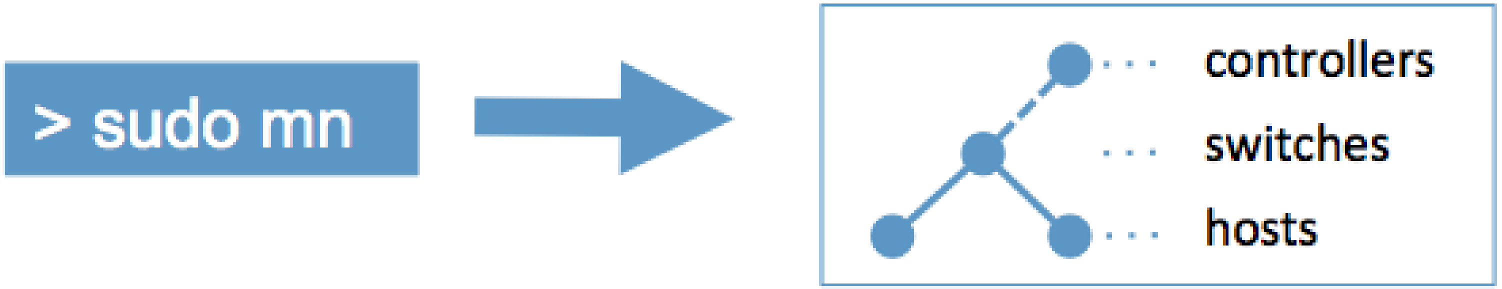
Mininet



```
> sudo mn
```

What is Mininet?

- A **virtual network environment** that can run on a single PC
- Runs real kernel, switch, and application code on a single machine
  - Command-line, UI, Python interfaces
- Many **OpenFlow features** are built-in
  - Useful: developing, deploying, and sharing

Why Use Mininet?

- Fast
- Possible to create custom topologies
- Can run real programs (anything that can run on Linux can run on a Mininet host)
- Programmable OpenFlow switches
- Easy to use
- Open source

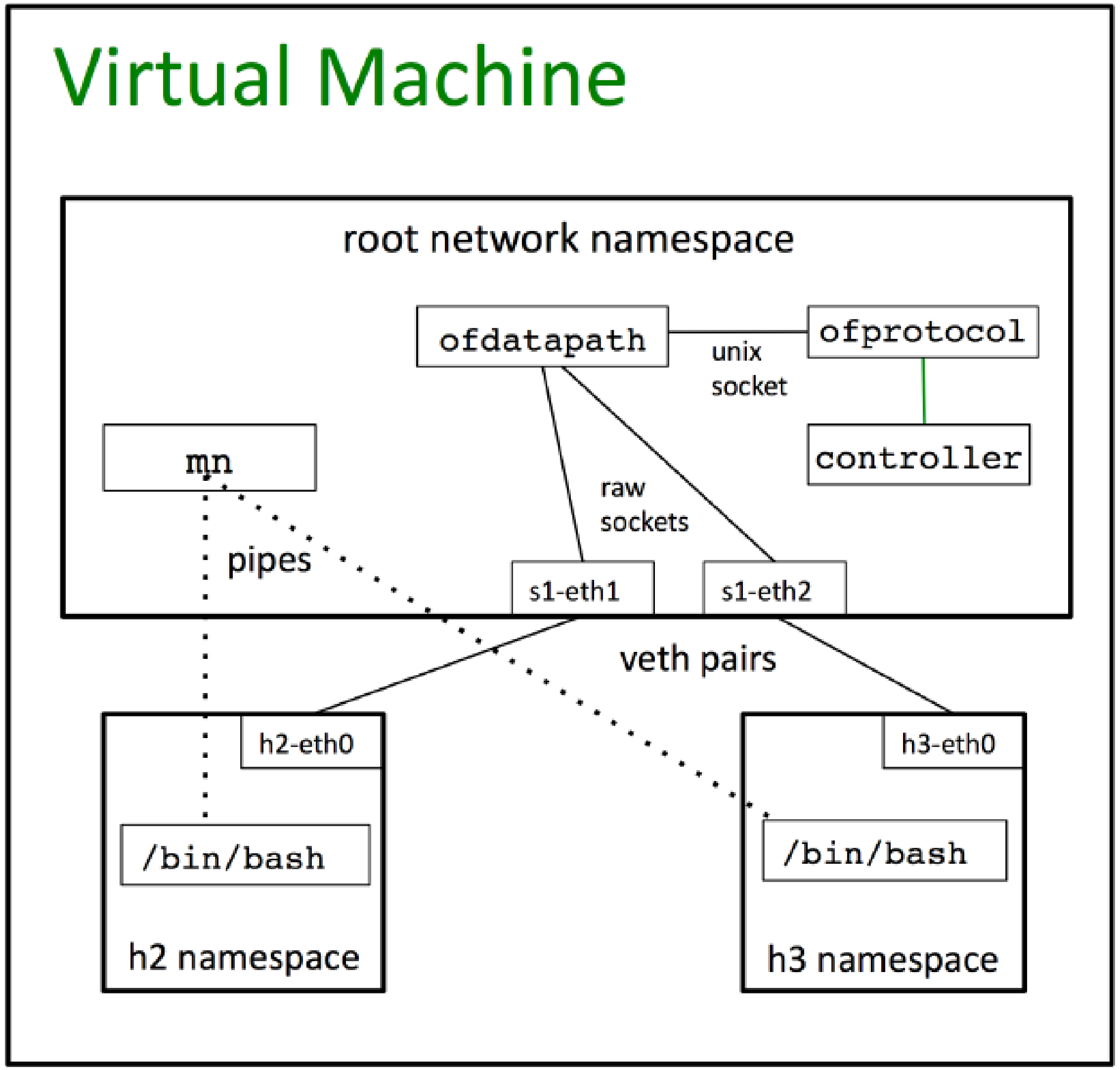
Alternatives

- **Real system:** Pain to configure

- **Networked VMs:** Scalability

- **Simulator:** No path to hardware deployment

The Mininet VM in a Nutshell



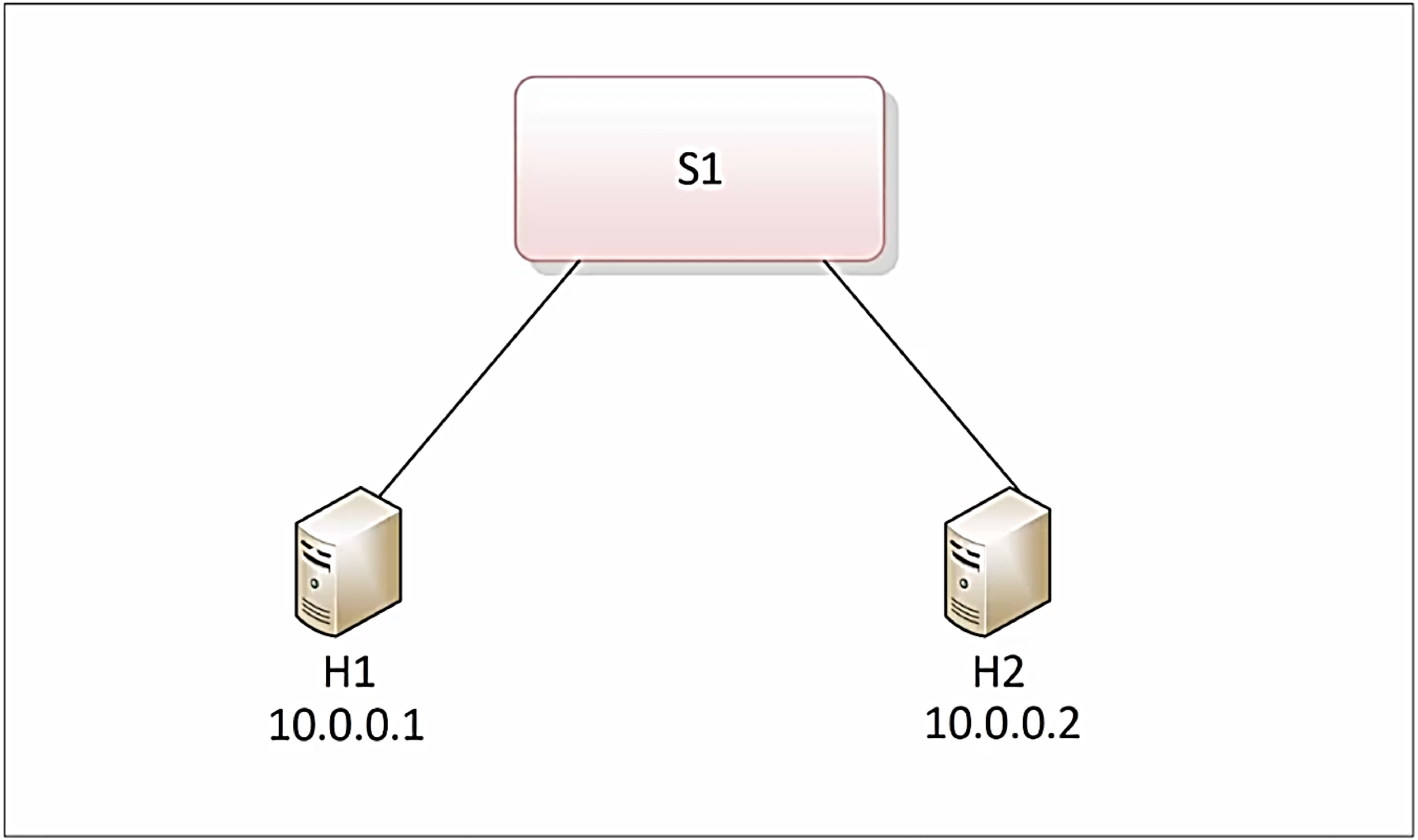
- Launch mininet process
- Per host
  - Bash process
  - Network namespace
- Create veth pairs and assign to namespaces
- Create OpenFlow switch to connect hosts
- Create OpenFlow controller

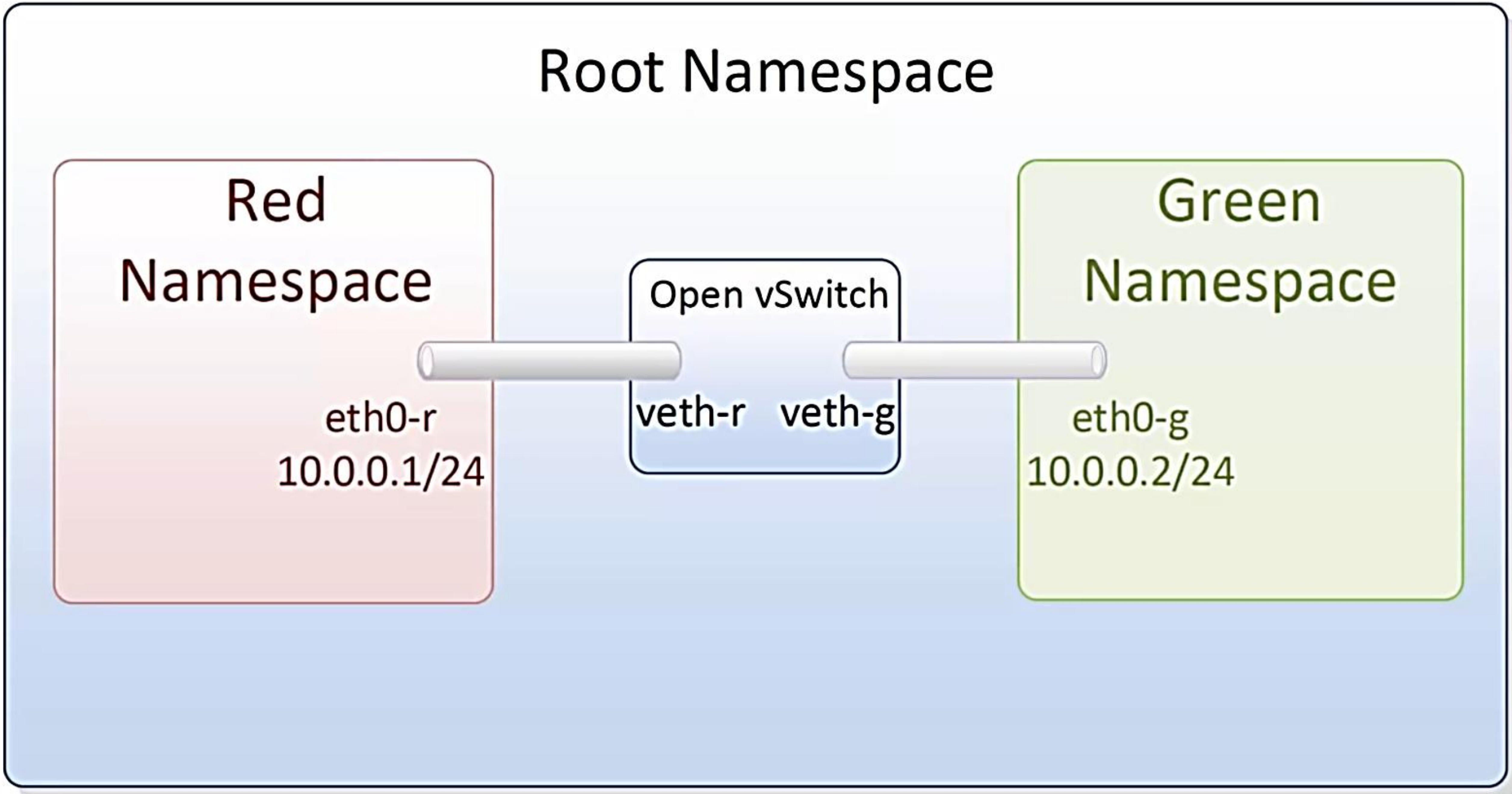
https://github.com/mininet/mininet/wiki/pdf/mininet-hotnets2010-final.pdf

What are Linux Network Namespaces?

- Multiple isolated networking environments running on a single physical host or VM
- Each network namespace has its own interfaces, routing tables and forwarding tables
- Processes can be dedicated to one network namespace
- Used in OpenStack, Mininet, Docker, more...

Example





Root Namespace

Red Namespace

eth0-r
10.0.0.1/24

Open vSwitch

veth-r veth-g

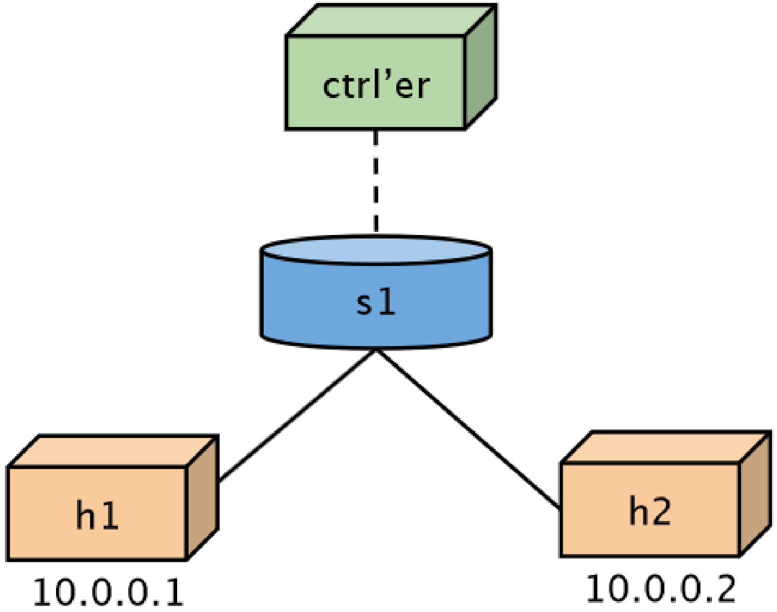
Green Namespace

eth0-g
10.0.0.2/24

Demo: basic network setup in Linux

```
sudo bash
# Create host namespaces
ip netns add h1
ip netns add h2
# Create switch
ovs-vsctl add-br s1
# Create links
ip link add h1-eth0 type veth peer name s1-eth1
ip link add h2-eth0 type veth peer name s1-eth2
ip link show
# Move host ports into namespaces
ip link set h1-eth0 netns h1
ip link set h2-eth0 netns h2
ip netns exec h1 ip link show
ip netns exec h2 ip link show
# Connect switch ports to OVS
ovs-vsctl add-port s1 s1-eth1
ovs-vsctl add-port s1 s1-eth2
ovs-vsctl show
# Set up OpenFlow controller
ovs-vsctl set-controller s1 tcp:127.0.0.1
ovs-controller ptcp: &
ovs-vsctl show
```

```
# Configure network
ip netns exec h1 ifconfig h1-eth0 10.1
ip netns exec h1 ifconfig lo up
ip netns exec h2 ifconfig h2-eth0 10.2
ip netns exec h1 ifconfig lo up
ifconfig s1-eth1 up
ifconfig s1-eth2 up
# Test network
ip netns exec h1 ping -c1 10.2
```



Testing a Simple Mininet Setup

- Try setting up a simple topology with three hosts connected to a single switch:

  -
    ```
    sudo mn --test pingall --topo single,3
    ```

- This setup uses a default switch controller and switch
  - Mininet also allows you to use custom remote controllers (and custom switches)

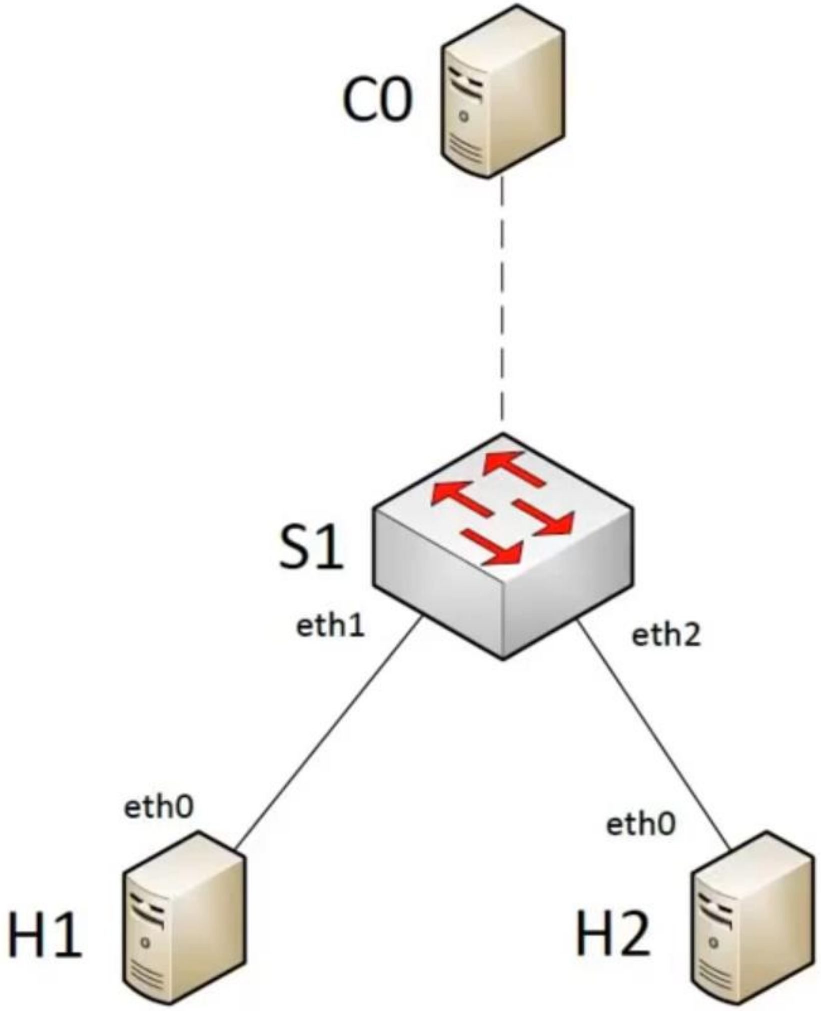
Basic Mininet Command Line

- **--topo** – defines a topology via command line upon mininet start-up.
- **--switch** – defines the switch to be used. By default the OVSK software switch is used.
- **--controller** – defines the controller to be used. If unspecified default controller is used with a default hub behavior.

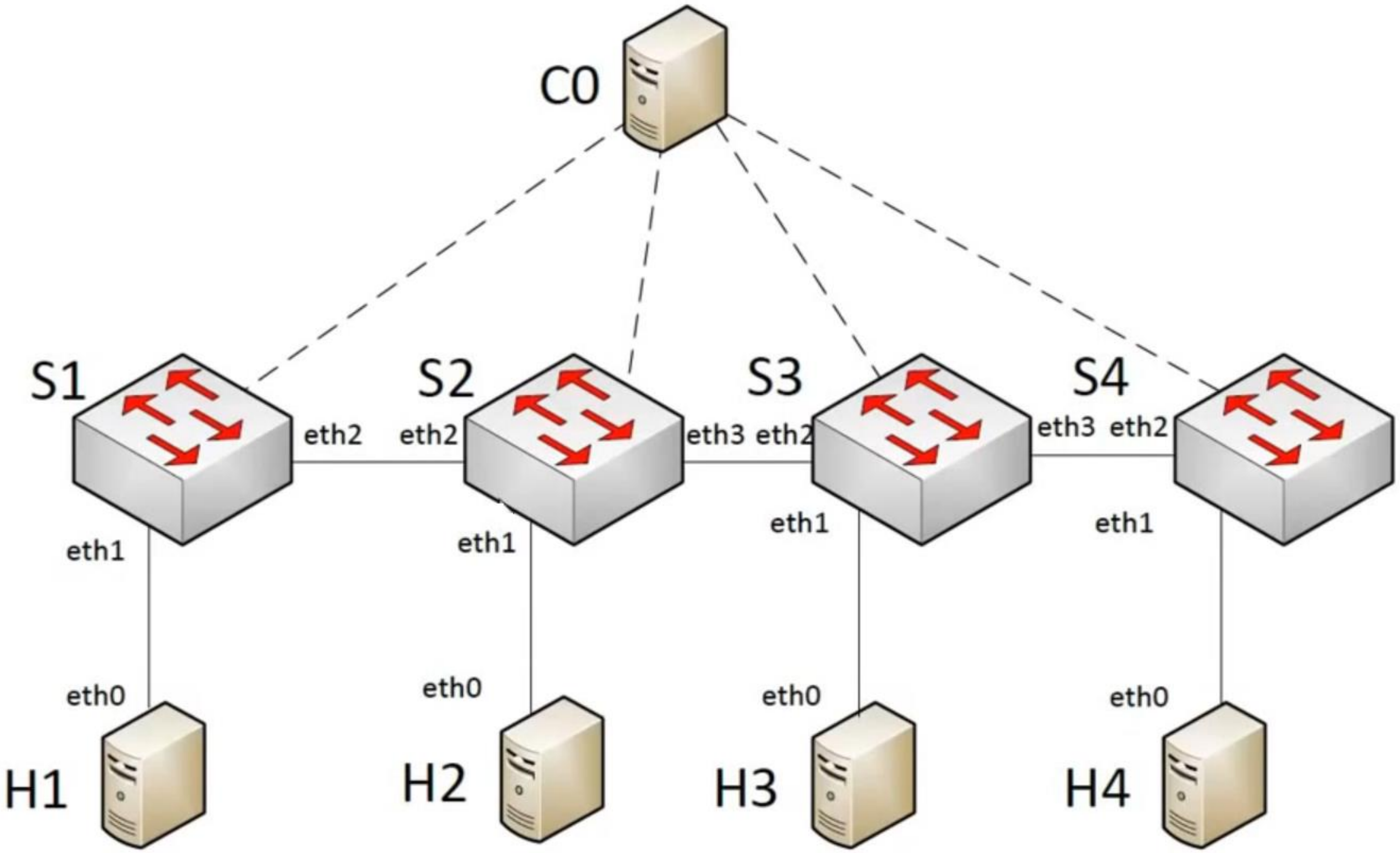
Trying Out Different Mininet Topologies

- Minimal network with two hosts, one (1) switch
  - sudo mn –topo minimal
- Example with 4 hosts and 4 switches
  - sudo mn --topo linear,4
- Example with 4 hosts all connected to one switch.
  - sudo mn --topo single,4
- Tree topology with defined depth and fan-out.
  - sudo mn --topo tree,depth=2,fanout=2

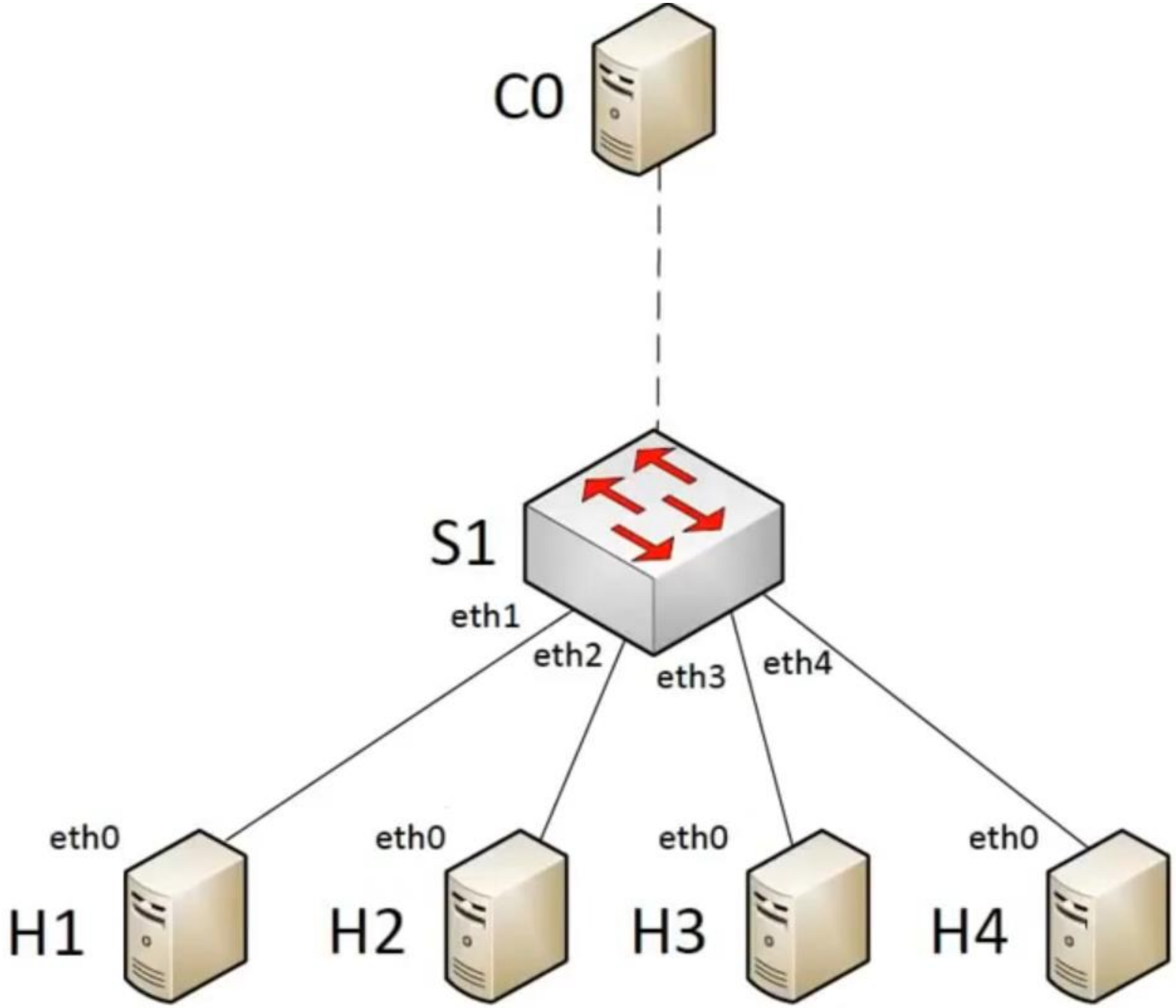
- Minimal network with two hosts, one (1) switch
  - sudo mn –topo minimal



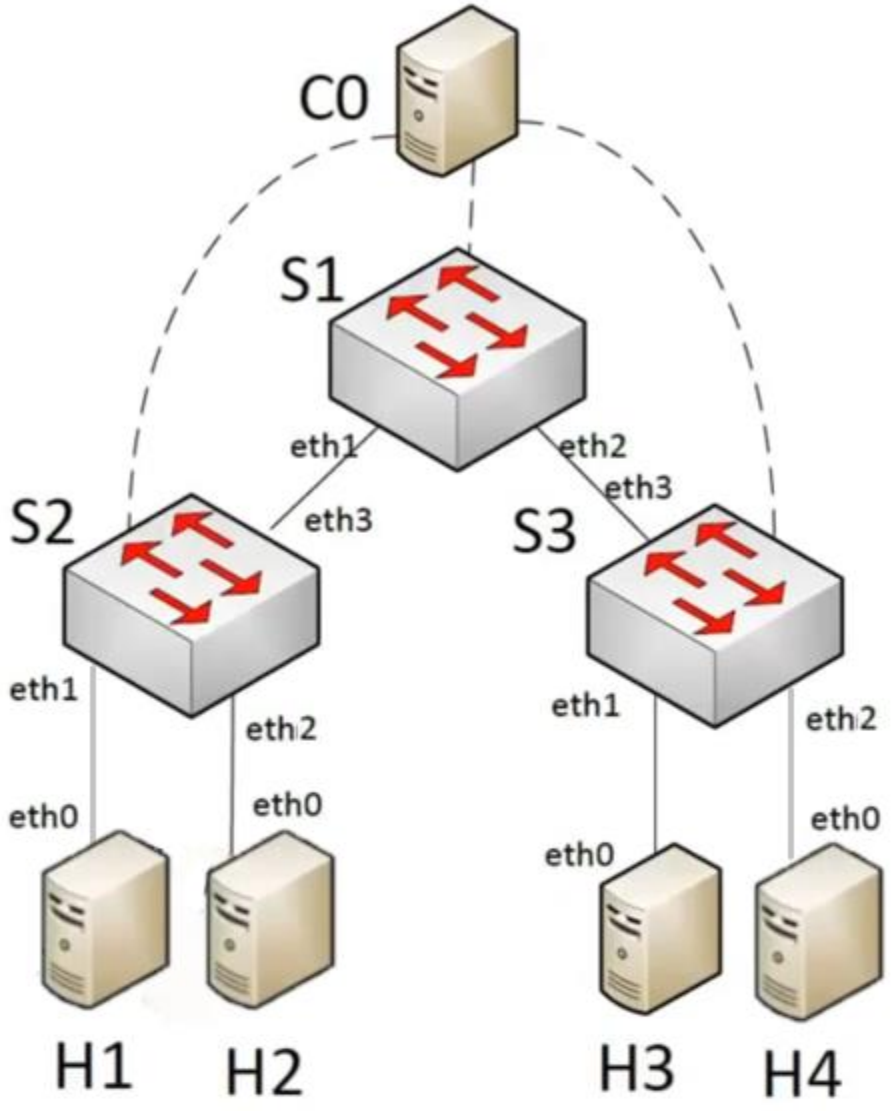
- Example with 4 hosts and 4 switches
  - sudo mn --topo linear,4



- Example with 4 hosts all connected to one switch.
  - sudo mn --topo single,4

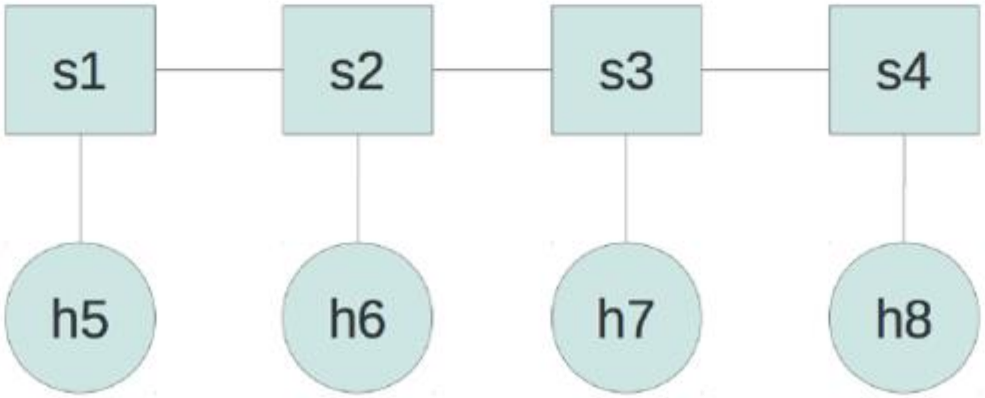


- Tree topology with defined depth and fan-out.
  - sudo mn --topo tree,depth=2,fanout=2



How mn Works: mn executes Python

- “mn” is a launch script that executes Python
- Consider: “—topo linear,4”



```
from mininet.net import Mininet

from mininet.topo import LinearTopo

Linear = LinearTopo(k=4)

net = Mininet(topo=Linear)

net.start()
net.pingAll()
net.stop()
```

Writing Your Own Mininet Topologies

- Example: Two hosts, one switch
- **mininet.cli.CLI(net)** before net.stop() will escape to interactive CLI before script terminates
- **addLink** allows you to specify: Bandwidth (bw) in Mbps, Delay (delay), Maximum Queue Size (max_queue_size), Loss (loss) in percentage

```
from mininet.net import Mininet
from mininet.util import createLink
net = Mininet()

# Creating nodes in the network.
c0 = net.addController()
h0 = net.addHost('h0')
s0 = net.addSwitch('s0')
h1 = net.addHost('h1')

# Creating links between nodes in network (2-ways)
net.addLink(h0, s0)
net.addLink(h1, s0)

# Configuration of IP addresses in interfaces
h0.setIP('192.168.1.1', 24)
h1.setIP('192.168.1.2', 24)

net.start()
net.pingAll()
net.stop()
```

https://github.com/mininet/mininet/wiki/Introduction-to-Mininet

More Complicated Topology Generation

```
#!/usr/bin/python

from mininet.topo import Topo
from mininet.net import Mininet
from mininet.util import dumpNodeConnections
from mininet.log import setLogLevel

class SingleSwitchTopo(Topo):
   "Single switch connected to n hosts."
   def __init__(self, n=2, **opts):

      # Initialize topology and default options
      Topo.__init__(self, **opts)
      switch = self.addSwitch('s1')

      # Python's range(N) generates 0..N-1
      for h in range(n):
         host = self.addHost('h%s' % (h + 1))
         self.addLink(host, switch)
```

```
def simpleTest():
   "Create and test a simple network"
   topo = SingleSwitchTopo(n=4)
   net = Mininet(topo)
   net.start()
   print "Dumping host connections"
   dumpNodeConnections(net.hosts)
   print "Testing network connectivity"
   net.pingAll()
   net.stop()

if __name__ == '__main__':
   # Tell mininet to print useful information
   setLogLevel('info')
   simpleTest()
```

Mininet Command Line Interface Usage

❖ Mininet Command Line Interface Usage

- *Interact with hosts and switches*

  - **Start a minimal topology**

    ```
    $ sudo mn
    ```

  - **Start a minimal topology using a remote controller**

    ```
    $ sudo mn --controller=remote,ip=[IP_ADDDR],port=[listening port]
    ```

  - **Start a custom topology**

    ```
    $ sudo mn --custom [topo_script_path] --topo=[topo_name]
    ```

  - **Display nodes**

    ```
    mininet> nodes
    ```

  - **Display links**

    ```
    mininet> net
    ```

  - **Dump information about all nodes**

    ```
    mininet> dump
    ```

Mininet Command Line Interface Usage

❖ Mininet Command Line Interface Usage

- Interact with hosts and switches
  - Check the IP address of a certain node

```
mininet> h1 ifconfig -a
```

  - Print the process list from a host process

```
mininet> h1 ps -a
```

- Test connectivity between hosts
  - Verify the connectivity by pinging from host1 to host2

```
mininet> h1 ping -c 1 h2
```

  - Verify the connectivity between all hosts

```
mininet> pingall
```

MiniNet commands

- (...) --link tc,bw=100,delay=1ms,loss=0,max_queue_size=1000,...

- ping (10 echo requests)
  - h1 ping h2 -c 10
- iperf
  - To perform a TCP bandwidth test between hosts
  - iperf h1 h2
- exit
  - Release resources