![geni — Exploring Networks of the Future]

Survey of Available GENI Resources

Aaron Falk

GENI Project Office

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- **Introduction**
- Resources
  - Compute & Programmable Systems
  - Wireless
  - Networks
  - Tools
- Getting access
- Wrap-up

- 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

GENI is Young

- These are early days with limited or inconsistent…
  - Availability, Reach, Scope, Tool integration
  - Changing rapidly, expect improvements in coming weeks and months

- The GPO is committed to helping experimenters identify, acquire, & connect the resources they need
  - Email: help@geni.net to get started

In the Pipeline

- As GENI matures, we expect to enhance those capabilities of greatest use.
    - GENI Racks on dozens, then 100's of campuses
    - OpenFlow deployments on dozens, then 100's of campuses
    - Wireless networks, including WiMax
    - Programmable network devices throughout the network
    - Real users able to directly join (i.e., opt-in) experiments
    - Deep and ubiquitous instrumentation and measurement

- Standard APIs will permit common tools to help with *resource discovery, orchestration, distributed debugging, and experiment management* across a range of technologies

Experiment Planning

- When planning a GENI experiment, consider what kind of resources you need and how they should interconnect
  - Resources (e.g., computation, storage, programmable network devices) are provided by *GENI Aggregates*

- Connectivity between aggregates comes in roughly four flavors
  - L2: Layer 2 (Ethernet VLANs)
  - OF: GPO-engineered OpenFlow Network *(traffic flowspec &/or programmable switch controller)*
 - IP: GPO-engineered IP
  - Internet

Subject to availability, an experiment can include *any resource* in *any location* using *any connectivity*

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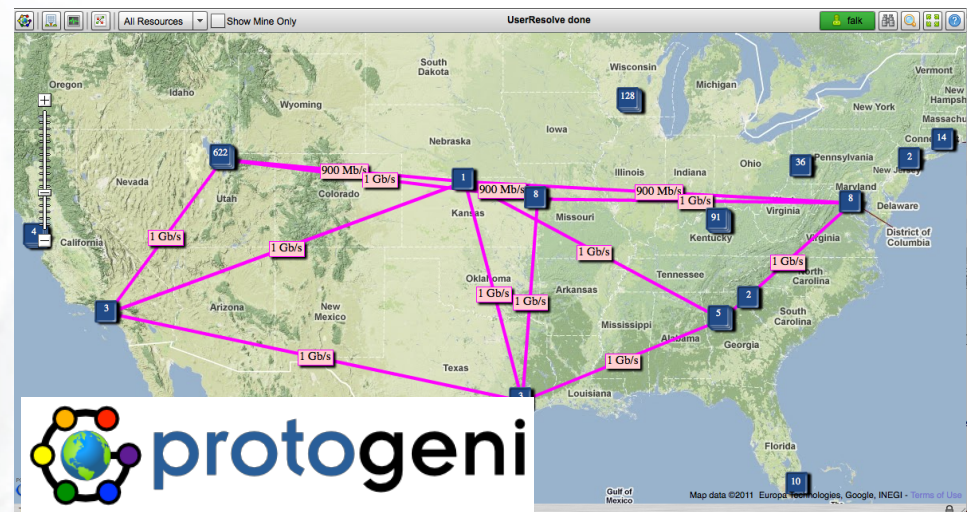# Compute Resources in GENI (highlights)

PlanetLab

- Global testbed of user-mode VMs on the Internet
- myPLC: local PlanetLabs often with 'interesting' connectivity options
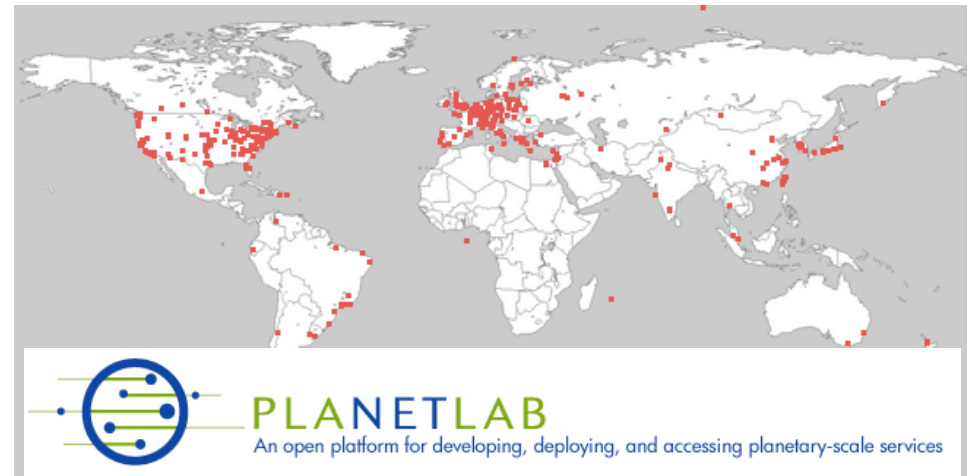
ProtoGENI

- Emulab-based compute clusters
- Experimenters get choice of OS; root access; local topology control
- Rapidly evolving tools for WAN topology control

GENI-enabled Compute Nodes: PlanetLab & MyPLC

Aggregate	Count	Location	Avail?	Connectivity			
				Internet	IP	L2	OF
PlanetLab	1000+ nodes at 500+ sites	Global	Y	Y			
MyPLC at BBN	3	Cambridge, MA	Y	Y	Y	Y	Y
MyPLC at Washington	2	Seattle, WA	BE	Y	Y	Y	Y
MyPLC at Stanford	3	Palo Alto, CA	BE	Y	Y	Y	Y
MyPLC at Georgia Tech	2	Atlanta, GA	BE	Y	Y	Y	Y
MyPLC at Clemson	2	Clemson, SC	BE	Y	Y	Y	Y
MyPLC at Indiana Univ.	?	Indianapolis, IN	BE	Y	Y	Y	Y
MyPLC at Wisconsin	2	Madison, WI	BE	Y	Y	Y	Y
MyPLC at Kansas State	6	Manhattan, KS	BE	Y	S	S	S

Availability: Y: supported now; BE: best effort; BP: by permission; S: coming soon

GENI-enabled Compute Nodes: ProtoGENI

Aggregate	Count	Location	Avail?	Connectivity			
				Internet	IP	L2	OF
ProtoGENI cluster: Utah	~600	Salt Lake City, UT	Y	Y	Y	Y	
ProtoGENI cluster: Internet2 backbone	18	LA, Kansas City, Houston, DC, Atlanta	Y	Y	Y	Y	
Wide Area ProtoGENI nodes	10	Clemson, Georgia Tech, Stanford, Rutgers	BE	Y	Y	Y	Y
ProtoGENI cluster: BBN	11	Cambridge, MA	Y	Y	Y	Y	Y
ProtoGENI cluster: UMass-Lowell	8	Lowell, MA	BE	Y	Y	Y	Y
ProtoGENI cluster: Kentucky	26	Lexington, KY	Y	Y	Y	Y	
ProtoGENI cluster: FIU	3	Miami, FL	BE	Y	Y	Y	
ProtoGENI cluster: LONI	2	Baton Rouge, LA	BE	Y	Y	Y	
ProtoGENI cluster: Wisc	38	Madison, WI	BE	Y			

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Other GENI-enabled Programmable Systems

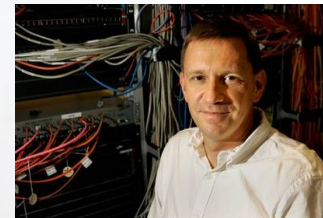| Aggregate	Count	Location	Avail?	Connectivity			
				Internet	IP	L2	OF
Seattle GENI *P2P hosting platform on home/office computers*	4000+ installs	U of Washington and volunteer participants	Y	Y			
Supercharged PlanetLab Platform *High-speed programmable router*	5 nodes	St. Louis, Salt Lake City, Kansas City, DC, Atlanta	Y	Y	Y		
Programmable Edge Node *Virtual router*	1 node	U of Massachusetts, Lowell	Y	Y	Y	Y	Y
GENI Cloud / Transcloud *Distributed Eucalyptus cluster*	100 cpus	HP, UCSD, Kaiserslautern, Northwestern	Y	Y	Y	S	
DETER *Compute cluster for security research*	200 nodes	Los Angeles, CA	BP	Y			
BGP Multiplexer *Buffered interface to global routing*	4	Wisconsin, GaTech, Princeton, and Clemson	BE	Y			
Data Intensive Cloud *Amazon EC2, S3, EBS Services*	variable	Via UMass Amherst	BP	Y			

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GENI Programmable WiMax Base Stations

Virtual GENI Router (at PoP)

GENI Backbone Network

GENI Access Network (Ethernet SW & Routers)

WiMAX Base Station (GBSN)

GENI terminals (WiMAX phone/PDA running GENI/Linux)

GENI Compliant WIMAX Base Station Controller
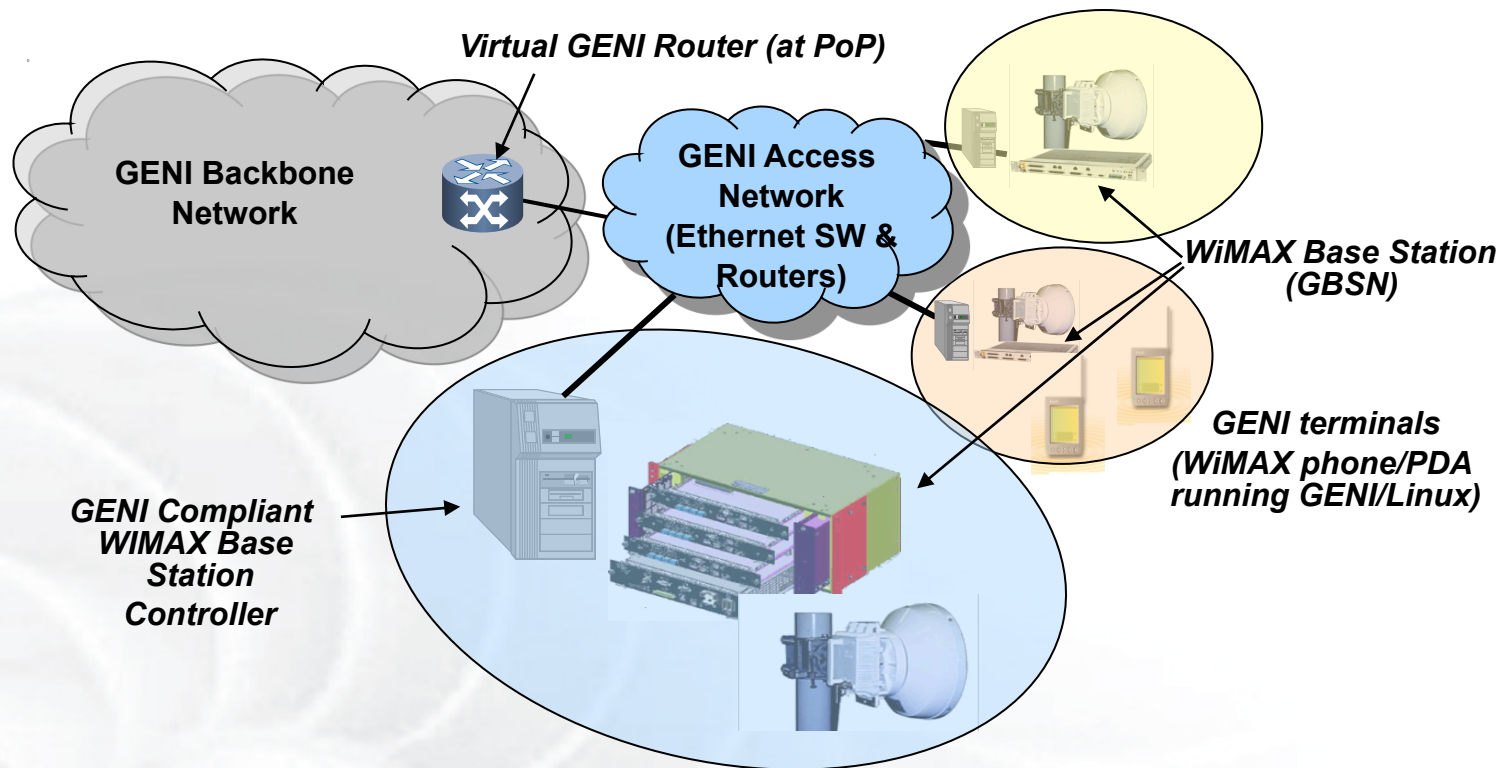
GENI WiMax:
- Commercial IEEE 802.16e WiMAX base station with virtualization & open, programmable interfaces
- Deployed on campuses (4 up now, 4 in deployment)
- Works with commercial clients & handsets
- Good resource for mobility & vehicular experiments

GENI-enabled Wireless Systems (WiMax & others)

Aggregate	Count	Location	Avail?	Connectivity			
				Inter-net	IP	L2	OF
Rutgers WiMax Network	1 base station	New Brunswick, NJ	BP	Y			
BBN WiMax	1 base station	Cambridge, MA	BP	Y	S	S	S
NYU Poly WiMax	1 base station	Brooklyn, NY	S	Y			
UCLA WiMax	1 base station	Los Angeles, CA	S	Y			
ORBIT *Large 802.11 Testbed w/ rich tools*	400 nodes	New Brunswick, NJ	Y	Y	Y	Y	Y
Kansei *Sensor Testbed*	96 nodes	Columbus, OH	Y	Y			
CMU Wireless Channel Emulator *FPGA-based, Real-time*	11 nodes	Pittsburgh, PA	Y	Y			
ViSE *Steerable weather radar*	3 nodes	Amherst, MA	Y	Y	Y	Y	
DOME *VMs on networked city buses*	35 nodes	Amherst, MA	Y	Y			

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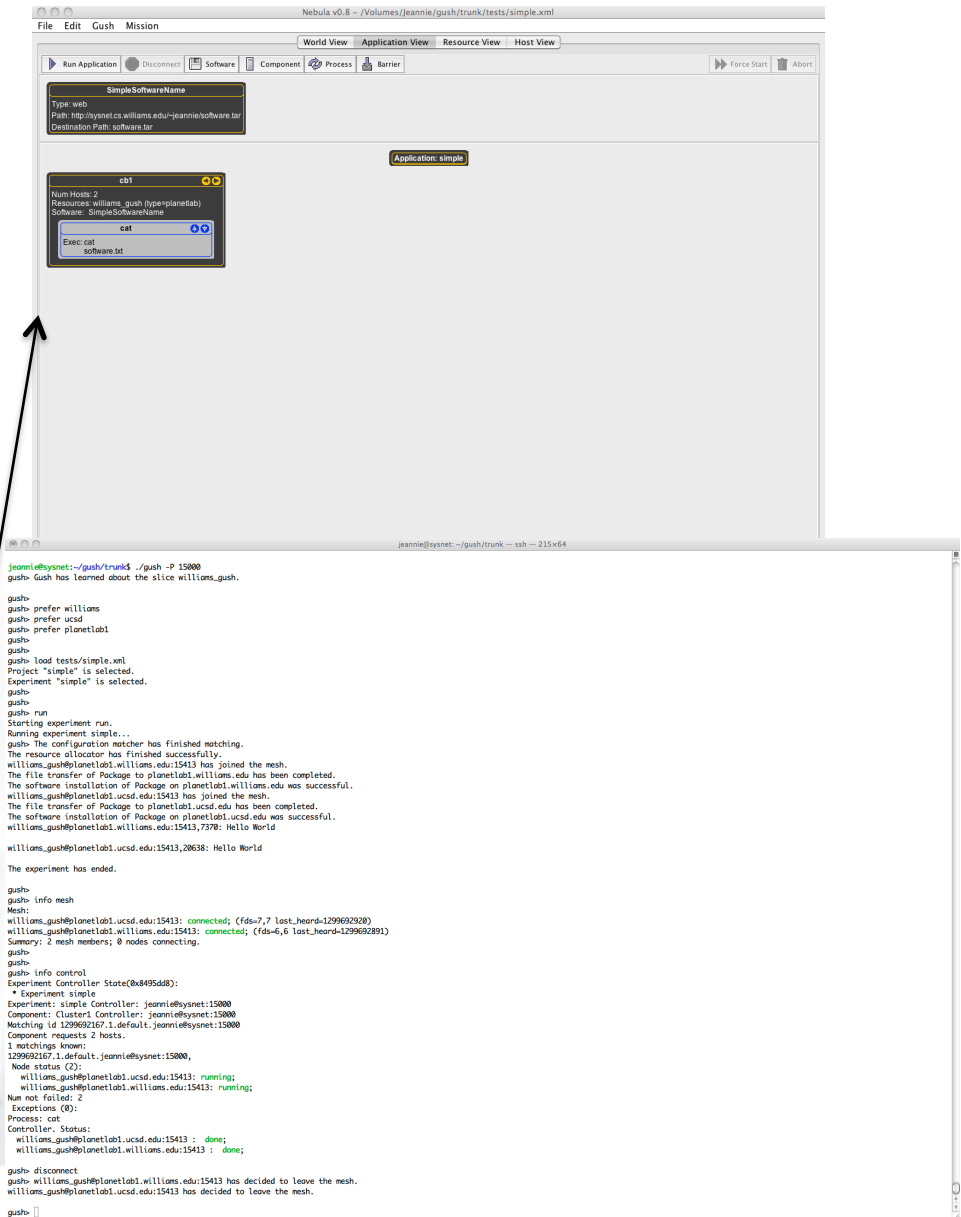 - Tools
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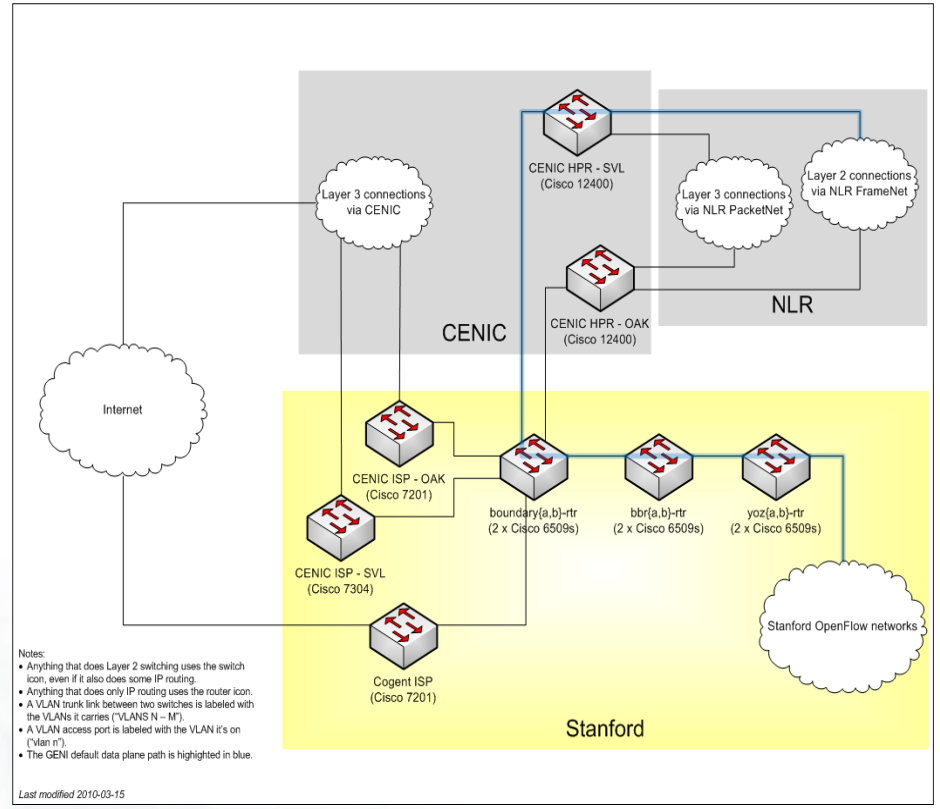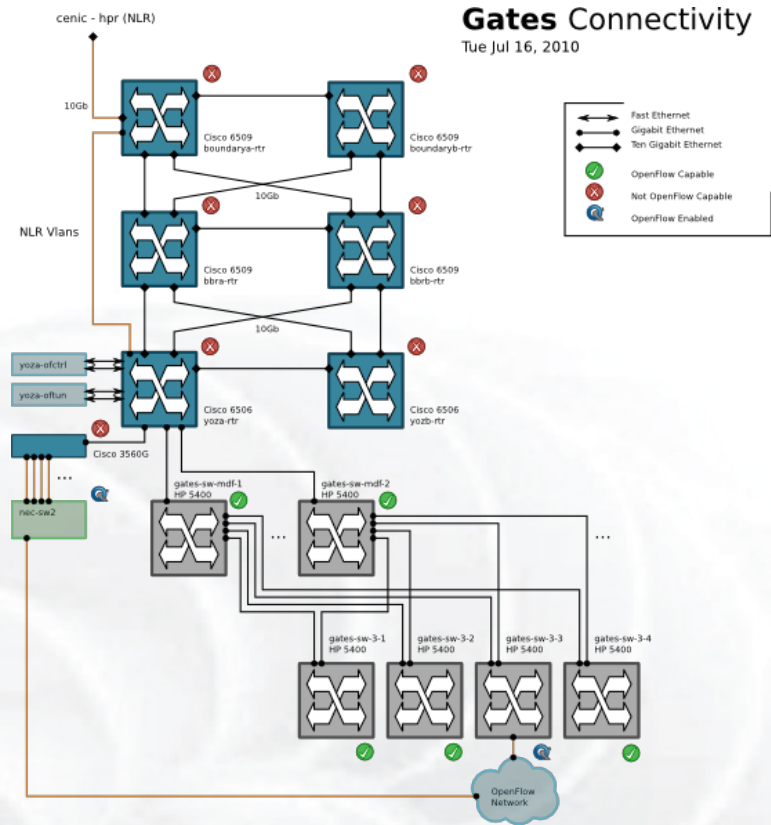
- OpenFlow production traffic *now*
- OpenFlow 1.0 ref implementation *now*
- Early integration with campus trials HP, NEC, Toroki, Quanta, and OpenWRT switches
- OF sw devel/sActiveport

Nick McKeown, PI   Guru Parulkar

GENI-enabled Networks

Many systems mentioned elsewhere also include network resources

Aggregate	Location	Avail?	Connectivity			
			Internet	IP	L2	OF
Internet2 Backbone	LA, Houston, Atlanta, DC, New York	Y	Y	Y	Y	Y
National Lambda Rail Backbone	Seattle, Sunnyvale, Denver, Chicago, Atlanta	Y	Y	Y	Y	Y
Regional Networks	E.g., CENIC, SOX, NOX, BEN, LONI	Y	Y	Y	Y	S
GpENI	Various locations in KS, MO, Europe	Y	Y		S	S
ProtoGENI Internet2 network	LA, Kansas City, Houston, DC, Atlanta	Y	Y	Y	Y	
BBN OpenFlow	Cambridge, MA	Y	Y	Y	Y	Y
Stanford Campus OpenFlow	Palo Alto, CA	Y	Y	Y	Y	Y
U Washington OpenFlow	Seattle, WA		Y	Y	Y	Y
U. Wisconsin OpenFlow	Madison, WI		Y	Y	Y	Y
Indiana OpenFlow	Indianapolis, IN (2 campuses)	Y	Y	Y	Y	Y
Rutgers OpenFlow	New Brunswick, NJ	Y	Y		Y	Y
Clemson Campus OpenFlow	Clemson, SC	Y	Y	Y	Y	Y
Georgia Tech OpenFlow	Atlanta, GA	Y	Y	Y	Y	Y

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Gush: Experiment Control Tool
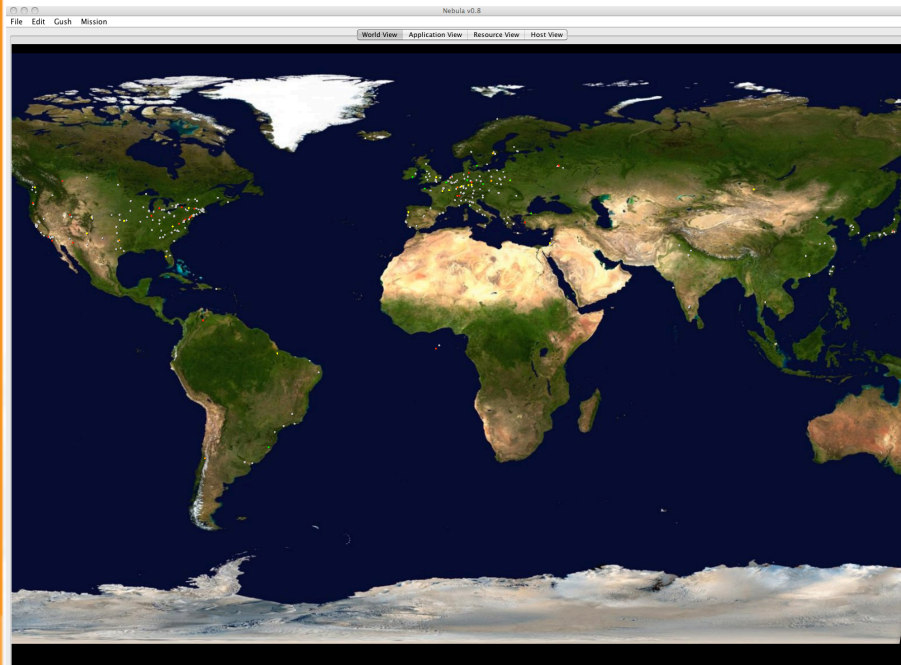
Nebula, a graphical front end to Gush, showing PlanetLab nodes available to an experimenter.

Nebula, a graphical front end to Gush, showing the status of an experiment controlled by Gush.

Gush, a command line based experiment control tool

GEC10:

ProtoGENI Map Client

ProtoGENI Map Client showing resources available through the ProtoGENI clearinghouse
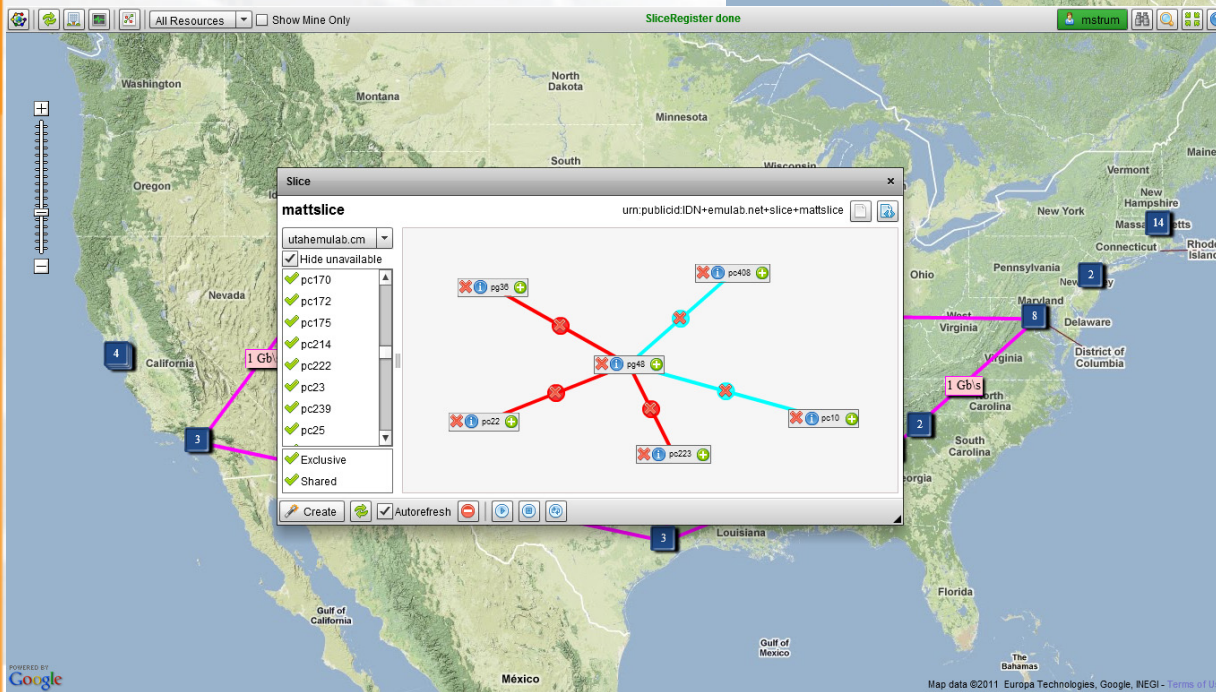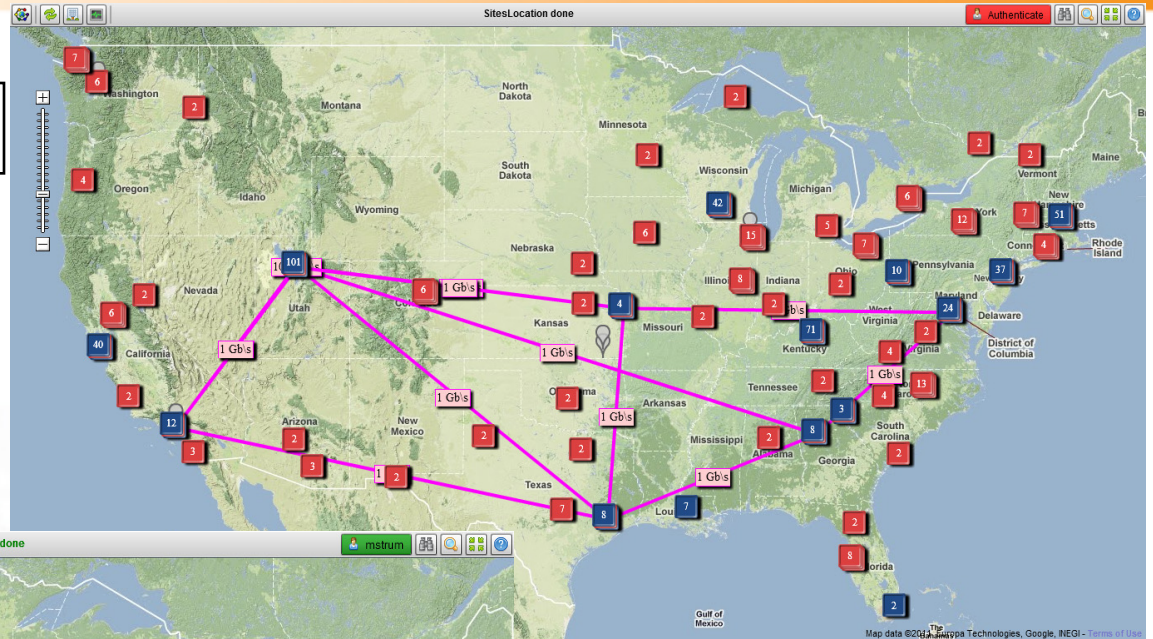
ProtoGENI Map Client showing a slice being created with resources from three aggregates
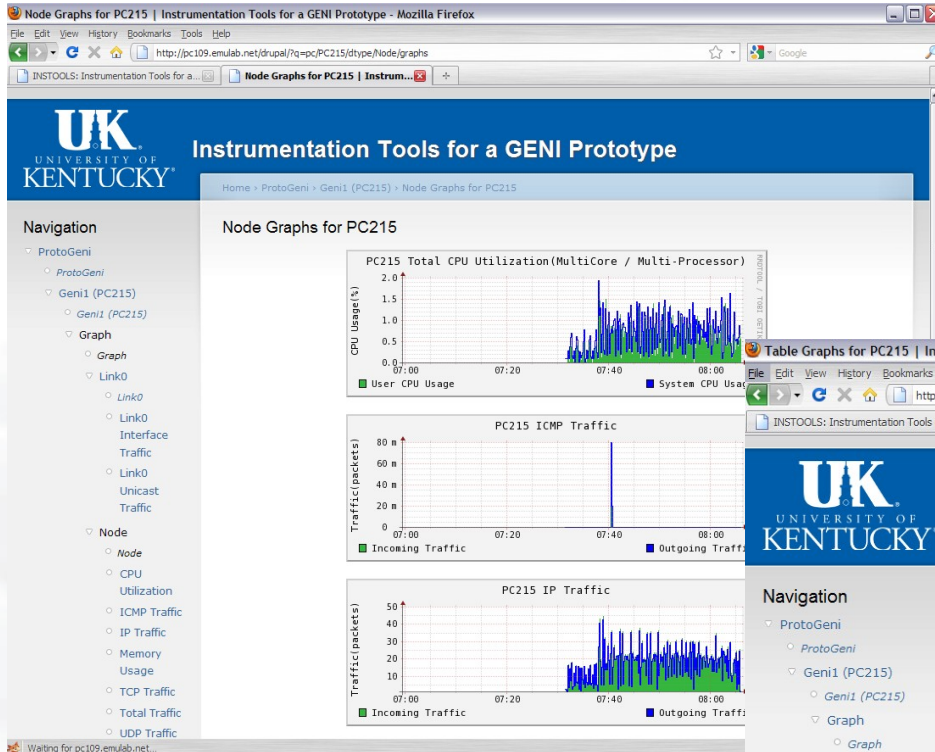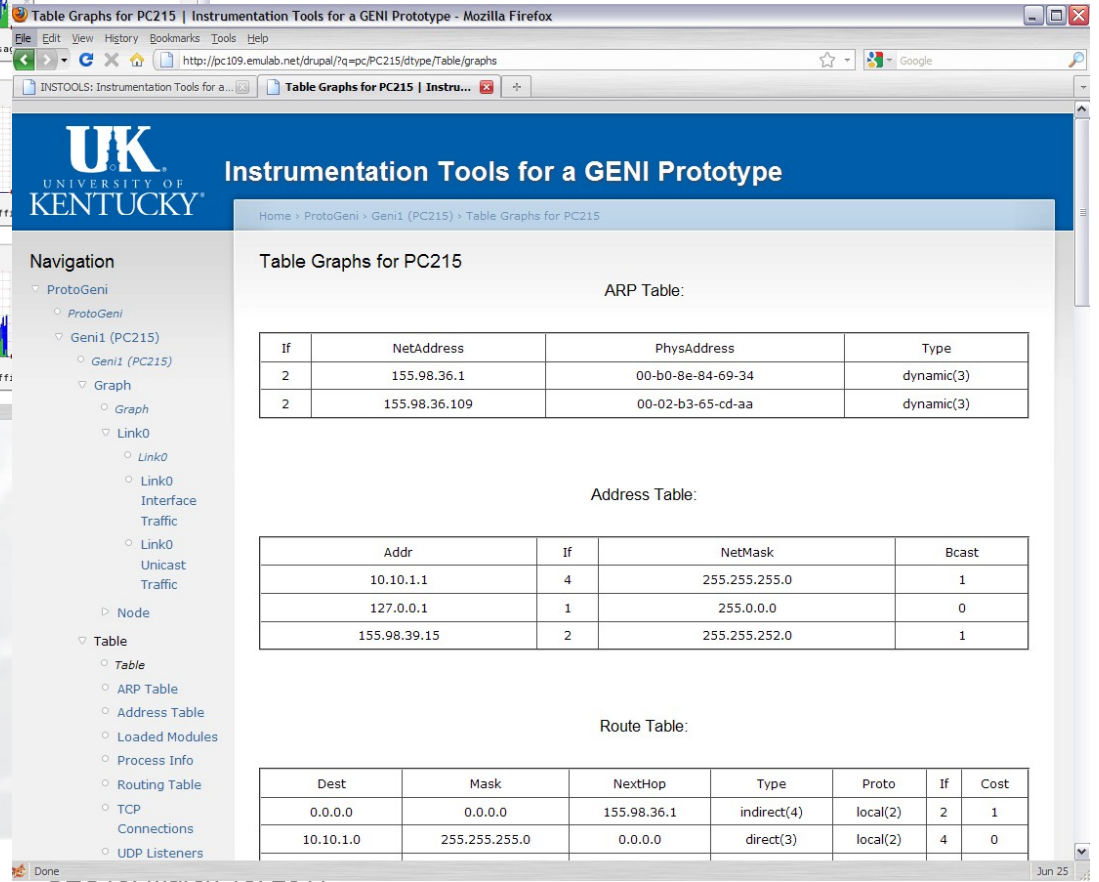
Kentucky Instrumentation Tool

Two different views of experiment data collected and analyzed using the Kentucky instrumentation tool.

The Raven suite of tools provide software package management and monitoring for large, long-running experiments

Two OMF suite of tools support experiment deployment, control and measurement.

GENI Experimenter Tools

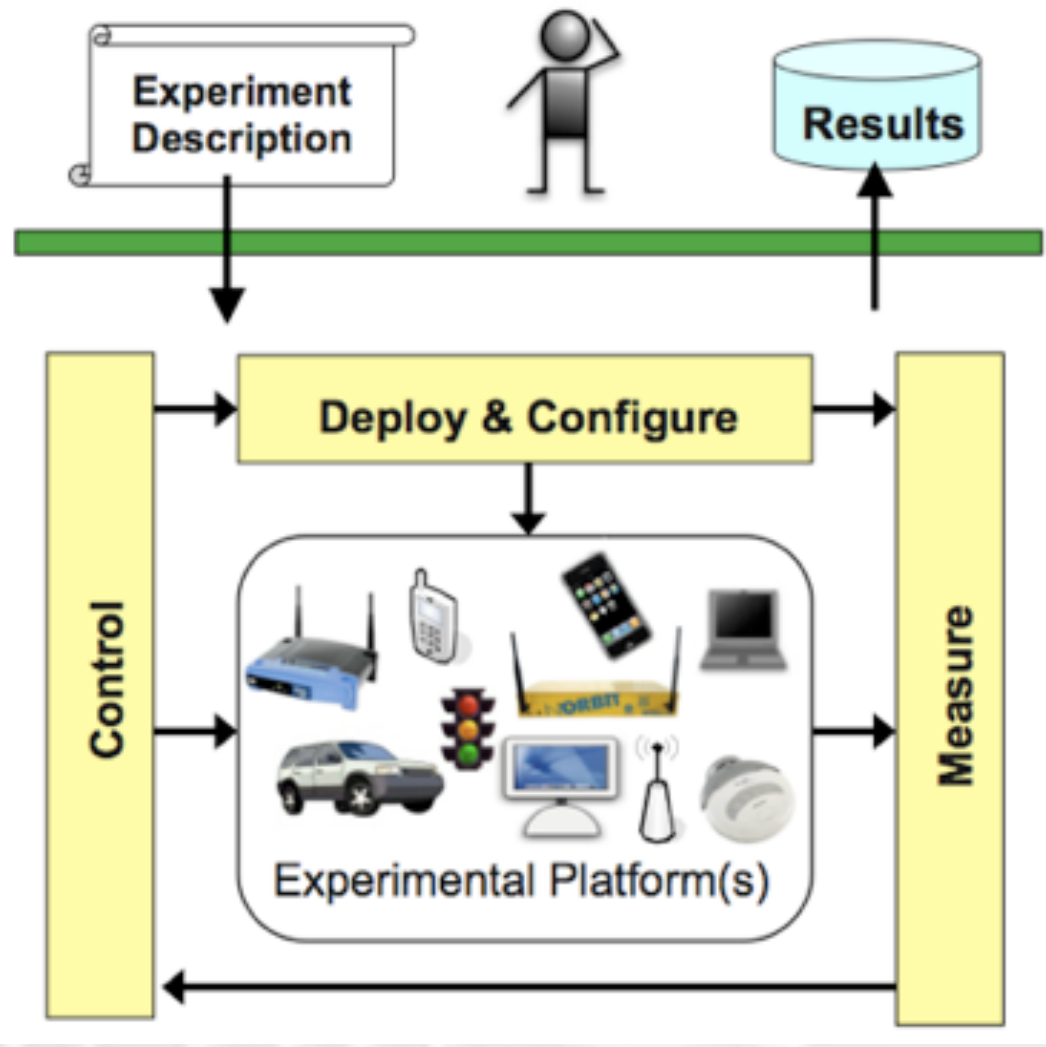| Resource	Description	Avail?	Works with…
OMNI	Resource acquisition	Y	PlanetLab, ProtoGENI, OpenFlow, myPLC
sfi	Resource acquisition	Y	PlanetLab, MyPLC
ProtoGENI Tools	Enhanced resource orchestration & topology tools	Y	ProtoGENI
ORCA	Resource acquisition	BE	DiCloud, ViSE, DOME, Kansei.
Seattle GENI Tools	Allows Seattle GENI to integrate with ProtoGENI systems	Y	Seattle GENI
GUSH	Experiment control and management	Y	PlanetLab, MyPLC, ProtoGENI
Raven	Distributed system provisioning & management tools	Y	PlanetLab
NOX	Customizable switch controller	Y	OpenFlow capable Ethernet switches
Expedient	GUI for provisioning OpenFlow & myPLC	BE	Some OpenFlow campuses, some myPLC
LAMP	perfSONAR instrumentation that runs within an experiment	Y	ProtoGENI
OMF/OML	Measurement tools & experiment control framework	Y	ORBIT, WiMax
Instrumentation Tools	Host and network measurement and monitoring	Y	Univ. Kentucky ProtoGENI cluster
On-Time Measurement	Orchestration & provisioning of active measurements within an experiment	BE	ProtoGENI

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- In general, any researcher can gain access to any GENI resource

- Access control typically requires first **getting an account** where you provide some information about you and your plans then **acquiring resources** where you ask for what you want

  – Access control mechanisms vary, but are consolidating

  – Details at http://groups.geni.net/geni/wiki/ExperimenterPortal

Let us help: email help@geni.net

Outline

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Looking ahead…

- **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

- ## Resource listing:
  - http://groups.geni.net/geni/wiki/ExperimenterPortal

- ## Connectivity Guide:
  - http://groups.geni.net/geni/wiki/ConnectivityOverview

- ## Advice & assistance:
  - help@geni.net