Subjective Video Streaming Quality Evaluation in 3G Cellular Networks

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Abstract - *A novel method for subjective QoS evaluation of streaming video is developed. The method, named Mobile Video Quality Prediction (MVQP), relies on a non reference QoE measuring tool. This is a hybrid between subjective and objective measurement. To validate this approach as a part of the MVQP project, a live video streaming platform is designed. The platform includes different video sequences (high and low motions). The results presented in this paper are based on subset of eight videos selected from the MVQP video quality database. A commercial, Sprint PCS 3G mobile networks was used for test evaluated. fifty subjects evaluated video quality using smart phones based on ITU recommendation. Mean Opinion Score (MOS) was compared with packet loss at the end of this study.*

Keywords: MVQP, Subjective test, 3G cellular networks

1   Introduction

The data traffic over cellular networks owes a great deal of its rise to the video-streaming applications. These applications cause a fluctuation on the data rates, which in turn influence the quality of streaming [1]. Ever since the world has been struck with massive usage of mobile based technologies, various users are using their mobile phones to watch videos. This has led to a revolutionary increase in mobile-video streaming amongst a large number of users [2]. The video streaming quality assessment is not an easy task. This assessment faces various challenges like limited computation powers of the mobile device [3].

Traditional Quality of Service (QoS) does not offer adequate means for assessing real-time video streaming applications. This is because an important attribute of user satisfaction cannot be assessed under such a method [4]. Multimedia techniques for quality measurement are based on the Quality of Service (QoS). However, it is deemed that these metrics of the traditional QoS do not sufficiently measure the actual quality of the multimedia applications; and therefore, changes will have to be incorporated in the future. One may say that the QoS metrics are purely network-based and as a result they cannot measure factors as perception and sensation of the user.

For that reason, the QoE is regarded as a more effective method for assessing the quality perceived by the end-users [5]. QoE is a measurement of the quality of satisfaction that is derived from a communication system [6]. QoE denotes how users perceive the quality of such running applications and the user perceived experience of the service provided by the network provider.

2   MVQP Project (3G)

Estimation of the video streaming quality in 3G Cellular Networks over smart phone device is an issue that has not been satisfactory addressed. At the moment not many solutions have been proposed. Partially, this may be attributed to computational, size and other inherent limitations of the mobile devices. The main goal of MVQP is to develop a new method for the prediction of video streaming quality through mobile networks. The method will be referred to as Mobile Video Quality Prediction (MVQP).

Subjective evaluation is the best method for the assessment of the video streaming quality. In subjective assessment, a human subject evaluates if the quality of the video is good, average, or poor. MVQP will use the subjective assessments to calibrate mapping between a set of objective engineering measurements and subjective QoE.

MVQP will be able to recognize the quality of the streaming video for network providers as an estimation for the quality of streamed video in mobile connections utilized by mobile devices. MVQP Technology will completed in two phases as shows in Figure 1.

Phase one contain development of MVQP raw video database and a set of factors that affecting video quality. MVQP aims not just to propose but also deliver a new scheme to predict the quality of the video streaming using the 3G Cellular Networks.

In phase two MVQP tools will be able to recognize the quality of the streaming video for network providers as an estimation for the quality of streamed video in 3G connections utilized by the smart mobile devices. After phase one, the quality affecting video streaming factors will be collected from this study. These factors will be used to

train and validate the MVQP algorithms. The ultimate goal is development of the automatic prediction of the user experience which is sometimes referred to as the E-MOS.
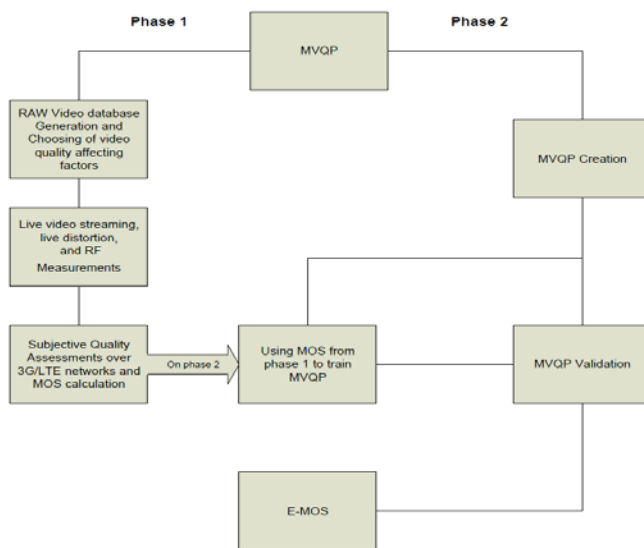

Figure 1. MVQP chart

3   Quality affecting factors

For this study, a set of factors that affect the QoE are selected. These set contains the packet loss with some Radio Frequency (RF) factors. It is assumed that the streaming video is delivered over UDP and hence, the delays usually found in the TCP are not relevant.

3.1   Packet loss

Packet loss is defined as a rate at which transmitted packets do not reach their destination. Packet loss is the most important objective factor affecting the quality of receiving videos [8].

3.2   Received signal code power (RSCP)

Received signal code power (RSCP) is the measure of power at the receiver. It is attributed to a specific physical communication channel. It signifies the strength of the signal used for data delivery [9].

3.3   Interference metric (Ec/Io)

(Ec) is the received pilot energy, (Io) is the total power spectral density or alternately the total received energy. Pilot quality is defined as the Ec to Io ratio that is expressed in dB [10]. This is a fundamental metric of the signal quality.

4   Live video streaming, live distortion, and RF measurements methodologies

In this study, eight raw videos from MVQP database [11] are selected. Different videos were selected to keep the test bed as diverse as it could possibly be and to ensure the results are obtained against a representative set of videos. The 4K raw video is down sampled to proper resolution for 3G bandwidth which is 480x320 by using H.264 codec in 30fps. The frame quality of a video is usually indicated by codec and bit-rate [4].

An efficient coding and reduction of bit-rates is recently developed in the video compression standard H.264. The H.264 shows significant improvements over the older standards of H.263 and MPEG-4 [7]. As an example, H.264 has some built in features that reduce the errors of coding such as providing small sizes of blocks and filters for de-blocking covered by [7].

The factors kept under consideration during the experiment are the Packet loss, RSCP, and (Ec/Io). A "CDMA2000/ EVDO-Rev A" on Sprint PCS provider with a bandwidth Up to 3.1 Mbps was used to stream the videos and to measure the impact of the above mentioned distortion factors. The results revealed a relationship between the factors, which is shown in part five of this paper.

4.1   Videos source

The lists below are a short description for eight of raw videos from MVQP database [11], and the snapshot of each of them are shown in Figure 2.

4.1.1   Soccer game (sg)

Shot on a campus on a sunny afternoon. Players are showing diverse contrasts and colors along with complex motions. The camera is tracking the players both sides horizontally.

4.1.2   Lawn service (ls)

Shot on campus on a sunny morning. A man is providing lawn services by making use of a lawn machine. The camera tracks the machine from left to right.

4.1.3   Pedestrian (pe)

Shot on campus on a sunny morning. Some students are entering while others are leaving. The camera was fixed.

4.1.4   Garden (ga)

Shot in a garden on a cloudy morning. There are light color contrasts and slow motion of tree leaves. The camera tilts the trees from bottom to top with a reflection of the cloudy sky.

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4.1.5 Turtle (tu)

Shot at a lake on a cloudy morning. The slow movement of turtle within the water has presented a fascinating scene. The camera was slowly tracking the turtle.

4.1.6 Large building (lb)

Shot on campus on a sunny morning. Many small leaves are visible, moving slowly in different directions. The camera was moving from the bottom of the building towards the blue sky diagonally.

4.1.7 Bridge (br)

Shot across the bridge in the city of Melbourne on a cloudy afternoon. Various cars are moving on the bridge while water waves are moving slowly downstream. The camera was fixed.

4.1.8 Basketball (ba)

Shot in a park basketball field on a sunny afternoon. Children are getting trained for basketball and a complex motion is being depicted through their movements. The camera was fixed.

(sg) *(ls)*

(pe) *(ga)*

(tu) *(lb)*

(br) *(ba)*

Figure 2. RAW Videos snapshots [11]

4.2 Measurements hardware

The computer server that was used in this study is an Intel based PC with 1TB hard drive and 8GB of RAM. The operating system is Linux. Internet speed average is 256 Mbps for uploading and downloading. The computer client is a ThinkPad laptop with Intel processor and has storage of 240 GB SSD with Windows 7 OS. It is set up to receive mobile video streaming from the server via Samsung Galaxy S4 while connected with a USB cable.

FEMPEG, an open source tool installed in both server and client, does live streaming video and stores the video files from the server.

4.3 Measurements applications

MVQP measurement application for collection of the radio frequency (RF) parameters was developed over android platform. Using Samsung mobile device the measurements are collected once per second. The measurement application collects Ec/Io and RSCP.

4.4 Subjective methodology

In subjective quality testing, a set of sequences of the processed video is set for evaluation before the human observers. There are several methods identified by the research community for testing. In case of videos, standards methods are defined in order to conduct subjective tests for television broadcasting standards [13] [14].

In the situation of a subjective quality evaluation for mobile-videos, a lot of efforts are required in order to examine the environment of the test, the display's set-up, test material assessment and the regulation of adequate viewing distance for the viewer [15].

The Absolute Category Rating (ACR) method is used in the quality tests. This method is a category judgment in which one test condition is presented only once to the viewers. This method is also known as Single Stimulus 2 Method. On the basis of category scale test sequences are rated separately. After each presentation viewers are asked to assess sequence's quality.

Figure 3 describes the time pattern for the incentive presentation. In the voting mechanism voting time should be less than or equal to the ten seconds. Time for the presentation can be decreased or increased on the basis of test material's content [13]

Pict.Ai	Grey	Pict.Bj	Grey	Pict.Ck
~10 s	≤10 s	~10 s	≤10 s	~10 s
	voting		voting	voting

Ai   Sequence A under test condition i
Bj   Sequence B under test condition j
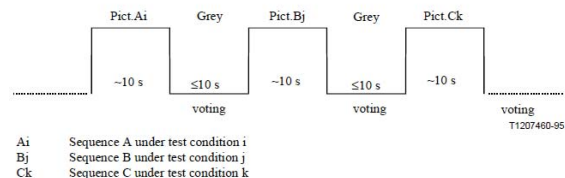Ck   Sequence C under test condition k

Figure 3: Stimulus presentation in the ACR method [13]

In this scheme after viewing or listening presentation subjects are asked to rate the presentation's quality. This stage is known as voting time. For rating most commonly used scale is five-level scale [16].

In this subjective test, fifty subjects participated with a real mobile devices by using our MVQP android subjective

test application. The application collected the subjective rating after showing them random sequence number of distorted videos. The sequence videos have been distorted in the live measurement streaming step.

Five Samsung Galaxy mobiles were used in this subjective test. The university lab was used with a five partition tables for the 160 rounds of test sequence. The subjects were divided into groups. Each subject rated 16 of a randomly distorted video collection sequence. A short presentation was given before each session. Each session was sent to the MVQP server immediately after each rating was stored in rating database.

5   Results

The results shown in Figs 4-11 are obtained using eight representative videos from the MVQP video database. Some of them are fast motion and the others are slow motion. Sprint PCS mobile network is used for our live video streaming experiment.

It is evident from the graphs of that the packet loss is higher if the signal (RSCP) is either high or low with the presence of interference (Ec/Io). Also, the MOS confirmed that if the packet loss is high then the MOS drops down.
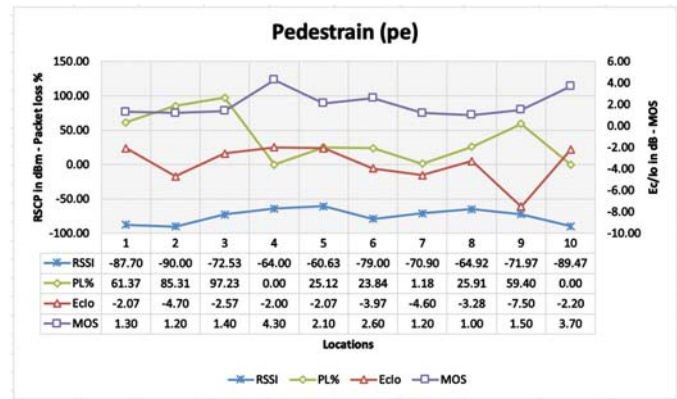

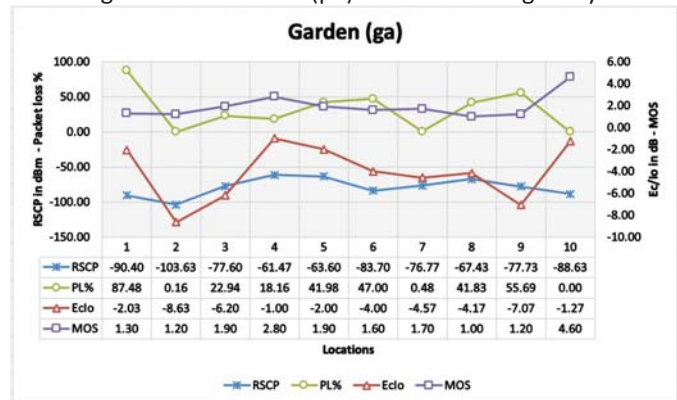Figure 6. Pedestrian (pe) video streaming analysis

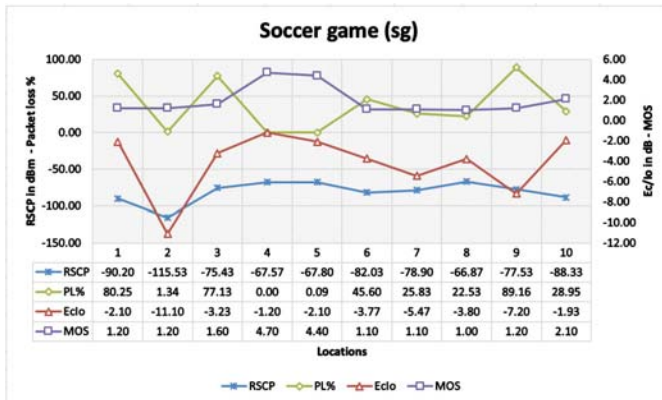Figure 7. Garden (ga) video streaming analysis

Figure 8. Turtle (tu) video streaming analysis
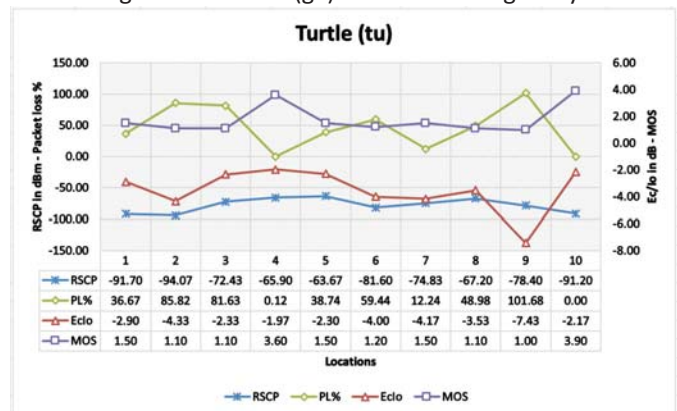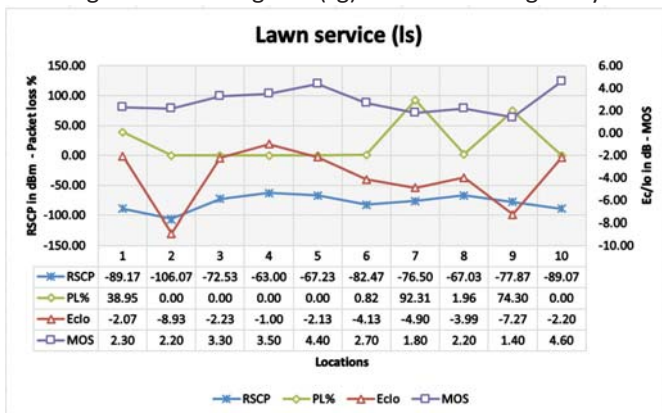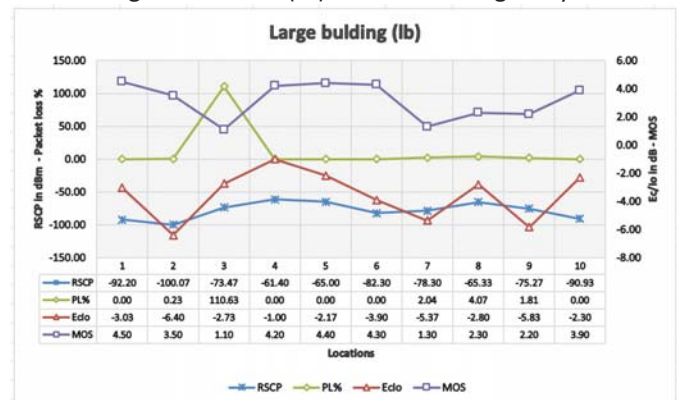

Figure 4. Soccer game (sg) video streaming analysis

Figure 5. Lawn service (ls) video streaming analysis

Figure 9. Large building (lb) video streaming analysis

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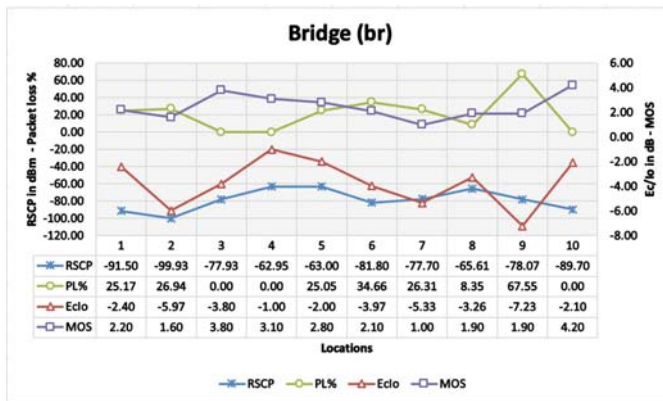

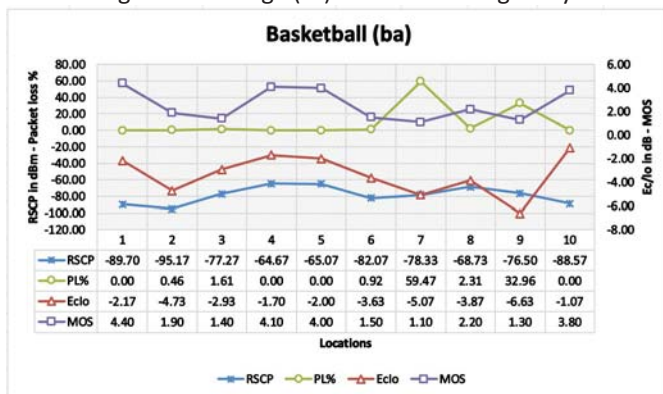Figure 10. Bridge (br) video streaming analysis

Figure 11. Basketball (ba) video streaming analysis

6   Conclusion and future works

This study evaluated the third stage of MVQP project (phase one). The study was backed up by the experimental results which showed a relationship between the considered distortion factors. In the future MVQP (phase two), a QoE tool will be built that can predict the video quality from the results that were collected from phase one. . In [12] and [17] we extended this study with another experiments that contained the in depth analysis of the experiments for LTE video quality streaming measurements.

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