

International Software-Defined Network Exchanges (iSDXs)

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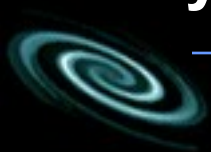
**GLIF Technical Meeting
Washington DC/Arlington Va.**

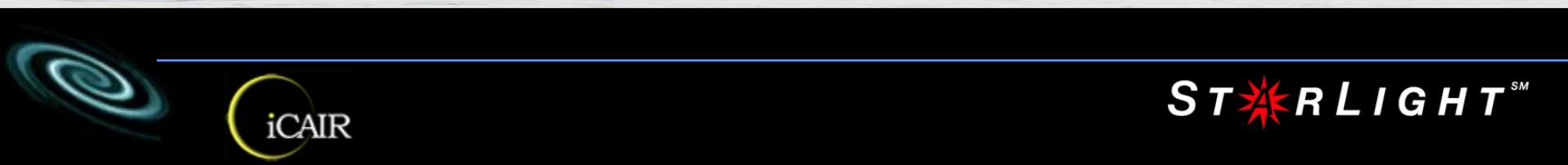
March 26-27, 2015



Macro Context

- All Major IT Revolutions Have Been Propelled By Creating Higher Levels of Abstractions Than Those That Previously Existed.
- Today Resource Virtualization Is A Major Macro Tread At All Levels: Architecture-as-a-Service (AaaS), Environment-as-a-Service (EaaS), Software-as-a-Service (SaaS), Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Container-as-a-Service (CaaS), Anything (and Everything)-as-a-Service (XaaS)
- Networks-as-a-Service (NaaS)!
- Network Virtualization Enables Highly Programmable Dynamic Networks (vs Traditional Static Networks)



[illegible]

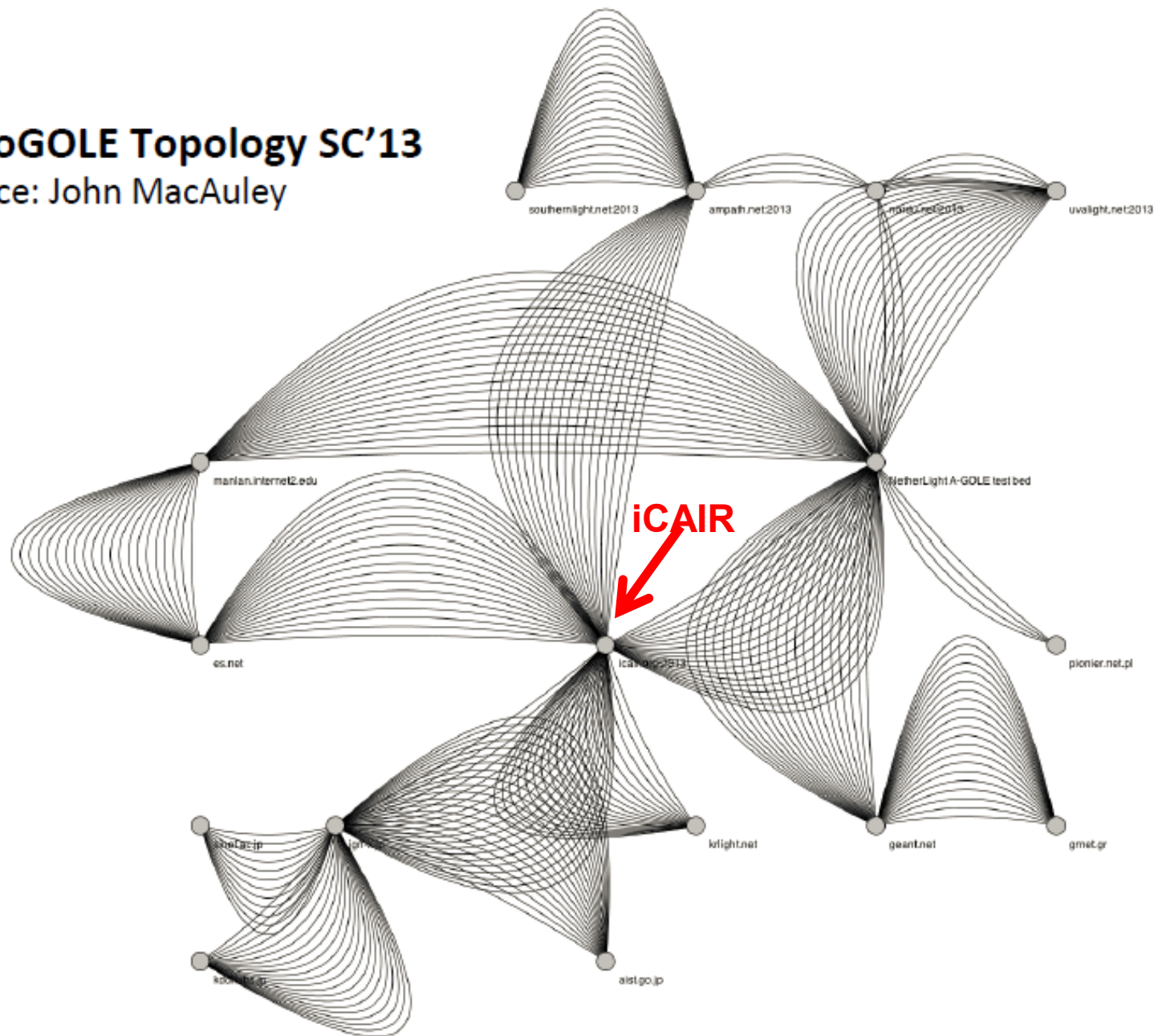
Automated GOLE Fabric



Source: GLIF Auto GOLE Group

AutoGOLE Topology SC'13

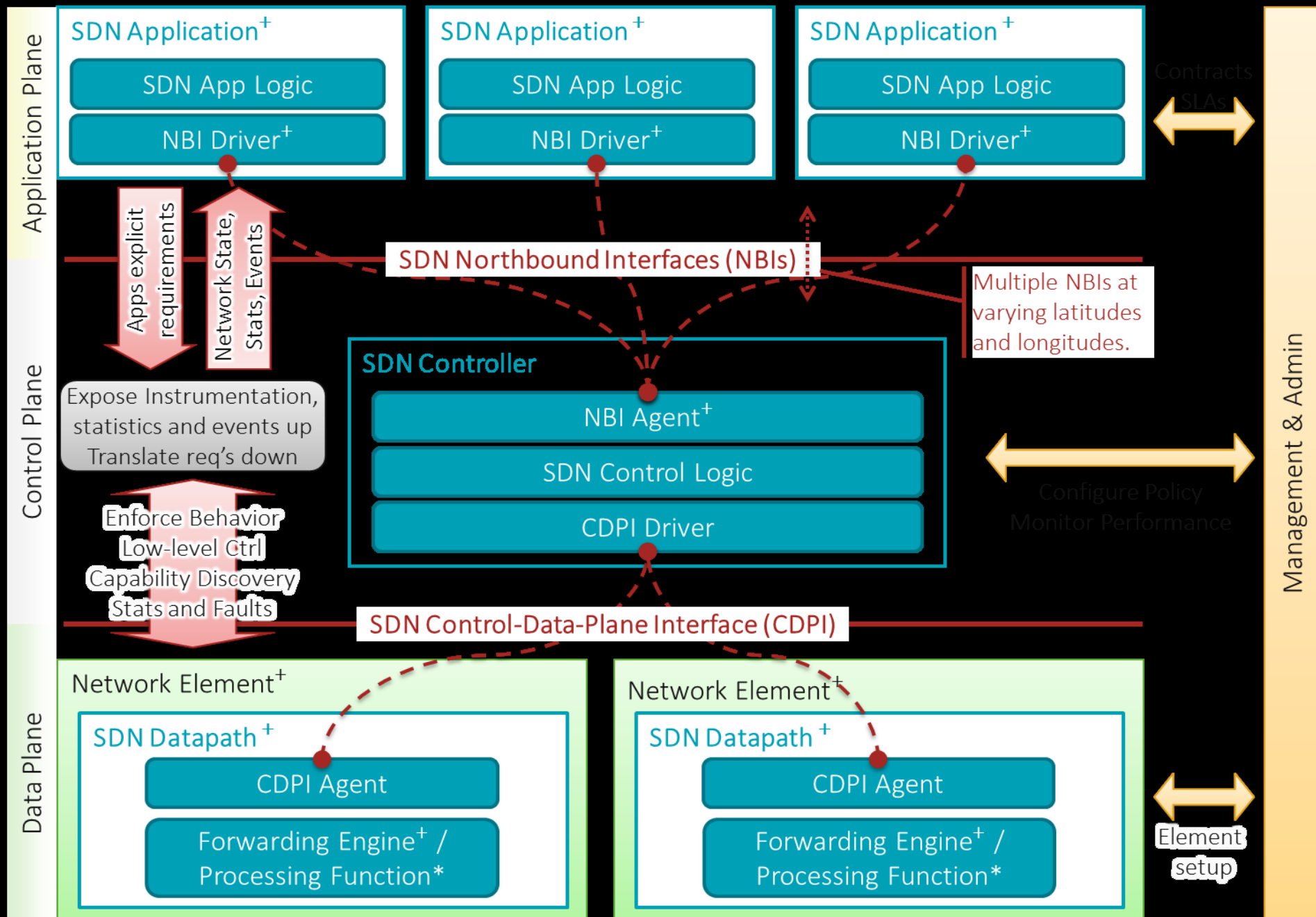
Source: John MacAuley



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 NSlv2 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



Source: Open Network Foundation

Benefits of SDN

- SDN Not Only Allows Network Designers To Create a Much Wider Range of Services and Capabilities Than Can Be Provided With Traditional Networks, But They Also Enable:
 - a) A More Comprehensive, Graulated View Into Network Capabilities and Resources
 - b) Many More Dynamic Provisioning and Adjustment Options, Including Those That Are Automatic and Implemented In Real Time
 - c) Faster Implementations of many New and Enhanced Services
 - d) Enabling Applications, Edge Processes and Even Individuals To Directly Control Core Resources;
 - e) Substantially Improved Options For Creating Customizable Networks
 - f) Enhanced Operational Efficiency and Effectiveness.
 - Etc



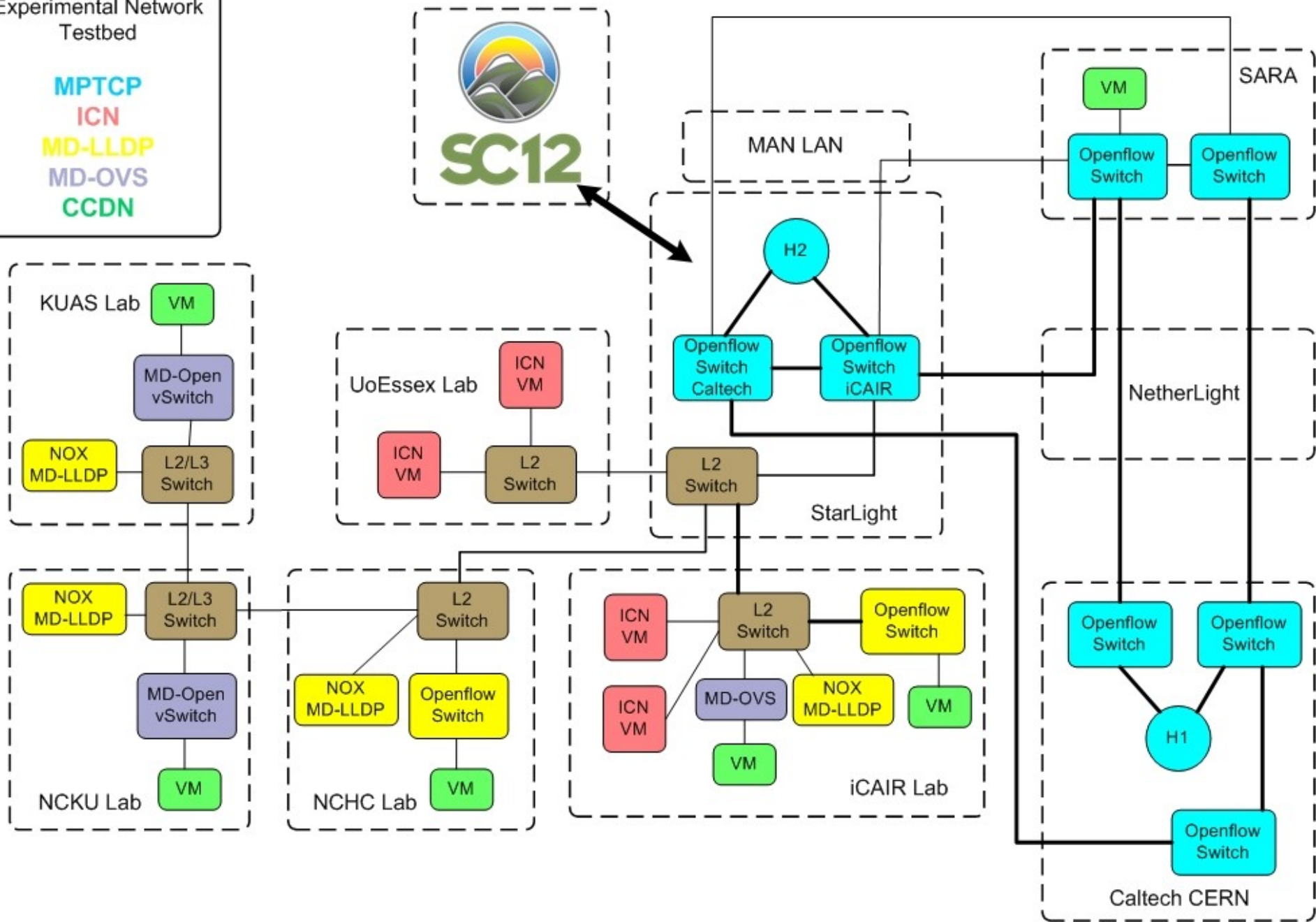
[illegible]



SC12 SRS

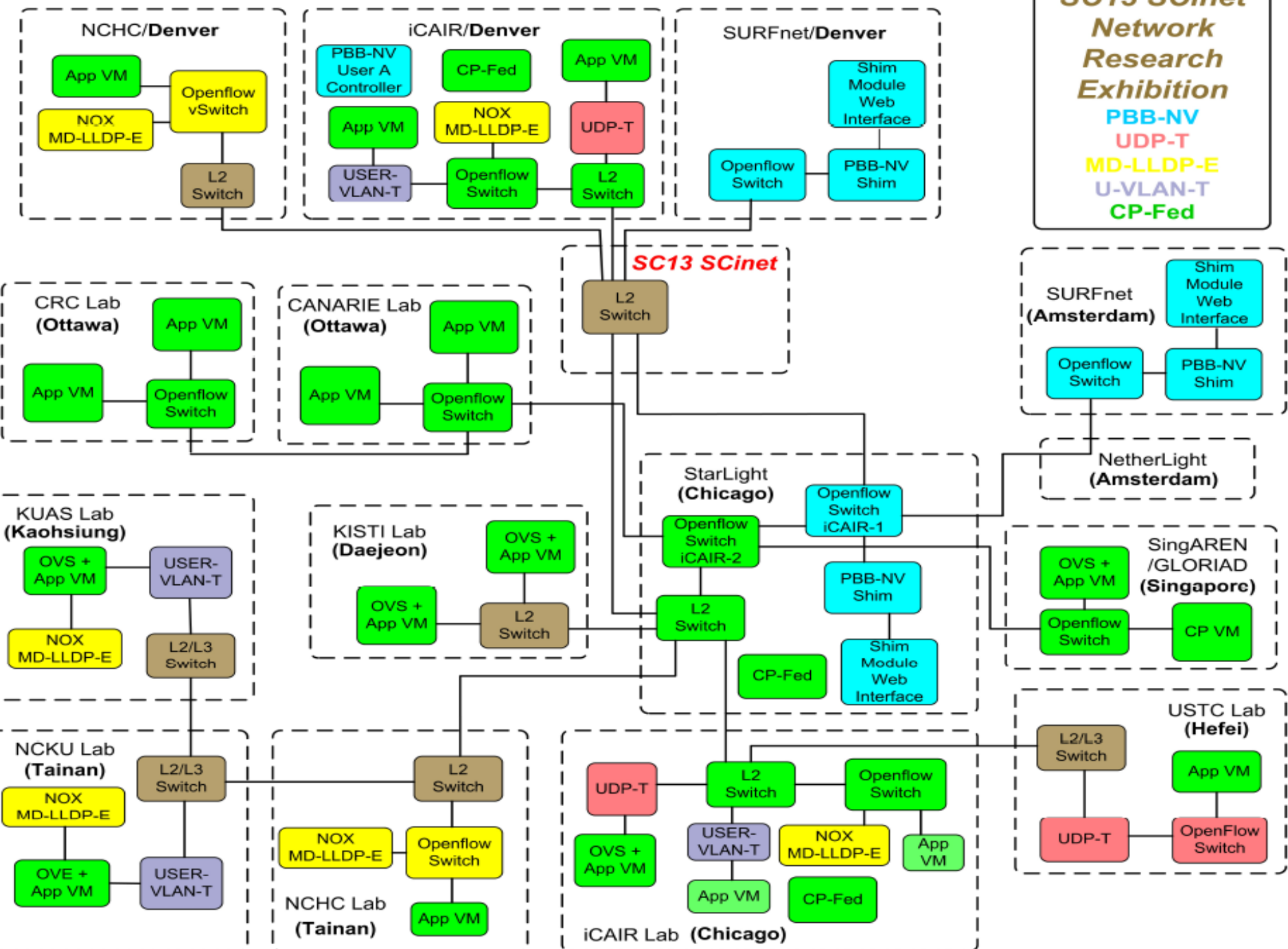
International Openflow
Experimental Network
Testbed

MPTCP
ICN
MD-LLDP
MD-OVS
CCDN

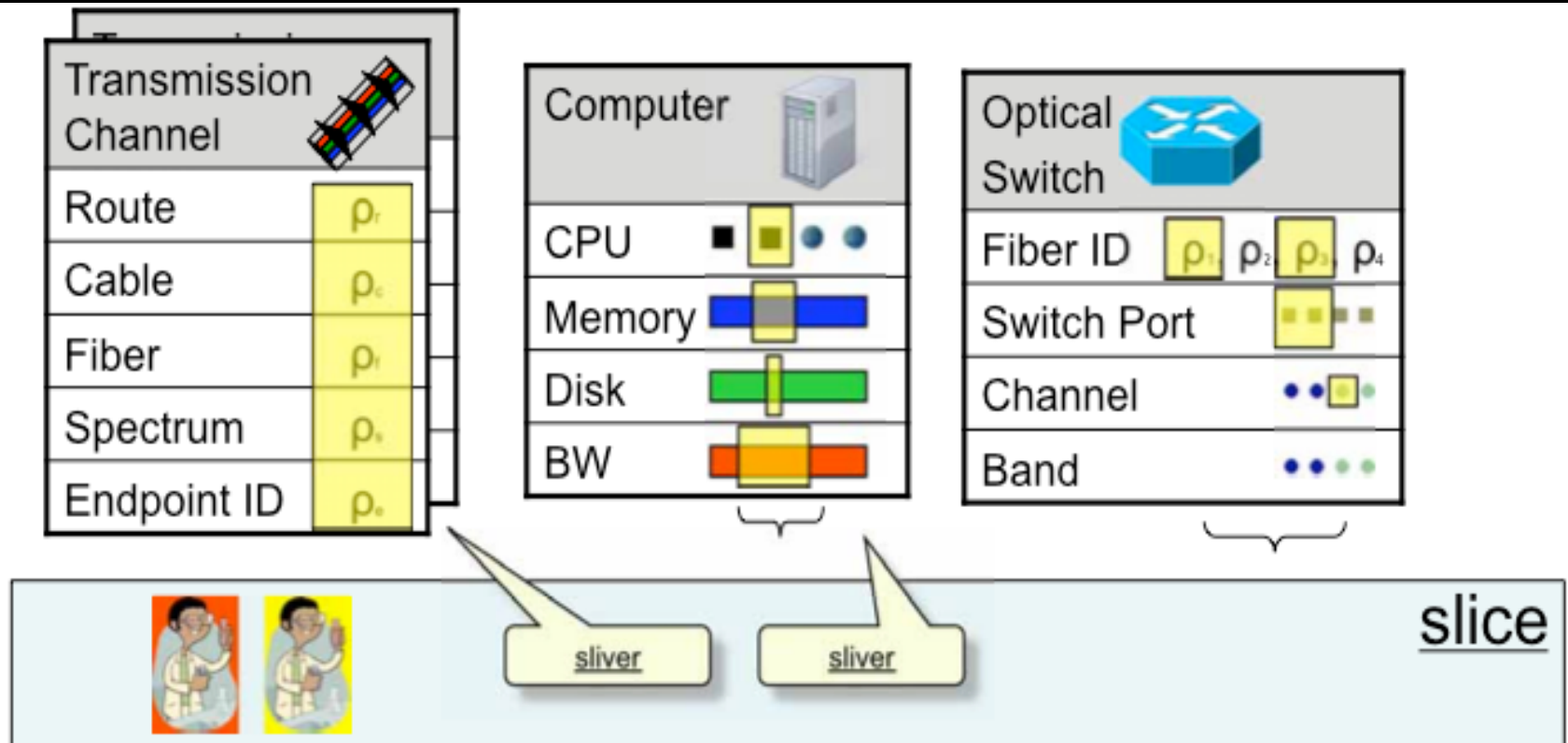


NCHC: Booth 3137**iCAIR: Booth 828****DRC: Booth 3322****SC13 SCinet
Network
Research
Exhibition**

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

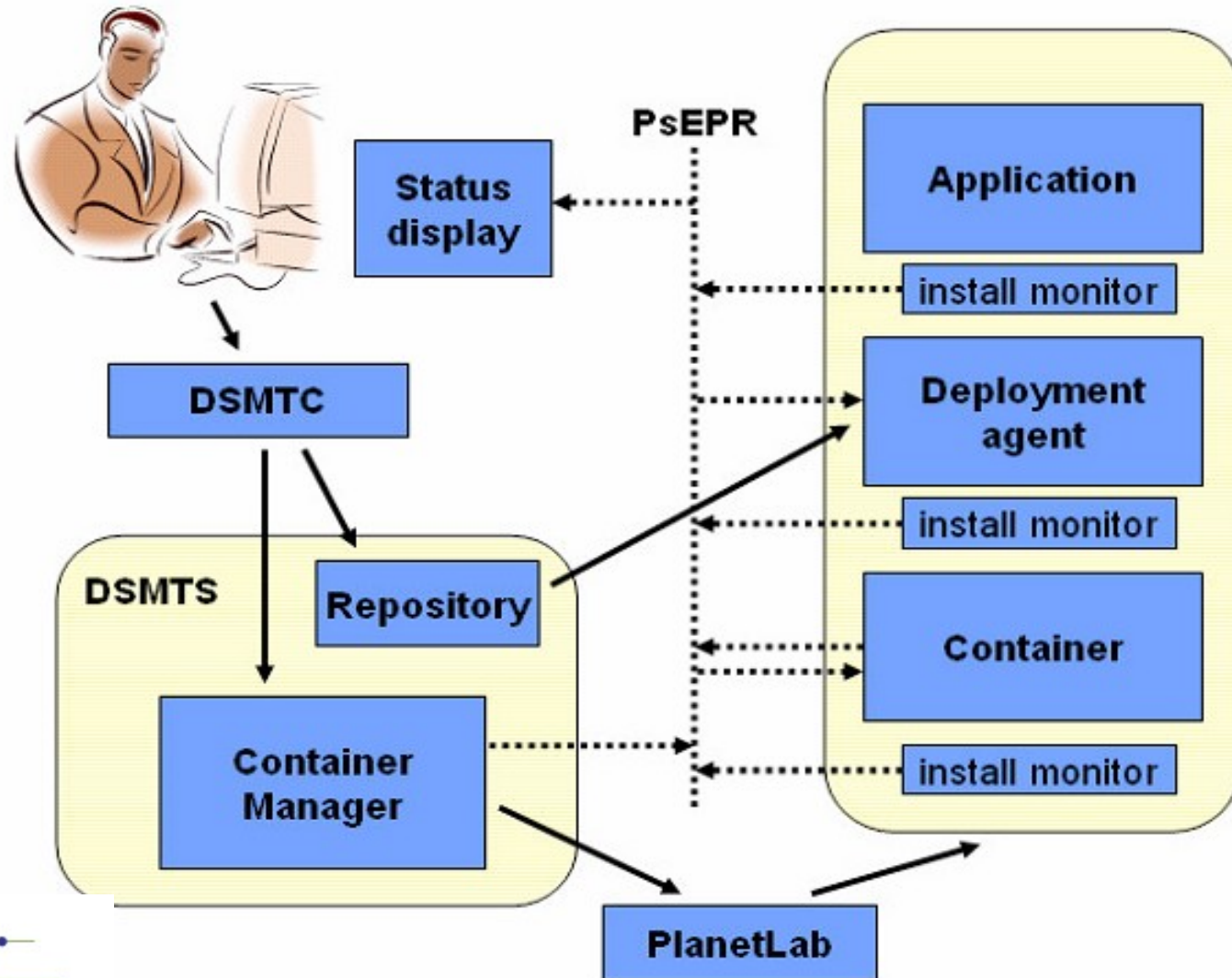


GENI Slicers and Slivers



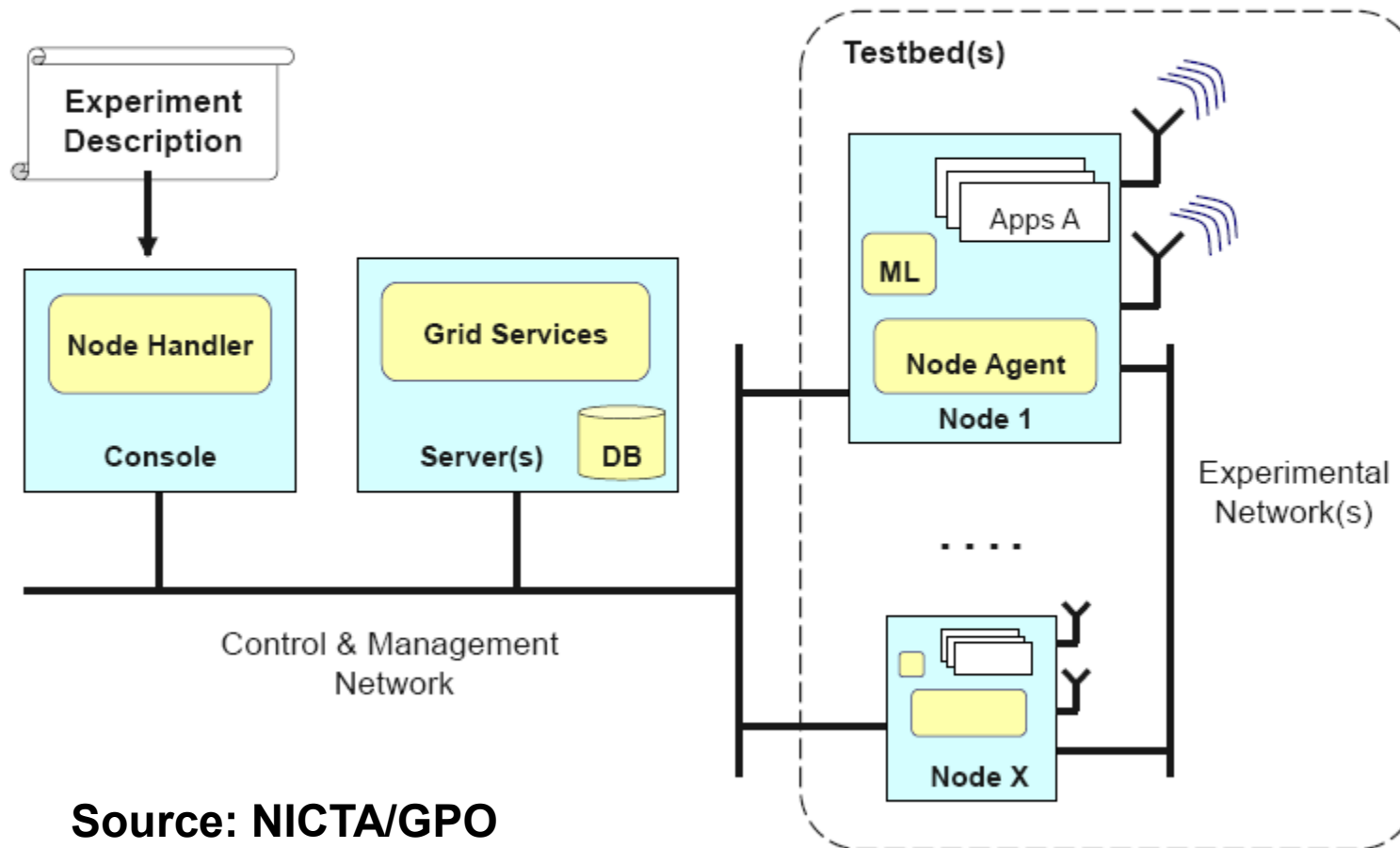
Source: BBN GENI Program Office

PlanetLab



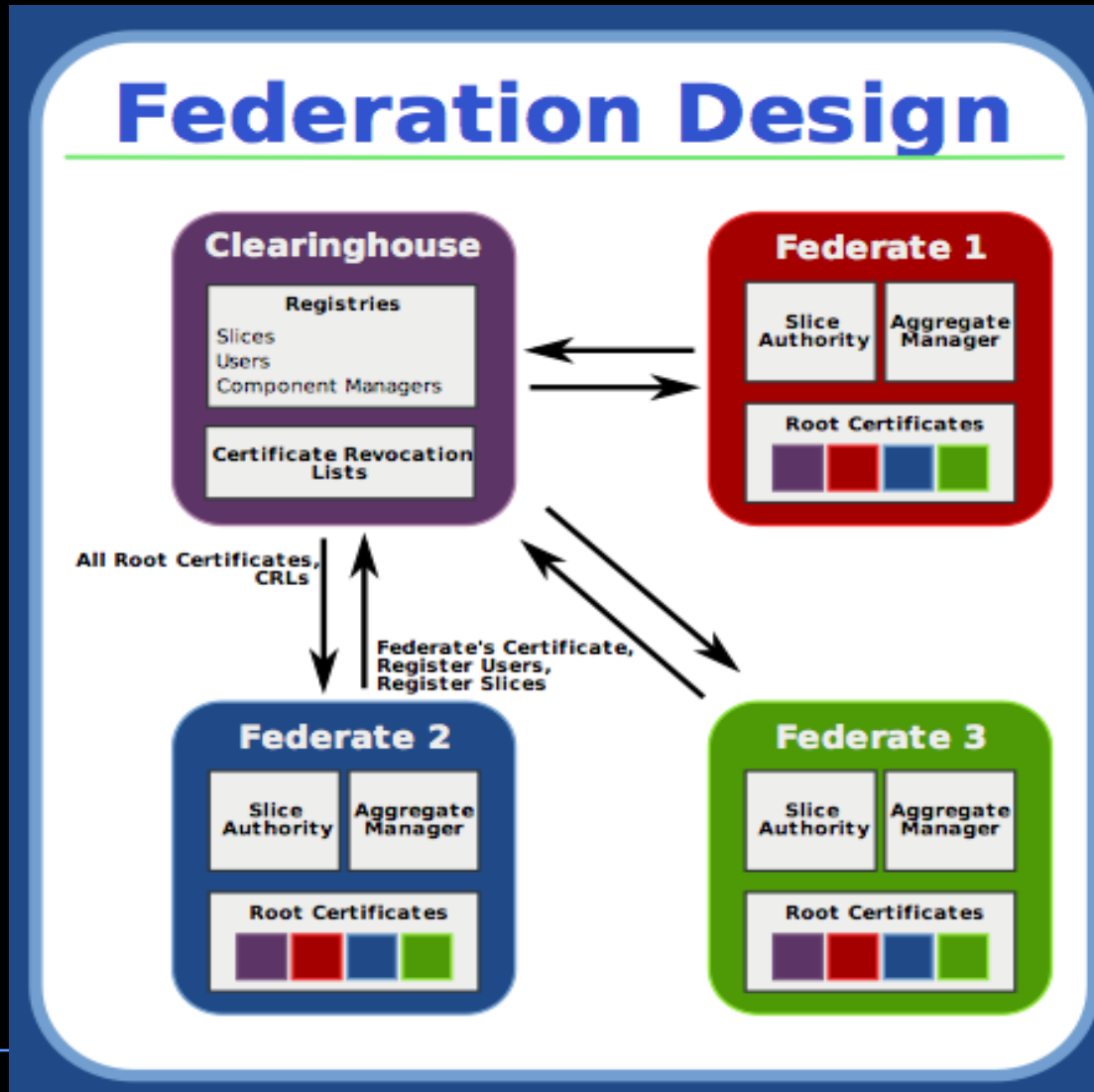
ORBIT Management Framework

OMF - Operator View



Source: NICTA/GPO

ProtoGENI Federation Design



Flack: Experimenter Interface

File Edit View History Bookmarks Tools Help

www.protogeni.net/trac/protogeni/wiki/Flack

Flack

Renew Floodlight: Renewed. All expire at the same time in 3 days, 17 hours, 12 minutes.

v1.4.46

Floodlight View Import Output GENI...

Add Resources Get Status

utahemulab.cm Renew Sliver: Renewed

Slices New

Show All Floodlight

Managers Add

Show/Hide

- ansp.br.cm
- bbn-pgeni.cm
- beelab.cm
- cis.fiu.edu.cm
- cmulab.cm
- cron.toni.org.cm
- ETRI-CM1.cm
- genicloud.hplabs...
- jonlab.cm
- mygeni.cm
- plc.sa
- shadowgeni.cm
- ukoeni.cm

3d 14h 13m Extend 3 Days

PC

lan0

lan1

lan2

lan3

lan4

lan5

lan6

lan7

PC-0

PC-1

PC-2

PC-3

PC-4

pc505.emulab.net:22
excl. raw-pc
UBUNTU12-64-STD
=> pc505

pc508.emulab.net:22
excl. raw-pc
UBUNTU12-64-STD
=> pc508

pc502.emulab.net:22
excl. raw-pc
UBUNTU12-64-STD
=> pc502

pc501.emulab.net:22
excl. raw-pc
UBUNTU12-64-STD
=> pc501

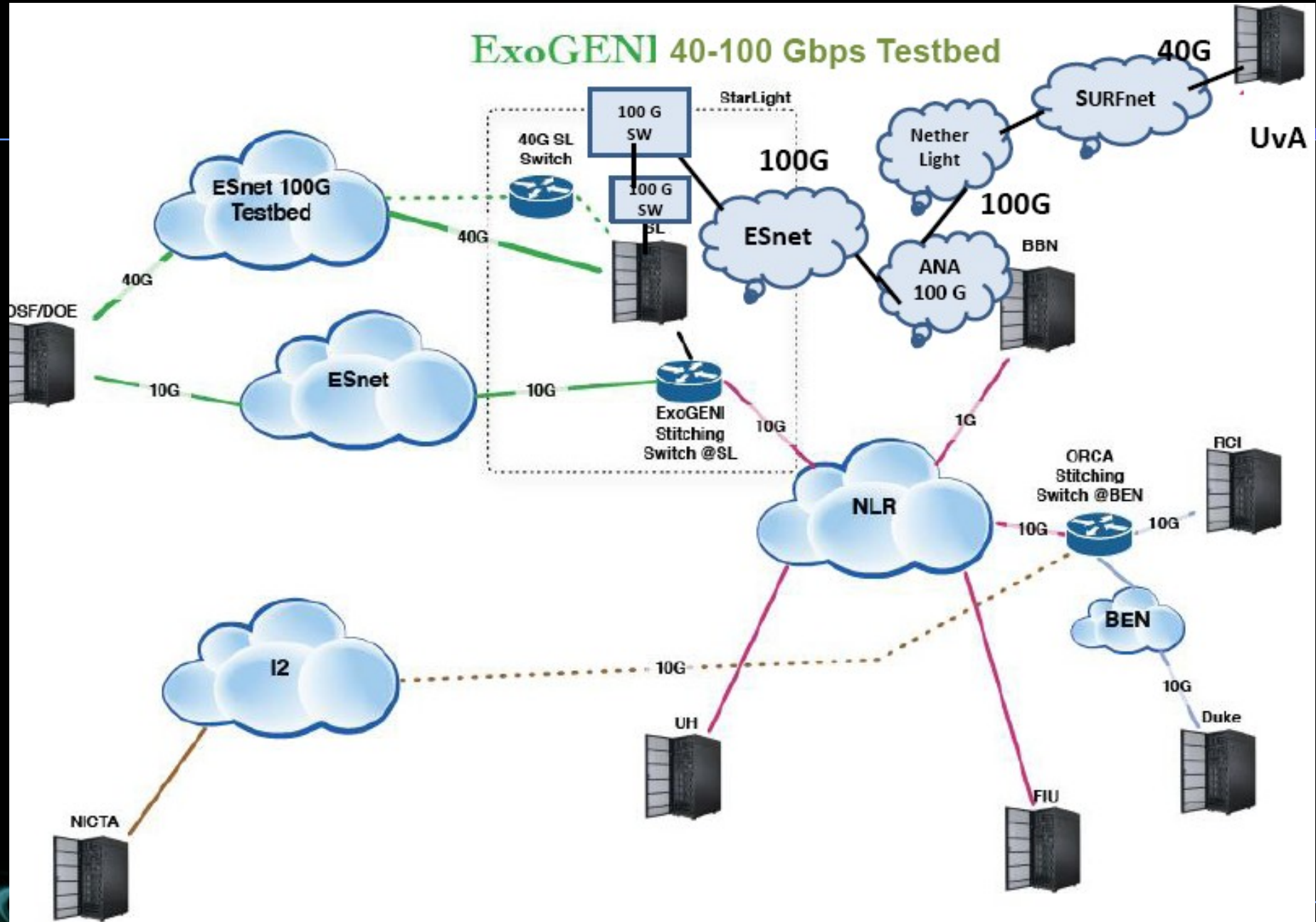
pc482.emulab.net:22
excl. raw-pc
UBUNTU12-64-STD
=> pc482

pc490.emulab.net:22
excl. raw-pc
UBUNTU12-64-STD
=> pc490

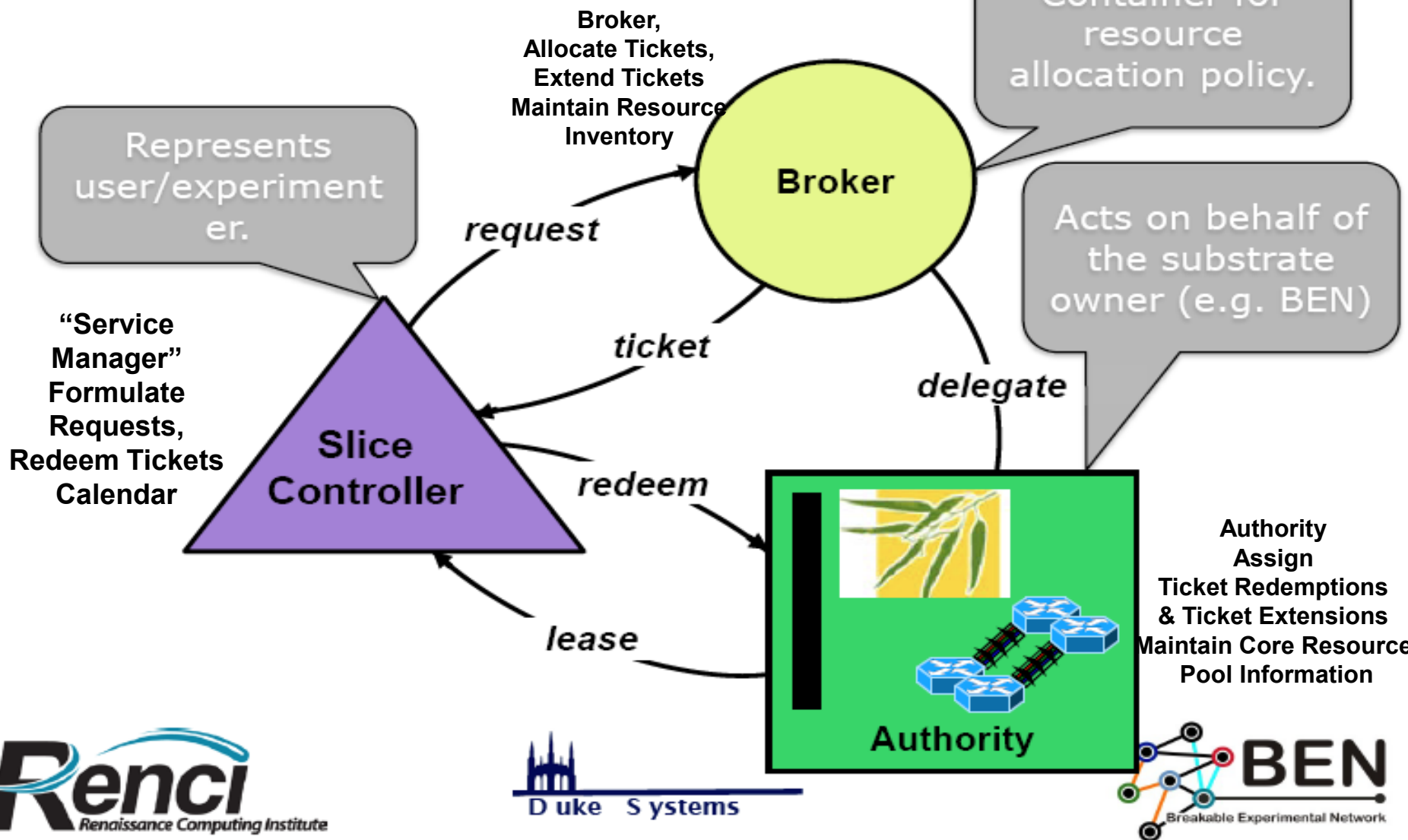
Delete

Find: buildroutes Previous Next Highlight all Match case

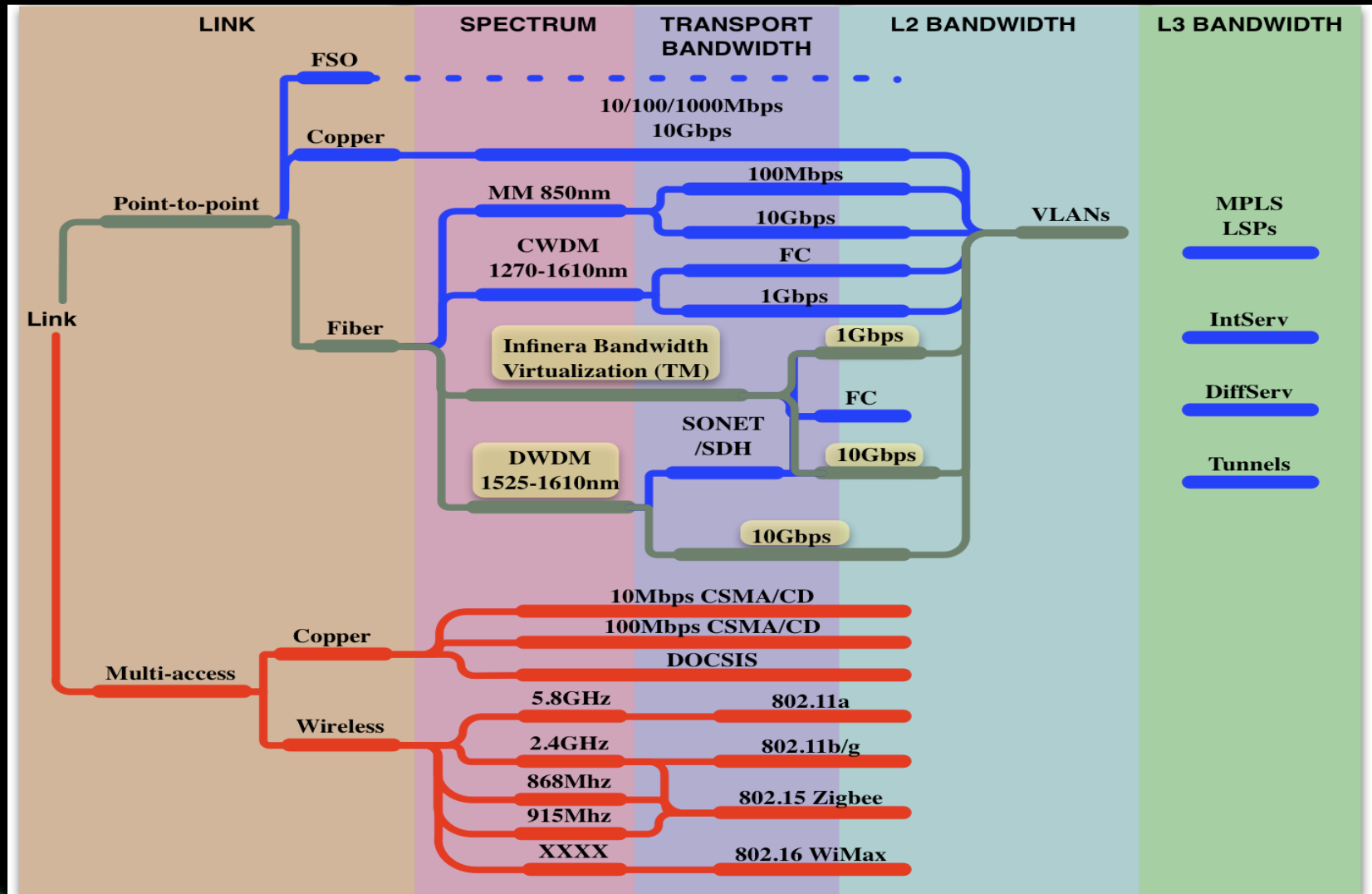
ExoGENI 40-100 Gbps Testbed



ORCA Architecture

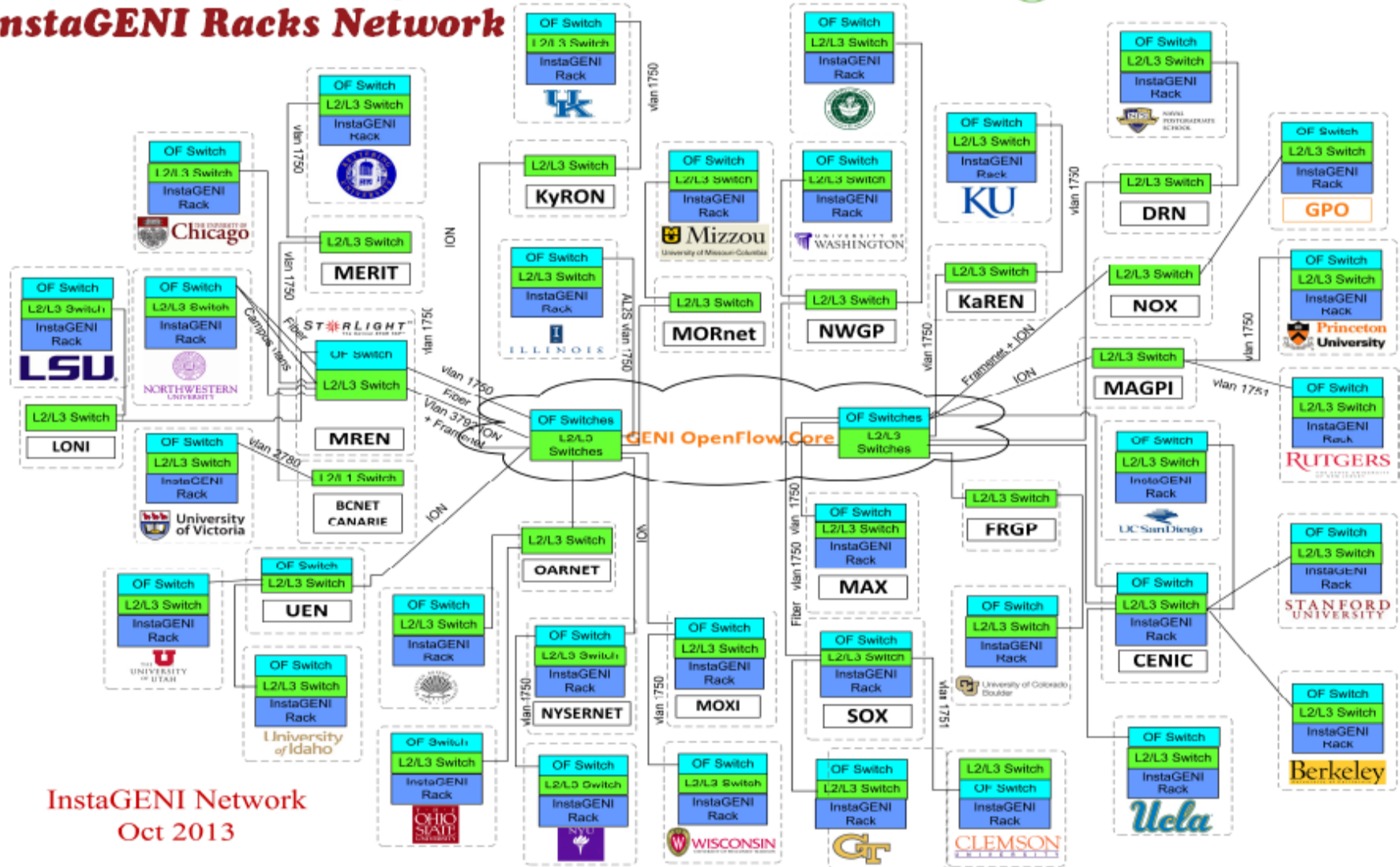


ORCA "Link" Slivering



GENI's InstaGENI Network & Rack Fabric

InstaGENI Racks Network



InstaGENI Network
Oct 2013

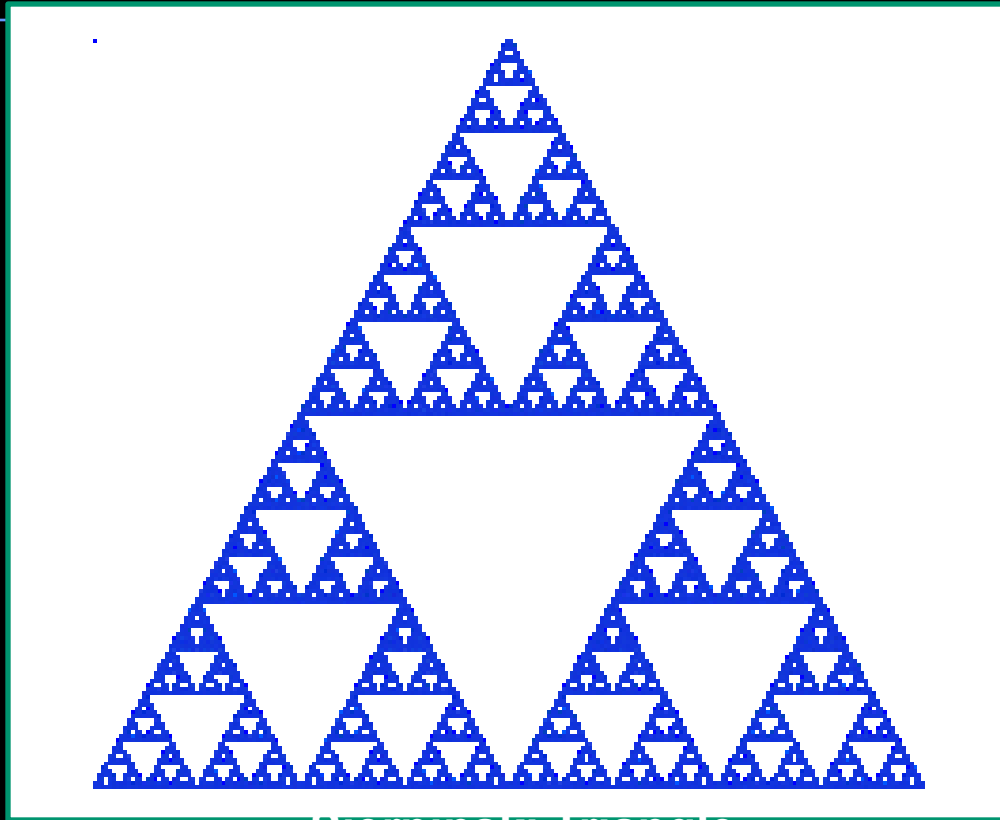
GENI Can Connect To Other Environments Via An SDX **ST*RLIGHT**SM

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**



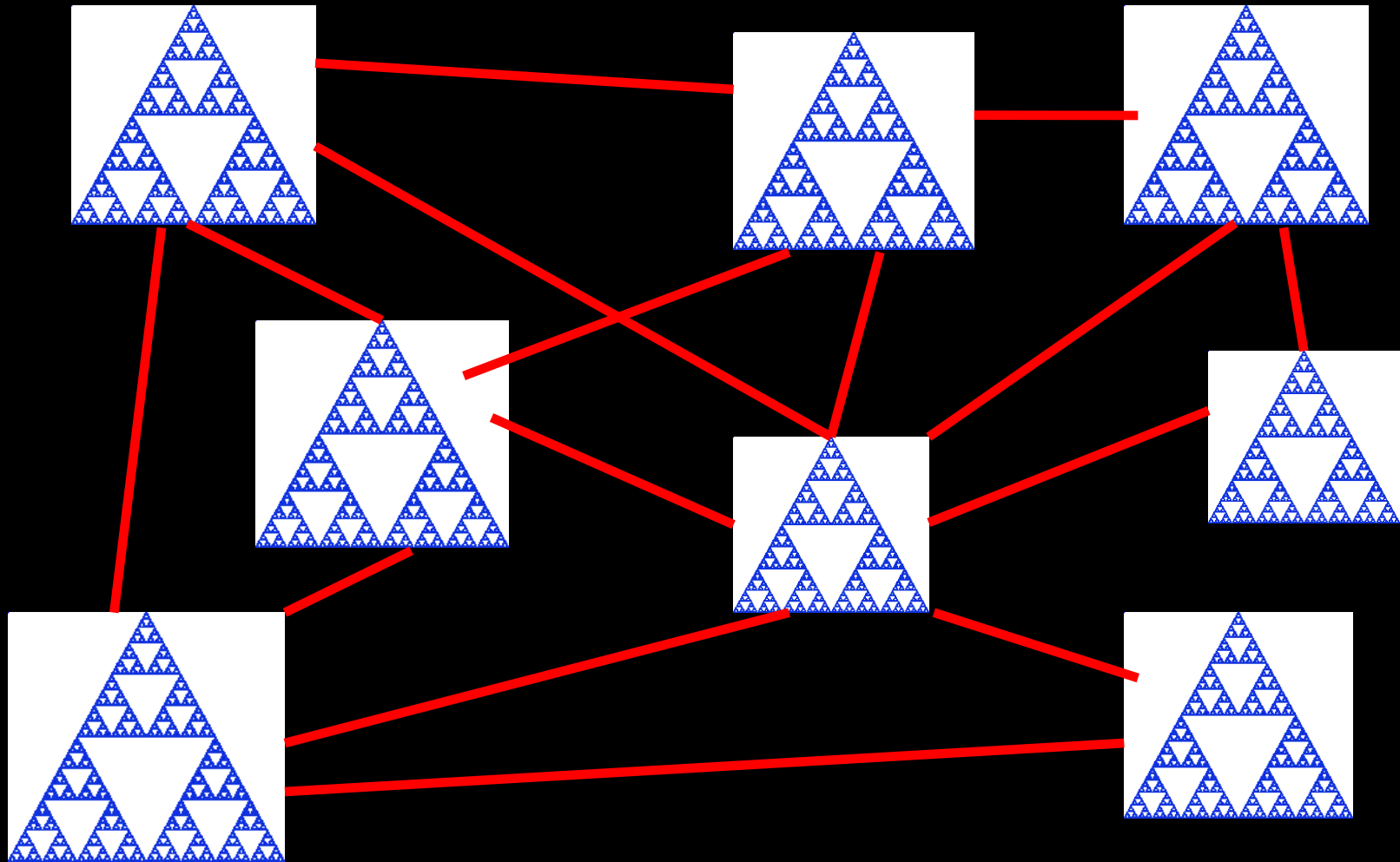
SDX As Recursive Virtual Switch

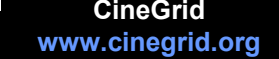
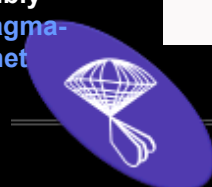
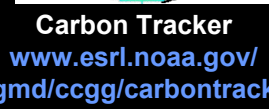
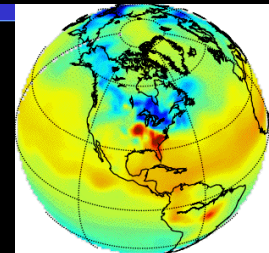
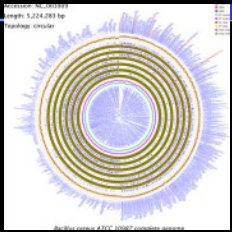
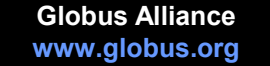
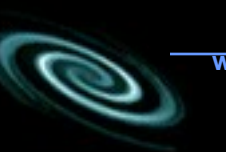
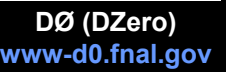
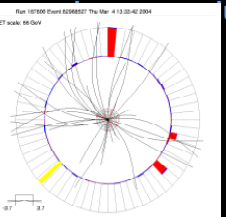
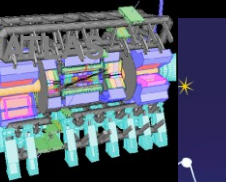
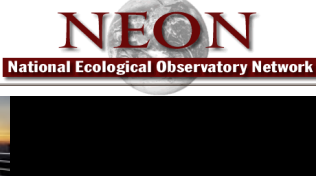


Sierpinski Triangle

**Unlimited Number of
Customized Virtual Switches
Within Macro Virtual Switch**

GLIF Based On SDXs Supporting Slice Exchanges

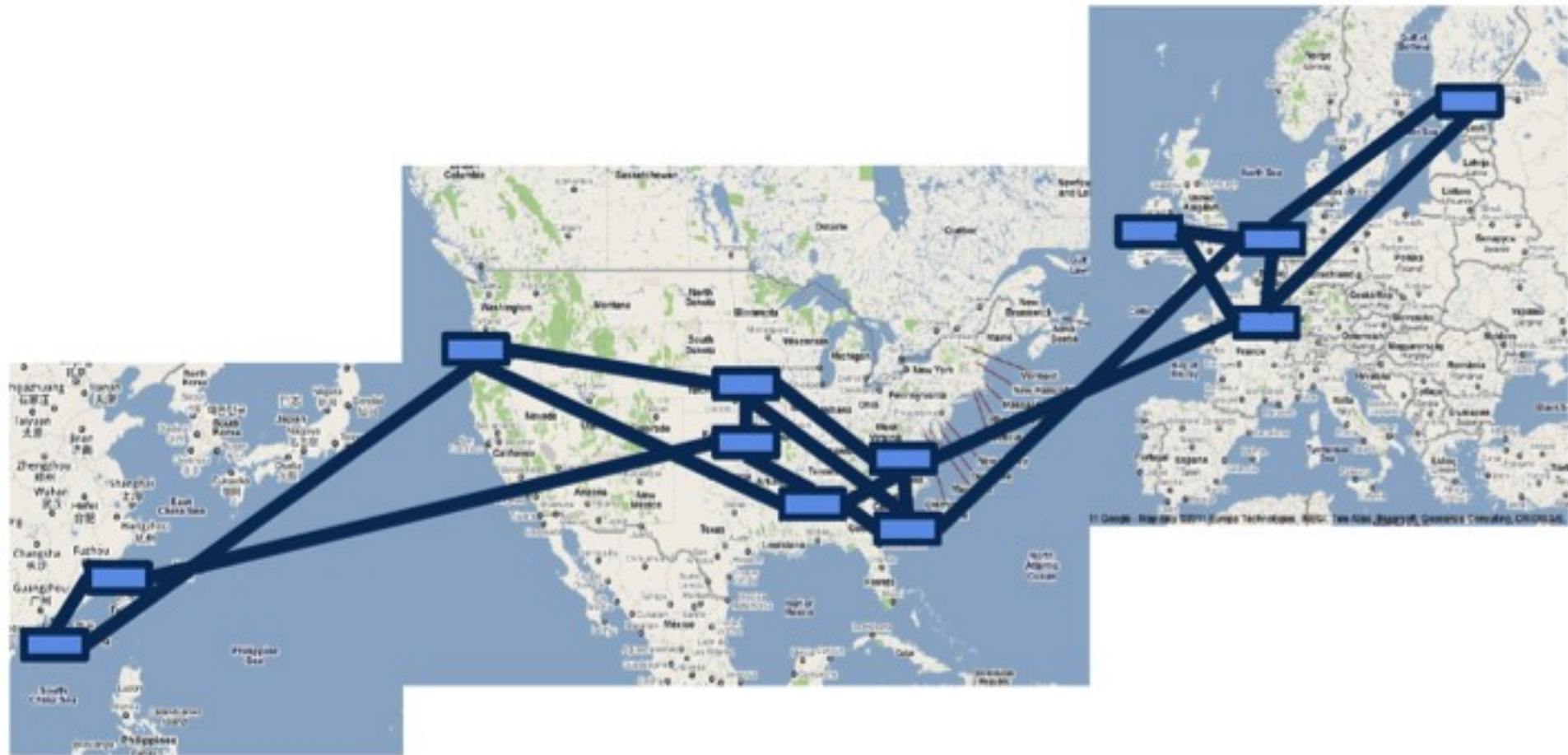




Compilation By Maxine Brown

STARLIGHTSM

Google's Software Defined WAN



Examples from NZ #2: SDX



12 November 2013

CityLink and NoviFlow sign agreement to create the first SDN Based Internet Exchange in the World

CityLink and NoviFlow today announced their agreement for the supply of Software Defined Networking (SDN) equipment, which will be deployed in New Zealand's Internet Exchange Points (IXPs) around the country.

Group Chief Technology Officer Jamie Baddeley said that "...the agreement is the conclusion of an exhaustive set of tests of key SDN switching vendors that has taken place at CityLink over the last 12 months. We have very exacting requirements when it comes to SDN and the IXPs. NoviFlow clearly demonstrated their capability and commitment to very high performance Software Defined Networking and because of that we're innovating the future architecture of Internet Exchange Points with them."

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



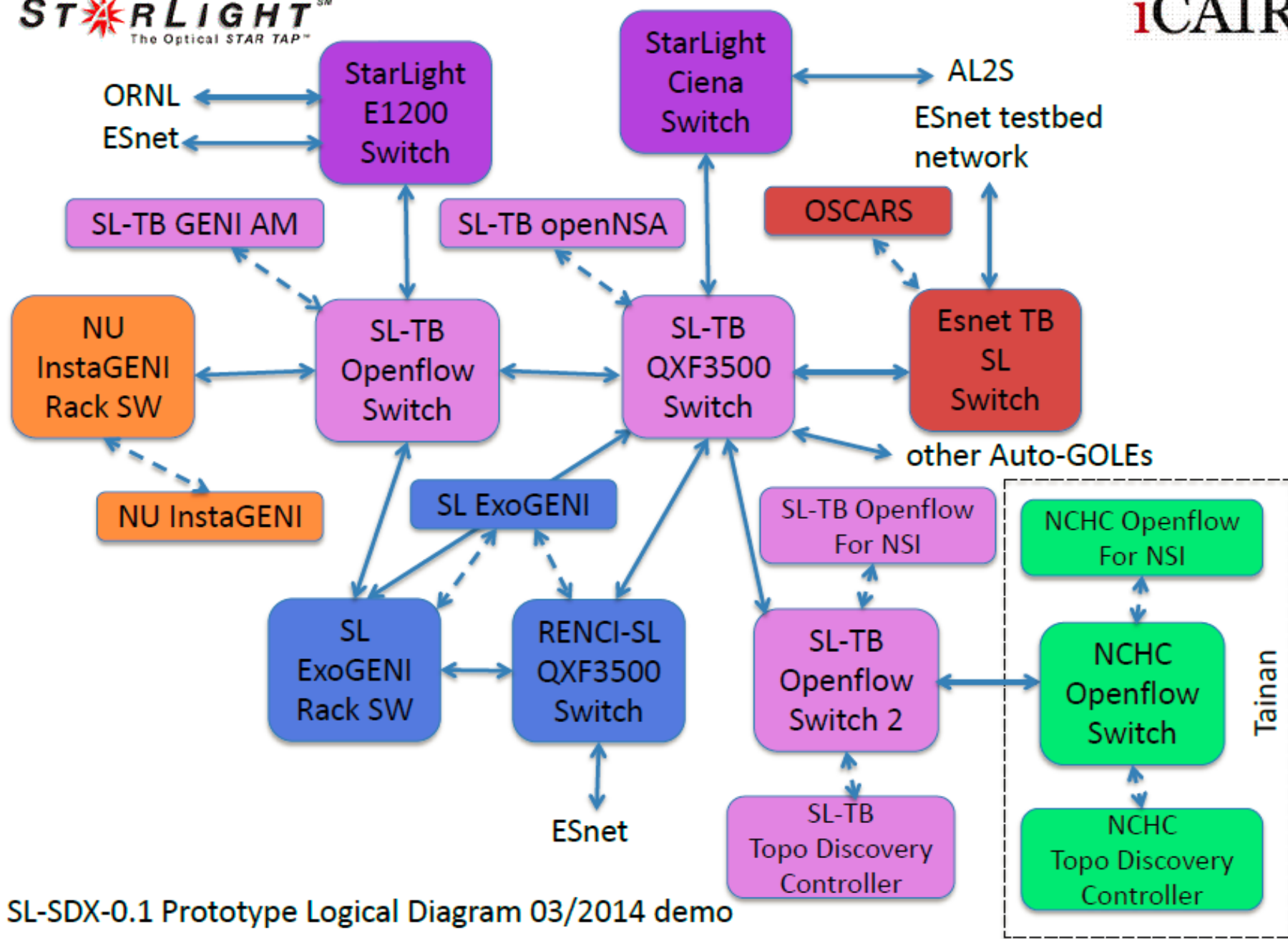
View from StarLight



Abbott Hall, Northwestern University's Chicago Campus



STARLIGHTSM



← → http://165.124... Fei1Yeh - Outlook Web App Switch Manager

iGENI **STARLIGHTSM** **iCAIR**
The Optical STAR TAP™

URL:
port:

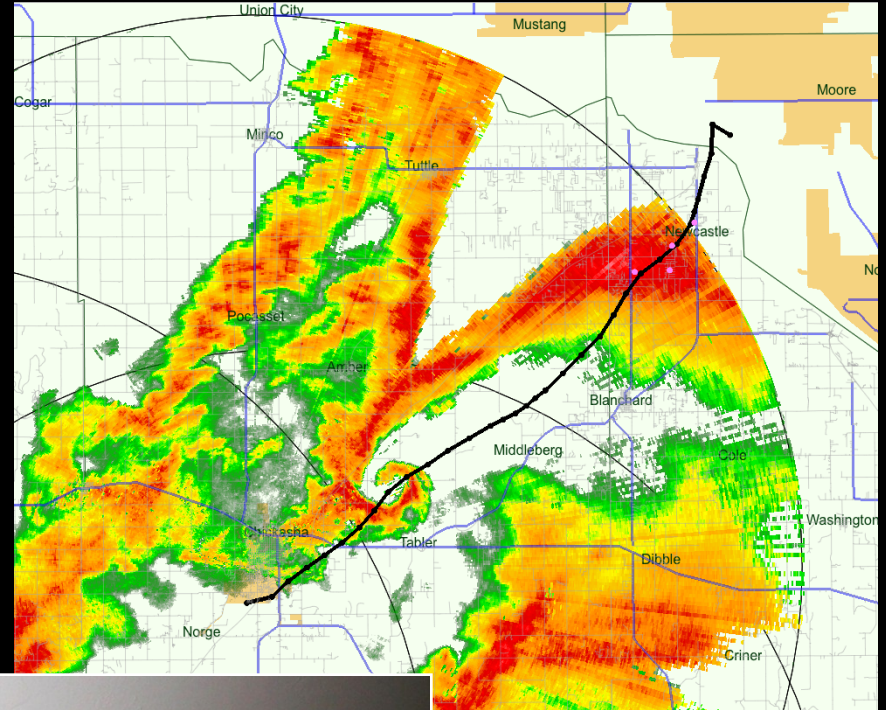
server: 165.124.3.79:8080
client: Not known

- ▶ Create VLAN
- ▶ Add/delete port from VLAN
- ▶ Show port
- ▶ Show VLAN
- ▶ Show/Add/Delete Flow
- ▼ Connectivity Functions
 - ☐ Ping ☐ Trace
 - Interface:
 - MAC address:
 -

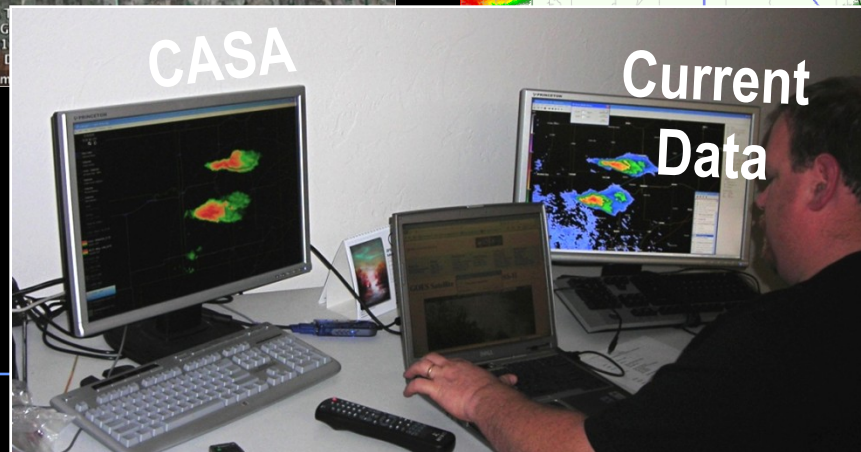
100%

Potential

Source: Mike Zink, UMass Amherst



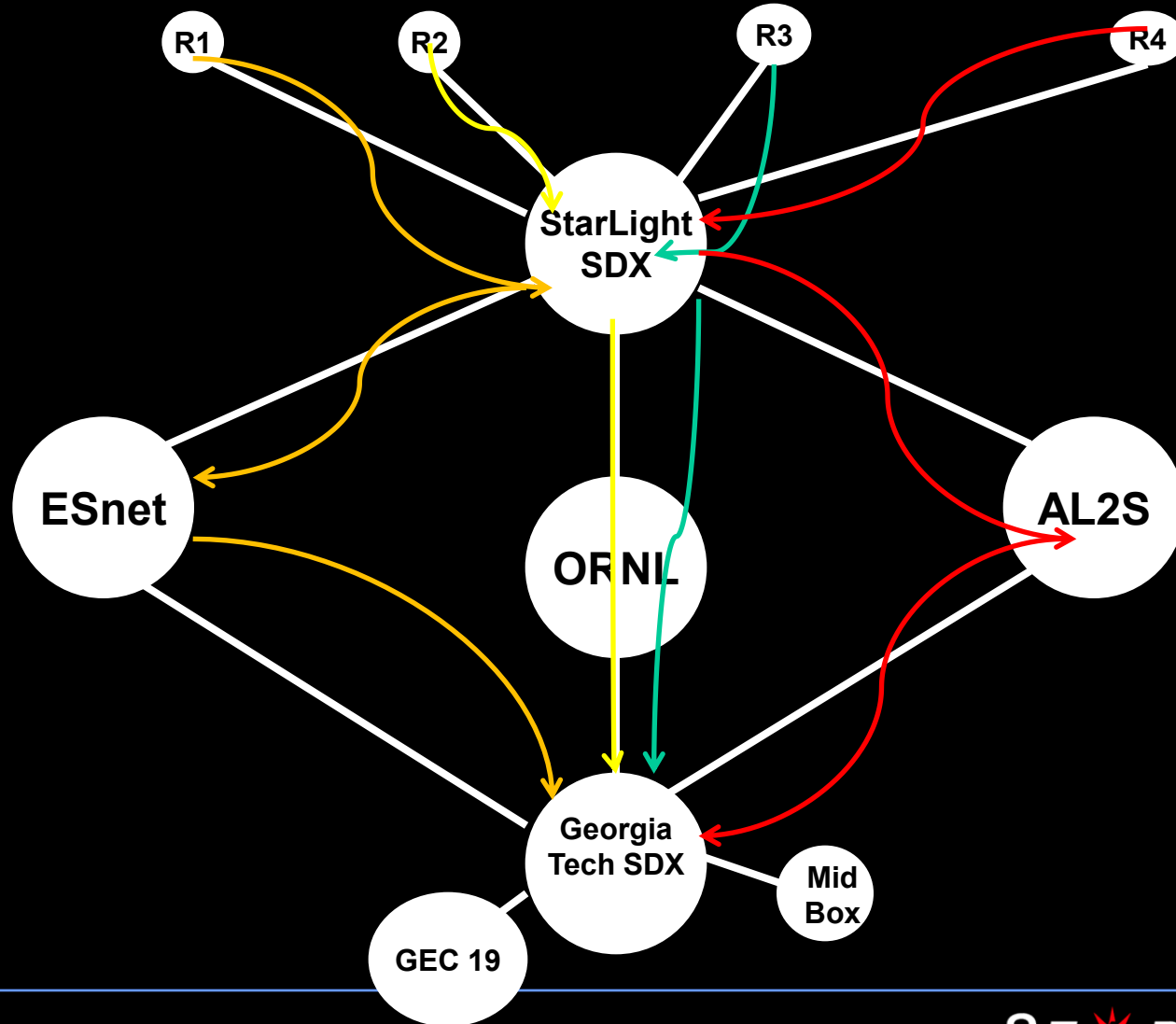
**CASA Data, EM
Decision-Making
Protects First
Responders and
Public**



STARLIGHTSM

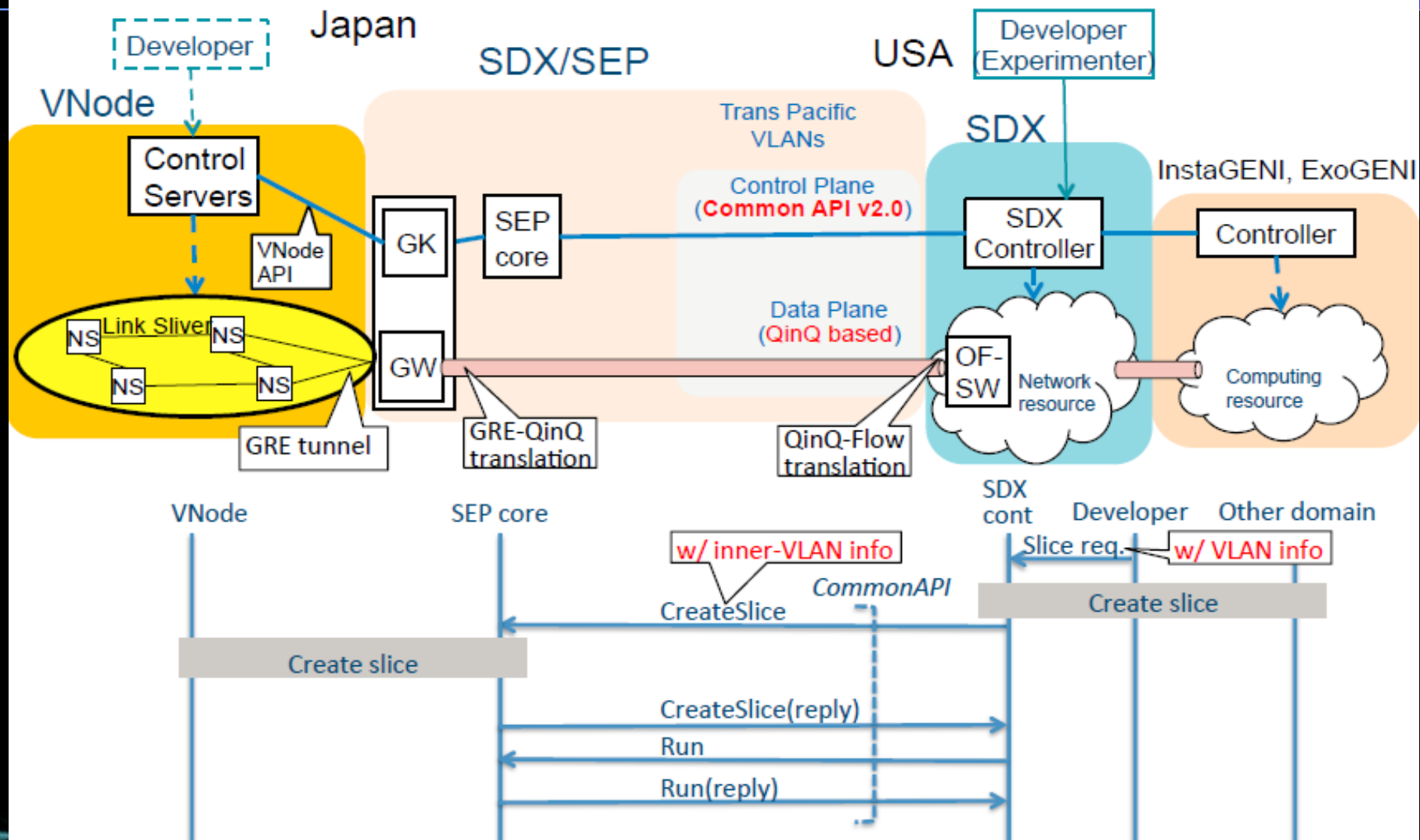
GENI SDX Demo Scenario

Simulated
Radar (4)

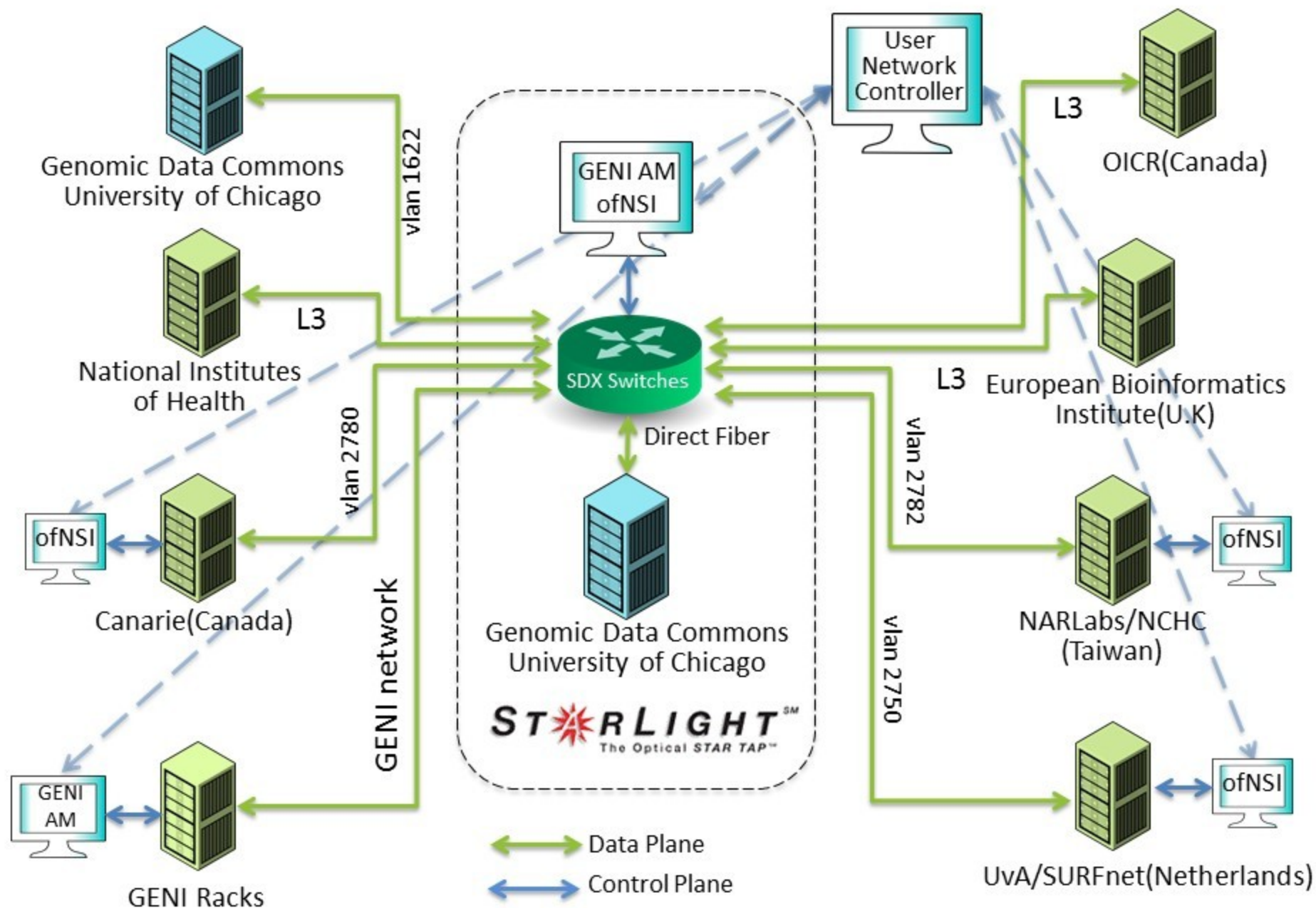


Inter-SDX federation for GEC21

Multi-architecture Federation



GEC22 Bioinformatics SDXs Demo Network



www.startap.net/starlight



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



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