Advanced Programmable Networks: A Demonstration of Software Defined Networks Over Multi-Layers, Multi-Domains, Multi-Continents OpenFlow Tesbed SC11 SRS

For the Advanced Programmable Networks Team: iCAIR/Northwestern University, National Center for High Performance Computing, LAC/University of Chicago, Communications Research Centre Canada, SARA, NCKU, KUAS, GENI, NLR, StarLight Consortium, Metropolitan Research and Education Network, GLIF, Open Cloud Consortium

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Introduction – Programmable Networks

- Programmable Networks = Instant New and Enhanced Services vs Legacy Multi-Year Schedule of Design, Development, and Deployment
  - Joint Project With Many Partners: iCAIR, iGENI, LAC, SARA, GENI, NCHC, CRC, StarLight, MREN, NLR, etc
  - iGENI Optimizes Programmable Dynamic Private Networks Consisting of Highly Distributed Resources

Context 1: Legacy Networking

- 1 Year To Define Service
- 1 Year To Define Architecture
- 1 Year To Define Technology
- 1 Year To Deploy
- N Years of Static Unchanged Implementation
- Minimal Enhancements
- Minimal Opportunities for Service Upgrades

Context 2: Advanced Programmable Networking

- Advanced =
  - Dynamic vs Static
  - Highly Customizable, Including At Edge
  - High Level of Abstractions, Including APIs
  - Flexible Middleware Processes That Can Be Dynamically Provisioned
  - Highly Distributed Processes vs Centralized Command and Control
  - Etc
- Programmable =
  - All Resource Elements As Objects
  - Discoverable/Integrateable
  - Programmability Extending To Hardware Components
  - Rich Semantics for Resource Discovery and Integration

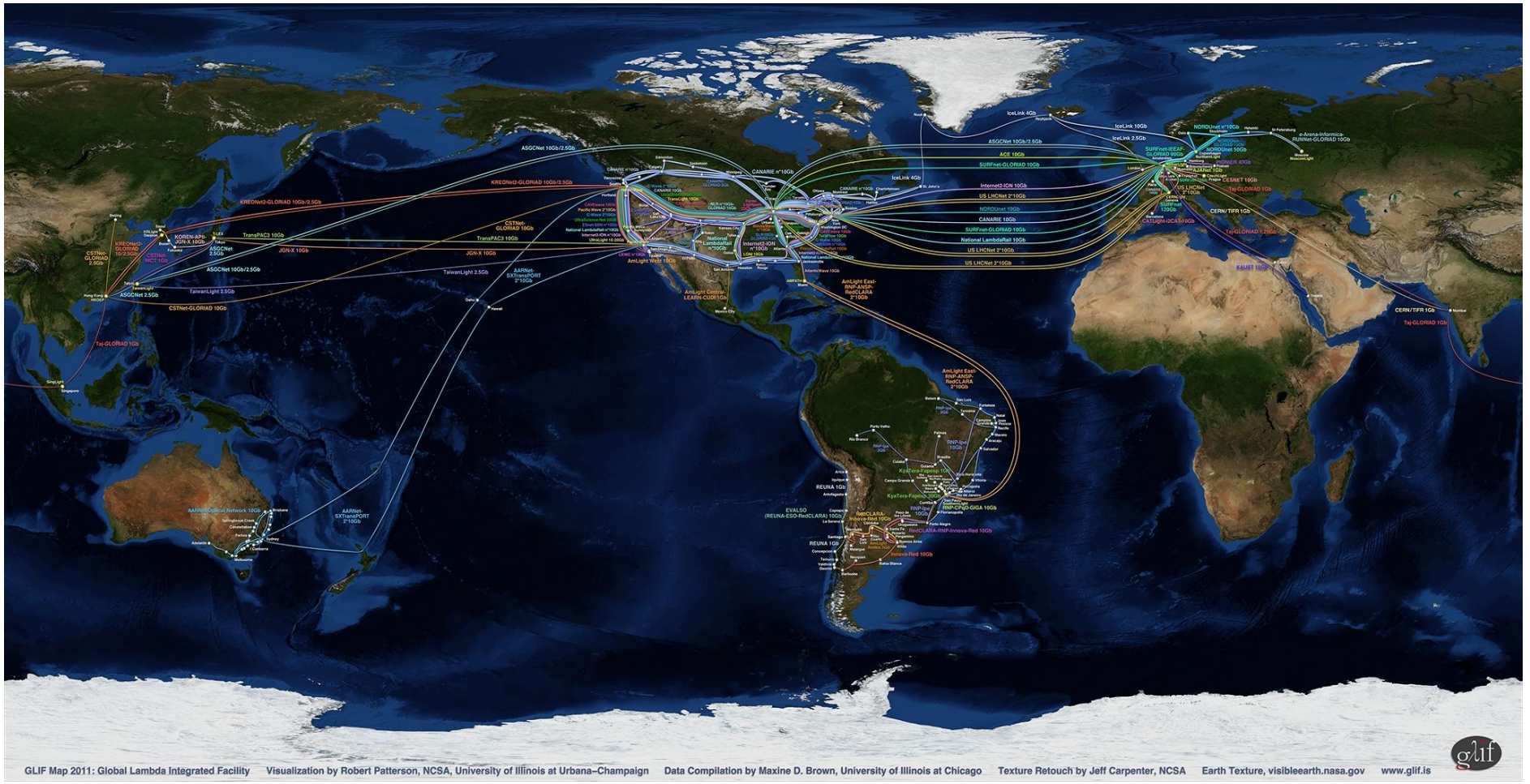
Context 3: Use Case

- Use Case: Ad Hoc Specialized Networks
- Legacy Approach: Try To Find a Provider To Create a New Communications Service (!)
- APN Approach: Create Private Network (Ref: TransCloud)
  - Private Optical Fiber/Lambdas/L2 VLANs
  - All Control Planes
  - All Management Planes
- Leverage
  - IaaS/NaaS
  - PaaS
  - SaaS
  - OaaS
  - XaaS
- More Leverage
  - Dynamic Clouds Closely Integrated With Dynamic Networks (Ref TransCloud, Note Demo At GEC10)

Use Case: Implication

- Ad Hoc Specialized Networks Can Lead To:
  - Personal Global Networks
  - Individualized Communication Services
  - Historic Note Progression From Monolithic To Individualized
    - Personal Computer vs Mainframe
    - Smart Phone vs Personal Computer
    - Intelligent Device vs Smart Phone
    - Etc.

Global Lambda Integrated Facility (GLIF)



Not a Network – A Global Programmable Facility

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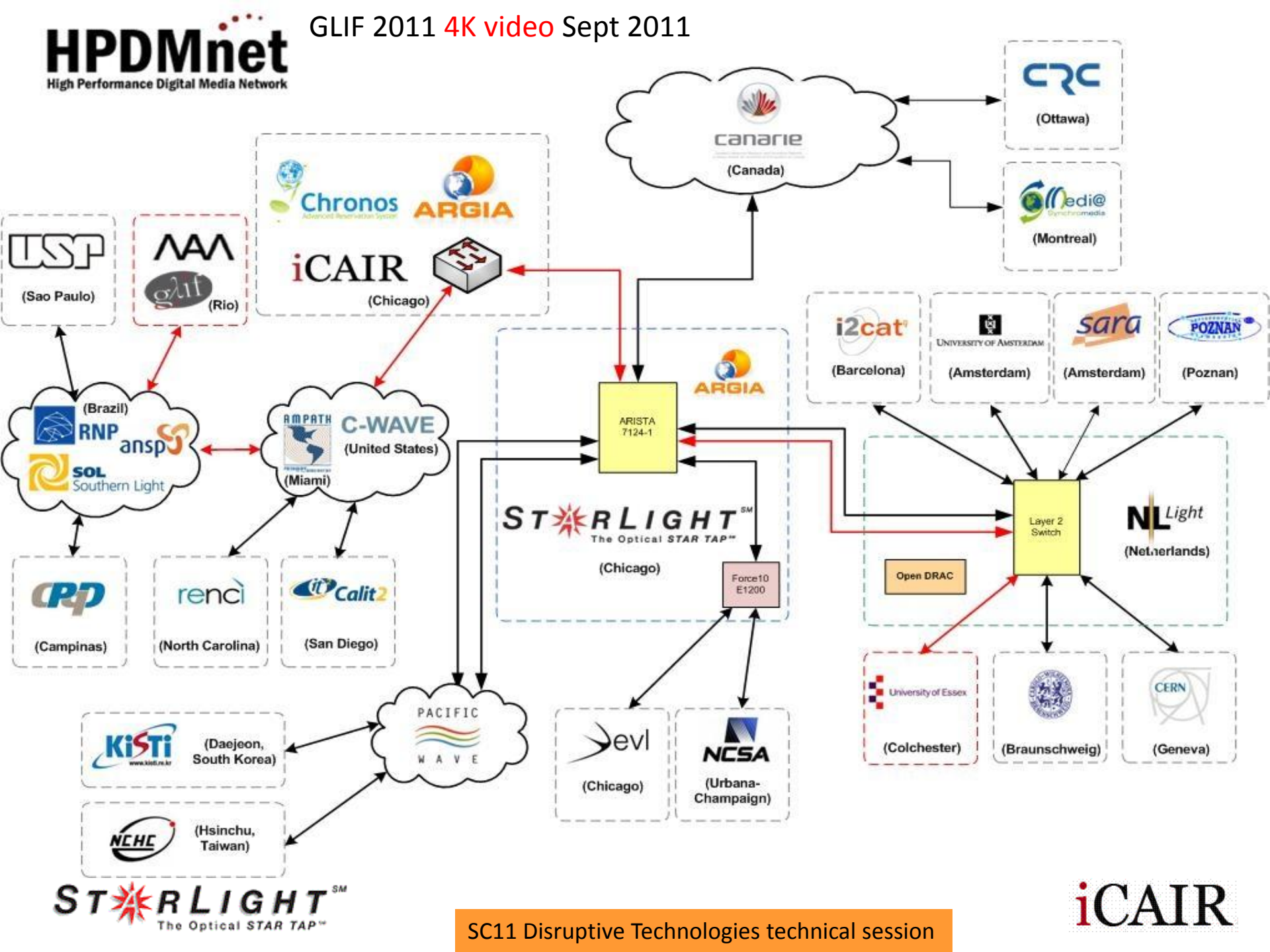
GLIF 2011 4K video Sept 2011



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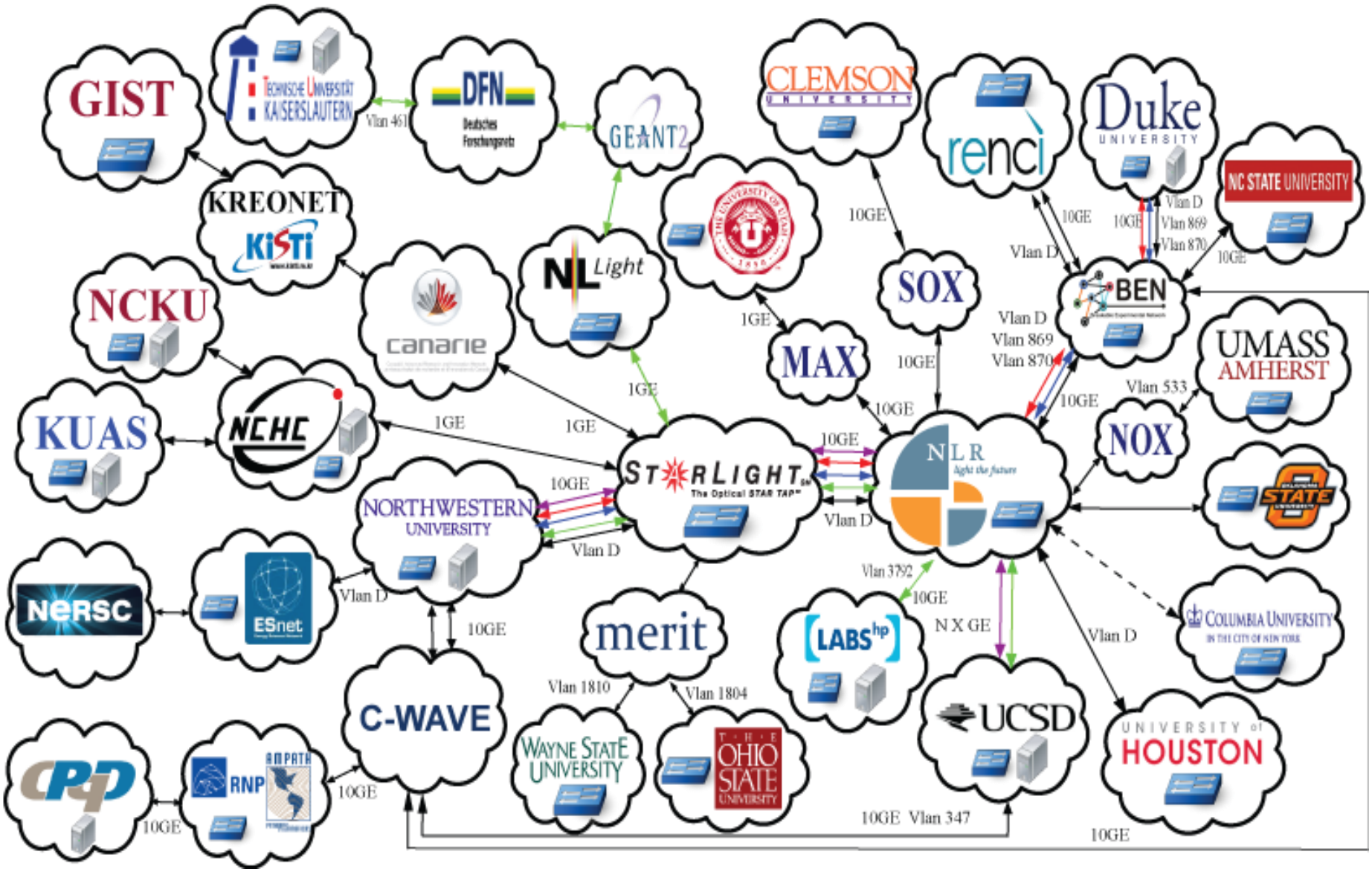
GCDnet + iGENI Partner Resources



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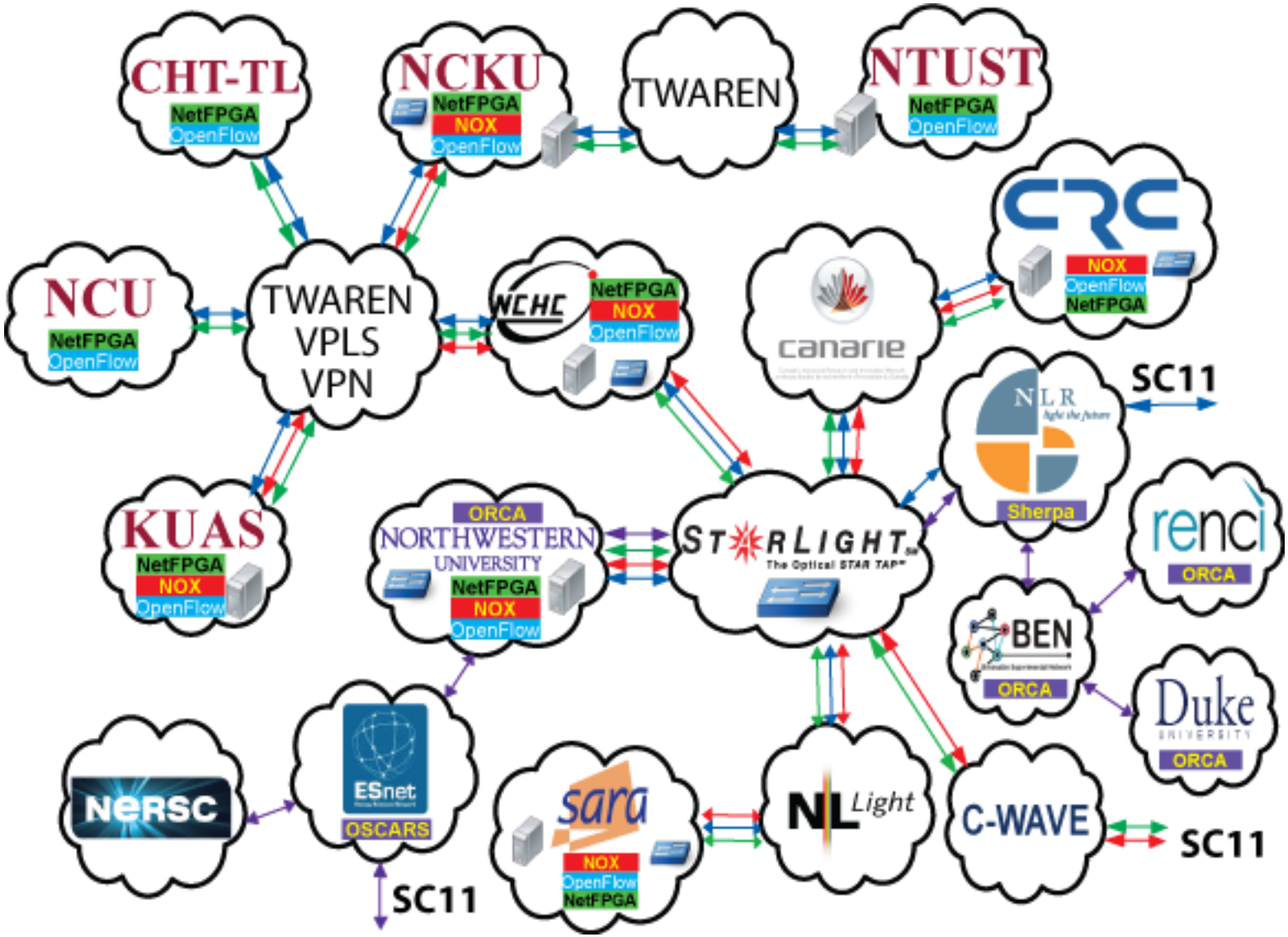
SC11 ORCA/OSCARS Demo and iCAIR Partners@**SC11** Openflow SRS Sandbox



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iCAIR & Partners Demonstrations

(Sites: International Center for Advanced Internet Research/Northwestern Univ, SARA, NCKU, KUAS, NCHC, CRC, LAC/U of Chicago)

An International Openflow Research Testbed

One Testbed, 3 Experiments, 4 countries, 5 cities

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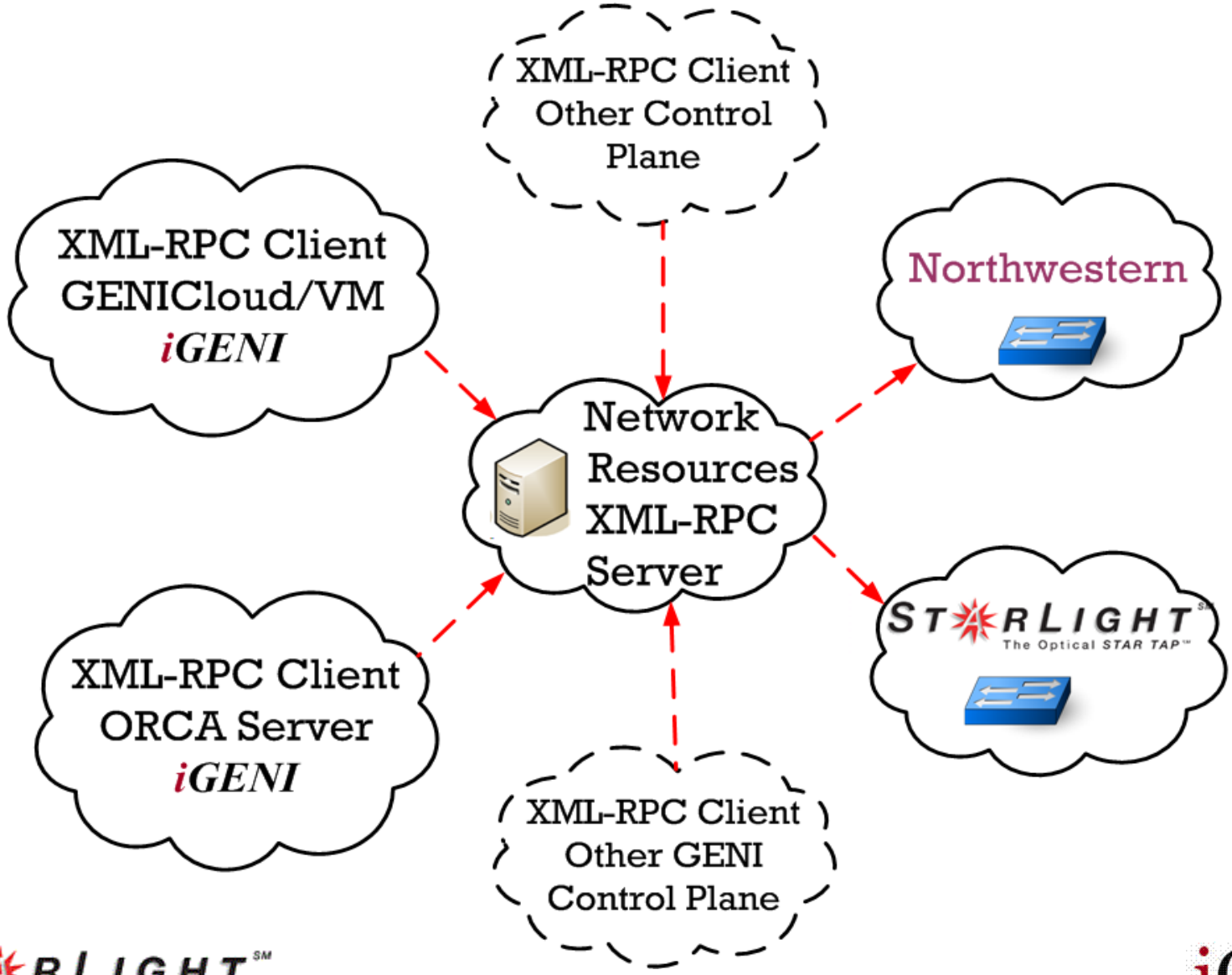
iGENI Dynamic Provisioning



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APN Overview

- 1) Current State - Partial Mesh of Paths
- 2) In Response To Dynamic Change In Requirements, Selection and Implementation of Alternative Paths Directly Via XML-RPC Client Control Over Dynamic Paths
- 3) Personnel Client Direct Control Over Switches With Embed XML-RPC Server.
- 4) Vlans/Flows Control & Test Implementation
- 5) Possible In Band or Out of Band Control
- 6) XML-RPC API For Control Plane Frameworks Or Apps Integration

APN at SC11 Openflow SRS

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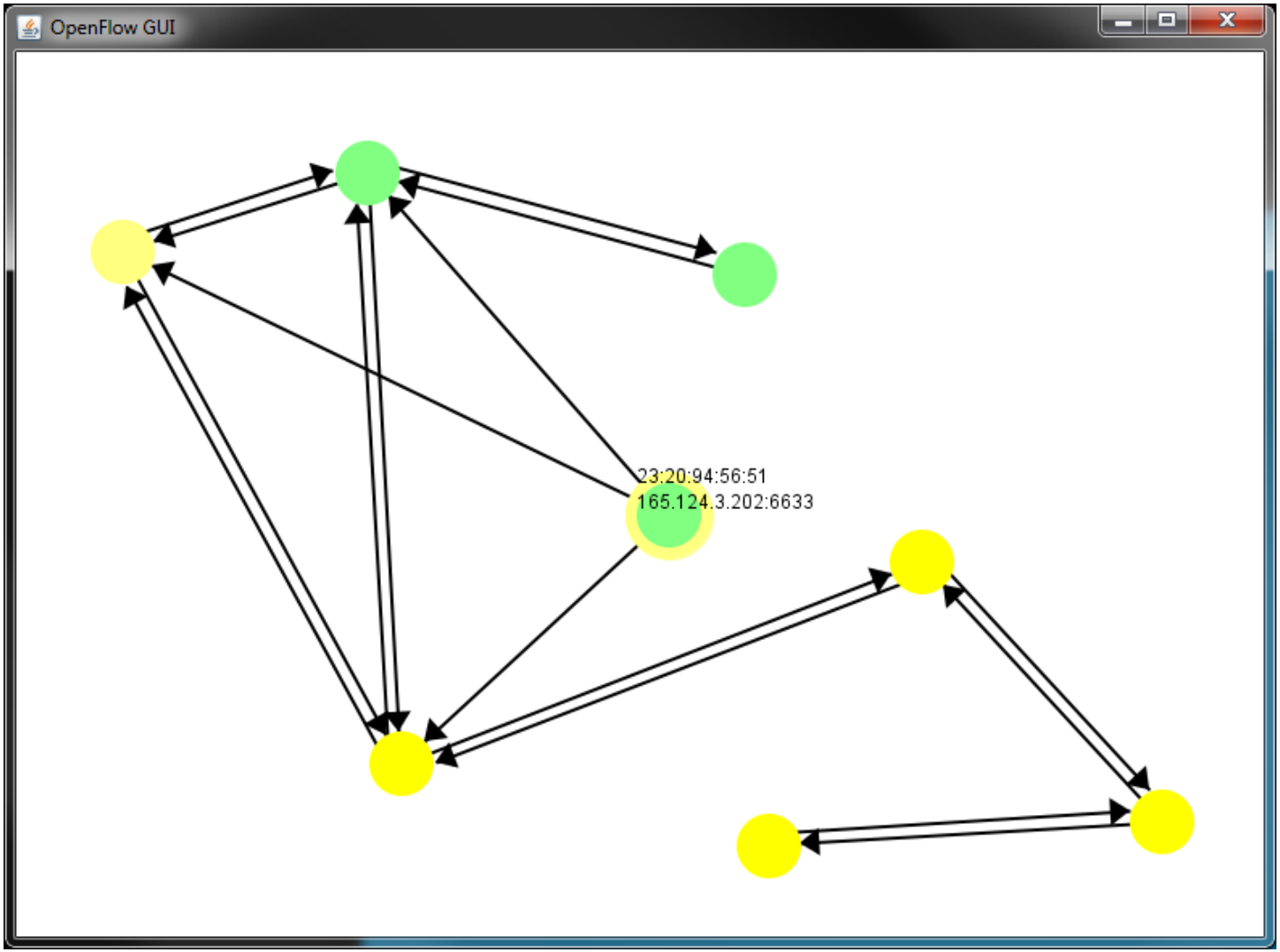
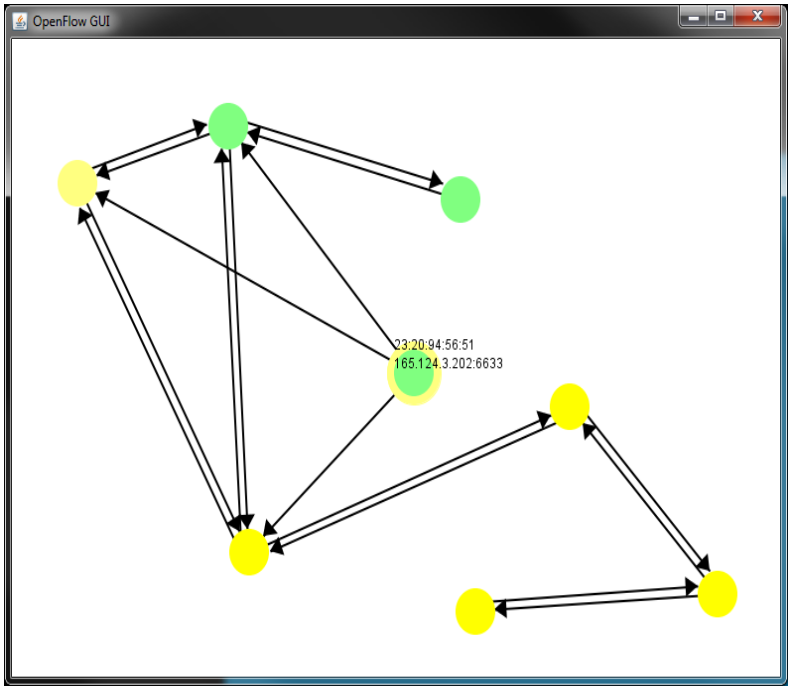
Inter-Domain LLDP Topology Discovery @ SC11 Openflow SRS



Inter-Domain Openflow Experimenter Environment @ SC11 Openflow SRS



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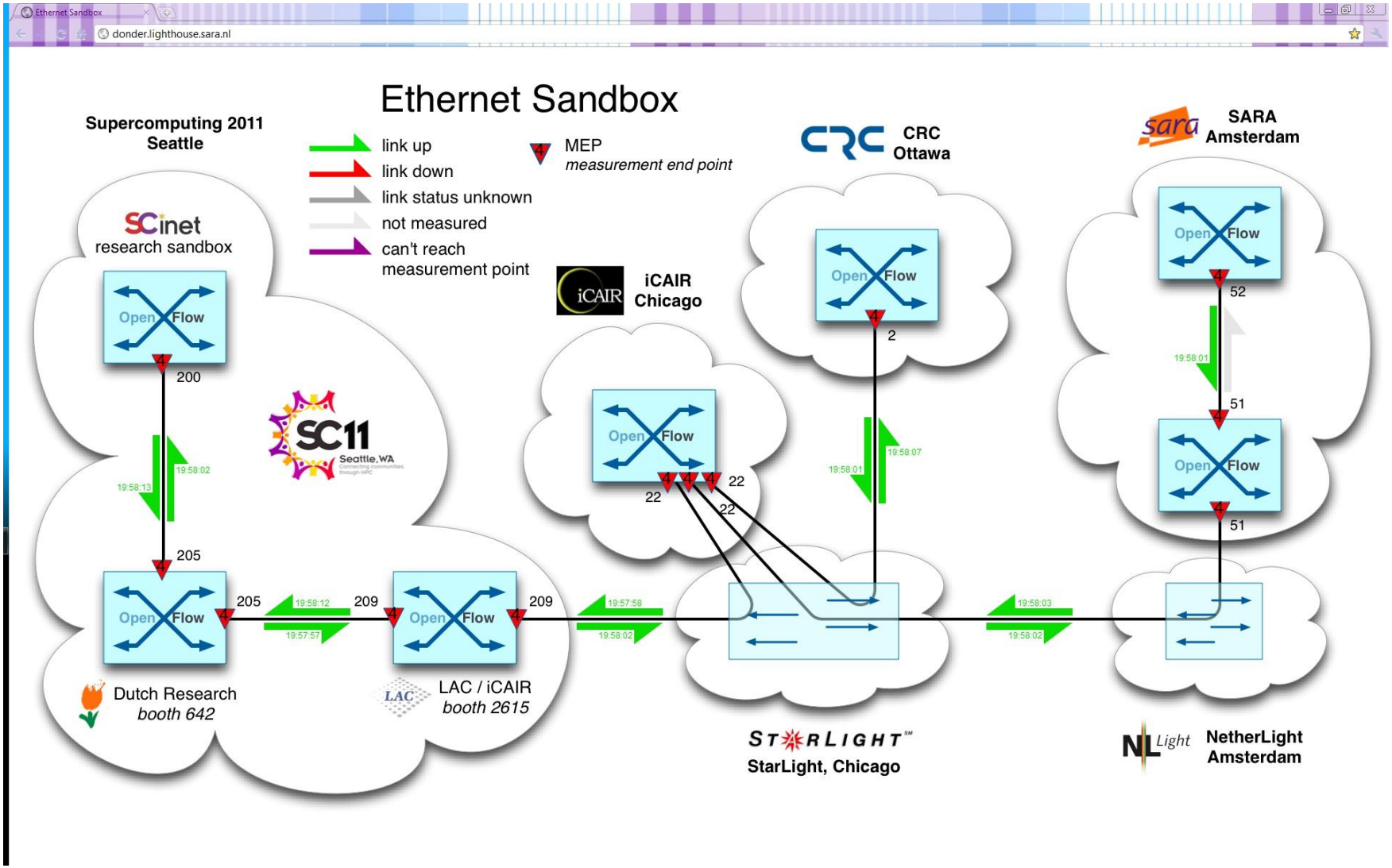
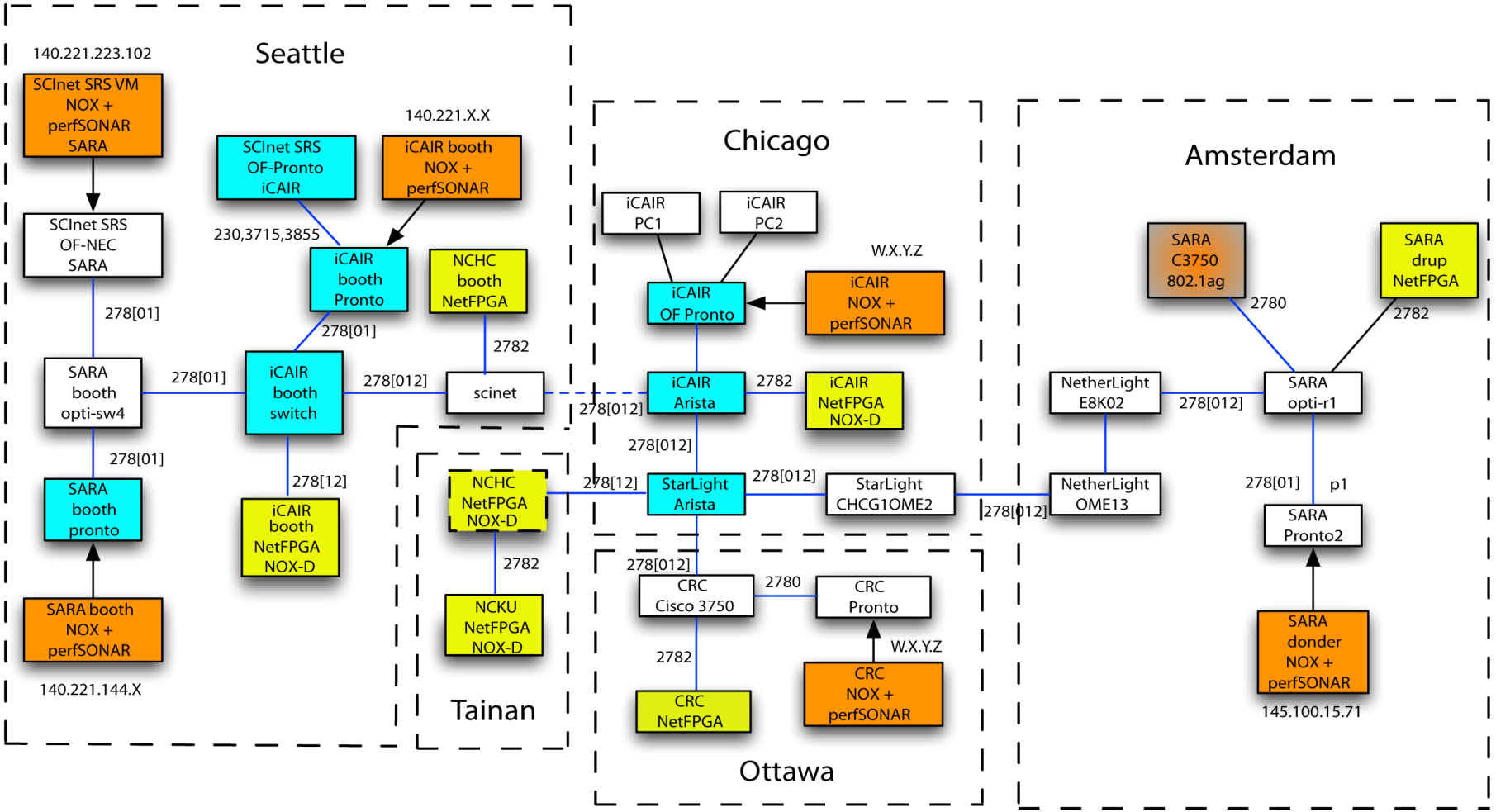
Inter-Domain Openflow Monitoring with 802.1ag @ SC11 Openflow SRS



SC11 SRS Openflow Sandbox
iCAIR And Partners Demonstration



5 Cities, 4 Countries, 3 Experiments

APN: iCAIR/Northwestern lead

802.1ag: SARA/Netherlands Lead

LLDP: NCHC/Taiwan Lead

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Summary – APN++

- Objective: Advanced User Programmable Networks
- Highly Customizable, With Individual Direct Control
- High Level APIs, Signaling, Via Client or API
- A Highly Programmable Environment
- Any Network Resource Can Be Integrated Into the Environment (Extensible)
- Abstraction Of Resources + Rich Set of Underlying Primitives

++ Integrated with:

- Openflow Inter-Domain Topology Discovery with LLDP For Openflow Research Experimenter Environment
- Inter-Domain Topology Testing/Monitoring with 802.1ag For Distributed Openflow Network testing & Monitoring

SC11 Openflow SRS
iCAIR & Partners Demonstration

- **Thanks!**
- **Questions?**
- **More Information:**
  Visit Booth 2615

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