The Role of Latency on Gaming Experience

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Abstract

Among Us is a popular video that gained popularity in 2020 at the height of the Coronavirus pandemic. The appeal was likely due to the social nature of the game during a time when face-to-face interactions were limited (Lorenz 2020). However, Among Us suffers from extremely high network latency, which negatively affects player satisfaction and leads to player dissatisfaction and leaving games prematurely (Chen 2008). Furthermore, high latency contributes to inequity in game events, such as one party being killed without even realizing the killer was nearby, as well as high user input delay and dissatisfaction, such as trying light switches not properly responding to a flick. Among Us is one of many potential case studies in demonstrating the mass appeal of games and the rise of the gaming industry, and in turn the impact that games now have on people's lives and many online communities. The rest of this paper will delve into this interlocking of gaming and latency by discussing its impacts on community-building, eSports industry, and player psychology.

The Role of Latency on Gaming Experience

Introduction

Distributed computing has long since eclipsed the potential that parallel computing provided. One highly efficient parallel-processing computer can no longer compete with the hordes of hosts and computing power offered by cloud services. Evidently, many new technologies have built their products on these distributed systems. However, these distributed applications are all burdened with a common problem: latency within the network. Failed responses, lag spikes, and server slowdowns are common issues seen in many internet-related technologies. As such, measuring and analyzing latency is crucial for network health, since extremely high latency is indicative of a failure of a node or server, and "results in poor performance, negatively affects SEO, and can induce users to leave the ... application altogether" (Cloudflare).

Previous Literature

Studies have been conducted that detail the effect of high latency on gaming performance as well as different methods of counteracting user delay. This form of latency may present as two possible forms: hardware latency and server latency. Although separate, players perceive the combination of the two lags as one holistic delay. Therefore, to improve player experience, both forms of latency must be addressed.

Zha et al. (2019) performed a 36-person study where emotional states were measured with respect to changes in latency. Player movement and hand-eye tracking were given input delay increases of 100ms every 30 seconds, and performance and emotions were tracked for a total of 200 seconds. The study found that players were able to consistently perceive increases in

lag, and this lag delay caused significantly worse performance as well as elevated heart rate and frustration levels.

Another study conducted by Sheldon et al. looked at the impact on Real-Time-Strategy (RTS) games with higher levels of latency. The study focused on the performance of players affected by lag with up to 1600 millisecond delay. Sheldon et al. found that RTS games were less impacted by network delays because decisions may take many seconds – or up to minutes – of coordination and execution. The literature provided here demonstrates the nuanced effects that high latency can have on different types of gaming.

Unfortunately, much of the network latency research has been in terms of cloud gaming, which although it is gaining prominence, lacks the user base and is not fully adopted. This gap in literature provides an opportunity to examine and extrapolate the effects of high network latency on online gaming. Furthermore, more can be analyzed in terms of broader societal effects, rather than player performance. My topic attempts to cover multiple facets of online gaming, including player performance and psychology, competitive gaming, and community building.

Methodology

The primary goal in this research is to determine the effects of high network latency on the gaming industry and how that may affect player psychology and mental health, online gaming communities, and the competitive gaming industry. Online gaming's societal impact is far beyond the scale of a simulation or survey, and so most data collection will come from historic examples and be found through online research. Case studies are very powerful tools in collecting this data as historic examples are unbiased, and thus may emphasize or counter my proposed ideas.

Every case study may contain a unique context and insight to be extrapolated. However, with all these case studies we can look for both qualitative and quantitative metrics. In particular, the overall player experience is vital in determining how a game is perceived and delves into both the player psychology and the game's ability to create online communities. Another important metric is the size of the player base. The number of players online during a period of high traffic can give insight into how high latency can affect player experience, especially when compared to normal periods of activity.

Implications of High Latency on Gaming

In the past few decades, gaming has become an important part of pop culture, entertainment, and industry. According to Statista, the gaming industry has earned $200 billion dollars in revenue in 2022, not including all revenue earned in eSports, which has become a billion-dollar industry, and streaming platforms such as Twitch and YouTube (Statista). However, with the popularity of online games, scalability poses a huge issue, especially across international borders. Many games require little to no latency to deliver a crisp and satisfying experience to players. In shooter games, as much as 100 millisecond delay can have drastic effects on the outcome of a situation. Thus, the necessity of low latency is exacerbated in competitive online gaming.

Inclusivity and Community Involvement

Advances in gaming technology such as cloud systems and better real-time applications are brought about with better access to internet services and Wi-Fi speeds. In 2022, 85.5% of households now have internet connection, an increase from 71% in 2010. This means that more households have the capabilities to connect and play online games than ever before, but at the same time 14.5% of households still lack any form of internet connection (Taylor 2023).

Furthermore, 0.6% on top of that are only connected through dial-up, and 4.1% were connected through satellite, both of which offer much slower speeds than required for online gaming (Roberts 2021). This means that almost 1 in 5 households have limited or no access to online gaming. In a time where digital consumerism and social media often form many online communities, being left behind technologically means no online interactions either.

Unfortunately, limited internet access is not the only obstacle in forming gaming communities. The games themselves sometimes hinder or halt social interaction when faced with high latency. One notable case study is the popular social-deduction game that surged during the Coronavirus pandemic: Among Us. Among Us particularly suffers from network latency issues. As mentioned above, Among Us rose in popularity during the height of the COVID-19 pandemic (Lorenz 2020). Although the game had been released for two years, the indie game did not expect such a sudden and large player base – as many as 3 million concurrent players – and so regional servers were constantly experiencing lag or failing (King 2020). This meant game synchronization issues between players (i.e., players being shown different events), players being forcibly disconnected from games, or game servers failing altogether.

This all shows that gaming has a large influence on personal community involvement. For many people, online gaming such as Among Us provides social interaction in an increasingly isolated age. Online communities form on YouTube and Twitch.tv based around gaming influencers, competitive gaming can be discussed same the way that traditional sports are often talked about, and online get-togethers provide friends great opportunities to bond and have fun. Without sufficient internet access or with games that cannot give a satisfactory player experience due to lag, people lose out on these great ways of feeling included and connected.

Player Experience and Mental Health

A large portion of gaming focuses on real time stimulus and rapid changes in the game environment that require instantaneous user input. Delays in this feedback process will drastically hinder a player's experience in game and will lead to higher stress levels and frustration from lack of control (Zha 2019). It is no surprise that players experiencing lag often prematurely quit or give up due to the lack of immediate audio, visual, and tactile feedback. According to Chen, network lag severely hinders a player's experience, and "affects a player's decision to leave a game prematurely" (Chen 2008).

In a 2019 study, Zha and Zhang created two games to test how stress levels and gaming performance were affected by increasing hardware latency. Their games *Sushi Shooter* and *Square Dodger* tested the aim-clicking and side-to-side movement in many common first-person-shooter (FPS) games respectively. On 36 participants, they found that over 200 seconds of increasing latency, the average performance diminished in both click and strafe speed. Furthermore, the emotional state of the participants exhibited higher levels of disgust and stress due to higher latency. Claypool found that "a suitable framerate is critical for adequate game performance" for FPS games such as Quake 3 (Claypool 2007). Some games are more forgiving of latency issues, such as real-time strategy (RTS) games than the previously mentioned FPS games. Strategy games, which rely more on overall strategy rather than millisecond reactions, will not be as greatly affected (Sheldon et al.).

Economics and eSports

Esports has gained tremendous success in the past decade with more fans, competitive earnings, media attention, and large sponsorships. Video games have eclipsed the earnings of both music and movie industries combined for the past eight years (Mangeloja 2019). Gaming has become a market earning almost 200 billion dollars in revenue in 2022 and has spawned

subsectors such as livestreaming that extend beyond the traditional market. Now, more than ever, there is a large influx of economic incentive in investing into eSports tournaments, content creators, and video game companies.

Fair network latency is crucial in the growing eSports industry. With a global market and teams from every continent competing to win, online tournaments must find a way to maintain equal opportunity in terms of in-game latency to ensure fair competition. For example, in 2021, professional Smash player Hungrybox lashed out at Nintendo for failure to ensure low lag at a Smash Ultimate tournament, claiming that a "server-side connection issue cause him to lag," losing him the game (Tsiaoussidis 2021). Oftentimes this is counteracted by hosting the tournaments on a local area network (LAN), which involves in-person competition at the competitive arena. This strategy is employed by most large tournaments, especially for the final rounds. However, this does not include all the qualifier and group stages which are largely done online and easily influenced by local hardware capabilities and network connections.

Latency and network connectivity extends beyond the economics of the tournaments, and into the vast number of content creators now livestreaming and making videos on online games. Livestreaming requires a robust network infrastructure to support high-quality video and audio transmission. This means that the network must be capable of handling high bandwidth traffic and low latency to maintain a seamless viewing experience for the audience. In addition to bandwidth, network demands also include the ability to handle simultaneous connections from multiple viewers, and the ability to quickly adapt to fluctuations in network traffic. Therefore, both creators and viewers need a strong network connection with low latency to properly enjoy a stream. Even a small drop off in latency or video quality can greatly affect the viewership of a stream.

Strategies to Improve Latency

The bulk of my technical work at Wickr involved creating a tool that could measure latency on the messaging network. This work can be extended to allow a dissection of the latency measurements, detailing what processes are taking the most time to get through, which API calls are the slowest, etc. The same methodology can be applied to online gaming. Subdividing the latency into different components such as Network Delay, Processing Delay, and Playout Delay (Chen 2008) would facilitate scalable development by informing developers of the root cause of the high latency. Once informed, developers can then attempt to improve the latency through automatically balancing latency, employing path in-lining, outlining, or cloning (Zander 2005, Mosberger 1996). There are further options for reducing in-game lag, such as "trading inconsistencies and tuning the decision point topology" (Brun 2006). Essentially, predictions can be made on the client-side that may greatly reduce latency at the expense of potentially causing a wrong calculation and having to revoke that prediction. As the system caches more data about potential outcomes, the decision can be fine-tuned to improve predictions and minimize errors.

Conclusion

Based on the findings and all prior research conducted, online gaming has much to benefit from low network latency. Gaming requires an immersive experience for the player due to the fast-paced nature of many competitive games, and a poor connection or server-side lag hinders the user experience. Beyond that, the gaming industry has much to lose if the latency does not match the player's expectations. Both competitive gaming and livestreaming must be built on reliable and fast network infrastructures since these real time events will greatly suffer in quality due to game delays. In eSports, the latency issue is exacerbated as fairness and equity are

important for a competitive scene to flourish. If players or teams regularly face connection issues, they are at a severe disadvantage and the competition loses integrity and respect from the viewers and sponsors.

Thankfully, developers are already aware of the necessity for low latency gameplay and have developed a variety of techniques to minimize delays. As mentioned above, subdividing the latency metrics can give a better understanding of the causes behind the lag. This information can then be used to target and load-balance the network traffic, or in a predictive model which can send events to the client before it is finished processing on the server. These solutions will become more prevalent as cloud gaming becomes more accessible and prevalent. Because cloud gaming involves running games on servers separate from the user's host, it will take load off the local hardware, with the tradeoff that the remote servers will bear all the load. Although this minimizes delays caused by hardware lag, it has the drawbacks of relying on internet connections entirely, making it more susceptible to high traffic and outages. Gaming innovations in cloud and VR technology will all face latency issues before full adoption, but the prospects are exciting.

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