Cascading Impact of Lag on User Experience in Multiplayer Games

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1. INTRODUCTION

Playing cooperative multiplayer games should be fun for everyone involved and part of having fun in games is being able to perform well, be immersed, and stay engaged [13, 17]. These indicators of enjoyment are part of a user's Quality of Experience (QoE), a measure which further includes additional metrics such as attention levels and ability to succeed. Players stop playing the game when it ceases to provide a high enough QoE, especially in cooperative and social games. [8, 18, 19].

Industry application development and current research both operate with the assumption that for any given individual in a group, that individual's QoE is affected only by their own network condition and not the network conditions of the other group members [4, 7, 8]. We show that this assumption is incorrect.

Our research shows that the QoE of all group members is negatively affected by a single member's lag (communication delay, or loss caused by poor network conditions). Understanding a user's QoE as a function that includes other users' network conditions has the potential to improve lag mitigation strategies for multiplayer games and other group applications.

2. RELATED WORK

Prior studies evaluate the effect of lag on a single user's QoE [3, 4, 5, 8, 9] and show that increasing a single user's lag through higher latency, jitter, or loss decreases that user's QoE in multiplayer games.

QoE for interactions of users in group applications has been studied with simulations using artificial intelligence (AI) players, observational studies of users in real-world applications, and as by-products of studies focused on single individuals' QoE [7, 10, 11, 14, 15, 16, 18, 22]. These previous studies considered QoE of group members with lag, but did not examine the QoE of group members not experiencing lag.

Our work explores a different aspect of user experience in that we look at QoE of all group members within a popular real world collaborative application. Unlike work of Park and Kenyon and of Beznosyk *et al.*, we consider interactions of more than two human participants [6, 16]. We examine the cascading impact of lag by adjusting the level of network performance on the path to the game server for only a single member of the group while taking QoE measurements for all group members.

3. METHODOLOGY

We measured QoE metrics during sessions of Mass Effect 3, a popular cooperative online game by Bioware [2]. Four factor sets were used to emulate lag for one of the group members. The factor sets include representative network conditions of a user located in the same city, state, country, and continent as the other group members [12].

QoE was measured during each game session using both subjective and objective metrics. A questionnaire given after each match was used to record Enjoyment, Immersion, and Engagement [21]. Game Score was recorded for each individual after each match. A wearable EEG device was used to measure player Attention level during the match [1].

QoE Metric	Correlation (r^2)	p-value
Enjoyment	≈ 0.56	< 0.002
Immersion	≈ 0.56	< 0.002
Engagement	≈ 0.38	< 0.015
Score	≈ 0.62	< 0.001
Attention	≈ 0.52	< 0.003

Table 1: QoE Metric Correlations

4. RESULTS

The collected data show that the QoE of a group member is negatively impacted by the decreased network conditions of other group members. This is counter to previous assumptions that a group member's QoE is only impacted by their own network conditions [4, 7, 8].

Table 1 shows each QoE metric's level and strength of correlation between the lagged individual's degradation of QoE due to lag and that of the other members of the group. All correlations have very strong p-values and significant correlation levels.

Our results indicate that reducing lag of of one user will improve their QoE and the QoE of the entire group. Having a group member lag decreases the enjoyment for everyone, but understanding that lag has a cascading impact opens many new areas of systems research and application development. For example, prioritizing game requests of only the lagged users in data centers using mechanisms such as D^3 can improve application ausability for all users [20].

5. REFERENCES

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