LAPORAN TUGAS BESAR
JARINGAN KOMPUTER

Universitas
Telkom

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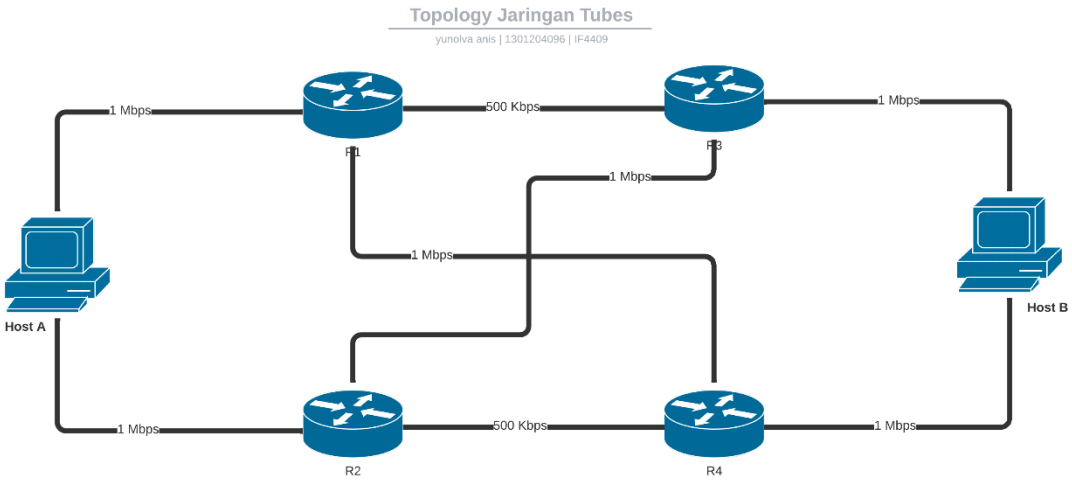
CLO 1 :

Goal : Build topology sesuai dengan soal.



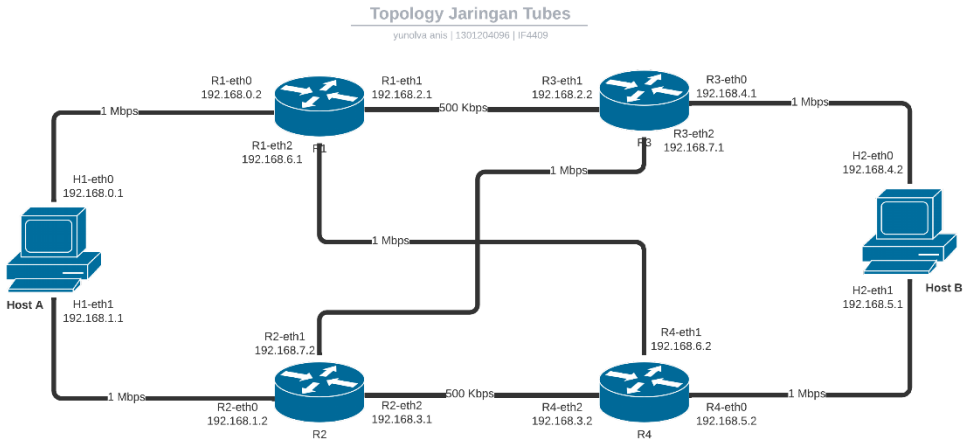
Pada topologi kali ini akan dibuat beberapa area di antaranya adalah sebagai berikut :

- Area 1 : Host A ke R1
- Area 2 : Host A ke R2
- Area 3 : Host B ke R3
- Area 4 : Host B ke R4
- Area 5 : R1 ke R3
- Area 6 : R1 ke R4
- Area 7 : R3 ke R2
- Area 8 : R2 ke R4

- **Desain subnet masing-masing network.**
  Subnet akan di design dengan menggunakan bantuan table subnetting. Sementara IP yang nantinya akan digunakan adalah 192.168.0.0/24

Nama	Needs	Alokasi	Network ID	Host Range	Broadcast	Prefiks	Subnetting
Area 1	2	256	192.168.0.0	192.168.0.1 - 192.168.0.254	192.168.0.255	\24	255.255.255.0
Area 2	2	256	192.168.1.0	192.168.1.1 - 192.168.1.254	192.168.1.255	\24	255.255.255.0
Area 4	2	256	192.168.2.0	192.168.2.1 - 192.168.2.254	192.168.2.255	\24	255.255.255.0
Area 5	2	256	192.168.3.0	192.168.3.1 - 192.168.3.254	192.168.3.255	\24	255.255.255.0
Area 6	2	256	192.168.4.0	192.168.4.1 - 192.168.4.254	192.168.4.255	\24	255.255.255.0
Area 7	2	256	192.168.5.0	192.168.5.1 - 192.168.5.254	192.168.5.255	\24	255.255.255.0
Area 8	2	256	192.168.6.0	192.168.6.1 - 192.168.6.254	192.168.6.255	\24	255.255.255.0
Area 9	2	256	192.168.7.0	192.168.7.1 - 192.168.7.254	192.168.7.255	\24	255.255.255.0

Berikut merupakan topologi yang telah disesuaikan :



- **Assign IP sesuai subnet.**

  Untuk membangun topologi di dalam mininet, maka perlu membangun host dan router terlebih dahulu, seperti yang ada pada gambar berikut :

```
def clo1():

        #Yunolva Anis Ramaziyah (1301204096)

        net = Mininet()

        #define host dan router
        r1 = net.addHost('r1')
        r2 = net.addHost('r2')
        r3 = net.addHost('r3')
        r4 = net.addHost('r4')
        h1 = net.addHost('h1')
        h2 = net.addHost('h2')
```

  Setelah melakukan assign host dan router maka akan diteruskan untuk membangun link yang ada pada masing-masing host dan router yang ada, seperti yang dapat dilihat pada gambar berikut :

```
#Yunolva Anis Ramaziyah (1301204096)
#add link
net.addLink(h1,r1, intfName1='h1-eth0', intfName2='r1-eth0', cls = TCLink, bw = 1)
net.addLink(h1,r2, intfName1='h1-eth1', intfName2='r2-eth0', cls = TCLink, bw = 1)
net.addLink(h2,r3, intfName1='h2-eth0', intfName2='r3-eth0', cls = TCLink, bw = 1)
net.addLink(h2,r4, intfName1='h2-eth1', intfName2='r4-eth0', cls = TCLink, bw = 1)
net.addLink(r1,r3, intfName1='r1-eth1', intfName2='r3-eth1', cls = TCLink, bw = 0.5)
net.addLink(r1,r4, intfName1='r1-eth2', intfName2='r4-eth1', cls = TCLink, bw = 1)
net.addLink(r2,r3, intfName1='r2-eth1', intfName2='r3-eth2', cls = TCLink, bw = 1)
net.addLink(r2,r4, intfName1='r2-eth2', intfName2='r4-eth2', cls = TCLink, bw = 0.5)
net.start()
net.build()
```

Setelah membangun topologi dengan menyambungkan antara masing-masing host dan router dengan menggunakan link. Kemudian akan dilakukan assign ip sesuai dengan subnet seperti sebagai berikut :

```
#Mengkonfigurasi IP address yang ada pada Host A dan Host B
h1.cmd("ifconfig h1-eth0 192.168.0.1/24 netmask 255.255.255.0")
h1.cmd("ifconfig h1-eth1 192.168.1.1/24 netmask 255.255.255.0")
h2.cmd("ifconfig h2-eth0 192.168.4.2/24 netmask 255.255.255.0")
h2.cmd("ifconfig h2-eth1 192.168.5.1/24 netmask 255.255.255.0")

#Konfigurasi Router
r1.cmd("ifconfig r1-eth0 192.168.0.2/24 netmask 255.255.255.0")
r1.cmd("ifconfig r1-eth1 192.168.2.1/24 netmask 255.255.255.0")
r1.cmd("ifconfig r1-eth2 192.168.6.1/24 netmask 255.255.255.0")
r1.cmd("sysctl net.ipv4.ip_forward=1")

r2.cmd("ifconfig r2-eth0 192.168.1.2/24 netmask 255.255.255.0")
r2.cmd("ifconfig r2-eth2 192.168.3.1/24 netmask 255.255.255.0")
r2.cmd("ifconfig r2-eth1 192.168.7.2/24 netmask 255.255.255.0")
r2.cmd("sysctl net.ipv4.ip_forward=1")

r3.cmd("ifconfig r3-eth1 192.168.2.2/24 netmask 255.255.255.0")
r3.cmd("ifconfig r3-eth0 192.168.4.1/24 netmask 255.255.255.0")
r3.cmd("ifconfig r3-eth2 192.168.7.1/24 netmask 255.255.255.0")
r3.cmd("sysctl net.ipv4.ip_forward=1")

r4.cmd("ifconfig r4-eth2 192.168.3.2/24 netmask 255.255.255.0")
r4.cmd("ifconfig r4-eth0 192.168.5.2/24 netmask 255.255.255.0")
r4.cmd("ifconfig r4-eth1 192.168.6.2/24 netmask 255.255.255.0")
r4.cmd("sysctl net.ipv4.ip_forward=1")
```

Pada masing masing command, terdapat “ifconfig”, perintah ini digunakan untuk menkonfigurasi inferface jaringan. Selain itu juga terdapat command “sysctl net.ipv4.ip_forward=1”, command ini digunakan untuk mengaktifkan dan menonaktifkan forwarding IP. Kemudian untuk mengecek terhubungnya masing-masing network yang ada dapat ditunjukkan dilakukan dengan sebagai berikut :

```
*** Starting CLI:
mininet> net
r1 r1-eth0:h1-eth0 r1-eth1:r3-eth1 r1-eth2:r4-eth1
r2 r2-eth0:h1-eth1 r2-eth1:r3-eth2 r2-eth2:r4-eth2
r3 r3-eth0:h2-eth0 r3-eth1:r1-eth1 r3-eth2:r2-eth1
r4 r4-eth0:h2-eth1 r4-eth1:r1-eth2 r4-eth2:r2-eth2
h1 h1-eth0:r1-eth0 h1-eth1:r2-eth0
h2 h2-eth0:r3-eth0 h2-eth1:r4-eth0
mininet>
```

- **Uji konektivitas dengan ping antara 2 host yang berada dalam 1 network.**
  Sebelum melakukan uji konektivitas, panggil terlebih dahulu masing masing IP address dan perangkat yang dihubungkan seperti sebagai berikut :

```
#Yunolva Anis Ramaziyah (1301204096)
print("Test Ping H1 - R1")
h1.cmdPrint("ping -c 3 192.168.0.2")
print("\n")

print("Test Ping R1 - H1")
r1.cmdPrint("ping -c 3 192.168.0.1")
print("\n")

print("Test Ping H1 - R2")
h1.cmdPrint("ping -c 3 192.168.1.2")
print("\n")

print("Test Ping R2 - H1")
r2.cmdPrint("ping -c 3 192.168.1.1")
print("\n")

print("Test ping H2 - R4")
h2.cmdPrint("ping -c 3 192.168.5.2")
print("\n")

print("Test ping R4 - H2")
r4.cmdPrint("ping -c 3 192.168.5.1")
print("\n")

print("Test ping H2 - R3")
h2.cmdPrint("ping -c 3 192.168.4.1")
print("\n")
```

Gambar di atas merupakan pemanggilan yang akan dilakukan antara host dengan router yang ada dalam satu network. Sedangkan gambar di bawah merupakan pemanggilan ping yang akan dilakukan antara masing-masing perangkat baik antara router dengan host maupun router dengan router pada masing – masing network.

```
#Yunolva Anis Ramaziyah (1301204096)
print("Test ping R3 - H2")
r3.cmdPrint("ping -c 3 192.168.4.2")
print("\n")

print("Test Ping R2 - R4")
r2.cmdPrint("ping -c 3 192.168.3.2")
print("\n")

print("Test ping R4 - R2")
r4.cmdPrint("ping -c 3 192.168.3.1")
print("\n")

print("Test ping R2 - R3")
r3.cmdPrint("ping -c 3 192.168.7.1")
print("\n")

print("Test ping R3 - R2")
r2.cmdPrint("ping -c 3 192.168.7.2")
print("\n")
```

```
print("Test ping R1 - R3")
r1.cmdPrint("ping -c 3 192.168.2.2")
print("\n")

print("Test ping R3 - R1")
r3.cmdPrint("ping -c 3 192.168.2.1")
print("\n")

print("Test ping R4 - R1")
r4.cmdPrint("ping -c 3 192.168.6.1 ")
print("\n")

print("Test ping R1 - R4")
r1.cmdPrint("ping -c 3 192.168.6.2 \n")
print("\n")


CLI(net)
net.stop()
```

Sehingga hasil yang didapat untuk pemanggilan secara keseluruhan adalah sebagai berikut :

```
Test Ping H1 - R1
*** h1 : ('ping -c 3 192.168.0.2',)
PING 192.168.0.2 (192.168.0.2) 56(84) bytes of data.
64 bytes from 192.168.0.2: icmp_seq=1 ttl=64 time=0.049 ms
64 bytes from 192.168.0.2: icmp_seq=2 ttl=64 time=0.060 ms
64 bytes from 192.168.0.2: icmp_seq=3 ttl=64 time=0.116 ms
--- 192.168.0.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2026ms
rtt min/avg/max/mdev = 0.049/0.075/0.116/0.029 ms

Test Ping R1 - H1
*** r1 : ('ping -c 3 192.168.0.1',)
PING 192.168.0.1 (192.168.0.1) 56(84) bytes of data.
64 bytes from 192.168.0.1: icmp_seq=1 ttl=64 time=0.049 ms
64 bytes from 192.168.0.1: icmp_seq=2 ttl=64 time=0.060 ms
64 bytes from 192.168.0.1: icmp_seq=3 ttl=64 time=0.080 ms
--- 192.168.0.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2043ms
rtt min/avg/max/mdev = 0.049/0.063/0.080/0.012 ms

Test Ping H1 - R2
*** h1 : ('ping -c 3 192.168.1.2',)
PING 192.168.1.2 (192.168.1.2) 56(84) bytes of data.
64 bytes from 192.168.1.2: icmp_seq=1 ttl=64 time=0.074 ms
64 bytes from 192.168.1.2: icmp_seq=2 ttl=64 time=0.093 ms
64 bytes from 192.168.1.2: icmp_seq=3 ttl=64 time=0.047 ms
--- 192.168.1.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2045ms
rtt min/avg/max/mdev = 0.047/0.071/0.093/0.018 ms

Test Ping R2 - H1
*** r2 : ('ping -c 3 192.168.1.1',)
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_seq=1 ttl=64 time=0.034 ms
64 bytes from 192.168.1.1: icmp_seq=2 ttl=64 time=0.053 ms
64 bytes from 192.168.1.1: icmp_seq=3 ttl=64 time=0.094 ms
--- 192.168.1.1 ping statistics ---
```

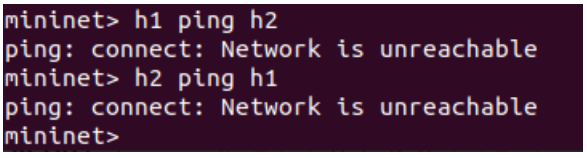
```
--- 192.168.1.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2045ms
rtt min/avg/max/mdev = 0.034/0.060/0.094/0.025 ms

Test ping H2 - R4
*** h2 : ('ping -c 3 192.168.5.2',)
PING 192.168.5.2 (192.168.5.2) 56(84) bytes of data.
64 bytes from 192.168.5.2: icmp_seq=1 ttl=64 time=0.122 ms
64 bytes from 192.168.5.2: icmp_seq=2 ttl=64 time=0.090 ms
64 bytes from 192.168.5.2: icmp_seq=3 ttl=64 time=0.091 ms
--- 192.168.5.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2010ms
rtt min/avg/max/mdev = 0.090/0.101/0.122/0.014 ms

Test ping R4 - H2
*** r4 : ('ping -c 3 192.168.5.1',)
PING 192.168.5.1 (192.168.5.1) 56(84) bytes of data.
64 bytes from 192.168.5.1: icmp_seq=1 ttl=64 time=0.022 ms
64 bytes from 192.168.5.1: icmp_seq=2 ttl=64 time=0.053 ms
64 bytes from 192.168.5.1: icmp_seq=3 ttl=64 time=0.091 ms
--- 192.168.5.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2042ms
rtt min/avg/max/mdev = 0.022/0.055/0.091/0.028 ms

Test ping H2 - R3
*** h2 : ('ping -c 3 192.168.4.1',)
PING 192.168.4.1 (192.168.4.1) 56(84) bytes of data.
64 bytes from 192.168.4.1: icmp_seq=1 ttl=64 time=0.042 ms
64 bytes from 192.168.4.1: icmp_seq=2 ttl=64 time=0.094 ms
64 bytes from 192.168.4.1: icmp_seq=3 ttl=64 time=0.091 ms
--- 192.168.4.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2043ms
rtt min/avg/max/mdev = 0.042/0.075/0.094/0.023 ms
```

```
Test ping R3 - H2
*** r3 : ('ping -c 3 192.168.4.2',)
PING 192.168.4.2 (192.168.4.2) 56(84) bytes of data.
64 bytes from 192.168.4.2: icmp_seq=1 ttl=64 time=0.021 ms
64 bytes from 192.168.4.2: icmp_seq=2 ttl=64 time=0.073 ms
64 bytes from 192.168.4.2: icmp_seq=3 ttl=64 time=0.040 ms
--- 192.168.4.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2043ms
rtt min/avg/max/mdev = 0.021/0.044/0.073/0.021 ms

Test Ping R2 - R4
*** r2 : ('ping -c 3 192.168.3.2',)
PING 192.168.3.2 (192.168.3.2) 56(84) bytes of data.
64 bytes from 192.168.3.2: icmp_seq=1 ttl=64 time=0.044 ms
64 bytes from 192.168.3.2: icmp_seq=2 ttl=64 time=0.042 ms
64 bytes from 192.168.3.2: icmp_seq=3 ttl=64 time=0.092 ms
--- 192.168.3.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2046ms
rtt min/avg/max/mdev = 0.042/0.059/0.092/0.023 ms

Test ping R4 - R2
*** r4 : ('ping -c 3 192.168.3.1',)
PING 192.168.3.1 (192.168.3.1) 56(84) bytes of data.
64 bytes from 192.168.3.1: icmp_seq=1 ttl=64 time=0.089 ms
64 bytes from 192.168.3.1: icmp_seq=2 ttl=64 time=0.092 ms
64 bytes from 192.168.3.1: icmp_seq=3 ttl=64 time=0.092 ms
--- 192.168.3.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2026ms
rtt min/avg/max/mdev = 0.089/0.091/0.092/0.001 ms

Test ping R2 - R3
*** r3 : ('ping -c 3 192.168.7.1',)
PING 192.168.7.1 (192.168.7.1) 56(84) bytes of data.
64 bytes from 192.168.7.1: icmp_seq=1 ttl=64 time=0.018 ms
```

```
64 bytes from 192.168.7.1: icmp_seq=2 ttl=64 time=0.073 ms

64 bytes from 192.168.7.1: icmp_seq=3 ttl=64 time=0.030 ms

--- 192.168.7.1 ping statistics ---

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

rtt min/avg/max/mdev = 0.018/0.040/0.073/0.023 ms


Test ping R3 - R2

*** r2 : ('ping -c 3 192.168.7.2',)

PING 192.168.7.2 (192.168.7.2) 56(84) bytes of data.

64 bytes from 192.168.7.2: icmp_seq=1 ttl=64 time=0.024 ms

64 bytes from 192.168.7.2: icmp_seq=2 ttl=64 time=0.032 ms

64 bytes from 192.168.7.2: icmp_seq=3 ttl=64 time=0.072 ms

--- 192.168.7.2 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2047ms

rtt min/avg/max/mdev = 0.024/0.042/0.072/0.021 ms


Test ping R1 - R3

*** r1 : ('ping -c 3 192.168.2.2',)

PING 192.168.2.2 (192.168.2.2) 56(84) bytes of data.

64 bytes from 192.168.2.2: icmp_seq=1 ttl=64 time=0.128 ms

64 bytes from 192.168.2.2: icmp_seq=2 ttl=64 time=0.043 ms

64 bytes from 192.168.2.2: icmp_seq=3 ttl=64 time=0.038 ms

--- 192.168.2.2 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2042ms

rtt min/avg/max/mdev = 0.038/0.069/0.128/0.041 ms64 bytes from 192.168.7.1:
icmp_seq=2 ttl=64 time=0.073 ms


Test ping R3 - R1

*** r3 : ('ping -c 3 192.168.2.1',)

PING 192.168.2.1 (192.168.2.1) 56(84) bytes of data.

64 bytes from 192.168.2.1: icmp_seq=1 ttl=64 time=0.036 ms

64 bytes from 192.168.2.1: icmp_seq=2 ttl=64 time=0.053 ms

64 bytes from 192.168.2.1: icmp_seq=3 ttl=64 time=0.050 ms

rtt min/avg/max/mdev = 0.036/0.046/0.053/0.007 ms
```

```
--- 192.168.2.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2045ms
rtt min/avg/max/mdev = 0.036/0.046/0.053/0.007 ms

Test ping R4 - R1
*** r4 : ('ping -c 3 192.168.6.1 ',)
PING 192.168.6.1 (192.168.6.1) 56(84) bytes of data.
64 bytes from 192.168.6.1: icmp_seq=1 ttl=64 time=0.061 ms
64 bytes from 192.168.6.1: icmp_seq=2 ttl=64 time=0.090 ms
64 bytes from 192.168.6.1: icmp_seq=3 ttl=64 time=0.091 ms
--- 192.168.6.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2045ms
rtt min/avg/max/mdev = 0.061/0.080/0.091/0.013 ms

Test ping R1 - R4
*** r1 : ('ping -c 3 192.168.6.2 \n',)
PING 192.168.6.2 (192.168.6.2) 56(84) bytes of data.
64 bytes from 192.168.6.2: icmp_seq=1 ttl=64 time=0.119 ms
64 bytes from 192.168.6.2: icmp_seq=2 ttl=64 time=0.092 ms
64 bytes from 192.168.6.2: icmp_seq=3 ttl=64 time=0.092 ms
--- 192.168.6.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2041ms
rtt min/avg/max/mdev = 0.092/0.101/0.119/0.012 ms
```

Dapat dilihat berdasarkan hasil tersebut masing – masing router dan host yang berada pada network yang sama berhasil di ping. Namun ketika mencoba melakukan ping pada host dengan host yang memiliki network berbeda maka hasilnya akan unreachable, seperti sebagai berikut :

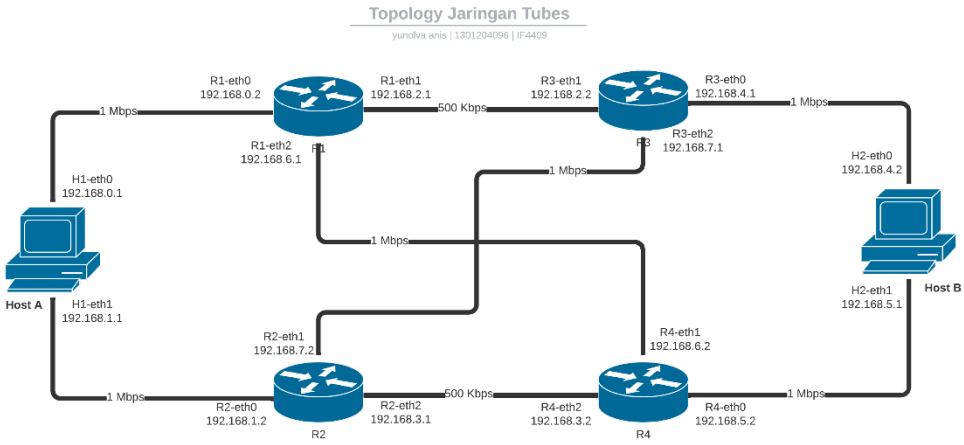


CLO 2

Goal : Mengimplementasikan mekanisme routing pada topologi yang ada.

- **Uji konektivitas menggunakan ping.**

- **Membuat tabel routing di semua host, dibuktikan dengan ping antar host.**



Setelah membangun topologi antar area atau pada jaringan yang sama dan dapat terhubung, maka selanjutnya akan dilakukan penghubungan antara setiap node dengan jaringan yang belum terhubung, sebagai contoh R3 dengan R4 dan R1 dengan R2. Pengimplementasian routing akan dilakukan secara manual atau secara static berdasarkan dengan table topologi di atas. Berikut merupakan bentuk implementasi routing berdasarkan topoologi dengan menggunakan code. Pertama, bangun subnet terlebih dahulu seperti pada CLO 1.

```
net = Mininet()
#Yunolva Anis_1301204096

r1 = net.addHost("r1")
r2 = net.addHost("r2")
r3 = net.addHost("r3")
r4 = net.addHost("r4")
h1 = net.addHost("h1")
h2 = net.addHost("h2")

net.addLink(h1,r1,intfName1='h1-eth0',intfName2='r1-eth0',cls = TCLink,bw=1)
net.addLink(h1,r2,intfName1='h1-eth1',intfName2='r2-eth0',cls = TCLink,bw=1)
net.addLink(h2,r3,intfName1='h2-eth0',intfName2='r3-eth0',cls = TCLink,bw=1)
net.addLink(h2,r4,intfName1='h2-eth1',intfName2='r4-eth0',cls = TCLink,bw=1)
net.addLink(r1,r3,intfName1='r1-eth1',intfName2='r3-eth1',cls = TCLink,bw=0.5)
net.addLink(r1,r4,intfName1='r1-eth2',intfName2='r4-eth1',cls = TCLink,bw=1)
net.addLink(r2,r3,intfName1='r2-eth1',intfName2='r3-eth2',cls = TCLink,bw=1)
net.addLink(r2,r4,intfName1='r2-eth2',intfName2='r4-eth2',cls = TCLink,bw=0.5)
net.start()
```

Setelah membentuk subnet maka selanjutnya konfigurasikan ip address dari masing-masing host yang ada.

```
# Konfigurasi IP Address Pada Host 1 dan Host 2
h1.cmd("ifconfig h1-eth0 192.168.0.1/24 netmask 255.255.255.0")
h1.cmd("ifconfig h1-eth1 192.168.1.1/24 netmask 255.255.255.0")

h2.cmd("ifconfig h2-eth0 192.168.4.2/24 netmask 255.255.255.0")
h2.cmd("ifconfig h2-eth1 192.168.5.1/24 netmask 255.255.255.0")
```

Kemudian atur routing untuk masing – masing host dan router. Berikut merupakan routing untuk h1.

```
#Routing Process
h1.cmd("ip rule add from 192.168.0.1 table 1")
h1.cmd("ip rule add from 192.168.1.1 table 2")

h1.cmd("ip route add 192.168.0.0/24 dev h1-eth0 link table 1")
h1.cmd("ip route add default via 192.168.0.2 dev h1-eth0 table 1")

h1.cmd("ip route add 192.168.1.0/24 dev h1-eth0 link table 2")
h1.cmd("ip route add default via 192.168.1.2 dev h1-eth0 table 2")

h1.cmd("ip route add default scope global nexthop via 192.168.0.2 dev h1-eth0")
h1.cmd("ip route add default scope global nexthop via 192.168.1.2 dev h1-eth1")
```

Sedangkan berikut merupakan routing untuk h2.

```
h2.cmd("ip rule add from 192.168.4.2 table 3")
h2.cmd("ip rule add from 192.168.5.1 table 4")

h2.cmd("ip route add 192.168.4.0/24 dev h2-eth0 link table 3")
h2.cmd("ip route add default via 192.168.4.1 dev h2-eth0 table 3")

h2.cmd("ip route add 192.168.5.0/24 dev h2-eth0 link table 4")
h2.cmd("ip route add default via 192.168.5.2 dev h2-eth1 table 4")

h2.cmd("ip route add default scope global nexthop via 192.168.4.1 dev h2-eth0")
h2.cmd("ip route add default scope global nexthop via 192.168.5.2 dev h2-eth1")
#Yunolva Anis -1301204096
```

Masing-masing dari h1 dan h2 akan dibentuk sebuah table yang akan menghubungkan, table tersebut digambarkan dengan table 1, table 2, table 3 dan table 4. Setelah melakukan konfigurasi routing untuk host, maka akan dilakukan konfigurasi routing secara statistic untuk router.

```
#Yunolva Anis -1301204096

r1.cmd("ifconfig r1-eth0 192.168.0.2 netmask 255.255.255.0")
r1.cmd("ifconfig r1-eth1 192.168.2.1 netmask 255.255.255.0")
r1.cmd("ifconfig r1-eth2 192.168.6.1 netmask 255.255.255.0")
r1.cmd("route add -net 192.168.1.0/24 gw 192.168.6.2")
r1.cmd("route add -net 192.168.1.0/24 gw 192.168.0.1")
r1.cmd("route add -net 192.168.3.0/24 gw 192.168.6.2")
r1.cmd("route add -net 192.168.4.0/24 gw 192.168.2.2")
r1.cmd("route add -net 192.168.5.0/24 gw 192.168.6.2")
r1.cmd("route add -net 192.168.7.0/24 gw 192.168.2.2")
r1.cmd("sysctl net.ipv4.ip_forward=1")

r2.cmd("ifconfig r2-eth0 192.168.1.2 netmask 255.255.255.0")
r2.cmd("ifconfig r2-eth1 192.168.7.2 netmask 255.255.255.0")
r2.cmd("ifconfig r2-eth2 192.168.3.1 netmask 255.255.255.0")
r2.cmd("route add -net 192.168.0.0/24 gw 192.168.7.1")
r2.cmd("route add -net 192.168.0.0/24 gw 192.168.1.1")
r2.cmd("route add -net 192.168.2.0/24 gw 192.168.7.1")
r2.cmd("route add -net 192.168.4.0/24 gw 192.168.7.1")
r2.cmd("route add -net 192.168.5.0/24 gw 192.168.3.2")
r2.cmd("route add -net 192.168.6.0/24 gw 192.168.3.2")
r2.cmd("sysctl net.ipv4.ip_forward=1")
```

```
r3.cmd("ifconfig r3-eth0 192.168.4.1 netmask 255.255.255.0")
r3.cmd("ifconfig r3-eth1 192.168.2.2 netmask 255.255.255.0")
r3.cmd("ifconfig r3-eth2 192.168.7.1 netmask 255.255.255.0")
r3.cmd("route add -net 192.168.0.0/24 gw 192.168.2.1")
r3.cmd("route add -net 192.168.1.0/24 gw 192.168.7.2")
r3.cmd("route add -net 192.168.3.0/24 gw 192.168.7.2")
r3.cmd("route add -net 192.168.5.0/24 gw 192.168.4.2")
r3.cmd("route add -net 192.168.6.0/24 gw 192.168.2.1")
r3.cmd("sysctl net.ipv4.ip_forward=1")

r4.cmd("ifconfig r4-eth0 192.168.5.2 netmask 255.255.255.0")
r4.cmd("ifconfig r4-eth1 192.168.6.2 netmask 255.255.255.0")
r4.cmd("ifconfig r4-eth2 192.168.3.2 netmask 255.255.255.0")
r4.cmd("route add -net 192.168.0.0/24 gw 192.168.6.1")
r4.cmd("route add -net 192.168.1.0/24 gw 192.168.3.1")
r4.cmd("route add -net 192.168.2.0/24 gw 192.168.6.1")
r4.cmd("route add -net 192.168.4.0/24 gw 192.168.5.1")
r4.cmd("route add -net 192.168.7.0/24 gw 192.168.3.1")
r4.cmd("sysctl net.ipv4.ip_forward=1")
```

Pengujian ping akan dilakukan dengan dua cara. Cara pertama adalah dengan melakukan test secara manual seperti yang ada pada code dibawah :

Sehingga hasil yang didapatkan adalah sebagai berikut :

```
Test ping R1 - R2
r1 : ('ping -c 3 192.168.7.2',)
PING 192.168.7.2 (192.168.7.2) 56(84) bytes of data.
64 bytes from 192.168.7.2: icmp_seq=1 ttl=63 time=0.072 ms
64 bytes from 192.168.7.2: icmp_seq=2 ttl=63 time=0.113 ms
64 bytes from 192.168.7.2: icmp_seq=3 ttl=63 time=0.051 ms

--- 192.168.7.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2051ms
rtt min/avg/max/mdev = 0.051/0.078/0.113/0.025 ms

Test ping R3 - R4
 r3 : ('ping -c 3 192.168.2.2',)
PING 192.168.2.2 (192.168.2.2) 56(84) bytes of data.
64 bytes from 192.168.2.2: icmp_seq=1 ttl=64 time=0.024 ms
64 bytes from 192.168.2.2: icmp_seq=2 ttl=64 time=0.061 ms
64 bytes from 192.168.2.2: icmp_seq=3 ttl=64 time=0.133 ms
```

```
Test ping Upper Interface for H1 - H2
* h1 : ('ping -c 3 192.168.4.2',)
PING 192.168.4.2 (192.168.4.2) 56(84) bytes of data.
64 bytes from 192.168.4.2: icmp_seq=1 ttl=62 time=0.210 ms
64 bytes from 192.168.4.2: icmp_seq=2 ttl=62 time=0.135 ms
64 bytes from 192.168.4.2: icmp_seq=3 ttl=62 time=0.134 ms
--- 192.168.4.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2009ms
rtt min/avg/max/mdev = 0.134/0.159/0.210/0.035 ms

Test ping Lower Interface for H1 - H2
* h2 : ('ping -c 3 192.168.5.1',)
PING 192.168.5.1 (192.168.5.1) 56(84) bytes of data.
64 bytes from 192.168.5.1: icmp_seq=1 ttl=64 time=0.069 ms
64 bytes from 192.168.5.1: icmp_seq=2 ttl=64 time=0.079 ms
64 bytes from 192.168.5.1: icmp_seq=3 ttl=64 time=0.055 ms
--- 192.168.5.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2009ms
rtt min/avg/max/mdev = 0.055/0.067/0.079/0.009 ms

Test ping Upper Interface for H2 - H1
* h2 : ('ping -c 3 192.168.0.1',)
PING 192.168.0.1 (192.168.0.1) 56(84) bytes of data.
64 bytes from 192.168.0.1: icmp_seq=1 ttl=62 time=0.060 ms
64 bytes from 192.168.0.1: icmp_seq=2 ttl=62 time=0.159 ms
64 bytes from 192.168.0.1: icmp_seq=3 ttl=62 time=0.148 ms
--- 192.168.0.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2045ms
rtt min/avg/max/mdev = 0.060/0.122/0.159/0.044 ms
```

```
Test ping Lower Interface for H1 - H2
* h1 : ('ping -c 3 192.168.1.1',)
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_seq=1 ttl=64 time=0.080 ms
64 bytes from 192.168.1.1: icmp_seq=2 ttl=64 time=0.075 ms
64 bytes from 192.168.1.1: icmp_seq=3 ttl=64 time=0.076 ms

--- 192.168.1.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2009ms
rtt min/avg/max/mdev = 0.075/0.077/0.080/0.002 ms
```

Selain menggunakan test ping seperti pada di atas dapat terlihat jika masing-masing node yang sebelumnya belum terhubung sekarang telah terhubung, maka akan dilakukan juga pengecekan ping kepada seluruh node melalui mininet, seperti berikut :

a. Ping H1 – H2

```
*** Starting CLI:
mininet> h1 ping h2
PING 192.168.4.2 (192.168.4.2) 56(84) bytes of data.
64 bytes from 192.168.4.2: icmp_seq=1 ttl=62 time=0.068 ms
64 bytes from 192.168.4.2: icmp_seq=2 ttl=62 time=0.194 ms
64 bytes from 192.168.4.2: icmp_seq=3 ttl=62 time=0.079 ms
64 bytes from 192.168.4.2: icmp_seq=4 ttl=62 time=0.082 ms
^C
--- 192.168.4.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3055ms
rtt min/avg/max/mdev = 0.068/0.105/0.194/0.051 ms
mininet>
```

b. Ping H2 – H1

```
mininet> h2 ping h1
PING 192.168.0.1 (192.168.0.1) 56(84) bytes of data.
64 bytes from 192.168.0.1: icmp_seq=1 ttl=62 time=0.063 ms
64 bytes from 192.168.0.1: icmp_seq=2 ttl=62 time=0.090 ms
64 bytes from 192.168.0.1: icmp_seq=3 ttl=62 time=0.085 ms
64 bytes from 192.168.0.1: icmp_seq=4 ttl=62 time=0.139 ms
^C
--- 192.168.0.1 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3049ms
rtt min/avg/max/mdev = 0.063/0.094/0.139/0.027 ms
mininet>
```

Ping yang berjalan menandakan bahwa pengiriman packet berhasil atau seluruh node berhasil disambungkan, lakukan proses tersebut hingga seluruh X yang ada pada saat pingall menghilang dan berganti dengan node.

```
*** Ping: testing ping reachability
r1 -> X r3 r4 X h2
r2 -> X r3 r4 X h2
r3 -> r1 r2 X X h2
r4 -> r1 r2 X X X
h1 -> r1 r2 r3 r4 h2
h2 -> r1 r2 r3 r4 X
*** Results: 33% dropped (20/30 received)
mininet>
```

Sehingga kan terisi seperti berikut :

```
*** 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>
```

- **Menganalisis routing yang digunakan menggunakan traceroute**

Setelah melakukan pengecekan ping maka akan dilakukan analisis routing dengan menggunakan traceroute, sehingga didapatkan hasil sebagai berikut :

a. Traceroute H1 – H2

```
mininet> h1 traceroute h2
traceroute to 192.168.4.2 (192.168.4.2), 30 hops max, 60 byte packets
 1  192.168.0.2 (192.168.0.2)  0.046 ms  0.011 ms  0.011 ms
 2  192.168.2.2 (192.168.2.2)  0.029 ms  0.013 ms  0.013 ms
 3  192.168.4.2 (192.168.4.2)  0.029 ms  0.018 ms  0.016 ms
mininet>
```

b. Traceroute H2 – H1

```
mininet> h2 traceroute h1
traceroute to 192.168.0.1 (192.168.0.1), 30 hops max, 60 byte packets
 1  192.168.4.1 (192.168.4.1)  0.041 ms  0.009 ms  0.008 ms
 2  192.168.2.1 (192.168.2.1)  0.020 ms  0.012 ms  0.013 ms
 3  192.168.0.1 (192.168.0.1)  0.024 ms  0.016 ms  0.017 ms
mininet>
```

CLO3
Goal : Membuktikan bahwa TCP telah diimplementasikan dengan benar pada topologi.

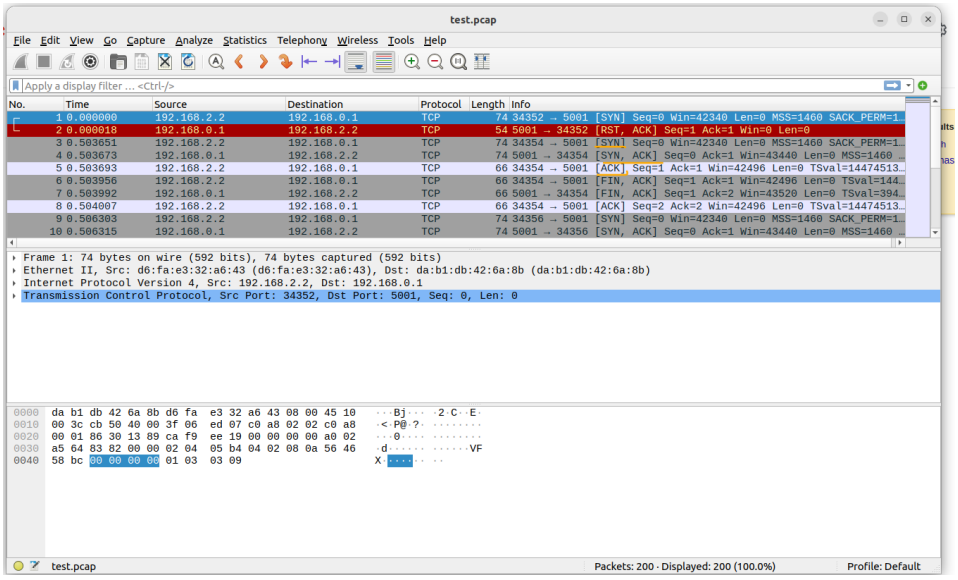
- **Generate traffic menggunakan iPerf.**
  Setelah node-node yang ada telah terisi seperti gambar berikut

```
*** 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>
```

Maka akan dilanjutkan untuk melakukan generate traffic menggunakan iperf, seperti yang ada pada gambar di bawah ini :

Command xterm akan mempopup kan sebuah cmd khusus untuk node h1, yang kemudian di dalam cmd node h1 tersebut akan dilakukan pengecekan oleh iperf yang kita masukkan. TCP (Transmission Control Protocol) merupakan sebuah protocol yang berada pada lapisan transport dan dapat mengirimkan paket satu persatu. Sementara UDP (User Diagram Protocol) yang dapat mengirimkan packet secara bersamaan.

- **Capture trafik menggunakan custom script atau Wireshark untuk diinspeksi, dibuktikan dengan trafik di Wireshark/tcpdump.**
  Pada gambar di atas dapat dilihat bahwa terdapat threeway handshake. Proses threeway handshake terjadi secara berurutan mulai dari :



a. SYN : 192.168.2.2 sebagai source menuju ke 192.168.0.1 sebagai destination
b. SYN, ACK : 192.168.0.1 sebagai source menuju ke 192.168.2.2 sebagai desination
c. ACK : terdapat 192.168.2.2 sebagai source menuju ke 192.168.0.1 sebagai destination.

CLO4

Goal : Menginspeksi penggunaan queue pada router jaringan.

- **Generate traffic menggunakan iPerf.**
  Generate traffic dengan menggunakan iperf akan dilakukan dengan command seperti berikut :

```
h2.cmd("iperf -s &")

h1.cmd("iperf -t 30 -B 192.168.0.1 -c 192.168.4.2 &")

h1.cmd("iperf -t 30 -B 192.168.1.1 -c 192.168.5.1 &")
```

- **Set ukuran buffer pada router : 20, 40, 60 dan 100.**

```
net = Mininet()
#definisi host
r1 = net.addHost("r1")
r2 = net.addHost("r2")
r3 = net.addHost("r3")
r4 = net.addHost("r4")
h1 = net.addHost("h1")
h2 = net.addHost("h2")

buffer= int(buffer)
#buffer= int(100)

net.addLink(h1,r1,max_queue_size=buffer,use_htb=True,intfName1='h1-eth0',intfName2='r1-eth0',cls = TCLink,bw=1)
net.addLink(h1,r2,max_queue_size=buffer,use_htb=True,intfName1='h1-eth1',intfName2='r2-eth0',cls = TCLink,bw=1)
net.addLink(h2,r3,max_queue_size=buffer,use_htb=True,intfName1='h2-eth0',intfName2='r3-eth0',cls = TCLink,bw=1)
net.addLink(h2,r4,max_queue_size=buffer,use_htb=True,intfName1='h2-eth1',intfName2='r4-eth0',cls = TCLink,bw=1)
net.addLink(r1,r3,max_queue_size=buffer,use_htb=True,intfName1='r1-eth1',intfName2='r3-eth1',cls = TCLink,bw=0.5)
net.addLink(r1,r4,max_queue_size=buffer,use_htb=True,intfName1='r1-eth2',intfName2='r4-eth1',cls = TCLink,bw=1)
net.addLink(r2,r3,max_queue_size=buffer,use_htb=True,intfName1='r2-eth1',intfName2='r3-eth2',cls = TCLink,bw=1)
net.addLink(r2,r4,max_queue_size=buffer,use_htb=True,intfName1='r2-eth2',intfName2='r4-eth2',cls = TCLink,bw=0.5)
net.start()
```

a. 20

```
[  1] local 192.168.0.1 port 42424 connected with
192.168.4.2 port 5001
[ ID] Interval       Transfer     Bandwidth
[  1] 0.0000-1.0000 sec   128 KBytes  1.05 Mbits/sec
[  1] 1.0000-2.0000 sec   177 KBytes  1.45 Mbits/sec
[  1] 2.0000-3.0000 sec  84.8 KBytes   695 Kbits/sec
[  1] 3.0000-4.0000 sec  76.4 KBytes   626 Kbits/sec
[  1] 4.0000-5.0000 sec  7.07 KBytes  57.9 Kbits/sec
[  1] 5.0000-6.0000 sec  8.48 KBytes  69.5 Kbits/sec
[  1] 6.0000-7.0000 sec  53.7 KBytes   440 Kbits/sec
[  1] 7.0000-8.0000 sec  9.90 KBytes  81.1 Kbits/sec
[  1] 8.0000-9.0000 sec  63.6 KBytes   521 Kbits/sec
[  1] 9.0000-10.0000 sec  0.000 Bytes  0.000 bits/sec
```

b. 40

```
[  1] local 192.168.0.1 port 42426 connected with
192.168.4.2 port 5001
[ ID] Interval       Transfer     Bandwidth
[  1] 0.0000-1.0000 sec  93.4 KBytes   765 Kbits/sec
[  1] 1.0000-2.0000 sec   106 KBytes   869 Kbits/sec
[  1] 2.0000-3.0000 sec   148 KBytes  1.22 Mbits/sec
[  1] 3.0000-4.0000 sec   103 KBytes   846 Kbits/sec
[  1] 4.0000-5.0000 sec  18.4 KBytes   151 Kbits/sec
[  1] 5.0000-6.0000 sec  14.1 KBytes   116 Kbits/sec
[  1] 6.0000-7.0000 sec  63.6 KBytes   521 Kbits/sec
[  1] 7.0000-8.0000 sec  63.6 KBytes   521 Kbits/sec
[  1] 8.0000-9.0000 sec  0.000 Bytes  0.000 bits/sec
[  1] 9.0000-10.0000 sec  63.6 KBytes   521 Kbits/sec
```

c. 60

```
[  1] local 192.168.0.1 port 42428 connected with 192.168.4.2
port 5001
[ ID] Interval       Transfer     Bandwidth
[  1] 0.0000-1.0000 sec   157 KBytes  1.29 Mbits/sec
[  1] 1.0000-2.0000 sec   127 KBytes  1.04 Mbits/sec
[  1] 2.0000-3.0000 sec   127 KBytes  1.04 Mbits/sec
[  1] 3.0000-4.0000 sec  62.2 KBytes   510 Kbits/sec
[  1] 4.0000-5.0000 sec  53.7 KBytes   440 Kbits/sec
[  1] 5.0000-6.0000 sec  7.07 KBytes  57.9 Kbits/sec
[  1] 6.0000-7.0000 sec  5.66 KBytes  46.3 Kbits/sec
[  1] 7.0000-8.0000 sec  63.6 KBytes   521 Kbits/sec
[  1] 8.0000-9.0000 sec  0.000 Bytes  0.000 bits/sec
[  1] 9.0000-10.0000 sec  63.6 KBytes   521 Kbits/sec
[  1] 10.0000-20.1167 sec  63.6 KBytes  51.5 Kbits/sec
```

d. 100

```
[  1] local 192.168.0.1 port 42422 connected with 192.168.4.2
port 5001
[ ID] Interval       Transfer     Bandwidth
[  1] 0.0000-1.0000 sec   248 KBytes  2.03 Mbits/sec
[  1] 1.0000-2.0000 sec   209 KBytes  1.71 Mbits/sec
[  1] 2.0000-3.0000 sec  69.3 KBytes   568 Kbits/sec
[  1] 3.0000-4.0000 sec  63.6 KBytes   521 Kbits/sec
[  1] 4.0000-5.0000 sec   127 KBytes  1.04 Mbits/sec
[  1] 5.0000-6.0000 sec   127 KBytes  1.04 Mbits/sec
[  1] 6.0000-7.0000 sec   127 KBytes  1.04 Mbits/sec
[  1] 7.0000-8.0000 sec   255 KBytes  2.09 Mbits/sec
[  1] 8.0000-9.0000 sec   191 KBytes  1.56 Mbits/sec
[  1] 9.0000-10.0000 sec   255 KBytes  2.09 Mbits/sec
[  1] 10.0000-20.4509 sec   127 KBytes  99.8 Kbits/sec
```

- **Capture pengaruh ukuran buffer terhadap delay.**
- **Analisis eksperimen hasil variasi ukuran buffer.**
- **Mahasiswa mengerti caranya mengubah buffer dan mengenai pengaruh besar buffer.**

Buffer Size			
20	40	60	100
Time (ms)			
1050	765	1290	2030
1040	869	1040	1710
695	1220	1040	568
626	846	510	1040
57.9	151	440	1040
69.5	116	46.3	1040
440	521	521	2090
81.1	521	0	1560
521	0	521	2090
Total			
4580.5	5009	5408.3	13168
Average			
508.9444	556.5556	600.9222	1463.111

Berdasarkan table di atas dapat disimpulkan jika besarnya buffer akan mempengaruhi besarnya waktu, karena semakin besar buffer maka akan semakin besar waktu delay yang ada.

Lampiran :

Video presentasi : https://youtu.be/z4Km4Z-axuQ