Open network architectures with service orchestration

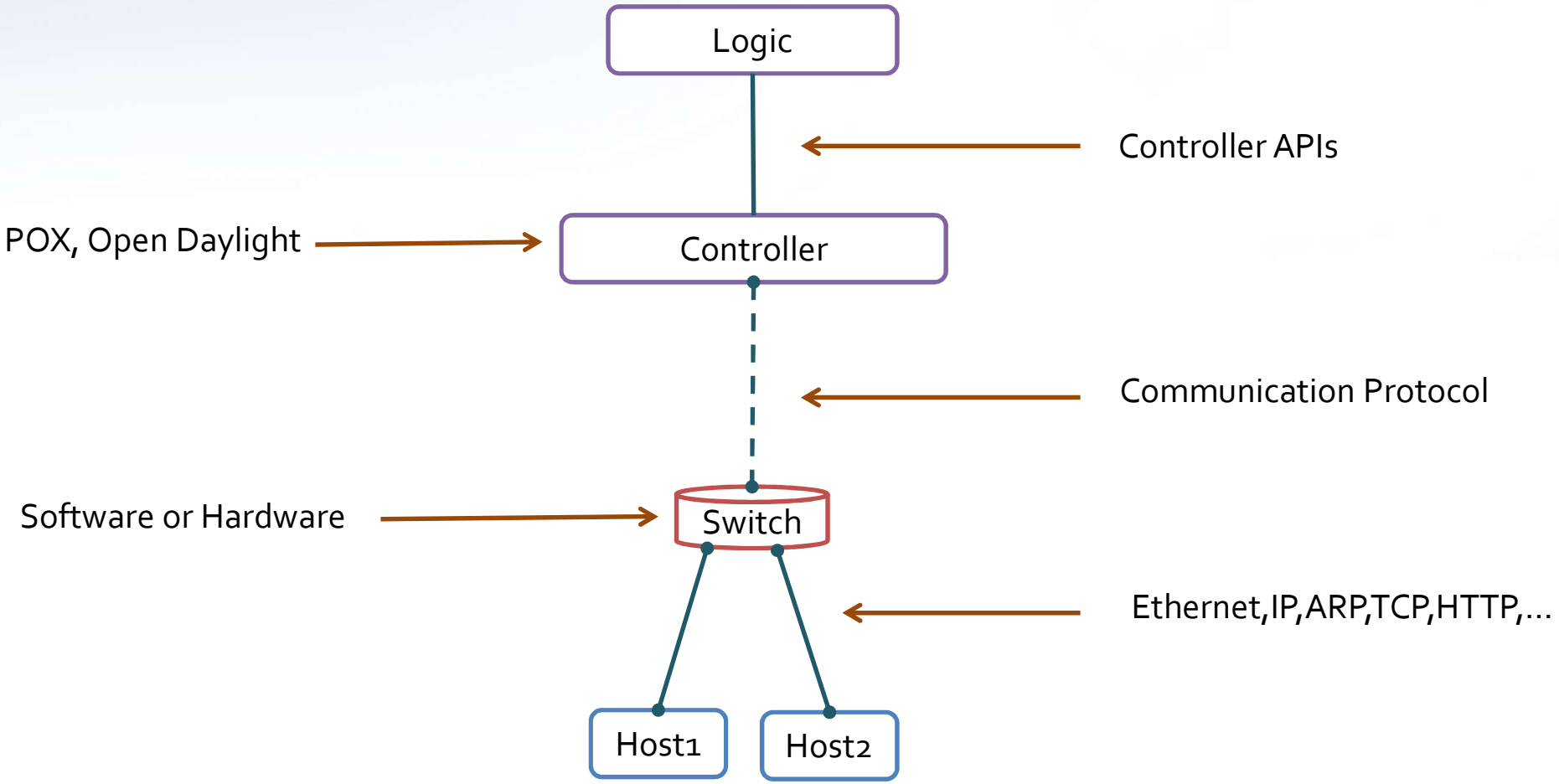
Workshop on SDN networking

Yannis Nikoloudakis Pasiphae Lab - TEIC

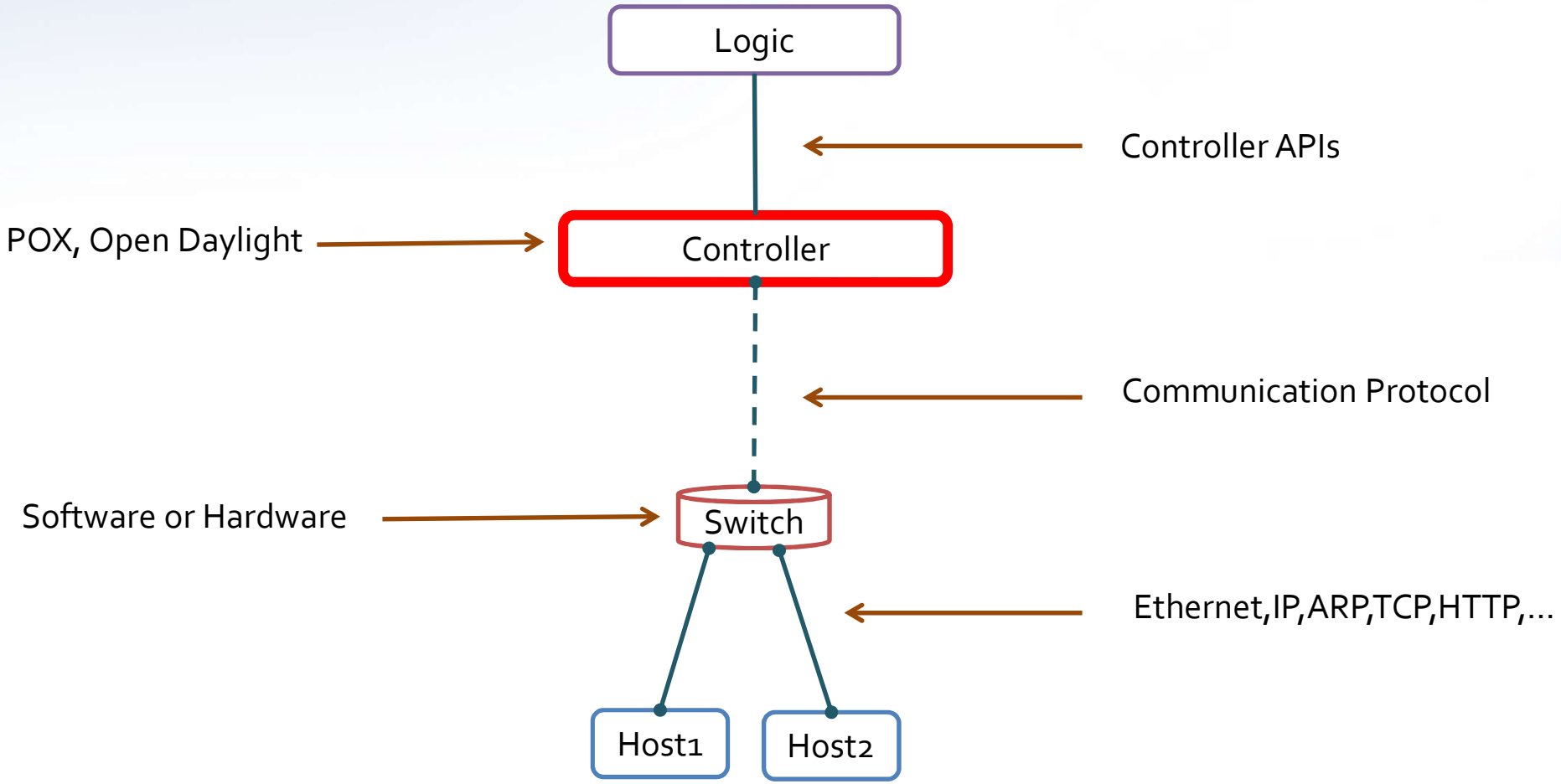
Agenda

- SDN Paradigm
- SDN Controllers
- OpenFlow
- SDN Switch
- Mininet
- Demo / Mininet Walkthrough

SDN Paradigm



SDN Paradigm



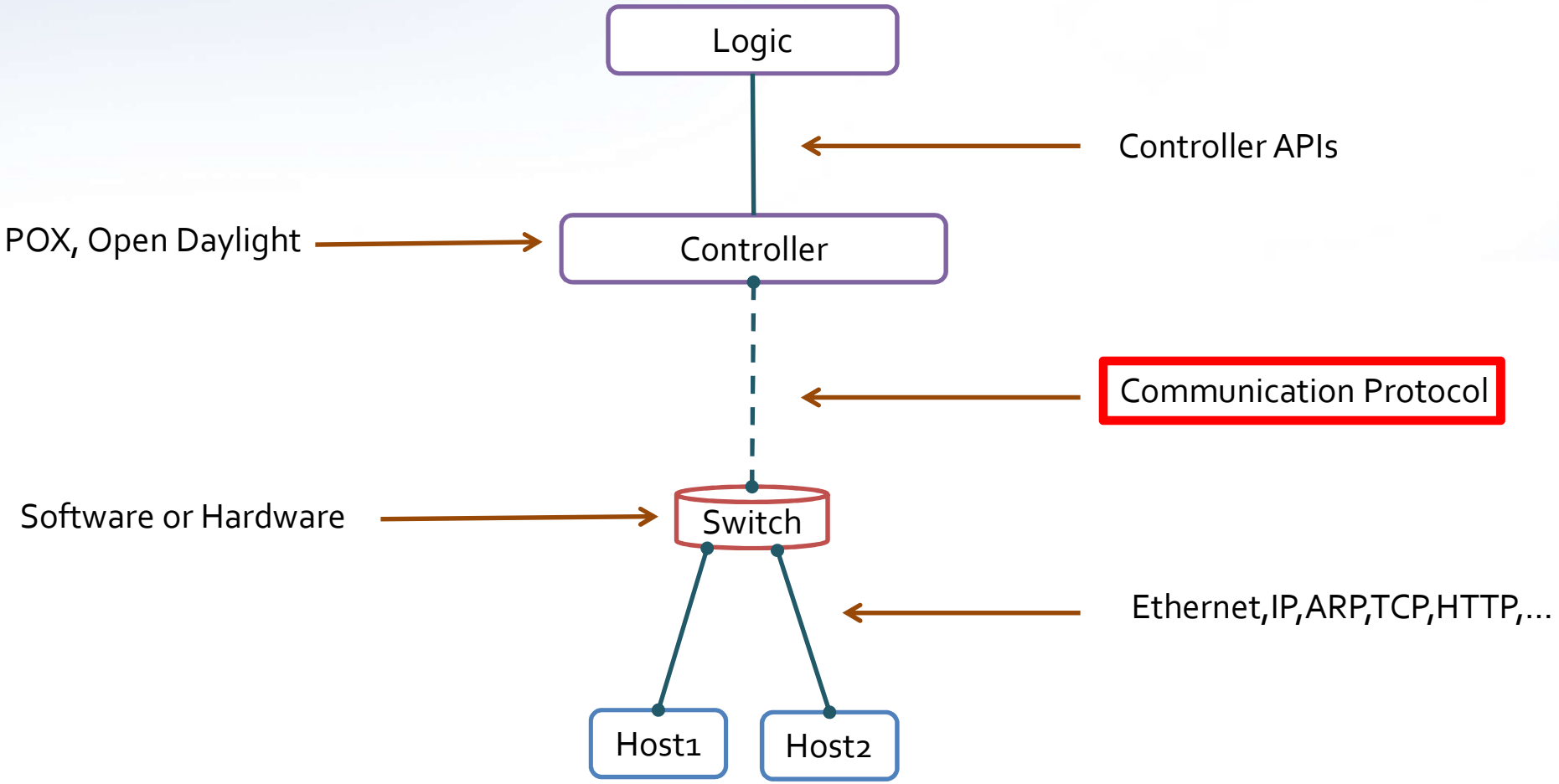
SDN Controllers

- The "*brains*" of the network
- Act as strategic control points inside the SDN network
- Manage flow control to the switches/routers below(via southbound APIs)
- Manage the applications' and business logic above (via northbound APIs)

SDN Controllers

- Open Daylight (Java)
- Project Floodlight (Java)
- ONOS (Java)
- NOX/POX (Python)
- Ryu Controller (Python)

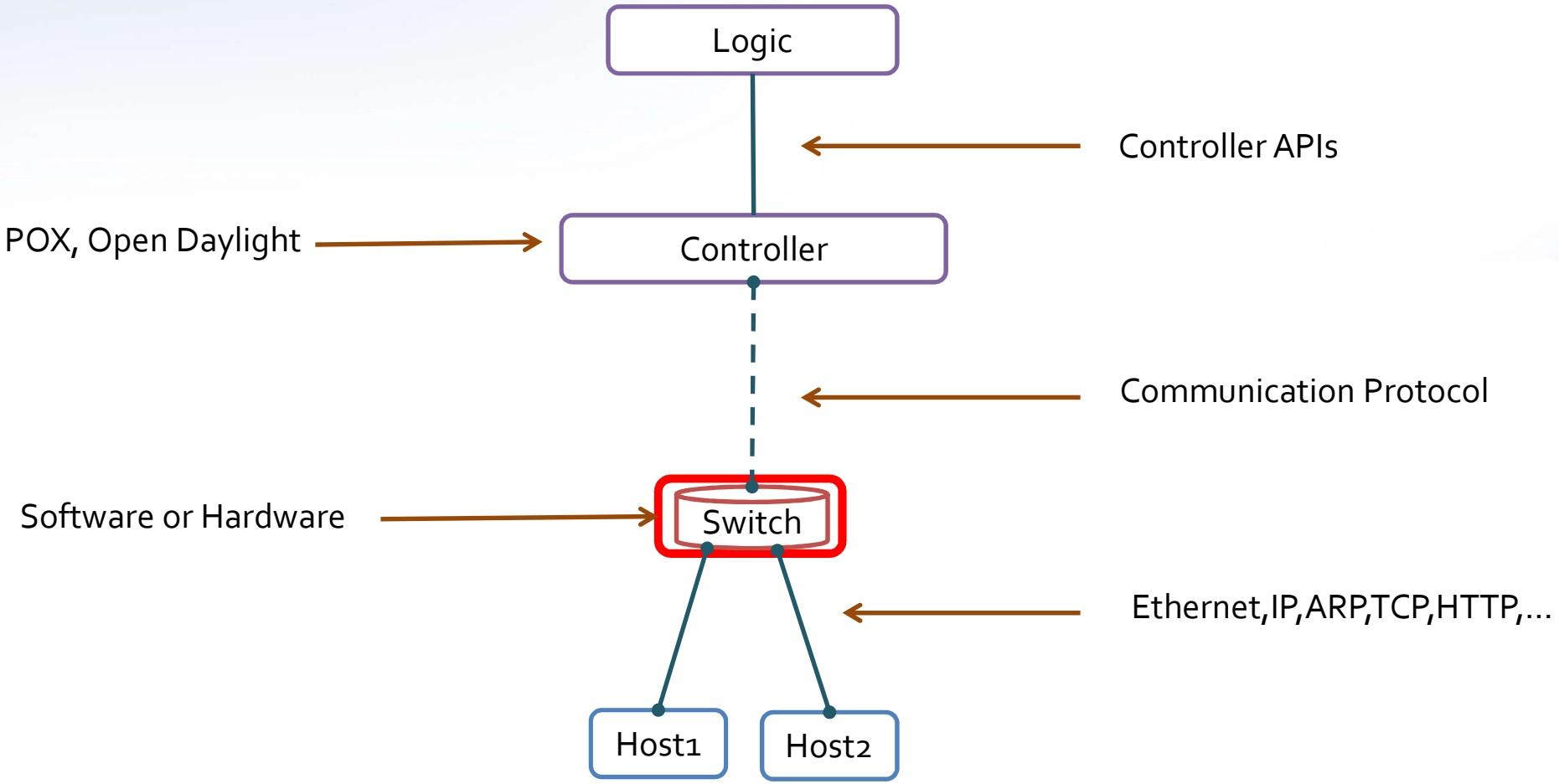
SDN Paradigm



OpenFlow

- One of the first SDN standards
- The communication protocol that enables an SDN Controller to directly interact with the forwarding plane of network devices (switches, routers) physical or virtual.

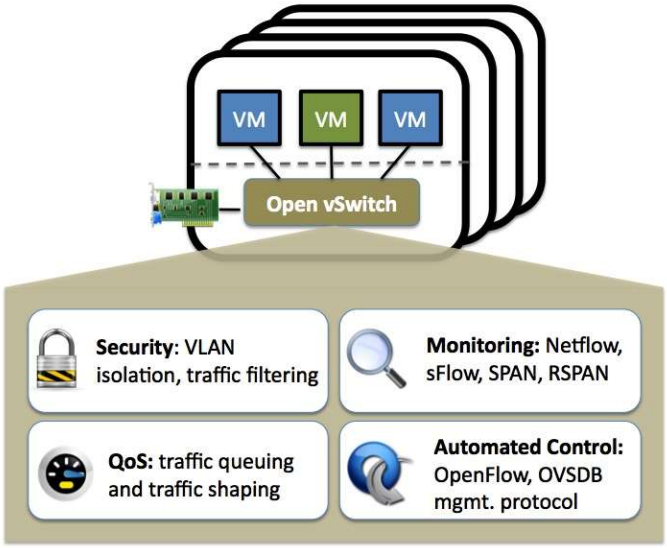
SDN Paradigm



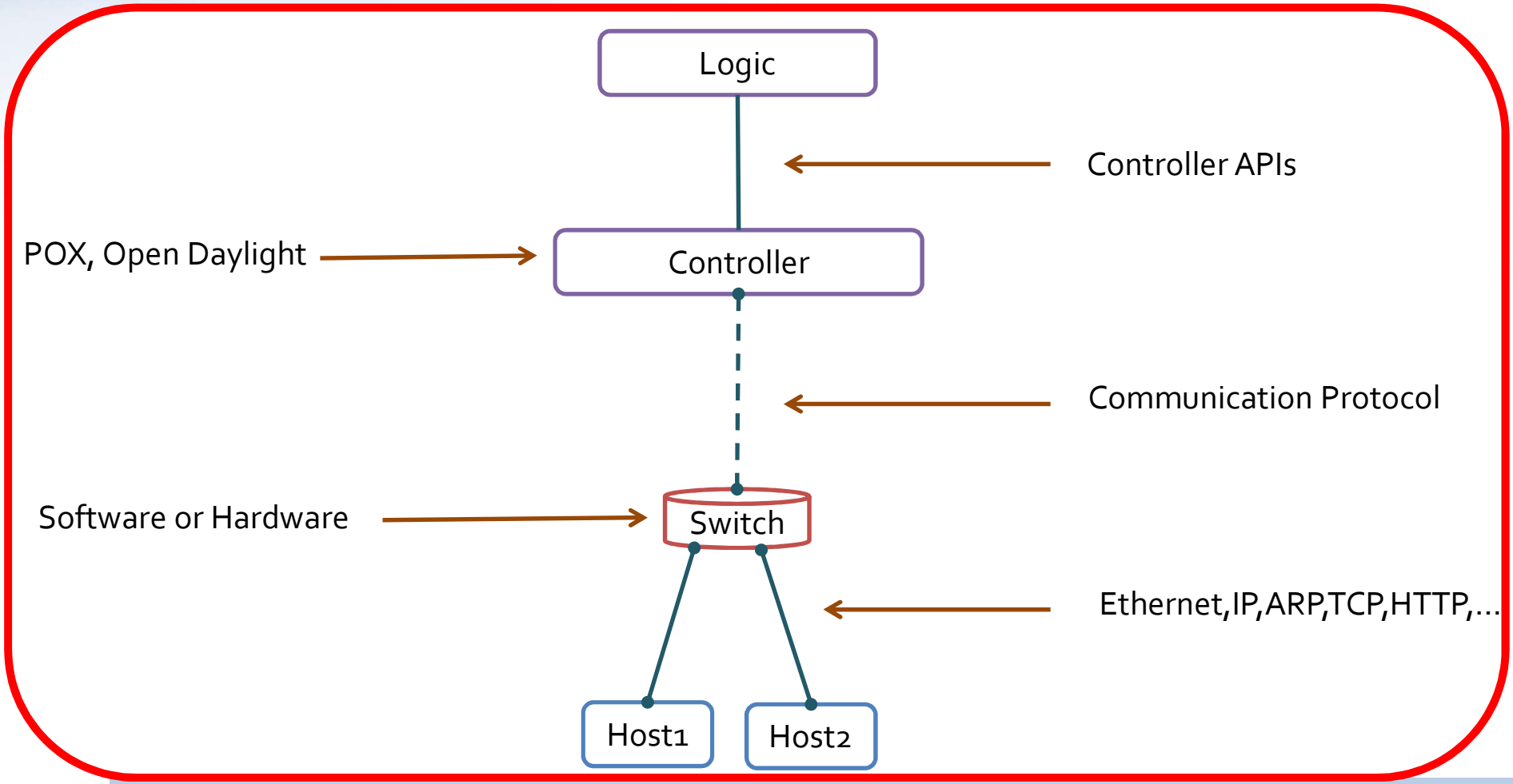
SDN Switch

- Physical
  - Pica8
  - Juniper
  - cisco

- Virtual
  - Open vSwitch



SDN Paradigm



Mininet

- Docker-based Emulation platform
- Rapid and lightweight prototyping of large networks on a single machine
- OS-level virtualization
  - Isolated network namespace
  - Constrained CPU usage on isolated namespace
- CLI and Python APIs

Demo

Prerequisites

- Linux operating System (pref. Ubuntu)
- Oracle VirtualBox Hypervisor
- Internet Connection
- Intermediate Python knowledge
- Familiarity with Linux environment
- SSH client

Demo

- Download Mininet Virtual Appliance
  - URL: https://drive.google.com/open?id=0B81Pl7s8lqu8SUhjSWZRMlVWYnc

Demo

Setup Virtual Machine

1. Start VirtualBox
2. Select File>Import Appliance and select the .ova file
3. Press the "Import" button
4. Check network interfaces*

VM User name – **mininet**
VM Password - **mininet**

Demo

Walkthrough

- $ sudo mn –h
  - Displays help about Mininet's startup options
- $ sudo mn
  - Starts Mininet, creating a default network topology (1 controller, 1 switch, 2 hosts)
- mininet> help
  - Displays available Mininet's CLI commands

Demo

Walkthrough

- mininet> nodes
  - Displays all created nodes
- mininet> net
  - Displays Links
- mininet> dump
  - Displays all information about node

Demo

Walkthrough

- mininet> h1 ifconfig –a
  - Display all network interfaces of host #1
- mininet> s1 ifconfig –a
  - Display all network interfaces of switch #1
- mininet> h1 ping –c1 h2
- mininet> pingall

Demo

Run Wireshark on Mininet VM

Ubuntu-host$ ssh –X mininet@<ip-of-MininetVM>

MininetVM$ sudo wireshark &

- Start capturing network traffic on **lo** interface
- In Wireshark Filter box, enter the keyword "**of**" and apply to show only OpenFlow network traffic
- Start a new terminal:

Ubuntu-host$ ssh –X mininet@<ip-of-MininetVM>

Demo

Run Wireshark on Mininet VM

MininetVM$ sudo mn

mininet>h1 ping –c1 h2

- Observe the OpenFlow traffic displayed in Wireshark
- Elaborate

Demo

Walkthrough

- mininet> h1 python –m SimpleHTTPServer 80 &
  - Run a simple http server on h1 as a bbackground process
- mininet> h2 wget –O – h1
  - Perform simple HTTP request
- mininet> h1 kill %python
  - Kill python process

Demo

Regression tests

- mininet> sudo mn --test pingpair
  - Runs Mininet, runs an all-pair-ping and tears down the whole topology
- mininet> sudo mn --test iperf
  - Runs Mininet, runs iperf server on one host, runs iperf client on the other host and parses the bandwidth achieved

Demo

Regression tests

- mininet> sudo mn --test iperf --link tc,bw=10
- mininet> sudo mn --test iperf --link tc,delay=100ms,loss=20

Demo

Custom Topologies

- $ sudo nano ~/mininet/custom/topo-2sw-2host.py
  - Review custom topology provided for testing purposes by Mininet

Run Mininet with Custom Topology

- $ sudo mn --custom ~/mininet/custom/topo-2sw-2host.py --topo mytopo --test pingall

Demo

Custom Topologies

```
from mininet.topo import Topo
class MyTopo( Topo ):
        "Simple topology example."
        def __init__( self ):
                "Create custom topo."
                # Initialize topology
                Topo.__init__( self )
                  # Add hosts and switches
                  leftHost = self.addHost( 'h1' )
                  rightHost = self.addHost( 'h2' )
                  leftSwitch = self.addSwitch( 's3' )
                  rightSwitch = self.addSwitch( 's4' )
                  # Add links
                  self.addLink( leftHost, leftSwitch )
                  self.addLink( leftSwitch, rightSwitch )
                  self.addLink( rightSwitch, rightHost )
topos = { 'mytopo': ( lambda: MyTopo() ) }
```

Demo

Using a Remote Controller

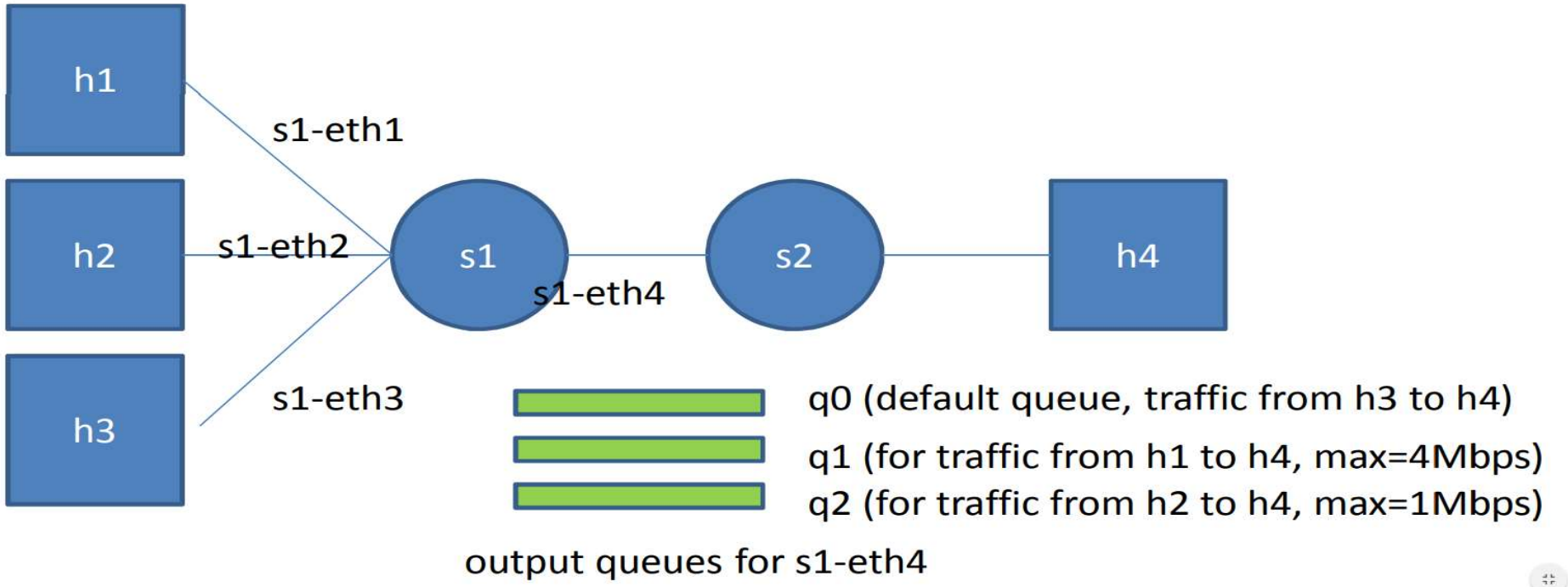
MininetVM$ sudo mn –controller=remote,ip=<controller-ip>,port=<controller-port>
ControllerVM$ cd ~/pox
ControllerVM$ ./pox.py forwarding.l2_learning

Demo

Defining QoS Rules

- Scenario
  - Create a custom topology
    - 1 Controller
    - 2 Switches
    - 4 Hosts

Demo


h1
h2
h3
s1-eth1
s1-eth2
s1-eth3
s1
s1-eth4
s2
h4
q0 (default queue, traffic from h3 to h4)
q1 (for traffic from h1 to h4, max=4Mbps)
q2 (for traffic from h2 to h4, max=1Mbps)
output queues for s1-eth4

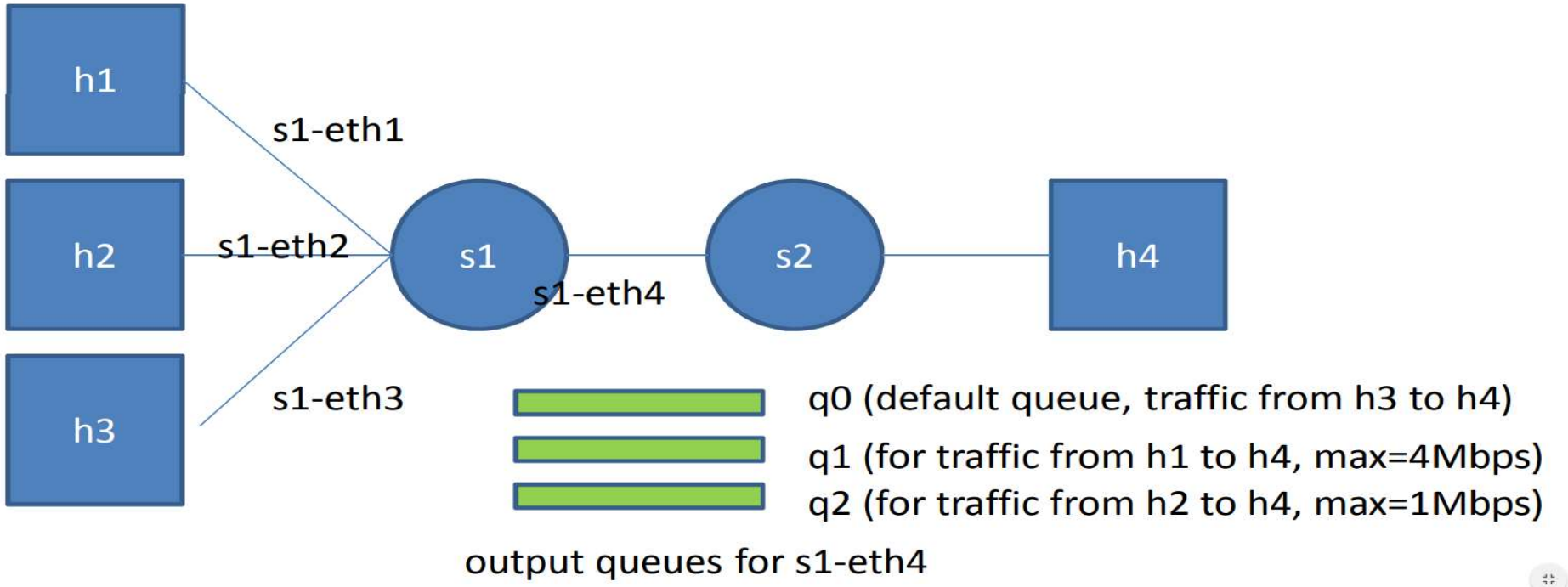
Demo

- $ sudo nano ~/mininet/custom/4h-2w.py
- elaborate

Demo

```
from mininet.topo import Topo
class MyTopo(Topo):
    def __init__(self):

        # Initialize topology
        Topo.__init__(self)

        # Add hosts and switches
        h1 = self.addHost('h1')
        h2 = self.addHost('h2')
        h3 = self.addHost('h3')
        h4 = self.addHost('h4')
        s1 = self.addSwitch('s1')
        s2 = self.addSwitch('s2')

        # Add links
        self.addLink(h1, s1)
        self.addLink(h2, s1)
        self.addLink(h3, s1)
        self.addLink(s1, s2)
        self.addLink(s2, h4)

topos = {'mytopo': (lambda: MyTopo())}
```

Demo


h1
h2
h3
s1-eth1
s1-eth2
s1-eth3
s1
s1-eth4
s2
h4
q0 (default queue, traffic from h3 to h4)
q1 (for traffic from h1 to h4, max=4Mbps)
q2 (for traffic from h2 to h4, max=1Mbps)
output queues for s1-eth4

Demo

- $ sudo nano ~/pox/ext/workshop.py
- Elaborate
- Ubuntu-Host$ ssh mininet@<mininet-vm-ip>
- Start mininet emulation without any QoS rules
- Mininet-VM$ cd ~/pox
- Mininet-VM$ ./pox.py workshop
- Start a new terminal
- Ubuntu-Host$ ssh mininet@<mininet-vm-ip>
- Mininet-VM$ sudo mn --custom ~/mininet/custom/4h-2w.py --topo=mytopo --controller=remote

Demo

- mininet> xterm h1 h2 h3 h4
- H4$ iperf -s -p 4000 & iperf -s -p 5000 & iperf -s -p 6000
- H1$ iperf -c 10.0.0.4 -p 4000
- H2$ iperf -c 10.0.0.4 -p 5000
- H3$ iperf -c 10.0.0.4 -p 6000
- Elaborate on the results

Demo

- Start a new terminal
- Ubuntu-Host$ ssh mininet@<mininet-vm-ip>
- Mininet-VM$ sudo ovs-vsctl -- set Port s1-eth4 qos=@newqos -- id=@newqos create QoS type=linux-htb other-config:max-rate=1000000000 queues=0=@q0,1=@q1,2=@q2 --id=@q0 create Queue other-config:min-rate=1000000000 other-config:max-rate=1000000000 --id=@q1 create Queue other-config:min-rate=4000000 other-config:max-rate=4000000 -- id=@q2 create Queue other-config:min-rate=1000000 other-config:max-rate=1000000

Demo

- Perform the previous steps
- Elaborate on the results

References

[1] "POX Wiki - Open Networking Lab - Confluence." [Online]. Available: https://openflow.stanford.edu/display/ONL/POX+Wiki. [Accessed: 24-Jul-2017].

[2] N. Mckeown, T. Anderson, H. Balakrishnan, G. Parulkar, L. Peterson, J. Rexford, S. Shenker, and J. Turner, "OpenFlow: Enabling Innovation in Campus Networks," 2008.

[3] "Mininet Walkthrough - Mininet." [Online]. Available: http://mininet.org/walkthrough/#part-1-everyday-mininet-usage. [Accessed: 24-Jul-2017].