Performance of Cloud-based P2P Game Architecture

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***Abstract* - The traditional multiplayer video game architecture requires costly investment in physical game servers and network infrastructure. The peer-to-peer network model alleviates some of these concerns, but makes cheat prevention, software updates, and system monitoring far more difficult for the game publisher. Recent advancements in Infrastructure as a Service (IaaS) cloud platform providers such as Amazon Web Services and Microsoft Azure offers video game companies the option to host virtual game servers in the cloud. These services now allow gamers to build custom game servers in the cloud. This paper explores the performance of a cloud-based First Person Shooter game server compared to established performance metrics.**

Keywords – Cloud; Gaming; Game Architecture; Network Performance.

I. INTRODUCTION

Traditional game server models utilize the familiar client-server architecture to host multiplayer games. This model represents the majority of multiplayer game systems and supports millions of game sessions every day. Here, the server is responsible for maintaining game state information between clients, synchronization, and communications [1]. This model is popular for many reasons such as cheating and piracy prevention, reliability and performance, and centralized control. However, the client-server architecture does suffer from high bandwidth requirements and infrastructure cost and scalability problems.

Conversely, the Peer-to-Peer (P2P) model synchronizes games states directly between hosts without necessarily requiring a central game server. Although this approach has excellent scalability and extremely low costs associated with the Client-Server model, the lack of an authoritative central server introduces a number of key problems [2]. Among these are poor access control, limited cheat prevention, and non-uniform state synchronization.

However, many game studios are turning to the cloud to reduce some of the costs associated with the client-server model. For example, Microsoft's 343 Industries [10] recently utilized the Microsoft Azure [9] cloud computing platform to support the release of "Halo 4," the latest release in Microsoft's tremendously popular video game franchise [3]. 343 cited cost and scalability as one of the key factors in deciding to host the multiplayer game on the cloud. Previously, game studios were forced to make a massive investment in server and network infrastructure to support the huge spike in players associated with a game's release. However, as games age, the player population typically drops rapidly, leaving a high number of unutilized servers. However, Azure allows 343 to dynamically and efficiently adjust server capacity to support the player base at a significant cost savings [3].

The cloud model also offers advantages to P2P game architectures. Gamers can now host 24x7 "peer servers" on the cloud, rather than locally on their machine or by renting commercial game server space. This offers great advantages in reliability, performance, security, and most of all, excellent cost savings. Gamers have long hosted games on their own computer, acting as a de facto game server. This enables the gamer maintain high levels of control over game parameters, access control, performance, and other factors. However, the huge associated bandwidth and security vulnerabilities put this method out-of-reach for many casual gamers. Cloud-based service providers such as Amazon Web Services now offer these gamers the option of building custom game servers on the cloud.

Iosup, et al., [4] explored the performance variability of cloud service providers, such as Amazon's web services (called AWS), through the use of "performance indicators." One example of said indicator is the response time of a "resource acquisition operation" provided by the Amazon EC2 Service. Iosup, et al. also investigated various performance metrics associated with so-called "social games" such as Farm Town and Mafia Wars. However, the study did not include First-Person Shooters.

A First-Person Shooter (FPS) is a prominent type of game in which gameplay generally focuses on weapon-based combat from a first-person perspective. Popular examples of FPS include the Doom, Half-Life, Halo, and the Call of Duty series. Players of FPS games have been shown to be especially sensitive to network conditions relative to other genres such as role playing games (RPG) or real-time strategy (RTS) games. For example, one study finds that while online RTS games are unaffected by latencies as high as 1000ms, the relatively faster-paced FPS requires a latency of less than 100ms [5].

Barker and Shenoy performed a gamer server case study wherein a popular First Person Shooter (Quake 3) dedicated server was installed and tested in a lab-based virtual machine [6]. The test included an evaluation of both map loading times and server latency metrics. However,

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there are no known studies evaluating the performance of an FPS game server hosted by a cloud provider.

This study will explore performance parameters of a cloud-based FPS game server compared to established performance requirements of traditional client-server architecture.

Section two of this paper will describe the setup of the study and the various configurations. Section two will also present some response time results. The third section will present the analysis of the results. Sections four and five will cover future work and the conclusion, respectively.

II. THE STUDY

Response time is a widely recognized measure of performance in a First Person Shooter [5]. Response times of 200 milliseconds or less are generally considered the benchmark for acceptable Quality of Experience in a FPS game [7]. For this study, a client-side response time will be measured by a player of a popular FPS game. Specifically, the virtual game server will be hosted on a cloud-based service provider. Client-side response times will be measured in a single-player (light server load), 8-player (moderate load), and 16-player (high server load) death match games.

The first step was to configure a game server on a cloud environment. The Source Dedicated Server platform functions as a dedicated virtual game server for Source-Engine games, such as the popular First Person Shooter “Half-Life” [8]. For this study, a Half-Life srdcs Game Server was configured on an Amazon EC2 instance. The server was installed on a “free usage tier” 32-bit Amazon Linux-based machine instance. The specific game server installed in this study can host up to 16 AI “bots” or human players.

The game server is initially configured for a single-player “deathmatch” game against fifteen AI-controlled bots. This will ensure data throughput consistent with a typical free-for-all type game session. However, the server load, with respect to network traffic, will be minimal. The client side response times are shown in Figure 1 below.

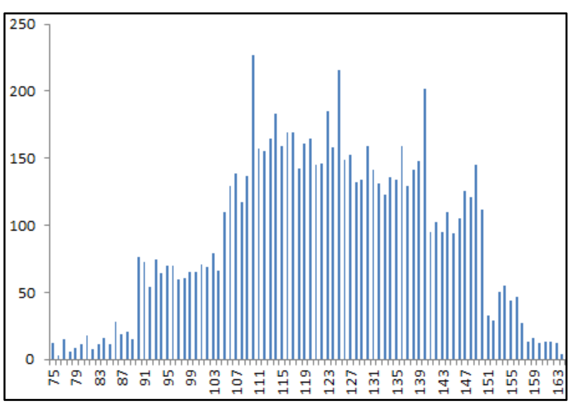

Figure 1. 1 Player Game Response Times

The next test session will simultaneously host 8 clients in a death match game. The remaining eight players will consist of AI bots. This test session will represent a moderate level of server network load. Response time measurements will again be taken client-side. These measurements are shown below in Figure 2.

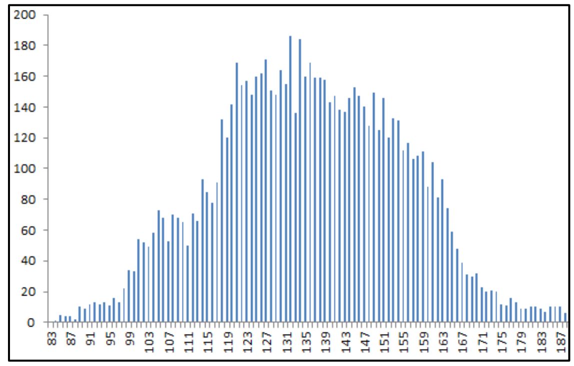

Figure 2. Eight Player Game Response Times

The final test session will consist of sixteen human players. This represents a maximum level of network load under typical death match conditions. Response time measurements will again be taken client-side. These measurements are shown below in Figure 3.

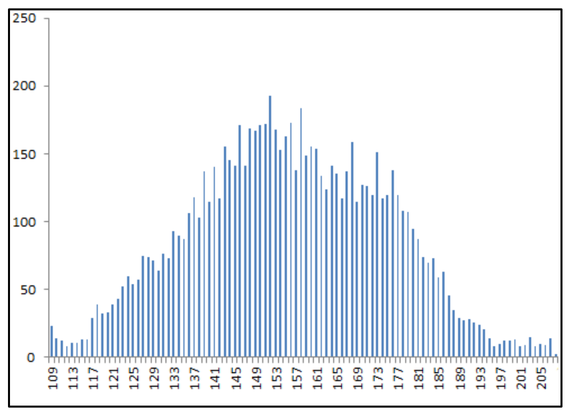

Figure 3. Sixteen Player Game Response Times

III. ANALYSIS

A single player game session showed response times well within established acceptable limits. As seen in Figure 1, this session saw a maximum response time of approximately 164 ms, with a vast majority of response within 90-150 ms. Figure 2, representing an eight-player game, also shows very good performance. However, the higher network traffic associated with an increase in human players shows a general increase in response times.

Figure 3 above represents relatively high server and network loads, featuring a maximum of sixteen simultaneous human players. During this test session, the client-side response times increased significantly from the single player baseline test. Compared to the single player game, average response times increased by well over 10%. In fact, approximately 25 responses exceeded the established threshold of 200 ms ideal for FPS games. The occurrence of these instances was relatively low however, accounting for approximately 1% of all traffic.

Although the sixteen-player test showed a significant increase in client-side response times from the single-player baseline test, approximately 99% of server responses were 200 ms or less. This represents an acceptable user Quality of Experience according to typical measures of FPS game performance. It is unclear whether the increased network activity of 16 simultaneous network connections, or the associated increase in server processing requirements, caused the increase in response times.

IV. FUTURE WORK

This study utilized a simple Source Dedicated Server hosted on an Amazon free usage tier EC2 instance. Although performance was acceptable up to full (sixteen-player) server and network loads, a general increase in response times was seen as the number of human players was increased. Future work may investigate the effects of thirty-two-player games of even Massively-Multiplayer Online (MMO) games to further explore the capabilities of cloud-based game servers. More advanced FPS games, such as Call of Duty or Crysis, will also increase the processing requirements of the server. Finally, network analysis or application performance monitoring may be used server-side in order to truly gauge game performance across multiple clients.

V. CONCLUSION

Traditionally, the client–server multiplayer video game architecture requires costly investment in physical game servers and network infrastructure. The peer-to-peer network model alleviates some of these concerns, but makes cheat prevention, software updates, and system monitoring far more difficult for the game publisher. However, modern cloud platform providers such as Amazon Web Services and Microsoft Azure offers video game companies the option to host virtual game servers in the cloud. These providers also give individual gamers the option to build and maintain custom game servers in the cloud. This study established the viability of a cloud-based FPS game server with respect to established performance parameters.

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