

Cloud server design for heavy workload gaming computing with Google cloud platform

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ABSTRACT

Cloud servers are generally used for data storage and remote office activities, but it can be applied for gaming purposes, where cloud servers can be paired with virtual machines and gaming platform that can be accessed by users via an internet connection. This makes the device used by user no longer needs to process resources because the workload is carried out by virtual machines on cloud server. The author designs a cloud gaming system using Google cloud platform as a cloud server and parsec as an optimizer that is attached to a virtual machine for game computing purposes. Author takes measurements of the cloud gaming system using 2 test games varying from low to middle specifications. Resource testing on central processing unit (CPU) and random-access memory (RAM) usage on the user side is below 40% when running game 1 and below 44% when running game 2, while on the system it reaches a capacity above 40% for CPU and RAM and 99% maximum on graphics processing unit (GPU). Quality of service testing of the system is carried out at bandwidths of 5, 10, and 30 Mbps with a minimum bandwidth of 10 Mbps. In general, there are a little difference that occurred between test game and different bandwidths.

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1. INTRODUCTION

Games are a popular service in various groups in this modern times. The diversity of game platforms gives users many choices to enjoy game services, but there are limitations in playing games on user devices that have low specifications where currently high specification devices are needed to run popular games [1]. Cloud computing is a new virtualization technology that distributes resources such as hardware, software, storage space, operating system, and infrastructure over the Internet [2]–[5]. Cloud computing also has several types of services with different specifications namely infrastructure as a service (IaaS), software as a service (SaaS), platform as a service (PaaS) and game as a service (GaaS) [6], [7]. Cloud gaming is a cloud computing technology, where users can play games without having to install the game on the user's device [8]. Cloud gaming uses servers to render games, then streams video [9]–[11] over the internet to users where users can play games [12], [13]. Cloud gaming can bridge users in operating games with low-spec devices.

In cloud gaming, generally the distance between the physical server and the user is in a local area network (LAN), there is limited flexibility of the user in playing games while outside the local area network. In research on the implementation of cloud servers for gaming, a cloud platform, namely Google cloud platform (GCP) [14], [15] will be used as a server where virtual machines will be installed [16] as a place to test games to analyze the quality of the server if given a heavy load in the form of games.

Research on the implementation of cloud gaming has been carried out by several researchers to measure the quality of service and workload that happen when running game on several device. For example, designing a cloud gaming system using in-home streams [17], then measuring resource usage to determine the quality produced when playing games [18]–[20]. Based on previous research on cloud gaming applications, the authors designed a system topology on GCP cloud server to be used in game testing that can be accessed by users in wide area network coverage with the result that user can access popular games with medium to high specifications through virtual machines, installed on the cloud server. Author will also use a low-end laptop for test game trials to make sure that the system could be applied to low specification laptop but achieve a high frames per second (fps) when running test game.

2. RESEARCH METHOD

In this research, measurements were made of resource usage, quality of service (QoS) [21] and frame usage which showed how well the test game ran on the virtual machine (VM), and what impact the VM had on the user's laptop if the game load was handled by the cloud server. For QoS parameters taken from 3 different categories, namely network delay, jitter, and throughput [22]. Measurement is carried out in each game with a duration of 1,800 seconds with data sampling every 180 seconds for resource and QoS parameter.

2.1. System design

The design of cloud gaming system in Figure 1 has two side which differ from user side who accesses the VM cloud server and the cloud server itself which provides resources in the form of a virtual machine. Users can access VM with an internet connection that uses a virtual private network for the security of the user when accessing, Then the user can open parsec as the entry gate to access VM. Parsec app purpose is to provide a smooth display output and act as a display optimizer so that the display produced by VM is no different from the output of laptop displays in general with high definition (HD) or full HD resolutions. If user can enter VM using parsec, the user can access VM like any laptop in general, to access available games the user only needs to log in to the Steam application where the game library is located. When the user plays the game, VM will stream the image and audio from cloud server to the user's laptop in real time, and all the game loads will be done by the cloud server without disturbing user's laptop resources.

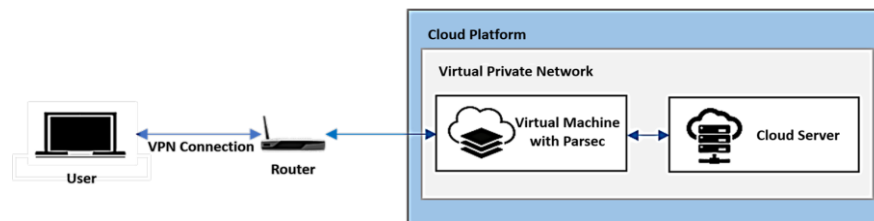


Figure 1. System design

2.2. System and user flowchart

In the application of flowchart system, it is divided into two, namely from the administrator side who will provide access to the user in Figure 2(a), and the user itself who will access the game library in Figure 2(b). Figure 2(a) describes how system process is executed. Administrator opens the google cloud platform to activate the VM and generate a key to enter the VM, next step is to open parsec application and synchronize between parsec and VM so that it can be accessed through parsec, then setup a virtual private network (VPN) to make a tunnel between cloud servers and users can connect with a stable connection. By running a VPN connection, the instance will maintain connectivity between the VM and the user over a secure network. If user wants to access the VM, it can be done through parsec application. VM can maintain connection between users if there is a stable internet connection. The cloud gaming system that is run will not burden the user's device. When the user activity in the VM is complete, the user can exit the VM, and the administrator will close.

Figure 2(b) of the flowchart begins by opening parsec application which will be pre-installed on the user's laptop and logging into parsec account. If user has successfully entered parsec, the application will immediately display the interface from the VM home screen. On VM home screen, user can access steam application to run games that are available in the library. When cloud server runs the game, user will send a command in the form of input, must make a request for a frame on the server and the server will receive the

input by sending the frame back in form of rendering images and sounds that are sent via stream to the user's device. At this stage, the user's laptop will maintain a stable connection with the cloud server to achieve good graphics output when running games. If the user has finished accessing the game services through the provided VM, user can exit the VM and close the parsec application from the user's device.

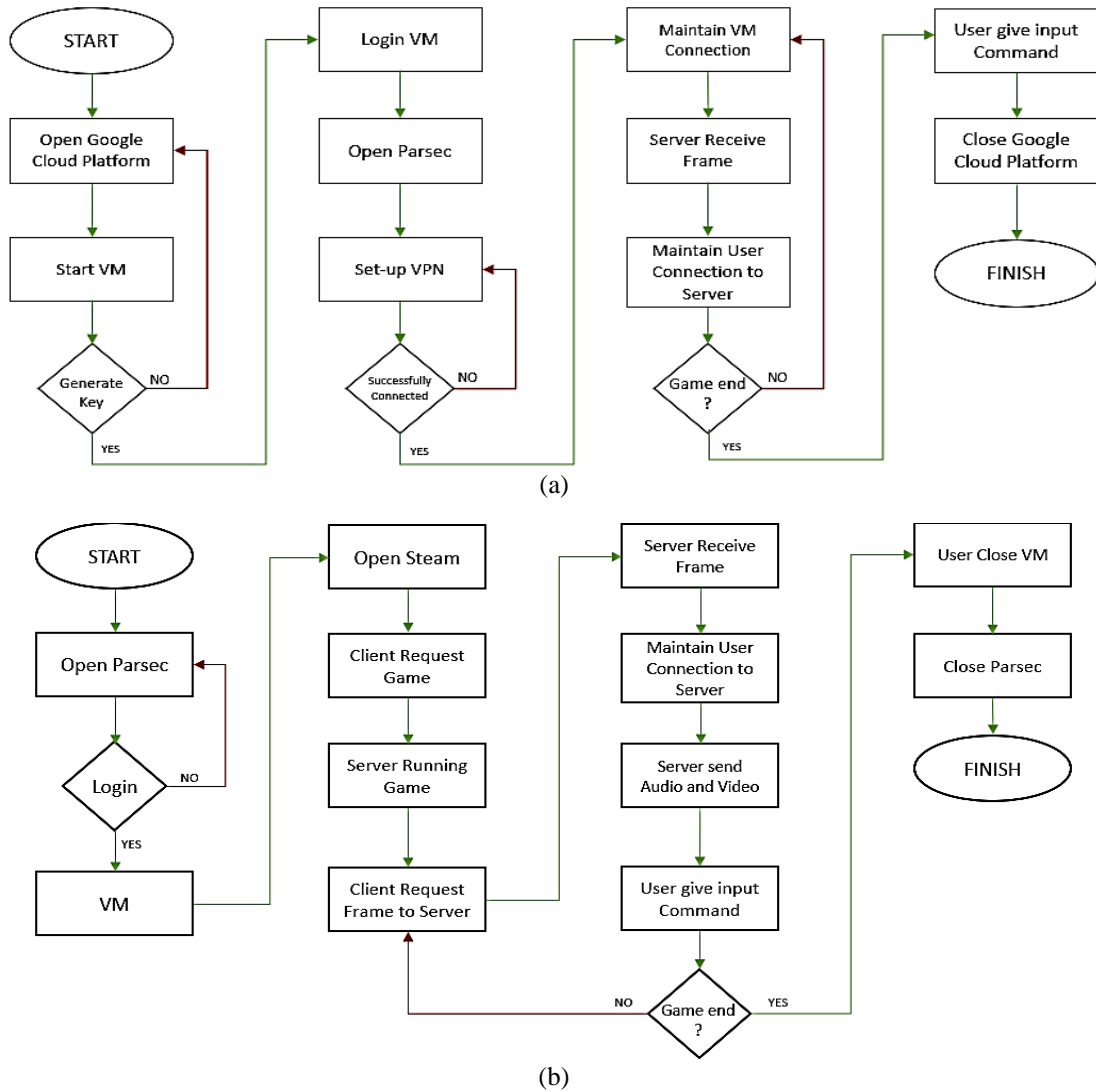


Figure 2. The flowcharts of (a) the system and (b) the user

2.3. Frame per second criteria

Fps is the number of images displayed in graphic form in one second. The more frames that are presented, the more detailed the quality of the resulting image output and comfortable to play [23], [24]. Fps measurement criteria is carried out by measuring it on the user's device that accesses the game from the VM cloud server while the user's laptop does not run other software or open any tabs. In this scenario, measurements are made on the user side who plays a low to middle specification game, namely Paladin, and a middle to high specification game with monster hunter world without bandwidth limitations.

2.4. Device specification

System measurement will use 2 kind of game which differ from the resource specification, game 1 will be low to middle specification and game 2 will be middle to high specification. The VM will be equipped with a Tesla T4 graphics processing unit (GPU) card and solid-state drive (SSD) as a storage. The specifications of the devices to be used in this system consist of server side and user side who will access the VM server, Table 1 show of user and server specifications. For the test game will be categorize in two different types. The first game that occupied low to middle specification will be using game titled Paladins,

a type of fps game [25] and for middle to high specification test game will be using a role-playing game (RPG) [26] named monster hunter world. These two games have different specification that can give the system 2 different result base on the requirement to run the game. Table 2 show the test game specifications.

Table 1. Server and user device specifications

System requirement	Server	User Low Specs Laptop
OS	Windows 10 64-bit	Windows 10 64-bit
Processor	8 vCPUs	Intel Core i7
Memory	30 GB RAM	16 GB RAM
Graphic Card	NVIDIA Tesla T4	NVIDIA GeForce GTX 1650
Storage	250 GB SSD	500 GB SSD

Table 2. Test game specifications

System Requirement	Game 1 (Paladins)	Game 2 (Monster Hunter World)
OS	Windows 8.1 64-bit/ 10 64-bit	Windows 8.1 64-bit/ 10 64-bit
Processor	Intel Core i5	Intel Core i7
Memory	6 GB RAM	8 GB RAM
Graphic Card	NVIDIA GeForce GTX 560	NVIDIA GeForce GTX 1060 6 GB
DirectX	Version 11	Version 11
Storage	10 GB	48 GB

3. RESULTS AND DISCUSSION

3.1. Resource usage on low specification laptop

Figure 3(a) shows the result of measuring resource usage in game 1 which is run on a virtual machine using a low specification user laptop where the load given to the VM when processing game 1 with a resolution of 720P and 1,400×900, namely the maximum resolution of the user's device has a significant difference in the aspect of CPU usage where the percentage of CPU at 720P quality reaches 31% and 1,400×900 reaches 34% at maximum graphics settings, while the use of data processed by RAM in range of 15-17% at 720P quality and 16-17% at 1,400×900 quality. In terms of GPU usage at 720P quality it reaches 37% and 1,400×900 at 39%. Therefore, in testing low to middle games such as game 1, the load on the server reached 40% in some parameters such as CPU usage, but the server could still handle the game load well in maximum settings and display output at HD and a resolution of 1,400×900 because the maximum display output of the user's laptop cannot reach 1080P resolution on the hardware.

Figure 3(b) shows the measurement of test game 2 resources on virtual machine. The load given to VM when processing game 2 with a resolution of 720P and 1,400×900 has no difference in the aspect of GPU usage because the percentage of GPU at 720P and 1,400×900 quality reaches 99% at maximum graphics settings which almost fills all the resources on the graphics card owned server, there is a significant difference in memory usage or data processed by RAM, which is 23% at 720P quality and 25% at 1,400×900 resolution. In CPU usage at 720P quality it reaches 58% and 1,400×900 at 71% at maximum settings. In testing the middle to high load game on the server, it almost reached 100% in almost all parameters such as maximum GPU and CPU usage which reached 71%, the cloud server can still handle the game load with 45 fps when played.

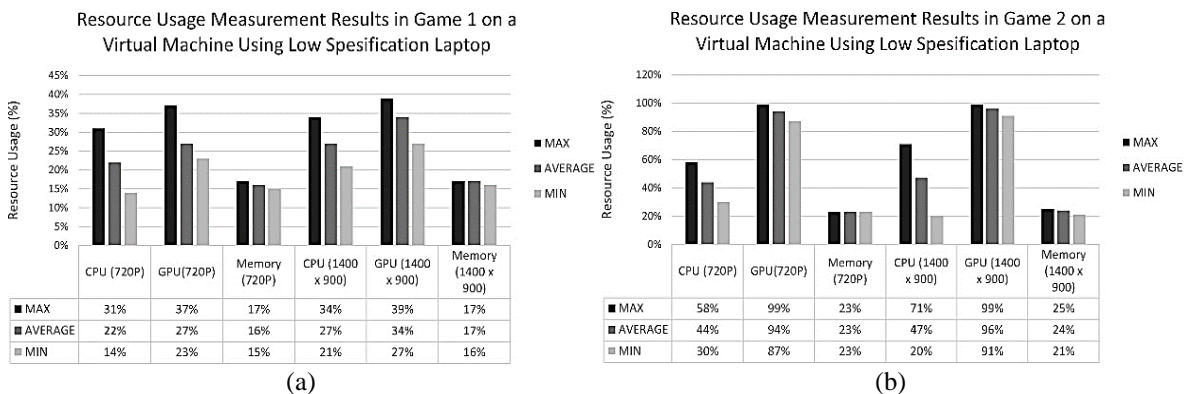


Figure 3. Resource usage on low specification laptop (a) game 1 and (b) game 2 on VM

3.2. Comparison between virtual machine and user’s laptop

As seen in Figure 4(a), user laptops have lower resource usage than 720P or HD resolution VMs in several aspects. This is caused by the user's laptop only receiving data in the form of video and audio streams sent by the server while the load only occurs on the VM cloud server. The difference occurs in memory usage where the user's laptop memory is higher than the VM, because the user's laptop memory capacity is only 4 GB where this size is smaller than a VM with 30 GB of memory.

Figure 4(b) shows that there is a difference in memory usage where the user's laptop memory reaches 23% when running test game 1, this situation occurs because the user's laptop memory capacity is smaller than the VM memory capacity. There is no load on the GPU on the user's laptop because the laptop used does not have a dedicated GPU to process test games.

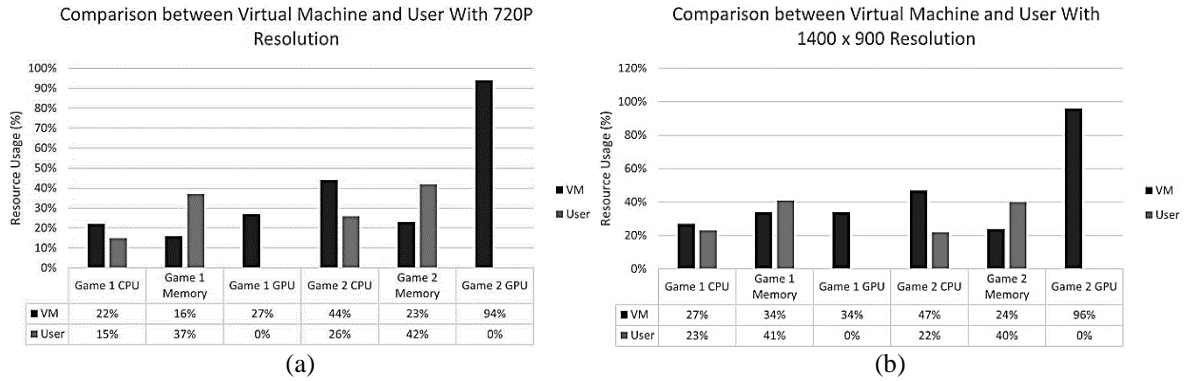


Figure 4. Comparison between virtual machine and user’s laptop (a) resource usage 720P and (b) resource usage 1,400×900

3.3. Comparison between Idle state and playing games

Figure 5(a) showing the comparison of the user's device when it is idle and running the test game 1. The results obtained in the condition of playing the game there is no extreme increase in the device resource load where a small increase occurs on the CPU side of 4%, and 1% RAM on low specification devices. Figure 5(b) shows the comparison of the user's device when it is idle and running the test game 2. In the condition of playing the test game 2 has differences on several sides because the type of game that consumes more resources. There is an increase from devices where a small increase occurs on the CPU side of 11%, and 6% RAM on low specification devices. GPU usage on low specification devices is 0% because the device does not have a dedicated GPU to run the game like a gaming specs laptop does.

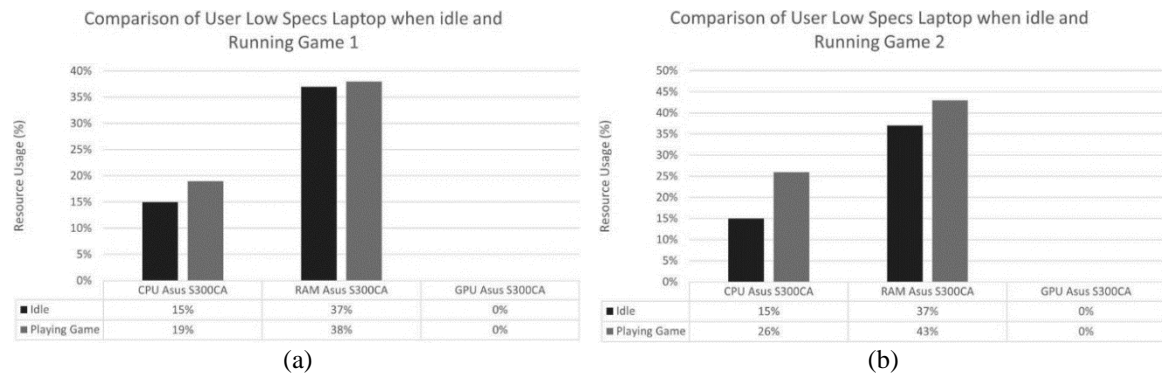


Figure 5. Comparison between idle state and playing games for (a) test game 1 and (b) test game 2

3.4. Quality of service when playing games

Figure 6(a) shows the network delay of the test game with measuring bandwidth of 5, 10 and 30 Mbps. The network delay generated by test games 1 and 2 gives results of 353.7 and 394.7 ms at 5 Mbps which indicates the results are not good enough because the normal network delay from the user to the server

located in America is 200-250 ms. By measuring the test game at a bandwidth of 10 and 30 Mbps the resulting network delay results decreased to 211.6 for the test game 1 and 217.1 for the test game 2. With the network delay value below 250 ms, the test game can be played without frame drop.

Figure 6(b) shows jitter graph with bandwidth measurement of 5, 10, 30 Mbps. The results in test games 1 and 2 at a bandwidth of 5 Mbps gave jitter results of 39.53 and 23.53 ms. The higher the bandwidth, the the jitter generated from the game test will decrease to 13.47 in the test game 1 and 13.08 in the test game 2. The smaller the jitter value in a game, the smoother the game played by the user.

Figure 6(c) shows the result of the test game throughput test on the measurement bandwidth of 5, 10, and 30 Mbps. The throughput generated at a bandwidth of 5 Mbps can be said to be quite small, namely 769.3 in the test game 1 and 795 in the test game 2. By increasing the measurement bandwidth to 10 Mbps the throughput results increase to 2621.5 for the test game 1 and 2031.5 for the test game 2. The highest throughput value there is a measurement bandwidth of 30 Mbps because of the large bandwidth, the throughput value generated by game 1 is 3707.8 kbps and game 2 is 3286.5 kbps. Where with a throughput value above 3000 kbps the test game can run smoothly.

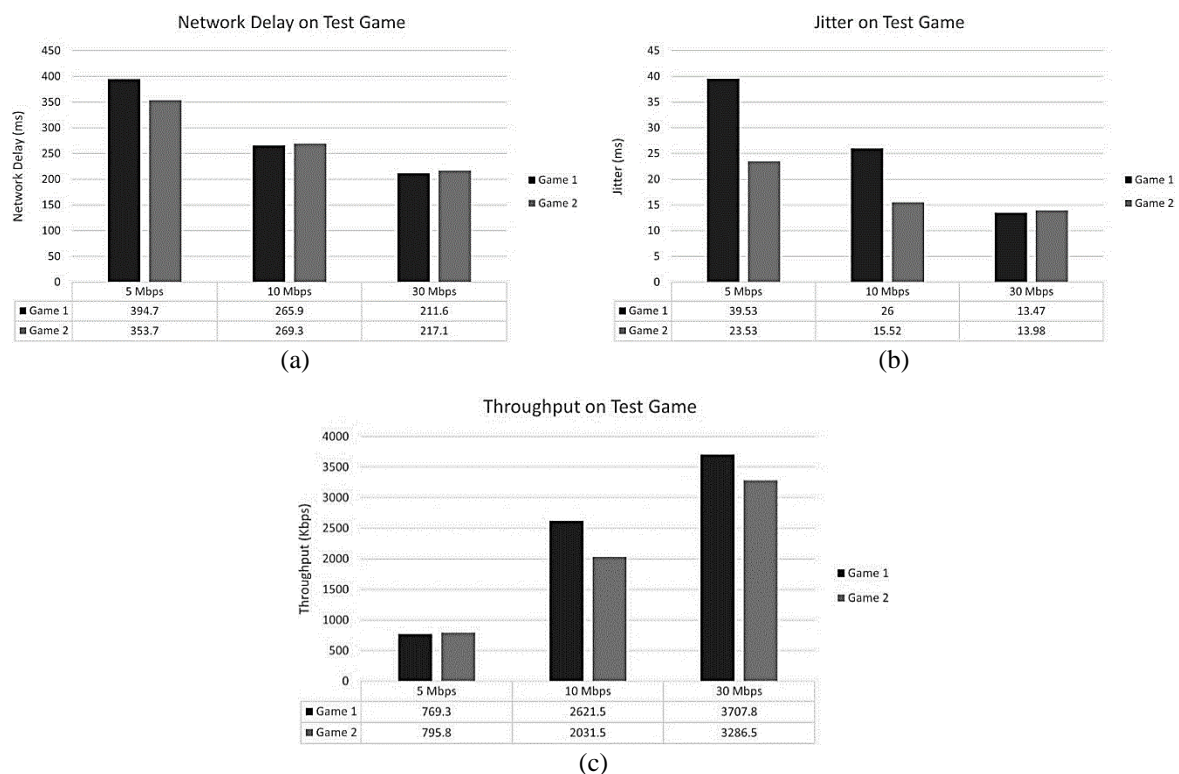


Figure 6. Quality of service when playing games (a) test game network delay, (b) test game jitter, and (c) test game throughput

3.5. Fps test game 1 and 2

The fps measurement is shown in Figure 7(a). Based on the measurement results obtained in the form of minimum fps data with a resolution of 720P at 120 fps while the data results at a resolution of 1,400×900 get the same fps as that produced by 720P resolution, namely at 120 fps. From the fps produced with a resolution of 720P and 1,400×900, it can be categorized as “very comfortable to play” because the fps obtained from two different resolutions reaches numbers above 60 fps.

In Figure 7(b), the measurement results show that a minimum fps resolution of 720P at 45 fps, an average of 51 fps and a maximum of 56 fps, while the data results at a resolution of 1,400×900 get a minimum fps of 50 fps, an average of 55 fps and a maximum of 60 fps. From the fps produced with 720P and 1080P resolutions, it can be categorized as “comfortable to play” because the fps obtained from the two different resolutions reaches a number between 45 to 60 fps, but there are obstacles on the user's part because the 1,400×900 specification is the maximum limit of the display. which can be processed by a user's device with low specifications.

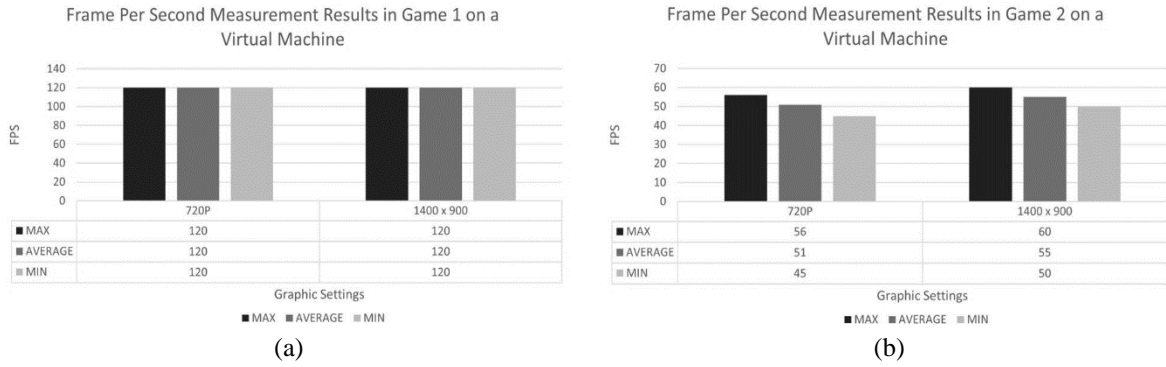


Figure 7. Fps test (a) game 1 and (b) game 2 on VM

3.6. Frame rate and frame drop test game 1 and 2

Figure 8(a) shows that the measurement results of the largest frame drop are at 5 Mbps bandwidth; this happens because the bandwidth used is still too small to run the game stably, resulting in a fairly large frame drop-in game 1 at 36.39% and game 2 at 69.51%. With a bandwidth of 10 Mbps in test games 1 and 2, the results of game 1 frame drop of 19.85% and 29.18% for game 2. 0% frame drop was obtained at a measurement bandwidth of 30 Mbps in running test games 1 and 2 due to the large bandwidth size to maintain stability of the game without any frame drop.

In Figure 8(b), the results of the smallest frame rate measurement are found in a bandwidth of 5 Mbps, this happens because the bandwidth used is still too small to run the game stably, so that the arrangement of images sent from the server to the user is not sent in full, but only partially where in the test game 1 it reaches frame rate of 39.53 fps and test game 2 only reached 18.86 fps. With a bandwidth of 10 Mbps in test games 1 and 2, the frame rate of test game 1 is 48.13 fps and 42.23 fps for test game 2. The highest results are obtained from a bandwidth of 30 Mbps which reaches an average of 60 fps for the frame rate of both games test.

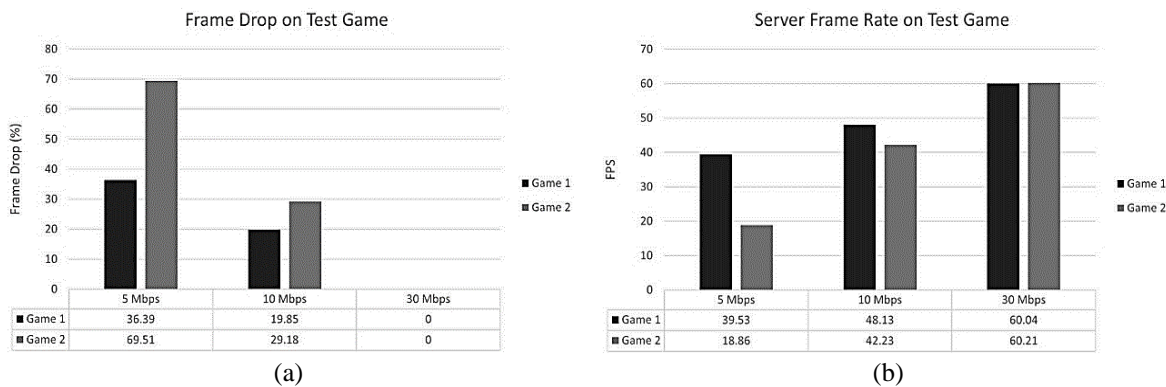


Figure 8. The test game (a) frame drops and (b) frame rate of game 1 and 2

4. CONCLUSION

From the system test with a bandwidth of 5 Mbps, we get a network delay of 374.2 ms, a jitter of 31.53 ms which is quite large, and a throughput value of 782.55 kbps which is too small to maintain the connection between user's device and cloud server. The average network delay of 267.6 ms, jitter of 20.76 ms, and throughput of 2326.5 kbps produced 10 Mbps can be said to be sufficient to run a stable system with a frame rate of 45.18 fps and a frame drop of 24.52%. With a bandwidth of 30 Mbps, the game test results obtained a network delay of 214.3 ms, a jitter of 13.72 ms, and a good throughput of 3497.3 kbps.

From the user's device measurement, resource usage is below 42% on CPU, RAM and GPU usage which is not much different from the device's idle condition, which is below 35%. From the fps measurement results obtained for test games 1 and 2 can be categorized as "comfortable to play" because it has reached the 45-60 fps range. The minimum bandwidth for users to play games comfortably is 10 Mbps. The average network delay of 267.6 ms, jitter of 20.76 ms and throughput of 2326.5 kbps produced 10 Mbps can be said




to be sufficient to run a stable system with a frame rate of 45.18 fps, and a frame drop of 24.52%. Even with a frame drop of 24.52% the system can operate smoothly at 45-50 fps.

The results of cloud server implementation with GCP shows that system could run the test game 1 and 2 without a dedicated GPU. By implementing a virtual machine on an instance in cloud server and installing an optimizer on the virtual private server display, user can access a system that has higher capabilities than the user's laptop by using a stable internet connection. In general, there are a little difference that occurred between test game 1 and 2 between different bandwidths.




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