CLEMSON UNIVERSITY

Software Defined Networking and OpenFlow for Universities: Motivation, Strategy, and Uses

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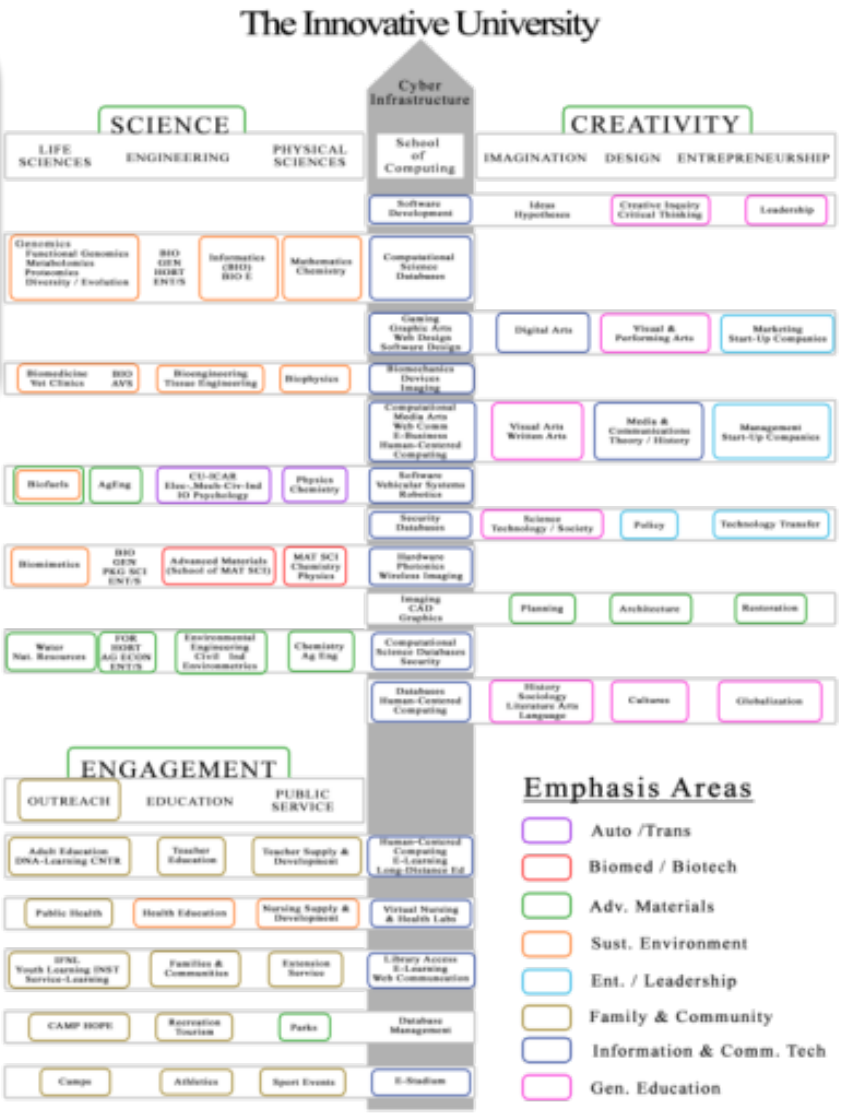
In collaboration with

Clemson Computing and Information Technologies

Motivation: Our Missions

"A university is an institution of **higher education** and **research**"

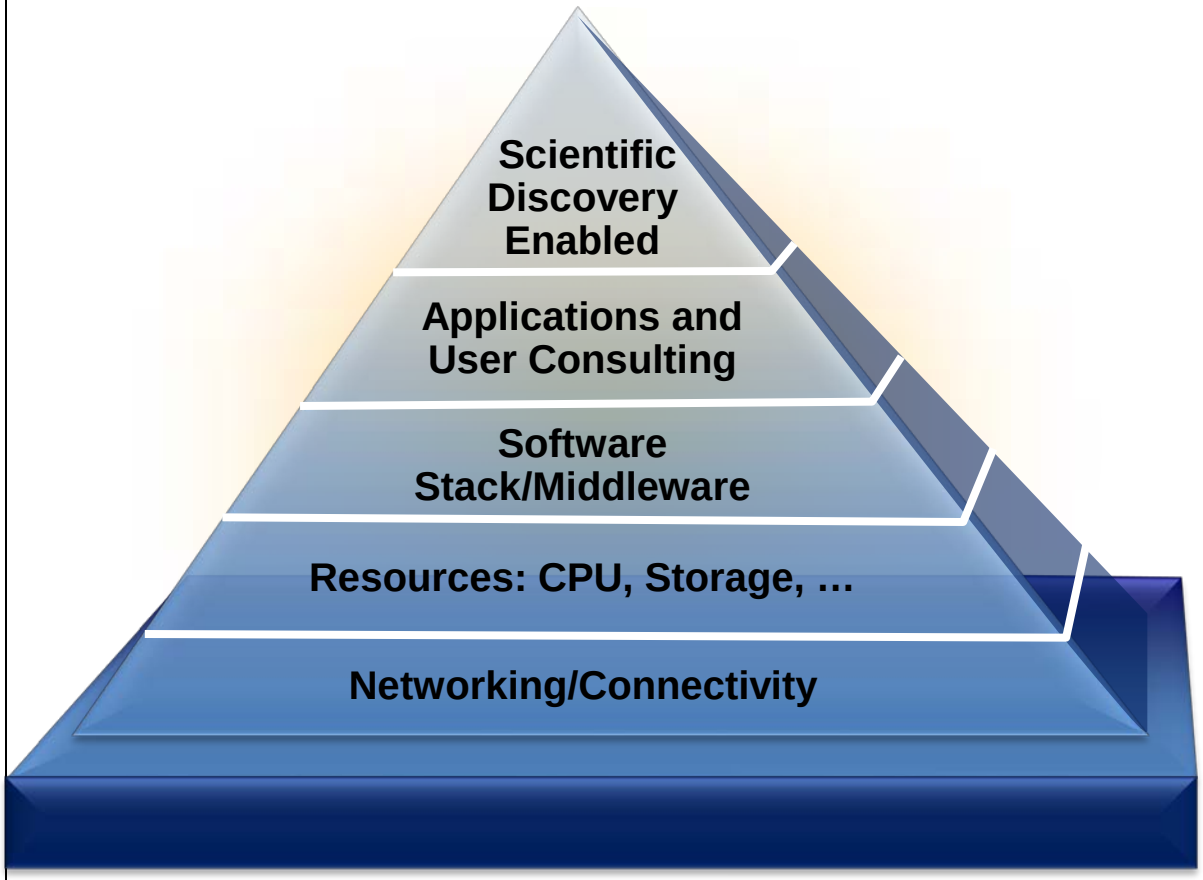
Wikipedia



"Cyberinfrastructure is the primary backbone that ties together innovation in research, instruction, and service to elevate Clemson to the Top 20"

Doris Helms
Provost

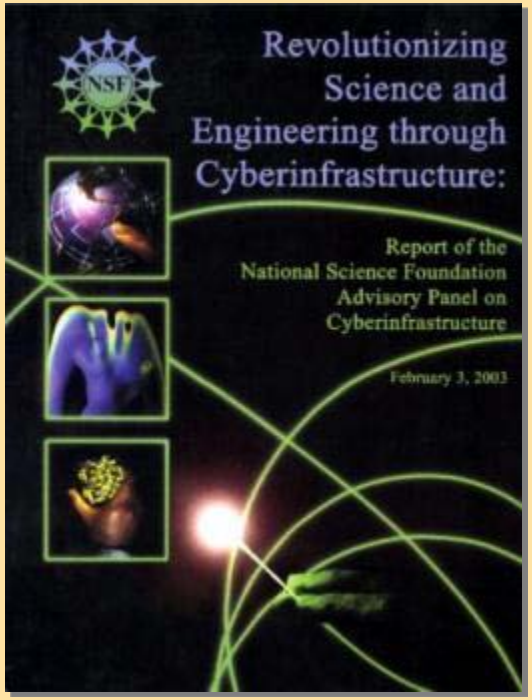
Cyberinfrastructure as a Core Strength



‡ David Hart in NCSA News release "National Science Foundation Releases New Report from Blue-Ribbon Advisory Panel on Cyberinfrastructure" February 3, 2003 http://access.ncsa.uiuc.edu/Releases/03Releases/02.03.03_National_S.html as quoted on Cyberinfrastructure Wikipedia entry.

2003 Blue Ribbon Panel: "Atkins Report"

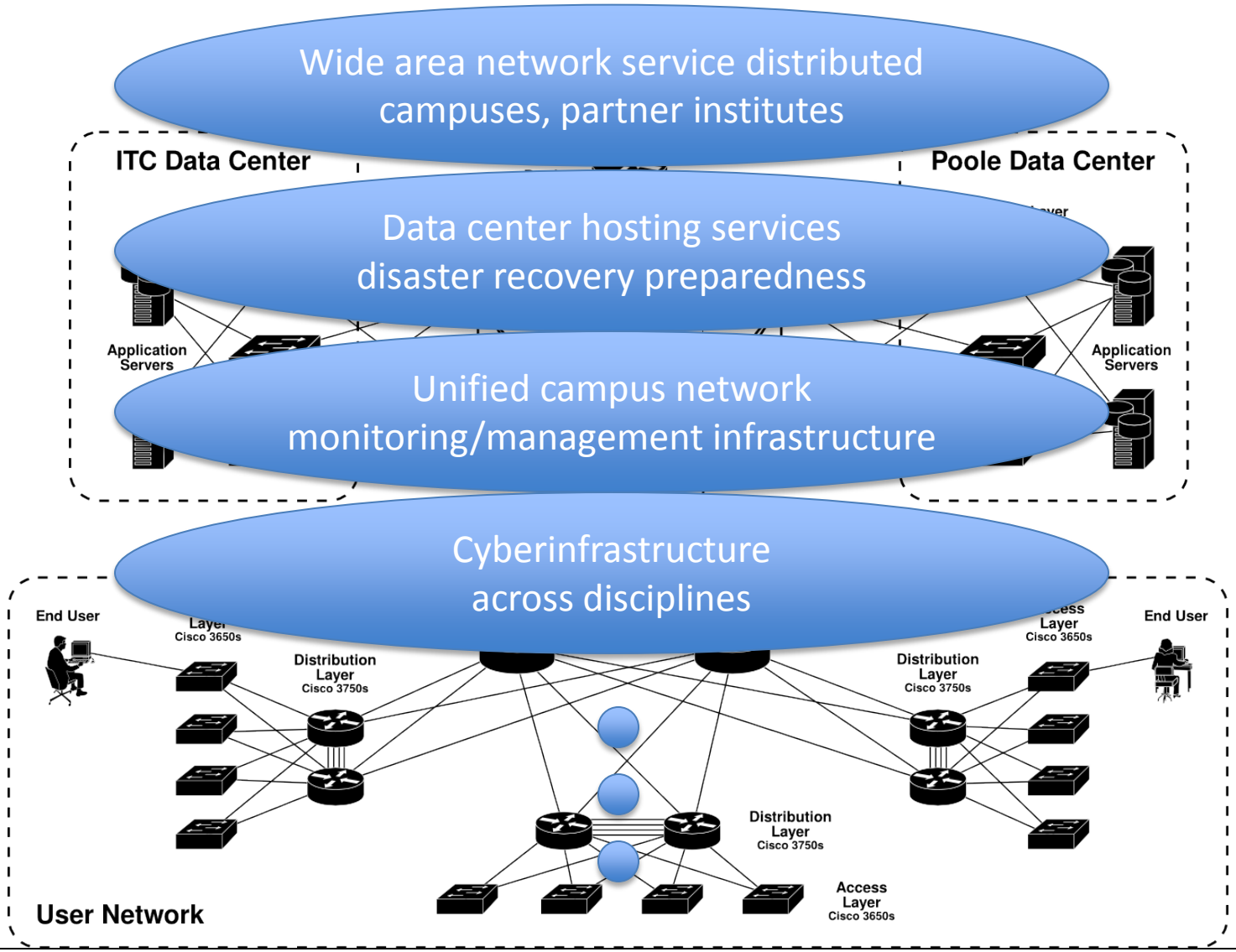
"Like the physical infrastructure of roads, bridges, power grids, telephone lines, and water systems that support modern society, **"Cyberinfrastructure"** refers to the distributed computer, information and communication technologies combined with the personnel and integrating components that provide a long-term platform to empower the modern scientific research endeavor" ‡



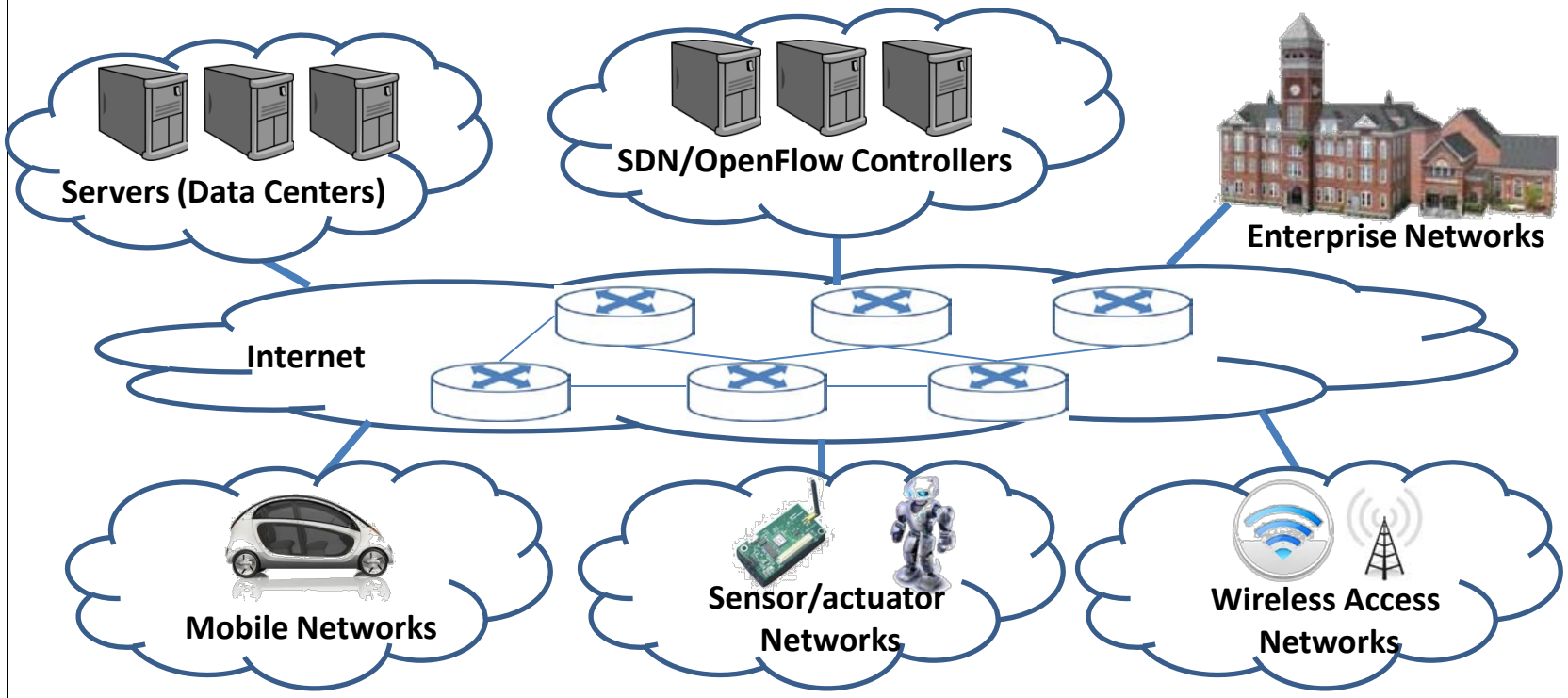
Challenges for University IT

- Increasing education service complexity
  - Complex education software (e.g., Blackboard)
  - Distributed, remote education
- Increasing research demand of IT resources
  - *With the same or less budget*
  - Cyberinfrastructure needs across disciplines
  - Demand for cost effective IT infrastructure
- Increasing liability and expected resiliency
  - *In a harsh world*
  - Campus safety and disaster preparedness
  - Critical applications (internal/external enterprise services)
  - Security exploits

To-Do List Grows Long Easily



How Can Software Defined Networking (SDN) Help



- Software Defined Networking (SDN)
  - OpenFlow as one first commercial SDN solution
  - Network switching by software controllers – automated operation
  - Single-view control plane – unified management
  - Virtualized infrastructure – seamless, secured/isolated sharing

Recent Development in SDN/OpenFlow

GENI Targets Same Challenges Faced by Today's IT

Science Issues

We cannot currently understand or predict the behavior of complex, large-scale networks

Innovation Issues

Substantial barriers to at-scale experimentation with new architectures, services, and technologies

Society Issues

We increasingly rely on the Internet but are unsure we can trust its security, privacy or resilience

The GENI Testbed

- GENI has a diverse, rapidly growing set of resources – mostly prototypes – available for experimenter use
  - Compute resources: VM, hosts, cloud
  - Network resources: programmable switches, routers, & wireless

A GENI ‘slice’ can interconnect any of them using a range of connectivity options

Nationwide Meso-scale Prototype

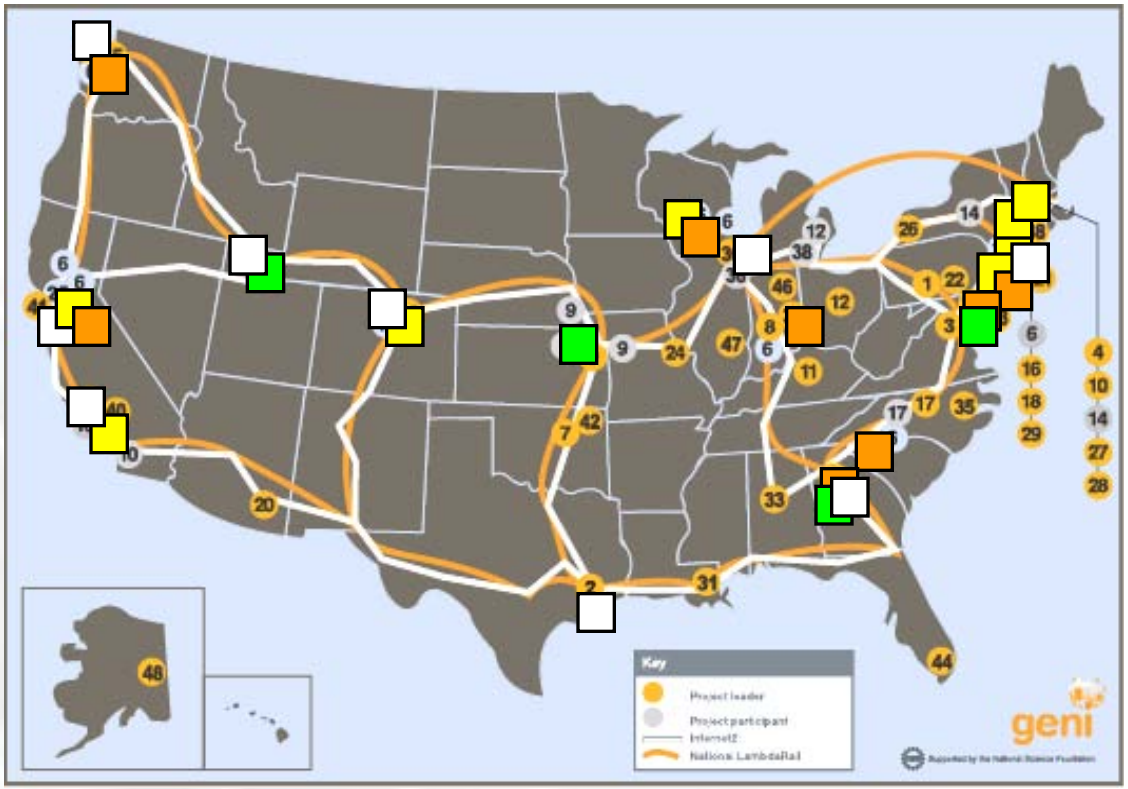
Current plans for locations & equipment

OpenFlow

Stanford
U Washington
Wisconsin U
Indiana U
Rutgers
Princeton
Clemson
Georgia Tech

ShadowNet

Salt Lake City
Kansas City
Washington, DC
Atlanta



WiMAX

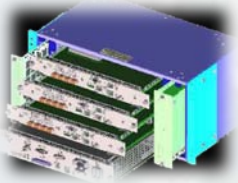
Stanford
UCLA
UC Boulder
Wisconsin
Rutgers
NYU Polytech
UMass
Columbia

OpenFlow Backbones

Seattle
Salt Lake City
Sunnyvale
Denver
New York City
Houston
Chicago
Los Angeles
Atlanta

HP ProCurve 5400 Switch

Juniper MX240 Ethernet Services Router



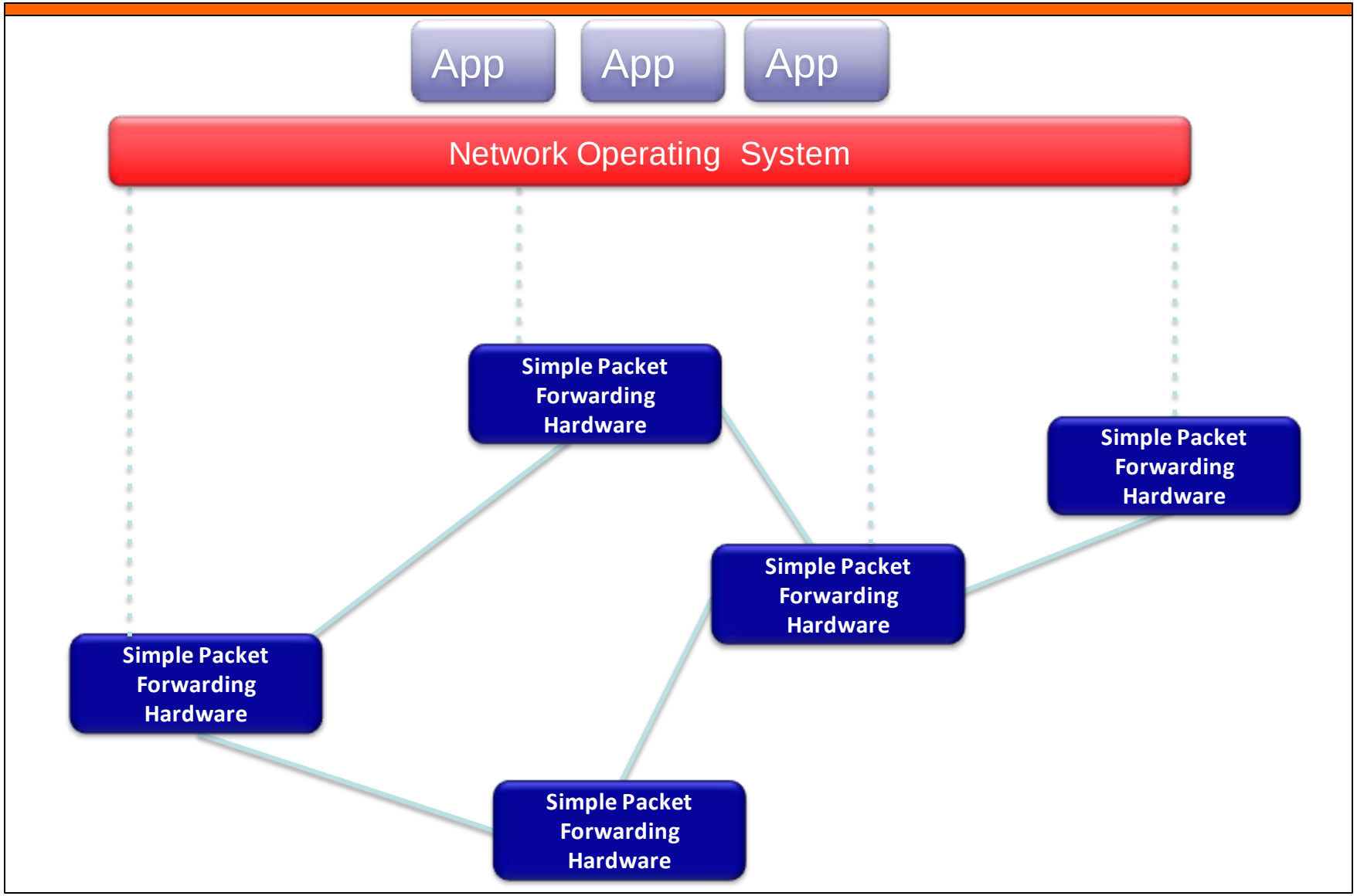
NEC WiMAX Base Station

Toroki LightSwitch 4810

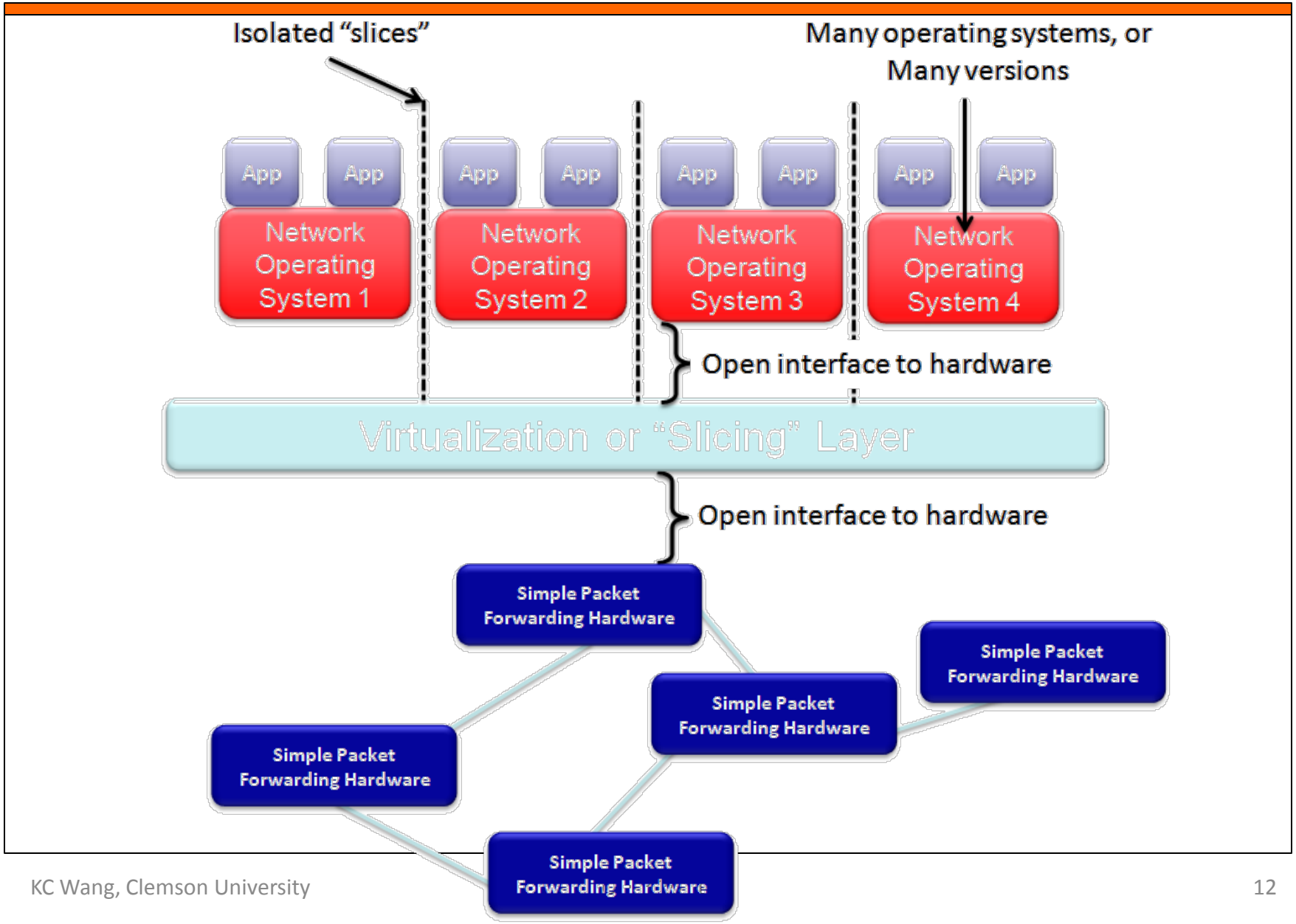
Arista 7124S Switch

NEC IP8800 Ethernet Switch

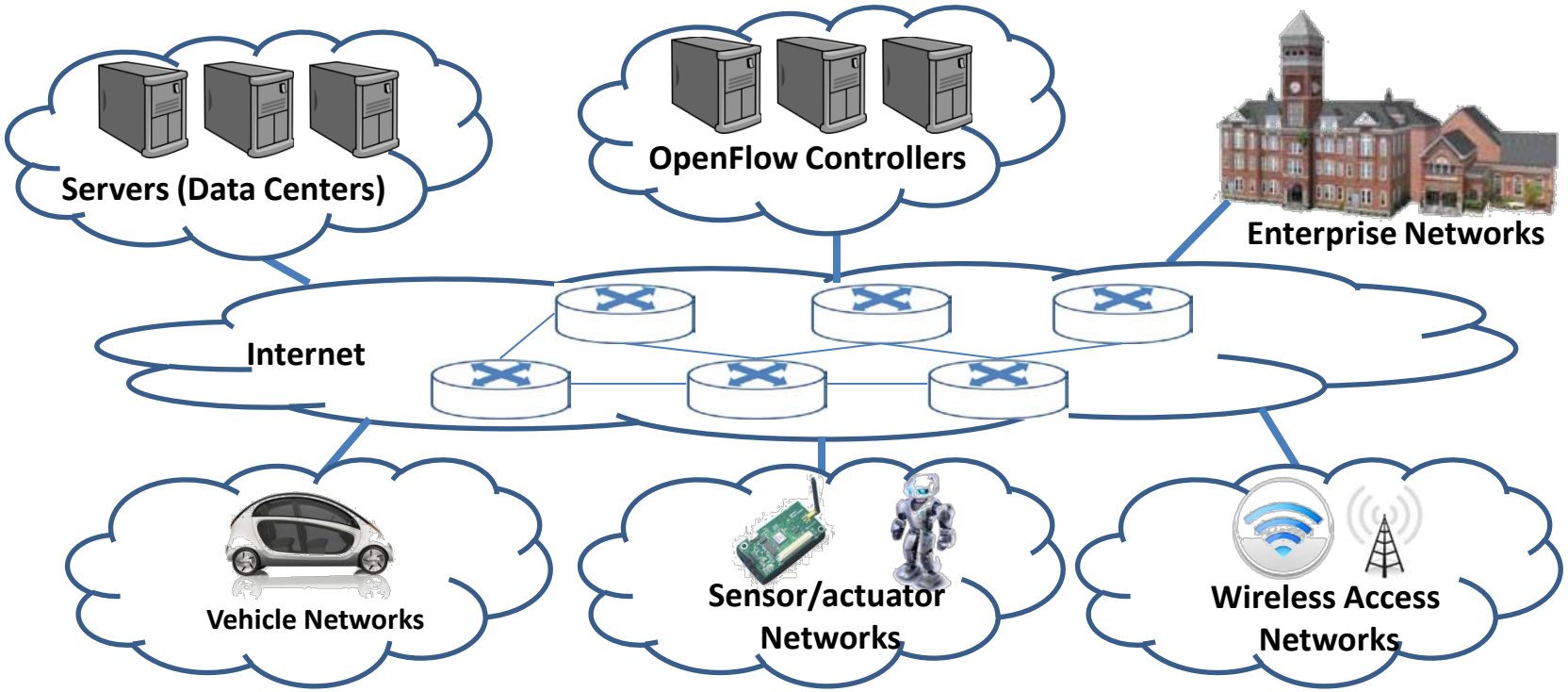
SDN→Clean Interface for Net Control



SDN→Virtualization



SDN Deployment at Clemson – Premises



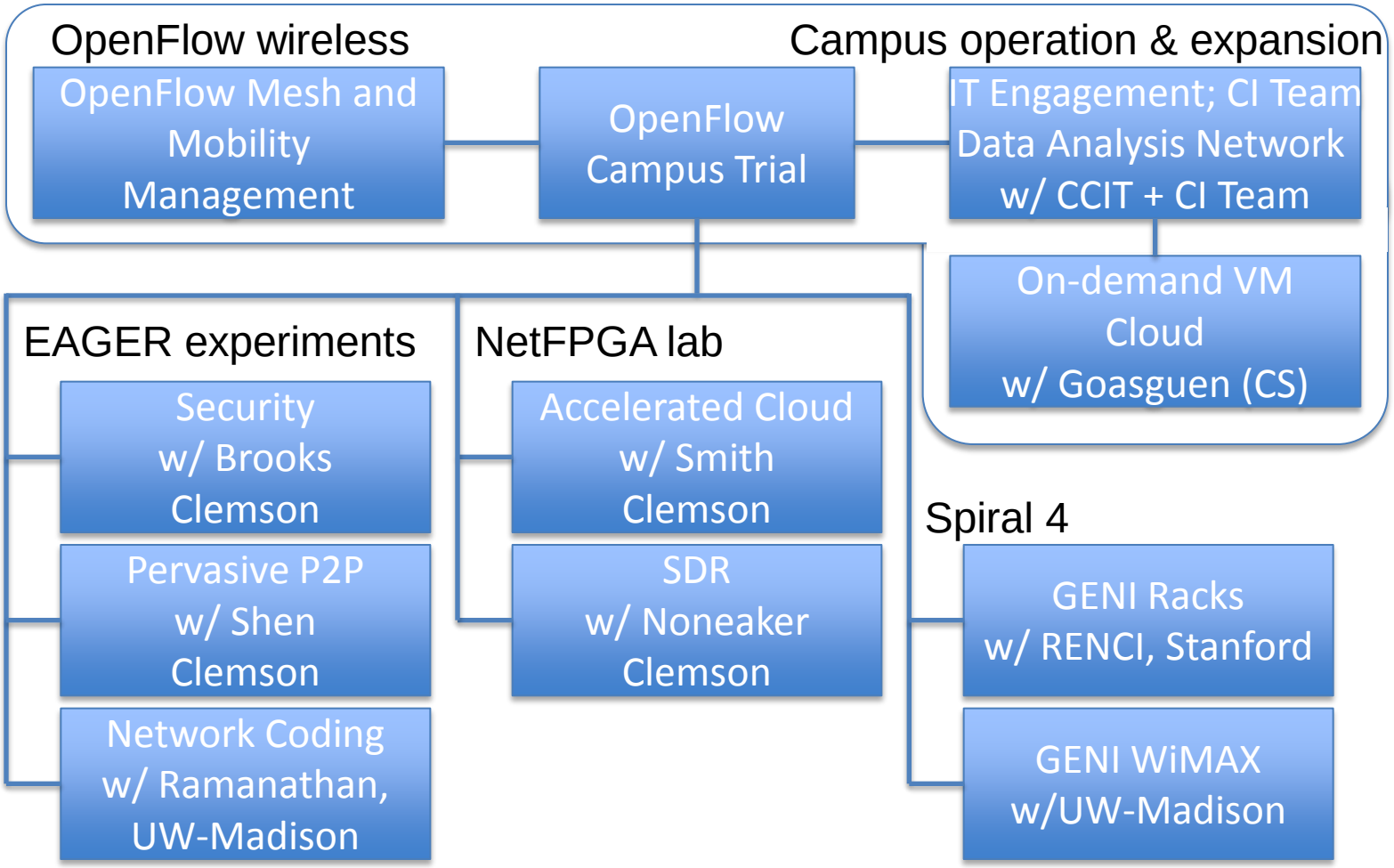
- Be cautious
  - There's a learning curve
  - You'll feel worried for a while
  - You will need help
- Be positive
  - It's our mission
  - We can do this
    - We can take risks
    - We never run out of brains

SDN Deployment at Clemson – Our Strategy

- Make it useful
  - "Discover " potential users
  - Build a community
- Do it incrementally
  - Implement real use cases
  - Collaborate with vendors
- Make it sustainable
  - IT-academic collaborative operation
  - Innovative funding model

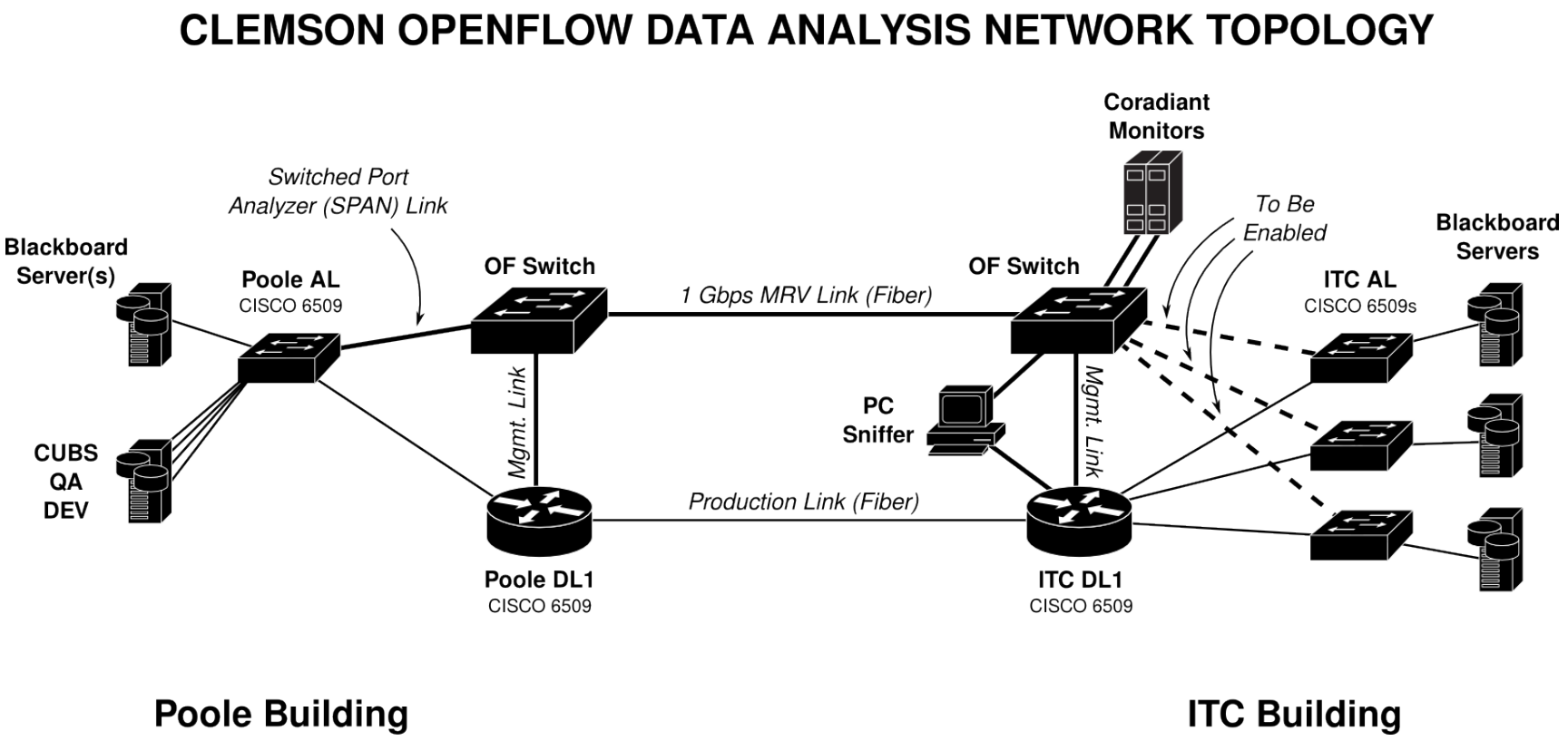
Make It Useful – "Discover" New Users

- They may not know it's good for them yet!



Make It Useful – Data Analysis Networks

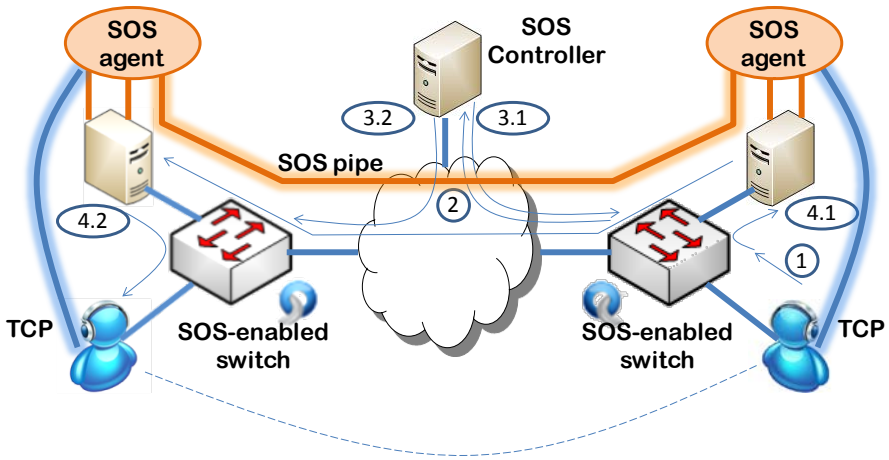
- Security group has been asking for distributed analysis solution
- Server group has been asking for application tracking solution



Make It Useful – Large Data Transport Enhancement

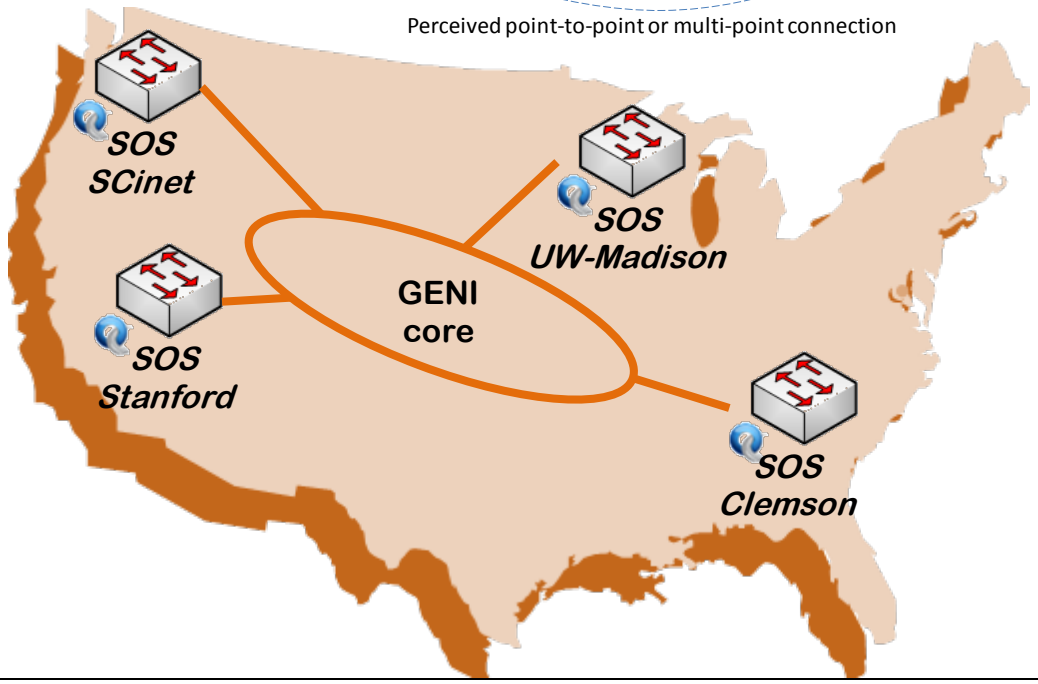
Steroid OpenFlow Service (SOS)
by Aaron Rosen and KC Wang

- *Seamless TCP throughput upgrade, e.g., 2.5 Mbps → 120 Mbps*
- *Multipath support*
- *Automatic site agent detection*

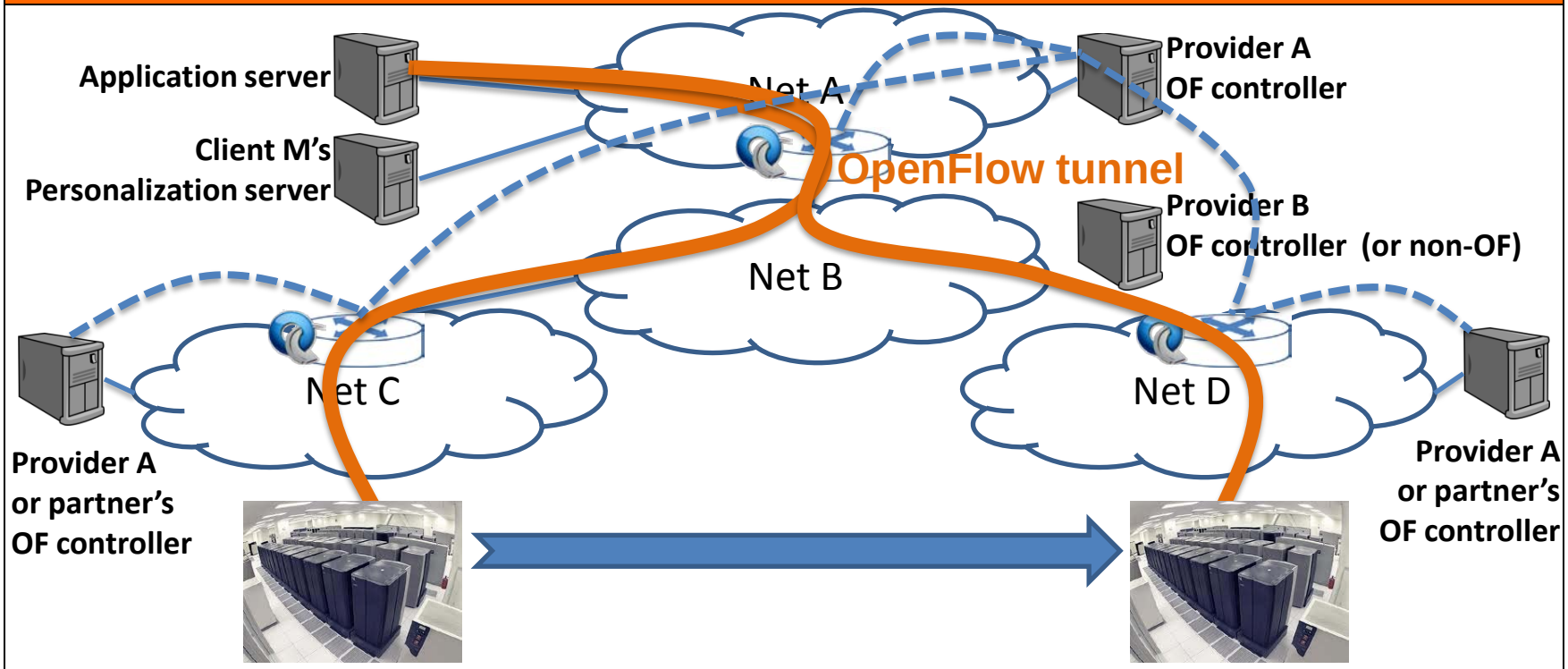


Upcoming demos of SOS at:

- *NSF 12th GENI conference, Kansas City, MO.*
- *Supercomputing 2011, Seattle, WA.*



Make It Useful – Data Center Disaster Recovery



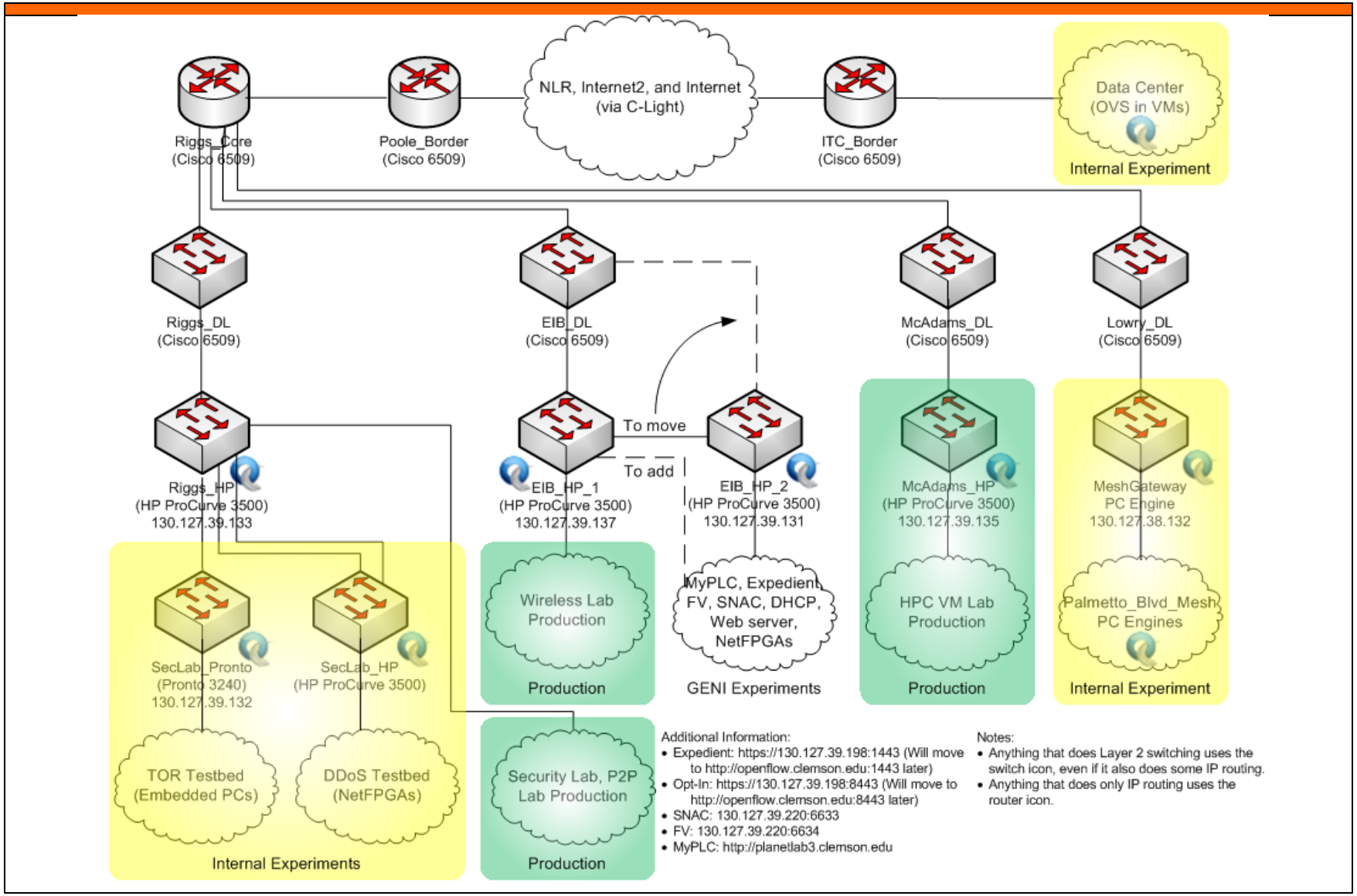
- From **reactive** to **proactive** networking
  - Mobile IP: Distributed, **reactive** (long latency), requires compatible agents everywhere, **provider-dictated**
  - OpenFlow: Centralized, **proactive**, solutions for diverse network scenarios, opportunities for both **provider and client customization**

Do It Incrementally – Our OpenFlow Footprint

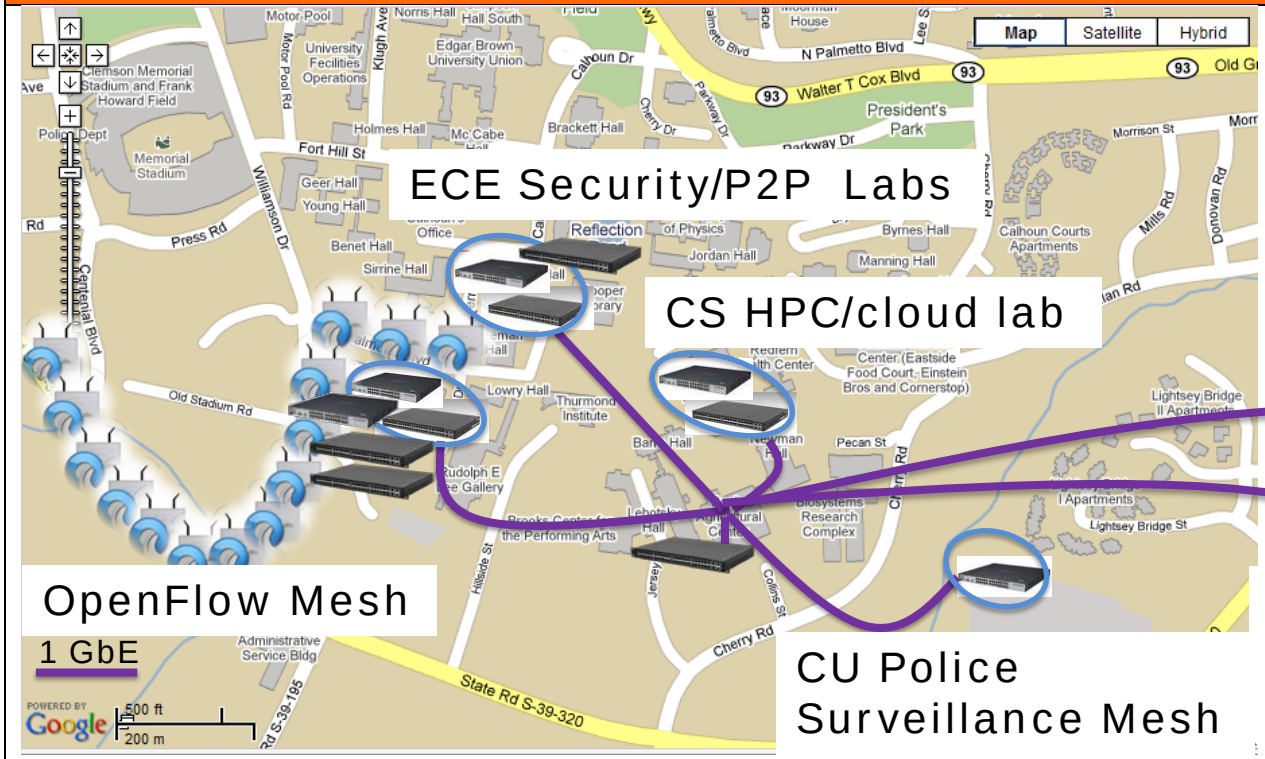
1. OpenFlow in one laboratory
   - Many backhaul options: VPN tunnel, VLAN, native L2
   - Try out in small network in the lab
   - Connect to the "grid": GENI OpenFlow core and campuses
   - Researchers start using GENI compute resources
     - At Clemson: ECE networking, security, P2P labs, CS HPC lab
2. OpenFlow across campus
   - Create OpenFlow VLANs spanning target buildings
     - If desired, cross-building VLANs can be replaced with OpenFlow later
   - Moving OpenFlow switch(es) into building closet
   - Moving friendly production users' wall ports onto OpenFlow

- Add IT services one at a time
- Explore projects with corporate partners

Clemson Campus OpenFlow Network



Clemson OpenFlow Deployment

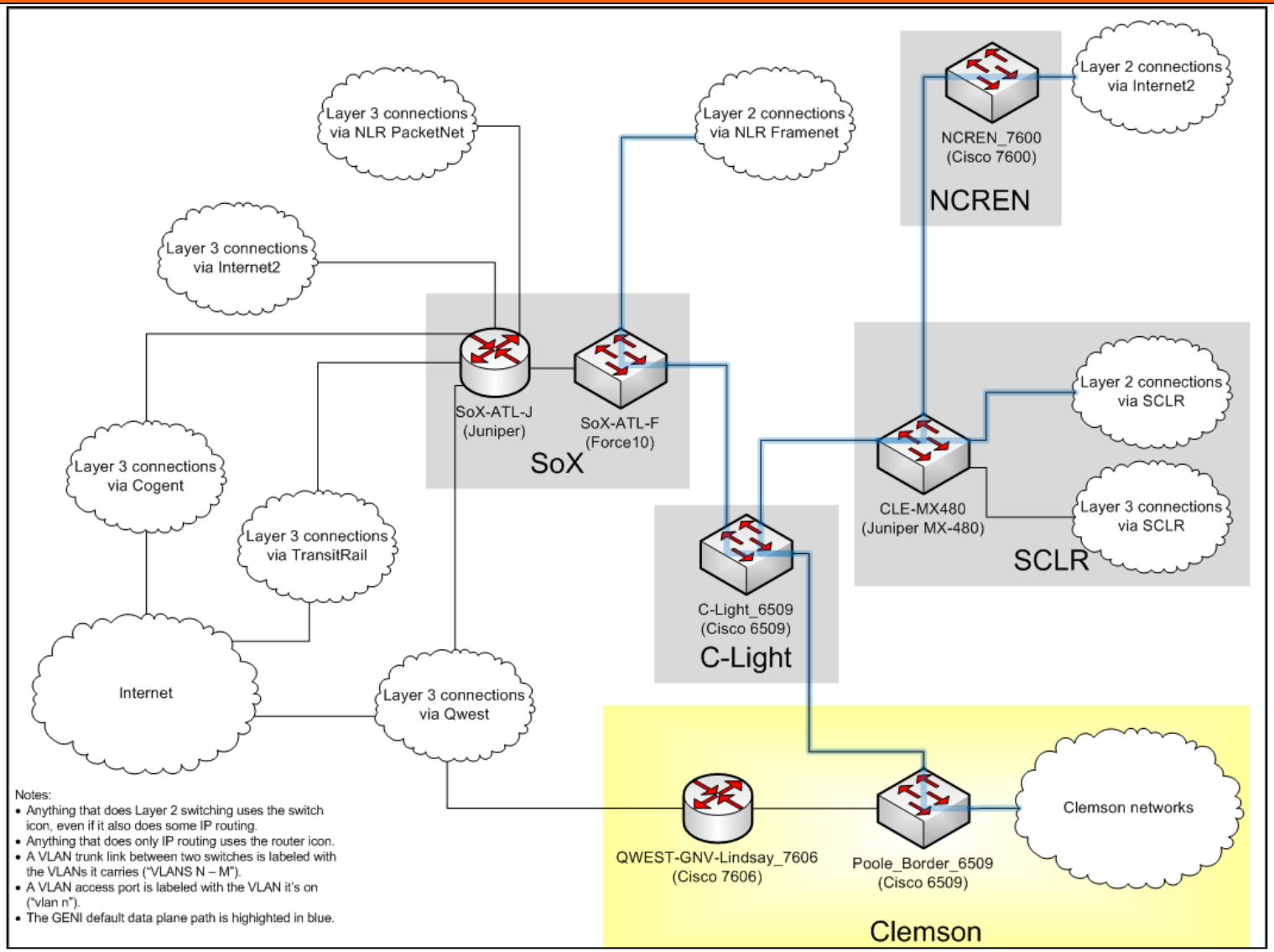


ECE Wireless, OpenFlow, NetFPGA Labs – mobile and mesh networks, cognitive/software defined radio

OF Ethernet : 5 HP, 9 Pronto switches
OF mesh: 5 APs deployed, 10+ to come
GENI OF and non-OF core vlans: connected

OpenVswitch in VMs at Palmetto Cluster

Clemson Regional OpenFlow Connectivity



GENI Racks and Real Users

- GENI Racks
  - Notionally: rack of ~40 computers & programmable switch, connected to a GENI backbone
  - Next 2-3 years: 20-40 racks in campuses, industrial research labs, topologically significant locations

GENI Racks

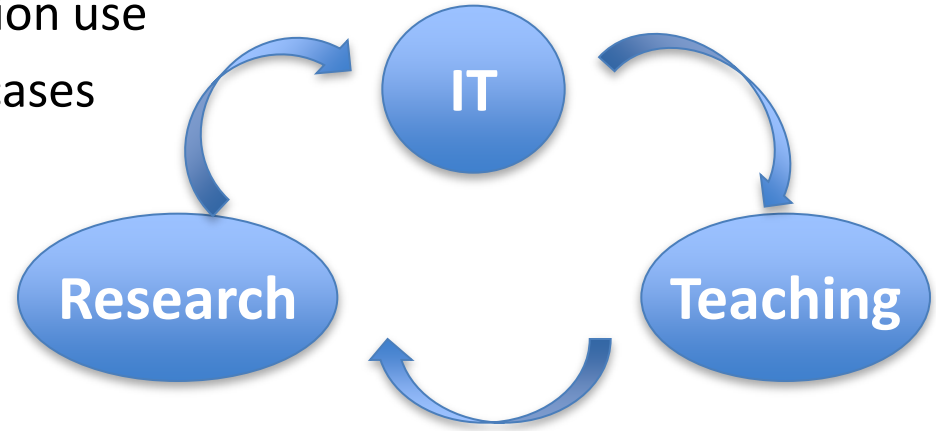
- Real users
  - Notionally: Enable campus networks to allow students , faculty, & staff to directly join (opt-in) in GENI experiments
  - Next 2-3 years: OpenFlow and WiMax deployments on 10-20 campuses enable direct-to-end-system experiments

Opt-In Users

GENI's vision: expand reach to 100-200 campuses

Make It Sustainable – Deep IT Integration

- To facilitate sustained growth and leverage the power of all parties in University to stay creative, we need a new model.
  - Students
    - Graduate research assistants
    - Undergraduate “Creative Inquiry” program
    - Undergraduate IT internship program + curriculum
  - Network engineers
    - Support researchers deploy and operate GENI
    - Operate GENI in production use
    - Innovative institute use cases
  - Faculty
    - Research
    - Teaching



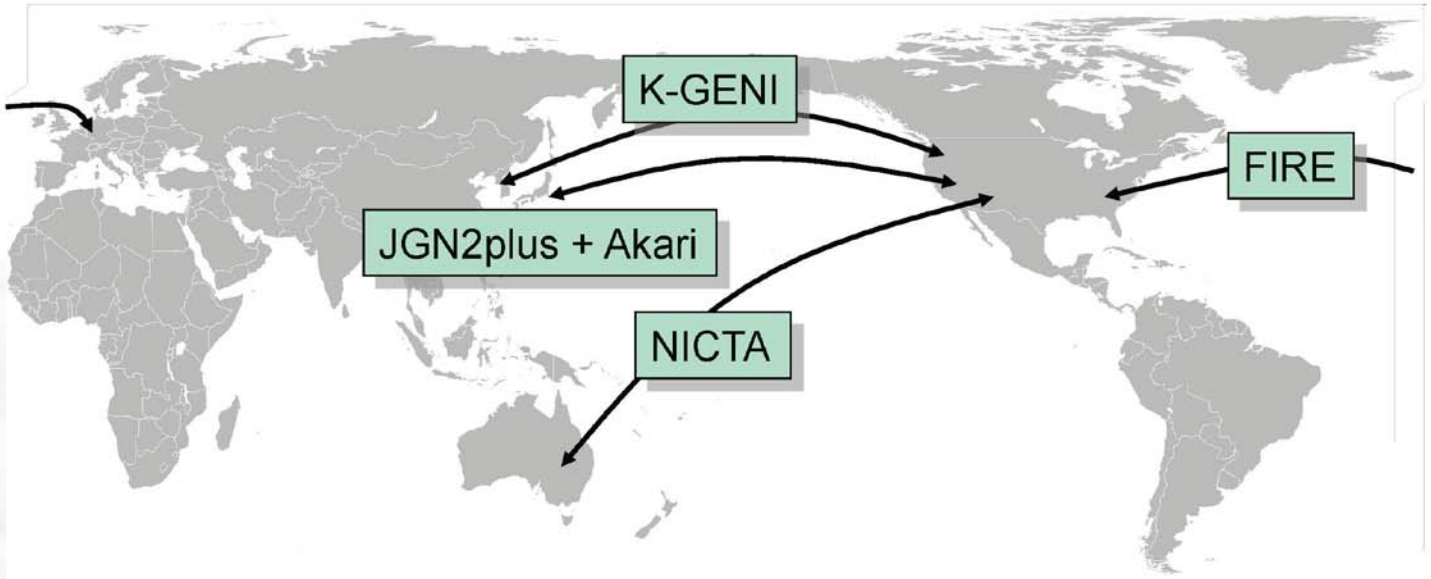
Make it Sustainable – Funding Model

- Research grants + IT support
  - NSF GENI OpenFlow Campus Trial project
  - CCIT cost share (engineers, space, server, travel)
  - Other research grants leveraging OpenFlow network
    - Cybersecurity testbed
    - Automotive and transportation testbed
- University IT internship program
  - Sustained university investment in IT evolution
- Partnerships
  - Corporate partnership
  - Regional/city partnership (e.g., US-IGNITE)

International Collaboration Too

geni
Exploring Networks of the Future

GENI's emerging international collaborations



The GENI Project Office is interested in federation with peer efforts outside the US, based on equality and arising from direct, "researcher to researcher" collaborations.

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37

Summary

- Clemson University is one of the few early OpenFlow adopters.
- Since 2010, we deployed on campus an OpenFlow network that spans academic buildings and data centers.
- We built a sustained team of faculty, students, and IT engineers.
- The process stimulated a series of research, education, and campus IT initiatives.
- We are finding innovative ways to realize a a collaborative framework for self-sustaining evolution of the campus IT in support of the university's core missions.

FURTHER QUESTIONS

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