Different Handover Policies in Different Environments

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I. Introduction

In our project, we proposed four different handover policy and compare their performances among different environment. We provide two different channel path models with different settings, such as the number and the mobility pattern of MS.

This report is orgnized as follows. In section II, we will provide our signal model with its equations. In section III, we will propose four different handover policies. In section IV, we will show how we implement our project. Simulation results are given in section V and VI concludes this paper.

II. Signal Propagation Model

There are three parts in our signal propagation model: path-loss, shadowing and fading[1].

Due to radio signal blocking by buildings, walls and other obstacles, received power fluctuates in large time-scale variation, which is called shadowing. We use log-normal distribution to simulate shadowing and show as below.

$$G_{shadowing} = 10^{\frac{x}{10}},\ x \in \mathcal{N}\left(0, \sigma^2\right). \tag{1}$$

Aside from large time-scale variation, there is small time-scale variation called fading resulting from multipath propagation. We propose two distribution, Rayleign and Rician, to simulate fading, namely

$$G_{fading} = \alpha^2, \tag{2}$$

where α is the random variable of Rayleigh and Rician distribution. The PDF of these two distribution is expressed as below

$$P(\alpha) = \begin{cases} \dfrac{\alpha}{\sigma^2} e^{\frac{-\alpha^2}{2\sigma^2}},\ \text{Rayleigh distribution} \\ \dfrac{\alpha}{\sigma^2} e^{\frac{-(\alpha^2+s^2)}{2\sigma^2}} I_0(\dfrac{\alpha s}{\sigma^2}),\ \text{Rician distribution} \end{cases} \tag{3}$$

where

$$I_0(x) = \frac{1}{2\pi}\int_0^{2\pi} e^{-x cos\theta} d\theta$$

We propose two path-loss model: smooth transition, two-ray-ground and COST231. Smooth transition model can be expressed as

$$g(d) = d^{-n_1}\left(1 + \frac{d}{b}\right)^{-n_2}, \tag{4}$$

where $n_1 = 2$, $n_2 = 4$ and $b = 150$ (ISD). Two-ray-ground model can be shown as

$$g(d) = \frac{(h_t h_r)^2}{d^4}, \tag{5}$$

where h_t and h_r are the height of the transmitter and receiver respectively.

III. Handover Policy

We propose four handover policy as Eager, Lazy, Eager Threshold (ET) and Relative Threshold (RT). In Eager mode, MS will switch to new BS if other BS has better SINR than current one. In Lazy mode, MS will switch to new BS if there is other BS has better SINR than current one in continuous 5 cycles. In ET mode, MS will switch to new BS if other BS has better SINR than current one and SINR is larger than a specific threshold. In RT mode, MS will switch to new BS if other BS has larger SINR than current one by a specific threshold.

IV. Implementation

In our project, we implement a system for simulation, namely, Handover Simulator. The system is implemented with Matlab, and it contains a user-friendly graphical user interface (GUI) which is shown in Fig.1.

The backend of the system is mainly controlled with a class named “Model”, and the frontend of the system is written in main.m. User may change numerous parameters of the class Model by operating on UI controls for different desired simulating environment. After setting parameters, user may press down the button “Render” for initialization, and as the user click on the button “Run”, the movements of mobile devices and several counters would be shown on the interface in real-time. During simulation, class Model would call corresponding functions in backend. Also, user may press down “Pause” to temporarily stall the simulation or press down “Stop” to abort the current simulation. The system would show the total counts of handover and failed connection as the simulation ends. User may also obtain some other simulating results by typing commands in Matlab workspace.

V. Simulation

There are two parts in this section. The first part analyzes our experiment of uplink case and the second part analyzes the downlink case.

In all our simultions, we set temperature 27°C, bandwidth 10 GHz, BS power 33 dBm, BS height 51.5 m, MS power 23 dBm, MS height 1.5 m, transmitter gain 14 dB and receiver gain 14 dB. Also, we set the threshold in ET mode is -50 dB and the threshold in ET mode is 3 dB. We consider MS is disconnect to BS if its SINR is lower than -55dB. Finally, we conduct each of our experiments with 3 tests and take the average of them and calculate their variance.

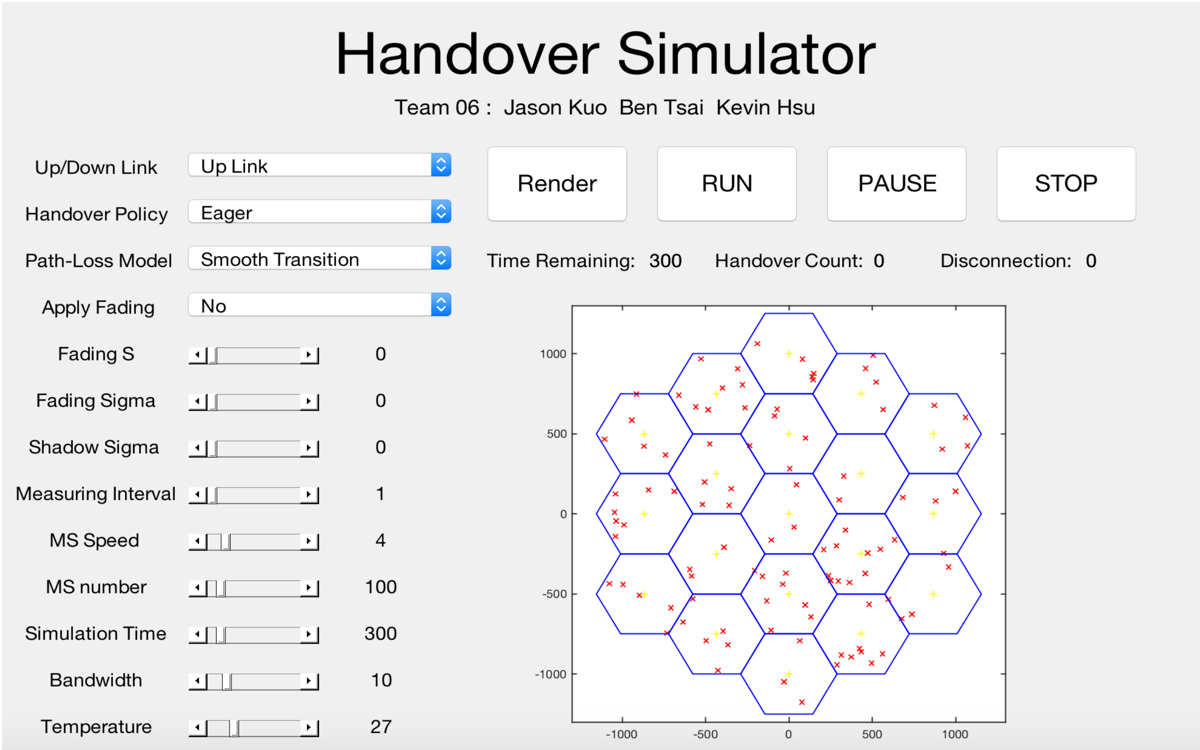

Fig. 1. The graphical user interface of our proposed simulator.

A. *Uplink*

1) Analysis of one variable: In the first simulation, we set the default setting as the number of MS is 300, the average speed of MS is 10 m/cycle, the channel model is smooth transition without fading and shadowing, the handover policy is eager with evaluation for each cycle and simulate time is 300 cycles. The result is showed in Fig. 2.

As showed in Fig. 2, different handover policies under default seetings don't make much difference except for Lazy mode. We think it is because the defaulting setting is too soft to make difference and Lazy mode reacts too slowly to switch to different BS. However, RT mode shows better performance in the number of handover because it prevents from changing to BS with about SINR of original BS.

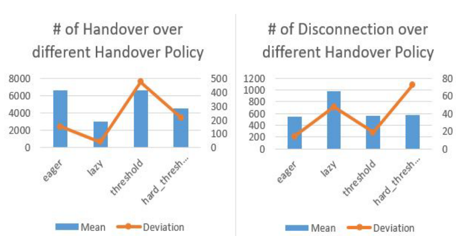

Fig. 2. The number of handover and disconnection under different handover policy.

As the result, we want to know which environment parameter has more impact on the performance of disconnection. We only change one parameter of default settings in every experiment and the results are showed in Fig. 3 to Fig. 11.

The performance under different channel model can be seen in Fig. 3 to Fig. 7. In Fig. 3, the two-ray-ground model has worse performance because of the order of the distance factor is the largest. Therefore, the signal power drop dramatically if the distance becomes larger and the near-far effect becomes more evident. In Fig. 4 to Fig. 7, with or without fading and shadowing doesn't make much difference.

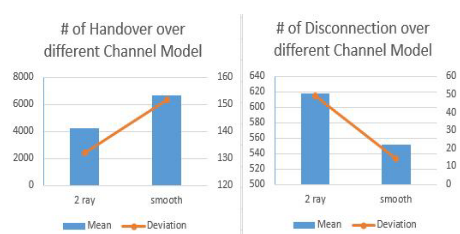

Fig. 3. The number of handover and disconnection under different path-loss model.

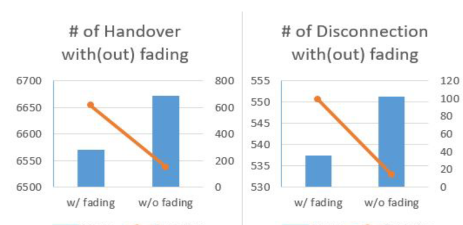

Fig. 4. The number of handover and disconnection with and without fading.

In Fig. 8, as the measuring interval becomes larger, MS will update its BS more slowly, resulting in disconnection number

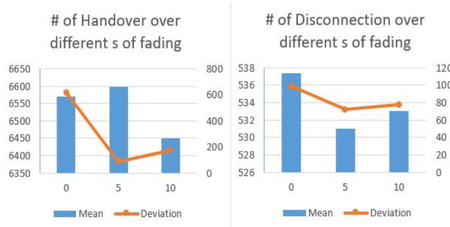

Fig. 5. The number of handover and disconnection under different S of fading.

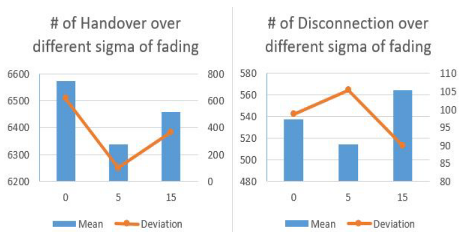

Fig. 6. The number of handover and disconnection under different Sigma of fading.

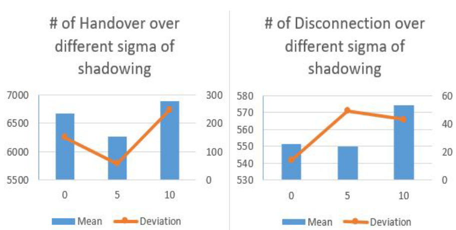

Fig. 7. The number of handover and disconnection under different Sigma of shadowing.

getting higher. However, there is no much difference between 5 and 20.

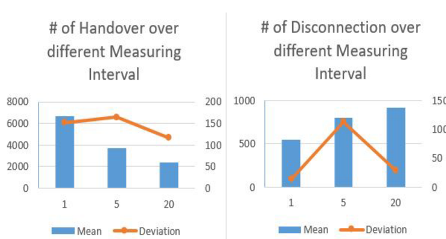

Fig. 8. The number of handover and disconnection under different measuring interval.

In Fig. 9, as the speed of MS becomes larger, MS will disconnect more easily and the number of disconnection increases faster than first order.

In Fig. 10, as the number of MS becomes larger, the interference from other MS gets larger, resulting disconnection more frequent. The number of disconnection increases faster than first order.

In summary, the parameters having more impact include the number of MS, the speed of MS, path-loss model and measuring interval.

2) Different handover policy on different channel model: In the first simulation, we set the number of MS is 300 and the average speed of MS is 10 m/s and simulate for 300 cycles. We want to anyalze the relationship between the number of handover and disconnect with different path-loss model under different handover policy. The result is showed as Fig. 11.

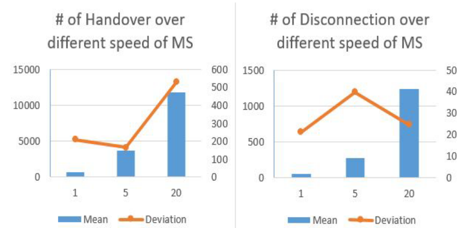

Fig. 9. The number of handover and disconnection under different speed of MS.

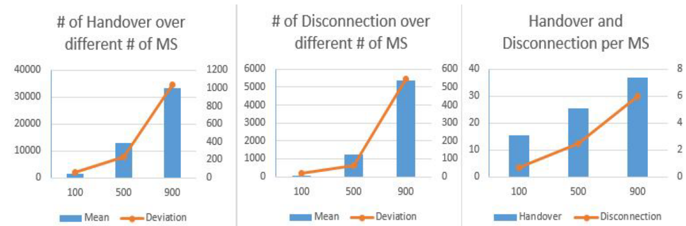

Fig. 10. The number of handover and disconnection under different number of MS.

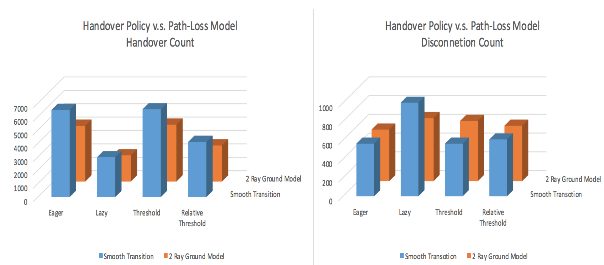

Fig. 11. The number of handover and disconnection under different path-loss model and handover policy.

We found that with path-loss model as smooth transition model, both handover and disconnection counts would be larger and had a larger variance among different handover polices. On the other hand, we found that with handover policy setting as eager and threshold handover, the handover counts are higher. Although with lazy handover policy we are able to get the lowest handover count, the disconnection count would be the greatest intuitively.

3) Different handover policy on different speed of MS: In the first simulation, we set the channel model is smooth transition, the number of MS is 300 and simulate for 300 cycles. We want to anyalze the relationship between the number of handover and disconnect with different mobility pattern of MS under different handover policy. The result is showed as Fig. 12.

When considering handover counts, threshold handover policy would result in a much greater transition as the speed of mobile devices increase. On the other hand, when considering disconnection counts, all handover policies except the eager one would result in a great transition. Among all handover

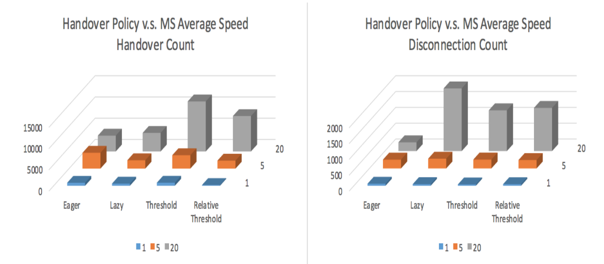

Fig. 12. The number of handover and disconnection under different mobility pattern of MS and handover policy.

policies, the eager handover policy seams to be the most stable one and with the lowest number of handover and disconnection counts overall.

4) Different handover policy on different number of MS: In the first simulation, we set the channel model is smooth transition, the average speed of MS is 10 m/s and simulate for 300 cycles. We want to anyalze the relationship between the number of handover and disconnect with different number of MS under different handover policy. The result is showed as Fig. 13.

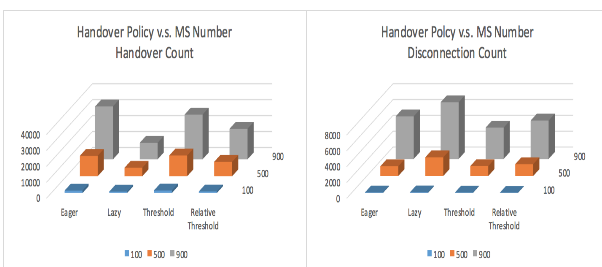

Fig. 13. The number of handover and disconnection under different number of MS and handover policy.

When considering handover counts, lazy and relative threshold handover polices seems to perform better. However, then considering disconnection counts, threshold handover policy seems to have the best performance, and the following are eager and relative handover policies. By considering both handover and disconnection counts altogether, relative handover policy seems to have the best performance in this case.

B. Downlink

1) Analysis of one variable: Similarly as uplink case, we set the default setting as the number of MS is 300, the average speed of MS is 10 m/cycle, the channel model is smooth transition without fading and shadowing, the handover policy is eager with evaluation for each cycle and simulate time is 300 cycles. The result is showed in Fig. 14.

As showed in Fig. 14, RT mode has the lowest disconnection number with lower handover number than eager mode. The ET mode performs the worst becasue of the absolute value threshold, causing MS to do handover inflexibly.

Also, we want to know which environment parameter has more impact on the performance of disconnection. We only change one parameter of default settings in every experiment and the results are showed in Fig. 15 to Fig. 22.

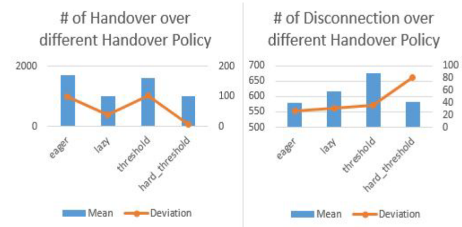

Fig. 14. The number of handover and disconnection under different handover policy.

The performance under different channel model can be seen in Fig. 15 to Fig. 19. We can see at the downlink case, path-loss model doesn't make much difference. The sigma of fading and shadowing plays more important role.

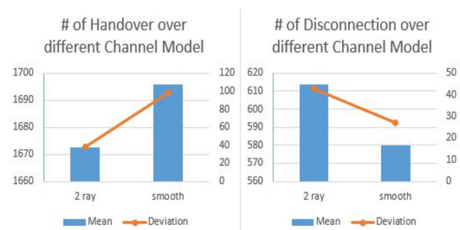

Fig. 15. The number of handover and disconnection under different path-loss model.

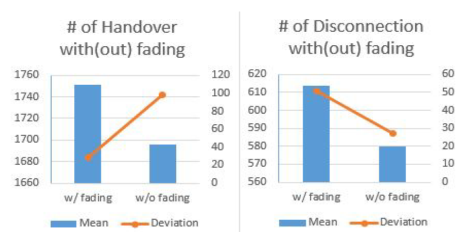

Fig. 16. The number of handover and disconnection with and without fading.

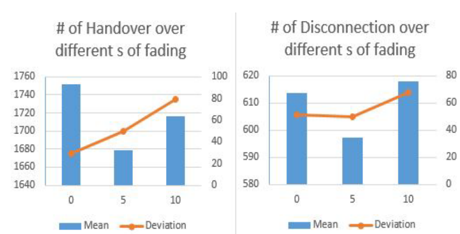

Fig. 17. The number of handover and disconnection under different S of fading.

In Fig. 20, it seems the measuring interval doesn't make much difference.

In Fig. 21, as the speed of MS becomes larger, MS will disconnect more easily and the number of disconnection increases faster than first order.

In Fig. 22, as the number of MS becomes larger, MS will disconnect more easily and the number of disconnection increases linearly.

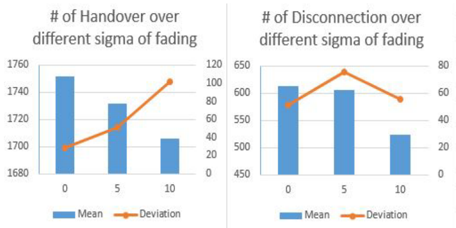

Fig. 18. The number of handover and disconnection under different Sigma of fading.

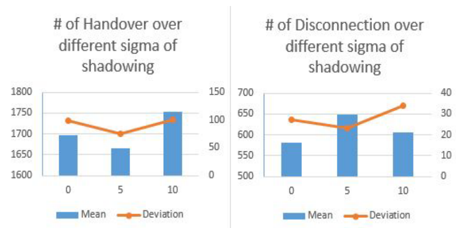

Fig. 19. The number of handover and disconnection under different Sigma of shadowing.

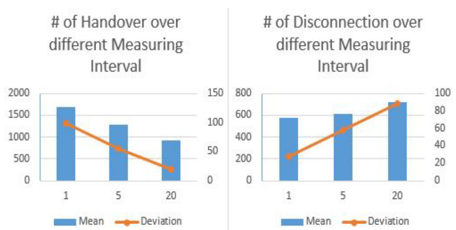

Fig. 20. The number of handover and disconnection under different measuring interval.

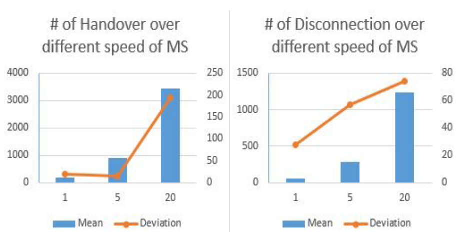

Fig. 21. The number of handover and disconnection under different speed of MS.

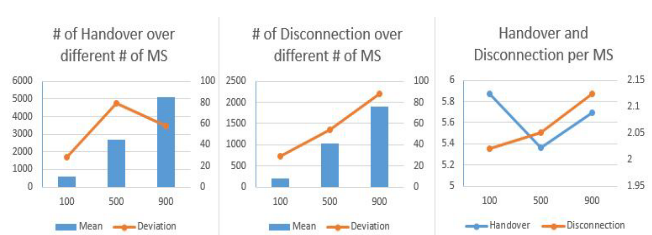

Fig. 22. The number of handover and disconnection under different number of MS.

In summary, the parameters having more impact include the number of MS, the speed of MS and shadowing and fading model.

2) Different handover policy on different channel model: In the first simulation, we set the number of MS is 300 and the average speed of MS is 10 m/s and simulate for 300 cycles. We want to anyalze the relationship between the number of handover and disconnect with different path-loss model under different handover policy. The result is showed as Fig. 23.

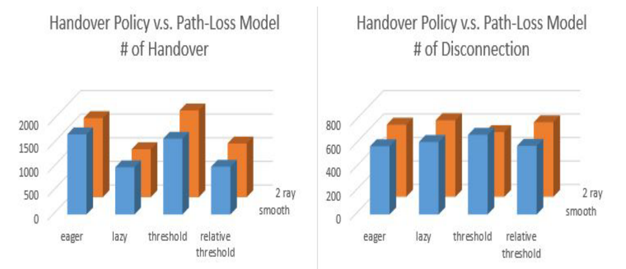

Fig. 23. The number of handover and disconnection under different path-loss model and handover policy.

We found that with path-loss model as smooth transition model or 2-ray model, both handover and disconnection counts would be similar among different handover polices, and with handover policy set as eager and eager-threshold handover, the handover counts are higher, but as lazy handover policy we are able to get the lowest handover count.

3) Different handover policy on different speed of MS: In the first simulation, we set the channel model is smooth transition, the number of MS is 300 and simulate for 300 cycles. We want to anyalze the relationship between the number of handover and disconnect with different mobility pattern of MS under different handover policy. The result is showed as Fig. 24.

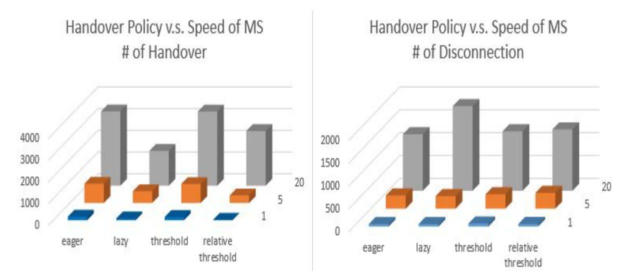

Fig. 24. The number of handover and disconnection under different mobility pattern of MS and handover policy.

When considering handover counts, lazy handover policy would result in handovers of the least but disconnections of the most as the speed of mobile devices increase, while relative-threshold handover policy has the most stable performance among all policies.

4) Different handover policy on different number of MS: In the first simulation, we set the channel model is smooth transition, the average speed of MS is 10 m/s and simulate for 300 cycles. We want to anyalze the relationship between the number of handover and disconnect with different number of

MS under different handover policy. The result is showed as Fig. 25.

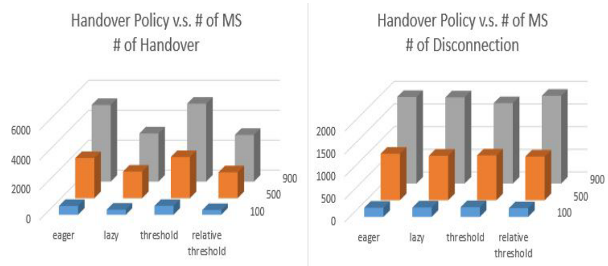

Fig. 25. The number of handover and disconnection under different number of MS and handover policy.

Lazy and relative-threshold would result in the least handovers but with same performance on disconnections.

VI. Conclusion

In this work, we provide four different handover policies, namely, eager, lazy, ET and RT. We implement it by MATLAB and propose a user-friendly GUI. By using it, we conduct many experiments under different parameters in uplink and downlink case, respectively.

In the uplink simulation, we found that parameter with large impact include the number of MS, the speed of MS, path-loss model and measuring interval. Also, among some critical environment, eager and RT policy generally plays the best in disconnection count. However, RT mode has far lower handover count compared to eager mode.

In the downlink case, we found that parameter with large impact include the number of MS, the speed of MS and shadowing and fading model. Lazy policy would result in a least handover counts but a most disconnection counts and RT policy would result in a relatively small handover counts with disconnection counts similar to other handover policies.

References

[1] J. H. Schiller, “Mobile communications,” 2nd ed. London: Addison-Wesley, 2011.

[2] En.wikipedia.org. “COST Hata model,” [online] Available at: https://en.wikipedia.org/wiki/COST_Hata_model, 2017.