## Title: Running RINA on GENI

## Overview:

Recursive InterNetwork Architecture (RINA) is a new network architecture based on the fundamental principle that networking is Inter-Process Communication (IPC). RINA separates mechanisms and policies, and enables policy-based dynamic service composition. This tutorial introduces the basic elements of the Recursive InterNetwork Architecture (RINA) (http://csr.bu.edu/rina/) and describes how to setup RINA experiments on GENI nodes.

# **Prerequisites**:

- A basic understanding of GENI concepts such as those covered in the Introduction to GENI and Experimentation using GENI tutorial (http://groups.geni.net/geni/wiki/GEC19Agenda/IntroToGENI).
- Comfortable with running your own experiments on GENI resources.
- Verify that you are able to log into the GENI Portal (https://portal.geni.net).
- A basic familiarity with using a UNIX command line.
- A laptop with Mac OS or Linux OS. For Windows users, install Cygwin, or a recent version of Virtual Box (https://www.virtualbox.org/) with an Ubuntu image.
- A basic understanding of the Recursive InterNetwork Architecture (RINA: http://csr.bu.edu/rina).

# Tools:

- GENI Portal.
- UNIX command line.

# Where to get help:

- For support and general questions about ProtoRINA, please contact the ProtoRINA team at *protorina-developers@cs.bu.edu*.
- You are welcome to subscribe to ProtoRINA users mailing list at <a href="http://cs-mailman.bu.edu/mailman/listinfo/protorina-users">http://cs-mailman.bu.edu/mailman/listinfo/protorina-users</a>

# **Experiment 4: Routing**

## **Tutorial Instructions:**



## Part1: Design/Setup

- Design the Experiment
- Establish the Environment

#### **Part2: Execute**

- Login to VMs
- Import configuration files
- **Start IDD and DNS**
- Start Node1
- Start Node2
- Start Node3
- Start Node4
- Stop Node2
- Analysis

Part3: Finish

#### **Experiment 4: Routing**

Part1: Design/Setup:



#### **1. Design the Experiment**

In this experiment, we use four RINA nodes (Node1, Node2, Node3 and Node4).

First we start Node1. It has one IPC process (IPC1) belonging to DIF1.



Second we start Node2. It has one IPC process (IPC2), and IPC2 will join DIF1 through IPC1.



Third we start Node3. It has one IPC process (IPC3), and IPC3 will join DIF1 through IPC2. The next hop of IPC1 to IPC3 is IPC2.



Fourth we start Node4. It has one IPC process (IPC4), and IPC4 will join DIF1 through IPC1. Also IPC4 and IPC3 are configured to be neighbors. Now there are two paths of the same cost in DIF1 between IPC1 and IPC3. IPC2 is the next hop of IPC1 to IPC3.



Last we terminate Node2, and the path from IPC1 to IPC3 through IPC2 is broken. Then after the routing information is updated in DIF1, the route between IPC 1 and IPC 3 adapts to the path IPC1- IPC4- IPC3.



## 2. Establish the Environment



# Skip this section if you have already established your environment for RINA

## 2.1. Pre-work:

- Ensure SSH keys are setup. If your SSH keys are not setup before, do the following steps:
  - Generate an SSH Private Key on the *Profile* page on the GENI portal
  - Download Private Key to ~/Downloads
  - Open terminal and execute
    \$ mv ~/Downloads/id\_geni\_ssh\_rsa ~/.ssh/.
    \$ chmod 0600 ~/.ssh/id\_geni\_ssh\_rsa
    \$ ssh-add ~/.ssh/id\_geni\_ssh\_rsa
- Ensure you are part of the project "ProtoRINA".

• To check this, go to portal.geni.net -> Projects. You should be able to see project "ProtoRINA" under "My Projects".

🙀 Home → Pr	ojects			
GENI Projec	bjects ts			
Ask Some Ask to be	Ask Someone to Create a Project Ask to be a Project Lead			
Project	Project Lead	Purpose	Slice Count	Create Slice
Name		Experimental Evaluation of Boston University's Prototype of RINA	1	Create

- Ensure that you are added to the slice by the lead.
  - To check this, go to portal.geni.net -> Slices. You should be able to see slice "RINATutorialSlice1" or "RINATutorialSlice2" under "My Slices".

Home Slices						
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ly Slices						
You have access	to <b>2</b> slices.					
Slices on which	Lam lead					
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Slice Name	Project	Slice Expiration	Slice Lead	Actions		
Slice Name	Project	Slice Expiration	Slice Lead	Actions Add Resources	Resource Status	Details
Slice Name RINATutorialSlic	Project	Slice Expiration 2014-03-11 20:10:11 Z	Slice Lead Nabeel Akhtar	Actions Add Resources Delete Resource	Resource Status es Launch Flack	Details

## 2.2. Check Resources:

• Click on "Launch Flack" on your slice. That might take a few minutes to display the whole GUI.

Slice Name	Project	Slice Expiration	Slice Lead	Actions		
				Add Resources	Resource Status	Details
RINATutorialSlice1	ProtoRINA	2014-02-27 22:49:32 UTC	Nabeel Akhtar	Delete Resource	Launch Flack	)
				GENI Desktop	LabWiki	



DO NOT DELETE RESOURCES!!!

• You should see the following on your Flack:



#### Part2: Execute:



## 1. Login to VMs

In this experiment, we will use five VMs (named Node1, Node2, Node3, Node 4 and IDD-DNS). You can see these five VMs on Flack.

a) To login to a VM, click on words on "Node1" as shown below:



b) Now, Click on shown below. A new terminal window will pop up.

Node1				]9
	User	rname nabeel Hostnam	e pc1.genirack.nyu.edu:397	739 Vititi SSH
	0		e <sup>go</sup>	
Manager	Binding			Slive
genirack.n	yu.edu 🔻 📵 🔵 Unbound 🗌	Туре		▼   emi
80.1	Bound to pc1			<b>-</b> [0]
Diek Image	Select advertised image			•
DISK IMAGE	Select a user for user-created disk ima	ges 👻	Select user-created disk i	mage 🗸 👻
• Name (	URL Select image above, paste URN	l, or manually type OSIE	)	
Version If re	equired, give a disk image version.			
Install		🕜 Add Install Se	ervice Execute	

To ssh from the command line, do the following (substituting with values shown on the screen).

ssh USERNAME@HOSTNAME -p PORT

- c) Go back to Flack, and ssh to the other four VMs (Node2, Node3, Node4 and IDD-DNS) following the instructions given above.
- d) Make sure you open two terminal windows for "IDD-DNS". We will run the IDD process and DNS process separately using two terminal windows.



You should have 6 terminal windows now: One for Node1, one for Node2, one for Node3, one for Node4 and two for IDD-DNS.



The IDD process provides RINA directory services

#### 2. Import configuration files

Now you will import configuration files to your home directory for five VMs respectively.

For each VM, copy your group files to your local directory as shown below. You can find your group number in the worksheet provided to you.

cp -r /users/Tutorial/ master/group1/ ~



Make sure you copy data for your own group provided in the handout.

#### 3. Start IDD and DNS

We will start the IDD process and DNS process now.

a) To start DNS, go to directory with the DNS properties file using one of the IDD-DNS terminal windows:

cd group1/IDD-DNS/DNS/

Now run the following command to run DNS:

java -jar /users/Tutorial/master/IDD-DNS/DNS/DNS.jar dns.properties

b) To run IDD, go to directory with the IDD properties file using the second IDD-DNS terminal window:

cd group1/IDD-DNS/IDD/

Now run the following command to run IDD:

java -jar /users/Tutorial/master/IDD-DNS/IDD/IDD.jar idd.properties

#### 4. Start Node1



Now we will start Node1 process on the first VM (Node1).

a) In the terminal for Node1, go to directory for Node1 as shown below:

cd group1/Configurations/exp4/Node1/

b) Start Node1 process using the following command:

java -jar /users/Tutorial/master/RINANode.jar Node1.properties

At this point, your Node1 should be up and running.

#### 5. Start Node2



We start Node 2 process. It has one IPC process (IPC2), and IPC2 joins DIF1 through IPC1.

a) In the terminal for Node2, go to directory for Node2 as shown below:

cd group1/Configurations/exp4/Node2

#### b) Start Node2 process using the following command:

```
java -jar /users/Tutorial/master/RINANode.jar Node2.properties
```

At this point, your Node2 should be up and running, and it will join DIF1 through IPC1 on Node1.

#### 6. Start Node3



In this step, we start Node3. It has one IPC process (IPC3), and IPC3 joins DIF1 through IPC2.

a) In the terminal for Node3, go to directory for Node3 as shown below:

cd group1/Configurations/exp4/Node3

#### b) Start Node3 process using the following command:

java -jar /users/Tutorial/master/RINANode.jar Node3.properties

#### 7. Start Node4

In this step, we start Node4. Node4 has one IPC process (IPC4), and IPC4 joins DIF1 through IPC1. Also IPC4 and IPC3 are configured to be neighbors.



a) In the terminal for Node4, go to directory for Node4 as shown below:

cd group1/Configurations/exp4/Node4

#### b) Start Node4 using the following command:

java -jar /users/Tutorial/master/RINANode.jar Node4.properties

Now there are two paths of the same cost in DIF1 between IPC1 and IPC3.

#### 8. Stop Node2

Now we stop Node2 process, and the path from IPC1 to IPC3 through IPC2 is broken.



In the terminal for Node2, press "Ctrl +c" on the keyboard to terminate Node2 process. Now after the routing information is updated in DIF1, the route between IPC1 and IPC3 adapts to the path IPC1 - IPC4 - IPC3.

#### 9. Analysis

Now we will analyze route adaptation by parsing the log file at Node1.

- 1. Stop Node1, Node2, Node3 and Node4.
  - You can terminate node processes by pressing "Ctrl+c" on the keyboard.



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2. We will look at the routing information. Type the following in the terminal for Node1 to parse the log file.

/users/Tutorial/master/RINALogChecker.sh -i rinaBU.log -o Routing

3. This will generate a log file for all routing information on Node1. To display this log file, type following:

cat Routing.log

Sample output is shown below.

Note that IPC1, IPC2, IPC3 and IPC4 have been assigned address (1, 11, 111, 12) respectively in DIF1. Observe that the next hop from IPC1 to IPC3 (address: 111) changes from IPC2 (address: 11) to IPC4 (address:12) once IPC2 fails.

ſ	nabeel@Node1	Node1]\$ cat	Routing.log		Info neighbor removed leads				
	2014-03-03	18:20:14740	addCostToNeighbor, leads to update FT	Il note Motol	38139 Timer_0 DEBUG 2014_				
	2014-03-03	18:20:14740	this.map: {1={11=1.0}, 11={}}	[Instrivote]	Info this man: 111-112-1.83				
	2014-03-03	18:20:14741	ForwardingTable is {11=11}		38140 Timer=0 (DFBUG 2014-				
	2014-03-03	18:20:14744	this.map: {1={11=1.0}, 11={1=1.0}}		Info ForwardinaTable is {12=				
	2014-03-03	18:20:14744	ForwardingTable is {11=11} University	KUDaily [All	38140 Timer-0 DEBUG 2014-				
	2014-03-03	18:20:24742	the new one has less entries that the old one		erTask Tasktask(checkNeighbc				
	2014-03-03	18:20:24743	oldEntrySet in the mapEisi{1=1.0} Kaynar		ajpot)				
	2014-03-03	18:20:24743	new EntrySet in the map is {1=1.0, 111=1.0}						
	2014-03-03	18:20:24744	this.map: {1={11=1.0}, 11={1=1.0, 111=1.0}, 111={}}		000 na				
	2014-03-03	18:20:24745	ForwardingTable is {11=11, 111=11}						
	2014-03-03	18:20:24746	this.map: {1={11=1.0}, 11={1=1.0, 111=1.0}, 111={11=1	.0}} = cs	ostToNeighbor, leads to upda				
	2014-03-03	18:20:24746	-ForwardingTable is {11=11, 111=11}		26892 Thread-7 DEBUG 2014-				
	2014-03-03	18:20:3898	addCostToNeighbor, leads to update FTCLL LinkStateRout		.map: {12={111=1.0, 1=1.0},				
	2014-03-03	18:20:3899	this.map: {1={11=1.0, 12=1.0}, 11={1=1.0, 111=1.0}, 11:	$1 = \{11 = 1.0\}, 1$	2={}}ForwardingTable, 11 is				
	2014-03-03	18:20:38100	<pre>ForwardingTable is {11=11, 12=12, 111=11}</pre>		26893 Thread-7 DEBUG 2014-				
	2014-03-03	18:20:38101	.01 this.map: {1={11=1.0, 12=1.0}, 11={1=1.0, 111=1.0}, 111={11=1.0}, 12={111=1.0}}						
	2014-03-03	18:20:38101	ForwardingTable is {11=11, 12=12, 111=11}		Exception in thread "Thread-				
	2014-03-03	18:20:40129	The new one has less entries that the old one		Open Hat rina.irm.impl.IRM				
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	2014-03-03	18:20:40129	Dnew EntrySet in the map is [11=1.0, 12=1.0] to the is true		28487/CThread=901/INEOU 2014-				
	2014-03-03	18:20:40129	this.map: {1={11=1.0, 12=1.0}, 11={1=1.0, 111=1.0}, 11	11={11=1.0, 1	2=1.0}, 12={111=1.0}} 1, thu				
	2014-03-03	18:20:40130	ForwardingTable is {11=11, 12=12, 111=11}		28489 Thread-10 INFO 2014-				
	2014-03-03	18:20:40130	, the new one has less entries that the old one = 1,0}, 1		not exist for dstAddr 1, thu				
	2014-03-03	18:20:40131	oldEntrySet in the map is {111=1.0}		28491 Thread-11 INFO 2014-				
	2014-03-03	18:20:40131	Znew EntrySet in the maplis {111=1.0, 1=1.0}	Rom Jer I	not exist for dstAddr 1, thu				
	2014-03-03	18:20:40131	⊥this.map: {1={11=1.0, 12=1.0}, 11={1=1.0, 111=1.0}, 1	11={11=1.0, 1	2=1.0}, 12={111=1.0, 1=1.0}}				
	2014-03-03	18:20:40132	Forwardinglable is {11=11, 12=12, 111=11}	Fw	74811 Ihread-3 ERRUR 2014-				
~	2014-03-03	18:20:59742	routingEntrySetForward is modified to clear info about	t 11	7873				
	2014-03-03	18:20:59742	heighbor removed, leads to update Fileno 4	BU hando	L for experiments 3 and 4 - T				
	2014-03-03	18:20:59742	this.map: {1={12=1.0}, 11={}, 111={11=1.0, 12=1.0}, 1	2={111=1.0, 1	=1.0}}				
	2014-03-03	18:20:59743	Forwardinglable is {12=12, 111=12, 11=12}		University's Annual Report -				
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# Part3: Finish:



You are done with the last experiment. Make sure you terminate all the processes on Node1, Node2, Node3, Node4 and IDD-DNS nodes.

YOU CAN CLOSE ALL TERMINAL WINDOWS NOW.