Subscribers' Expectations of Internet Speed for Multiplayer Online Battle Arena (MOBA) Game

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Abstract— Internet bandwidth is crucial for many businesses and applications related to people's social and commercial activities in this current generation. This research examines the factors influencing Internet bandwidth service's fluctuation on unlimited Internet plans from four Internet Service Providers (ISP) companies in Malaysia (Umobile, Hotlink, Yes 4G, Xpax). The research's motivation lies with the fact that whether ISPs were really providing what they are advertising, or there is a need for expressing doubt on the maximum bandwidth users pay for and can actually get those bandwidths or not. Based on this issue, this research proposes an experimental analysis to investigate the factors influencing the fluctuation of Internet bandwidth when using a Multiplayer online battle arena (MOBA) game because it is a huge bandwidth-demanding game. The MOBA game selected for this particular study is Dota 2. Different simulation scenarios were formulated to measure latency, packet loss, and traffic used to identify the factors of fluctuating bandwidth usage. A PowerShell is used for determining those attributes, while in-game monitoring and cFosspeed are also used for tracking bandwidth and real-time ping, packet loss. The actual bandwidth measure was conducted with the Ookla application for testing the bandwidth. The simulation scenarios were undertaking for a round-period of time but at the same location for all the SIMs. After 30 minutes of simulation, the results indicate that Xpax is the best among ISP companies in terms of latency, bandwidth usage, traffic used, and player's experience. Still, for the packet loss, Hotlink and Yes 4G performed better. Umobile failed to stay 30 minutes of the simulation due to a connection problem and cannot reconnect. For the actual bandwidth test, the results indicate that the time (Peak, Off-Peak) a user accesses the internet has affected the maximum bandwidth for some ISP companies (e.g., Hotlink). The research findings reveal that an actual bandwidth result depends on location and congestion indicated by the signal bar. Moreover, the simulation found out that ping is the main factor for bandwidth usage while playing the MOBA game. If there is a ping spiking scenario, the bandwidth will use more than usual, more or less is dependent on how severe occurrences of spiking scenario. The finding concluded that Ping spikes and lag spikes in-game are ISP issues and are the factors influencing the fluctuation of internet bandwidth service for MOBA games

Keywords— MOBA, DOTA 2, Internet Bandwidth, Latency, Internet Traffic, Packet

I. Introduction

4G is the generation that brought people closer to the digital era. In 3G, we might have seen how big of a jump 2G to 3G was [1]. For example, always-on internet connection. However, with 3G, many users are faced with limited bandwidth and an unstable signal which causes interruptions when users use the internet to watch a video or surf the internet [2]. 4G in the present time has three system standards, and each standard depends on the decision of the country. 1. LTE-A (Long Term Evolution Advanced) is a standard that meets IMT-Advanced requirements [3], as defined by ITU Radiocommunication Sector (ITU-R). LTE-A has a peak bandwidth at 1Gbps. 2. LTE (Long Term Evolution) was the first LTE to release that does not fully comply with the IMT-Advanced requirements. This standard is based on GSM/EDGE and UMTS/HSPA technologies, which is the standard of 3GPP [4]. The peak bandwidth of LTE is 100 Mbps. 3. Mobile WiMAX (IEEE 802.16e) is a mobile wireless broadband access (MWBA) standard, which was branded as 4G. Even though it was branded as 4G, it does not meet IMT-Advanced requirements [5]. The peak bandwidth of Mobile WiMAX is 128 Mbps.

The problem of 4G or wireless connection is fluctuation, where stability is different from the wired connection. The big fluctuations in 4G download speeds are most likely caused by congestion on the network as the slowest speeds always occur when demand for mobile data is the highest [6]. This problem mostly occurs in urban areas. The data from OpenSignal [7] shows that Malaysian 4G experience has extreme speed variability depending on the time of day. Speeds ranged from a minimum of 9 Mbps, at Malaysia's peak hour of 10 pm, up to a maximum of 21 Mbps at off-peak hours between 1 am to 3 am.

The significance of this project is to acquire results from investigating internet bandwidth provided by telecommunication companies, with such results answering research questions. The results from investigating can benefit people who want to choose the best experience for

MOBAs among the samples. The results can give a deciding factor to people who want to know which unlimited pre-paid plan is suitable for them, including the preceived fluctuation of internet bandwidth and its utilization.

In the context of internet access, the word “Broadband” is used loosely to mean “access that is always on and faster than the traditional dial-up access” [8]. There are more correct definitions of speed that have been prescribed. For example, the standard CCITT in 1988 states that “broadband service” must have enough channels for supporting bandwidth that is greater than the primary rate, ranging from around 1.5 to 2 Mbps. In 2010, the standard was changed to 4 Mbps for downstream and 1 Mbps for upstream by the Federal Communications Commission (FCC) in 2010. Broadband includes several high-speed transmission technologies such as Digital Subscriber Line, cable modem, fiber optic, broadband over powerline, and wireless [9] [10] [11] [12] [13].

Nielsen's law states that "(high-end) Users' bandwidth grows by 50% per year." On their website, Nielsen Normal Group [14] [15] states that Nielsen's law is similar to Moore's law. However, when comparing the two laws, it shows that bandwidth grows slower than computing power (Moore's law). Moore's law says that "Computer double in capabilities every 18 months." which corresponds to about a 60% annual growth rate. The law was proposed by Jakob Nielsen of Nielsen Norman Group (NNG) in 1998 and then updated in 2008, with the latest update being in 2019. Nielson started to look at big data, which goes back to the 300bps modem used in 1984. In 1998 Nielsen measured a growth rate at 53 % per year and rounded it to 50%. Ten years later, between 1998 and 2008, Nielsen measured the growth rate to be 49% per year. This law held steady for a period of 36 years for himself and other big data users. Thus, users’ bandwidth will reach approximately 1 Gbps by 2021 [16].

II. METHODOLOGY

This research study utilizes a non-experimental method. Non-experimental research is the type of research that does not involve manipulating control or independent variables or both. But instead, it relies on interpretation, observation, or interactions to conclude. Typically, there are three types of non-experimental research including cross-section, correlation, and observation. In this non-experimental research, the author measures variables as they naturally occur without any further manipulation and uses observational research because it is related to observing behaviours of unlimited internet plans from four telecom companies. Observational research will be carried out and focused on latency (ping), packet loss, traffic used, and bandwidth [17]. Ping and packet loss will be observed and by ping to the server via PowerShell. Traffic used and bandwidth can be observed via cFosSpeed. The flowcharts displaying all activities are shown in Figure 1 and 2

A. *Simulation Flowcharts*

This flowchart (Fig.1) shows how to use PdaNet+ (Android Version). This process is the heart of experiment because unlimited internet plans do not allow for a normal tether. Therefore, this application is the main material for doing this project.

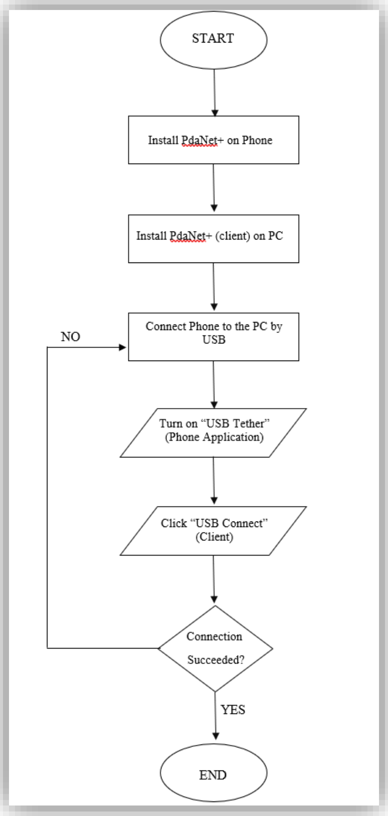

Fig. 1 Pre-Simulation Flowchart

A simulation (Fig.2) started opening Dota 2 and PowerShell. Inside Dota 2, a custom lobby dedicated to the Singapore server was created. In PowerShell, an input script for creating a log was put in. Both (Ping to Singapore server and start lobby) activities started at the same time. Simultaneously, while the game is in progress, the cFosSpeed was opened to monitor traffic usage and bandwidth usage. All activities were run for 30 minutes before data collection. Only in-game monitoring was used to capture ping and packet loss behaviour. If the game is disconnected from the server, the researcher will try to reconnect, but if it failed to reconnect, in-game monitoring and traffic usage, and bandwidth will stop. PowerShell will not stop until 30 minutes has passed.

B. *Experimental Procedure*

The procedure for this experiment is designed to uncover the issues associated with latency (ping), packet loss, traffic used, and bandwidth usage while play MOBAs. There are three steps to find these results.

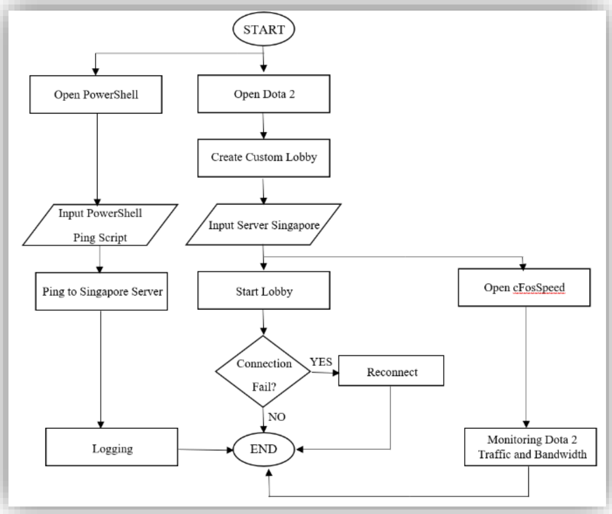

Fig. 2 Simulation Flowchart

1) Start playing Dota 2 by creating a custom match dedicated to the Singapore server.

2) Using Windows PowerShell to ping a Singapore server (sgp-1.valve.net) at the same time when the game started for logging packets and ping. Script for ping is set to 1800 packets (60 seconds x 30 Minutes). cFosSpeed is used for monitoring Dota 2 traffic and bandwidth.

3) Game session and logging will take 30 minutes to finish.

C. *Base Scenario Set-Up*

All scenarios will be based on this set-up. The change is only for SIM cards.

- Video Game: Dota 2
- Game Mode: Custom Match
- Server: Singapore
- Duration for Each Scenario: 30 Minutes
- Network: PdaNet Broadband Adapter
- Phone Model: Samsung Galaxy Note 8
- Application for Passthrough Internet: PdaNet+ Ver. 5.23.1 (Full Version) by USB tether
- SIM Cards: Umobile, Hotlink, Yes 4G, Xpax
- Phone Location: IIUM, Mahallah: Bilal, Black: PG/3rd Floor

D. *Criteria for Choose SIMs*

There are a lot of telecommunications in Malaysia but for the specific experimental criteria for choose telecommunication, we can list 4 telecommunications that follow these 4 criteria

1) It has to be Unlimited Internet Plan
2) The price of internet plan must not above 50rm
3) Pre-Paid plan only
4) 4G only

E. *Scenario 1 (Umobile)*

The game was perfectly smooth from the start until twenty minutes, with no high ping spiking (noticeable) or packet loss while playing. About twenty minutes into the game, there was a massive ping spike, which caused a "Connection Problem" message and a failure to reconnect even after multiple retries. It was reveals that there are several time-outs and high ping spikes, which lasted for about seven minutes. The highest ping recorded was 3813 ms (millisecond) followed by 146 ms on average and 25 ms was the lowest ping recorded. Twenty packets were lost out of 1800 packets sent. Fig.7 showed a constant three-bar signal that did not drop during testing.

The last one was about traffic used and bandwidth usage. In column tx (transmit) was 6,479,640 bytes (or 6.4 megabytes) and rx (receive) was 19,080,709 bytes (or 19 megabytes), a combined total of 25.4 megabytes. Additionally, bandwidth usage for transmitting and receiving was 4,516 bytes and 18,305 bytes, respectively. This game session finished at 23.16 minutes due to a failure to reconnect.

F. *Scenario 2 (Hotlink)*

The signal bar of Hotlink mostly stayed between one to two bars, but sometimes reverted to 3G depending on the weather and phone location. There is a loss in/out in the game due to the phone having to shuffle between 3G and 4G for a few seconds; the loss in/out could only be captured with in-game monitoring because it is a real-time monitor. However, there was no repeat of this shuffling of signals after the initial one. There were some high ping spikes between 150 and 400 ms which only occurred for one to two seconds but was barely noticeable and did not interrupt playing.

The maximum ping logged in PowerShell was 2181 ms. This occurred due to a fall in signal from 4G to 3G before coming back to 4G again after a few seconds. Additionally, 23 ms was the minimum recorded with 43 ms being the average. Packet loss logged outside of game was zero, but not in-game. The traffic used in 30 minutes of Dota 2 was used in this analysis. In column tx (transmit) was 16,258,865 bytes (or 16.2 megabytes) and rx (receive) was 24,505,329 bytes (or 25.5 megabytes), combining to a total of 41.7 megabytes. Bandwidth usage for transmitting and receiving was 4,481 bytes and 15,241 bytes, respectively.

G. *Scenario 3 (Xpax)*

Xpax had a bars constant three-bar signal during testing and surprisingly recorded low ping and little fluctuation. Starting from 1 minute until 30 minutes onwards, there were no ping spikes, which made this internet plan the best. The analysis shows a surprising all ping summary with a maximum ping of only 134 ms (barely happened), a minimum of 19 ms and an average 29 ms. Only one packet was lost out of 1800 sent.

The last analysis shows traffic used during 30 minutes in Dota 2. In column tx (transmit) is 14,396,997 bytes (or 14.3 megabytes) and rx (receive) was 23,739,587 bytes (or 23.7megabytes), a total of 38 megabytes. Bandwidth usage for transmitting and receiving was 4,511 bytes and 12,523 bytes, respectively.

H. *Scenario 4 (Yes 4G)*

There is a two-bar signal that did not fluctuate while testing. The testing shows ping spikes between 200 to 450 ms many times, but those spikes lasted only a half-second in most cases with some spikes lasting up to 2 or3 seconds in rare cases. Thes testing indicate Fig. 22 shows a good maximum ping (521 ms) compared to other telecom companies, but given player experience, it was not what it looked like in the log. As mentioned above, although ping spikes were brief, it could ruin the feeling of playing the game. The average ping was 54 ms and the minimum is 24 ms. Packets loss was zero in-game during monitoring and logs.

the tsting shows traffic used during 30 minutes in Dota 2. In column tx (transmit) was 13,587,889 bytes (or 13.2 megabytes) and rx (receive) was 33,792,266 bytes (or 33.7 megabytes), a total of 46.9 megabytes. Bandwidth was surprisingly higher for receiving data (29,603 bytes) compared to other telecom companies, but bandwidth for transmitting data (4,882 bytes) was similar to others.

III. PRESENTATION OF RESULTS

The presentation of results is separated into four parts: Ping, Traffic used, Bandwidth usage, and packet loss.

A. *Latency (Ping)*

Figure 3 shows a ping comparison between four telecom companies. The graph shows three values: minimum, average, and maximum ping. Umobile had the highest maximum ping (3813 ms). This was 86.3% higher than Yes 4G, 42.8% higher than Hotlink, and 96.4% more than Xpax. Yes 4G had a maximum ping at 521 ms. Compared to Umobile, Yes 4G was significantly lower than Umobile at around 631%. With Hotlink, Yes 4G was also significantly lower than Hotlink with around 318.6%, and with Xpax, Yes 4G was now higher than Xpax at 74.2%. Next was Hotlink; Hotlink had a maximum ping of 2181 ms. Compared to Umobile, Hotlink was lower than Umobile at 74.8%, and with Yes 4G, Hotlink had a higher maximum ping than Yes 4G at 76.1%. As for Xpax; Hotlink was dramatically higher than Xpax at 93.8%. Moreover, Xpax was comparatively the best telecom company with a maximum ping of only 134 ms. Compared to Umobile, Xpax was lower than Umobile at 2,745.5%. Compared to Yes 4G, Xpax could achieve a lower number than Yes 4G at 288.8%, and with Hotlink, Xpax was lower than Hotlink at 1,527.6%.

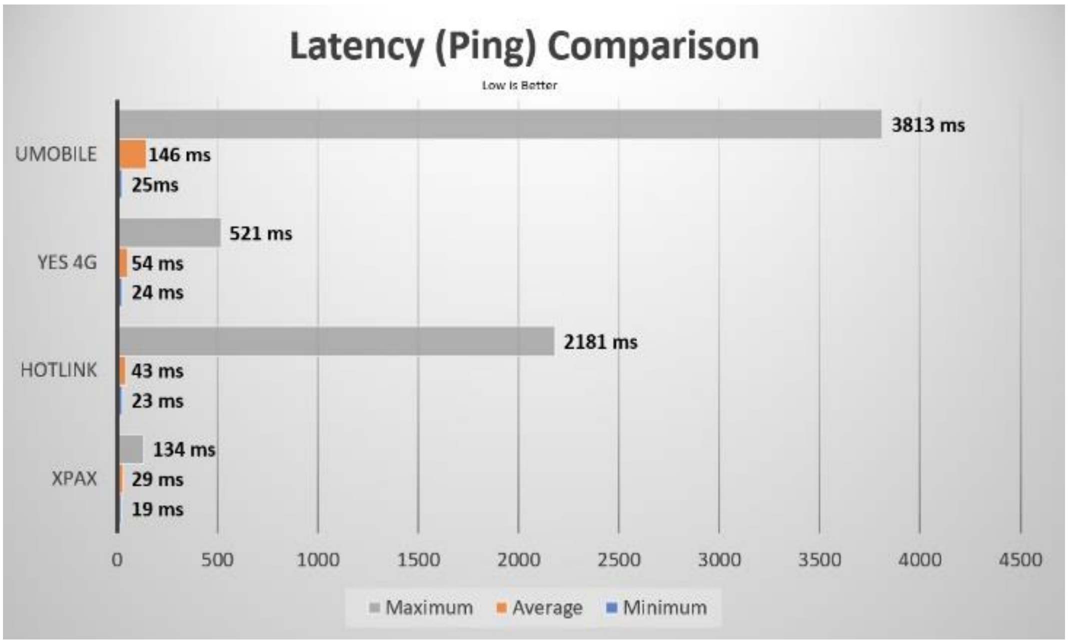

Fig. 3 Latency (Ping) Comparison

Umobile had an average ping of 146 ms. Compared to Yes 4G, Umobile was higher than Yes 4G at 63.4%, and with Hotlink, Umobile was higher than Hotlink at 70.5%. Finally, with Xpax, Umobile was higher than Xpax at 80%. Yes 4G had an average ping if 54ms. Compared to Umobile, Yes 4G was lower than Umobile at 170.3%, and with Hotlink, Yes 4G was higher than Hotlink at 20.3%, and with Xpax, Yes 4G was higher than Xpax at 46.2%. Hotlink had an average ping of 43ms. Hotlink was lower than Umobile at 239.5%, lower than Yes 4G at 25.5%, and higher than Xpax at 32.5%. Xpax had an average ping of 29 ms. Xpax was significantly lower than Umobile, Xpax, and Hotlink at 403.4%, 86.2%, and 48.2%, respectively

Umibile had a minimum ping of 25 ms. Compared to Yes 4G, Umobile was slightly higher than Yes 4G at 4%, and with Hotlink, Umobile was also slightly higher than Hotlink at 8%, and with Xpax, Umobile was higher than Xpax at 24%. Yes 4G had a minimum ping of 24 ms. Compared to Umobile, Yes 4G was slightly lower than Umobile at 4.1% the same percentage as Hotlink, but Yes 4G was a bit higher, and with Xpax, Yes 4G was 20.8% higher than Xpax. Hotlink had a minimum ping of 23 ms. Compared to Umobile, Hotlink was lower than Umobile at 8.6%, and with Yes 4G, Hotlink was lower than Yes 4G at 4.3%, and with Xpax, Hotlink was higher than Xpax at 17.3%. Finally, Xpax had the lowest minimum ping of 19 ms. Compared to Umobile, Xpax was lower than Umobile at 31.5%, and with Yes 4G, Xpax was lower than Yes 4G at 26.3%, and with Hotlink, Xpax was lower than Hotlink at 21%.

Figure shows packets sent and received as well as packet loss for a period of 30 minutes in which packets 1,800 were sent. Therefore, all telecom companies sent the same value. Only the received value is different. Two telecom companies; namely, Yes 4G and Hotlink, received 1,800 packets without any loss. Xpax lost one packet, or 0.05% of 1800 packets sent. However, Umobile lost 20 packets, or 1.1%.

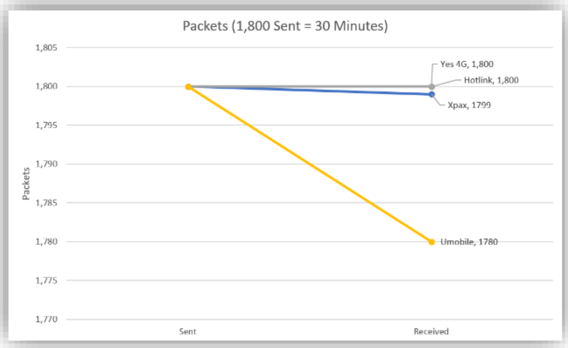

Fig. 4 Packets Sent and Receive

B. *Bandwidth Usage*

Figure 5 shows the bandwidth usage of all telecom companies, showing two main values, which are tx/s (transmit/second) and rx/s (receive/second). Regarding the tx/s value of the four companies, there was no significant difference between the four telecom companies with the difference being between only one to eight percent.

On the other hand, rx/s across the four companies had a significant difference due to ping and packet loss which impacted the rx/s value. Xpax had rx/s at 12,523 bytes/second. Compared to the other three, Xpax was lower than Hotlink, Yes 4G, and Umobile at 21.7%, 136.3%, and 46.1%, respectively. Hotlink had rx/s at 15,241 bytes/second. Compared to Yes 4G and Umobile, Hotlink is lower than Yes 4G and Umobile at 94.2% and 20.1%. Hotlink was higher than Xpax at 17.8%. Yes 4G had the highest rx/s value at 29,603 bytes/second. Compared to Xpax, Hotlink, and Umobile, Yes 4G were higher than Xpax, Hotlink, and Umobile at 57.6%, 48.5%, and 38.1%, respectively. Umobile had rx/s at 18,305 bytes/second. Compared to Xpax and Hotlink, Umobile was higher than Xpax and Hotlink at 31.5% and 16.7%. Umobile was lower than Yes 4G at 61.7%.

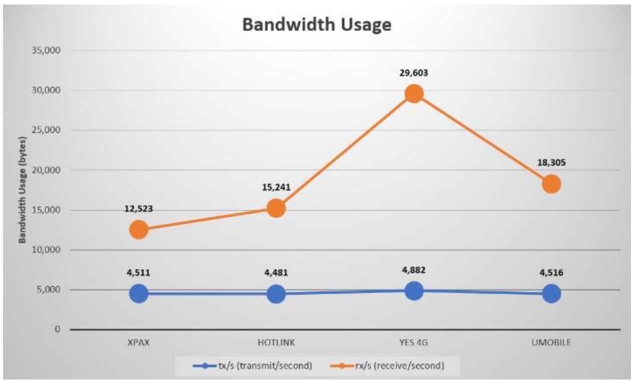

Fig. 5 Bandwidth Usage

C. *Traffic Used in 30 Minutes*

Figure 6 shows the traffic used in 30 minutes. Umobile was eliminated from the graph due to being unable to reach 30 minutes of the simulation. Yes 4G used the lowest tx (transmit) at 13.5 MB. Compared to Hotlink, Yes 4G was lower than hotlink at 20%, and Yes 4G at 5.9%. Hotlink used tx highest in the graph (16.2 MB). Compared to Yes 4G and Xpax, Hotlink is higher than Yes 4G and Xpax at 16.6% and 11.7% respectively. Xpax used 14.3 MB tx. Compared to Yes 4G, Xpax is higher than Yes 4G at 5.5%, and with Hotlink, Xpax is lower than Hotlink at 13.2%.

For rx (receive) value, Yes 4G used 33.7 MB rx, which is highest in the graph. Compared to Hotlink and Xpax, Yes 4G was higher than both plans with 27.2% and 29.6% respectively. Hotlink used 24.5 MB rx. Compared to Yes 4G, Hotlink is lower than Yes 4G at 37.5%, and with Xpax, Hotlink is slightly higher than Xpax at 3.2%. Xpax used 23.7 MB rx. Compared to Yes 4G and Hotlink, Xpax was lower than both plans with 42.1% for Yes 4G and 3.3% for Hotlink.

The combination of both tx and rx can show the real traffic used in 30 minutes of Dota 2. Yes 4G was the highest with 46.9 MB. Compared to Hotlink and Xpax, Yes 4G was higher than both 11% and 18.9%, respectively. The combined total of Hotlink was 41.7 MB. Compared to Yes 4G, Hotlink was lower than Yes 4G at 12.4%, and Xpax at 8.8%. Xpax's total used traffic was 38 MB. Compared to both Yes 4G and Hotlink, Xpax is significantly lower than Yes 4G at 23.4% and Hotlink at 9.7%.

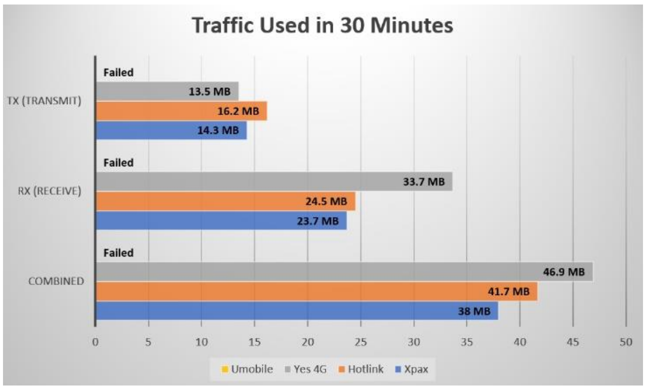

Fig. 7Traffic Used in 30 Minutes

TABLE I
Unlimited Internet Plans Comparison

Telecom	Plan	Maximum Bandwidth	Price
Yes 4G	Unlimited HD EPIK	4 Mbps	RM 40
Hotlink (Maxis)	Unlimited Internet 45	6 Mbps	RM 45
Xpax (celcom)	Monthly Unlimited	6 Mbps	RM 45
Umobile	Giler Unlimited	6 Mbps	RM 30

IV. CONCLUSION

Telecom companies advertising their unlimited internet plans (Table 1). However, the actual speed that consumers receive is not the same as their advertising. From the simulation, some telecom companies do not give them exactly what they are stated in advertising due to many reasons (e.g., crowded connections, weather). Some telecom companies still gave exactly what they are advertising (fluctuation of bandwidth not above 5%), referring to base scenario set-up location.

MOBA games require a stable ping connection and no loss packet. Telecom companies advertised their unlimited internet plan as an all-around use. Therefore, the online game should be included in this. From the simulation, in real-world usage is not the same as their advertising. From the simulation, only two companies (Hotlink, Xpax) are capable of handling MOBA gaming.

The three problems that affect the utilization of internet bandwidth are latency, type of transmission, and packet loss. Through simulation, it was found that ping was the main factor affecting the utilization of internet bandwidth the most. The results show that ping spikes caused higher bandwidth usage than usual. Additionally, in cases where packet loss was high, it caused the game to freeze and incorrectly display the wrong animation on the computer screen while gaming.

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