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Mobile cloud game in high performance computing environment

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ABSTRACT

Mobile cloud game is a solution to play high-end games in indigent thin clients with a diversity of end-user devices, and as real-time gaming, mobile cloud game hosting game engines in the cloud. Moreover, frequent change in network quality is another issue that should be limited to run the real fast cloud game. Thus, reliable software components between cloud and user devices as clients, including using artificial intelligence (AI) algorithms such as machine learning, deep learning and so on will enhance the game performance, particularly in multiplayer and real-time conditions. In this paper, we list the mobile cloud game architecture in the high-performance computing (HPC) environment, where a load of the game will be distributed between servers as cloud and clients. The server node as clouds or clients will consist of more than one server with many processors (cores) or sometimes can be recognized as distributed computing. Using HPC for cloud games will boost the game performance where the execution times will be dispersed not only in some node in servers and clients but in many cores of each server or client. The involvement of the internet of things (IoT) and ubiquitous access from heterogeneous devices will give benefit to enjoyment in the game itself.

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1. INTRODUCTION

The Internet has become one of society. People cannot live without the internet. The Internet itself has become a part of human life in this beautiful world. The internet provides many opportunities for people to develop themselves. The Internet also helps people to connect with their friends and loved ones. Meanwhile, gaming also has become a part of human life, whether it is a board game or a computer game, people play daily for their entertainment. However, newer games nowadays use too much hardware resources that make people have to upgrade their hardware, which cost much money continually. This is where cloud computing can be used for gaming. With cloud gaming, users do not need to upgrade their hardware because cloud servers will render the game for them, and users can play those games with a less powerful computer. Moreover, the extension of a powerful, affordable smartphone with the highest random-access memory (RAM) till 8 GB and internal memory till 512 GB, including using multiprocessors such as quad-core, octa-core, and more. For example, you can buy Samsung Galaxy Note 9 with price Rp 14,500,000.00 with

huge specifications such as processor Exynos 9810 Octa-Core (2.7GHz Quad + 1.7GHz Quad), 64-bit, 10 nm, RAM 8 GB, Internal memory 512 GB.

In this article, we will mention "cloud computing" a lot since cloud gaming is directly derived from it. Before continuing to cloud gaming, first, we need to explain what is cloud gaming means. National Institute of Standards and Technologies (NIST) definition of cloud computing as: "Cloud computing as a model for ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.[1]". With cloud computing, people can now access their data anywhere with any platform, because cloud computing store your data in a data center and creates security where only you and the selected few can edit the file. The purpose of cloud computing is to reduce hardware usage when open and edit files [2]; the same could be said to cloud gaming wherein cloud gaming, the game is rendered in the server and not in your thin client. However, what about online gaming? Where there are millions of people already playing it. What is the difference between online and cloud gaming? Firstly, we need to tackle what is online gaming. Based on the researcher's experience, online gaming essentially is where we can connect and play games with other people by using the internet. The scope of online gaming is so vast that you can meet and play with someone from the other side of the world. With the online gaming description above, now we will explain the difference between online gaming and cloud gaming [3]:

a. Cloud gaming is an on-demand service, which means that you can use cloud gaming services to play games anytime and anywhere. The online game is not an on-demand service, which means you cannot play online games anywhere because it requires your client to render the game.
b. Cloud gaming uses minimum hardware usage than online games. Because the rendering is all done by the server on the cloud. Online games only use the server so that we, as a player, can synchronize with other players within the same platform game.

2. PREVIOUS RESEARCH

Online gaming has connected people around the world where people can play with each other without actually meet them [4]. Cloud gaming attracts both players and game developers because of its vast advantages, two of those advantages are cloud gaming allows players to play the same game on different platforms and also enables game developers to support more platforms [5]. Moreover, UBC Games was proposed as a client-server cloud game where distributed execution of game components not into server only but to the client as well and included component-based cognitive ubiquitous gaming system [6]. Cloud gaming video using importance factor weighted peak signal-to-noise ratio (IFWPSNR) was proposed as an extension of weighted peak signal-to-noise ratio (WPSNR), where important factor (IF) table was created in three steps by creating a list of all the activities, list the objects in each activity and record all the gaze point for each object in each activity [7]. Foveated video encoding (FVE) was used to reduce bandwidth requirements by applying real-time gaze tracking which decreases 10% to encode and transmits the game's data to the cloud gaming client [8]

This kind of thing open new opportunity for people around the world to develop new kind of gaming mechanism and cloud system has become the new target for gaming world development. However, there are some obstacles that people have to overcome first before getting to a better cloud system. Due to large varieties of applications, database services on the cloud must support large-scale data analytical jobs [9]. Choy, Wong, Simon & Rosenburg [10] research on-demand gaming (cloud gaming) the article said that the current cloud computing infrastructure could not meet the latency requirement necessary for gameplay for many players, resulting in the limited number of potential users for cloud gaming.

A study about cloud gaming in Indonesia has been conducted before where Wijanarko and Kosala [11] in their paper investigates the potential of cloud computing as a gaming platform. However, the primary purpose is to address the issue that there are many users with reduced internet bandwidth in Indonesia. Shea, Liu, Ngai, and Cui [12] also states that different game styles have a different threshold for the maximum tolerable delay. The maximum tolerance delay refers to the different time between the client, which receiving user input and the client which displaying the game frame reflecting that user input [13]. The article also states that although the maximum tolerable delay was only a problem for online multiplayer games, cloud gaming changes this into a problem for single player games because of how the cloud gaming system works. Moreover, also, different games need different tolerable latency to keep a good quality of experience when gaming [14].

The implementation cloud game in a smartphone is recognized as a mobile cloud game where multiplayer mobile cloud game is implemented without worry to lack of hardware requirement using Citrix and VMware technologies [15]. Another mobile cloud game was efficient using some approaches such as

multiple transmission, avatar blinking, dead-reckoning, blue banana, and COPSS-based gaming [16]. Multiple transmission reduces mobile network bandwidth by transmitting lost packet two or three times, and avatar blinking where player waits to shoot before other avatars. Dead-reckoning is activated where the packet is lost and switch on for at most ten screen updates, and blue banana is employed to predict avatar movements for efficiency performance. COPSS-based gaming is content-centric, which separates the action receivers from the performers.

Some machine learning algorithms have been used to equipped cloud games to increase performance and reduce latency and bandwidth. Machine learning algorithm such as genetic algorithm (GA) was developed and highly robust to support cloud game, by optimizing both the server running cost and the software storage cost and running queueing theory for system behaviors under different request dispatching [17]. K-means clustering algorithm was applied with some cloud games that were clustered into two clusters where cluster one is a low video motion cloud game, and cluster two is a high video motion cloud game [18]. A novel method to minimize end to end latency, optimization for reducing delay, and lagrangian relaxation (LR) time-efficient heuristic algorithm was proposed to increase the game's performance [19].

No less impressive, using high-end powerful server devices on low-end devices is a new issue and using high-performance computing (HPC) or distributed computing [20, 21] is the value-added to increase the performance of cloud game as server game. Moreover, content multiple PC or recognized as a node and every node has many cores used effectively and using graphics processing unit (GPU) as well can be used to decrease latency and bandwidth consumption [22, 23]. Moreover, distribution cloud game execution both on server and client will give performance benefit where server and client workload is distributed, and the mutual-benefit algorithm was proposed for balancing execution between GPU server and clients [24]. An algorithm virtualized GPU resources Adaptive scheduling algorithm (vGASA) was proposed to run in GPU machine for algorithm scheduling in graphic API of the operating system [25].

3. IDEAS FOR CLOUD GAMING

In this section, it is explained the results of research and at the same time is given a comprehensive discussion. Results can be presented in figures, graphs, tables, and others that make the reader understand easily. The discussion can be made in several sub-chapters. A cloud is a collection of technology on the internet, interconnected and recognized as a virtual computer which dynamically invisible as one or more connected computer based on approval service level agreement establish through connection and negotiation between consumer and service provider [26]. Cloud is some kind of place used by people to execute some processes. The conventional way to execute processes is in devices that people hold. With a cloud system, the executing process can be done without the device executing the process.

Figure 1 shows the mobile cloud game architecture where the implementation will include rendering and compression techniques, including using Artificial Intelligent algorithms such as machine learning or deep learning for making the process of the game better. Moreover, thread() function can be applied where some process in servers will be run in parallel and distributed concepts and this is as the legacy of the mobile game in high-performance computing (HPC) where the process will be paralleled and distributed in several servers which equipped with many cores. For increasing the enjoyment of the game then the game devices should be applied with the internet of things (IoT) or ubiquitous where some games will be equipped with sensors to get the reality of the game environment. Finally, for increasing the performance then the game should be better when having multi-cores clients where the process not only running parallel in the server but can do the parallel thing in clients. All the process will be executing in the application server. The device will ask for input from the user and send it to the server, then the server will execute all the processes and produce the resulting process. Moreover, the server will send the result to the device and show the result to the user. Right now, the use of a cloud system merely for storing data. So instead of using the device's memory to store the data, the user can store the data in the server. This will make the device work more efficiently.

Figure 2 shows how the user can use their PC or smartphone to cloud platform using cloud providers such as Microsoft Azure, Google Cloud, or any Internet Service Provider. Besides the security as the most important for secure access for users, the cloud will give benefit in three primary operations in IaaS (infrastructure as a service), PaaS (platform as a service) and SaaS (software as a service). Moreover, many researchers try to implement a cloud system in another platform, for example, in the gaming world. Many researchers try to optimize the gaming experience for people who enjoy playing games for a stress reliever.

Meanwhile, cloud gaming works by rendering the game application remotely in the cloud and streams the game scenes as a video sequence to the player through the internet as can be seen in Figure 3. Then, the player interacts with the game application through a thin client (i.e., personal computer

or smartphone), which responsible for displaying the video from the cloud rendering server and also responsible for collecting the player's commands and inputs and sending it back to the cloud. So, the cloud runs the game's logic, rendering, and sending the stream to the player and what player needs to do is just input commands and send it back to the cloud server [27].

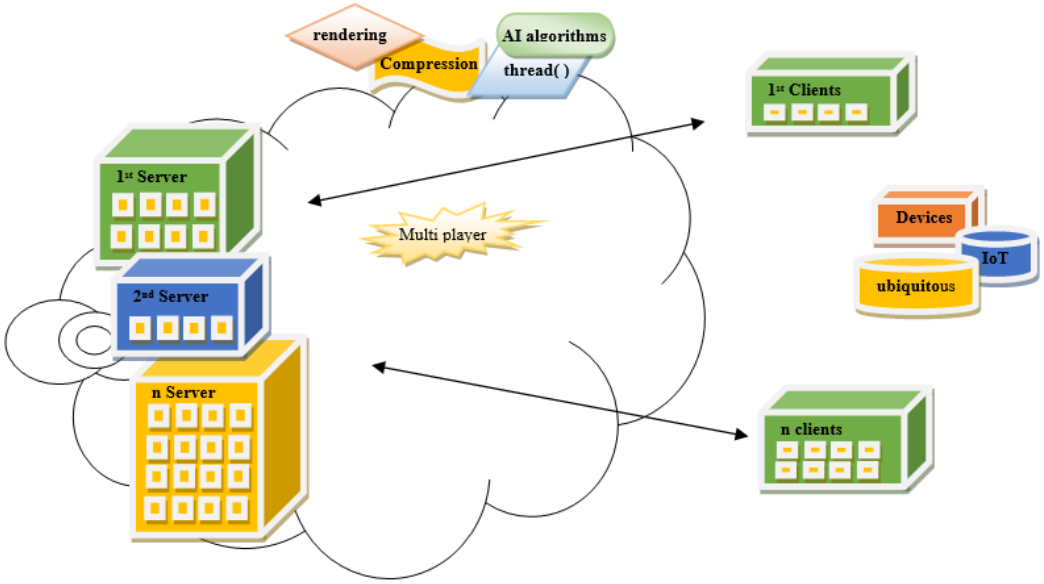

Figure 1. Mobile cloud game architecture

Figure 2. Cloud computing infrastructure for user

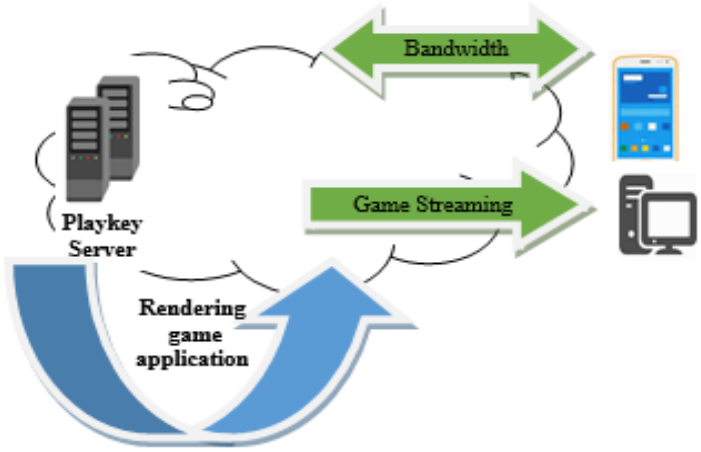

Figure 3. Rendering and streaming cloud gaming

Furthermore, cloud gaming should be implemented in the Indonesian gaming industry where with cloud gaming, the production cost can be reduced. Also, cloud gaming will reduce the needs of buying more expensive PC hardware or buying expensive gaming platform and move the previous cost to upgrade home internet, thus reducing tolerable delay when playing games. Cloud gaming is one of the ways to enjoy playing games. Cloud gaming allows people to play a lot of different games with a simple device or not the latest device. As seen in Figure 3, the device only sends the command that inputted by the user, and the server will execute all the commands. The server then gives the output to the device, and it looks like streaming because the feedback from the server is a video that moves based user input.

However, the problem that occurs with a cloud gaming system is latency. It is like a delay. In the conventional system, when the game is run in each device, the output of user input will be directly sent to the output device of the processing device. Users can immediately see the result. In cloud gaming, the user has to wait for the output produced by the server to send to the output device, and that takes a while. Several things cause latency, network delay, processing delay, playout delay [28]. Network delay is related to the internet connection. Processing delay is related to the processing power that the server has and how big the bandwidth the user uses and how many players are engaged. Despite the latency produced by cloud gaming, there are several advantages compare to the usual gaming system. From the FPS (Frame per Second), cloud gaming is more potent than regular gaming because cloud gaming let the server to process all the data sent by the user. In regular gaming, the user's device will process the input and send it to the output device. It entirely depends on the device that processes the inputted data.

Sophisticated graphic renderings are one way to increase gaming experience for users [29]. It requires a powerful processor to make a realistic image. In recent games, the requirement to render a realistic image is exceptionally high. The user needs a powerful device to process the realistic image or the user will be forced to downgrade the image quality. With cloud gaming, what kinds of problems can be avoided? The image will be rendered by the server and send to the user in the form of an image that moved (like streaming a video). The only thing that users need is a good connection to the server. Music and sound can also make gaming experience becoming more realistic. In regular gaming, when the device's memory is running low, the device will prioritize some process that needs few memories to run, and that is music and sound. So, the result is unsynchronized between the music and the image. With cloud gaming, the latency between image and music can be eliminated because the server memory is large enough to process both images and music.

4. PLATFORM

To realize the idea of cloud gaming, people use many platforms for implementing cloud gaming. For example, one popular console called PlayStation (PS) already implementing cloud gaming in their process. The user no longer needs a massive external memory to store the game. Instead, they use their servers to store the game [30]. The other platform to use cloud gaming is a website. Several people already make a website to play with cloud gaming. For example, the website "gaming.liquidsky.com." This website as seen in Figure 4 allows the user to play the games through that website without downloading the game. Supporting the game with High-Performance Computing which equipped with many servers and cores will increase the performance of the game without the need to download and install the game. Moreover, running in the client with multiple core processors will increase the performance where some parallel processes will be running in the client machine.

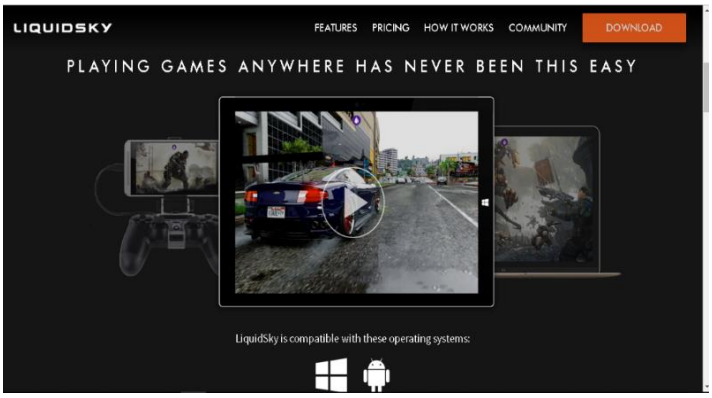

Figure 4. Example of a figure caption

Many games can be played through that website. The problem that may occur with that website is that the server is not in Indonesia. So, to use that website, the user needs an excellent connection to the server. The solution that can be done is creating our website for cloud gaming that the server is locating in Indonesia so that Indonesian users can access it with regular connection. To do that many challenges need to be clear of first. One of the problems is cost. The cost to rent a server in the Indonesia region is quite expensive. To close the cost that used to rent the server, people will charge the user for paying before using cloud gaming. It is the same as a regular gaming system where the user must pay the game first before playing the game.

To calculate the cost that needed to play the game, cloud gaming is cheaper than regular gaming. The cost of a regular game is higher because the company has to pay more for packaging their games. In cloud gaming, packaging a game is not required to sell the game. The company can distribute the game into people that have a cloud gaming server. Then people who have the server will sell their service, in providing the server to play, to the user who wants to play the game. This way, the cost of creating a game can be reduced, and the game itself will be cheaper than the regular game.

5. CONCLUSION

Cloud gaming is a rapidly advancing technology that can unlock many possibilities. Despite the numerous advantages of using cloud gaming as a gaming platform, its disadvantages cannot be thoroughly explained in this paper. By implementing a cloud gaming system in Indonesia, can help Indonesia's gaming industry becoming more advance. The system cloud gaming also can help gamers to save money. Cloud gaming frees gamers from upgrading their computers. One of the possible platforms to play cloud gaming is a website-based application because it is more accessible for the most useful in the world.

Moreover, the implementation of mobile cloud game will be faster when applying in high-performance computing (HPC) both in server and client, where the process in the server will be executed in parallel and/or distributed condition and the process in the client faster where running in parallel condition with multiple core client. In the future, there will be possible when connection among the client will be carried not only to having a connection to the servers but can connect to near clients for sharing resources to increase the performance particularly for saving bandwidth connection. At the end of the day, using HPC in the game will increase benefits for multiple user games where people can easily join and enjoy the game without a low internet connection problem.

REFERENCES

[1] P. Mell, T. Grance, "The NIST definition of cloud computing," NIST-National Institute of Standards and Technology, 2011. [Online]. Available: https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf. Accessed: 14 July 2019.

[2] X. Zhang, H. Chen, Y. Zhao, Z. Ma, Y. Xu, H. Huang, H. Yin, and D. O. Wu, "Improving Cloud Gaming Experience through Mobile Edge Computing," *IEEE Wireless Communications*, vol. 26, no. 4, pp. 178-183, 2019.

[3] S. J. S. Aboutorabi, M. H. Rezvani, "A Self-organizing Price-based Mechanism for Frame Rate Optimization in Cloud Gaming Networks Considering Quality of Experience," *2018 2nd National and 1st International Digital Games Research Conference: Trends, Technologies, and Applications (DGRC)*, pp. 51 – 60, 2018

[4] M. Manzano, J. A. Hernandez, M. Uruena, and E. Calle, "An empirical study of Cloud Gaming," *2012 11th Annual Workshop on Network and Systems Support for Games (NetGames)*, 2012.

[5] C. Huang, C. Hsu and K. Chen, "GamingAnywhere: an open-source cloud gaming platform," *ACM SIGMultimedia Records*, vol. 7, no.1, pp. 3-5, 2015. doi: https://doi.org/10.1145/2792999.2793001.

[6] W. Cai, Y. Ci, C. Zhou, C. Zhu and V.C.M. Leung, "UBCGaming: Ubiquitous Cloud Gaming System," *IEEE Systems Journal*, vol. 12, no. 3, 2018.

[7] S. S. Sabet, M.R. Hashemi, S. Shirmohammadi and M. Ghanbari, "A Novel Objective Quality Assessment Method for Perceptually-Coded Cloud Gaming Video," *2018 IEEE Conference on Multimedia Information Processing and Retrieval (MIPR)*, Miami, FL, USA, 10-12 April 2018.

[8] G. Illahi, T.V. Gemert, M. Siekkinen, E. Masala, A. Oulasvirta and A.Y. Jääski, "Cloud Gaming with Foveated Graphics," *ACM Trans. Multimedia Comput. Commun. Appl.*, vol. 9, no. 4, pp. 1-23, 2018.

[9] J. Wang, S. Wu, H. Gao, J. Li, and B. C. Ooi, "Indexing multi-dimensional data in a cloud system," *Proceedings of the 2010 international conference on Management of Data - SIGMOD 10*, pp. 591-602, 2010.

[10] S. Choy, B. Wong, G. Simon, and C. Rosenberg, "The brewing storm in cloud gaming: A measurement study on the cloud to end-user latency," *2012 11th Annual Workshop on Network and Systems Support for Games (NetGames)*, 2012.

[11] A. Wijanarko and R. Kosala, "A Study of Cloud Computing Performance as a Game Platform: An Indonesia Case," *Journal of Computational and Theoretical Nanoscience*, vol. 20, no. 1, pp. 32–36, Jan 2014.

[12] R. Shea, J. Liu, E. C. H. Ngai, Y. Cui, "Cloud gaming: architecture and performance," *IEEE Network*, vol. 27, no. 4, pp. 16–21, 2013.

[13] C. Y. Huang, D. Y. Chen, C. H. Hsu, K. T. Chen, "GamingAnywhere: an open-source cloud gaming testbed," *Proceedings of the 21st ACM international conference on Multimedia - MM 13*, pp. 827–830, 2013.
[14] Y. T. Lee, K. T. Chen, H. I. Su, C. L. Lei, "Are all games equally cloud-gaming-friendly? An electromyographic approach," *2012 11th Annual Workshop on Network and Systems Support for Games (NetGames)*, 2012.
[15] R. Bose and D. Sarddar, "A new approach in mobile gaming on cloud-based architecture using Citrix and VMware technologies," *Brazilian Journal of Science and Technology*, vol. 2, no. 1, 2015.
[16] M. Hosseini, "A Survey of Bandwidth and Latency Enhancement Approaches for Mobile Cloud Game Multicasting," arXiv:1707.00238, 2017.
[17] Y. Li, Y. Deng, X. Tang, W. Cai, X. Liu and G. Wang, "Cost-Efficient Server Provisioning for Cloud Gaming," ACM *Transactions on Multimedia Computing, Communications, and Applications*, 2018. doi: https://doi.org/10.1145/3190838.
[18] I. Slivar, M. Suznjevic, L. S. Kapov, "Game Categorization for Deriving QoE-Driven Video Encoding Configuration Strategies for Cloud Gaming," *ACM Transactions on Multimedia Computing, Communications, and Applications*, 2018. doi: https://doi.org/10.1145/3132041.
[19] M. Amiri, H.A. Osman, S. Shirmohammadi and M. Abdallah, "Toward Delay-Efficient Game-Aware Data Centers for Cloud Gaming," *ACM Transactions on Multimedia Computing, Communications, and Applications*, 2016. doi: https://doi.org/10.1145/2983639.
[20] M. Basiri, A. Rasoolzadegan, "Delay-Aware Resource Provisioning for Cost-Efficient Cloud Gaming," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 28, no. 4, pp. 972-983, 2018.
[21] W. Zhang, X. Liao, P. Li, H. Jin, L. Lin, and B.B. Zhou, "Fine-Grained Scheduling in Cloud Gaming on Heterogeneous CPU-GPU Clusters," *IEEE Network*, vol. 32, no. 1, pp. 172-178, 2018.
[22] Y. Xu, Q. Shen, X. Li, Z. Ma, "A Cost-Efficient Cloud Gaming System at Scale," *IEEE Network*, vol. 32, no. 1, pp. 42-47, 2018.
[23] W. Cai, R. Shea, C. Y. Huang, K. A. Chen, J. Liu, V. C. M. Leung, C. H. Hsu, "A Survey on Cloud Gaming: Future of Computer Games," *IEEE Access*, vol. 4, pp. 7605-7620, 2016.
[24] R. Jitpukdeebodintra, S. Witosurapot, "Hybrid Method for Adaptive Cloud Gaming Contents," *GSTF Journal on Computing (JoC)*, vol. 4, no. 2, pp. 21-26, 2015.
[25] C. Zang, Z. Qi, J. Yao, M. Yu, and H. Guan, "vGASA: Adaptive Scheduling Algorithm of Virtualized GPU Resource in Cloud Gaming," *IEEE Transactions on Parallel and Distributed Systems*, vol. 25, no. 11, pp. 3036-3045, 2014.
[26] R. Buyya, C. Yeo, S. Venugopal, J. Broberg, I. Brandic, "Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility," *Future Generation Computer Systems*, vol. 25, no.6, pp. 599-616, 2009.
[27] S. Shirmohammadi, "Adaptive streaming in mobile cloud gaming," *IEEE COMSOC Multimedia Communications Technical Committee E-Letter*, 2013
[28] K. T. Chen, Y. C. Chang, P. H. Tseng, C. Y. Huang, C. L. Lei, "Measuring the latency of cloud gaming systems," *Proceedings of the 19th ACM international conference on Multimedia - MM 11*, 2011
[29] S. Chuah, C. Yuen, N. Cheung," Cloud gaming: a green solution to massive multiplayer online games," *IEEE Wireless Communications*, vol. 21, no. 4, pp. 78-87, 2014.
[30] Jacob Roach, "The Best Cloud Gaming Services: Welcome Gaming to the Web," Cloudwards, 2020. [Online]. Available: https://www.cloudwards.net/top-five-cloud-services-for-gamers/. Accessed: 13 July 2019.