Practice 5 Report

20170481 Yuseung Lee

Task 1.

[1.1.3]

```
Flow 1 (10.0.0.1 -> 10.0.0.2)
  Tx Packets: 2142
  Tx Bytes:   3058776
  TxOffered:  2.71891 Mbps
  Rx Packets: 1409
  Rx Bytes:   2012052
  Throughput: 1.78849 Mbps
Flow 2 (10.0.0.3 -> 10.0.0.2)
  Tx Packets: 2411
  Tx Bytes:   3442908
  TxOffered:  3.06036 Mbps
  Rx Packets: 1807
  Rx Bytes:   2580396
  Throughput: 2.29369 Mbps
```

Above is the per flow statistics of the WIFI_PHY_STANDARD_80211g & A fixed at (15, 0, 0). RTS/CTS is disabled in this case.

	Tx Packets	Tx Bytes	Tx Offered (Mbps)	Rx Packets	Rx Bytes	Throughput (Mbps)
Flow 1 (A to B)	2,142	3,058,776	2.71891	1,409	2,012,052	**1.78849**
Flow 2 (C to B)	2,411	3,442,908	3.06036	1,807	2,580,396	2.29369

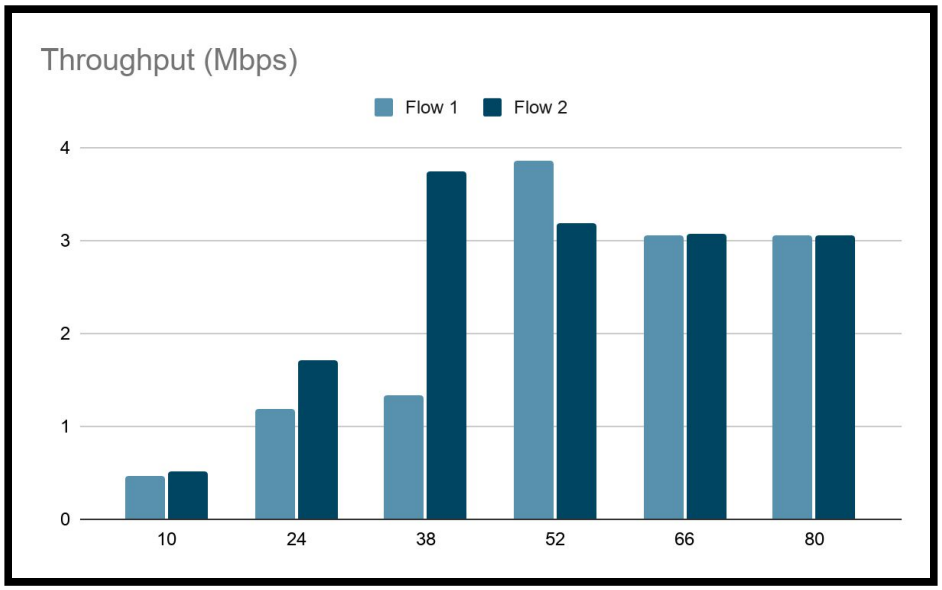
[1.2]

```
Flow 1 (10.0.0.1 -> 10.0.0.2)
  Tx Packets: 2142
  Tx Bytes:   3058776
  TxOffered:  2.71891 Mbps
  Rx Packets: 1567
  Rx Bytes:   2237676
  Throughput: 1.98905 Mbps
Flow 2 (10.0.0.3 -> 10.0.0.2)
  Tx Packets: 2411
  Tx Bytes:   3442908
  TxOffered:  3.06036 Mbps
  Rx Packets: 2175
  Rx Bytes:   3105900
  Throughput: 2.7608 Mbps
```

Above is the per flow statistics of the WIFI_PHY_STANDARD_80211g & A moving from (10, 0, 0) to (80, 0, 0) in 5 fixed intervals. RTS/CTS is disabled in this case.

	Tx Packets	Tx Bytes	Tx Offered (Mbps)	Rx Packets	Rx Bytes	Throughput (Mbps)
Flow 1 (A to B)	2,142	3,058,776	2.71891	1,567	2,237,676	**1.98905**

Flow 2 (C to B)	2,411	3,442,908	3.06036	2,175	3,105,900	2.7608



[Graph 1]

Graph 1 shows the average throughput for each flow based on the position of A. The x axis indicates the x coordinate of A, and we can see that Flow 1 (A → B) has increased when A went farther away from B. At the same time Flow 2 (C → B) had also increased, and as A's position changed to x=80 we can see that the throughput for two flows have become almost equal. From this result we can learn that when A, C were both close to B they were interfering with each other's flow towards B. Whereas as A goes farther from B, the amount of interference decreases so A and C can both have a better throughput and the overall throughput has increased.

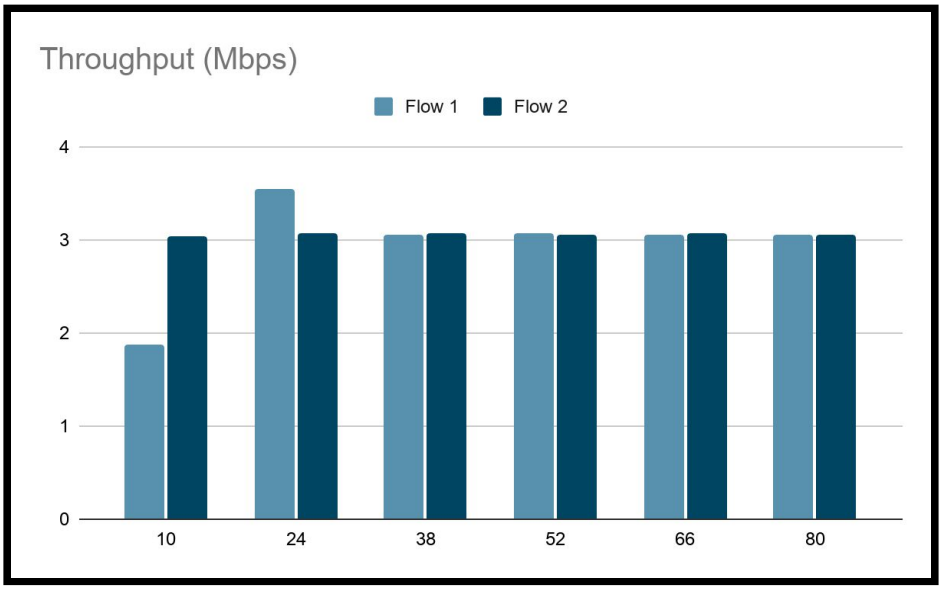
Also, we can see in the above table that the total average throughput for Flow 1 is 1.98905 Mbps while the average sending rate was 2.71891 Mbps. And the total average throughput for Flow 2 is 2.7608 Mbps while the average sending rate was 3.06036 Mbps. We can see that in this case (with 2.4GHz range) the throughput was lower than the sending rate.

[1.3]

```
Flow 1 (10.0.0.1 -> 10.0.0.2)
  Tx Packets: 2142
  Tx Bytes:   3058776
  TxOffered:  2.71891 Mbps
  Rx Packets: 2142
  Rx Bytes:   3058776
  Throughput: 2.71891 Mbps
Flow 2 (10.0.0.3 -> 10.0.0.2)
  Tx Packets: 2411
  Tx Bytes:   3442908
  TxOffered:  3.06036 Mbps
  Rx Packets: 2411
  Rx Bytes:   3442908
  Throughput: 3.06036 Mbps
```

Above is the per flow statistics of the WIFI_PHY_STANDARD_80211_10MHZ & A moving from (10, 0, 0) to (80, 0, 0) in 5 fixed intervals. RTS/CTS is disabled in this case.

	Tx Packets	Tx Bytes	Tx Offered (Mbps)	Rx Packets	Rx Bytes	Throughput (Mbps)
Flow 1 (A to B)	2,142	3,058,776	2.71891	2,142	3,058,776	**2.71891**
Flow 2 (C to B)	2,411	3,442,908	3.06036	2,411	3,442,908	3.06036



[Graph 2]

Graph 2 shows the average throughput for each flow based on the position of A. The x axis indicates the x coordinate of A. When A goes from x=10 to x=24 Flow 1's throughput does increase, but after that the throughput of both Flow 1 and Flow 2 are steady at about 3 Mbps. Also, the total average throughput for Flow 1 is 2.71891 Mbps, which is equal to the sending rate for Flow 1. And the total average throughput for Flow 2 is 3.06036 Mbps, which is equal to its sending rate. So we can see that in this case using WIFI_PHY_STANDARD_80211_10MHZ (range of 5GHz), the average throughput is the same as the sending rate, whereas in the previous case using 2.4GHz the throughput was not as high as the sending rate.

[1.4]

In the simulation Node C can cause the hidden terminal problem, because B knows the existence of C but A does not. So when A transmits packets to B, the throughput result is lower than expected because C is also sending packets to B. When A and C both transmit to B simultaneously, collision can occur and this results in packet drops. As we could see in the above simulations, when A and C were both close to B this packet drop happens frequently and the total throughput was much less than the available throughput. But as A went far away from B, we could see that the total throughput of Flow 1 and Flow 2 increased and packet collisions happened less frequently. RTS/CTS flow control can solve this hidden terminal problem by securing the channel before sending the data packets.

Task 2.

[2.4] This is the terminal output of the simulation with RTS/CTS enabled. We can see that 8 flows and their received packets and throughput are printed.

```
Flow ID: 1 Src Addr 10.0.0.1 Dst Addr 10.0.0.64
Tx Packets = 19999
Rx Packets = 12
Throughput: 6.82388 Kbps
Flow ID: 2 Src Addr 10.0.0.57 Dst Addr 10.0.0.8
Tx Packets = 19874
Rx Packets = 24
Throughput: 3.84251 Kbps
Flow ID: 3 Src Addr 10.0.0.17 Dst Addr 10.0.0.24
Tx Packets = 19749
Rx Packets = 23
Throughput: 4.88875 Kbps
Flow ID: 4 Src Addr 10.0.0.41 Dst Addr 10.0.0.48
Tx Packets = 19624
Rx Packets = 47
Throughput: 8.10467 Kbps
Flow ID: 5 Src Addr 10.0.0.59 Dst Addr 10.0.0.3
Tx Packets = 19499
Rx Packets = 27
Throughput: 4.04465 Kbps
Flow ID: 6 Src Addr 10.0.0.6 Dst Addr 10.0.0.62
Tx Packets = 19374
Rx Packets = 119
Throughput: 18.1233 Kbps
Flow ID: 7 Src Addr 10.0.0.27 Dst Addr 10.0.0.54
Tx Packets = 19249
Rx Packets = 178
Throughput: 27.2166 Kbps
Flow ID: 8 Src Addr 10.0.0.14 Dst Addr 10.0.0.52
Tx Packets = 9499
Rx Packets = 86
Throughput: 14.6601 Kbps
```

[2.5]

RTS/CTS Enabled	RTS/CTS Disabled
Flow ID: 1 Src Addr 10.0.0.1 Dst Addr 10.0.0.64 Tx Packets = 19999 Rx Packets = 12 Throughput: 6.82388 Kbps Flow ID: 2 Src Addr 10.0.0.57 Dst Addr 10.0.0.8 Tx Packets = 19874 Rx Packets = 24 Throughput: 3.84251 Kbps Flow ID: 3 Src Addr 10.0.0.17 Dst Addr 10.0.0.24 Tx Packets = 19749 Rx Packets = 23 Throughput: 4.88875 Kbps Flow ID: 4 Src Addr 10.0.0.41 Dst Addr 10.0.0.48 Tx Packets = 19624 Rx Packets = 47 Throughput: 8.10467 Kbps Flow ID: 5 Src Addr 10.0.0.59 Dst Addr 10.0.0.3 Tx Packets = 19499 Rx Packets = 27 Throughput: 4.04465 Kbps Flow ID: 6 Src Addr 10.0.0.6 Dst Addr 10.0.0.62 Tx Packets = 19374 Rx Packets = 119 Throughput: 18.1233 Kbps Flow ID: 7 Src Addr 10.0.0.27 Dst Addr 10.0.0.54 Tx Packets = 19249 Rx Packets = 178 Throughput: 27.2166 Kbps Flow ID: 8 Src Addr 10.0.0.14 Dst Addr 10.0.0.52 Tx Packets = 9499 Rx Packets = 86 Throughput: 14.6601 Kbps	Flow ID: 1 Src Addr 10.0.0.1 Dst Addr 10.0.0.64 Tx Packets = 19999 Rx Packets = 7 Throughput: 1.02019 Kbps Flow ID: 2 Src Addr 10.0.0.57 Dst Addr 10.0.0.8 Tx Packets = 19874 Rx Packets = 22 Throughput: 84.9083 Kbps Flow ID: 3 Src Addr 10.0.0.17 Dst Addr 10.0.0.24 Tx Packets = 19749 Rx Packets = 2 Throughput: 3.70135 Kbps Flow ID: 4 Src Addr 10.0.0.41 Dst Addr 10.0.0.48 Tx Packets = 19624 Rx Packets = 3 Throughput: 1.13973 Kbps Flow ID: 5 Src Addr 10.0.0.59 Dst Addr 10.0.0.3 Tx Packets = 19499 Rx Packets = 0 Throughput: -0 Kbps Flow ID: 6 Src Addr 10.0.0.6 Dst Addr 10.0.0.62 Tx Packets = 19374 Rx Packets = 19 Throughput: 2.87602 Kbps Flow ID: 7 Src Addr 10.0.0.27 Dst Addr 10.0.0.54 Tx Packets = 19249 Rx Packets = 137 Throughput: 26.5883 Kbps Flow ID: 8 Src Addr 10.0.0.14 Dst Addr 10.0.0.52 Tx Packets = 9499 Rx Packets = 19 Throughput: 3.86708 Kbps

When we compare the two cases with and without RTS, we can see that the number of received packets have decreased in every flow. The decrease rate is big in most flows especially in Flow 5 which has received no packet when the RTS was disabled. But Flow 2 has only a slight decrease in received packets (24 → 22) and its throughput has actually increased when the RTS was disabled (3.84251 Kbps → 84.9083 Kbps). For every other flow, throughput was decreased when the RTS was disabled, compared to when RTS was enabled. Therefore we can conclude that when there are multiple flows in the network, RTS/CTS flow control prevents the throughput from being concentrated to one flow (in this case, Flow 2) and instead gives chance to other flows to transmit their packets and in consequence increase the total number of received packets in the network. When there is no RTS/CTS in a multiple flow network, the throughput could be concentrated in only a few flows which means that other flows will not be able to send enough packets.

Task 3. Survey