Modeling and performance evaluation of eICIC-ABS in the context of H-CRANs

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Abstract

The study of inter-cell interference coordination solutions by simulating scenarios of insertion of micro-cells inside the range of another antenna and the coordination between two antennas in the interference range (joint transmition). In this study I will discuss about the technology and when is it worth it, thus finding optimal point where it shows improvement over the scenario without it.

1 Introduction

The interferences and noises are one of the biggest problems in the area of signal transmission. In our case of study, the LTE, it's always being improved to solve problems related to interference.

It's often the scenario of big events and other phenomena which causes big differences in the distribution of people in the area covered by the antenna. It's known too that the distance (and other signal dissipation phenomena as interference by buildings) from the antenna to the user causes the need of more resources to provide the same quality of service.

So scenarios with a large number of people far from the antenna forms an inefficient use of resources, and to solve this problem, a technology called Enhanced Inter-Cell Interference Coordination (eICIC) was introduced. The general idea behind is to solve problems in medium-high interferences scenarios by coordinating the signal from the antennas and avoiding interference.

2 Micro-cells

In this case of study, the idea is to use in our favor the information of a high user density in a place with high interference/signal ratio (a football match far from the antenna, a concert in a closed place, a big workplace hidden by buildings etc.). In this situations, without any improvement to the standard technology, all of those users will use more resources than normal and the quality of service will decrease for everyone.

By bringing a mobile antenna or placing a fixed antenna close to this strategical area we can provide a better service, but how to deal with interference?

The solution to avoid interference in this case is to reserve some of the slots in the frame to this smaller antenna, separating the signals in the time-spectrum.

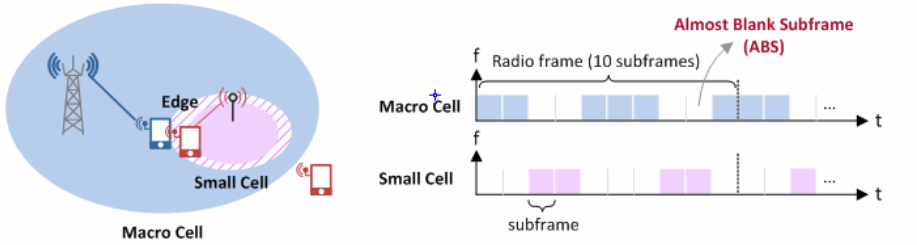

Figure 1: At the left, an exemple of the placement of a micro cell, to the right the illustration of the reservation of slots for the micro cell

3 Joint Transmission

In this study we coordinate 2 or more cells to provide a solution to the problem of bad radio conditions due to distance and mobility and interference.

In this case we use the resources (slots) from two neighbor cells to provide a better service for people in between the cells. See figure 2. To do that it's necessary to synchronize very well one slot from each cell to send the same data to the user in between the cells, so they can have the sum of the signals (avoiding interference, and providing a stronger signal), thus, a better radio condition in very distant areas. And with the coverage from different antennas when the user gets closer from one antenna, his's resources are already allocated, providing better quality of service in the scenario of mobility.

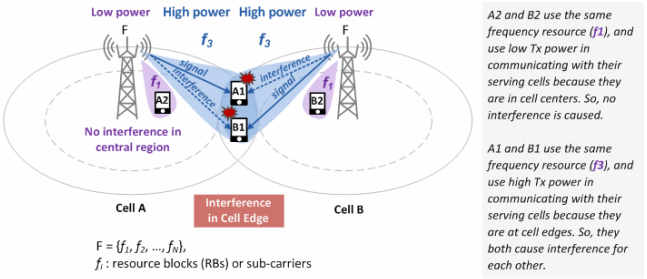

Figure 2: Scheme for joint transmission.

4 Experiment

4.1 Separating good and bad radio condition areas

4.1.1 Methods

First, I defined a range to separate the good from the bad signal by suposing that everyone inside 70% of the radius has good radio conditions and from 70% to 100% has poor radio conditions. Assuming that all the users are evengly distributed, than the proportion of the bad signal area/total area is the proportion of the bad signal users/ total number of users. We have then:

$$\lambda_{inner-region} = \lambda * \frac{\pi(0.7 * R)^2}{\pi * R^2} = \lambda * 0.49$$

$$\lambda_{outter-region} = \lambda - \lambda_{inner-region} = \lambda * 0.51$$

That shows that in this situtation, 49% of the users have good signals conditions and 51% of the users have bad radio conditions. So, suposing bad radio condition users use 2 GRB/packet (group of resource blocks) and good radio conditions use 1 GRB/packet, than we have:

$$freq = 1/\mu = 1 * \frac{\lambda_{inner-region}}{\lambda} + 2 * \frac{\lambda_{outter-region}}{\lambda}$$

With that, we can use queue theory to calculate the blocking probability using the following formula:

$$P_{block} = \frac{\frac{(\lambda/\mu)^n}{n!}}{\sum_{n=1}^{\infty} \frac{(\lambda/\mu)^n}{n!}}$$

And so:

$$Throughput = \lambda * (1 - P_{block})$$

4.1.2 Results

With that experiment we've got the results showing in the figure 3.It shows that after 300 demands from people/second the network is full and its not possible to serve more people. In a scenario where everyone were in the good signal area we could serve up to 600 people, which would be ideal.

4.2 Inserting micro cell

4.2.1 Methods

In this case we introduce a cell with high density of people and keep the other proprierties from the case above.

In that sense the changes are:

- Separation of slots for micro cell
- People in micro cell uses 1 GRB/packet
- Percentage of arrival rate in micro cell, dividing arrival rate

4.2.2 Results

The results show in the figure 5, and more datailed in the figures at the end of the document in the section 6 Attachments.

From the figure we can observe that up to 10% arrival rate in the micro cell it's a bad idea to reserve slots, and analyzing this scenario specifically, we observe that the best performances comes from reserving one slot per 10%. It

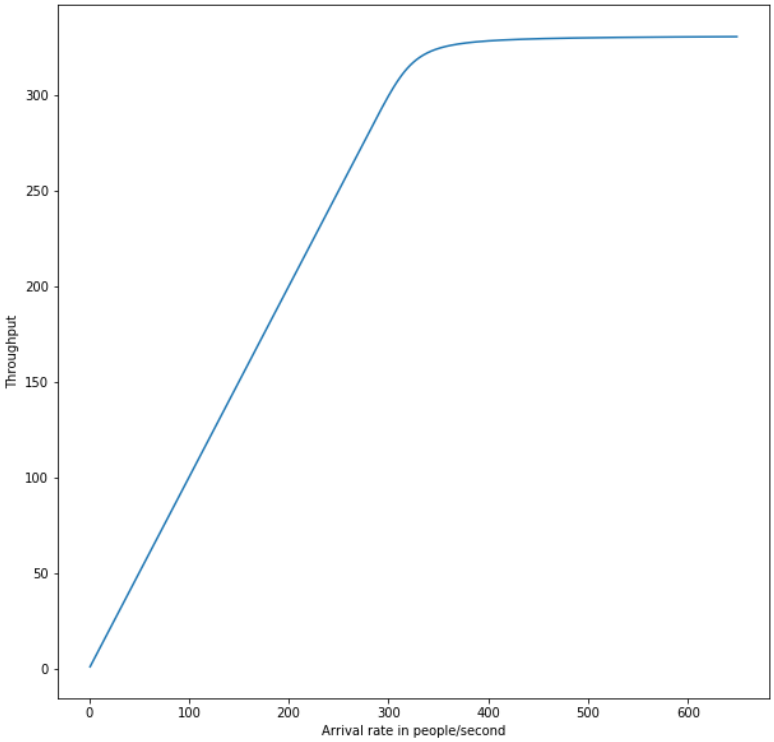

Figure 3: Plot of the throughput in function of arrival rate for the scenario above.

makes sense due to each slot represents 10% of the total number of slots. But we can observe too that in many cases the total number of people served increased, showing for exemple in figure 12 that reserving 1, 2 or 3 slots for 17% arrival rate in the micro cell we have better results than 0 (not using the micro cell).

4.3 Using Joint Transmission

4.3.1 Methods

Here we use the same idea of 0.7% of the inner radius for good radio conditions and the rest has bad radio conditions, using 1 GRB/packet and 2 GRBs/packet respectively.

To do that we reserve in each cell synchronized slots to help users in the intersecting area. So for the people in the area we have one slot for each cell providing him a good signal resulting in 1 GRB/packet for them.

4.3.2 Results

As you can see in the figure 4 and more detailes in the section 6 Attachments, it start to be advantageous when we have at least 7% arrival rate of the total sum of the 2 cells, that is in our test 70 packets/sec. From that point on we have that the total throughput keep raising and raising, and in this test it reaches more than 70% compared to the 60% without joint transmission.

5 Conclusion

It's a good idea to use those technologies, there are many cases of events that reunite a lot of people, and the micro-cell solution improves a lot the quality of service for the whole region. For the joint transmission it's a very common case of use, and helps a lot regarding the mobility, in that sense the results were of success, proving to be an objective improvement to LTE.

References

[1] Github of the python code of the plots: https://github.com/oramleo/tsp/tree/master/wireless

6 Attachments

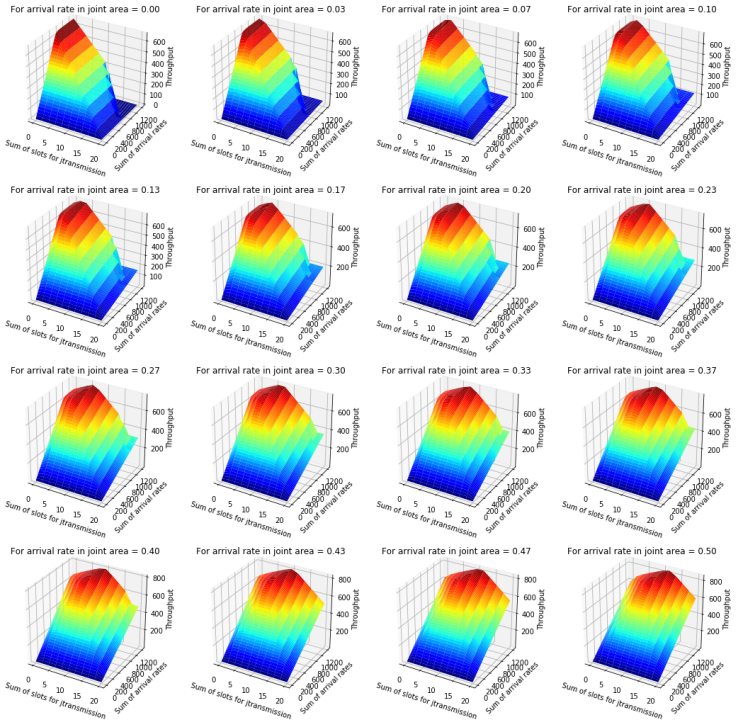

Figure 4: One plot for each of 16 steps from 0% to 50% arrival rate in the joint transmission area for various throughputs in function of sum of arrival rates and number of reserved slots used for the joint transmission.

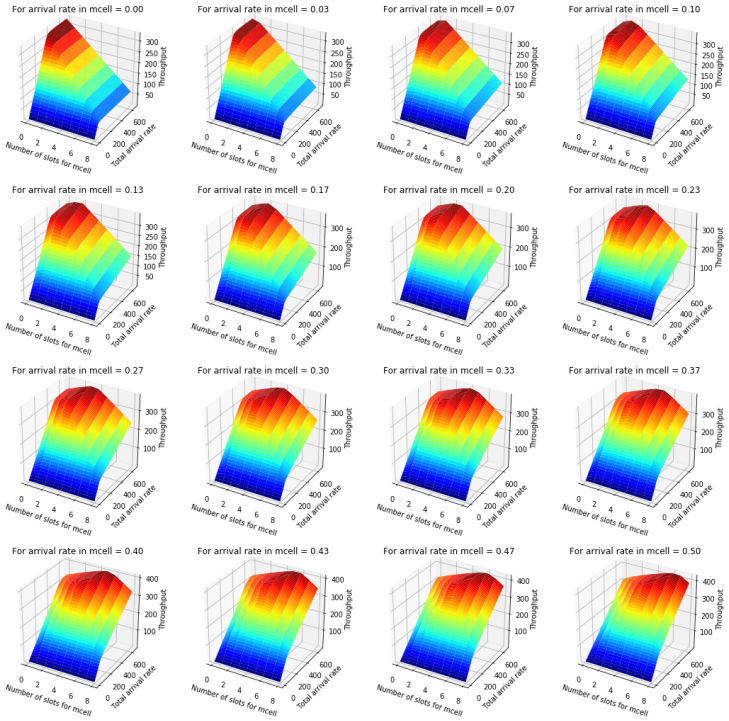

Figure 5: One plot for each of 16 steps from 0% to 50% arrival rate in micro cell of the various throughputs in function of arrival rate and number of reserved slots for the scenario with micro cell.

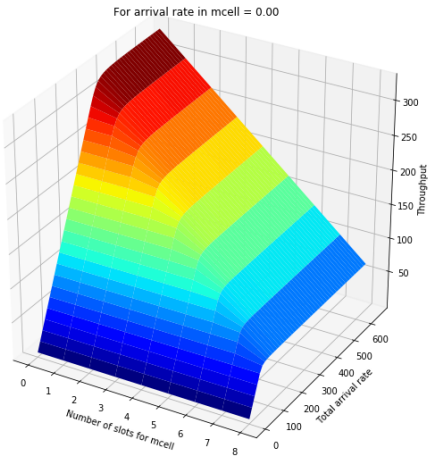

Figure 6: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 0%.

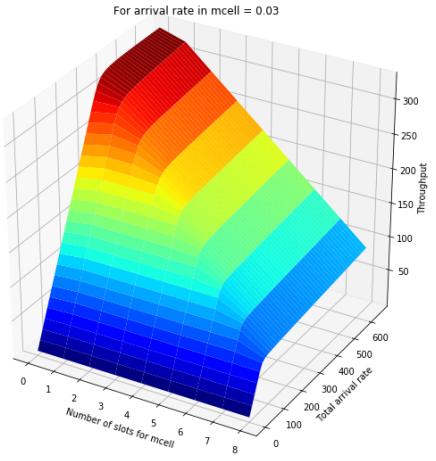

Figure 7: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 3%.

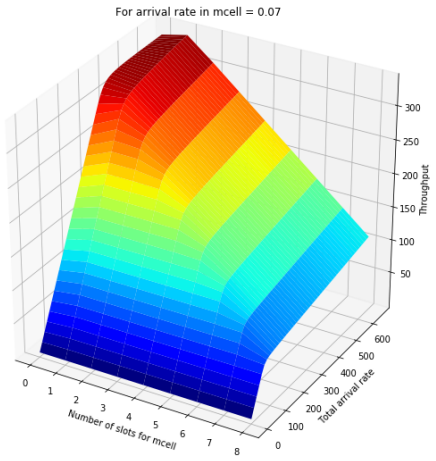

Figure 8: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 7%.

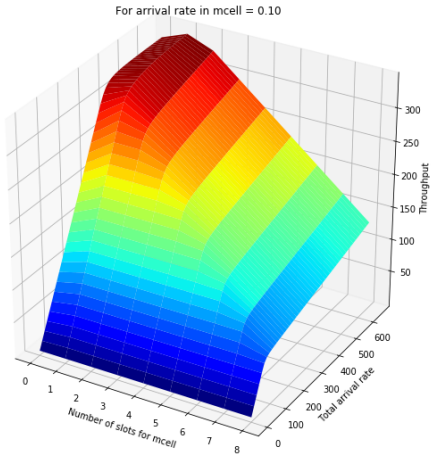

Figure 9: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 10%.

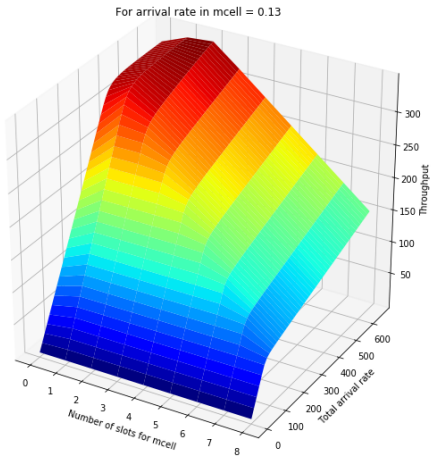

Figure 10: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 13%.

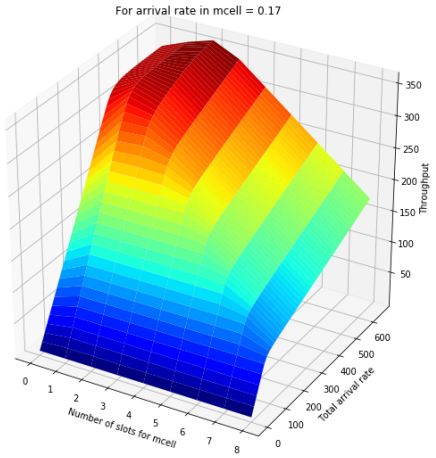

Figure 11: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 17%.

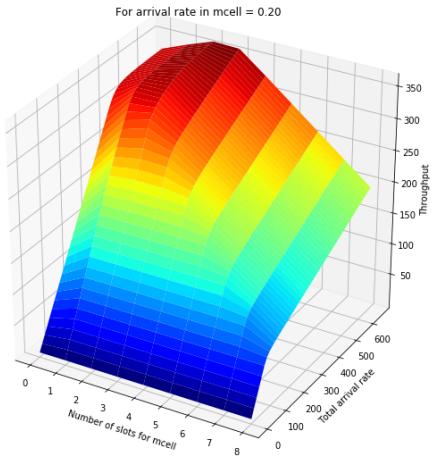

Figure 12: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 20%.

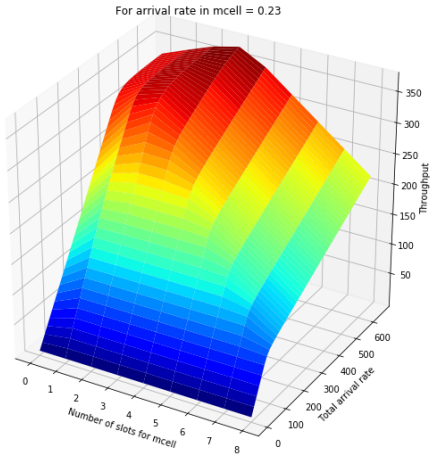

Figure 13: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 23%.

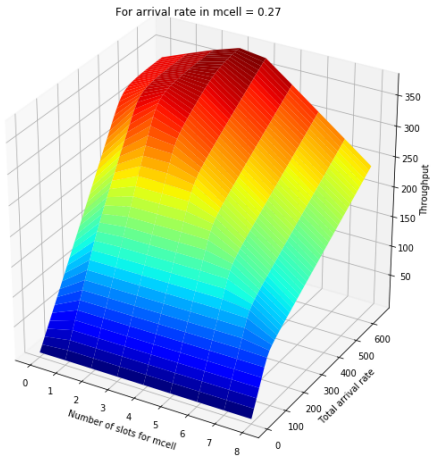

Figure 14: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 27%.

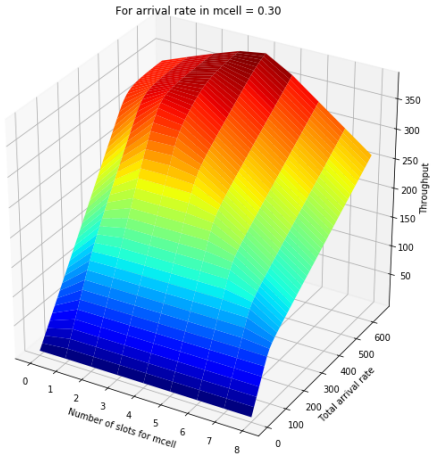

Figure 15: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 30%.

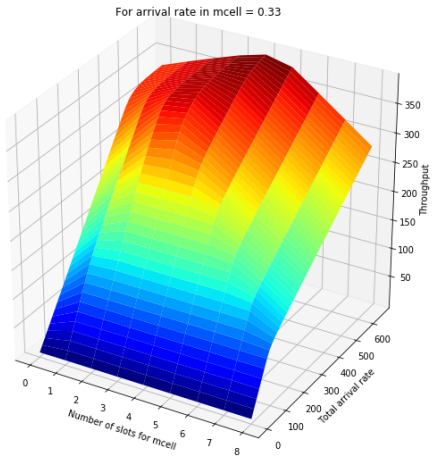

Figure 16: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 33%.

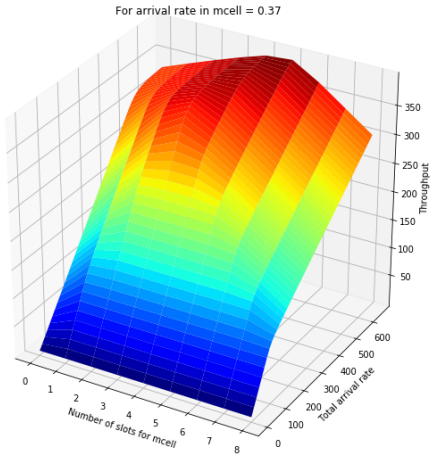

Figure 17: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 37%.

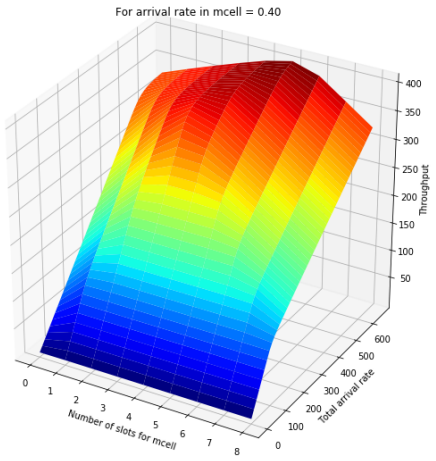

Figure 18: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 40%.

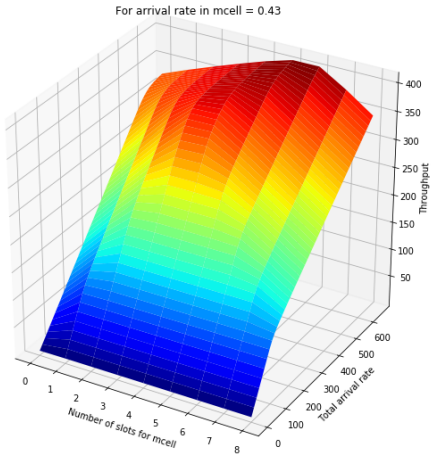

Figure 19: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 33%.

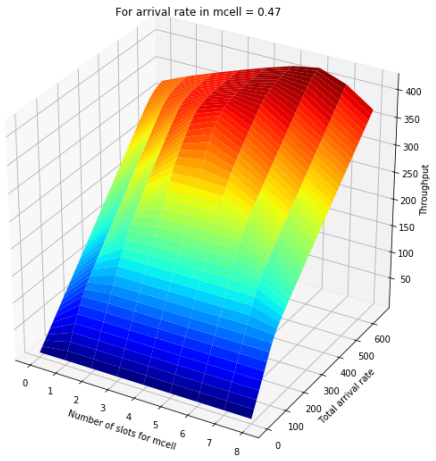

Figure 20: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 47%.

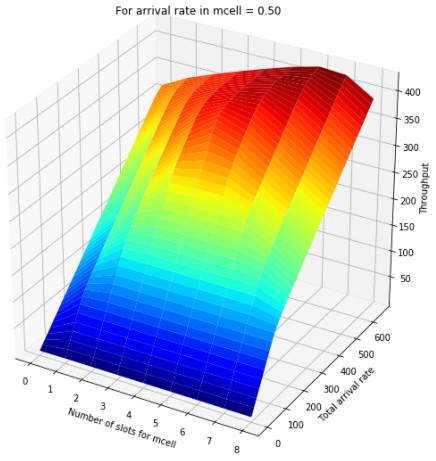

Figure 21: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with micro cell with arrival rate of 50%.

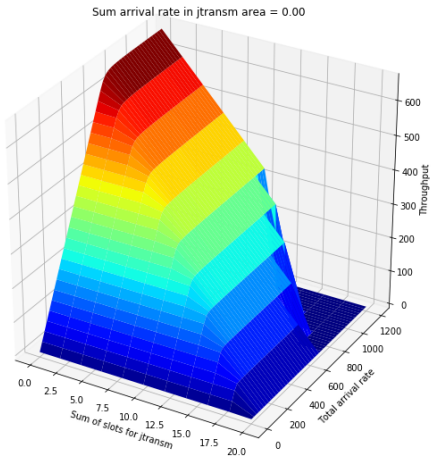

Figure 22: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0% in the joint transmition area. (points on 0 are result of precision error)

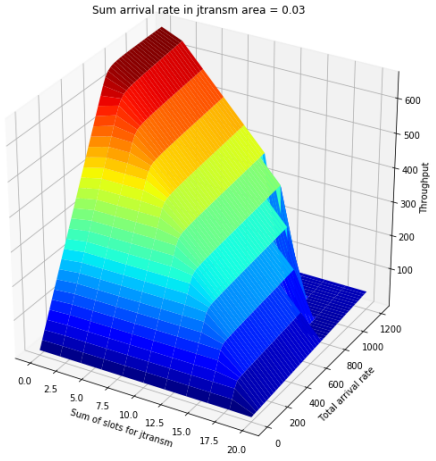

Figure 23: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.03% in the joint transmition area. (points on 0 are result of precision error)

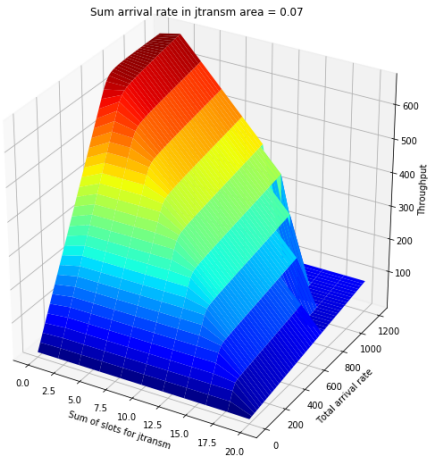

Figure 24: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.07% in the joint transmition area. (points on 0 are result of precision error)

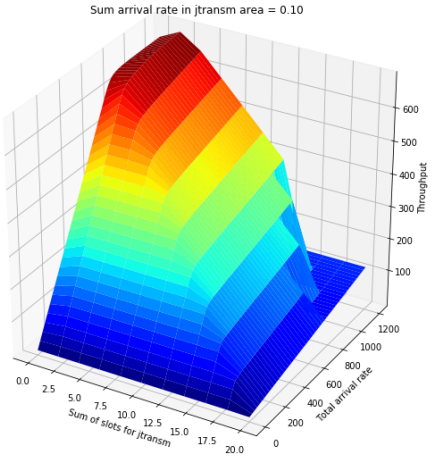

Figure 25: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.1% in the joint transmition area. (points on 0 are result of precision error)

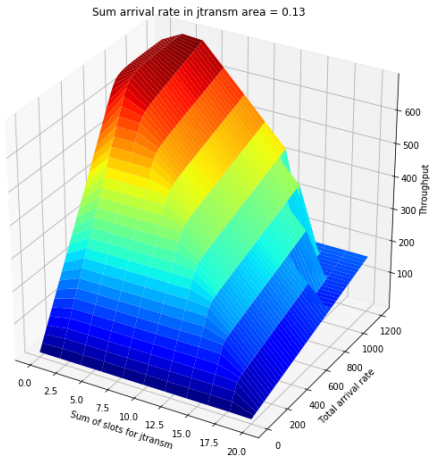

Figure 26: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.13% in the joint transmition area. (points on 0 are result of precision error)

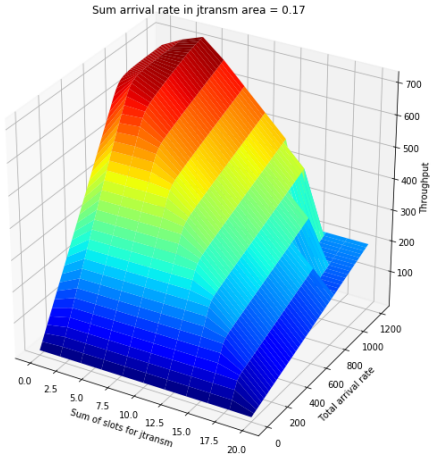

Figure 27: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.17% in the joint transmition area. (points on 0 are result of precision error)

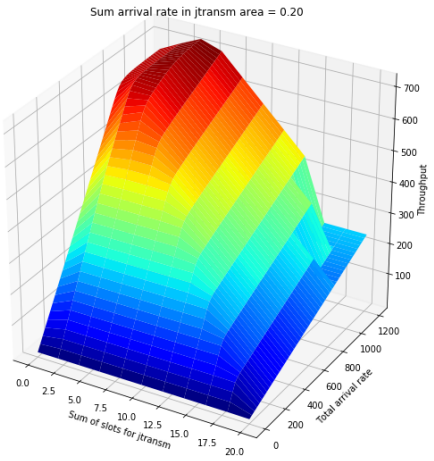

Figure 28: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.20% in the joint transmition area. (points on 0 are result of precision error)

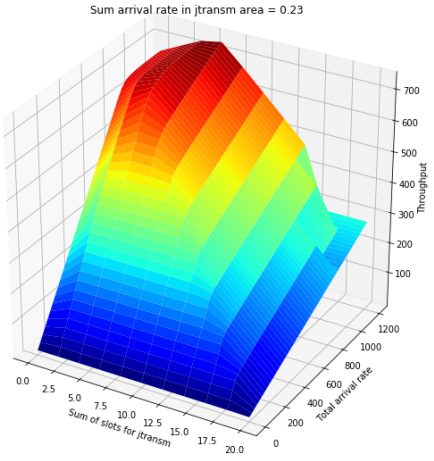

Figure 29: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.23% in the joint transmition area. (points on 0 are result of precision error)

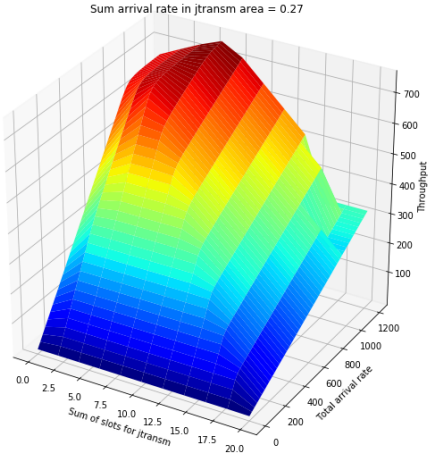

Figure 30: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.27% in the joint transmition area. (points on 0 are result of precision error)

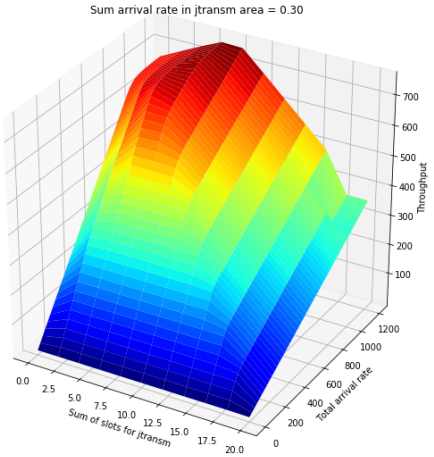

Figure 31: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.30% in the joint transmition area. (points on 0 are result of precision error)

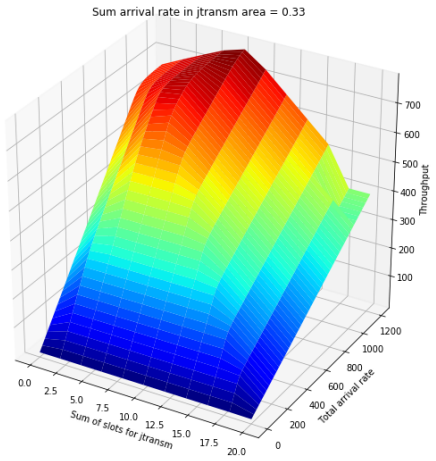

Figure 32: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.33% in the joint transmition area. (points on 0 are result of precision error)

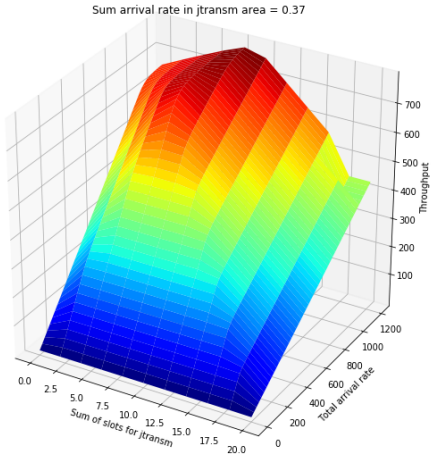

Figure 33: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.37% in the joint transmition area. (points on 0 are result of precision error)

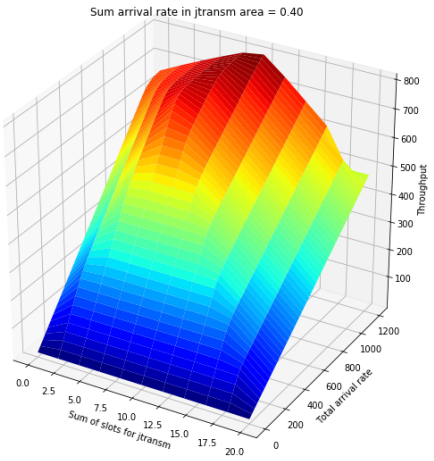

Figure 34: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.40% in the joint transmition area. (points on 0 are result of precision error)

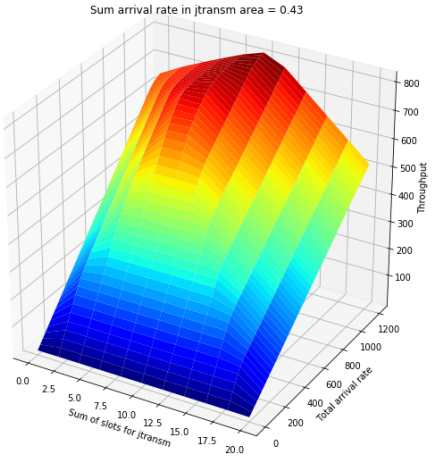

Figure 35: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.43% in the joint transmition area. (points on 0 are result of precision error)

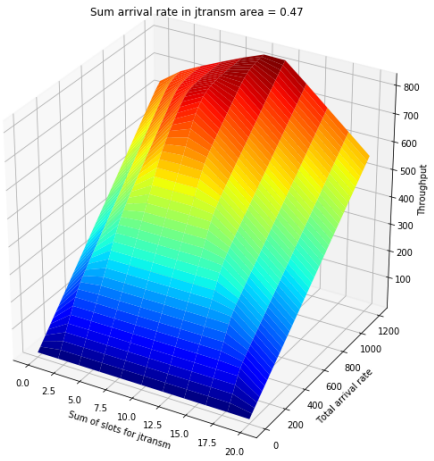

Figure 36: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.47% in the joint transmition area. (points on 0 are result of precision error)

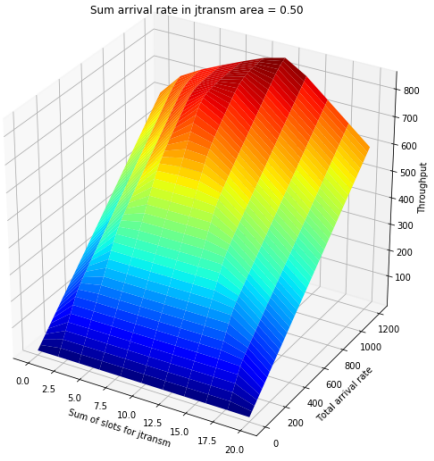

Figure 37: Plot of the throughput in function of arrival rate and number of reserved slots for the scenario with joint transmission with arrival rate of 0.50% in the joint transmition area. (points on 0 are result of precision error)