Simulating the effects of admission control on CDMA system

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I. INTRODUCTION

To maintain balance between the number of users and the quality of the service has always been a challenge for the service providers. Many techniques like frequency reuse, spread spectrum are invented over the years to improve the quality of service to occupy large number of users. Despite these techniques, whenever the new network is being deployed in an area, quality of service becomes a major problem for the network provider. Initially the network provider's primary aim is to increase the coverage area. While increasing the cell coverage more users tries to connect in the system which results in the decrease of the quality of service. To dealt with this problem, network providers use admission control to maintain the quality of service. In this project, I am simulating the admission control using Python language. This simulation implements call breathing to control the number of users on the system. This modification is implemented by incrementing and decrementing the EIPR for the users who are trying to connect with the system. This experiment analysis the effects on the system in two situations:

- Changing the number of users from 1000 to 10000
- Changing admission control parameters from Cd = 57, Ci = 0 to Cd = 20 to Ci = 15

II. ALGORITHM

The script for the simulation is written in Python Language. I have used two python libraries, Numpy and Matplotlib.pyplot. This algorithm consist of three modules: LossCalculations.py, Main.py and SupportingMethods.py. The Main.py consists the code for the simulation, LossCalculations.py consists the methods to calculate the Shadowing, Fading and Path Loss and SupoortingMethods.py contains methods to calculate received signal level, signal to interference plus noise ratio and some other methods to support the simulation. Some of important libraries functions which are used in the project are:

1) Numpy.random.rayleigh(): This function returns a value from a Rayleigh distribution. It is used to calculate the fading effect per second.
2) Numpy.random.choice(): This function return a value from the list of choices based on the corresponding probability of these values. It is used to calculate the number of users who attempt to call at each second.
3) Numpy.random.normal(): This function returns a value from the normal distribution based on the mean and variance. It is used to calculate the shadowing effect on each 10m by 10m square in the region.
4) Numpy.random.exponential(): This function returns a value from the exponential distribution. It is used to calculate the call duration time for each user.

III. RESULTS

The results of the simulation are taken for four different cases. The initial 2 min and final 2 hour summaries are discussed in the following results. However, I have submitted the summaries for full two-hour simulation in text file along with the python scripts.

1) Cd = 57, Ci = 0, users = 1000; This case shows the behavior of the simple CDMA system without the implementation of admission control. The below are the summaries of the system. It can be concluded from the summaries that the system is overwhelmed with the users because more than 34% calls drops occurred. To show the farthest users from the base station, I have used the circle radius same as the radius of the farthest user in figure 1. In the case of Cd = 57 and Ci = 0, the cell radius will change from 0 to 10 km. However, it will be shown in later cases, how the cell radius will be decreased for admission control.

Number of call attempts not counting retries: 202
Number of call attempts including retries: 557
Number of dropped calls: 63
Number of blocked calls due to signal strength: 69
Number of blocked calls due to channel capacity: 0
Number of successfully completed calls: 43
Number of calls in progress at any given time: 22
Number of failed calls (blocks + drops): 132
Cell Radius: [9.46023583]

Summary 1: System's summary at 2 min

Number of call attempts not counting retries: 11539
Number of call attempts including retries: 32964
Number of dropped calls: 4073
Number of blocked calls due to signal strength: 4339
Number of blocked calls due to channel capacity: 0
Number of successfully completed calls: 3100
Number of calls in progress at any given time: 25
Number of failed calls (blocks + drops): 8412
Cell Radius: [8.44779234]

Summary 2: System's summary at 7200 min

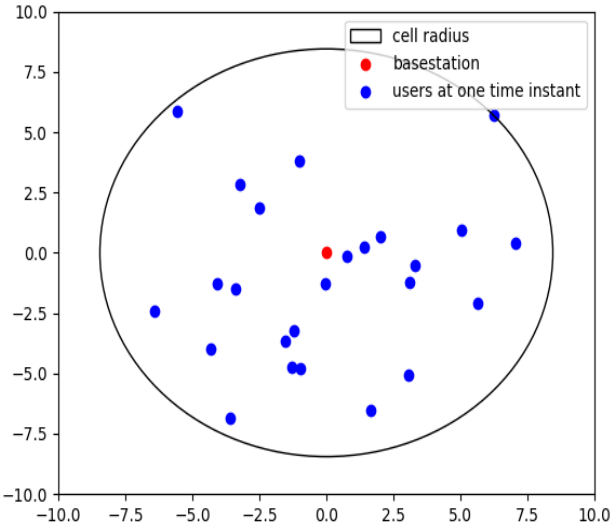

Fig 1 Cd = 57, Ci = 0, users = 1000 System display at 7200 min with cell breathing

2) Cd = 57, Ci = 0, users = 10000; This case shows the behavior of the simple CDMA system without the implementation of admission control. The below are the summaries of the first two minute and last two minute of the system. The blocked calls due to channel capacity has increased which is due to increase in number of users, thus increase in users on call at each second. By observing the figure 2, you can visualize the implementation of admission control in respect to the cell breathing phenomenon. You can imagine from the figure that if the cell radius decreases, it will leave some of the users outside its boundary. These users will connect to the neighbor cell in real world. This leaving the users out of the cell radius is the phenomenon of admission control. It will be discussed in next case.

Number of call attempts not counting retries: 1956
Number of call attempts including retries: 5876
Number of dropped calls: 1029
Number of blocked calls due to signal strength: 741
Number of blocked calls due to channel capacity: 18
Number of successfully completed calls: 96
Number of calls in progress at any given time: 43
Number of failed calls (blocks + drops): 1788
Cell Radius: [9.93570819]

Summary 3: System's summary at 2 min

Number of call attempts not counting retries: 119642
Number of call attempts including retries: 362673
Number of dropped calls: 65258
Number of blocked calls due to signal strength: 45973
Number of blocked calls due to channel capacity: 1333
Number of successfully completed calls: 7001
Number of calls in progress at any given time: 47
Number of failed calls (blocks + drops): 112564
Cell Radius: [9.51261588]

Summary 4: System's summary at 7200 min

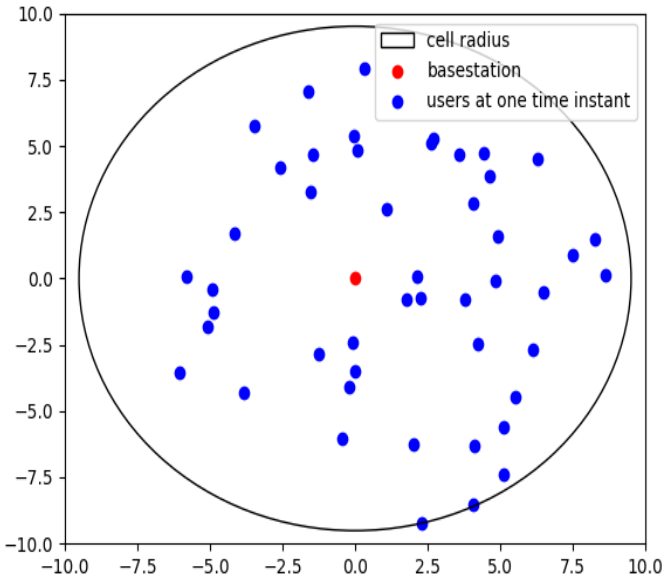

Fig 2 Cd = 57, Ci = 0, users = 10000 System display at 7200 min without considering cell breathing

3) Cd = 20, Ci = 15, users = 1000; This case shows the behavior of the simple CDMA system with the implementation of admission control. The below are the summaries for first two minute and last two minute of the system. The effect of admission control is clearly seen in the summaries. The dropped calls have drastically decreased but the blocked calls due to signal strength has increased. This is resulted because the change in EIRP value for the users who attempts to call. In other words, we are decreasing the cell radius by decreasing the EIRP value. This decrease in radius leads to less users on the system, thus decrease the interference.

Number of call attempts not counting retries: 191
Number of call attempts including retries: 618
Number of dropped calls: 2
Number of blocked calls due to signal strength: 126
Number of blocked calls due to channel capacity: 0
Number of successfully completed calls: 47
Number of calls in progress at any given time: 13
Number of failed calls (blocks + drops): 128
Cell Radius: [6.77949455]

Summary 5 System's summary at 2 min

Number of call attempts not counting retries: 11627
Number of call attempts including retries: 42336
Number of dropped calls: 63
Number of blocked calls due to signal strength: 9464
Number of blocked calls due to channel capacity: 0
Number of successfully completed calls: 2073
Number of calls in progress at any given time: 24
Number of failed calls (blocks + drops): 9527
Cell Radius: [9.22545857]

Summary 6 System's summary at 7200 min

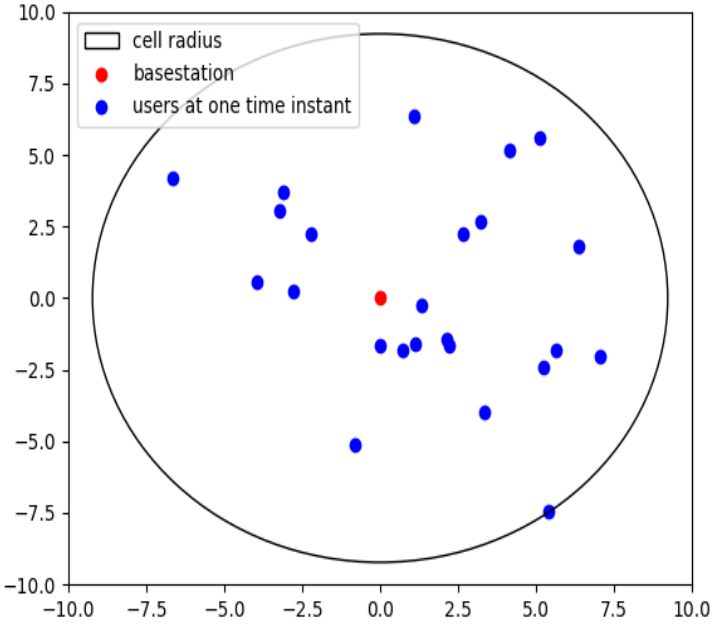

Figure 3 Cd = 20, Ci = 15, users = 1000 System display at 7200 min without considering cell breathing

4) Cd = 20, Ci = 15, users = 10000; This case shows the behavior of the simple CDMA system with the implementation of admission control. The below are the summaries of the system after the first two minute and 2 hour. The admission control also works on the system with high number of users. The drop calls are very less as compared to the dropped calls without admission control. It can be inferred from the summaries that the system takes less than two minutes to change its EIRP to mitigate the dropped calls and accommodate maximum users provided good quality service. It can also be observed from the summaries that the blocked calls due to channel capacity has also decreased because of the availability of the free channels.

Number of call attempts not counting retries: 1969
Number of call attempts including retries: 7443
Number of dropped calls: 120
Number of blocked calls due to signal strength: 1739
Number of blocked calls due to channel capacity: 0
Number of successfully completed calls: 39
Number of calls in progress at any given time: 22
Number of failed calls (blocks + drops): 1859
Cell Radius: [3.65026065]
Summary 7 *System's summary at 2 min*

Number of call attempts not counting retries: 118781
Number of call attempts including retries: 468790
Number of dropped calls: 983
Number of blocked calls due to signal strength: 114773
Number of blocked calls due to channel capacity: 0
Number of successfully completed calls: 2957
Number of calls in progress at any given time: 24
Number of failed calls (blocks + drops): 115756
Cell Radius: [3.00071927]
Summary 8 System's summary at 7200 min

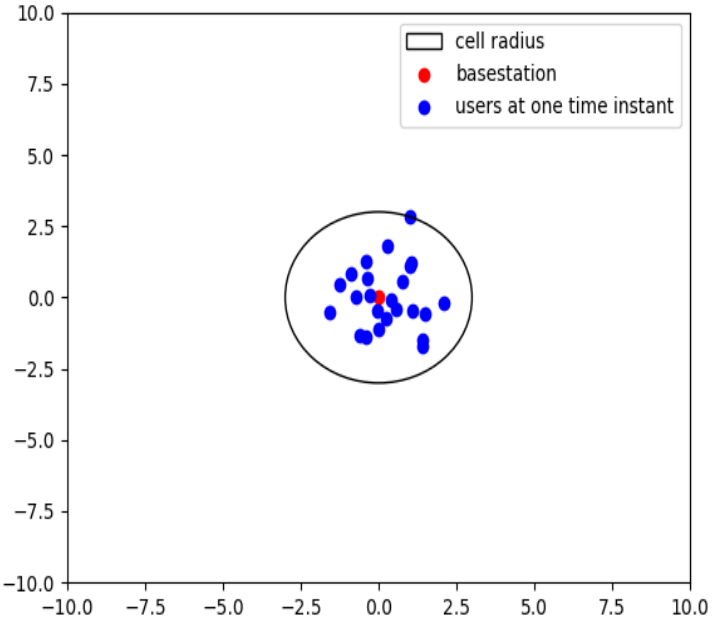

Figure 4 Cd = 20, Ci = 15, users = 10000 System display at 7200 min without considering cell breathing

IV. CONCLUSION

It can be seen from the summaries that the number of dropped calls have decreased after the implementation of admission control. This is one of the way in which admission control achieves the good quality of service.

Q1: what is the ratio of the number of dropped calls to the number of completed calls? What is the main reason for call failure? Are blocks for channel capacity?

- Number of dropped call to Number of completed calls = 4073/3100 = 1.3138
- The main reason of call failure is the interference between the users. As the number of users increase on the system the SINR decrease and results in drop calls. Since the system is overwhelmed, the huge dropped calls are expected.
- Number of blocked calls due to channel capacity = 0

Q2: Change the values of C_d and C_i to 20 and 15 respectively. What happens to your statistics? What is the ratio of dropped calls to completed calls now? How has the number of blocked calls changed? What is the effect on the cell radius?

- Number of dropped call to Number of completed calls = 63/2073 = 0.030
- Number of blocked calls due to signal strength without admission control = 4339
- Number of blocked calls due to signal strength with admission control = 9464
- Number of blocked calls due to channel capacity = 0
- It can be seen from above values that the number of blocked calls due to signal strength has increased. The reason for this shift is the decrease of EIRP value which further decrease the received signal level for the users. This decrease in RSL make it difficult for the users to decode the CDMA code, thus users are unable to connect to the system.
- The cell radius after the implementation of admission control changes according to the number of users on the system. When number of users on the system is greater than 20, cell radius keeps on decreasing because of decrease in EIRP value and cell radius increases when the number of users is less than 15 with respect to the EIRP value. It can be seen from the figure 5 and 6 that the average cell radius of the system without admission control is larger than with admission control. The trend can be seen by referring figure 7, 8, 9 and 10.

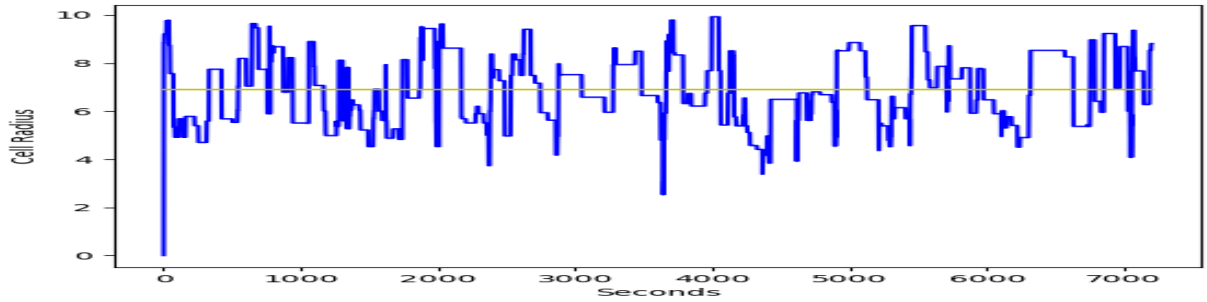

Figure 6 Cell radius for each second with admission control

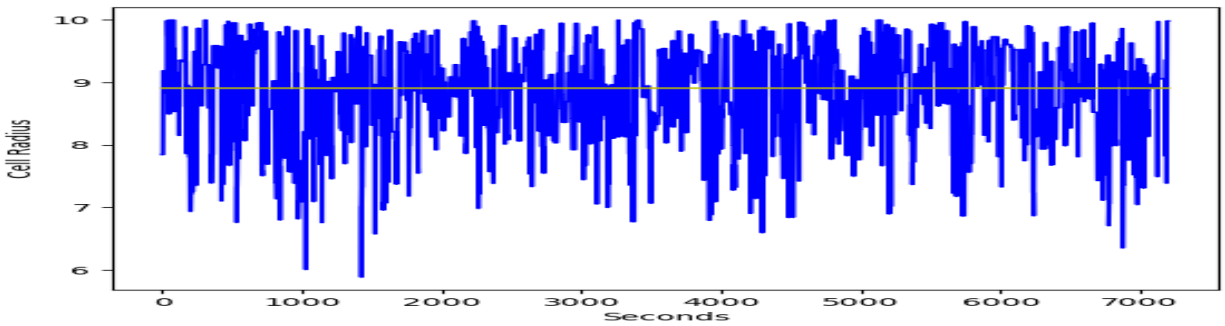

Figure 5 Cell radius for each second without admission control

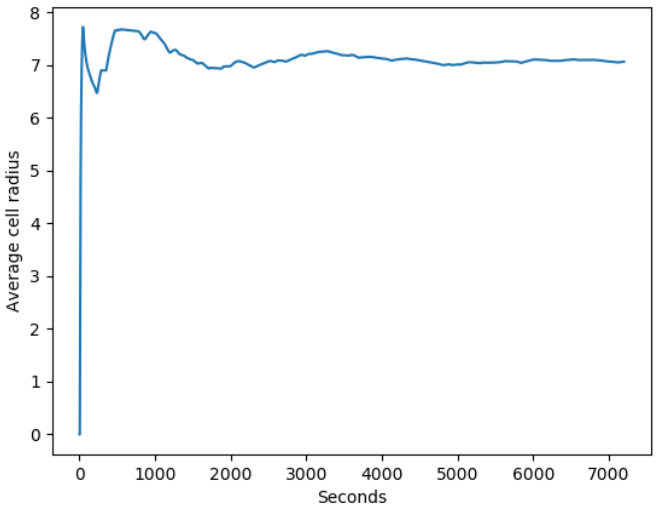

Figure 7 Cd = 20, Ci = 15, Users = 1000

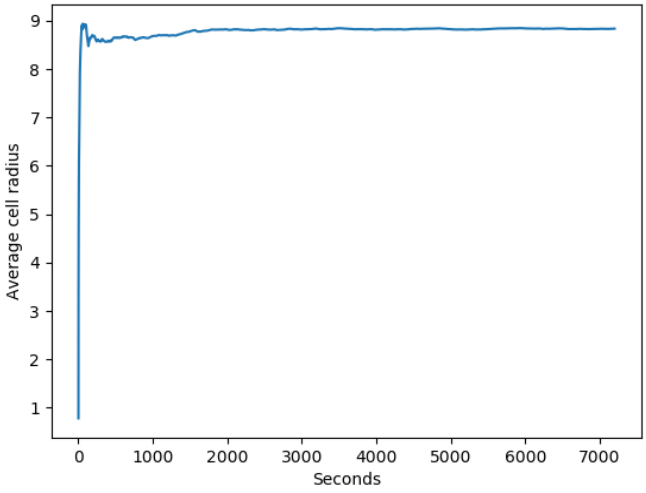

Figure 8 Cd = 57, Ci = 0, Users = 1000

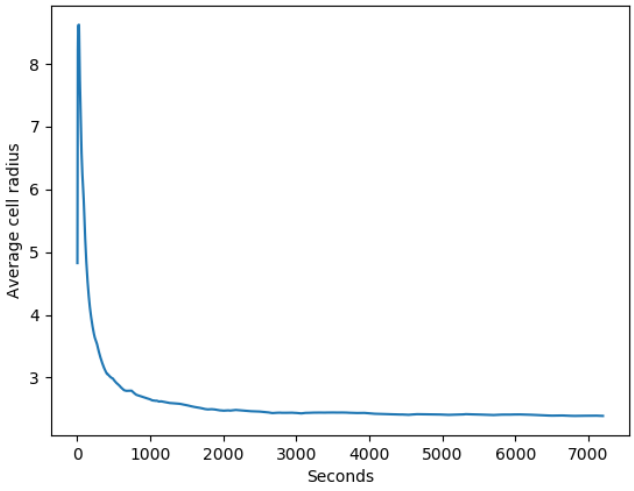

Figure 9 Cd = 20, Ci = 15, Users = 10000

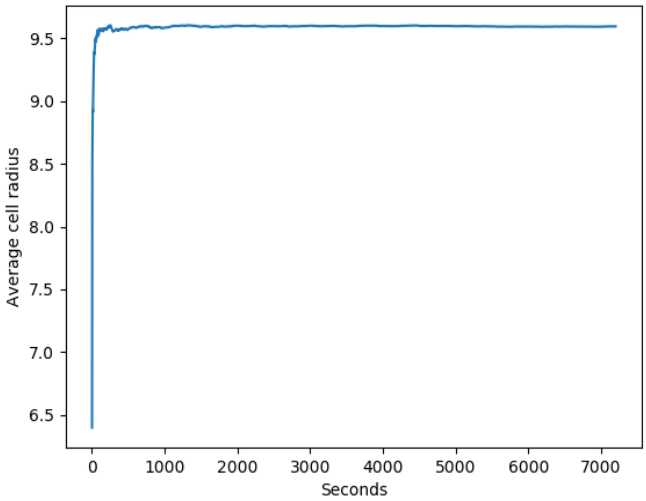

Figure 10 Cd = 57, Ci = 0, Users = 10000

Q3: Increase the number of users to 10000 and rerun your simulation, first with no admission control (i.e. Cd and Ci set to 57 and 0 respectively) and then with the Cd and Ci values from Q2. What happens to the blocks due to channel capacity? How do they change when the Cd and Ci values change?

- Number of blocked calls due to channel capacity at Cd = 57, Ci = 0 is 1333
- Number of blocked calls due to channel capacity at Cd = 20, Ci = 15 is 0
- The blocked due to channel capacity has increased when the size of users is increased. It is because the 10000 users will run on full capacity. In other words, it will use near about 56 channels, so in the cases where all the channels will be occupied, the call will be blocked due to channel capacity. On the other hand, 1000 users' system will not use full channel capacity. Therefore, there is zero call block due to channel capacity in 1000 users' system. After implementation of admission control the blocked call due to channel capacity will be zero because the change in EIRP value makes sure that the user will always have available channels.

V. ACKNOWLEDGMENT

This project required in-depth research, a huge amount of work and dedication. Implementation would not have been possible if I did not have the support of many individuals.

I would like to extend mine sincere gratitude to all of them. First, I am thankful to professor Mike Dellomo for the provision of expertise and technical support in the completion of this project. Without their superior knowledge and experience, it would have been impossible for me to complete the project in the given timeline.

I would also like to express mine sincere thanks to Chaitra Poojary who devoted his time and knowledge in the implementation of this project and constant encouragement which helped me in completion of this project.

HONOR PLEDGE: I pledge on my honor that I have not given or received any unauthorized assistance on this assignment.

Sahil Khanna-