

A Proposed Audiovisual Quality Assessment Model Associated with Multiplayer Online Battle Arena Game: A Pilot Study with ROV

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Abstract—This study proposes an audiovisual quality assessment model for a popular gaming scenario, called the Multiplayer Online Battle Arena (MOBA) gaming. The subjective data about voice quality during conversation of the game players, the video quality, the overall quality, and the weighted percentage of voice and video have been gathered from 40 participants who competed in a small competition event of the Garena ROV (Arena of Valor) in Thailand. Then, three quarters of data have been used to create the model, while the last quarter of data has been used for model evaluation. After creating the model, it has been evaluated using Mean Absolute Percentage Error (MAPE) with three audiovisual quality evaluation models that provide good performances. It has been found that the proposed audiovisual quality assessment model provides better performance than previous works with MAPE of 6.16 %, while other models provide MAPE of 7.67 - 8.54%. Therefore, this evidence supports that the proposed model could be applied for evaluation of audiovisual quality based on the MOBA gaming scenario.

Keywords—*QoE, MOS, MOBA, Online game, Subjective tests*

I. INTRODUCTION

After emergence of Internet technology, other related technologies such as telecommunications, mobile communications and multimedia communications have developed considerably. It has been predicted that mobile communications (e.g., 4G/LTE) will support many kinds of data traffic including video traffic in the near future, see Fig.1 [1]. The availability of mobile Internet in this digital era has changed entertainment medium dramatically, including gaming industry [2]. The market size of gaming industry in 2017 was estimated as 105 billion USD [3]. In 2018, mobile games were downloaded more than 38 billion times worldwide (see Fig. 2), while the total number of video game players worldwide grew to more than 2,350 million players [4-5]. Therefore, it could be projected that the gaming industry would generate around 148 billion USD in revenue in 2019 [6].

Nowadays while there are many kinds of games, one of the most popular games is the Multiplayer Online Battle Arena (MOBA) game. Particularly, one of the most popular one in Asia is ROV. This MOBA game provides the scenario that two groups of game players can fight with

each other in order to win the game. While playing the game, each one in the group can communicate to his or her team members via Voice over IP (VoIP) which is one of the ROV's features. However, game players may encounter technical problems (e.g., unclear voice quality and low video quality) if their network cannot provide them good quality of service (QoS). Therefore, measuring or assessing audiovisual quality might be an option to evaluate the overall quality of experience that the game players perceive from playing the game. This is the reason for proposing a new audiovisual quality assessment method in the context of MOBA gaming.

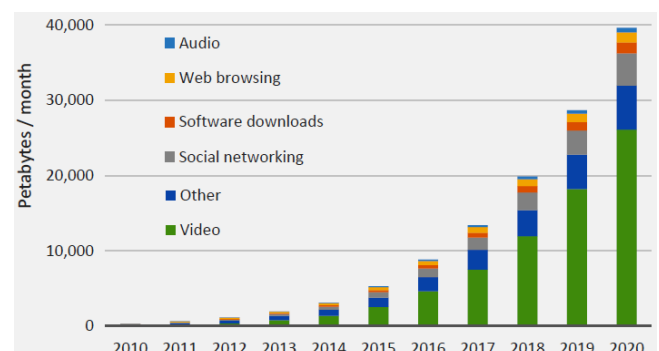


Figure 1. Global Mobile Data Traffic from 2010-2016 with Forecasts from 2017-2020, by Application Type [1]

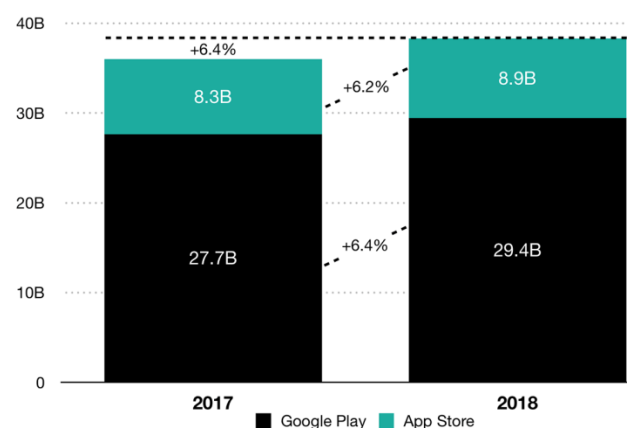


Figure 2. Worldwide Mobile Game Downloads 2018 [4]

II. BACKGROUND

A. Multiplayer Online Battle Arena (MOBA) Games: ROV

There are many MOBA games in the gaming industry (e.g., League of Legend and Heroes of the Storms). ROV, which stands for Realm of Valor (it is known as Arena of Valor (Global name) and Honor of Kings (in China)), is one of the most attractive and popular MOBA games on mobile phones because its gamification tool is utilized to explore and analyze the key elements in ROV's competitive and entertainment experience. It has been confirmed by the number of downloads that reached 100 million downloads [7]. ROV is a Free-to-Play (F2P) game which can be downloaded, installed and played for free. It has short game period (15-20 minutes approximately) and easy controller for playing on mobile phones; therefore, it can provide entertainment to every group of users. It is a game of 5 versus 5, which supports both Android and iOS, played by the Blue team and the Red team. The goal of each team is to destroy the opponent's tower located at the opponent's base [2].

B. Audiovisual Quality and Its Metrics

Audiovisual quality assessment methods can be divided into two main methods, subjective and objective [8]. Both of these are referred to as Quality of Experience (QoE) methods. QoE directly focuses on user perception of applications and/or services. It has been mentioned in [9] that QoE is the key determining factor in the success of multimedia applications or services. QoE contains more factors and covers a wider range of aspects than Quality of Service (QoS). Also, it has also been mentioned in [10] that QoE directly reflect users' acceptance of the services, thus it is very suitable for the evaluation of service quality in applications, systems and/or networks.

For QoE, the key quality factor is Mean Opinion Score or MOS in short, which directly shows the QoE level [11]. It is usually a 5-point scale to quantify level of multimedia quality perception (e.g., 5 = excellent, 4 = good, ..., and 1 = bad). MOS is widely used as it presents the QoE level provided by real-time applications. So, from the users' point of view, it is very useful to assess applications, systems, networks and services [12].

C. Previous Related Research Works

There are interesting past studies associated with online game QoE assessments like the proposed model from Wattimena *et al.* [13]. They presented an objective MOS model referring to delay, loss and jitter as in (1) in Table I, called G-model. This model shows a very high correlation ($R = 0.98$) with the subjective data. This model has been mentioned and/or applied in several other studies; for example, in [14][15]. Ries *et al.* [16] investigated the impact of delay and jitter on the perceived QoS. They focused on Massively Multiplayer Online Games (MMOG), as there are large number of active users and the popularity of MMOG. They finally proposed an objective MOS model associated with delay and jitter as in (3) in Table I. In addition, Slivar *et al.* [17] reported the results of a study whereby an in-home game streaming scenario is set up using the GamingAnywhere platform, and participants were asked to provide subjective QoE assessments while playing World of Warcraft, a Massive Multiplayer Online Role

Playing Game (MMORPG). They also presented their MOS model as in (4) in Table I. However, the above mentioned works are objective models referring to network parameters (e.g., delay, loss and jitter). Therefore, the relevant previous studies associated with QoE modeling for audiovisual quality assessment with subjective methods must be mentioned in this paper as well. There are several interesting works [18-22], including Hands' model, Winkler and Faller's models and ITU-T's model, however, only select few models with good reliability and performance have been selected and described. Belmudez and Moller [21] proposed their MOS models referring to audio quality and video quality (see (5)-(6) in Table I). The first one, the MOS_{AV-BM1} model has been created for the short conversation test (SCT), while the second one, the MOS_{AV-BM2} model has been created for the audiovisual short conversation test (AVSCT), which is intended to simulate an 'average' video telephony conversation with a balanced use of the audio and video channels. Pornpongtachavanich and Daengsi [22] proposed the last model, as shown in (7) in Table I. It is a simple QoE model. It has been created for video telephony quality based on short conversation scenario using subjective tests with Thai users.

D. Mean Absolute Percentage Error

One of the most popular evaluation techniques is the Mean Absolute Percentage Error (MAPE). The evaluation result from MAPE calculation using (8) is called MAPE value (%); for example, where $0\% < \text{MAPE} < 10\%$ means excellent, and $10\% < \text{MAPE} < 20\%$ means good. It means a model with the lowest MAPE value is the best model in comparison; where MAPE is the mean absolute percentage error (%), $S_{\text{calculation}}$ is the calculated score from the model, and $S_{\text{reference}}$ is the reference score from the test set [22-23].

III. METHODOLOGY AND RESULTS

This study is based on subjective tests and focuses on conversation or calling of gamers while playing the online game via mobile phones. The game in this study was the Garena ROV or ROV in short, which is one of the most popular MOBA in Thailand. In order to recruit a lot of participants at the same period of time, the test was set up as a competitive event from 9-10 September 2019, in Prachuap Khiri Khan. All participants were students of RMUTR (Wang Klai Kangwon Campus) who applied to participate in the competition of the '5 versus 5' (5v5) mode of the ROV game. There were 8 teams, consisting of 27 male and 13 female participants with an average age of 18.75 ± 0.71 years. The IP network provided by RMUTR was specifically configured for the competition, providing the bandwidth of 1 Gbps. Headsets were provided by RMUTR as well, whereas mobile phones (with iOS and Android operating systems) were provided by participants. All participants had to assess the voice quality and the video quality while calling and playing game in the first round of the competition. Also, they had to vote on the percentage of voice quality from calling and the video quality from the game (for example, audio/video = 60 % / 40 %, 50 % / 50 %, and 40 % / 60 %). After gathering the results, the data was separated into two parts randomly. The first set of data was three quarters of the whole data (from 21 male and 9 female participants), while the rest of data

consisted of the remaining one quarter (from 6 male and 4 female participants), see Table II.

IV. PROPOSED MODEL AND ITS EVALUATION

After creating the model based on the first set of data in Table II, the new model has been proposed as in (9). Then, it has been evaluated by comparing its performance with the model (5)-(7) as shown in Table I only, while the model (1) and (3)-(4) have been omitted because those models require objective parameters.

For evaluation, one of the most popular evaluation techniques is Mean Absolute Percent Error (MAPE). The data set, called the test set, as in the 2nd part in Table II was obtained from 10 participants with 6 male and 4 female participants (their average age was 18.60 ± 0.52 years). It was used for MAPE calculation using (8), then the MAPE results were obtained, as shown in Table III, the MAPE_{Proposed-MOBA} provides the lowest MAPE values with MAPE of 6.16 %.

TABLE I. LIST OF RELATED RESEARCH WORKS

Ref.	Proposed concept	
[13]	$MOS_{model} = -0.00000587 \cdot X_3 + 0.00139 \cdot X_2 - 0.114 \cdot X + 4.37$	(1)
	Where $X = 0.104 \cdot Ping_average + Jitter_average$	(2)
[16]	$MOS = 5.17 - 0.012 \cdot Delay - 0.018 \cdot Jitter$	(3)
[17]	$MOS = 4.7059 - 0.00094 \cdot Delay - 5.83444 \cdot Loss$	(4)
[21]	$MOS_{AV-BM1} = 0.584 \cdot MOS_A + 0.357 \cdot MOS_V + 0.0013 \cdot MOS_A \cdot MOS_V + 0.127$	(5)
	$MOS_{AV-BM2} = 0.030 \cdot MOS_A + 0.079 \cdot MOS_V + 0.123 \cdot MOS_A \cdot MOS_V + 1.374$	(6)
[22]	$MOS_{AVSCT-Thai} = 0.65 \cdot MOS_A + 0.35 \cdot MOS_V$	(7)

$$MAPE = \frac{\sum_{i=1}^n \left| \frac{S_{calculation_i} - S_{reference_i}}{S_{reference_i}} \right|}{n} \quad (8)$$

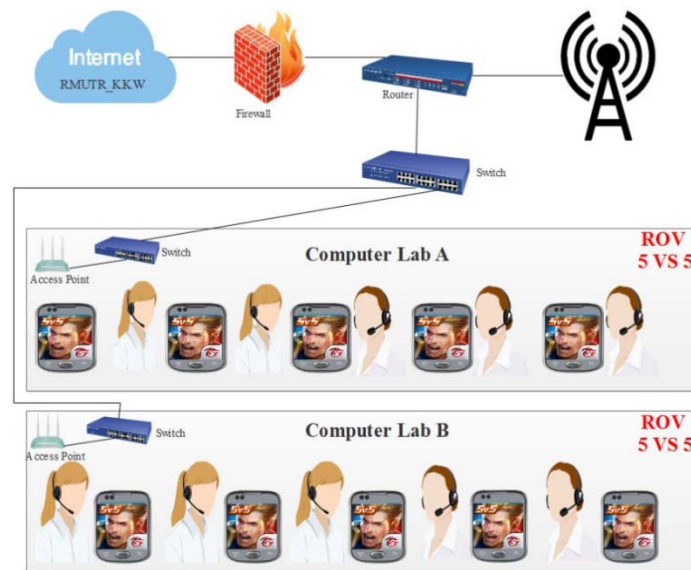


Figure 3. The competition scenario overview

TABLE II. RESULTS FROM THE COMPETITION

Group of Participants	N		MOS $\pm$ SD		Weighted Percentage		Remark
	Male	Female	Voice	Video	Voice	Video	
1 st part	21	9	4.00 ± 0.69	4.23 ± 0.57	48 %	52 %	For modeling
2 nd part	6	4	4.10 ± 0.74	4.00 ± 0.67	50 %	50 %	For evaluation

$$MOS_{Proposed-MOBA} = 0.48 \cdot MOS_{voice} + 0.52 \cdot MOS_{video} \quad (9)$$

TABLE III. EVALUATION RESULTS

Model	MOS	MAPE	Remark
MOS _{AV-BM1}	3.971 ± 0.585	8.54	
MOS _{AV-BM2}	3.855 ± 0.652	7.67	
MOS _{AVSCT-Thai}	4.065 ± 0.621	8.34	
MOS _{Proposed-MOBA}	4.048 ± 0.597	6.16	The highest performance

V. DISCUSSION

In this section, there are few issues to be discussed as follows:

1) From Table II, the first part of the participants, called the training set, perceived good voice quality and video quality with MOS of 4.00 ± 0.69 and 4.23 ± 0.57 respectively. For the second part of participants, called the test set, perceived good voice quality and video quality with MOS of 4.10 ± 0.74 and 4.00 ± 0.67 respectively. The slightly different perception between two groups is acceptable.

2) This study did not follow [13][16-17], because those studies were based on objective assessment referring to network parameter (e.g., delay, loss and jitter) but this study was conducted based on subjective assessment.

3) MOS_{Proposed-MOBA} provides the lowest MAPE value of 6.16%, whereas MOS_{BM2}, MOS_{AVSCT-Thai} and MOS_{BM1} are 7.67, 8.34 and 8.54 respectively, indicating that is model is highly reliable when being compared with other previous models.

4) According to the contribution of this work, the methodology with subjective tests as presented in this study might be applied to study other kinds of games. Besides, the proposed model might be applied to assess other MOBA games with high reliability.

VI. CONCLUSION AND FUTURE WORKS

This paper presents a new audiovisual quality assessment model with reference to MOBA games using subjective tests with ROV (5v5 mode). After obtaining the data, QoE modeling and evaluation were conducted. The evaluation results show that the proposed QoE model for MOBA gaming provides very good performance with MAPE value of 6.16 % which is better than MAPE values from pervious QoE models. Nevertheless, this study with subjective tests is only based on 5v5 mode; the mathematical model with other modes (e.g., 2v2, 3v3 and 4v4) should be presented in future work.

ACKNOWLEDGMENTS

Thank you to Rajamangala University of Technology Phra Nakhon, Rajamangala University of Technology Rattankosin (Wang Klai Kangwon Campus) and King Mongkut's University of Technology North Bangkok for supporting. Finally, thank you to all participants for joining the game competition with subjective tests and Dr. Montarat Rungruangthum and Mr. Bhaskar Laha for English editing.

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