

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 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 usability for all users [20].

5. REFERENCES

- [1] Neurosky's esense meters and detection of mental state. white paper, September 2009.
- [2] Bioware accolades. <http://masseffect.bioware.com/about/accolades/>, February 2013.
- [3] G. Armitage. An experimental estimation of latency sensitivity in multiplayer Quake 3. In *International Conference on Networks*, 2003.
- [4] G. Armitage, M. Claypool, P. Branch, J. Wiley, G. Armitage, and M. Claypool. *Networking and Online Games - Understanding and Engineering Multiplayer Internet Games*. John Wiley & Sons Ltd, June 2006.
- [5] T. Beigbeder, R. Coughlan, C. Lusher, J. Plunkett, E. Agu, and M. Claypool. The effects of loss and latency on user performance in unreal tournament 2003®. In *SIGCOMM workshop on Network and system support for games*, August 2004.
- [6] A. Beznosyk, P. Quax, K. Coninx, and W. Lamotte. Influence of network delay and jitter on cooperation in multiplayer games. In *Virtual Reality Continuum and Its Applications in Industry (VRCAI)*, December 2011.
- [7] M. Bredel and M. Fidler. A measurement study regarding quality of service and its impact on multiplayer online games. In *Workshop on Network and Systems Support for Games*, November 2010.
- [8] K.-T. Chen, P. Huang, and C.-L. Lei. Effect of network quality on player departure behavior in online games. *Parallel Distributed Systems*, 20:593–606, May 2009.
- [9] M. Claypool and K. Claypool. Latency and player actions in online games. *Communications of the ACM*, 49:40–45, November 2006.
- [10] M. Dick, O. Wellnitz, and L. Wolf. Analysis of factors affecting players' performance and perception in multiplayer games. In *SIGCOMM workshop on Network and system support for games*, October 2005.
- [11] T. Fritsch, H. Ritter, and J. Schiller. The effect of latency and network limitations on MMORPGs: a field study of Everquest 2. In *SIGCOMM workshop on Network and system support for games*, October 2005.
- [12] O. Goga and R. Teixeira. Speed measurements of residential Internet access. In *Passive and Active Measurement*, January 2012.
- [13] R. Hirota and S. Kurabayashi. Evaluation of fairness in multiplayer network games. In *Pacific Rim Conference on Communications, Computers and Signal Processing (PacRim)*. August, 2011.
- [14] A. Kaiser, D. Maggiorini, N. Achir, and K. Boussetta. On the objective evaluation of real-time networked games. In *Global Telecommunications Conference*, November 2009.
- [15] W. Palant, C. Griwodz, and P. Halvorsen. Consistency requirements in multiplayer online games. In *SIGCOMM workshop on Network and system support for games*, October 2006.
- [16] K. S. Park and R. V. Kenyon. Effects of network characteristics on human performance in a collaborative virtual environment. In *IEEE Virtual Reality*, March 1999.
- [17] M. Seif El-Nasr, B. Aghabegi, D. Milam, M. Erfani, B. Lameman, H. Maygoli, and S. Mah. Understanding and evaluating cooperative games. In *International conference on Human factors in computing systems*, April 2010.
- [18] M. Suznjevic, O. Dobrijevic, and M. Matijasevic. MMORPG player actions: Network performance, session patterns and latency requirements analysis. *Multimedia Tools and Applications*, 45:191–214, October 2009.
- [19] P. Tarng, K. Chen, and P. Huang. On prophesying online gamer departure. In *Network and Systems Support for Games (NetGames)*, November 2009.
- [20] C. Wilson, H. Ballani, T. Karagiannis, and A. Rowtron. Better never than late: meeting deadlines in datacenter networks. In *SIGCOMM Computer Communication Review*, August 2011.
- [21] W. Wu, A. Arefin, R. Rivas, K. Nahrstedt, R. Sheppard, and Z. Yang. Quality of experience in distributed interactive multimedia environments: toward a theoretical framework. In *International conference on Multimedia*, October 2009.
- [22] T. Yasui, Y. Ishibashi, and T. Ikeda. Influences of network latency and packet loss on consistency in networked racing games. In *SIGCOMM workshop on Network and system support for games*, October 2005.