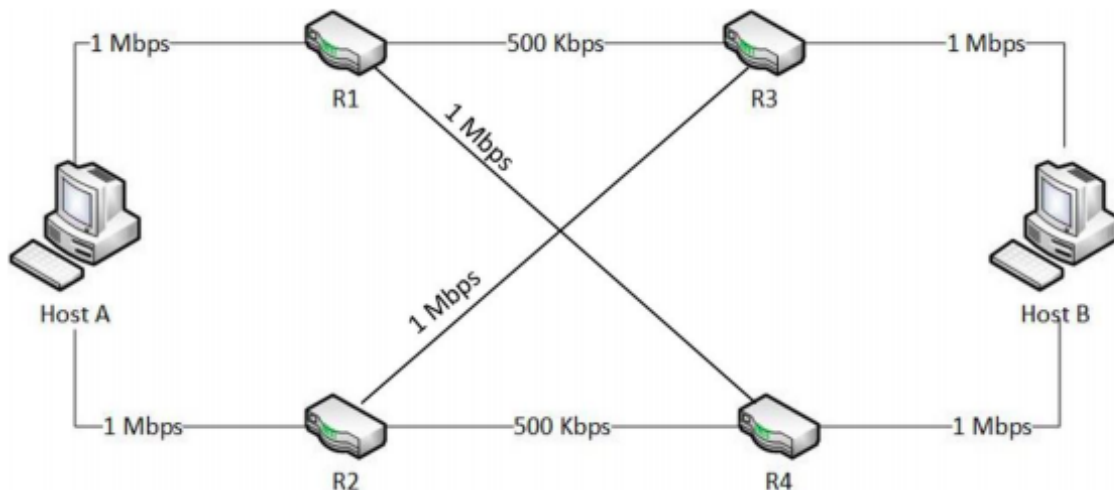


LAPORAN TUGAS BESAR JARINGAN KOMPUTER

Ryan Abdurrohman (1301191171)
IF-43-10 S-1 Informatika

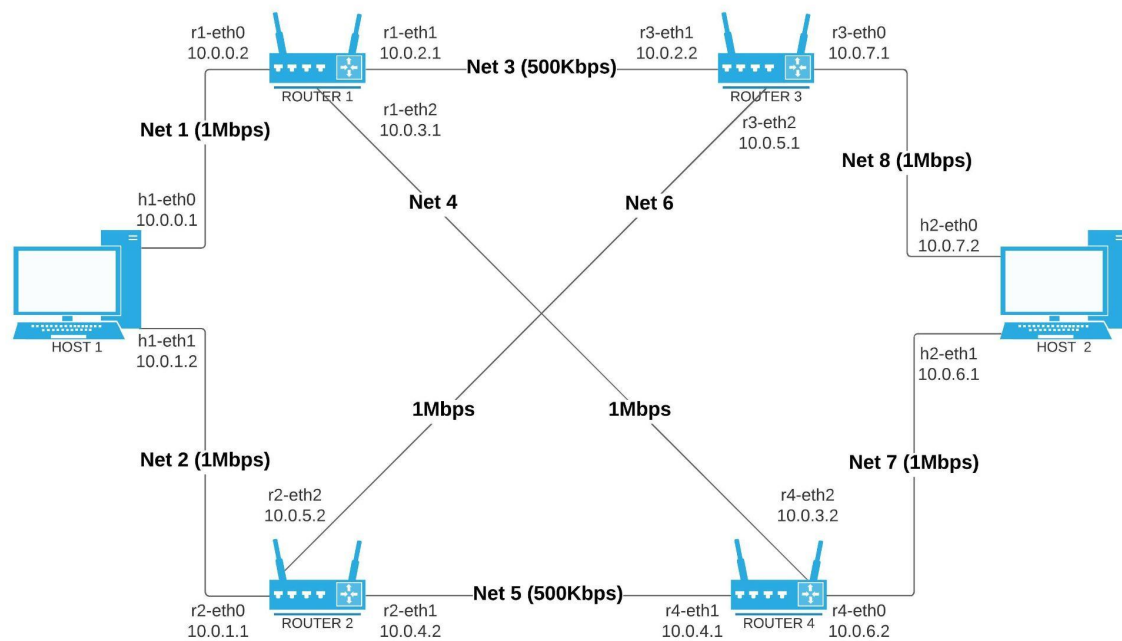
1. Membangun Topologi



Topologi yang akan dibangun adalah topologi dengan 2 Host dan 4 Router. Topologi ini membutuhkan 8 jaringan. Di sini saya menggunakan IP Private 10.0.0.0/24. Penggunaan prefix /24 hanya untuk memudahkan saja dalam pembangunan topologi, disamping dengan alokasi yang seharusnya.

1.1 Tabel Subnet dan Ilustrasi Topologi yang Dibangun

	Butuh	Alokasi	Net ID	Host Range		Broadcast	Prefix	Subnet Mask
Net 1	2	256	10.0.0.0	10.0.0.1	10.0.0.254	10.0.0.255	/24	255.255.255.0
Net 2	2	256	10.0.1.0	10.0.1.1	10.0.1.254	10.0.1.255	/24	255.255.255.0
Net 3	2	256	10.0.2.0	10.0.2.1	10.0.2.254	10.0.2.255	/24	255.255.255.0
Net 4	2	256	10.0.3.0	10.0.3.1	10.0.3.254	10.0.3.255	/24	255.255.255.0
Net 5	2	256	10.0.4.0	10.0.4.1	10.0.4.254	10.0.4.255	/24	255.255.255.0
Net 6	2	256	10.0.5.0	10.0.5.1	10.0.5.254	10.0.5.255	/24	255.255.255.0
Net 7	2	256	10.0.6.0	10.0.6.1	10.0.6.254	10.0.6.255	/24	255.255.255.0
Net 8	2	256	10.0.7.0	10.0.7.1	10.0.7.254	10.0.7.255	/24	255.255.255.0



1.2 Uji Konektivitas dari Topologi yang Dibangun

Berikut sampel kode mininet dari topologi yang dibangun:

```

Activities Visual Studio Code Min Jun 13 09:24 70%
tubes.py - Visual Studio Code
File Edit Selection View Go Run Terminal Help
tubes.py
home > ryan > Desktop > tubes.py > simpleTopo > addLink
54 class simpleTopo:
55     def __init__(self):
56         self.net = Mininet( link=TCLink )
57
58         #Add Router
59         self.r1 = self.net.addHost('r1', cls=LinuxRouter, ip='10.0.0.2/24')
60         self.r2 = self.net.addHost('r2', cls=LinuxRouter, ip='10.0.1.1/24')
61         self.r3 = self.net.addHost('r3', cls=LinuxRouter, ip='10.0.7.1/24')
62         self.r4 = self.net.addHost('r4', cls=LinuxRouter, ip='10.0.6.2/24')
63
64         #Add Host
65         self.h1 = self.net.addHost('h1', ip='10.0.0.1/24')
66         self.h2 = self.net.addHost('h2', ip='10.0.7.2/24')
67
68     def addLink(self):
69         self.net.addLink(self.h1, self.r1, intfName1='h1-eth0',intfName2='r1-eth0', bw=1,max_queue_size = 100)
70         self.net.addLink(self.h1, self.r2, intfName1='h1-eth1',intfName2='r2-eth0', bw=1)
71         self.net.addLink(self.h2, self.r3, intfName1='h2-eth0',intfName2='r3-eth0',bw=1 )
72         self.net.addLink(self.h2, self.r4, intfName1='h2-eth1',intfName2='r4-eth0',bw=1 )
73         self.net.addLink(self.r1, self.r3, intfName1='r1-eth1', intfName2='r3-eth1', bw=0.5)
74         self.net.addLink(self.r1, self.r4, intfName1='r1-eth2', intfName2='r4-eth2', bw=1)
75         self.net.addLink(self.r2, self.r3, intfName1='r2-eth2', intfName2='r3-eth2', bw=1)
76         self.net.addLink(self.r2, self.r4, intfName1='r2-eth1', intfName2='r4-eth1', bw=0.5)
77
78     def configIP(self):
79
80         self.h1.cmd('ifconfig h1-eth1 10.0.1.2 netmask 255.255.255.0')
81         self.h2.cmd('ifconfig h2-eth0 10.0.7.2 netmask 255.255.255.0')
82         self.h2.cmd('ifconfig h2-eth1 10.0.6.1 netmask 255.255.255.0')
83
84         self.r1.cmd('ip addr add 10.0.0.2/24 brd + dev r1-eth0')
85         self.r1.cmd('ip addr add 10.0.2.1/24 brd + dev r1-eth1')

```

Uji konektivitas dilakukan dengan melakukan ping antar node yang ada dalam satu jaringan. Misal, untuk menguji koneksi antar Host 1 dan Router 1 dilakukan ping pada h1 dengan: `self.h1.cmdPrint('ping -c 3 10.0.0.2')`. Hal ini dilakukan pada semua jaringan yang ada. Hasilnya adalah semuanya terkoneksi dengan baik. Untuk hasil selengkapnya, terdapat pada Lampiran 1.

```
Activities Terminal Min Jun 13 09:29 root@Ryan: /home/ryan/Desktop
(1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0
.50Mbit) (0.50Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0.50Mbit) (0.50Mbit) ***
Configuring hosts
r1 r2 r3 r4 h1 h2
*** Starting controller

*** Starting 0 switches

-----HOST 1 PING ROUTER 1-----
*** h1 : ('ping -c 3 10.0.0.2',)
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=0.070 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.059 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.059 ms

--- 10.0.0.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2043ms
rtt min/avg/max/mdev = 0.059/0.062/0.070/0.005 ms

-----HOST 1 PING ROUTER 2-----
*** h1 : ('ping -c 3 10.0.1.1',)
PING 10.0.1.1 (10.0.1.1) 56(84) bytes of data
```

Kita juga dapat mengecek dan mencocokkan keterhubungan topologi yang dibangun di mininet dengan topologi yang diharapkan dengan mengetikkan links di mininet CLI.

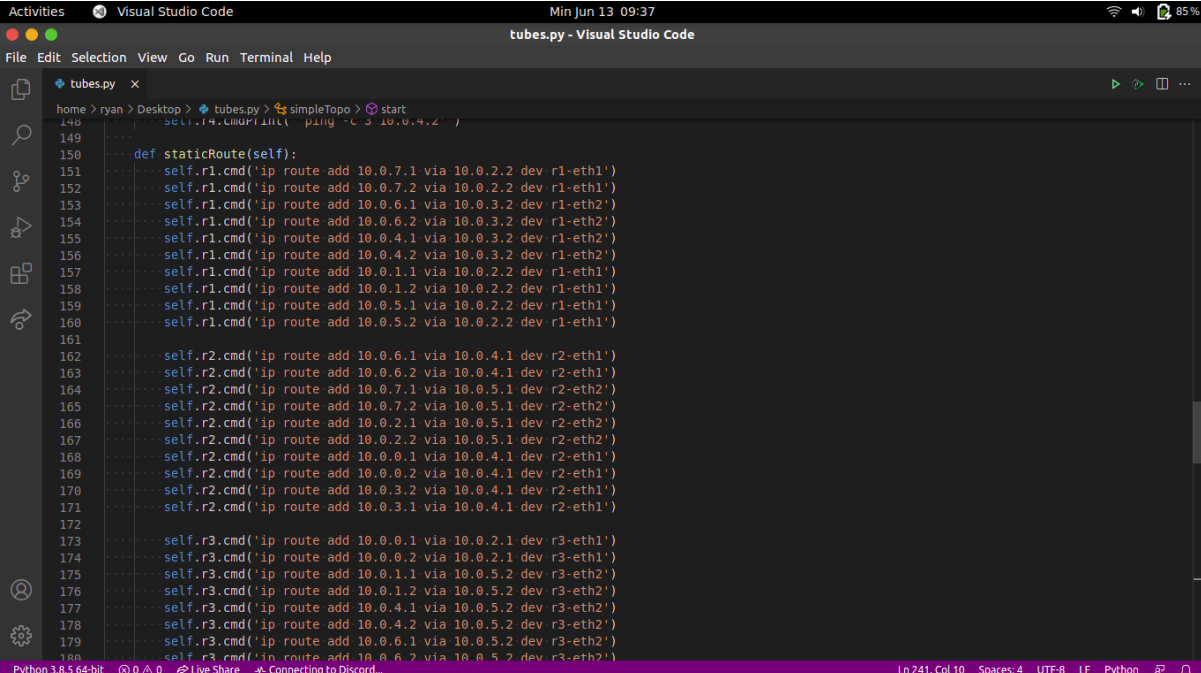
```
Activities Terminal Min Jun 13 09:33 root@Ryan: /home/ryan/Desktop
(1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0
.50Mbit) (0.50Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0.50Mbit) (0.50Mbit) ***
Configuring hosts
r1 r2 r3 r4 h1 h2
*** Starting controller

*** Starting 0 switches

*** Starting CLI:
mininet> links
h1-eth0<->r1-eth0 (OK OK)
h1-eth1<->r2-eth0 (OK OK)
h2-eth0<->r3-eth0 (OK OK)
h2-eth1<->r4-eth0 (OK OK)
r1-eth1<->r3-eth1 (OK OK)
r1-eth2<->r4-eth2 (OK OK)
r2-eth2<->r3-eth2 (OK OK)
r2-eth1<->r4-eth1 (OK OK)
mininet> 
```

2. Implementasi Mekanisme Routing

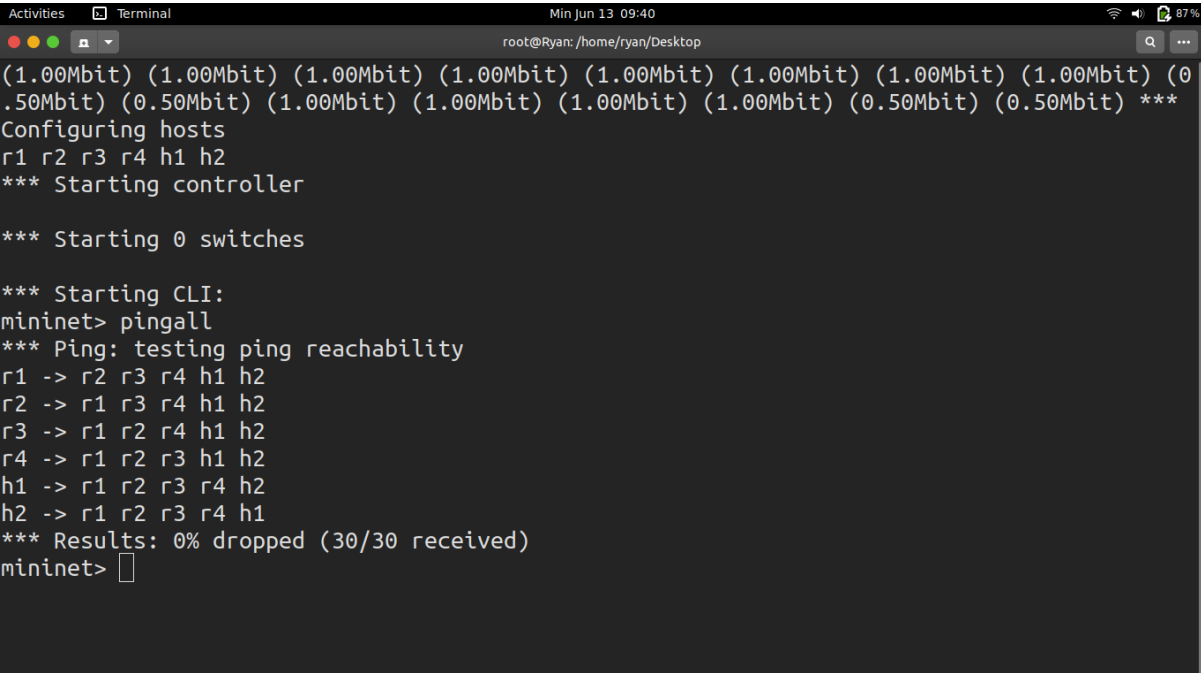
Saya menggunakan mekanisme Static Routing yaitu mengetikkan secara manual tabel routing dari topologi yang ada. Berikut sampel kode di mininet:



```
home > ryan > Desktop > tubes.py > simpleTopo > start
148 self.r1.cmd('ping -c 3 10.0.4.2')
149
150 def staticRoute(self):
151     self.r1.cmd('ip route add 10.0.7.1 via 10.0.2.2 dev r1-eth1')
152     self.r1.cmd('ip route add 10.0.7.2 via 10.0.2.2 dev r1-eth1')
153     self.r1.cmd('ip route add 10.0.6.1 via 10.0.3.2 dev r1-eth2')
154     self.r1.cmd('ip route add 10.0.6.2 via 10.0.3.2 dev r1-eth2')
155     self.r1.cmd('ip route add 10.0.4.1 via 10.0.3.2 dev r1-eth2')
156     self.r1.cmd('ip route add 10.0.4.2 via 10.0.3.2 dev r1-eth2')
157     self.r1.cmd('ip route add 10.0.1.1 via 10.0.2.2 dev r1-eth1')
158     self.r1.cmd('ip route add 10.0.1.2 via 10.0.2.2 dev r1-eth1')
159     self.r1.cmd('ip route add 10.0.5.1 via 10.0.2.2 dev r1-eth1')
160     self.r1.cmd('ip route add 10.0.5.2 via 10.0.2.2 dev r1-eth1')
161
162     self.r2.cmd('ip route add 10.0.6.1 via 10.0.4.1 dev r2-eth1')
163     self.r2.cmd('ip route add 10.0.6.2 via 10.0.4.1 dev r2-eth1')
164     self.r2.cmd('ip route add 10.0.7.1 via 10.0.5.1 dev r2-eth2')
165     self.r2.cmd('ip route add 10.0.7.2 via 10.0.5.1 dev r2-eth2')
166     self.r2.cmd('ip route add 10.0.2.1 via 10.0.5.1 dev r2-eth2')
167     self.r2.cmd('ip route add 10.0.2.2 via 10.0.5.1 dev r2-eth2')
168     self.r2.cmd('ip route add 10.0.0.1 via 10.0.4.1 dev r2-eth1')
169     self.r2.cmd('ip route add 10.0.0.2 via 10.0.4.1 dev r2-eth1')
170     self.r2.cmd('ip route add 10.0.3.2 via 10.0.4.1 dev r2-eth1')
171     self.r2.cmd('ip route add 10.0.3.1 via 10.0.4.1 dev r2-eth1')
172
173     self.r3.cmd('ip route add 10.0.0.1 via 10.0.2.1 dev r3-eth1')
174     self.r3.cmd('ip route add 10.0.0.2 via 10.0.2.1 dev r3-eth1')
175     self.r3.cmd('ip route add 10.0.1.1 via 10.0.5.2 dev r3-eth2')
176     self.r3.cmd('ip route add 10.0.1.2 via 10.0.5.2 dev r3-eth2')
177     self.r3.cmd('ip route add 10.0.4.1 via 10.0.5.2 dev r3-eth2')
178     self.r3.cmd('ip route add 10.0.4.2 via 10.0.5.2 dev r3-eth2')
179     self.r3.cmd('ip route add 10.0.6.1 via 10.0.5.2 dev r3-eth2')
180     self.r3.cmd('ip route add 10.0.6.2 via 10.0.5.2 dev r3-eth2')
```

2.1 Uji Konektivitas

Uji konektivitas dilakukan dengan menuliskan perintah pingall pada mininet CLI. Terlihat bahwa semua node telah terhubung sepenuhnya.



```
root@Ryan: /home/ryan/Desktop
(1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0
.50Mbit) (0.50Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0.50Mbit) (0.50Mbit) ***
Configuring hosts
r1 r2 r3 r4 h1 h2
*** Starting controller

*** Starting 0 switches

*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
r1 -> r2 r3 r4 h1 h2
r2 -> r1 r3 r4 h1 h2
r3 -> r1 r2 r4 h1 h2
r4 -> r1 r2 r3 h1 h2
h1 -> r1 r2 r3 r4 h2
h2 -> r1 r2 r3 r4 h1
*** Results: 0% dropped (30/30 received)
mininet> 
```

2.2 Traceroute

Pada traceroute, paket akan dikirimkan dari node pengirim ke penerima, namun paket tersebut akan melakukan mekanisme penambahan TTL pada setiap hop yang dilewati. Kita bisa melihat hop mana saja yang dilewati untuk ketika paket dikirimkan ke tujuan.

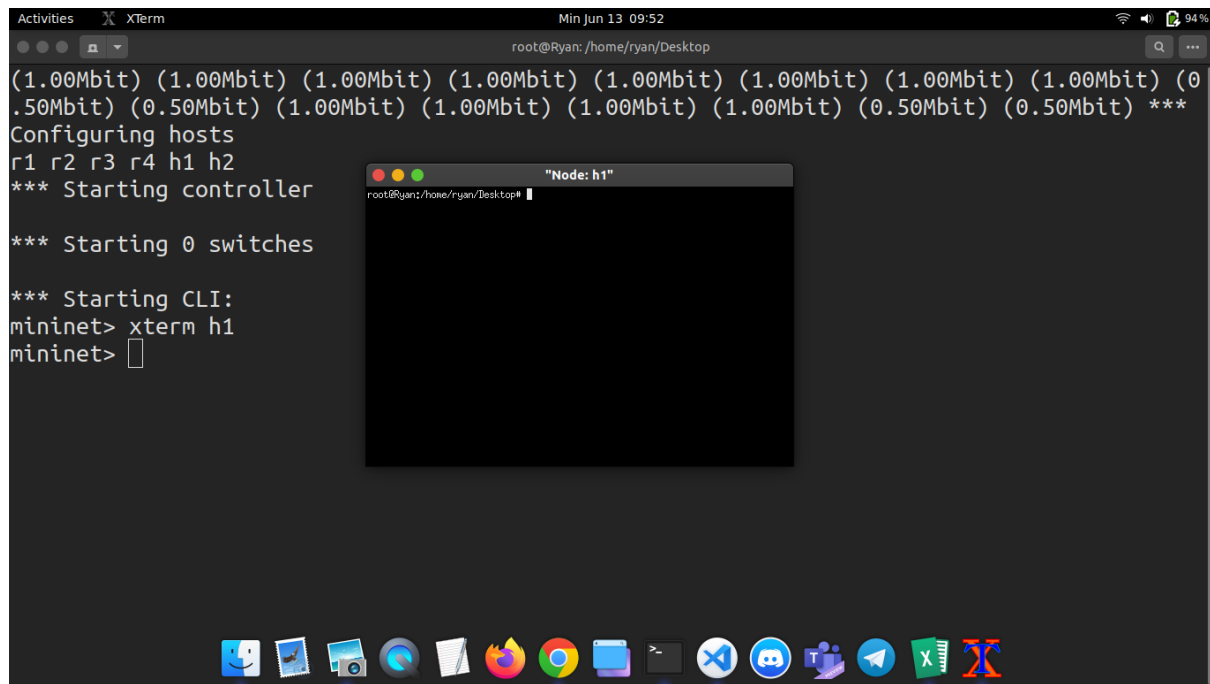
```
Activities Terminal Min Jun 13 09:43 root@Ryan: /home/ryan/Desktop
h1 -> r1 r2 r3 r4 h2
h2 -> r1 r2 r3 r4 h1
*** Results: 0% dropped (30/30 received)
mininet> h1 traceroute h2
traceroute to 10.0.7.2 (10.0.7.2), 30 hops max, 60 byte packets
 1 10.0.1.1 (10.0.1.1) 0.511 ms 0.440 ms 0.423 ms
 2 10.0.5.1 (10.0.5.1) 0.405 ms 0.371 ms 0.348 ms
 3 10.0.7.2 (10.0.7.2) 0.325 ms 0.287 ms 0.259 ms
mininet> h1 traceroute r4
traceroute to 10.0.6.2 (10.0.6.2), 30 hops max, 60 byte packets
 1 10.0.1.1 (10.0.1.1) 0.430 ms 0.365 ms 0.345 ms
 2 10.0.6.2 (10.0.6.2) 0.327 ms 0.292 ms 0.270 ms
mininet> h2 traceroute h1
traceroute to 10.0.0.1 (10.0.0.1), 30 hops max, 60 byte packets
 1 10.0.7.1 (10.0.7.1) 0.454 ms 0.391 ms 0.373 ms
 2 10.0.2.1 (10.0.2.1) 0.356 ms 0.323 ms 0.300 ms
 3 10.0.0.1 (10.0.0.1) 0.278 ms 0.237 ms 0.209 ms
mininet> h2 traceroute r2
traceroute to 10.0.1.1 (10.0.1.1), 30 hops max, 60 byte packets
 1 10.0.7.1 (10.0.7.1) 0.429 ms 0.365 ms 0.346 ms
 2 10.0.1.1 (10.0.1.1) 0.329 ms 0.298 ms 0.274 ms
mininet> 
```

Misal, kita bisa mengecek hop mana saja yang dilewati ketika paket dikirimkan dari h1 ke h2. Bisa kita lihat bahwa hop yang dilewati antara lain router 2 dan router 3 lalu sampai pada akhirnya ke host 2 (10.0.7.2). Traceroute akan berhenti jika sudah mencapai tujuan, atau telah mencapai maksimum hop yaitu 30.

```
mininet> h1 traceroute h2
traceroute to 10.0.7.2 (10.0.7.2), 30 hops max, 60 byte packets
 1 10.0.1.1 (10.0.1.1) 0.511 ms 0.440 ms 0.423 ms
 2 10.0.5.1 (10.0.5.1) 0.405 ms 0.371 ms 0.348 ms
 3 10.0.7.2 (10.0.7.2) 0.325 ms 0.287 ms 0.259 ms
```

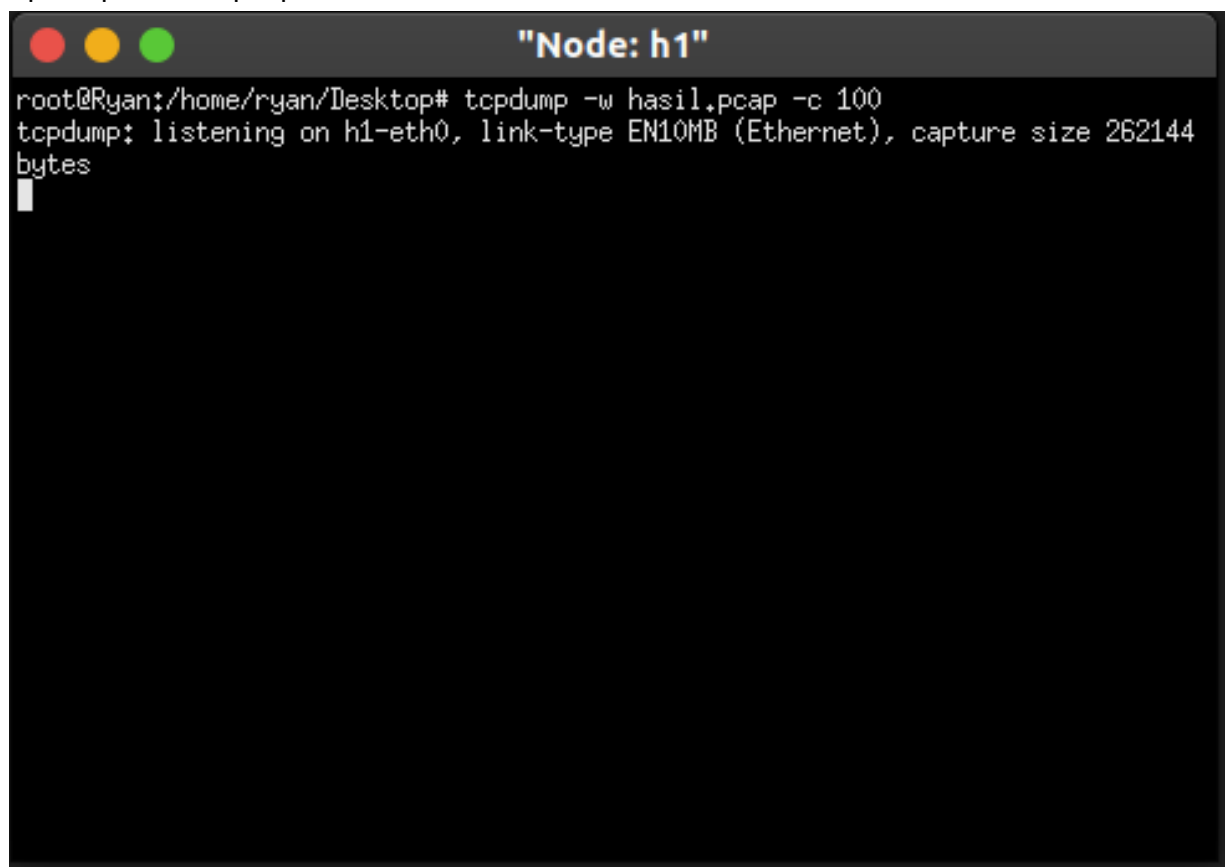
3. Membuktikan bahwa TCP telah diimplementasikan dengan Benar

Pertama, kita bisa mengetikkan xterm h1 (pada kasus ini node h1/host 1) untuk membuka terminal pada host 1 di mininet CLI.

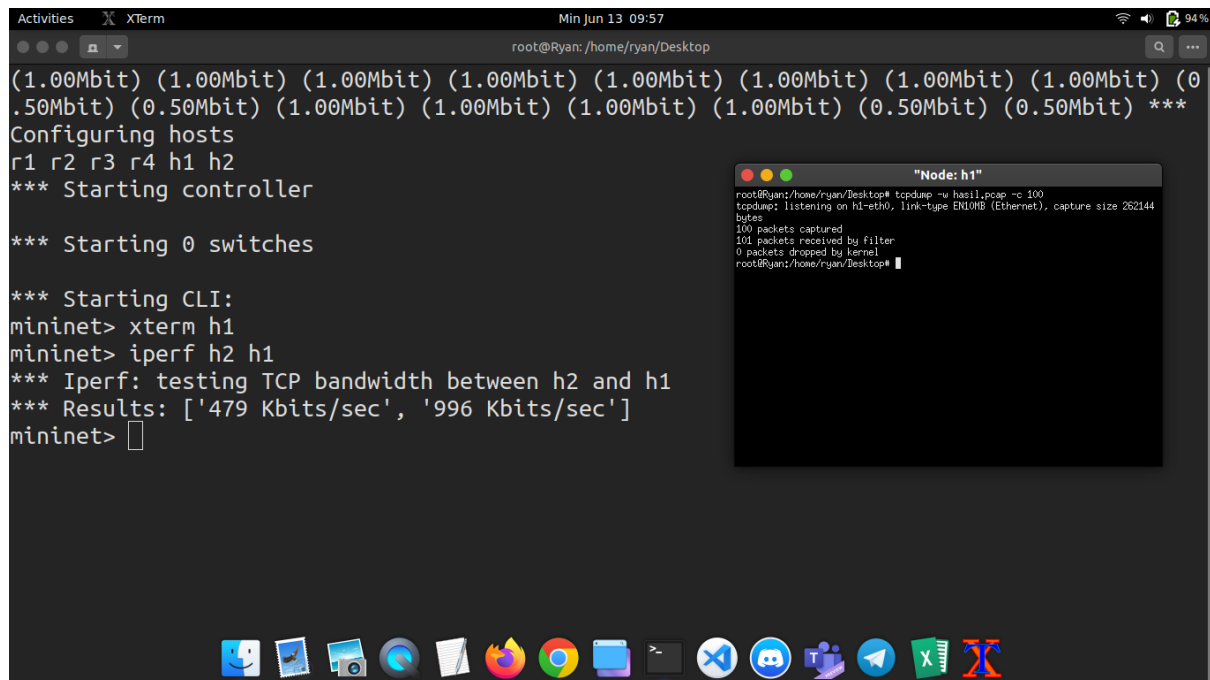


Kedua, pada xterm, kita akan mengetikkan perintah untuk meng-capture paket menggunakan tcpdump. Paket yang akan dicapture sebanyak 100 paket. Maka command yang digunakan:

```
tcpdump -w hasil.pcap -c 100
```



Ketiga, kita generate traffic menggunakan iperf. Misal kita akan generate traffic dari h2 ke h1. Maka kita ketikkan iperf h2 h1 pada mininet CLI. Tunggu hingga paket selesai tercapture.

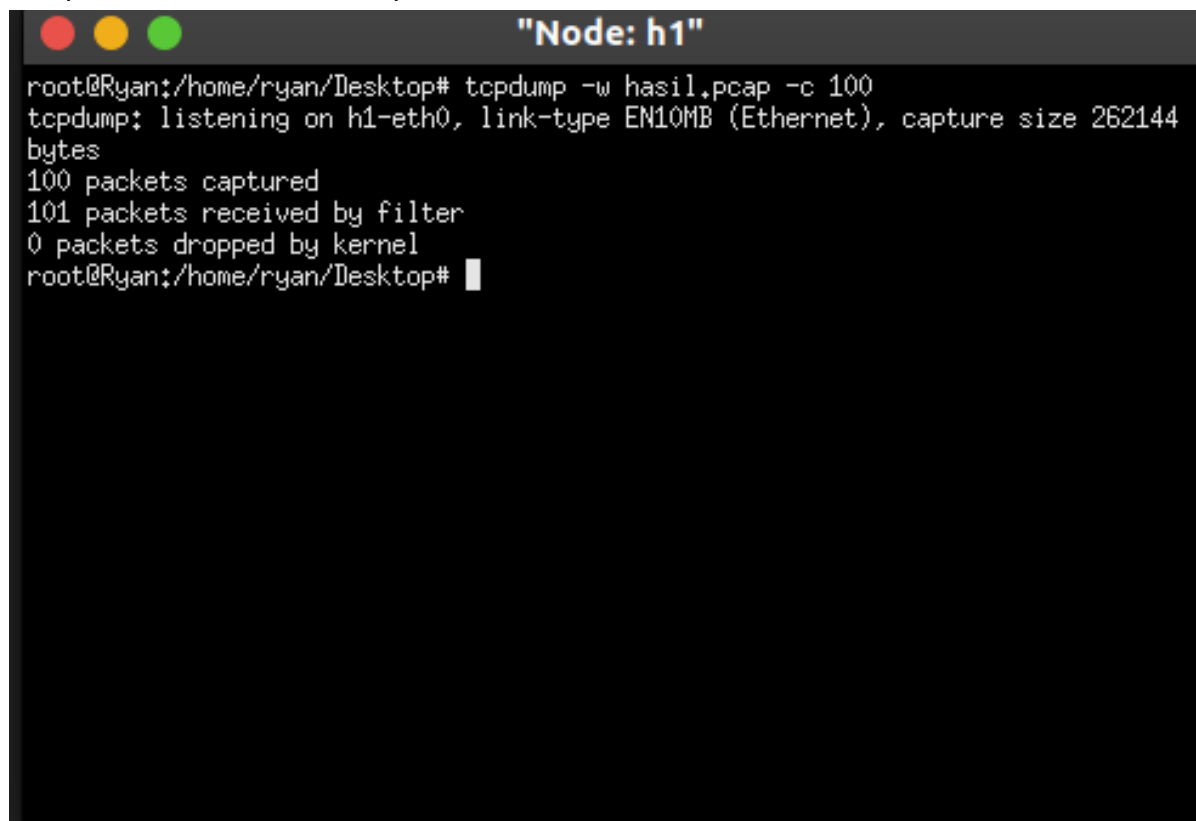


```
root@Ryan: /home/ryan/Desktop
(1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0
.50Mbit) (0.50Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0.50Mbit) (0.50Mbit) ***
Configuring hosts
r1 r2 r3 r4 h1 h2
*** Starting controller

*** Starting 0 switches

*** Starting CLI:
mininet> xterm h1
mininet> iperf h2 h1
*** Iperf: testing TCP bandwidth between h2 and h1
*** Results: ['479 Kbits/sec', '996 Kbits/sec']
mininet> 
```

Jika paket telah berhasil tercapture, maka akan muncul:



```
root@Ryan:/home/ryan/Desktop# tcpdump -w hasil.pcap -c 100
tcpdump: listening on h1-eth0, link-type EN10MB (Ethernet), capture size 262144
bytes
100 packets captured
101 packets received by filter
0 packets dropped by kernel
root@Ryan:/home/ryan/Desktop# 
```

Keempat, kita buka hasil dari capture pada file hasil.pcap pada wireshark. Terlihat bahwa paket yang ada adalah TCP. Sehingga, terbukti bahwa TCP telah diimplementasikan dengan benar.

Activities Wireshark Min Jun 13 10:01 hasil.pcap

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
7	88.074267	10.0.7.2	10.0.0.1	TCP	66	42028 → 5001 [FIN, ACK] Seq=1 Ack=1 Win=42496 Len=0 TSval=635...
8	88.077996	10.0.7.2	10.0.0.1	TCP	74	42030 → 5001 [SYN] Seq=0 Win=42340 Len=0 MSS=1460 SACK_PERM=1...
9	88.078047	10.0.7.2	10.0.0.1	TCP	66	42030 → 5001 [ACK] Seq=1 Ack=1 Win=42496 Len=0 TSval=63599925...
10	88.078246	10.0.7.2	10.0.0.1	TCP	7306	42030 → 5001 [PSH, ACK] Seq=1 Ack=1 Win=42496 Len=7240 TSval=...
11	88.175938	10.0.7.2	10.0.0.1	TCP	7306	42030 → 5001 [PSH, ACK] Seq=7241 Ack=1 Win=42496 Len=7240 TSv...
12	88.296965	10.0.7.2	10.0.0.1	TCP	10202	42030 → 5001 [PSH, ACK] Seq=14481 Ack=1 Win=42496 Len=10136 T...
13	88.466512	10.0.7.2	10.0.0.1	TCP	4410	42030 → 5001 [PSH, ACK] Seq=24617 Ack=1 Win=42496 Len=4344 TS...
14	88.539268	10.0.7.2	10.0.0.1	TCP	66	42028 → 5001 [ACK] Seq=2 Ack=2 Win=42496 Len=0 TSval=63599925...
15	88.540230	10.0.7.2	10.0.0.1	TCP	1514	42030 → 5001 [ACK] Seq=28961 Ack=1 Win=42496 Len=1448 TSval=6...
16	88.564460	10.0.7.2	10.0.0.1	TCP	4410	42030 → 5001 [PSH, ACK] Seq=30409 Ack=1 Win=42496 Len=4344 TS...
17	88.637112	10.0.7.2	10.0.0.1	TCP	66	[TCP Dup ACK 14#1] 42028 → 5001 [ACK] Seq=2 Ack=2 Win=42496 L...
18	88.638169	10.0.7.2	10.0.0.1	TCP	1514	42030 → 5001 [PSH, ACK] Seq=34753 Ack=1 Win=42496 Len=1448 TS...
19	88.662427	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=36201 Ack=1 Win=42496 Len=2896 TS...
20	88.710838	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=39097 Ack=1 Win=42496 Len=2896 TS...
21	88.759290	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=41993 Ack=1 Win=42496 Len=2896 TS...
22	88.807751	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=44889 Ack=1 Win=42496 Len=2896 TS...
23	88.856228	10.0.7.2	10.0.0.1	TCP	1514	[TCP Retransmission] 42030 → 5001 [ACK] Seq=24617 Ack=1 Win=4...
24	88.880475	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=47785 Ack=1 Win=42496 Len=2896 TS...
25	88.928866	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=50681 Ack=1 Win=42496 Len=2896 TS...
26	88.977318	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=53577 Ack=1 Win=42496 Len=2896 TS...
27	89.025763	10.0.7.2	10.0.0.1	TCP	66	[TCP Dup ACK 14#2] 42028 → 5001 [ACK] Seq=2 Ack=2 Win=42496 L...
28	89.026813	10.0.7.2	10.0.0.1	TCP	1514	42030 → 5001 [PSH, ACK] Seq=56473 Ack=1 Win=42496 Len=1448 TS...
29	89.051149	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=57921 Ack=1 Win=42496 Len=2896 TS...
30	89.095518	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=60817 Ack=1 Win=42496 Len=2896 TS...
31	89.147952	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=63713 Ack=1 Win=42496 Len=2896 TS...
32	89.196385	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=66609 Ack=1 Win=42496 Len=2896 TS...
33	89.244832	10.0.7.2	10.0.0.1	TCP	2962	42030 → 5001 [PSH, ACK] Seq=69505 Ack=1 Win=42496 Len=2896 TS...

Frame 1: 70 bytes on wire (560 bits), 70 bytes captured (560 bits)

```

0000 33 33 00 00 00 02 de 31 91 38 8c 49 86 dd 60 00 33.....1 8 I...
0010 00 00 00 10 3a ff fe 80 00 00 00 00 00 dc 31 .....:.....1
0020 91 ff fe 38 8c 49 ff 02 00 00 00 00 00 00 00 ...B I...
0030 00 00 00 00 02 85 00 87 c6 00 00 00 00 01 01 .....

```

hasil.pcap Packets: 100 · Displayed: 100 (100.0%) Profile: Default

4. Menginspeksi Penggunaan Queue

Di sini menggunakan Class Based Queue (CBQ). Router yang diamati adalah router 3. Traffic dilakukan melalui client (h1) ke server (h2). Berikut besaran ukuran buffer menggunakan variabel buff yang bisa diisi parameternya ketika method dipanggil, variabel buff ini dimasukkan ke dalam parameter max_queue_size pada method addLink:

Activities Visual Studio Code Min Jun 13 19:22 tubes.py - Visual Studio Code

File Edit Selection View Go Run Terminal Help

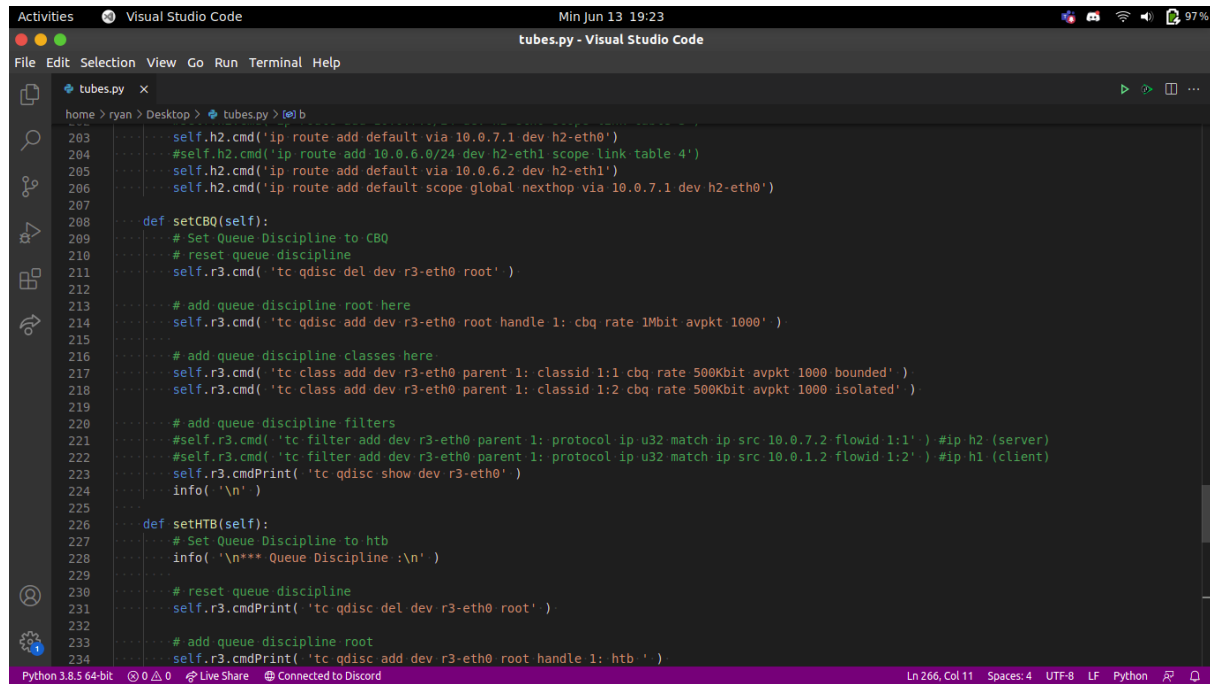
```

1  tubes.py
2
3  home > ryan > Desktop > tubes.py > b
4
5  51
6  52 class simpleTopo:
7  53     def __init__(self):
8  54         self.net = Mininet( link=TCLink )
9  55
10 56         #Add Router
11 57         self.r1 = self.net.addHost('r1', cls=LinuxRouter, ip='10.0.0.2/24')
12 58         self.r2 = self.net.addHost('r2', cls=LinuxRouter, ip='10.0.1.1/24')
13 59         self.r3 = self.net.addHost('r3', cls=LinuxRouter, ip='10.0.7.1/24')
14 60         self.r4 = self.net.addHost('r4', cls=LinuxRouter, ip='10.0.6.2/24')
15 61
16 62         #Add Host
17 63         self.h1 = self.net.addHost('h1', ip='10.0.0.1/24')
18 64         self.h2 = self.net.addHost('h2', ip='10.0.7.2/24')
19 65
20 66     def addLink(self, buff):
21 67         self.net.addLink(self.h1, self.r1, intfName1='h1-eth0', intfName2='r1-eth0', bw=1)
22 68         self.net.addLink(self.h1, self.r2, intfName1='h1-eth1', intfName2='r2-eth0', bw=1)
23 69         self.net.addLink(self.h2, self.r3, intfName1='h2-eth0', intfName2='r3-eth0', bw=1, max_queue_size=buff)#, use_htb=True)
24 70         self.net.addLink(self.h2, self.r4, intfName1='h2-eth1', intfName2='r4-eth0', bw=1)
25 71         self.net.addLink(self.r1, self.r3, intfName1='r1-eth1', intfName2='r3-eth1', bw=0.5, max_queue_size=buff)#, use_htb=True)
26 72         self.net.addLink(self.r1, self.r4, intfName1='r1-eth2', intfName2='r4-eth2', bw=1)
27 73         self.net.addLink(self.r2, self.r3, intfName1='r2-eth2', intfName2='r3-eth2', bw=1, max_queue_size=buff)#, use_htb=True)
28 74         self.net.addLink(self.r2, self.r4, intfName1='r2-eth1', intfName2='r4-eth1', bw=0.5)
29 75
30 76     def configIP(self):
31 77         self.h1.cmd('ifconfig h1-eth1 10.0.1.2 netmask 255.255.255.0')
32 78         self.h2.cmd('ifconfig h2-eth0 10.0.7.2 netmask 255.255.255.0')
33 79         self.h2.cmd('ifconfig h2-eth1 10.0.6.1 netmask 255.255.255.0')
34 80
35 81         self.r1.cmd('ip addr add 10.0.0.2/24 brd + dev r1-eth0')
36 82         self.r1.cmd('ip addr add 10.0.2.1/24 brd + dev r1-eth1')

```

Python 3.8.5 64-bit Live Share Connected to Discord Ln 266, Col 11 Spaces: 4 UTF-8 LF Python

Berikut konfigurasi CBQ-nya:



```
203 self.h2.cmd('ip route add default via 10.0.7.1 dev h2-eth0')
204 #self.h2.cmd('ip route add 10.0.6.0/24 dev h2-eth1 scope link table 4')
205 self.h2.cmd('ip route add default via 10.0.6.2 dev h2-eth1')
206 self.h2.cmd('ip route add default scope global nexthop via 10.0.7.1 dev h2-eth0')
207
208 def setCBQ(self):
209     # Set Queue Discipline to CBQ
210     # reset queue discipline
211     self.r3.cmd('tc qdisc del dev r3-eth0 root')
212
213     # add queue discipline root here
214     self.r3.cmd('tc qdisc add dev r3-eth0 root handle 1: cbq rate 1Mbit avpkt 1000')
215
216     # add queue discipline classes here
217     self.r3.cmd('tc class add dev r3-eth0 parent 1: classid 1:1 cbq rate 500Kbit avpkt 1000 bounded')
218     self.r3.cmd('tc class add dev r3-eth0 parent 1: classid 1:2 cbq rate 500Kbit avpkt 1000 isolated')
219
220     # add queue discipline filters
221     self.r3.cmd('tc filter add dev r3-eth0 parent 1: protocol ip u32 match ip src 10.0.7.2 flowid 1:1') #ip h2 (server)
222     self.r3.cmd('tc filter add dev r3-eth0 parent 1: protocol ip u32 match ip src 10.0.1.2 flowid 1:2') #ip h1 (client)
223     self.r3.cmdPrint('tc qdisc show dev r3-eth0')
224     info('\n')
225
226 def setHTB(self):
227     # Set Queue Discipline to htb
228     info('\n*** Queue Discipline :\n')
229
230     # reset queue discipline
231     self.r3.cmdPrint('tc qdisc del dev r3-eth0 root')
232
233     # add queue discipline root
234     self.r3.cmdPrint('tc qdisc add dev r3-eth0 root handle 1: htb')
```

Untuk hasil pengaruh buffer terhadap delay, di sini digunakan percobaan dengan me-generate traffic dari h1 ke h2 menggunakan iperf3. Berikut hasilnya (hasil output ada di Lampiran 2):

Buffer	Delay (s)
20	0.06
40	0.06
60	0.07
100	0.07

Hasil analisis menunjukkan bahwa semakin tinggi ukuran buffer, maka semakin tinggi pula delay. Hal ini dikarenakan antrian paket akan semakin panjang. Namun, tentu paket yang di-drop akan semakin sedikit. Sebaliknya, semakin rendah buffer, maka rendah pula waktu delaynya, karena memang antriannya tidak panjang. Namun, konsekuensinya akan peluang paket terkena drop akan tinggi karena antrian akan penuh dengan cepat.

Lampiran 1: Hasil Uji Konektivitas Antarhost dalam Satu Jaringan

-----HOST 1 PING ROUTER 1-----

*** h1 : ('ping -c 3 10.0.0.2',)

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=0.070 ms

64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.059 ms

64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.059 ms

--- 10.0.0.2 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2043ms

rtt min/avg/max/mdev = 0.059/0.062/0.070/0.005 ms

-----HOST 1 PING ROUTER 2-----

*** h1 : ('ping -c 3 10.0.1.1',)

PING 10.0.1.1 (10.0.1.1) 56(84) bytes of data.

64 bytes from 10.0.1.1: icmp_seq=1 ttl=64 time=0.084 ms

64 bytes from 10.0.1.1: icmp_seq=2 ttl=64 time=0.057 ms

64 bytes from 10.0.1.1: icmp_seq=3 ttl=64 time=0.058 ms

--- 10.0.1.1 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2026ms

rtt min/avg/max/mdev = 0.057/0.066/0.084/0.012 ms

-----HOST 2 PING ROUTER 3-----

*** h2 : ('ping -c 3 10.0.7.1',)

PING 10.0.7.1 (10.0.7.1) 56(84) bytes of data.

64 bytes from 10.0.7.1: icmp_seq=1 ttl=64 time=0.087 ms

64 bytes from 10.0.7.1: icmp_seq=2 ttl=64 time=0.070 ms

64 bytes from 10.0.7.1: icmp_seq=3 ttl=64 time=0.057 ms

--- 10.0.7.1 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2026ms

rtt min/avg/max/mdev = 0.057/0.071/0.087/0.012 ms

-----HOST 2 PING ROUTER 4-----

*** h2 : ('ping -c 3 10.0.6.2',)

PING 10.0.6.2 (10.0.6.2) 56(84) bytes of data.

64 bytes from 10.0.6.2: icmp_seq=1 ttl=64 time=0.092 ms

64 bytes from 10.0.6.2: icmp_seq=2 ttl=64 time=0.059 ms

64 bytes from 10.0.6.2: icmp_seq=3 ttl=64 time=0.054 ms

--- 10.0.6.2 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms

rtt min/avg/max/mdev = 0.054/0.068/0.092/0.016 ms

-----ROUTER 1 PING ROUTER 4-----

*** r1 : ('ping -c 3 10.0.3.2',)

PING 10.0.3.2 (10.0.3.2) 56(84) bytes of data.

64 bytes from 10.0.3.2: icmp_seq=1 ttl=64 time=0.112 ms
64 bytes from 10.0.3.2: icmp_seq=2 ttl=64 time=0.052 ms
64 bytes from 10.0.3.2: icmp_seq=3 ttl=64 time=0.055 ms

--- 10.0.3.2 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms
rtt min/avg/max/mdev = 0.052/0.073/0.112/0.027 ms

-----ROUTER 1 PING ROUTER 3-----

*** r1 : ('ping -c 3 10.0.2.2',)

PING 10.0.2.2 (10.0.2.2) 56(84) bytes of data.

64 bytes from 10.0.2.2: icmp_seq=1 ttl=64 time=0.094 ms
64 bytes from 10.0.2.2: icmp_seq=2 ttl=64 time=0.053 ms
64 bytes from 10.0.2.2: icmp_seq=3 ttl=64 time=0.068 ms

--- 10.0.2.2 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms
rtt min/avg/max/mdev = 0.053/0.071/0.094/0.016 ms

-----ROUTER 1 PING HOST 1-----

*** r1 : ('ping -c 3 10.0.0.1',)

PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.

64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.063 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.048 ms
64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.058 ms

--- 10.0.0.1 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms
rtt min/avg/max/mdev = 0.048/0.056/0.063/0.006 ms

-----ROUTER 2 PING HOST 1-----

*** r2 : ('ping -c 3 10.0.1.2',)

PING 10.0.1.2 (10.0.1.2) 56(84) bytes of data.

64 bytes from 10.0.1.2: icmp_seq=1 ttl=64 time=0.061 ms
64 bytes from 10.0.1.2: icmp_seq=2 ttl=64 time=0.059 ms
64 bytes from 10.0.1.2: icmp_seq=3 ttl=64 time=0.061 ms

--- 10.0.1.2 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms
rtt min/avg/max/mdev = 0.059/0.060/0.061/0.000 ms

-----ROUTER 2 PING ROUTER 4-----

*** r2 : ('ping -c 3 10.0.4.1',)

PING 10.0.4.1 (10.0.4.1) 56(84) bytes of data.

64 bytes from 10.0.4.1: icmp_seq=1 ttl=64 time=0.118 ms
64 bytes from 10.0.4.1: icmp_seq=2 ttl=64 time=0.058 ms
64 bytes from 10.0.4.1: icmp_seq=3 ttl=64 time=0.063 ms

--- 10.0.4.1 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2026ms
rtt min/avg/max/mdev = 0.058/0.079/0.118/0.027 ms

-----ROUTER 2 PING ROUTER 3-----

*** r2 : ('ping -c 3 10.0.5.1',)

PING 10.0.5.1 (10.0.5.1) 56(84) bytes of data.

64 bytes from 10.0.5.1: icmp_seq=1 ttl=64 time=0.103 ms

64 bytes from 10.0.5.1: icmp_seq=2 ttl=64 time=0.059 ms

64 bytes from 10.0.5.1: icmp_seq=3 ttl=64 time=0.067 ms

--- 10.0.5.1 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms
rtt min/avg/max/mdev = 0.059/0.076/0.103/0.019 ms

-----ROUTER 3 PING ROUTER 1-----

*** r3 : ('ping -c 3 10.0.2.1',)

PING 10.0.2.1 (10.0.2.1) 56(84) bytes of data.

64 bytes from 10.0.2.1: icmp_seq=1 ttl=64 time=0.061 ms

64 bytes from 10.0.2.1: icmp_seq=2 ttl=64 time=0.051 ms

64 bytes from 10.0.2.1: icmp_seq=3 ttl=64 time=0.057 ms

--- 10.0.2.1 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms
rtt min/avg/max/mdev = 0.051/0.056/0.061/0.004 ms

-----ROUTER 3 PING HOST 2-----

*** r3 : ('ping -c 3 10.0.7.2',)

PING 10.0.7.2 (10.0.7.2) 56(84) bytes of data.

64 bytes from 10.0.7.2: icmp_seq=1 ttl=64 time=0.062 ms

64 bytes from 10.0.7.2: icmp_seq=2 ttl=64 time=0.053 ms

64 bytes from 10.0.7.2: icmp_seq=3 ttl=64 time=0.082 ms

--- 10.0.7.2 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms
rtt min/avg/max/mdev = 0.053/0.065/0.082/0.012 ms

-----ROUTER 3 PING ROUTER 2-----

*** r3 : ('ping -c 3 10.0.5.2',)

PING 10.0.5.2 (10.0.5.2) 56(84) bytes of data.

64 bytes from 10.0.5.2: icmp_seq=1 ttl=64 time=0.058 ms

64 bytes from 10.0.5.2: icmp_seq=2 ttl=64 time=0.065 ms

64 bytes from 10.0.5.2: icmp_seq=3 ttl=64 time=0.053 ms

--- 10.0.5.2 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms
rtt min/avg/max/mdev = 0.053/0.058/0.065/0.005 ms

-----ROUTER 4 PING HOST 2-----

*** r4 : ('ping -c 3 10.0.6.1',)

PING 10.0.6.1 (10.0.6.1) 56(84) bytes of data.

64 bytes from 10.0.6.1: icmp_seq=1 ttl=64 time=0.074 ms

64 bytes from 10.0.6.1: icmp_seq=2 ttl=64 time=0.056 ms

64 bytes from 10.0.6.1: icmp_seq=3 ttl=64 time=0.059 ms

--- 10.0.6.1 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms

rtt min/avg/max/mdev = 0.056/0.063/0.074/0.007 ms

-----ROUTER 4 PING ROUTER 1-----

*** r4 : ('ping -c 3 10.0.3.1',)

PING 10.0.3.1 (10.0.3.1) 56(84) bytes of data.

64 bytes from 10.0.3.1: icmp_seq=1 ttl=64 time=0.063 ms

64 bytes from 10.0.3.1: icmp_seq=2 ttl=64 time=0.048 ms

64 bytes from 10.0.3.1: icmp_seq=3 ttl=64 time=0.054 ms

--- 10.0.3.1 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms

rtt min/avg/max/mdev = 0.048/0.055/0.063/0.006 ms

-----ROUTER 4 PING ROUTER 2-----

*** r4 : ('ping -c 3 10.0.4.2',)

PING 10.0.4.2 (10.0.4.2) 56(84) bytes of data.

64 bytes from 10.0.4.2: icmp_seq=1 ttl=64 time=0.063 ms

64 bytes from 10.0.4.2: icmp_seq=2 ttl=64 time=0.052 ms

64 bytes from 10.0.4.2: icmp_seq=3 ttl=64 time=0.055 ms

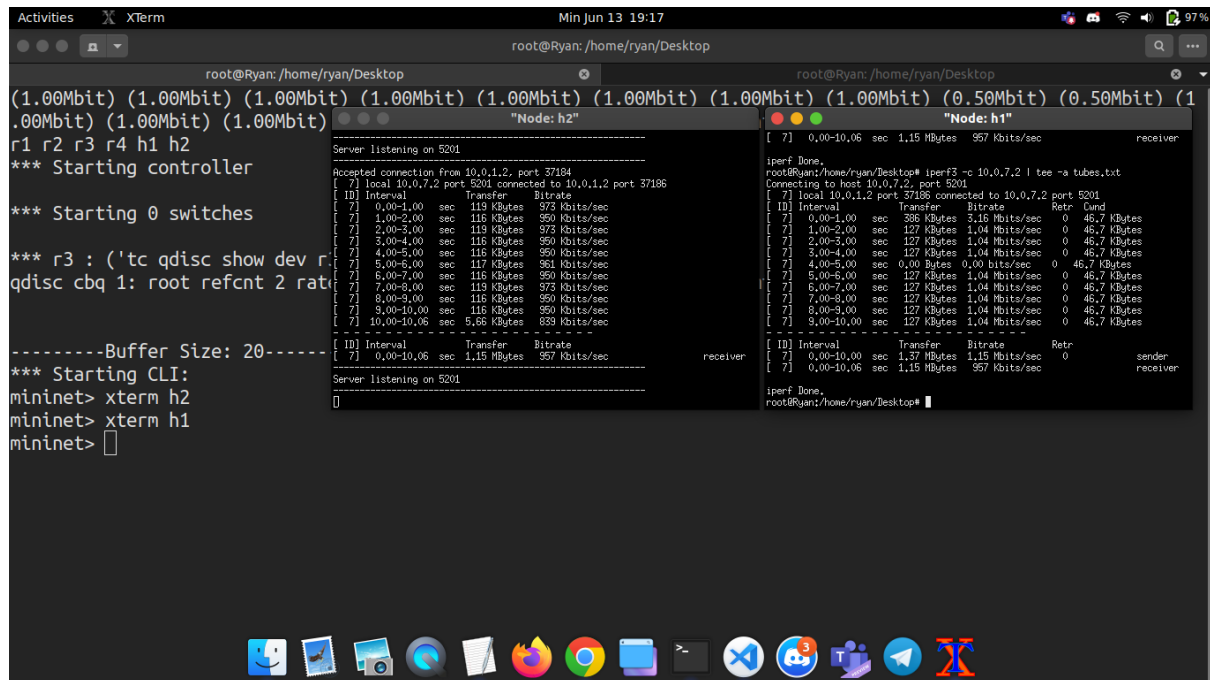
--- 10.0.4.2 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2027ms

rtt min/avg/max/mdev = 0.052/0.056/0.063/0.004 ms

Lampiran 2: Hasil Generate Traffic Iperf3

Buffer 20:



```
root@Ryan: /home/ryan/Desktop
(1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0.50Mbit) (0.50Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit)
r1 r2 r3 r4 h1 h2
*** Starting controller
*** Starting 0 switches
*** r3 : ('tc qdisc show dev r
qdisc cbq 1: root refcnt 2 rat

-----Buffer Size: 20-----
*** Starting CLI:
mininet> xterm h2
mininet> xterm h1
mininet>

Node: h2
Server listening on 5201
Accepted connection from 10.0.1.2, port 37184
[ 7] local 10.0.7.2 port 5201 connected to 10.0.1.2 port 37186
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  119 KBytes  973 Kbits/sec
[ 7] 1.00-2.00 sec  116 KBytes  950 Kbits/sec
[ 7] 2.00-3.00 sec  119 KBytes  973 Kbits/sec
[ 7] 3.00-4.00 sec  116 KBytes  950 Kbits/sec
[ 7] 4.00-5.00 sec  116 KBytes  950 Kbits/sec
[ 7] 5.00-6.00 sec  117 KBytes  951 Kbits/sec
[ 7] 6.00-7.00 sec  116 KBytes  950 Kbits/sec
[ 7] 7.00-8.00 sec  119 KBytes  973 Kbits/sec
[ 7] 8.00-9.00 sec  116 KBytes  950 Kbits/sec
[ 7] 9.00-10.00 sec 116 KBytes  950 Kbits/sec
[ 7] 10.00-10.06 sec 5.56 KBytes 839 Kbits/sec
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.06 sec 1.15 MBytes 957 Kbits/sec
Server listening on 5201

Node: h1
iperf Done.
root@Ryan:/home/ryan/Desktop# iperf3 -c 10.0.7.2 | tee -a tubes.txt
Connecting to host 10.0.7.2, port 5201
[ 7] local 10.0.1.2 port 37186 connected to 10.0.7.2 port 5201
[ ID] Interval      Transfer    Bitrate    Retr  Cwnd
[ 7] 0.00-1.00 sec  386 KBytes  3.16 Mbits/sec  0  46.7 KBytes
[ 7] 1.00-2.00 sec  127 KBytes  1.04 Mbits/sec  0  46.7 KBytes
[ 7] 2.00-3.00 sec  127 KBytes  1.04 Mbits/sec  0  46.7 KBytes
[ 7] 3.00-4.00 sec  127 KBytes  1.04 Mbits/sec  0  46.7 KBytes
[ 7] 4.00-5.00 sec   0.00 Bytes  0.00 bits/sec  0  46.7 KBytes
[ 7] 5.00-6.00 sec  127 KBytes  1.04 Mbits/sec  0  46.7 KBytes
[ 7] 6.00-7.00 sec  127 KBytes  1.04 Mbits/sec  0  46.7 KBytes
[ 7] 7.00-8.00 sec  127 KBytes  1.04 Mbits/sec  0  46.7 KBytes
[ 7] 8.00-9.00 sec  127 KBytes  1.04 Mbits/sec  0  46.7 KBytes
[ 7] 9.00-10.00 sec  127 KBytes  1.04 Mbits/sec  0  46.7 KBytes
[ ID] Interval      Transfer    Bitrate    Retr
[ 7] 0.00-10.00 sec  1.37 MBytes  1.15 Mbits/sec  0  sender
[ 7] 0.00-10.06 sec  1.15 MBytes  957 Kbits/sec  receiver
iperf Done.
root@Ryan:/home/ryan/Desktop#
```

Connecting to host 10.0.7.2, port 5201

[7] local 10.0.1.2 port 37186 connected to 10.0.7.2 port 5201

[ID]	Interval	Transfer	Bitrate	Retr	Cwnd
[7]	0.00-1.00 sec	386 KBytes	3.16 Mbits/sec	0	46.7 KBytes
[7]	1.00-2.00 sec	127 KBytes	1.04 Mbits/sec	0	46.7 KBytes
[7]	2.00-3.00 sec	127 KBytes	1.04 Mbits/sec	0	46.7 KBytes
[7]	3.00-4.00 sec	127 KBytes	1.04 Mbits/sec	0	46.7 KBytes
[7]	4.00-5.00 sec	0.00 Bytes	0.00 bits/sec	0	46.7 KBytes
[7]	5.00-6.00 sec	127 KBytes	1.04 Mbits/sec	0	46.7 KBytes
[7]	6.00-7.00 sec	127 KBytes	1.04 Mbits/sec	0	46.7 KBytes
[7]	7.00-8.00 sec	127 KBytes	1.04 Mbits/sec	0	46.7 KBytes
[7]	8.00-9.00 sec	127 KBytes	1.04 Mbits/sec	0	46.7 KBytes
[7]	9.00-10.00 sec	127 KBytes	1.04 Mbits/sec	0	46.7 KBytes

[ID]	Interval	Transfer	Bitrate	Retr	
[7]	0.00-10.00 sec	1.37 MBytes	1.15 Mbits/sec	0	sender
[7]	0.00-10.06 sec	1.15 MBytes	957 Kbits/sec		receiver

iperf Done.

Buffer 40:

```

root@Ryan: /home/ryan/Desktop
(1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0.50Mbit) (0.50Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit)
r1 r2 r3 r4 h1 h2
*** Starting controller

*** Starting 0 switches

*** r3 : ('tc qdisc show dev r
qdisc cbq 1: root refcnt 2 rat

-----Buffer Size: 40-----
*** Starting CLI:
mininet> xterm h2
mininet> xterm h1
mininet>

root@Ryan: /home/ryan/Desktop
"Node: h2"
Server listening on 5201
Accepted connection from 10.0.1.2, port 37150
[ 7] local 10.0.7.2 port 5201 connected to 10.0.1.2 port 37152
[ ID] Interval      Transfer     Bitrate
[ 7] 0.00-1.00 sec  113 KBytes  973 Kbits/sec
[ 7] 1.00-2.00 sec  116 KBytes  950 Kbits/sec
[ 7] 2.00-3.00 sec  119 KBytes  973 Kbits/sec
[ 7] 3.00-4.00 sec  116 KBytes  950 Kbits/sec
[ 7] 4.00-5.00 sec  116 KBytes  950 Kbits/sec
[ 7] 5.00-6.00 sec  117 KBytes  961 Kbits/sec
[ 7] 6.00-7.00 sec  116 KBytes  950 Kbits/sec
[ 7] 7.00-8.00 sec  113 KBytes  973 Kbits/sec
[ 7] 8.00-9.00 sec  116 KBytes  959 Kbits/sec
[ 7] 9.00-10.00 sec 116 KBytes  950 Kbits/sec
[ 7] 10.00-10.06 sec 5.56 KBytes 840 Kbits/sec
-----
[ ID] Interval      Transfer     Bitrate
[ 7] 0.00-10.06 sec 1.15 MBytes  957 Kbits/sec
Server listening on 5201

root@Ryan: /home/ryan/Desktop
"Node: h1"
iperf Done.
root@Ryan: /home/ryan/Desktop# iperf3 -c 10.0.7.2 -t 10 -a tubes.txt
Connecting to host 10.0.7.2, port 5201
[ 7] local 10.0.1.2 port 37152 connected to 10.0.7.2 port 5201
[ ID] Interval      Transfer     Bitrate      Retr      Cwnd
[ 7] 0.00-1.00 sec  386 KBytes  3.16 Mbits/sec  0         46.7 KBytes
[ 7] 1.00-2.00 sec  127 KBytes  1.04 Mbits/sec  0         46.7 KBytes
[ 7] 2.00-3.00 sec  127 KBytes  1.04 Mbits/sec  0         46.7 KBytes
[ 7] 3.00-4.00 sec  127 KBytes  1.04 Mbits/sec  0         46.7 KBytes
[ 7] 4.00-5.00 sec  0.00 Bytes  0.00 bits/sec  0         46.7 KBytes
[ 7] 5.00-6.00 sec  127 KBytes  1.04 Mbits/sec  0         46.7 KBytes
[ 7] 6.00-7.00 sec  127 KBytes  1.04 Mbits/sec  0         46.7 KBytes
[ 7] 7.00-8.00 sec  127 KBytes  1.04 Mbits/sec  0         46.7 KBytes
[ 7] 8.00-9.00 sec  127 KBytes  1.04 Mbits/sec  0         46.7 KBytes
[ 7] 9.00-10.00 sec  127 KBytes  1.04 Mbits/sec  0         46.7 KBytes
-----
[ ID] Interval      Transfer     Bitrate      Retr
[ 7] 0.00-10.00 sec  1.37 MBytes  1.15 Mbits/sec  0         sender
[ 7] 0.00-10.06 sec  1.15 MBytes  957 Kbits/sec  receiver
iperf Done.
root@Ryan: /home/ryan/Desktop#

```

Connecting to host 10.0.7.2, port 5201

[7] local 10.0.1.2 port 37152 connected to 10.0.7.2 port 5201

[ID] Interval Transfer Bitrate Retr Cwnd

[7] 0.00-1.00 sec 386 KBytes 3.16 Mbits/sec 0 46.7 KBytes

[7] 1.00-2.00 sec 127 KBytes 1.04 Mbits/sec 0 46.7 KBytes

[7] 2.00-3.00 sec 127 KBytes 1.04 Mbits/sec 0 46.7 KBytes

[7] 3.00-4.00 sec 127 KBytes 1.04 Mbits/sec 0 46.7 KBytes

[7] 4.00-5.00 sec 0.00 Bytes 0.00 bits/sec 0 46.7 KBytes

[7] 5.00-6.00 sec 127 KBytes 1.04 Mbits/sec 0 46.7 KBytes

[7] 6.00-7.00 sec 127 KBytes 1.04 Mbits/sec 0 46.7 KBytes

[7] 7.00-8.00 sec 127 KBytes 1.04 Mbits/sec 0 46.7 KBytes

[7] 8.00-9.00 sec 127 KBytes 1.04 Mbits/sec 0 46.7 KBytes

[7] 9.00-10.00 sec 127 KBytes 1.04 Mbits/sec 0 46.7 KBytes

[ID] Interval Transfer Bitrate Retr

[7] 0.00-10.00 sec 1.37 MBytes 1.15 Mbits/sec 0 sender

[7] 0.00-10.06 sec 1.15 MBytes 957 Kbits/sec receiver

iperf Done.

Buffer 60:

```

root@Ryan: /home/ryan/Desktop
(1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0.50Mbit) (0.50Mbit) (1
.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0.50Mbit) (0.50Mbit) *** Configuring hosts
r1 r2 r3 r4 h1 h2
*** Starting controller

*** Starting 0 switches

*** r3 : ('tc qdisc show
qdisc cbq 1: root refcnt

-----Buffer Size: 60
*** Starting CLI:
mininet> xterm h2
mininet> xterm h1
mininet>

"Node: h2"
Server listening on 5201
Accepted connection from 10.0.1.2, port 37130
[ 7] local 10.0.1.2 port 5201 connected to 10.0.1.2 port 37132
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  119 KBytes  973 Kbits/sec
[ 7] 1.00-2.00 sec  119 KBytes  973 Kbits/sec
[ 7] 2.00-3.00 sec  115 KBytes  938 Kbits/sec
[ 7] 3.00-4.00 sec  119 KBytes  973 Kbits/sec
[ 7] 4.00-5.00 sec  116 KBytes  950 Kbits/sec
[ 7] 5.00-6.00 sec  116 KBytes  950 Kbits/sec
[ 7] 6.00-7.00 sec  116 KBytes  950 Kbits/sec
[ 7] 7.00-8.00 sec  119 KBytes  973 Kbits/sec
[ 7] 8.00-9.00 sec  115 KBytes  938 Kbits/sec
[ 7] 9.00-10.00 sec 119 KBytes  973 Kbits/sec
[ 7] 10.00-10.07 sec 5.66 KBytes 689 Kbits/sec
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.07 sec 1.15 MBytes 957 Kbits/sec
Server listening on 5201
0

"Node: h1"
root@Ryan:/home/ryan/Desktop# iperf3 -c 10.0.7.2 | tee -a tubes.txt
Connecting to host 10.0.7.2, port 5201
[ 7] local 10.0.1.2 port 37132 connected to 10.0.7.2 port 5201
[ ID] Interval      Transfer    Bitrate      Retr    Cwnd
[ 7] 0.00-1.00 sec  354 KBytes  2.90 Mbits/sec  0    42.4 KBytes
[ 7] 1.00-2.00 sec  127 KBytes  1.04 Mbits/sec  0    42.4 KBytes
[ 7] 2.00-3.00 sec  127 KBytes  1.04 Mbits/sec  0    42.4 KBytes
[ 7] 3.00-4.00 sec  127 KBytes  1.04 Mbits/sec  0    42.4 KBytes
[ 7] 4.00-5.00 sec  127 KBytes  1.04 Mbits/sec  0    42.4 KBytes
[ 7] 5.00-6.00 sec  127 KBytes  1.04 Mbits/sec  0    42.4 KBytes
[ 7] 6.00-7.00 sec  0.00 Bytes  0.00 bits/sec  0    42.4 KBytes
[ 7] 7.00-8.00 sec  127 KBytes  1.04 Mbits/sec  0    42.4 KBytes
[ 7] 8.00-9.00 sec  127 KBytes  1.04 Mbits/sec  0    42.4 KBytes
[ 7] 9.00-10.00 sec  127 KBytes  1.04 Mbits/sec  0    42.4 KBytes
[ ID] Interval      Transfer    Bitrate      Retr    sender  receiver
[ 7] 0.00-10.00 sec  1.34 MBytes 1.12 Mbits/sec  0
[ 7] 0.00-10.07 sec  1.15 MBytes 957 Kbits/sec

iperf Done.
root@Ryan:/home/ryan/Desktop#

```

Connecting to host 10.0.7.2, port 5201

[7] local 10.0.1.2 port 37132 connected to 10.0.7.2 port 5201

[ID] Interval Transfer Bitrate Retr Cwnd

[7] 0.00-1.00 sec 354 KBytes 2.90 Mbits/sec 0 42.4 KBytes

[7] 1.00-2.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 2.00-3.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 3.00-4.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 4.00-5.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 5.00-6.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 6.00-7.00 sec 0.00 Bytes 0.00 bits/sec 0 42.4 KBytes

[7] 7.00-8.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 8.00-9.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 9.00-10.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[ID] Interval Transfer Bitrate Retr

[7] 0.00-10.00 sec 1.34 MBytes 1.12 Mbits/sec 0 sender

[7] 0.00-10.07 sec 1.15 MBytes 957 Kbits/sec receiver

iperf Done.

Buffer 100:

```

root@Ryan: /home/ryan/Desktop
(1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0.50Mbit) (0.50Mbit) (1
.00Mbit) (1.00Mbit) (1.00Mbit) (1.00Mbit) (0.50Mbit) (0.50Mbit) *** Configuring hosts
r1 r2 r3 r4 h1 h2
*** Starting controller

*** Starting 0 switches

*** r3 : ('tc qdisc show d
qdisc cbq 1: root refcnt 2

-----Buffer Size: 100-
*** Starting CLI:
mininet> xterm h2
mininet> xterm h1
mininet>

"Node: h2"
Server listening on 5201
Accepted connection from 10.0.1.2, port 37118
[ 7] local 10.0.7.2 port 5201 connected to 10.0.1.2 port 37120
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00 sec  119 KBytes  973 Kbits/sec
[ 7] 1.00-2.00 sec  115 KBytes  938 Kbits/sec
[ 7] 2.00-3.00 sec  119 KBytes  973 Kbits/sec
[ 7] 3.00-4.00 sec  116 KBytes  950 Kbits/sec
[ 7] 4.00-5.00 sec  116 KBytes  950 Kbits/sec
[ 7] 5.00-6.00 sec  115 KBytes  950 Kbits/sec
[ 7] 6.00-7.00 sec  116 KBytes  950 Kbits/sec
[ 7] 7.00-8.00 sec  119 KBytes  973 Kbits/sec
[ 7] 8.00-9.00 sec  116 KBytes  950 Kbits/sec
[ 7] 9.00-10.00 sec 117 KBytes  961 Kbits/sec
[ 7] 10.00-10.07 sec 5.56 KBytes  708 Kbits/sec
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.07 sec 1.15 MBytes  958 Kbits/sec
receiver

"Node: h1"
[ 7] 0.00-10.05 sec 1.15 MBytes  957 Kbits/sec
receiver
iperf Done.
root@Ryan:/home/ryan/Desktop# iperf3 -c 10.0.7.2 | tee tubes.txt
Connecting to host 10.0.7.2, port 5201
[ 7] local 10.0.1.2 port 37120 connected to 10.0.7.2 port 5201
[ ID] Interval      Transfer    Bitrate    Retr  Cwnd
[ 7] 0.00-1.00 sec  354 KBytes  2.30 Mbits/sec  0  42.4 KBytes
[ 7] 1.00-2.00 sec  127 KBytes  1.04 Mbits/sec  0  42.4 KBytes
[ 7] 2.00-3.00 sec  127 KBytes  1.04 Mbits/sec  0  42.4 KBytes
[ 7] 3.00-4.00 sec  127 KBytes  1.04 Mbits/sec  0  42.4 KBytes
[ 7] 4.00-5.00 sec  127 KBytes  1.04 Mbits/sec  0  42.4 KBytes
[ 7] 5.00-6.00 sec  127 KBytes  1.04 Mbits/sec  0  42.4 KBytes
[ 7] 6.00-7.00 sec  0.00 Bytes  0.00 bits/sec  0  42.4 KBytes
[ 7] 7.00-8.00 sec  127 KBytes  1.04 Mbits/sec  0  42.4 KBytes
[ 7] 8.00-9.00 sec  127 KBytes  1.04 Mbits/sec  0  42.4 KBytes
[ 7] 9.00-10.00 sec 127 KBytes  1.04 Mbits/sec  0  42.4 KBytes
[ ID] Interval      Transfer    Bitrate    Retr
[ 7] 0.00-10.00 sec 1.34 MBytes  1.12 Mbits/sec  0
[ 7] 0.00-10.07 sec 1.15 MBytes  958 Kbits/sec
sender
receiver
iperf Done.
root@Ryan:/home/ryan/Desktop#

```

Connecting to host 10.0.7.2, port 5201

[7] local 10.0.1.2 port 37120 connected to 10.0.7.2 port 5201

[ID] Interval Transfer Bitrate Retr Cwnd

[7] 0.00-1.00 sec 354 KBytes 2.90 Mbits/sec 0 42.4 KBytes

[7] 1.00-2.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 2.00-3.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 3.00-4.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 4.00-5.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 5.00-6.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 6.00-7.00 sec 0.00 Bytes 0.00 bits/sec 0 42.4 KBytes

[7] 7.00-8.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 8.00-9.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[7] 9.00-10.00 sec 127 KBytes 1.04 Mbits/sec 0 42.4 KBytes

[ID] Interval Transfer Bitrate Retr

[7] 0.00-10.00 sec 1.34 MBytes 1.12 Mbits/sec 0 sender

[7] 0.00-10.07 sec 1.15 MBytes 958 Kbits/sec receiver

iperf Done.