

Lab 2

OpenFlow Protocol Observation and Flow Rule Installation

Deadline 2024/09/25 (WED) 23:59

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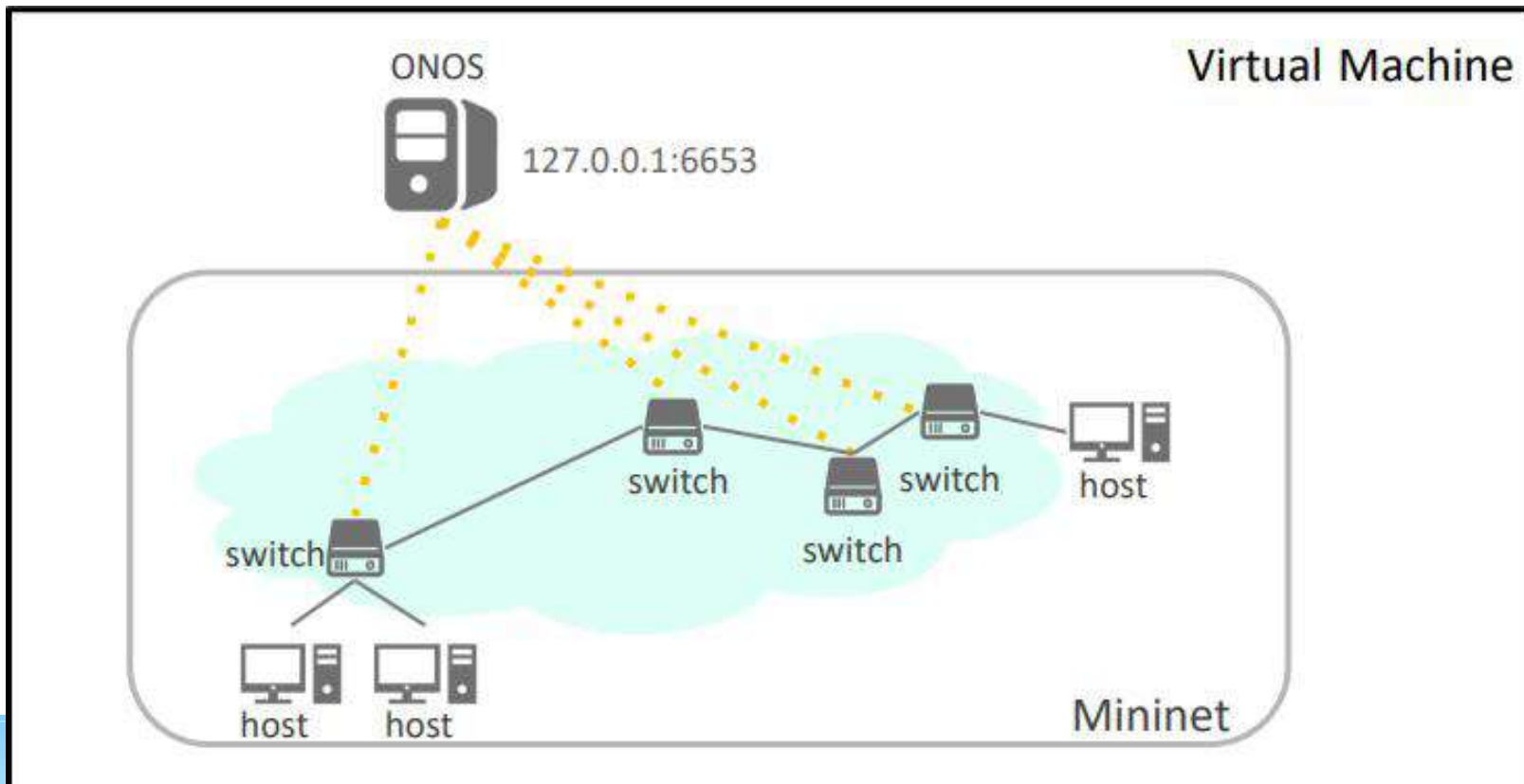
Outline

- OpenFlow Messages
 - Monitor Traffic between ONOS & Switches
 - OpenFlow Message Observation
- Install/Delete Flow Rules
 - Rest, JSON file, and Curl introduction
 - ONOS and Topology Setup
 - Method 1: via Command “curl”
 - Method 2: via ONOS Web GUI
- Lab 2 Requirements
 - Part 1: Answer Questions
 - Part 2: Install Flow Rules
 - Part 3: Create Broadcast Storm
 - Part 4: Trace ReactiveForwarding



OpenFlow Protocol

- OpenFlow is a Software Defined Network (SDN) control protocol
- ONOS SDN controller uses OpenFlow messages to communicate with OVS switches.
 - Hello, Packet-in/out, Flow Install/Remove, etc.





Wireshark Installation

- Wireshark is an open-source and widely-used network packet analyzer
 - Can capture packets on any specified interface

- Installation steps:

1. Update package information

```
$ sudo apt update          # update all packages information
```

2. Install Wireshark

```
$ sudo apt install wireshark -y
```

- Start Wireshark

```
$ sudo wireshark
```

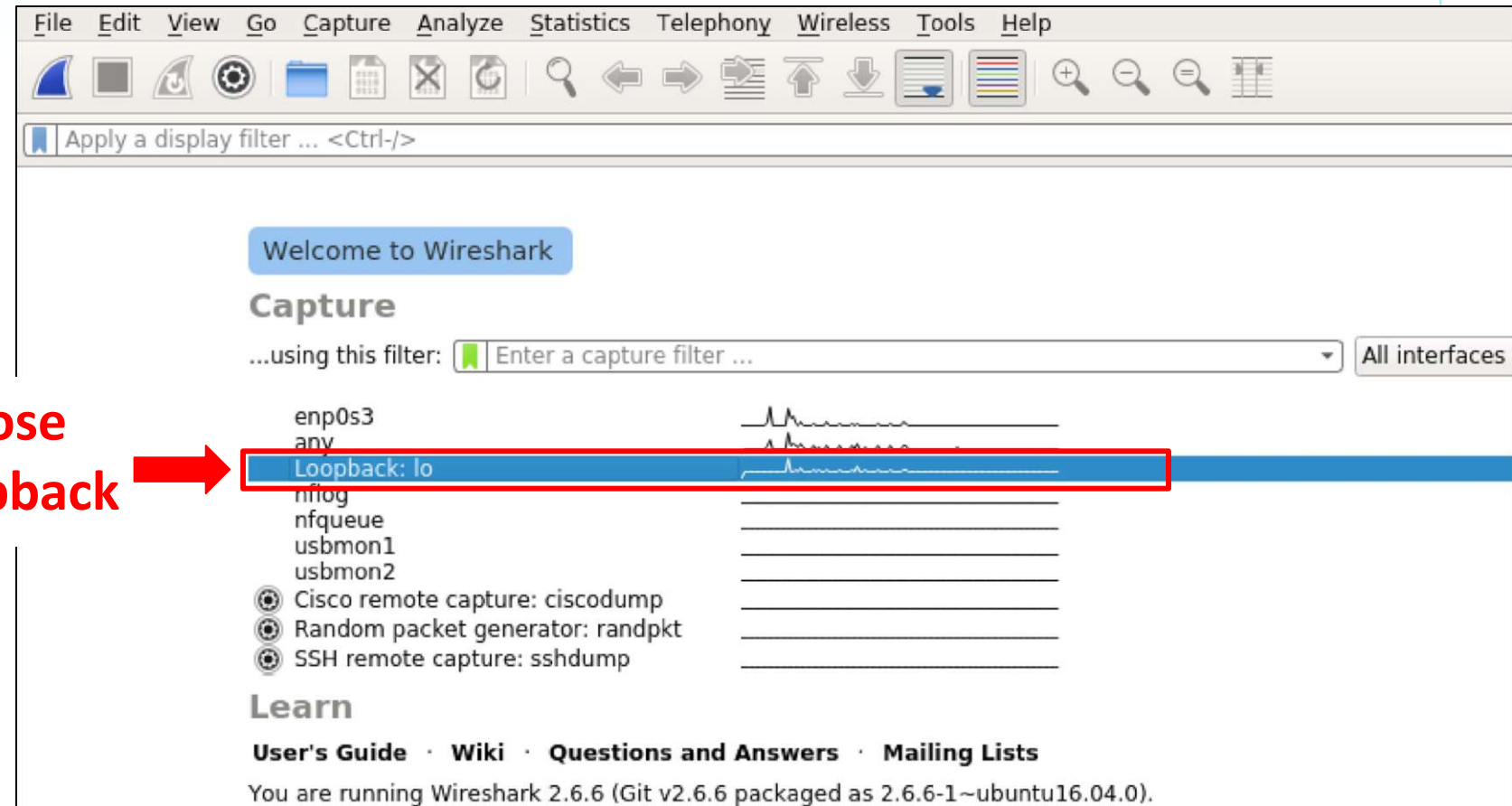




Capture Packets in Wireshark

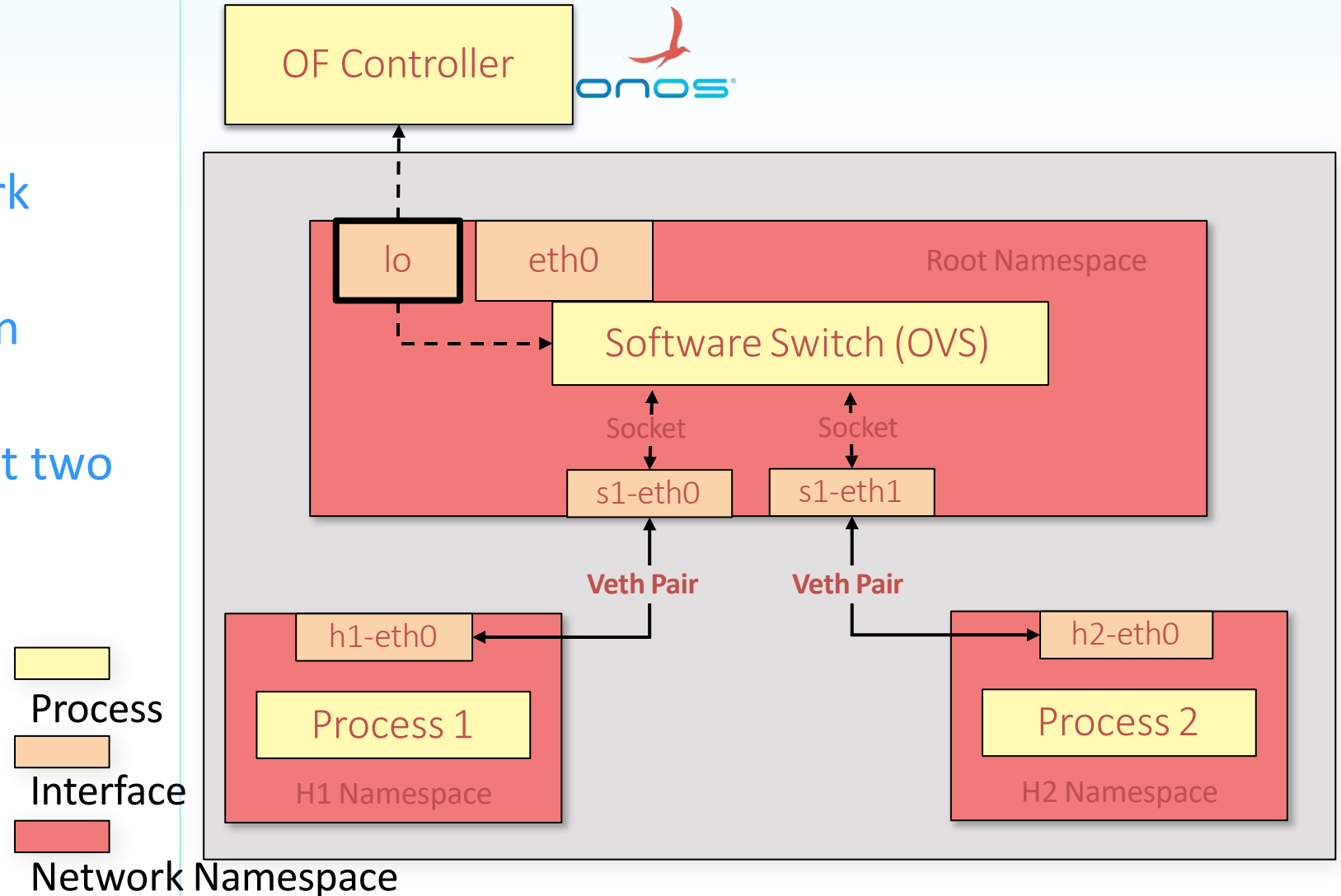
- Both ONOS and Mininet run locally in VM
 - We can capture packets on the Loopback (lo) interface
- Loopback:
Route data streams back to the source without intentional processing or modification.

**Choose
Loopback**



Mininet and Network Namespace

- Mininet uses network namespace to emulate networks
- OVS runs in root network namespace
- Each host runs in its own network namespace
- Use Veth pair to connect two networks of different namespaces





Sending OpenFlow Messages

1. Start ONOS

2. Activate ReactiveForwarding

```
onos> apps -a -s          # (optional) check activated application
onos> app activate fwd     # activate ReactiveForwarding
```

3. Start Mininet with default topology

```
$ sudo mn --controller=remote,127.0.0.1:6653 --switch=ovs,protocols=OpenFlow14
```


4. H1 ping H2 in Mininet

```
mininet> h1 ping h2 -c 5          # send five ICMP echo_request packets
```

5. Exit Mininet when ping terminates


6. Stop capturing packets in Wireshark

7. Observe captured OpenFlow packets

Stop 

*Loopback: lo			
File Edit View Go Capture Analyze Statistics Telephony Wire			
openflow_v5			
No.	Time	Source	Destination
7	2.292051175	127.0.0.1	127.0.0.1
9	3.339081631	127.0.0.1	127.0.0.1
11	3.339389581	127.0.0.1	127.0.0.1
13	3.565351844	127.0.0.1	127.0.0.1
14	3.565699740	127.0.0.1	127.0.0.1



- 
- The screenshot shows the Wireshark interface. The packet list pane on the left has a red box around the entry 'openflow_v5'. The packet details pane on the right shows the 'Ethernet II' section with 'Destination: 08:00:27:00:00:00' and 'Source: 08:00:27:00:00:00'. The packet bytes pane on the right shows the raw data of the packet.

-
- The screenshot shows the Wireshark interface with a packet list on the left, a packet details pane in the middle, and a context menu open over the packet details pane. The packet list shows a packet of type OFPT_PACKET_OUT. The packet details pane shows the structure of the OFPT_PACKET_OUT packet, including Transaction ID, Buffer ID, In port, and Actions. The context menu is open, showing options like Collapse Subtrees, Expand All, Collapse All, Apply as Column, Apply as Filter, Prepare a Filter, Conversation Filter, Colorize with Filter, and Follow. The 'Apply as Filter' option is highlighted, and a submenu is open showing options like Selected, Not Selected, ...and Selected, ...or Selected, and ...and not Selected.
- 335 9.900829544 127.0.0.1 OpenFlow 245 Type: OFPT_PACKET_OUT
337 9.901126392 127.0.0.1 OpenFlow 245 Type: OFPT_PACKET_OUT
340 9.901371527 127.0.0.1 OpenFlow 245 Type: OFPT_PACKET_OUT
344 9.902342278 127.0.0.1 OpenFlow 245 Type: OFPT_PACKET_OUT
- ▶ Frame 340: 245 bytes on wire (1960 bits), 245 bytes captured (1960 bits) on interface 0
▶ Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
▶ Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
▶ Transmission Control Protocol, Src Port: 6653, Dst Port: 43640, Seq: 4808, Ack: 19327, Len: 179
▼ OpenFlow 1.4
Version: 1.4 (0x05)
Type: OFPT_PACKET_OUT (13)
Length: 179
Transaction ID: 164
Buffer ID: OFF_NO_BUFFER (429496729)
In port: OFPP_CONTROLLER (429496729)
Actions length: 16
Pad: 00000000000000
▶ Action
▶ Data
- Expand Subtrees Shift+Right
Collapse Subtrees Shift+Left
Expand All Ctrl+Right
Collapse All Ctrl+Left
Apply as Column Ctrl+Shift+I
Apply as Filter ▶ Selected
Prepare a Filter ▶ Not Selected
Conversation Filter ▶ ...and Selected
Colorize with Filter ▶ ...or Selected
Follow ▶ ...and not Selected



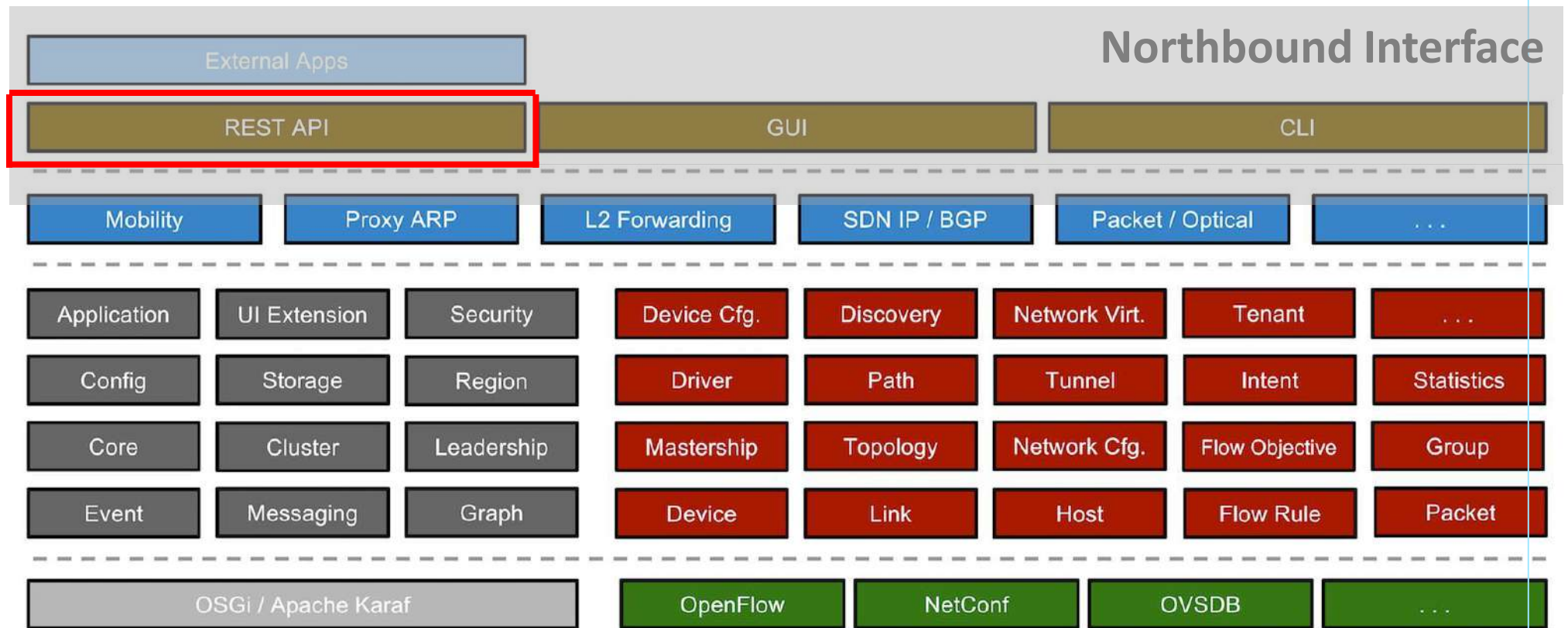
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ONOS Northbound Interface

- Northbound Interface of ONOS is the interface that interacts with programmers
- REST is a **software architectural style** for Web services
- We will use the REST API to install/delete flow rules





Create a JSON file of flow rules

flows1.json

- What is a JSON (JavaScript Object Notation)?
 - JSON
 - An open standard file format and data interchange format
 - Uses human-readable text to store and transmit data objects consisting of
 - attribute–value pairs
 - arrays
 - other serializable values
- E.g., flows1.json: JSON file for a flow rule
- Hint:
 - Priority of preinstalled flow rules: 40000
 - The priorities of flow rules **MUST** be 40001 to 65535
- Ref: Flow Rule Criteria & Instructions

```
{
  "priority": 50000,
  "timeout": 0,
  "isPermanent": true,
  "selector": {
    "criteria": [
      {
        "type": "IN_PORT",
        "port": 1
      }
    ]
  },
  "treatment": {
    "instructions": [
      {
        "type": "OUTPUT",
        "port": 2
      }
    ]
  }
}
```

JSON File: Match Fields (criteria)

flows1.json

```
{
  "priority": 50000,
  "timeout": 0,
  "isPermanent": true,
  "selector": {
    "criteria": [
      {
        "type": "IN_PORT",
        "port": 1
      }
    ]
  },
  "treatment": {
    "instructions": [
      {
        "type": "OUTPUT",
        "port": 2
      }
    ]
  }
}
```

- Match fields may have dependency; please refer to OpenFlow spec v1.4.0.

```
"selector": {
  "criteria": [
    {
      "type": "IN_PORT",
      "port": 1
    },
    { ... },
    ...
  ]
},
```

JSON File: Actions (instructions)

flows1.json

```
{
  "priority": 50000,
  "timeout": 0,
  "isPermanent": true,
  "selector": {
    "criteria": [
      {
        "type": "IN_PORT",
        "port": 1
      }
    ]
  },
  "treatment": {
    "instructions": [
      {
        "type": "OUTPUT",
        "port": 2
      }
    ]
  }
}
```

```
"treatment": {
  "instructions": [
    {
      "type": "OUTPUT",
      "port": 2
    },
    { ... },
    ...
  ]
}
```



Curl – Command Tool for Transferring Data with URL

- Command format

```
curl [options] [URL...]
```

- Transferring data with URL

```
$ curl -u <user:password> -X <method-type> -H <header> -d <data> [URL...]
```

option "-X" specifies a HTTP request method

option "-H" includes extra header in the HTTP request

option "-d" sends specified data in a POST request

URL (Uniform Resource Locator)

- "<data>" can be a file name with prefix "@"

```
$ curl -u <user:password> -X <method-type> -H <header> -d @<filename> [URL...]
```

- References:

- ["request methods" in HTTP](#)
- [Manpage for command "curl"](#)

Review:

- user: onos
- password: rocks



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ONOS & Topology Setup

1. Restart ONOS

1. <ctrl+c> in the ONOS log panel to shutdown the ONOS instance
2. Start ONOS

```
demo@SDN-NFV:~/onos$ ok clean  
# ok is an alias of command "bazel run onos-local -- "
```

2. Deactivate ReactiveForwarding APP

```
onos> app deactivate fwd # deactivate ReactiveForwarding
```

3. Start Mininet with default (minimal) topology

```
$ sudo mn --controller=remote,127.0.0.1:6653 --switch=ovs,protocols=OpenFlow14
```

4. Make sure that two hosts CAN NOT ping each other

```
mininet> h1 ping h2
```

```
mininet> h1 ping h2  
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.  
From 10.0.0.1 icmp_seq=1 Destination Host Unreachable  
From 10.0.0.1 icmp_seq=2 Destination Host Unreachable  
From 10.0.0.1 icmp_seq=3 Destination Host Unreachable  
From 10.0.0.1 icmp_seq=4 Destination Host Unreachable
```




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Upload JSON File to ONOS

- Install flow rules on ONOS with JSON file (flows1.json)

```
$ curl -u onos:rocks -X POST \  
> -H 'Content-Type: application/json' \  
> -d @flow1.json \  
> 'http://localhost:8181/onos/v1/flows/of:000000000000000001'
```

#Recall command from p.15
\$ curl -u <user:password>
-X <method-type>
-H <header>
-d @<filename>
[URL...]

Device ID

- DeviceID MUST be the URI shown in the ONOS web GUI
- DeviceID can be set by either ONOS or user specified topology file (i.e. *.py)





of:000000000000000001

URI : of:000000000000000001
Vendor : Nicira, Inc.
H/W Version : Open vSwitch



Check whether the flow rule is installed (1/2)

1. Go to ONOS web GUI (<http://localhost:8181/onos/ui>)
2. Left click on  . Then, the panel of switch info will pop out
3. Left click on  .

2. Left click



3. Left click



Flow rules in switch

STATE	PACKETS	DURATION	FLOW PRIORITY	TABLE NAME	SELECTOR	TREATMENT	APP NAME
Added	0	36	50000	0	IN_PORT:1	imm[OUTPUT:2], cleared:false	*rest
Added	0	960	40000	0	ETH_TYPE:bddp	imm[OUTPUT:CONTROLLER], cleared:true	*core
Added	0	960	40000	0	ETH_TYPE:lldp	imm[OUTPUT:CONTROLLER], cleared:true	*core
Added	12	960	40000	0	ETH_TYPE:arp	imm[OUTPUT:CONTROLLER], cleared:true	*core



Check whether the flow rule is installed (2/2)

SELECTOR

IN_PORT:1

TREATMENT

imm[OUTPUT:2], cleared:false

APP NAME

*rest

STATE	PACKETS	DURATION ▲	FLOW PRIORITY	TABLE NAME	SELECTOR	TREATMENT	APP NAME
Pending Add	0	0	50000	0	IN_PORT:1	imm[OUTPUT:2], cleared:false	*rest
Added	0	10,485	40000	0	ETH_TYPE:bddp	imm[OUTPUT:CONTROLLER], cleared:true	*core
Added	0	10,485	40000	0	ETH_TYPE:arp	imm[OUTPUT:CONTROLLER], cleared:true	*core
Added	0	10,485	40000	0	ETH_TYPE:lldp	imm[OUTPUT:CONTROLLER], cleared:true	*core

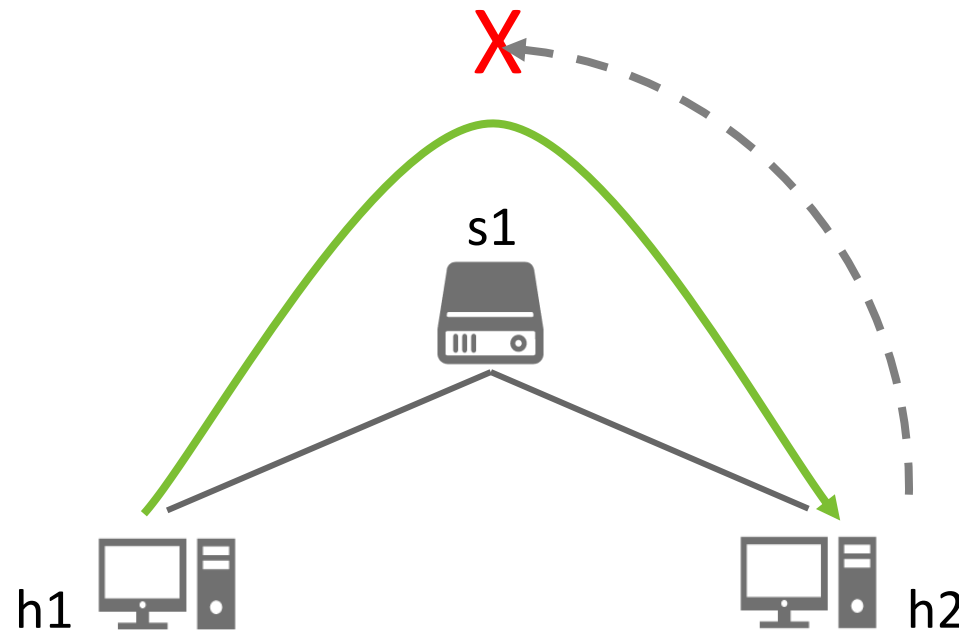
- Flow Rule States:

- **PENDING_ADD** - ONOS has received a request from the application to install the flow rule, but that flow has NOT yet been observed on the device.
- **ADDED** - Once the flow rule subsystem observes the flow on the device, it will change to this state.



Why Hosts Still Cannot Ping Each Other?

- Because we have only installed a flow rule for one direction
 - s1 can forward packets from h1 to h2
 - But, s1 CANNOT forward packets from h2 to h1
 - By default, s1 drops a packet if the packet does not match any flow rule
 - i.e. **table-miss**



Delete Flow Rules (1/2)

- Use URL to find flow rule IDs **in a switch**

Ex. <http://localhost:8181/onos/v1/flows/of:000000000000000001>

```
▼ flows:
  ▶ 0:      {}
  ▼ 1:
    groupId: 0
    state:    "ADDED"
    life:     515
    liveType: "UNKNOWN"
    lastSeen: 1695031088914
    packets:  9
    bytes:    378
    id:       "49539596291667367"
    appId:    "org.onosproject.rest"
    priority: 50000
    timeout:  0
    isPermanent: true
    deviceId: "of:000000000000000001"
    tableId:  0
    tableName: "0"
    ▶ treatment: {}
    ▶ selector:  {}
  ▶ 2:      {}
  ▶ 3:      {}
```

```
id: "49539596291667367"
appId: "org.onosproject.rest"
```

- ID of the flow we just added is 49539596291667367

- Alternatively, we could use “curl” to get flow information

```
$ curl -u onos:rocks -X GET -H 'Accept: application/json' \
'http://localhost:8181/onos/v1/flows/of:000000000000000001'
```



Delete Flow Rules (2/2)

- Then, delete the flow rule with flowID: 49539596291667367

```
$ curl -u onos:rocks \  
-X DELETE \  
-H 'Accept: application/json' \  
'http://localhost:8181/onos/v1/flows/of:000000000000000001\  
/49539596291667367'
```

Flow ID

Device ID



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REST API on ONOS Web GUI

- Browse <http://localhost:8181/onos/v1/docs>

ONOS Core REST API

ONOS Core REST API

docs : REST API documentation	Show/Hide	List Operations	Expand Operations
applications : Manage inventory of applications	Show/Hide	List Operations	Expand Operations
cluster : Manage cluster of ONOS instances	Show/Hide	List Operations	Expand Operations
configuration : Manage component configurations	Show/Hide	List Operations	Expand Operations
keys : Query and Manage Device Keys	Show/Hide	List Operations	Expand Operations
devices : Manage inventory of infrastructure devices	Show/Hide	List Operations	Expand Operations
diagnostics : Provides stream of diagnostic information	Show/Hide	List Operations	Expand Operations
nextobjectives : Get Flow objective next list	Show/Hide	List Operations	Expand Operations
flowobjectives : Manage flow objectives	Show/Hide	List Operations	Expand Operations
flows : Query and program flow rules	Show/Hide	List Operations	Expand Operations
groups : Query and program group rules	Show/Hide	List Operations	Expand Operations
hosts : Manage inventory of end-station hosts	Show/Hide	List Operations	Expand Operations



Using Web GUI to Install Flow Rule (1/2)

- Fill out required fields ("appld" could be arbitrary string)

Select

[POST] /flows/{deviceId}

- Corresponding curl command

```
$ curl -u onos:rocks \
-X POST \
-H 'Content-Type: application/json' \
-d @flows1.json \
'http://localhost:8181/onos/v1/flows/of:0000000000000001'
```

Type In

deviceId
appld
JSON file

flows : Query and program flow rules

Method	Path	Description
GET	/flows/table/{tableId}	Gets all flow entries for a table
DELETE	/flows/application/{appld}	Removes flow rules by application ID
GET	/flows/application/{appld}	Gets flow rules generated by an application
DELETE	/flows	Removes a batch of flow rules
GET	/flows	Gets all flow entries
POST	/flows	Creates new flow rules
DELETE	/flows/{deviceId}/{flowId}	Removes flow rule
GET	/flows/{deviceId}/{flowId}	Gets flow rules
GET	/flows/pending	Gets all pending flow entries
GET	/flows/{deviceId}	Gets flow entries of a device
POST	/flows/{deviceId}	Creates new flow rule

Implementation Notes

Creates and installs a new flow rule for the specified device.
Flow rule criteria and instruction description: <https://wiki.onosproject.org/display/ONOS/Flow+Rules>

Parameters

Parameter	Value	Description	Parameter Type	Data Type
deviceId	of:0000000000000001	device identifier	path	string
appId	app	application identifier	query	string
stream	<pre>{ "priority": 40000, "timeout": 0, "isPermanent": true, "deviceId": "of:0000000000000001", "treatment": { "instructions": [{ "type": "OUTPUT", </pre>	flow rule JSON	body	Model Example Value

Parameter content type: application/json



Using Web GUI to Install Flow Rule (2/2)

- Click “Try it out!”
 - Web will pass the JSON stream to ONOS
 - Status code 201 represents HTTP Request is granted

The screenshot shows the ONOS web GUI for installing a flow rule. The 'appId' is set to 'app'. The 'stream' field contains a JSON object: `{ "type": "IN_PORT", "port": "1" }`. The 'flow rule JSON' field contains a JSON object: `{ "priority": 40000, "timeout": 0, "isPermanent": true, "deviceId": "of:0000000000000001", "treatment": { "instructions": [{ "type": "OUTPUT", "port": "CONTROLLER" }] } }`. The 'Parameter content type' is set to 'application/json'. The 'Response Messages' table shows a status code of 200 and a reason of 'successful operation'. The 'Try it out!' button is highlighted with a red box. Below the button, the 'Curl' command is displayed: `curl -X POST --header 'Content-Type: application/json' --header 'Accept: application/json' -d '{ \`

Click “Try it out!”

HTTP response replied by ONOS

Response Body

no content

Response Code

201 status code

Response Headers

```
{
  "content-length": "0",
  "location": "http://127.0.0.1:8181/onos/v1/flows/of:0000000000",
  "server": "Jetty(9.4.18.v20190429)",
  "content-type": null
}
```

- In case of “curl”, use “-i” option to include HTTP Response header in the output



Delete Flow Rule via ONOS Web GUI (1/2)

Response Code

201

Response Headers

```
{
  "content-length": "0",
  "location": "http://localhost:8181/onos/v1/flows/of:000000000000000001/49821071268378023",
  "server": "Jetty(9.4.28.v20200408)",
  "content-type": null
}
```

flowId



Delete Flow Rule via ONOS Web GUI (2/2)

- Same procedure as installing flow rules

Select

[DELETE] /flows/{deviceId}/{flowId}



flows : Query and program flow rules Show/Hide List Operations Expand Operations

GET	/flows/table/{tableId}	Gets all flow entries for a table
DELETE	/flows/application/{appId}	Removes flow rules by application ID
GET	/flows/application/{appId}	Gets flow rules generated by an application
DELETE	/flows	Removes a batch of flow rules
GET	/flows	Gets all flow entries
POST	/flows	Creates new flow rules
DELETE	/flows/{deviceId}/{flowId}	Removes flow rule
GET	/flows/{deviceId}/{flowId}	Gets flow rules
GET	/flows/pending	Gets all pending flow entries
GET	/flows/{deviceId}	Gets flow entries of a device
POST	/flows/{deviceId}	Creates new flow rule

Implementation Notes
Creates and installs a new flow rule for the specified device.
Flow rule criteria and instruction description: <https://wiki.onosproject.org/display/ONOS/Flow+Rules>

Parameters

Parameter	Value	Description	Parameter Type	Data Type
deviceId	of:0000000000000001	device identifier	path	string
appId	app	application identifier	query	string
stream	<pre>{ "priority": 40000, "timeout": 0, "isPermanent": true, "deviceId": "of:0000000000000001", "treatment": { </pre>	flow rule JSON	body	Model Example Value

Parameter content type: application/json

```
{
  "priority": 40000,
  "timeout": 0,
  "isPermanent": true,
  "deviceId": "of:0000000000000001",
  "treatment": {
    "instructions": [
      {
        "type": "OUTPUT",

```



Outline

- OpenFlow Messages
- Install/ Delete Flow Rules
- Lab 2 Requirements
 - Part 1: Answer Questions (15%)
 - Part 2: Install Flow Rules (15%)
 - Part 3: Create Broadcast Storm (20%)
 - Part 4: Trace ReactiveForwarding (10%)
 - Project 2 Demo(40%)



Part 1: Answer Questions (1/2)

● Preparation:

please refer to the commands on p.8

1. Start capturing packets on the loopback interface (lo) with Wireshark.
2. Create a default topology.
3. Activate “org.onosproject.fwd”.
4. Execute command “h1 ping h2 -c 5” in Mininet CLI.
5. Observe the flow rules shown in the GUI.
6. Exit Mininet and stop capturing packets **when the forwarding rules disappear**.

● Questions:

1. How many **OpenFlow headers** with type “OFPT_FLOW_MOD” and command “OFPFC_ADD” are there among all the packets?
2. What are **the match fields** and the corresponding **actions** in each “OFPT_FLOW_MOD” message?
3. What are the **Idle Timeout values** for all flow rules on s1 in **GUI**?

Report format

Ex: There are x distinct “OFPT_FLOW_MOD” headers during the experiment.

Match fields	actions	Timeout values
IN_PORT=1	Output port=4	0
.....		



Part 1: Answer Questions (2/2)

● Hints

- A single OpenFlow packet may contain multiple OpenFlow message headers
- Only count the number of **distinct** OpenFlow **headers**
 - If match fields of two headers are the same, just count once
- Value of timeout can be zero
- There will be an `Unknown` type, please refer to ONOS's [Source Code](#) to find what it is

```
▼ OpenFlow 1.4
  Version: 1.4 (0x05)
  Type: OFPT_FLOW_MOD (14)
  Length: 96
  Transaction ID: 7
  Cookie: 0x00010000021b41dc
  Cookie mask: 0x0000000000000000
  Table ID: 0
  Command: OFPFC_ADD (0)
  Idle timeout: 0
  Hard timeout: 0
  Priority: 5
  Buffer ID: OFP_NO_BUFFER (4294967295)
  Out port: OFPP_ANY (4294967295)
  Out group: OFPG_ANY (4294967295)
  ▶ Flags: 0x0001
  Importance: 0
  ▼ Match
    Type: OFPMT_OXM (1)
    Length: 10
    ▼ OXM field
      Class: OFPXMC_OPENFLOW_BASIC (0x8000)
      0000 101. = Field: OFPXMT_OFB_ETH_TYPE (5)
      .... ..0 = Has mask: False
      Length: 2
      Value: IPv4 (0x0800)
      Pad: 000000000000
```

```
Type: OFPT_FLOW_MOD (14)
Length: 96
Transaction ID: 7
Cookie: 0x00010000021b41dc
Cookie mask: 0x0000000000000000
Table ID: 0
Command: OFPFC_ADD (0)
```

```
▼ Match
  Type: OFPMT_OXM (1)
  Length: 10
  ▼ OXM field
    Class: OFPXMC_OPENFLOW_BASIC (0x8000)
    0000 101. = Field: OFPXMT_OFB_ETH_TYPE (5)
    .... ..0 = Has mask: False
    Length: 2
    Value: IPv4 (0x0800)
    Pad: 000000000000
```

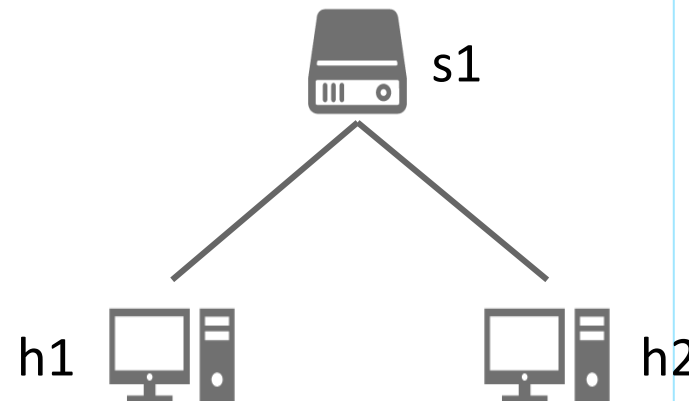



Part 2: Install Flow Rules (1/3)

- Please deactivate all the Apps, **except the following Apps** initially activated:

- “org.onosproject.hostprovider”
- “org.onosproject.lldpprovider”
- “org.onosproject.optical-model”
- “org.onosproject.openflow-base”
- “org.onosproject.openflow”
- “org.onosproject.drivers”
- “org.onosproject.gui2”

- Use the following topology (i.e. h1-s1-h2):



```
$ sudo mn --controller=remote,127.0.0.1:6653 --switch=ovs,protocols=OpenFlow14
```



Part 2: Install Flow Rules (2/3)

1. Install **one** flow rule to forward ARP packets
 - Match Fields
 - Ethernet type (ARP)
 - Actions
 - Forwarding ARP packets to all port **in one instruction**
- Take screenshot to verify the flow rule you installed

```
mininet> h1 arping h2                # send ARP request
```

```
mininet> h1 arping h2
ARPING 10.0.0.2
42 bytes from 5e:c0:96:3f:8e:ab (10.0.0.2): index=0 time=4.134 msec
42 bytes from 5e:c0:96:3f:8e:ab (10.0.0.2): index=1 time=6.226 usec
42 bytes from 5e:c0:96:3f:8e:ab (10.0.0.2): index=2 time=5.839 usec
42 bytes from 5e:c0:96:3f:8e:ab (10.0.0.2): index=3 time=3.860 usec
42 bytes from 5e:c0:96:3f:8e:ab (10.0.0.2): index=4 time=3.991 usec
42 bytes from 5e:c0:96:3f:8e:ab (10.0.0.2): index=5 time=7.219 usec
```



Part 2: Install Flow Rules (3/3)

2. Install **two** flow rules to forward IPv4 packets
 - Match Fields
 - IPv4 destination address and other required dependencies
 - Actions
 - Forwarding IPv4 packets to the right host
- Take screenshot to verify the flow rules you installed

```
mininet> h1 ping h2          # send ICMP request
```

```
mininet> h1 ping h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.339 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.056 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.057 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.064 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.055 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.054 ms
```

Hint: Match fields may have dependency; please refer to OpenFlow spec v1.4.0.



Part 3: Create Topology with Broadcast Storm

- Steps:

- Create a topology that may cause a “Broadcast Storm”.
- Install flow rules on switches.
- Send packets from one host to another host.
- Observe link status of the network and the CPUs utilization of VM

- **Do NOT** activate any other APPs, except for those initially activated by ONOS
- Describe what you have observed and explain why the broadcast storm occurred
- **Take screenshot** of CPU’s utilization
- Hand in Topology file (*.py) and flow rule files (*.json)

Hint: ONOS would initially install several flow rules.



Part 4: Trace ReactiveForwarding

- Activate only “org.onosproject.fwd” and other initially activated APPs.
- Use Mininet default topology and let h1 ping h2.
- Observe what happens in control and data planes
 - From the time when h1 pings h2 until h2 receives the first ICMP request
 - Write down every operation made by control and data planes
 - Please refer to the ONOS ReactiveForwarding application
 - [Source Code](#)
- Describe what you observed step by step in report
- **Don't** need to take screenshot

Hint: Tracing Source code with Wireshark to finish this Part



Submission (1/2)

- Files:
 - A report: **lab2_<studentID>.pdf**
 1. Part 1: Answers to those three questions in **p.31** format
 2. Part 2: Take screenshots of arping/ping result
 3. Part 3: Take screenshots and answer the question
 4. Part 4: Write down what you have observed step by step
 5. What you've learned or solved
 - JSON files for installing flow rules in part 2 and part 3
 - Please follow naming convention
 - A Python script for creating topology in part 3



Naming Convention

- Use the following convention to name the files created in both part 2 and part 3.
 1. Python script for the topology: `topo_<studentID>.py`
 2. JSON files for flow rules: `flows_s<i>-<j>_<studentID>.json`
 - “i” is the switch number
 - “j” is the flow rule number, starting from 1, on a switch.

e.g.

File Name	Meaning
<code>flows_s1-1_0748787.json</code>	#1 flow rule to install on s1
<code>flows_s1-2_0748787.json</code>	#2 flow rule to install on s1
<code>flows_s2-1_0748787.json</code>	#1 flow rule to install on s2



Submission (2/2)

- Directory structure:
 - Create root folder: **lab2_<studentID>**
 - In root folder, create part2 and part3 folders and move files (i.e. *.json, *.py) into the corresponding folders

e.g.

```
project2_0748787/  
├── part2  
│   ├── flows_s1-1_0748787.json  
│   ├── flows_s1-2_0748787.json  
│   └── flows_s1-3_0748787.json  
├── part3  
│   ├── flows_s1-1_0748787.json  
│   ├── flows_s1-2_0748787.json  
│   ├── flows_s2-1_0748787.json  
│   ├── flows_s3-1_0748787.json  
│   └── topo_0748787.py  
└── project2_0748787.pdf
```

- Zip root folder: **lab2_<studentID>.zip**
- Wrong file name or format will result in 10 points deduction



Lab 2 Demo

- The demo dates will be in the week after lab 2 deadline.
- Demo question will show when demo start.
- The questions involve modification of the code and the content related to the lecture and the lab



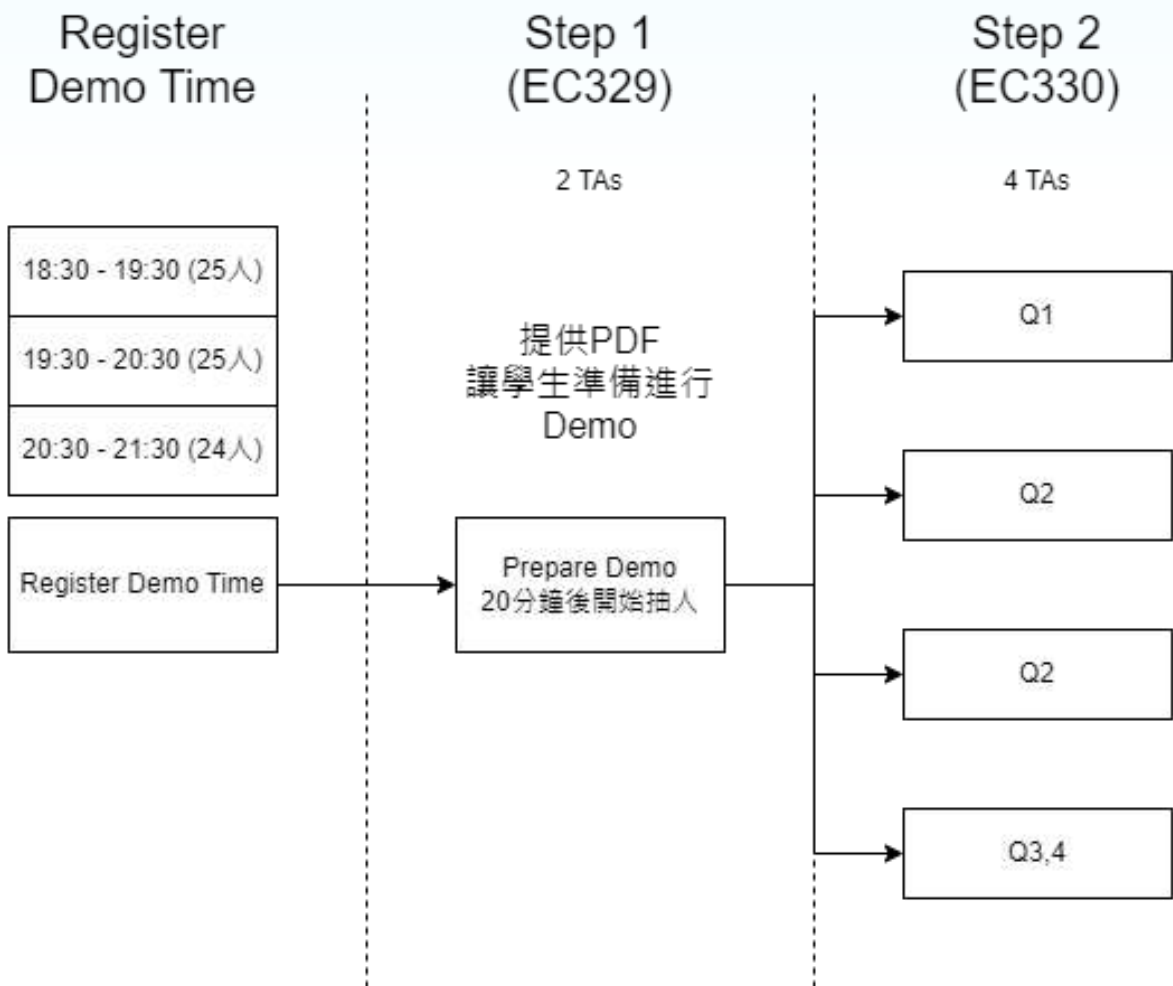
Lab Assign, Due, and Demo Time

		Assign Time	Due Time	Demo Time
Lab 1	ONOS and Mininet Installation	09/05	09/25 (WED) 23:59	-
Lab 2	OpenFlow Protocol Observation & Flow Rule installation	09/12	09/25 (WED) 23:59	09/30 (MON) 18:30 – 21:30
Lab 3	ONOS Application Development: SDN-enabled Learning Bridge and ARP Proxy	09/26	10/16 (WED) 23:59	10/21 (MON) 18:30 – 21:30
Lab 4	Meter Table and Bandwidth Control	10/17	11/06 (WED) 23:59	11/11 (MON) 18:30 – 21:30
Lab 5	Network Function Virtualization: Software Router and Containerization	11/07	11/27 (WED) 23:59	12/02 (MON) 18:30 – 21:30
Final Project	SDN network as vRouter (Group project)	11/28	待定	待定



Lab 2 Demo Flow Chart

● Lab 2 Demo Flow Chart





Lab 2 Demo Time-reserved Table

- Lab 2 Demo Time-reserved Table
 - URL : <https://anurl.app/xhDBIb>
 - Date of completion: now ~ 9/25 (WED) 23:59

Lab 2 Demo 時段登記									
日期: 2024/09/30	學號	姓名	學號	姓名	學號	姓名	學號	姓名	學號
時段 1 18:30 - 19:30									
時段 2 19:30 - 20:30									
時段 3 20:30 - 21:30									

Ex: 313551001 Ex: 王小明



[Lab 2 Demo Time-reserved Table](https://anurl.app/xhDBIb)



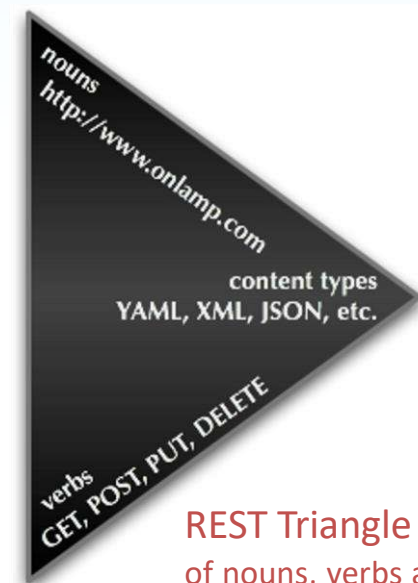
References

- OpenFlow spec v1.4.0
 - <https://opennetworking.org/wp-content/uploads/2014/10/openflow-spec-v1.4.0.pdf>
- Wireshark wiki
 - <https://wiki.wireshark.org/Home>
- ONOS REST API
 - <https://wiki.onosproject.org/display/ONOS/Appendix+B%3A+REST+API>
- JSON Format for Installing Flow Rules
 - <https://wiki.onosproject.org/display/ONOS/Flow+Rules>



Appendix—REST (REpresentational State Transfer)

- REST is a **software architectural style** for creating Web services
- Architectural constraints:
 - Client-server architecture
 - Stateless
 - Cacheable
 - Uniform interface
 - Layered system
- Allow us to access and manipulate web resources
 - Commonly we use HTTP method
 - Payload could be formatted in HTML, XML, JSON



REST Triangle
of nouns, verbs and content types

Source: Soul & Shell Blog



About help!

- **For lab problem, ask at e3 forum**
 - Ask at the e3 forum
 - TAs will help to clarify Lab contents instead of giving answers!
 - Please describe your questions with sufficient context,
 - , e.g., Environment setup, Input/Output, Screenshots, ...
- **For personal problem mail to sdnta@win.cs.nycu.edu.tw**
 - You have special problem and you can't meet the deadline
 - You got weird score with project
- **No Fixed TA hours**



Q & A