

SDN DEMO PREP

Iteration 3

By

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Mininet/OpenDaylight walkthrough

Result:

- **Start the OpenDayLight (ODL) Controller and Mininet**

[illegible]

- **Install additional features & check installed features**

```
File Machine View Input Devices Help
opendaylight-user@root>feature:install odl-restconf odl-l2switch-switch odl-netconf-connector-all
opendaylight-user@root>feature:install odl-mdsal-apidocs odl-dlux-core odl-dluxapps-applications odl
-dluxapps-nodes odl-dluxapps-topology odl-dluxapps-yangui odl-dluxapps-yangvisualizer
opendaylight-user@root>feature:list -i
```

```

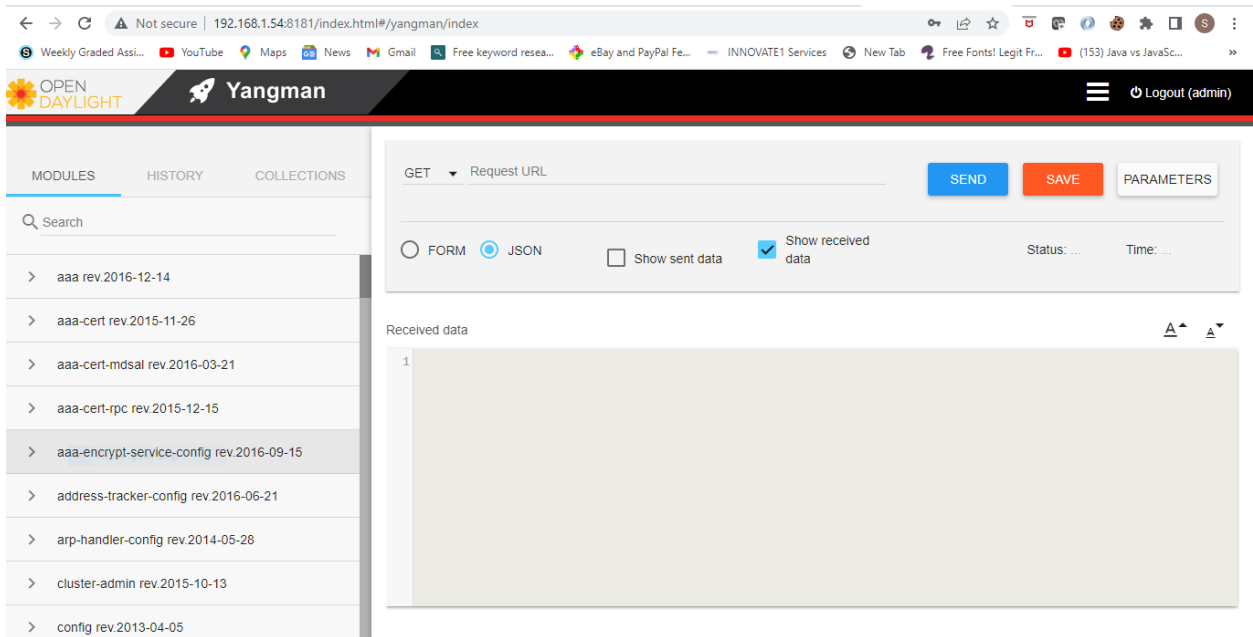
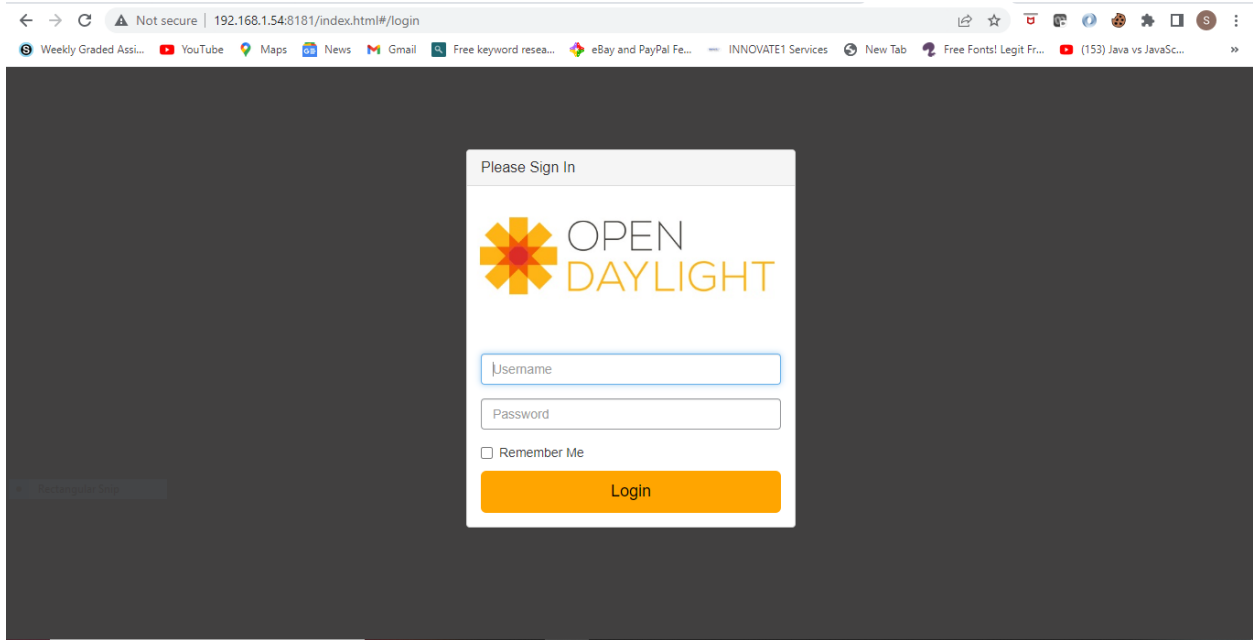
File  Machine  View  Input  Devices  Help
odl-config-netconf-connector | 1.2.4-Carbon | x | odl-netconf-1.2.4-Ca
rbon | OpenDaylight :: Netconf :: Connector
odl-netconf-netty-util | 1.2.4-Carbon | x | odl-netconf-1.2.4-Ca
rbon | OpenDaylight :: Netconf :: Netty Util
odl-netconf-client | 1.2.4-Carbon | x | odl-netconf-1.2.4-Ca
rbon | OpenDaylight :: Netconf :: Client
odl-netconf-monitoring | 1.2.4-Carbon | x | odl-netconf-1.2.4-Ca
rbon | OpenDaylight :: Netconf :: Monitoring
odl-netconf-notifications-api | 1.2.4-Carbon | x | odl-netconf-1.2.4-Ca
rbon | OpenDaylight :: Netconf :: Notification :: Api
odl-netconf-notifications-impl | 1.2.4-Carbon | x | odl-netconf-1.2.4-Ca
rbon | OpenDaylight :: Netconf :: Monitoring :: Impl
odl-netconf-ssh | 1.2.4-Carbon | x | odl-netconf-1.2.4-Ca
rbon | OpenDaylight :: Netconf Connector :: SSH
odl-netconf-tcp | 1.2.4-Carbon | x | odl-netconf-1.2.4-Ca
rbon | OpenDaylight :: Netconf Connector :: TCP
odl-aaa-netconf-plugin | 1.2.4-Carbon | x | odl-netconf-1.2.4-Ca
rbon | OpenDaylight :: AAA :: ODL NETCONF Plugin
odl-config-persister | 0.6.4-Carbon | x | odl-config-persister
-0.6.4-Carbon | OpenDaylight :: Config Persister
odl-config-startup | 0.6.4-Carbon | x | odl-config-persister
-0.6.4-Carbon | OpenDaylight :: Config Persister:: Config Startup
odl-config-manager-facade-xml | 0.6.4-Carbon | x | odl-config-persister
-0.6.4-Carbon | OpenDaylight :: Config Persister:: Mapping for Con
odl-openflowplugin-flow-services | 0.4.4-Carbon | x | openflowplugin-0.4.4
-Carbon | OpenDaylight :: Openflow Plugin :: Flow Services
odl-openflowplugin-southbound | 0.4.4-Carbon | x | openflowplugin-0.4.4
-Carbon | OpenDaylight :: Openflow Plugin :: Li southbound A
odl-openflowplugin-nsf-model | 0.4.4-Carbon | x | openflowplugin-0.4.4
-Carbon | OpenDaylight :: OpenflowPlugin :: NSF :: Model
odl-openflowplugin-app-config-pusher | 0.4.4-Carbon | x | openflowplugin-0.4.4
-Carbon | OpenDaylight :: Openflow Plugin :: Application - d
odl-openflowplugin-app-topology | 0.4.4-Carbon | x | openflowplugin-0.4.4
-Carbon | OpenDaylight :: Openflow Plugin :: Application - t
odl-openflowplugin-app-forwardingrules-manager | 0.4.4-Carbon | x | openflowplugin-0.4.4
-Carbon | OpenDaylight :: Openflow Plugin :: Application - F
opendaylight-user@root>_

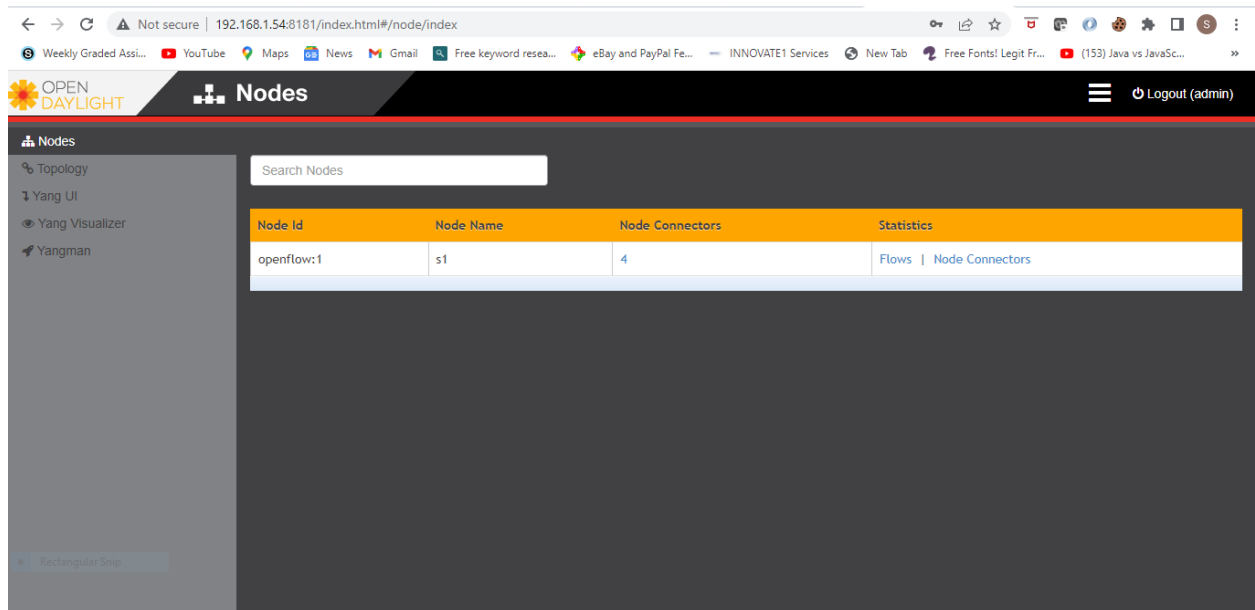
```

- Check open ports

```
File Machine View Input Devices Help
ks-sdn@sdn_server:~$ sudo netstat -tunlpo | grep java
[sudo] password for ks-sdn:
tcp6      0      0 :::8101          :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 :::1830          :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 :::6633          :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 :::6666          :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 :::1099          :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 127.0.0.1:34831  :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 :::8080          :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 :::8181          :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 :::35829         :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 127.0.0.1:2550   :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 :::8185          :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 :::44444         :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 :::6653          :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 127.0.0.1:8383   :::*             LISTEN      4694/java
off (0.00/0/0)
tcp6      0      0 127.0.0.1:36416  127.0.0.1:1830   ESTABLISHED 4694/java
off (0.00/0/0)
tcp6      0      0 127.0.0.1:1830   127.0.0.1:36416  ESTABLISHED 4694/java
off (0.00/0/0)
ks-sdn@sdn_server:~$ _
```

- Using a browser window, connect the VM to open the ODL
- By typing the following url in the address bar:
 - <http://192.168.1.54:8181/index.html#/login>
 - Note that the ip address will differ in another VM
 - username= admin
 - password= admin





- **Start Mininet**

```
ks-sdn@sdn_server:~$ sudo mn --topo tree,3 --mac --controller 'remote,ip=192.168.1.54,port=6653' --s
with ovsk,protocols=OpenFlow13
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8
*** Adding switches:
s1 s2 s3 s4 s5 s6 s7
*** Adding links:
(s1, s2) (s1, s5) (s2, s3) (s2, s4) (s3, h1) (s3, h2) (s4, h3) (s4, h4) (s5, s6) (s5, s7) (s6, h5) (
s6, h6) (s7, h7) (s7, h8)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8
*** Starting controller
c0
*** Starting 7 switches
s1 s2 s3 s4 s5 s6 s7 ...
*** Starting CLI:
mininet>
```

- **Mininet Network appear in Nodes Menu**

Not secure | 192.168.1.54:8181/index.html#/node/index

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OPEN DAYLIGHT Nodes Logout (admin)

Nodes

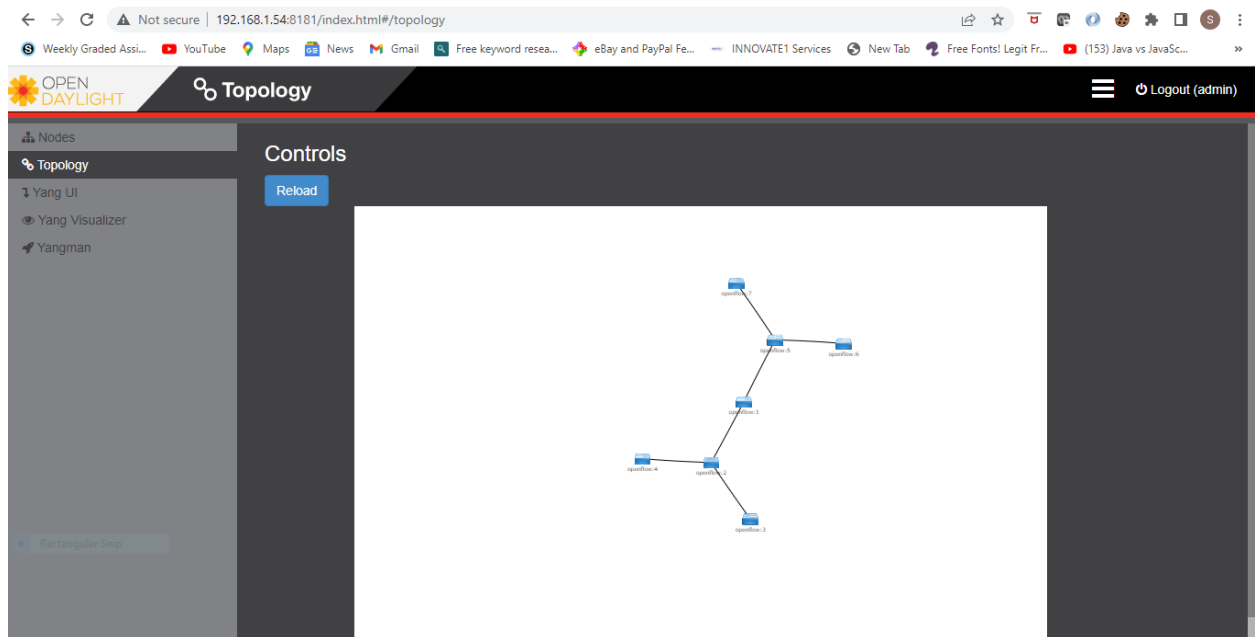
Topology Yang UI Yang Visualizer Yangman

Search Nodes

Node Id	Node Name	Node Connectors	Statistics
openflow:3	s3	4	Flows Node Connectors
openflow:2	s2	4	Flows Node Connectors
openflow:1	s1	3	Flows Node Connectors
openflow:7	s7	4	Flows Node Connectors
openflow:6	s6	4	Flows Node Connectors
openflow:5	s5	4	Flows Node Connectors
openflow:4	s4	4	Flows Node Connectors

Rectangular Snip

- Network Topology before pingall command



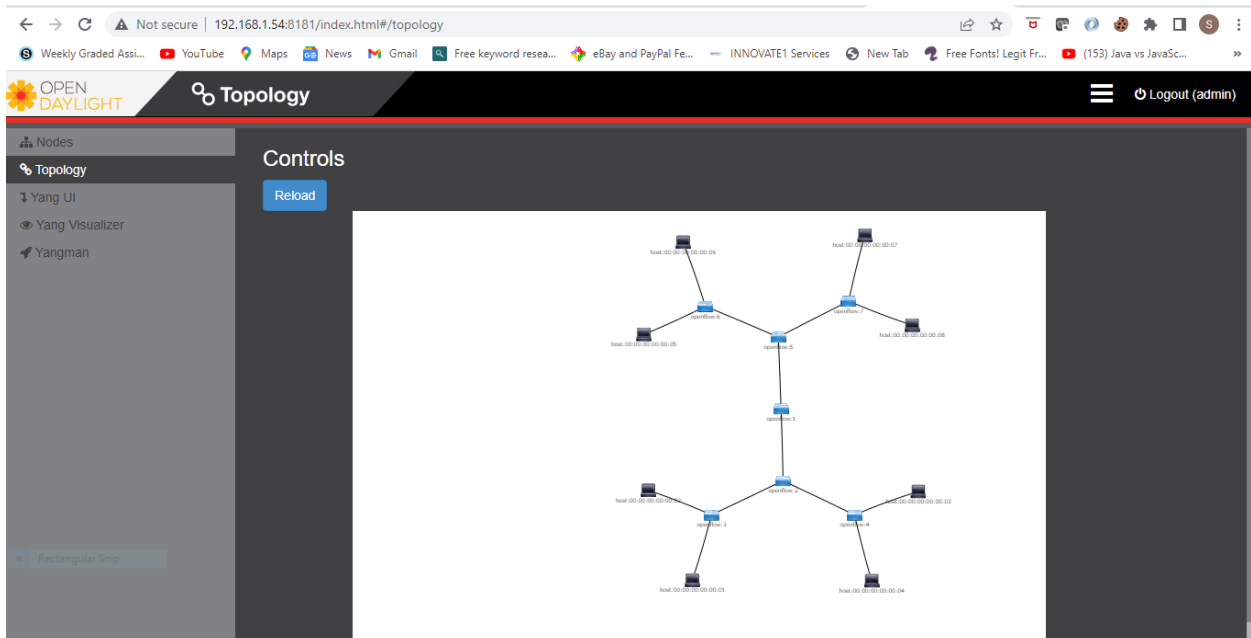
- Pingall command used to ping all nodes

```

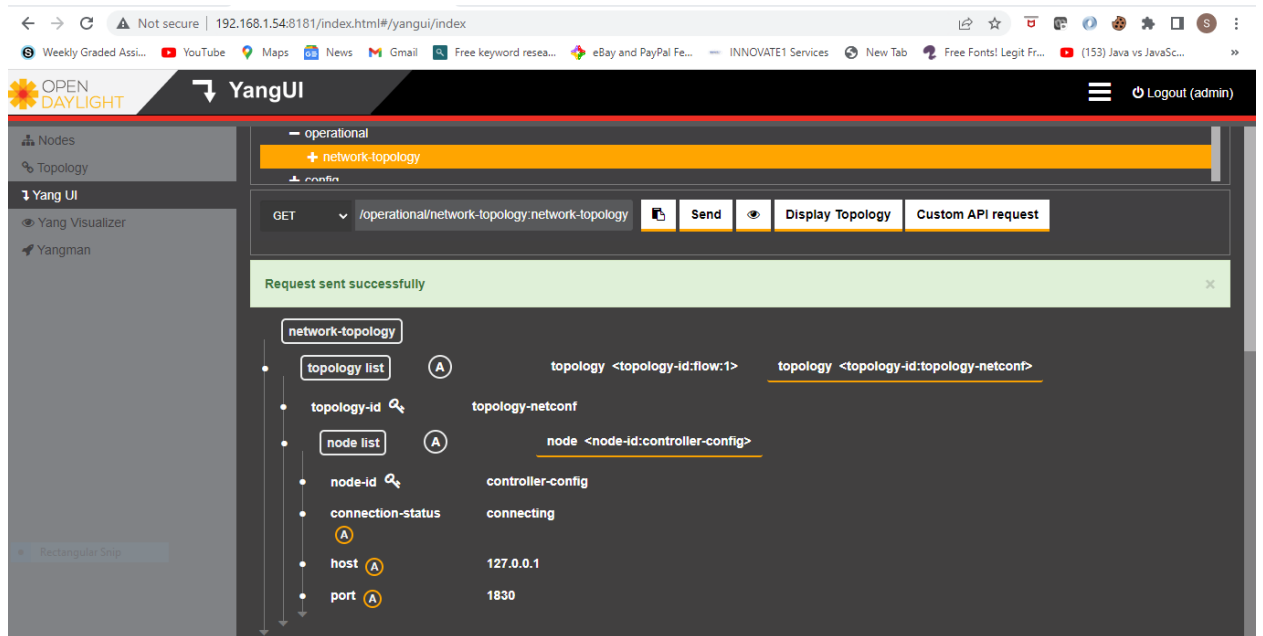
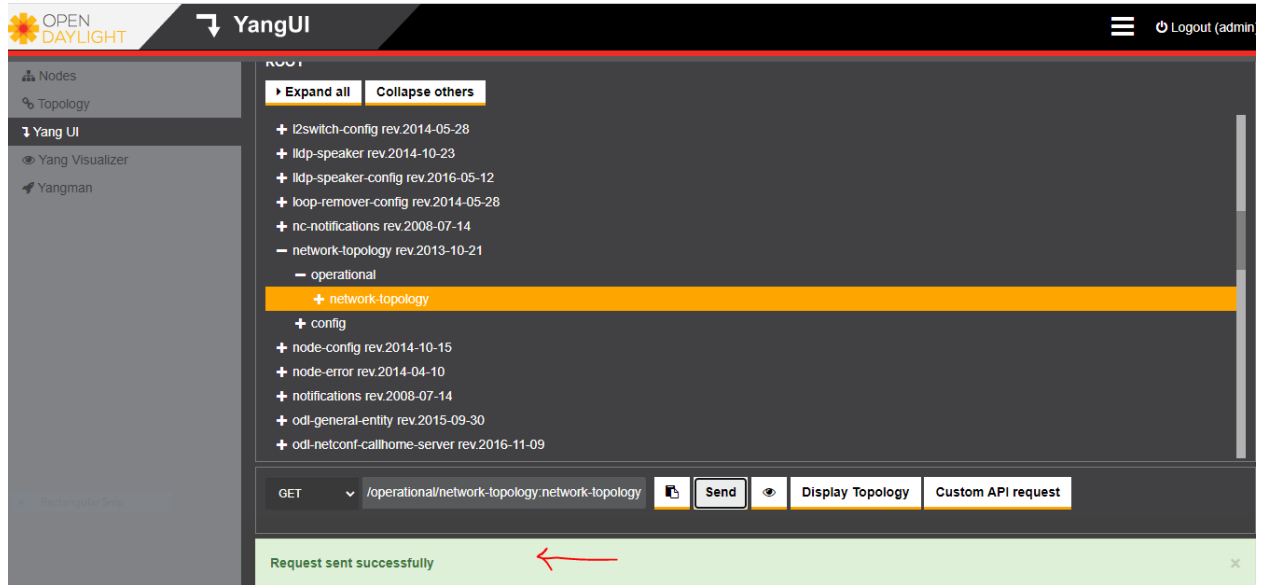
ks-sdn@sdn_server:~$ sudo mn --topo tree,3 --mac --controller 'remote,ip=192.168.1.54,port=6653' --s
witch ovsk,protocols=OpenFlow13
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8
*** Adding switches:
s1 s2 s3 s4 s5 s6 s7
*** Adding links:
(s1, s2) (s1, s5) (s2, s3) (s2, s4) (s3, h1) (s3, h2) (s4, h3) (s4, h4) (s5, s6) (s5, s7) (s6, h5) (
s6, h6) (s7, h7) (s7, h8)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8
*** Starting controller
c0
*** Starting 7 switches
s1 s2 s3 s4 s5 s6 s7 ...
*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5 h6 h7 h8
h2 -> h1 h3 h4 h5 h6 h7 h8
h3 -> h1 h2 h4 h5 h6 h7 h8
h4 -> h1 h2 h3 h5 h6 h7 h8
h5 -> h1 h2 h3 h4 h6 h7 h8
h6 -> h1 h2 h3 h4 h5 h7 h8
h7 -> h1 h2 h3 h4 h5 h6 h8
h8 -> h1 h2 h3 h4 h5 h6 h7
*** Results: 0% dropped (56/56 received)
mininet>

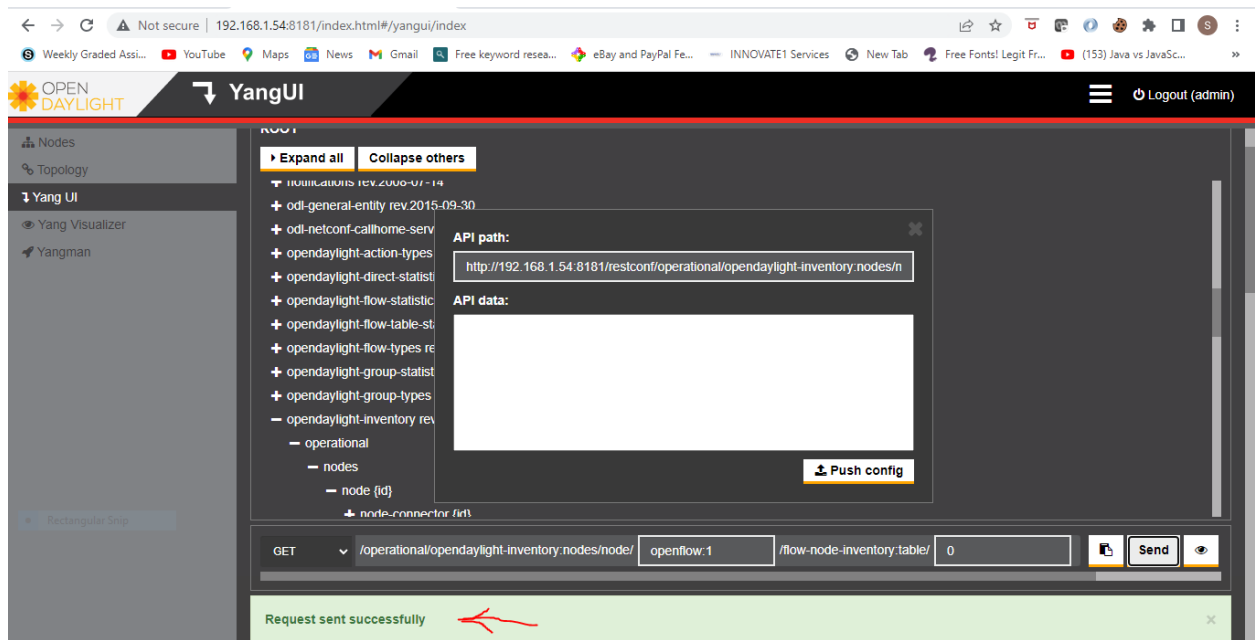
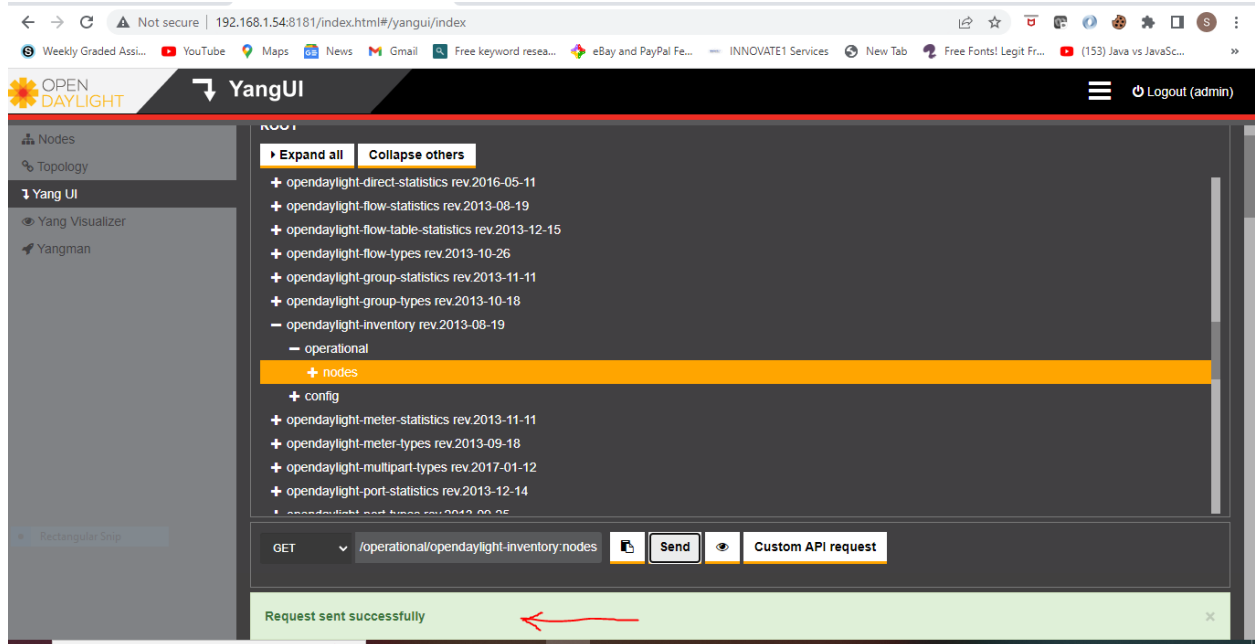
```

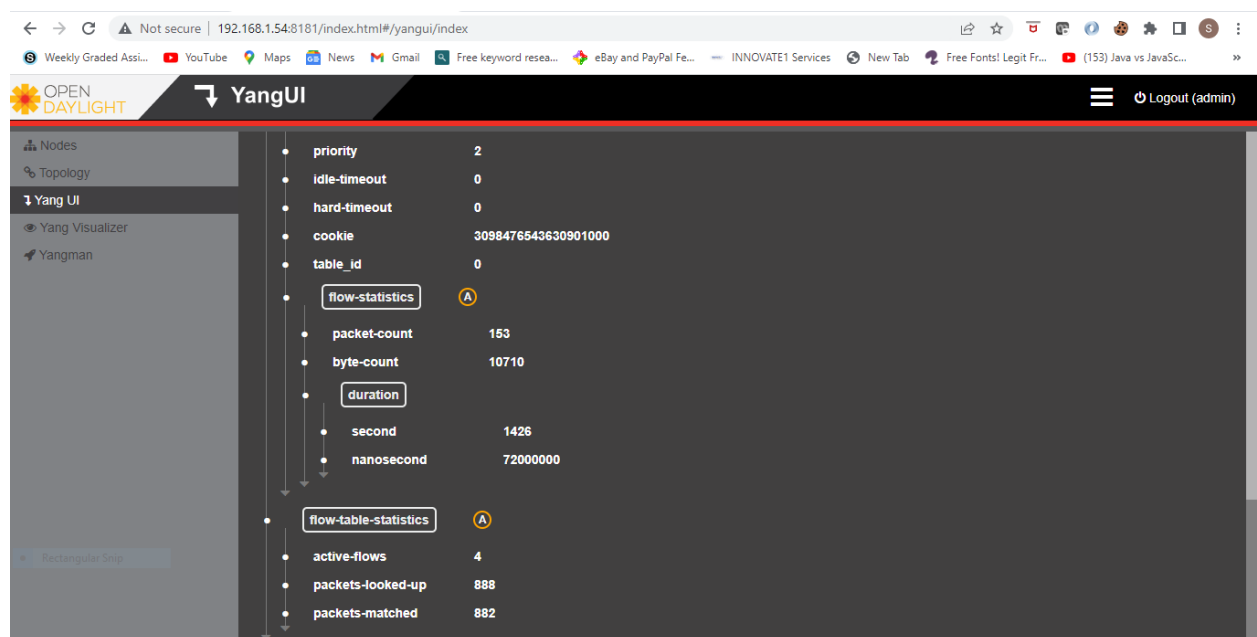
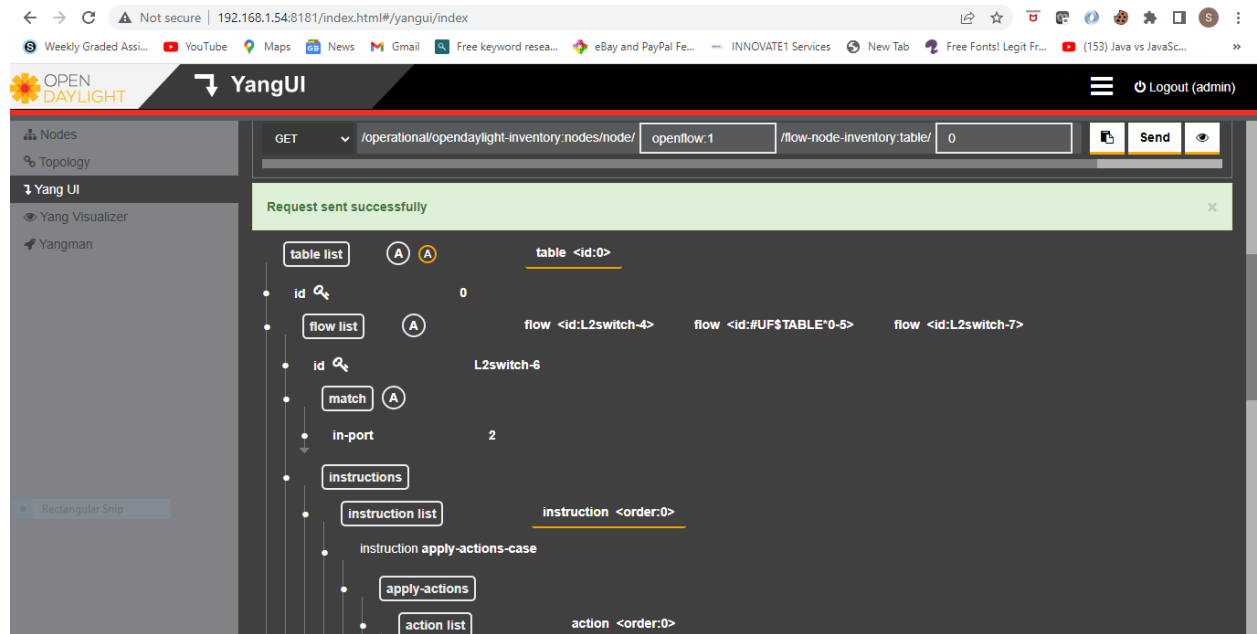
- Network topology after pingall command



- Using Yang GUI to display topology







ODL API Documentation (Swagger)

- Open the API Doc url at the web browser:
 - <http://192.168.1.54:8181/apidoc/explorer/index.html>
 - username= admin
 - password= admin

OpenDaylight RestConf API Documentation

Controller Resources Mounted Resources

Below are the list of APIs supported by the Controller.

aaa(2016-12-14)	Show/Hide	List Operations	Expand Operations	Raw
aaa-cert(2015-11-26)	Show/Hide	List Operations	Expand Operations	Raw
aaa-cert-mdsal(2016-03-21)	Show/Hide	List Operations	Expand Operations	Raw
aaa-cert-rpc(2015-12-15)	Show/Hide	List Operations	Expand Operations	Raw
aaa-encrypt-service-config(2016-09-15)	Show/Hide	List Operations	Expand Operations	Raw
address-tracker-config(2016-06-21)	Show/Hide	List Operations	Expand Operations	Raw
arp-handler-config(2014-05-28)	Show/Hide	List Operations	Expand Operations	Raw
cluster-admin(2015-10-13)	Show/Hide	List Operations	Expand Operations	Raw
config(2013-04-05)	Show/Hide	List Operations	Expand Operations	Raw
entity-owners(2015-08-04)	Show/Hide	List Operations	Expand Operations	Raw

- Click **network-topology(2013-10-21)**
- Scroll down **/operational/network-topology:network-topology/**
- Click on **Try it out!** Button to get the result shown below
 - Response Code: **200**
 - Response Body: topology in **JSON format**

lldp-speaker-config(2016-05-12) Show/Hide List Operations Expand Operations Raw

loop-remover-config(2014-05-28) Show/Hide List Operations Expand Operations Raw

nc-notifications(2008-07-14) Show/Hide List Operations Expand Operations Raw

netconf-node-topology(2015-01-14) Show/Hide List Operations Expand Operations Raw

network-topology(2013-07-12) Show/Hide List Operations Expand Operations Raw

network-topology(2013-10-21) Show/Hide List Operations Expand Operations Raw

POST /config

GET /config/network-topology:network-topology

PUT /config/network-topology:network-topology

DELETE /config/network-topology:network-topology

POST /config/network-topology:network-topology

GET /config/network-topology:network-topology/topology/{topology-id}

PUT /config/network-topology:network-topology/topology/{topology-id}

DELETE /config/network-topology:network-topology/topology/{topology-id}

POST /config/network-topology:network-topology/topology/{topology-id}

Not secure | 192.168.1.54:8181/apidoc/explorer/index.html#/network-topology(2013-10-21)/GET_network_topology_get_198

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GET /operational/network-topology:network-topology

Response Class
Model | Model Schema
(operational)network-topology

Response Content Type [Try it out!](#) [Hide Response](#)

Request URL
`http://192.168.1.54:8181/restconf/operational/network-topology:network-topology`

Response Body

```
{
  "network-topology": {
    "topology": [
      {
        "topology-id": "flow:1",
        "node": [
          {
            "node-id": "host:00:00:00:00:02",
            "termination-point": [
              {
                "tp-id": "host:00:00:00:00:02"
              }
            ]
          }
        ],
        "host-tracker-service:addresses": [
```

Not secure | 192.168.1.54:8181/apidoc/explorer/index.html#/network-topology(2013-10-21)/GET_network_topology_get_198

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```
{
  "tp-id": "openflow:3:1",
  "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inv",
},
{
  "tp-id": "openflow:3:2",
  "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inv",
},
{
  "tp-id": "openflow:3:LOCAL",
  "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inv",
},
{
  "tp-id": "openflow:3:3",
  "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inv",
}
],
},
}
```

Response Code
200

Response Headers

```
{
  "Content-Encoding": "gzip",
  "Content-Type": "application/json",
  "Server": "Jetty(8.1.19.v20160209)",
  "Transfer-Encoding": "chunked",
  "Vary": "Accept-Encoding, User-Agent"
}
```

EXERCISE 1

- **Get topology details**

```

File Machine View Input Devices Help
ks-sdn@sdn_server:~$ curl -s -u admin:admin -X GET http://192.168.1.54:8181/restconf/operational/network-topology:network-topology/topology/flow:1 | python -m json.tool

```

```

File Machine View Input Devices Help
{
  "node-id": "openflow:6",
  "opendaylight-topology-inventory:inventory-node-ref": "/opendaylight-inventory:nodes/opendaylight-inventory:node[opendaylight-inventory:id='openflow:6']",
  "termination-point": [
    {
      "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inventory:node[opendaylight-inventory:id='openflow:6']/opendaylight-inventory:node-connector[opendaylight-inventory:id='openflow:6:2']",
      "tp-id": "openflow:6:2"
    },
    {
      "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inventory:node[opendaylight-inventory:id='openflow:6']/opendaylight-inventory:node-connector[opendaylight-inventory:id='openflow:6:3']",
      "tp-id": "openflow:6:3"
    },
    {
      "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inventory:node[opendaylight-inventory:id='openflow:6']/opendaylight-inventory:node-connector[opendaylight-inventory:id='openflow:6:LOCAL']",
      "tp-id": "openflow:6:LOCAL"
    },
    {
      "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inventory:node[opendaylight-inventory:id='openflow:6']/opendaylight-inventory:node-connector[opendaylight-inventory:id='openflow:6:1']",
      "tp-id": "openflow:6:1"
    }
  ]
},
  "topology-id": "flow:1"
}
ks-sdn@sdn_server:~$ _

```

- Get node details

```

File  Machine  View  Input  Devices  Help
      "node-id": "openflow:6",
      "opendaylight-topology-inventory:inventory-node-ref": "/opendaylight-inventory:nodes/opendaylight-inventory:node[opendaylight-inventory:id='openflow:6']",
      "termination-point": [
        {
          "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inventory:node[opendaylight-inventory:id='openflow:6']/opendaylight-inventory:node-connector[opendaylight-inventory:id='openflow:6:2']",
          "tp-id": "openflow:6:2"
        },
        {
          "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inventory:node[opendaylight-inventory:id='openflow:6']/opendaylight-inventory:node-connector[opendaylight-inventory:id='openflow:6:3']",
          "tp-id": "openflow:6:3"
        },
        {
          "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inventory:node[opendaylight-inventory:id='openflow:6']/opendaylight-inventory:node-connector[opendaylight-inventory:id='openflow:6:LOCAL']",
          "tp-id": "openflow:6:LOCAL"
        },
        {
          "opendaylight-topology-inventory:inventory-node-connector-ref": "/opendaylight-inventory:nodes/opendaylight-inventory:node[opendaylight-inventory:id='openflow:6']/opendaylight-inventory:node-connector[opendaylight-inventory:id='openflow:6:1']",
          "tp-id": "openflow:6:1"
        }
      ]
    },
    "topology-id": "flow:1"
  ]
}

ks-sdn@sdn_server:~$ curl -s -u admin:admin -X GET http://192.168.1.54:8181/restconf/operational/opendaylight-inventory:nodes/node/openflow:1 | python -m json.tool_

```

```
File  Machine  View  Input  Devices  Help
      "transmitted": 1338
    },
    "receive-crc-error": 0,
    "receive-drops": 0,
    "receive-errors": 0,
    "receive-frame-error": 0,
    "receive-over-run-error": 0,
    "transmit-drops": 0,
    "transmit-errors": 0
  },
  "stp-status-aware-node-connector:status": "forwarding"
}
],
"opendaylight-group-statistics:group-features": {
  "actions": [
    67076097
  ],
  "group-capabilities-supported": [
    "opendaylight-group-types:chaining",
    "opendaylight-group-types:select-weight",
    "opendaylight-group-types:select-liveness"
  ],
  "group-types-supported": [
    "opendaylight-group-types:group-indirect",
    "opendaylight-group-types:group-all",
    "opendaylight-group-types:group-ff",
    "opendaylight-group-types:group-select"
  ],
  "max-groups": [
    4294967040
  ]
}
}
]
}
ks-sdn@sdn_server:~$
```

- Get node flows info (JSON-default)

```
ks-sdn@sdn_server:~$ curl -s -u admin:admin -X GET http://192.168.1.54:8181/restconf/operational/opendaylight-inventory:nodes/node/openflow:1/table/0/ | python -m json.tool
```



```
File Machine View Input Devices Help
}
}
}
}
},
"order": 0
}
]
},
"match": {
  "ethernet-match": {
    "ethernet-type": {
      "type": 35020
    }
  }
},
"opendaylight-flow-statistics:flow-statistics": {
  "byte-count": 264860,
  "duration": {
    "nanosecond": 342000000,
    "second": 7788
  },
  "packet-count": 3116
},
"priority": 100,
"table_id": 0
},
],
"id": 0,
"opendaylight-flow-table-statistics:flow-table-statistics": {
  "active-flows": 4,
  "packets-looked-up": 3260,
  "packets-matched": 3254
}
}
]
}
ks-sdn@sdn_server:~$
```

- Get node flows info (XML)

```
File  Machine  View  Input  Devices  Help
ks-sdn@sdn_server:~$ curl -s -u admin:admin -H 'Accept: application/xml' -H 'Content-Type: applicati
on/xml' -X GET http://192.168.1.54:8181/restconf/operational/opendaylight-inventory:nodes/node/openf
low:1/table/0/ | xmllint --format -

Command 'xmllint' not found, but can be installed with:

sudo snap install libxml2          # version 2.9.9+pkg-0333, or
sudo apt install libxml2-utils

See 'snap info libxml2' for additional versions.

ks-sdn@sdn_server:~$ sudo apt install libxml2-utils
[sudo] password for ks-sdn:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  libxml2-utils
0 upgraded, 1 newly installed, 0 to remove and 33 not upgraded.
Need to get 35.9 kB of archives.
After this operation, 173 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 libxml2-utils amd64 2.9.4+dfsg1-
6.1ubuntu1.6 [35.9 kB]
Fetched 35.9 kB in 0s (80.4 kB/s)
Selecting previously unselected package libxml2-utils.
(Reading database ... 143510 files and directories currently installed.)
Preparing to unpack .../libxml2-utils_2.9.4+dfsg1-6.1ubuntu1.6_amd64.deb ...
Unpacking libxml2-utils (2.9.4+dfsg1-6.1ubuntu1.6) ...
Setting up libxml2-utils (2.9.4+dfsg1-6.1ubuntu1.6) ...
Processing triggers for man-db (2.8.3-2ubuntu0.1) ...
ks-sdn@sdn_server:~$
```

```
File Machine View Input Devices Help
<duration>
  <nanosecond>699000000</nanosecond>
  <second>8954</second>
</duration>
<byte-count>304640</byte-count>
</flow-statistics>
<priority>100</priority>
<table_id>0</table_id>
<cookie_mask>0</cookie_mask>
<hard-timeout>0</hard-timeout>
<match>
  <ethernet-match>
    <ethernet-type>
      <type>85020</type>
    </ethernet-type>
  </ethernet-match>
</match>
<cookie>3098476543630901250</cookie>
<flags/>
<instructions>
  <instruction>
    <order>0</order>
    <apply-actions>
      <action>
        <order>0</order>
        <output-action>
          <max-length>65535</max-length>
          <output-node-connector>CONTROLLER</output-node-connector>
        </output-action>
      </action>
    </apply-actions>
  </instruction>
</instructions>
<idle-timeout>0</idle-timeout>
</flow>
</table>
ks-sdn@sdn_server:~$
```

- **Get node port details**

```
File Machine View Input Devices Help
ks-sdn@sdn_server:~$ curl -s -u admin:admin -X GET http://192.168.1.54:8181/restconf/operational/opendaylight-inventory:nodes/node/openflow:1/node-connector/openflow:1:2 | python -m json.tool
```

```
File Machine View Input Devices Help
{"flow-node-inventory:name": "s1-eth2",
 "flow-node-inventory:peer-features": "",
 "flow-node-inventory:port-number": 2,
 "flow-node-inventory:state": {
   "blocked": false,
   "link-down": false,
   "live": true
 },
 "flow-node-inventory:supported": "",
 "id": "openflow:1:2",
 "opendaylight-port-statistics:flow-capable-node-connector-statistics": {
   "bytes": {
     "received": 164606,
     "transmitted": 165306
   },
   "collision-count": 0,
   "duration": {
     "nanosecond": 549000000,
     "second": 9360
   },
   "packets": {
     "received": 1949,
     "transmitted": 1959
   },
   "receive-crc-error": 0,
   "receive-drops": 0,
   "receive-errors": 0,
   "receive-frame-error": 0,
   "receive-over-run-error": 0,
   "transmit-drops": 0,
   "transmit-errors": 0
 },
 "stp-status-aware-node-connector:status": "forwarding"
 }
 ]
}
ks-sdn@sdn_server:~$ _
```

EXERCISE TWO

- Created flows file
 - l2-flows.json
 - Shown below

```
1  "flow-node-inventory:table" : [  
    {  
      "flow" : [  
        {  
          "cookie": 3026418949592973313,  
          "cookie_mask": 0,  
          "flags": "",  
          "hard-timeout": 300,  
          "id": "#UF$TABLE*0-4",  
          "idle-timeout": 600,  
          "instructions": {  
            "instruction": [  
              {  
                "apply-actions": {  
                  "action": [  
                    {  
                      "order": 0,  
                      "output-action": {  
                        "max-length": 65535,  
                        "output-node-connector": "1"  
                      }  
                    }  
                  ]  
                },  
                "order": 0  
              }  
            ]  
          },  
          "match": {  
            "ethernet-match": {  
              "ethernet-destination": { "address": "00:00:00:00:00:01" },  
[ Read 484 lines ]
```

```
        {
          "order": 0,
          "output-action": {
            "max-length": 65535,
            "output-node-connector": "1"
          }
        }
      ],
      "order": 0
    },
    "match": {
      "ethernet-match": {
        "ethernet-destination": { "address": "00:00:00:00:00:01" },
        "ethernet-source": { "address": "00:00:00:00:00:03" }
      },
      "opendaylight-flow-statistics:flow-statistics": {
        "byte-count": 0,
        "duration": {
          "nanosecond": 310000000,
          "second": 7
        },
        "packet-count": 0
      },
      "priority": 10,
      "table_id": 0
    },
    "cookie": 3026418949592973312,
```

```
        "duration": {
          "nanosecond": 310000000,
          "second": 7
        },
        "packet-count": 0
      },
      "priority": 10,
      "table_id": 0
    },
    "cookie": 3026418949592973315,
    "cookie_mask": 0,
    "flags": "",
    "hard-timeout": 300,
    "id": "L2switch-3",
    "idle-timeout": 600,
    "instructions": {
      "instruction": [
        {
          "apply-actions": {
            "action": [
              {
                "order": 0,
                "output-action": {
                  "max-length": 65535,
                  "output-node-connector": "2"
                }
              }
            ]
          }
        },
        {
          "order": 0
        }
      ]
    }
  }
}
```

```
    "instructions": {
      "instruction": [
        {
          "apply-actions": {
            "action": [
              {
                "order": 0,
                "output-action": {
                  "max-length": 65535,
                  "output-node-connector": "2"
                }
              }
            ]
          },
          "order": 0
        }
      ]
    },
    "match": {
      "ethernet-match": {
        "ethernet-destination": { "address": "00:00:00:00:00:02" },
        "ethernet-source": { "address": "00:00:00:00:00:03" }
      }
    },
    "opendaylight-flow-statistics:flow-statistics": {
      "byte-count": 0,
      "duration": {
        "nanosecond": 310000000,
        "second": 7
      },
      "packet-count": 0
    },
  },
```



```
    ]
  },
  "match": {
    "ethernet-match": {
      "ethernet-destination": { "address": "00:00:00:00:00:02" },
      "ethernet-source": { "address": "00:00:00:00:00:03" }
    }
  },
  "opendaylight-flow-statistics:flow-statistics": {
    "byte-count": 0,
    "duration": {
      "nanosecond": 310000000,
      "second": 7
    },
    "packet-count": 0
  },
  "priority": 10,
  "table_id": 0
},
{
  "cookie": 3098476543630901250,
  "cookie_mask": 0,
  "flags": "",
  "hard-timeout": 0,
  "id": "L2switch-2",
  "idle-timeout": 0,
  "instructions": {
    "instruction": [
      {
        "apply-actions": {
          "action": [
            {
```

```
        "priority": 10,  
        "table_id": 0  
    },  
    {  
        "cookie": 3098476543630901250,  
        "cookie_mask": 0,  
        "flags": "",  
        "hard-timeout": 0,  
        "id": "L2switch-2",  
        "idle-timeout": 0,  
        "instructions": {  
            "instruction": [  
                {  
                    "apply-actions": {  
                        "action": [  
                            {  
                                "order": 2,  
                                "output-action": {  
                                    "max-length": 65535,  
                                    "output-node-connector": "CONTROLLER"  
                                }  
                            },  
                            {  
                                "order": 1,  
                                "output-action": {  
                                    "max-length": 65535,  
                                    "output-node-connector": "2"  
                                }  
                            }  
                        ],  
                        "order": 0,  
                        "output-action": {
```

```
        "order": 2,  
        "output-action": {  
            "max-length": 65535,  
            "output-node-connector": "CONTROLLER"  
        }  
    },  
    {  
        "order": 1,  
        "output-action": {  
            "max-length": 65535,  
            "output-node-connector": "2"  
        }  
    },  
    {  
        "order": 0,  
        "output-action": {  
            "max-length": 65535,  
            "output-node-connector": "3"  
        }  
    }  
]  
},  
"order": 0  
}  
]  
},  
"match": {  
    "in-port": "1"  
},  
"opendaylight-flow-statistics:flow-statistics": {  
    "byte-count": 0,  
    "duration": {
```

```
        "max-length": 65535,  
        "output-node-connector": "3"  
      }  
    ]  
  },  
  "order": 0  
},  
],  
},  
"match": {  
  "in-port": "1"  
},  
"opendaylight-flow-statistics:flow-statistics": {  
  "byte-count": 0,  
  "duration": {  
    "nanosecond": 105000000,  
    "second": 10  
  },  
  "packet-count": 0  
},  
"priority": 2,  
"table_id": 0  
},  
{  
  "cookie": 3026418949592973314,  
  "cookie_mask": 0,  
  "flags": "",  
  "hard-timeout": 300,  
  "id": "#UF$TABLE*0-5",  
  "idle-timeout": 600,  
  "instructions": {
```

```
        "nanosecond": 105000000,  
        "second": 10  
    },  
    "packet-count": 0  
},  
"priority": 2,  
"table_id": 0  
},  
{  
    "cookie": 3026418949592973314,  
    "cookie_mask": 0,  
    "flags": "",  
    "hard-timeout": 300,  
    "id": "#UF$TABLE*0-5",  
    "idle-timeout": 600,  
    "instructions": {  
        "instruction": [  
            {  
                "apply-actions": {  
                    "action": [  
                        {  
                            "order": 0,  
                            "output-action": {  
                                "max-length": 65535,  
                                "output-node-connector": "3"  
                            }  
                        }  
                    ]  
                }  
            ]  
        },  
        "order": 0  
    ]  
}
```

```
        "instruction": [
          {
            "apply-actions": {
              "action": [
                {
                  "order": 0,
                  "output-action": {
                    "max-length": 65535,
                    "output-node-connector": "3"
                  }
                }
              ]
            },
            "order": 0
          }
        ],
        "match": {
          "ethernet-match": {
            "ethernet-destination": { "address": "00:00:00:00:00:03" },
            "ethernet-source": { "address": "00:00:00:00:00:02" }
          }
        },
        "opendaylight-flow-statistics:flow-statistics": {
          "byte-count": 0,
          "duration": {
            "nanosecond": 310000000,
            "second": 7
          },
          "packet-count": 0
        },
        "priority": 10,
```

```
    },
    "match": {
      "ethernet-match": {
        "ethernet-destination": { "address": "00:00:00:00:00:03" },
        "ethernet-source": { "address": "00:00:00:00:00:02" }
      }
    },
    "opendaylight-flow-statistics:flow-statistics": {
      "byte-count": 0,
      "duration": {
        "nanosecond": 310000000,
        "second": 7
      },
      "packet-count": 0
    },
    "priority": 10,
    "table_id": 0
  },
  {
    "cookie": 3098476543630901249,
    "cookie_mask": 0,
    "flags": "",
    "hard-timeout": 0,
    "id": "L2switch-1",
    "idle-timeout": 0,
    "instructions": {
      "instruction": [
        {
          "apply-actions": {
            "action": [
              {
                "order": 2,
```

```
    "table_id": 0
  },
  {
    "cookie": 3098476543630901249,
    "cookie_mask": 0,
    "flags": "",
    "hard-timeout": 0,
    "id": "L2switch-1",
    "idle-timeout": 0,
    "instructions": {
      "instruction": [
        {
          "apply-actions": {
            "action": [
              {
                "order": 2,
                "output-action": {
                  "max-length": 65535,
                  "output-node-connector": "CONTROLLER"
                }
              },
              {
                "order": 1,
                "output-action": {
                  "max-length": 65535,
                  "output-node-connector": "1"
                }
              },
              {
                "order": 0,
                "output-action": {
                  "max-length": 65535,
```



```
        "output-action": {
          "max-length": 65535,
          "output-node-connector": "CONTROLLER"
        },
      },
      {
        "order": 1,
        "output-action": {
          "max-length": 65535,
          "output-node-connector": "1"
        }
      },
      {
        "order": 0,
        "output-action": {
          "max-length": 65535,
          "output-node-connector": "3"
        }
      }
    ],
    "order": 0
  },
  "match": { "in-port": "2" },
  "opendaylight-flow-statistics:flow-statistics": {
    "byte-count": 0,
    "duration": {
      "nanosecond": 104000000,
      "second": 10
    }
  },
}
```

```
        "output-node-connector": "3"
      }
    }
  ],
  "order": 0
},
{
  "match": { "in-port": "2" },
  "opendaylight-flow-statistics:flow-statistics": {
    "byte-count": 0,
    "duration": {
      "nanosecond": 104000000,
      "second": 10
    },
    "packet-count": 0
  },
  "priority": 2,
  "table_id": 0
},
{
  "cookie": 3098476543630901248,
  "cookie_mask": 0,
  "flags": "",
  "hard-timeout": 0,
  "id": "L2switch-0",
  "idle-timeout": 0,
  "match": {},
  "opendaylight-flow-statistics:flow-statistics": {
    "byte-count": 0,
    "duration": {
```

```
        "packet-count": 0
      },
      "priority": 2,
      "table_id": 0
    },
    {
      "cookie": 3098476543630901248,
      "cookie_mask": 0,
      "flags": "",
      "hard-timeout": 0,
      "id": "L2switch-0",
      "idle-timeout": 0,
      "match": {},
      "opendaylight-flow-statistics:flow-statistics": {
        "byte-count": 0,
        "duration": {
          "nanosecond": 741000000,
          "second": 11
        },
        "packet-count": 0
      },
      "priority": 0,
      "table_id": 0
    },
    {
      "cookie": 3026418949592973319,
      "cookie_mask": 0,
      "flags": "",
      "hard-timeout": 300,
      "id": "L2switch-7",
      "idle-timeout": 600,
      "instructions": {
```

```
        "nanosecond": 741000000,  
        "second": 11  
      },  
      "packet-count": 0  
    },  
    "priority": 0,  
    "table_id": 0  
  },  
  {  
    "cookie": 3026418949592973319,  
    "cookie_mask": 0,  
    "flags": "",  
    "hard-timeout": 300,  
    "id": "L2switch-7",  
    "idle-timeout": 600,  
    "instructions": {  
      "instruction": [  
        {  
          "apply-actions": {  
            "action": [  
              {  
                "order": 0,  
                "output-action": {  
                  "max-length": 65535,  
                  "output-node-connector": "2"  
                }  
              }  
            ]  
          }  
        },  
        {  
          "order": 0  
        }  
      ]  
    }  
  }  
]
```

```
    "instruction": [
      {
        "apply-actions": {
          "action": [
            {
              "order": 0,
              "output-action": {
                "max-length": 65535,
                "output-node-connector": "2"
              }
            }
          ]
        },
        "order": 0
      }
    ],
    "match": {
      "ethernet-match": {
        "ethernet-destination": { "address": "00:00:00:00:00:02" },
        "ethernet-source": { "address": "00:00:00:00:00:01" }
      }
    },
    "opendaylight-flow-statistics:flow-statistics": {
      "byte-count": 0,
      "duration": {
        "nanosecond": 906000000,
        "second": 3
      },
      "packet-count": 0
    },
    "priority": 10,
```

```
    },
    "match": {
      "ethernet-match": {
        "ethernet-destination": { "address": "00:00:00:00:00:02" },
        "ethernet-source": { "address": "00:00:00:00:00:01" }
      }
    },
    "opendaylight-flow-statistics:flow-statistics": {
      "byte-count": 0,
      "duration": {
        "nanosecond": 906000000,
        "second": 3
      },
      "packet-count": 0
    },
    "priority": 10,
    "table_id": 0
  },
  {
    "cookie": 3026418949592973318,
    "cookie_mask": 0,
    "flags": "",
    "hard-timeout": 300,
    "id": "L2switch-6",
    "idle-timeout": 600,
    "instructions": {
      "instruction": [
        {
          "apply-actions": {
            "action": [
              {
                "order": 0,
```

```
    "table_id": 0
  },
  {
    "cookie": 3026418949592973318,
    "cookie_mask": 0,
    "flags": "",
    "hard-timeout": 300,
    "id": "L2switch-6",
    "idle-timeout": 600,
    "instructions": {
      "instruction": [
        {
          "apply-actions": {
            "action": [
              {
                "order": 0,
                "output-action": {
                  "max-length": 65535,
                  "output-node-connector": "1"
                }
              }
            ]
          },
          "order": 0
        }
      ]
    },
    "match": {
      "ethernet-match": {
        "ethernet-destination": { "address": "00:00:00:00:00:01" },
        "ethernet-source": { "address": "00:00:00:00:00:02" }
      }
    }
  }
}
```

```
        "output-action": {
          "max-length": 65535,
          "output-node-connector": "1"
        }
      ],
    },
    "order": 0
  }
],
},
"match": {
  "ethernet-match": {
    "ethernet-destination": { "address": "00:00:00:00:00:01" },
    "ethernet-source": { "address": "00:00:00:00:00:02" }
  },
},
"opendaylight-flow-statistics:flow-statistics": {
  "byte-count": 0,
  "duration": {
    "nanosecond": 907000000,
    "second": 3
  },
  "packet-count": 0
},
"priority": 10,
"table_id": 0
},
{
  "cookie": 3098476543630901248,
  "cookie_mask": 0,
  "flags": "",
```



```
    },
    "opendaylight-flow-statistics:flow-statistics": {
      "byte-count": 0,
      "duration": {
        "nanosecond": 907000000,
        "second": 3
      },
      "packet-count": 0
    },
    "priority": 10,
    "table_id": 0
  },
  {
    "cookie": 3098476543630901248,
    "cookie_mask": 0,
    "flags": "",
    "hard-timeout": 0,
    "id": "#UF$TABLE*0-2",
    "idle-timeout": 0,
    "instructions": {
      "instruction": [
        {
          "apply-actions": {
            "action": [
              {
                "order": 2,
                "output-action": {
                  "max-length": 65535,
                  "output-node-connector": "CONTROLLER"
                }
              }
            ]
          }
        }
      ]
    }
  }
}
```

```
"hard-timeout": 0,  
"id": "#UF$TABLE*0-2",  
"idle-timeout": 0,  
"instructions": {  
  "instruction": [  
    {  
      "apply-actions": {  
        "action": [  
          {  
            "order": 2,  
            "output-action": {  
              "max-length": 65535,  
              "output-node-connector": "CONTROLLER"  
            }  
          },  
          {  
            "order": 1,  
            "output-action": {  
              "max-length": 65535,  
              "output-node-connector": "1"  
            }  
          },  
          {  
            "order": 0,  
            "output-action": {  
              "max-length": 65535,  
              "output-node-connector": "2"  
            }  
          }  
        ]  
      }  
    },  
    {  
      "order": 0
```

```
        "order": 1,
        "output-action": {
          "max-length": 65535,
          "output-node-connector": "1"
        }
      },
      {
        "order": 0,
        "output-action": {
          "max-length": 65535,
          "output-node-connector": "2"
        }
      }
    ]
  },
  "order": 0
}
],
"match": {
  "in-port": "3"
},
"opendaylight-flow-statistics:flow-statistics": {
  "byte-count": 0,
  "duration": {
    "nanosecond": 104000000,
    "second": 10
  },
  "packet-count": 0
},
"priority": 2,
"table_id": 0
```

```
    }
  ]
},
"match": {
  "in-port": "3"
},
"opendaylight-flow-statistics:flow-statistics": {
  "byte-count": 0,
  "duration": {
    "nanosecond": 104000000,
    "second": 10
  },
  "packet-count": 0
},
"priority": 2,
"table_id": 0
},
{
  "cookie": 3098476543630901248,
  "cookie_mask": 0,
  "flags": "",
  "hard-timeout": 0,
  "id": "#UF$TABLE*0-1",
  "idle-timeout": 0,
  "instructions": {
    "instruction": [
      {
        "apply-actions": {
          "action": [
            {
              "order": 0,
              "output-action": {
```

```
    },
    {
      "cookie": 3098476543630901248,
      "cookie_mask": 0,
      "flags": "",
      "hard-timeout": 0,
      "id": "#UF$TABLE*0-1",
      "idle-timeout": 0,
      "instructions": {
        "instruction": [
          {
            "apply-actions": {
              "action": [
                {
                  "order": 0,
                  "output-action": {
                    "max-length": 65535,
                    "output-node-connector": "CONTROLLER"
                  }
                }
              ]
            }
          },
          {
            "order": 0
          }
        ]
      }
    },
    {
      "match": {
        "ethernet-match": { "ethernet-type": {
          "type": 35020 }
        }
      }
    },
    "opendaylight-flow-statistics:flow-statistics": {
```

```
        "max-length": 65535,  
        "output-node-connector": "CONTROLLER"  
      }  
    ]  
  },  
  "order": 0  
}  
],  
"match": {  
  "ethernet-match": { "ethernet-type": {  
    "type": 35020 }  
  }  
},  
"opendaylight-flow-statistics:flow-statistics": {  
  "byte-count": 0,  
  "duration": {  
    "nanosecond": 740000000,  
    "second": 11  
  },  
  "packet-count": 0  
},  
"priority": 100,  
"table_id": 0  
},  
"id": 0,  
"opendaylight-flow-table-statistics:flow-table-statistics": {  
  "active-flows": 0,  
  "packets-looked-up": 0,  
  "packets-matched": 0  
}
```

```
File  Machine  View  Input  Devices  Help
GNU nano 2.9.3 12-flows.json

        "byte-count": 0,
        "duration": {
            "nanosecond": 740000000,
            "second": 11
        },
        "packet-count": 0
    },
    "priority": 100,
    "table_id": 0
}
},
"id": 0,
"opendaylight-flow-table-statistics:flow-table-statistics": {
    "active-flows": 0,
    "packets-looked-up": 0,
    "packets-matched": 0
}
}
]
}
```

^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos M-U Undo
^X Exit ^R Read File ^_ Replace ^U Uncut Text ^I To Spell _ Go To Line M-E Redo

- Push flows via API

```
File  Machine  View  Input  Devices  Help
ks-sdn@sdn_server:~$ curl -u admin:admin -H 'Accept: application/json' -H 'Content-Type:application/
json' -X PUT -d @12-flows.json http://192.168.1.54:8181/restconf/config/opendaylight-inventory:nodes
/node/openflow:1/table/0/_
```

```
File Machine View Input Devices Help
g.apache.shiro.web.servlet.AdviceFilter.doFilterInternal(AdviceFilter.java:137)\n\tat org.apache.shi
ro.web.servlet.OncePerRequestFilter.doFilter(OncePerRequestFilter.java:125)\n\tat org.apache.shiro.w
eb.servlet.ProxiedFilterChain.doFilter(ProxiedFilterChain.java:66)\n\tat org.apache.shiro.web.servle
t.AdviceFilter.executeChain(AdviceFilter.java:108)\n\tat org.apache.shiro.web.servlet.AdviceFilter.d
oFilterInternal(AdviceFilter.java:137)\n\tat org.apache.shiro.web.servlet.OncePerRequestFilter.doFil
ter(OncePerRequestFilter.java:125)\n\tat org.apache.shiro.web.servlet.ProxiedFilterChain.doFilter(Pr
oxiedFilterChain.java:66)\n\tat org.apache.shiro.web.servlet.AbstractShiroFilter.executeChain(Abstra
ctShiroFilter.java:449)\n\tat org.apache.shiro.web.servlet.AbstractShiroFilter$1.call(AbstractShiroF
ilter.java:365)\n\tat org.apache.shiro.subject.support.SubjectCallable.doCall(SubjectCallable.java:9
0)\n\tat org.apache.shiro.subject.support.SubjectCallable.call(SubjectCallable.java:83)\n\tat org.ap
ache.shiro.subject.support.DelegatingSubject.execute(DelegatingSubject.java:383)\n\tat org.apache.sh
iro.web.servlet.AbstractShiroFilter.doFilterInternal(AbstractShiroFilter.java:362)\n\tat org.apache.
shiro.web.servlet.OncePerRequestFilter.doFilter(OncePerRequestFilter.java:125)\n\tat org.eclipse.jet
ty.servlet.ServletHandler$CachedChain.doFilter(ServletHandler.java:1478)\n\tat org.eclipse.jetty.ser
vlet.ServletHandler.doHandle(ServletHandler.java:499)\n\tat org.ops4j.pax.web.service.jetty.internal
.HttpServiceServletHandler.doHandle(HttpServiceServletHandler.java:69)\n\tat org.eclipse.jetty.serve
r.handler.ScopedHandler.handle(ScopedHandler.java:137)\n\tat org.eclipse.jetty.security.SecurityHand
ler.handle(SecurityHandler.java:557)\n\tat org.eclipse.jetty.server.session.SessionHandler.doHandle(
SessionHandler.java:231)\n\tat org.eclipse.jetty.server.handler.ContextHandler.doHandle(ContextHandl
er.java:1086)\n\tat org.ops4j.pax.web.service.jetty.internal.HttpServiceContext.doHandle(HttpService
Context.java:240)\n\tat org.eclipse.jetty.servlet.ServletHandler.doScope(ServletHandler.java:427)\n\t
at org.eclipse.jetty.server.session.SessionHandler.doScope(SessionHandler.java:193)\n\tat org.eclip
se.jetty.server.handler.ContextHandler.doScope(ContextHandler.java:1020)\n\tat org.eclipse.jetty.ser
ver.handler.ScopedHandler.handle(ScopedHandler.java:135)\n\tat org.ops4j.pax.web.service.jetty.inter
nal.JettyServerHandlerCollection.handle(JettyServerHandlerCollection.java:75)\n\tat org.eclipse.jet
ty.server.handler.HandlerWrapper.handle(HandlerWrapper.java:116)\n\tat org.eclipse.jetty.server.Serve
r.handle(Server.java:370)\n\tat org.eclipse.jetty.server.AbstractHttpConnection.handleRequest(Abstra
ctHttpConnection.java:494)\n\tat org.eclipse.jetty.server.AbstractHttpConnection.headerComplete(Abst
ractHttpConnection.java:973)\n\tat org.eclipse.jetty.server.AbstractHttpConnection$RequestHandler.he
aderComplete(AbstractHttpConnection.java:1035)\n\tat org.eclipse.jetty.http.HttpParser.parseNext(Htt
pParser.java:647)\n\tat org.eclipse.jetty.http.HttpParser.parseAvailable(HttpParser.java:231)\n\tat
org.eclipse.jetty.server.AsyncHttpConnection.handle(AsyncHttpConnection.java:82)\n\tat org.eclipse.j
etty.io.nio.SelectChannelEndPoint.handle(SelectChannelEndPoint.java:696)\n\tat org.eclipse.jetty.io.
nio.SelectChannelEndPoint$1.run(SelectChannelEndPoint.java:53)\n\tat org.eclipse.jetty.util.thread.Q
ueuedThreadPool.runJob(QueuedThreadPool.java:608)\n\tat org.eclipse.jetty.util.thread.QueuedThreadPo
ol$3.run(QueuedThreadPool.java:543)\n\tat java.lang.Thread.run(Thread.java:748)\n\n}}}}ks-sdn@sdn_ser
ver:~$
```

- Get flows info via API

```
o1$3.run(QueuedThreadPool.java:543)\n\tat java.lang.Thread.run(Thread.java:748)\n\n}}}}ks-sdn@sdn_ser
ver:~$
ks-sdn@sdn_server:~$ curl -s -u admin:admin -X GET http://192.168.1.54:8181/restconf/operational/ope
ndaylight-inventory:nodes/node/openflow:1/table/0/ | python -m json.tool_
```



```
File Machine View Input Devices Help
"order": 0,
"output-action": {
  "max-length": 65535,
  "output-node-connector": "1"
}
}
]
},
"order": 0
}
]
},
"match": {
  "in-port": "2"
},
"opendaylight-flow-statistics:flow-statistics": {
  "byte-count": 15890,
  "duration": {
    "nanosecond": 283000000,
    "second": 33918
  },
  "packet-count": 227
},
"priority": 2,
"table_id": 0
}
],
"id": 0,
"opendaylight-flow-table-statistics:flow-table-statistics": {
  "active-flows": 4,
  "packets-looked-up": 14034,
  "packets-matched": 14034
}
}
]
}
ks-sdn@sdn_server:~$
```

- Perform the tests via MN console

```

mininet> dpctl dump-flows - OpenFlow13
*** s1 -----
ovs-ofctl: 'dump-flows' command takes at most 2 arguments
*** s2 -----
ovs-ofctl: 'dump-flows' command takes at most 2 arguments
*** s3 -----
ovs-ofctl: 'dump-flows' command takes at most 2 arguments
*** s4 -----
ovs-ofctl: 'dump-flows' command takes at most 2 arguments
*** s5 -----
ovs-ofctl: 'dump-flows' command takes at most 2 arguments
*** s6 -----
ovs-ofctl: 'dump-flows' command takes at most 2 arguments
*** s7 -----
ovs-ofctl: 'dump-flows' command takes at most 2 arguments
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5 h6 h7 h8
h2 -> h1 h3 h4 h5 h6 h7 h8
h3 -> h1 h2 h4 h5 h6 h7 h8
h4 -> h1 h2 h3 h5 h6 h7 h8
h5 -> h1 h2 h3 h4 h6 h7 h8
h6 -> h1 h2 h3 h4 h5 h7 h8
h7 -> h1 h2 h3 h4 h5 h6 h8
h8 -> h1 h2 h3 h4 h5 h6 h7
*** Results: 0% dropped (56/56 received)
mininet> _

```

```

ks-sdn@sdn_server:~$ curl -u admin:admin -H 'Accept: application/json' -H 'Content-Type: application
/json' -X DELETE -d @12-flows.json http://192.168.1.54:8181/restconf/config/.opendaylight-inventory:n
odes/node/openflow:1/table/0/

```

```

ks-sdn@sdn_server:~$ curl -u admin:admin -H 'Accept: application/json' -H 'Content-Type: application
/json' -X DELETE -d @12-flows.json http://192.168.1.54:8181/restconf/config/.opendaylight-inventory:n
odes/node/openflow:1/table/0/
{"errors":[{"error":[{"error-type":"protocol","error-tag":"data-missing","error-message":"Data does n
ot exist for path: /(urn:opendaylight:inventory?revision=2013-08-19)nodes/node/node[{{(urn:opendaylig
ht:inventory?revision=2013-08-19)id=openflow:1}}/AugmentationIdentifier{childNames=[(urn:opendaylight:
flow:inventory?revision=2013-08-19)supported-match-types, (urn:opendaylight:flow:inventory?revisio
n=2013-08-19)supported-instructions, (urn:opendaylight:flow:inventory?revision=2013-08-19)supported-
actions, (urn:opendaylight:flow:inventory?revision=2013-08-19)switch-features, (urn:opendaylight:flow:
inventory?revision=2013-08-19)manufacturer, (urn:opendaylight:flow:inventory?revision=2013-08-19)h
ardware, (urn:opendaylight:flow:inventory?revision=2013-08-19)software, (urn:opendaylight:flow:inven
tory?revision=2013-08-19)serial-number, (urn:opendaylight:flow:inventory?revision=2013-08-19)descrip
tion, (urn:opendaylight:flow:inventory?revision=2013-08-19)port-number, (urn:opendaylight:flow:inven
tory?revision=2013-08-19)ip-address, (urn:opendaylight:flow:inventory?revision=2013-08-19)meter, (ur
n:opendaylight:flow:inventory?revision=2013-08-19)stale-meter, (urn:opendaylight:flow:inventory?revi
sion=2013-08-19)group, (urn:opendaylight:flow:inventory?revision=2013-08-19)stale-group, (urn:openda
ylight:flow:inventory?revision=2013-08-19)table, (urn:opendaylight:flow:inventory?revision=2013-08-1
9)table-features]}(urn:opendaylight:flow:inventory?revision=2013-08-19)table/table[{{(urn:opendaylig
ht:flow:inventory?revision=2013-08-19)id=0}}"]}]}]}ks-sdn@sdn_server:~$

```

```

mininet>
mininet> dpctl dump-flows -O OpenFlow13_

```

```

File  Machine  View  Input  Devices  Help
port="s4-eth1" actions=output:"s4-eth3",output:"s4-eth2",CONTROLLER:65535
cookie=0x2b00000000000004, duration=34946.801s, table=0, n_packets=23, n_bytes=2038, priority=0 act
ions=drop
*** s5 -----
cookie=0x2b00000000000003, duration=34946.959s, table=0, n_packets=20904, n_bytes=1776840, priority
=100,d1_type=0x88cc actions=CONTROLLER:65535
cookie=0x2b0000000000000e, duration=34833.494s, table=0, n_packets=358, n_bytes=25060, priority=2,i
n_port="s5-eth3" actions=output:"s5-eth2",output:"s5-eth1"
cookie=0x2b0000000000000f, duration=34833.493s, table=0, n_packets=162, n_bytes=11340, priority=2,i
n_port="s5-eth2" actions=output:"s5-eth3",output:"s5-eth1"
cookie=0x2b00000000000010, duration=34833.492s, table=0, n_packets=162, n_bytes=11340, priority=2,i
n_port="s5-eth1" actions=output:"s5-eth3",output:"s5-eth2"
cookie=0x2b00000000000003, duration=34946.959s, table=0, n_packets=17, n_bytes=1442, priority=0 act
ions=drop
*** s6 -----
cookie=0x2b00000000000000, duration=34947.131s, table=0, n_packets=6968, n_bytes=592280, priority=1
00,d1_type=0x88cc actions=CONTROLLER:65535
cookie=0x2b0000000000000b, duration=34833.534s, table=0, n_packets=537, n_bytes=37590, priority=2,i
n_port="s6-eth3" actions=output:"s6-eth2",output:"s6-eth1"
cookie=0x2b0000000000000c, duration=34833.532s, table=0, n_packets=72, n_bytes=5040, priority=2,in_
port="s6-eth2" actions=output:"s6-eth3",output:"s6-eth1",CONTROLLER:65535
cookie=0x2b0000000000000d, duration=34833.530s, table=0, n_packets=72, n_bytes=5040, priority=2,in_
port="s6-eth1" actions=output:"s6-eth3",output:"s6-eth2",CONTROLLER:65535
cookie=0x2b00000000000000, duration=34947.131s, table=0, n_packets=25, n_bytes=2230, priority=0 act
ions=drop
*** s7 -----
cookie=0x2b00000000000006, duration=34946.725s, table=0, n_packets=6968, n_bytes=592280, priority=1
00,d1_type=0x88cc actions=CONTROLLER:65535
cookie=0x2b00000000000008, duration=34833.555s, table=0, n_packets=72, n_bytes=5040, priority=2,in_
port="s7-eth2" actions=output:"s7-eth1",output:"s7-eth3",CONTROLLER:65535
cookie=0x2b00000000000009, duration=34833.554s, table=0, n_packets=72, n_bytes=5040, priority=2,in_
port="s7-eth1" actions=output:"s7-eth2",output:"s7-eth3",CONTROLLER:65535
cookie=0x2b0000000000000a, duration=34833.553s, table=0, n_packets=538, n_bytes=37660, priority=2,i
n_port="s7-eth3" actions=output:"s7-eth2",output:"s7-eth1"
cookie=0x2b00000000000006, duration=34946.725s, table=0, n_packets=23, n_bytes=2074, priority=0 act
ions=drop
mininet> _

```

EXERCISE THREE

- Created XML file (flow) PUSH via API

```

File  Machine  View  Input  Devices  Help
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<input xmlns="urn:opendaylight:flow:service">
  <node xmlns:inv="urn:opendaylight:inventory"/>inv:nodes/inv:node[inv:id="openflow:1"] </node>
  <table_id>0</table_id>
  <priority>2</priority>
  <match>
    <ethernet-match>
      <ethernet-type>
        <type>2048</type>
      </ethernet-type>
    </ethernet-match>
    <ipv4-destination>10.0.0.0/24</ipv4-destination>
  </match>
  <instructions>
    <instruction>
      <order>0</order>
      <apply-actions>
        <action>
          <output-action>
            <output-node-connector>1</output-node-connector>
          </output-action>
          <order>0</order>
        </action>
      </apply-actions>
    </instruction>
  </instructions>
</input>

ks-sdn@sdn_server:~$ curl -u admin:admin -H 'Accept: application/xml' -H 'Content-Type: application/xml' -X POST -d @push-flow_sal.xml http://192.168.1.54:8181/restconf/operations/sal-flow:add-flow
ks-sdn@sdn_server:~$

```

- **View a flow via API**

```

File  Machine  View  Input  Devices  Help
ks-sdn@sdn_server:~$ curl -s -u admin:admin -H 'Accept: application/xml' -H 'Content-Type: application/xml' -X GET http://192.168.1.54:8181/restconf/operational/opendaylight-inventory:nodes/node/openflow:1/table/0/ | xmllint --format -_

```

```

File  Machine  View  Input  Devices  Help
<flow>
  <id>L2switch-6</id>
  <flow-statistics xmlns="urn:opendaylight:flow:statistics">
    <packet-count>331</packet-count>
    <duration>
      <nanosecond>185000000</nanosecond>
      <second>6591</second>
    </duration>
    <byte-count>24626</byte-count>
  </flow-statistics>
  <priority>2</priority>
  <table_id>0</table_id>
  <cookie_mask>0</cookie_mask>
  <hard-timeout>0</hard-timeout>
  <match>
    <in-port>2</in-port>
  </match>
  <cookie>3098476543630901254</cookie>
  <flags/>
  <instructions>
    <instruction>
      <order>0</order>
      <apply-actions>
        <action>
          <order>0</order>
          <output-action>
            <max-length>65535</max-length>
            <output-node-connector>1</output-node-connector>
          </output-action>
        </action>
      </apply-actions>
    </instruction>
  </instructions>
  <idle-timeout>0</idle-timeout>
</flow>
</table>
ks-sdn@sdn_server:~$

```

- **Remove a Flow via API**

```

File  Machine  View  Input  Devices  Help
<flow-statistics xmlns="urn:opendaylight:flow:statistics">
  <packet-count>331</packet-count>
  <duration>
    <nanosecond>185000000</nanosecond>
    <second>6591</second>
  </duration>
  <byte-count>24626</byte-count>
</flow-statistics>
<priority>2</priority>
<table_id>0</table_id>
<cookie_mask>0</cookie_mask>
<hard-timeout>0</hard-timeout>
<match>
  <in-port>2</in-port>
</match>
<cookie>3098476543630901254</cookie>
<flags/>
<instructions>
  <instruction>
    <order>0</order>
    <apply-actions>
      <action>
        <order>0</order>
        <output-action>
          <max-length>65535</max-length>
          <output-node-connector>1</output-node-connector>
        </output-action>
      </action>
    </apply-actions>
  </instruction>
</instructions>
<idle-timeout>0</idle-timeout>
</flow>
</table>
ks-sdn@sdn_server:~$ curl -u admin:admin -H 'Accept: application/xml' -H 'Content-Type: application/
xml' -X POST -d @push-flow_sal.xml http://192.168.1.54:8181/restconf/operations/sal-flow:remove-flow
ks-sdn@sdn_server:~$ _

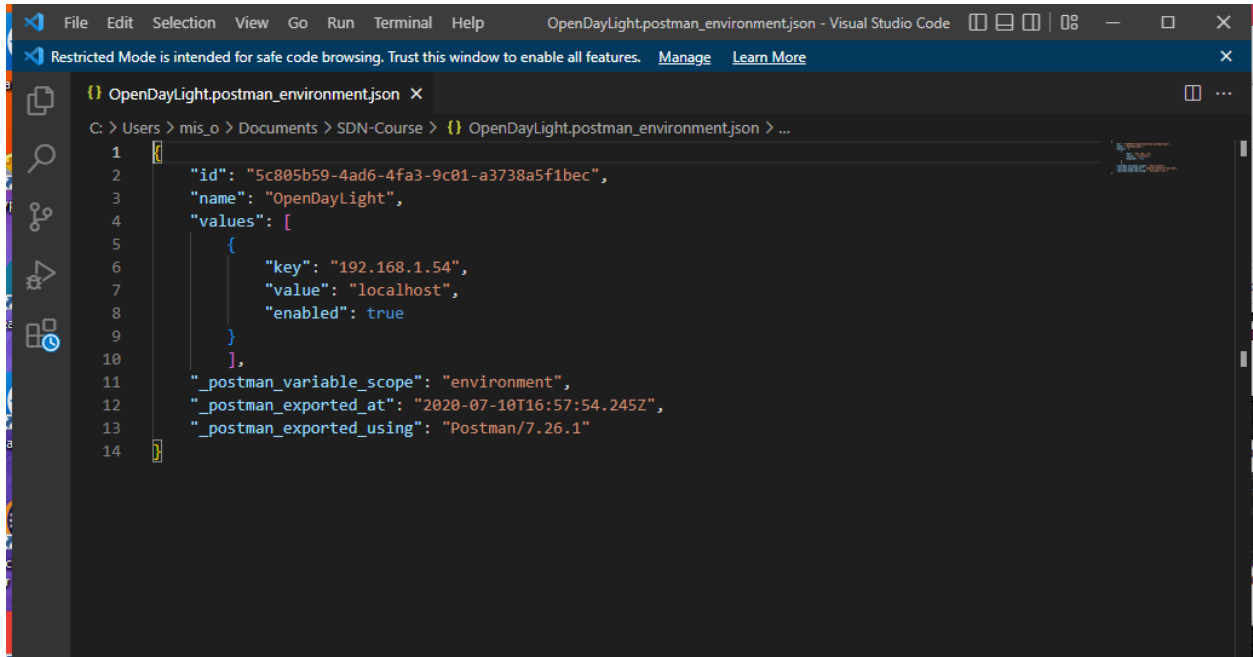
```

ODL & Postman

- **Created json files:**
 - Postman collection file: **OpenDayLight.postman_collection.json**
 - Postman environment file: **OpenDayLight.postman_environment.json**

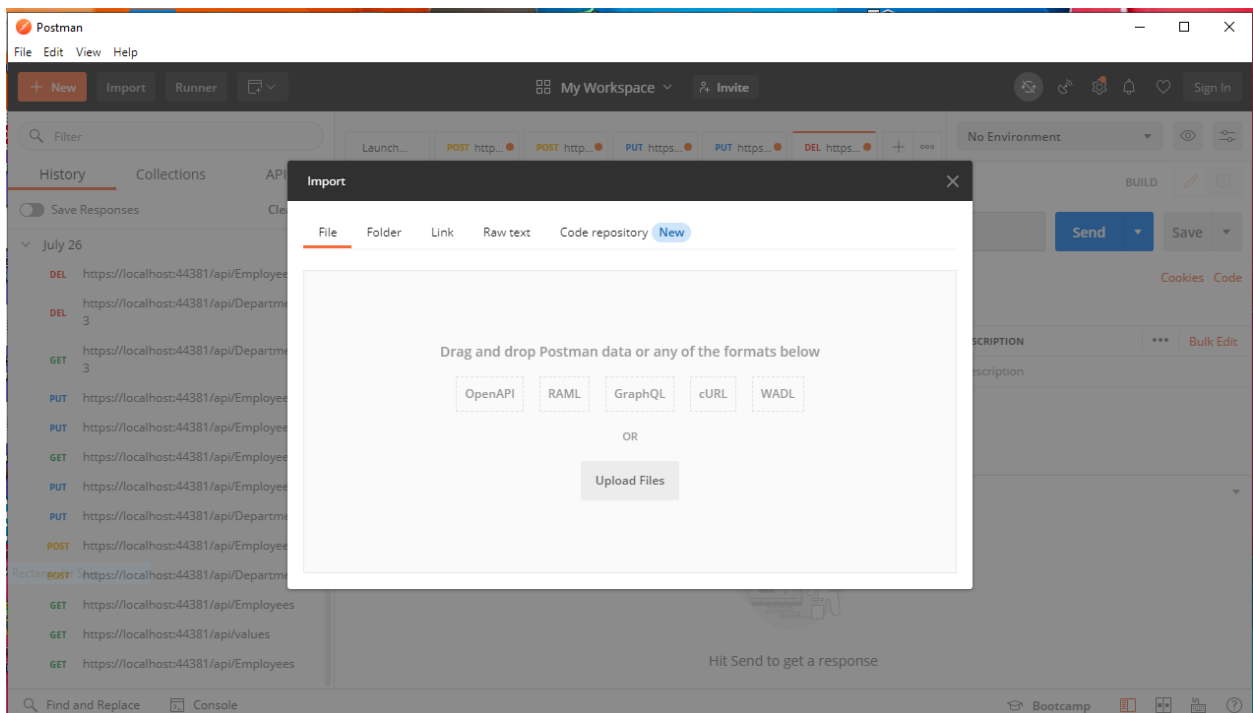
```
OpenDayLight.postman_collection.json X
C: > Users > mis_o > Documents > SDN-Course > OpenDayLight.postman_collection.json > [ ] item > { } 1 > { } request
1 {
2   "info": {
3     "_postman_id": "5101c91b-bda6-4987-b72b-580c8887114d",
4     "name": "OpenDayLight",
5     "schema": "https://schema.getpostman.com/json/collection/v2.1.0/collection.json",
6   },
7   "item": [
8     {
9       "name": "RESTCONF Capabilities",
10      "request": {
11        "method": "GET"
12        "header": [],
13        "url": {
14          "raw": "http://{{192.168.1.54}}:8181/restconf/operational/i",
15          "protocol": "http",
16          "host": [
17            "{{192.168.1.54}}"
18          ],
19          "port": "8181",
20          "path": [
21            "restconf",
22            "operational",
23            "ietf-restconf-monitoring:restconf-state",
24            "capabilities"
25          ]
26        }
27      },
28      "response": []
29    },
30    {
31      "name": "Nodes - Inventory",
32      "request": {
33        "method": "GET"
```

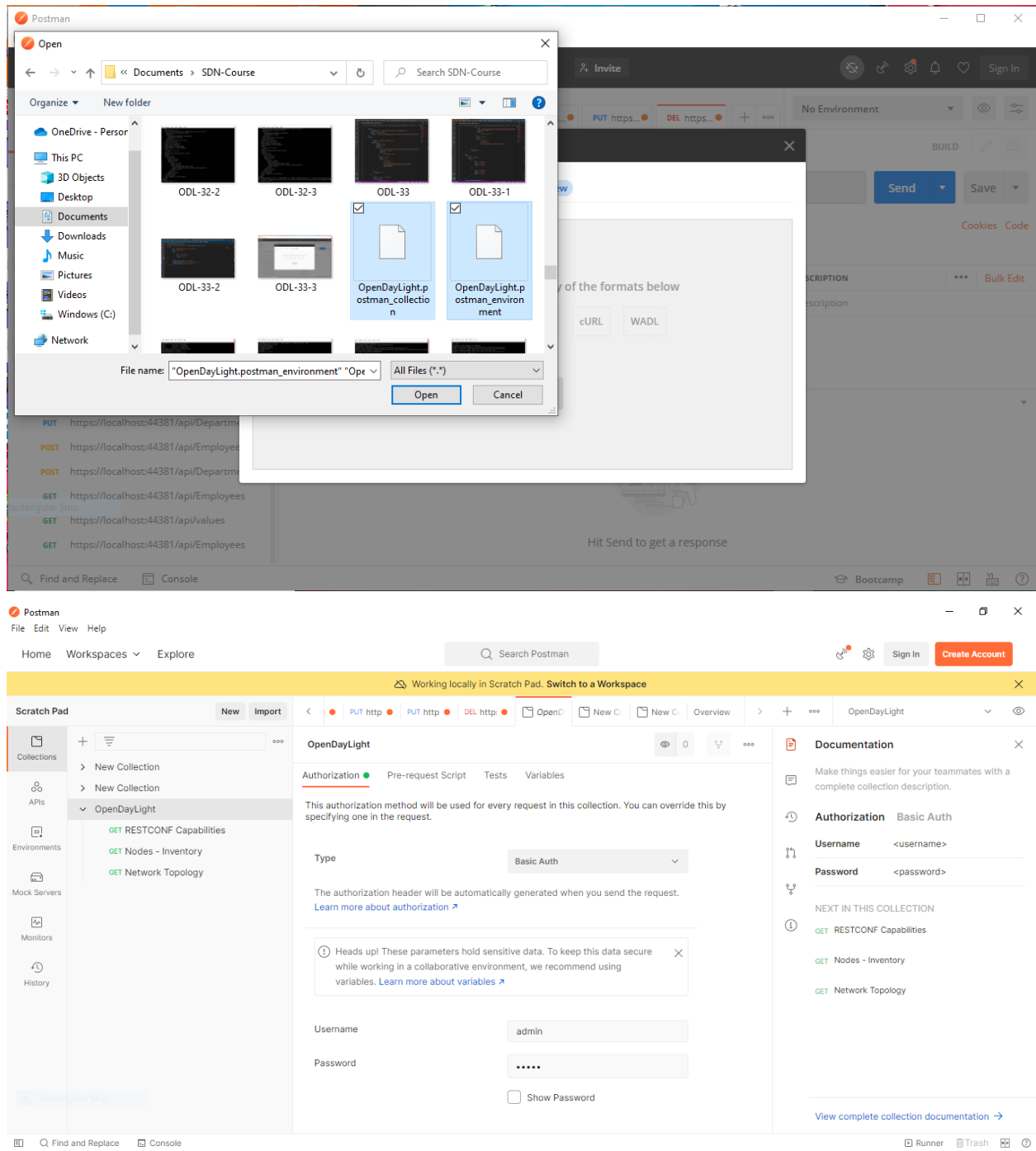
```
File Edit Selection View Go Run Terminal Help OpenDayLight.postman_collection.json - Visual Studi...
OpenDayLight.postman_collection.json X
C: > Users > mis_o > Documents > SDN-Course > {} OpenDayLight.postman_collection.json > [ ] item > {} 1 > {} request
56     "url": {
57         "raw": "http://{{192.168.1.54}}:8181/restconf/operational/
58         "protocol": "http",
59         "host": [
60             "{{192.168.1.54}}"
61         ],
62         "port": "8181",
63         "path": [
64             "restconf",
65             "operational",
66             "network-topology:network-topology"
67         ]
68     },
69     "response": []
70 },
71 },
72 ],
73 "auth": {
74     "type": "basic",
75     "basic": [
76         {
77             "key": "password",
78             "value": "admin",
79             "type": "string"
80         },
81         {
82             "key": "username",
83             "value": "admin",
84             "type": "string"
85         }
86     ]
87 },
88 "protocolProfileBehavior": {}
```

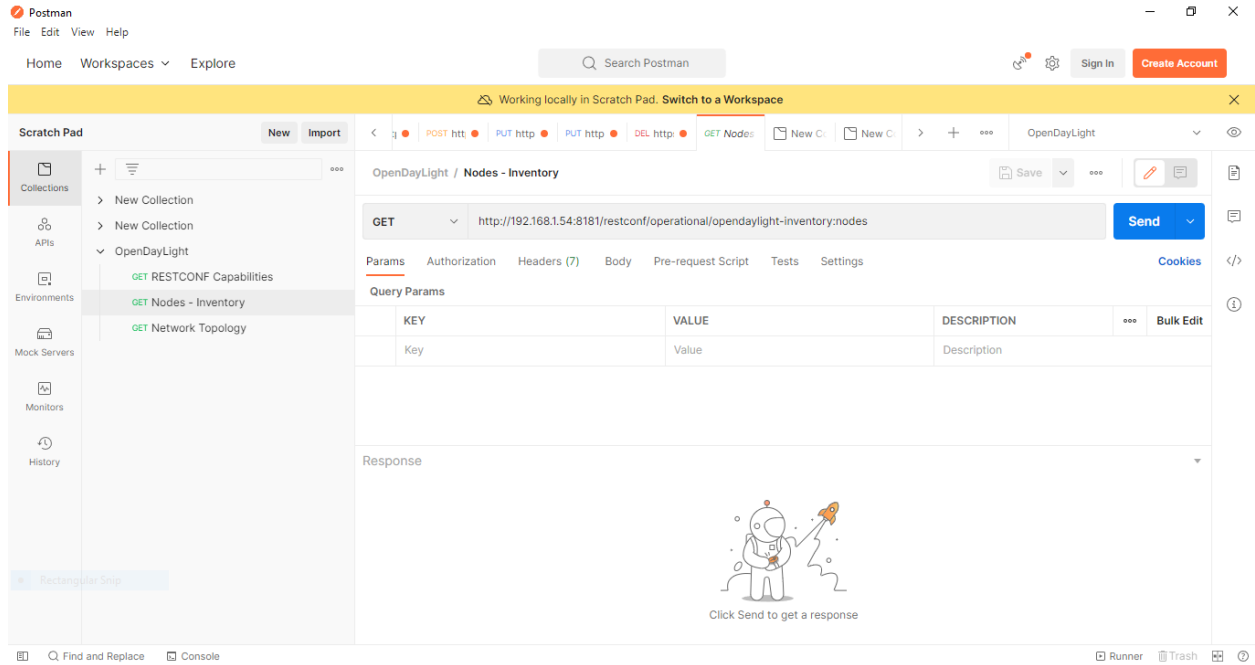
- **Import Configuration files to Postman**

- Click import button
- Click Upload Files
- Select collection, and environment files from local machine

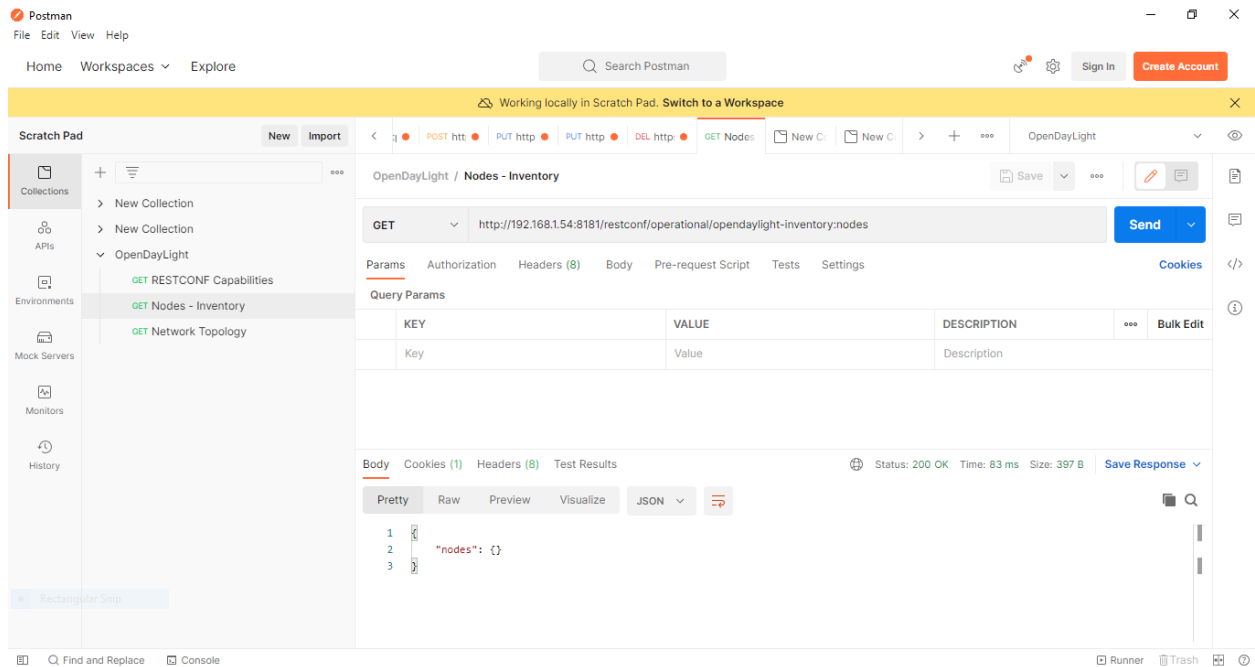




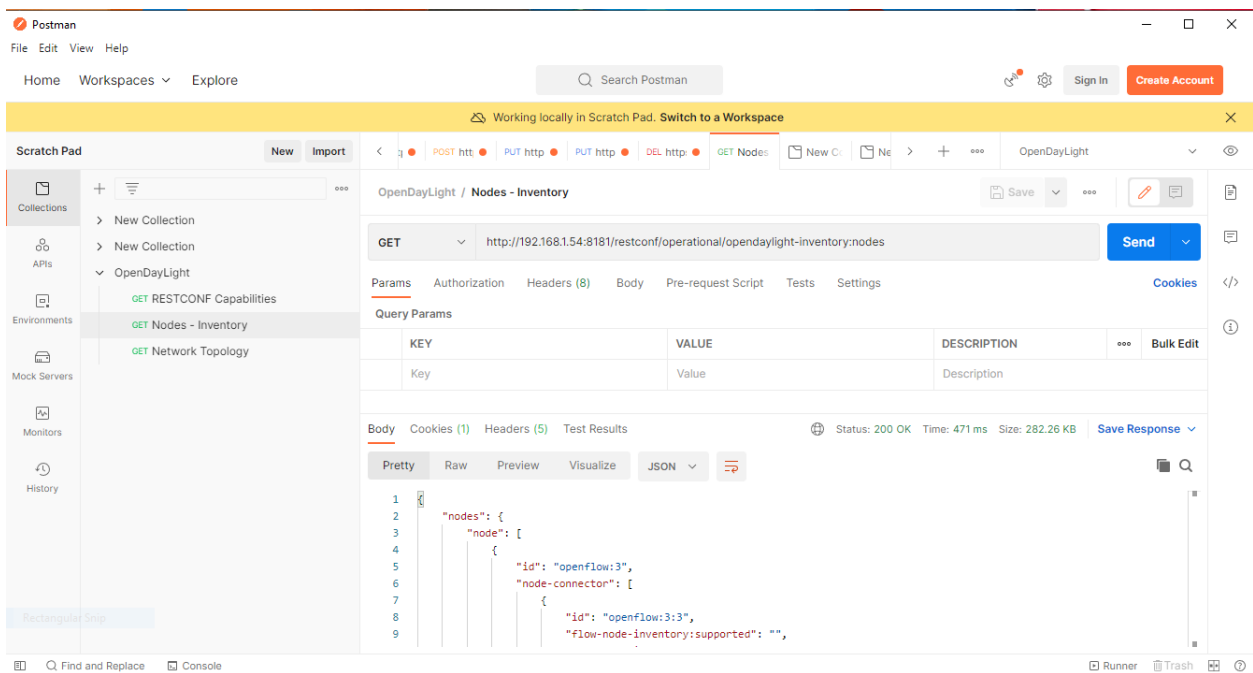
● Using Postman



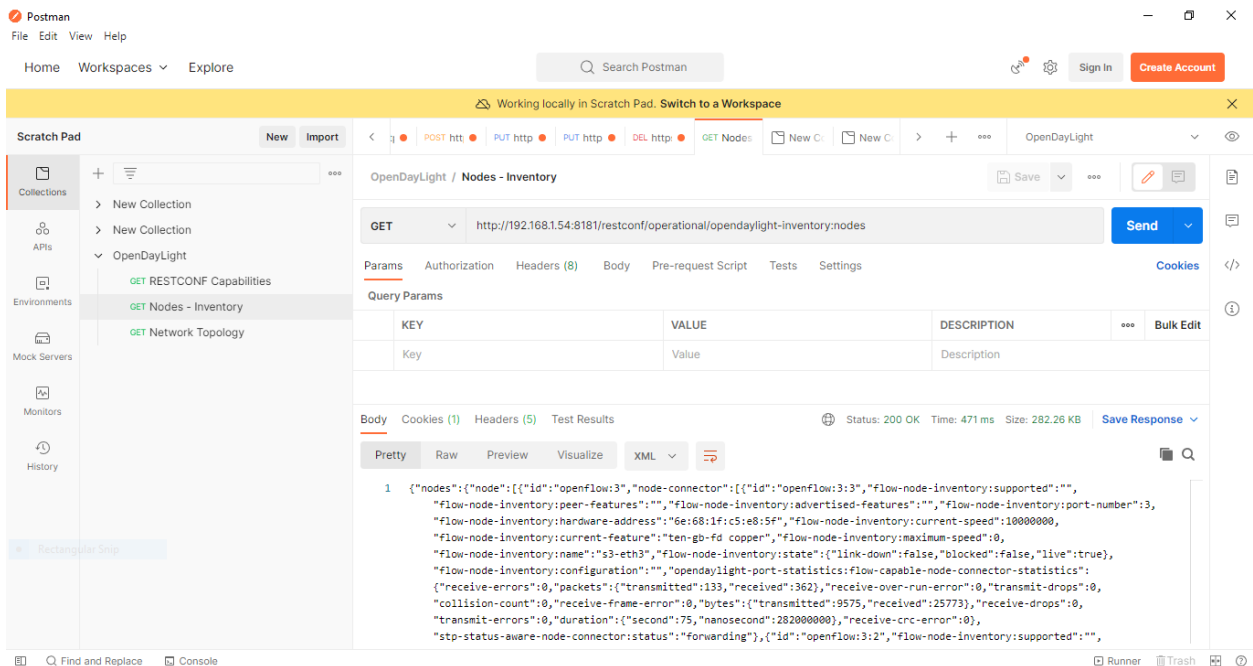
- Mininet Not started
- Checking Node Inventory



- Start Mininet Network
- Checking Node Inventory



- Viewing REST API call in different Code format
- XML Format



- HTML

Postman

File Edit View Help

Home Workspaces Explore

Search Postman

Sign In Create Account

Working locally in Scratch Pad. Switch to a Workspace

Scratch Pad

New Import

OpenDayLight / Nodes - Inventory

GET http://192.168.1.54:8181/restconf/operational/.opendaylight-inventory:nodes

Send

Params Authorization Headers (8) Body Pre-request Script Tests Settings Cookies

Query Params

KEY	VALUE	DESCRIPTION	Bulk Edit
Key	Value	Description	

Body Cookies (1) Headers (5) Test Results

Status: 200 OK Time: 471 ms Size: 282.26 KB Save Response

Pretty Raw Preview Visualize HTML

```
1 {
  "nodes": {
    "node": {
      "id": "openflow:3",
      "node-connector": {
        "id": "openflow:3:3",
        "flow-node-inventory:supported": "",
        "flow-node-inventory:peer-features": "",
        "flow-node-inventory:advertised-features": "",
        "flow-node-inventory:port-number": 3,
        "flow-node-inventory:hardware-address": "6e:68:1f:c5:e8:5f",
        "flow-node-inventory:current-speed": 10000000,
        "flow-node-inventory:current-feature": "ten-gb-fd",
        "flow-node-inventory:maximum-speed": 0,
        "flow-node-inventory:name": "s3-eth3",
        "flow-node-inventory:state": "copper",
        "link-down": false,
        "blocked": false,
        "live": true,
        "flow-node-inventory:configuration": "",
        "opendaylight-port-statistics:flow-capable-node-connector-statistics": {
          "receive-errors": 0,
          "packets": {
            "transmitted": 133,
            "received": 362,
            "receive-over-run-error": 0,
            "transmit-drops": 0,
            "collision-count": 0,
            "receive-frame-error": 0,
            "bytes": {
              "transmitted": 9575,
              "received": 25773,
              "receive-drops": 0,
              "transmit-errors": 0,
              "duration": {
                "second": 75,
                "nanosecond": 282000000,
                "receive-crc-error": 0,
                "stp-status-aware-node-connector:status": "forwarding"
              },
              "id": "openflow:3:2",
            }
          }
        }
      }
    }
  }
}
```

- View REST API call via Python-Request

Postman

File Edit View Help

Home Workspaces Explore

Search Postman

Sign In Create Account

Working locally in Scratch Pad. Switch to a Workspace

Scratch Pad

New Import

OpenDayLight / Nodes - Inventory

GET http://192.168.1.54:8181/restconf/operational/open

Send

Params Auth Headers (8) Body Pre-req. Tests Settings

Query Params

KEY	VALUE	DESCRIP	Bulk Edit
Key	Value	Description	

Body

200 OK 471 ms 282.26 KB Save Response

Pretty Raw Preview Visualize JSON

```
7 {
8   "id": "openflow:3:3",
9   "flow-node-inventory:supported": "",
10  "flow-node-inventory:peer-features": "",
11  "flow-node-inventory:advertised-features": "",
12  "flow-node-inventory:port-number": 3,
13  "flow-node-inventory:hardware-address": "6e:68:1f:c5:e8:5f",
14  "flow-node-inventory:current-speed": 10000000,
15  "flow-node-inventory:current-feature": "ten-gb-fd",
16  "flow-node-inventory:maximum-speed": 0,
17  "flow-node-inventory:name": "s3-eth3",
18  "flow-node-inventory:state": "copper",
19  "link-down": false,
20  "blocked": false,
21  "live": true,
22  "flow-node-inventory:configuration": "",
23  "opendaylight-port-statistics:flow-capable-node-connector-statistics": {
24    "receive-errors": 0,
25    "packets": {
26      "transmitted": 133,
27      "received": 362,
28      "receive-over-run-error": 0,
29      "transmit-drops": 0,
30      "collision-count": 0,
31      "receive-frame-error": 0,
32      "bytes": {
33        "transmitted": 9575,
34        "received": 25773,
35        "receive-drops": 0,
36        "transmit-errors": 0,
37        "duration": {
38          "second": 75,
39          "nanosecond": 282000000,
40          "receive-crc-error": 0,
41          "stp-status-aware-node-connector:status": "forwarding"
42        },
43        "id": "openflow:3:2",
44      }
45    }
46  }
47 }
```

Code snippet

Python - Requests

```
1 import requests
2
3 url1 = "http://192.168.1.54:8181/restconf/operational/.opendaylight-inventory:nodes"
4
5 payload={}
6 headers = {
7     'Authorization': 'Basic YhRtaW46YhRtaW4=',
8     'Cookie': 'JSESSIONID=4bnwjpkn8n137kioog9w5sm'
9 }
10
11 response = requests.request("GET", url1, headers=headers, data=payload)
12
13 print(response.text)
14
```

- Create text file of **Python-Request** Code in the ODL server, named: **odl_get_nodes-inventory.py**

```
File  Machine  View  Input  Devices  Help
GNU nano 2.9.3      odl_get_nodes-inventory.py

import requests

url = "http://192.168.1.54:8181/restconf/operational/opendaylight-inventory:nodes"

payload={}
headers = {
    'Authorization': 'Basic YWRtaW46YWRtaW4=',
    'Cookie': 'JSESSIONID=4bnwwjpkkn0h137kiog9w5sm'
}

response = requests.request("GET", url, headers=headers, data=payload)

print(response.text)

ks-sdn@sdn_server:~$ _
```

- Run the python code REST API call

```
File Machine View Input Devices Help
GNU nano 2.9.3 od1_get_nodes-inventory.py

import requests

url = "http://192.168.1.54:8181/restconf/operational/opendaylight-inventory:nodes"

payload={}
headers = {
    'Authorization': 'Basic YWRtaW46YWRtaW4=',
    'Cookie': 'JSESSIONID=4bnwwjpkkn0h137kioog9w5sm'
}

response = requests.request("GET", url, headers=headers, data=payload)

print(response.text.encode('utf8'))

ks-sdn@sdn_server:~$ python ./od1_get_nodes-inventory.py | python -m json.tool
```

File Machine View Input Devices Help

```
        "received": 0,
        "transmitted": 0
    },
    "receive-crc-error": 0,
    "receive-drops": 0,
    "receive-errors": 0,
    "receive-frame-error": 0,
    "receive-over-run-error": 0,
    "transmit-drops": 0,
    "transmit-errors": 0
}
}
],
"opendaylight-group-statistics:group-features": {
    "actions": [
        67076097
    ],
    "group-capabilities-supported": [
        "opendaylight-group-types:chaining",
        "opendaylight-group-types:select-weight",
        "opendaylight-group-types:select-liveness"
    ],
    "group-types-supported": [
        "opendaylight-group-types:group-indirect",
        "opendaylight-group-types:group-all",
        "opendaylight-group-types:group-ff",
        "opendaylight-group-types:group-select"
    ],
    "max-groups": [
        4294967040
    ]
}
}
]
}
}
ks-sdn@sdn_server:~$ _
```