







# **GENI** Exploring Networks of the Future

www.geni.net





- What is GENI?
- How is GENI being used?
- Key GENI Concepts
- Demo: A simple experiment using GENI



## **GENI: Infrastructure for Experimentation**



# GENI provides compute resources that can be connected in experimenter specified Layer 2 topologies.

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## **GENI** Compute Resources



## GENI Wireless compute nodes

#### **GENI Racks**

Existing Testbeds (e.g. Emulab)

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4



## **Examples of GENI Networking Resources**



## **GENI: Infrastructure for Experimentation**



# GENI provides compute resources that can be connected in experimenter specified Layer 2 topologies.

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## Multiple GENI Experiments run Concurrently



#### Resources can be shared between slices

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## GENI is "Deeply Programmable"





### OpenFlow part of the experiment not only the infrastructure

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## How is GENI being Used?



## Research

- Future Internet
   architectures
- Software defined networking
- Large scale evaluation of smart grid protocols



- Networking and Distributed systems classes
- Cloud computing classes
- WiMAX classes

## As of October 2013, GENI had over a 1200 users!



## Three FIA Teams have Slices on GENI



### **GENI** is the only testbed that can support these teams.

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GENI Introduction - 15 January 2014

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## Aster\*x Load Balancing (OpenFlow) Stanford University



12



## **GENI** in the Classroom – A great success!



Jeannie Albrecht (Williams College) with students from her Spring 2012 Distributed Systems class

#### Fall 2012:

Rudra Dutta (NCSU) Zongming Fei (U. of KY) Fraida Fund (NY Poly) Kaiqi Xiong (RIT)

#### Spring 2013:

Jay Aikat (U. of NC) Rudra Dutta (NCSU) Khaled Harfoush (NCSU) Jelena Marasevic (Columbia U) Parmesh Ramanathan (U. Wisc) Violet Syrotiuk (Arizona State U.) KC Wang (Clemson) Michael Zink (U. of MA)

#### Fall 2013:

Prasad Calyam (U. of Missouri) Zongming Fei (U. of KY) John Geske (Kettering U.) Deniz Gurkan (U. of Houston) Christos Papadopoulos (Col. State) Violet Syrotiuk (Arizona State U.) Zhi-Li Zhang (U. of MN)

13



**GENI at Upcoming Conferences** 

# SIGCSE ATLANTA 2114

IC2E 2014: IEEE International Conference on Cloud Engineering







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- Slice: Abstraction for a collection of resources capable of running experiments
  - An experiment uses resources in a slice
  - Slices isolate experiments
  - Experimenters are responsible for their slices





## **GENI: Terms and Definitions**

- Slice authority: Creates and registers slices

   GENI slice authorities: GENI Portal, PlanetLab, ProtoGENI
- Aggregate: Provides resources to GENI experimenters
  - Typically owned and managed by an organization
  - Examples: GENI Racks, Internet2, Emulab, PlanetLab
  - Aggregates implement the GENI AM API





- A slice : One or more resources provided by an aggregate
  - E.g. Bare machines, virtual machines, VLANs





- RSpecs: Lingua franca for describing and requesting resources
  - "Machine language" for negotiating resources between experiment and aggregate
  - Experimenter tools eliminate the need for most experimenters to write or read RSpec



- Advertisement RSpec: What does an aggregate have?
- Request RSpec: What does the experimenter want?
- Manifest RSpec: What does the experimenter have?







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## Putting it all Together: Demo

- Demo
  - Create a slice
  - Create a sliver at one aggregate
    - Two computers (raw PCs), connected by a LAN
  - Install and run software on the machines
  - View output of software
  - Delete sliver
- Experimenter tool: Flack



## GENI Tools: Instrumentation & Measurement

- Two major I&M systems being implemented
  - GEMINI (Indiana U. & U. of Kentucky)
  - GIMI (U. of Massachusetts, RENCI, NICTA)
- Support for active and passive measurements
- Repositories for archiving (and searching) for measurement data & meta-data



#### The GENI Desktop and GEMINI

LEUTIN		
		Encos
	git:geni-johren:repo/oidl/step3-ping_e2e.rb	geni-johren-johren-pinge2e-2013-09-13T12-13-26-04-00
In this tutorial we describe a series of experiment that will allow a user to:		
	1 defrequenty('sourcel', 'sodat', 'ID of a resource')	Comp
<ul> <li>Verify that a slice has been set up correct</li> </ul>	<pre>2 defProperty('source2', 'sode8', 'ID of a resource')</pre>	Experiment geni-johren-johren-pinge2e-2013-09-13T12-13-26-04-00 finished after 0x10
<ul> <li>Establish certain routes within the slice</li> </ul>	<pre>defProperty('source3', 'sodeC', 'ID of a resource') defInemental'source3', 'modeC', 'ID of a resource')</pre>	1.8 BINGOUTT = Tec. 106. 1.18 (bitrig)
<ul> <li>Verify that routes have been set up correct</li> </ul>	) deffregenty('sources', 'model', 'ID of a resource')	1.3 INFO graph = "true" (String)
Execute a throughput measurement	<pre>6 defroperty('graph', true, "Display graph or not")</pre>	1.3 Source5 = 'nodeE' (String)
Verification of Tonology	deffromerty('sinkeddril', '192,160,1,13', 'Fing destination address')	1.3 Source4 = 'nodeD' (String)
	3 defFroperty('minkeddr12', '192.168.3.13', 'Fing destination address')	1.3 NO source3 = 'nodeC' (String)
After establishing the slice on which the experiment will be executed, the experimenter will be most licely be interested in unificities of the slice has been initiated remember to the fair total of the one on OME	<pre>10 defProperty('sinkeddr13', '192.168.6.14', 'Fing destination address') </pre>	1.3 NEO source2 = 'node0' (String)
experiment script that executes pings between neighboring nodes. The following figure shows that a	<pre>12 defroperty('sinkaddr21', '192.168.6.14', 'Ping destination address')</pre>	1.3 source1 = 'nodeA' (String)
total of 12 (between each pair of nodes and in each direction) ping are performed.	11	1.3 Isad /var/lb/omfwebapos/exp.repos/geni-johren/repo/gid/step3-ging_e2e.rb
D Elever 1 12 elever	<pre>is detroperty("sinkeddr42", '192.160.5.11', 'Fing destination address") is defFroperty("sinkeddr42", '192.160.5.11', 'Fing destination address")</pre>	1.3 NO isod system excernetilb
N reflected to the builder	16 defFreperty('sinkeddr43', '192.168.6.14', 'Fing destination address')	1.3 NO resultring = 1 (forum)
The corresponding experiment script can be found under "gec16/step1-ping_sll.rb" To run the	37 18 defenseerss 'standards', 198 168 5 11', Telas destination address's	12 March 12 Communit
experiment perform the following:	1) deffroperty('minkeddr52', '192.160.2.10', 'Fing destination address')	1.0 DEC realization of the set
<ul> <li>Simply type "stent_nim, all rh" in the search field all the way on the typ of the "Prenare widnet" and</li> </ul>	20 defFreperty('minkeddr53', '192.160.3.13', 'Fing destination address')	1.3 Load system exposible
select the file and the scrip will show up in the prepare widget.	21 22 defined instituti 'ning and's 'ningenolitor') de [a]	1.3 Multi AM support disabled - any service calls will fail
<ul> <li>Drag the loop on top of the "Prepare" widget to the "Execute" widget.</li> </ul>	23 a.path = "/root/pingwrap.rb"	0.6 Message authentication is disabled
· Charle Mall the second and second second second	24 a.version(1, 2, 0)	0.8 Experiment ID: geni-johren-johren-pinge2e-2013-09-13T12-13-26-04-00
Check if all the specified parameters are correct.	26 a.description = "ping application"	0.6 Sice ID: johrenGIMI
<ul> <li>Start the experiment.</li> </ul>	27 s.defFreperty('dest_addr', 'Address to ping', '-s', (type -> ratring, rdynamic -> fals	0.6 MF Experiment Controller 5.4 (git testing)
Setup Routing in Experiment Topology	21 s.defProperty('count', 'Runber of times to ping', '-o', (rtype ⇒ rinteger, rdynamic ⇒ s.defProperty('interval', 'Interval between mines in s', 'al', (rtype ⇒ rinteger, rdyn	
In more complex trackates mution has to be set up. In our case, this is achieved with the aid of an	30	▼ Graphs
OMF experiment script.	31 s.defMeasurement('myping', '', istream_name -> 'pingmonitor_myping') do [m]	
	3) m.defNetric('dest eddr', retring)	
The corresponding experiment script can be found under "gec16iistep2-routing.rb" To run the experiment perform the following:	34 m.defNetrio('ttl', sist)	45
and a second a second a	31 m.defMetric('rst', (float)	
<ul> <li>Simply type "step2-routing.rb" in the search field all the way on the top of the "Prepare widget" and select the file and the and/ will show up in the prepare widget.</li> </ul>	37 and	
Drag the joon on top of the "Prepare" widget to the "Execute" widget.	31 453	
Check if all the specified parameters are correct	40 defGroup('Sourcel', property-sourcel) do [sode] 41 mode.addtoplicatios('ping app') do [app]	3
Ptot the exception	41 app.sotProperty('dest_addr', property.sinkaddr11)	E 25
	4 app.sotProperty('cont', Jo) 4 app.sotProperty('interval', 1)	
The step2-routing /b script can be easily adapted if the experimenter wishes to set up the routing between the nodes differently.	45 app.measure('myping', reamples => 1)	-
between the material and any.	(6 end	1.5
Verification of Routing	() node.addroplicatios("ping app") do [app]	
After establishing the muting, we use an OME experiment social that exercises nings between each	4) app.metProperty('dest_addr', property.minkaddr12)	
pair of nodes that contains one hop, to verify the correctness of routing setup.	50 app.metProperty('count', 30)	0.5
	52 app.measure('myping', reamples ⇒ 1)	2 4 6 8 10 12 14 16
Figure 2. Route verification.	53 end	010,000
	54	Figure: RTT of received packets.

#### LabWiki and GIMI



## **Omni: Resource Reservation tool**

- A command line experimenter tool
- Useful for making AM API calls on aggregates
- Written in and scriptable from Python
- Works with aggregates that implement the GENI AM API
  - ProtoGENI, PlanetLab,
     OpenFlow, InstaGENI,
     ExoGENI

```
Options as run:
```

```
aggregate: https://www.emulab.
framework: pgeni
native: True
```

Args: createsliver aliceslice myRSpec.xml

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

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# **QUESTIONS?**