CS 252: Lab 5

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Contents

Question 1

a.

For default parameters (`dataRate` = 10.0Mbps),

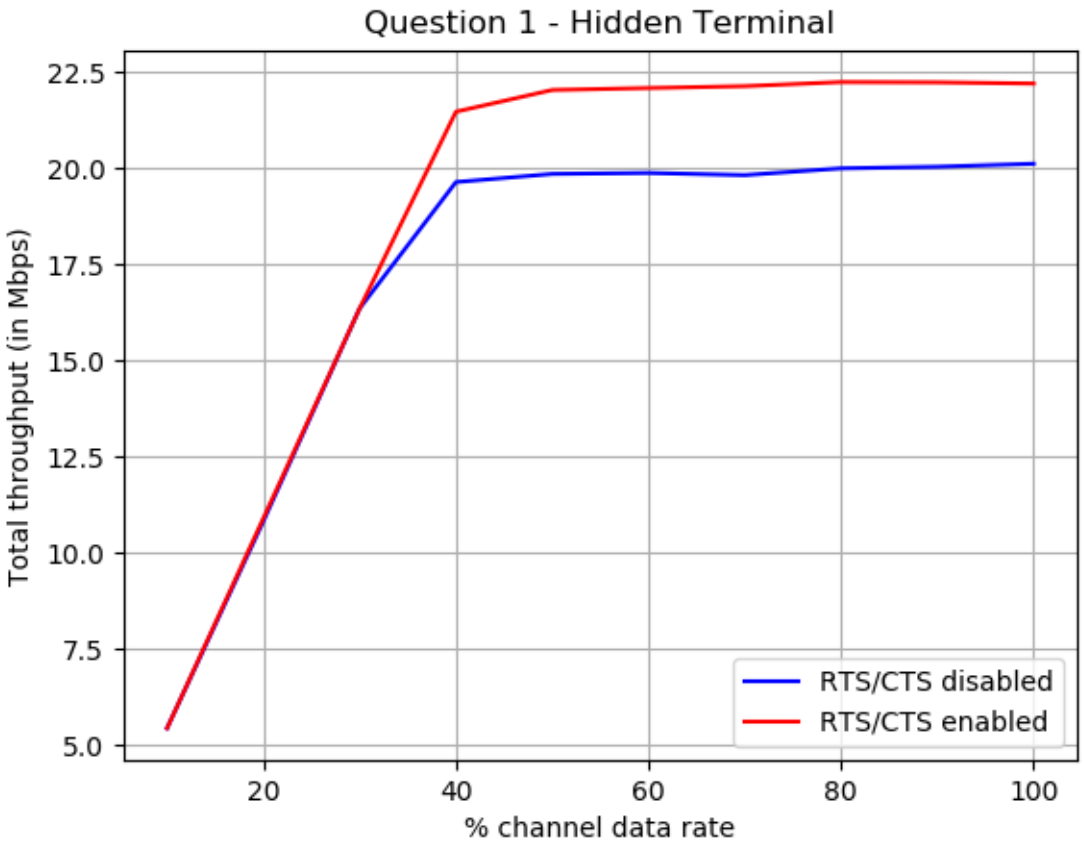
Throughput for Flow 1 (Node n1 → Node n0):
9.7141 Mbps (RTS/CTS disabled), 10.1113 Mbps (RTS/CTS enabled)

Throughput for Flow 2 (Node n2 → Node n0):
9.3780 Mbps (RTS/CTS disabled), 10.0960 Mbps (RTS/CTS enabled)

Total Channel Throughput:
19.0921 Mbps (RTS/CTS disabled), 20.2073 Mbps (RTS/CTS enabled)

b.

Channel data rate is 54 Mbps.



Total Data Rate Offered	`dataRate`	Total Throughput	
		RTS/CTS disabled	RTS/CTS enabled
10% of channel date rate	2.7Mbps	5.4541 Mbps	5.4541 Mbps
20% of channel date rate	5.4Mbps	10.8344 Mbps	10.9108 Mbps
30% of channel date rate	8.1Mbps	16.3675 Mbps	16.3675 Mbps
40% of channel date rate	10.8Mbps	19.6522 Mbps	21.4805 Mbps
50% of channel date rate	13.5Mbps	19.8636 Mbps	22.0457 Mbps
60% of channel date rate	16.2Mbps	19.8890 Mbps	22.0967 Mbps
70% of channel date rate	18.9Mbps	19.8330 Mbps	22.1450 Mbps
80% of channel date rate	21.6Mbps	20.0087 Mbps	22.2520 Mbps
90% of channel date rate	24.3Mbps	20.0495 Mbps	22.2444 Mbps
100% of channel date rate	27.0Mbps	20.1284 Mbps	22.2138 Mbps

We can see that Total throughput increases with Offered Load and almost flattens to a constant value by the end.
We also see that RTS/CTS disabled network has less maximum throughput than RTS/CTS enabled network.

c.

Only Flow 1 (Node n1 → Node n0)
RTS/CTS disabled: Total throughput saturates at 25.6182 Mbps for `dataRate` = 35 Mbps.
RTS/CTS enabled: Total throughput saturates at 22.6696 Mbps for `dataRate` = 24 Mbps.

We can see that Total throughput increases with Offered Load and almost flattens to a constant value by the end.
We also see that RTS/CTS disabled network has more maximum throughput than RTS/CTS enabled network.

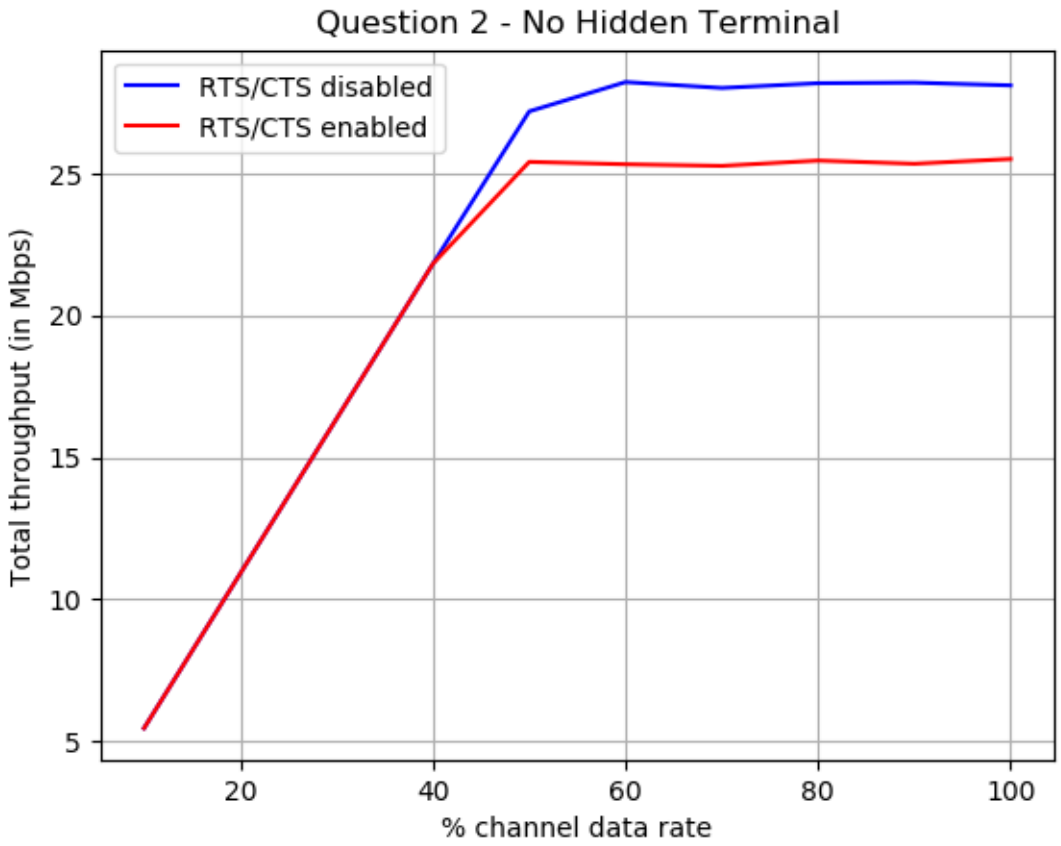
d.

- Total throughput is less than total data rate offered in all cases.
- We can see that Total throughput increases with Offered Load and almost flattens to a constant value by the end, both for two source and one source
- We also see that RTS/CTS disabled network has less maximum throughput than RTS/CTS enabled network when we have two sources but has more maximum throughput when we have only one source.
- We reach saturation for both cases when total data rate offered is about 40% of channel data rate.

Question 2

a.

Channel data rate is 54 Mbps.



Total Data Rate Offered	`dataRate`	Total Throughput	
		RTS/CTS disabled	RTS/CTS enabled
10% of channel date rate	2.7Mbps	5.4541 Mbps	5.4541 Mbps
20% of channel date rate	5.4Mbps	10.9108 Mbps	10.9108 Mbps
30% of channel date rate	8.1Mbps	16.3675 Mbps	16.3675 Mbps
40% of channel date rate	10.8Mbps	21.8242 Mbps	21.8242 Mbps
50% of channel date rate	13.5Mbps	27.1943 Mbps	25.4145 Mbps
60% of channel date rate	16.2Mbps	28.2281 Mbps	25.3305 Mbps
70% of channel date rate	18.9Mbps	28.0193 Mbps	25.2744 Mbps
80% of channel date rate	21.6Mbps	28.1874 Mbps	25.4603 Mbps
90% of channel date rate	24.3Mbps	28.2078 Mbps	25.3483 Mbps
100% of channel date rate	27.0Mbps	28.1110 Mbps	25.5163 Mbps

We can see that Total throughput increases with Offered Load and almost flattens by the end.
We also see that RTS/CTS disabled network has more maximum throughput than RTS/CTS enabled network.

b.

- Total throughput is less than total data rate offered in all cases.
- We can see that Total throughput increases with Offered Load and almost flattens to a constant value by the end, both for two source and one source
- We also see that RTS/CTS disabled network has more maximum throughput than RTS/CTS enabled network.
- We reach saturation for both cases when total data rate offered is about 50% of channel data rate.
- The saturation level as compared to Question 1 (where a hidden terminal pair was present) is more for both cases.

Question 3

a.

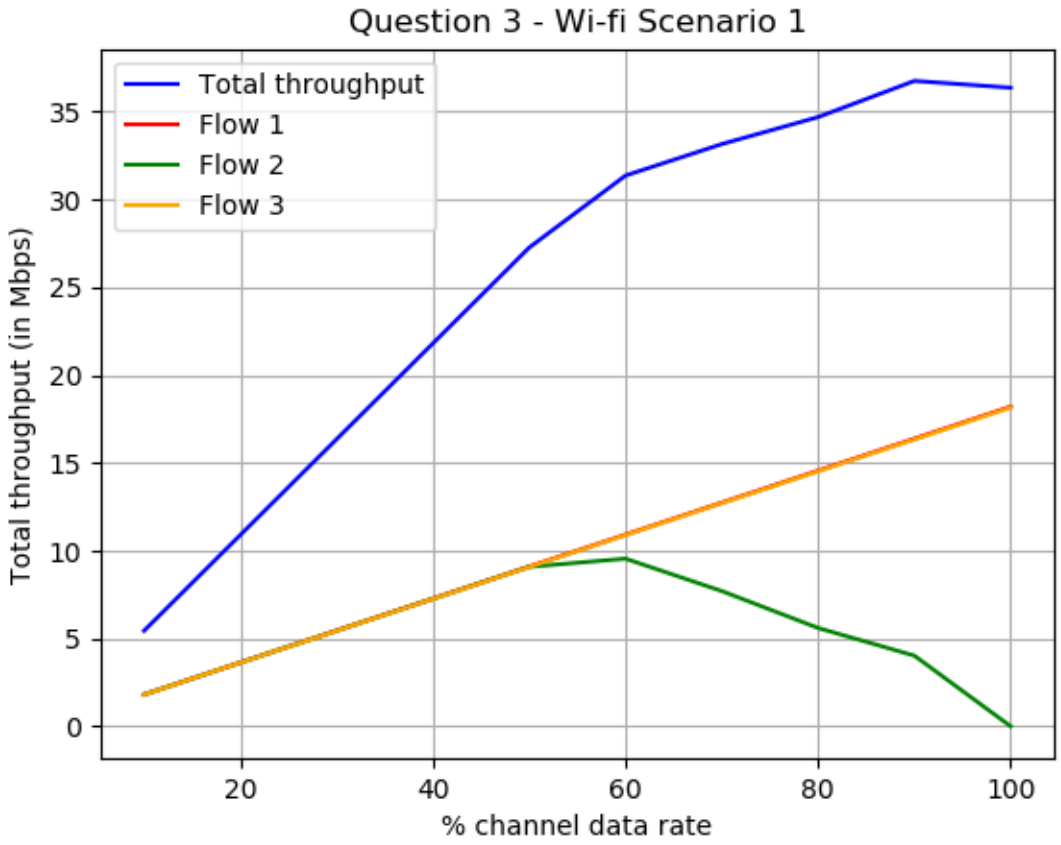
For default parameters (`dataRate` = 10.0Mbps),

Throughput for Flow 1 (Node A1 → Node A2): 10.1088 Mbps (RTS/CTS enabled)
Throughput for Flow 2 (Node B1 → Node B2): 9.5536 Mbps (RTS/CTS enabled)
Throughput for Flow 3 (Node C1 → Node C2): 10.0782 Mbps (RTS/CTS enabled)

Total Channel Throughput: 29.7406 Mbps (RTS/CTS enabled)

b.

Channel data rate is 54 Mbps.



Total Data Rate Offered	`dataRate`	Flow 1	Flow 2	Flow 3	Total Throughput
10% of channel date rate	1.8Mbps	1.8180 Mbps	1.8155 Mbps	1.8130 Mbps	5.4465 Mbps
20% of channel date rate	3.6Mbps	3.6386 Mbps	3.6335 Mbps	3.6285 Mbps	10.9006 Mbps
30% of channel date rate	5.4Mbps	5.4592 Mbps	5.4516 Mbps	5.4440 Mbps	16.3548 Mbps
40% of channel date rate	7.2Mbps	7.2798 Mbps	7.2671 Mbps	7.2595 Mbps	21.8064 Mbps
50% of channel date rate	9.0Mbps	9.1004 Mbps	9.0852 Mbps	9.0724 Mbps	27.2580 Mbps
60% of channel date rate	10.8Mbps	10.9185 Mbps	9.5486 Mbps	10.8879 Mbps	31.3550 Mbps
70% of channel date rate	12.6Mbps	12.7391 Mbps	7.7050 Mbps	12.7034 Mbps	33.1475 Mbps
80% of channel date rate	14.4Mbps	14.5597 Mbps	5.6044 Mbps	14.5189 Mbps	34.6830 Mbps
90% of channel date rate	16.2Mbps	16.3803 Mbps	4.0282 Mbps	16.3344 Mbps	36.7429 Mbps
100% of channel date rate	18.0Mbps	18.2009 Mbps	0.0076 Mbps	18.1474 Mbps	36.3559 Mbps

We can see that Throughputs of Flow 1 and Flow 3 are coincident straight lines increasing proportionally with Offered Load.
We can see that Throughput of Flow 3 increases till 50% and then decreases to almost zero.
We can see that Total throughput increases with Offered Load and almost flattens to a constant value by the end.

c.

- Total throughput is less than total data rate offered.
- We can see that Total throughput increases with Offered Load and almost flattens to a constant value by the end.
- We reach saturation when total data rate offered is about 90% of channel data rate.
- Comparing between the flows, we can see that Throughputs of Flow 1 and Flow 3 are almost equal.
- Throughputs of Flow 1 and Flow 3 are more than Flow 2.
- For around till 50%, we see that the collisions are negligible and all the flows are almost at peak (the linear growth).
- After that, we see a dip in Flow 2. This is due to collisions, Flow and 3 over-powering Flow 2.
- Flow 1 and 3 are non-overlapping, so both of them rise linearly till the end, however, we see dip in Flow 2 as the collisions increase (as `dataRate` is increased).
- This scenario was also part of CS 224 Homework Assignment 2. Theoretically, I had shown that Flow 1 $\approx$ Flow 3 $>$ Flow 2. See Appendix 1.

Question 4

a.

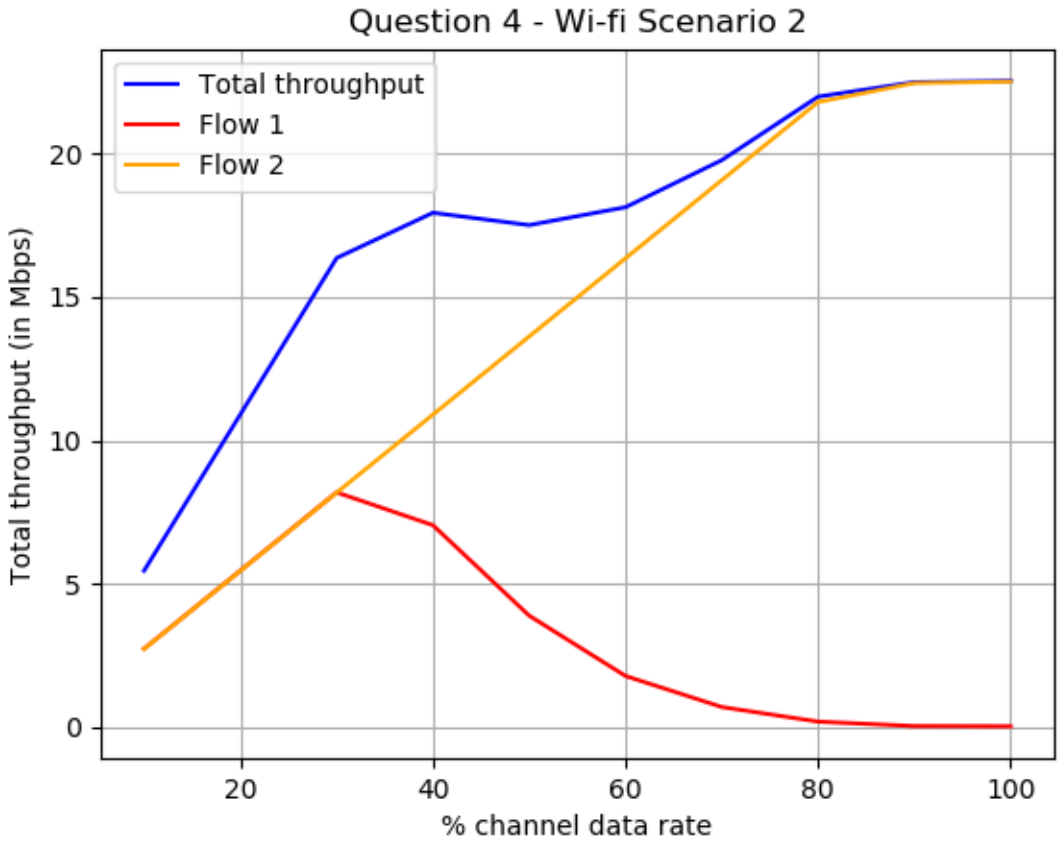
For default parameters (`dataRate` = 10.0Mbps),

Throughput for Flow 1 (Node A → Node B): 7.7993 Mbps (RTS/CTS enabled)
Throughput for Flow 2 (Node C → Node D): 10.0960 Mbps (RTS/CTS enabled)

Total Channel Throughput: 17.8953 Mbps (RTS/CTS enabled)

b.

Channel data rate is 54 Mbps.



Total Data Rate Offered	`dataRate`	Flow 1	Flow 2	Total Throughput
10% of channel date rate	2.7Mbps	2.7296 Mbps	2.7245 Mbps	5.4541 Mbps
20% of channel date rate	5.4Mbps	5.4592 Mbps	5.4516 Mbps	10.9108 Mbps
30% of channel date rate	8.1Mbps	8.1888 Mbps	8.1787 Mbps	16.3675 Mbps
40% of channel date rate	10.8Mbps	7.0430 Mbps	10.9032 Mbps	17.9462 Mbps
50% of channel date rate	13.5Mbps	3.8856 Mbps	13.6303 Mbps	17.5159 Mbps
60% of channel date rate	16.2Mbps	1.7824 Mbps	16.3573 Mbps	18.1397 Mbps
70% of channel date rate	18.9Mbps	0.6977 Mbps	19.0844 Mbps	19.7821 Mbps
80% of channel date rate	21.6Mbps	0.1884 Mbps	21.8090 Mbps	21.9974 Mbps
90% of channel date rate	24.3Mbps	0.0331 Mbps	22.4710 Mbps	22.5041 Mbps
100% of channel date rate	27.0Mbps	0.0255 Mbps	22.5219 Mbps	22.5474 Mbps

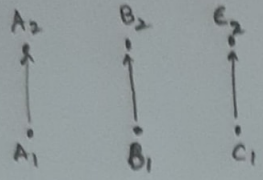
We can see that Total throughput increases with Offered Load and almost flattens to a constant value by the end with a minor dip in middle.

c.

- Total throughput is less than total data rate offered.
- We can see that Total throughput increases with Offered Load and almost flattens to a constant value by the end with a minor dip in middle.
- We reach saturation when total data rate offered is about 80% of channel data rate.
- The minor dip in the middle is due to more decrease in Flow 1 than increase in Flow 2.
- Throughputs of Flow 2 is more than Flow 1.
- For around till 30%, we see that the collisions are negligible and all the flows are almost at peak (the linear growth).
- After that, we see a dip in Flow 1. This is due to increase in collisions (as `dataRate` is increased), Flow 2 over-powering Flow 1.
- This scenario was also part of CS 224 Midsem. Theoretically, I had shown that Flow 1 $<$ Flow 2. See Appendix 2.

Appendix 1

4.

2. 

C_1, C_2 are hidden from A_1, A_2
A_1, A_2 are hidden from C_1, C_2

By symmetry, $T_A \approx T_C$

We need to compare T_B with $T_A (\approx T_C)$.

CASE 1: B_1 transmits before A_1 and C_1

$B_1 \rightarrow B_2, A_1, A_2, C_1, C_2$

$\Rightarrow A_1, C_1$ carrier sense and waits for NAV(RTS)

CASE 2: A_1 (or C_1) transmits before B_1 and C_1 (or A_1)

$A_1 \rightarrow A_2, B_1, B_2$

$\Rightarrow C_1$ can't hear and so may send RTS to C_2.

$\Rightarrow B_1$ carrier senses and waits for NAV(RTS)

$C_1 \rightarrow C_2, B_1, B_2$

$\Rightarrow A_1$'s signal is not affected.

$\Rightarrow B_1$ now has to wait

CASE 3: A_1 (or C_1) and B_1 transmit simultaneously

$A_1 \rightarrow A_2, B_2, B_2$; $B_1 \rightarrow B_2, A_1, A_2, C_1, C_2$

$\Rightarrow$ Collision at A_2, B_2 and both don't send CTS.

All other cases are similar and would result in collision.

$P(\text{CASE 1}) \simeq 2 \times P(\text{CASE 2})$

BAC
CAB

ABC CBA
ACB CAB

NAV(RTS) is same for all as Data length is equal.

$\therefore T_B < T_A \approx T_C$

Appendix 2

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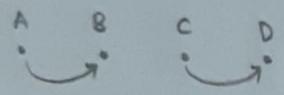
2.



A is hidden from C, D
B is hidden from D
C is hidden from A
D is hidden from B, A

CASE 1: A transmits before C

A → B (RTS)
B → A, C (CTS) ⇒ C carrier senses and waits for NAV(CTS)

CASE 2: C transmits before A

C → B, D (RTS) ⇒ A can't hear, so may send RTS.
A → B (RTS) ⇒ B waits for NAV(RTS) before sending CTS to A. [of C]

CASE 3: A and C transmit simultaneously

C → B, D ; A → B ⇒ Collision at B, doesn't send CTS to A. (has re-transmit RTS)
(RTS) (RTS) ⇒ No collision at D, returns CTS to C.

We know that as the data size is same
NAV (CTS) < NAV(RTS)
In case 1, "C → D" has to wait for NAV(CTS).
In case 2, "A → B" has to wait for NAV(RTS).
In case 3, "A → B" has to retransmit RTS.
∴ $T_A < T_C$