Performance Evaluation of Mobile Devices in LTE (Long Term Evolution) during handover

ENSC 833 NETWORK PROTOCOLS AND PERFORMANCE

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TEAM #2

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Outline

- Introduction
- Background and Overview of LTE
- Modeler Model and Test beds
- Simulation Results:
  - Handover Delay
  - EPS Bearer Throughput, EPS Bearer Delay
- Results and Conclusion
- Future Work
- References

Introduction

LTE

- Low-cost, extremely fast, efficient, and intelligent communication network
- Communication so far was about people talking to people, now Internet of Things!
- Switchover to LTE from 3G is as simple as remote software upgrade

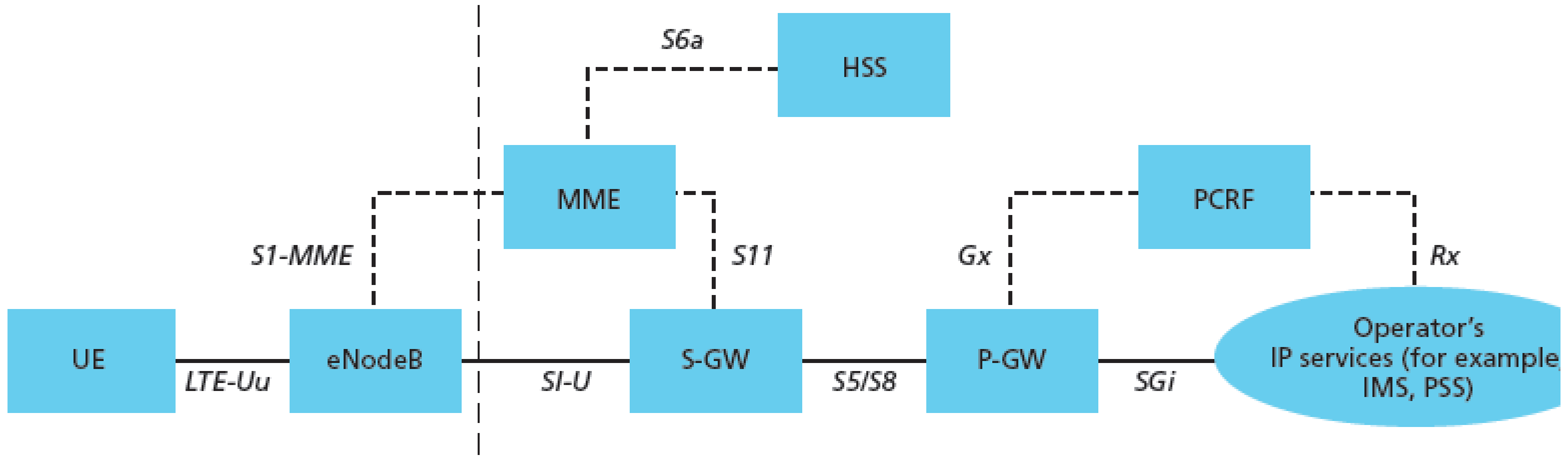
GOAL

The goal of the project is to evaluate the performance of mobile devices (UE's) during handover given different traffic types (QoS); type of handover based on interface and mobility of the UE at the downlink of LTE-Uu inteface. The observed parameters are handover delay, EPS bearer throughput, EPS bearer delay and other throughput related parameters for VoLTE, Video Conferencing, and HTTP Web TV.

Background

- L. Zhang, T. Okamawari, T. Fujii, "Performance evaluation of TCP and UDP during LTE handover"
  - performance evaluation for intra-frequency handover for TCP and UDP while varying A3-mechanism related handover parameters was done
- D. Han, S. Shin, H. Cho, J. m. Chung, D. Ok and I. Hwang, "Measurement and stochastic modeling of handover delay and interruption time of smartphone real-time applications on LTE networks"
  - stochastic modelling using real devices (smartphones) where handover interruption time was further broken down in every step
- S. Trabelsi, A. Belghith and F. Zarai, "Performance evaluation of a decoupled-level Qos-aware downlink scheduling algorithm for LTE networks"
  - QoS-aware and Channel aware downlink scheduling algorithms were evaluated but performance was not evaluated in terms of handover
- H. S. Park and Y. S. Choi, "Taking Advantage of Multiple Handover Preparations to Improve Handover Performance in LTE Networks"
  - a “handover preparation” algorithm was proposed where multiple handover messages are sent to the UE for faster handover sequence

LTE Architecture



UE : User Equipment

HSS : Home Subscriber Server

S – GW : Serving Gateway

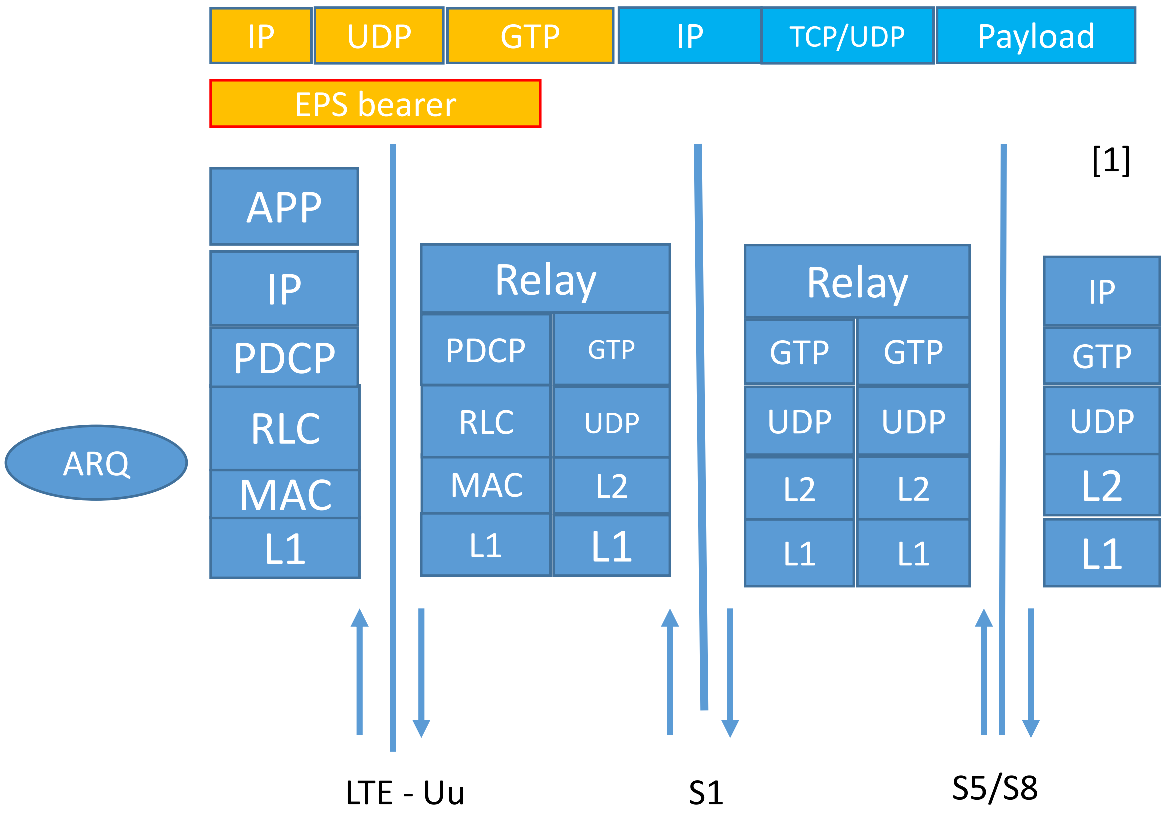
MME : Mobility Management Entity

PCRF : Policy and Charging Rules Function

P-GW : Packet Gateway

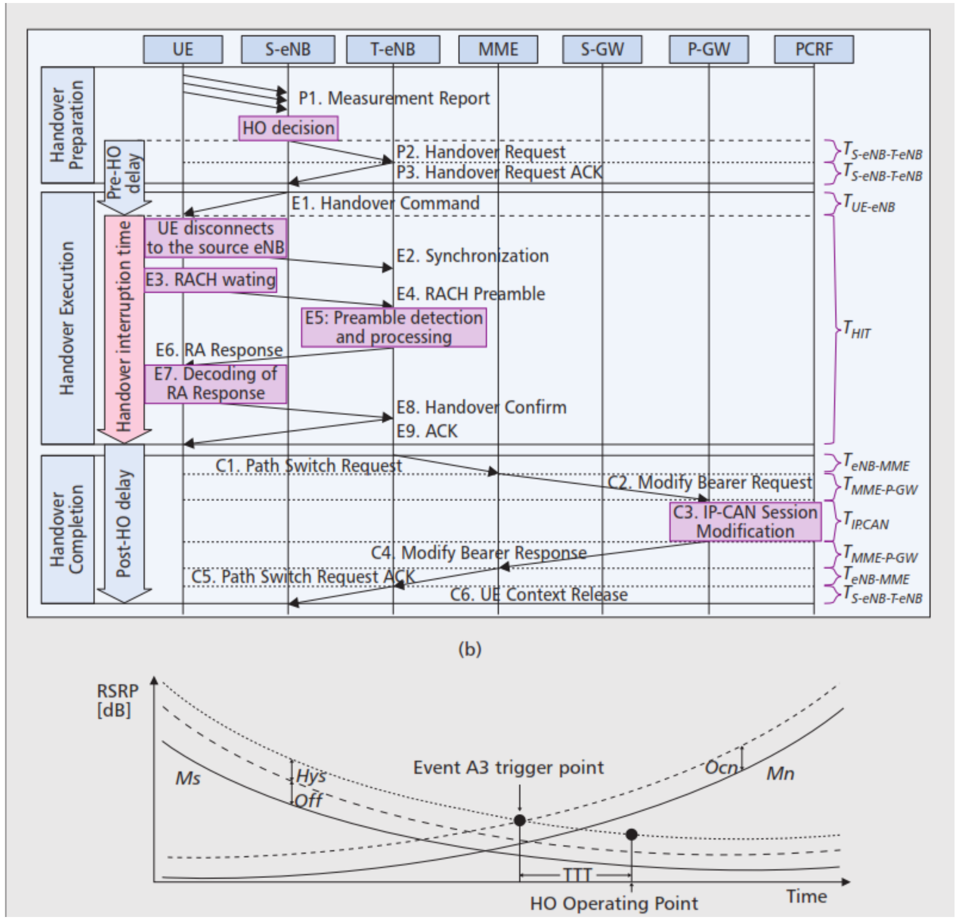
LTE Overview

User plane protocol



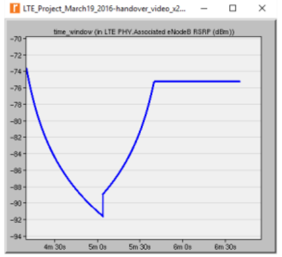
- Modeler 18.5 encapsulates the IP datagram for the LTE network
- Modeler 18.5 has a UE, eNodeB and EPC (MME, S-GW, P-GW) node models
- Modeler 18.5 supports X2 and S1 handover and handover failures
- Modeler 18.5 supports GBR and Non-GBR bearers
- Given the huge scope of the topic and complexity of the model we focused on downlink aspect of the radio interface (LTE-Uu)

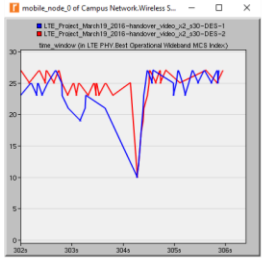
LTE Handover

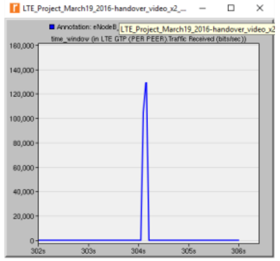


[7] D. Han, S. Shin, H. Cho, J. m. Chung, D. Ok and I. Hwang, "Measurement and stochastic modeling of handover delay and interruption time of smartphone real-time applications on LTE networks," in IEEE Communications Magazine, vol. 53, no. 3, pp. 173-181, March 2015.

- Handover can be broken down into 3 sections : Handover Preparation, Handover execution, Handover completion
- We used A3 event as our handover triggering with A3-offset 2dB, triggering at -90dB mechanism focusing on intra-frequency handover
- Modeler 18.5 has a 50% weighted trigger for RSRP and RSRQ
- Graphs below shows RSRP A3 offset triggering, message coding scheme change during handover, X2 interface bits forwarded







Simulation Parameters

Traffic	Bearer	Description
Voice	2 (Gold)	PCM Quality Speech 16KB/s (G.711) [4],[5]
Video Conferencing	3 (Silver)	Live streaming packet, CBR traffic: packet arrival 20ms (50 packets/s) target bit rate 312 kb/s; DSCP = AF41 [5]
HTTP	6 (Bronze)	HTTP web TV; Best effort ToS(0); RLC acknowledge mode

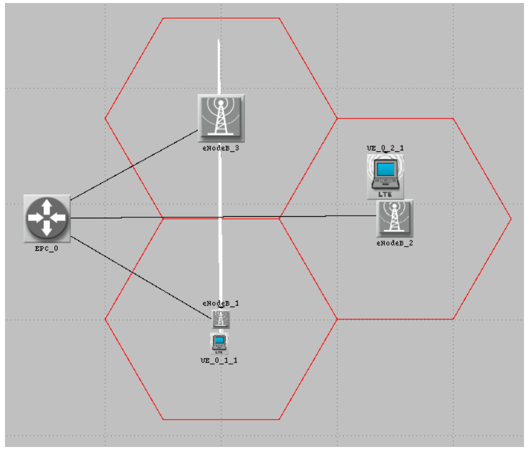
Physical Layer Parameters	Value
Channel BW	20MHz
UL antenna	UL SC-FDMA
DL antenna	DL OFDMA
Pathloss	Free space
Scheduling	Link adaptation and channel dependent scheduling

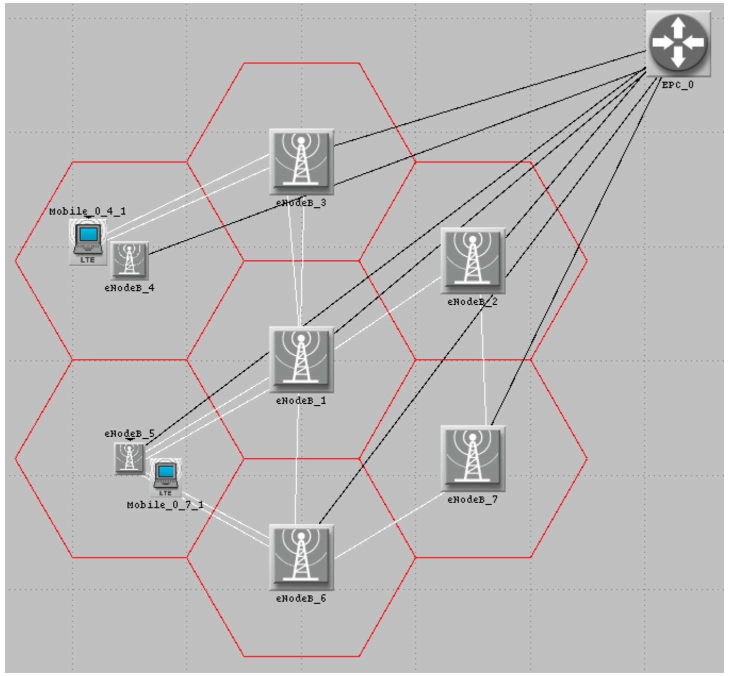
Simulation Parameters	Values
Speed of UE	30, 60, 120
Size of Cell	3-cell, 7-cell, 19-cell
Background traffic	Video, Voice, HTTP
Interfaces	S1, X2

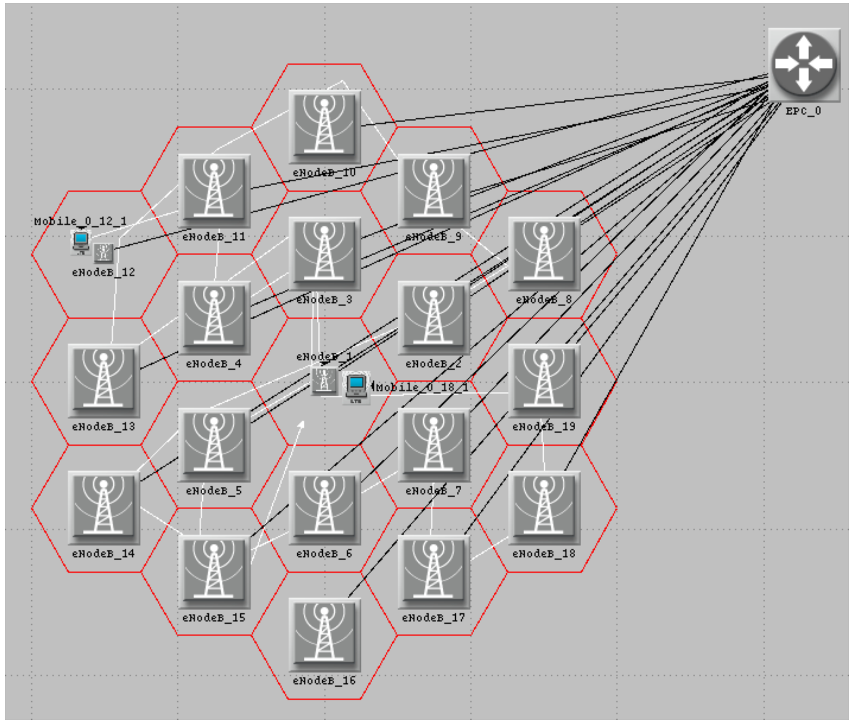
Simulation #1

- **Two scenarios** are considered for evaluating the performance of handover:

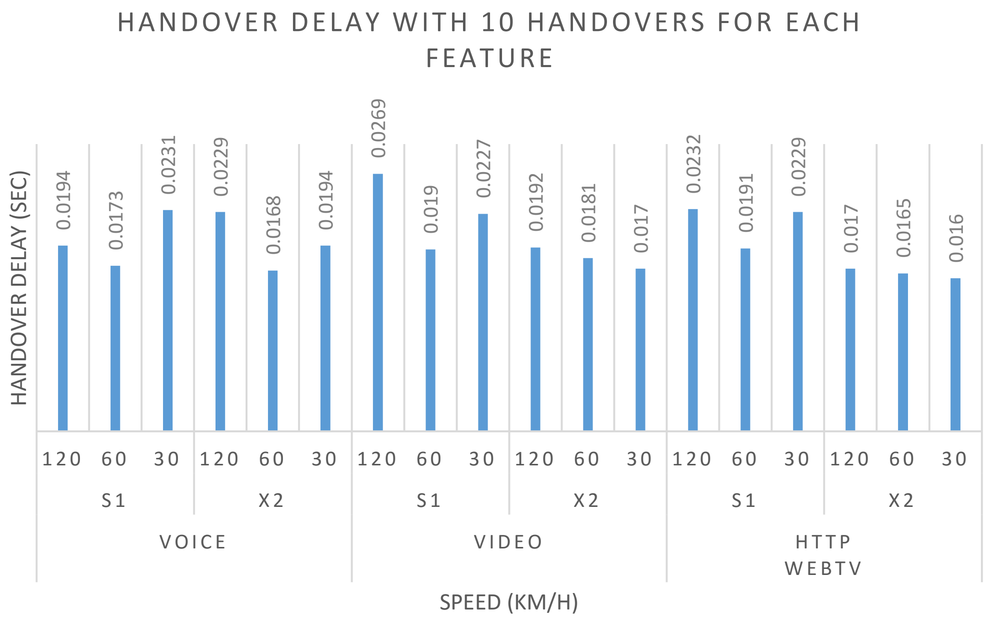
1) 10 handovers of each application with different speeds
2) 30 minutes of simulation for VoLTE with different speeds on all three topologies



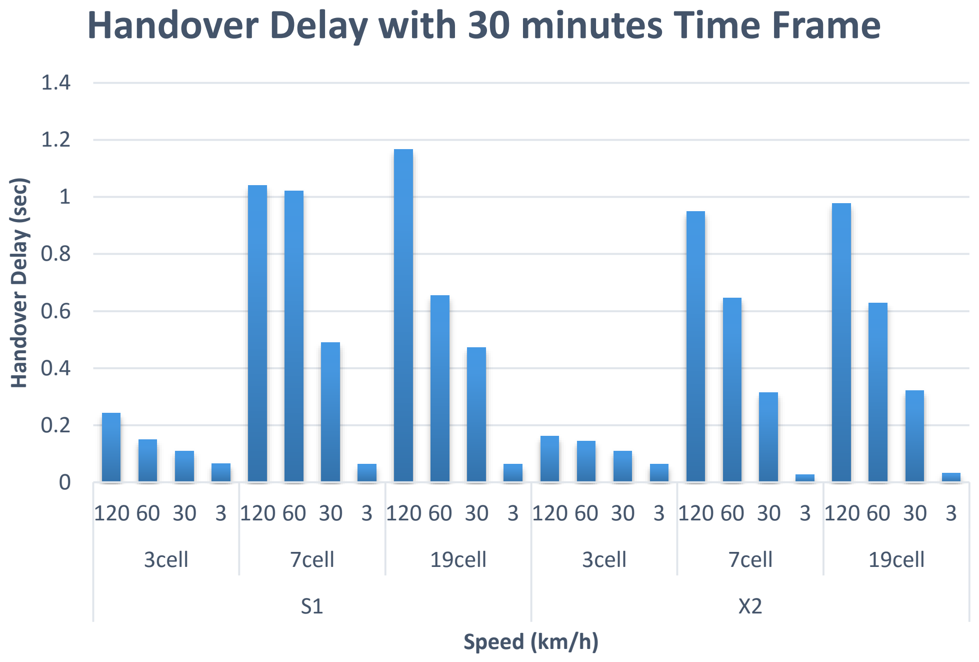




Handover Delay Data

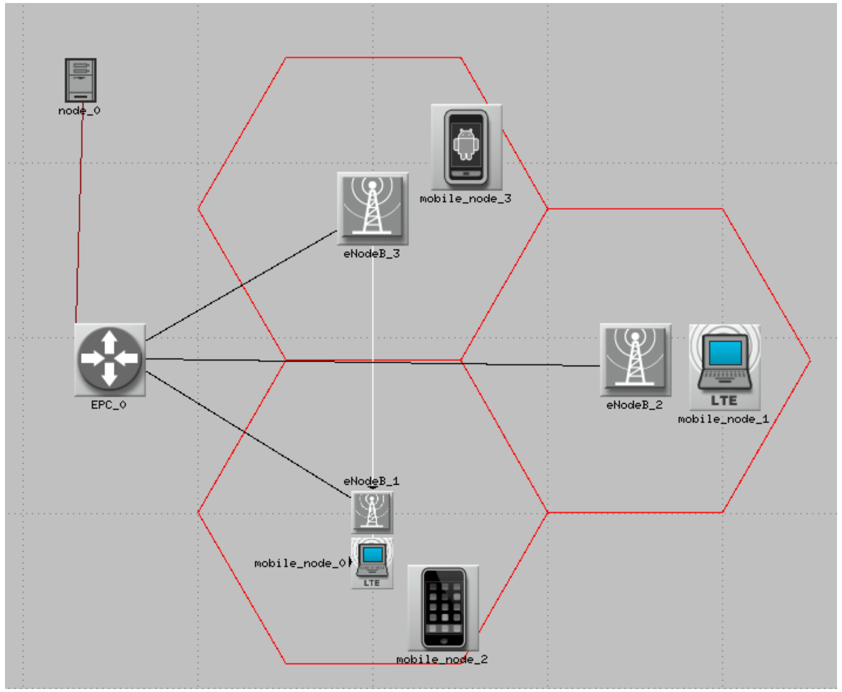


Scenario -1



Scenario - 2

Simulation #2



Statistics to use

EPS Bearer Throughput (bits/s), EPS bearer delay (sec), Other metrics e.g. Traffic received (bytes/s) by the UE

EPS Bearer Throughput %

When output < input, then there are retransmissions

% retransmission = (output – input) / output

When input > output , then there is a loss

% loss = (output / input) – 1

Sample Size

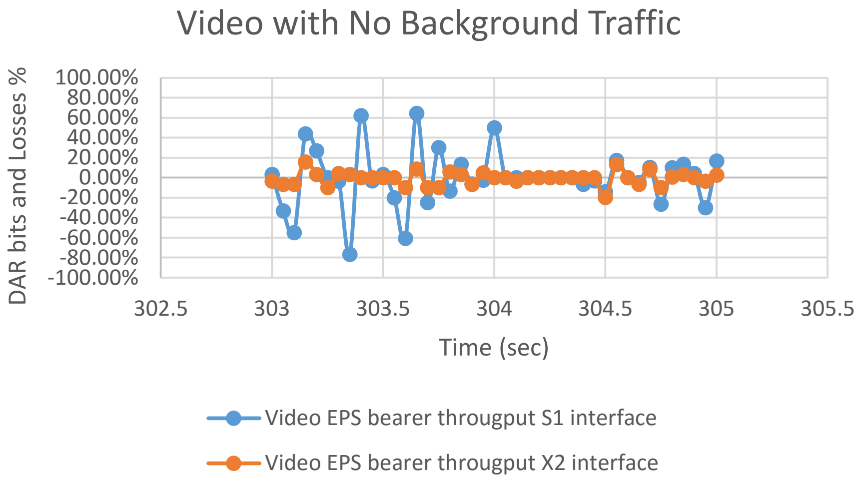
10 runs per point by varying start time for the application profile

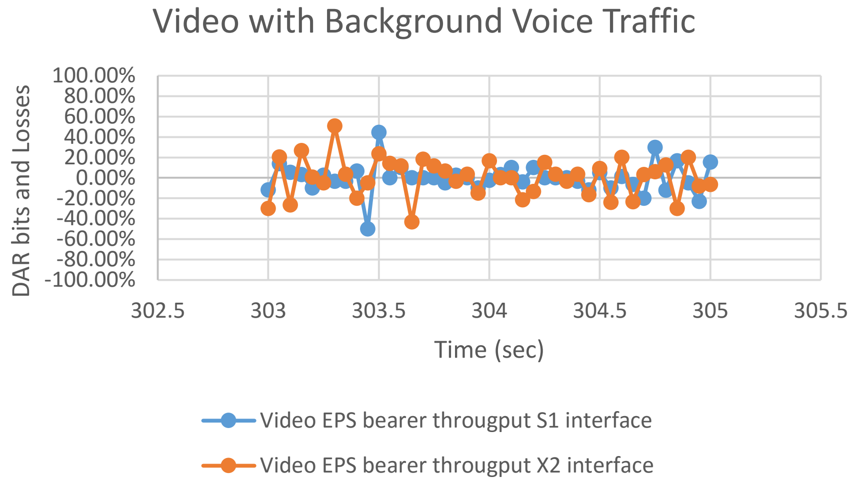
Time coverage

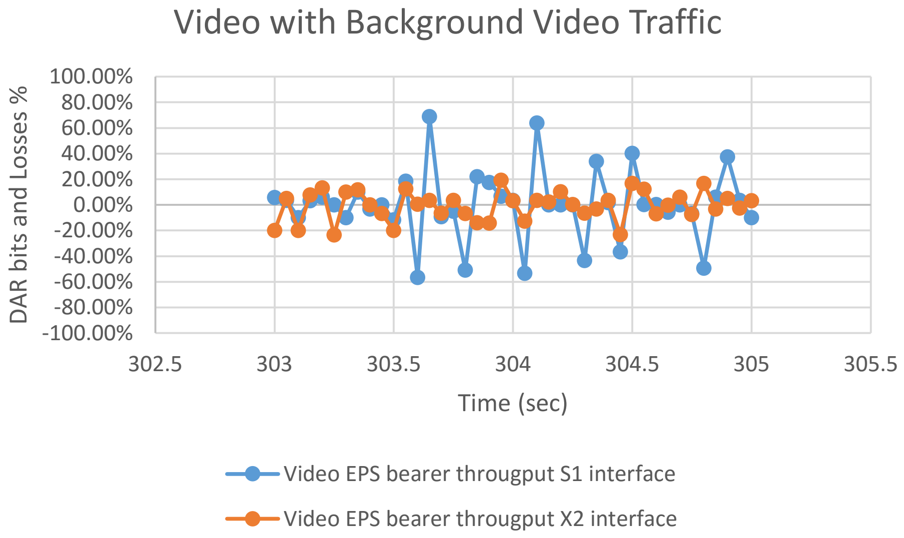
80% of handover occurs in 304-304.25 sec for speed 30km/hr

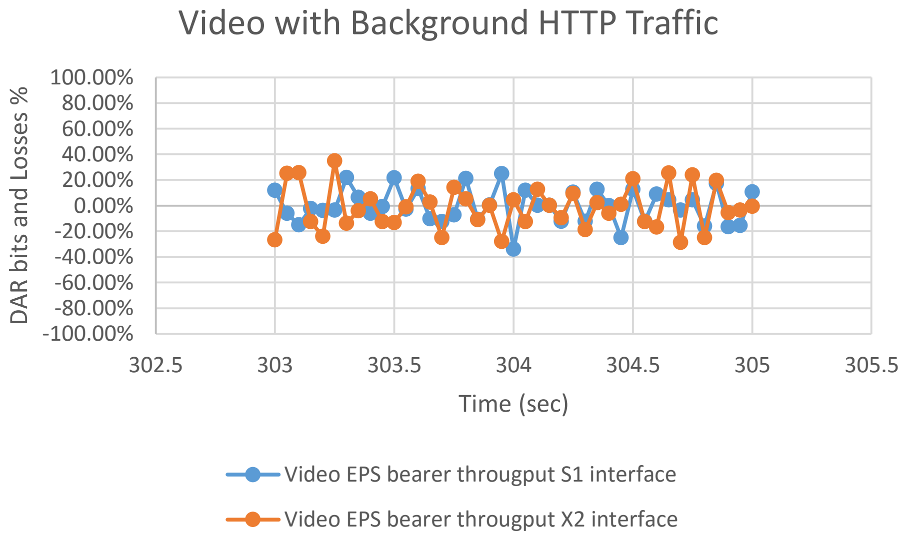
EPS Bearer Throughput Data

DAR – Delay and Retransmitted

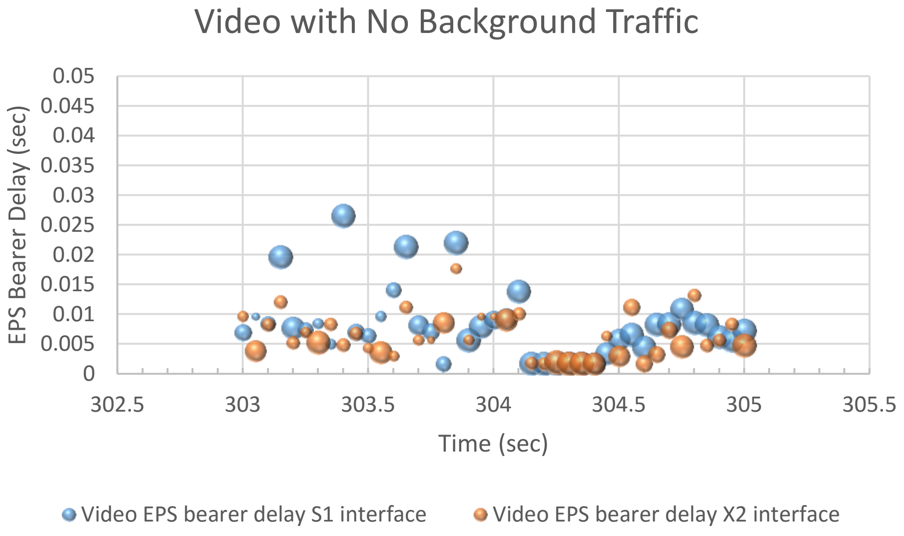


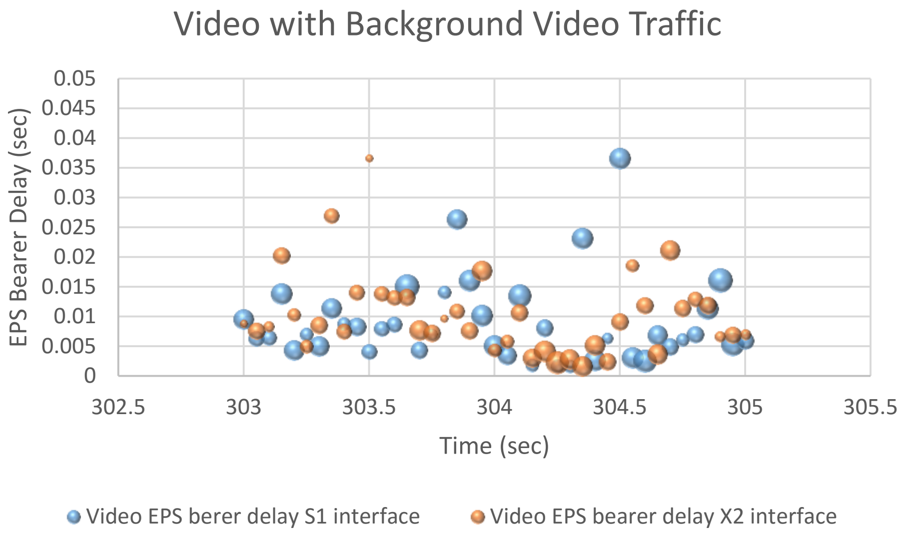


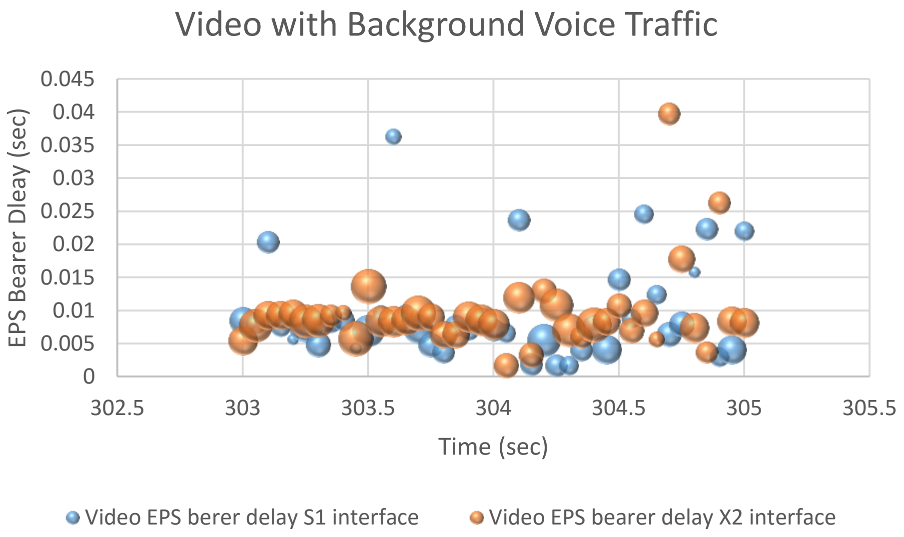


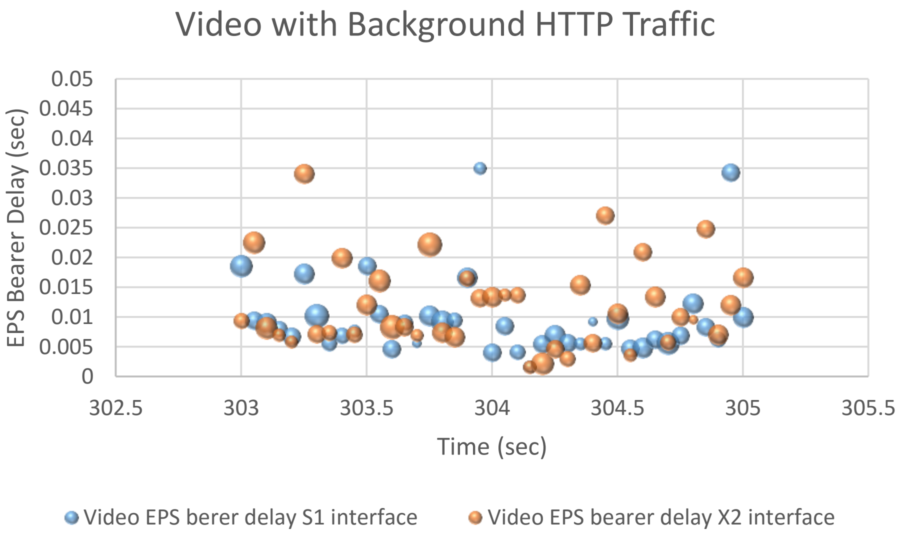


EPS Bearer Delay

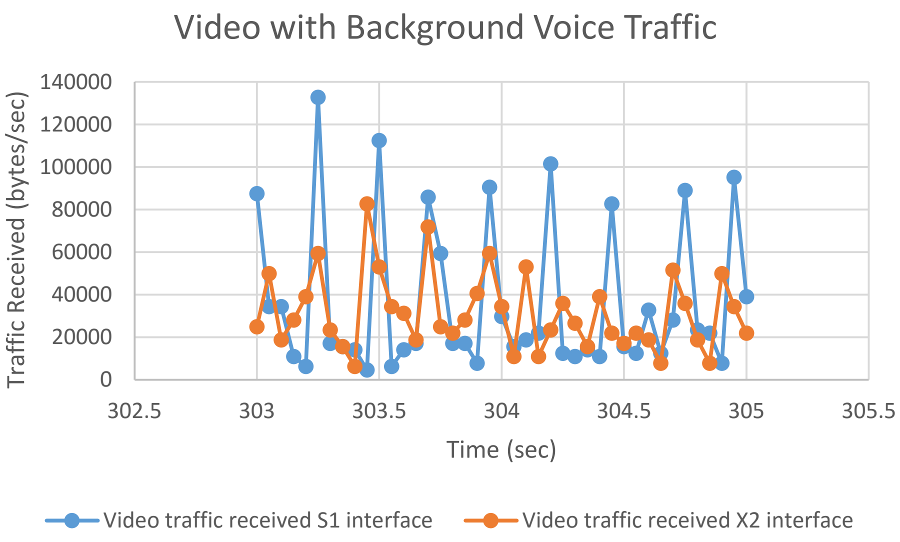


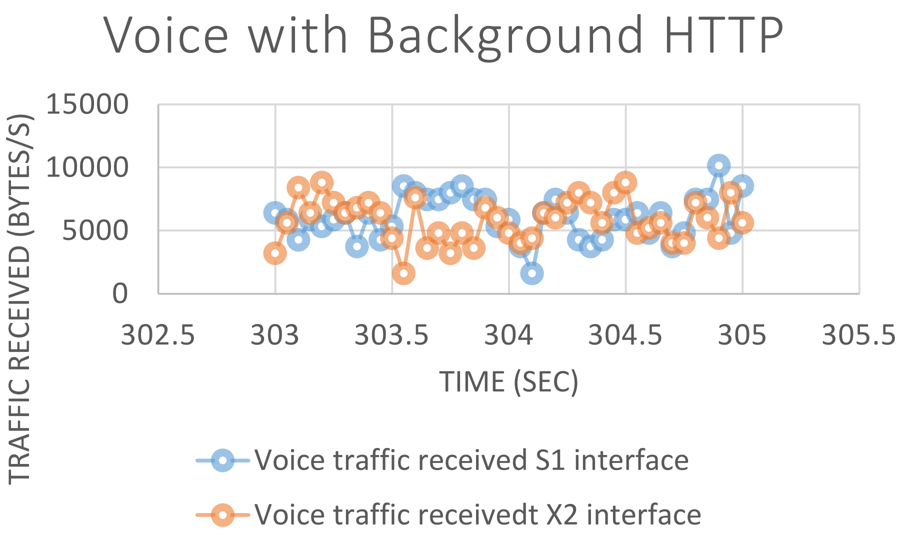






Other Metrics





Results and Conclusions

- Overall performance with X2 interface is better than with S1 interface in terms of throughput and handover delay
- Increasing the number of eNBs with one evolved packet core increases the interference with neighbour eNBs resulting in higher handover delay
- EPS bearer delay is more dependent on the scheduling and background traffic load during the handover than the type of interface the handover happens
- Background traffic affect the same type of traffic that is involved during handover the most
- HTTP traffic is bursty that the results must be approached with caution or with better stochastic analysis method

Future Work

- There is no definite point for knowing where the packet loss and retransmission occurred during the handover so we are only estimating based on the “Handover delay” location. Identifying the delay and retransmitted bits/packets would result in better analysis.
- Expand the analysis to use an increasing background traffic on a higher cell count scenario, e.g. 19-cell
- The statistics could be presented in some other form and stochastically analyzed plus more samples can be taken

References

[1] S. Sesia and I. Toufik, *LTE - The UMTS Long Term Evolution*, 2nd ed. West Sussex, United Kingdom: Wiley, 2011

[2] L. Zhang, T. Okamawari, T. Fujii, "Performance evaluation of TCP and UDP during LTE handover," in Proc. 2012 IEEE Wireless Communications And Networking Conference, Shanghai, China, April 2012, pp. 1993-1997.

[3] A. Vizzarri, "Analysis of VoLTE end-to-end Quality of Service using OPNET," in Proc. 2014 UKSim-AMSS 8th European Modelling Symposium, Pisa, Italy, Oct. 2014, pp. 452-457.

[4] H. S. Park and Y. S. Choi, "Taking Advantage of Multiple Handover Preparations to Improve Handover Performance in LTE Networks," 2014 8th International Conference on Future Generation Communication and Networking, Haikou, 2014, pp. 9-12.

[5] S. Trabelsi, A. Belghith and F. Zarai, "Performance evaluation of a decoupled-level Qos-aware downlink scheduling algorithm for LTE networks," in Proc. 2015 IEEE International Conference on Data Science and Data Intensive Systems, Sydney, Australia, Dec. 2015, pp. 696-704

[6] F. Amirkhan, O. Arafat and M.A. Gregory, “Reduced packet loss vertical handover between LTE and mobile WiMAX,” in Proc. 2014 2014 International Conference on Electrical, Electronics and System Engineering, Kuala Lumpur, Malaysia, Dec. 2014, pp. 24-59

[7] D. Han, S. Shin, H. Cho, J. m. Chung, D. Ok and I. Hwang, "Measurement and stochastic modeling of handover delay and interruption time of smartphone real-time applications on LTE networks," in IEEE Communications Magazine, vol. 53, no. 3, pp. 173-181, March 2015.

[8] Modeler Documentation Set, 18.5, Riverbed Technology, San Francisco, CA, 2015, Chapter 12.