ENSC 833: NETWORK PROTOCOLS AND PERFORMANCE

FINAL PROJECT PRESENTATION
SPRING 2016

EFFICIENT HANDOVER IMPLEMENTATION IN LTE-BASED FEMTO-CELL ENVIRONMENT

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OVERVIEW

- **Introduction**
  - Project overview
  - LTE
  - Femto Cells
  - Types of handover
- **Implementation of proposed algorithm**
  - Handover Algorithm
  - Handover Parameters
  - Results
- **Discussion**
- **References**

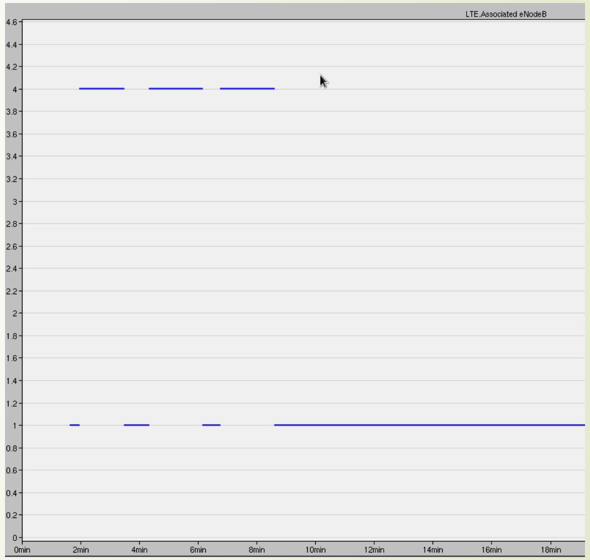
INTRODUCTION

PROJECT OVERVIEW

- Proposed algorithm is to be implemented in an LTE based femtocell environment
- Femtocells have low cost and power requirement, and relatively small coverage area. Typically private owned and deployed indoors
- Ping-pong effect usually more frequent femtocells largely due to its small coverage area
- Handover of interest is User Equipment's (UEs) moving between femtocells and macrocells
- Proposed algorithm aims to reduce frequent ping-pong handover using occurring at the boundary of the cell
- User Equipment's (UEs) that are candidates for handover are categorised first based on their speed
- UEs within a certain speed range are given priority for handover depending on the type of service

PING-PONG EFFECT

- Ping-pong is common phenomenon which occurs as result of unnecessary handovers and can reduce the system efficiency by as far as 40%.
- Our aim is to eliminate this problem in high speed Vehicular/medium speed traffic environment.



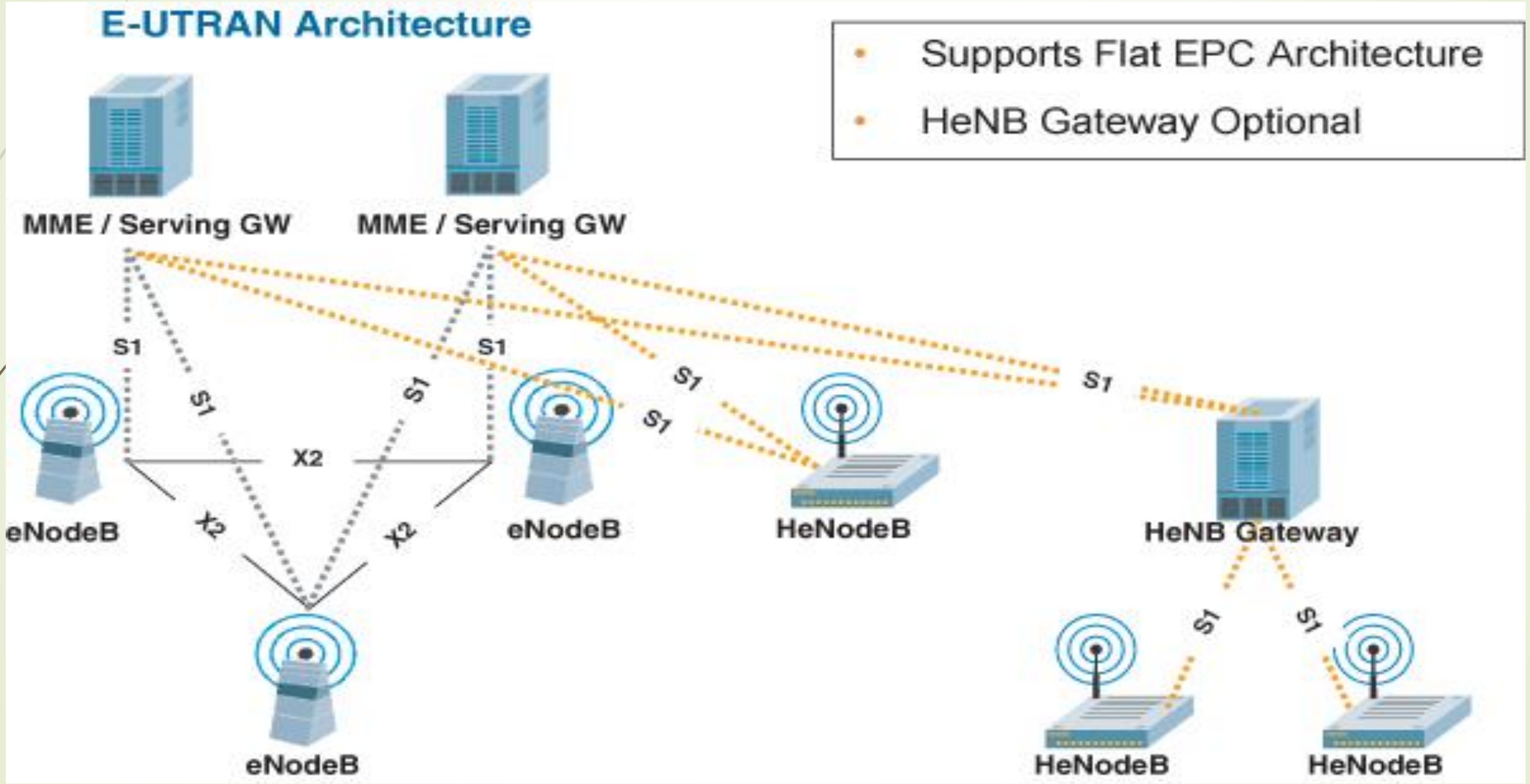
WHAT IS LTE ?

- LTE (Long-Term Evolution , commonly marketed as 4G LTE) is a standard for wireless communication of high-speed data for mobile phones and data terminals.
- It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements.
- The standard is developed by the 3GPP (3rd Generation Partnership Project) and is specified in its Release 8 document series, with minor enhancements described in Release 9.

FEMTO-CELL OVERVIEW

- Femto-cells are defined as the low power cells that are normally used for indoor radio reception.
- They are normally part of macro-cells.
- 5G technologies are currently in the process of using millimeter wave and would deploy femto-cells in commercial environment.
- Our decision to study femto-cells stem from the fact that they part an important part of next generation networks.

FEMTO CELL ARCHITECTURE



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HANDOVER IN LTE

- X2 Handover

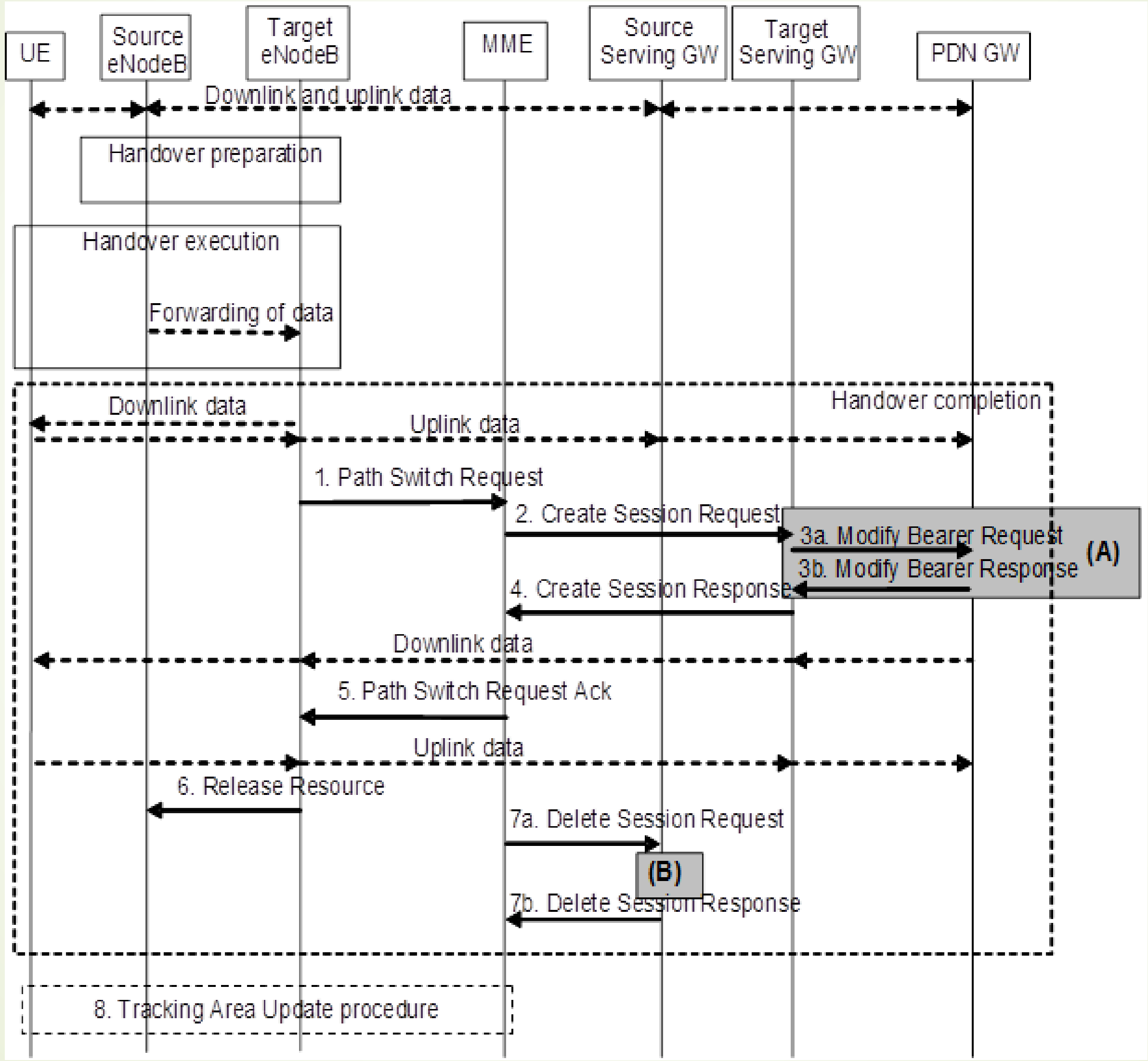
This type of handover occurs between two macro cells belonging to the same Core network. X-2 interface exists between the two e-nodeB.

- S1 Handover

This type of handover occurs between macro cells belonging to the different core networks. It flows through the core network instead of the radio network.

  - *S1 handover is implemented between femtocells and macrocells as communication between macrocells (eNB) and femtocells (HeNB) are routed via the core network and not through the X2-interface (direct communication)*

S-1 BASED HANDOVER



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IMPLEMENTATION

LENA HANDOVER ALGORITHMS

- **RSRP Algorithm**

Reference Signal Received Power (RSRP), is defined as the linear average over the power contributions (in [W]) of the resource elements that carry cell-specific reference signals within the considered measurement frequency bandwidth.
For RSRP determination the cell-specific reference signals R0 according TS 36.211 [3] shall be used. If the UE can reliably detect that R1 is available it may use R1 in addition to R0 to determine RSRP.

- **RSRQ Algorithm**

Reference Signal Received Quality (RSRQ) is defined as the ratio N×RSRP/(E-UTRA carrier RSSI), where N is the number of RB's of the E-UTRA carrier RSSI measurement bandwidth. The measurements in the numerator and denominator shall be made over the same set of resource blocks.

- **Noop Algorithm**

No handover algorithm.

Base LENA configuration

- **Soft Frequency Reuse**

In Soft Frequency Reuse (SFR) scheme each eNb transmits over the entire system bandwidth, but there are two sub-bands, within UEs are served with different power level. Since cell-center UEs share the bandwidth with neighboring cells, they usually transmit at lower power level than the cell-edge UEs. SFR is more bandwidth efficient than Strict FR, because it uses entire system bandwidth, but it also results in more interference to both cell interior and edge users.

- **Proportional Fair Mac Scheduler**

The Proportional Fair (PF) scheduling supports high resource utilization while maintaining good fairness among network flows. A user is likely to be scheduled when its instantaneous channel quality is high relative to its own average channel condition over time

FEMTO CELL CREATION IN NS-3

Macro-cell

- Create a standard Macro cell

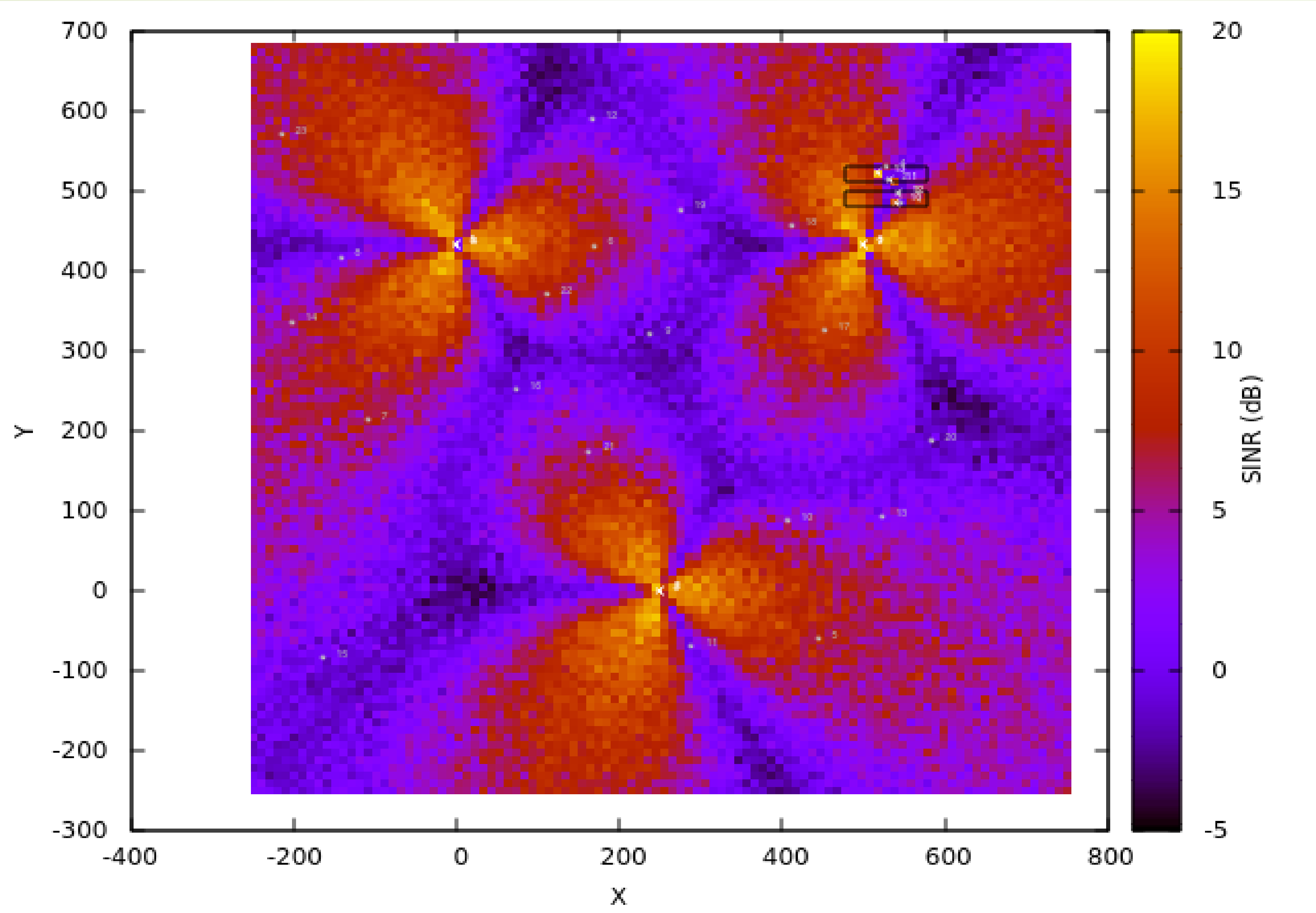
Assign Building Block

- Use building size equal to femto cell area

Place Femto Cell Transmitter

- Isotropic antenna, Building loss model, Fading model, low power

RADIO ENVIRONMENT MAP



- The radio environment map shows three distinct macro cells, each having three sectors.
- The box shows the building covered by the femto cells.

CELL PARAMETER SELECTION

PARAMETER NAME	MACRO CELL	FEMTO CELL
Cellular layout	14 three-sectored sites in hexagonal layout(42 cells in total)	Single Cell (4 Placed inside each Macro cell)
Inter-site distance	500m	50m
Cell Tx power	30 dBm	10 dBm
Path loss model	L = 128:1 + 37:6 log10 R Channel fading Typical urban	Indoor propagation model with fading
Carrier frequency	2 GHz	2 GHz
System bandwidth	5 MHz (25 RBs)	5 MHz (25 RBs)
Error model	None	None
UE distribution	14 UEs distributed randomly in front of each eNodeB (588 UEs in total)	6 in each femto cell
UE measurement interval	25 ms	25 ms
Simulation duration	1200 s	1200 s

MOBILITY PARAMETER SELECTION

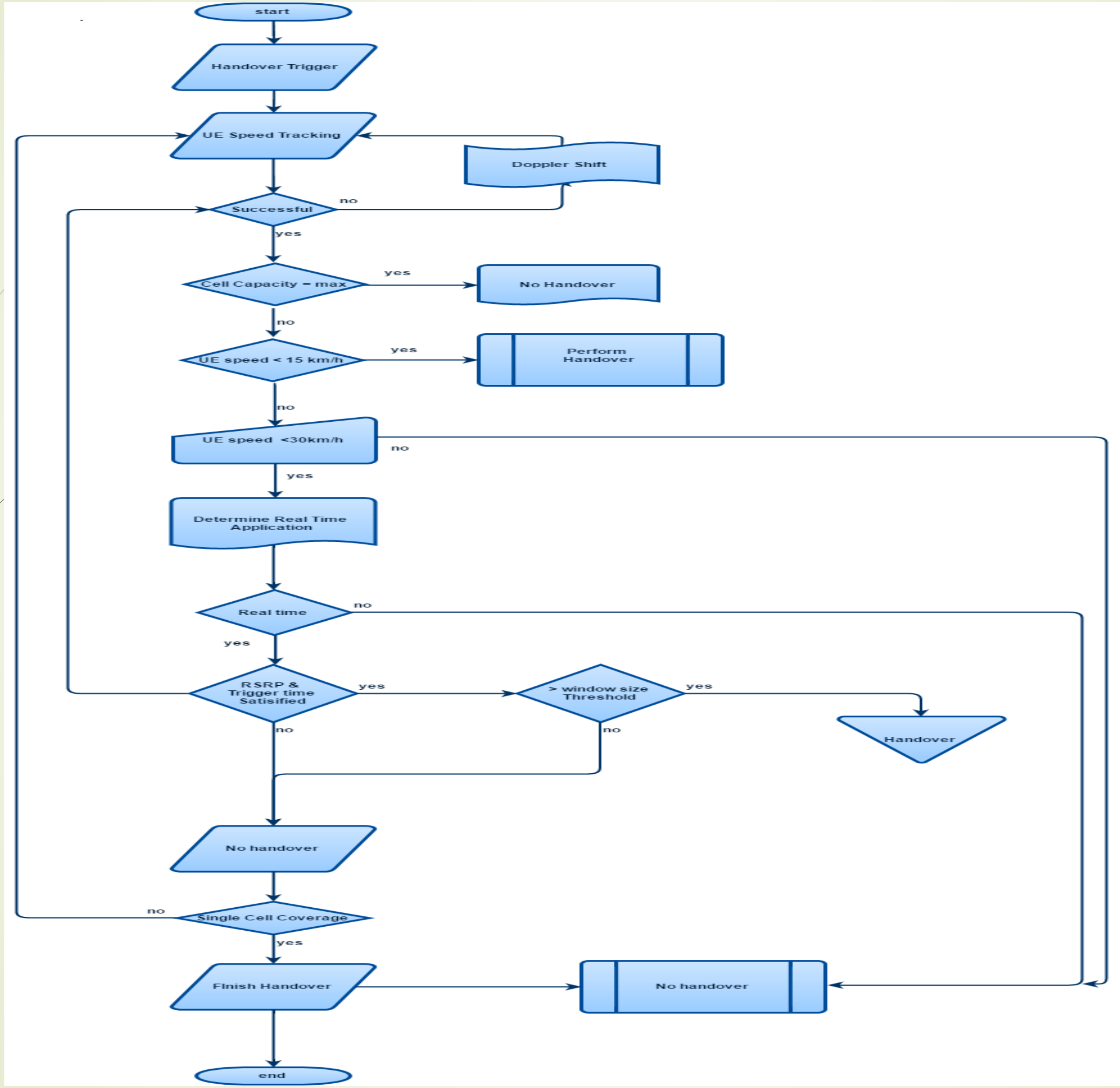
PARAMETER NAME	VEHICULAR		PEDESTRIAN		URBAN	
UE Type	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor
UE average speed	38 km/h	5 km/h	10 km/h	4 km/h	24 km/h	4 km/h
UE direction	Coverage Edge	Random Indoor	Random Edge	Random Indoor	Random	Random
Direction Change	5s	3s	5s	3s	Random	Random
UE type percentage	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

TRAFFIC MODELING

PARAMETER NAME	UDP	TCP	TCP
Application Type	udp echo server	Voice Constant bit rate	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

PSEUDO CODE

```
Initialization
Check for handover trigger conditions.
If(Handover threshold satisfied)
{Track the mobile speed using the Doppler shift
        If(UE Speed is determined)
                { if !(Cell Max capacity)
                        {
                                If (UE Speed < 15km/h)
                                        {Perform handover
                                                {else if (UE Speed <=30km/h)
                                                        Determine whether the application is real time
                                                        If(Real Application)
                                                 { Perform handover}
                                                         else {no handover}}}
                                If(UE Speed > 30km/h)
                                { no handover }
                    }
                else { no handover}}}
```


start
Handover Trigger
UE Speed Tracking
Doppler Shift
Successful
no
yes
Cell Capacity = max
yes
No Handover
no
UE speed < 15 km/h
yes
Perform Handover
no
UE speed <30km/h
no
yes
Determine Real Time Application
Real time
no
yes
RSRP & Trigger time Satisified
yes
> window size Threshold
yes
Handover
no
no
No handover
no
Single Cell Coverage
yes
Finish Handover
No handover
end

SIMULATION SCENARIOS

- **Scenario 1:**

Apply the algorithm to the vehicular environment.

- **Scenario 2:**

Determine the effect of different handover parameters in the pedestrian environment.

- **Scenario 2(a):**

Analyze the effect of Time to trigger on the handover performance.

- **Scenario 2(b):**

Analyze the effect of Threshold hysteresis on the number of handover.

- **Scenario 2(c):**

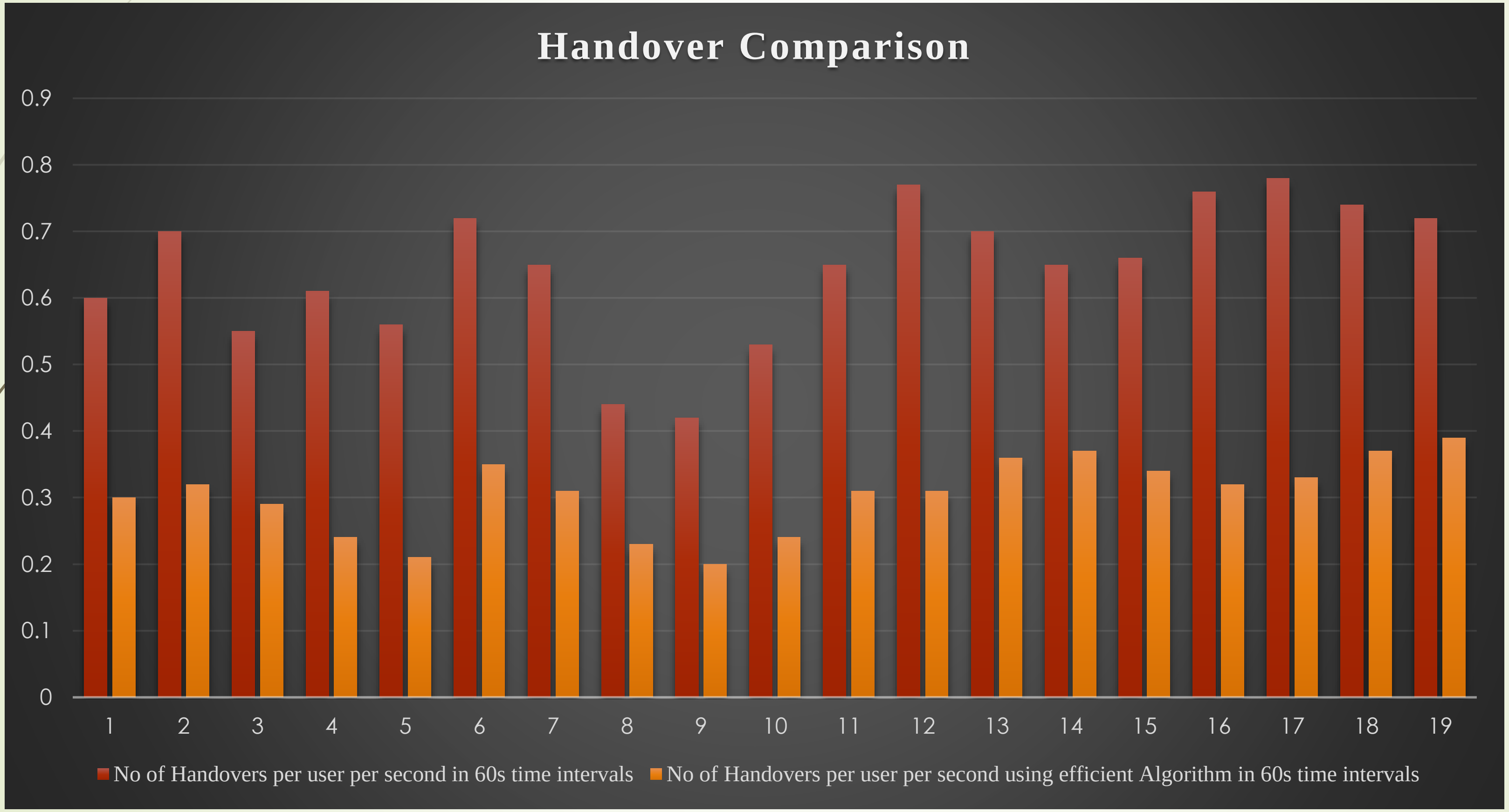
Analyze the effect of window interval on the handover performance.

- **Scenario 3:**

Apply the optimized parameters and algorithm to the urban environment and analyze the results.

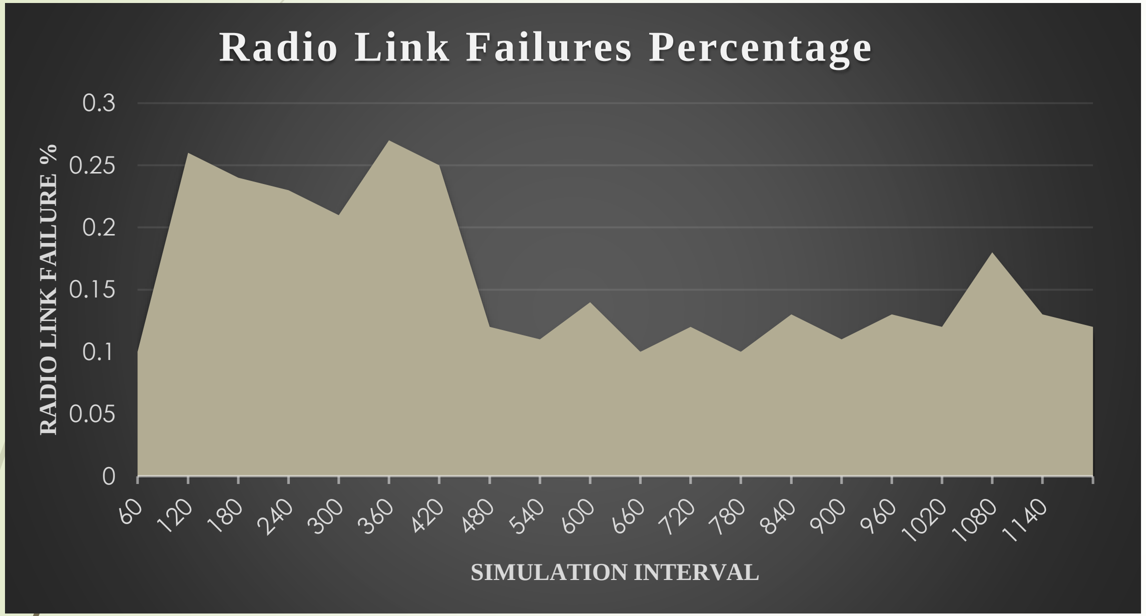
1.VEHICULAR ENVIRONMENT

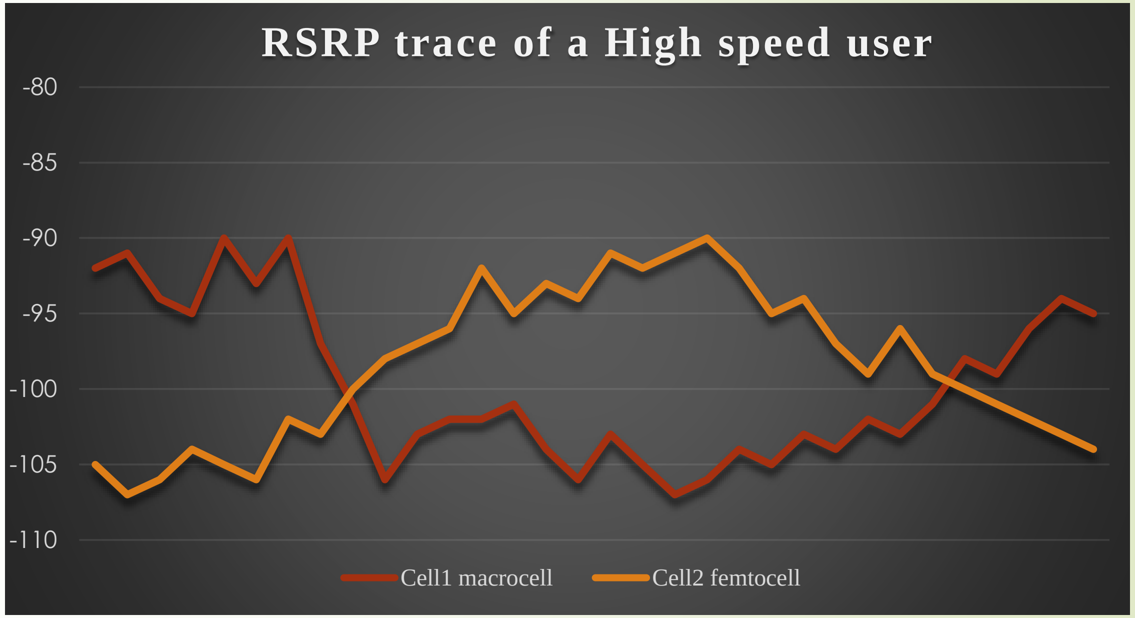
a). Handover Comparison using algorithm



- The graph shows that per user handover decreases considerably for high speed users using our implemented algorithm. The performance improvement is almost 40 percent.

b). Radio link Statistics

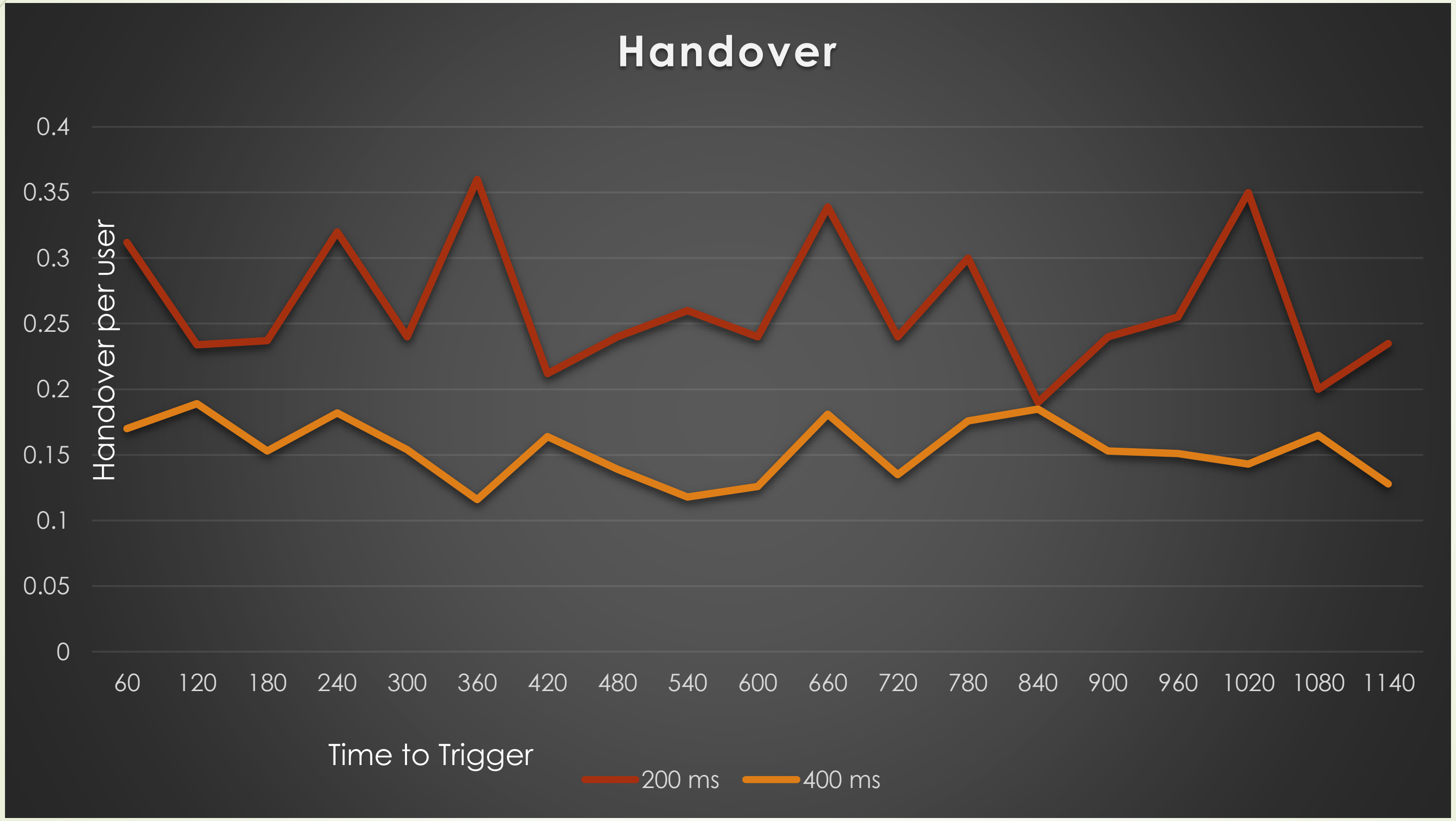




- The radio failure percentage is limited to 0.25 percent which shows a lot of users are still able to receive good radio reception of the macro cells when they are crossing the boundary.
- The second graph shows the SINR trace of a single high speed user. This shows that the user though has degraded experience for a few seconds is able to continue normal service. Since, there is no handover the user is continually scanning for radio signals from both eNodeb and Home eNodeb.

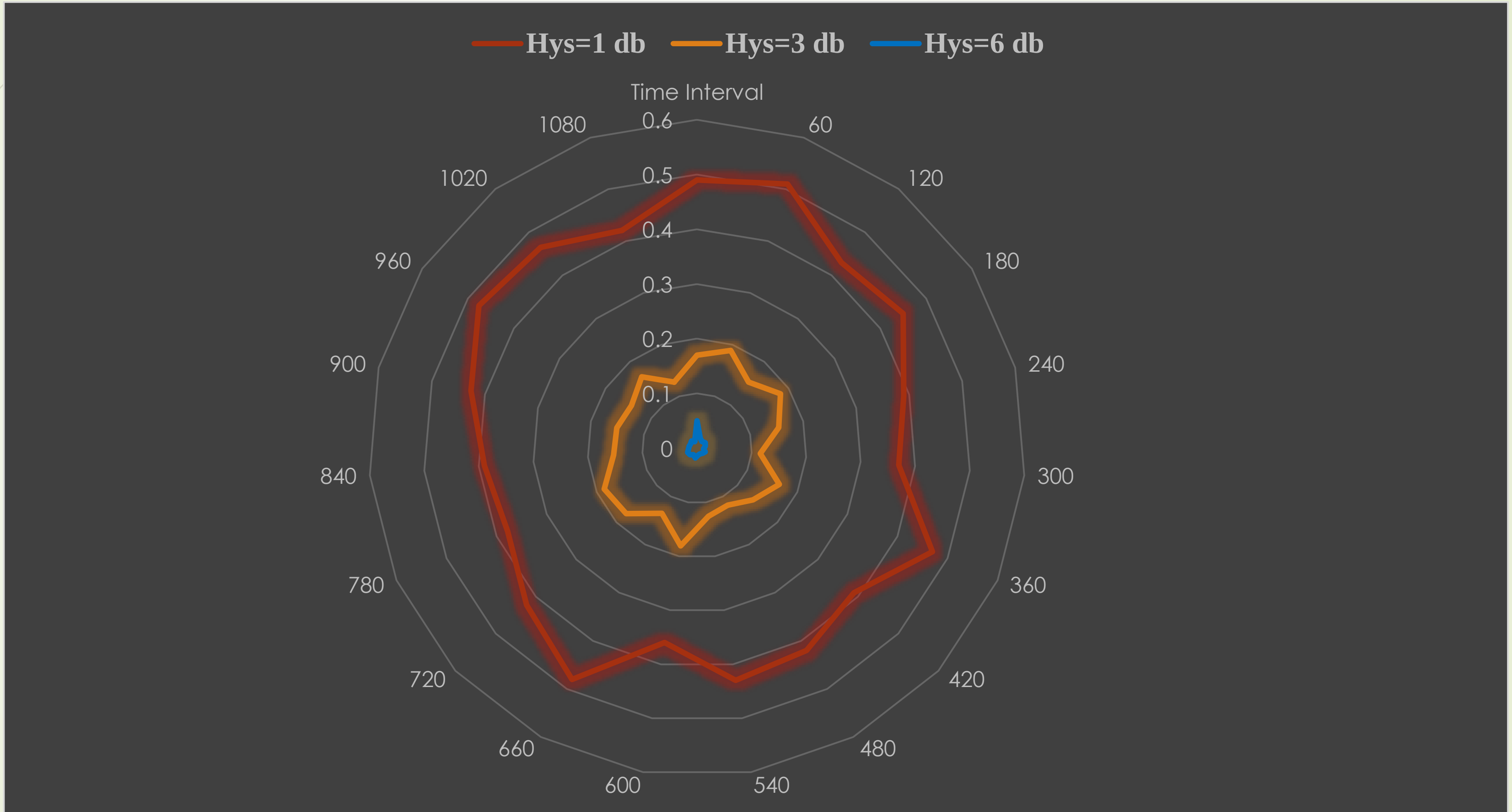
2.PEDESTRIAN ENVIRONMENT

a). Time to Trigger



- The graph shows that per user handover decreases considerably for pedestrian traffic when the time to trigger is increased, as the eNodeb takes more time to initiate handover procedure once the UE increases the offset threshold

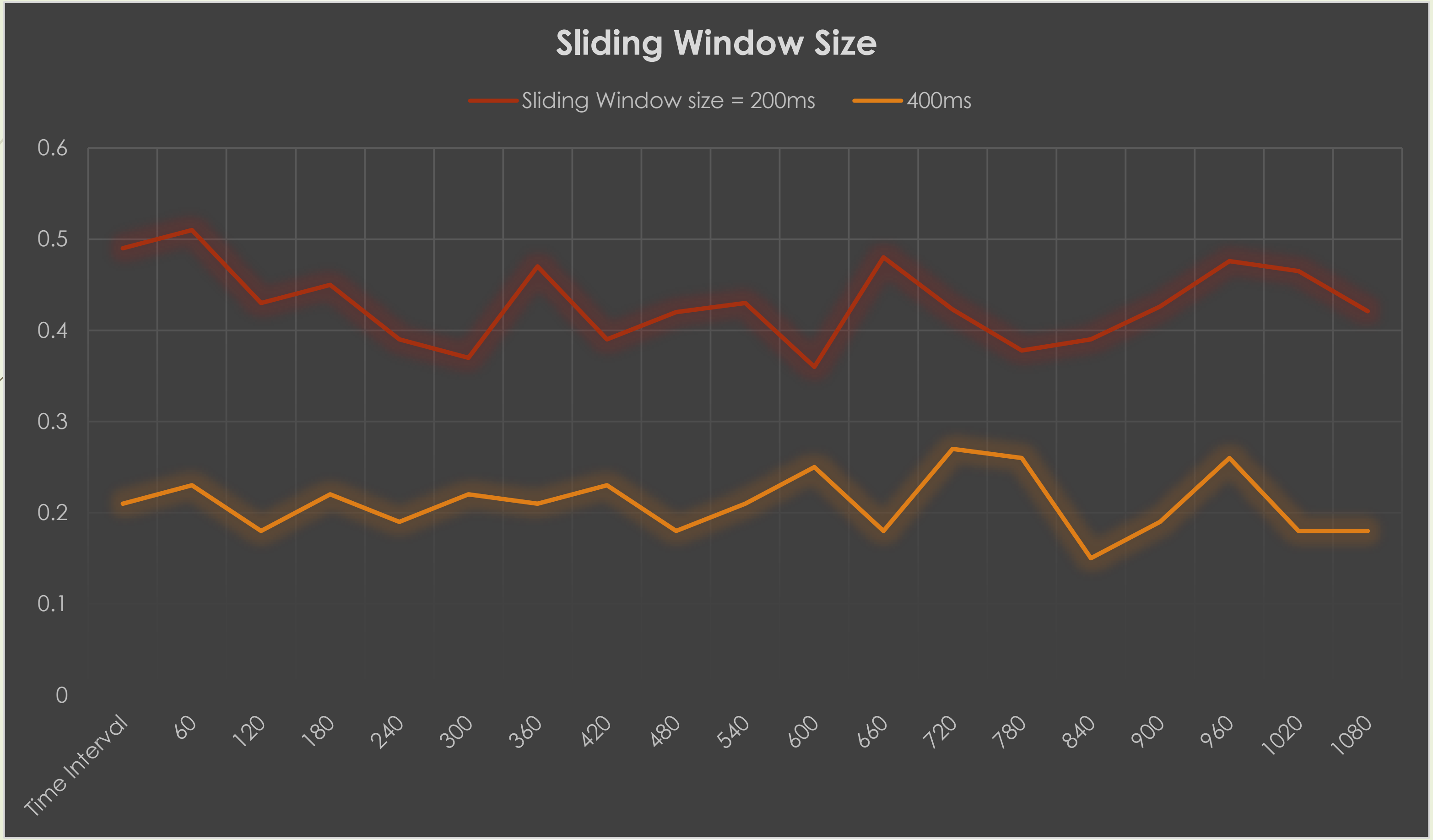
b). Handover Hysteresis



Handover per user at Multiple Hysteresis Values

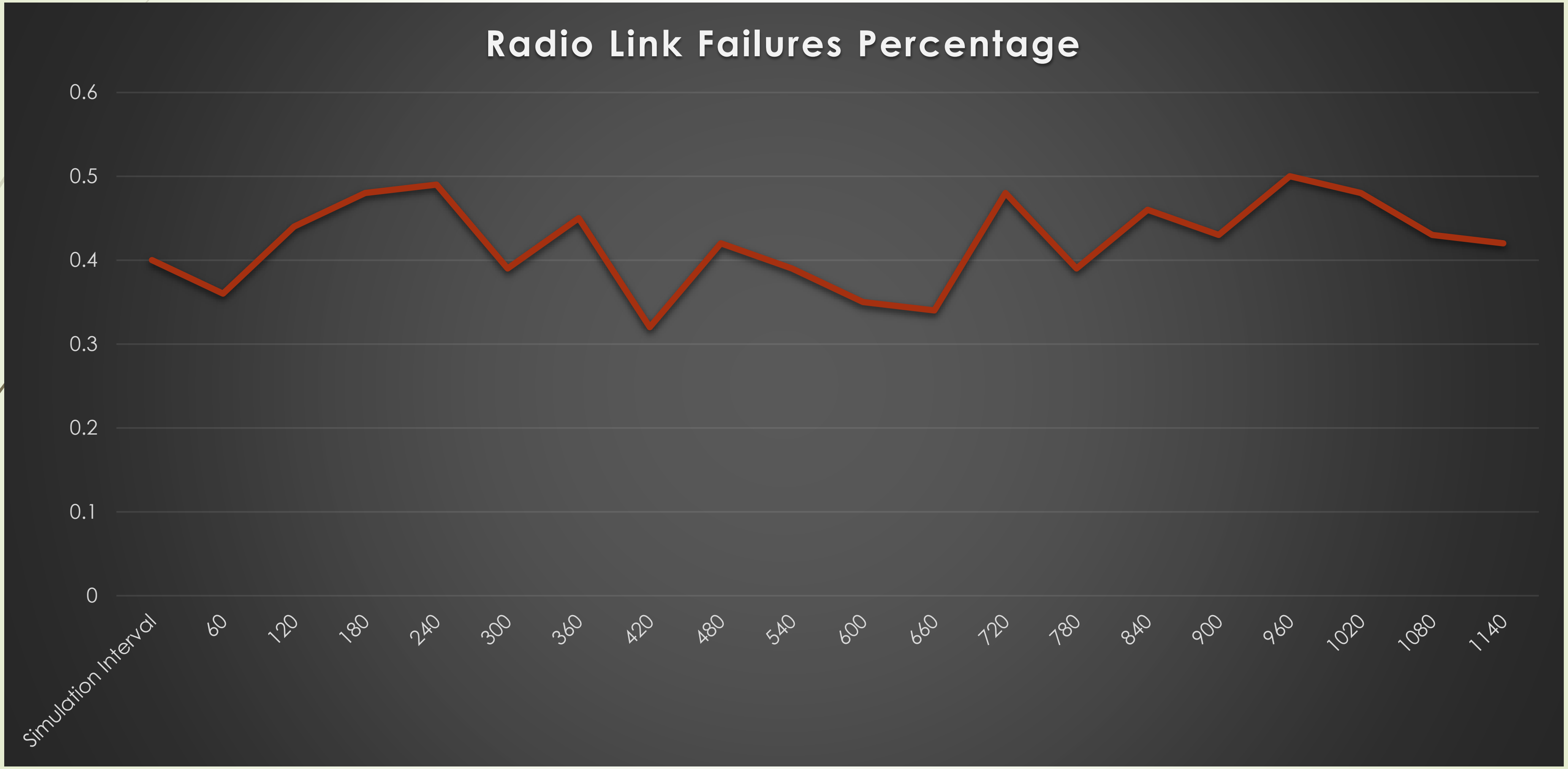
- Increasing the threshold hysteresis decreases the overall number of handovers. However, this may results in more radio failures and performance degradation.

c). Window Size



- The graph shows that sliding window has a positive effect in decreasing the number of ping pong handovers. The sliding window is the time period where eNodeb averages the user power measurements to make a decision on handover.

RADIO LINK FAILURES FOR WORST CASE



3.URBAN ENVIRONMENT

a). Handover Parameter Calculation

- Urban radio network is a combination of vehicular and pedestrian environment.
- Determine the value of optimized handover parameters on the basis of the preceding environment behavior.
- Hysteresis = 3db. The optimized value for choosing the handover threshold.
- Window size = a x W(ped)+b x W(veh)

whereas W(ped) corresponds to sliding window value for pedestrian environment. W(veh) corresponds to the value of the parameter in the vehicular environment.

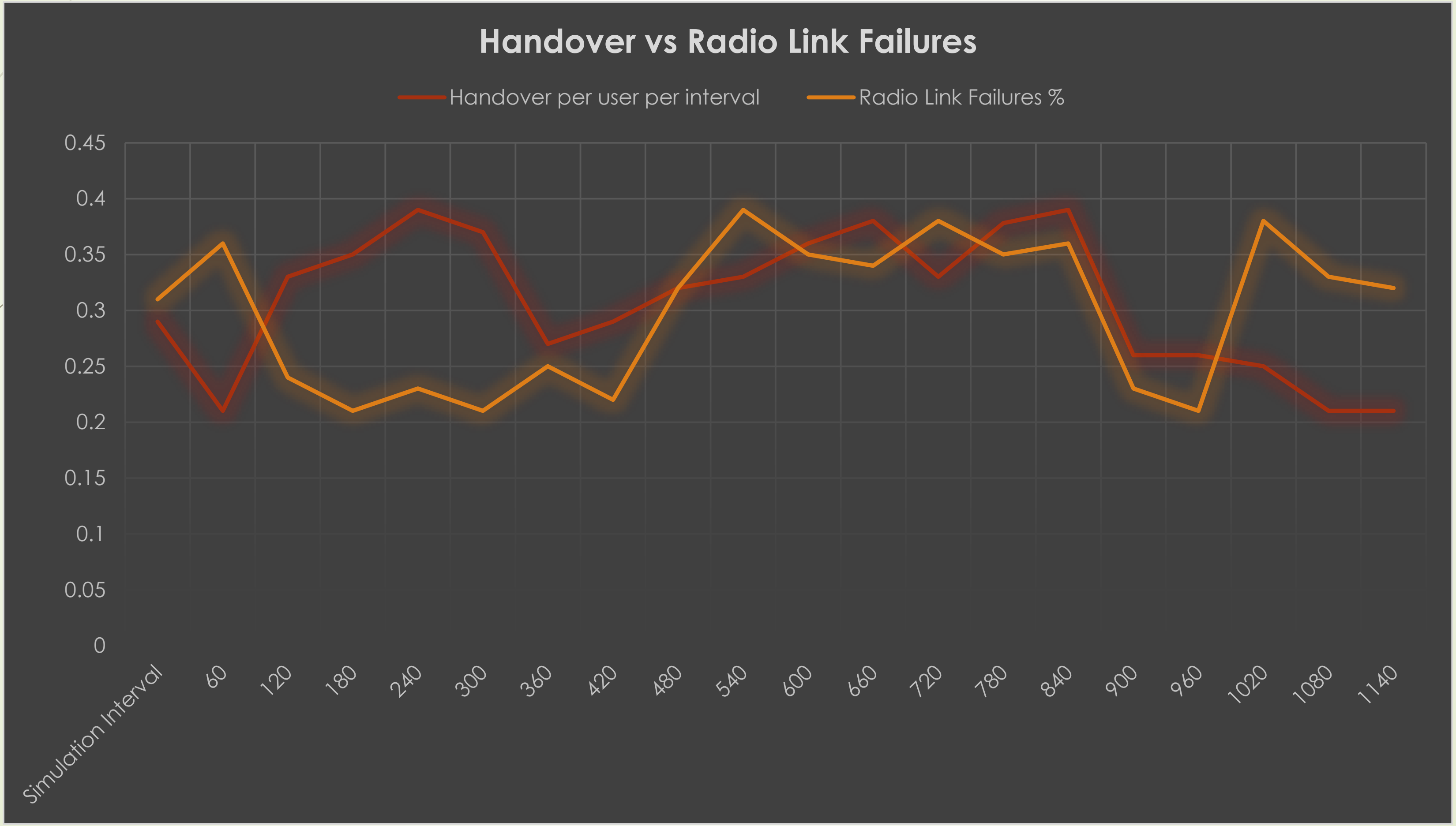
- Trigger time = a x T(ped)+b x T(veh).

whereas T(ped) corresponds to handover trigger timer value for pedestrian environment. T(veh) corresponds to the value of the parameter in the vehicular environment.

a and b are the fraction of UEs' in the pedestrian and vehicular environment.

We will choose W=300 ms and T= 300ms.

b). Handover Performance evaluation



- The graph shows that the radio link failures do not exceed our benchmark of 0.5%.

CONCLUSION

- We have finished the detailed modeling using vehicular and pedestrian environment and combining them both to form urban environment. It has given us insights on the radio behavior.
- We demonstrated that proposed handover algorithm is efficient in reducing unnecessary handovers
- The proposed algorithm had radio link failure rate of less than 0.3%
- The categorization of network users based on speed and type of traffic reduced the amount of resources reduces the number of handovers while having minimal impact on quality of service
- Every urban environment can be modeled as the combination of the vehicular and the pedestrian environment.
- The optimization of the handover can be done by following the step by step approach.
- High Speed vehicles passing through the boundary of femto-macro cell has still enough radio coverage to continue service reception.

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.

FUTURE RECOMMENDATIONS

- Neural network based algorithm can be developed for self optimizing network.
- Doppler shift can be implemented for calculating the velocity on the e-nodeb level.
- Femto to femto handover can be further explored which has been our 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.

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QUESTIONS ?