Software Defined Networking

Lab Work 2 Solution

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INTRODUCTION TO

OpenFlow Controller / RYU

Short Recap

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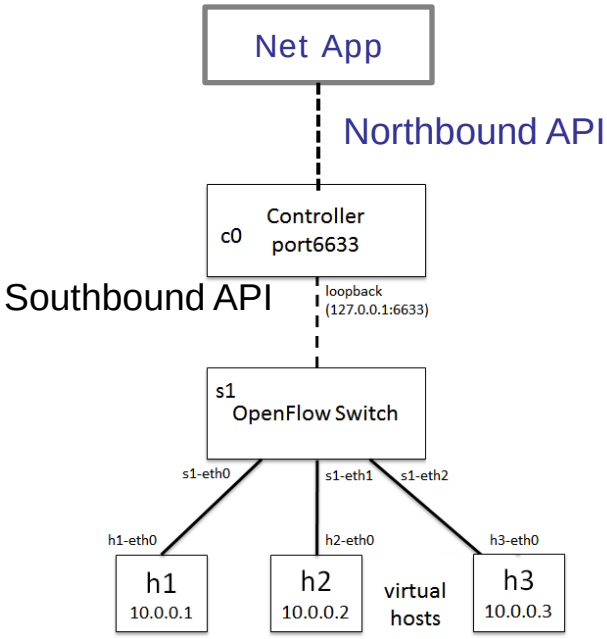
- Previously we manually added rules in the switch
  - `$ dpctl add-flow tcp:127.0.0.1:6634\ in_port=1,idle_timeout=0,actions=output:2`
- This should be done automatically
  - Task of a Network Application (App)
  - E.g. a simple switching App



[1] http://sdnhub.org/resources/useful-mininet-setups/

Installing Ryu

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- Reboot your existing Mininet VM and enter:
  - `$ sudo -s`
  - `$ apt-get install python-eventlet python-routes python-webob python-paramiko python-pip python-dev libxml2-dev libxslt-dev zlib1g-dev`
  - `$ pip install ryu`
  - `$ mn -c`

Run a simple_switch

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- Enter:
  - `$ mn --topo single,3 --mac --arp --switch ovsk\ --controller=remote,ip=127.0.0.1`
  - `$ h1 ping h2 -> timeout`
- Open a second terminal and connect to the VM
  - Execute
    - `$ ryu-manager ryu.app.simple_switch --verbose`
  - h1 ping h2 ➡ success
  - Investigate the OpenFlow rules in switch s1
    - New tool: ovs-ofctl
    - `$ ovs-ofctl dump-flows s1`

Understand how it works

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- A step-by-step explanation can be found here
  - http://osrg.github.io/ryu-book/en/html/switching_hub.html
  - Read it carefully!
- Other resources like books and tutorials available
  - E.g. http://books.google.de/books?id=JC3rAgAAQBAJ

Task 1: Packet Replication 1 / 2

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- Modify the *simple_switch.py* in a way that all received ICMP request packets are sent through the two other *out_ports* of the switch. The packet should not be sent back to the port from where it originated.
  - The basis for the task is the Ryu application simple_switch.py and OF 1.0: https://github.com/osrg/ryu/blob/master/ryu/app/simple_switch.py
  - A ping request from h1 to h2 should result in a ping reply to h1 from h2 and h3. As a result, h1 receives more packets then it has sent.
    - It is sufficient for the solution to work for in the example network with 3 hosts
    - Mininet provides a fixed mapping between OpenFlow port numbers, MAC, and IP addresses. This information should be used for implementation.
  - Carefully think about what actions need to be applied to the ICMP packets
  - Have a look at the respective standards documents:
    - OpenFlow Switch Specification 1.0.0 & Errata

    https://www.opennetworking.org/sdn-resources/technical-library

Task 1: Packet Replication 2 / 2

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Debugging

- How to open a third terminal and connect it to one of the hosts?
  - Use xterm if you have a GUI installed
  - Open a second ssh session to the mininet VM
  - In Mininet run: `mininet> py h3.pid -> 3013`
  - Attach to h3 by running `$ sudo mnexec –a 3013 bash`
  - Verify by running `$ ip a` -> you should see the interfaces of h3 only
- Run tcpdump on h3
  - Open a terminal on h3
  - `$ tcpdump –eUvi h3-eth0`
  - `mininet> h1 ping h3`
  - With the packet duplication code in place
  - `mininet> h1 ping h2`
  - A packet copy of the ICMP request to h2 should be visible in the tcpdump output
    - Why does h3 not send an ICMP reply to the ICMP request?

Lab 2 Task 1 Solution (1)

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- Some confusion/uncertainty regarding the task
  - We will stick to this line in the description: “A ping from h1 to h2 should result in a ping from h1 to h2 and h3. As a result, h1 receives more packets than it has sent.”

```
mininet> h1 ping h2
64 bytes from 10.0.0.2: icmp_seq=343 ttl=64 time=0.076 ms
64 bytes from 10.0.0.2: icmp_seq=343 ttl=64 time=0.079 ms (DUP!)
```

  - Verify using tcpdump

```
:~$ sudo tcpdump -ei s1-eth1
52 00:00:00:00:00:01 > 00:00:00:00:00:02, ethertype IPv4 (0x0800), length 98: 10.0.0.1 > 10.0.0.2:
ICMP echo request, id 5168, seq 48, length 64
92 00:00:00:00:00:02 > 00:00:00:00:00:01, ethertype IPv4 (0x0800), length 98: 10.0.0.2 > 10.0.0.1:
ICMP echo reply, id 5168, seq 48, length 64
95 00:00:00:00:00:03 > 00:00:00:00:00:01, ethertype IPv4 (0x0800), length 98: 10.0.0.3 > 10.0.0.1:
ICMP echo reply, id 5168, seq 48, length 64
```

Lab 2 Task 1 Sample Solution (1)

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- See the file „simple_switch_duplicate.py“ for a complete example solution
- The network is static and known: Add a host list

```
# Code by Patrick Welzel and Mahshid Okhovatzadeh
       self.hosts_for_omniping = [
                                    {'port': 1,
                                     'ip': '10.0.0.1',
                                     'mac': '00:00:00:00:00:1'},
                                    {'port': 2,
                                     'ip': '10.0.0.2',
                                     'mac': '00:00:00:00:00:2'},
                                    {'port': 3,
                                     'ip': '10.0.0.3',
                                     'mac': '00:00:00:00:00:3'},
                                   ]
```

Lab 2 Task 1 Sample Solution (2)

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- Add additional output rules

```
Adarsh Chikkaballapur Umashankar
Bhargava Narasipura
  actions=[]
  # install a flow to avoid packet_in next time
  if out_port != ofproto.OFPP_FLOOD:
    for host in self.hosts_for_omniping:
      if msg.in_port != host['port']:
        if out_port != host['port']:
          actions.append(datapath.ofproto_parser.OFPActionSetDlDst(haddr_to_bin(host['mac'])))
          actions.append(datapath.ofproto_parser.OFPActionSetNwDst(ofctl.ipv4_to_int(host['ip'])))
        actions.append(datapath.ofproto_parser.OFPActionOutput(host['port']))
      self.logger.info("actions is %s ", actions)
      self.add_flow(datapath, msg.in_port, dst, actions)
```

- OpenFlow rules

```
mininet@mininet-vm:~$ sudo ovs-ofctl dump-flows s1
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=41.308s, table=0, n_packets=32, n_bytes=3136, idle_timeout=20, idle_age=9,
icmp,in_port=2 actions=output:1,mod_dl_dst:00:00:00:00:00:03,mod_nw_dst:10.0.0.3,output:3
 cookie=0x0, duration=41.311s, table=0, n_packets=32, n_bytes=3136, idle_timeout=20, idle_age=9,
icmp,in_port=1 actions=output:2,mod_dl_dst:00:00:00:00:00:03,mod_nw_dst:10.0.0.3,output:3
 cookie=0x0, duration=41.308s, table=0, n_packets=32, n_bytes=3136, idle_timeout=20, idle_age=9,
icmp,in_port=3 actions=output:1,mod_dl_dst:00:00:00:00:00:02,mod_nw_dst:10.0.0.2,output:2
```

Solution: Terminal Output

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Terminal1

```
mininet@mininet-vm:~$ sudo mn --topo single,3 --mac --arp --switch ovsk --
controller=remote,ip=127.0.0.1
```

Terminal2

```
mininet@mininet-vm:~$ sudo ryu-manager ./simple_switch_duplicate.py
loading app ./simple_switch_duplicate.py
loading app ryu.controller.ofp_handler
instantiating app ./simple_switch_duplicate.py of SimpleSwitch app
ryu.controller.ofp_handler of OFPHandler
```

Terminal1

```
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=2.99 ms
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=3.14 ms (DUP!)
```