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Efficient Handover Implementation for LTE based Femto-cell Environment

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ENSC 833: NETWORK PROTOCOLS AND PERFORMANCE
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SEMESTER PROJECT

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ACRONYMS

E-UTRAN- Evolved Universal Terrestrial Radio Access

NS-3 – Network Simulator 3

LENA – LTE Enhanced Network Adaptor

EPC – Evolved Packet Core

MME- Mobile Mobility

SGW- Serving Gateway

UE – Universal Entity

eNodeb- Enhanced Node Base station

Tx- Transmitter

MHz- Mega Hertz

CSG – Closed Subscriber Group

UDP- Uniform Datagram Protocol

TCP- Transmission Control Protocol

CBR- Constant Bit Rate

VoIP- Voice over Internet Protocol

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ABSTRACT

This project deals with Femto-cells and their interaction with macro-cells when mobile devices perform a handover. Femto-cells are low power indoor radio cells used in HSDPA, LTE to extend the coverage area inside urban environment. Our interest in the research stems from the increasing intensive research focus on 5th generation mobile technology. The next generation technology plans on using femto cells as normal outdoor radio cells. Since, millimeter wave is badly affected by the fading, shadowing, non-Line Of Sight propagation, therefore it is important to integrate macro cells with Femto-cells. There are a lot of handover algorithms proposed for the interworking between these two types of cells. We would focus this project on one such algorithm considering speed and real time application of any mobile device to be the trigger factor. We have also conducted a similar experiment with certain handover parameters and analyze the results to propose an addendum to the existing handover algorithm.

CHAPTER 1

MOTIVATION

5G is emerging technology which will supersede all existing technologies. Our motivation comes from the fact that the new millimeter wave technology in 5G would be implemented in femto cells, since at higher frequencies, the radio waves cannot travel further and also subjected to extreme fading, shadowing and propagation losses. Therefore, small cells like femto and pico are chosen for the all new emerging technological trends. As, new operators would incorporate femto cells in their existing network, researchers must find a way to develop interaction protocols between femto and existing macro cells so that system performance is not degraded with increasing speeds. Our approach is to implement one such approach and see if the results are really promising. This will create the necessary framework and encourage other people to explore this important field.

CHAPTER 2

2.1 INTRODUCTION

Over 50% of current voice and data traffic in wireless communication originates from indoors [6]. To meet these demand, femtocells have been deployed to increase indoor coverage and capacity. Femtocells have low power requirements, relatively less expensive and can easily be integrated into existing macro-cell network [1]. Due to its low cost and power requirements for increasing indoor connectivity, femtocells have become increasingly popular. As at 2011, over 2million femtocells have already been deployed [1].

With its relatively small coverage area, and high mobility of users within this area, femtocells are characterized with frequent handovers; between femtocells-to-femtocells and femtocells-to-macrocells. Most if this handover is experienced at the boundary of femtocells. For instance, a waiter at a coffee shop serving customers outside the shop or building. This ping-pong handover might not be necessary and could reduce network efficiency [6]. We intend to simulate an enhancement in a Long Term Evolution (LTE) network that reduces the number of handover experienced and still maintain good quality of service in femtocells. This simulation was implemented using Riverbed modeler

The LTE architecture can be broadly divided into two: the access network and the core network. The access network, called Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) comprises mainly of evolved base stations (eNodeB or eNB) and the User Equipment (UE). These two components are analogous with Base Transceiver Station (BTS) and Mobile Station (MS) in 2G/3G networks respectively. The core network is called the Evolved Packet Core (EPC). In femtocells, the eNB is called Home eNB (HeNB). It is worth pointing out here that HeNB and eNB do not communicate directly over the X2 interface, but rather route packets via the EPC over the public network (internet). An overview of the LTE architecture is shown in figure 1 [7]. The enhancement we intend to simulate will be largely implemented at the access or E-UTRAN section of the network.

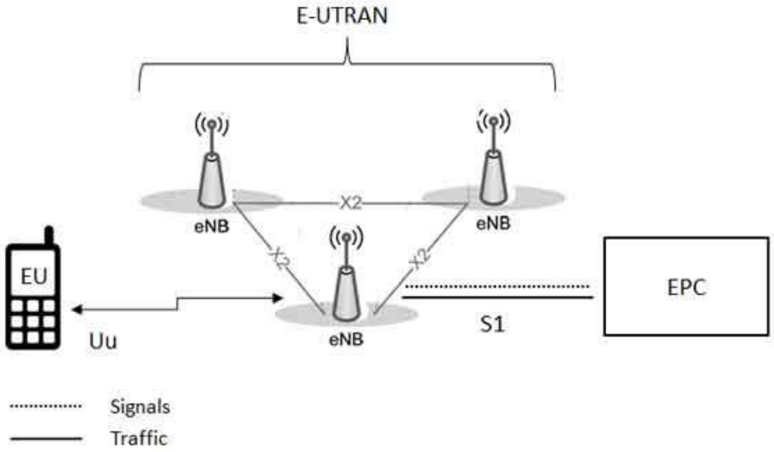

Figure 1: basic LTE architecture
http://www.tutorialspoint.com/lte/lte_network_architecture.htm

2.2 HANDOVER

Handover in mobile communication refers to the transfer of radio connection from the serving eNB to the target Enb [4]. Handover can be of two types: vertical or horizontal. In vertical handover, the UE is moving between areas of coverage of different cellular technology such as 3G to LTE. While in horizontal handover, both the serving and target eNB are in the same technology.

HANDOVER TECHNIQUES

The major types of handover techniques are hard handover and soft handover. We will look at the major features of these techniques below:

i. HARD HANDOVER

This is also called break-before-make handover. In this case, the UE breaks connection with the serving eNB before making connecting to the target eNB. This type of handover is implement in LTE network.

ii. SOFT HANDOVER

This is also called connect-before-break. Here, the UE makes connection with the target eNB before disconnecting serving eNB. Thus, the connection to target eNB is established before the serving eNB connection is disconnected. This scheme is more efficient in guarding against call drops or packet loss during handover as there is always a connection with an eNB.

As mentioned earlier, hard handover is implemented in LTE networks. Handover in LTE can be further sub-divided in two: S1 and X2. The X2-handover is implemented in scenarios where there is an X2 interface link between participating eNBs. The handover procedure is initiated and conclude via this interface.

S1-handover is deployed when there is X2 interface between the participating eNBs. In this case, the handover procedure is implemented via the EPC and packets are routed via the S1 interface. For instance, handover from femtocell to macrocell. We will be focused on this procedure of handover in this paper

CHAPTER 3 SIMULATOR

3.1 NETWORK SIMULATOR-3

Before simulation of any scenario, we need to take this three step approach in ns-3:

1. Define all possible scenarios: specify the affected parameters, simulation time.
2. Write the simulation program that would fit the above mentioned scenario.
3. Change the configuration parameters, include any performance indicators to evaluate the results.

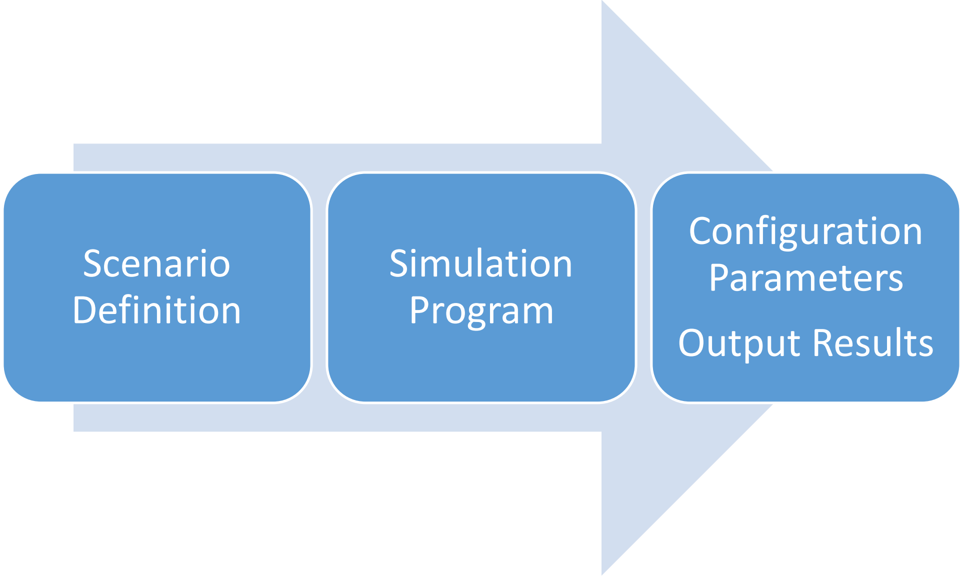

Figure 3.1(a) Ns-3 LENA Simulation

3.2 PROCEDURE

1. First step to create femto cells and assign mobile UEs. This process is the longest and need to be tested to evaluate whether cell testing proves that the designed femto cell is following the design considerations.
2. The next step is to assign these femto cells inside a macro cells. An appropriate radio interference model needs to be assigned to simulate the real world radio network. UEs are also assigned at this point, they are normally moving across the femto cell boundary in different configurations.
3. After the radio and access network is defined, we can now connect the radio network to EPC to connect to internet. EPC consists of MME, SGW and internet.
4. Traffic Modeling is necessary to ensure that all different kinds of traffic are incorporated in the model. We have approached this problem by using constant bit rate, busty traffic and video tcp traffic.
5. Once the traffic modeling is completed, we need to create statistic wire at different points so that appropriate results can be collected and analyzed.
6. Finally, we can now create different scenarios from the base configurations.

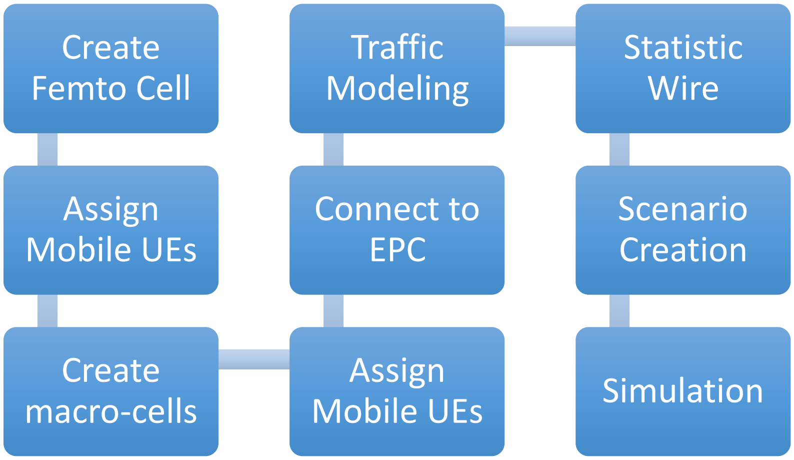

Figure 3.2(a) Handover Simulation

CHAPTER 4 IMPLEMENTATION

4.1 MACRO CELL CREATION

The first step of our simulation is to create three-sector macro-cell. Since macro-cells have sectored radio output they use parabolic antennas for radio transmission. This gives them almost 110-115 degrees radio signal dispersion. There are three important aspects in creating any e-node b in a simulator:

1. Assign a realistic propagation model to the cell.
2. The inter-cell interference should be accounted for.
3. Fading and shadowing effect must be considered and imitated by software models.

An important aspect of macro-cell creation is the transmission power, since it can play a major role in coverage and directivity. There are three important factors that need to be taken into consideration when configuring the transmitter power:

a). Coverage b). Signal Directivity c). UE battery drainage

Inter-site distance determines the interference and coverage areas of a particular radio environment. As, the inter-site distance becomes very large handover would be impossible as the UE would experience a radio drop in blind radio coverage before re-connection. The bandwidth of the UE is 25 which specifies the number of Resource Blocks. The area margin factor determines how much the coverage extends outside the designated enode-b area.

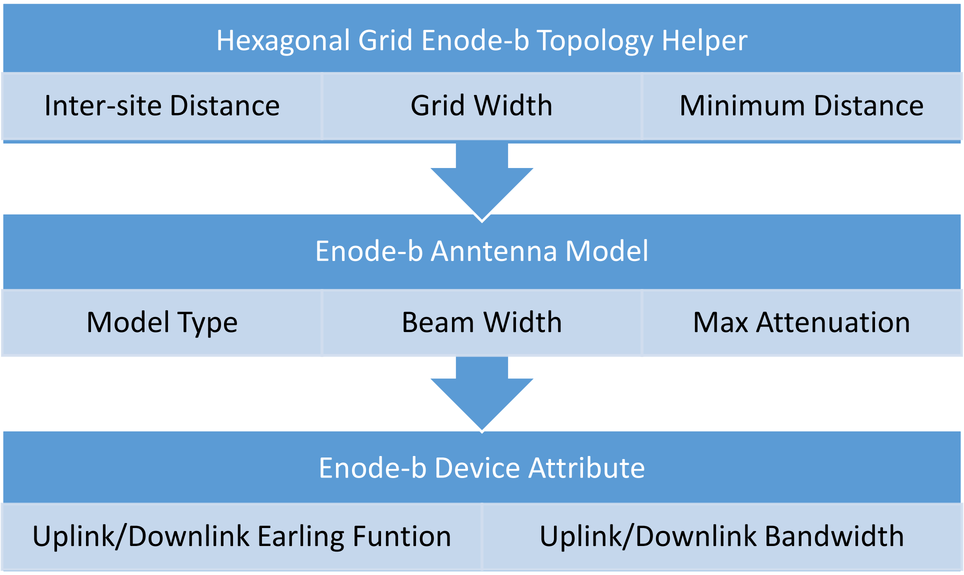

Figure 4.1(a) Macro Cell Creation

PARAMETER NAME	MACRO CELL
Cellular layout	14 three-sectored sites in hexagonal layout(42 cells in total)
Inter-site distance	500m
Minimum Distance	250m
Grid Width	14m
Cell Tx power	30 dBm
Enode b Antenna Model	Parabolic for sectored transmission
Beam Width	70
Maximum Attenuation	20
Downlink/Uplink Bandwidth	25 Resource Blocks
Path loss model	L = 128:1 + 37:6 log10 R Channel fading Typical urban
Carrier frequency	2 GHz
System bandwidth	5 MHz (25 RBs)
Error model	None

Table 4.1(b) Macro Cell Parameters

4.2 FEMTO CELL CREATION

The creation of femto cell is somewhat more complex in NS-3. Femto cells can exist independently and interact with femto-cell gateway to forward data and control plane traffic to EPC. However due to the nature of our project, we are interested in the interaction between femto-cell and macro-cell. For this reason, all femto-cells exist in the macro-cells. The femto-cell coverage is provided inside building and boundary effects on the UE is studied. These cells are called indoor femto cells or home eNode-b. There are also outdoor femto-cells but the interference with macro-cell has not been fully developed in NS-3.

We have placed 4 femto-cells inside each macro-cell. The positioning of the femto cells is along the boundary of the structure to make sure the radio interaction between these two different types of cells. This creates an interesting flow of traffic in two dimensions:

1. UEs moving along the boundary adjacent to the femto cell causing femto to macro cell handovers and vice-versa. Due to sake of simplicity, femto to femto handovers are not implemented in this project.
2. UEs inside the building away from the boundary creating traffic load on the femto cells. These UEs will generate radio failure when they access new femto cell and are not considered in our performance evaluation.

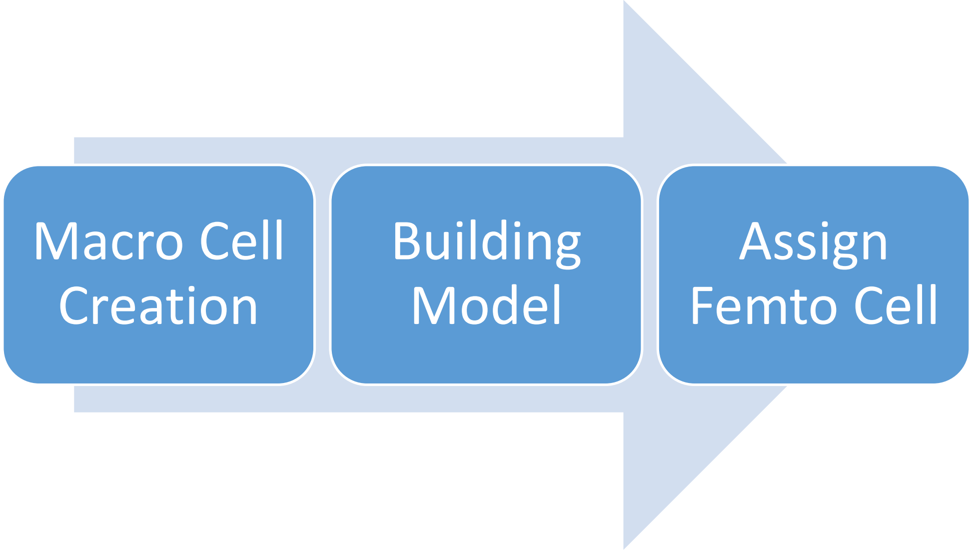

Figure 4.2(a) Femto Cell Creation

The Building Path-loss model is assigned to the structure which will accommodate for the loss of from the building walls. The type of material is also specified which creates an accurate loss model of the building. The length, width and height of the building are specified according to the requirements. After setting the exterior walls or boundaries, we can now position nodes with in the building. Each node can assigned a random pattern or designated path according to the requirements.

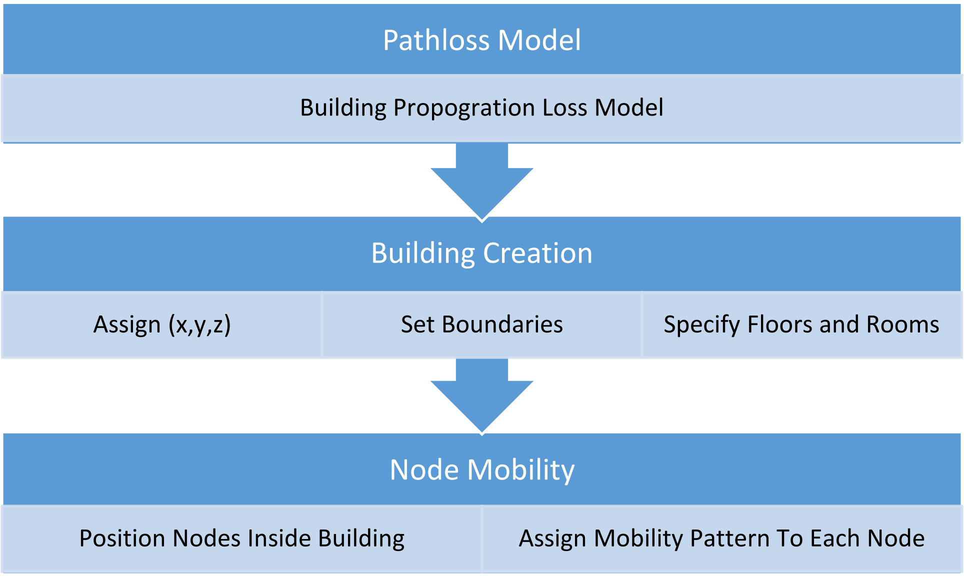

Figure 4.2(b) Building Creation

The femtocell creation involves changing the default transmitter power to 10 dB to decrease the coverage. The antenna type is isotropic so that the signals are spread evenly and all users have equal access. An important feature of the femto cells is the Close Subscriber Group Indicator. This indicates that since femto cells are used for indoor coverage, only limited number of users can access it. This feature can used for limit a single femto cell to only a certain group of subscribers. UEs in certain femto cell only belong to that particular closed subscriber group whereas the UEs in the boundary belong to all the femto cells' CSG.

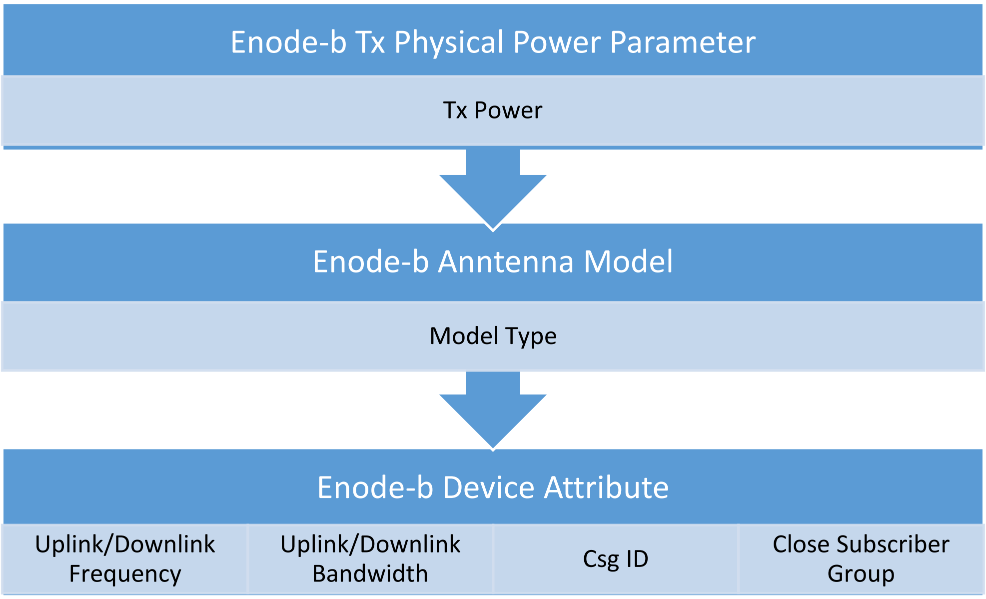

Figure 4.2(c) Femto-Cell Creation

The uplink and downlink frequency is the same as the macro cell to ensure close to real world radio environment. The Bandwidth is configured same as the macro-cell.

PARAMETER NAME	**FEMTO CELL**
Cellular layout	4 Femto Cells inside each Macro Cell
Inter-site distance	50m
Minimum Distance	250m
Grid Width	14m
Cell Tx power	10 dBm
Downlink/Uplink Bandwidth	25 Resource Blocks
Path loss model	Typical Indoor Propagation Model
Carrier frequency	2 GHz
Error model	None

Table 4.2(d) Femto-Cell Parameters

CHAPTER 5 HANDOVER ALGORITHM

5.1 SCENARIO CREATION

Our project consists of three distinct phases. First we have applied the velocity based algorithm to all three environments. We found out through analysis that this algorithm is most suited for Vehicular environment. Next we carried out the handover parametric study of pedestrian environment which is the most difficult scenario to optimize. Finally, we integrated the results from two previous analysis to form a novel algorithm. This novel algorithm has not been implemented in ns-3 yet but is proposed for future studies.

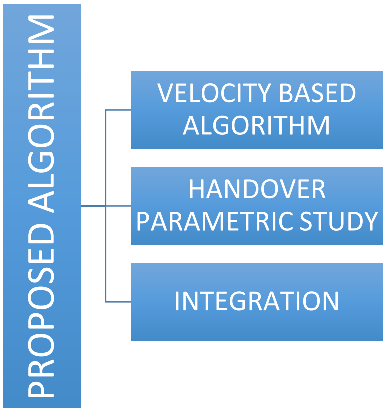

Figure 5.1(a) Handover Optimization

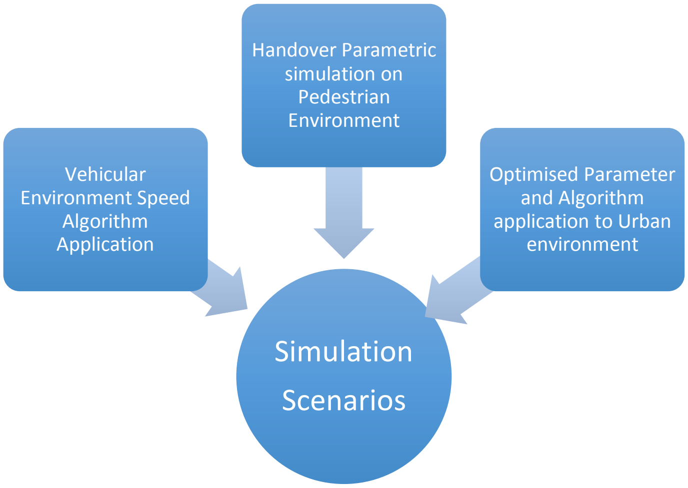

Figure 5.1(b) Simulation Scenarios

5.2 EFFICIENT ALGORITHM IMPLEMENTATION

The implemented algorithm defines speed as the cut-off point for RSRP based algorithm. A speed on 30km/h has been considered as high speed whereas less than 30 km/h and greater than 15km/h is considered medium speed and rest are all low speed users. The grouping of user based on speed determines a relationship between the speed of user and its effect on the performance of handovers. High-speed users passing through femto-cell environment usually have macro-cell coverage for the period they receive femto-cells radio coverage. But the increase in the RSRP is so momentary that before the UE establishes a connection, it normally has already passed the point of interest causing a secondary handover back to the macro-cell. This give rise to increasing number of ping-pong handovers and thus degrade the system performance.

This algorithm works very well in the vehicular environment which consists of dense and clustered high speed mobile UEs. The algorithm efficiently reduces the lateral radio signal fluctuation from macro-cells to femto-cells. It is also to be noted that if UE starts from femto-cell and moves to macro-cell, a radio failure is bound to happen due to no handover policy, this can be imagined as a mobile UE in the car park of a building and accelerate to the road. However, these complex cases can be further explored in the future studies.
The algorithm starts when the handover trigger conditions are met: RSRP threshold, RSRQ threshold, trigger time are within the handover limits.

The eNodeb gets the UE speed through Doppler shift to start the decision process. If the speed cannot be determined, the handover process is halted and it then awaits for a new trigger. After determining the UE speed, algorithm checks the maximum cell capacity to make sure that the cell capacity is not being exceeded. In the latter case where the cell is congested, eNodeb does not trigger handover and process is completed.

After making sure that the cell capacity has not exceeded the maximum allowable limit, the handover makes decision based on UE velocity. If the UE's speed is greater than 30 km/h, no handover is initiated and process is completed.If the UE speed is less than 30 km/h, the algorithm then determines whether the user is using a real time application. It can determined either by using the QCI or the traffic behavior in averaging window.

If the UE application is real time, then the handover process is initiated else no handover takes place. This algorithm is strictly applicable to vehicular environment and all UEs are assumed to be above at least 15 km/h.

5.3 FLOW CHART

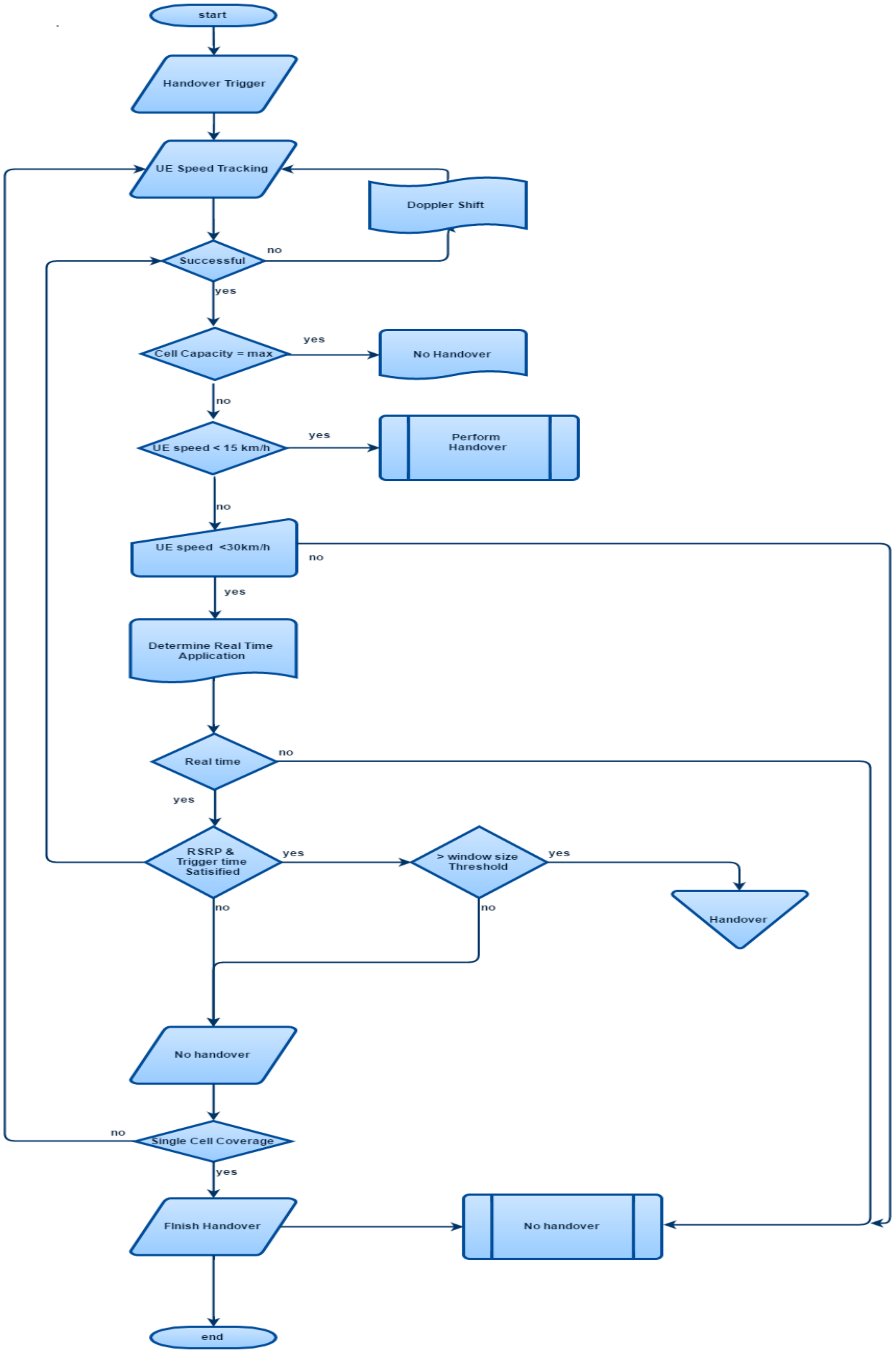

Figure 5.3(a) Flow Chart

CHAPTER 6 PARAMETRIC HANDOVER STUDY

6.1 HANDOVER PARAMETERS

We have chosen three distinct optimizable parameters that we will apply to the pedestrian environment.

1. Hysteresis Threshold
2. Trigger Time
3. Averaging Window Size.

Hysteresis Threshold:

This threshold gives us the difference between the reported RSRP of serving cell and target cell. When the target cell reported RSRP becomes better than serving cell by this threshold, a handover can be initiated. If this parameter has a very large value it will cause a lot of radio link failures. On the other hand, a small value can cause a massive increase in the handovers.

Trigger Time:

The trigger time specifies the period when Hysteresis threshold condition is met and handover decision is not taken. This time makes sure that no un-necessary handovers have taken place if the UEs are along the boundary or temporarily affected by the radio coverage. Fast moving UEs can have small values for efficient handover trigger whereas the pedestrian walking with less than 4 km/h need to have large handover trigger values to avoid ping pong handovers.

Averaging Window Size:

This parameter specifies the time period in which the RSRP measurements are averaged to make a decision based on continuous decrease in radio power rather than a momentarily spike in the radio power. This parameter is instrumental in making handover decision. It is noted that large window size reduces the number of handovers.

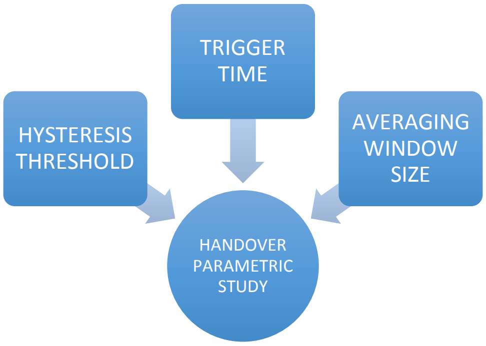

Figure 6.1(a) Parametric Handover

CHAPTER 7 MOBILITY MODEL

The Mobility model divides the user based on their movement patters including speed, direction, area of movement, frequency of random direction change. We have divided the mobility model according to the type of environment and scenario. There are currently three different scenarios namely vehicular, pedestrian and urban. Each environment is made up of both indoor and outdoor traffic to make it more realistic. However, each environment is dominated by certain type of mobile UEs. The average speed gives us good estimate of type of UEs we are dealing with.

The Vehicular environment consists of high speed vehicular traffic which is evident by the outdoor traffic percentage. The movement of mobile UEs is clustered to induce handover along the radio coverage boundary and study the effect of the ping-pong handover.

The pedestrian traffic consists of slow moving indoor and outdoor traffic. The traffic is configured to move along the edge randomly. It simulates a scenario similar to huge people concentration along a busy intersection.

Finally, the urban traffic consists of addition of both of these traffics as described earlier to create a real world scenario. The percentage of both indoor and outdoor traffic is close to 50%.

PARAMETER NAME	VEHICULAR		PEDESTRIAN		URBAN	
UE Type	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor
UE average speed	38 km/h	5 km/h	10 km/h	4 km/h	24 km/h	4 km/h
UE direction	Coverage Edge	Random Indoor	Random Edge	Random Indoor	Random	Random
Direction Change	5s	3s	5s	3s	Random	Random
UE type percentage	80%	20%	60%	40%	45%	55%
UE distribution	Cluster	Random	Cluster	Random	Random	Random
UE movement pattern	Random	Indoor path	Random	Indoor path	Random	Random
UE Min. Speed	25 km/h	2 km/h	2 km/h	2 km/h	15 km/h	0
UE Max. Speed	60 km/h	7 km/h	20 km/h	7 km/h	60 km/h	6 km/h

Table 7(a) Mobility Model

CHAPTER 8 TRAFFIC MODEL

We have simulated real time application and non-real time applications to check the algorithm consistency. Video over TCP is one such example of continuous real-time traffic. We have considered both small packet and busty traffic in non-real time application. This type of traffics has been assigned to random users to check the cumulative affect on handover performance and create realistic bandwidth and delay in the system.

PARAMETER NAME	**UDP**	**TCP**	**TCP**
Application Type	udp echo server	Voice CBR	Bulk Send Application
Real Time	No	Yes	No
Description	Ping server	VoIP	Send Max Bytes
QCI	No	3	No
Start time	0.0	0.0	0.0
End time	1200	1200	1200
Interval	No	No	Burst traffic Reset 60s
Bandwidth	Available	EPC Guaranteed bit rate	Maximum available bit rate

Table 8(a) Traffic Model

CHAPTER 9 RESULTS AND ANALYSIS

9.1 OBSERVATIONS

Observation 1:

The application of speed based handover algorithm greatly increases the system efficiency reducing the ping pong handovers.

Observation 2:

User Experience is minimally degraded for vehicular environment by radio link failure if the user is using a non-real time application and adversely if real time application is in use.

Observation 3:

Clustered users give us better results than isolated users in handover performance improvement.

Observation 4:

Handover parametric study gives us different results for vehicular and pedestrian environment.

Observation 5:

A high value of time to trigger gives less handover for pedestrian environment but does not significantly increase in radio link failures. Contrary to pedestrian environment, vehicular environment results in high number of radio link failures as the value of time of trigger is increased.

Observation 6:

A large of threshold hysteresis decreases the number of ping pong handover and results in the overall better performance.

Observation 7:

A large value of Window averaging results in the decrease of number of handovers in both pedestrian and vehicular environment. However, the radio link failures rise sharply in vehicular environment.

9.2 DATA TABLES

Scenario 1 VEHICULAR ENVIRONMENT:

Handover performance comparison for High Speed Users with algorithm implementation:

No of Handovers per user per second in 60s time intervals	No of Handovers per user per second using efficient Algorithm in 60s time intervals
0.6	0.3
0.7	0.32
0.55	0.29
0.61	0.24
0.56	0.21
0.72	0.35
0.65	0.31
0.44	0.23
0.42	0.2
0.53	0.24
0.65	0.31
0.77	0.31
0.7	0.36
0.65	0.37
0.66	0.34
0.76	0.32
0.78	0.33
0.74	0.37
0.72	0.39

Table 9.2(a)

RSRP trace of a mobile user moving between femto and macro-cell:

Cell1 macrocell	Cell2 femtocell
-92	-105
-91	-107
-94	-106
-95	-104
-90	-105

-93	-106
-90	-102
-97	-103
-101	-100
-106	-98
-103	-97
-102	-96
-102	-92
-101	-95
-104	-93
-106	-94
-103	-91
-105	-92
-107	-91
-106	-90
-104	-92
-105	-95
-103	-94
-104	-97
-102	-99
-103	-96
-101	-99
-98	-100
-99	-101
-96	-102
-94	-103
-95	-104

Table 9.2(b)

Radio Link Failure Percentage:

Simulation Interval	Radio Link Failures Percentage
60	0.1
120	0.26
180	0.24
240	0.23
300	0.21
360	0.27
420	0.25
480	0.12
540	0.11
600	0.14

660	0.1
720	0.12
780	0.1
840	0.13
900	0.11
960	0.13
1020	0.12
1080	0.18
1140	0.13
1200	0.12

Table 9.2(c)

Scenario 2 PEDESTRIAN ENVIRONMENT:

Time to trigger effect on Handover:

Interval	Time to trigger=200 ms	Time to trigger=400 ms
60	0.312	0.17
120	0.234	0.189
180	0.237	0.153
240	0.32	0.182
300	0.24	0.154
360	0.36	0.116
420	0.212	0.164
480	0.24	0.139
540	0.26	0.118
600	0.24	0.126
660	0.339	0.181
720	0.24	0.135
780	0.3	0.176
840	0.19	0.185
900	0.24	0.153
960	0.255	0.151
1020	0.35	0.143
1080	0.2	0.165
1140	0.235	0.128

Table 9.2(d)

Hysteresis Threshold effect on Handover:

Time Interval	Hys=1 db	Hys=3 db	Hys=6 db
60	0.49	0.17	0.05
120	0.51	0.189	0.0189
180	0.43	0.153	0.0153
240	0.45	0.182	0.0182
300	0.39	0.154	0.0154
360	0.37	0.116	0.0116
420	0.47	0.164	0.0164
480	0.39	0.139	0.0139
540	0.42	0.118	0.0118
600	0.43	0.126	0.0126
660	0.36	0.181	0.0181
720	0.48	0.135	0.0135
780	0.423	0.176	0.0176
840	0.378	0.185	0.0185
900	0.39	0.153	0.0153
960	0.426	0.151	0.0151
1020	0.476	0.143	0.0143
1080	0.465	0.165	0.0165
1140	0.421	0.128	0.0128

Table 9.2(e)

Sliding Averaging Window size effect on Handover:

Time Interval	Sliding Window size = 200ms	Sliding Window size = 400ms
60	0.49	0.21
120	0.51	0.23
180	0.43	0.18
240	0.45	0.22
300	0.39	0.19
360	0.37	0.22
420	0.47	0.21
480	0.39	0.23
540	0.42	0.18
600	0.43	0.21
660	0.36	0.25
720	0.48	0.18
780	0.423	0.27

840	0.378	0.26
900	0.39	0.15
960	0.426	0.19
1020	0.476	0.26
1080	0.465	0.18
1140	0.421	0.18

Table 9.2(f)

Radio Link Failure Percentages:

Simulation Interval	Radio Link Failures Percentage
60	0.4
120	0.36
180	0.44
240	0.48
300	0.49
360	0.39
420	0.45
480	0.32
540	0.42
600	0.39
660	0.35
720	0.34
780	0.48
840	0.39
900	0.46
960	0.43
1020	0.5
1080	0.48
1140	0.43
1200	0.42

Table 9.2(g)

Scenario 3 URBAN ENVIRONMENT:

Handover per user and Radio Link Failures:

Simulation Interval	Handover per user per interval	Radio Link Failures %
60	0.29	0.31
120	0.21	0.36
180	0.33	0.24
240	0.35	0.21
300	0.39	0.23
360	0.37	0.21
420	0.27	0.25
480	0.29	0.22
540	0.32	0.32
600	0.33	0.39
660	0.36	0.35
720	0.38	0.34
780	0.33	0.38
840	0.378	0.35
900	0.39	0.36
960	0.26	0.23
1020	0.26	0.21
1080	0.25	0.38
1140	0.21	0.33
1200	0.21	0.32

Table 9.2(h)

9.3 GRAPHS

Scenario 1 VEHICULAR ENVIRONMENT:

1). Handover Comparison:

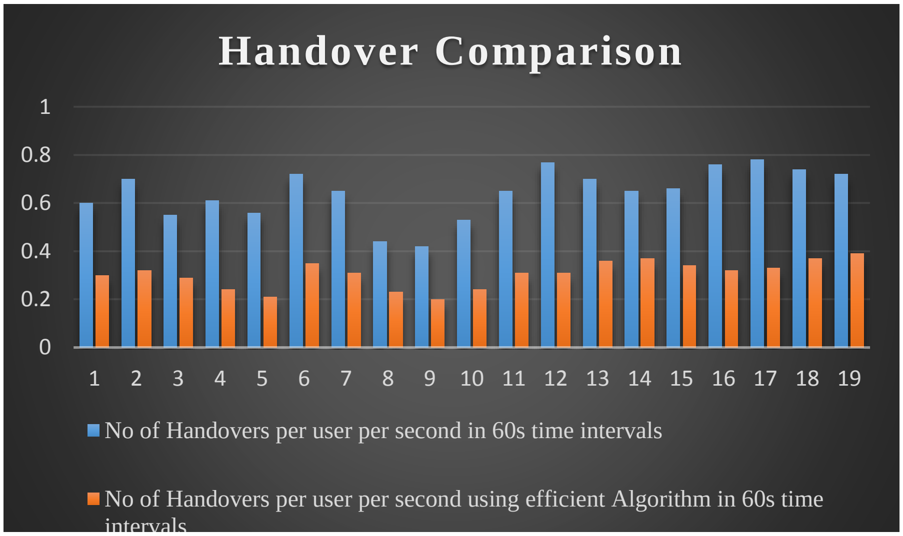

Figure 9.3(a)

2). RSRP trace of a high speed user:

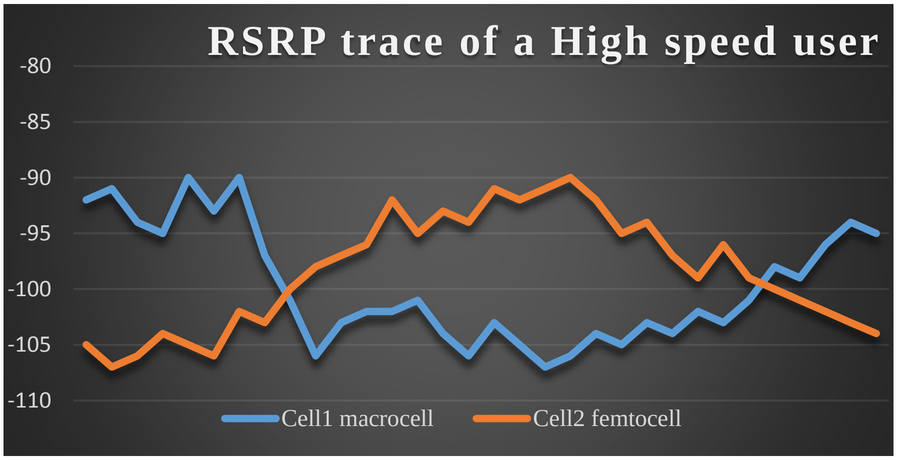

Figure 9.3(b)

3). Radio Link Failure Percentage:

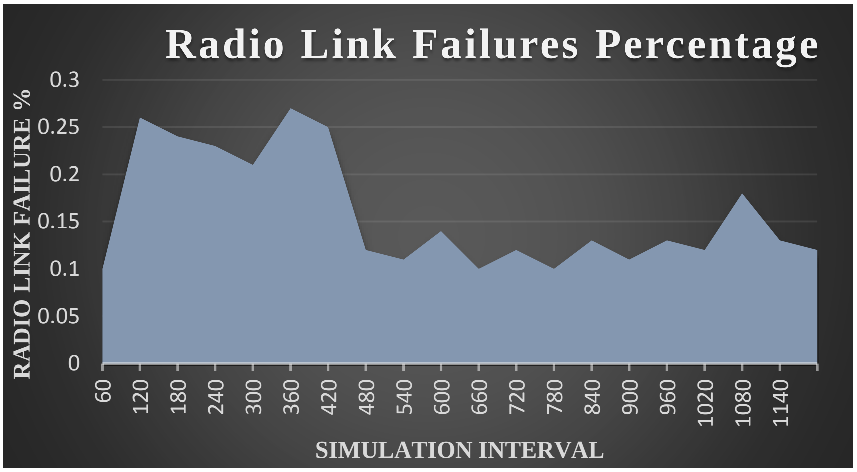

Figure 9.3(c)

Scenario 2 PEDESTRIAN ENVIRONMENT:

1. Time to Trigger:

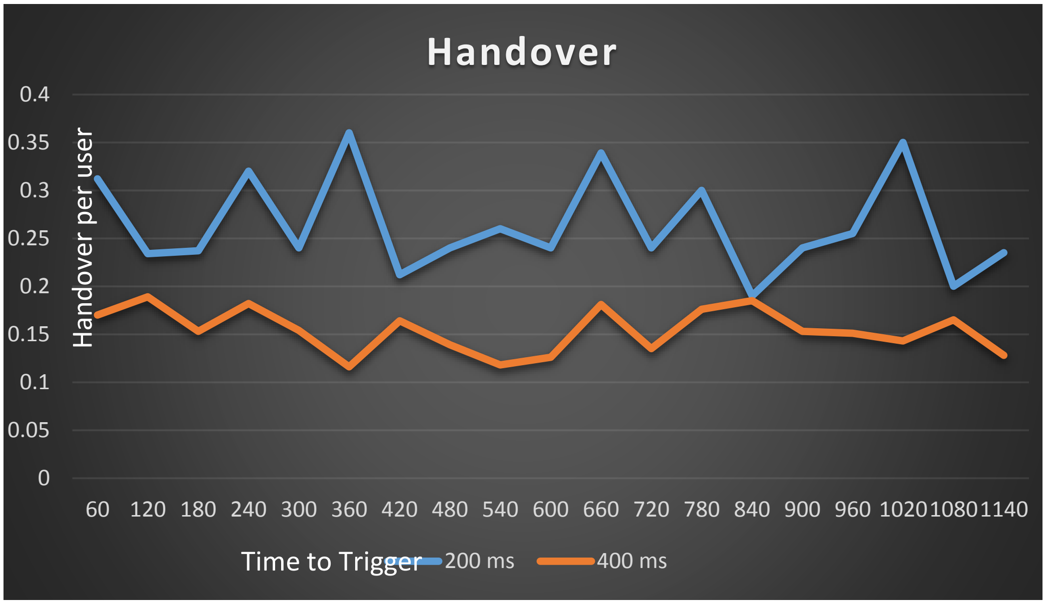

Figure 9.3(d)

2. Hysteresis Threshold:

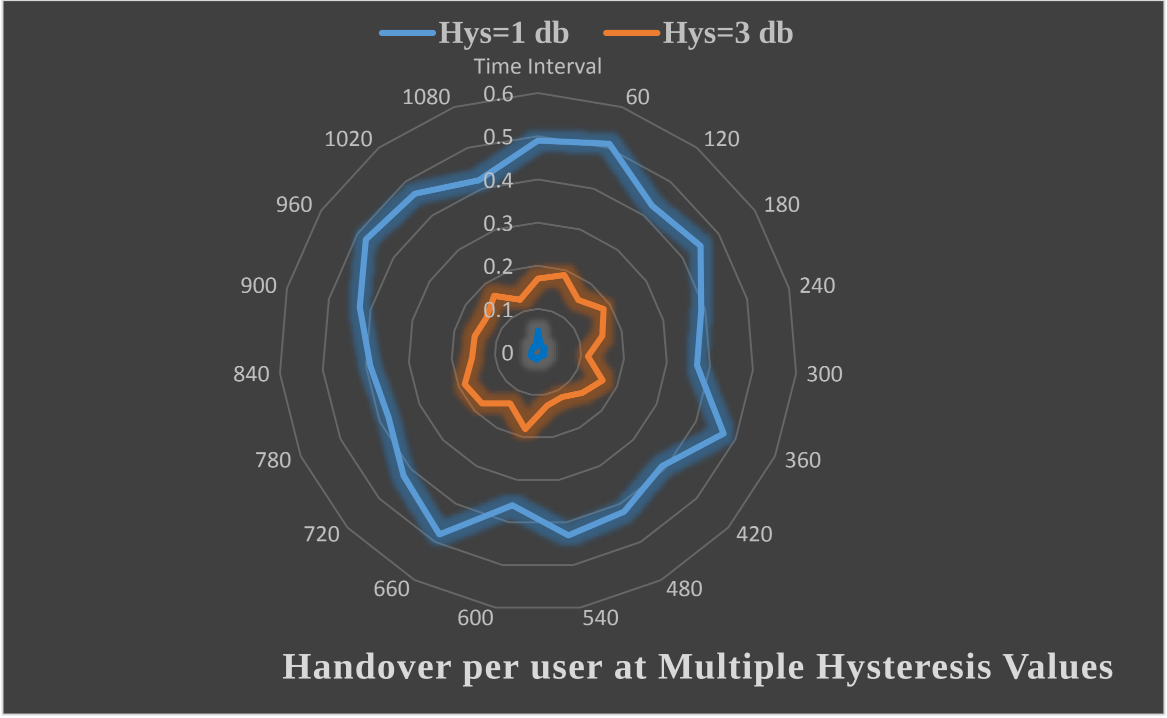

Figure 9.3(e)

3. Averaging Window Size:

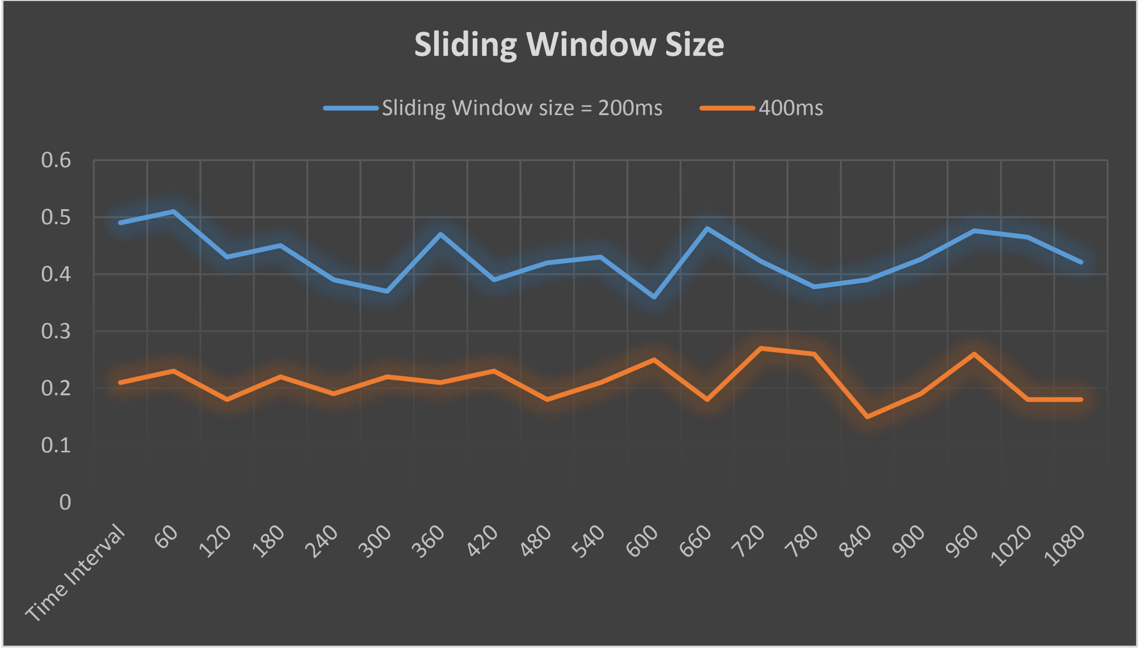

Figure 9.3(f)

4. Radio Link Failures:

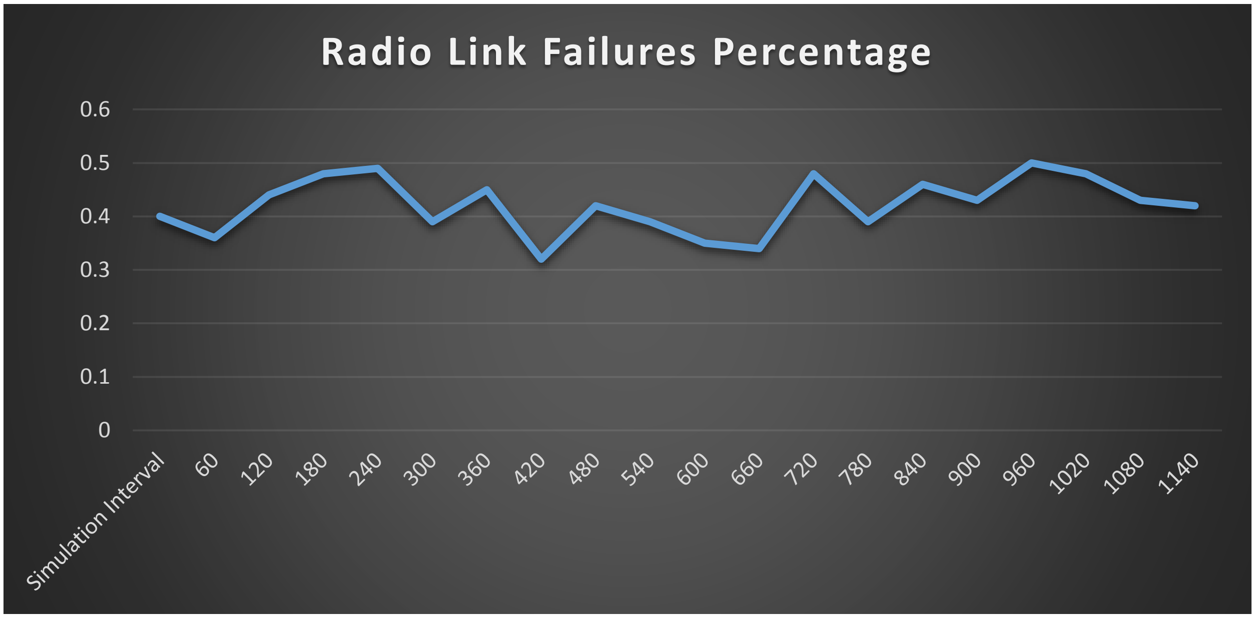

Figure 9.3(g)

Scenario 3 URBAN ENVIRONMENT:

1). Integrated Graph for urban environment:

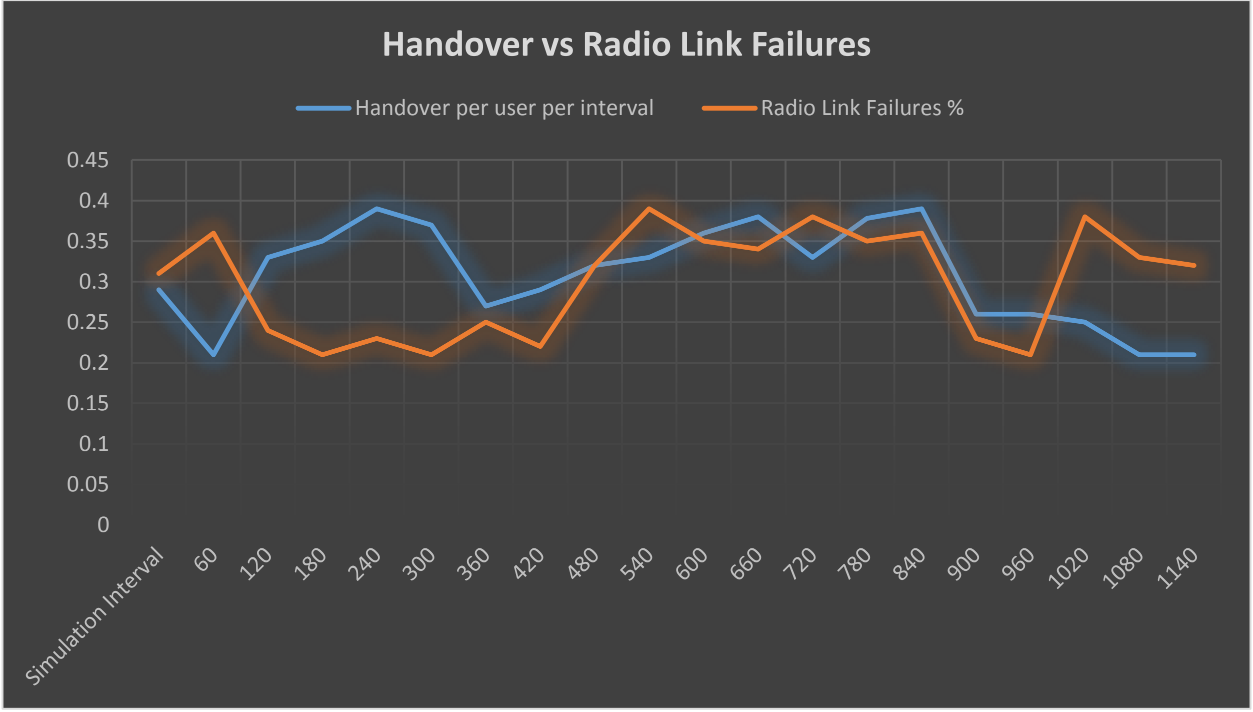

Figure 9.3(g)

CHAPTER 10

NOVEL ALGORITHM PROPOSAL

- Let Tv and Tp be the trigger time for the vehicular and pedestrian environment.
- Let Wv and Wp be the sliding window averaging for the vehicular and pedestrian environment.
- Alpha and Beta represent the fraction of UEs’ moving with less and more than 30 km/h respectively.
- ‘e’ represents the error during the previous computation.
- Ts and Ws represent the stable values of trigger time and window averaging respectively.
- Ti and Wi represent the indicated values of the above mentioned parameters.
- Pp is defined as the function of ping pong handovers and pedestrian traffic. All handover between same Ues’ within 2 seconds are determined as ping pong.
- Pv is defined as the function of ping pong handovers and vehicular traffic.
- For every averaging interval,
  Determine
  Ti=alpha*Tp+Beta*Tv-e*Ti
  Wi=alpha*Wp+Beta*Wv-e*Wi
- Error ‘e’= (Pp*alpha+Pv*beta)/Total Handovers e is positive if more errors are caused by vehicular traffic and negative otherwise.

CHAPTER 11 CONCLUSION

We have implemented the speed based algorithm for vehicular environment and completed a handover parametric study with promising results. In the end, we have combined the two different approaches to optimize the existing algorithm for handover between femto and macro-cell. There is still a lot to be done in this field, but an efficient handover algorithm is necessary for the advancement of the next generation of technology. Our limitation included the ns-3 simulator among others as certain LTE features are not supported. We have also had to simplify the problem so that semester based project could be completed in time since the project is extremely complicated.

RELATED WORK

(1). B.Herman, D.Petrov, J.Puttonen and J.Kurjenniemi, “A3-Based Measurements and Handover Model for NS-3 LTE”, Mobility 3rd Conference on Mobile Services, Resources and Users, 2013.

(2). A.Ulvan, R.Bestak and M.Ulvan, “Handover Scenario and Procedure in LTE-based Femtocell Networks”, The Fourth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, 2010.

[3] U. Dampage and C. Wavegedara, "A low-latency and energy efficient forward handover scheme for LTE-femtocell networks," IEEE 8th International Conference on Industrial and Information Systems, 2013.

[4] A. Rath and S. Panwar, "Fast handover in cellular networks with femtocells," 2012 IEEE International Conference on Communications (ICC), 2012.

FUTURE WORK

- Neural network based algorithm can be developed for self-optimizing network.
- Doppler shift can be implemented for calculating the velocity on the e-node b level.
- Femto to femto handover can be further explored which has been out of the scope of this project.
- User-user communication is also an emerging handover algorithm which can be efficient.
- Application layer traffic can be changed to focus the studies more on the impact of type of traffic and handover.

REFERENCES

[1] U. Dampage and C. Wavegedara, "A low-latency and energy efficient forward handover scheme for LTE-femtocell networks," IEEE 8th International Conference on Industrial and Information Systems, 2013.
[2] C. Lee and J. Kim, "System Information Acquisition Schemes for Fast Scanning of Femtocells in 3GPP LTE Networks," IEEE Communications Letters, vol. 17, no. 1, pp. 131- 134, 2013.
[3] A. Rath and S. Panwar, "Fast handover in cellular networks with femtocells," 2012 IEEE International Conference on Communications (ICC), 2012.
[4] I. Shayea, M. Ismail and R. Nordin, "Advanced handover techniques in LTE- Advanced system," International Conference on Computer and Communication Engineering (ICCCE), 2012.
[5] M. Lee and S. K. Oh, "Fast handover scheme using handover notification with no acknowledgement," 2011 IEEE MTT-S International Microwave Workshop Series on Intelligent Radio for Future Personal Terminals, 2011.
[6] Y. Wang, W. Peng, X. Qui, "Automated Handover Optimization Mechanism for LTE Femtocells" 7th International ICST Conference on Communications and Networking in China (CHINACOM), 2012
[7] C. Lin, K. Sandrasegaran, H. Ramli, R. Basukala, "Optimized Performance Evaluation Of LTE Hard Handover Algorithm With Average RSRP Constraint" International Journal of Wireless & Mobile Networks (IJWMN) Vol. 3, No. 2, April 2011
[8] LTE Network Architecture. Retrieved, from
http://www.tutorialspoint.com/lte/lte_network_architecture.htm
[9] H. Lee and Y. Lin, "A cache scheme for femtocell reselection," IEEE Commununication Letter, vol. 14, no. 1, pp. 27–29, 2010.
[10] J. Moon and D. Cho, "Efficient handoff algorithm for inbound mobility in hierarchical macro/femto cell networks," IEEE Communication Letter, vol. 13, no. 10, pp. 755–757, 2009.
[11] E. Dahlman, "LTE 3G Long Term Evolution," Expert Radio Access Technologies Ericsson Research, March 27, 2007.
[12] Z. Naizheng and J. Wigard,," On the Performance of Integrator Handover Algorithm in LTE Networks," in Proc. IEEE Vehicular Technology Conference. (VTC), pp. 1-5, 2008.
[13] I. Shayea et al,"Advanced handover techniques in LTE- Advanced system," in Proc. International Conference. on Computer and Communication. Engineering, pp.74-79, 2012.
[14] A. Rath et al., "Fast handover in cellular networks with femtocells," in Proc. 2012 IEEE International. Conference on Commununication. (ICC), pp. 2752-2757, June 2012.
[15] M.S. Shbat and V.Tuzlukov, "Handover technique between femtocells in LTE network using collaborative approach," in Proc. Asia-Pacific Conf. on Commun. (APCC), pp. 61-66, 2012.
[16] V. Chandrasekhar, "Femtocell networks: a survey," IEEE Commun.Mag., vol. 46, pp. 59-67, Sept 2008.
[17] C. Jiming, et al," Adaptive soft frequency reuse scheme for inbuilding dense femtocell networks," China Commun., vol. 10, no.1, pp. 44-55, 2013.
[18] K. Ivanov, G. Spring, 'Mobile speed sensitive handover in a mixed cell environment'. Vehicular Technology Conference, July 1995, vol. 2, pp. 892–896

[19] W. Luo, X. Fang, M. Cheng, X. Zhou, ‘‘an optimized handover trigger scheme in LTE systems for high-speed railway’’. Signal Design and its Applications in Communications (IWSDA), October 2011, pp. 193–196
[20] P. Legg, G. Hui, J. Johansson, “A simulation study of LTE intra-frequency handover performance”. Vehicular Technology Conference Fall (VTC), September 2010, pp. 1–5.
[21] LENA ns-3 Retrieved, from *http://www.nsnam.com*

APPENDIX

Code Listing

```
if (ue->GetVelocity < ue_min_threshold)
{
        RSRP

else if (ue->GetVelocity < ue_max_threshold)
{
        if(Real_Application)
                {
                        RSRP}

        Else
                 {
                        noop}
}}
if (ue->GetVelocity > ue_max_threshold)
        {
        noop}


//KPIs

If(Handover_Notify)
{
  Hand_success++
}
else
{
Radio_link_error++
}
If (Ts==60)
{
Hand_60(i)=Hand_success;
}
Hand_per_UE=Hand_60/Total_UE;
```