LTE Simulation Project

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1 Introduction

1) With a given power of transmission, at what distance does the modulation change?

The following image shows how, for a constant transmitted power of 30W, the MCS changes with the distance. This information was obtained from the file DlRxPhyStats.txt generated by the simulation, which ran using only one UE and one Enodeb and changing distances in between simulations. We also evaluated the SiNR and it is as expected.

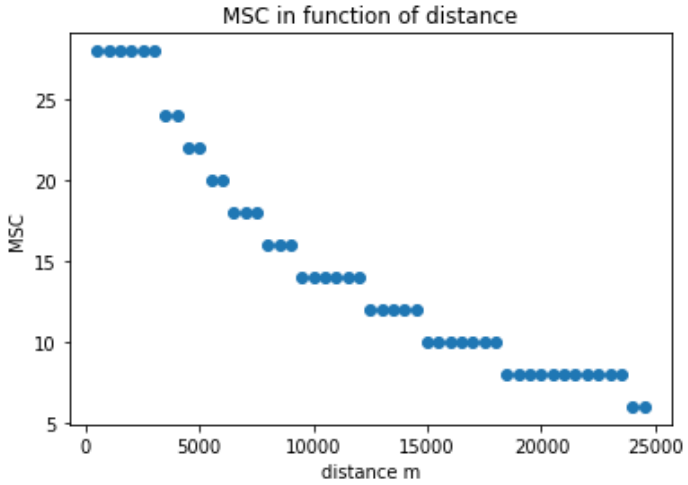

Figure 1: M
SC as function of distance

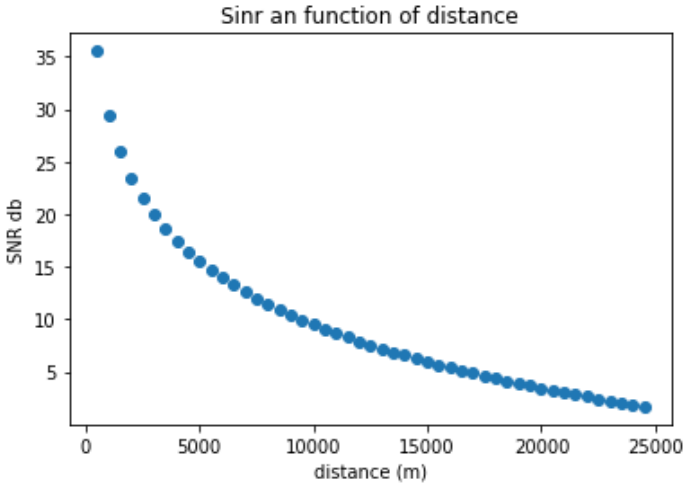

Figure 2: SInr as a function of distance

Analyzing the documentation about LTE we can find the relationship beetween the MCS and the following parameters: Modulation type, coding rate etc. This will allow us in the following questions to estimate certain results. This information is on figure 4.

2) What is the difference between the Round Robin Scheduler, Proportional Fair Scheduler and Maximum Throughput Scheduler, in terms of total bytes sent, when there are users with different transmission conditions?

To test the effectiveness of each of the algorithms, we used two APs - station pairs, one of which is separated by 2 km away (A - blue) and the other by 20 km away (B - orange).We obtained the following results for the throughput ,PDu frame size and number of PDUs frames sent.

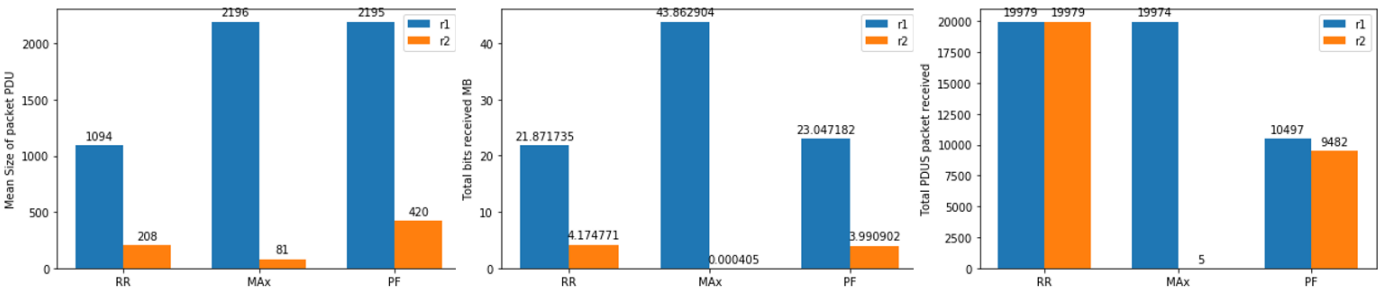

Figure 3

With the help of the graph above, which shows the evolution of the MCS used by the system according to the distance between the two elements, we were able to verify the value for each of the users, with the MCS for user A being 28 and for user B it's about 8.

With the help of the annex presented below, it is possible to better understand the behavior of the code, according to its value.

MCS	I_TBS	Modulation	TBS	User Data	Code Rate
			100 PRBs	100 PRBs	
0	0	QPSK	2,792	30,000	0.094
1	1	QPSK	3,624	30,000	0.122
2	2	QPSK	4,584	30,000	0.154
3	3	QPSK	5,736	30,000	0.192
4	4	QPSK	7,224	30,000	0.242
5	5	QPSK	8,761	30,000	0.293
6	6	QPSK	10,296	30,000	0.344
7	7	QPSK	12,216	30,000	0.408
8	8	QPSK	14,112	30,000	0.471
9	9	QPSK	15,840	30,000	0.529
10	9	16 QAM	15,840	60,000	0.264
11	10	16 QAM	17,658	60,000	0.295
12	11	16 QAM	19,848	60,000	0.331
13	12	16 QAM	22,920	60,000	0.382
14	13	16 QAM	25,456	60,000	0.425
15	14	16 QAM	28,336	60,000	0.473
16	15	16 QAM	30,576	60,000	0.510
17	15	64QAM	30,576	90,000	0.340
18	16	64QAM	32,856	90,000	0.365
19	17	64QAM	36,696	90,000	0.408
20	18	64QAM	39,232	90,000	0.436
21	19	64QAM	43,816	90,000	0.487
22	20	64QAM	46,888	90,000	0.521
23	21	64QAM	51,024	90,000	0.567
24	22	64QAM	55,056	90,000	0.612
25	23	64QAM	57,336	90,000	0.637
26	24	64QAM	61,664	90,000	0.685
27	25	64QAM	63,776	90,000	0.709
28	26	64QAM	75,326	90,000	0.837

Figure 4

For MCS = 28, we have a 64QAM with code rate 0.837 modulation. For MCS = 8, the modulation is QPSK with code rate 0.471.
Comparing with each other, we can say that the bit rate presented by QAM modulation, in relation to QPSK modulation, is much higher, since QAM modulation takes 64 symbols with it, 8 bits. The code rate used also plays a significant role in this.

As we can see in our results and comparing to the theory , we see that the Max rate scheduler was indeed the one that managed higher throughput (43MB) this is explained because ,has we also can see by the number of packets send to the user 2, it only sent packets to the user 1 (because this connection is better ,as we saw above ,64QAM vs 4QAM).And the Max scheduler always chooses the best connection to transmit (it starved the user2)

In other regard the RR and Propotional Fair had very similar results in terms of total throughput (RR (25MB) ,PF(27MB)). The explanation behind this throuhput for the RR is easy , because this protocol alocates exactly the same amount of radio resources for each user (as we can see in the third graph ,that shows that the number of PDU packets sent was equal). So in half the time user 1 was served (having a total bits sent of half the bits of the user1 in Max scheduler (21.8Mb) , in which user 1 had 100 percent of the time)). and the user 2 had the rest of the time to send. So: 64 QAM with code 0.837 sends 6*0.837 = 5.022 bits of information per symbol ,QAM with code rate 0.437 sends : 2* 0.437 = 0.874 bits of information per symbol , one over the other gives 5.74. So we can expect the bit rates to have this relationship : we obtained for user 1 21,87MB sent and for 2 4.174 MB sent , dividing this two number gives 5.23 wich is very close from what we expected.

It is well known for the theory that PF has always better total throughput than the RR , in our scenario the differences were not very notorious. but we can see that the user 1 sent more than the user 2 in compassion with the example for the RR , this is because this algorithm gives more resources to the users that transmit more but on the opposite of Max scheduling it tries to not starve none , as we could see in our data. (the user 2 managed to transmit almost as much as in Round Robin)

3) How is the bandwidth separated by the users?
in the following image we have represents the bandwith distribution for 1,2...8,22 users ,the bandwoth is the horizontal Axis and it his in MB

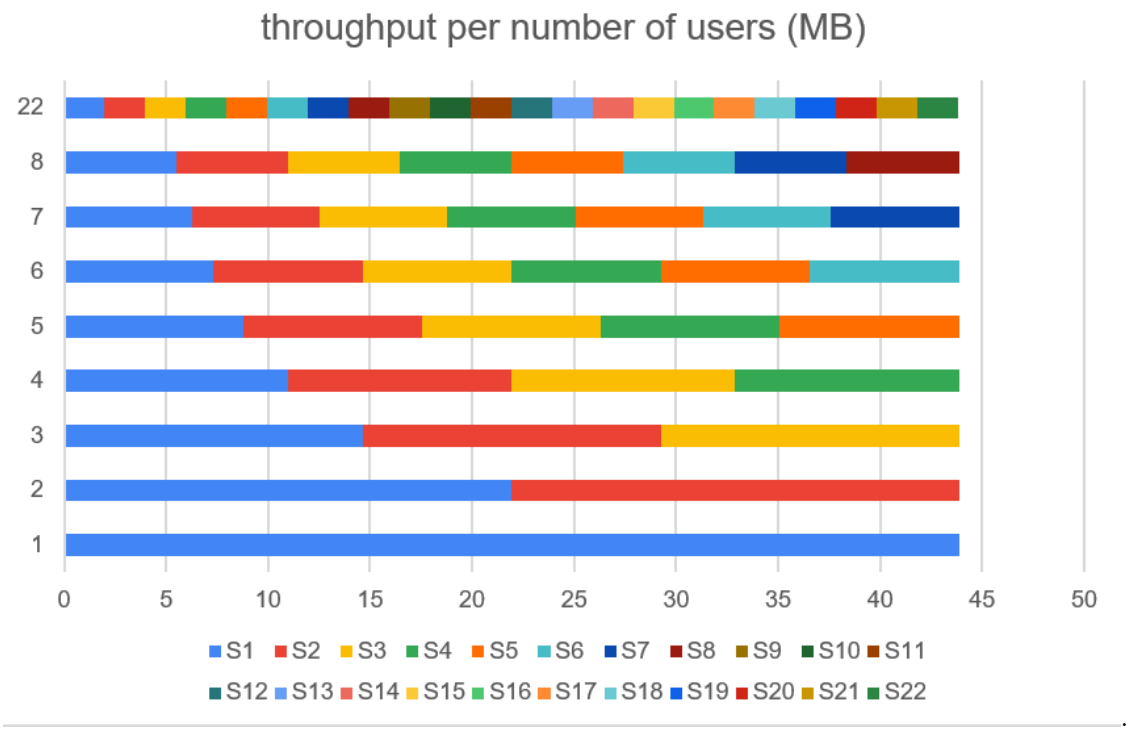

Figure 5

By placing them in a circle, we simulate an increasing amount of users, and see how the bandwidth is divided between them. We can easily see in the above graph that with which user added, the bandwidth is evenly distributed.

4) Does the MCS change with the number of users? Using the same data from the previous question, we can also analyze whether the MCS changes only when the link quality diminishes, or if the amount of users/load in the network can also affect it.

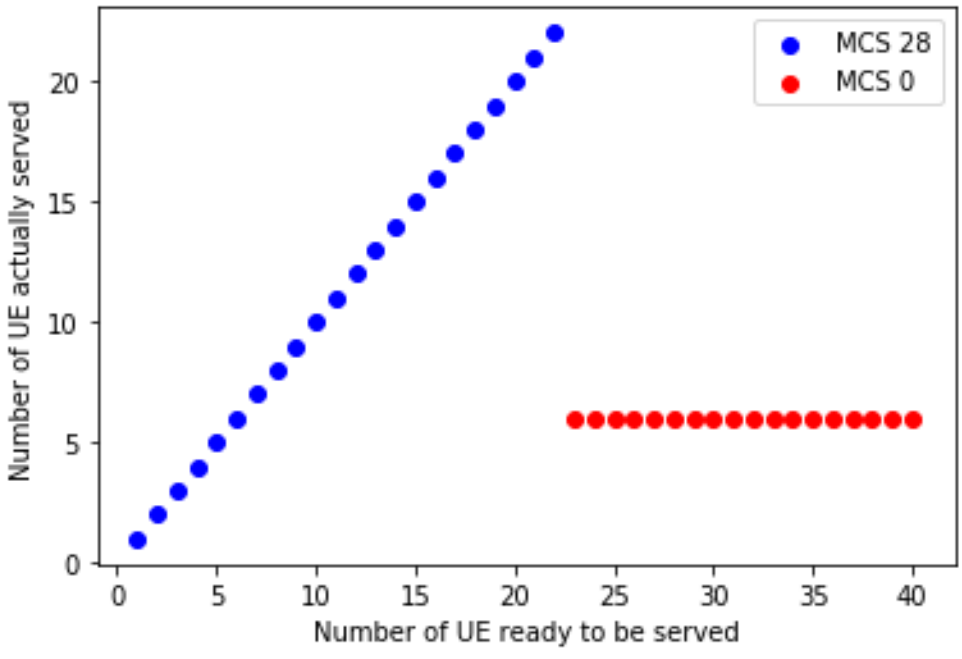

Figure 6

We were not expecting that the MCS changed so drastically. Our simulation originally tried to fit in 50 users, but we were greeted with the error message "too many UEs (41) for current SRS periodicity 40" after a while. Since after about 21 users, not only did the MCS drop but also new users stopped showing up in the statistics, we are not sure whether we have reached a limit in the simulator, or it's a defined parameter. Our research did not provide any definitive answer to this.

In Annex it is the code that we used to make the simulation