This presentation slide is available at
http://trema.github.com/trema/
or google “Trema”

Trema updates and introduction to GENI researchers

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NEC's OpenFlow activities related to GENI

- "ProgrammableFlow"
  - Production quality OpenFlow switches and controller for data center networks
- "Trema"
  - OpenFlow controller platform for research and academia
  - Free software (GPLv2)
  - Originally developed by NEC research lab.

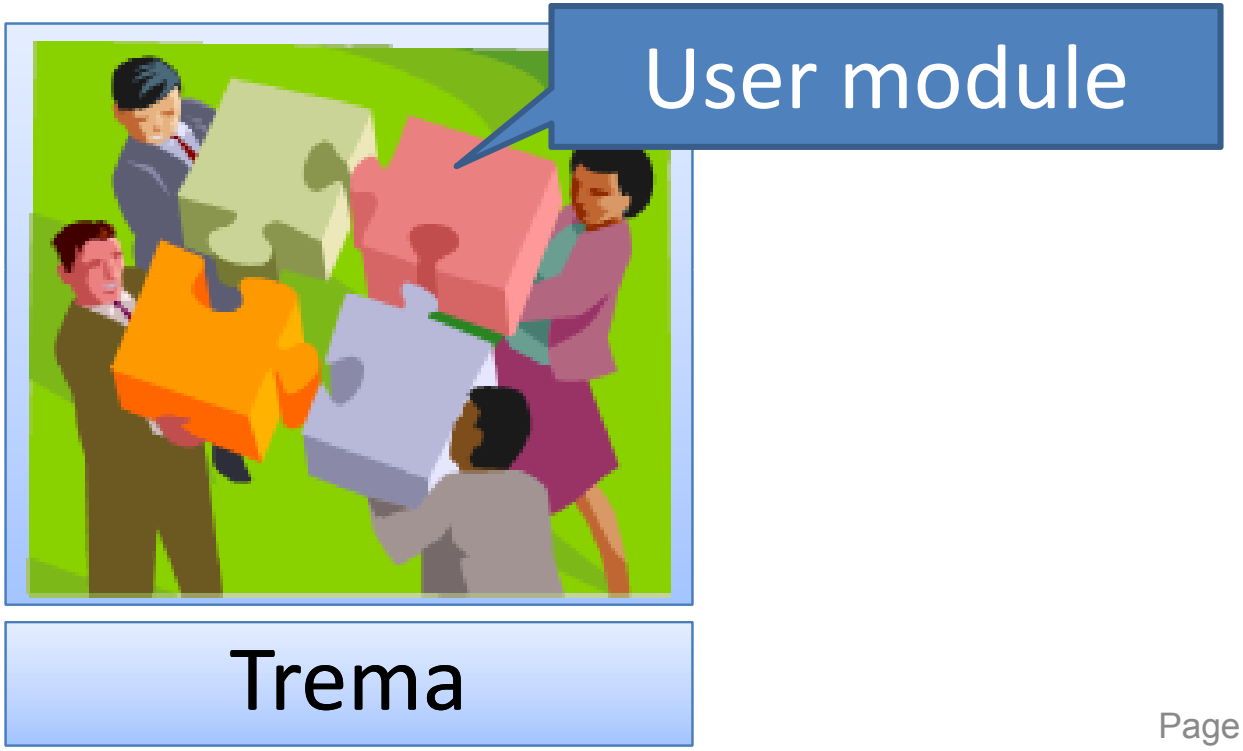
Goal of Trema project

- Provide fairly good quality OpenFlow controller platform to researchers and developers
  - Continuous development, maintenance, bug-fixes and user support from the project team (researchers and professional programmers at NEC and other companies)

- Help GENI experimenters for their OpenFlow related activities :-)

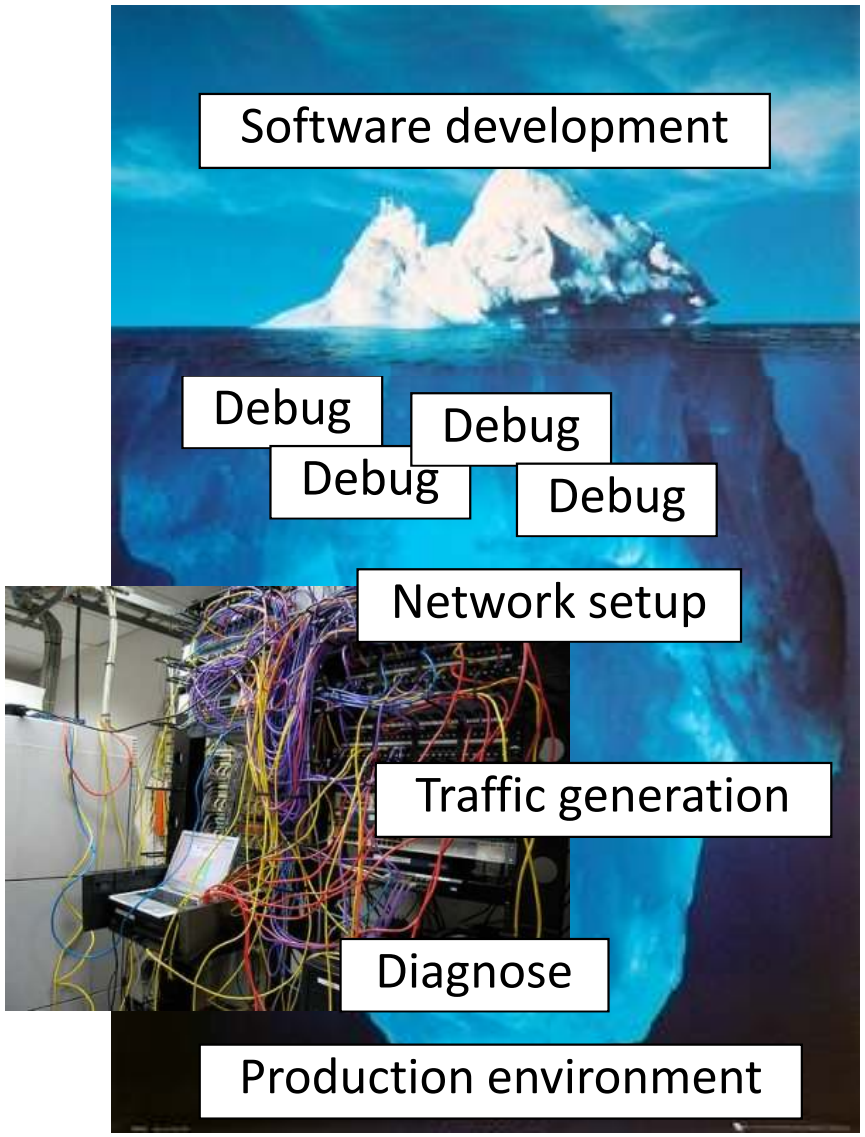
IMPORTANT goal of Trema project

- Researchers develop their own controllers on top of Trema and contribute to the community
  - Recycling controller modules accelerates our research activities
  - Independent repository @ https://github.com/trema/apps



Motivation

OpenFlow iceberg



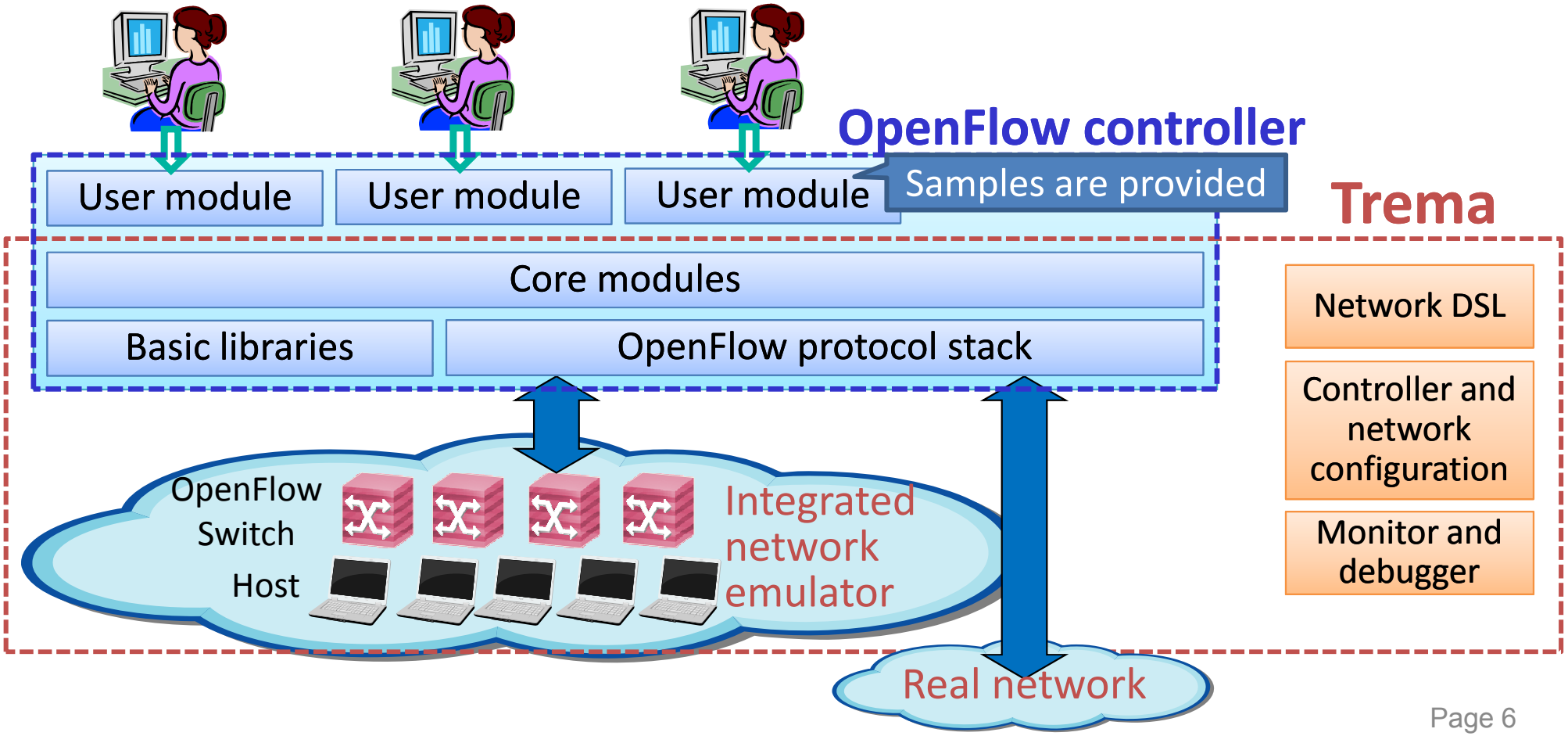
Scope of Trema

Trema is an OpenFlow platform for entire development process (like Ruby on Rails)

- ***Shorter development cycle***
- ***Reduce labor cost***
- ***More and more research outputs :-)***

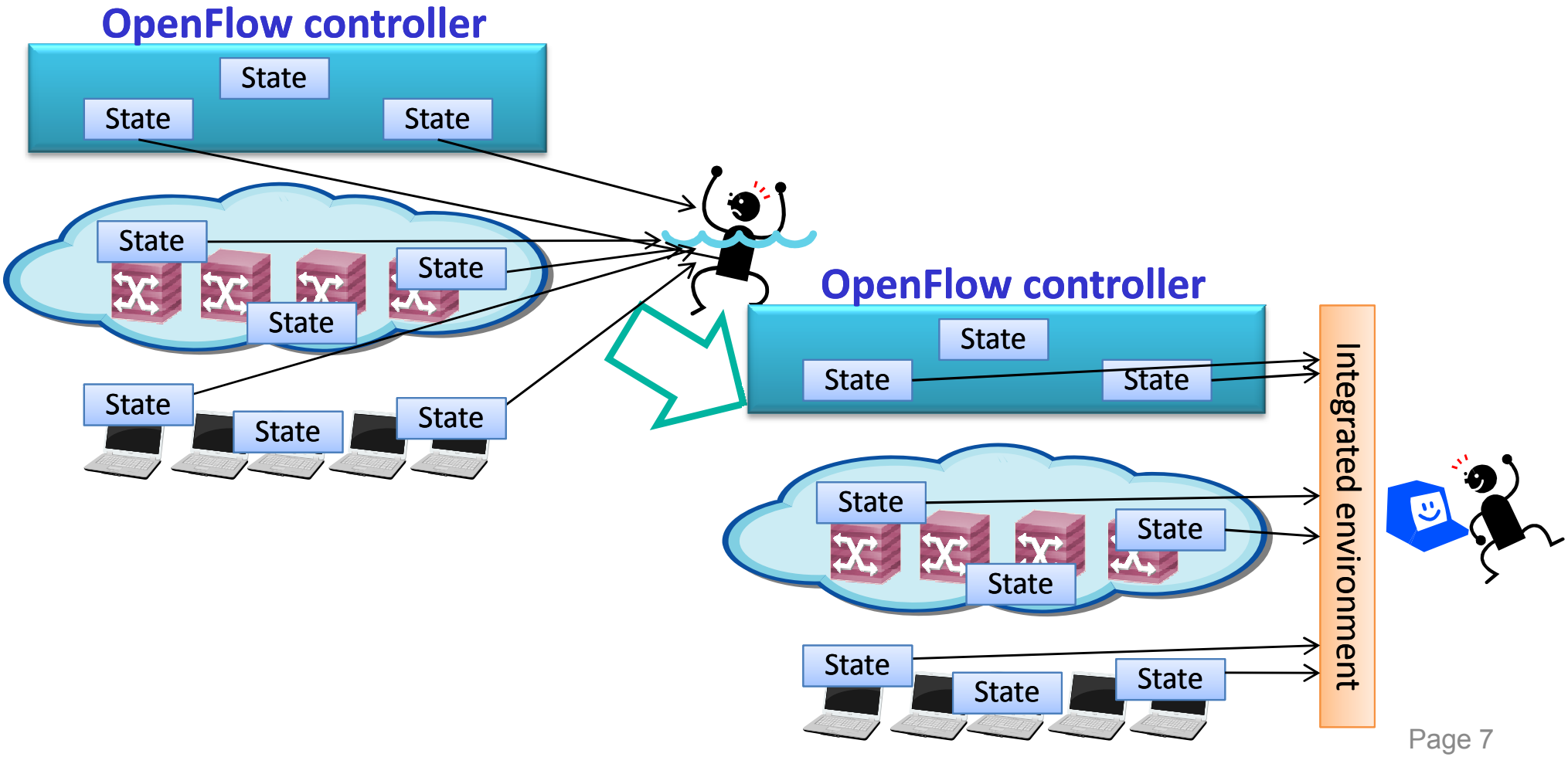
Scope of Trema

- OpenFlow controller = Trema + user modules
- Trema = OpenFlow controller platform + integrated testing and debugging environment



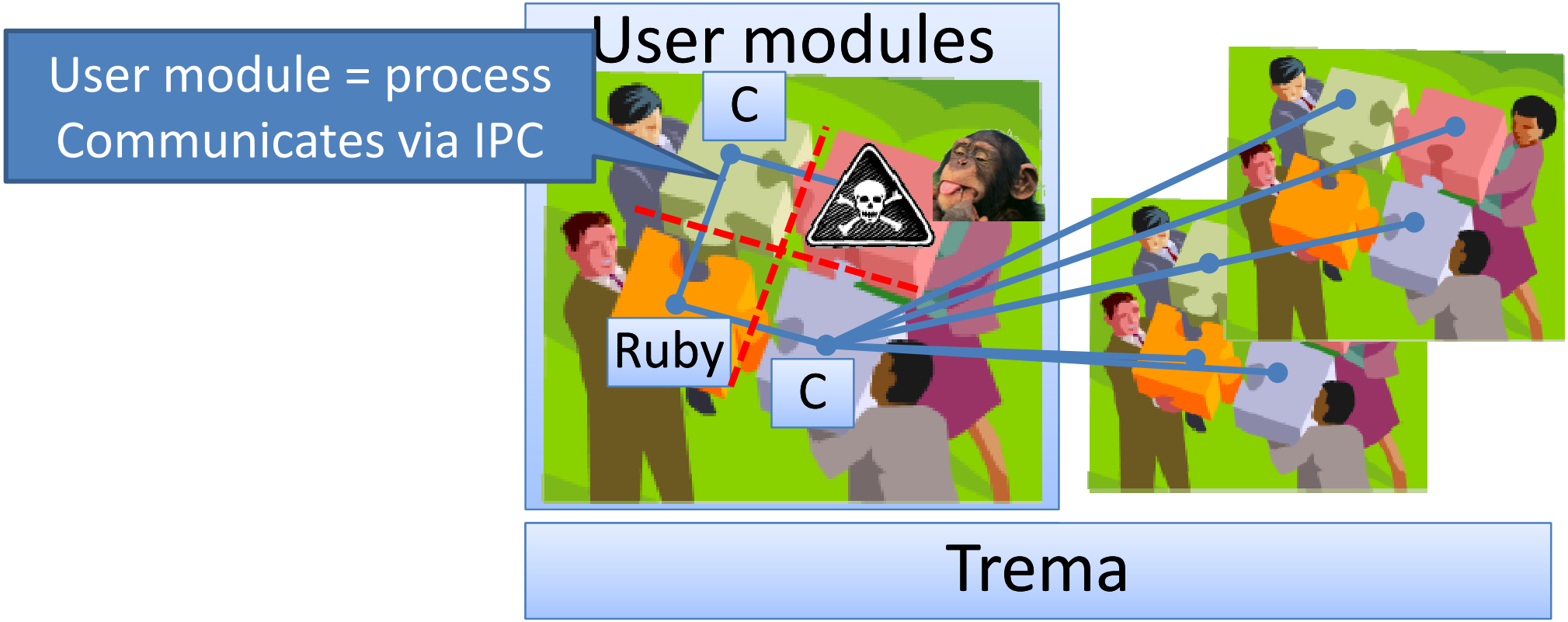
Integrated testing and debugging environment

- Network programming is essentially distributed programming
- Trema provides a system support to manage, monitor, and diagnosis entire system



Multi-process modular architecture

- Extensibility and stability
- User modules written in C or Ruby
- Can be extended to distributed controller



How to get started

1. Trema tutorial @http://trema.github.com/trema/
    1. Download and build – quite easy
    2. Try examples – quite easy

How to start your own project

Backup

1. Create your controller
    1. Develop your controller from scratch or modifying existing 3rd party user modules
    2. Combine 3rd party user modules with your controller
2. Create your network environment
    1. Configure emulated network
    2. And/or connect real OpenFlow switches
3. Test your system
    1. Operate OpenFlow controller and emulated network with Trema
4. Deploy to GENI infrastructure and enjoy !

Trema network DSL helps all these steps

How to learn to program

Backup

- Learn from tutorials
  - http://trema.github.com/trema
  - https://github.com/trema/trema/wiki
- Learn from examples
  - https://github.com/trema/trema/tree/develop/src/examples
  - Copy-and-paste the code for your own modules
- Learn from actual use cases (Trema Apps)
  - https://github.com/trema/apps
  - Many projects use and modify “Routing Switch”

Backup

Meta

- Web: http://trema.github.com/trema/
- ML: trema-dev@googlegroups.com
- Repository
  - Trema : https://github.com/trema/trema
  - User modules (Trema Apps): https://github.com/trema/apps
- Tutorial
  - http://trema.github.com/trema
  - https://github.com/trema/trema/wiki
- API document
  - Ruby: http://rubydoc.info/github/trema/trema/master/frames

Recent activities

C and Ruby support completed

- Complete set of APIs available for both C and Ruby programmers
  - OpenFlow 1.0.0, packet parser, logging, timer, messenger, etc.
  - Different modules can use different languages
    - Ruby's productivity and C's performance
  - C and Ruby examples
    - https://github.com/trema/trema/tree/develop/src/examples
  - Ruby API documents
    - http://rubydoc.info/github/trema/trema/master/frames

Ruby support – an example

- Writing repeater-hub emulation code with Ruby

```
class RepeaterHub < Trema::Controller
  def packet_in datapath_id, message
    send_flow_mod_add(
      datapath_id,
      :match => Match.from( message ),
      :actions => Trema::ActionOutput.new( OFPP_FLOOD )
    )
    send_packet_out(
      datapath_id,
      :buffer_id => message.buffer_id,
      :actions => Trema::ActionOutput.new( OFPP_FLOOD ),
      :data => message.buffered? ? nil : message.data
    )
  end
end
```

Create new controller class

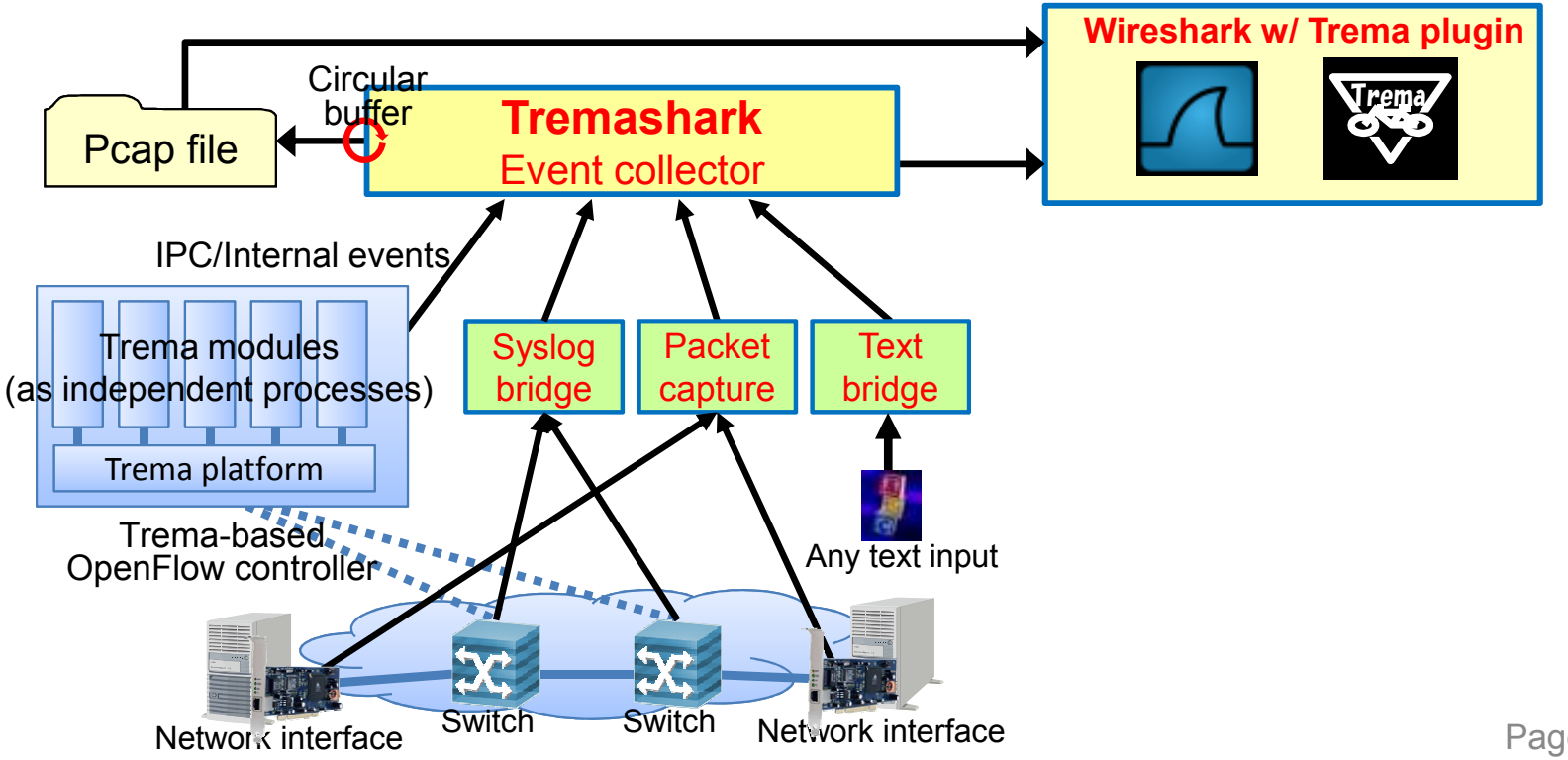
Define a handler for packet_in event

Send flow_mod

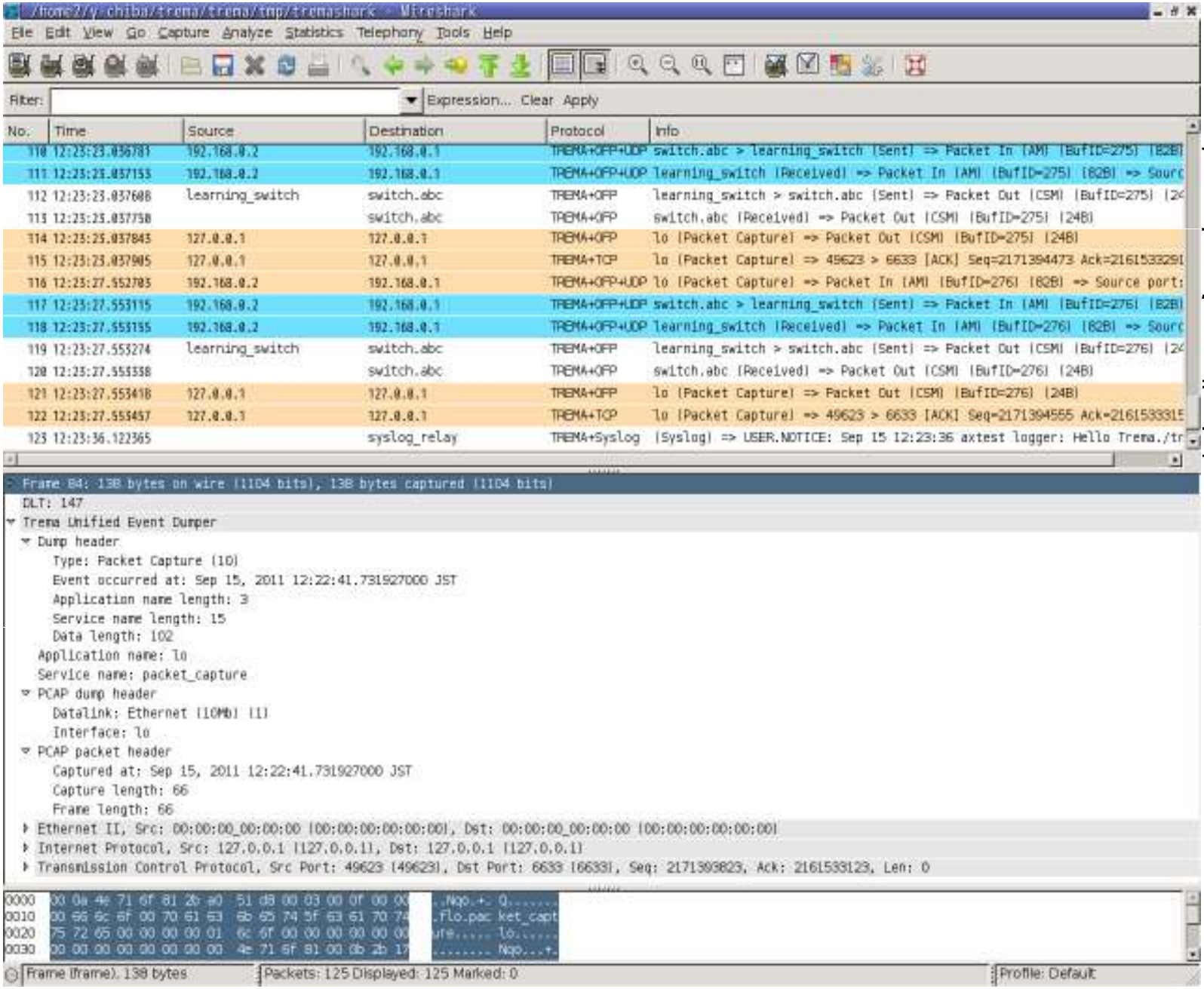
Send packet_out

Tremashark

- Collects/monitors various events in a single verifiable point
  - IPC/Internal events in Trema-based OpenFlow controller, log outputs, packet exchanges, etc
- Stores events in a circular buffer to monitor running system
- Powerful event filtering function leveraging Wireshark and its extensibility



Tremashark – screen shot



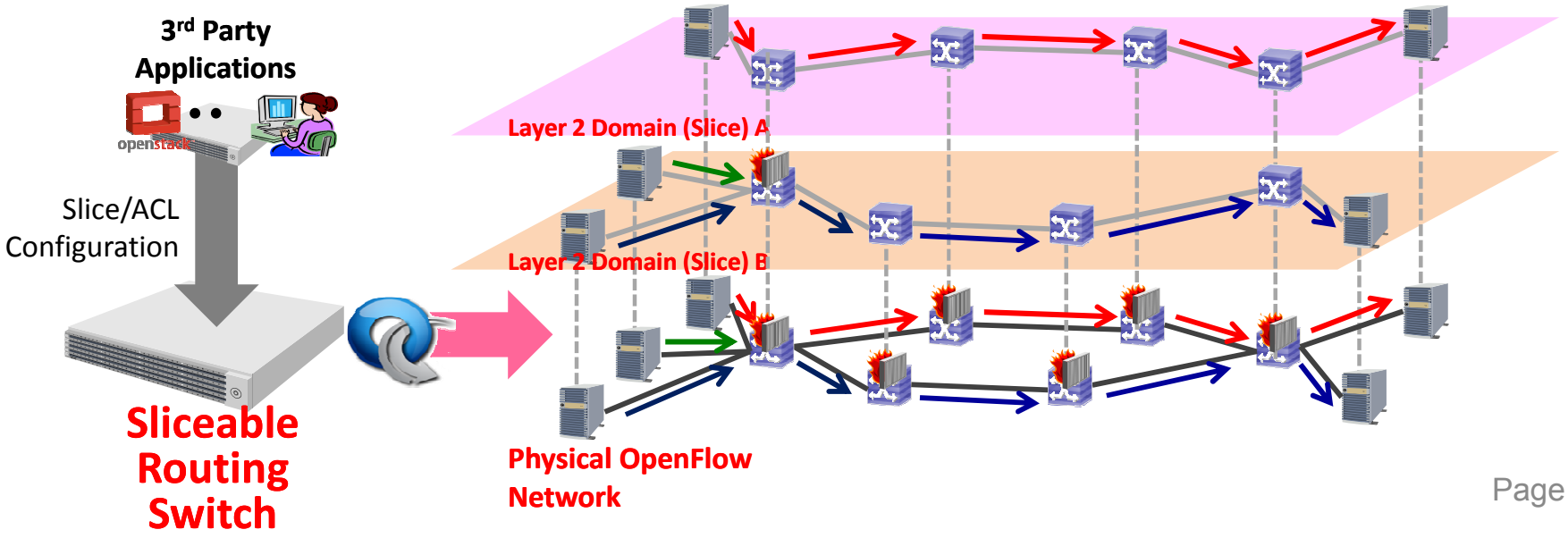
NEWS!

New Trema-based controller
“Sliceable Routing Switch”
is available now @Trema Apps

https://github.com/trema/apps/tree/master/sliceable_routing_switch

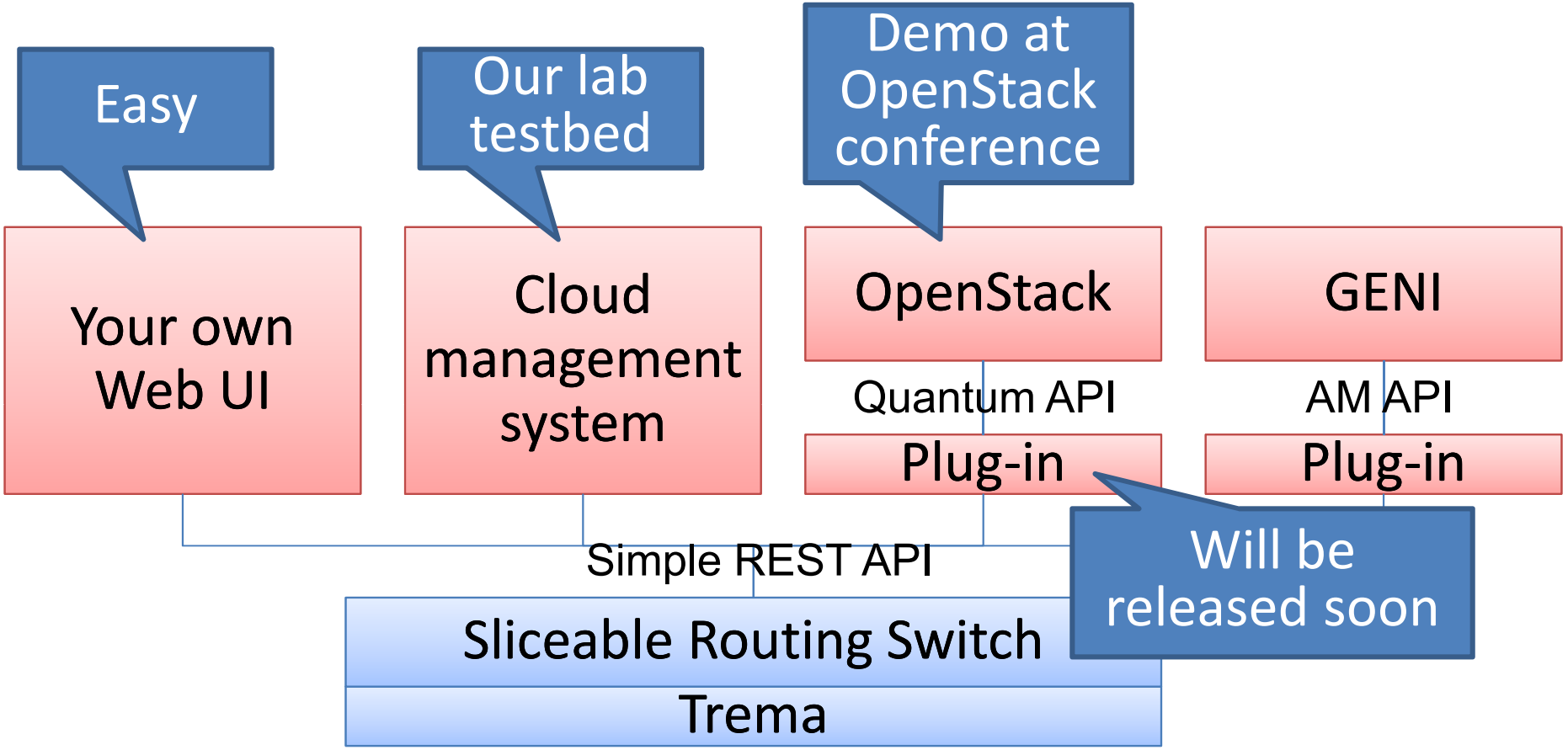
Sliceable Routing Switch

- Focused on most commonly used slicing (in cloud computing)
  - Virtual flat L2 network domains + L1-4 access control list
  - No VLAN ID dependency - no 4K limitation
- Very simple REST-API to manage the slices
  - Create slice with just only slice name
  - Attach host by port or MAC address
- Modify for your own projects
  - We use this for our own production network, but production quality/performance is NOT guaranteed



Sliceable Routing Switch – use case

- Virtual L2 network service on your local network
- Shared L2 network pool for backbone network
- Private cloud system (with OpenStack or whatever)



Sliceable Routing Switch - detail

Backup

- Creates flat layer 2 domains with multiple OpenFlow switches
  - Topology discovery using LLDP
  - Shortest path setup for L4 flows (work with loop topologies)
- Slicing function for creating multiple layer 2 domains
  - Port and MAC-based host-to-slice bindings
  - Several operation modes for broadcast handling
- Global access control list (ACL) function for filtering traffic within a slice
  - Layer 1 – 4 filters for each incoming L4 flows

Sliceable Routing Switch – REST APIs

Backup

Date: 2011/10/3, Revision: 0.05

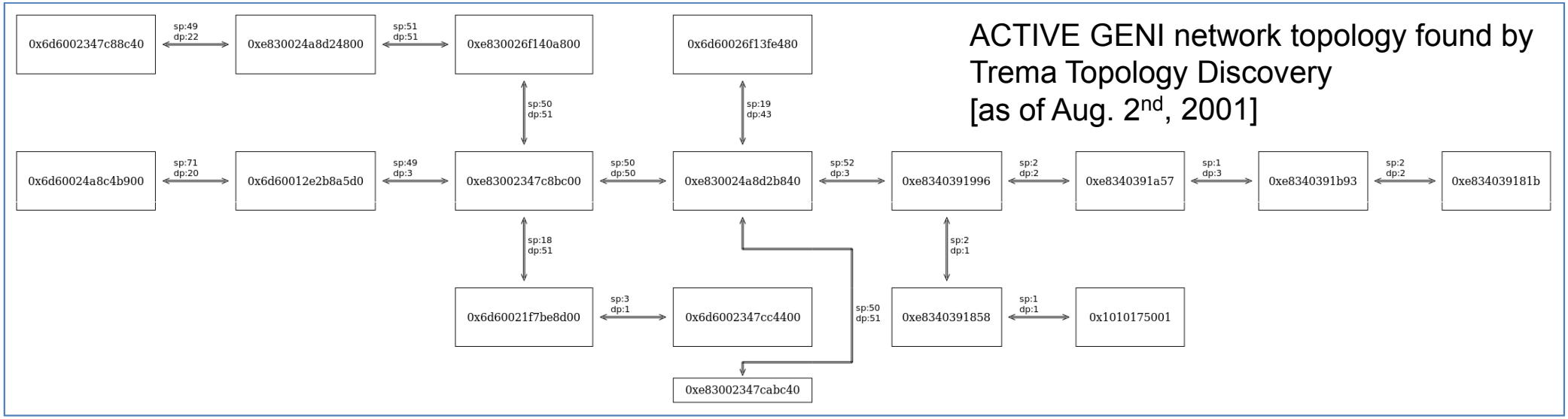
Path	Method	Behavior
/tenants/*<tenant_id>*/networks	GET	List summary of networks associated with a tenant.
	POST	Create a new network associated with a tenant.
/tenants/*<tenant_id>*/networks/*<net_id>*	GET	Show details of network identified by *net_id*.
	PUT	Update details of network identified by *net_id*.
	DELETE	Remove the network identified by *net_id*.
/tenants/*<tenant_id>*/networks/*<net_id>*/ports	GET	List all the ports currently defined.
	POST	Create a logical port on the network specified in the request URI.
/tenants/*<tenant_id>*/networks/*<net_id>*/ports/*<port_id>*	GET	Retrieve detail of the port *port_id* configured for the network *net_id*.
	DELETE	Remove a port from the network.
/tenants/*<tenant_id>*/networks/<net_id>/ports/*<port_id>*/attachments	GET	List complete information about the attachment currently plugged into the specified port.
	POST	Plug resources into a logical port on a virtual network.
/tenants/*<tenant_id>*/networks/*<net_id>*/ports/*<port_id>*/attachments/*<attachment_id>*	GET	Show information about the attachment specified by the request URI.
	DELETE	Remove the attachment specified by the request URI.
/tenants/*<tenant_id>*/networks/*<net_id>*/attachments	GET	Retrieve all the resources currently attached to a network.
	POST	Plug resources into a virtual network.
/tenants/*<tenant_id>*/networks/*<net_id>*/attachments/*<attachment_id>*	GET	Show information about the attachment specified by the request URI.
	DELETE	Remove the attachment specified by the request URI.

Other Trema use cases

- Wakame-vdc (cloud management software)
  - http://wakame.jp/
- Radware demonstration at Open Networking Summit
  - Anomaly traffic detection
- 10 controllers on Trema Apps
  - https://github.com/trema/apps
- 10+ experimental controllers in NEC
  - Operating at our production network more than 6 month
- NICT and several Japanese universities
- Other projects may be happening (if so, please let us know)

Other Trema use cases

- Tests at GENI
  - @ GPO lab OpenFlow testbed (TangoGENI)
  - Several Trema-based controllers tested
    - Learning Switch, Routing Switch, Topology Discovery and Topology Viewer, Flow Statistics Monitor



WANTED

- User module developers and experimenters
  - Experiments at GENI infrastructure
  - Share your modules with others
- Questions and comments to Trema mailing list
  - trema-dev@googlegroups.com
- Contributors to Trema (core) development

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