Partnerships for Advanced Global Networking: GENI, iGENI, and the International Network Research Community

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)

GENI Engineering Conference 8 (GEC 8)
July 20-22
San Diego, California

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# Introduction to The *International* Center For Advanced Internet Research

Accelerating Leading Edge Innovation and Enhanced Global Communications through Advanced Internet Technologies, in Partnership with the Global Community

- **Creation and Early Implementation of Advanced Networking Technologies - The Next Generation Internet, All Optical Networks, Terascale Networks, Networks for Petascale Science – *Multiple* Network Research Testbeds – Including National & International**

- **Advanced Applications, Middleware, Large-Scale Infrastructure, NG Optical Networks and Testbeds, Public Policy Studies and Forums Related to NG Networks**

- **Three Major Areas of Activity: a) Basic Research b) Design and Implementation of Prototypes c) Operations of Specialized Communication Facilities (e.g., StarLight)**

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Paradigm Shift – Ubiquitous Services Based on Large Scale Distributed Facility vs Isolated Services Based on Separate Component Resources

Traditional Provider Services: Invisible, Static Resources, Centralized Management, Highly Layered
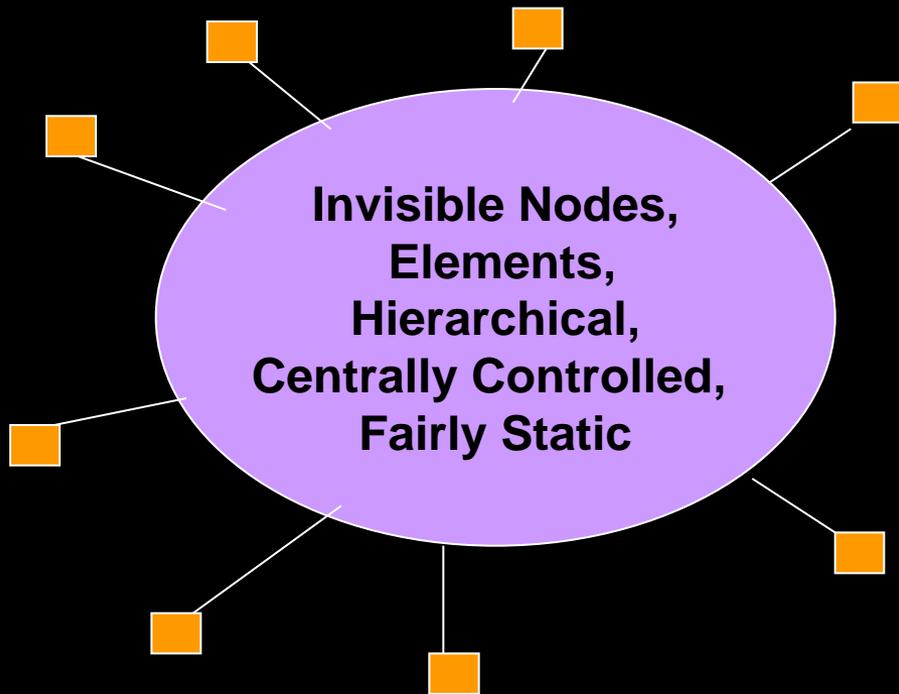
Distributed Programmable Resources, Dynamic Services, Visible & Accessible Resources, Integrated As Required, Non-Layered

Invisible Nodes, Elements, Hierarchical, Centrally Controlled, Fairly Static

Limited Services, Functionality, Flexibility
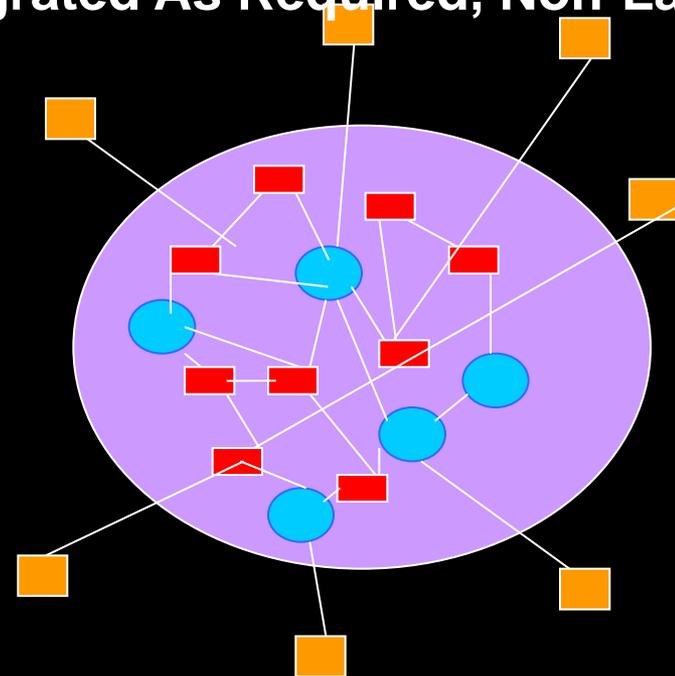
Unlimited Services, Functionality, Flexibility

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Global Environment for Network Innovations (GENI)

- **GENI Is a Virtual Laboratory For Exploring Future Internets At Scale – Consequently It Must Be Global (NB: "GLOBAL" Environment…)**

- **GENI Is Similar To Instruments Used By Other Science Disciplines, e.g., Astronomers – Telescopes, HEP – Synchrotrons**

- **All Of These Types of Major Facilities Require Global Collaboration and International Partnerships for Success**

- **GENI Creates Major Opportunities To Understand, Innovate and Transform Global Networks and Their Interactions with Society – World-Wide.**

- **International Partnerships Significantly Enhance Those Opportunities and Enable Many Additional Valuable Research Perspectives and Contributions**

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iGENI: International Global Environment for Network Innovations

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)
Partner, StarLight/STAR TAP, PI-OMNINet (www.icair.org/omninet)

Maxine Brown, Associate Director (maxine@uic.edu)
Electronic Visualization Laboratory (www.evl.uic.edu)
University of Illinois at Chicago

Tom DeFanti, Research Scientist (tdefanti@ucsd.edu)
California Institute for Telecommunications and Information Technology
(www.calit2.net),
University of California, San Diego

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iGENI: The International GENI

- The iGENI Initiative Is Designing, Developing, Implementing, and Operating a Major New National and International Distributed Infrastructure.

- iGENI Is Placing the "G" in GENI Making GENI Truly Global.

- iGENI Is Creating a Unique Distributed Infrastructure To Support <u>GLOBAL</u> Research and Development for Next-Generation Network Communication Services and Technologies.

- This Infrastructure Is Being Integrated With Current and Planned GENI Resources.

- iGENI Infrastructure Is Interconnecting Its Resources With Current GENI National Backbone Transport Resources, With Current and Planned GENI Regional Transport Resources, and With International Research Networks and Projects

- iGENI Is Highly Leveraging Existing International Advanced Networking Facilities

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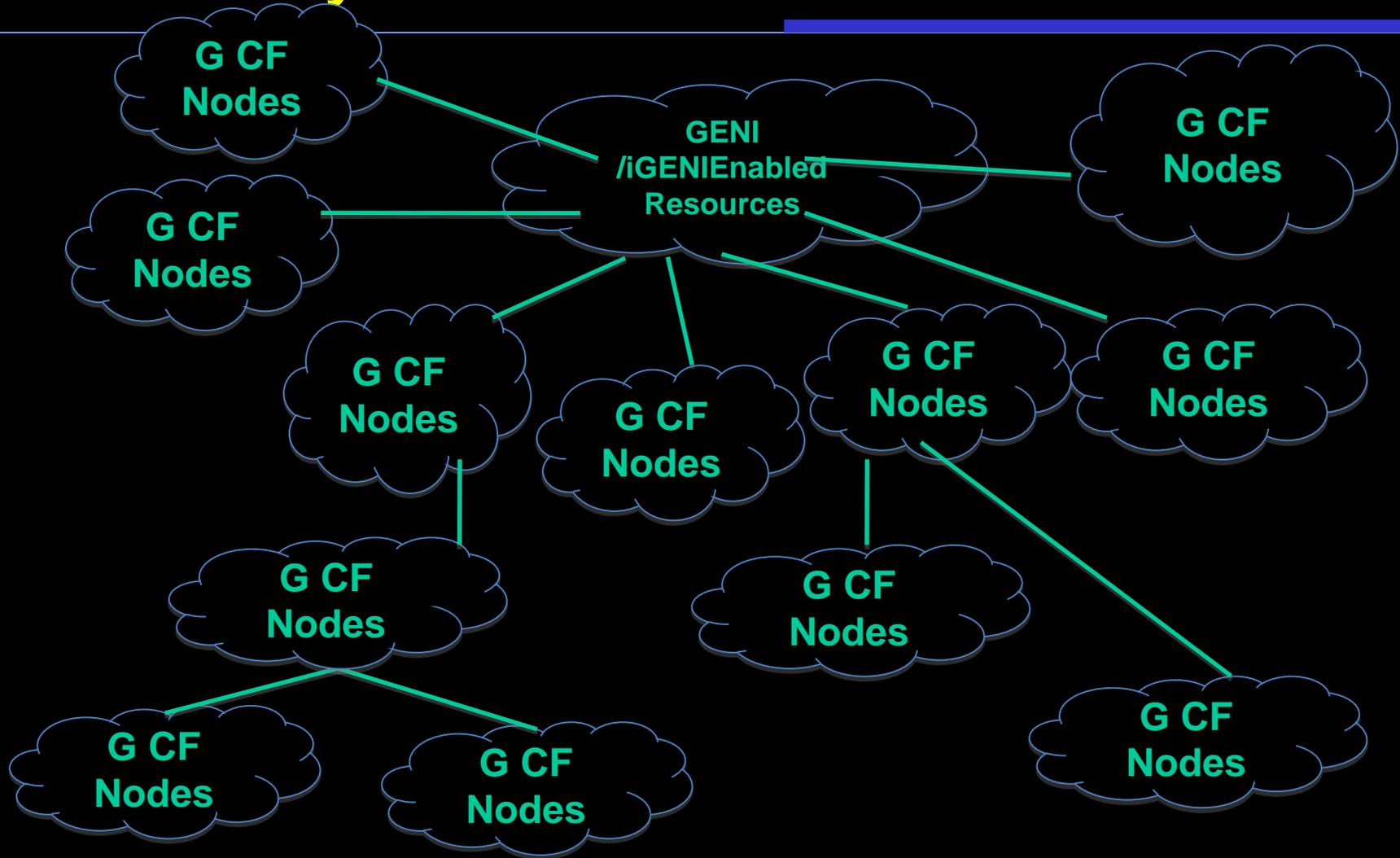
Initial iGENI Consortium

- **Consortium Partners Include Several Major Network Research Organizations:**
  - International Center for Advanced Internet Research (iCAIR) at Northwestern University,
  - Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago
  - The California Institute for Telecommunications and Information Technology (Calit2) at the University of California, San Diego
  - Cisco Systems, Inc. Research
  - BBN Technologies GENI Program Office (GPO).
  - The StarLight Consortium
  - RENCI and North Carolina University Partners, e.g. Duke, North Carolina State
  - Other Cluster D Participants (Univ of Mass - Amherst, Columbia, Ohio State, Wayne State, Univ of Houston, Rice, Texas A&M, UT Austin, Oklahoma State)

  - iGENI Initiatives Also Extend To Activities In Other GENI Clusters
  - *iGENI Research Initiatives Have Multiple International Partners*

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Building On Existing Partnerships, Current & Future International Partners Include Researchers From Many Countries

- **Australia**
- **Brazil**
- **Canada**
- **China**
- **Egypt**
- **Germany**
- **India**
- **Japan**
- **Korea**
- **Taiwan**
- **Spain**

- **Singapore**
- **Netherlands**
- **Spain**
- **New Zealand**
- **Sweden**
- **UK**
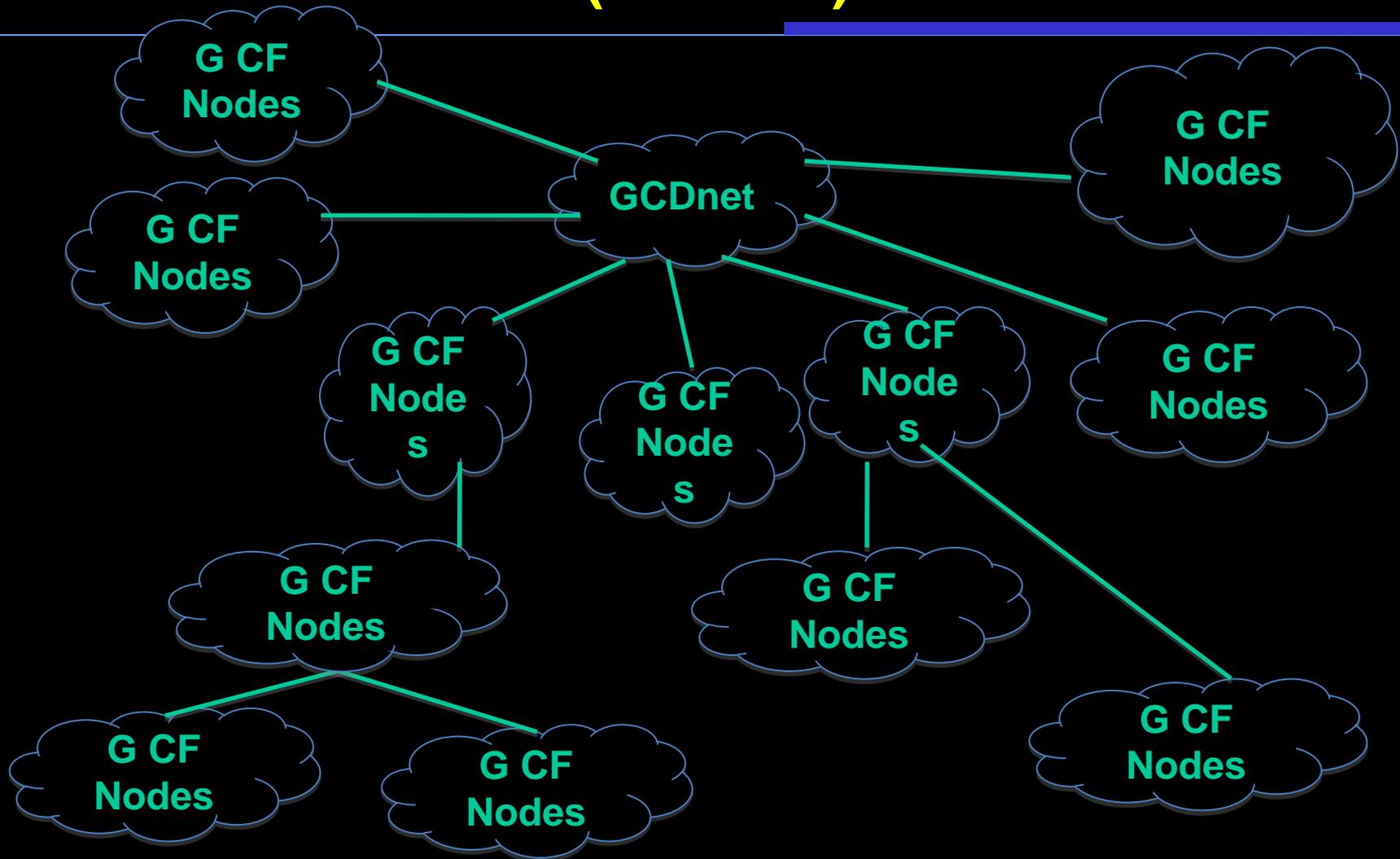- **Et Al**

- **All Are Welcome To Participate!**

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iGENI & Partners Are Providing Paths Managed By a GENI Control Framework

CF Nodes = Core Resources *Dedicated* **To iGENI CF Functions**

An Initial Prototype: GENI Cluster-D Network (GCDnet)

G CF Nodes

G CF Nodes

GCDnet

G CF Nodes

G CF Nodes

G CF Nodes

G CF Nodes

G CF Nodes

G CF Nodes

G CF Nodes

G CF Nodes

G CF Nodes

G CF Nodes

CF Nodes = Core Resources *Dedicated* To iGENI Controlled By G CF

ORCA Control Framework

- **The iGENI Consortium Has Integrated Its Initial Infrastructure With the Open Resource Control Architecture (ORCA) Control Framework**

- **ORCA Was Developed by GENI-funded Colleagues at RENCI (Renaissance Computing Institute) and Duke University,**

- **ORCA Enables iGENI Researchers to Dynamically Control International Network Services, Associated Transport Resources and GENI Aggregates.**

- **ORCA Is Being Continually Enhanced**

- **Note That A Project Has Been Established To Integrate OpenFlow and ORCA**

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Cluster D Initiatives

- **ORCA/BEN -- Primary Distinction Among Other Control Frames = A Unique Comprehensive Strategy Cross-Layer Provisioning and Experimentation**

- **DOME -- Diverse Outdoor Mobile Environment**

- **ViSE -- Sensor Virtualization and Slivering in an Outdoor Wide-Area Wireless -- GENI Sensor/Actuator Network Testbed**

- **ERM -- Embedded Real-Time Measurements**

- **KANSAI – KanseiSensorNet**

- **DICLOUD – Data Intensive Cloud Control**

- **OKGEMS – Cyber-Physical System**

- **IMF – Integrated Measurement Network**

- **LEARN – Measurement Handler and Network Integration (Programmable Measurements)**

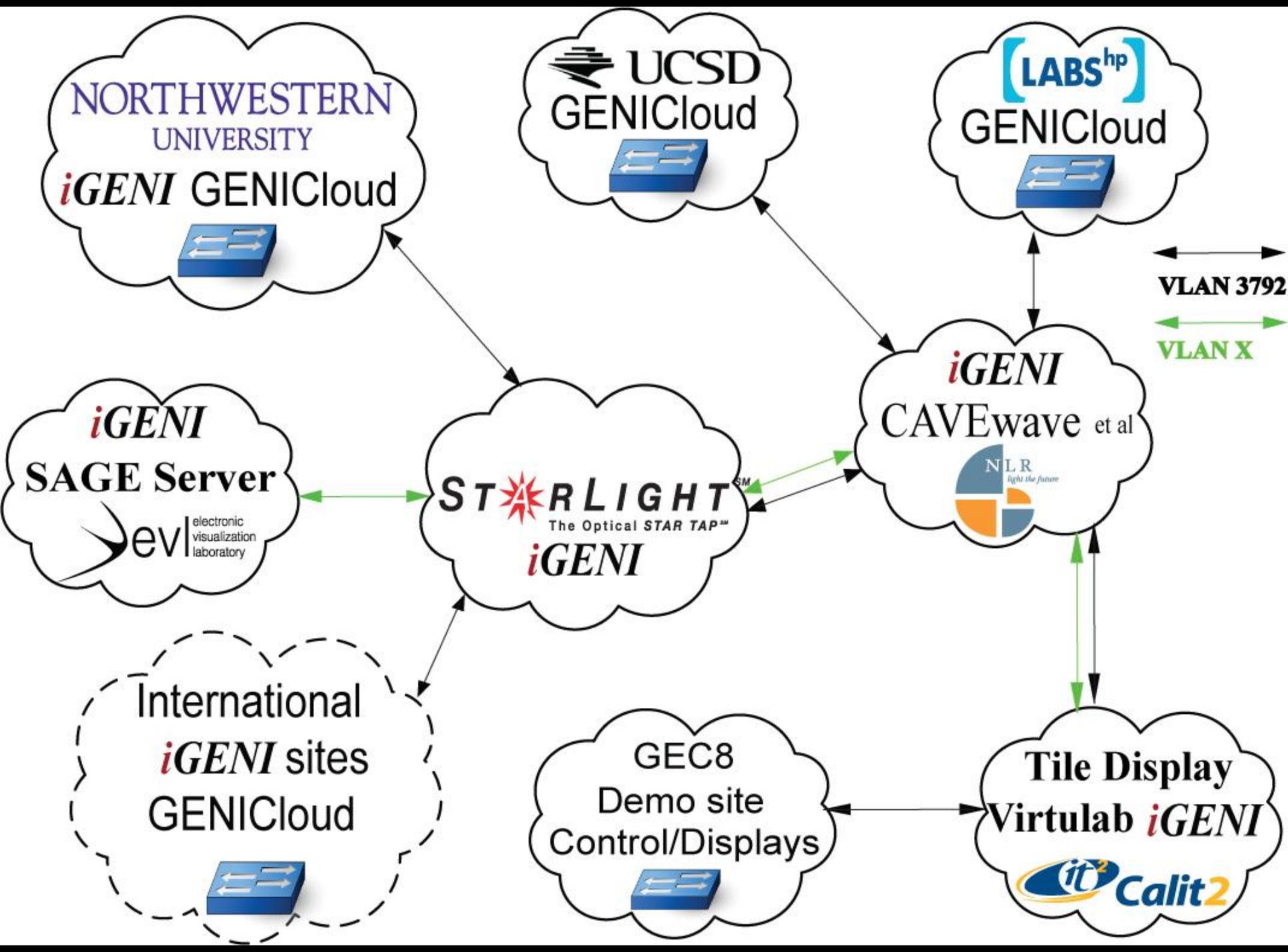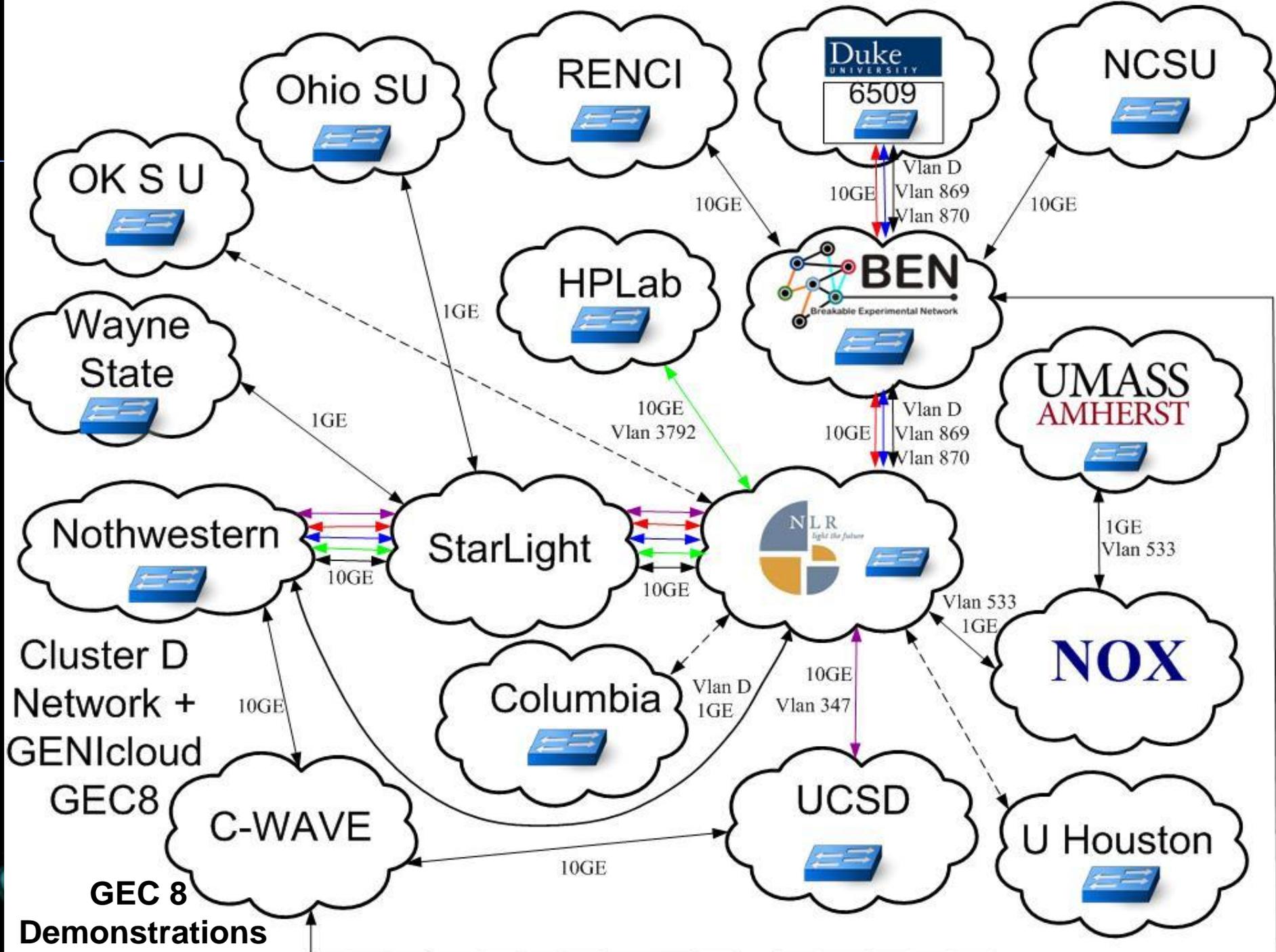- **BBN ORCA Xen Cluster**

- **iGENI**
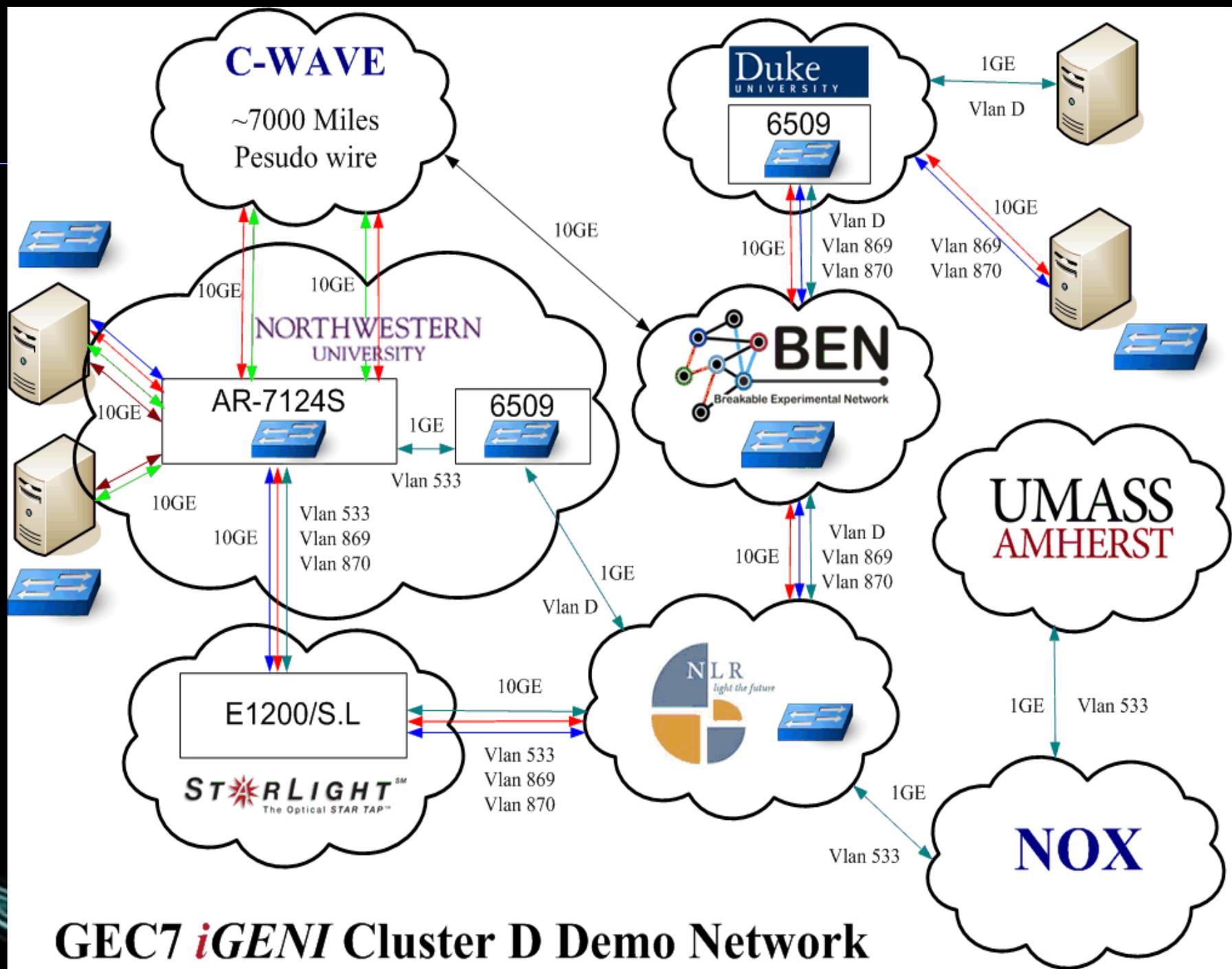
GEC7 *iGENI* Cluster D Demo Network
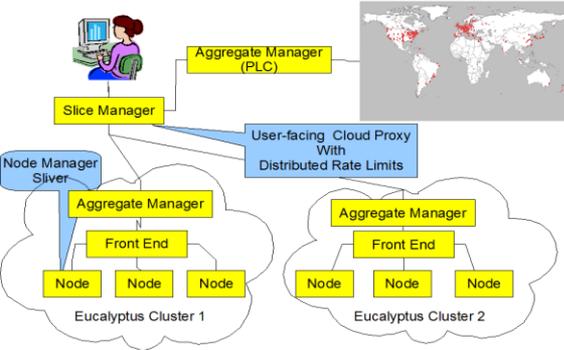
GEC 8 Demonstrations
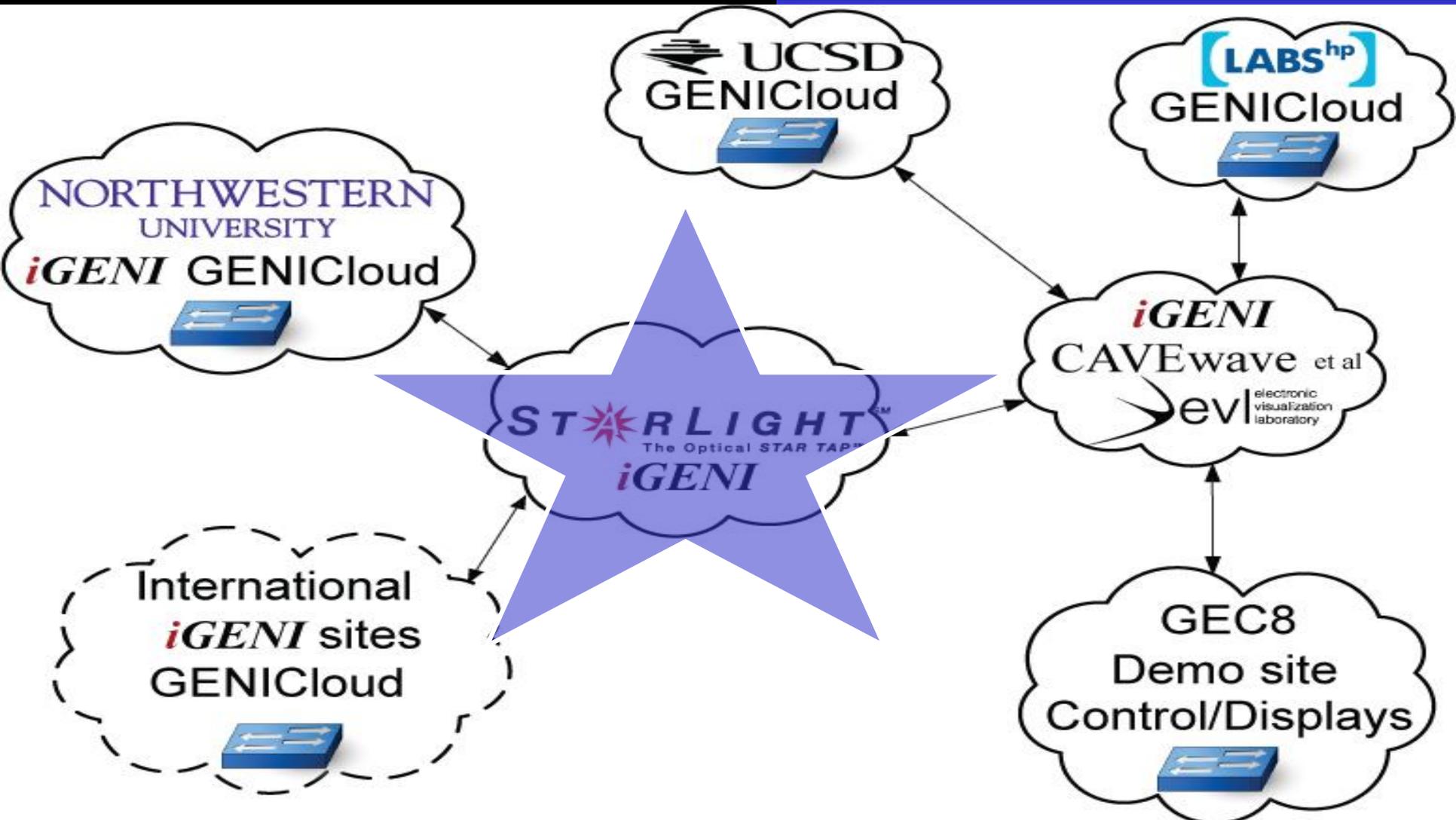
GENICloud

Andy Bavier, Jessica Blaine, Daniel Catrein, Jim Chen, Yvonne Coady, James Kempf, Christian Lottermann, Joe Mambretti, Rick McGeer, Alex Snoeren, Johannes Willig, Marco Yuen, Alvin AuYoung

GENICloud Architecture

Status and Accomplishments

- Integrated Eucalyptus and GENI
  - Eucalyptus release supporting the SFA
- Unified API interface to Eucalyptus and SFA
  - GENI tools now work on (our) Clouds
- RSpec for Eucalyptus
- Resource Discovery
  - Kernel/Disk images
  - Instance Types
- Jobs instantiated on multiple Clouds
- Distributed Rate Limiting over multiple Clouds

Roadmap

- Full integration of PlanetLab and Eucalyptus
- Complete "Slice Manager" – user-facing multiple-SFA facility controller
- Integrate DRL into cross-facility slices
- New GUI for PlanetLab, Eucalyptus, cross-SFA Facilities

GENICloud Demo
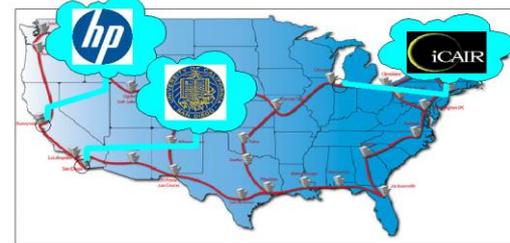
- Transcoding on Eucalyptus Clouds at UCSD, HP Labs, iCAIR (Northwestern)
- Transcoding app thanks to Ericsson Research
- For GEC-9:
  - Integration with NLR (CAVEWave)
  - Integrated Distributed Rate Limiting

Transcoding videos at three clouds:
- **HP OpenCirrus**
- **Northwestern Univ. OpenCloud**
- **UCSD**
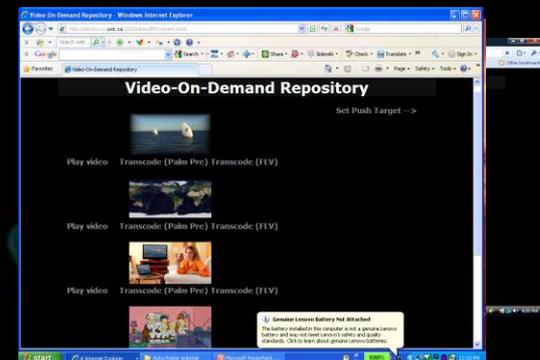
Demo: Transcoding in the Cloud
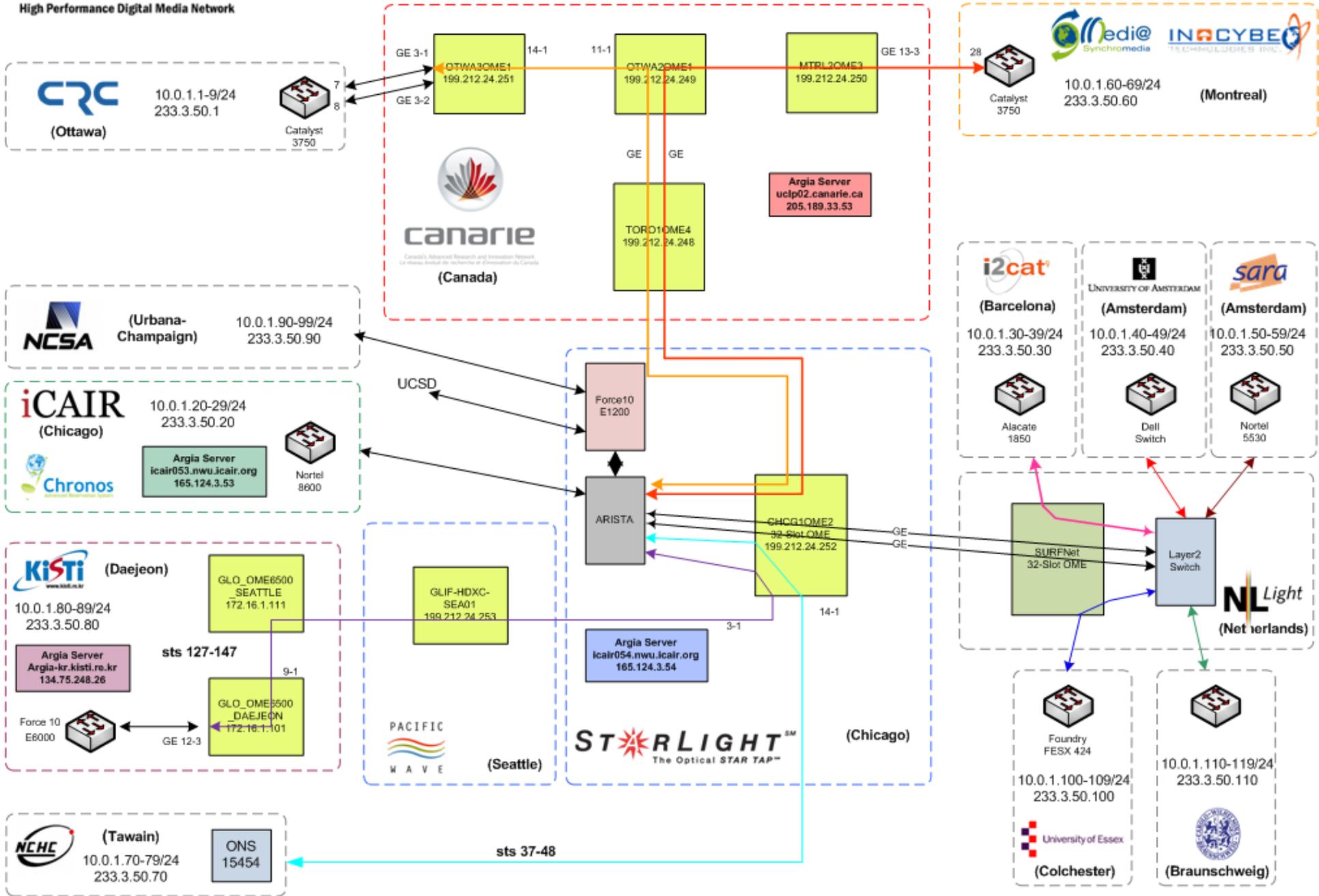**http://electro.cs.uvic.ca:2020/demo/MyContent.html**

**VirtuLab Tile Display:
Directly Connected To National 10 Gbps Testbed
With Core at the StarLight Facility**

HPDMnet
High Performance Digital Media Network

CRC (Ottawa)
10.0.1.1-9/24
233.3.50.1

Catalyst 3750
7
8

GE 3-1
GE 3-2

OTWA3OME1
199.212.24.251
14-1

11-1

OTWA2OME1
199.212.24.249

MTRL2OME3
199.212.24.250
GE 13-3

28
Catalyst 3750

Medi@ Synchromedia   IN CYBE
10.0.1.60-69/24
233.3.50.60
(Montreal)

GE   GE

canarie
Canada's Advanced Research and Innovation Network
Le réseau évolué de recherche et d'innovation du Canada
(Canada)

TORO1OME4
199.212.24.248

Argia Server
uclp02.canarie.ca
205.189.33.53

NCSA (Urbana-Champaign)
10.0.1.90-99/24
233.3.50.90

iCAIR (Chicago)
10.0.1.20-29/24
233.3.50.20

Chronos
Advanced Reservation System

Argia Server
icair053.nwu.icair.org
165.124.3.53

Nortel 8600

UCSD

Force10 E1200

ARISTA

i2cat (Barcelona)
10.0.1.30-39/24
233.3.50.30

Alacate 1850

UNIVERSITY OF AMSTERDAM (Amsterdam)
10.0.1.40-49/24
233.3.50.40

Dell Switch

sara (Amsterdam)
10.0.1.50-59/24
233.3.50.50

Nortel 5530

CHCG1OME2
32-Slot OME
199.212.24.252
GE
GE

SURFNet
32-Slot OME

Layer2 Switch

NL Light (Netherlands)

KiSTi (Daejeon)
www.kisti.re.kr
10.0.1.80-89/24
233.3.50.80

GLO_OME6500
_SEATTLE
172.16.1.111

GLIF-HDXC-
SEA01
199.212.24.253

sts 127-147

Argia Server
Argia-kr.kisti.re.kr
134.75.248.26

9-1

GLO_OME6500
_DAEJEON
172.16.1.101

Force 10 E6000

GE 12-3

14-1

3-1

Argia Server
icair054.nwu.icair.org
165.124.3.54

PACIFIC WAVE
(Seattle)

STARLIGHT
The Optical STAR TAP
(Chicago)

Foundry FESX 424
10.0.1.100-109/24
233.3.50.100

University of Essex
(Colchester)

10.0.1.110-119/24
233.3.50.110

(Braunschweig)

NCHC (Tawain)
10.0.1.70-79/24
233.3.50.70

ONS 15454

sts 37-48

iGENI and StarLight

- **iGENI Will Integrate Multiple Network Resources, Including:**
  - **Resources at the StarLight International Communications Exchange in Chicago - StarLight Currently Supports Over 20 Major Network Research Testbeds, Including National and International Fabrics**
  - **Segments of National Research and Education Network Infrastructures**
  - **National Wide-Area Private Networks**
  - **Components of the International Optical-Networking GLIF Fabric.**
- **StarLight Is More Than a Facility – It Is a Major National and International *Community* Dedicated To Designing and Implementing Advanced Networking Services and Technologies**

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StarLight – "By Researchers For Researchers"

StarLight is an advanced national and international communication exchange facility optimized for high-performance data intensive applications

World's "Largest" 10G Exchange Over 100 10 Gbps Channels Interoperability Services At All Layers

View from StarLight

**Abbott Hall, Northwestern University's Chicago downtown campus**

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iGENI and GLIF

- **iGENI Consortium Members Have Partnered with Many Other Participants of the Global Lambda Integrated Facility (GLIF) To Undertake Multiple Experimental Network Research Projects**

- **The iGENI Initiative Will Build On That Experience To Create and Exploring New Prototypes of Innovative Communication Services and Technologies.**

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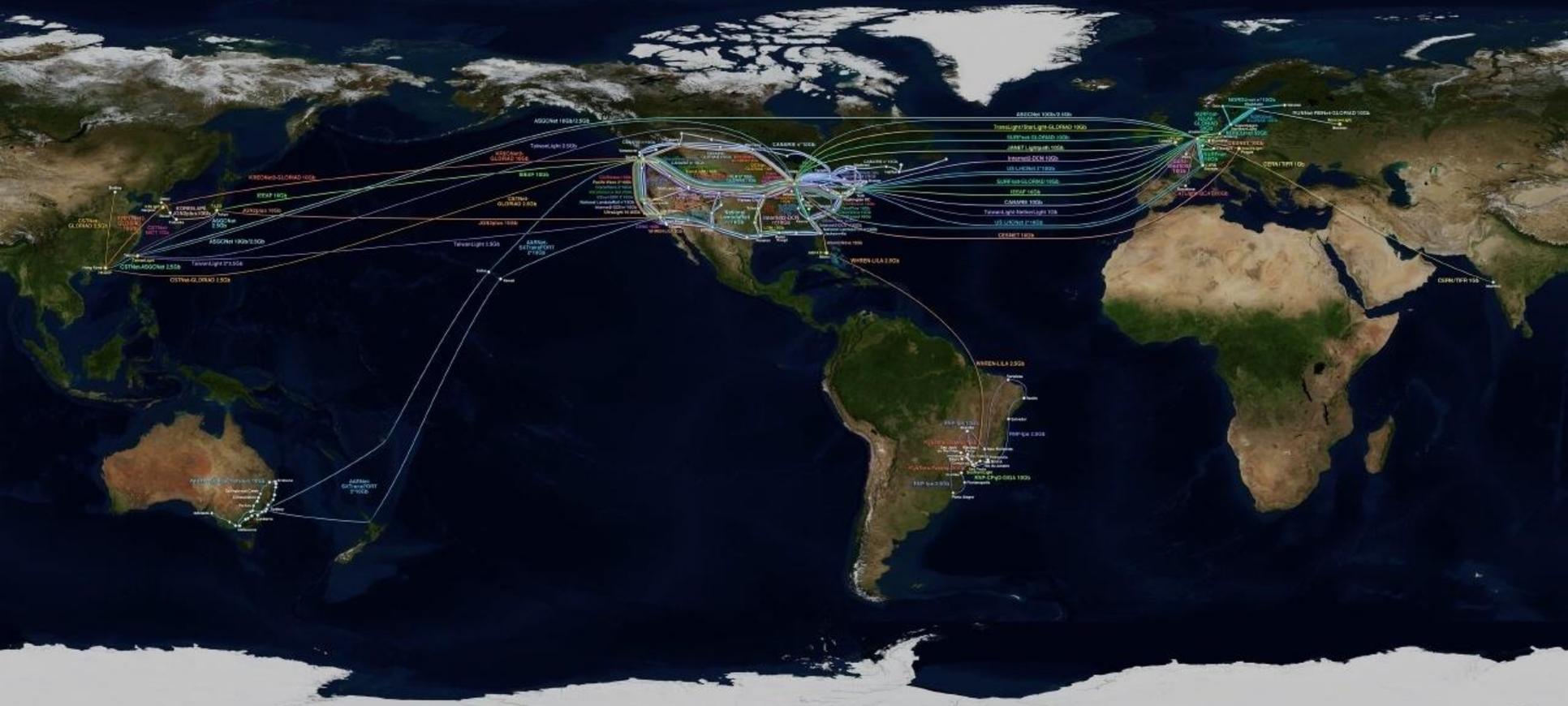
GLIF Map 2008: Global Lambda Integrated Facility   Visualization by Robert Patterson, NCSA, University of Illinois at Urbana-Champaign   Data Compilation by Maxine D. Brown, University of Illinois at Chicago   Earth Texture, visibleearth.nasa.gov   www.glif.is

www.glif.is

IRNC ProNet: TransLight/StarLight

Announced: July 13, 2010

Tom DeFanti, Maxine Brown, Joe Mambretti, Tajana Rosing

Calit2, University of California, San Diego
Electronic Visualization Lab, University of Illinois at Chicago
International Center for Advanced Internet Research, Northwestern University

20 years of NSF-Funded High-Performance International Networking for Advanced Applications (1995-2014)

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IRNC TL/SL Deliverables

- **Continue Enabling Multi-National Application and Middleware Experiments Through Innovative Services and Technologies On International Networks:**
  - *High-Performance Digital Media Network (HPDMnet)*
  - *iGENI: the GENI-funded international GENI project* ##*
  - *SAGE: connecting people and their data at high-res**
  - *CineGrid: it's all about visual communications*
  - *GreenLight International: less watts/terabyte**
  - *Science Cloud Communication Services Network (SCCSnet)*: the impending disruption*
- **Build Cooperative National and International Partnerships***
- **Provide New Services, Including Many with Industrial Partners**
- **Capitalize On Other Emerging Opportunities***

 ## Now, In Part, A CISE/OCI Partnership!!

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TransLight/StarLight Collaborates with All IRNC/GLIF Initiatives

C-Wave Summer 2010

Westin
Seattle

Level3
Sunnyvale

Equinix
Los Angeles

CalIT(2)
San Diego

StarLight
Northwestern University
Chicago

Level3
McLean, VA

Cisco
Herndon, VA

Level3
RTP, NC

Level3
Jacksonville, FL

www.icair.org, www.startap.net/starlight

**Thanks to: NSF, DOE, NASA, USGS, NIH, DARPA
Universities, National Labs,
International Partners, Commercial Partners
and Other Supporters**

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