Project 1
ONOS and Mininet Installation

Environment Setup & Basic Operation

Deadline 2022/10/5 (WED) 23:59

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Outline

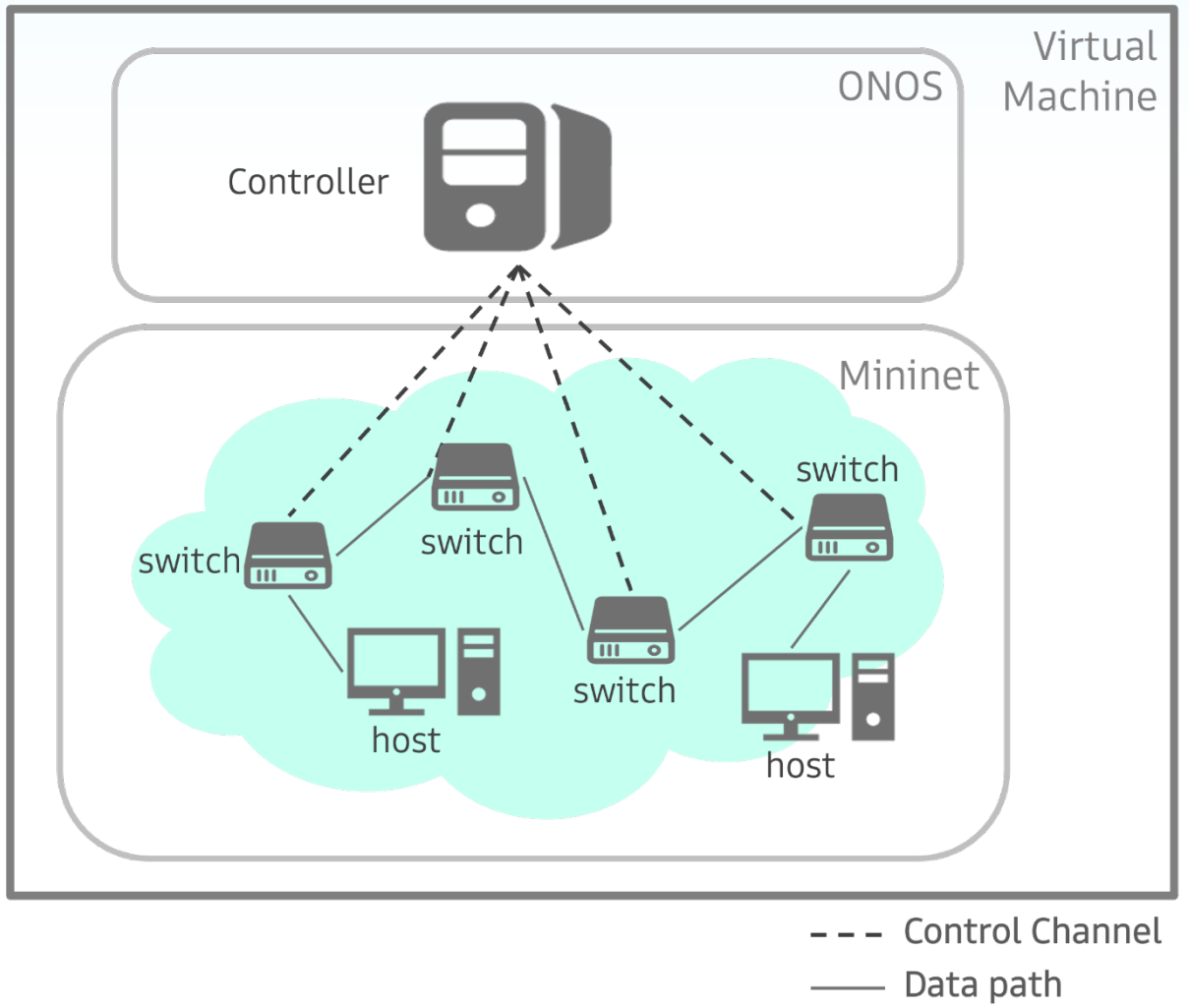
- Environment Introduce & Setup
  - Overview introduction
  - VirtualBox, Bazel, ONOS, Mininet and OVS Installation
- Building virtual network
  - Build ONOS
  - Activate control plane function
  - Create a topology controlled with Mininet
- Project Requirements
  - Part 1: Answer Questions
  - Part 2: Write a Custom Topology
  - Part 3: Statically Assign Hosts IP Address In Mininet

Overview

If we want to emulate a network we will need

- controller for control
- Mini-topology with switches
- Switches with propriate protocols

- Controller connect with switch through control channel
- Package go through data path from host to host



Virtual box, Bazel, ONOS, Mininet and OVS Installation

- Bazel: Free software tool for “automation of building and testing of SW.”
- Open Network Operating System (ONOS): Open source network controller for SDN.
- Mininet: a software emulator for prototyping a large network on a single machine.
- Open vSwitch (OVS):
  - an open-source implementation of a distributed virtual multilayer switch.
  - Provides a switching stack for hardware virtualization environments while supporting multiple protocols and standards used in computer networks
- Installation:
  - Follow SDN_Environment_Setup.pdf
  - Use TA-provided env_setup.sh

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- Building Virtual network
  - Build ONOS
    - ONOS CLI
    - ONOS GUI
  - Activate Control plane function
    - Method1 : Via ONOS CLI
    - Method2 : Via ONOS GUI
  - Create a topology controlled with Mininet
    - Method 1: Built-in Topology
    - Method 2: Custom Topology
- Project Requirements

Build ONOS

Start ONOS in localhost

```
demo@SDN-NFV:~$ cd $ONOS_ROOT
demo@SDN-NFV:~/onos$ bazel run onos-local -- clean debug
            # option 'clean' to delete all previous running status
                # option 'debug' to enable remote debugging (port 5005)
```

```
demo@SDN-NFV:~/onos$ bazel run onos-local -- clean debug
INFO: Analyzed target //:onos-local (0 packages loaded, 0 targets configured).
INFO: Found 1 target...
Target //:onos-local_current-jdk up-to-date:
  bazel-bin/onos-runner_current-jdk
INFO: Elapsed time: 0.486s, Critical Path: 0.00s
INFO: 0 processes.
INFO: Build completed successfully, 1 total action
INFO: Build completed successfully, 1 total action
Killing ONOS server...
Using JDK in /tmp/onos-2.2.0-jdk...
```

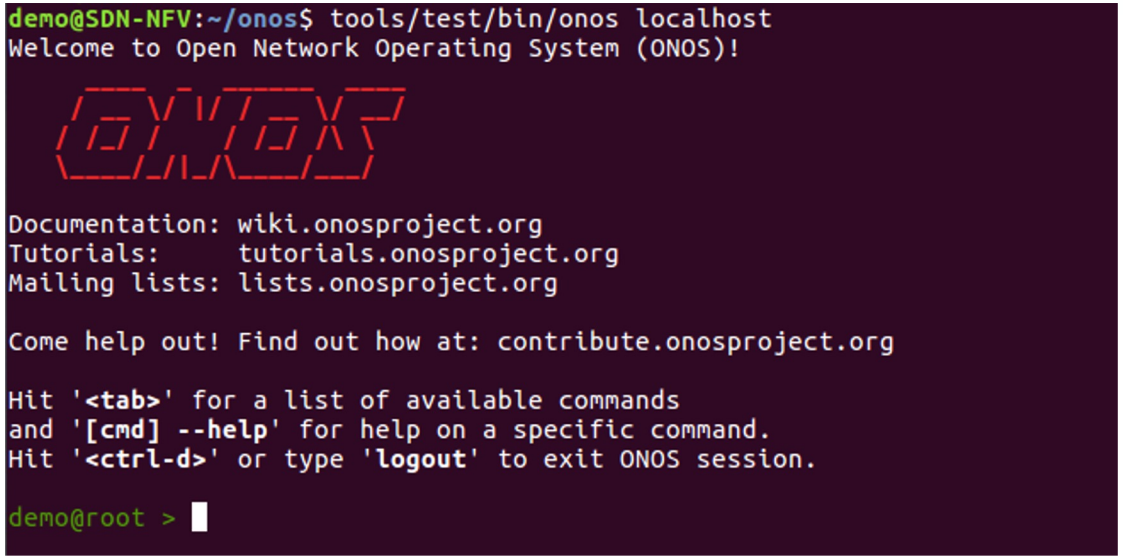
```
 ConfigurationEvent: pid=org.onosproject.net.intent.impl.IntentCleanup) | OpenFlowRuleProvider            | 203 - org.onosproject.onos-provid

 ConfigurationEvent: pid=org.onosproject.net.intent.impl.IntentCleanup) | OpenFlowRuleProvider            | 203 - org.onosproject.onos-provid
se
tomixClusterStore               | 192 - org.onosproject.onos-core-primitives - 2.2.0 | Updated node 127.0.0.1 state to READY
```

ONOS CLI

- Bring up another new terminal and enter ONOS CLI

```
demo@SDN-NFV:~/onos$ onos localhost
```



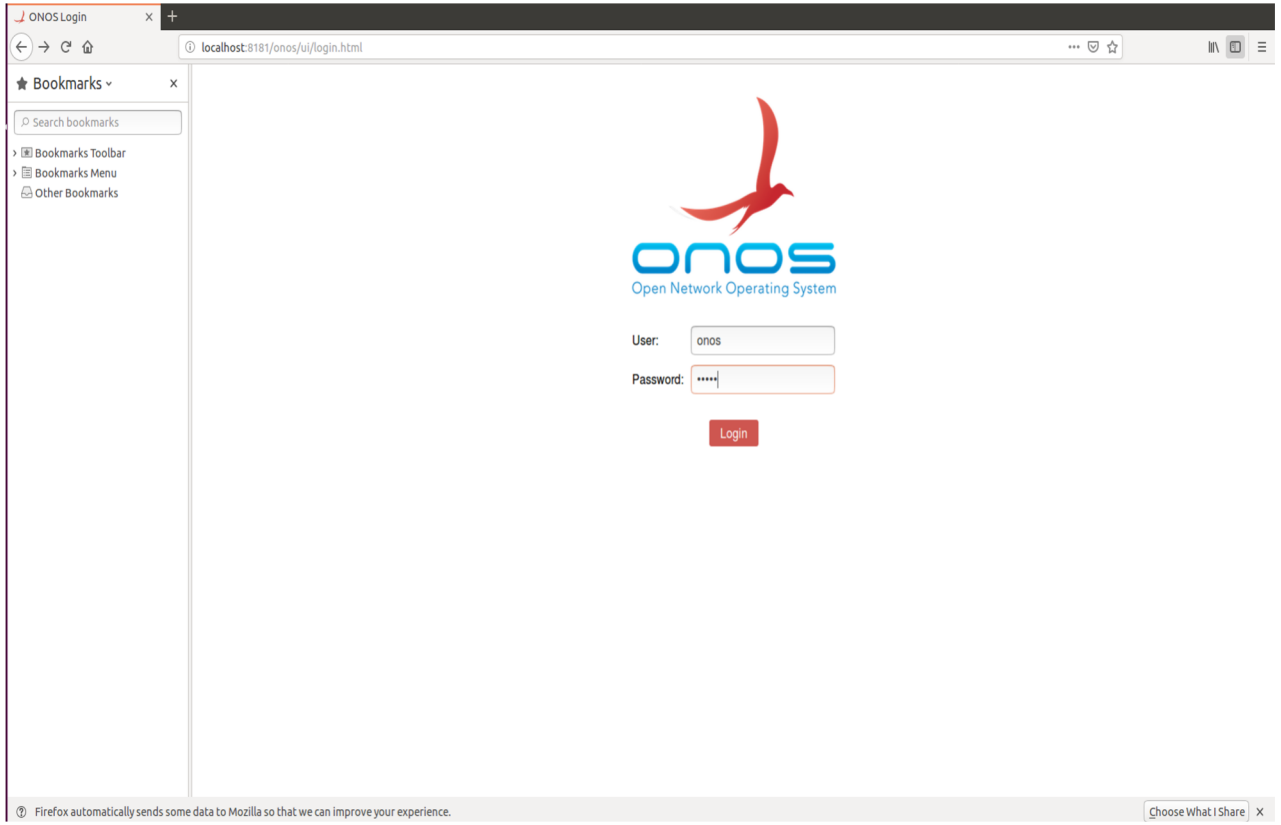
- Reference: ONOS CLI command

ONOS Web GUI

- Open web browser (e.g. Firefox)
  visit http://localhost:8181/onos/ui

User/Password: onos/rocks

- Reference: ONOS GUI tutorial



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    - ONOS CLI
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Cli show APPs

- You can check all applications that is installed on the ONOS

```
onos> apps  -s
      # Show all apps in short
```

```
demo@root > apps -s                                                    23:14:08
    3 org.onosproject.portloadbalancer     2.7.0    Port Load Balance Service
    4 org.onosproject.mcast                2.7.0    Multicast traffic control
    5 org.onosproject.tunnel               2.7.0    Tunnel Subsystem
*   6 org.onosproject.optical-model        2.7.0    Optical Network Model
*   7 org.onosproject.openflow-base        2.7.0    OpenFlow Base Provider
*   8 org.onosproject.lldpprovider         2.7.0    LLDP Link Provider
*   9 org.onosproject.hostprovider         2.7.0    Host Location Provider
   10 org.onosproject.route-service        2.7.0    Route Service Server
   11 org.onosproject.simplefabric         2.7.0    SONA SimpleFabric
   12 org.onosproject.ovsdb-base           2.7.0    OVSDB Provider
   13 org.onosproject.drivers.ovsdb        2.7.0    Generic OVSDB Drivers
   14 org.onosproject.k8s-node             2.7.0    Kubernetes Node Application
   15 org.onosproject.k8s-networking       2.7.0    Kubernetes Networking Applic
ation
   16 org.onosproject.linkdiscovery        2.7.0    Link Discovery Provider
   17 org.onosproject.faultmanagement      2.7.0    Fault Management
   18 org.onosproject.netconf              2.7.0    NETCONF Provider
   19 org.onosproject.drivers.netconf      2.7.0    Generic NETCONF Drivers
   20 org.onosproject.drivers.ciena.c5162  2.7.0    Ciena 5162 Drivers
   21 org.onosproject.gui                  2.7.0    ONOS Legacy GUI
   22 org.onosproject.messaging-perf       2.7.0    Messaging Performance Test
   23 org.onosproject.events               2.7.0    Event History
   24 org.onosproject.influxdbmetrics      2.7.0    InfluxDB Report and Query
   25 org.onosproject.protocols.grpc       2.7.0    gRPC Protocol Subsystem
   26 org.onosproject.protocols.gnmi       2.7.0    gNMI Protocol Subsystem
   27 org.onosproject.generaldeviceprovider 2.7.0    General Device Provider
   28 org.onosproject.protocols.gnoi       2.7.0    gNOI Protocol Subsystem
   29 org.onosproject.drivers.gnoi         2.7.0    gNOI Drivers
   30 org.onosproject.yang                 2.7.0    YANG Compiler and Runtime
*  31 org.onosproject.drivers              2.7.0    Default Drivers
   32 org.onosproject.drivers.optical      2.7.0    Basic Optical Drivers
   33 org.onosproject.models.common        2.7.0    Common YANG Models
   34 org.onosproject.models.ciena.waveserverai 2.7.0    Ciena Waveserver Ai YAN
G Models
   35 org.onosproject.drivers.ciena.waveserverai 2.7.0    Ciena Waveserver Ai Dr
ivers
   36 org.onosproject.network-troubleshoot 2.7.0    Network Troubleshooter
   37 org.onosproject.dhcp                 2.7.0    DHCP Server
*  38 org.onosproject.openflow             2.7.0    OpenFlow Provider Suite
   39 org.onosproject.ovsdbhostprovider    2.7.0    OVSDB host Provider
   40 org.onosproject.ovsdb                2.7.0    OVSDB Southbound Meta
   41 org.onosproject.workflow             2.7.0    Workflow
   42 org.onosproject.workflow.ofoverlay   2.7.0    Openflow overlay
   43 org.onosproject.openstacknode        2.7.0    OpenStack Node Bootstrap
   44 org.onosproject.openstacknetworking  2.7.0    OpenStack Networking Applica
tion
```

Activate basic ONOS APPS via CLI

```
onos> apps -a -s                    # Show activated apps only
```

```
demo@root > apps -a -s                                              02:39:00
*   6 org.onosproject.optical-model         2.7.0    Optical Network Model
*   7 org.onosproject.openflow-base         2.7.0    OpenFlow Base Provider
*   8 org.onosproject.lldpprovider          2.7.0    LLDP Link Provider
*   9 org.onosproject.hostprovider          2.7.0    Host Location Provider
*  31 org.onosproject.drivers               2.7.0    Default Drivers
*  38 org.onosproject.openflow              2.7.0    OpenFlow Provider Suite
* 168 org.onosproject.gui2                  2.7.0    ONOS GUI2
```

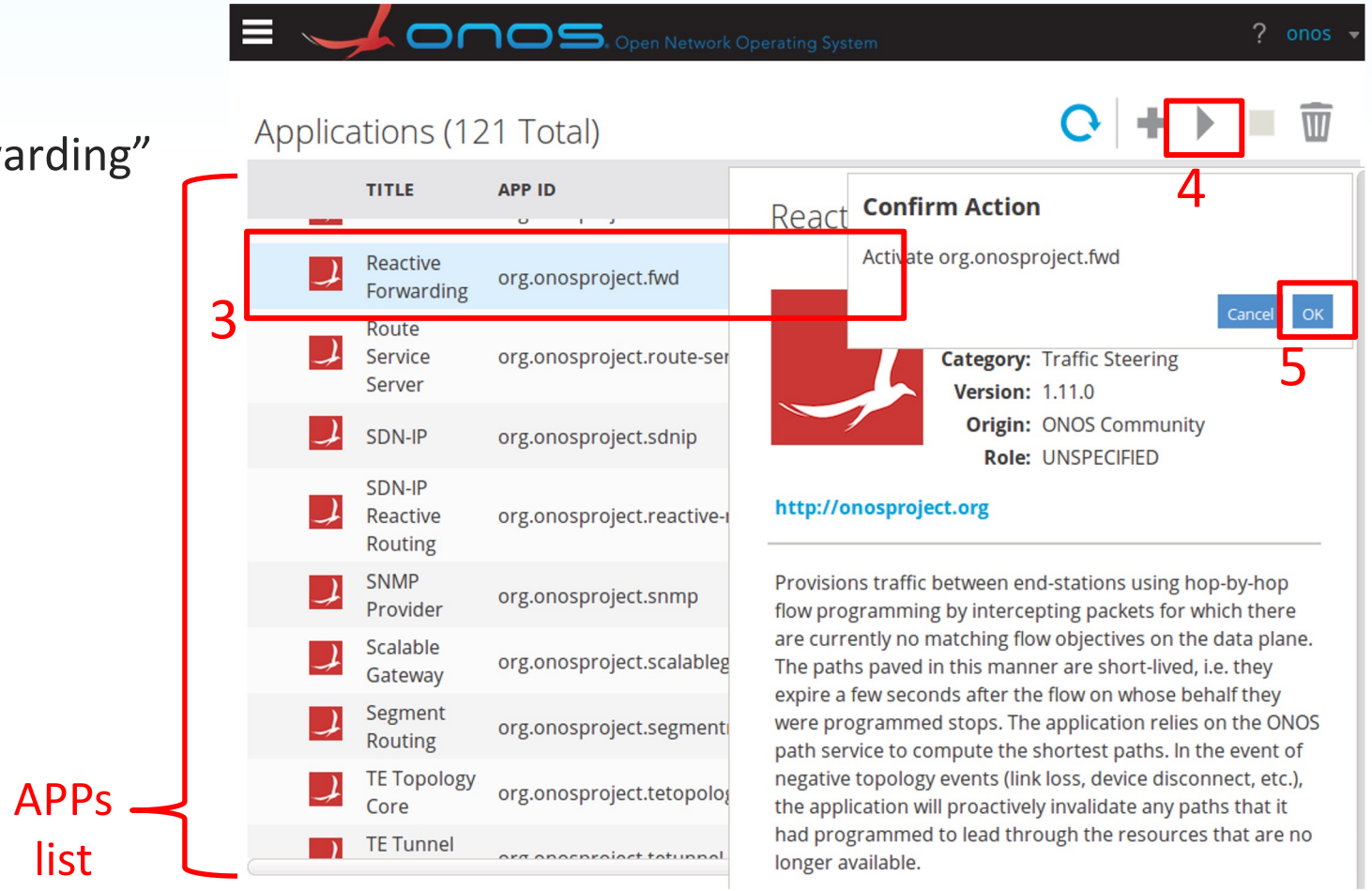
```
onos> app activate <name>           # activate onos app
onos> app deactivate <name>         # deactivate onos app
```

```
demo@root > app activate org.onosproject.openflow                   02:39:21
Activated org.onosproject.openflow
demo@root > app activate org.onosproject.fwd                        02:40:10
Activated org.onosproject.fwd
```

```
onos> app --help          # display command help message
```

Activate basic ONOS APPS via GUI

- Via ONOS GUI
  1. Click ☰
  2. Choose “Applications”
  3. Choose “Reactive Forwarding” from APPs list
  4. Click ▶
  5. Click “OK”



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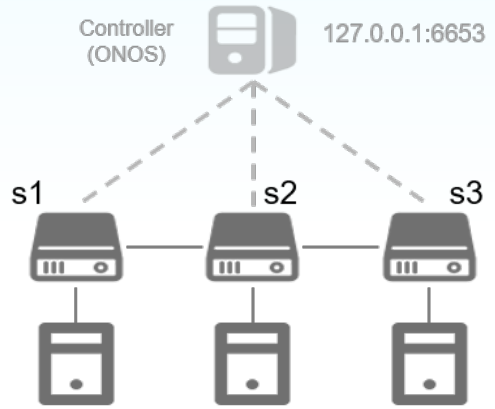
Build-in Topology in Mininet

- Five Built-in topologies:
  - Minimal
    Also called “Default
  - Single
  - Linear
  - Torus
  - Tree



Linear Topology

```
$ sudo mn --topo=linear,3 --controller=remote,127.0.0.1:6653 \
>--switch=ovs,protocols=OpenFlow14
```

- Command for Mininet : mn [Options]
  --switch: chose switch interface
  --controller: add the controller
  --topo: specifies the topology
  --custom: read custom classes parameter from .py file

```
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1 s2 s3
*** Adding links:
(h1, s1) (h2, s2) (h3, s3) (s2, s1) (s3, s2)
*** Configuring hosts
h1 h2 h3
*** Starting controller
c0
*** Starting 3 switches
s1 s2 s3 ...
*** Starting CLI:
mininet>
```

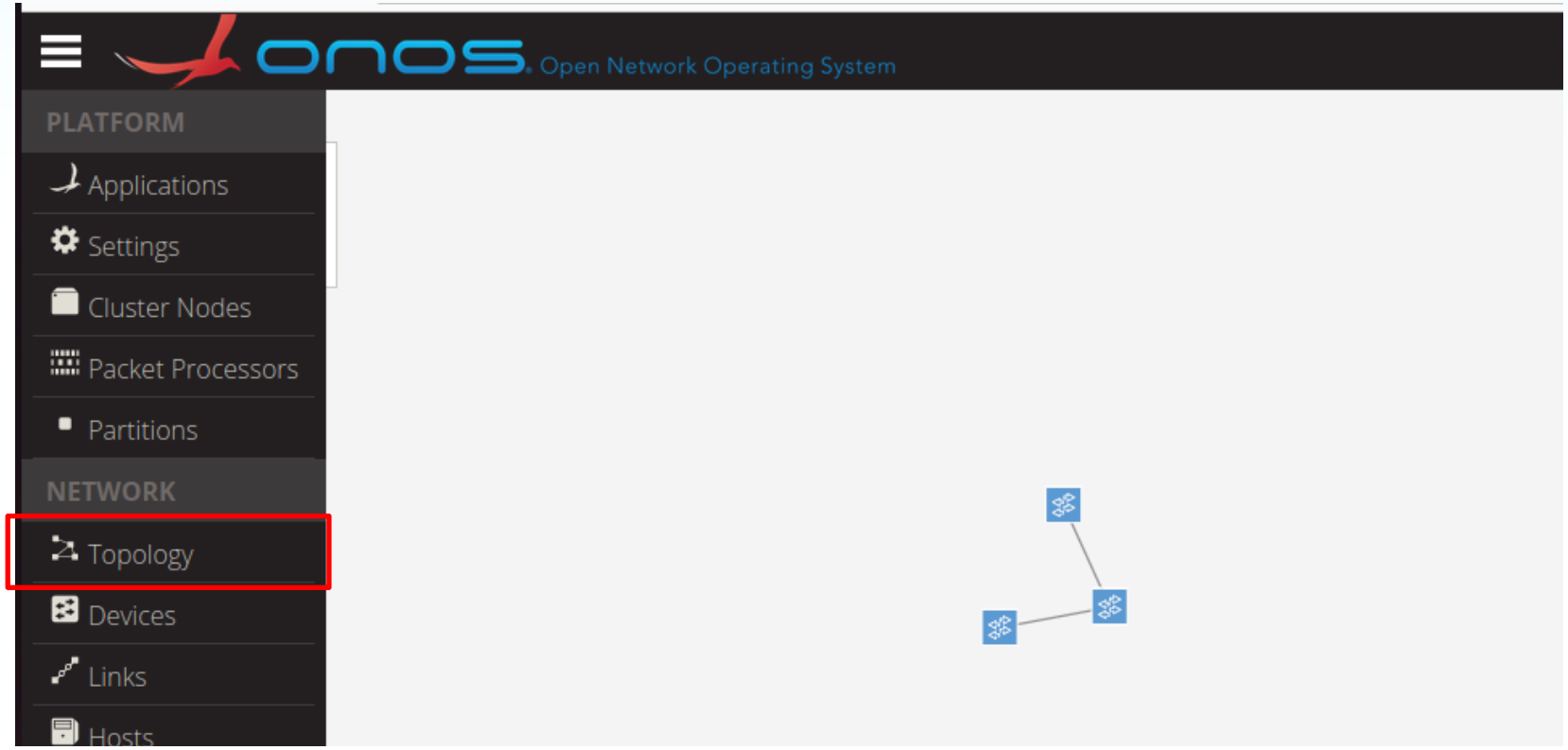
Clear your Experiment Environment

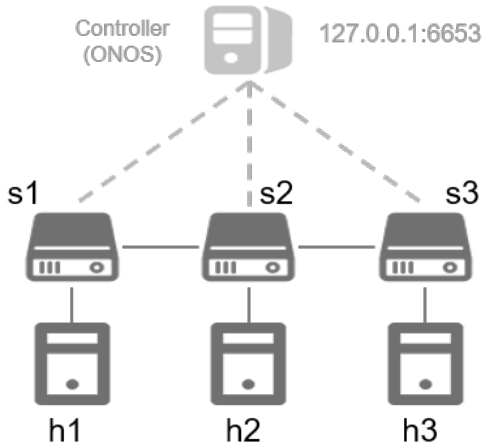
- Note: Make sure to clean up the environment of Mininet after every time you exit Mininet CLI

```
mininet> exit          # exit mininet cli
$ sudo mn -c           #clean and exit
                       #A "cleanup" command to get rid of junk (interfaces, processes,
                       files in /tmp,etc.) which might be left around by Mininet or
                       Linux.
```

Check Topology on ONOS GUI

- After building topology with mininet, you can view Topology on ONOS GUI





- Question: why can't see hosts?
  - Switches spontaneously connect to Controller, but hosts do not.
  - Controller knows the existence of switches, but not hosts

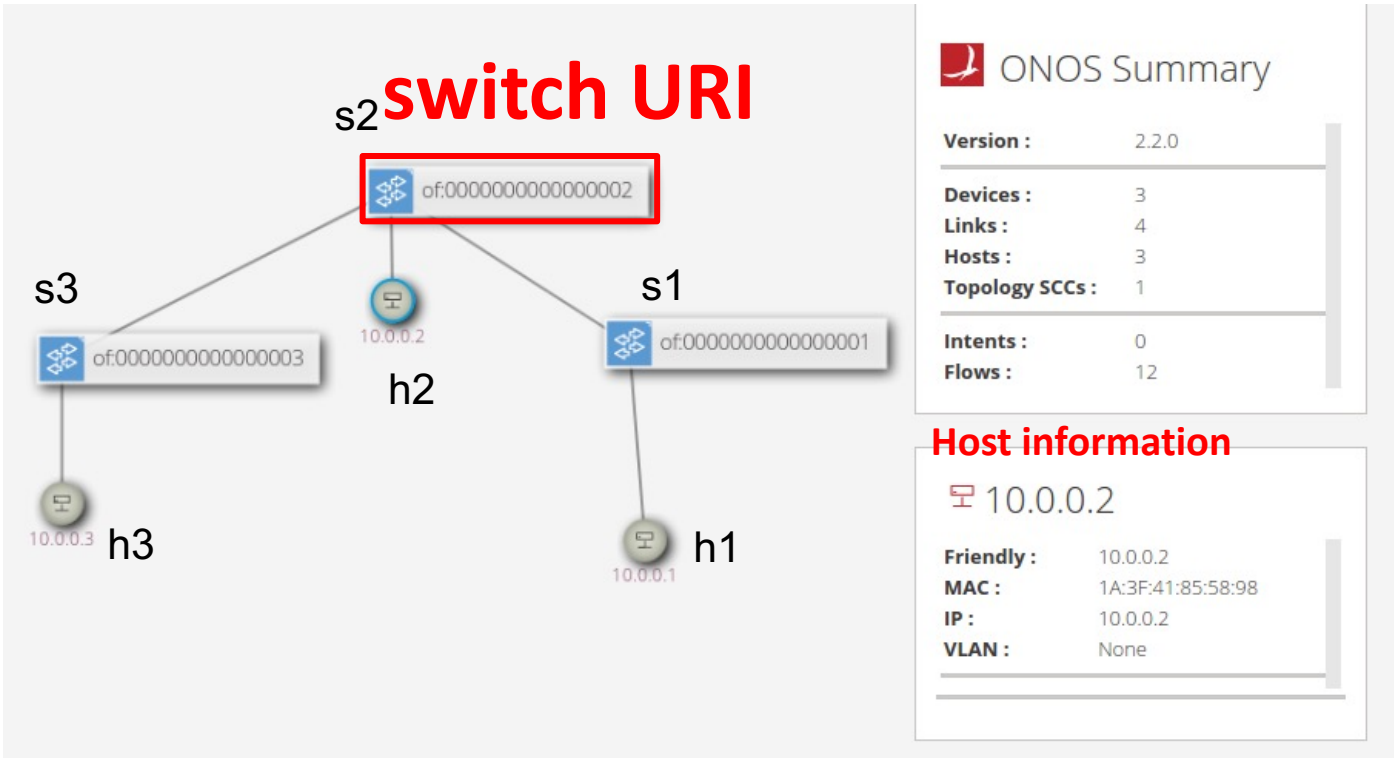
Make hosts appear in ONOS GUI

1. First, use “pingall” with Mininet CLI

```
mininet> pingall     # ping between all hosts
```

```
*** Ping: testing ping reachability
h1 -> h2 h3
h2 -> h1 h3
h3 -> h1 h2
*** Results: 0% dropped (6/6 received)
```

2. Hotkeys on GUI
   - “h” to show hosts
   - “l” to show switch URI

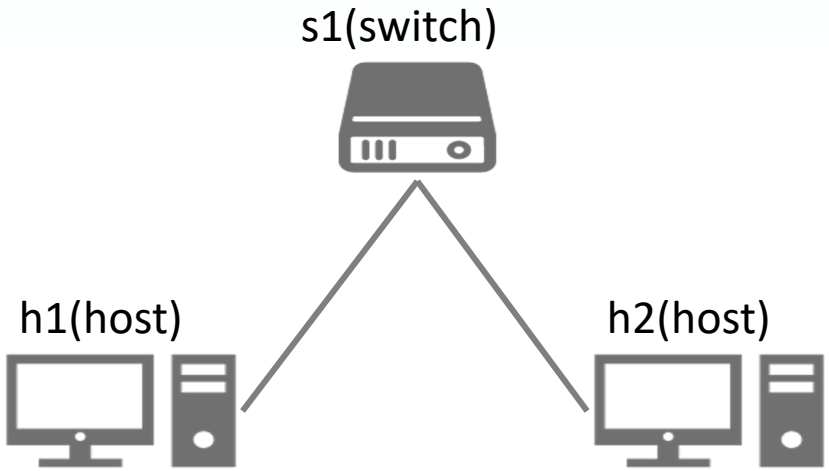


Create a custom topology

1. Specify topology in Python script

```python
from mininet.topo import Topo

class MyTopo( Topo ):
    def __init__( self ):
        Topo.__init__( self )

        # Add hosts
        h1 = self.addHost( 'h1' )
        h2 = self.addHost( 'h2' )

        # Add switches
        s1 = self.addSwitch( 's1' )

        # Add links
        self.addLink( h1, s1 )
        self.addLink( h2, s1 )

topos = { 'mytopo': MyTopo }
```

sample.py



2. Run Mininet with options “custom”, “topo”, “controller”, and “switch”

```
$ sudo mn --custom=sample.py --topo=mytopo \
>--controller=remote,ip=127.0.0.1,port=6653 \
>--switch=ovs,protocols=OpenFlow14
```

Topology Dictionary

- Recall: create a custom topology specified in sample.py

```
from mininet.topo import Topo

class MyTopo( Topo ):
    def __init__( self ):
        Topo.__init__( self )

        # Add hosts
        h1 = self.addHost( 'h1' )
        h2 = self.addHost( 'h2' )

        # Add switches
        s1 = self.addSwitch( 's1' )

        # Add links
        self.addLink( h1, s1 )
        self.addLink( h2, s1 )

topos = { 'mytopo': MyTopo }
```

```
topos = { 'mytopo': MyTopo }
```

- It is a Python datatype : Dictionary = { key : value}
- ”topos” is a reserved word in mininet

```
$ sudo mn --custom=sample.py --topo=mytopo \
>--controller=remote,ip=127.0.0.1,port=6653 \
>--switch=ovs,protocols=OpenFlow14
```

- Other functions for creating topology
- Topo example

References

- Basic ONOS tutorial
  - https://wiki.onosproject.org/display/ONOS/Basic+ONOS+Tutorial
- ONOS GUI:
  - https://wiki.onosproject.org/display/ONOS/The+ONOS+Web+GUI
- ONOS CLI:
  - https://wiki.onosproject.org/display/ONOS/The+ONOS+CLI
- Mininet intro:
  - https://github.com/mininet/mininet/wiki/Introduction-to-Mininet#creating
- Mininet Python API :
  - http://mininet.org/api/annotated.htm
- Topo example:
  - https://github.com/mininet/mininet/tree/master/examples
- Manpage for Linux command
  - netstat: http://manpages.ubuntu.com/manpages/trusty/man8/netstat.8.html
  - mn: http://manpages.ubuntu.com/manpages/bionic/man1/mn.1.html

Outline

- Environment Introduce & Setup
- Building virtual internet
- Project Requirements
  - Part1: Answer Questions (40%)
  - Part2: Create a Custom Topology (50%)
  - Part3: Statically Assign Hosts IP Address IP in Mininet (10%)

Part1 : Answer Questions

Activate ONOS APPS

1. When ONOS activates “org.onosproject.openflow,” what are the APPs which it also activates?
2. After activate ONOS and run P.14 command. Will H1 ping H2 successfully? Why or why not?

   Hint: Please refer to the reference “Basic ONOS Tutorial” at p.19

Observe listening port with terminal command “netstat"

3. Which TCP port the controller listens for the OpenFlow connection request from the switch? screenshot
4. In question 3, which APP enables the controller to listen on the TCP port?

Hint: Observe the Network connection

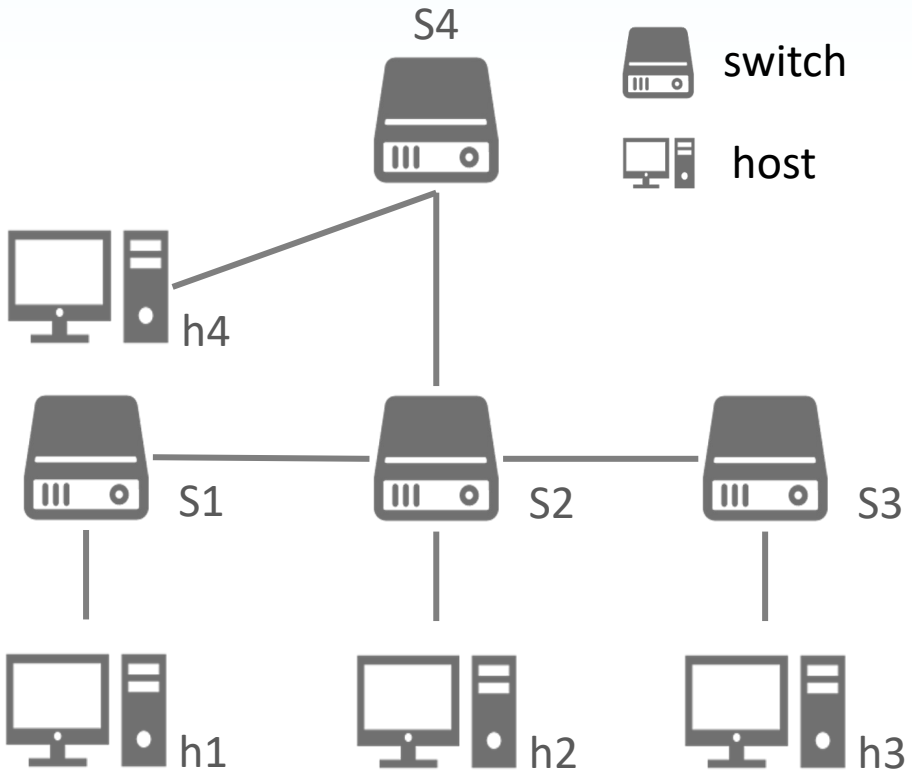
1.Bring up and enter a new terminal

2.Dearivate/activate apps and use “netstat: in the new terminal to observe network connection

```
$ netstat -nlpt                 #check out command detail with command $man netstat
```

Part2 : Create a custom Topology

- Write a Python script to build the following topology:



Naming Conventions for part 2

- Naming conventions in your python script
  a. Name of Python script: project1_part2_<studentID>.py
  b. Name of topology class: Project1_Topo_<studentID>
  c. Name of dictionary's key: topo_part2_<studentID>

➢ Command to execute your script:

```
$ sudo mn --custom=project1_part2_<studentID>.py \
  --topo=topo_part2_<studentID> \
  --controller=remote,ip=127.0.0.1:6653
```

Part3 : Statically assign Hosts IP Address in Mininet (1)

- Reuse the topology in part 2
- By default, Mininet automatically assigns an IP address and a subnet mask to each host interface

  (i.e. 10.0.0.1/8, 10.0.0.2/8, 10.0.0.3/8)

```
mininet> dump
<Host h1: h1-eth0:10.0.0.1 pid=11188>
<Host h2: h2-eth0:10.0.0.2 pid=11190>
```

```
mininet> h1 ifconfig
h1-eth0   Link encap:Ethernet  HWaddr ae:c2:c4:b8:d3:ac
          inet addr:10.0.0.1  Bcast:10.255.255.255  Mask:255.0.0.0
          inet6 addr: fe80::acc2:c4ff:feb8:d3ac/64 Scope:Link
```

Part3 : Statically assign Hosts IP Address in Mininet (2)

- Format for manual assignment of host IP address:
  - 192.168.0.0/27
  - netmask 255.255.255.224

Host	IP Address
h1	192.168.0.1
h2	192.168.0.2
	…

- **Statically assign IP addresses with Python** and hand in the Python script you've edited

Naming Conventions for part 3

- Naming conventions in your python script
  a. Name of Python script: project1_part3_<studentID>.py
  b. Name of topology class: Project1_Topo_<studentID>
  c. Name of dictionary's key: topo_part3_<studentID>

➢ Note: Command to execute your script:

```
$ sudo mn --custom=project1_part3_<studentID>.py \
  --topo=topo_part3_<studentID> \
  --controller=remote,ip=127.0.0.1:6653 \
  --switch=ovs,protocols=OpenFlow14
```

Naming Conventions & Submission

- Files
  - Two Python scripts:
    - project1_part2_<studentID>.py
    - project1_part3_<studentID>.py
  - A report: project1_<studentID>.pdf
    1. Part 1: Answers to those four questions
    2. Part 2: Take screenshots and explain what you've done
    3. Part 3: Take screenshots and explain what you've done
    4. What you've learned or solved
- Submission
  - Put two Python scripts and report in a directory project1_<studentID>
  - Zip Python scripts and the report into a zip file
    - Named: project1_<studentID>.zip
  - Wrong file name or format will result in 10 points deduction
  - **Deduction 20% for late submission in one week. Won't accept submission over 1 week**

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.nctu.edu.tw**
  - You have special problem and you can't meet the deadline
  - You got weird score with project
- **No Fixed TA hour**

Q & A