CS 252 Lab 5

Sambit Behera
190050104

08 April 2021

Question 1

a We get the following values:-

Sender	Receiver	Throughput(without RTS/CTS)	Throughput(with RTS/CTS)
10.0.0.2	10.0.0.1	9.71408 Mbps	10.1113 Mbps
10.0.0.3	10.0.0.1	9.37797 Mbps	10.096 Mbps

Total channel throughput without RTS/CTS enabled = **19.0921 Mbps**
Total channel throughput with RTS/CTS disabled =**20.2073 Mbps**

b Total channel throughput needs to be 54Mbps and should be equally divided between the two flows, hence 10% of each flow implies data rate = **2.7Mbps** for each node.

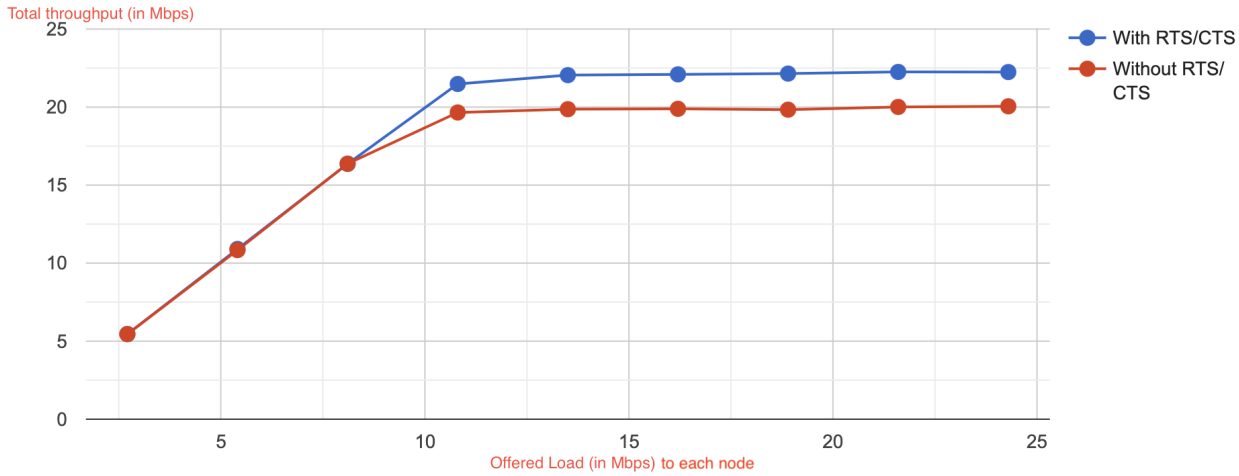
With RTS/CTS disabled:

Offered Load	Observed throughput(in Mbps)
10%	5.45414
20%	10.8344
30%	16.3675
40%	19.6522
50%	19.8636
60%	19.889
70%	19.833
80%	20.0087
90%	20.0495

There is a linear increase till **40%** after which it increases very slowly and has the maximum value at **90%** among the recorded values.
With RTS/CTS enabled:

Offered Load	Observed throughput(in Mbps)
10%	5.45414
20%	10.9108
30%	16.3675
40%	21.4805
50%	22.0457
60%	22.0967
70%	22.145
80%	22.252
90%	22.2444

Observed throughput increases linearly till **40%** after which it increases very slowly and has the maximum value at **90%** among the recorded values. We can observe that the maximum value when RTS/CTS is enabled is **22.2444 Mbps** which is greater than when disabled ie. **20.0495**.



c **With RTS/CTS disabled:**

Offered Load	Observed throughput(in Mbps)
10%	5.45924
20%	10.921
30%	16.3803
40%	21.842
50%	25.6156
60%	25.6156
70%	25.6182
80%	25.6182
90%	25.6182

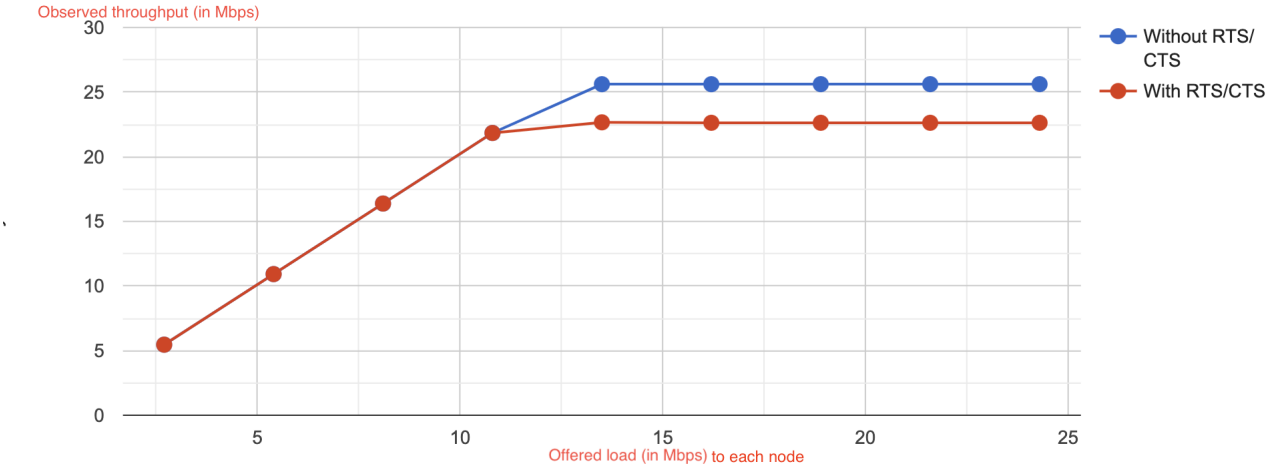
Observed throughput value increases linearly till **50%** after which it saturates and has a very insignificant increase and becomes constant. The maximum total throughput observed is **25.6182 Mbps** at a total offered load value of **37.8, 43.2, 48.6 Mbps** ie **70, 80, 90%** per node.

With RTS/CTS enabled:

Offered Load	Observed throughput(in Mbps)
10%	5.45924
20%	10.921
30%	16.3803
40%	21.842
50%	22.6645
60%	22.6288
70%	22.6288
80%	22.6288
90%	22.6288

Observed throughput value increases linearly till **50%** after which it saturates and has a slight decrease in value. The maximum total throughput observed is **22.6455 Mbps** at a total offered

load value of **27Mbps (50%)** total throughput.



d For both the cases, at lower values of offered load, the throughput values are same independent of RTS/CTS. This is because the rate of collision will be very negligible due to low data rate and will not affect the throughput.

When we had 3 nodes in space, with 2 of them emitting and one listener, there were several collisions at the common receiver because of which packet losses occurred, if no RTS/CTS was being used. Hence, to restrict this collision, CSMA-CA protocol was effective and hence resulted in higher maximum total throughput values.

When one of the emitters were switched off, we only had 2 devices, one emitting and one listening. In this situation, there is no scope of collision and hence no packet losses. But, if we used CSMA-CA protocol, there would be use of extra bandwidth to transmit and receive RTS and CTS which reduces the total throughput observed and hence we get lower max values for observed throughputs then when protocol was disabled.

Question 2

a We set the datarate as **2.7 Mbps** for each node corresponding to 10% of offered load because we have two flows and a total offered throughput of 54 Mbps. We get the following values:-

With RTS/CTS disabled:

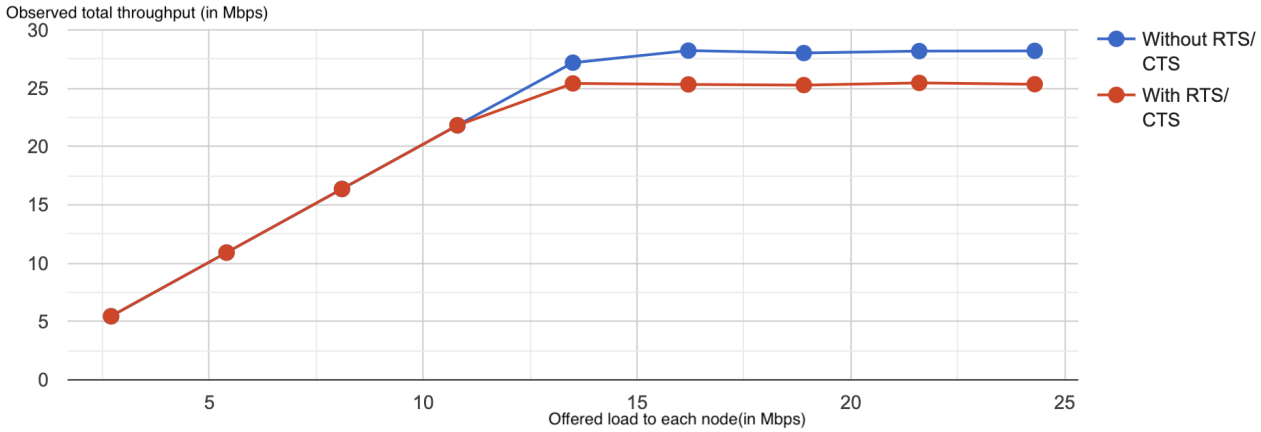
Offered Load	Observed throughput(in Mbps)
10%	5.45414
20%	10.9108
30%	16.3675
40%	21.8242
50%	27.1943
60%	28.2281
70%	28.0193
80%	28.1874
90%	28.2078

Observed throughput value increases linearly till **50%** after which it saturates and has a very insignificant increase and also a slight dip. Maximum total throughput observed is **28.2281 Mbps** at **60%** of total permitted load.

With RTS/CTS enabled:

Offered Load	Observed throughput(in Mbps)
10%	5.45414
20%	10.9108
30%	16.3675
40%	21.8242
50%	25.4145
60%	25.3305
70%	25.2744
80%	25.4603
90%	25.3483

Observed throughput value increases linearly till **50%** after which it saturates and has a very insignificant increase. Maximum total throughput observed is **25.4603 Mbps** at **80%** of total permitted load.



b It can be clearly seen that the values obtained in the case of enabled RTS/CTS for higher values of offered load are less than when it is disabled. This validates the hypothesis in question that RTS/CTS was designed mainly to solve the hidden terminal problem and it is not very useful when there aren't any hidden terminals.

This is because, RTS/CTS was introduced to solve the hidden node problem, and if there are no hidden nodes then career sensing is enough to detect any transmission. Also, RTS/CTS also takes considerable amount of time to transmit, decreasing the total throughput of the channel. For lower offered load values, this difference is not much significant because of low collision rate. But at higher values, we can observe the trend and hence can easily conclude the redundancy of RTS/CTS.

Question 3

a We get the following data

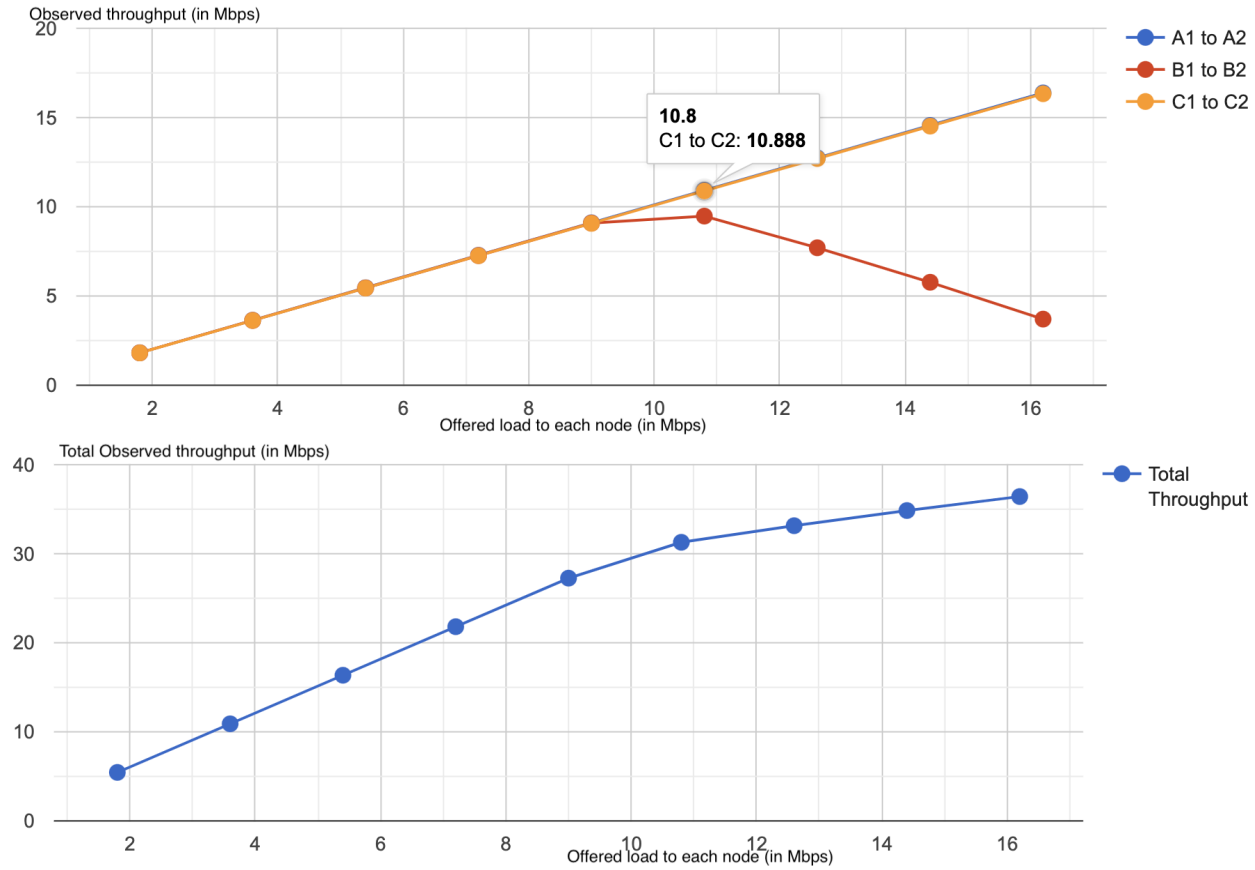
Sender	Receiver	Throughput(with RTS/CTS)
10.0.0.1(A1)	10.0.0.2(A2)	10.1088 Mbps
10.0.0.3(B1)	10.0.0.4(B2)	9.52565 Mbps
10.0.0.5(C1)	10.0.0.6(C2)	10.0807 Mbps

The total channel throughput observed is **29.7152 Mbps**

b We set the datarate as **1.8 Mbps** for each node corresponding to 10% of offered load because we have three flows and a total offered throughput of 54 Mbps. We obtain the following data(all in Mbps):-

Offered Load	A1 to A2	B1 to B2	C1 to C2	Total Throughput
10%	1.81805	1.8155	1.81296	5.44651
20%	3.63864	3.63355	3.62846	10.9006
30%	5.45924	5.4516	5.44396	16.3548
40%	7.27983	7.2671	7.25946	21.8064
50%	9.10043	9.08515	9.07242	27.258
60%	10.9185	9.47728	10.8879	31.2837
70%	12.7391	7.70251	12.7034	33.145
80%	14.5597	5.7698	14.5189	34.8485
90%	16.3803	3.70485	16.3344	36.4195

The maximum throughput value increases linearly and then it slows down a bit. The maximum value is **36.4195 Mbps** achieved at **90%** of maximum total throughput.



c For lower values of offered load, there is no observable difference among the flows because of lower rate of collision. We can see that the plots for throughput values from A1 to A2 and from C1 to C2 almost overlap on each other, while the throughput value for B1 to B2 starts decreasing after a point. This is because the case for A1 to A2 and C1 to C2 is symmetric about the middle transmission. When the throughput value on A and C nodes increase, B2 gets the RTS from A1 and C1 and hence wont return CTS to B1. This leads to even lesser throughput value for B nodes, leading to decrease. Also, we can observe that the total throughput value as a whole increases linearly at first and slows down a bit, this is because throughput values of each flow increases and after a certain point, B flow starts decreasing and hence decrease in the amount of growth of total throughput.

Question 4

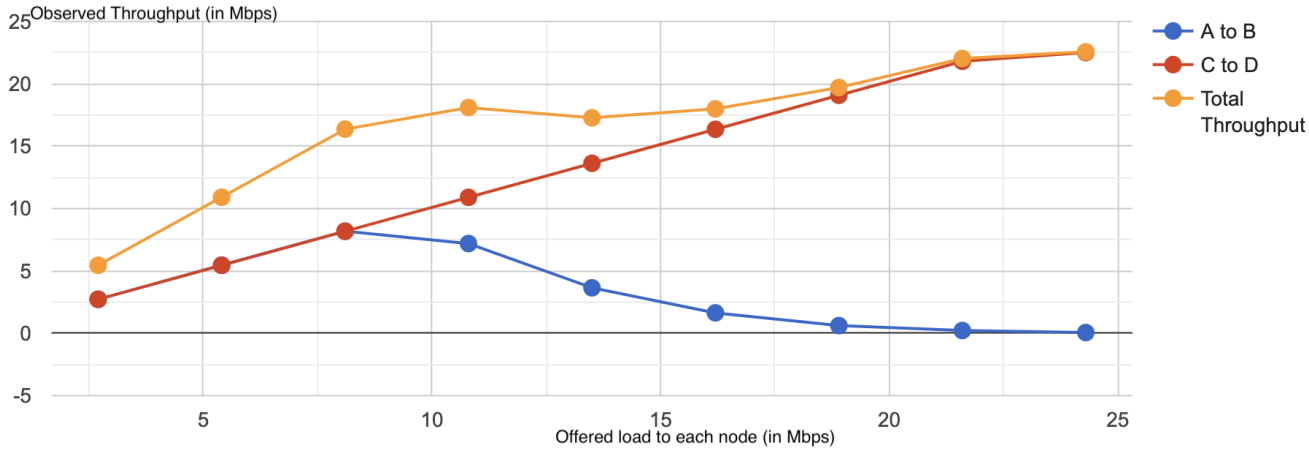
a We get the required data as

Sender	Receiver	Throughput(with RTS/CTS)
10.0.0.1(A)	10.0.0.2(B)	8.2423 Mbps
10.0.0.3(C)	10.0.0.4(D)	10.096 Mbps

Total throughput value that we get is **18.3383 Mbps**

b We set the datarate as **2.7 Mbps** for each node corresponding to 10% of offered load because we have two flows and a total offered throughput of 54 Mbps. We get the following values(all in Mbps) as

Offered Load	A to B	C to D	Total Throughput
10%	2.72962	2.72453	5.45414
20%	5.45924	5.4516	10.9108
30%	8.18885	8.17867	16.3675
40%	7.1958	10.9032	18.099
50%	3.64628	13.6303	17.2765
60%	1.63981	16.3573	17.9971
70%	0.618747	19.0844	19.7032
80%	0.221527	21.8089	22.0305
90%	0.0611109	22.5066	22.5677



c For lower values of offered load to each node, both the throughputs are similar because there will not be many collisions. We can observe that the throughput value for C to D transmission increases while for A to B, it starts decreasing after a certain point. This is because, when the medium is free, if both A and C transmit an RTS, then B hears C as well as A, and hence won't respond to A's RTS. If, C is transmitting and A sends an RTS, then B won't send back CTS and A will backoff exponentially. In the reverse scenario, C must have heard CTS from B and would wait for the notified period of time, hence would start transmitting as soon as A stops transmitting. Hence, we can see that C has a clear advantage over A in transmitting, which is also observed from the table. The total throughput value increases linearly, and is also affected somewhat by the decrease in throughput value for A to B.