Mininet Network Emulation

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Contents

Chapter 1

Static routing

1.1 Network topology

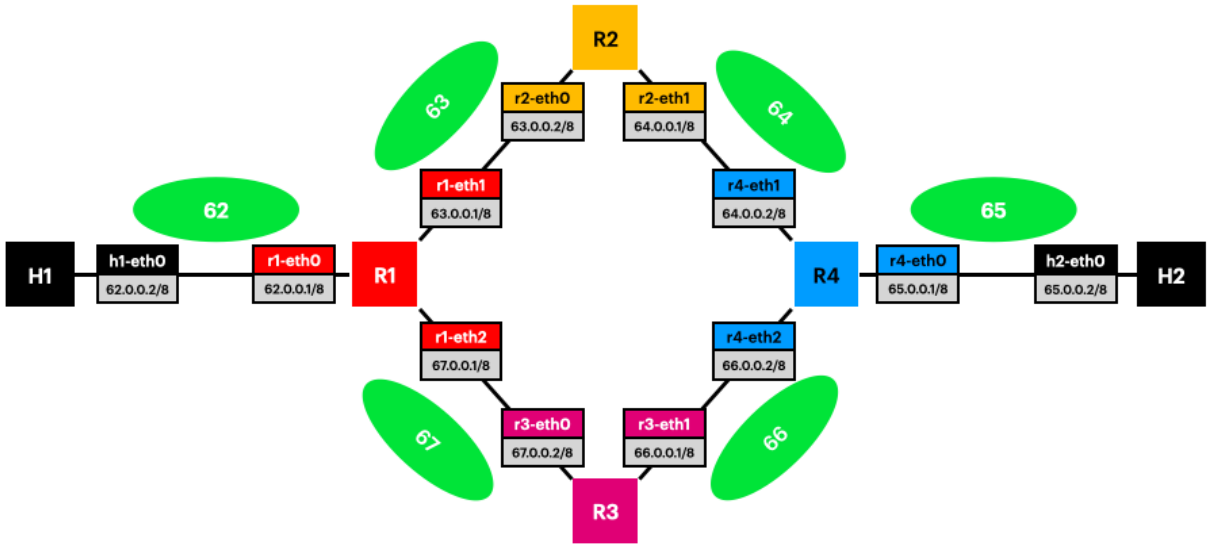

Figure 1.1: Topology

1.2 Routing tables

1.2.1 Router R1

Destination	Gateway	Genmask	Flags	Metric	Ref	Use	Iface
0.0.0.0	63.0.0.2	0.0.0.0	UG	0	0	0	r1-eth1
62.0.0.0	0.0.0.0	255.0.0.0	U	0	0	0	r1-eth0
63.0.0.0	0.0.0.0	255.0.0.0	U	0	0	0	r1-eth1
66.0.0.0	67.0.0.2	255.0.0.0	UG	0	0	0	r1-eth2
67.0.0.0	0.0.0.0	255.0.0.0	U	0	0	0	r1-eth2

1.2.2 Router R2

```
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
0.0.0.0         64.0.0.2        0.0.0.0         UG    0      0        0 r2-eth1
62.0.0.0        63.0.0.1        255.0.0.0       UG    0      0        0 r2-eth0
63.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r2-eth0
64.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r2-eth1
67.0.0.0        63.0.0.1        255.0.0.0       UG    0      0        0 r2-eth0
```

1.2.3 Router R3

```
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
0.0.0.0         66.0.0.2        0.0.0.0         UG    0      0        0 r3-eth1
62.0.0.0        67.0.0.1        255.0.0.0       UG    0      0        0 r3-eth0
63.0.0.0        67.0.0.1        255.0.0.0       UG    0      0        0 r3-eth0
66.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r3-eth1
67.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r3-eth0
```

1.2.4 Router R4

```
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
0.0.0.0         64.0.0.1        0.0.0.0         UG    0      0        0 r4-eth1
64.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r4-eth1
65.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r4-eth0
66.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r4-eth2
67.0.0.0        66.0.0.1        255.0.0.0       UG    0      0        0 r4-eth2
```

1.2.5 Static routing

The **ip route** command is used to add static routes on a node. The syntax of the command is as follows:

```
ip route [dest-network-address] via [next-hop-ip]
    dev [src-exit-interface-name]
```

Few things to be careful about:

1. **dest-network-address** should contain the cidr decimal
2. **next-hop-ip** should NOT contain the cidr decimal
3. **next-hop-ip** and **src-exit-interface-name** should be on the same network

For every node in the network, static routes are added for every destination network which the node is not a part of or whose network prefix doesn't match the network prefix for any of the node's interfaces.

1.3 Traceroute output

1.3.1 H1 to H2

```
traceroute to 65.0.0.2 (65.0.0.2), 5 hops max, 60 byte packets
 1  62.0.0.1 (62.0.0.1)  0.049 ms  0.008 ms  0.006 ms
 2  63.0.0.2 (63.0.0.2)  0.024 ms  0.010 ms  0.009 ms
 3  64.0.0.2 (64.0.0.2)  0.025 ms  0.011 ms  0.011 ms
 4  65.0.0.2 (65.0.0.2)  0.027 ms  0.015 ms  0.013 ms
```

1.3.2 H2 to H1

```
traceroute to 62.0.0.2 (62.0.0.2), 5 hops max, 60 byte packets
 1  65.0.0.1 (65.0.0.1)  0.034 ms  0.006 ms  0.004 ms
 2  64.0.0.1 (64.0.0.1)  0.012 ms  0.006 ms  0.006 ms
 3  63.0.0.1 (63.0.0.1)  0.014 ms  0.008 ms  0.007 ms
 4  62.0.0.2 (62.0.0.2)  0.017 ms  0.010 ms  0.009 ms
```

Chapter 2

BIRD inter-domain routing

2.1 Routing tables

2.1.1 Router R1

```
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
62.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r1-eth0
62.0.0.0        0.0.0.0         255.0.0.0       U     32     0        0 r1-eth0
63.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r1-eth1
63.0.0.0        0.0.0.0         255.0.0.0       U     32     0        0 r1-eth1
64.0.0.0        63.0.0.2        255.0.0.0       UG    32     0        0 r1-eth1
66.0.0.0        67.0.0.2        255.0.0.0       UG    32     0        0 r1-eth2
67.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r1-eth2
67.0.0.0        0.0.0.0         255.0.0.0       U     32     0        0 r1-eth2
```

2.1.2 Router R2

```
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
62.0.0.0        63.0.0.1        255.0.0.0       UG    32     0        0 r2-eth0
63.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r2-eth0
63.0.0.0        0.0.0.0         255.0.0.0       U     32     0        0 r2-eth0
64.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r2-eth1
64.0.0.0        0.0.0.0         255.0.0.0       U     32     0        0 r2-eth1
65.0.0.0        64.0.0.2        255.0.0.0       UG    32     0        0 r2-eth1
66.0.0.0        64.0.0.2        255.0.0.0       UG    32     0        0 r2-eth1
67.0.0.0        63.0.0.1        255.0.0.0       UG    32     0        0 r2-eth0
```

2.1.3 Router R3

```
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
62.0.0.0        67.0.0.1        255.0.0.0       UG    32     0        0 r3-eth0
63.0.0.0        67.0.0.1        255.0.0.0       UG    32     0        0 r3-eth0
64.0.0.0        66.0.0.2        255.0.0.0       UG    32     0        0 r3-eth1
65.0.0.0        66.0.0.2        255.0.0.0       UG    32     0        0 r3-eth1
66.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r3-eth1
66.0.0.0        0.0.0.0         255.0.0.0       U     32     0        0 r3-eth1
```

```
67.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r3-eth0
67.0.0.0        0.0.0.0         255.0.0.0       U     32     0        0 r3-eth0
```

2.1.4 Router R4

```
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
62.0.0.0        64.0.0.1        255.0.0.0       UG    32     0        0 r4-eth1
63.0.0.0        64.0.0.1        255.0.0.0       UG    32     0        0 r4-eth1
64.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r4-eth1
64.0.0.0        0.0.0.0         255.0.0.0       U     32     0        0 r4-eth1
65.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r4-eth0
65.0.0.0        0.0.0.0         255.0.0.0       U     32     0        0 r4-eth0
66.0.0.0        0.0.0.0         255.0.0.0       U     0      0        0 r4-eth2
66.0.0.0        0.0.0.0         255.0.0.0       U     32     0        0 r4-eth2
67.0.0.0        66.0.0.1        255.0.0.0       UG    32     0        0 r4-eth2
```

2.2 Tracing routes

```
traceroute to 65.0.0.2 (65.0.0.2), 5 hops max, 60 byte packets
 1  62.0.0.1 (62.0.0.1)  0.030 ms  0.006 ms  0.005 ms
 2  63.0.0.2 (63.0.0.2)  0.014 ms  0.007 ms  0.008 ms
 3  64.0.0.2 (64.0.0.2)  0.015 ms  0.008 ms  0.009 ms
 4  65.0.0.2 (65.0.0.2)  0.017 ms  0.011 ms  0.010 ms
```

2.3 Getting a link down

The command to get any link down in mininet is as follows:

`link [node-1-name] [node-2-name] down`

You can also get the link down using python code as follows:

`info(net.configLinkStatus('node-1-name','node-2-name','down'))`

2.4 Tracing routes after a link is down

```
traceroute to 65.0.0.2 (65.0.0.2), 5 hops max, 60 byte packets
 1  62.0.0.1 (62.0.0.1)  0.026 ms  0.005 ms  0.004 ms
 2  67.0.0.2 (67.0.0.2)  0.014 ms  0.008 ms  0.007 ms
 3  66.0.0.2 (66.0.0.2)  0.015 ms  0.010 ms  0.008 ms
 4  65.0.0.2 (65.0.0.2)  0.015 ms  0.010 ms  0.010 ms
```

Chapter 3

Network performance

3.1 Manipulating router buffer sizes

3.1.1 Buffer size = 10Kb

Server

```
------------------------------------------------------------
Server listening on 8000
------------------------------------------------------------
Accepted connection from 62.0.0.2, port 52640
[  5] local 65.0.0.2 port 8000 connected to 62.0.0.2 port 52642
[ ID] Interval           Transfer     Bandwidth
[  5]   0.00-10.00  sec  73.5 MBytes  61.7 Mbits/sec
[  5]  10.00-11.28  sec  6.60 MBytes  43.3 Mbits/sec
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth       Retr
[  5]   0.00-11.28  sec  84.9 MBytes  63.2 Mbits/sec    0             sender
[  5]   0.00-11.28  sec  80.1 MBytes  59.6 Mbits/sec                  receiver
```

Client

```
Connecting to host 65.0.0.2, port 8000
[  4] local 62.0.0.2 port 52642 connected to 65.0.0.2 port 8000
[ ID] Interval           Transfer     Bandwidth       Retr  Cwnd
[  4]   0.00-10.00  sec  84.9 MBytes  71.2 Mbits/sec    0   6.57 MBytes
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth       Retr
[  4]   0.00-10.00  sec  84.9 MBytes  71.2 Mbits/sec    0             sender
[  4]   0.00-10.00  sec  80.1 MBytes  67.2 Mbits/sec                  receiver

iperf Done.
```

3.1.2 Buffer size = 5Mb

Server

```
------------------------------------------------------------
Server listening on 8000
------------------------------------------------------------
```

```
Accepted connection from 62.0.0.2, port 52644
[  5] local 65.0.0.2 port 8000 connected to 62.0.0.2 port 52646
[ ID] Interval           Transfer     Bandwidth
[  5]   0.00-10.00  sec  82.7 MBytes  69.4 Mbits/sec
[  5]  10.00-11.41  sec  8.00 MBytes  47.7 Mbits/sec
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth       Retr
[  5]   0.00-11.41  sec  93.5 MBytes  68.8 Mbits/sec    0             sender
[  5]   0.00-11.41  sec  90.7 MBytes  66.7 Mbits/sec                  receiver
```

Client

```
Connecting to host 65.0.0.2, port 8000
[  4] local 62.0.0.2 port 52646 connected to 65.0.0.2 port 8000
[ ID] Interval           Transfer     Bandwidth       Retr  Cwnd
[  4]   0.00-10.00  sec  93.5 MBytes  78.5 Mbits/sec    0   8.14 MBytes
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth       Retr
[  4]   0.00-10.00  sec  93.5 MBytes  78.5 Mbits/sec    0             sender
[  4]   0.00-10.00  sec  90.7 MBytes  76.1 Mbits/sec                  receiver

iperf Done.
```

3.1.3 Buffer size = 25Mb

Server

```
-----------------------------------------------------------
Server listening on 8000
-----------------------------------------------------------
Accepted connection from 62.0.0.2, port 52648
[  5] local 65.0.0.2 port 8000 connected to 62.0.0.2 port 52650
[ ID] Interval           Transfer     Bandwidth
[  5]   0.00-10.00  sec  83.9 MBytes  70.4 Mbits/sec
[  5]  10.00-11.48  sec  7.17 MBytes  40.6 Mbits/sec
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth       Retr
[  5]   0.00-11.48  sec  95.5 MBytes  69.7 Mbits/sec    0             sender
[  5]   0.00-11.48  sec  91.1 MBytes  66.6 Mbits/sec                  receiver
```

Client

```
Connecting to host 65.0.0.2, port 8000
[  4] local 62.0.0.2 port 52650 connected to 65.0.0.2 port 8000
[ ID] Interval           Transfer     Bandwidth       Retr  Cwnd
[  4]   0.00-10.00  sec  95.5 MBytes  80.1 Mbits/sec    0   7.09 MBytes
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth       Retr
[  4]   0.00-10.00  sec  95.5 MBytes  80.1 Mbits/sec    0             sender
[  4]   0.00-10.00  sec  91.1 MBytes  76.4 Mbits/sec                  receiver

iperf Done.
```

3.2 Analysis

Bandwidth-delay product (BDP) is given by the product of the bandwidth and the RTT.

Since we assume the bandwidth to be 100Mb and delay to be 30ms, we can calculate the BDP as follows:

```
BDP = 100Mb * 30ms = 3 Mbits
```

The throughput should be close to the bandwidth (100Mb) when the router buffer size is greater than or equal to the BDP. Similarly, when the router buffer size is less than the BDP, the throughput is reduced.

From the results obtained in section 1, we see that throughput with a buffer size of 10k is much lesser than that with buffer sizes of 5Mb and 25Mb.