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 interface. 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"
  o performance evaluation for intra-frequency handover for TCP and UDP while varying A3-mechanism related handover parameters was done

  o 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"
  o 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"
  o 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

- 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 Parameters

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

### Physical Layer Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel BW</td>
<td>20MHz</td>
</tr>
<tr>
<td>UL antenna</td>
<td>UL SC-FDMA</td>
</tr>
<tr>
<td>DL antenna</td>
<td>DL OFDMA</td>
</tr>
<tr>
<td>Pathloss</td>
<td>Free space</td>
</tr>
<tr>
<td>Scheduling</td>
<td>Link adaptation and channel dependent scheduling</td>
</tr>
</tbody>
</table>

### Simulation Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of UE</td>
<td>30, 60, 120</td>
</tr>
<tr>
<td>Size of Cell</td>
<td>3-cell, 7-cell, 19-cell</td>
</tr>
<tr>
<td>Background traffic</td>
<td>Video, Voice, HTTP</td>
</tr>
<tr>
<td>Interfaces</td>
<td>S1, X2</td>
</tr>
</tbody>
</table>
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

#### Handover Delay with 10 Handovers for Each Feature

<table>
<thead>
<tr>
<th>Feature</th>
<th>Handover Delay (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>0.0194</td>
</tr>
<tr>
<td>X2</td>
<td>0.0219</td>
</tr>
<tr>
<td>S1</td>
<td>0.0173</td>
</tr>
<tr>
<td>X2</td>
<td>0.0219</td>
</tr>
</tbody>
</table>

#### Handover Delay with 30 minutes Time Frame

<table>
<thead>
<tr>
<th>Feature</th>
<th>Handover Delay (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3cell</td>
<td>0.120</td>
</tr>
<tr>
<td>7cell</td>
<td>0.120</td>
</tr>
<tr>
<td>19cell</td>
<td>0.120</td>
</tr>
</tbody>
</table>

**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

Video with No Background Traffic

Video with Background Voice Traffic

Video with Background Video Traffic

Video with Background HTTP Traffic
EPS Bearer Delay

Video with No Background Traffic

EPS Bearer Delay (sec)  
Time (sec)

Video with Background Video Traffic

EPS Bearer Delay (sec)  
Time (sec)

Video with Background Voice Traffic

EPS Bearer Delay (sec)  
Time (sec)

Video with Background HTTP Traffic

EPS Bearer Delay (sec)  
Time (sec)
Other Metrics

Video with Background Voice Traffic

Voice with Background HTTP

- Video traffic received S1 interface
- Video traffic received X2 interface
- Voice traffic received S1 interface
- Voice traffic received X2 interface
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


