

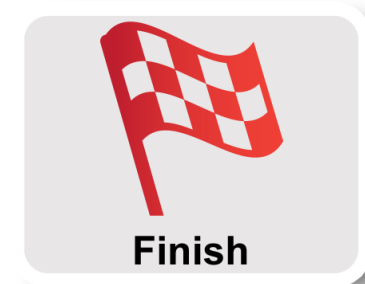
# **GENI in the Classroom – Session 2**

**Ben Newton, Jay Aikat, and Kevin Jeffay**

**University of North Carolina at Chapel Hill**

- Hands-on – Named Data Networking Experiment
  - Using Omni, the GENI AM API and Rspecs
- Tips for running a class on GENI
- Wrap-up

# Behind the Scenes of GENI Experimentation *featuring Named Data Networking*



- Reinforce new concepts using a Named Data Networking (NDN) based experiment\*
  - New concepts: RSpecs and AM API
- Named Data Networking (NDN)
  - A Future Internet Architecture (FIA) project\*\*

\* Based on a classroom exercise developed by Sonia Fahmy, Ethan Blanton & Sriharsha Gangam of Purdue U.; Christos Papadopoulos & Susmit Shannigrahi of Colorado State U.

\*\* <http://named-data.net>

## PRINCIPLE

Focus on **what** you need; **not on where** you find it

## TODAY

Must know the **location** of information (aka URL)

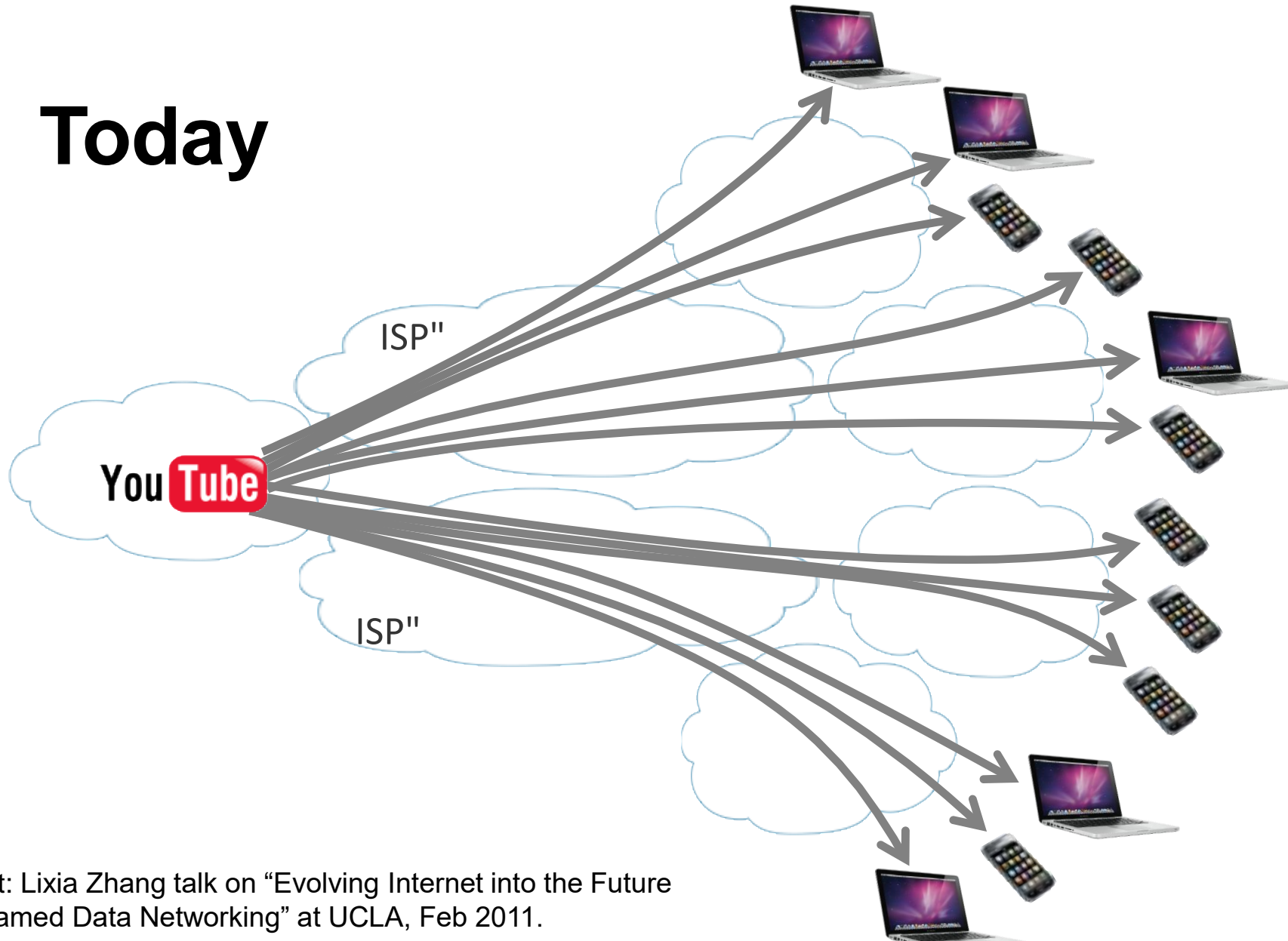
- Search engines map the *what* to the *where*
- Most Internet information look-ups start with search engines

## CCN (NDN)

- New network architecture reflects Internet usage
- CCN protocols cache data at all network levels
  - routers, hosts

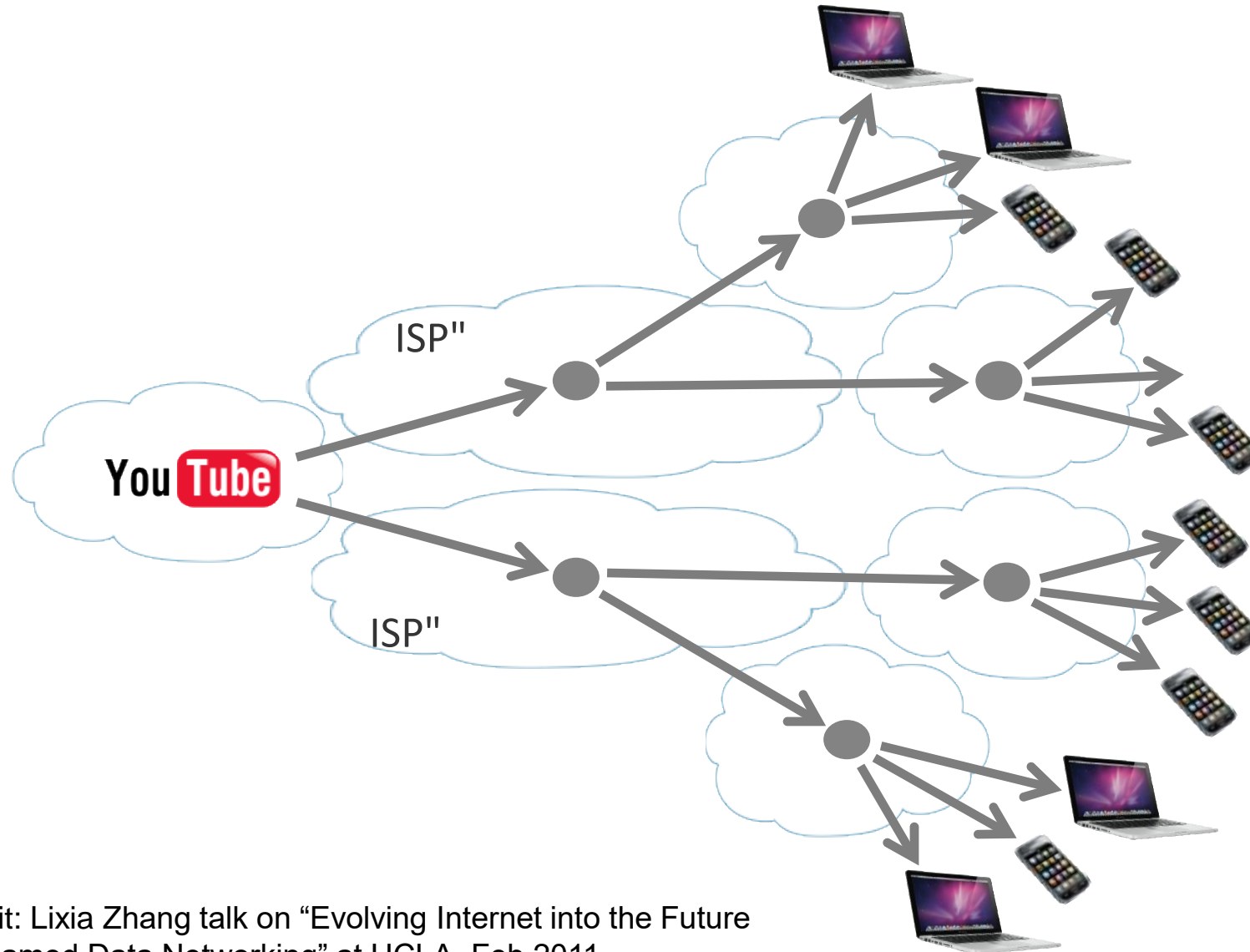
# Point-to-point for data distribution

Today



Credit: Lixia Zhang talk on "Evolving Internet into the Future via Named Data Networking" at UCLA, Feb 2011.

# NDN: Scalable Data Dissemination



Credit: Lixia Zhang talk on “Evolving Internet into the Future via Named Data Networking” at UCLA, Feb 2011.

- An implementation of NDN by Xerox PARC
- Our exercise uses CCNX software
  - Software runs on all nodes in our experiment
  - All nodes cache information that passes through them
  - When a node gets a data request it:
    - Returns data from local cache, if available
    - Passes request to neighbor if data not in cache
    - Caches data returned by neighbor

<http://www.ccnx.org>

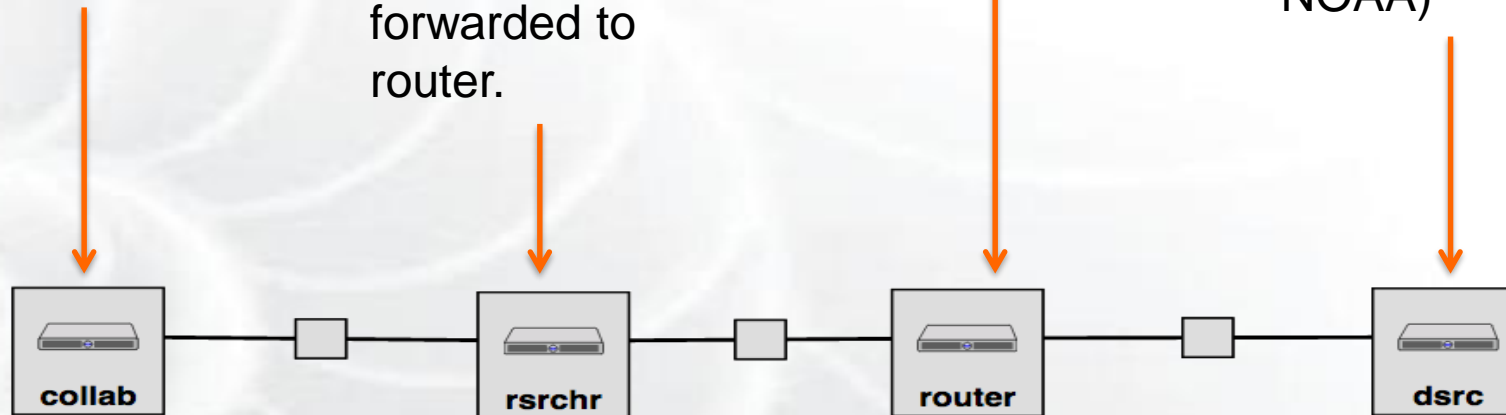


**Collaborator**  
(collab)  
fetches data by  
name.  
Requests  
not in cache  
forwarded to  
researcher.

**Researcher**  
(rschr)  
fetches data by  
name  
(e.g. precip  
data from  
1901/01/01 to  
1901/01/02).  
Requests  
not in cache  
forwarded to  
router.

**Intermediate  
node** (router).  
Requests  
not in local  
cache  
forwarded to  
data source.

**Data Source**  
(dsrcl): Holds  
precipitation  
data from  
1 Jan 1901 to  
31 Jan 1902  
(data from  
NOAA)



- Log into the researcher node (`rsrchr`) and fetch data
  - Use a client program already installed on the node
    - Installed using an install script in the RSpec
- Note how long it takes to get data
- Fetch same data again and note time
- If time permits
  - Repeat the above at the collaborator node (`collab`)
    - Data is not in local cache but in `rsrchr` node cache
  - Fetch new data at the collaborator node (`collab`)
    - Data is not in local cache or in `rsrchr` node cache
- Later: Use GENI Desktop/GEMINI to view graphs of traffic on links
  - Helps visualize when data comes from a local cache and when it comes from a neighbor

- **Configure Omni** (Step 2.2 of instructions)
- **View and edit an RSpec** using Jacks (Steps 3.2 – 3.5)
- **Request resources** specified in RSpec using Omni (Step 3.6)
- When resources are ready, log into a node to **run the CCN application** (Step 5)
- (Later) **Visualize the experiment** using the GENI Desktop and GEMINI
  - GENI Instrumentation and Measurement system

- Cut-and-paste is your friend!
  - Cut-and-paste URLs, commands, etc. from instructions into text boxes, terminal windows, etc
- If at any step you don't understand why you are doing something, ask!
- If you fall behind, let us know!
  - We will help you catch up

# Running a Class in GENI



# GENI Accounts and Projects

**Resources for Instructors**

**Tips**

**Wrap Up**

Leverage InCommon for  
single sign-on authentication

## InCommon®

Experimenters from 304  
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.

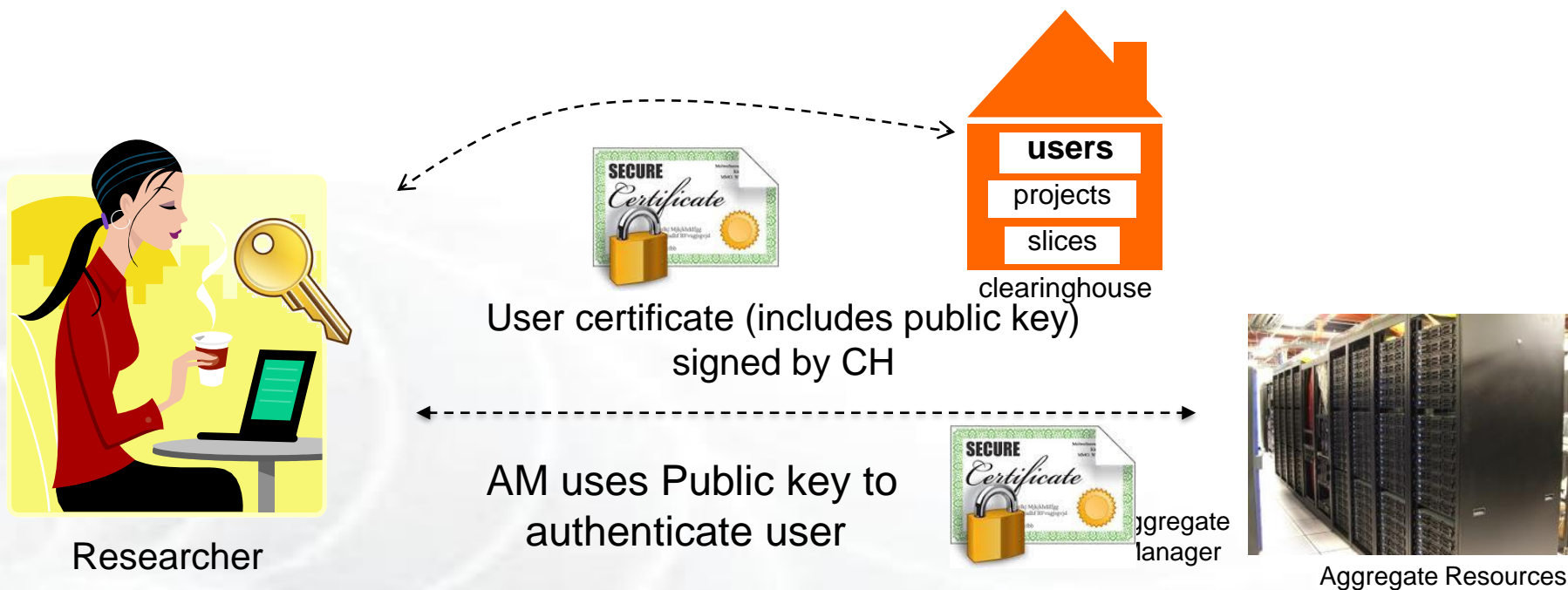
**Asymmetric cryptography**, a.k.a. public-key cryptography is based on using **different keys** for encryption and decryption



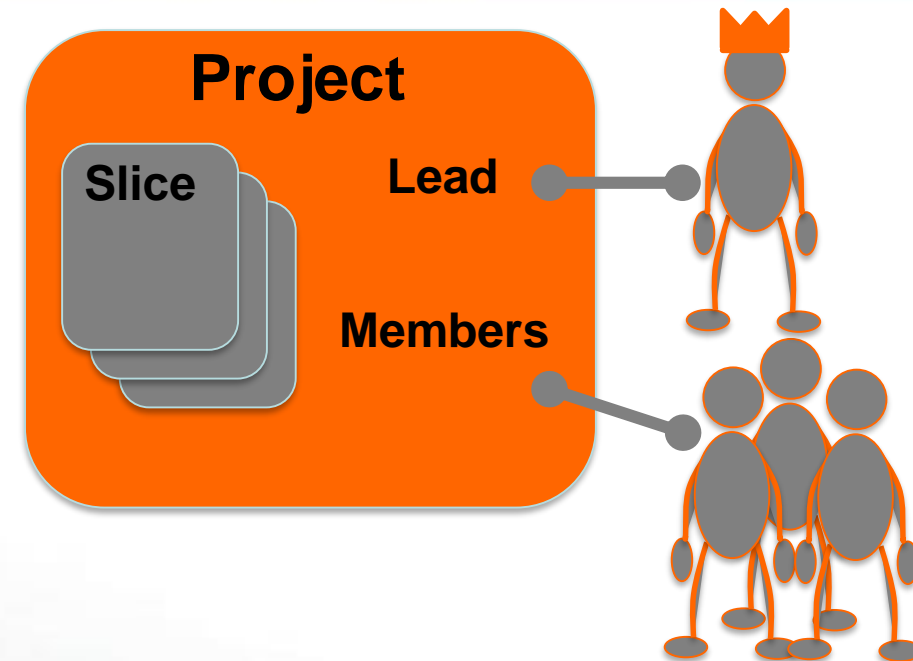
Only the private key can decrypt challenges created with the public key. Private key is usually protected with a passphrase.

[http://en.wikipedia.org/wiki/Public-key\\_cryptography](http://en.wikipedia.org/wiki/Public-key_cryptography)





## Projects organize research in GENI



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

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

# Project Membership example

Projects have 1 **Lead** and any number of **Admins**, **Members**, and **Auditors**



<http://groups.geni.net/geni/wiki/GENIConcepts#Project>

## 1. Member-initiated

Each experimenter asks to join a project, approval needed

- Typical for Research projects

Project	Purpose	Project Lead	Join
ADAMANT	Use GENI to demonstrate use in data-driven computational workflows	Ilya Baldin	<input type="button" value="Join"/>
ASU-GREE-Summer-Camp-2013		Violet Syrotiuk	<input type="button" value="Join"/>

## 1. Admin-initiated

Project Lead/Admin bulk-adds experimenters

- Typical for Classrooms or Tutorials

**Upload Project Members**

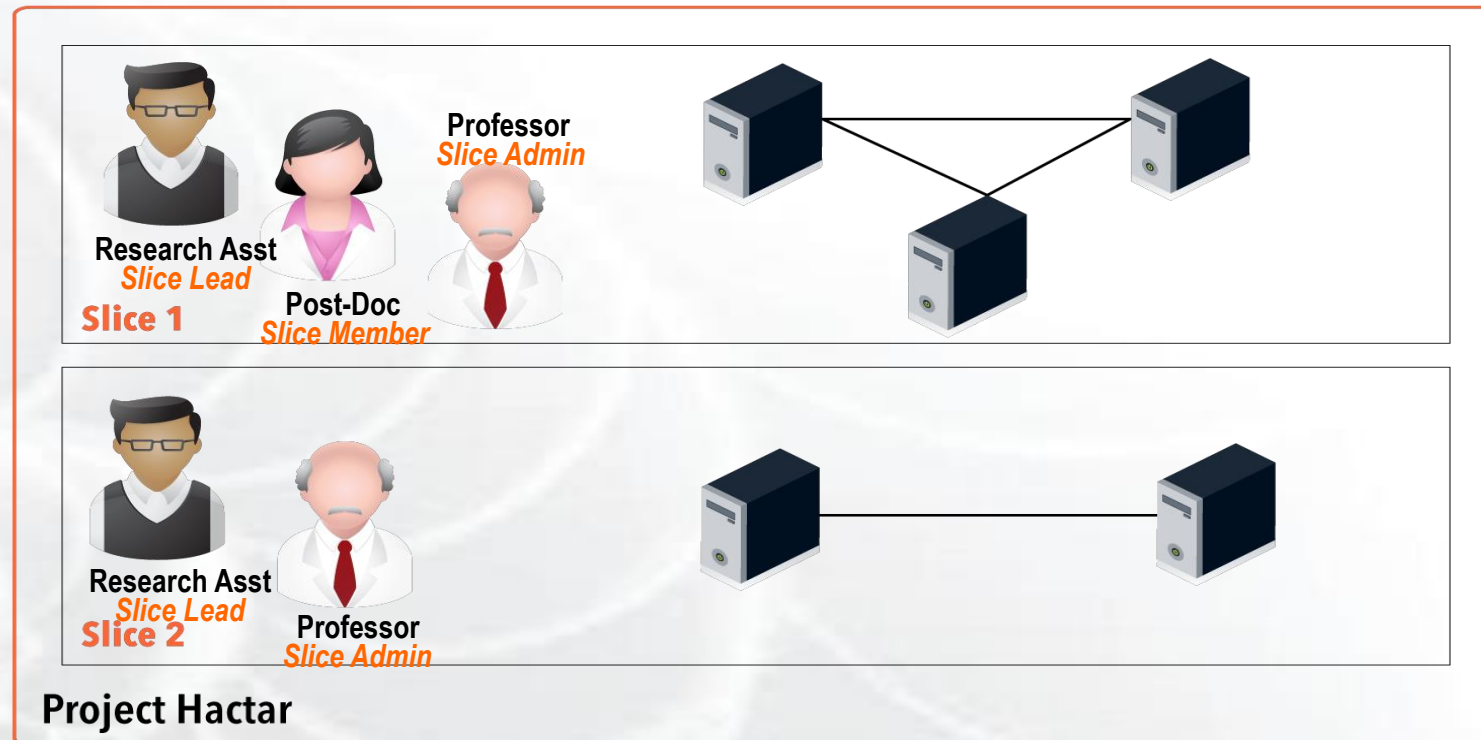
**Action Legend**  
**Add as ...** Candidates who already use the portal will be added to your project with the specified role immediately.  
**Invite as ...** Others will receive an invitation email with instructions on joining your project.

Candidate Name	Candidate Email	Action
Niky Riga	nriga@bbn.com	Already Member
Sarah Edwards	sedwards@bbn.com	<input type="button" value="Add as Member"/>
Vic Thomas	vthomas@geni.net	<input type="button" value="Invite as Member"/>



Slices have:

- 1 **Lead** (person who **created** the slice)
- any number of **Admins**, **Members**, and **Auditors**
- **Project Lead/Admins** added as slice Admins



<http://groups.geni.net/geni/wiki/GENIConcepts#Slice>

# Project and Slice Roles

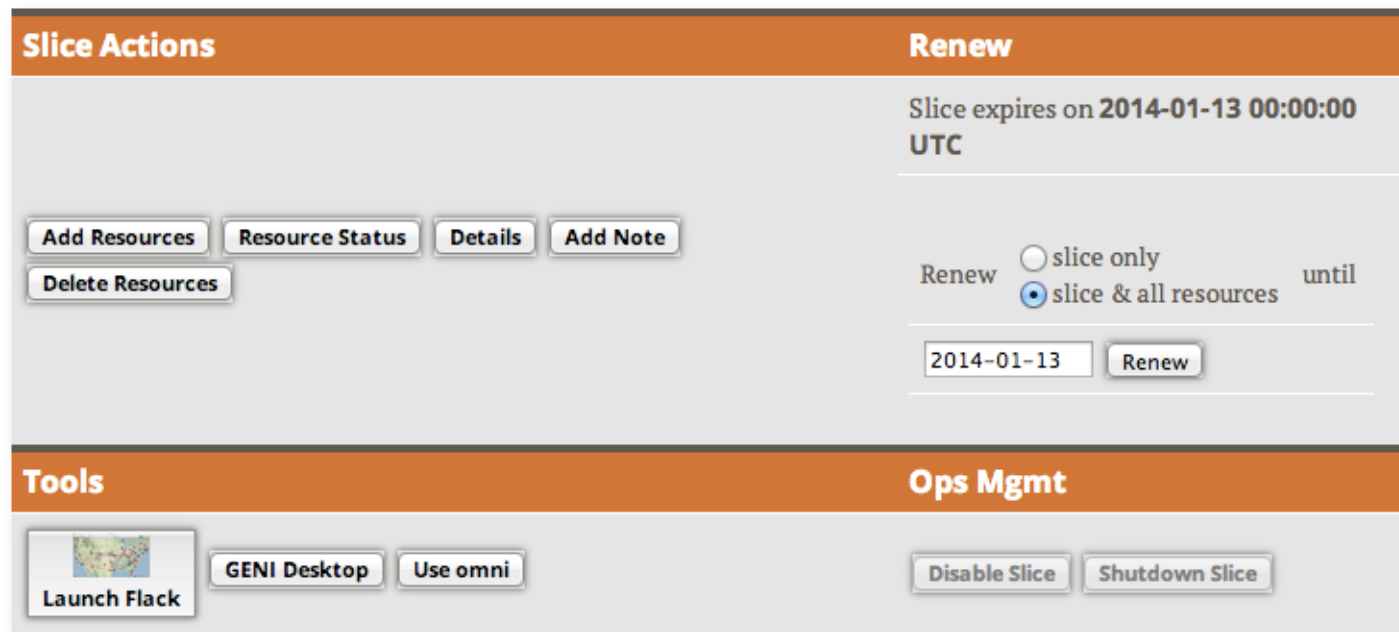
		<b>Create project</b>	<b>Modify project &amp; manage membership</b>	<b>Create slice</b>	<b>View project</b>
<b>Project</b>	Lead	✓	✓	✓	✓
	Admin		✓	✓	✓
	Member			✓	✓
	Auditor				✓
		<b>Manage slice membership</b>	<b>Act on slice</b>	<b>View slice</b>	<b>Account/keys loaded on slice</b>
<b>Slice</b>	Lead	✓	✓	✓	✓
	Admin	✓	✓	✓	✓
	Member		✓	✓	✓
	Auditor			✓	✓

<http://groups.geni.net/geni/wiki/ProjectSlicesRoles>

Being a member of a slice means you can act on a slice:

- Add resources
- Check status
- Delete resources
- Renew resources

**With any tool!**



The screenshot shows a web interface for managing a slice. It is divided into four main sections:

- Slice Actions:** Contains buttons for "Add Resources", "Resource Status", "Details", "Add Note", and "Delete Resources".
- Renew:** Displays the expiration date "Slice expires on 2014-01-13 00:00:00 UTC". It includes radio buttons for "slice only" and "slice & all resources" (which is selected), and a "Renew" button next to a date input field showing "2014-01-13".
- Tools:** Features a "Launch Flack" button with a map icon, and buttons for "GENI Desktop" and "Use omni".
- Ops Mgmt:** Contains buttons for "Disable Slice" and "Shutdown Slice".

# Slice Access: Logging in to resources



**Slice membership does *not* always guarantee ability to login to resources!**

To ensure access in student's resources:

**Option 1: Reserve resources from Portal/Jacks/Omni [recommended]**

- fix the membership of the slice before reserving resources

**Option 2: Ensure common public key is loaded**

- distribute common public key to students
- ask students to upload it in their profile
- use corresponding private key to login

**Ability to login can help in debugging!**



# GENI Accounts and Projects

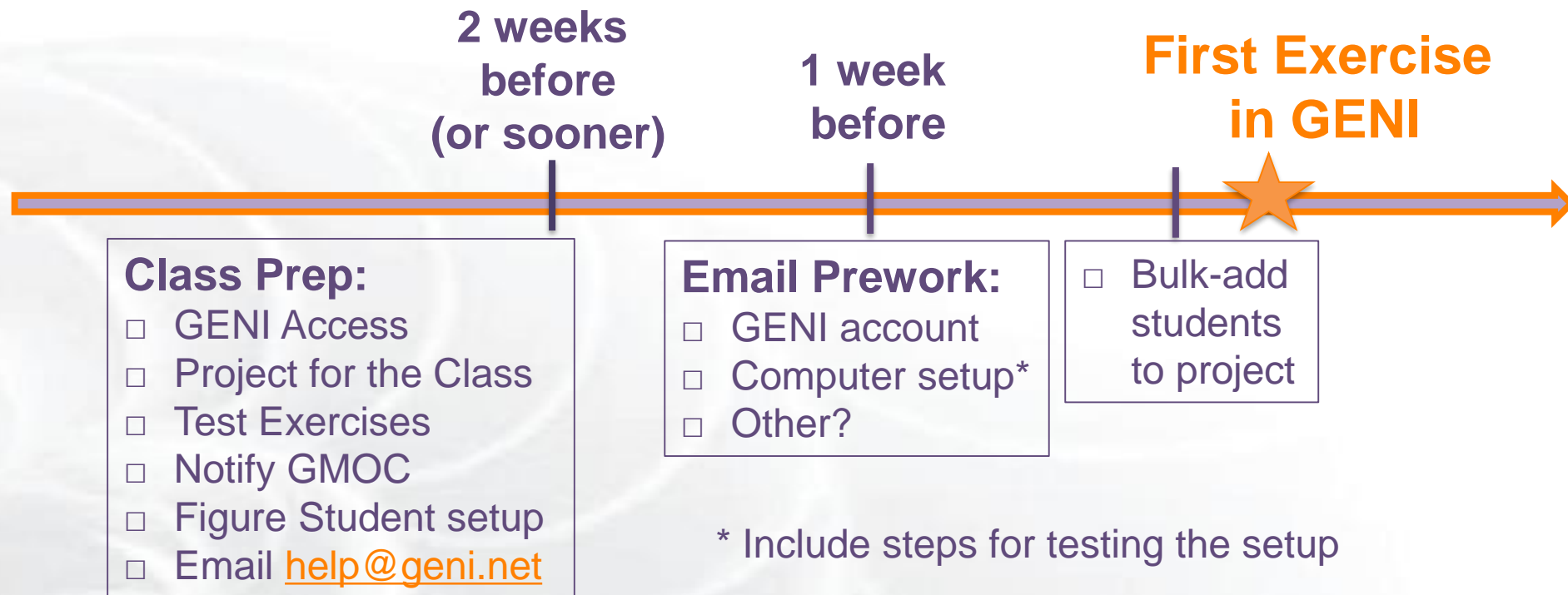
## Resources for Instructors

Tips

Wrap Up

# Instructor Checklist

**TIP: Start early!**



Full checklist at: <http://groups.geni.net/geni/wiki/GENIEducation/Resources>

## Creating Repeatable Computer Science and Networking Experiments on Shared, Public Testbeds

by S. Edwards, X. Liu, N. Riga

In *Operating Systems Review*, Jan '15

For students designing their own experiments

Concise advice for novices on designing experiments to run on a testbed:

1. Formulate a clear plan
2. Automate the execution/analysis of your experiment using best practices
3. Build scalable experiments  
a.k.a. Start small. *Then* scale up

Plus a case study created by a PhD student.



[Link to ACM Library](#)

- **List of sample assignments and tutorials:**

- Use as they are
- Modify to meet your needs



- **Annotated:**

- Type
- Purpose
- Resources needed
- Difficulty/Duration



- **Each sample exercise has:**
  - Handouts / Instructions for students
  - Further information about the instructors
  - For solutions email [help@geni.net](mailto:help@geni.net)
- **Instruction format:**
  - 3 Steps based on standard experiment lifecycle

## Tutorials:



- **Lab Zero**  
Basic GENI understanding, ensures students setup their environment
- **Intro To OpenFlow**  
Basic OpenFlow introductory tutorial, students learn how to setup OVS and write simple controllers

## Assignments:

- **IPv4 Routing**  
Students understand IPv4 forwarding and how to configure static routes
- **TCP Network Awareness**  
Students explore different TCP flavors and TCP parameters



Tutorials: <http://groups.geni.net/geni/wiki/GENIExperimenter/Tutorials>

Assignments: <http://groups.geni.net/geni/wiki/GENIEducation/SampleAssignments>

geni.web.unc.edu



The screenshot shows the GENI Education Modules website. At the top left is the 'geni education' logo. To the right are navigation links: 'Home', 'Modules' (highlighted), 'Instructors', and 'About'. Below the navigation is the heading 'Education Modules'. There are six module cards arranged in a 2x3 grid:

- geni portal**: GENI Setup. Introduces the basics of GENI Portal, and Flack by walking through the process of creating a slice, designing a network, and adding resources to a slice.
- genidesktop**: Instrumentation. Introduces the basics of GENI Desktop, walking through the process of instrumentizing a slice and opening graphs and SSH sessions for the nodes.
- Web Server**: A hands-on experience installing and interacting with a web server. First, install and start a web server. Then, generate a simple HTML file and retrieve it on a client node.
- TCP Traffic**: TCP Traffic. Generate and analyze TCP flows. Iperf is used to create a flow and view the sawtooth behavior. Then, a second flow is introduced to show how TCP flows share a link.
- Effect of RTT and Window Size on TCP Throughput**: Experiment with how RTT and TCP window size affect TCP throughput. Learn how to adjust the RTT of a TCP connection by adding delay, as well as how to adjust the window size of an iperf TCP flow.
- ping TCPDUMP**: Traffic Analysis. Introduces key tools for network traffic analysis, featuring ping and tcpdump.



## 1. Figure out GENI Resources/Tools

- Wireless/Wired
- Flack, Omni, Portal, I&M?

## 2. Test your exercise

## 3. Adjust writeup for GENI

- Remember to include Clean Up!



- **Run through the exercise**
- **Automate:**
  - Install scripts (HowTo/WriteInstallScripts)
  - Custom Image



**Create RSpec that instantiate the topology**  
– install scripts, images are included

## 1. Students make the reservation:

- RSpec (URL, File, Upload it in Portal)
  - Or the topology if they are just drawing it in Flack (e.g. Lab 0)
- AMs, Tool

## 2. \*Admin (Prof., TA) makes all the reservations:

- Create a Slice per student/group
- Make the student(s) member of the slice
- Ensure they have keys (email us if needed)
- Reserve resources **from the Portal or omni**
- Omni scripts automate this process

\* **Lab Exercises:** Resource reservation might take time

**Assignments:** Resource reservation is complicated/unique or out of scope

# GENI Accounts and Projects

## Resources for Instructors

**Tips**

**Wrap Up**

## Tip #1: Load Balance the students

- Split students/groups between equivalent resources (e.g. racks) to avoid resource contention
- If using scarce resources consider a rolling deadline



### **GMOC: GENI Meta-operation Center**

- Keeps track of outages
- Notification system for resource reservation



### **GMOC Google Calendar keeps track of reservations/outages**

<http://groups.geni.net/geni/wiki/HowTo/PreReserveGENIResources>

- **Use their personal laptop**
  - **LabZero** is a good way to get setup
  - There are Mac/Windows Binaries for Omni
- **Use Lab computers**
  - Go through the exercises in lab computers
  - stress-test the resources or split students
- **Use a VM with all the software loaded**
  - <http://groups.geni.net/geni/wiki/HowTo/CreateTutorialVM>

**Make sure they test it early in the class!**

## Tip #4: Accessing GENI Resources: SSH

Login to all GENI compute resources using  
*ssh keys – no password*



If you are ever **prompted** for a **password** during login to **GENI nodes** something is **wrong**

Using key-pair to SSH:



**Public key:** is public to everyone, loaded to nodes

**Private key:** kept private in your computer, provided to SSH to verify it matches the loaded public key



- Students might not be familiar with CLI
- Students might not be familiar with public key cryptography
  - Hard to distinguish between private and public
  - Hard to distinguish between password and passphrase

**Consider a brief SSH tutorial/intro**

*<http://groups.geni.net/geni/wiki/HowTo/LoginToNodes>*



## SSH with keys from **Windows** is **non-trivial**

- No built-in ssh client

## Possible Solutions



- BitVise
- FireSSH – javascript plugin for Firefox
- SecureCRT (not free)
- cygwin
- *Linux VM – make use of a slim OS*
- PuTTY (private key format different)

**Need to address this early!**

<http://groups.geni.net/geni/wiki/HowTo/LoginToNodes>

- Ask students to be specific about what is not working
  - Step-by-step run through usually helps
- Ask for what they see:
  - screenshots
  - omni output errors
- Gather as much information as you can
  - get slice name
  - tool they used
  - rspec
- Remember you have access to their slices, check for yourself!
- Register for resource mailing lists
  - Better that you, not the students, contact resource owners

## Problem: Can't login to a node

### Possible causes:

- **Slice/sliver expired**
- Wrong username
- Public key isn't loaded, Private key is wrong or non-existing
- Private key has wrong permissions (it should have 0600)
- Technical issue with node

### Debug strategy:

1. Check the status of the Slice/sliver
2. Try logging in to the node yourself
  - Look for loaded keys

```
sudo cat <student_user_path>/.ssh/authorized_keys
```

3. Ask them to use `'-v'` option

```
ssh -v foo@bar.example.net
```

## Tell your students ...

**Do NOT manually create  
user accounts with insecure  
passwords on your VMs**

# GENI Accounts and Projects

## Exercises on GENI

## Tips

## Wrap up

# Have a question? Answer is

**help@geni.net**

which is an email list which only goes to members of the GPO including...



Vic Thomas

(However, the archive of the list is public)



- Sign Up for :  
[geni-users@googlegroups.com](mailto:geni-users@googlegroups.com)
- Sign Up for :  
[geni-educators@googlegroups.com](mailto:geni-educators@googlegroups.com)
- Use #geni IRC chatroom
- Go over HowTo pages

*<http://groups.geni.net/geni/wiki/GENIExperimenter/GetHelp>*

- GENI wiki
  - Pages for **Instructors** and **Experimenters**

<http://groups.geni.net/geni/wiki>



The screenshot shows the GENI Wiki homepage. At the top left is the GENI logo. A navigation bar contains links for Wiki, Newcomers, Experimenters, Instructors, Aggregate Providers, Operations, Developers, Spiral Four, and GPO Docs. Below this is a 'Welcome to the GENI Wiki' section with introductory text and a 'Table of Contents' box. A 'Finding Information in this Wiki' section features a row of nine icons representing different user roles: Newcomers to GENI, Experimenters, Instructors, Opt-in Users, GENI Aggregate Providers, GENI Operations, GENI Developers, GENI Project Office (GPO), and Related Projects. Two arrows, one grey and one orange, point to the 'Instructors' and 'Experimenters' links in the navigation bar and their corresponding icons in the resource row.





- Listed under the “Experimenters” section
- Each “How To” is a short descriptions of how to do various tasks
- New entries being added all the time

## Using GENI

- [How to Pick a Slice Name](#)
- [How to Login to Nodes](#)
- [How to Write Install Scripts](#)
- [How to pre-reserve GENI resources \(aka How to Notify GMOC\)](#)



[Tutorials](#)  
[PlanetLab](#)  
[Index](#)

## Omni

- [How to Specify Aggregates In Omni](#)
- [How to Specify RSpecs In Omni](#)
- [How to Add Users to an `omni\\_config`](#)

## OpenFlow

- [How to Install OVS in ProtoGENI](#)
- [How to Run OpenFlow tutorial](#)
- [How to write OpenFlow v3 rspecs](#)
- [How to run the OpenFlow Nox controller in Fedora8 \(OS in many MyPlc hosts\)](#)

## RSpecs

- [How to Convert ProtoGENI v2 to GENI v3 RSpecs](#)

## GENI Nice

December 12, 2016

*Irvine, CA*



Thank you  
for attending!

