# QoS and QoE Modelling for Video Stream over Wireless and Mobile Network

Herman Herman [1], Azizah Abdul Rahman [2], Yoanda Alim Syahbana [3], Kamalrulnizam Abu Bakar [4]
Universiti Teknologi Malaysia
Faculty of Computer Science and Information System
Johor, Malaysia
[1]herman8@live.utm.my, [2]azizahar@utm.my, [3]asyoanda2@live.utm.my, [4]knizam@utm.my

***Abstract*-Customer satisfaction is essential in every service. In video stream service over wireless and mobile network, customer satisfaction is determined by objective Quality of Service (QoS) that derived from network, application and mobile device parameters. Some of these parameters can be adjusted i.e. video resolution, audio rate, and bandwidth while the others are not fully controllable i.e. network throughput, delay, and packet lost probability. However, the customer satisfaction in this service is not only determined by QoS. There is subjective Quality of user Experience (QoE). It defines customer perceived quality over the service. It is influence by intrinsic factors (customer experience, customer expectation, and customer interest) and extrinsic factors (saliency awareness, frame loss distribution, and frame loss to frame rate awareness). This journal will discuss a holistic view of the quality of video stream service over wireless and mobile network in order to elaborate intermingled interrelation of QoS parameters, nonlinearity of QoE factors and their contribution to enhance customer satisfaction. The contribution of this journal is to propose a methodology in developing schemes that model the QoS and QoE.**

***Keywords - wireless and mobile network, video streaming, quality of experience modelling***

## I. INTRODUCTION

Advancement of video processing technologies, heterogeneous wireless and mobile networks, and mobile device capabilities have encouraged the emergence of many new and creative mobile multimedia service. One of the services is video stream service over wireless and mobile network. The service is varied into video call, video teleconference, IP television (IPTV), and mobile Video on Demand (mobile-VoD). Essentially, the service is comprised by three service components. There are video that will be streamed over the network, wireless and mobile network infrastructure, and mobile device. The video can be captured video from mobile device in video call service or video file that resides in video server for mobile-VoD service. The video can be streamed over heterogeneous network e.g. Wi-Fi, WiMAX, UMTS, and HSDPA. Service customer may receive the video using various types of mobile device e.g. notebook, Personal Digital Assistant (PDA), and mobile phone.

Quality of these service components is essential consideration. It influences how well the video that streamed over the network (streamed video) is received by mobile device. It is known as objective Quality of Service (QoS). QoS is determined by objective parameters that derived from the service components. There are video application parameters (video rate, audio rate, frame rate, and coding mechanism), network parameters (bandwidth, delay, jitter, packet loss and Channel Quality Indicator (CQI)), and mobile device capabilities (display brightness, deep of color, display size, processing speed, and memory capacity).

QoS is an aspect that contributes to influence customer satisfaction of the service. However, it is not the only aspect. There is second aspect called subjective Quality of user Experience (QoE). It can be defined by how well the service quality is perceived by the customer. It is determined by subjective factors that can be categorized into intrinsic factors (i.e. customer experience, customer expectation, and customer interest) and extrinsic factor (i.e. saliency to specific area in video) [1].

QoS and QoE aspects arise with some issues in determining customer satisfaction. QoS has intermingled interrelation among its objective parameters. The interrelation brings various influences to quality of streamed video. QoE with its subjective factors involves nonlinearity that influences how the service quality is perceived. These issues are mainly related to quality of streamed video as the most influencing service component [2] [3] [4].

This journal is motivated to simplify these issues regarding the essential of customer satisfaction in the service. This journal proposes methodology to model QoS and QoE in video stream service over wireless and mobile network. The methodology generates two schemes, namely basic scheme and advanced scheme. The basic scheme examines influence of objective parameters in determining QoS while the advanced scheme studies influence of subjective factors to QoE.

The journal is organized in five sections including this first introduction section. Section 2 describes background of the problem regarding issue in QoS and QoE. The proposed methodology is detailed in Section 3. The detail also explains some preliminary experiment in relation to proposed methodology. Result of the proposed methodology is discussed in Section 4. Finally, summary for the journal is provided in Section 5.

## II. BACKGROUND OF THE PROBLEM

In video stream service over wireless and mobile network, customer satisfaction is influenced by objective Quality of Service (QoS) and subjective Quality of user Experience (QoE). This section discusses these two aspects as background of the problem.

### *A. Intermingled Interrelation of Objective Parameters*

Refer to Chen [5] and Huang [6], QoS can be classified into two levels. The first level is called as application-level QoS. It is comprised by some objective parameters e.g. delay, delay variation (jitter), packet error and packet loss ratio, and throughput. The second level is called connection-level QoS that is related to connectivity and continuity of the network. It is involves two objective parameters i.e. new call blocking probability and handoff dropping probability.

Other researchers, Agboma [7] and Khan [8], classify the QoS parameters into Application-level QoS (QoSA) and Network-level QoS (QoSN).QoSA consists of video coding and compression parameters such as video rate, audio rate, frame rate, and coding mechanism [9] [10] [11]. QoSN is comprised by network parameters such as bandwidth, delay, jitter, packet loss and Channel Quality Indicator (CQI) [12]. This journal uses this second kind of classification and includes mobile device capabilities (display brightness, deep of color, display size, processing speed, and memory capacity) to consider third service component, the mobile device.

The QoS parameters involves with intermingled interrelation [7] [9] [13] [14]. For instance, QoSA parameters such as configuration of video rate and audio rate depend on video content [5]. Based on recommendation in [15], news video content requires higher audio rate configuration than requirement of video rate. It is due to characteristic of news video content that concerns on information delivery. Different from news video content, action movie content is characterized by high video and audio quality that supported by high configuration of video and audio rate.

The video rate, audio rate, and frame rate also has intermingled interrelation toward quality of streamed video. In general, regardless its video content, video rate and audio rate determine video and audio clarity. The frame rate determines smoothness of the streamed video. High configuration of these parameters results to high quality of streamed video. However, it absolutely increases size of video file which will be affected by the following mentioned intermingled interrelation.

The next intermingled interrelation may be seen from relation between coding mechanism as one of QoSA parameters and bandwidth as one of QoSN parameters. In case of mobile-VoD service, video file is splitted into some of video packets before it is streamed to the mobile device. The video packet is encoded by coding mechanism to prevent influence of channel distortion in the network. The coding mechanism increases size of the video packet. Consequently, this condition also increases bandwidth requirement to stream the video packet. Due to classical constraint of bandwidth scarcity, there is a tradeoff between this requirement of bandwidth and optimization of coding mechanism. The consideration is how to keep video packet from influence of channel distortion while it still optimizes bandwidth utilization.

The bandwidth also has intermingled interrelation by indirectly influences other QoSN parameters e.g. delay, jitter, and packet loss. Large bandwidth probably results on low transmission delay, minimum jitter, and low packet loss probability. In consequences, the delay prolongs time for streaming process while the jitter results on jerky video. The jitter itself introduces disorganized video packet that leads to packet loss. As a result, it causes occurrence of blockiness, image artifacts, and color error in the streamed video. Moreover, it may also result in misaligned of video and audio part of the streamed video.

Some researchers also have found intermingled interrelation of QoSN and QOSA parameters regarding quality of streamed video. Research by Agboma [7] has found that QoSA parameters affect overall quality of streamed video while QoSN parameters only affect limited area of the streamed video. For instance, the frame rate (QoSA parameter) influences overall smoothness of streamed video while packet loss (QoSN parameter) only influences limited area of video frame and video timeline. In different research by Frank and Incera [9], QoSN parameters have dominant influence than QoSA parameters. For example, customer may prefer video with low resolution (QoSA parameter) than jerky video that is caused by jitter (QoSN parameter).

### *B. Nonlinearity of Subjective Factors*

Continued to the second aspect, influence of subjective factor regarding its nonlinearity is discussed. Unlike objective parameters that determine quantitative influence to quality of streamed video, these subjective factors determine qualitative part of how well the streamed video is perceived by the customer.

Subjective factor is categorized into intrinsic factors and extrinsic factor. Customer experience is the first example of intrinsic factor. Customer has different experience with video quality [2]. In sequential mobile-VoD video sighting, previous quality of streamed video influences current and next streamed video experience. Once the customer has viewed good quality of streamed video, the customer is hard to please with lower video quality in current and next streamed video experience.

The second example of intrinsic factor is called customer expectation. In customer mind, there is expectation how the streamed video should be played. This factor varies among the customer. It is personal standard in perceiving video quality. If quality of streamed video meets customer expectation, then they will be satisfied. Otherwise, if the quality is below their expectation, they will be dissatisfied.

The third example of intrinsic factor is namely customer interest. This intrinsic factor can be observed by comparing two kind of customer that has different interest over a video content. Action movie fans prefers video with high detail and smooth scene changes, while customer that eager to update latest information from news video content prefers clear audio that video quality [7]. These intrinsic factors bring nonlinearity in how well the streamed video is perceived by the customer.

Second category of subjective factor, extrinsic factor, also arises with nonlinearity in quality of streamed video. Saliency awareness is one of the examples. Saliency in streamed video is region of streamed video frame that catches more customer attention [16]. The region can be focused spot or moving object in the streamed video frame. It can be center of the field (focused spot) in the football match video or moving boat in the boat race video. Saliency awareness relates to quality of this saliency in streamed video. When the region is influenced by some distortion, it degrades level of customer perception even if the other region is distortion-free.

## III. QoS AND QoE MODELLING IN VIDEO STREAM SERVICE

Due to intermingled interrelation in objective parameters and nonlinearity in subjective factors, this journal is motivated to simplify this issue. The journal proposed methodology to model these two aspects, QoS and QoE, in order to elucidate influence of objective parameters and subjective factors to quality of streamed video. Fig. 1 depicts entire proses of the modelling.

The methodology is begun with selecting three video contents that has its own specific characteristics. In this design, the three contents are news video, sports video, and music clip. These three video contents are configured by some QoSA parameters. There are audio rate, video rate, and frame rate. The audio rate is varied into 32 kbps, 24 kbps, and 16 kbps while the video rate is varied into 512 kbps, 384 kbps, 256 kbps, and 128 kbps. The video frame rate is also varied into 25 fps, 15 fps, and 5 fps. The variations of QoSA parameters are aimed to describe interrelation between these QoSA parameters and video content characteristic. Equation (1) shows these parameters configuration in form of function. QoSApar 1, 2, 3 ...n, are key parameter of QoS at application level.

$$F_{QoSA} = f(QoS_A par1,\ QoS_A par2, \ldots QoS_A par\ n) \quad (1)$$

To consider mobile device capability, especially on video display size, the video contents is also varied by size. This design uses three kind of video size i.e. 4CIF (704x576 pixels), CIF (352x288 pixels), and QCIF (176x144 pixels). Equation (2) shows these device configurations in form of function. In total, there will be 324 video file as a video test material.

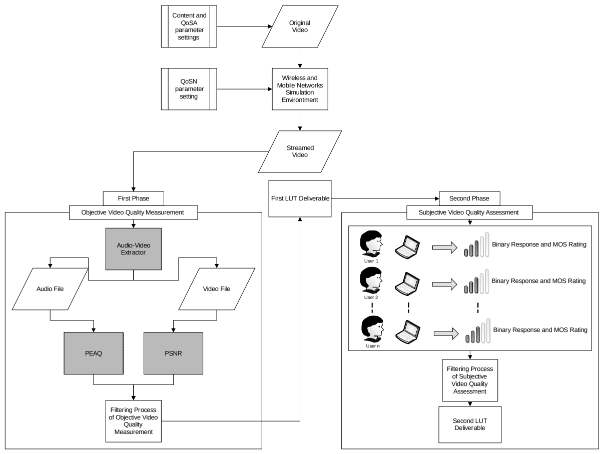


Figure 1. Methodology framework

$$F_{Dev} = f\left(dev_{par}1, dev_{par}2, dev_{par}3, \ldots dev_{par}\ n\right) \quad (2)$$

In the second step, the video test material is streamed over network. This designed methodology uses NS-2 as the network simulator. To simulate the streaming process, this streaming is conducted based on video stream simulation Evalvid by [17] and combined with improved video stream simulation tools MYEvalvid_RTP [18]. The improved tools is purposed to consider audio part in quality of the video stream. Fig. 3 illustrates framework of MYEvalvid_RTP.

This design uses EURANE [19] as streaming network infrastructure. EURANE is HSDPA network infrastructure that may implemented in NS2 network simulator. In general, the QoSN parameters may be design in form of function as represented in Equation (3).

$$F_{QoSN} = f\ (QoS_N par1, QoS_N par1, \ldots QoS_N par\ n) \quad (3)$$

Due to existence of QoSN parameter that can be controlled (bandwidth) and cannot be controlled (delay, delay variation, and packet loss), this design use one parameter to determine the network quality. It is called as Channel Quality Indicator (CQI). CQI value describes strength of transmitted signal that perceived by the mobile device. This design uses CQI that experiments by Brouwer et al. in [20]. Based on conducted initial experiment result as shown in Fig. 4, this design uses three value of CQI i.e. 6, 11, 18.

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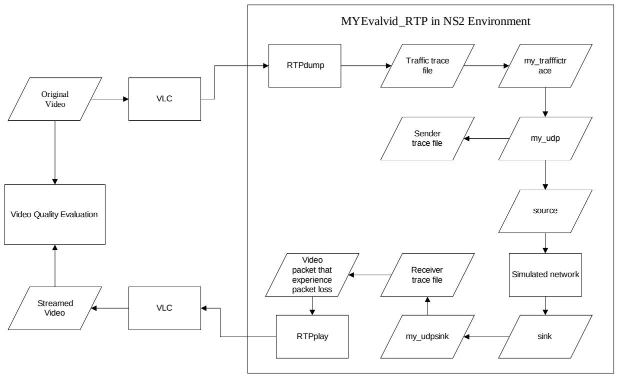


Figure 2. MYEvalvid_RTP framework

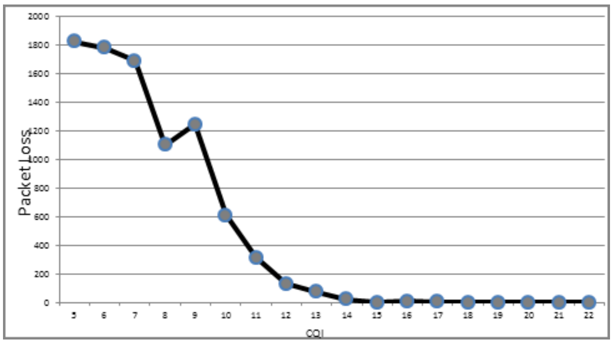


Figure 3. Preliminary result of CQI experiment

The following Fig. 5 depicts topography of utilized EURANE.

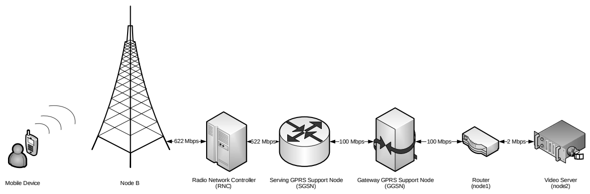

Figure 4. EURANE network topography

## IV. RESULT AND DISCUSSION

After conducting the video streaming simulation, this methodology will have two video files, original video and streamed video. In order to measure the video stream service quality, the streamed video needs to be measured by objective Video Quality Measurement (VQM). At the first step, video and audio part should be extracted in order to measure the video and audio file separately. It will be measured by two quality measurement methods i.e. Peak Signal to Noise Ratio (PSNR) [21] for video quality and Perceptual Evaluation Audio Quality (PEAQ) [22] [23] [24] for audio quality. The following Table 1 and Table 2 present quality interpretation of these two quality measurement results.

TABLE I. PSNR VALUE DESCRIPTION

| PSNR Value | Description |
|---|---|
| PSNR > 33 dB | Excellent Quality |
| 33 dB > PSNR > 30 dB | Fair Quality |
| PSNR < 30 dB | Poor Quality |

TABLE II. PEAQ VALUE DESCRIPTION

| PEAQ Value | Description |
|---|---|
| 0.00 | Perceptible |
| -1.00 | Perceptible, but not annoying |
| -2.00 | Slightly annoying |
| -3.00 | Annoying |
| -4.00 | Very annoying |

Result from these two quality measurements will be filtered in order to obtain streamed video with acceptable QoS. For PSNR, this design only selects video with quality above “30 dB” and for PEAQ, this design select audio quality above “-2”. At this point, the methodology has produced the first deliverable that shows QoS parameters interrelation towards streamed video quality. The following Table 3 presents Look-Up Table (LUT) design for this first deliverable.

QoE in video stream service may be defined as how well the service perceived by the customer. It is influenced by subjective factors. Due to its subjective and qualitative characteristic, QoE is measured by subjective Video Quality Assessment (VQA). The filtered video from objective video quality measurement is assessed based on two assessment scale, namely, binary response and Mean Opinion Score (MOS) scale. The binary response is purposed to detect acceptance limit towards the streamed video quality. The binary response decides the acceptance of video quality by scoring “1” and the non-acceptance by scoring “0”. MOS is used to measure qualitative value of the video in quantitative score. MOS interpretation is represented in the Table 4. Result from this subjective VQA is filtered in order to obtain streamed video with acceptable QoE value. The following Table 5 presents Look-Up Table (LUT) design for this second deliverable.

## V. SUMMARY

This journal is purposed to simplify interrelation between QoS parameters towards objective Quality of Service (QoS) and QoE factors towards subjective Quality of user Experience (QoE) in form of Look-Up Table (LUT) modelling. Due to completeness of the methodology, the modelling is contributed to accommodate scientific study of quality of video stream service. It is also contributes to support stakeholders efforts in order to manage quality of video stream service. This journal has provided research methodology that generates two modelling schemes, basic QoS scheme and advanced QoS scheme. It has summarized entire process and any related aspects that contribute to generate the modelling schemes.

TABLE III. FIRST LUT DELIVERABLE

| Video Configurations | Video Size: 704x576 pixels | | | | | | |
|---|---|---|---|---|---|---|---|
| | Video Content | QoSN | QoSA | | | PSNR | PEAQ |
| | | CQI | AR | VR | FR | | |
| 1 | News | 6 | 32 | 512 | 25 | | |
| 2 | | | | | 15 | | |
| 3 | | | | | 10 | | |
| 4 | | | | 384 | 25 | | |
| 5 | | | | | 15 | | |
| 6 | | | | | 10 | | |
| 7 | | | | 256 | 25 | | |
| 8 | | | | | 15 | | |
| 9 | | | | | 10 | | |
| 10 | | | | 128 | 25 | | |
| 11 | | | | | 15 | | |
| 12 | | | | | 10 | | |
| 13 | | | 24 | 512 | 25 | | |
| 14 | | | | | 15 | | |
| 15 | | | | | 10 | | |
| 16 | | | | 384 | 25 | | |
| 17 | | | | | 15 | | |
| 18 | | | | | 10 | | |

TABLE IV. MOS SCALE INTERPRETATION

| **Rank** | **Description** |
|---|---|
| 5 | Excellent |
| 4 | Very Good |
| 3 | Good |
| 2 | Fair |
| 1 | Poor |

TABLE V. SECOND LUT DELIVERABLE

| Video Configurations | Video Size: 704x576 pixels | | | | | | |
|---|---|---|---|---|---|---|---|
| | Video Content | QoSN | QoSA | | | Binary Response | MOS |
| | | CQI | AR | VR | FR | | |
| 1 | News | 6 | 32 | 512 | 25 | | |
| 2 | | | | | 15 | | |
| 3 | | | | | 10 | | |
| 4 | | | | 384 | 25 | | |
| 5 | | | | | 15 | | |
| 6 | | | | | 10 | | |
| 7 | | | | 256 | 25 | | |
| 8 | | | | | 15 | | |
| 9 | | | | | 10 | | |
| 10 | | | | 128 | 25 | | |
| 11 | | | | | 15 | | |
| 12 | | | | | 10 | | |
| 13 | | | 24 | 512 | 25 | | |
| 14 | | | | | 15 | | |
| 15 | | | | | 10 | | |
| 16 | | | | 384 | 25 | | |
| 17 | | | | | 15 | | |
| 18 | | | | | 10 | | |

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