Insensitivity to Network Delay: Minecraft Gaming Experience of Casual Gamers

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***Abstract*—Assessing the impact of network delay on perceived quality of gaming has been subject to many studies involving different genres ranging from fast-paced first-person shooters to strategy games. This paper assesses the impact of network latency on the Quality of Experience (QoE) of casual gamers playing Minecraft. It is based on a user study involving 12 casual gamers with no prior experience with Minecraft. QoE is assessed using the Game Experience Questionnaire (GEQ) and dedicated questions for the overall perceived quality and experienced gameplay interruptions. The main finding is that casual Minecraft players are rather insensitive to network delay of up to 1 sec.**

***Keywords*-Quality of Experience, Gaming, Latency**

I. Introduction

Quality of Experience (QoE) aware network management concerns the optimization of networked applications with respect to improving QoE as their utility (see e. g., [1], [2]). This management relies on predictive models mapping technical parameters, often in terms of QoS, to QoE. One technical parameter that particularly influences the quality of interactive applications is (network) delay. A critical class of delay sensitive applications that serves as an example in this paper are digital games which require the transmission of data, such as multiplayer games and also cloud-based games. Since network management is informed by the employed QoE prediction models, their prediction accuracy is crucial for optimal QoE network management.

However, even the mapping of a single QoS parameter, such as network delay, to QoE is a challenging task. This challenge is rooted in the complex nature of human perception. For example, the QoE of the playing person in a gaming situation depends on a multitude of factors (see [3] for an extensive overview) such as individual prior experiences, expectations, and also the digital game itself (e. g., genre such as fast-paced shooters vs. strategy games). Assessing the sensitivity to delay has been subject to a larger body of studies that report game dependent delay sensitivities (see Sec. II). This sensitivity is further expressed by the monetization of delay optimization mechanisms by ISPs—e. g., premium offers to disable ADSL interleaving ("FastPath")—but also by customer complaints in case network problems causing unexpected latency increases [4]. One recent problem related to network management is the existence of large buffers having the potential of contributing delays in the order of seconds (i. e., buffer bloat [5]). With regard to providing a satisfying QoE to a playing person, telecommunication providers need proper assessment methods.

To optimize these methods, this paper emphasizes the importance of *i)* different gaming tasks and *ii)* the users' familiarity with a service for quality assessment. Depending on the users' familiarity with a game, delay assessments can be inconclusive or users can even exhibit delay insensitivities. While the impact of experience and expectations on gaming QoE have been mentioned as influence factor [3], they have not been empirically studied. As a first step in this direction, this paper complements prior work with a subjective assessment of network latency on QoE using Minecraft with *casual* gamers. Minecraft is an open world multi-player construction game that also includes combat scenarios, which are potentially sensitive to increases in latency. Minecraft provides a rich-platform client, i. e., user input, rendering, and caching happens on the user's device, while the shared world state is synchronized with a server managing the open world. In contrary to prior work on latency and its impact on delay, we found casual gamers to be *insensitive* to additional one-way delay ranging from 0 ms to 1000 ms. This rather unexpected finding emphasizes the need to consider additional factors, such as experience and expectation, as the impact of latency on QoE depends on the playing person and its perception. We therefore posit that a deeper understanding of the involved effects and ultimately improved assessment methods are needed and can contribute to the ongoing ITU-T standardization of gaming assessment methods [6].

II. Related Work

The impact of latency on QoE has been investigated already for a large body of different game genres, including First Person Shooter games (e. g., [7]–[9]), Massively Multiplayer Online Role-Playing games (e. g., [10], [11]), sport simulations [12], or Real Time Strategy games (e. g., [13]). Further studies assessed delay impacts on games that were rendered remotely and delivered as video stream from a data center to the gaming client (see e.g., [14], [15]). It has been found that increasing latency leads to a decrease of the perceived quality if a perception threshold is reached. The reported perception thresholds are largely dependent on the genre (e. g., shooting games were found be more delay sensitive than strategy games), dependent on game mechanics, and implementation details (e. g., delay compensation algorithms). Besides assessing the impact of constant delay, related work identified critical sections of game-play that are more sensitive

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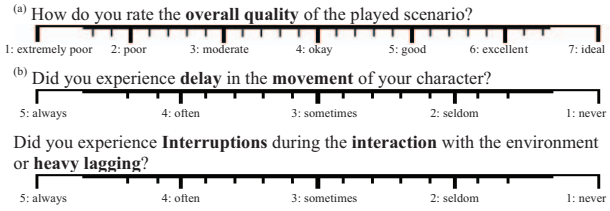


Figure 1. Scales and questions presented after each scenario (coding not presented): *(a)* perceived quality on the continuous 7-point scale (ITU-T P.851), *(b)* perceived delay, and *(c)* perceived interruptions due to delay.

to network degradations [16]. This paper complements related work by showing that gaming QoE assessment is even further challenged by *i)* different gaming tasks and *ii)* the user familiarity with the service as additional factors.

III. Study Design

We assessed the impact of latency on QoE for Minecraft players in a laboratory user study by using a within subject design. The study assessed *casual* gamers with no prior Minecraft experience in a task-driven evaluation. This evaluation relies on two tasks, i. e., construction and survival, to investigate the impact of different tasks on QoE. In the *construction* task, the player was asked to build a cabin. The cabin needed to have a size 5×5 blocks consisting of wood planks. The wood planks needed to be collected by chopping down several trees. In the—assumed to be more delay sensitive—*survival* task, the player was asked to explore a cave potentially containing enemies and collect minerals. In this cave, the player needed to defeat three enemies with his sword before he could reach the minerals. Each task was played for a maximum of 10 min.

As impairment factors, three one-way additional network delay settings were evaluated denoted as *low* (0 ms), *medium* (170 ms), and *high* (1000 ms). The *medium* delay condition was found in a pilot study using Minecraft, involving three subjects and set to the perception threshold in which the additional delay began to be noticeable. Both the *medium* and the *high* delay settings introduced noticeable degradations to the gameplay, whose assessment is subject to this study. In this study, one computer running the Minecraft client was connected via Ethernet with a second computer running the Minecraft server. Participants used the computer running the Minecraft client, while the second computer inserted a constant one-way network delay in each direction via NetEM (i. e., the experienced round-trip-time is double the configured delay).

The experiment consisted of two stages. First, in an initial *training phase* of 10 minutes length participants were introduced to Minecraft as well as to both task. That is, the training was split into two steps, where the participants had first to train the construction and then the combat task. The training allowed the participants to familiarize themselves with the two tasks and the Minecraft itself. The training involved no delay impairments.

In the second part, the participants played 6 scenarios (i. e., construction and combat, each subject to three delay conditions) in randomized order (Latin square design). This step involved the actual assessment of QoE and lasted for circa 60 min. In this stage, six conditions were presented with a duration of 10 min each. Here, the two tasks were presented in all three network delay settings.

After the presentation of each condition, the experience was assessed. Following [3], we used the *Game Experience Questionnaire* (GEQ) [17] to assess the quality factors challenge, competence, flow, negative and positive affect, immersion, and tension. After each played scenario, players assessed *i)* the overall quality, *ii)* the experienced delay, and *iii)* interruptions in the interaction due to delay (see the used rating scales in Figure 1, which *additionally* shows the coding scheme used in this paper).

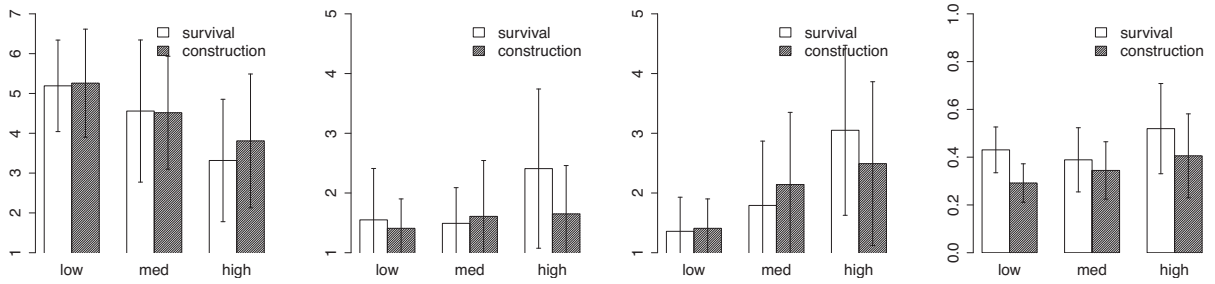
The experiment was conducted in an artificially lighted room, so that all participants were exposed to the same environmental conditions. Twelve casual gamers participated in the study (3 female, 9 male; average age of 28 years). All participants were selected to be *casual* gamers, i. e., playing games for at most 8 hours per week and having no prior experience with Minecraft. The participants stated an average of 1.8 hours/week ($\sigma = 2.4$).

IV. Results

We show the quality dimensions for three delay conditions (low, med, high) and for four selected quality factors in Figure 2. The presentation of all the seven quality factors assessed by the GEQ is limited to showing the factor *tension* since all other factors follow the same overall behavior and no significant effect was found. *Tension* increases slightly with increasing delay values, although only for the *construction* scenario (see Fig. 2(d)). In contrast, the *survival* scenario generally exhibits higher tension ratings that might be caused by the higher risk of failure at the combat task. Due to the limited combat performance (caused by the lack of skill and/or experience), the danger of failing was always present, whereas the risk of an on screen death was non-existent during the building task. Regarding the remaining GEQ factors (not shown), *positive affect* shows a slight decrease in the mean between *low, medium* delay and *high* delay in case of the *construction* scenario. The negative affect ratings are not impacted by delay conditions. The mean immersion ratings are not affected by delay and scenario. We further find the results to exhibit task-dependent differences.

The biggest overall effect can be observed for the *overall quality*, which decreases with increasing delay (see Fig. 2(a)). A similar trend can be seen in the *interaction quality* (see Fig. 2(c)). Further, the *construction* scenario with *high* delay was perceived worse than the *survival* scenario with *high* delay.

Although there are (minimal) effects visible in the *mean* quality ratings, these effects are, however, not statistically significant, as suggested by overlapping standard deviations and confirmed by statistical tests (i. e. the Kruskal-Wallis rank sum test yielded $P \gg 0.05$ for all assessed variables). Thus, we could not find a statistically significant effect of delay on quality for casual Minecraft gamers.



(a) Overall quality of played scenario (1 = extremely poor, 7 = ideal)
(b) Delay experienced in movements (1 = never, 5 = always)
(c) Interruptions experienced during interaction (1 = never, 5 = always)
(d) GEQ: Normalized tension rating (0 = no tension experienced)

Figure 2. μ and σ for four selected quality dimensions.

V. Discussion

Despite of severe delay degradations of up to 1000 ms one-way delay, the *casual* player's quality perception was not significantly impacted. This finding is in contrast to related work that found *experienced* players to be able to compensate delay to a certain extend but perceive large delays as intolerable and even canceled experiments [18]. This rather unexpected finding raises the question on why delay is barely reflected in quality ratings. Comments by participants during the study showed that the players usually noticed the delay-induced effects. However, while these effects *can* be noticeable, their effect on the assessed quality aspects is at best indicated and not statistically significant. Whereas the observed noise in the standard deviations can stem from the low number of participants, the study highlights the particular challenge of QoE prediction in which the user judgments to a given network condition largely vary.

The most influential factor for this result is, however, likely the lack of experience with the played game. Lacking experience challenges the attribution of delay induced errors to actual errors rather than intended game behavior ("I thought it was supposed to be this way"). This can result in inconclusive quality assessments as observed in this study. The results of our study therefore highlight the importance of *i)* the users' familiarly with a service and *ii)* different gaming tasks on the quality assessment. One implication of this observation is that subjective tests should involve players experienced with the game or at least with the game genre and involve different tasks. Further, future quality monitoring tools should incorporate the gamers experience in their predictions, e.g., by omitting clients for which traffic of a particular game is observed for the first time. Exemplified by our preliminary study, we thus aim at motivating future work to explore further perceptive aspects to be reflected in extended quality models.

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