# Survey of Available GENI Resources

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# Outline

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

# Introduction

- 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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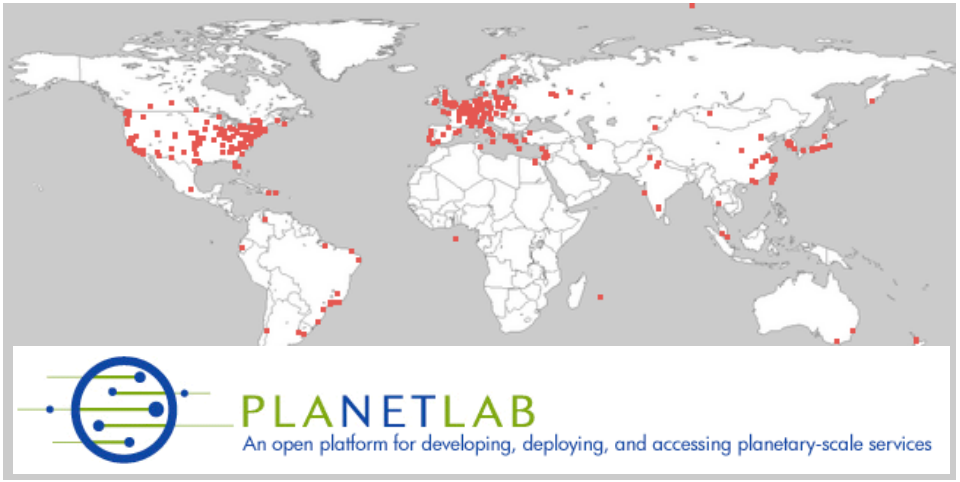
# Compute Resources in GENI (highlights)

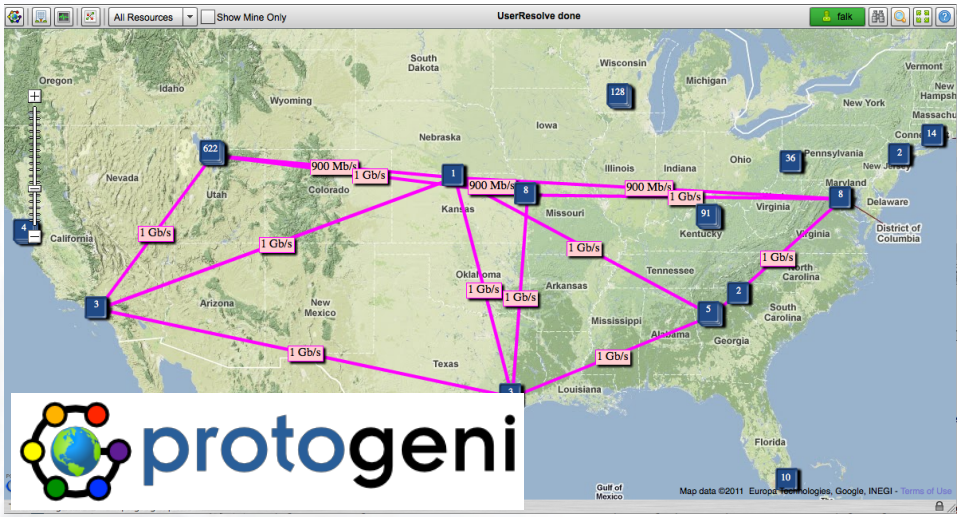
## PlanetLab

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

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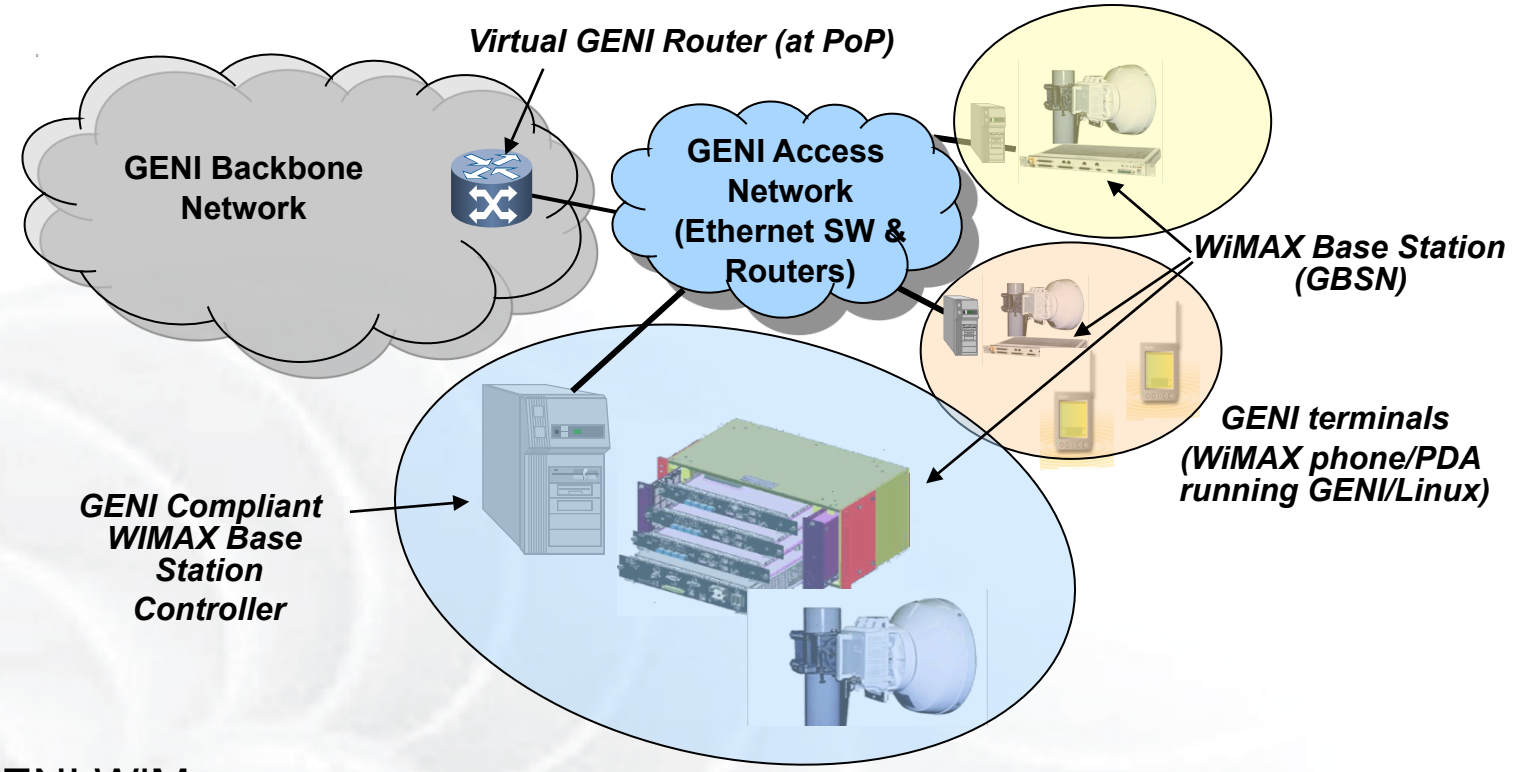
# GENI Programmable WiMax Base Stations




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<br>*Large 802.11 Testbed w/ rich tools* | 400 nodes | New Brunswick, NJ | Y | Y | Y | Y | Y |
| Kansei<br>*Sensor Testbed* | 96 nodes | Columbus, OH | Y | Y | | | |
| CMU Wireless Channel Emulator<br>*FPGA-based, Real-time* | 11 nodes | Pittsburgh, PA | Y | Y | | | |
| ViSE<br>*Steerable weather radar* | 3 nodes | Amherst, MA | Y | Y | Y | Y | |
| DOME<br>*VMs on networked city buses* | 35 nodes | Amherst, MA | Y | Y | | | |

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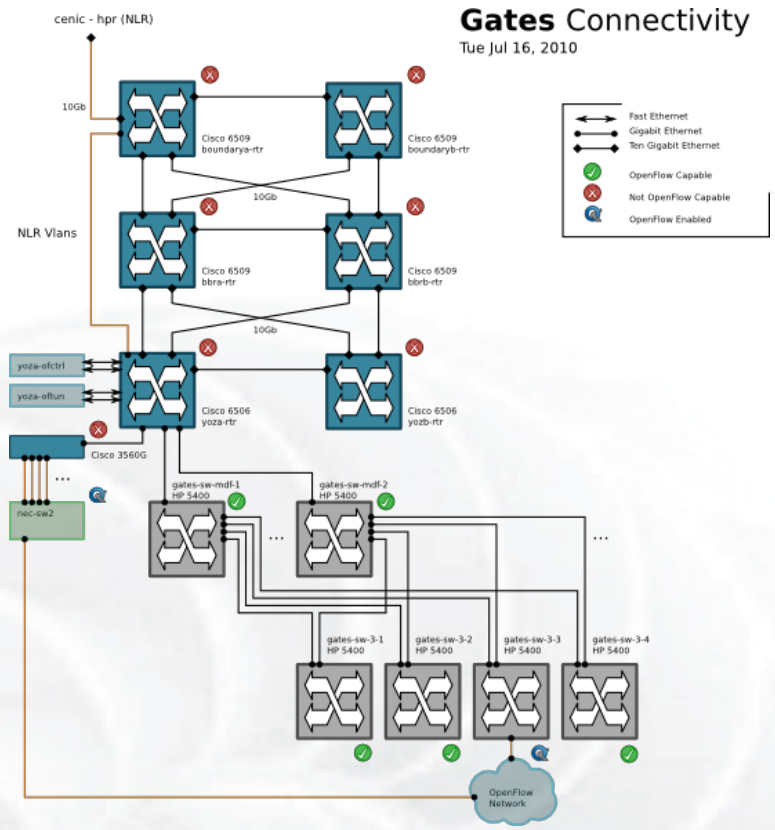
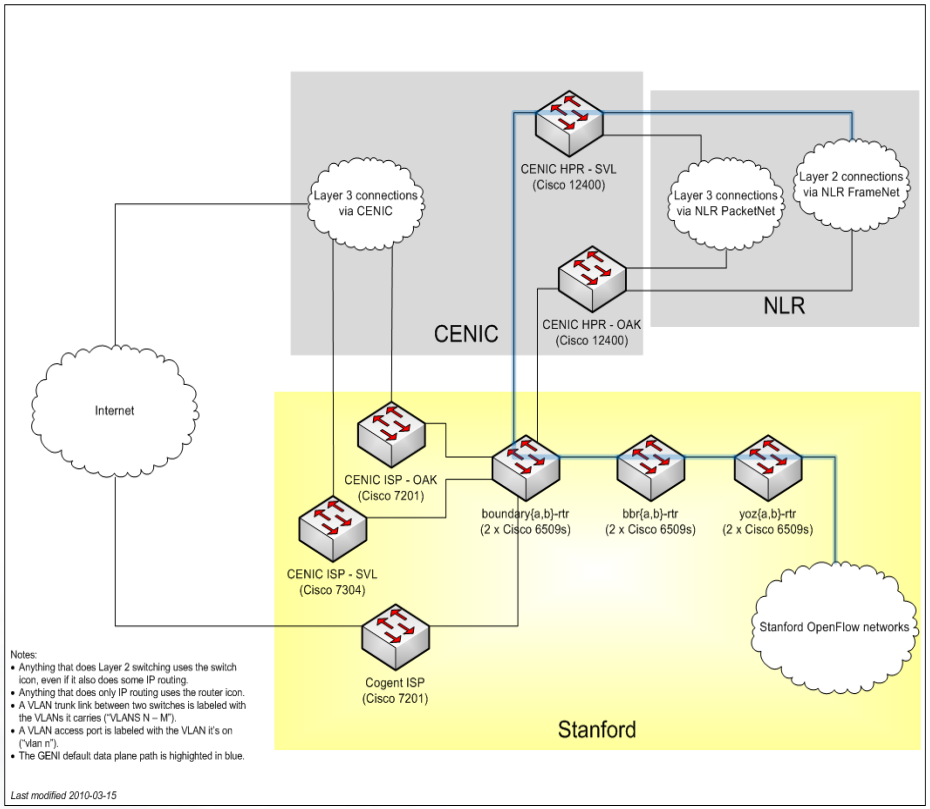
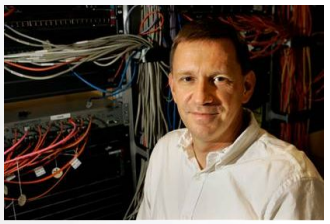
# OpenFlow Campus: Stanford GENI Network




- 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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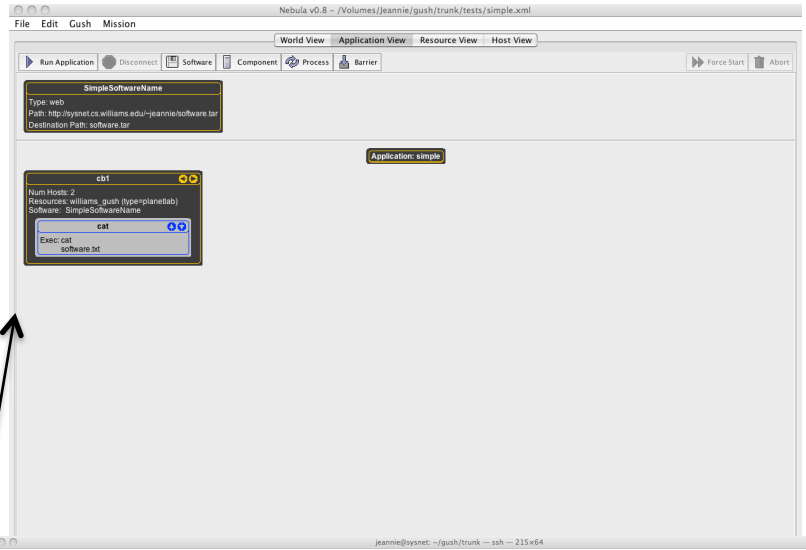
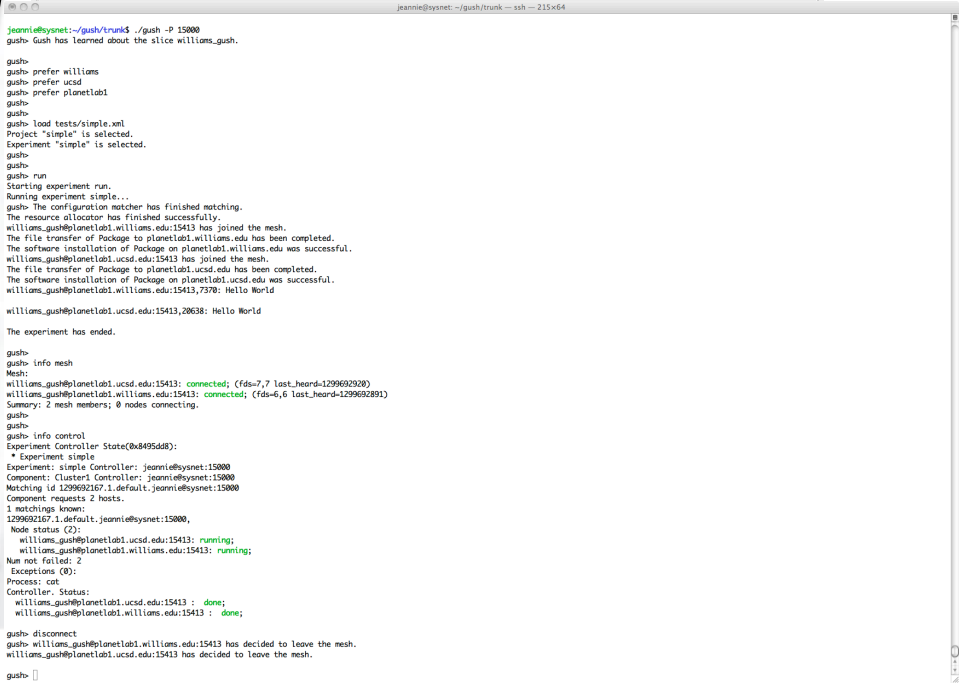
# Gush: Experiment Control Tool


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.

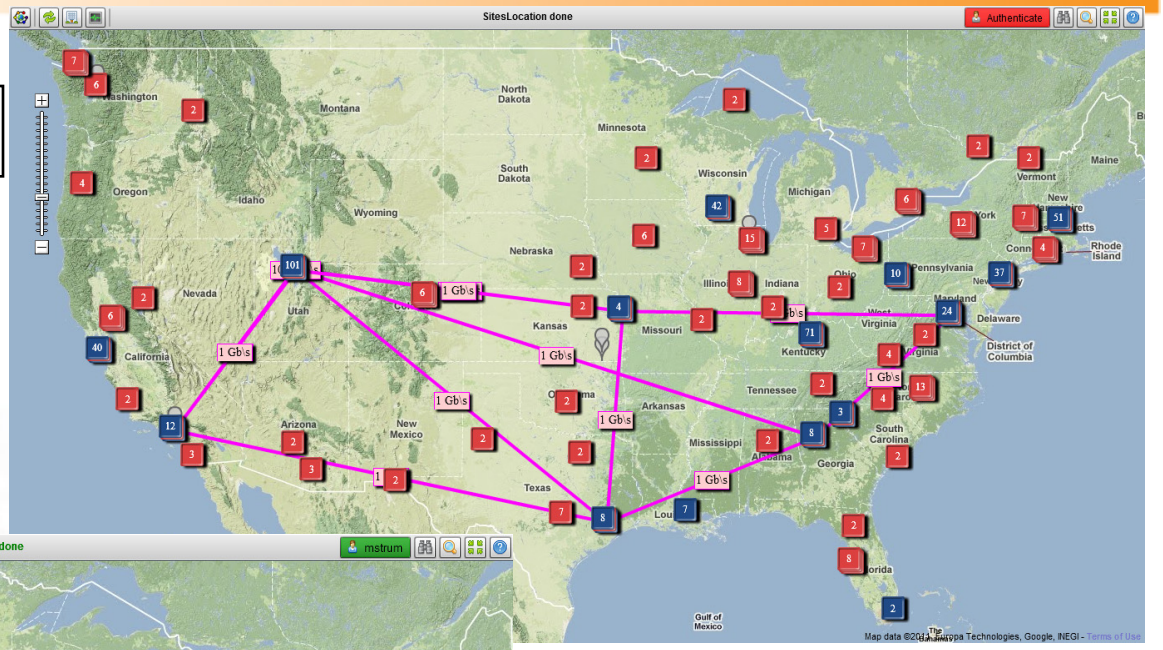


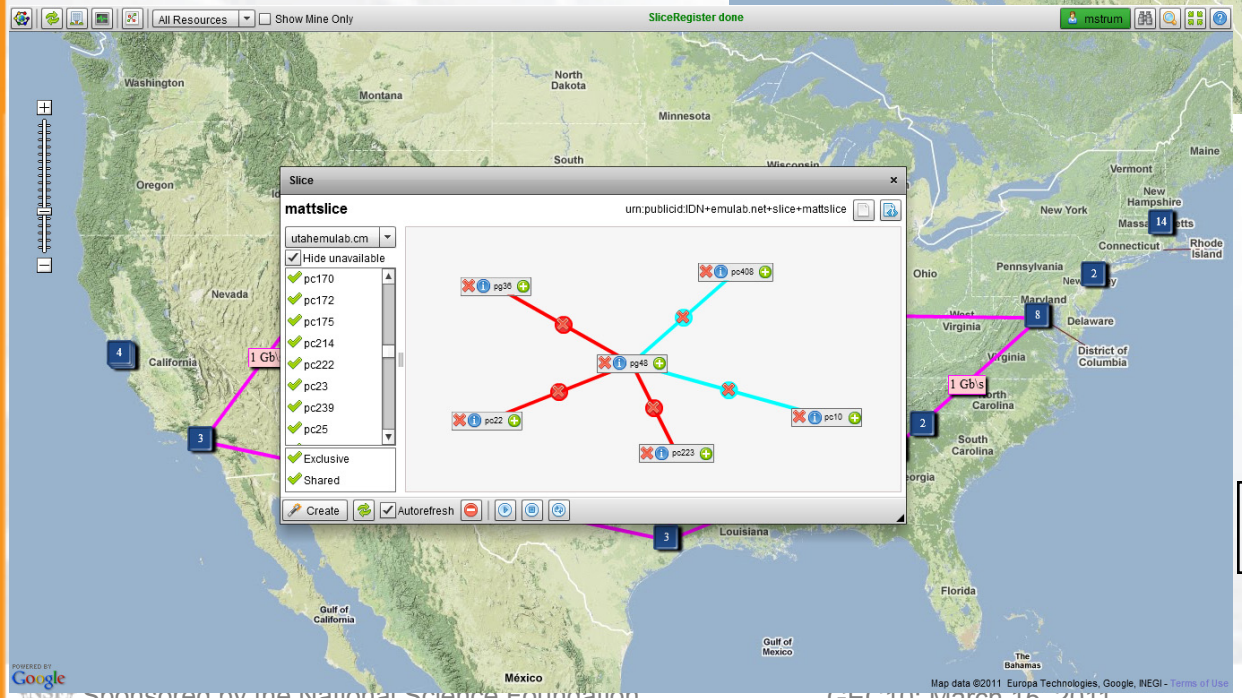
```
jeannie@sysnet:~/gush/trunk$ ./gush -P 15000
gush> Gush has learned about the slice williams_gush.

gush>
gush> prefer williams
gush> prefer ucsd
gush> prefer planetlab1
gush>
gush>
gush> load tests/simple.xml
Project "simple" is selected.
Experiment "simple" is selected.
gush>
gush>
gush> run
Starting experiment run.
Running experiment simple...
gush> The configuration matcher has finished matching.
The resource allocator has finished successfully.
williams_gush@planetlab1.williams.edu:15413 has joined the mesh.
The file transfer of Package to planetlab1.williams.edu has been completed.
The software installation of Package on planetlab1.williams.edu was successful.
williams_gush@planetlab1.ucsd.edu:15413 has joined the mesh.
The file transfer of Package to planetlab1.ucsd.edu has been completed.
The software installation of Package on planetlab1.ucsd.edu was successful.
williams_gush@planetlab1.williams.edu:15413,7370: Hello World

williams_gush@planetlab1.ucsd.edu:15413,20638: Hello World

The experiment has ended.

gush>
gush> info mesh
Mesh:
williams_gush@planetlab1.ucsd.edu:15413: connected; (fds=7,7 last_heard=1299692920)
williams_gush@planetlab1.williams.edu:15413: connected; (fds=6,6 last_heard=1299692891)
Summary: 2 mesh members; 0 nodes connecting.
gush>
gush>
gush> info control
Experiment Controller State(0x8495dd8):
 * Experiment simple
Experiment: simple Controller: jeannie@sysnet:15000
Component: Cluster1 Controller: jeannie@sysnet:15000
Matching id 1299692167.1.default.jeannie@sysnet:15000
Component requests 2 hosts.
1 matchings known:
1299692167.1.default.jeannie@sysnet:15000,
 Node status (2):
   williams_gush@planetlab1.ucsd.edu:15413: running;
   williams_gush@planetlab1.williams.edu:15413: running;
Num not failed: 2
 Exceptions (0):
Process: cat
Controller. Status:
  williams_gush@planetlab1.ucsd.edu:15413 :  done;
  williams_gush@planetlab1.williams.edu:15413 :  done;

gush> disconnect
gush> williams_gush@planetlab1.williams.edu:15413 has decided to leave the mesh.
williams_gush@planetlab1.ucsd.edu:15413 has decided to leave the mesh.

gush>
```

Gush, a command line based experiment control tool

# ProtoGENI Map Client

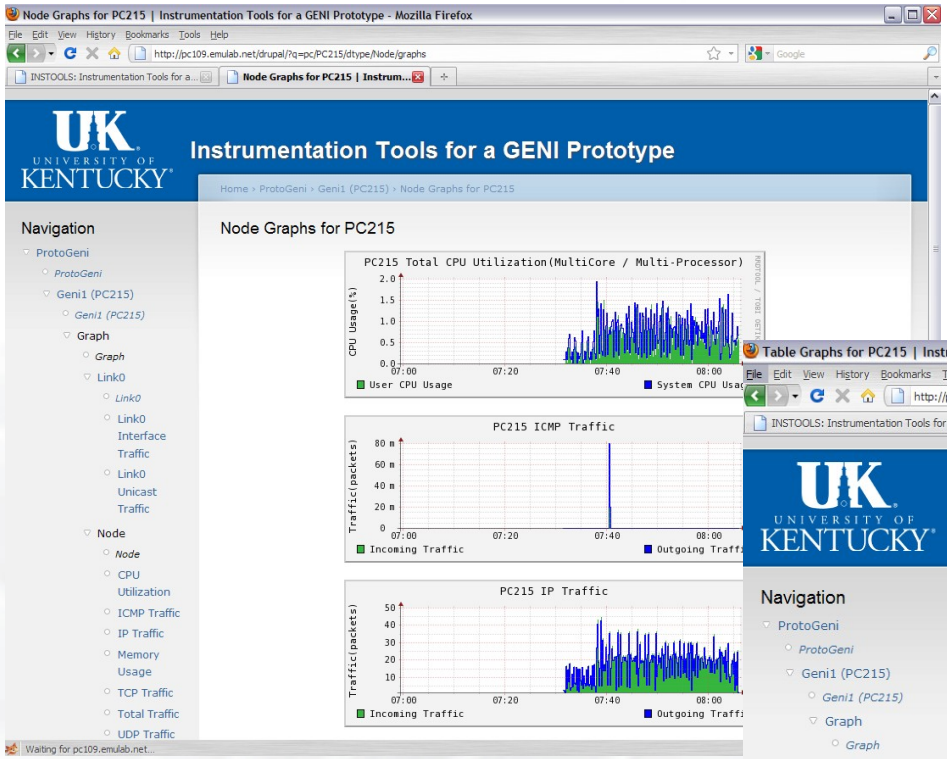
ProtoGENI Map Client showing resources available through the ProtoGENI clearinghouse

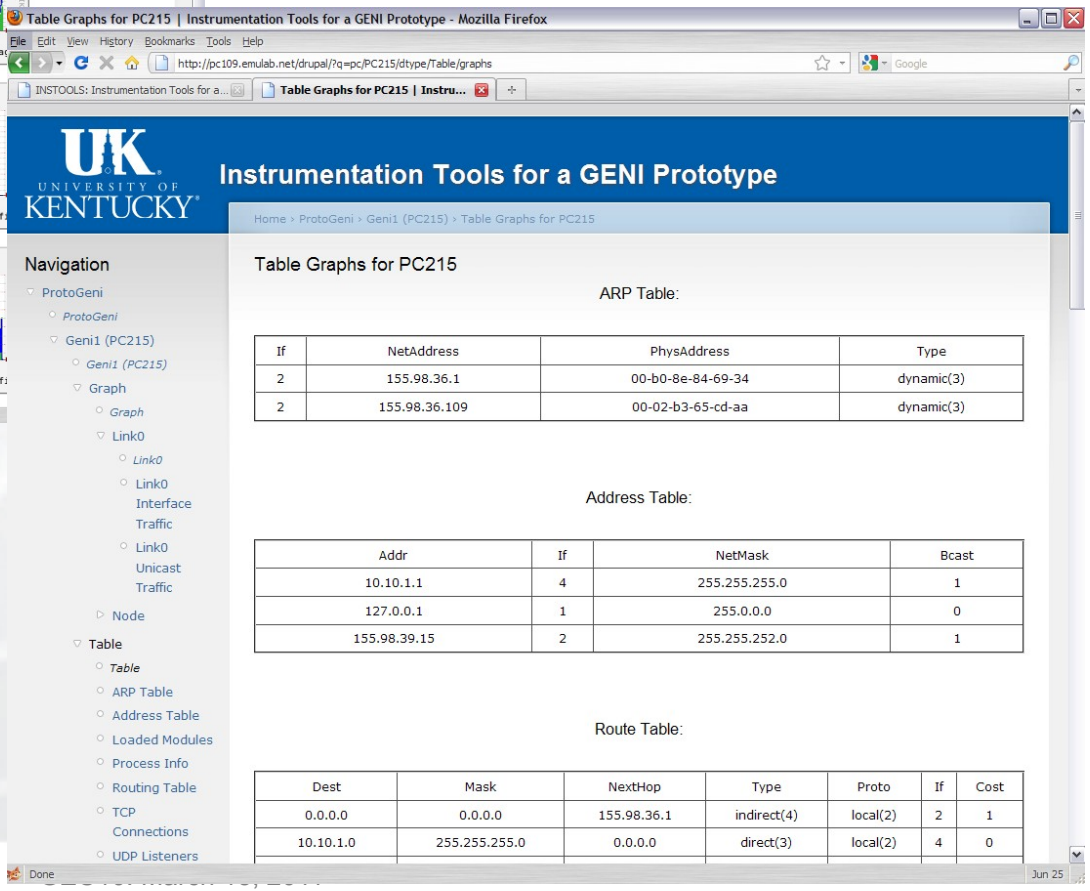



ProtoGENI Map Client showing a slice being created with resources from three aggregates

# Kentucky Instrumentation Tool




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

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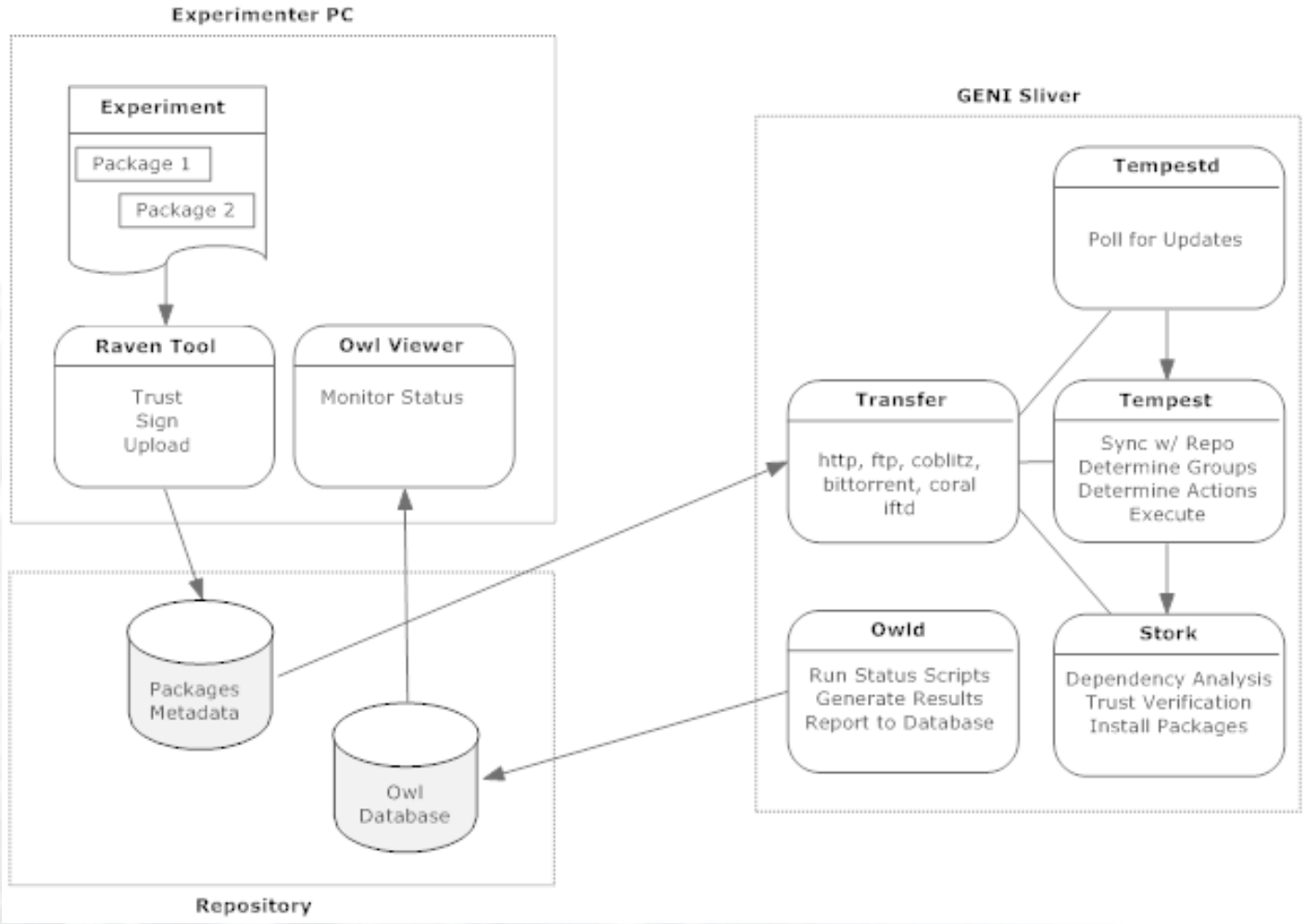
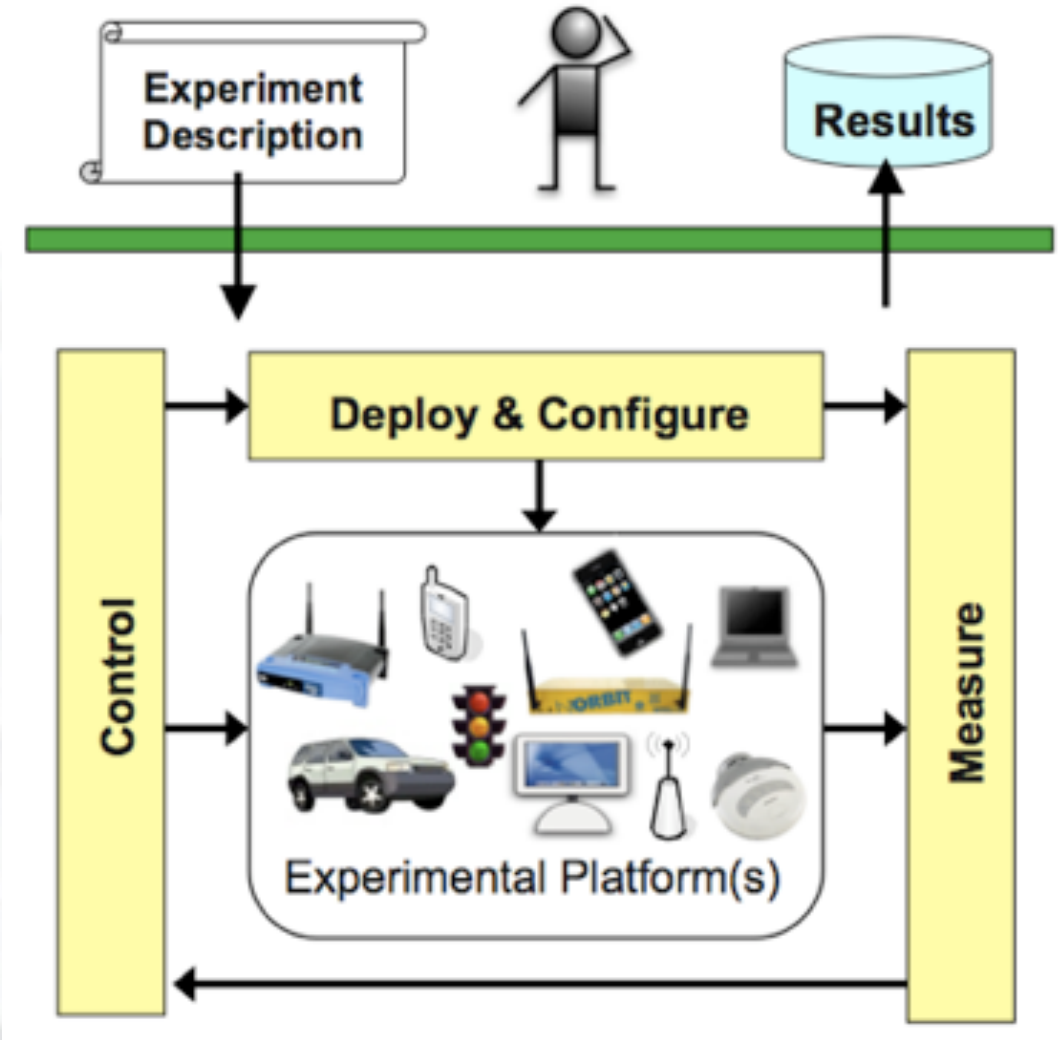
# Raven: Distributed System Provisioning and Management




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

# ORBIT Management Framework (OMF): Experiment Deployment, Control, Mgmt




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 | Y | ProtoGENI, PlanetLab, CRON, INSTOOLS, and Gush |

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# Getting Access

- 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

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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**

# Helpful Links

- Resource listing:
  - http://groups.geni.net/geni/wiki/ExperimenterPortal
- Connectivity Guide:
  - http://groups.geni.net/geni/wiki/ConnectivityOverview
- Advice & assistance:
  - help@geni.net