A QoE Evaluation and Adaptation Method for Multi-player Online Games

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Abstract. To evaluate the performance of multi-player online games (MPOGs) (e.g., the online Chinese poker game), this paper presents a novel Effective Quality of Experience (EQoE) concept that considers the interaction among multiple players. A novel QoE evaluation and adaptation method is proposed utilizing EQoE. Specifically, the proposed method assigns different weights to different players according to their roles in the multi-player online poker game. Some players with a lower weight are willing to reduce their own QoE to save network resources for players with a higher weight in order to keep the game going under poor network conditions. Our simulation study demonstrates the feasibility of the proposed QoE evaluation and adaptation method.

Keywords: Multi-Player Online Game (MPOG) · Resource allocation · Quality of Experience (QoE) · Mean Opinion Score (MOS) · 5G wireless

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1 Introduction

As an important metric to evaluate users' satisfaction with perceived quality, Quality of Experience (QoE) is becoming one of the key metrics in the design of 5G/future networks [1], where a new era of personalized services are emerging that emphasize service experience and users' QoE [2]. QoE has been widely used to describe the overall level of satisfaction of service quality from user's perspective, and is a vital factor to evaluate the success of network traffic over future network systems (such as the 5G Tactile Internet).

Among many emerging multimedia applications, Multi-Player Online Game (MPOG) is nowadays one of the most popular applications, which usually is of large-scale over wide geographical locations and keeps attracting a large number of players. In 2010, the number of gamers has reached 20 million worldwide [3], and the PC online game market worldwide reaches $44.2 billion USD in 2020 (according to statistics.com). The MPOG is a mixture that consists of a number of different subgenres, which all have various, but stringent responsiveness requirements [3]. Different MPOGs can tolerate different performance thresholds, for example, 100 ms for First Person Shooter (FPS), 500 ms for Role Playing Game (RPG), and 1000 ms for Real Time Strategy (RTS) [4].

1.1 Motivation

It has been recognized that ensuring an acceptable QoE for all players is a fundamental criterion to sustain the economic success of the MPOG industry, which has been growing at a rapid pace and has attracted enormous attention in recent years [4]. Different from individual Quality of Service (QoS) metrics, the impact of various system factors on QoE depends on the ongoing interaction among users in the multiuser scenario [5].

Going beyond conversational single-user services, MPOGs are offered in different circumstances. For example, Destiny is a blend of shooter game and massive multi-player online game. It has attracted dozens of millions of players so far. In the game world, MPOG provides a platform for hundreds of thousands of players to participate in a game simultaneously. By dividing the game world into linked mini regions that are then distributed between servers, the players in each region are fetched by the server(s) hosting the region. Since game event handling, non-player character (NPC) control, physical hardware restrictions (such as CPU speed and the amount of memory that is available), and persistence in the game world management, MPOG's servers are usually heavily loaded [6].

Most existing research efforts on QoE evaluation are limited to the single-user scenario, which rarely consider issues or provide enhancements for multiuser scenarios. Considering fast development of MPOGs that should be offered with an acceptable QoE to all the concurrent players [6], this paper is focused on the challenging problem of QoE evaluation for MPOGs.

1.2 Challenges and Existing Solutions

A major challenge here is how to provide effective QoE evaluation, since QoE is influenced by both subjective and objective factors. The former includes bit rate, jitter, delay, and so forth. The latter involves user profile, emotion, education, surroundings, etc., which are related to human subjective factors and are hard to measure and quantify. There exists many prior works on QoE evaluation to address this challenging problem. For example, the authors in [7] proposed a continuous QoE prediction engine, which was driven by three QoE-aware inputs: a QoE memory descriptor that accounts for recency, rebuffering-aware information, and an objective measure of the perceptual video quality. In [8], Mok, Chang, and Li aimed to construct a predictive model by incorporating supervised learning algorithms, in which multiclass Naïve Bayes classifiers were applied to train a model. In a recent work [9], the authors proposed a variety of recurrent dynamic neural networks that conduct continuous-time subjective QoE prediction. A study was presented in another recent work [10] on subjective and objective quality assessment of compressed 4K ultra-high-definition videos in an immersive viewing environment. However, such existing research efforts on QoE evaluation are usually limited to the single-user scenario, which rarely consider the unique challenges arising in multiuser scenarios. Therefore, such approaches may not be effectively extended for MPOGs.

Unlike QoS, QoE is a subjective assessment of media quality of users and takes into account both technical parameters and usage context variables. System factors, context, and user, along with user behavior, will all influence a user's QoE, which in turn will influence the user's behavior and the current state of the user [5]. In practice, variations in service quality is unavoidable. For example, the same user may change her QoE requirements for the same traffic condition but in different scenes. Therefore, it is a non-trivial challenge for network operators and service providers, which are interested in seeking effective solutions to improve the overall network performance and revenue. The evaluation of QoE for the multiuser scenario is still an evolving, open problem, which requires far more works to be done in this domain. In this paper, we aim to tackle this challenging problem with a properly designed QoE evaluation method, which takes into account the interactions among multi-players to offer uninterrupted services in future network systems such as the 5G Tactile Internet.

1.3 Methodology and Innovations

Without loss of generality, we use interactive multi-player online poker game as an example, for which QoE modeling is a vital design factor. However, owing to the individual application types and user preferences, different players often have different QoE requirements even with the same data rate in the same game; even the same player may have different QoE requirements in different game scenes. Therefore, a multi-level QoE model should be maintained for the game players at runtime.

Since the players play the online poker game without needing 3D graphic rendering hardware or software, game streaming often consumes very little bandwidth. For a specific player, the throughput does not need to be overly increased, because the player's QoE cannot be further improved when the throughput is sufficiently large. In the interactive multi-player online poker game, players often have different levels of priority depending on their roles in the game. As illustrated in Fig. 1, some players can adjust their QoE requirements according to the

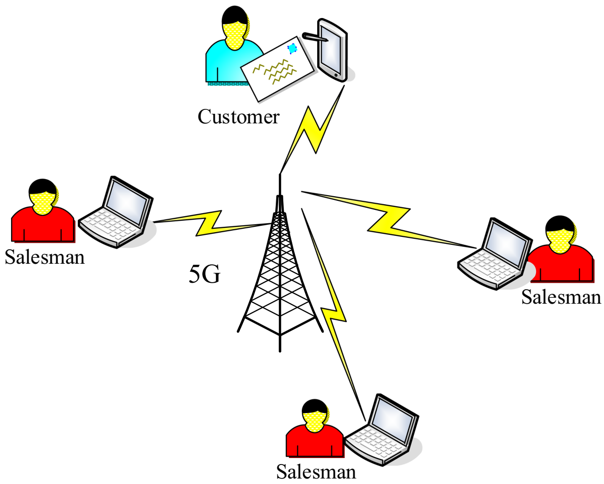

Fig. 1. An example scenario of the online Chinese poker game.

dynamic conditions to play the game with an acceptable QoE. Some players are more willing to neglect a decrease in network resources to maintain an optimal communication frequency for an enjoyable game. In the example shown in Fig. 1, a few salesman are playing the game to social with their customers. Because the online poker game will be terminated when any of the players decides to quit due to poor QoE, the salesmen are more willing to keep playing the game by decreasing their QoE level to provide more network resources to the customers.

Considering that different players usually have different roles in the game, due to different purposes such as business, social, team building, etc., we can make appropriate network selections accordingly in order to minimize the effect of poor network conditions for better game interactivity and an enjoyable user experience. Because some players are willing to save or provide network resources for some other players with a higher priority, by decreasing their own QoE level in order to continue the game, it is possible to maintain the quality of the game by relaxing some network constraints for such players.

Many existing methods are focused on individual player's perception of service quality, while ignoring the mutual influence of multiple players. We propose to consider the special characteristics of the multi-player online poker game, which influence the player's QoE accordingly. A new QoE evaluation method should reduce the impact of poor and unstable network conditions on the interactivity of the game, and maintain an enjoyable game for players even with poor or unstable network capabilities.

In this particle, our main objectives and contributions are: (i) to propose an "Effective QoE" (EQoE) concept by considering the interactions among multi-players; (ii) based on the concept of EQoE, we propose a novel QoE evaluation method considering the interactions among multi-players.

1.4 Organization

The remainder of this article is organized as follows. We discuss research challenges and existing solutions in Sect. 2. Our proposed QoE evaluation method is presented in Sect. 3. We then present a case study to demonstrate the performance of the proposed new approach in Sect. 4. Finally, we discuss open problems and future research directions in this problem area in Sect. 5, and conclude this paper in Sect. 6.

2 Research Challenges and Existing Solutions to Address These Challenges

Compared to the existing solutions that mainly implement QoE prediction for an individual user [9,10], some of the new challenges for QoE evaluation method for MPOGs include:

- It is non-trivial, if not impossible, to quantify the impact of various factors that influence end users' QoE.
- Devices need to have high processing capabilities to meet the high CPU demand imposed by online games.
- Since hundreds of thousands of players may be served (and hence constrained by) a single server, the players tend to flock to one area, causing the game related traffic to reach an unacceptable level, and eventually causing a low QoE for the players [6].
- How to model the activities of multiple players based on effective simulation models [11]?
- How to model the impact of various subjective and objective factors on the QoE?
- How to identify new, effective Key Performance Indicators (KPIs), which can truthfully represent the QoE?
- How to model players' preferences? The flocking of players to a hot-spot may be triggered either by players preference for a particular region of the game, or preference of players to achieve a bonus scores to improve their profiles [6]. All such factors should be considered in the QoE model.
- How to employ an integrated empirical and theoretical approach towards finding the structural patterns in gaming behaviors of both humans and artificial agents [11]?

Researchers have been making great effort to tackle some of the above issues. For example, in [12], the authors proposed a multiuser MAC scheduling scheme for the Wireless Virtual Reality service in a 5G MIMO-OFDM system, aiming to maximize the number of simultaneous Wireless Virtual Reality clients while guaranteeing their three ultra-high (3UH) QoE requirements. This scheme was composed of three novel functions, including video frame differentiation and delay-based weight calculation, spatial-frequency user selection based on maximum aggregate delay-capacity utility (ADCU), and link adaptation with a dynamic block-error-rate (BLER) target. In [13], the authors assessed the impact of several system factors, in the context of multi-party video-conferencing, on (i) user behavior, especially the interaction of participants, and (ii) the QoE considering user factors. Nightingale, et al. in [14] focused on providing a QoE prediction model for ultra-high-definition (UHD) video flows in emerging 5G networks. To improve QoE fairness and utilization of network resources, the authors in [15] presented an optimization framework based on sigmoidal programming to maximize the sigmoidal utility functions subject to network constraints. In this framework, the network bandwidth allocation problem for video traffic was formulated as a network utility maximization problem, which was a nonconvex optimization problem, and then solved with sigmoidal programming.

Although some advances having been made, the existing studies have not considered the weight effects of players participating in the game. Most of these QoE evaluation methods are focused on the single-user scenario, but rarely consider issues or provide enhancements for multi-player scenarios. Such approach are hard to be extended for effective QoE evaluation for MPOGs.

3 Proposed QoE Evaluation/Adaptation Method

3.1 System Framework

In the illustrative example shown in Fig. 1, there are four players participating in the online Chinese poker game, with strong interactivity among the multi-players. The players have different priorities depending on their roles in the game. However, a higher priority player will still be forced out of the Chinese poker game if any of the four players quits the game (i.e., the game will be terminated when the first player quits the game).

Generally, the player with a higher priority has more control of running the poker game. For example, the salesmen are more willing to play the poker game even if they have a low QoE (to social with the customer), while the customer wants to continue the game only if his/her QoE is satisfactory. Meanwhile, the individual QoE should be considered since different players have different QoEs. When any of the multi-players has a poor QoE, the corresponding player will quit from this game. In this case, the poker game will be interrupted even if the others with a higher priority are enjoying a satisfactory QoE.

In order to provide more network resources to the player with a higher priority, some other players should be willing to downgrade their QoE requirements due to other considerations (i.e., if they wish to play the game longer). In such cases, the players with a lower priority may still maintain a high Mean Opinion Score (MOS) value as estimated by typical QoE prediction methods.

Since some low-priority players can tolerate QoE variations within a certain range, we aim to design an effective QoE evaluation method from the user demand-centric perspective in terms of classical MOS for the multi-player scenario. We focus only on QoE evaluation, and assume that the priorities can be assigned with an existing method such as deep learning [17,18]. An agent located at the Base Station (BS) collects information from all players, and analyzes individual QoE levels and priorities in a particular context. After executing the proposed evaluation method, the agent can make an appropriate network selection according to the player's priority and network resource requirement. The main idea is that the proposed method may degrade some low-priority player's QoE momentarily, but the overall QoE the game will be maintained.

3.2 QoE Assessment

To represent the satisfaction for different players, this paper adopts MOS as a qualitative measure to characterize QoE since MOS has been recognized as the most popular descriptor of perceived multiple media quality. MOS is defined in ITU-T P.800, P.910 and P.920, which generally consists of five QoE levels. From high to low, the value of MOS represents "Best," "Excellent," "Good," "Poor," and "Bad" for users' QoE, respectively. "Bad" means that the perceived quality drops to an unacceptable level, while "Best" indicates that the user has enjoyed the most satisfactory experience [16].

Depending on whether the player is directly involved in the assessment, existing QoE prediction methods can be categorized into subjective methods and objective methods. The former is a direct means to obtain QoE by asking players. Therefore, it is expensive and ineffective to measure. The latter utilizes numerical quality metrics to approximate user-perceived service quality.

Since the data rate is one of the most important factors in determining QoE [7], throughput is sometimes used to represent the QoE a player can obtain for simplicity. In this paper, we adopt the QoE assessment method proposed in paper [16] for individual QoE assessment. Based on the method in [16], we utilize a discrete MOS model with five limited grades to evaluate each of the players, and consider a MOS of 2 as the minimum required rating to keep the game running. Assume there are N players. The relationship between data rate and MOS can be written as a bounded logarithmic relationship function as follows [16]:

$$\mathrm{MoS}(\theta_n) = \begin{cases} 5, & \text{for } \theta_n > \theta_n^4 \\ 4, & \text{for } 3 < a\log(\frac{\theta_n}{b}) \leq 4 \\ 3, & \text{for } 2 < a\log(\frac{\theta_n}{b}) \leq 3 \\ 2, & \text{for } 1 < a\log(\frac{\theta_n}{b}) \leq 2 \\ 1, & \text{for } \theta_n < \theta_n^1, \end{cases} \quad \text{for } n \in \{1, 2, ..., N\}, \tag{1}$$

where

$$\begin{cases} a = \frac{3.5}{\log(\theta_n^4/\theta_n^1)} \\ b = \theta_n^1 \left(\frac{\theta_n^1}{\theta_n^4}\right)^{\frac{1}{3.5}} \\ 0 \leq \theta_n^1 < \theta_n^4, \end{cases} \quad \text{for } n \in \{1, 2, ..., N\}. \tag{2}$$

In this model, θ_n denotes the average throughput of user n, and a, b, θ_n^1, and θ_n^4 are model parameters, where θ_n^1 represents the required minimum throughput and θ_n^4 is the recommended throughput.

3.3 The Concept of Effective QoE

For interactive multi-player online poker games, it is difficult to maintain a good game quality by considering only the individual QoE levels. When any of the players decides to quit due to an unacceptable QoE level, the online poker game will be stopped even if the other players have a satisfactory QoE. Therefore, we not only take account into the individual QoEs, but also consider the group QoE. By levering the network resources among the players, the game can be maintained at a high quality of QoE.

To effectively allocate network resources among the players, a concept of Effective QoE (EQoE) is proposed in this paper, which is different from the individual QoE. The formulation of EQoE is given in the following.

$$\mathrm{QoE}_e = \mathrm{QoE}_m + \sum_{n=1, n\neq m}^{N} \lambda_n (\mathrm{QoE}_n - \mathrm{MoS}_L) \tag{3}$$

$$\sum_{n=1}^{N} \lambda_n = 1, \tag{4}$$

where QoE_e represents EQoE, N is the number of players in the multi-player game, the nth player has the corresponding QoE value QoE_n obtained as in (1), λ_n denotes the player weight of the nth player, $\lambda_m = \max_n\{\lambda_n\}$, QoE_m is the QoE value of the player with weight λ_m, $\mathrm{MoS}_L = \theta_n^1$ represents the lowest acceptable QoE value, which is the minimal acceptable data rate of the player.

By computing (3), EQoE can be obtained for the poker game. According to the value of EQoE, we can adjust the network resource allocation to maintain the game at a good quality level. When $\mathrm{QoE}_e > \mathrm{QoE}_m$, there is extra QoE resource for the player with the highest weight in this case, and thus we can adjust the resource allocation to decrease other players' QoE level until $\mathrm{QoE}_e = \mathrm{QoE}_m$ one by one according to the ascending order of player weight. Otherwise, there is no extra QoE resource for the player with the highest weight in this case.

The player weights can be obtained by applying some existing methods (e.g., see reference [17] for details) or historical records of the players. This paper focuses on the design of a novel QoE evaluation method for multi-player online poker game.

3.4 The QoE Evaluation/Adaptation Method

Base on the above concept and model of EQoE, we propose a novel QoE evaluation method for the online Chinese poker game, in which the network resources are dynamically adjusted according to the network condition and player QoE levels until no extra QoE resource remains. The procedure of the proposed method is shown in Fig. 2. A detailed description of the scheme is given in the following.

Step 1: The MoS of each player n can be calculated based on an existing QoE evaluation method for individual QoE, as proposed in [16] (e.g., using (1)).

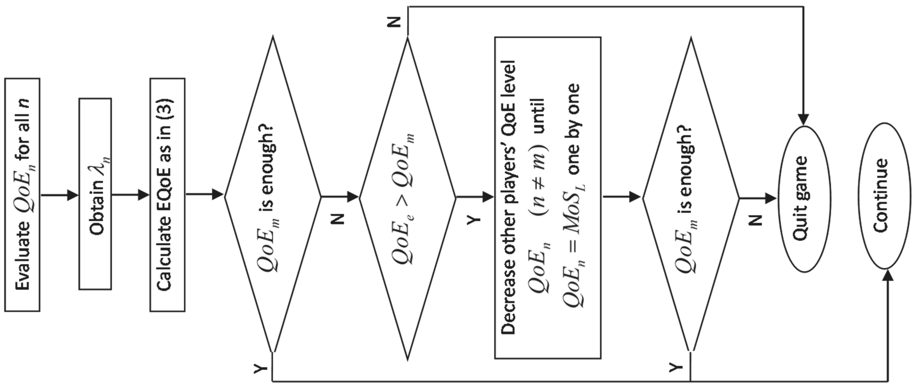

Fig. 2. Procedure of the proposed QoE prediction and adaptation method.

Step 2: Player weight is obtained by applying the deep learning method proposed in [17] or the historical records of each player.
Step 3: EQoE is obtained as in (3).
Step 4: If the player with the highest weight has enough QoE resource to play the poker game, then the agent goes to Step 11.
Step 5: According to the result of Step 3, the agent decides whether to adjust network resource allocation or not.
Step 6: If $\text{QoE}_e > \text{QoE}_m$, the agent has the capacity to adjust the network resource allocation, by decreasing the QoEs of the players with a lower weight to release network resource for the player with the highest weight or a higher priority. Then the agent goes to Step 8.
Step 7: If $\text{QoE}_e \leq \text{QoE}_m$, all of players will quit the current poker game. The agent goes to Step 12.
Step 8: By decreasing the QoE level of players with a lower weight until $\text{QoE}_n = \text{MoS}_L$ one by one according to ascending order of player weights, the agent allocates more network resources to the player with the highest weight.
Step 9: If QoE_m is satisfactory, the agent goes to Step 11.
Step 10: If QoE_m is not satisfactory, the agent goes to Step 12.
Step 11: Players can continual to play the game.
Step 12: Players need to quit the game.

Unlike the existing method [16], the proposed QoE evaluation and adaptation method takes into account that the players have different priorities depending on their roles in the game, and exploits the characteristics of the online Chinese poker game to guarantee the quality of game with the proposed EQoE concept.

4 Case Study

In this section, we evaluate the effectiveness of our proposed method using the online Chinese poker game as an example. Each game is typically played by 4 players, while a server can support a large number of games (and thus players) simultaneously. In the simulations of the typical online Chinese poker game, we assume 128 kbps as the required minimal throughput and 512 kbps as the recommended throughput as used for Skype. Therefore we have $\theta_n^1 = 128$ kbps and $\theta_n^4 = 512$ kbps.

In order to evaluate the effectiveness of our proposed method, we use the traditional method in [7] as a baseline scheme. The simulations are executed using the Matlab platform, and each result is the average of 50 runs. We compared the utilization of throughput in the proposed method with that of traditional QoE prediction method. It is assumed that the user's QoE and weight follow the Gaussian distribution in the range of [128 kbps, 512 kbps]. During the Chinese poker game, there are also some other real-time traffic with a higher priority (such as banking by phone, e-health services) transmitted, which also follows the Gaussian distribution in the range of [0, 50 Mbps].

When there is background traffic with higher priority, the available network throughput for the game players will be reduced. The traffic with higher priority will be protected by decreasing the game player's QoE levels temporarily with the proposed method. However, the traditional method will interrupt some players to provide network resources for the high-priority traffic. Therefore, we can see that the proposed method has obviously achieved a better performance than the traditional method in terms of throughput utilization and the number of players supported, as shown in Fig. 3, Fig. 4, Fig. 5, and Fig. 6.

Specifically, Fig. 3 shows that the proposed method has achieved higher throughput utilization than the traditional method under the same influence from the higher priority background traffic. This is because the traditional method does not take into account that all the 4 players of an online Chinese poker game will be interrupted when any of the players is interrupted due to insufficient throughput. Unlike the traditional method, the 4 players of the online Chinese poker game are assigned with different weights in the proposed scheme. Some players with a lower weight are willing to reduce their QoE level to save network resources for players with higher weights, in order to continue playing the game.

Figure 4 shows that the proposed method can accommodate more players than the traditional method. During the period of time when the high-priority background traffic is heavy, the number of players still remains high with the proposed method. However, the number of players is much smaller with the traditional method under the same background traffic pattern. This is also due to the specific design of the proposed scheme that introduce different priorities to the game players and exploit the priorities in network resource allocation.

Figure 5 presents the average throughputs of player with different weights with the proposed method. It can be seen that the throughputs are very different, since the proposed method maintains players' QoE according to their weights. When the background traffic with a higher priority is heavy, the average throughput of player with higher weight keeps stable. However, the average throughput of the player with a lower weight is much lower than that of the

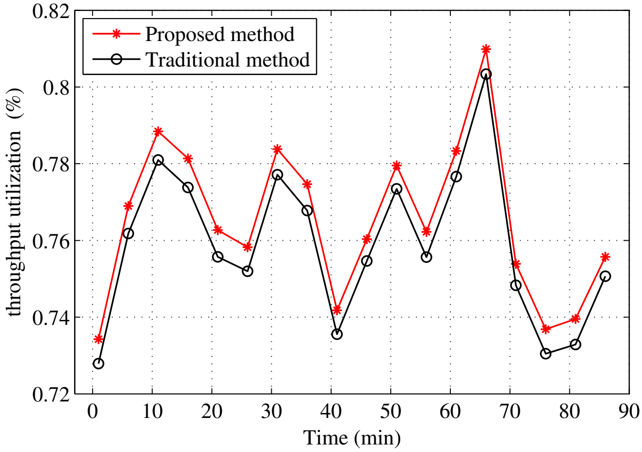

Fig. 3. Comparison of two methods in terms of throughput utilization.

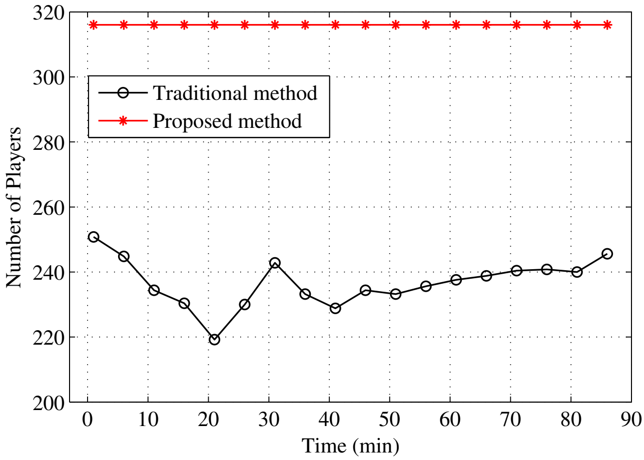

Fig. 4. Comparison of two methods in terms of the number of concurrent players supported.

player with a higher weight, and it changes with the requirements of the background traffic with higher priority. The average throughput of the player with a lower weight is decreased to better accommodate the higher priority traffic in order to keep the game going under poor network conditions. In Fig. 6, we can see that the average throughput of the player with a higher weight remains high, even though the high-priority background traffic is continuously increased, while the average throughput of the player with a lower weight decreases with the increased background traffic.

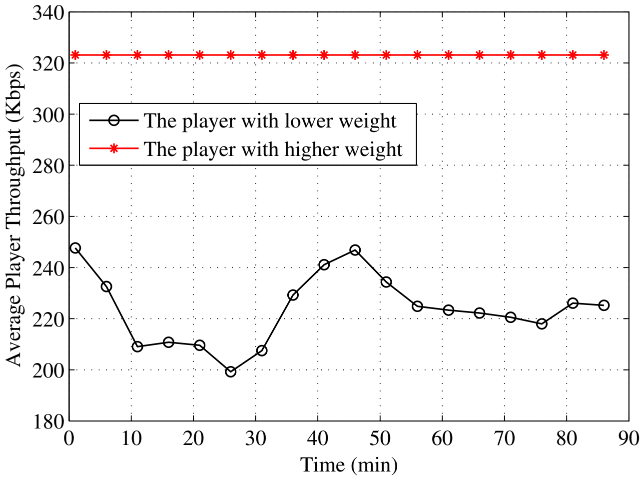

Fig. 5. Comparison of the average throughput of players with different weights over time.

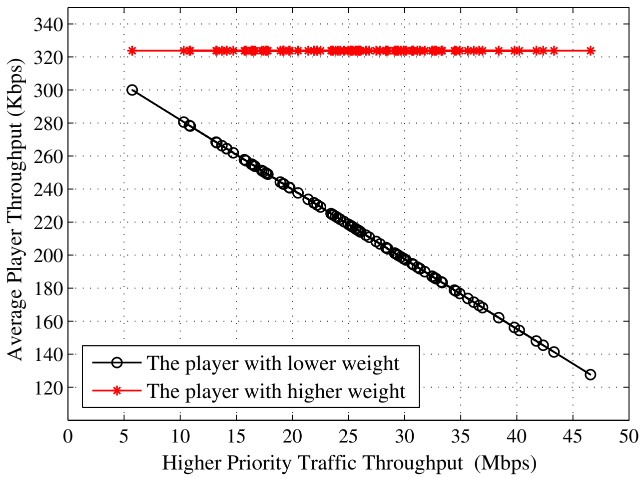

Fig. 6. Comparison of the average throughput of players wit different weights under increased high-priority background traffic.

Unlike the existing works that consider only individual QoE, our proposed method takes into account the fact that different players have different roles and weights in the multi-player online poker game, where some players with a lower weight are willing to reduce their QoEs to save network resources for players with a higher weight to keep the game going under poor network conditions.

5 Future Directions and Open Problems

QoE-related research and applications are still in the infancy stage, and only limited work has been done in the field. QoE-related technologies are lacking on a systemic and in-depth research. There are many obstacles in the development of QoE-related applications. In 5G and beyond network systems, many new online multimedia services and traffic types are emerging. Some potential challenges in the fields of QoE research are provided as follows.

- Subjective factors: QoE is influenced by a lot of subjective factors, such as user's mood, specific preference, attention, expectations, service ease of use, context, etc. Until today, there are also a lot of unknown factors. Some factors mentioned above still need further study. It is difficult to find kernel factors to describe QoE since a lot of subjective factors are highly sophisticated. Meanwhile, it is a challenge to effectively quantize and model these factors.
- Nonlinear fusion: QoE is affected by a variety of factors from different fields. The knowledge of factors is generally obtained from heterogeneous, autonomous sources, which utilize different technologies to acquire. It is very difficult to obtain the analytical relationship between QoE and the influencing factors. To mine potential and useful information, nonlinear fusion plays a vital role in the fields of QoE modeling. A new fusion method should be designed, which would solve the above problems.
- Dynamic QoE prediction: Because the user's QoE often evolves with time, space, context, knowledge, circumstance, and scenarios, the observed factors are often transient. Therefore, a prediction method should be capable of predicting future trends and should analyze and model dynamic factors together with dynamic requirements simultaneously.
- Real-time, online QoE assessment: With the explosion of data volume, traditional QoE prediction systems may not be able to handle the data effectively. In many applications, it is impossible to obtain the eventual data scale since the data is accumulated over time. Furthermore, different factors have different degrees of importance for different analytical goals. The QoE assessment method needs to consider the computational and storage loads of big data. From the perspective of data-processing platforms, an effective and efficient processing approach is critical for real-time online QoE prediction. Meanwhile, the QoE assessment method should also be focused on the complexity and scalability issues encountered in the development of QoE applications in future research.
- User-centric QoE methods: The QoE assessment methods should be capable of discovering users' latent intention from limited observed data. It should consider user profiles, social networks, and behaviors to model the user's intention.
- Security and privacy: Since QoE involves a lot of individual data, security and privacy should be considered, which still remain an open problem. For analyzing user's QoE, different data owners should warrant that analyzers have different access rights. The QoE method should avoid the violation of users'

privacy. Meanwhile, a QoE safety mechanism should be designed, including effective cryptography approaches, safety management, access control, and safe communications.

– Modeling: It is still a challenging task to model the various influencing factors since most of such factors are immeasurable. Meanwhile, it is difficulty to effectively observe the factors which are related to social psychology and cognitive science. The numerical presentation of QoE is still challenging since the QoE model could be different from time to time, impacted by both the network side and human side factors [19].
– The utility function: both the parametric QoE model and the personalized QoE model have several parameters calibrating the presentation of QoE, and thus, depending on the choice of parameters, the utility function may not be concave at all, making it hard to optimize in resource allocation [19].

We also note that the research on QoE evaluation for multiple players is still in its infancy. Heterogeneous network conditions and dynamic requirements make the multi-user QoE evaluation problem even more challenging. As discussed above, these and similar problems are subject to our future research.

6 Conclusions

This paper proposed a new QoE evaluation and adaptation method for MOPGs (especially, the online Chinese poker game), which considers the fact that different players have different weights when playing the game. Some player with a lower weight are willing to reduce their own QoE level to provide more network resources for players with a higher weight, in order to keep the game going under poor network conditions. We presented an EQoE concept and model by considering the interactions among multiple players. Simulation results reveal that the proposed method could effectively improve the game performance with respect to throughput utilization and the number of players supported, as compared to a traditional baseline method.

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