Mobile Videos Quality Measurements for Long Term Evolution (LTE) Network

Hamad Almohamedh, Fahad Al Qurashi, Ivica Kostanic
Department of Electrical and Computer Engineering
Florida Institute of Technology
Melbourne, Florida, USA
halmoham@my.fit.edu, falqurashi2008@my.fit.edu, kostanic@fit.edu

Abstract - *This paper presents an evaluation of live mobile video streaming measurements over a Long-Term Evolution (LTE) network using User Datagram Protocol (UDP). Also, it describes a high quality videos database that was created as a part of the evaluation. The objectives are to quantify the impact of Receive Signal Strength Indicator (RSSI), Reference Signal Received Power (RSRP) and Reference Signal Received Quality (RSRQ) measurement on mobile video streaming over an LTE network and to provide 4k resolution raw videos for video quality assessment. A testing environment is created with a client server method to record parameters. For testing of video streaming, a real AT&T network is used at multiple locations for the same video to get different readings. Results of the live video streaming and live measurement show high consistency and correlation between the RSSI, RSRP, RSRQ and packet loss and provide the observation that these parameters vary at different locations within the cellular network*

Keywords: LTE; Mobile Video Streaming Quality; RSRP; RSRQ; RSSI

1 Introduction

Broadband cellular access technologies and smart phones have brought about a major increase in the traffic over cellular networks. Data centric applications have been gaining importance. Among them the video streaming is one of the most resource consuming one. This has played a major role in tremendous increase in the traffic. Based on Cisco's predictions, cellular video streaming traffic in the year 2014 will be double that of the previous year 2013. See figure 1 [1].

AT&T projects growth of mobile video traffic in the range of 8000% over the 4-year period between 2011 and 2014. Cellular device manufacturing companies predict that this growth will continue to increase at an average rate of 92% per year for the next 5 years [2]. Different studies of mobile video usage show that with the increase of fast and handy devices, such usage continues to increase to even greater volumes. Different studies on the mobile video usage have shown that with the increase of fast and handy devices, the mobile video streaming has increased to a great volume. Easily adaptable and faster cellular networks have contributed towards mobile video steaming explosion. People are getting addicted to it as they can access videos anytime and anywhere from their mobile phones. Most studies have focused on the need for improvement of quality of the videos and design of interface for the video browsing [3].

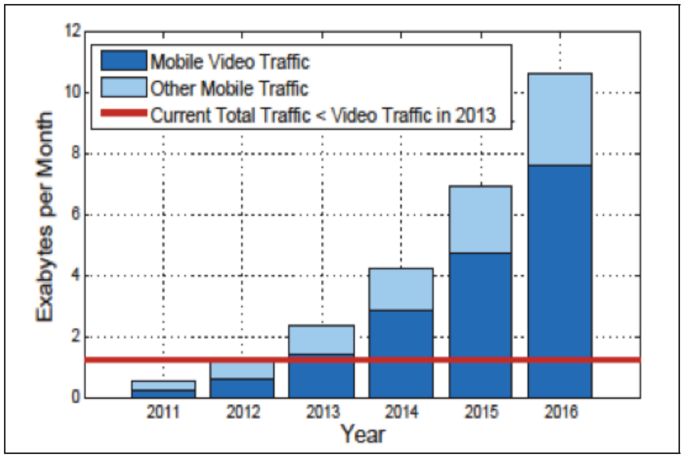

Figure 1. Prediction of mobile video traffic taken from [1].

2 VIDEO QUALITY AFFECTING FACTORS OVER LTE NETWORKS

Video quality over the LTE network is dependent upon several factors that contribute to overall quality. It is important to note some of these key factors that affect streaming video quality over LTE cellular network.

2.1 Reference Signal Strength Indicator (RSSI)

RSSI is the total power received by the resource element in dBm. The resource element is the smallest unit which consist of one subcarrier for duration of one orthogonal frequency division multiplex (OFDM) symbol [4]. RSSI is a combination of the signals received from all sources including the power from serving cell, non-serving cell, co-channel, and adjacent channel interference [5].

2.2 Reference Signal Received Power (RSRP)

RSRP is the reference signal received power that measures the power in a single resource element. RSRP main purpose is to help determining the serving cell for initial random access or LTE handover. RSRP value rang from -140 to -44 dBm [6].

2.3 Reference Signal Receive Quality (RSRQ)

RSRQ is the quality of the power received in the resource element. RSRQ is a measure of the quality of the signal rather than the quantity of received signal strength. RSRQ is dependent on both RSSI and RSRP and can be calculated by using the following equation (1) where N is the number of resource blocks (RBs) used for RSSI.

$$RSRQ = N\frac{RSRP}{RSSI}. \qquad (1)$$

2.4 Packet Loss

Data communication takes place in the form of packets. Packet loss results when packets fail to reach the desired destination [7]. As such, the packet loss represents a fundamental measure of the quality for a data communication link. In LTE networks, the packet loss is related to factors such as RSSI, RSRP and RSRQ.

3 EXPERIMENT METHODOLOGY

Setting up the experiment in a simple and professional manner is important for the testing methodology. The main aim is to test video quality over the LTE network using simple devices that can manage the task. User equipment is registered with the LTE base station. This base station is further connected to the server through the Internet as shown in figure 2.

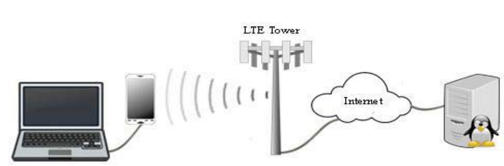

Figure 2. Experiment Process Illustration

In all test cases, Samsung Galaxy S3 is utilized as user equipment (UE) in a real AT&T LTE network. All measurements were performed in 10MHz LTE network in Melbourne, Florida, USA. Video traffic was streamed over UDP protocol using a mobile video quality prediction (MVQP) streaming server. A Samsung Galaxy S3 is connected to a laptop and signal measurements are stored in both the laptop and in the MVQP server. The streaming video process starts with shooting the raw videos which are then converted to MP4 and down sampled to flow in the LTE network.

3.1 SOURCE VIDEOS

The videos used in this study were recorded with a Sony PMW-F5 camera. A 16-bit RAW data were captured at a resolution of 4K. This resolution preserves more tonal values than what may be differentiated by human eye. All videos recordings were captured at 29.97 frames per second in various selected locations in city of Melbourne, Florida, USA. A total of 10 videos were used in this study from a collection of 40 videos that are available in the MVQP database [8]. Figure 2 provides a brief description for each of the ten videos [9].

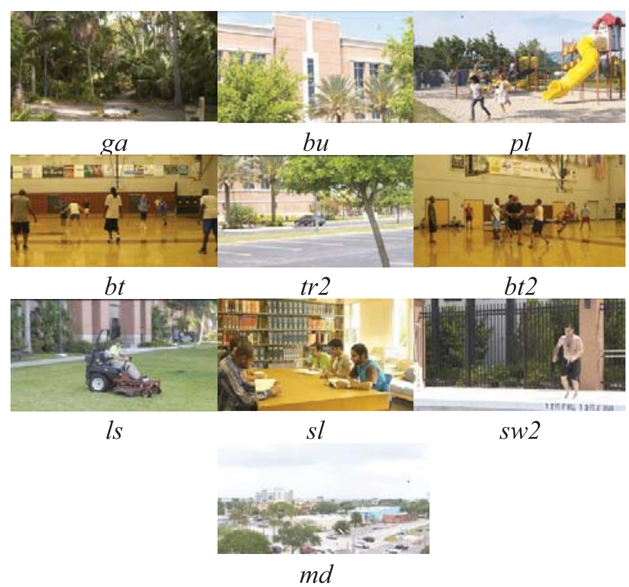

Figure 3. Thumbnail for each video frame.

3.1.1 **Garden (ga).** Shot at Florida Institute of Technology (FIT) campus garden on a sunny afternoon. There are light contrasts. The camera tilts the trees from bottom to top.

3.1.2 **Building (bu).** Shot at FIT's campus on a sunny afternoon. The building is surrounded with number of trees. The camera pans from left to right.

3.1.3 **Playground (pl).** Shot in a park on a sunny afternoon. Children are playing on slides. Filled with bright and fascinating colors.

3.1.4 Basketball Training (bt). Shot inside Clemente Center at FIT. Many players show diverse contrasts and complex motions. The camera is stationary.

3.1.5 Tree (tr2). Shot near a road side on a sunny afternoon. The camera pans across the scene from up to down.

3.1.6 Basketball Training (bt2). Shot inside Clemente Center at FIT. Different ratios of light are shown with the movement of players. The camera shows a steady movement.

3.1.7 Lawn Service (ls). Shot at FIT campus. A man is mowing a lawn. The camera tracks him from left to right.

3.1.8 Students at Library (sl). Shot in main library at FIT on early morning. The stationary camera zooms out.

3.1.9 Swimming Pool 2 (sw2). Shot at FIT's swimming pool on a sunny afternoon. A man jumps into the swimming and bright twinkle of waves are clearly visible in water. The camera pans from right to left.

3.1.10 Melbourne Downtown (md). Shot from the top of the roof on a cloudy afternoon. The entire area is comprised of tall buildings and trees and various cars are moving on the road. The camera pans from right to left.

3.2 Server/Client Setup

The server/client were set up for live video streaming. The server used in this study is based on central processing unit of Intel, Core i3, 2100 with memory of 8 GB. Graphics card is Gallium, 0.4 on AMD CEDAR. The operating system is Linux based Ubuntu 13.10 working on 64-bit version. The hard drive is 1 Terabyte revolving at 7200 RPM. Gigabit Ethernet is used to incorporate speeds of 1 GB/s and Internet speed average is 256 Mb/s for the uplink and downlink. The client machine is a Lenovo ThinkPad L430 laptop working on a Core i3 processor of 2.4 GHz. The memory is same as the server, 8 GB. Hard drive is 240 GB solid-state drive. Operating system is Windows 7, 64 bit professional. It is set up to receive mobile video streaming from the server through Samsung Galaxy S3 connected with USB cable. FFMPEG tools [10] were installed in both the server and the client computer for streaming videos. The streamed videos were saved in the client computer to conduct the mean opinion score (MOS) in future work. FFMPEG is also used to measure streaming parameters such as packet loss, bit rate, and codec type which are then saved in file.

3.3 MVQP MEASURMENT APPLICATION

MVQP measurement application is developed for the android platform compatible with the Samsung device that works on the android operating system. MVQP application is used to measure and save radio frequency (RF) signals each second. This application saves the values of the parameters such as RSSI and RSRQ at each instant for later use and analysis.

3.4 LIVE MEASUREMENTS AND DISTORTED VIDEOS

Random locations were selected based on RSSI levels ranging from values of -87 dBm to -51 dBm. For each location, live streaming was done over the UDP protocol. The following steps were carried out in order to complete the study.

3.4.1 Streaming server was run by using FFserver for the selected videos.

3.4.2 FFMPEG was run in the client PC to receive and save the distorted video over the LTE network.

3.4.3 MVQP measurement application was started to save the Radio frequency signal measurement.

4 STUDY ANALYSIS AND RESULTS

Ten different locations were selected for this study. Figures 3-12 show the values of RSSI, RSRP, RSRQ, and the percentage of the total packet loss for each video in each location. The graphs illustrate that when RSSI, RSRP, and RSRQ decrease, the packet loss increases, affecting video quality based on the total percentage of lost packet. Chart legends show different colors for RSSI, RSRQ, RSRP and packet loss. The garden (ga) video's graph depicts a strong dip for RSSI RSRP and RSRQ values at locations 5 and 9 where there are peaks of packet loss (as shown in figure 3). RSSI values are less than -79 dBm, RSRP values less than -111 dBm, and RSRQ less than -12 dB at these locations where packet loss occurred. Remaining graphs indicate very similar in behavior, as shown below.

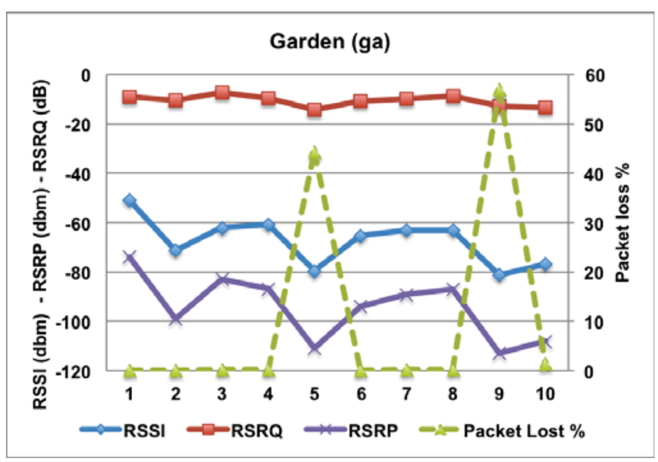

Figure 4. Garden (ga) video

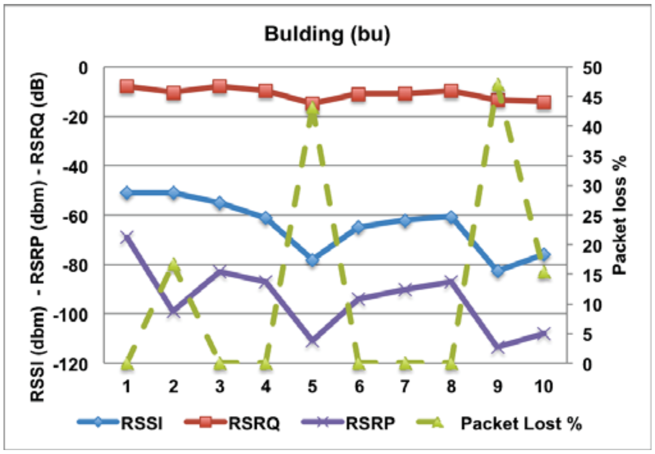

Figure 5. Building (bu) video

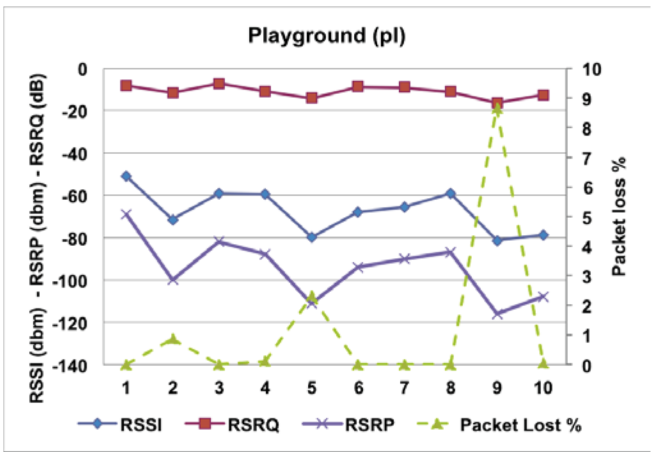

Figure 6. Playground (pl) video

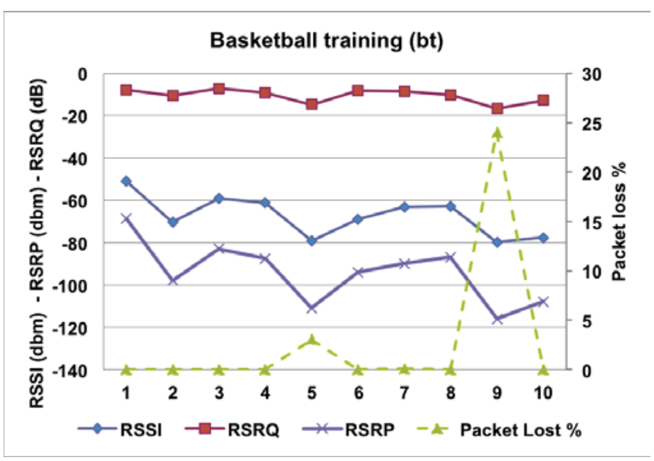

Figure 7. Basketball training (bt) video

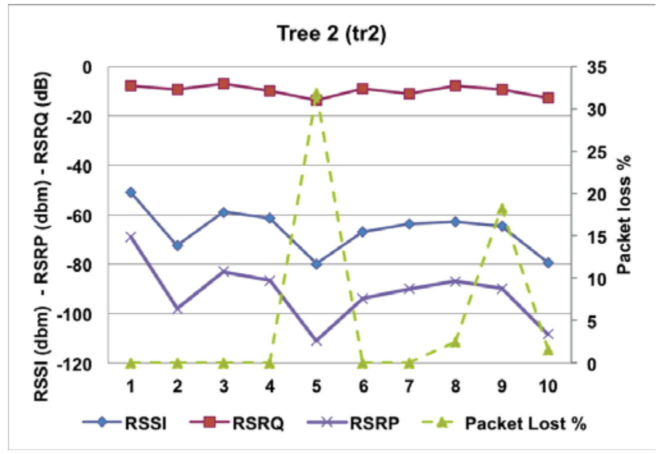

Figure 8. Tree 2 (tr2) video

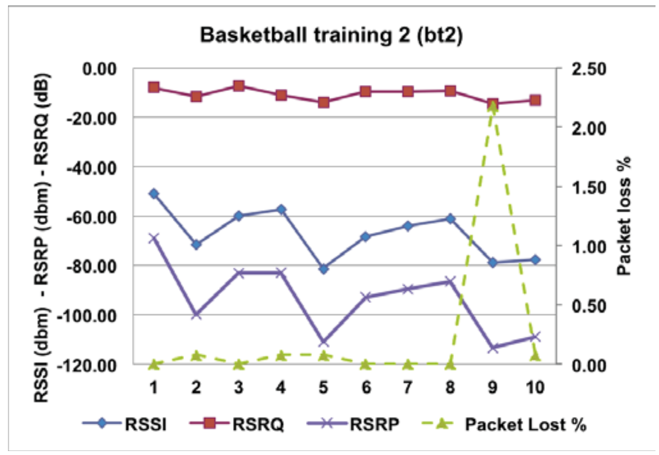

Figure 9. Basketball training 2 (bt2)

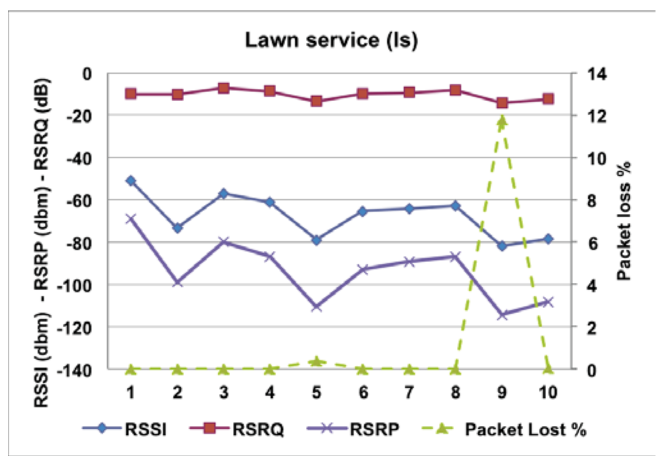

Figure 10.Lawn services (ls) video

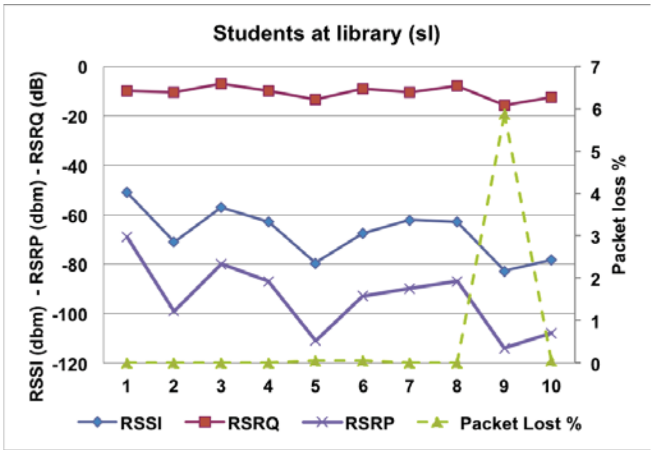

Figure 11. Students at library (sl)

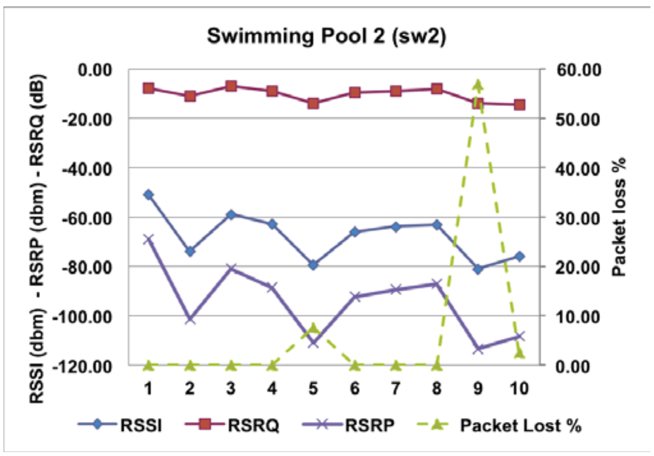

Figure 12. Swimming pool 2 (sw2) video

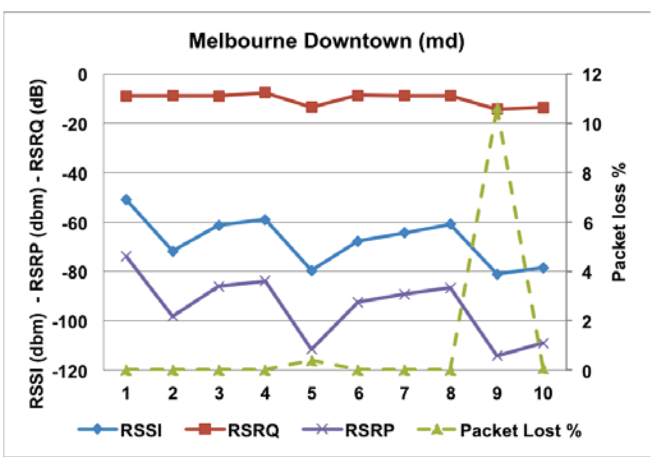

Figure 13. Melbourne downtown (md) video

5 CONCLUSION

In this experiment, three major factors are studied at 10 different locations for live streaming videos. Results of live measurement show high consistency and correlation between the signal strength, RSRQ, and packet loss. For RSRQ, lower values than -10 dB correspond to high packet losses in the video. The study also shows that locations 5 and 9 in particular are not suitable for video streaming, possibly due to congestion or higher distance from the serving cell. This implies that the quality of service varies at different locations with the cellular network. An extended study based on this paper was conducted. The study focused on compute the mean opinion score (MOS) and compared it with the packet loss [11].

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