

International Optical SDN Across the Globe And Software-Defined Network Exchanges (SDXs)

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Northwestern University

Director, Metropolitan Research and Education Network (www.mren.org)

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

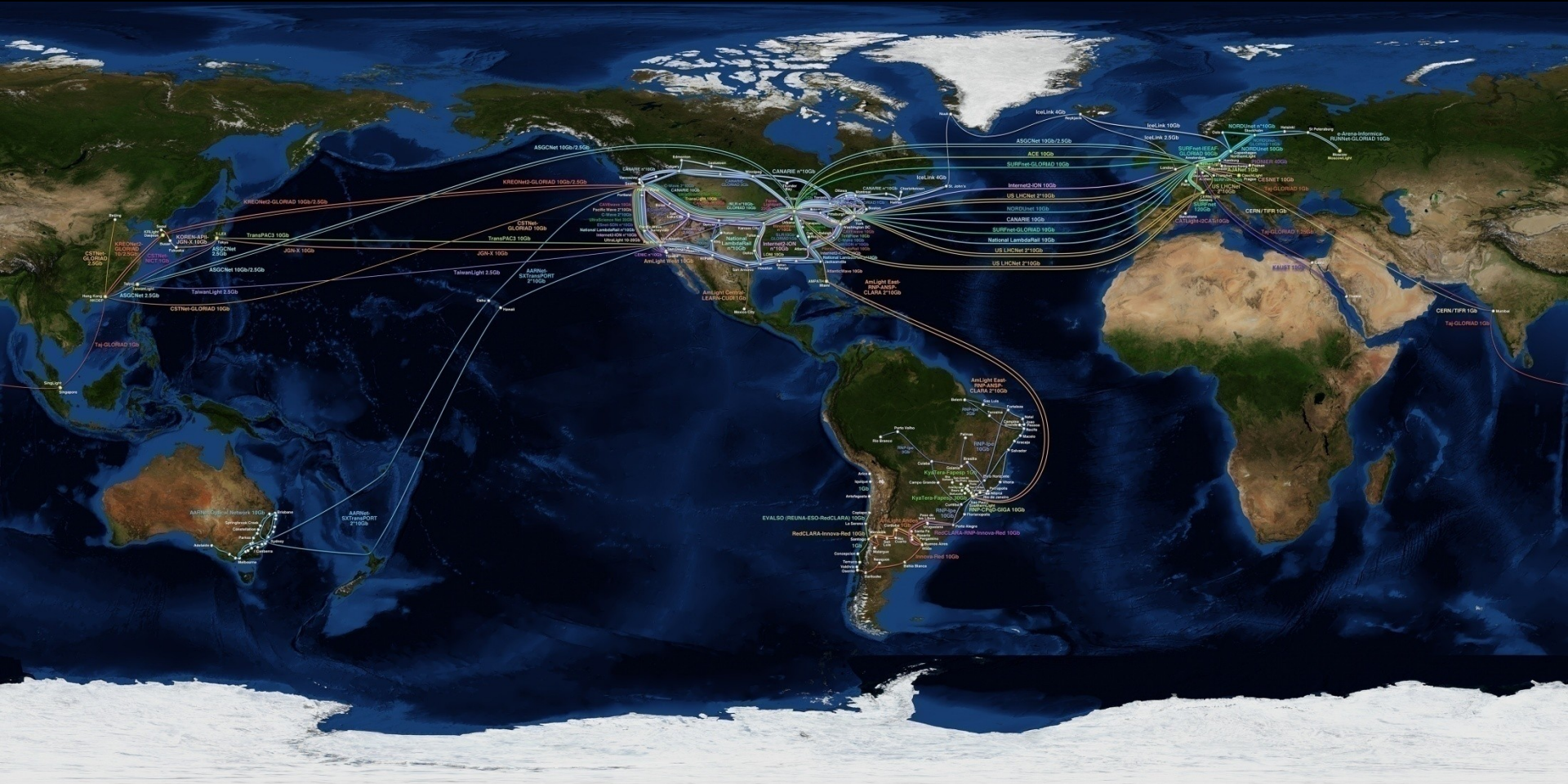
Optical Software Defined Networking Workshop

Davis, California

June 22, 2014



Programmable Lightpaths -- The Global Lambda Integrated Facility

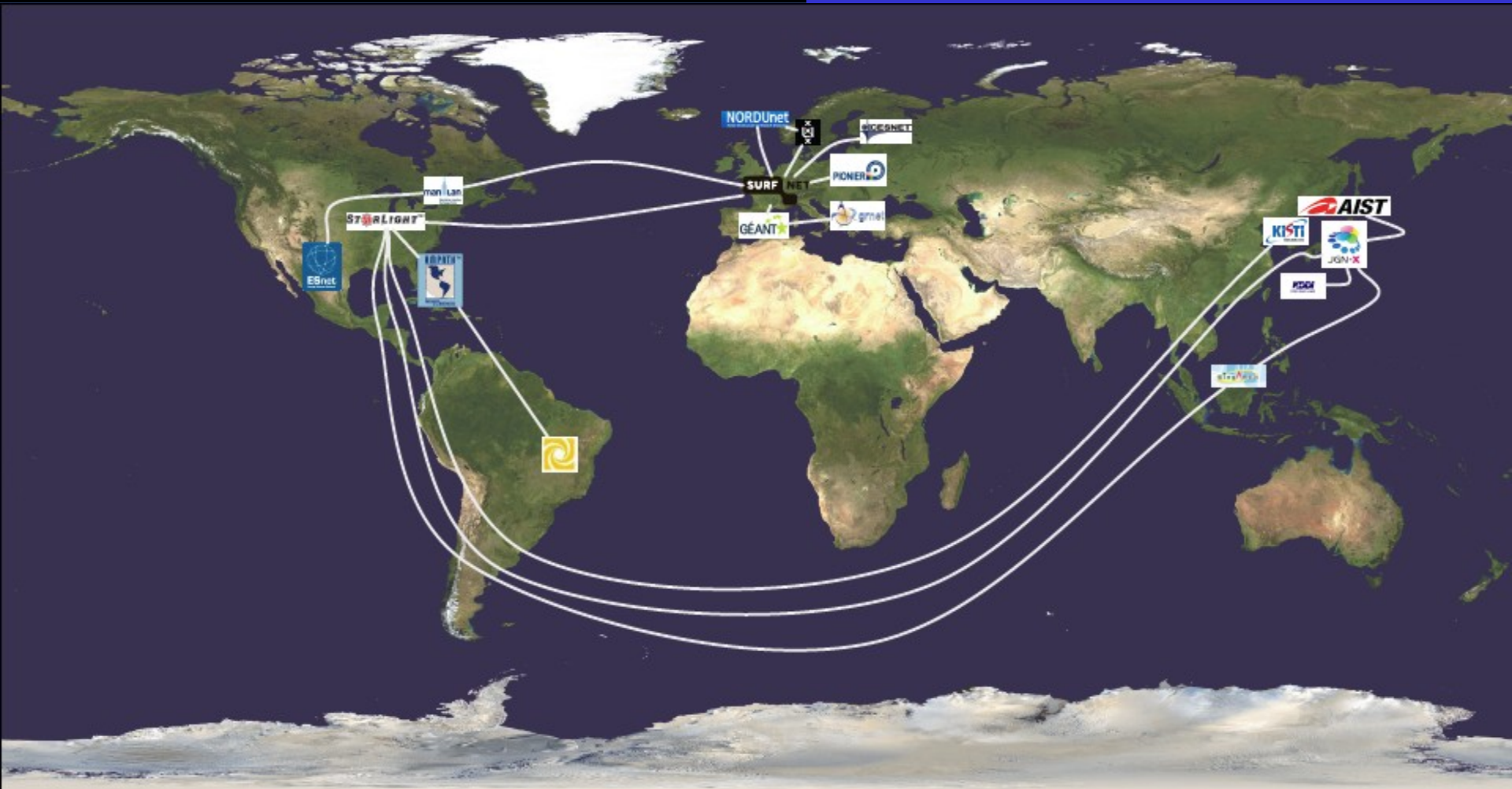


Automated GOLE Fabric



Source: GLIF Auto GOLE Group

GLIF AutoGOLE Initiative Oct 2013

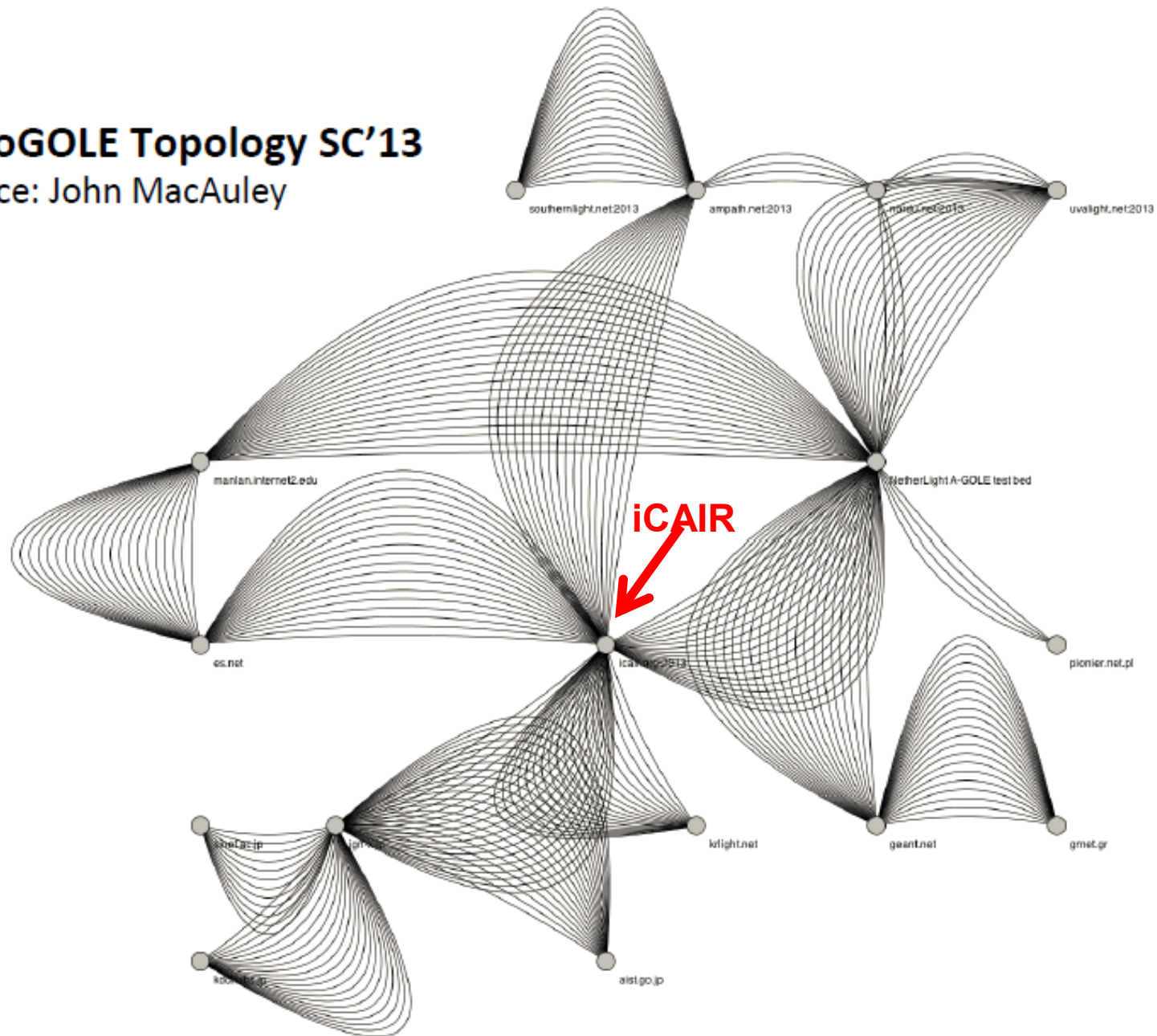


Source: GLIF Auto GOLE Group

STARLIGHTSM

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	Tanguir Courouarn to look for someone to lead (uniform) perational issues

The iGENI Consortium Uses The Global Lambda Integrated Facility





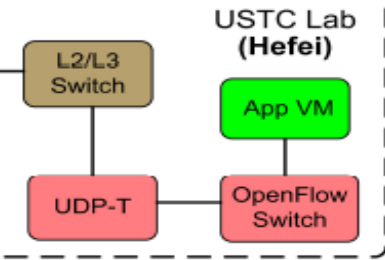
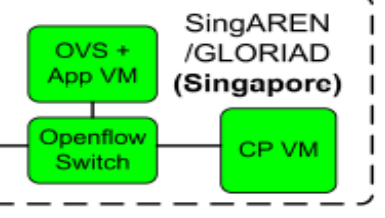
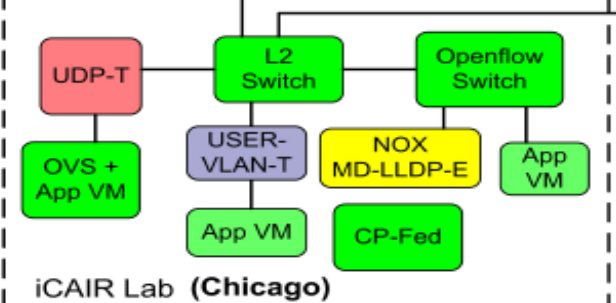
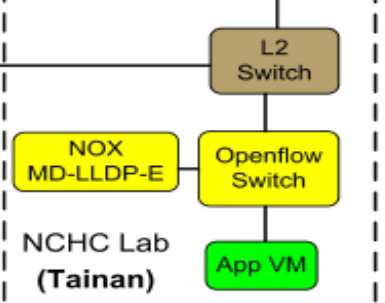
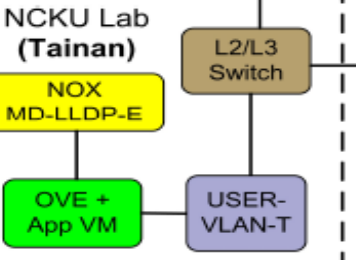
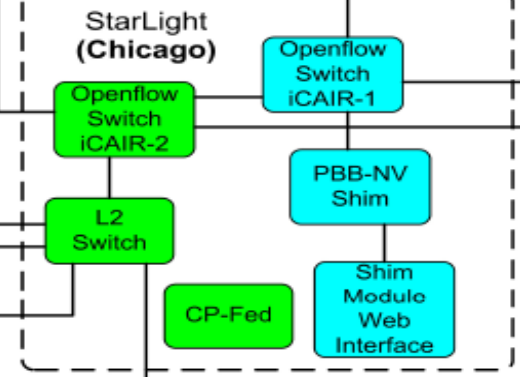
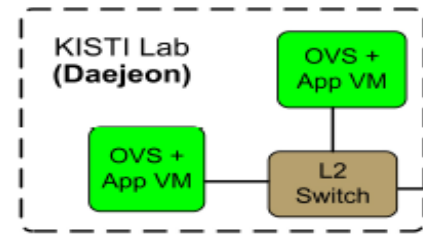
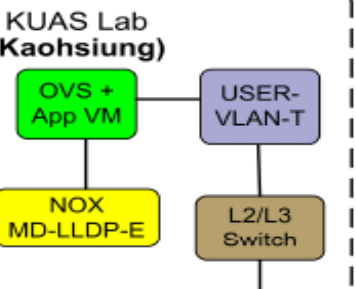
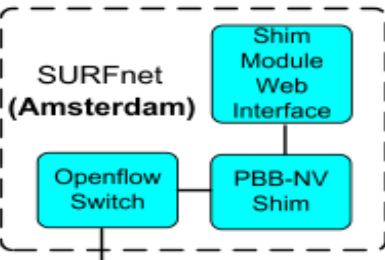
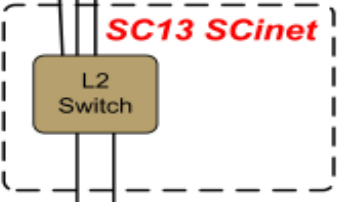
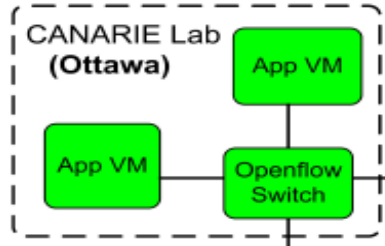
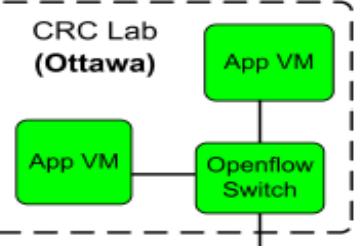
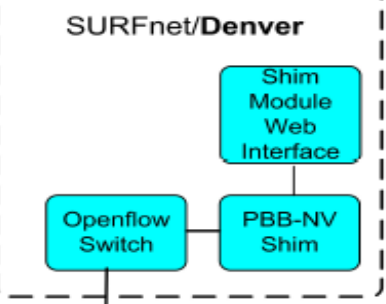
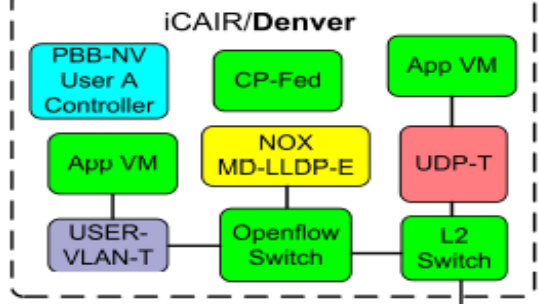
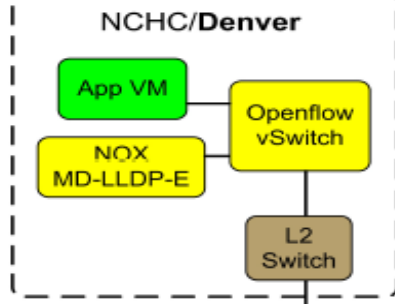
NCHC: Booth 3137

iCAIR: Booth 828

DRC: Booth 3322

SC13 SCinet
Network
Research
Exhibition

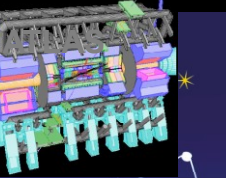
PBB-NV
 UDP-T
 MD-LLDP-E
 U-VLAN-T
 CP-Fed



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**

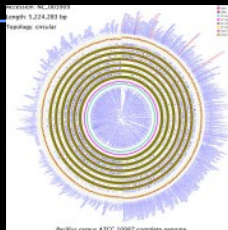




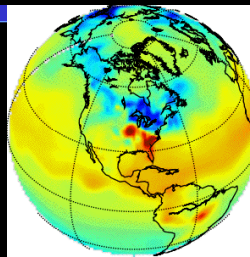
ANDRILL: Antarctic Geological Drilling
www.andrill.org



BIRN: Biomedical Informatics Research Network
www.nbirn.net



CAMERA metagenomics
camera.calit2.net



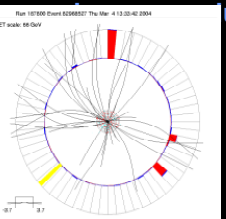
Carbon Tracker
www.esrl.noaa.gov/gmd/ccgg/carbontrack



CineGrid
www.cinegrid.org



LHCONE
www.lhccone.net



DØ (DZero)
www-d0.fnal.gov



GEON: Geosciences Network
www.geongrid.org



GLEON: Global Lake Ecological Observatory Network



OOI-CI
ci.oceanobservatories.org



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



CLASS
www.class.noaa.gov



IVOA: International Virtual Observatory
www.ivoa.net



LIGO
www.ligo.org



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



PRAGMA
www.pragma-grid.net



TeraGrid
www.teragrid.org



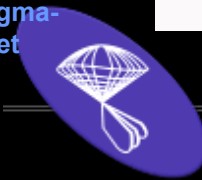
OSG
www.opensciencegrid.org



Globus Alliance
www.globus.org



SKA
www.skatelescope.org



Sloan Digital Sky Survey
www.sdss.org



XSEDE
www.xsede.org



Compilation By Maxine Brown

STARLIGHTSM

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.**

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



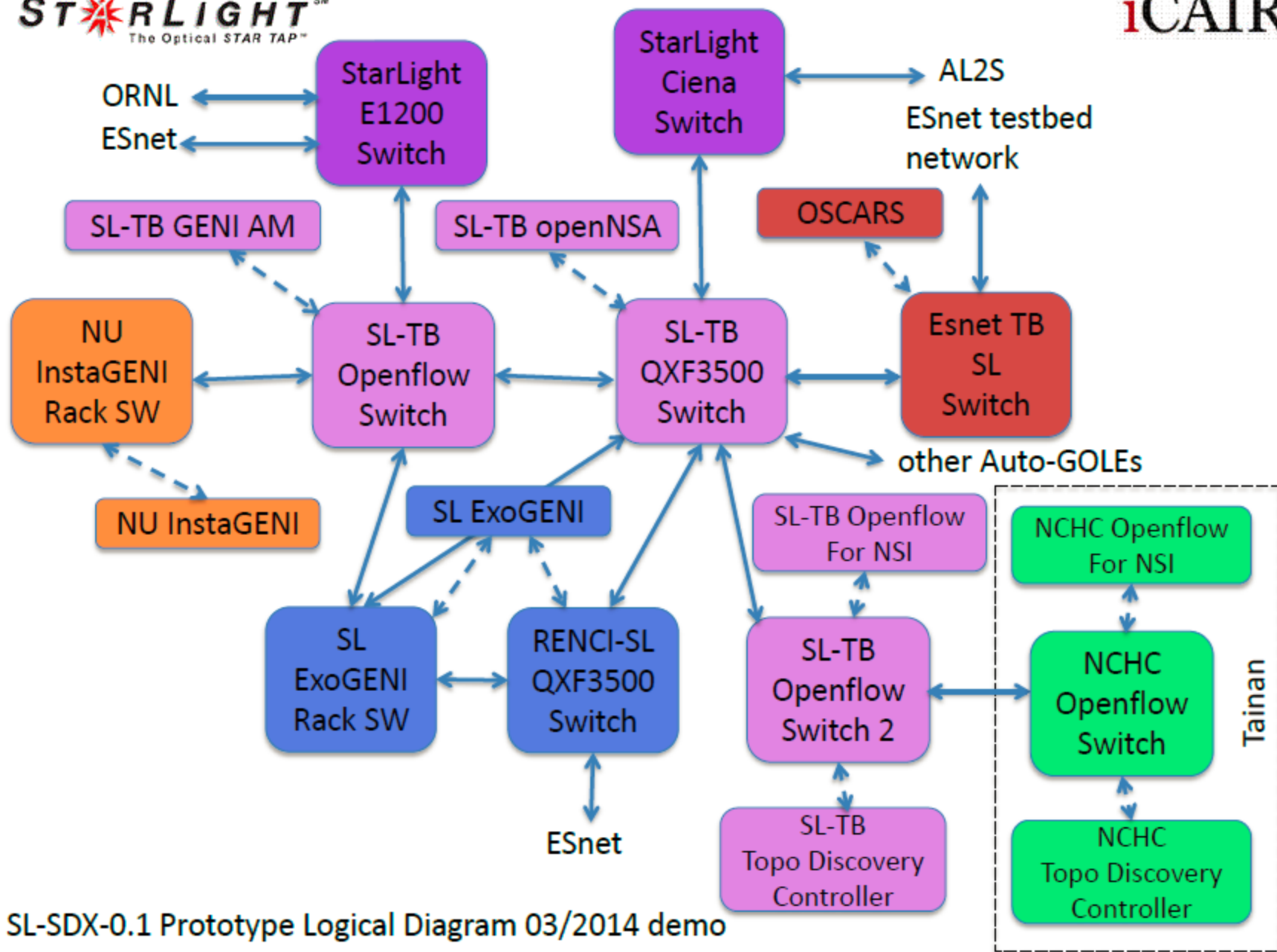
Abbott Hall, Northwestern University's Chicago Campus



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**





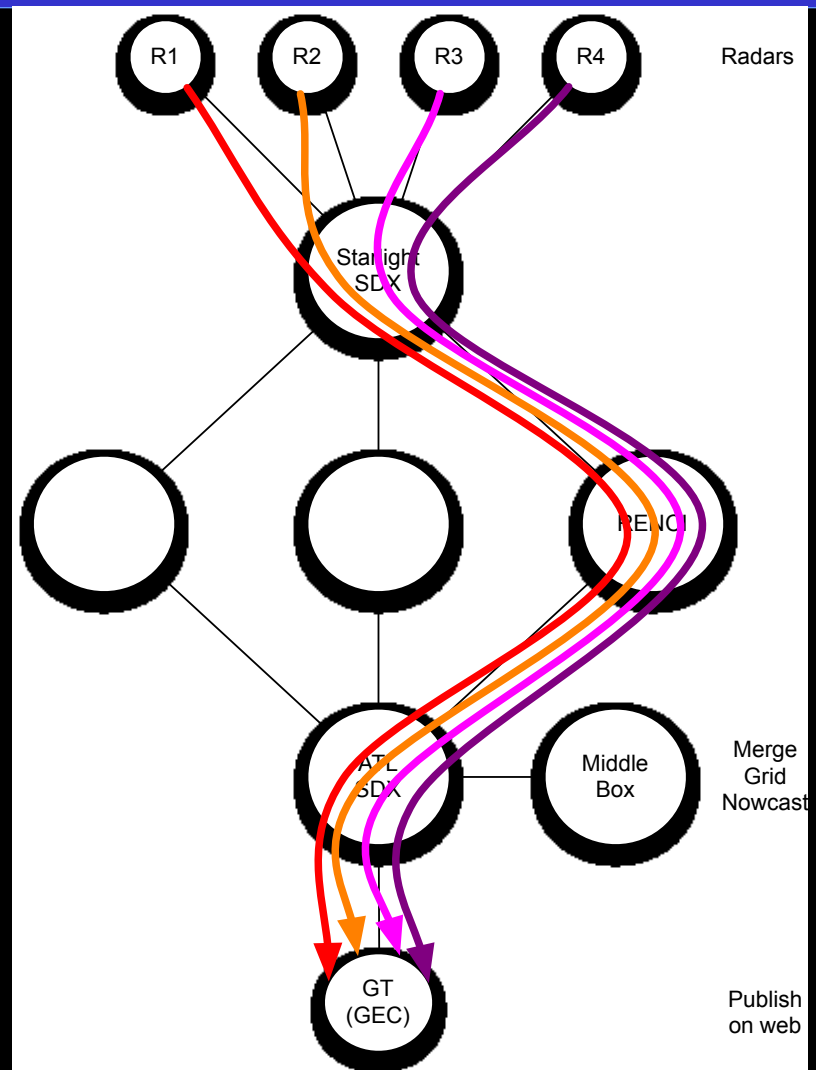
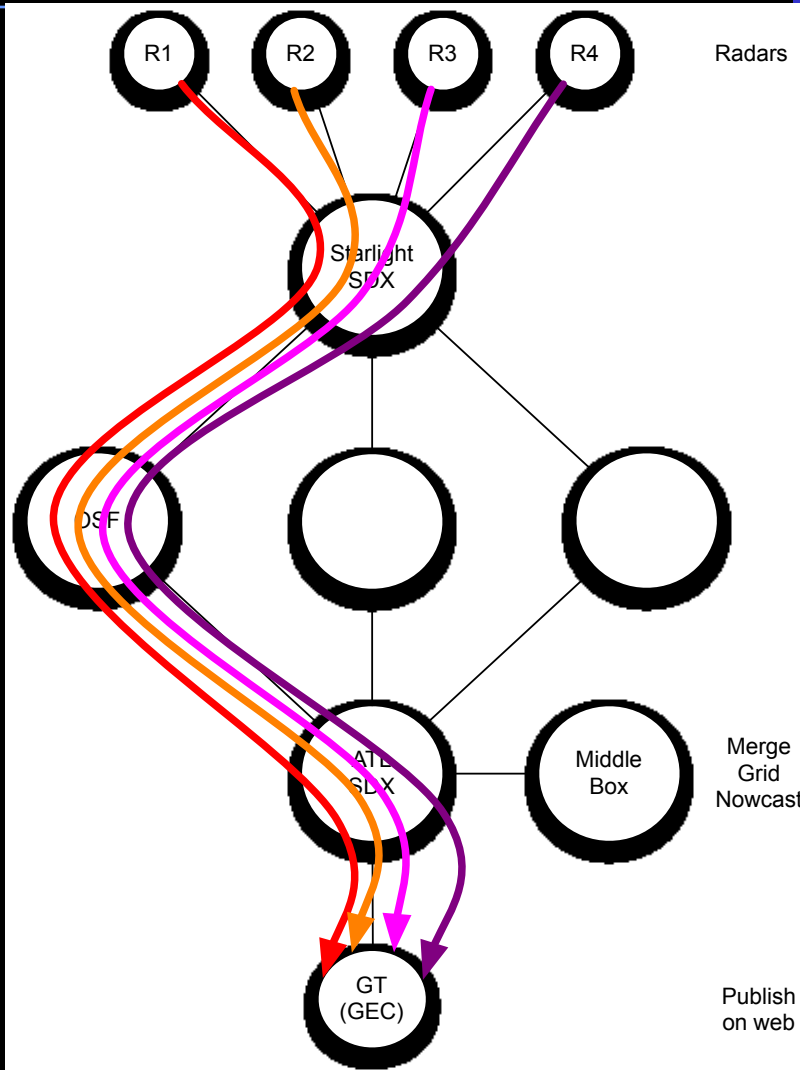
SL-SDX-0.1 Prototype Logical Diagram 03/2014 demo

Multi-Domain Provisioning Tool

The screenshot shows a web browser window with the following elements:

- Browser Tabs:** "Fei J Yeh - Outlook Web App" and "Switch Manager".
- Address Bar:** "http://165.124...".
- Page Header:** Logos for **iGENI**, **STARLIGHT™** (The Optical STAR TAP™), and **iCAIR**.
- Form Fields:** "URL:" and "port:" with corresponding input boxes, and a "submit" button.
- Server/Client Info:** "server: 165.124.3.79:8080" and "client: Not known".
- Navigation Menu:** A list of menu items with expandable arrows:
 - ▶ Create VLAN
 - ▶ Add/delete port from VLAN
 - ▶ Show port
 - ▶ Show VLAN
 - ▶ Show/Add/Delete Flow
 - ▶ **Connectivity Functions** (highlighted with a yellow border)
- Connectivity Functions Section:** Includes radio buttons for "Ping" and "Trace", input fields for "Interface:" and "MAC address:", and a "submit" button.
- Footer:** "100%" zoom level indicator.

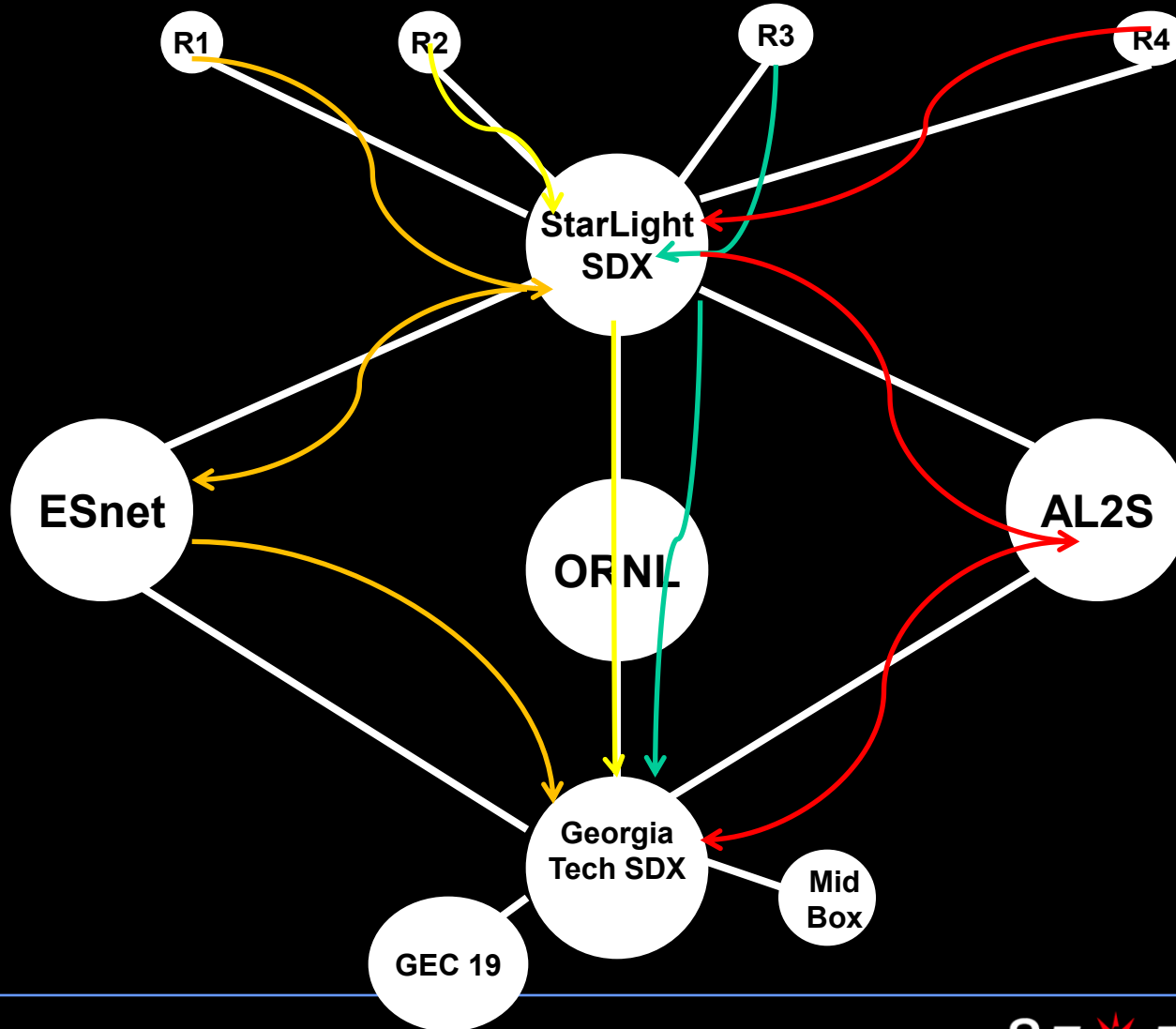
GENI SDX Demo Scenario 1: Mike Zink's Nowcast



Slide by Mike Zink, UMass Amherst

GENI SDX Demo Scenario 2: Mike Zink's Nowcast

Simulated
Radar (4)



SDX StarLight ↔ NetherLight

STARLIGHT™
The Optical STAR TAP™

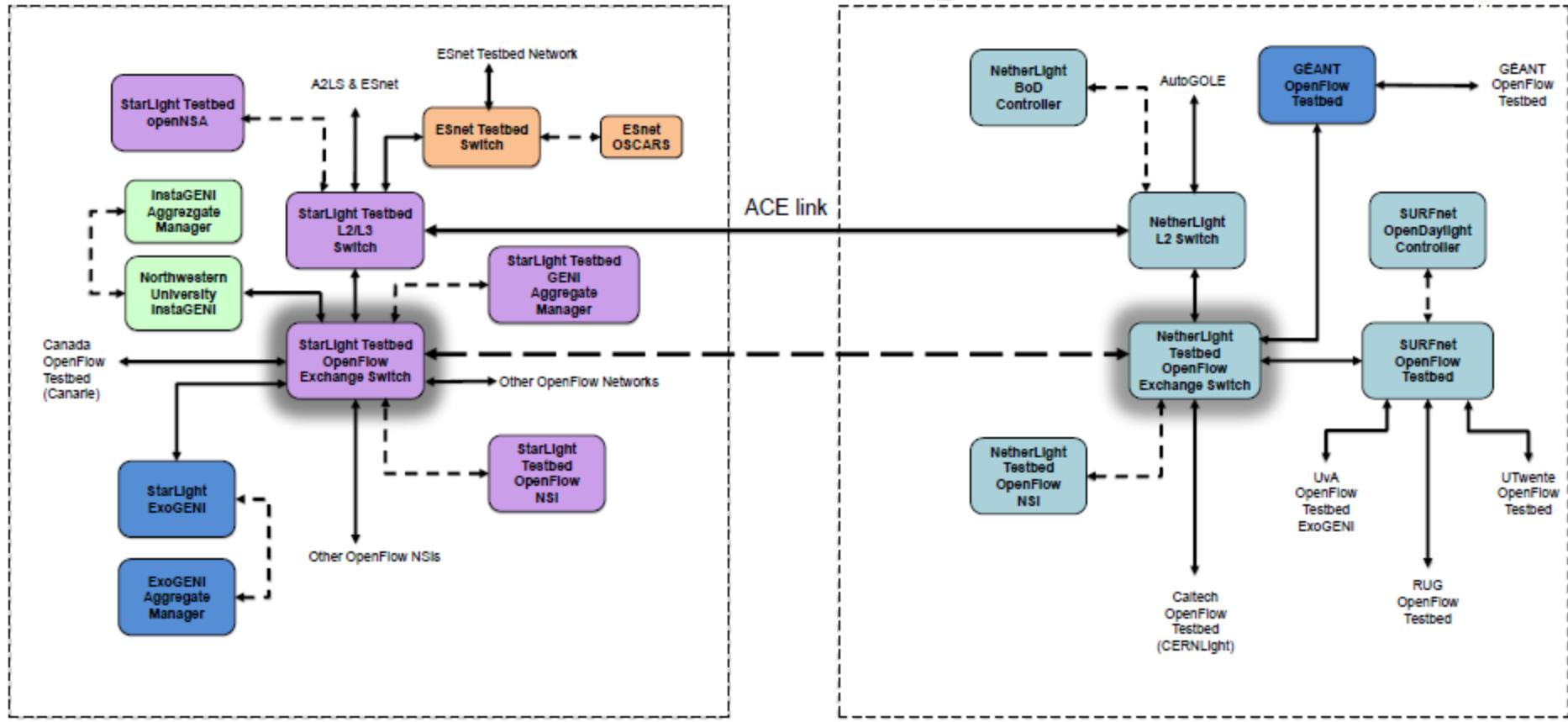
StarLight, Chicago

iCAIR

SURF NET

NetherLight, Amsterdam

NL Light

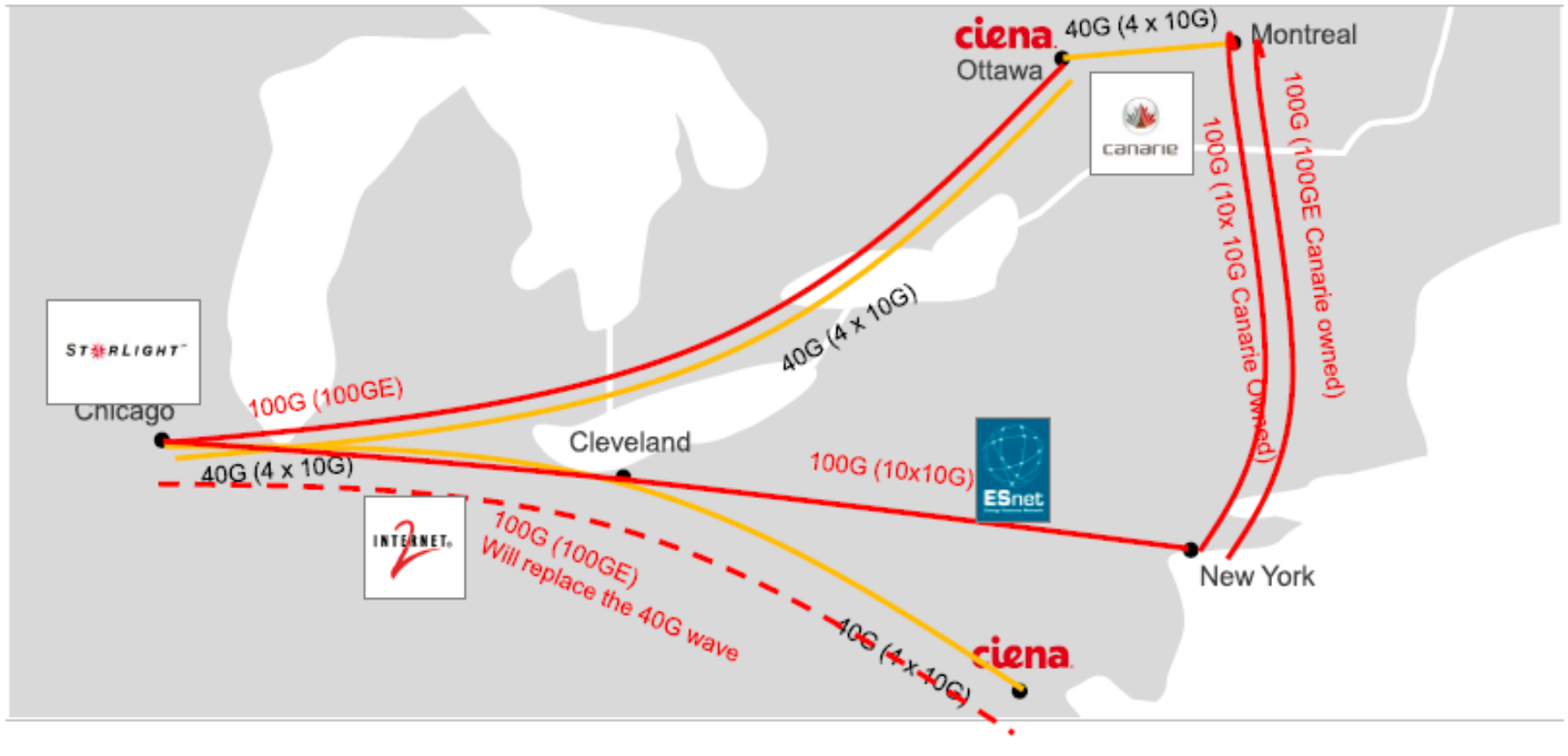


Ronald van der Pol, Joe Mambretti, Jim Chen, John Shillington

STARLIGHTSM

SDN Optical Testbed

Ciena's OPⁿ research network testbed Wavelengths topology



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

Thanks to the NSF, DOE, DARPA
Universities, National Labs,
International Partners,
and Other Supporters

