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

GENI Engineering Conference (GEC 15)
Houston, Texas

Overview

- **A Basic Goal of This International Consortium Is To Create A Large Scale Distributed Environment (Platform) for Basic Network Science Research, Experiments, and Demonstrations.**
- **This Initiative Is Designing, Implementing, and Demonstrating An International Highly Distributed Environment (at Global Scale) That Can Be Used for Advanced Next Generation Communications and Networking.**
- **The Environment Is Much More Than "A Network" – Other Resources Include Programmable Clouds, Sensors, Instruments, Specialized Devices, and Other Resources.**
- **This Environment Is Based On Interconnections Among Major Network Research Centers Around the World**
- ***=> The Initial Concept for the "Slice Around the World" Demonstration Was Suggested By Chip Elliott!***

Initiative Motivation

- **This Project Is Inspired By Multiple Innovative Network Research Initiatives Around the World**
  - **The National Science Foundation Funded Global Environment for Network Innovations (GENI)**
  - **The European Union Future Internet Research Environment (FIRE)**
  - **The Japanese New Generation Network (NGN)**
  - **The Korean Future Internet Initiatives**
  - **G-Lab At Kaiserslautern**
  - **And Many Others.**

Implementation of Initial Environments and Staging Demonstrations

- **This Initiative Is:**
  - **A) Implementing An Initial Environment With Wide Range of Resources Around the World That Can Be Discovered, Integrated, Programmed, Utilized for Experiments, etc**
  - **B) Designing and Staging a Series of Demonstrations That Can Illustrate a The Advantages of This Highly Distributed Environment At Global Scale - That Can Showcase Next Generation Communications.**
  - **Expanding Resources and Implementing Enhancements**
- **Three Major Components To the Demonstrations**
  - **Applications/Services**
  - **A Highly Distributed, Highly Programmable Communications Environment, In Part, Based On OpenFlow**
  - **International Foundation Facilities**

Current Organizational Participants and Leads

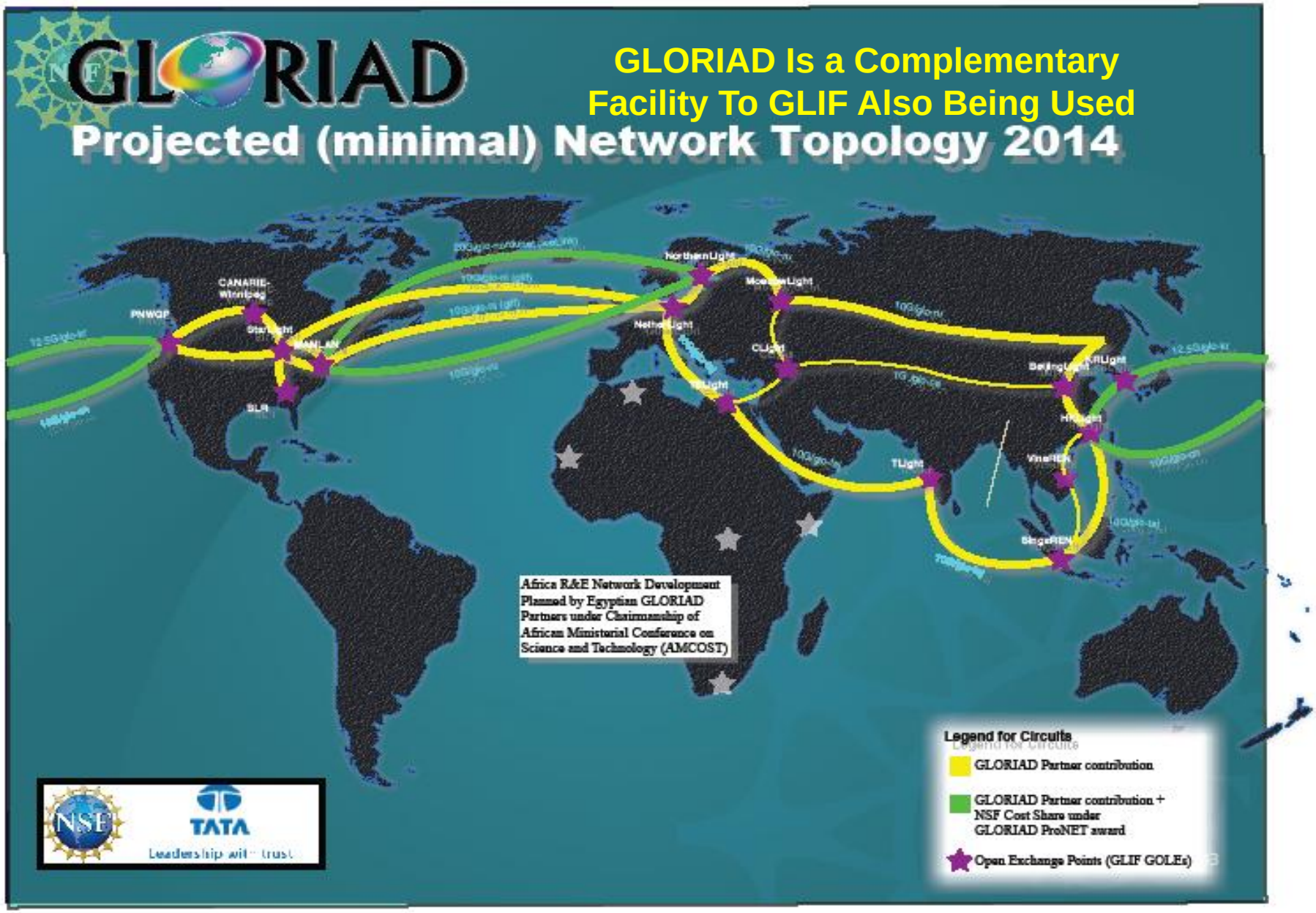
- *ANSP, São Paulo, Luis Fernandez Lopez*
- *Applied Research Center for Computer Network at Skolkovo, Moscow, Ruslan Smeliansky*
- *Centro de Pesquisa e Desenvolvomento de Telabras, São Paulo, Marcos Rogerio Salvador*
- *Canadian Communications Research Centre, Ottawa, Scott Campbell*
- *Computer Network Information Center, Chinese Academy of Sciences, Beijing,* Jungling Yu
- *Duke University, Durham, Jeff Chase*
- *Electronic and Telecommunications Institute, Daejeon, Myung-Ki Shin*
- *HP Research Labs, Palo Alto, Rick McGeer*
- *International Center for Advanced Internet Research, Northwestern University, Chicago, Joe Mambretti, Jim Chen*
- *Korea Institute of Science and Technology Information, Daejeon, Dongkyun Kim*
- *National Center for High-Performance Computing of Taiwan, Tainan, Te-Lung Liu*
- *National Cheng-Kung University, Tainan, Chu-Sing Yang*

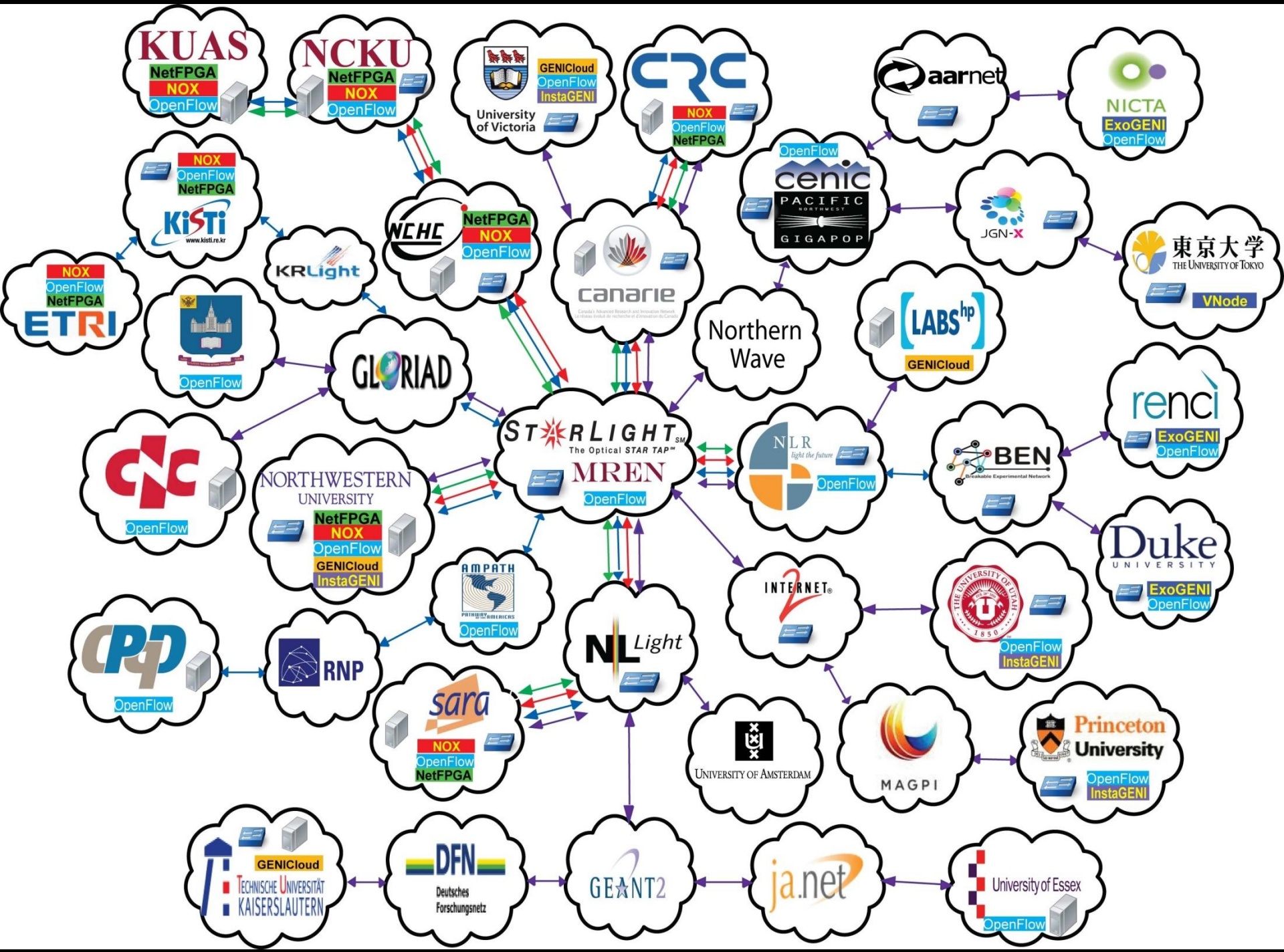
Current Participants

- *National Institute of Information and Communications Technology, Tokyo, Aki Nakao*
- *National Kao Hsiung University of Applied Science, Kaohsiung, Mon-Yen Lou*
- *NICTA, Australia, Max Ott*
- *Princeton University, Princeton, Andy Bavier*
- *Rede Nacional de Ensino e Pesquisa, Brazil, Michael Stanton*
- *Renaissance Computing Institute (RENCI), Chapel Hill, Ilia Baldine*
- *SARA, Amsterdam, Ronald van der Pol*
- *Technische Universitat Kaiserslautern, Kaiserslautern, Paul Muller*
- *University of Amsterdam, Cees de Laat*
- *University of Essex, Colchester, Martin Reed*
- *University of Tokyo, Tokyo, Aki Nakao*
- *University of Utah, Salt Lake City, Rob Ricci*

The Global Lambda Integrated Facility (GLIF) Provides Advanced Resources and Facilities for Research

The Slice Around the World Demonstration Was Staged at the Annual GLIF Meeting, Which Was in Chicago, Oct 11-12, 2012

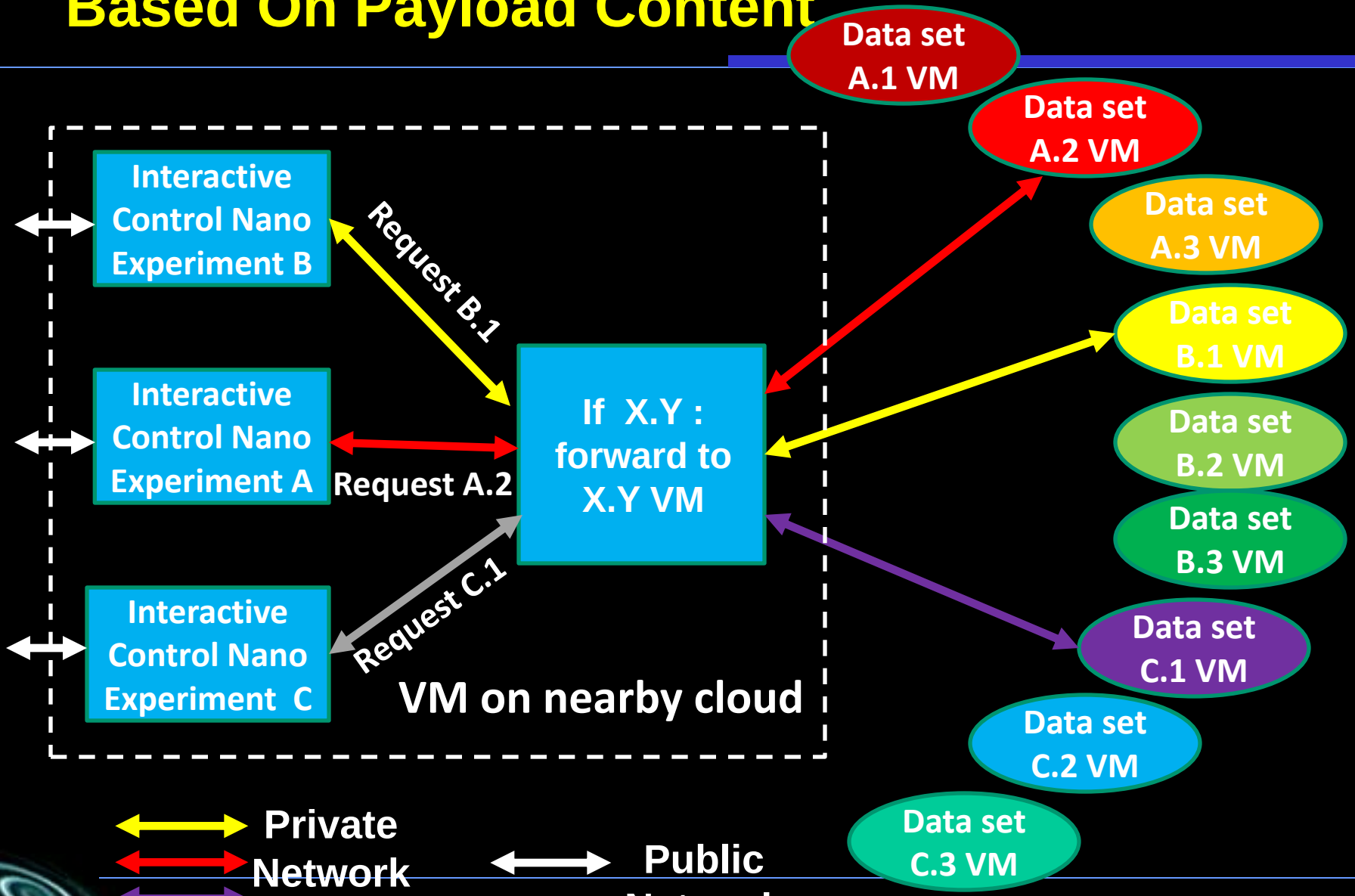

GLORIAD
GLORIAD Is a Complementary Facility To GLIF Also Being Used
Projected (minimal) Network Topology 2014
CANARIE-Winnipeg
PNWGP
StarLight
MANLAN
SLR
NorthernLight
NetherLight
CLight
TLight
MoscowLight
BeijingLight
KRLight
HKLight
VnnREN
SingAREN
Africa R&E Network Development Planned by Egyptian GLORIAD Partners under Chairmanship of African Ministerial Conference on Science and Technology (AMCOST)
Legend for Circuits
GLORIAD Partner contribution
GLORIAD Partner contribution + NSF Cost Share under GLORIAD ProNET award
Open Exchange Points (GLIF GOLEs)
NSF
TATA
Leadership with trust


KUAS
NetFPGA
NOX
OpenFlow
NCKU
NetFPGA
NOX
OpenFlow
University of Victoria
GENICloud
OpenFlow
InstaGENI
CRC
NOX
OpenFlow
NetFPGA
aarnet
NICTA
ExoGENI
OpenFlow
NOX
OpenFlow
NetFPGA
KiSTi
www.kisti.re.kr
NCHC
NetFPGA
NOX
OpenFlow
OpenFlow
cenic
PACIFIC NORTHWEST GIGAPOP
JGN-X
東京大学
THE UNIVERSITY OF TOKYO
VNode
NOX
OpenFlow
NetFPGA
ETRI
KRLight
canarie
OpenFlow
GLORIAD
Northern Wave
LABS hp
GENICloud
renci
ExoGENI
OpenFlow
CNC
OpenFlow
STARLIGHT
The Optical STAR TAP
MREN
OpenFlow
NLR
light the future
OpenFlow
BEN
Breakable Experimental Network
NORTHWESTERN UNIVERSITY
NetFPGA
NOX
OpenFlow
GENICloud
InstaGENI
AMPATH
PATHWAY TO THE AMERICAS
OpenFlow
Duke
UNIVERSITY
ExoGENI
OpenFlow
INTERNET2
THE UNIVERSITY OF UTAH
1850
OpenFlow
InstaGENI
CPqD
OpenFlow
RNP
NLLight
sara
NOX
OpenFlow
NetFPGA
UNIVERSITY OF AMSTERDAM
MAGPI
Princeton University
OpenFlow
InstaGENI
GENICloud
TECHNISCHE UNIVERSITÄT KAISERSLAUTERN
DFN
Deutsches Forschungsnetz
GÉANT2
ja.net
University of Essex
OpenFlow

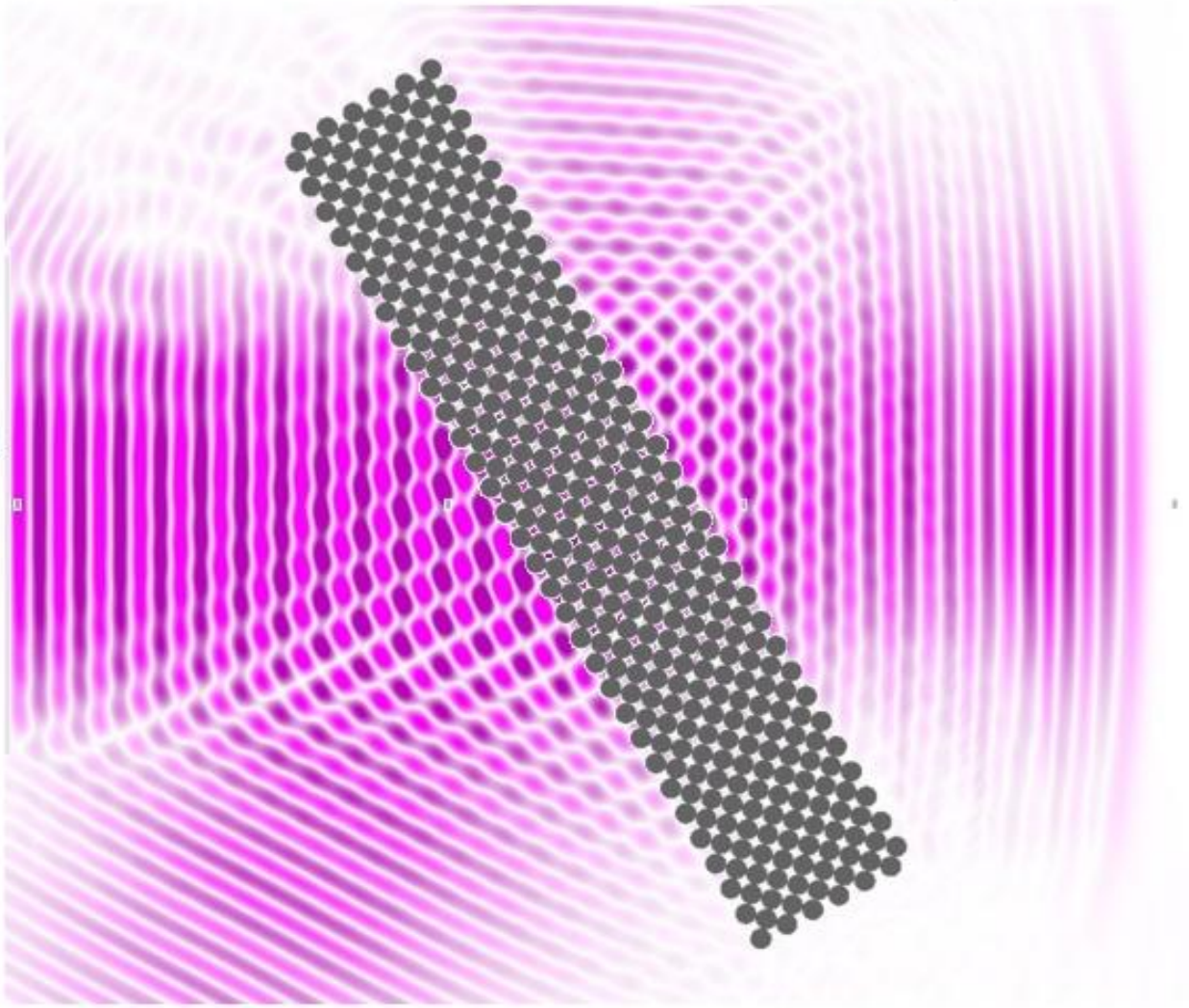
Initial Selected Application: Scientific Visualization For Nanotechnology –Viewing Scope For Invisible Objects

- Creating A Viewing Scope for Invisible Objects
- Based on Ad Hoc Networking Provisioning and Use
- Dynamic Change Including for Rendering in Real Time (e.g., Incorporates Real-Time Data Viewing/Steering)
- Demonstrates Capabilities Not Possible to Accomplish Today Using the General Internet or Standard R&E Networks
- Customizable Networking Specific To Application Requirements -- at Network Edge.
- Resolves A Real Current Challenge, Although The Platform Is Oriented to Providing Suites Of Capabilities

Slice Using Forwarding Rules Based 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

TransCloud Experiments and Demonstrations

Alvin AuYoung, Andy Bavier, Jessica Blaine, Jim Chen, Yvonne Coady, Paul Muller, Joe Mambretti, Chris Matthews, Rick McGeer, Chris Pearson, Alex Snoeren, Fei Yeh, Marco Yuen

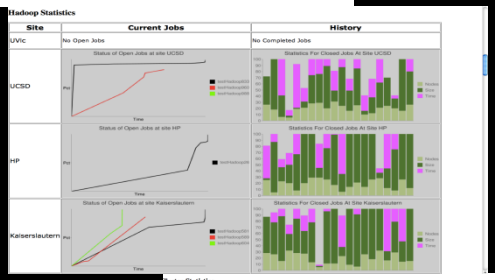
TransCloud Today

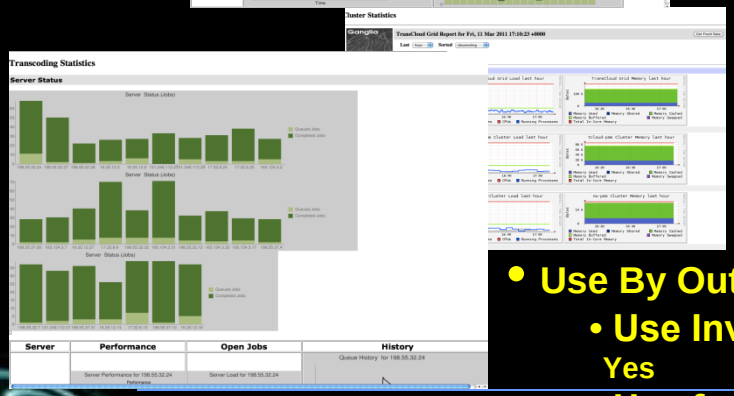
TransCloud: Based on iGENI and GENICloud

- Transcontinental Federation of Cloud Systems
- Slice-Based Federation Architecture for sign on and trans-cluster slice management
- SFA cluster manager at each site
  - Currently, enhanced Eucalyptus
- Private 10 Gb/s transcontinental network linking sites
  - Thanks to GLIF, NLR, NetherLight, CAVEWave, StarLight, DFN

Roadmap

- Accept experimenters ***now***
- Federation expansion
  - TU Amsterdam immediately
  - Brazil, Asia by July
  - All interested parties at any time
- Full integration with PlanetLab Control Framework (July)
- High-level programming environment based on RePy and NaCl
- High-level distributed query environment





Example of working in the TransCloud

[1] Build trans-continental applications spanning clouds:

- **Distributed query application based on Hadoop/Pig**
- **Store archived Network trace data using HDFS**
- **Query data using Pig over Hadoop clusters**

[2] Perform distributed query on TransCloud, which currently spans the following sites:

- **HP OpenCirrus**
- **Northwestern OpenCloud**
- **UC San Diego**
- **Kaiserslautern**

- **Use By Outside Researchers? Yes**
  - **Use Involving Multiple Aggregates? Yes**
  - **Use for Research Experiments? Yes**

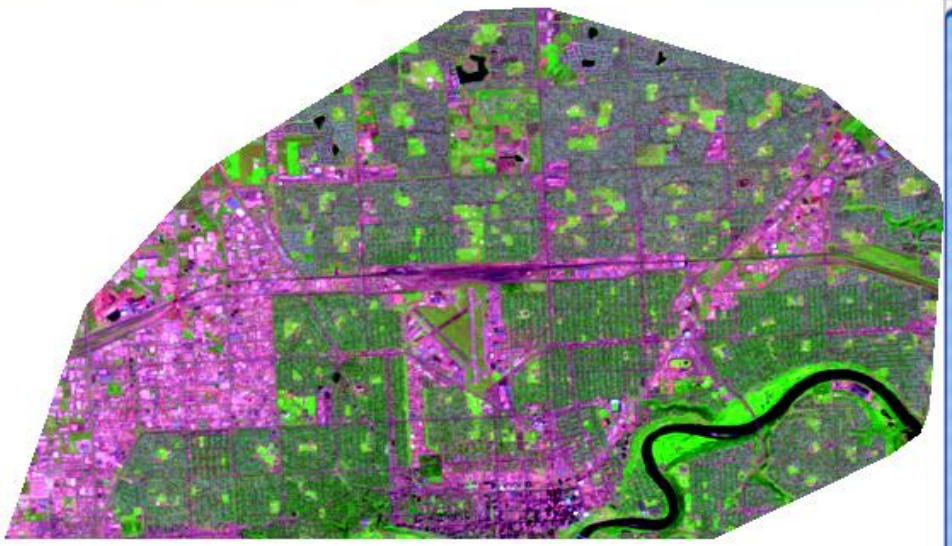
Also Ref: Experiments in High Perf Transport at GEC 7

Demo: http://tcdemo.dyndns.org/

TransGeo: An Open, Distributed, Federated GIS/System Cloud –Rick McGeer Chris Matthews et al

- GIS Data Is Large, Collected By Many Sources, Needed All Over the World
- Use Today Is Mostly Desktop Fat Clients (Quantum GIS, ESRI)
- Many Want to Compute in the Cloud
- Open and Available To Everyone
- Distributed Swift as Federated Store
- Distributed Disco as MapReduce Computation Engine
- Open-Source Standard Tools For Point Computation (GRASS, GDAL)

green.cities.trans-cloud.net:8080/geoserver/www/maps/view.html



GreenCities Demo

A demonstration of TransGeo, an open-source multisite GIS Cloud developed at the University of Victoria

Big Data jobs are a key use case for federating clouds at multiple sites. In this project, we are developing a prototype open-source system to demonstrate Big Data processing at multiple sites. This system uses a single PostGIS database as a repository for meta-data, and landsat (or other) satellite image data in Swift repositories, and distributed Disco jobs to do the analysis

bing™

Image courtesy of NASA © 2012 Microsoft Corporation

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GRASS-6.4.2-5-Snow.dmg

Show All

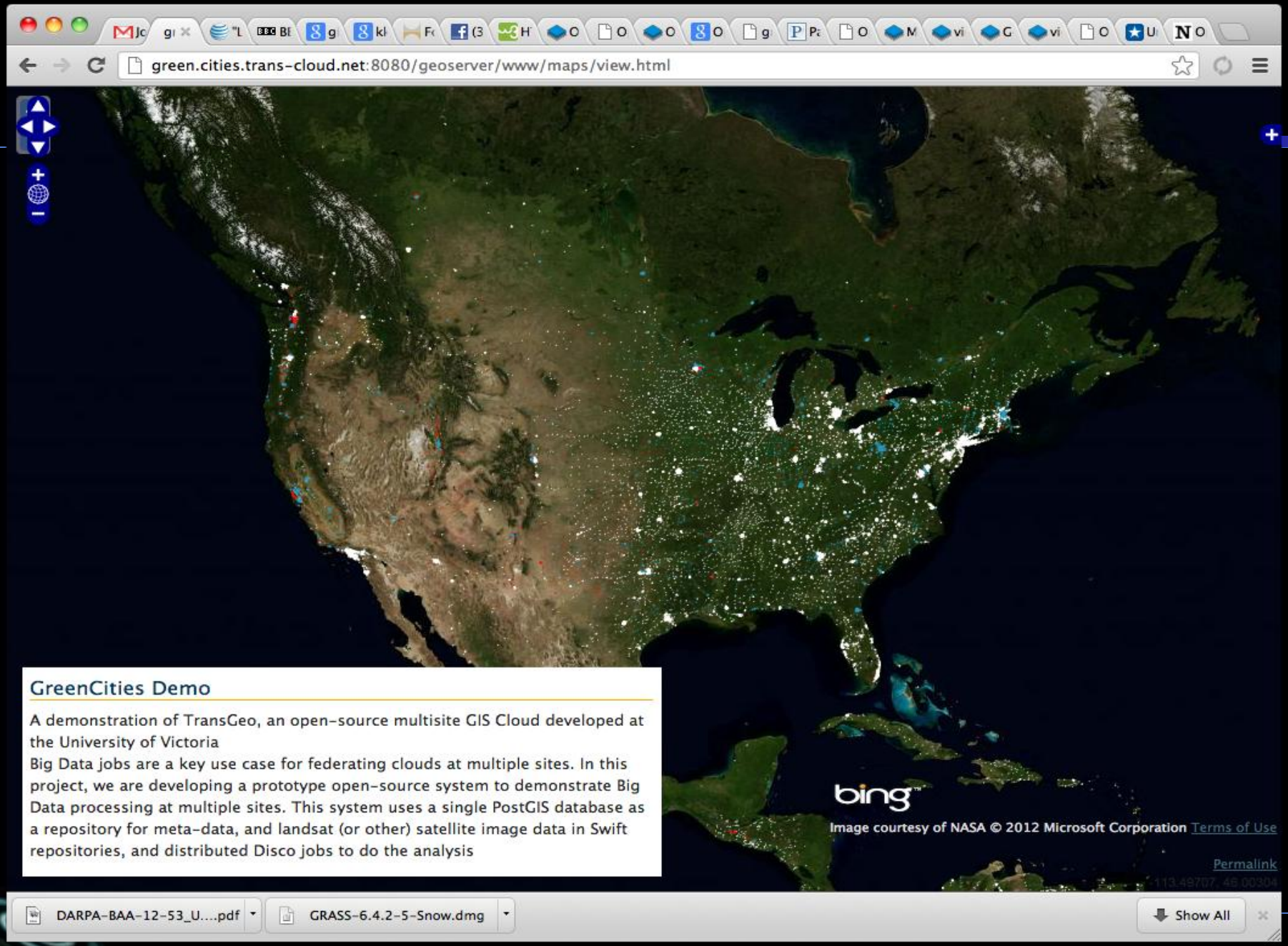
green.cities.trans-cloud.net:8080/geoserver/www/maps/view.html
GreenCities Demo
A demonstration of TransGeo, an open-source multisite GIS Cloud developed at the University of Victoria
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Image courtesy of NASA © 2012 Microsoft Corporation Terms of Use
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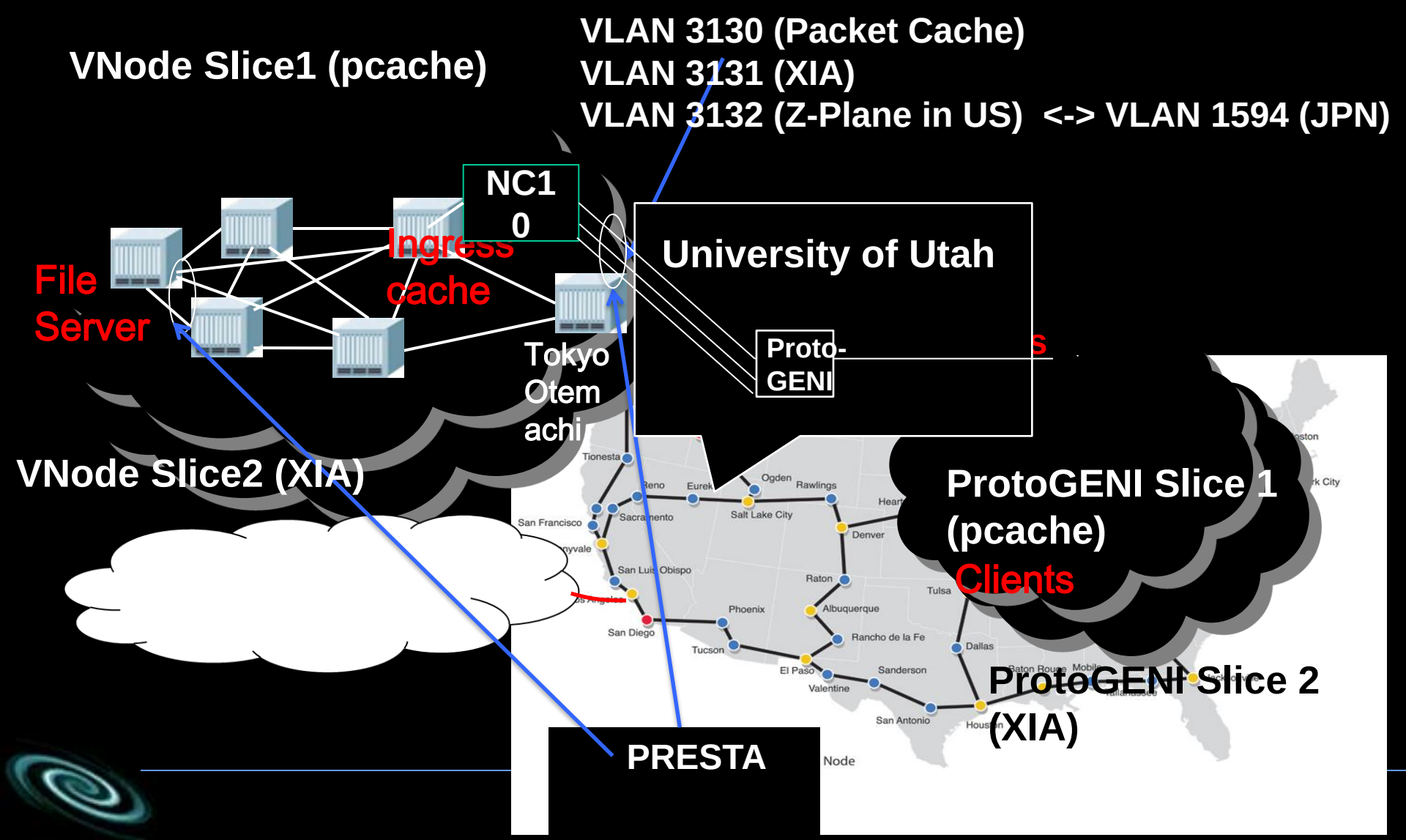
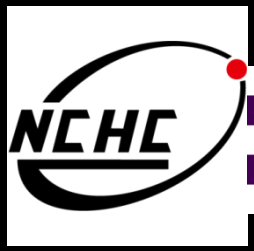
GRASS-6.4.2-5-Snow.dmg
Show All

Aki's Packet Cache and XIA



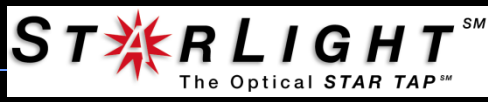
SC12 SRS: International OpenFlow Experimental Network Testbed

Joe Mambretti, Jim Chen, Fei Yeh, iCAIR
Martin Reed, Xuan Du, Elliott Thompson, Vassilios Vassilakis UoEssex
Te-Lung Liu, NCHC, Taiwan
Mon-Yen Luo, KUAS, Taiwan, Chu-Sing Yang, NCKU, Taiwan
Ronald van der Pol, Sander Boele, Freek Dijkstra, SARA
Artur Barczyk, Azher Mughal, Caltech
Michael Bredel, Ramiro Voicu, Caltech
Gerben van Malenstein, SURFnet



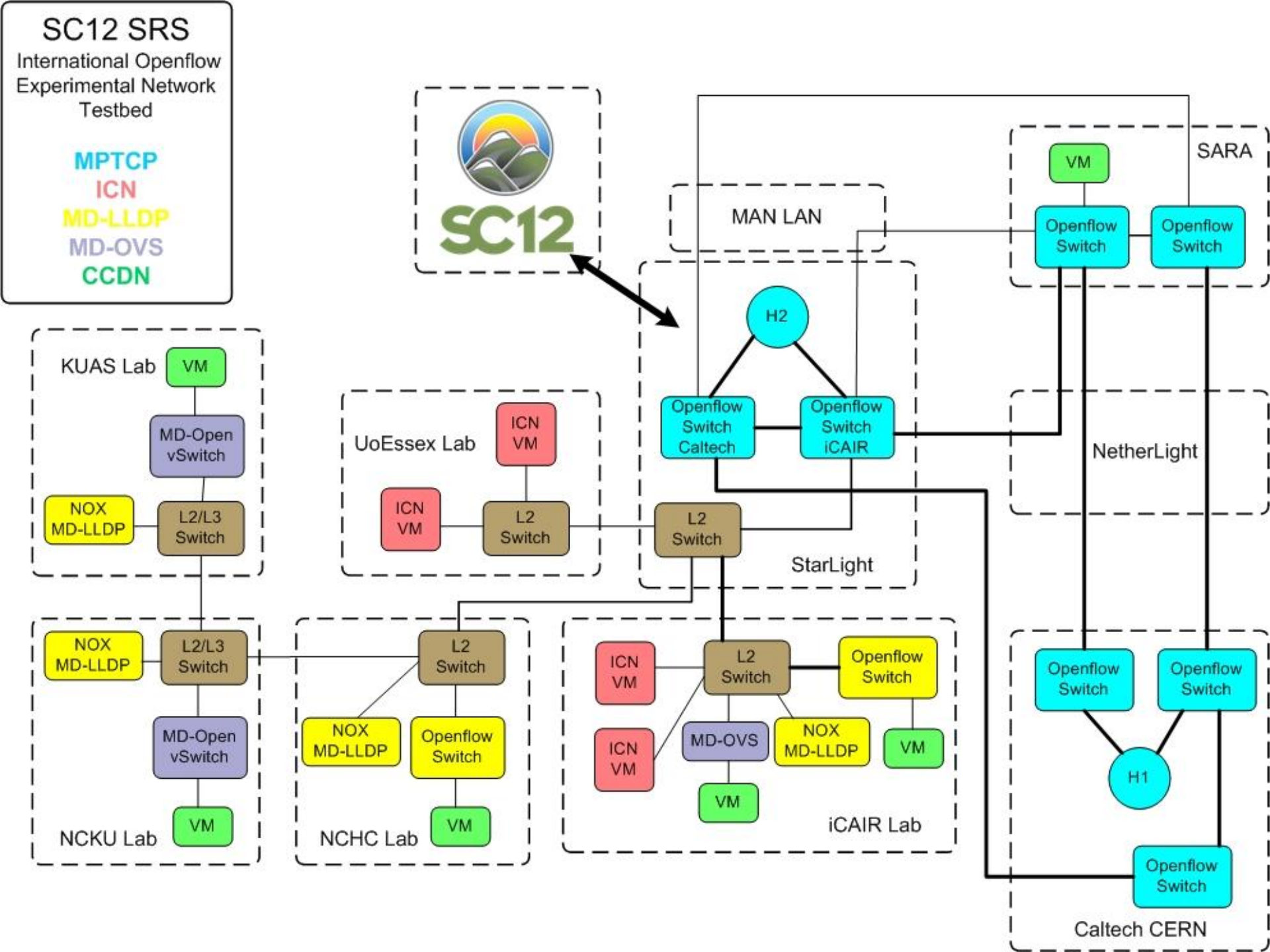
MREN

GLIF



Selected Demonstrations Will Be Showcased at SC12

- SC12 Provides An Excellent Venue for Large Scale Experimental Networking and Demonstrations
- Large Bandwidth Capacity Brought To Conference Center (Multiple 100 Gbps Paths)
- SCINet Conference Network (100 G Available)
- SCINet Supports An OpenFlow Network
- Dark Fiber Provided As An Option
- An International OpenFlow Testbed Is Being Provisioned For SC12
- ***A Paper on This International Experimental/Demonstration Testbed Was Accepted By SC Proceedings***


SC12 SRS
International Openflow Experimental Network Testbed
MPTCP
ICN
MD-LLDP
MD-OVS
CCDN
SC12
MAN LAN
SARA
VM
Openflow Switch
Openflow Switch
H2
Openflow Switch Caltech
Openflow Switch iCAIR
NetherLight
KUAS Lab
VM
MD-Open vSwitch
NOX MD-LLDP
L2/L3 Switch
UoEssex Lab
ICN VM
ICN VM
L2 Switch
L2 Switch
StarLight
NOX MD-LLDP
L2/L3 Switch
MD-Open vSwitch
VM
NCKU Lab
L2 Switch
NOX MD-LLDP
Openflow Switch
VM
NCHC Lab
ICN VM
ICN VM
L2 Switch
Openflow Switch
MD-OVS
NOX MD-LLDP
VM
VM
iCAIR Lab
Openflow Switch
Openflow Switch
H1
Openflow Switch
Caltech CERN

Multiple Experiments Share A Persistence International Openflow Testbed

- **MPTCP: Multi-Path TCP**

Lead: SARA, Surfnet, Caltech, CERN

- **ICN: Information Centric Networking**

Lead: University of Essex

- **MD-LLDP: Multi-Domain Openflow Topology Discovery and Management with LLDP**

Lead: NCHC, Taiwan

- **ML-OVS: Multi-Layers Open vSwitch networking**

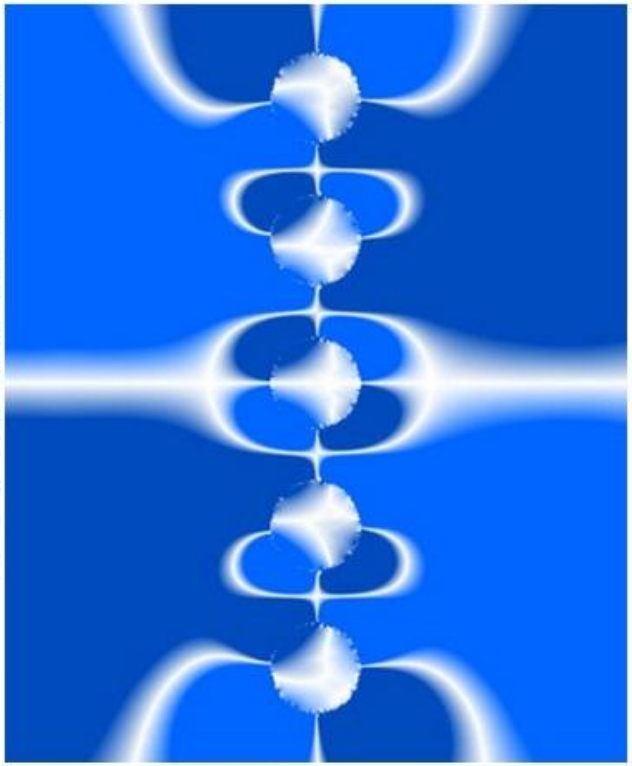
Lead: KUAS, NCKU, Taiwan

- **CCDN: Content Centric Distributed Network**

Lead: iCAIR

Content Centric Distribution Network

Silver nano chain simulation



Click the picture to zoom in (picture will appear in a new window)

1. Choose the color of light source. Wavelength appears in nm

Indigo (460 **nm)**

300 nm 700

Electric Field

\- 0 +

2. Choose particle radius (in nanometers)

particle radius is 35 **nm**

5 nm 40

3. Choose distance between nanoparticles in nm

gap is 40 **nm**

0 nm 50

4. Choose Type of simulation

Type is Ey Only

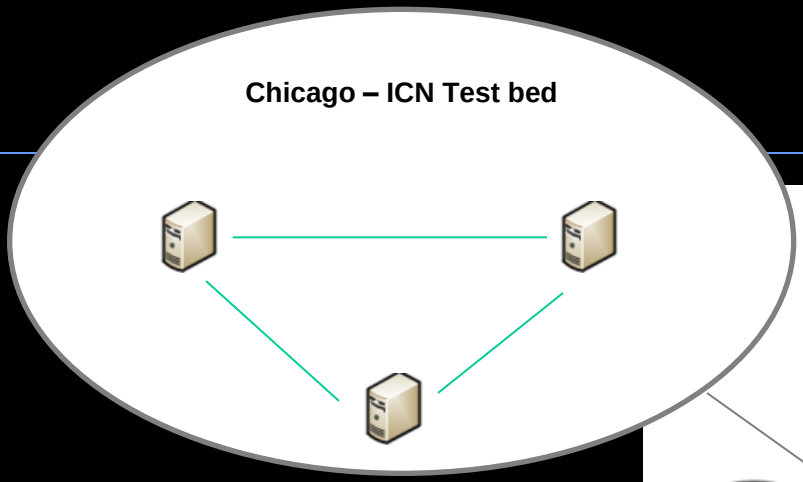
Energy Ex only Ey only

5. Watch the animation

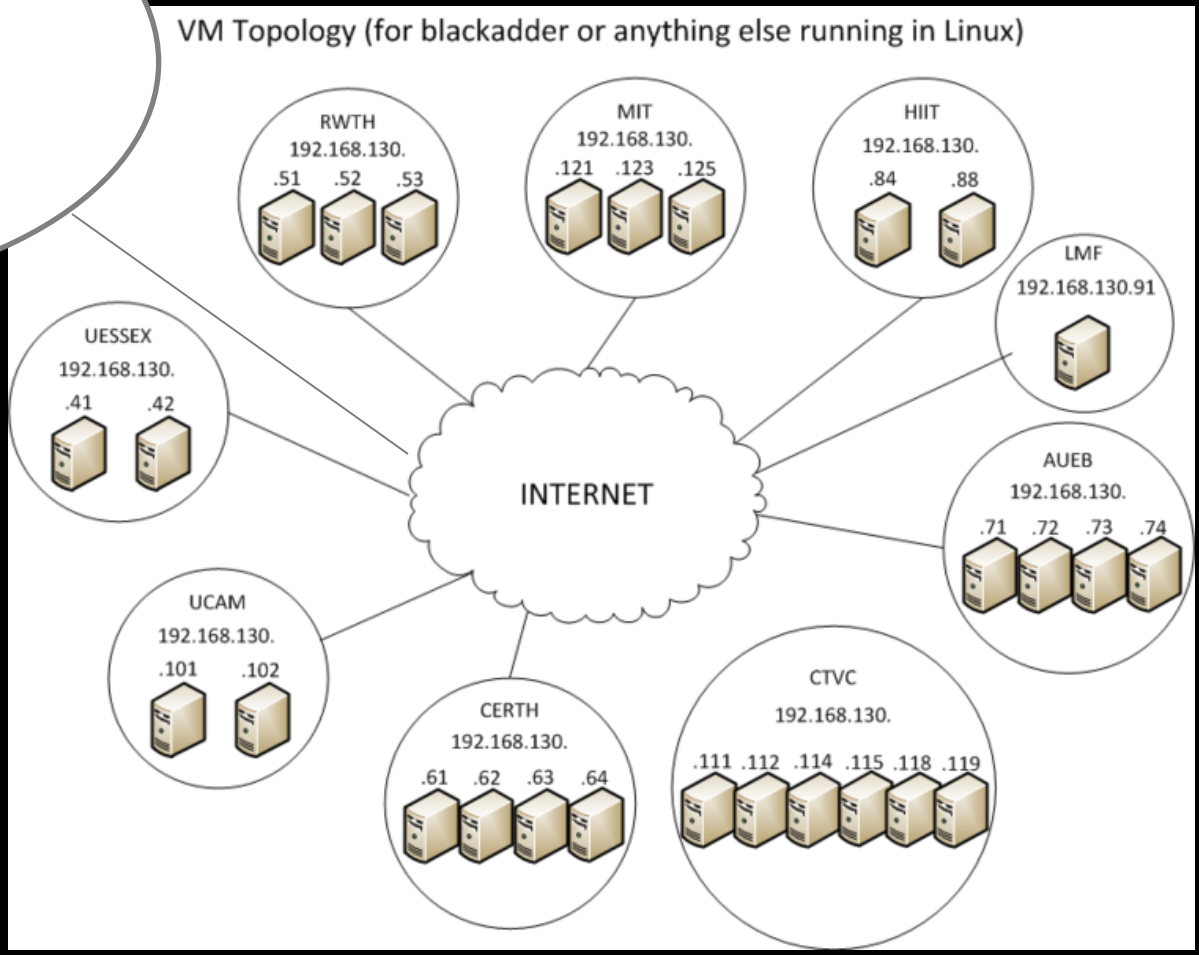
1 **Frame # 37 , time is 5.55 fs** 37

> ||

Information Centric Network



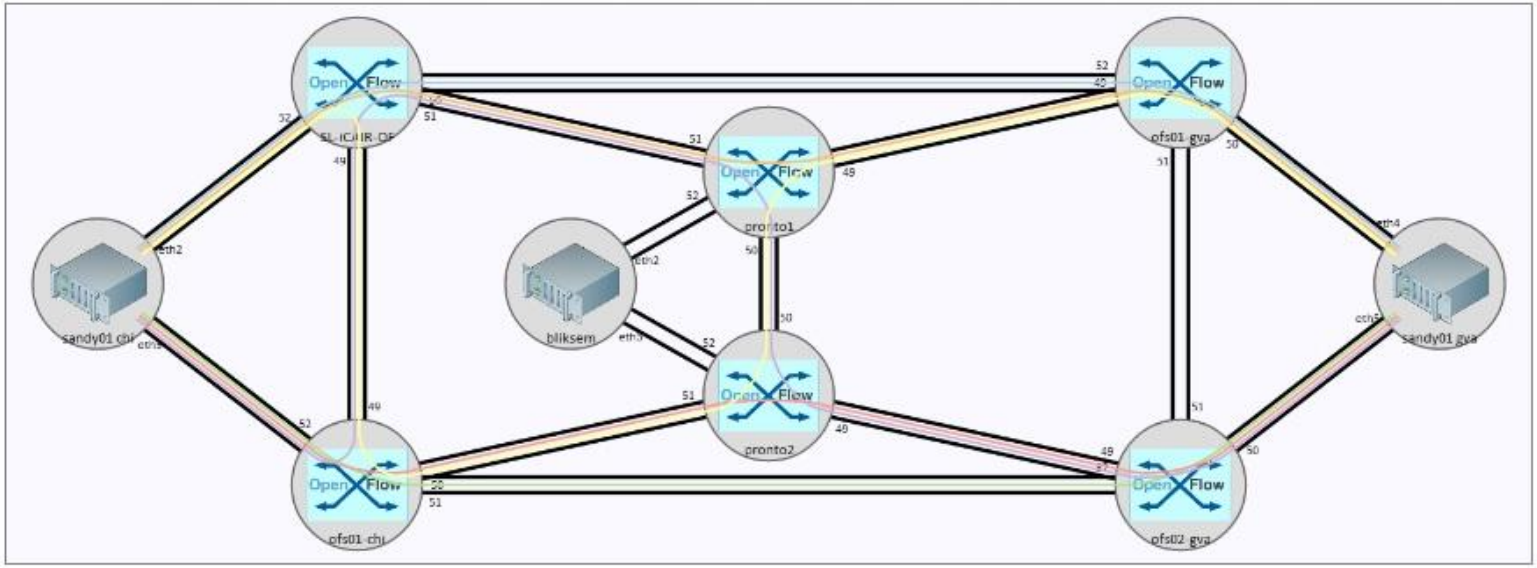
Beyond IP -- Content Routed Networking



Slide Provide by University of Essex

Paper on This Experiment/Demonstrated Accepted By SC Proceedings

Multipath TCP streaming from Geneva to Chicago over OpenFlow controlled paths



Demo partners:

iCAIR

sara

SURFNET

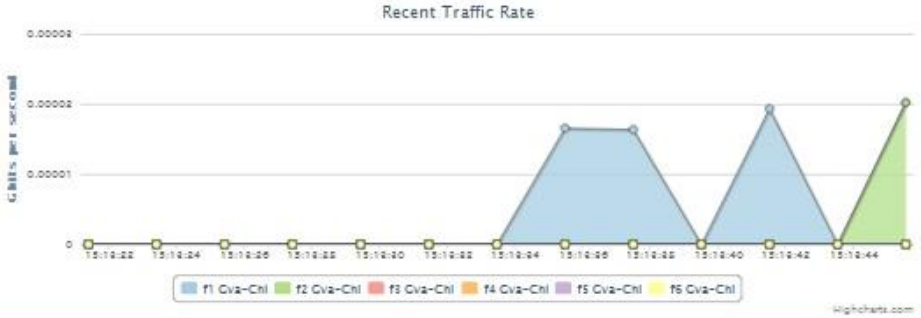
Current Traffic Rate

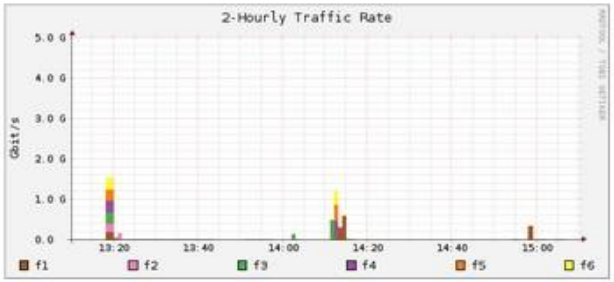
Name	Bandwidth
f1 Gva-Chi	0.00 b/s
f2 Gva-Chi	20.22 kb/s
f3 Gva-Chi	0.00 b/s
f4 Gva-Chi	0.00 b/s
f5 Gva-Chi	0.00 b/s
f6 Gva-Chi	0.00 b/s
Total	20.22 kb/s

Reset to defaults

Start Measurements

Stop Measurements

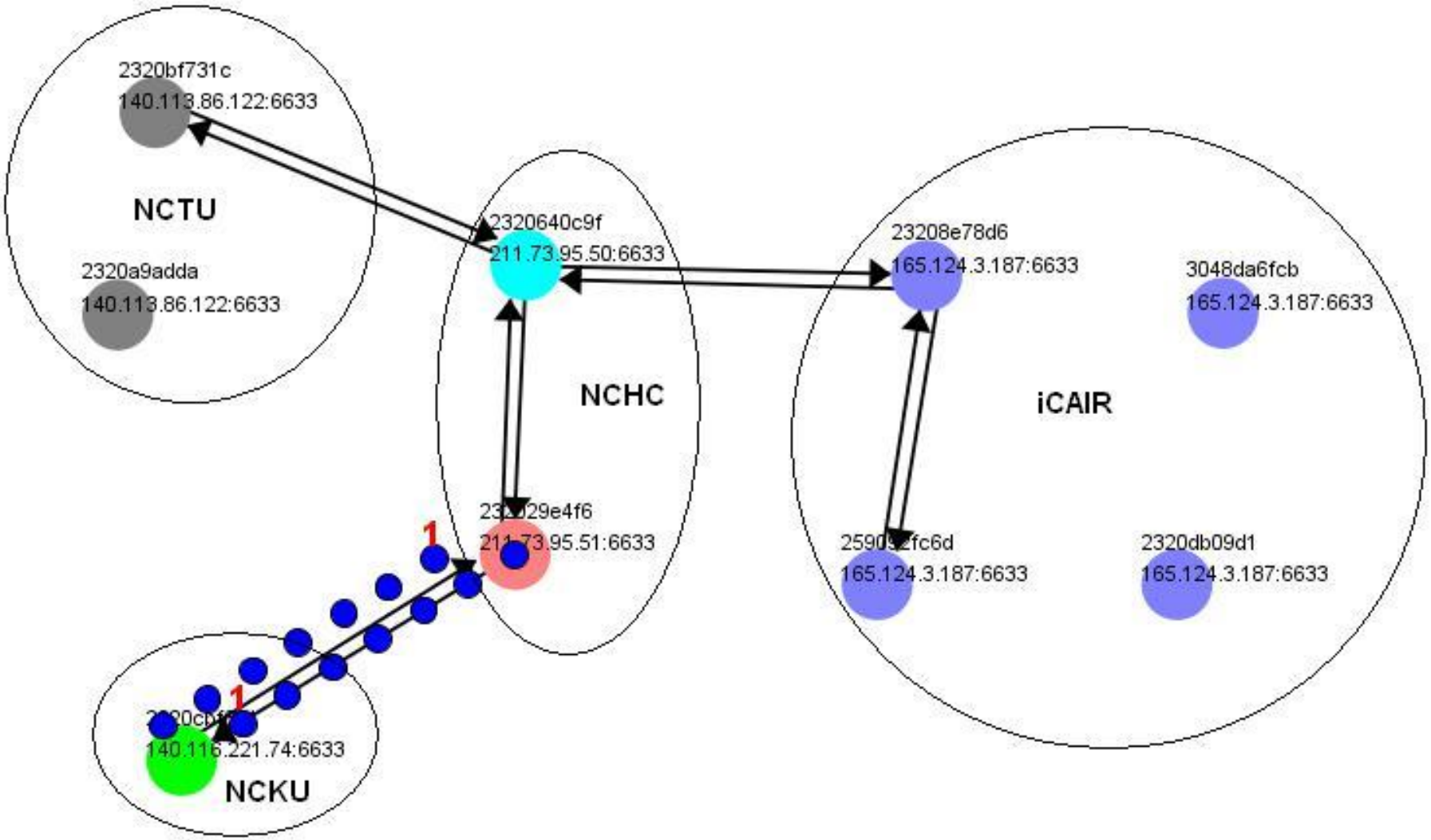


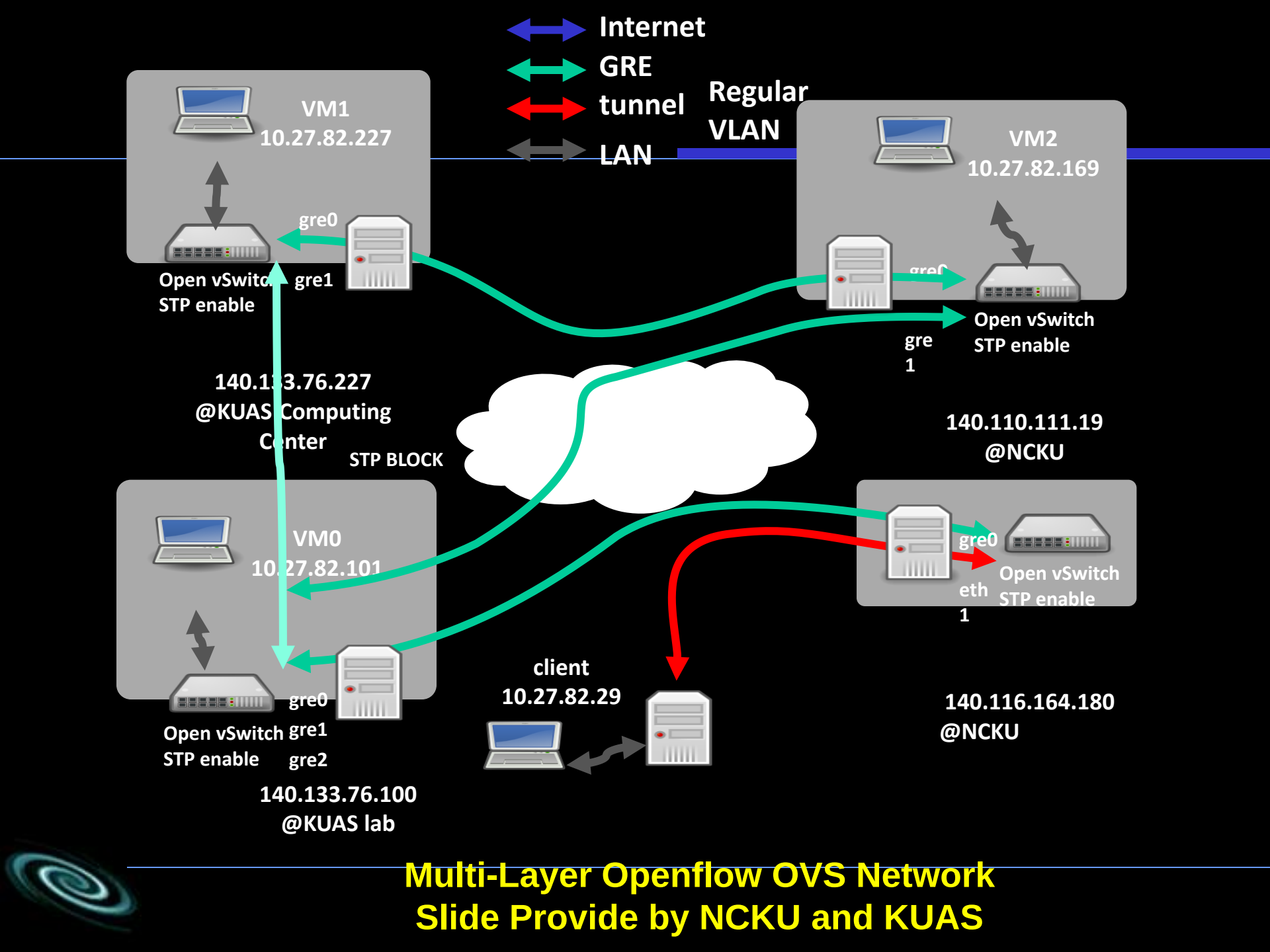


ow f1 Gva-Ams ends at [Port 50 of 00:00:e8:9a:8f:d2:80:57 (ofs01-gva)] (no flow entry for IP 10.0.200.2)
ow f2 Gva-Ams ends at [Port 50 of 00:00:60:eb:69:fe:49:14 (ofs02-gva)] (no flow entry for IP 10.0.201.2)
ow f3 Gva-Ams ends at [Port 50 of 00:00:60:eb:69:fe:49:14 (ofs02-gva)] (no flow entry for IP 10.0.202.2)

Slide Provide by Caltech,SARA, Surfnet

Inter-Domain Openflow
Topology Discovery & Monitoring
Slide Provide By NCHC (Paper on Technique Accepted for Publication)





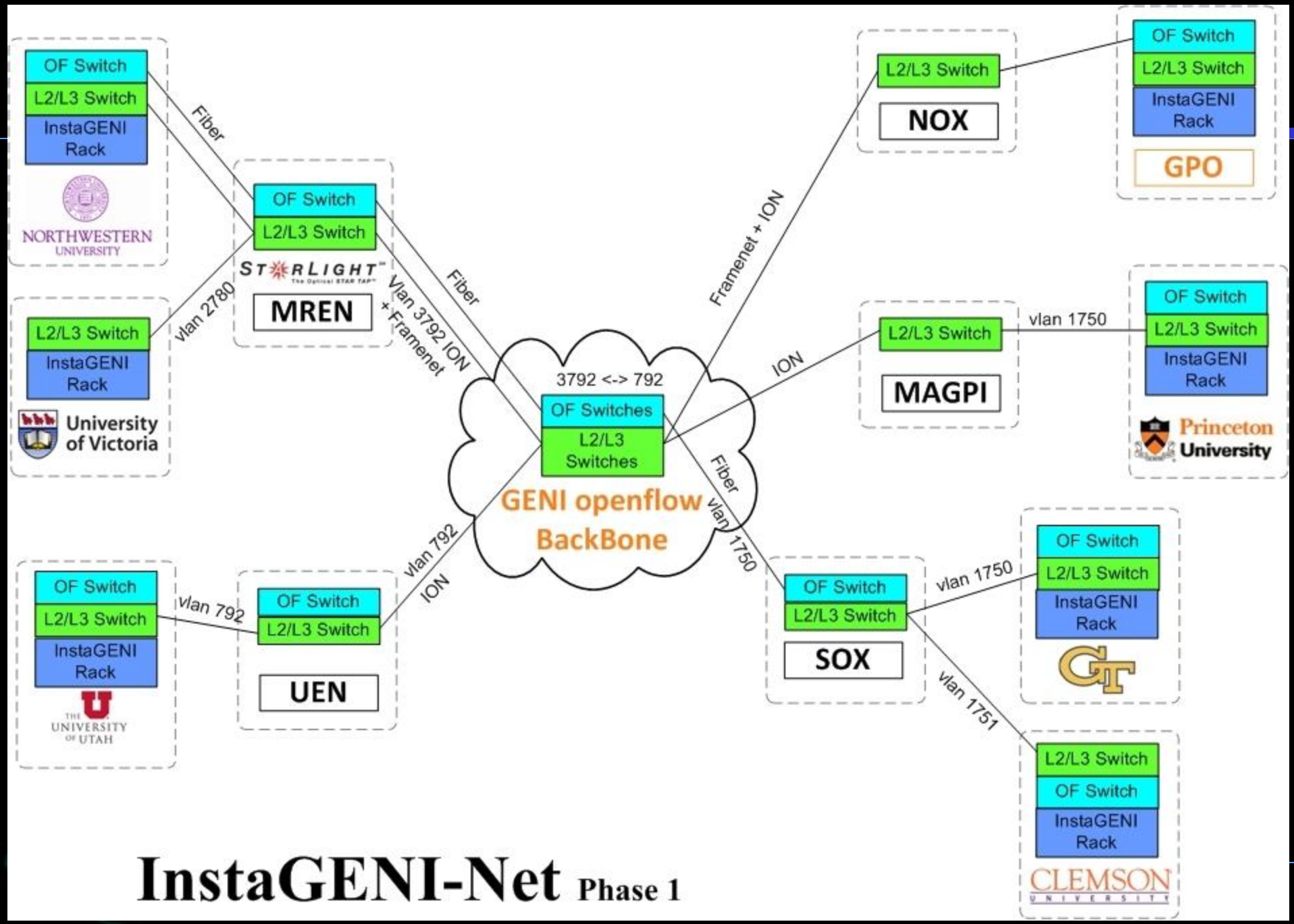
Multi-Layer Openflow OVS Network
Slide Provide by NCKU and KUAS

GEC 15 Demonstration

- **Live Demonstration of Application Enabled By International Distributed Research Environment**

Next Steps

- Ref: Next Presentation
- Transition To Federation/Integration of Multi-Domain Control Frameworks Across the World
- E.g., Initial Integration of V-NODE and ProtoGENI (Next Demonstration)
- Expansion of Integrations Internationally
- Continuous Expansion of Functions/Capabilities
- Many More Demonstrations Planned



InstaGENI-Net Phase 1

Demonstration Schedule

- The 14th GENI Engineering Conference (GEC 14) July 9-11 in Boston Massachusetts (Done)
- EuroView2012 the 12th Würzburg Workshop on IP: ITG Workshop "Visions of Future Generation Networks“ July 23-24 in Würzberg, Germany, Co-Hosted By G-Lab (Paul Muller) (Done)
- AsiaFI Network Virtualization Workshop, Kyoto, Japan, August 23rd, 2012 (Aki Nakao) (Done)
- The 1st Federated Clouds Workshop and the 7th Open Cirrus Summit Co-Located With the International Conference on Autonomic Computing on September 21in San Jose, California (Postponed)
- The Global LambdaGrid (GLIF) Workshop in Chicago on October 10-12, co located with the IEEE e-Science Conference , the Microsoft e-Science Conference and the Open Grid Forum (OGF) (Done)
- The 15th Annual GENI Engineering Conference (GEC 15) In Oct in Houston, Texas (Current)
- The SC12 International Supercomputing Conference on November 10-16 in Salt Lake City. Utah. (Planned)
- The 16th Annual GENI Engineering Conference (GEC 16) March Salt Lake City, Utah (Planned)

Conclusion: The Future Is Based On Programmable Networks

- Thanks!!
- Questions?
- Comments?

Houston, Texas