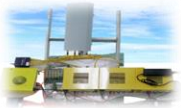


GENI in the Classroom – Session 1

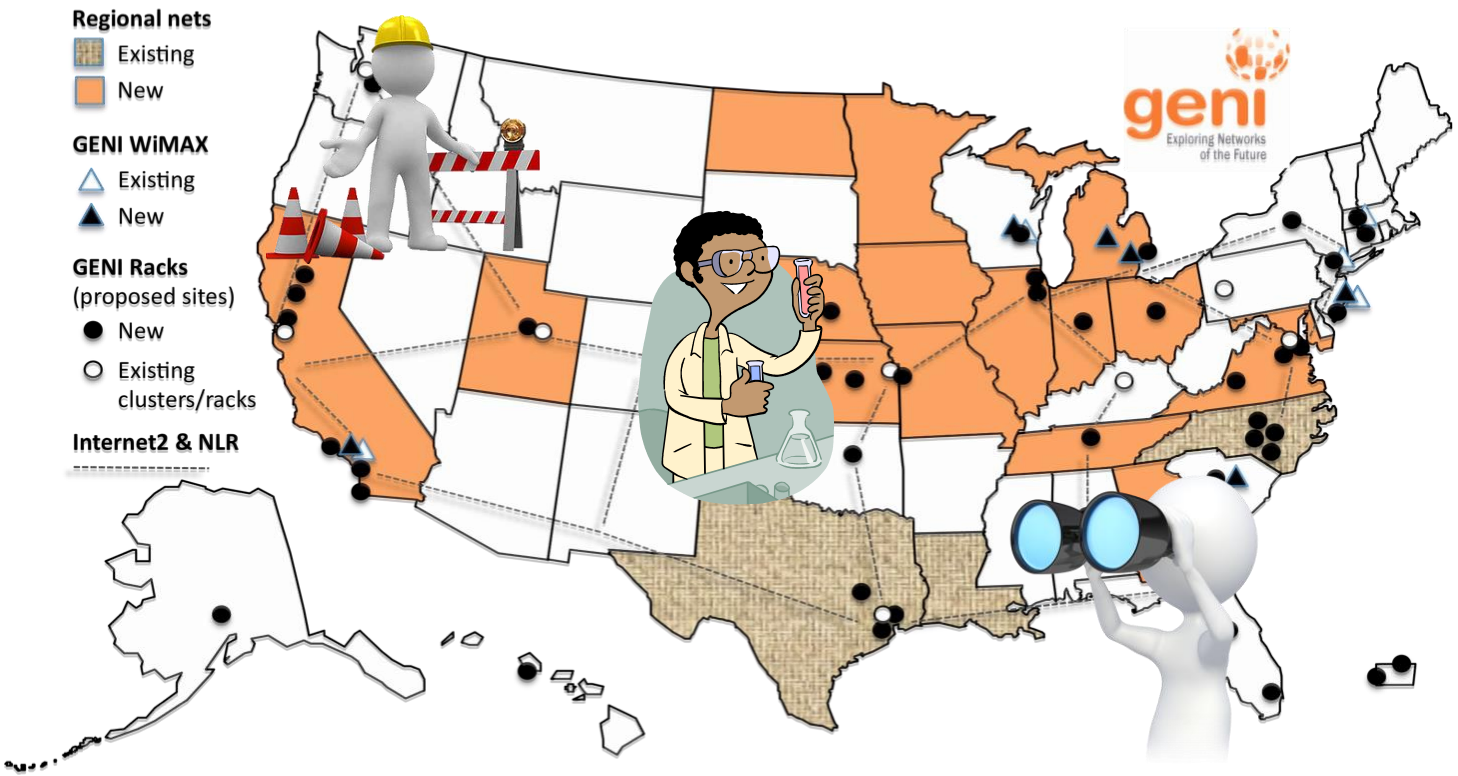
Ben Newton, Jay Aikat, and Kevin Jeffay

www.geni.net

Sponsored by the National Science Foundation

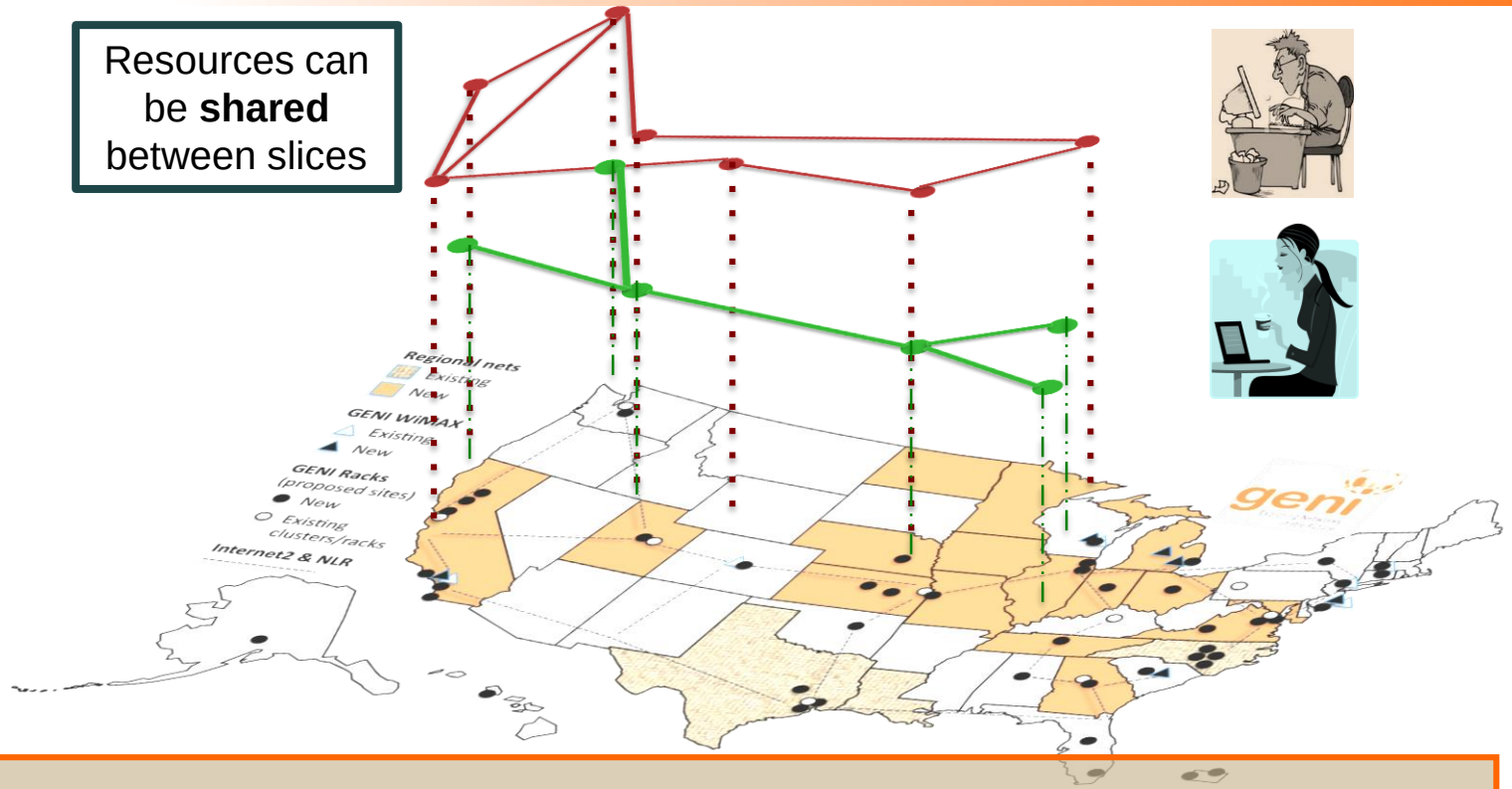
- Welcome
- Introductions
- Tips for effective webinar
- Schedule
  - GENI Overview – Jay
  - GENI Terminology, SSH, Expiration and Renewal of Resources - Ben
  - Hands-on Lab – Ben and Jay
  - Behind the Scenes - Ben
  - Wrap-up

Outline


Regional nets
Existing
New
GENI WiMAX
Existing
New
GENI Racks
(proposed sites)
New
Existing
clusters/racks
Internet2 & NLR
geni
Exploring Networks
of the Future

Multiple GENI Experiments run Concurrently

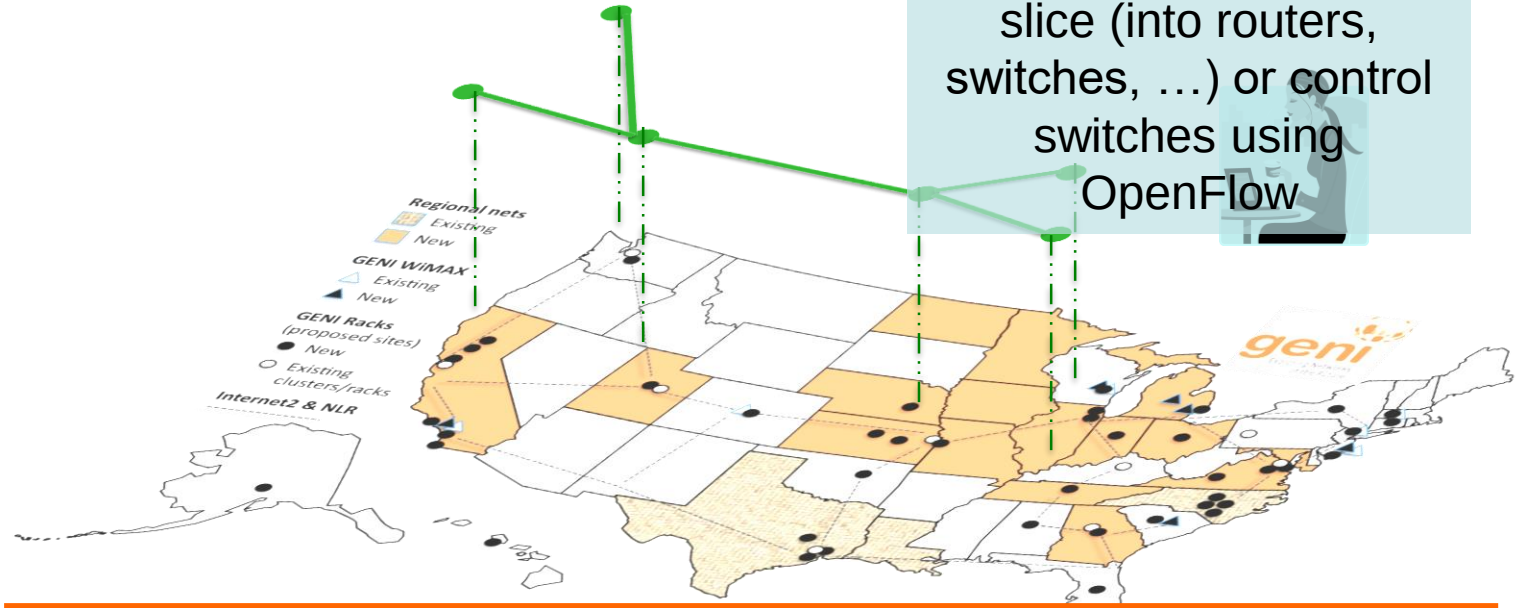
Resources can be **shared** between slices



Experiments live in **isolated** “slices”

GENI is “Deeply Programmable”

I install software I want throughout my network slice (into routers, switches, …) or control switches using OpenFlow



Experimenters can set up custom topologies, protocols and switching of flows

Compute Resources

GENI Racks: small clouds

Virtual Machines

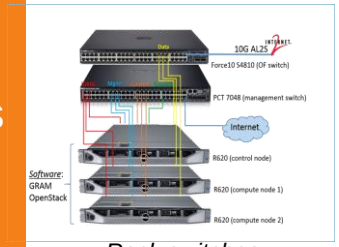
Bare metal Machines

Android Phones

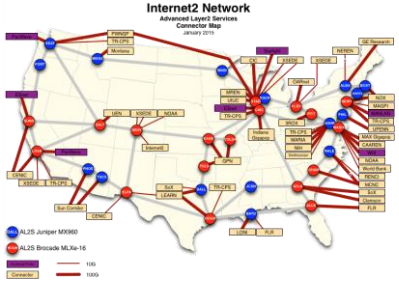
Existing Testbeds

Network Resources

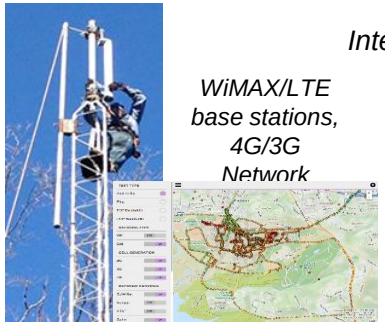
Layer 2 VLANS and Access to Programmable Switches



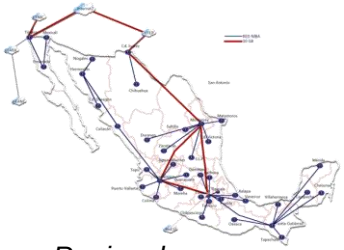
Rack switches



Internet2: US Research Backbone



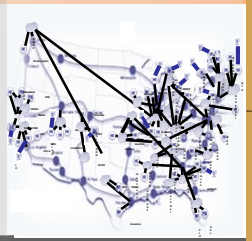
WiMAX/LTE base stations, 4G/3G Network



Regionals

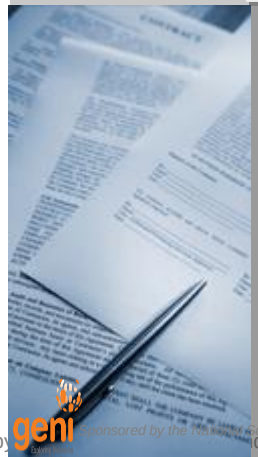
GENI Use By Numbers

4300
Users



2600
Students trained on GENI by
45
Different instructors

200
+
publications

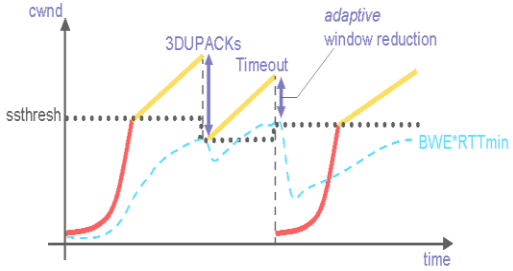


180
Universities

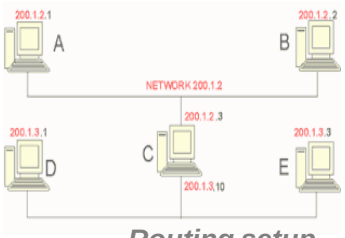
30
Countries

100,000+
Experiments instantiated

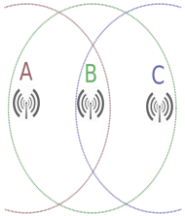
Use of GENI in Education



Protocol Behavior

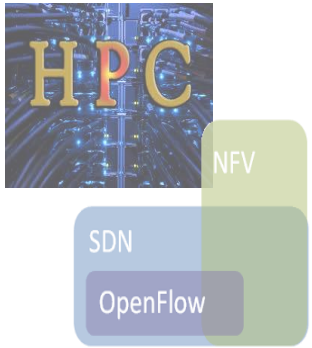


Routing setup

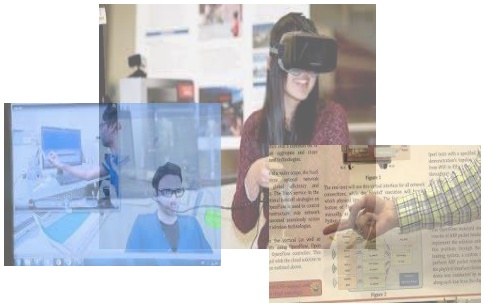


Wireless Communication

Teach Basic Concepts

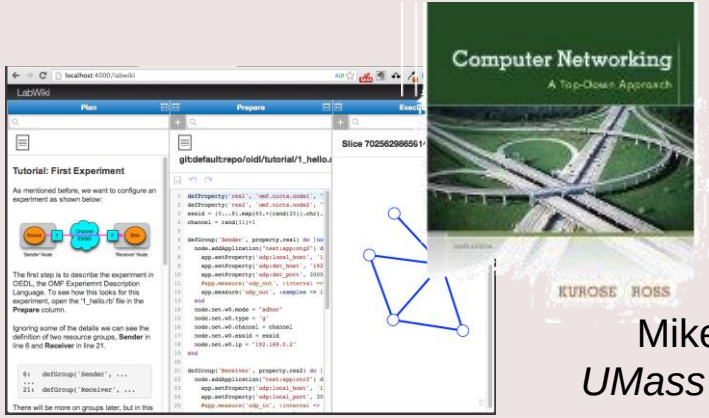


New technologies



Semester Projects

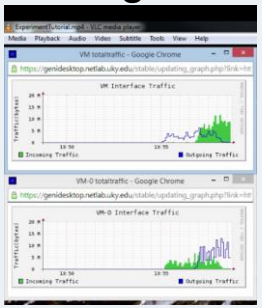
GENI in the Classroom



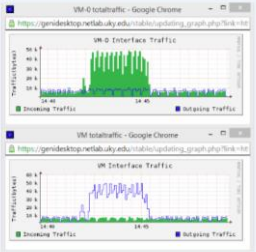
Labs on GENI for networking textbook

Mike Zink
UMass Amherst

GENI Modules to teach networking concepts

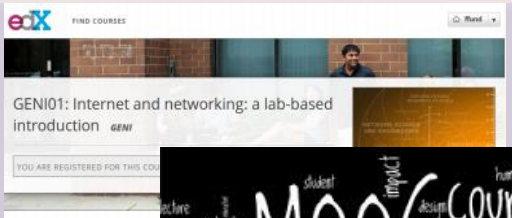


Example Demo Module



Example Assignment

Kevin Jeffay, Jay Aikat
UNC-Chapel Hill



Massive Online Open Courses on GENI

Shivendra Panwar, Thanasis Korakis
NYU Poly

Use GENI to educate the Internet users, not the Internet creators.

GENI Terminology

slice

project

experimenter

resource

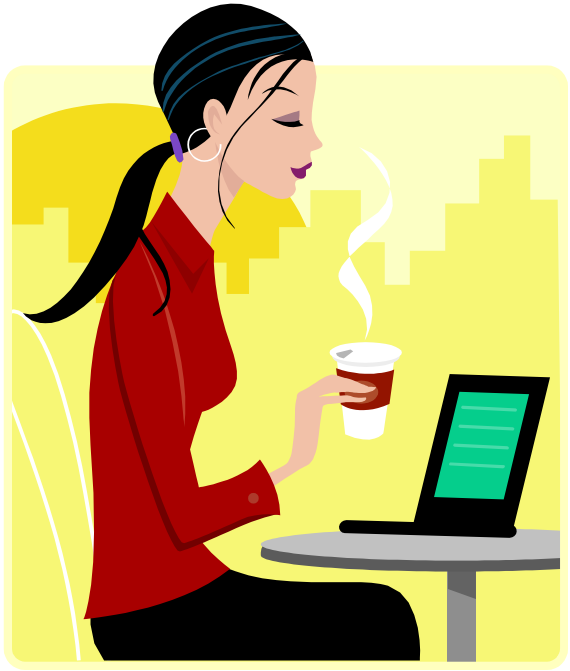
aggregate

An **experimenter**

is a researcher who uses GENI resources

Different types of experimenters have different roles and permissions:

- Advisor vs Grad Student
- Teacher vs TA vs Student



Experimenter

Creating an Account

GENI Portal is at:

https://portal.geni.net

GENI User Authentication

The GENI Portal leverages InCommon
for single sign-on authentication

InCommon®

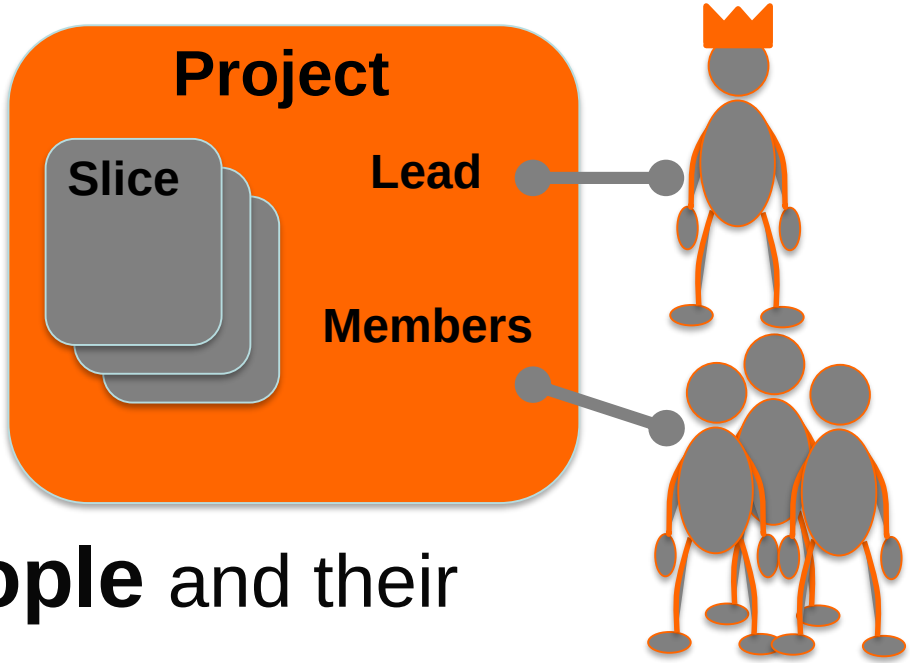
Students from 518 educational and research institutions have InCommon accounts

For many experimenters:

- no new passwords
- familiar login screens

GENI Project Office runs a federated IdP to **provide accounts** for non-federated organizations.

Projects organize research in GENI



Projects contain both **people** and their **experiments**

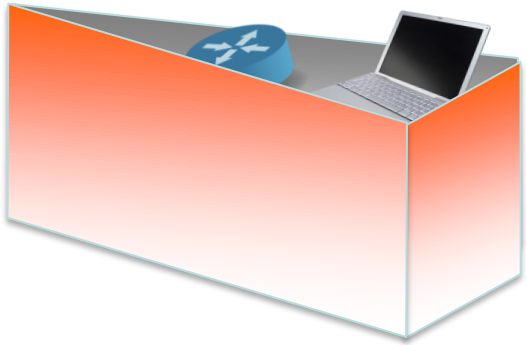
A project is led by a single responsible individual: the **project lead**

A **slice** is a *container* of resources used in an *experiment*.

A slice can contain resources from one or more aggregates

A slice is in a single project

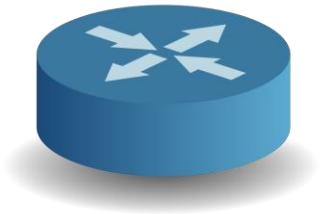
A slice has an ***expiration***



Slice names are ***public***, ***reusable*** and ***unique*** *(within a project)*

A **resource**

is a piece of infrastructure



A resource can be real or virtual.

Resource specifications (aka. **RSpecs**) are used to describe and request resources.

Examples:

- Compute: computer vs virtual machine (VM)
- Wireline Network: VLAN or OpenFlow
- Wireless: WiMAX

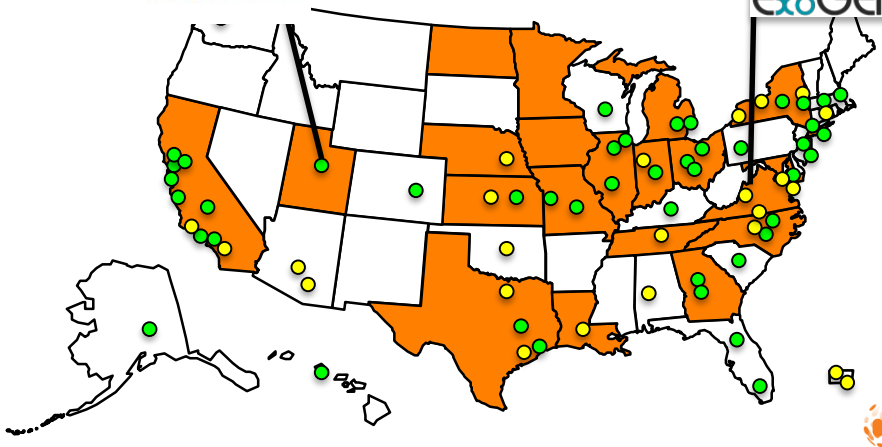
An **aggregate** manages a set of reservable **resources**

Aggregates include:

- GENI racks
- OpenFlow
- WiMAX

InstaGENI Rack

ExoGENI Rack



project

Lead:

Experimenter
(aka Professor)

Member:

Experimenter
(aka Student)

slice

aggregate

Layer 2

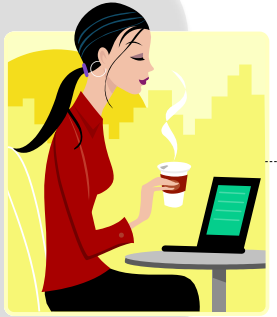
How SSH *With a Private Key* Works

Sponsored by the National Science Foundation

SSH with a *password*

*nix-based system (Windows behavior may vary)

```
local> ssh jdoe@remote.edu
jdoe@remote.edu's password:
########
Welcome to remote!
jdoe@remote> exit
local> ssh jdoe@remote2.edu
jdoe@remote2.edu's password:
########
```



User enters password once for *each* connection to *each* machine

Hash of password stored on each remote machine

SSH with a *private key*

*nix-based system (Windows behavior may vary)

```
local> ssh-add ~/.ssh/id_rsa
Enter passphrase for ~/.ssh/id_rsa:
########
local> ssh jdoe@remote.edu
Welcome to remote!
jdoe@remote> exit
local> ssh jdoe@remote2.edu
Welcome to remote2!
jdoe@remote2> exit
local> ssh jdoe@remote3.edu
Welcome to remote3!
jdoe@remote3> exit
local> ssh-add -D
```

User enters passphrase to unlock private key for *all* connections to *all* machines

Private key is stored only on local machine

Public key is stored on each remote machine

SSH with a private key is both *easier to use* and *more secure*

Sponsored by the National Science Foundation

www.geni.net

You should *never* be prompted for a password to log into a GENI compute node.

If you are, something has *always* gone wrong.

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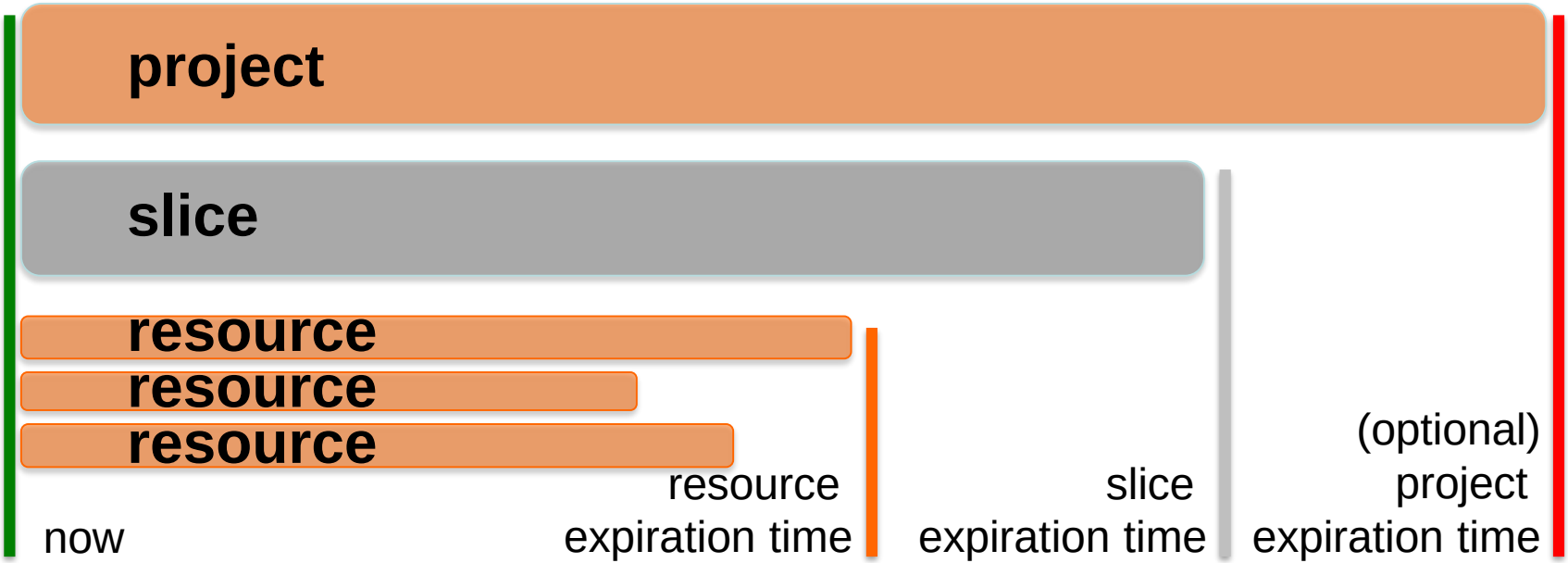
www.geni.net

GENI Expiration and Renewal



To extend the lifetime of your resource reservation, you must renew the **slice** and **all resources**

Are you ready for the tutorial?

1. Grab a Worksheet and instructions
2. Did you do the pre-work?
   A. Do you have an account?
   B. Have you installed the tools?
      * SSH
3. Connect to the network

GENI Portal is at:

http://portal.geni.net

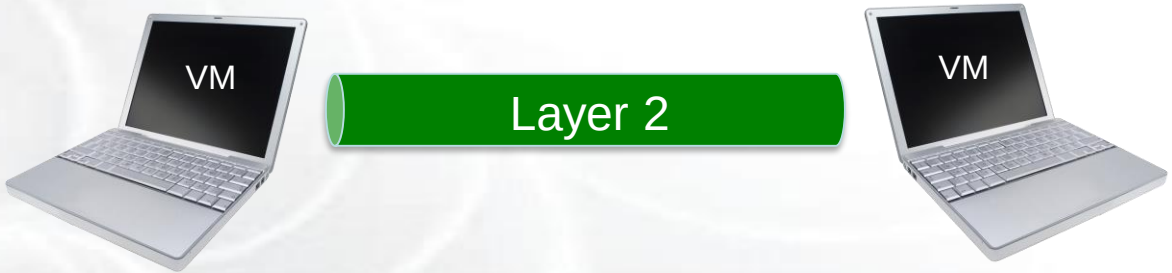
Lab Zero:
A First Experiment using GENI

Ben Newton, Jay Aikat, and Kevin Jeffay
UNC Chapel Hill

Sponsored by the National Science Foundation

Do a Simple Experiment in GENI

Reserve two VMs connected at Layer 2



Use the GENI Portal

geni
Exploring Networks of the Future

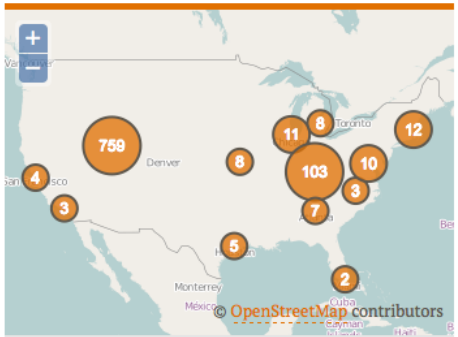
WELCOME TO GENI

GENI is a new, nationwide suite of infrastructure supporting "at scale" research in networking, distributed systems, security, and novel applications. It is supported by the National Science Foundation, and available without charge for research and classroom use.

Use GENI

Find out more about using GENI

- Information for GENI experimenters
- Published research that used GENI resources
- Get help using GENI



These are some of the many resources being used in GENI experiments across the country.

Experiment Workflow

- Part I: Design/Setup
- Part II: Execute
- Part III: Finish

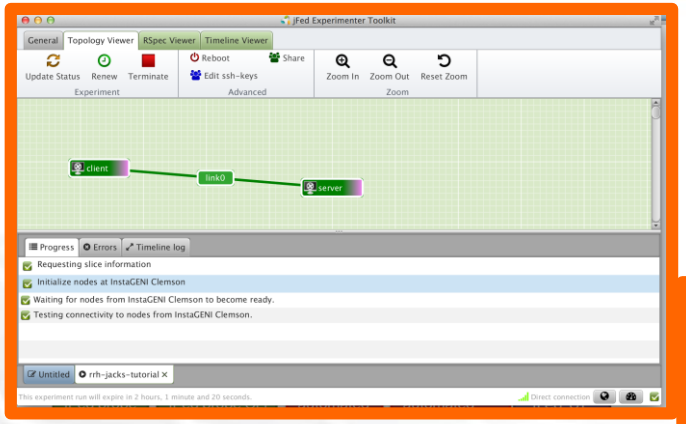
The GENI Portal is…

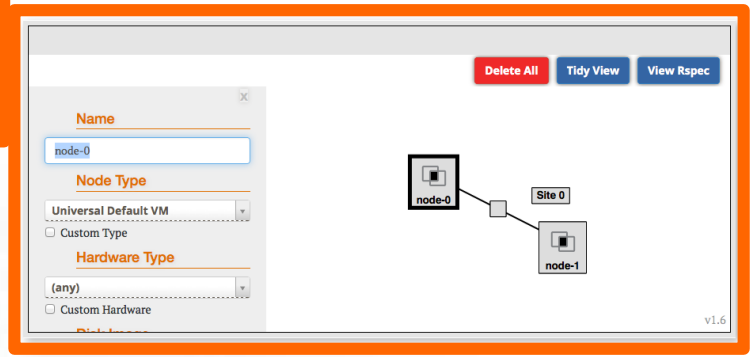
Use GENI

A web-based tool for experimenters to manage **experimenters**, **projects**, and **slices**.

Includes simple tools to reserve **resources**.

Jacks and jFed are …





Graphical user interfaces (GUIs) for:

– **designing topologies** in GENI

– **reserving resources** in GENI

Experiment Workflow

- **Part I: Design/Setup**
- Part II: Execute
- Part III: Finish

Part I: Establish Management Environment

1 Pre-work: Design your experiment

2.1 Pre-work: Create a GENI account

2.2 Pre-work: Project lead (aka professor) adds you to project

Project Name: TrainTheTA

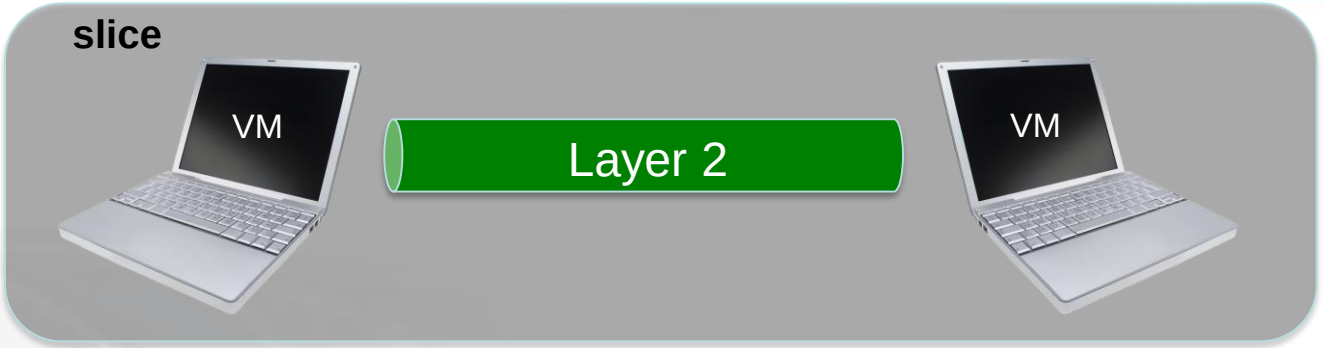
2.3 Generate and Download SSH Keypair

2

On your local machine…

```
> mv ~/Downloads/id_geni_ssh_rsa
~/.ssh/.
> chmod 600 ~/.ssh/id_geni_ssh_rsa
> ssh-add ~/.ssh/id_geni_ssh_rsa
```

Part I continued: Obtain Resources



3.1 Create a slice

3.2 (optional) Renew your slice

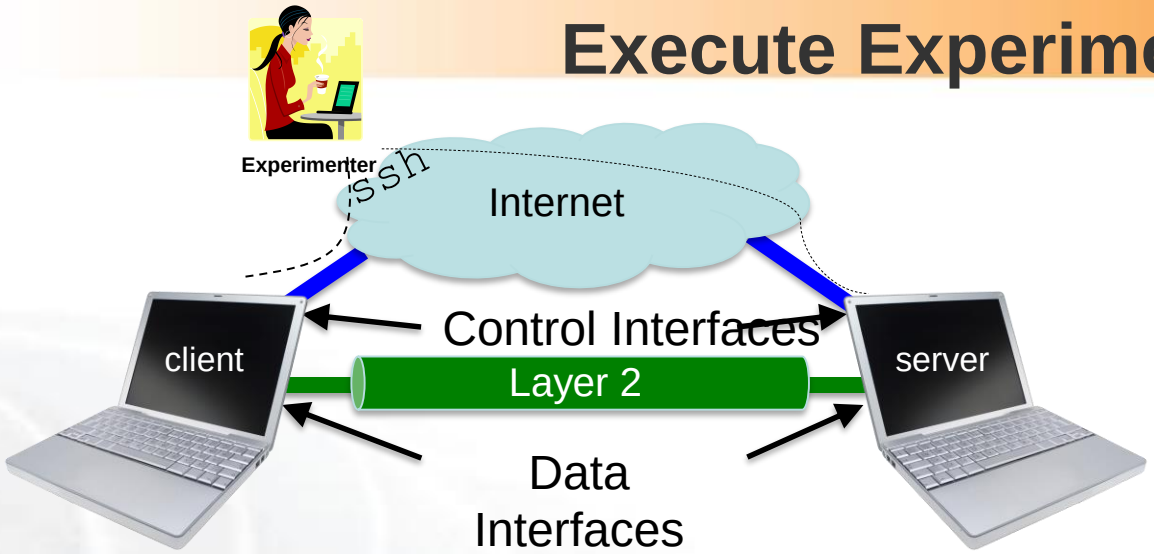
3.3 Reserve two VMs at one aggregate

3.4 Check Whether VMs are Ready to be Used

Experiment Workflow

- Part I: Design/Setup
- **Part II: Execute**
- Part III: Finish

Part II: Execute Experiment



4.1 Login to all three nodes

5.1 Test Connectivity

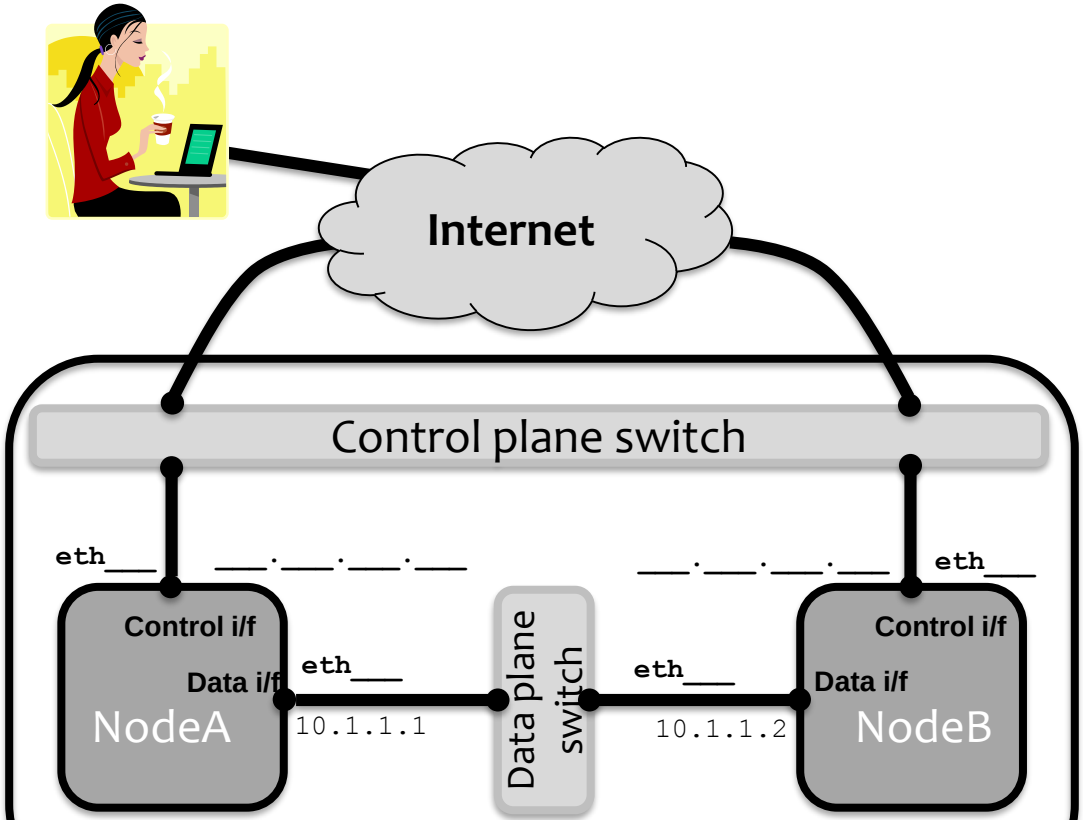
5.2 Explore the Data and Control Planes

6.1 Logout of nodes

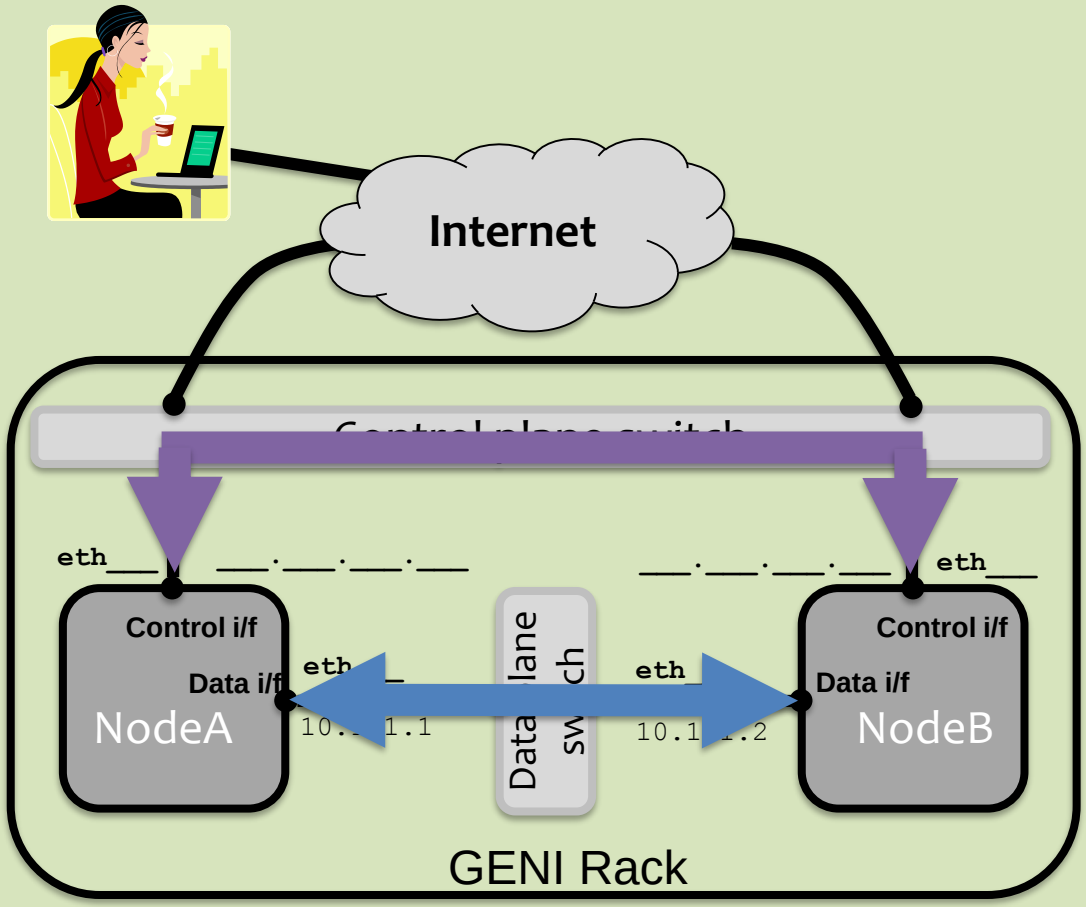
5.1

Worksheet

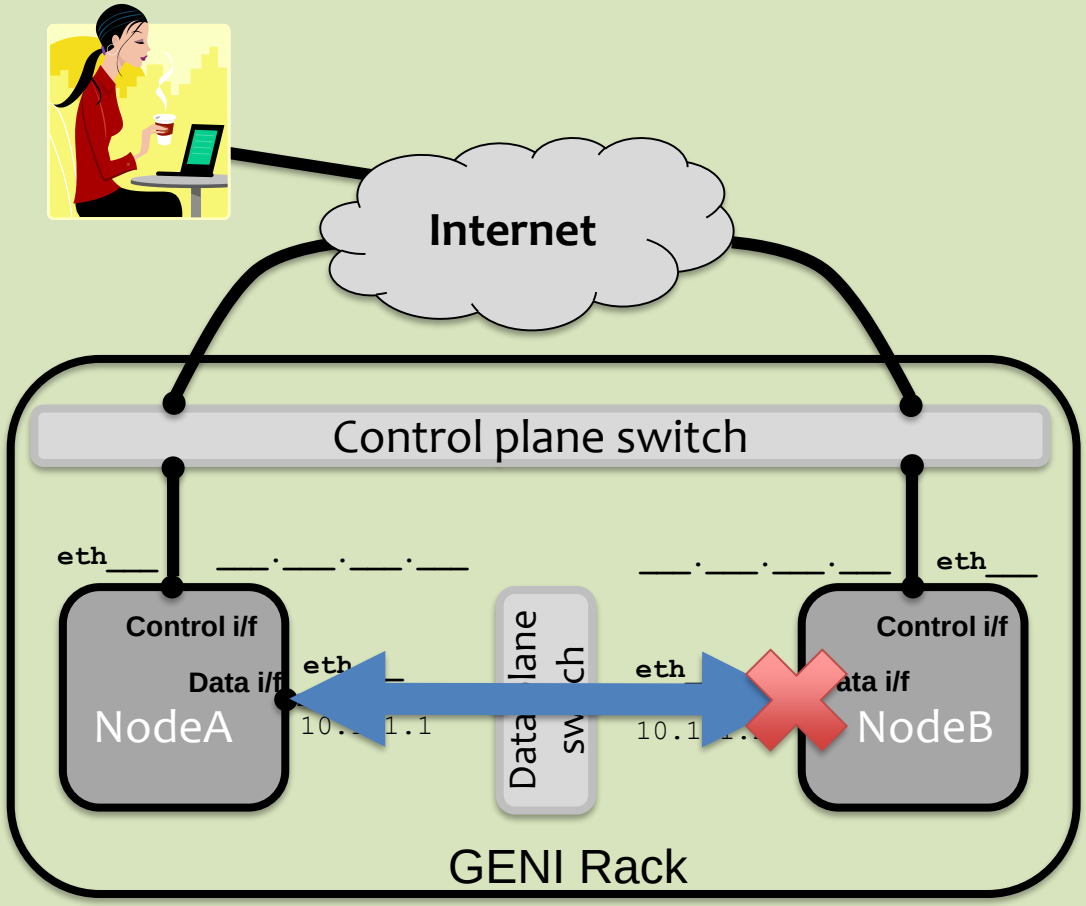
Slice Name: lab0<your initials>



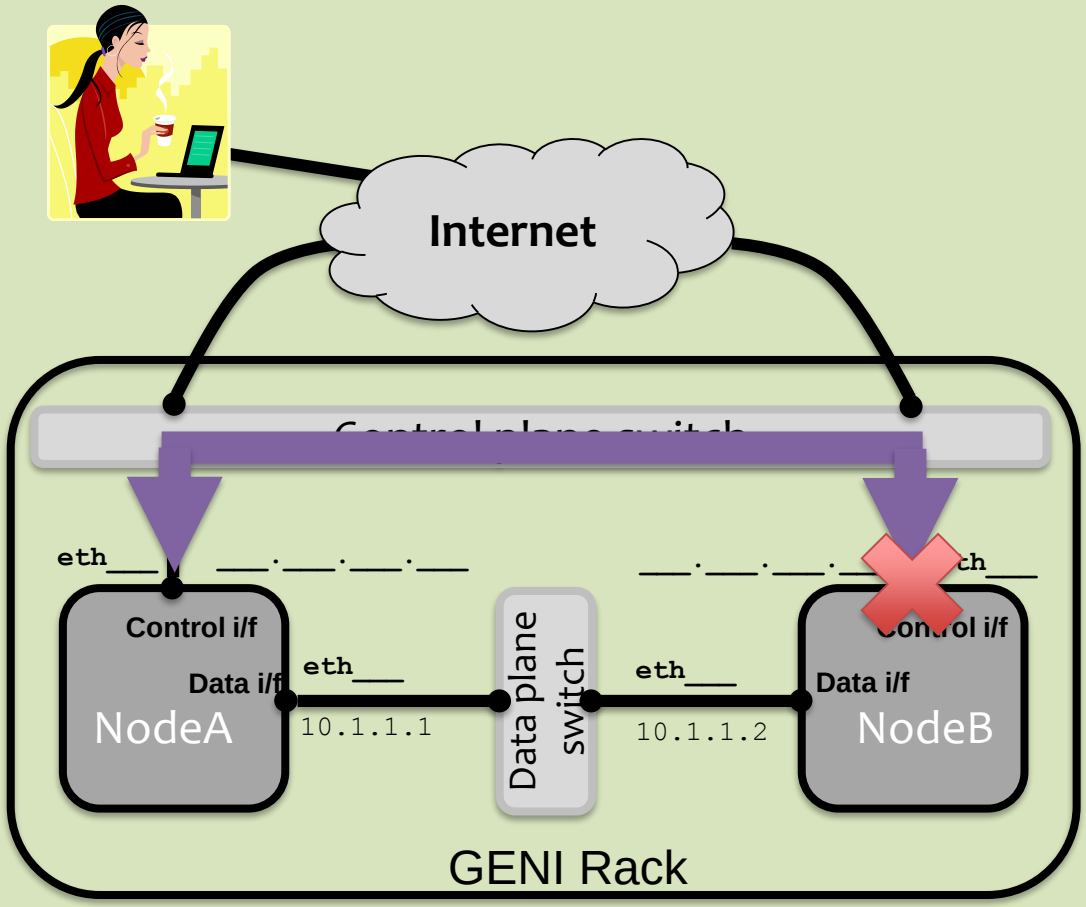
5.1 *What is the bandwidth of the **data** link? Why?*
*What is the bandwidth of the **control** link? Why?*



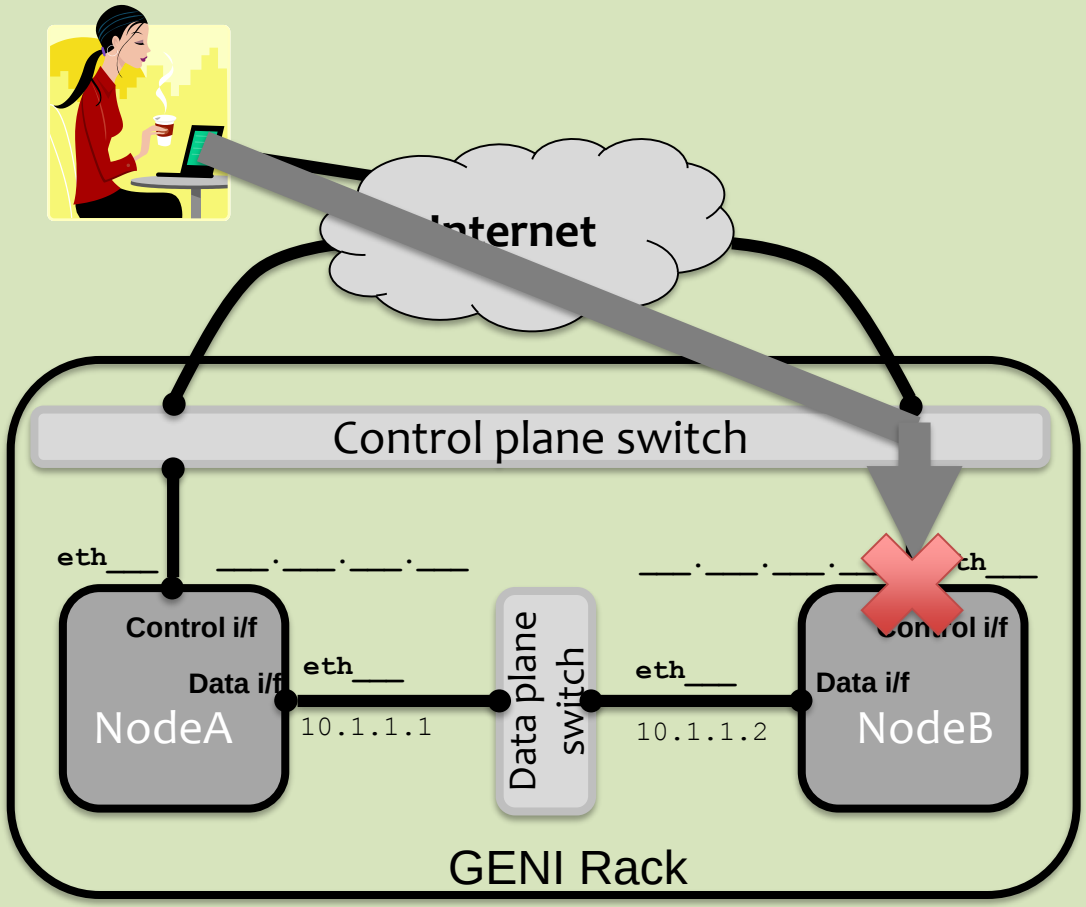
5.3 *When you bring down the **data** interface, the destination should become unreachable. Why?*



5.3 *After you bring down the **control** interface, the destination becomes unreachable. Why?*



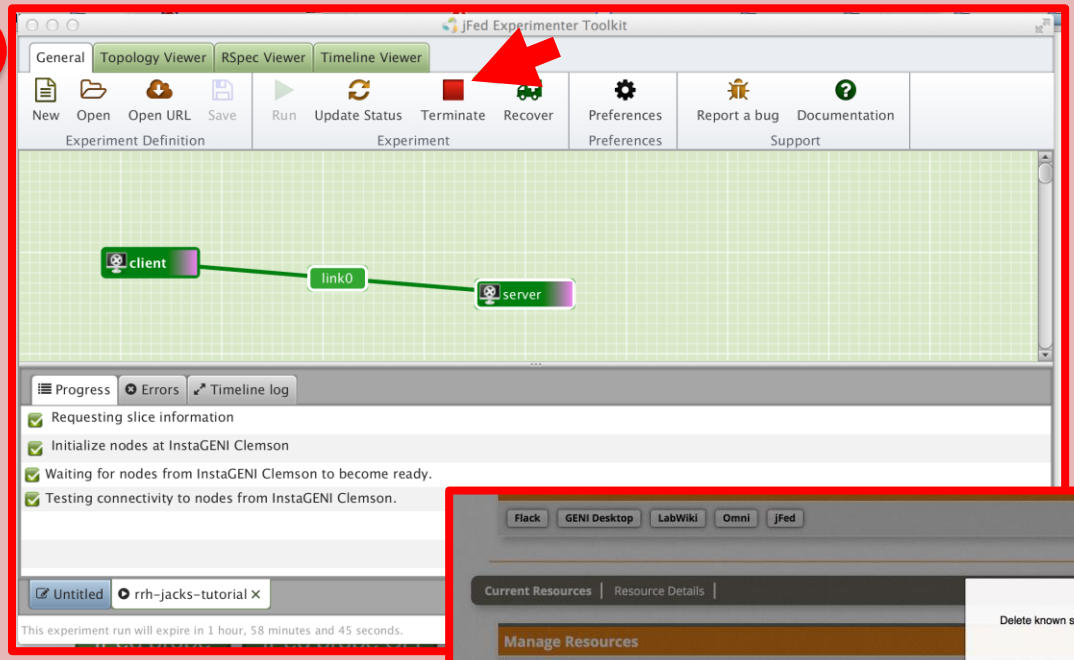
5.3 *After you bring down the **control** interface, your ssh session should immediately hang. Why?*

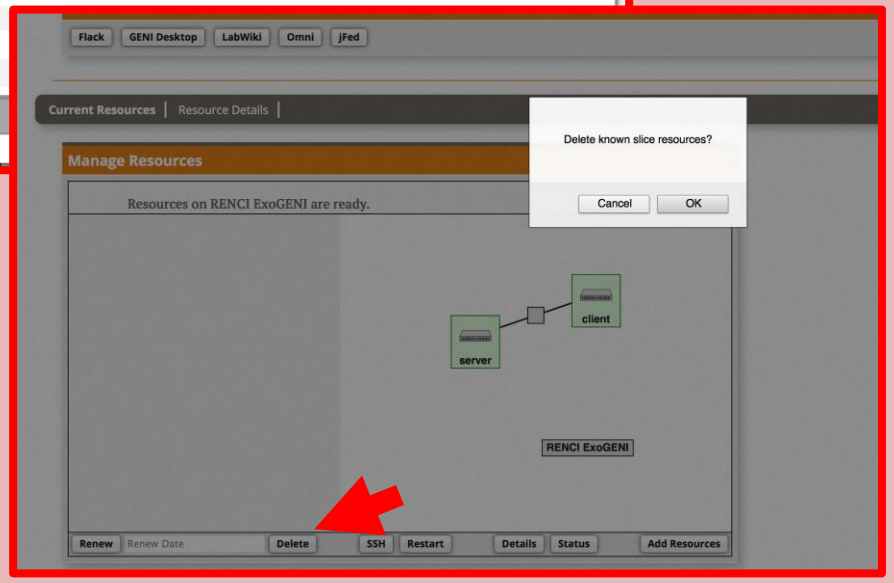


Experiment Workflow

- Part I: Design/Setup
- Part II: Execute
- **Part III: Finish**

7





Delete Resources

Part III: Finish Experiment

project
resource
experimenter
aggregate
slice

When your experiment is done, you should always release your resources.

- Normally this is when you would archive your data
- Delete your resources at **each** aggregate

Congratulations!

You have…

- Run your first GENI Experiment!
- Exercised your knowledge of GENI terminology
- Used the GENI Portal and Jacks or jFed

Welcome to GENI!

Behind the Scenes of GENI Experimentation

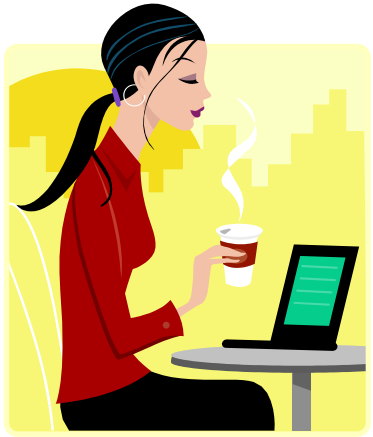
Understanding GENI AM API and RSpec

Sponsored by the National Science Foundation

What happens behind the scenes when reserving resources on GENI?

All GENI resource reservation tools use the same data formats and APIs

RSpecs	GENI Resource Specifications
GENI AM API	GENI Aggregate Manager API



researcher

tool

create slice

CH APIs

slice credential

users

projects

slices

clearinghouse

slice, RSpec

Aggregate Manager API

aggregate

resources

GENI **Resource Specifications** (or **Rspecs**) are XML documents that describe resources

```
<?xml version="1.0" encoding="UTF-8"?>
<rspec type="request" …
    xmlns="http://www.geni.net/resources/rspec/3">
     <node client_id="server"
component_manager_id="urn:publicid:IDN+instageni.gp
olab.bbn.com+authority+cm">
        <sliver_type name="emulab-xen"/>
        <interface client_id="server:if0"/>
     </node>
</rspec>
```

RSpec for a virtual machine with one interface

Three flavors of RSpec

Advertisement RSpecs

Aggregates describe what they have

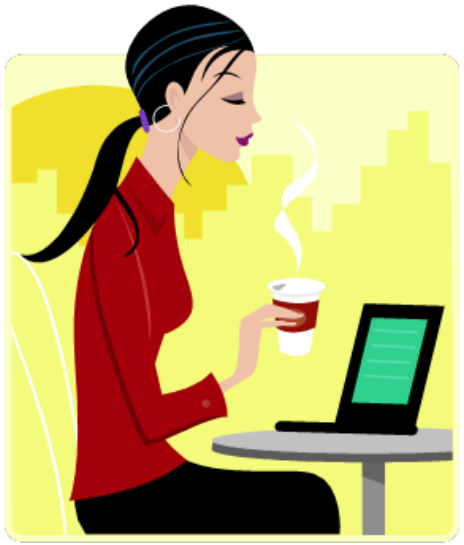
Request RSpecs

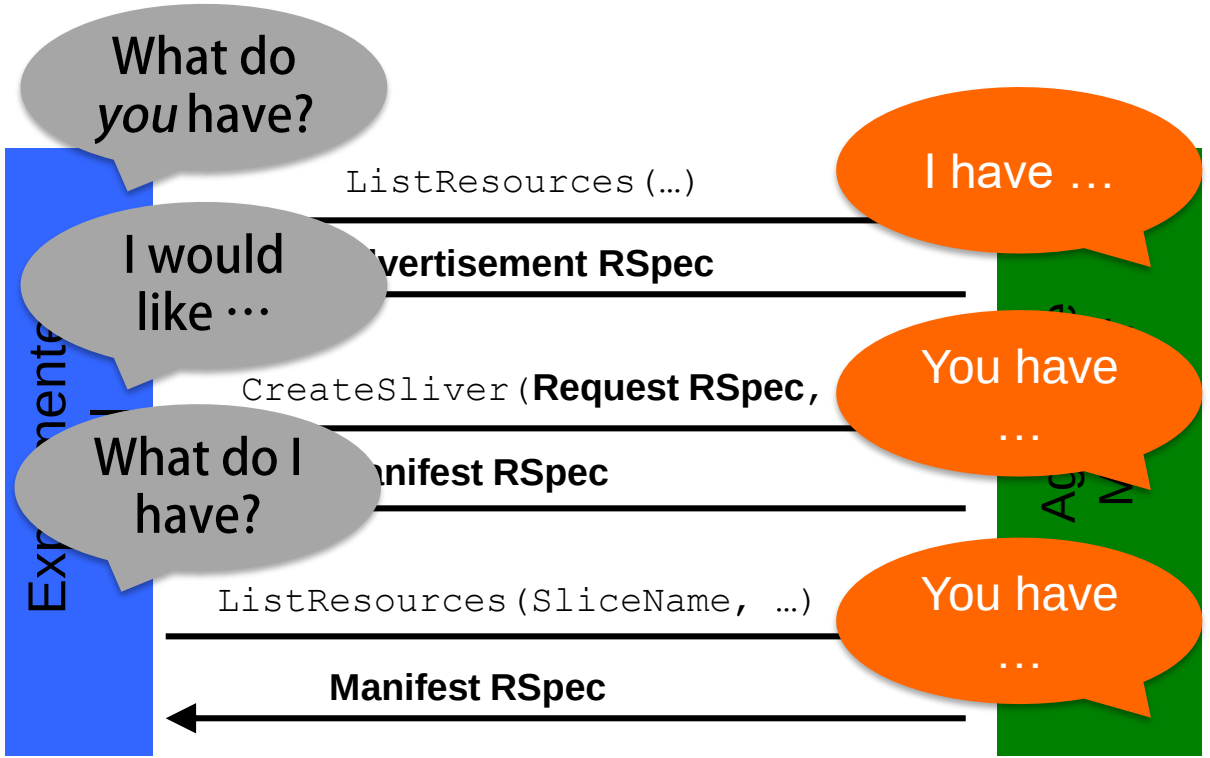
Experimenters describe the resources they want

Manifest RSpecs

Aggregates describe resources allocated to an experimenter

Experimenter tools and aggregates talk to each other using the GENI Aggregate Manager API or **GENI AM API**





All GENI resource reservation tools use the same data format (RSpec) and APIs (AM API)

Pick the tool that works best for the current task

An Introduction to GENI Tools

Jacks in the Portal and omni

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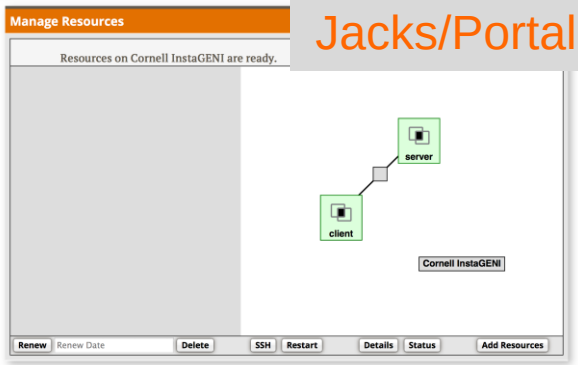
All GENI **resource reservation tools** speak AM API and RSpec…

Hosted

Local

Jacks/Portal



omni

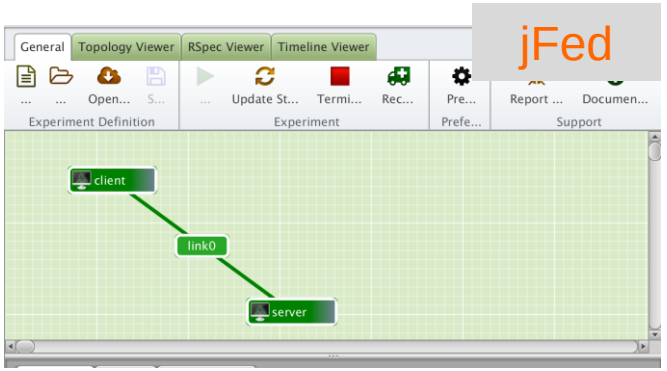
```
$ omni createsliver aliceslice myRS
INFO:omni: ------------------------
INFO:omni: Completed createsliver:

  Options as run:
                aggregate: https://www.emulab.
                framework: pgeni
                native: True

  Args: createsliver aliceslice myRSpec.xml

  Result Summary: Slice urn:publicid:IDN+pgeni
Reserved resources on https://www.emulab.net/p
  Saved createsliver results to aliceslice-man
INFO:omni: ================================
```

jFed



GENI Tool: Jacks in the Portal

A graphical user interface

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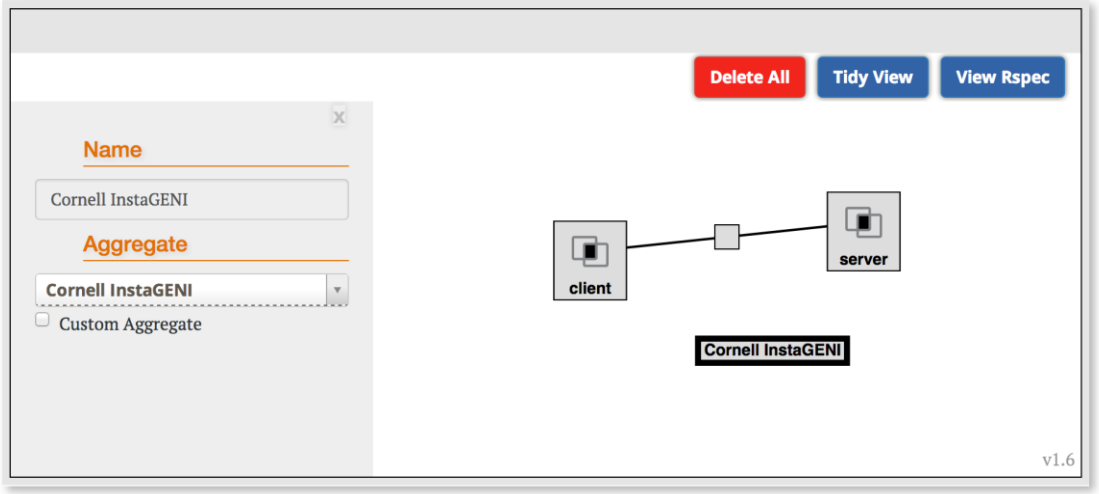
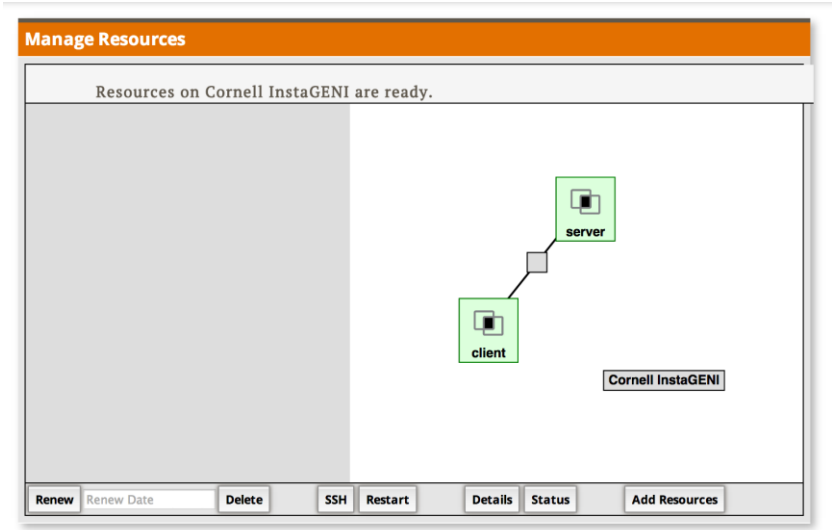
When you draw a topology using a tool, it creates a request RSpec describing the resources

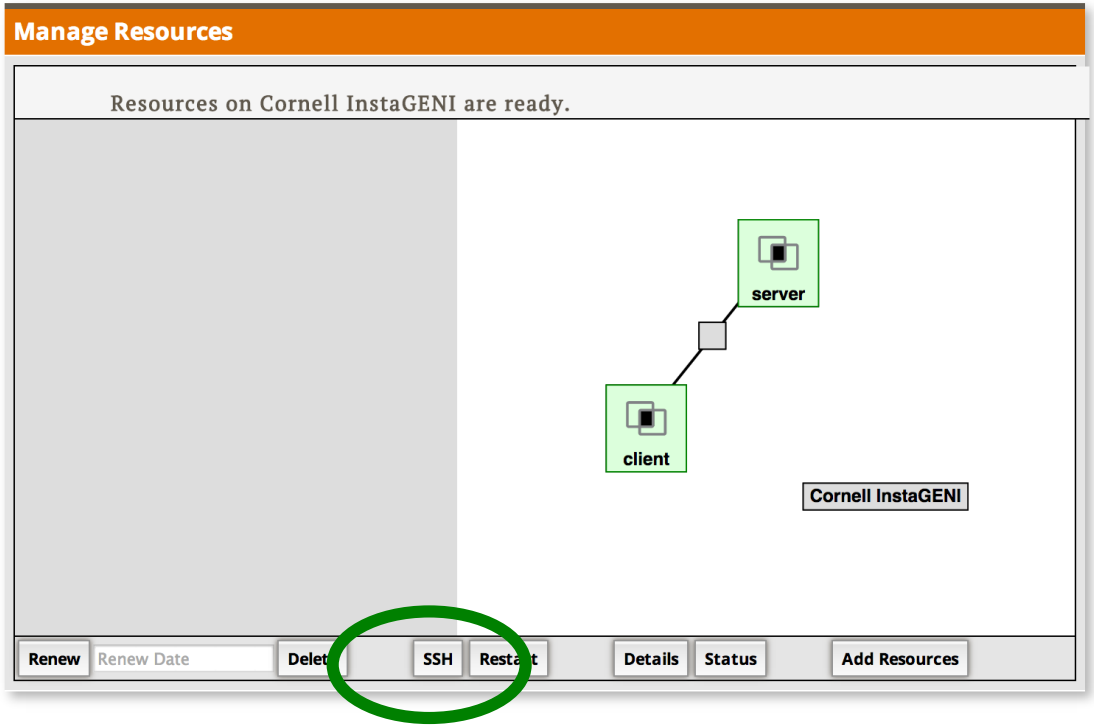


When you reserve resources at an aggregate, `createSliver` is called using that request

Tools periodically call `sliverStatus` at each used aggregate

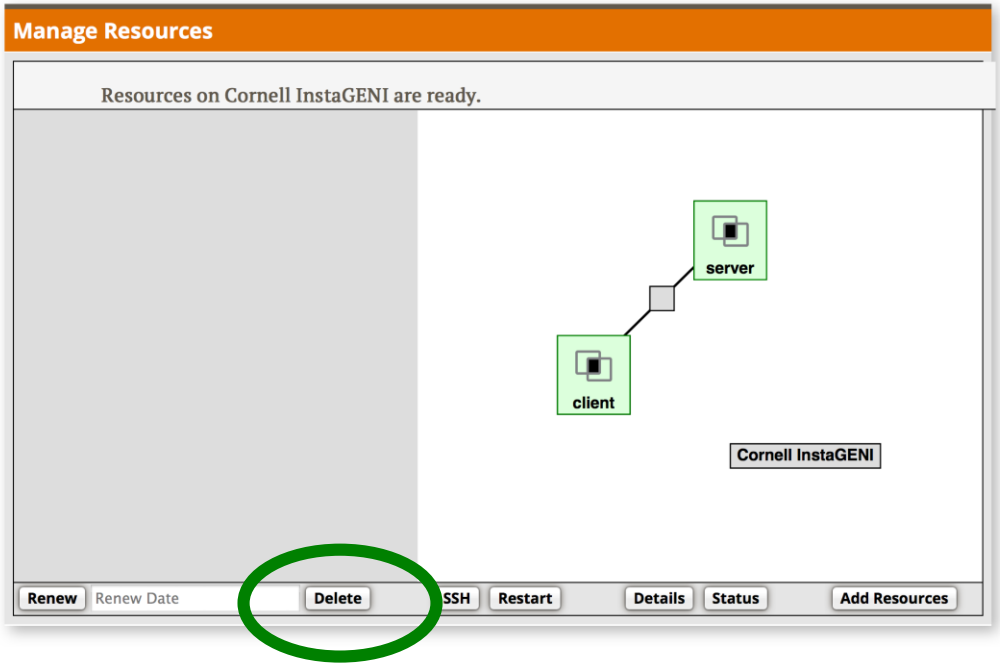
When the returned status is “ready”, the resources turn green





ListResources on a slice returns a manifest RSpec

Manifest includes info to log into VMs



When you delete resources, tool calls `deleteSliver` on aggregates

GENI Tool: Omni

A command line tool

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`omni` Resource Reservation Tool

A command line tool for making AM API calls at *any* aggregate that implements the GENI AM API

Written in and scriptable from Python

```
$ omni.py createsliver aliceslice myRSpec.xml
INFO:omni:Loading config file omni_config
INFO:omni:Using control framework pgeni
INFO:omni:Slice urn:publicid:IDN+pgeni.gpolab.
          expires within 1 day on 2011-07-07
INFO:omni:Creating sliver(s) from rspec file
INFO:omni:Writing result of createsliver for
INFO:omni:Writing to 'aliceslice-manifest-rspe
INFO:omni: ----------------------------------
INFO:omni: Completed createsliver:

  Options as run:
                aggregate: https://www.emulab.
                framework: pgeni
                native: True

  Args: createsliver aliceslice myRSpec.xml

  Result Summary: Slice urn:publicid:IDN+pgeni
Reserved resources on https://www.emulab.net/p
  Saved createsliver results to aliceslice-man
INFO:omni: ==================================
```

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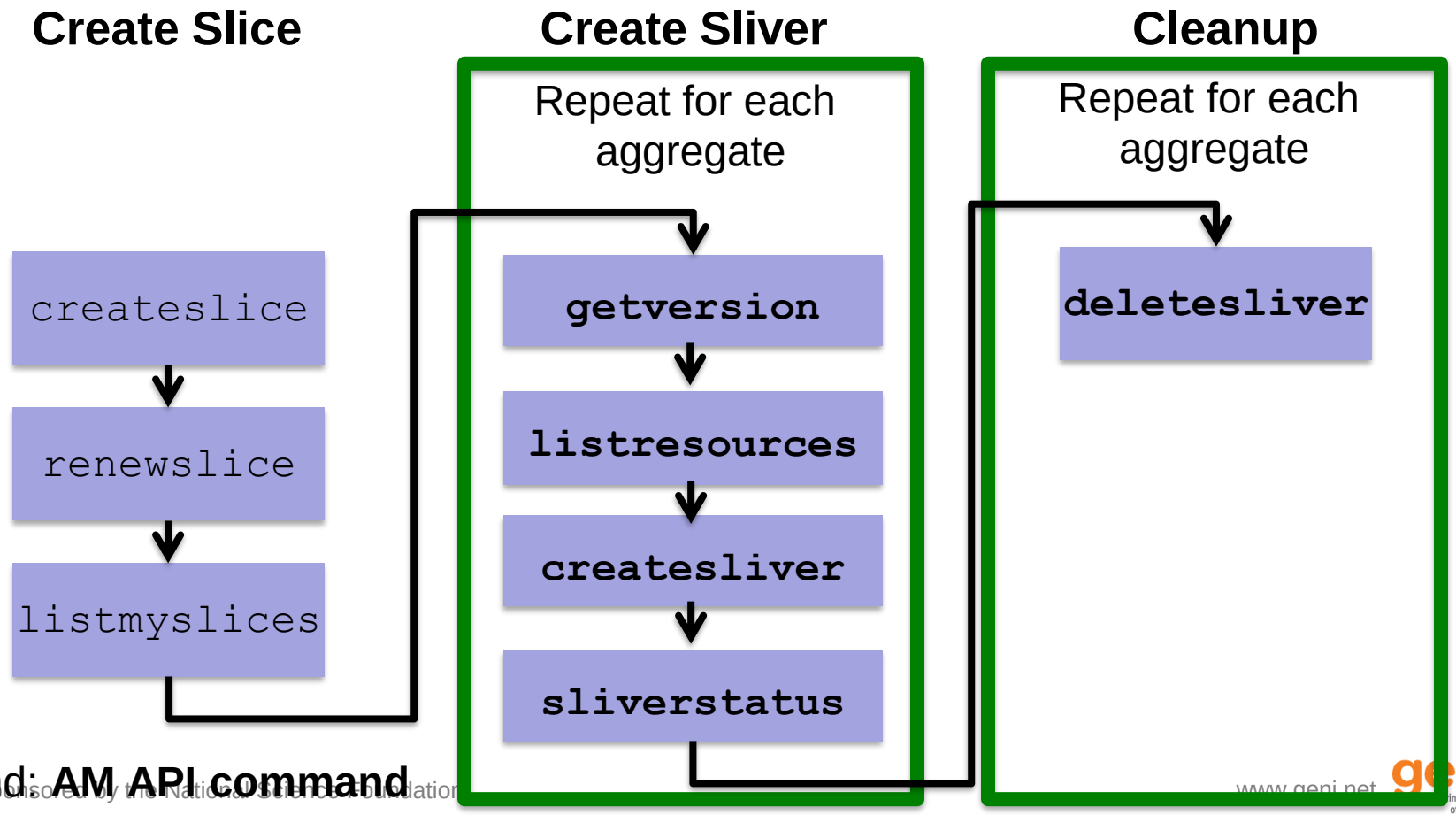
omni Workflow



Legend: **AM API command**

Sample Commands

```
omni -a aggregatename listresources

omni -a aggregatename createsliver slicename requestRSpec

omni -a aggregatename sliverstatus slicename

omni -a aggregatename listresources slicename

omni -a aggregatename deletesliver slicename

readyToLogin -a aggregatename slicename
```

Returns the ssh commands needed to log into nodes

Mentioned in this talk

GENI Portal

`https://portal.geni.net`

Omni

`http://trac.gpolab.bbn.com/gcf/wiki/Omni`

GENI Support for Automating Resource Reservation

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There are three basic techniques for automating experiment configuration:

- OS images
- Install scripts
- Configuration management tools

Operating System Images

use standard images as is

OR

snapshot them to create custom images

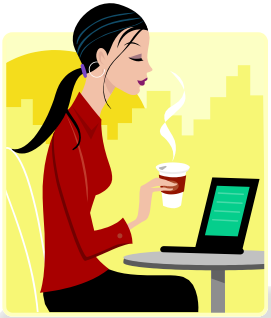
```
<node client_id="node" …>
  <sliver_type name="emulab-xen">
    <disk_image name="…+image+emulab-ops:UBUNTU12-64-STD"/>
  </sliver_type>
</node>
```

DO use custom OS images if the software installation is complicated or slow

DO NOT use custom OS images as a substitute to being able to reproduce the installation

Install and Execute Scripts

Install and Execute Scripts



myserver.com

/local

```
<node client_id="node" …>
  <services>
    <install url="http://myserver.com/mycode.tar.gz"
             install_path="/local" />
    <execute command="sudo /local/install-script.sh"…/>
  </services>
</node>
```

DO use install scripts for frequently used configurations which must run at start time

DO NOT use install scripts for infrequent tasks

Configuration Management (CM) Tools

- Ensure experiment is in a known configuration
- Easily reproduce experiment configurations

  for multiple runs, changing parameters, scaling up, etc

Ansible and Chef open source CM tools are regularly used with GENI

DO use configuration management tools for every day tasks and to ensure repeatable experiments

Automate your experiments using a combination of

- *OS image*,
- *install scripts,* and
- *configuration management tools*

Thank you!

Next Session

3:00 PM ET on Fri, Feb 10

In the meantime, please try the Take-home assignment on:
http://groups.geni.net/geni/wiki/GENIExperimenter/Tutorials/TrainTheTA-Spring2016

If you have questions, please contact:

Ben Newton (bn@cs.unc.edu)