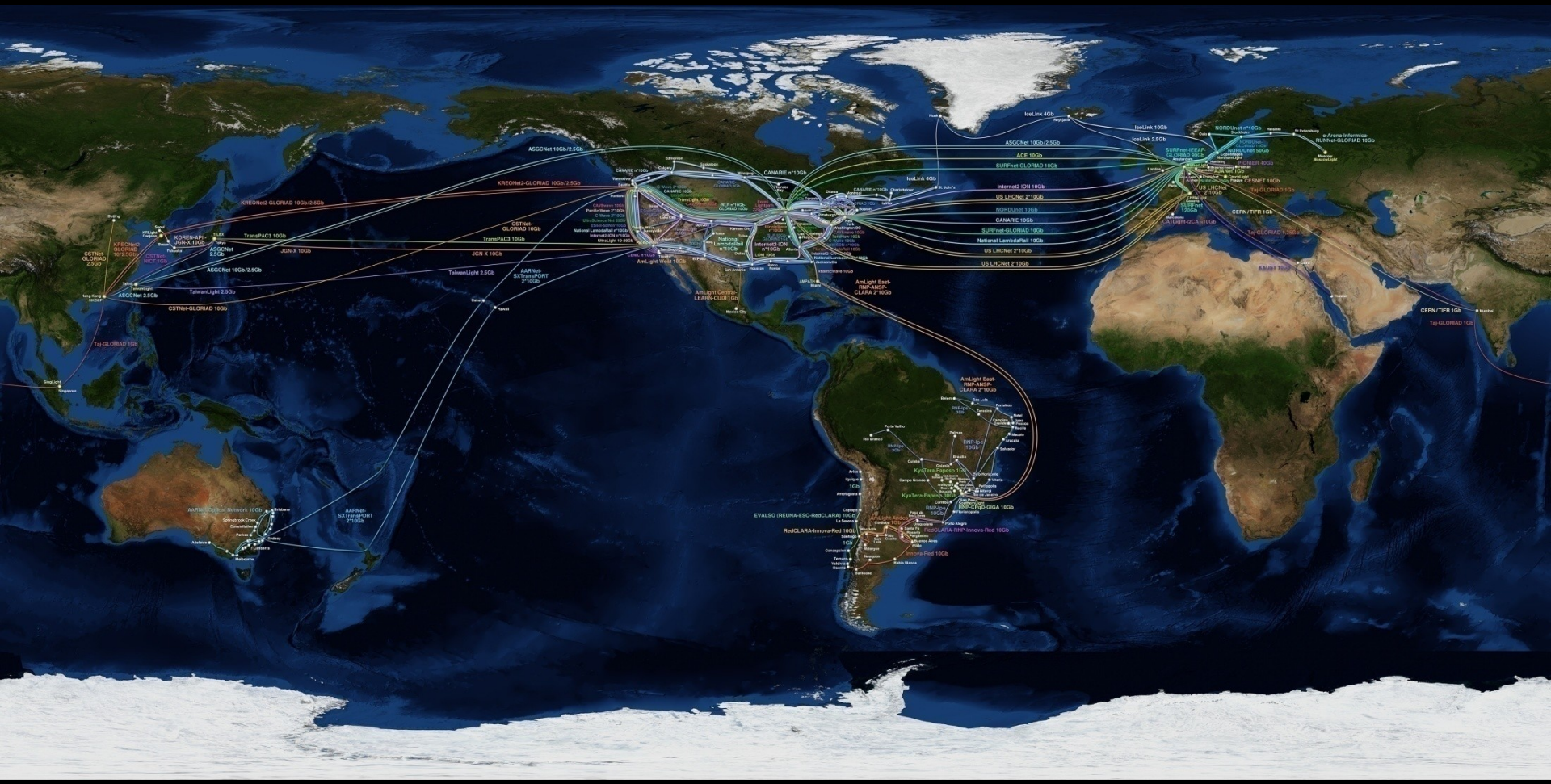


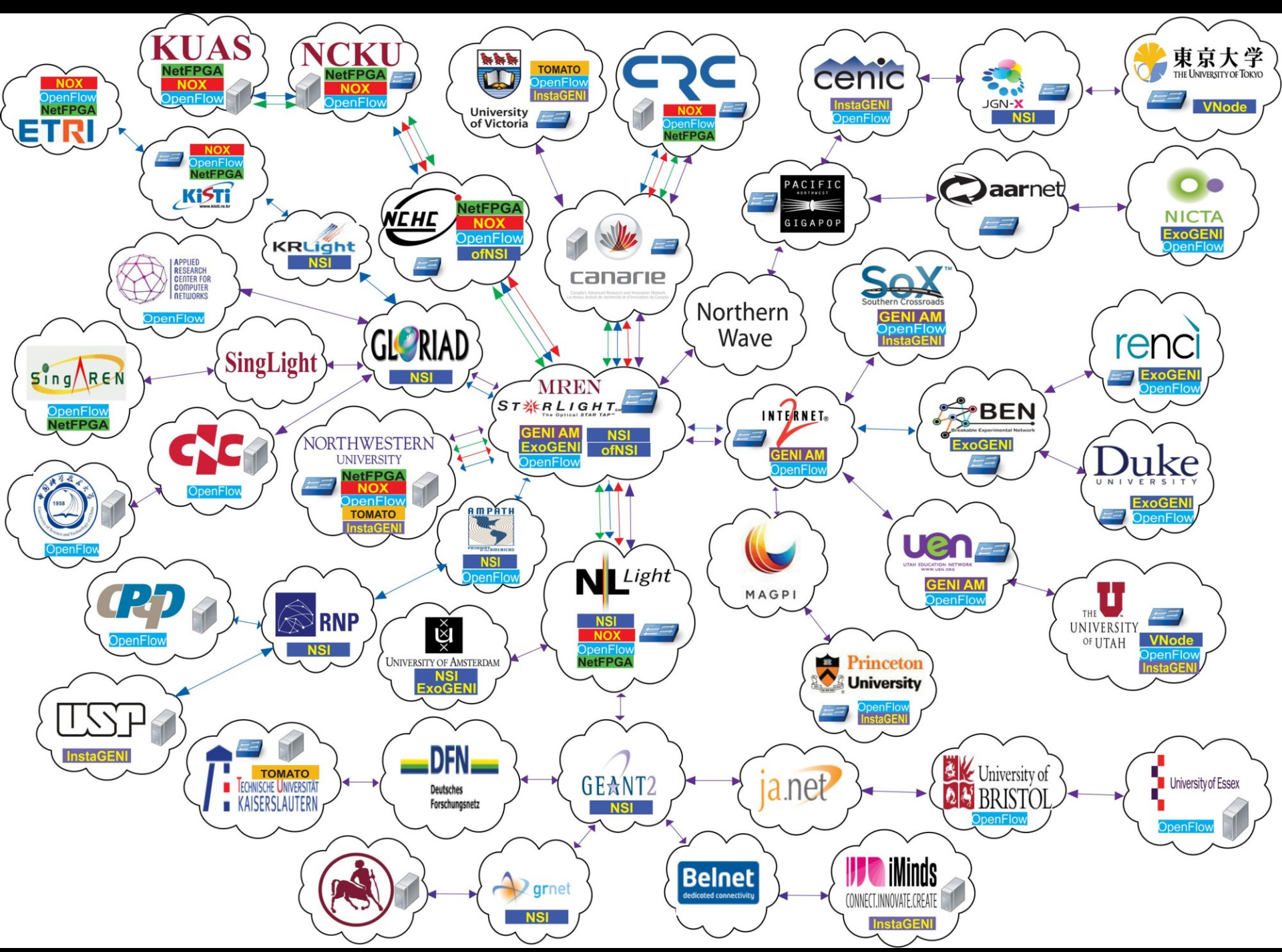
Tasks/Goals For 2014

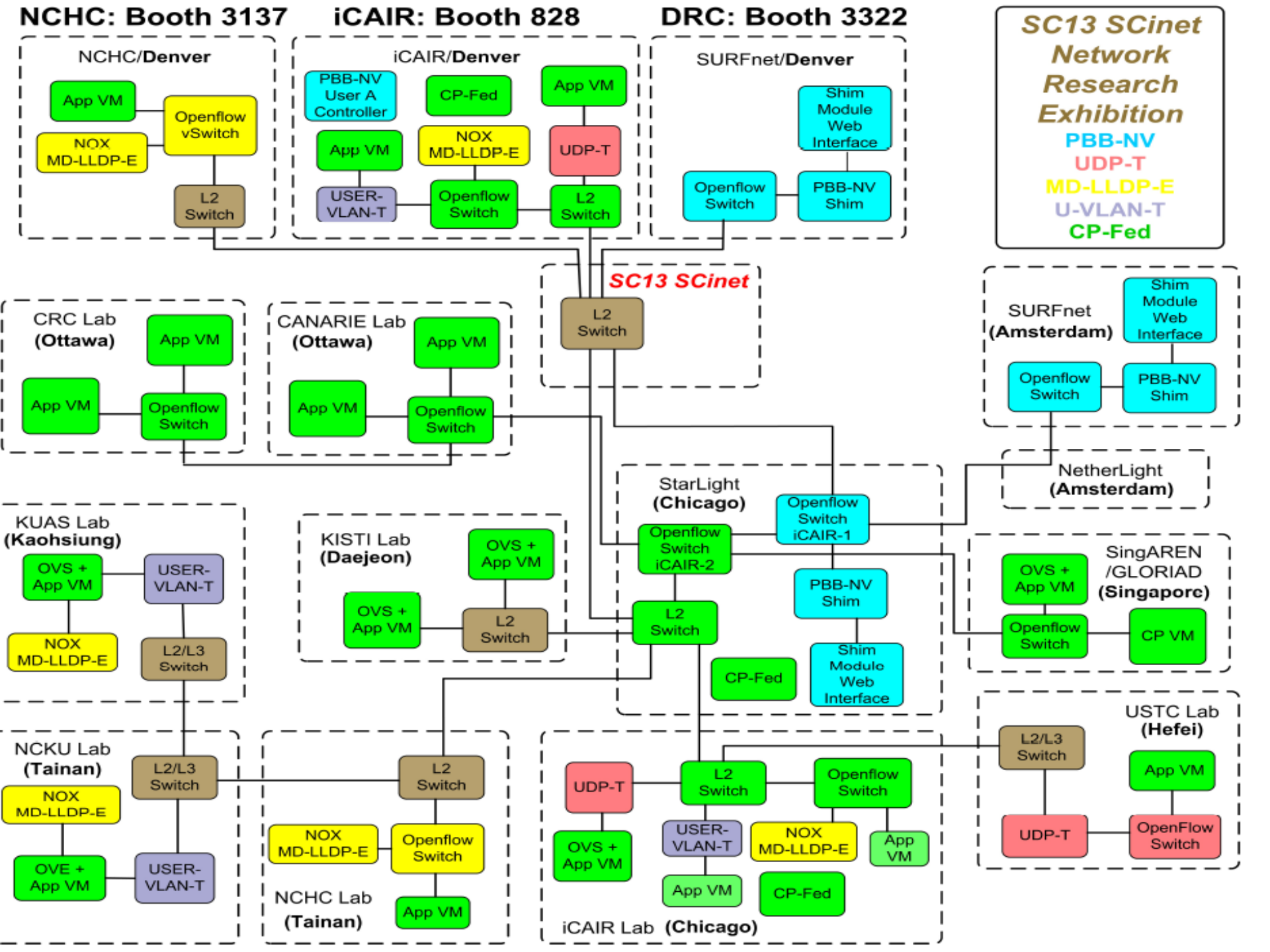
Work items 2014

Item	Description	Due	Leading organization
Authentication / Authorization	Creating a AAI framework that allows secure setup of services	TNC2014	SURFnet (Hans Trompert)
Topology Exchange	Creating a mechanism that exchanges topology descriptions of GOLEs automatically	SC'14	ESnet, UvA (Chin Guok, Miroslav Zivkovic)
Retagging capabilities	Describing what's necessary to implement retagging capabilities inside the AutoGOLE fabric – also creating a plan for implementing	SC'14	Group effort
SDN/OpenFlow inside the AutoGOLE	It's foreseen that AutoGOLE NRMs could be talking OpenFlow to actual hardware. This item results in deployment of an OpenFLow controller speaking NSIv2 inside the AutoGOLE	Q4	iCAIR (Jim Chen, Joe Mambretti)
Operational items	Creating concepts on strengthening operations, implementing these	Q4	Tangui Coulouarn to look for someone to lead (uniform) perational issues

The iGENI Consortium Uses The Global Lambda Integrated Facility




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


NCHC: Booth 3137
iCAIR: Booth 828
DRC: Booth 3322
SC13 SCinet Network Research Exhibition
PBB-NV
UDP-T
MD-LLDP-E
U-VLAN-T
CP-Fed
NCHC/Denver
App VM
Openflow vSwitch
NOX MD-LLDP-E
L2 Switch
iCAIR/Denver
PBB-NV User A Controller
CP-Fed
App VM
NOX MD-LLDP-E
UDP-T
USER-VLAN-T
Openflow Switch
L2 Switch
SURFnet/Denver
Shim Module Web Interface
Openflow Switch
PBB-NV Shim
SC13 SCinet
L2 Switch
CRC Lab (Ottawa)
App VM
Openflow Switch
CANARIE Lab (Ottawa)
App VM
Openflow Switch
SURFnet (Amsterdam)
Shim Module Web Interface
Openflow Switch
PBB-NV Shim
NetherLight (Amsterdam)
StarLight (Chicago)
Openflow Switch iCAIR-2
Openflow Switch iCAIR-1
PBB-NV Shim
L2 Switch
CP-Fed
Shim Module Web Interface
KUAS Lab (Kaohsiung)
OVS + App VM
USER-VLAN-T
NOX MD-LLDP-E
L2/L3 Switch
KISTI Lab (Daejeon)
OVS + App VM
OVS + App VM
L2 Switch
SingAREN /GLORIAD (Singapore)
OVS + App VM
Openflow Switch
CP VM
USTC Lab (Hefei)
L2/L3 Switch
App VM
UDP-T
OpenFlow Switch
NCKU Lab (Tainan)
L2/L3 Switch
NOX MD-LLDP-E
OVE + App VM
USER-VLAN-T
L2 Switch
NOX MD-LLDP-E
Openflow Switch
App VM
NCHC Lab (Tainan)
UDP-T
L2 Switch
Openflow Switch
OVS + App VM
USER-VLAN-T
NOX MD-LLDP-E
App VM
App VM
CP-Fed
iCAIR Lab (Chicago)

Software Defined Networking Exchanges (SDXs)

- With the Increasing Deployment of SDN In Production Networks, the Need for an SDN Exchange (SDX) Has Been Recognized.
- Current SDN Architecture Is Single Domain Centralized Controller Oriented
- Required Capabilities for Multi-Domain Distributed SDN Resource Discovery, Signaling Provisioning, Operations, and Fault Detection and Recovery Are Fairly Challenging.
- Nonetheless – Many Motivations Exist for SDXs

GriPhyN
Data Intensive Science

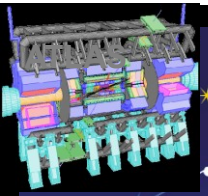
NEPTUNE
A Fiber-Optic Telescope to Inner Space

NEES

GENOMES to LIFE
BIOLOGICAL SOLUTIONS FOR ENERGY CHALLENGES
U.S. DEPARTMENT OF ENERGY

NG Digital Sky Survey

NEON
National Ecological Observatory Network

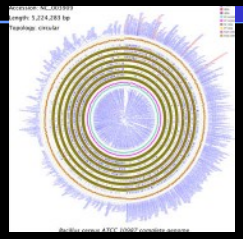


ALMA: Atacama Large Millimeter Array

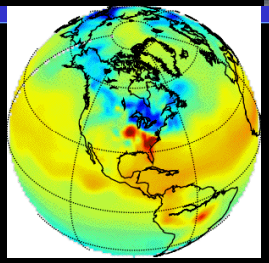
ANDRILL: Antarctic Geological Drilling
www.andrill.org

BIRN

BIRN: Biomedical Informatics Research Network
www.nbirn.net



CAMERA metagenomics
camera.calit2.net

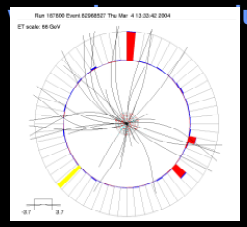


Carbon Tracker
www.esrl.noaa.gov/gmd/ccgg/carbontracker

CineGrid™

CineGrid
www.cinegrid.org

LHCONE
www.lhcone.net



DØ (DZero)
www-d0.fnal.gov

GEON

GEON: Geosciences Network
www.geongrid.org

GLEON: Global Lake Ecological Observatory Network

OOI
OCEAN OBSERVATORIES INITIATIVE
CYBERINFRASTRUCTURE
Providing a link between ocean research and discovery

OOI-CI
ci.oceanobservatories.org

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

CLASS

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

LIGO
www.ligo.org

PRAGMA

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

WLCG
Worldwide LHC Computing Grid

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

TeraGrid™

TeraGrid
www.teragrid.org

IVOA

IVOA: International Virtual Observatory
www.ivoa.net

Open Science Grid

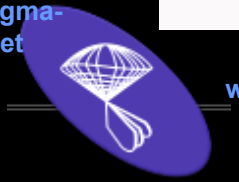
OSG
www.opensciencegrid.org

the globus alliance

Globus Alliance
www.globus.org

SKA
SQUARE KILOMETRE ARRAY

SKA
www.skatelescope.org



Sloan Digital Sky Survey
www.sdss.org

XSEDE

XSEDE
www.xsede.org

Compilation By Maxine Brown

STARLIGHT℠

Software Defined Networking Exchanges (SDXs)

- Today, No Production SDX Exists.
- However, Currently the International Center for Advanced Internet Research (iCAIR) and Its Research Partners Are Designing and Implementing a Prototype SDX at the StarLight International/National Communications Exchange Facility
- Georgia Tech and SOX Are Prototyping a SDX In Atlanta
- Progressing With Support from the National Science Foundation's Global Environment for Network Innovations (GENI) Program/GENI Program Office (GPO).
- The StarLight SDX Is a Multi-Domain Service Enabling Federated Controllers To Exchange Signaling and Provisioning Information.

STARLIGHT℠

Selected SDX Architectural Attributes

- Control and Network Resource APIs
- Multi Domain Integrated Path Controller
- Controller Signaling, Including Edge Signaling
- SDN/OF Multi Layer Traffic Exchange
- Multi Domain Resource Advertisement/Discovery
- Topology Exchange
- Multiple Service Levels At All Layers
- Granulated Resource Access (Policy Based), Including Through Edge Processes
- Foundation Resource Programmability
- Various Types of Gateways To Other Network Environments
- Integration of OF and Non-OF Paths, Including 3rd Party Integration
- Programmability for Large Scale Large Capacity Streams

StarLight – "By Researchers For Researchers"

StarLight is an experimental optical infrastructure and proving ground for network services optimized for high-performance applications

Multiple 10GE+100 Gbps StarWave

Multiple 10GEs Over Optics – World's "Largest" 10G/100G Exchange

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

View from StarLight

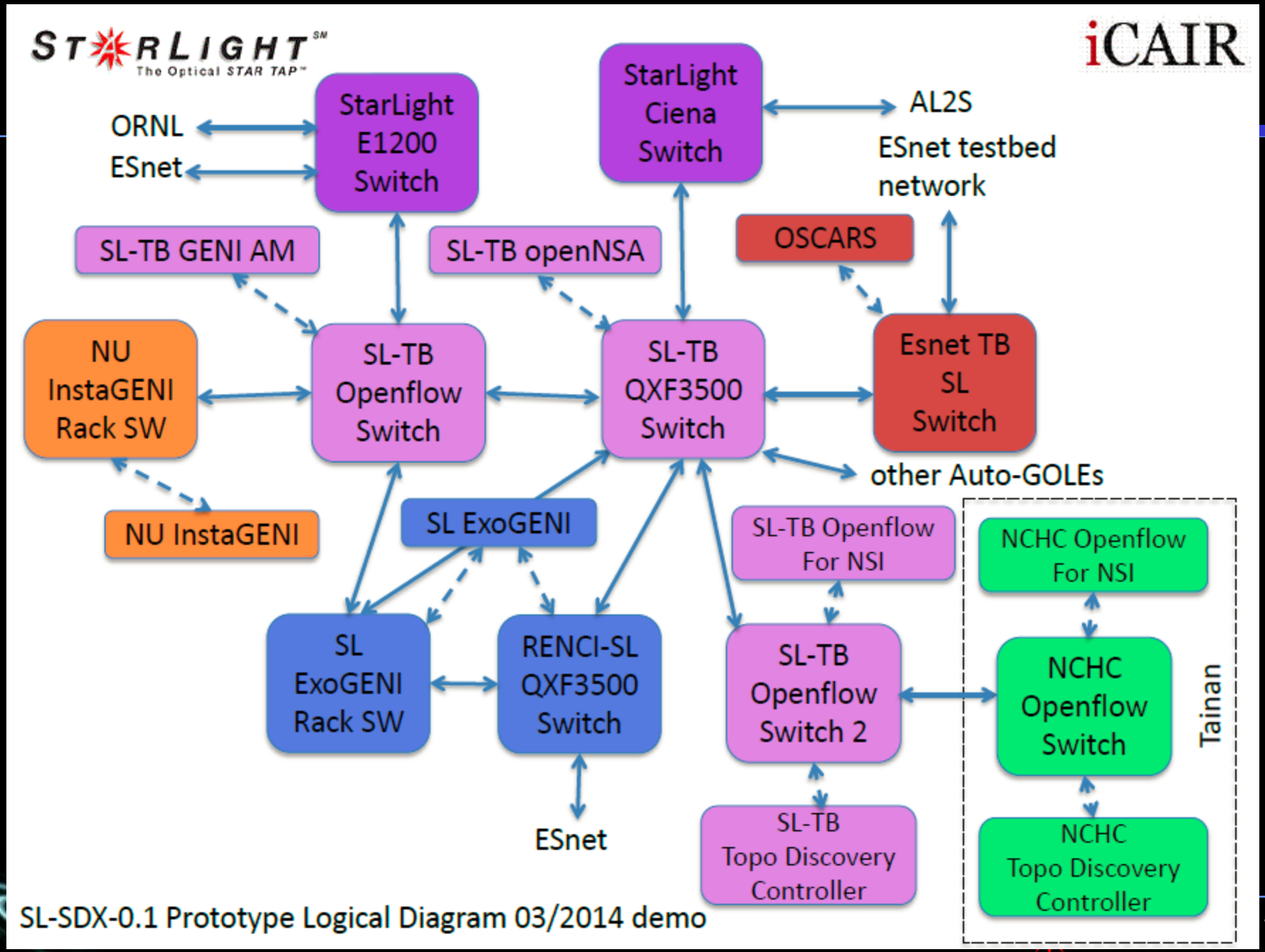
Abbott Hall, Northwestern University's Chicago Campus

iCAIR

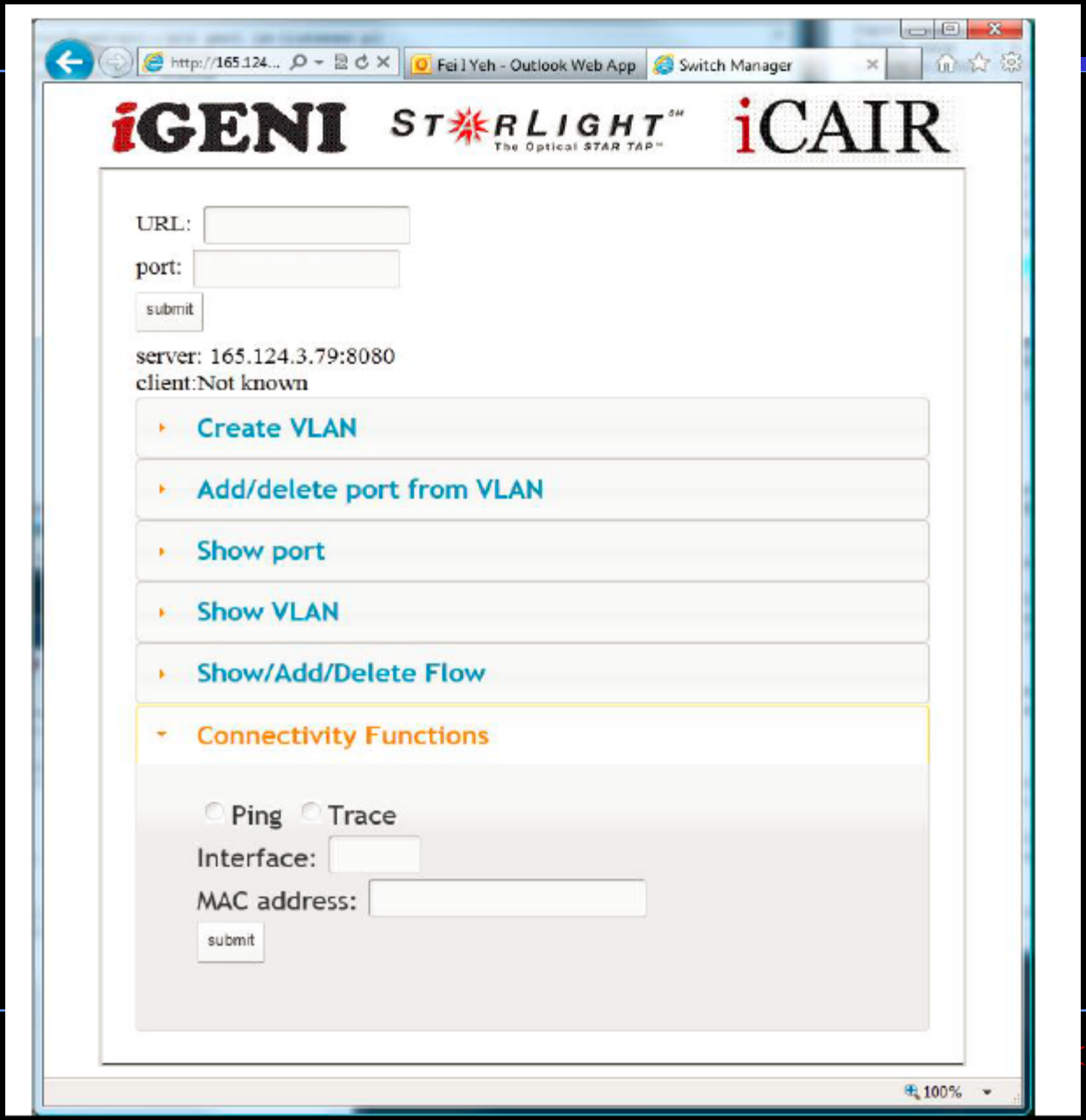
STARLIGHT℠

SDX As A Large Scale Virtual Switch

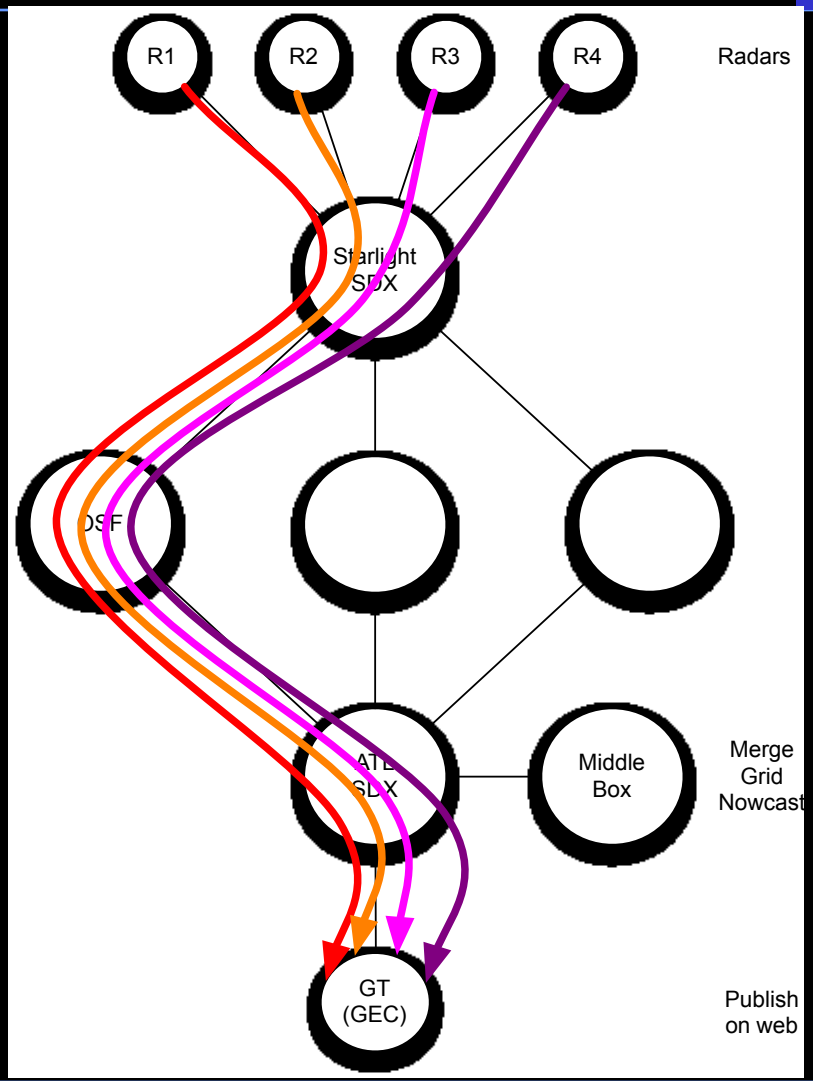
- Ultra Large Scale Virtual Switch Comprised of Resources That Can Be Partitioned For Use by External Controllers Within Other Domains
- Foundation = Actual SDN/OpenFlow Switches
- Resources Appear As Components That Are Extensions Of Those External Domains
- Architectural Design Intended To Remove Middle Processes Between Domains
- Federation Policies and Processes Are Key

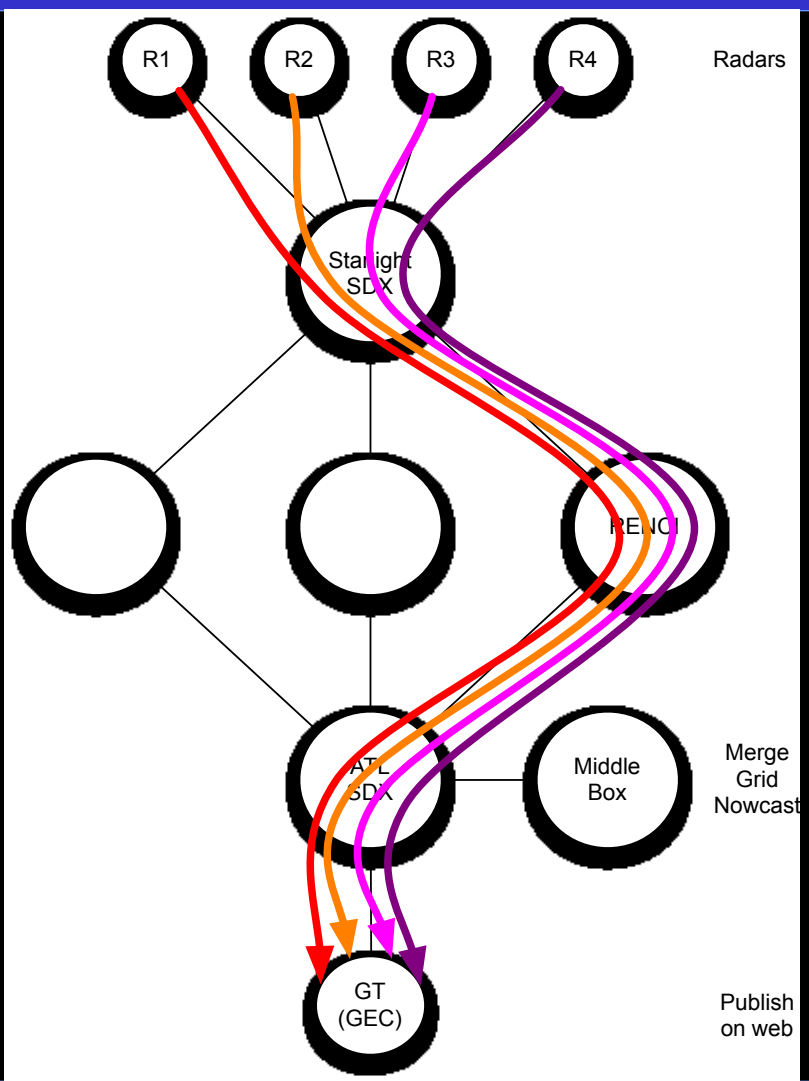

STARLIGHT
The Optical STAR TAP
iCAIR
ORNL
ESnet
StarLight E1200 Switch
StarLight Ciena Switch
AL2S
ESnet testbed network
SL-TB GENI AM
SL-TB openNSA
OSCARS
NU InstaGENI Rack SW
SL-TB Openflow Switch
SL-TB QXF3500 Switch
Esnet TB SL Switch
other Auto-GOLEs
NU InstaGENI
SL ExoGENI
SL-TB Openflow For NSI
NCHC Openflow For NSI
SL ExoGENI Rack SW
RENCI-SL QXF3500 Switch
SL-TB Openflow Switch 2
NCHC Openflow Switch
Tainan
ESnet
SL-TB Topo Discovery Controller
NCHC Topo Discovery Controller
SL-SDX-0.1 Prototype Logical Diagram 03/2014 demo

Multi-Domain Provisioning Tool



GENI SDX Demo Scenario 1: Mike Zink's Nowcast



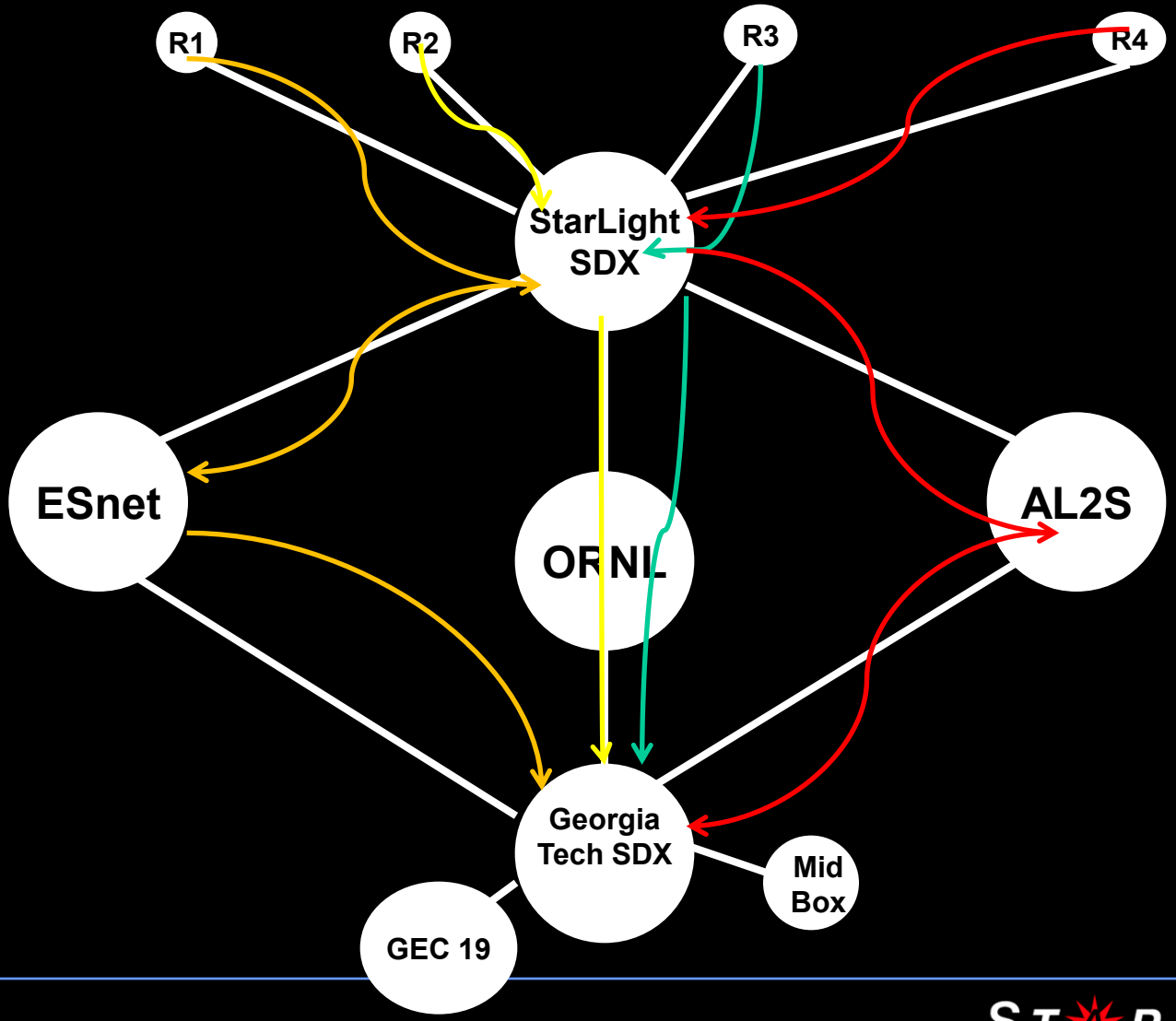


Slide by Mike Zink, UMass Amherst

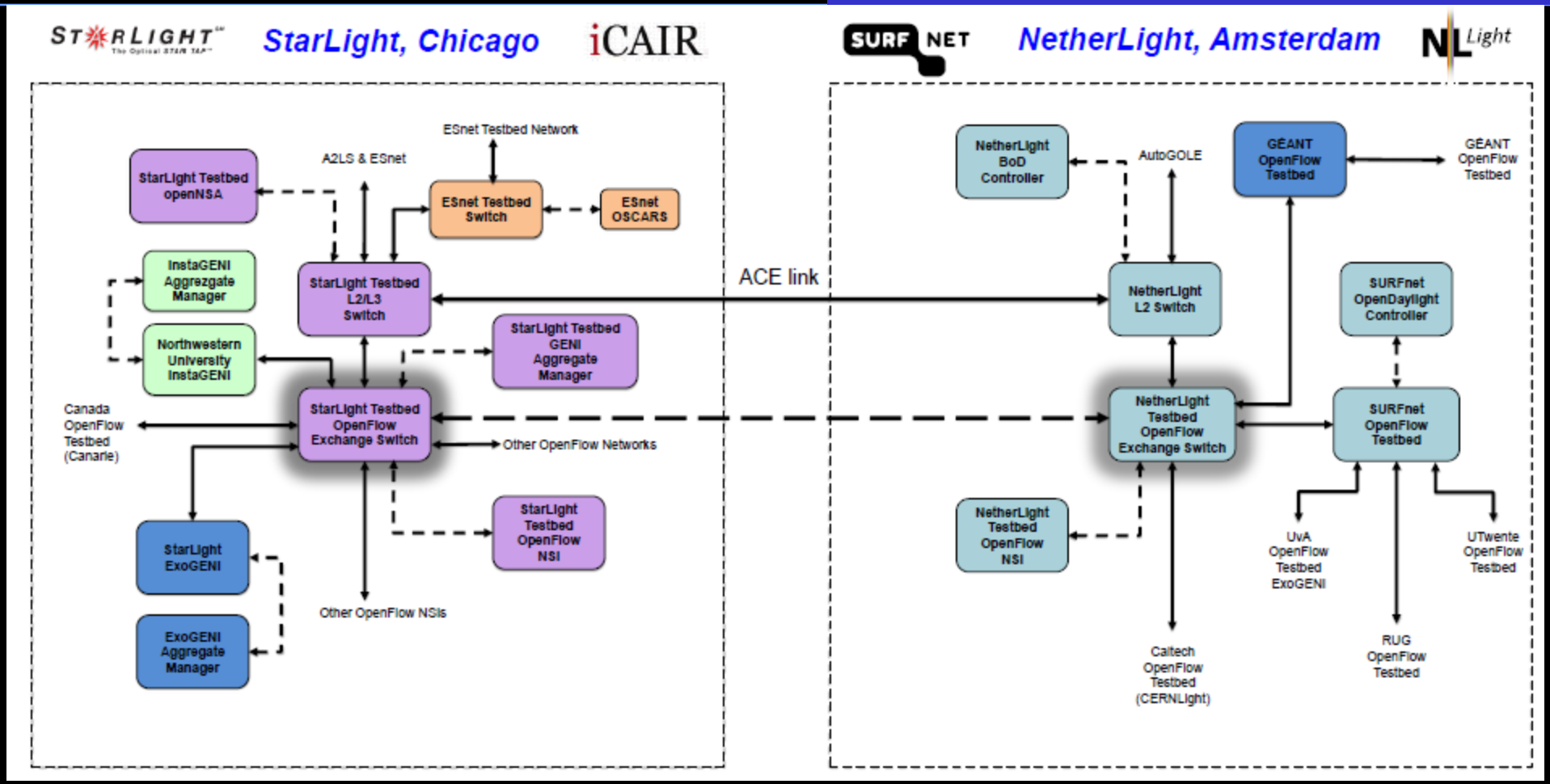
STARLIGHT℠

GENI SDX Demo Scenario 2: Mike Zink's Nowcast

Simulated Radar (4)



SDX StarLight⇔NetherLight



Ronald van der Pol, Joe Mambretti, Jim Chen, John Shillington

STARLIGHT SM

Software Defined Infrastructure (SDI)

- Extensions of Architecture, Techniques Technologies To Other Resources
- Already Being Developed By Many Communities
- Computational Grids
- High Performance Computational Clouds
- Highly Virtualized Storage
- Distributed Sensor Networks
- Virtualized Large Scale Instruments
- Specialized Distributed Environments

Forthcoming StarLight SDX Presentations and Demonstrations

- GEC 20, Davis California
- Global LambdaGrid Workshop (GLIF), Queenstown New Zealand (Joint Project With REANNZ, StarLight, CANARIE, SURFnet, Google, etc)
- GEC 21, Indianapolis Indiana
- SC14, New Orleans
- etc

www.startap.net/starlight