Well-Provisioned First Person Shooter and Massively Multiplayer Online Role-Playing Games Traffic in Enhanced EPON

Vahid Golderzehi, I-Shyan Hwang, and AliAkbar Nikoukar

***Abstract*—Massively multiplayer online games (MMOGs) have gained enormous popularity amongst the game communities, industries and academic researches. In particular, first person shooter (FPS) and massively multiplayer online role-playing game (MMORPG) genres are most famed. FPS traffic is very delay sensitive like voice and its interactivity is similar to the multimedia. However, MMORPG traffic is less delay sensitive than FPS, nevertheless, FPS traffic is more packet loss ratio tolerant than MMORPG. To address the low latency, packet loss and large bandwidth requirements of those game genres, Ethernet passive optical network (EPON) would be an eminent election amongst broadband access networks. In this paper, we introduce an enhanced EPON architecture, a new queue scheduling mechanism to queue the FPS and MMORPG separately, and a game dynamic bandwidth allocation (Game DBA) to assign bandwidth to FPS and MMORPG and guarantee an overall QoS metrics based on the games requirements. The proposed Game DBA is capable to delay MMORPG traffic for some cycle, in which users do not sense this delay. Simulation results have illustrated that our proposed architecture can improve the games quality of service (QoS) in terms of mean packet delay and packet loss ratio.**

***Index Terms*—Massively multiplayer online games (MMOGs), first person shooter (FPS), massively multiplayer online role-playing game (MMORPG), Ethernet passive optical network (EPON), game dynamic bandwidth allocation (Game DBA).**

I. Introduction

MASSIVELY multiplayer online games are large distributed applications where players interact in a virtual world with hundreds of thousands people around the World. During the recent years, MMOGs have attracted the attention of both the game industry and the academic research, and have been regarded as one of the most profitable and popular Internet services [1]. Since the number of MMOG players has been grown, the MMOG network traffic occupies about 5 percent of Internet traffic, which is still growing very fast. [1,2]. MMOG genres consist of first person shooter (FPS), massively multiplayer online role-playing games (MMORPGs), real-time strategy (RTS), massively multiplayer online racing (MMOR), massively multiplayer online social games (MMOSG), sports games, fighting games and puzzle games. Among the MMOG genres, MMORPG and FPS indicate the two largest game genres, which have occupied 34% and 48% of academic research efforts respectively in the past decade [3].

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In terms of the number of users, MMORPG is the most popular game genre. Players are depicted as virtual avatars who can interact with other players in an MMORPG. Game environment is a virtual world with historical or mysterious stories designing. The player can control avatar's actions (e.g., walking, talking, shooting, and fighting). Avatars can be considered into various types with different roles and responsibility. All information of each avatar actions should be disseminated towards the all nearby avatars, in which generates large amount of game traffics [1,4].

FPS game genre is one of the prevalent and fast growing video game genres [5]. In FPS, players combat against each other with weapons in a first person perspective. FPS games join short matches with the repetitive virtual environment. In order to fulfill the real time interaction of large number of MMORPG and FPS subscribers, network operators need to care about the game traffic requirements.

In the broadband access networks, passive optical network (PON) with the point to multipoint topology and huge bandwidth rate emerged towards the fast extension around the world. In the PON standard, IEEE 802.3ah Ethernet passive optical network (EPON), which support 1Gbps bandwidth rate, and IEEE 802.3av EPON which support multi-rate bandwidth (i.e., 1Gbps up to 10Gbps) are represented. EPON is widely deployed and considered as one of the best solutions in the access networks with the large bandwidth, simplicity scalability, and cost-effective benefits [6,7].

Essentially, EPON consists of an optical line terminal (OLT) located at the central office (CO) and one or more passive splitters. OLT connects to the several ONUs, which are located at the user's curb through these passive splitters via optical fibers. Due to using passive splitters instead of active components maintenance cost is reduced. The OLT broadcasts the data packets and control messages by use of whole channel bandwidth to the ONUs over the point to multipoint topology in the downstream direction. By doing so, each ONU can receive related data packets via the matched logical link identifier (LLID). LLID is the specific ID that is assigned to each ONU by the OLT in the ONU registration procedure. In the upstream direction, all ONUs using share transmission channel towards the OLT. To avoid data collisions, shared channel is operated with time division multiple access (TDMA) and each ONU have to send upstream data in its transmission timeslot. Hence, the IEEE 802.3ah and IEEE 802,3av standards have developed a Multipoint Control Protocol (MPCP). Thus, the point to point upstream transmission of each ONU within a dedicated timeslot via the shared channel is implemented [7,8].

The MPCP relies on GATE and REPORT control messages. The OLT by use of GATE message designates the assorted share of upstream bandwidth to the ONUs with the aid of DBA algorithm. The REPORT message is used by each ONU to report its queue length to the OLT. Once all REPORT messages received by the OLT, it executes a dynamic bandwidth allocation (DBA) scheme to calculate and allocate the transmission timeslots to each ONU. The DBA dynamically allocates bandwidth based on received REPORT message information of ONUs, and each ONU transmits within a dedicated timeslot toward the OLT. The DBA has the main duty in terms of bandwidth allocation efficiency, shared resource utilization, and offer the enhanced quality of service (QoS) to the end users [8,9].

In this paper, we focused on the guarantee of FPS and MMORPG games traffic in EPON. By doing so, a new queue scheduling in the ONU architecture with new components is proposed to handle these two game genres based on their network traffic requirements including delay and packet loss. Moreover the new game DBA scheme is proposed to hold MMORPG traffic for some cycle in order to pass the different network traffics with no effect on the MMORPG game quality.

The remainder of this paper is organized as follows. On section II, MMOG and especially FPS and MMORPG traffic characteristics are presented; in section III, the new queue scheduling in ONU architecture and the game DBA scheme are proposed; section IV debates the performance evaluation of proposed mechanism and, finally, section V concludes the paper.

II. MMOG Traffic Characteristics

Most popular MMOGs are based on the client-server architecture, which take advantages of authentication, copy protection, billing, and easy update of the clients [10]. MMOG traffic mainly involves periodically sent back and forth of information between the server and all clients. MMOG requires low-latency point-to-point upstream transmission from each client to the server and also requires low-latency from the server to the clients. Thus, it has different requirements from the web traffics. Due to the small sizes of game packets and real time interactions, low latencies, and packet loss ratio are required to improve the quality and synchronous logic of game [6].

A. FPS Traffic Characteristics

All FPS games use client-server network architecture [5]. Clients and servers can occasionally generate burst traffic due to the destroying buildings, and dying or any harm of the avatar during a match. Clients need to generate normal information in the shooting, walking or running actions.

The FPS game traffic in the upstream direction usually consists of small packet size, short, and burst interarrival time, which mostly use the extreme value distribution. Commonly, this kind of distribution is used for unusual events such as, natural disaster (e.g. typhoon and earthquake). The similar trend occurs in gameplay of this genre [3,11].

Since these games require real-time, low latency, and instant reactions, fast packet delivery is a key factor in the network architecture. FPS games as fast-paced games use UDP that generate small and highly periodic data packets, which is useful for low latency data packet delivery procedure [3,5,11].

Generally, FPS packets size are generated in the range of 15-110 bytes, and 5-300 bytes by the clients and the servers, respectively. The packet interarrivall time of the clients and the servers would be 5-120 ms and 10-200 ms, respectively [3,5].

B. MMORPG Traffic Characteristics

As MMORPGs have the largest number of players among MMOG genres, they will generate huge data quantity with the unique requirements. Most of the MMORPG games require real time interactions and reliable transmission mechanisms. However, the maximum tolerable delays are much larger than other real time game genres (like FPS games) [1,2]. MMORPGs use TCP to data transmission, which is connection oriented transport protocol and presents reliable data delivery in the access networks [2,3].

Each client will use point to point transmission data towards the server, whereas the server will broadcast or multicast the updates or some other information to all clients. Therefore, size of packets generated by the server is larger than the client’s packets size. Generally, the size of the client’s packets and the server’s packets would be in the range of 1-154 bytes, and 4-636 bytes, respectively [3]. The client’s interarrival time would be 0-1264 ms and for the servers, it would be 0-3179 ms, which are represented a wide range, and indicates that they are slow-paced MMOG game genre [3].

Based on the different range of the interarrival time between MMORPG and FPS games, MMORPG players have more time to make decisions such as seconds or even minutes, while players in a FPS game have to make decisions instantly. Moreover, the size of the packets for MMORPG game is much larger than FPS packets size [3].

III. Proposed Architecture

In this section, a new queue scheduling in the NOU architecture is proposed to change the priority of the game traffics (i.e., FPS and MMORPG) and to improve the quality of game play. Furthermore, a Game DBA is proposed to allocate the bandwidth to different kind of traffics based on their requirements. Moreover, it may apply delay for some cycle to the MMORPG traffic and pass the other traffics to improve the overall QoS in EPON architecture. The applied delay in MMORPG traffics affected no impact on the quality of MMORPG’s game play.

A. ONU Architecture and Operation

Figure 1 depicts the proposed scheme of the ONU architecture. Once ONU receives different type of traffics from the user network interface (UNI) or optical distribution network (ODN), traffic classifier classifies the incoming traffics with the aid of ingress rule, class of service (CoS) and type of service (ToS), and the routing table. Afterward, it will forward the classified packets to the related queues.

The conventional queue scheduling in ONU architecture consists of a priority queue (PQ), which transmits expedited forwarding (EF) as the high priority traffic, assured forwarding (AF) with the medium priority traffic and best effort (BE) located at the low priority traffic. The proposed queue scheduling represents the modified PQ, in which EF has the highest priority, FPS has the second priority, third

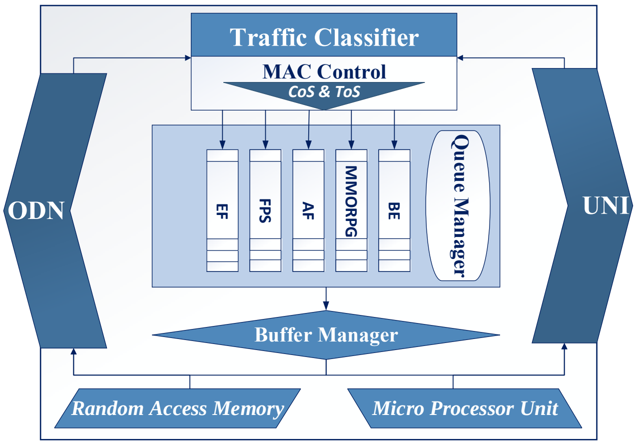

Fig. 1. Detailed ONU diagram.

priority is allocated to the AF traffic, MMORPG is occupied the fourth priority and finally BE is placed at the lowest priority as shown in Fig. 2. As aforementioned, in the conventional access networks the game traffics have considered as web traffics (i.e., BE). Thus in the proposed mechanism FPS and MMORPG traffics are separated from the BE traffics and located to the second (i.e., FPS) and fourth (i.e., MMORPG) priorities based on their different network requirements. The modified queue manager is intended to handle five different traffic types. It will help the OLT and ONU to exploit the required information.

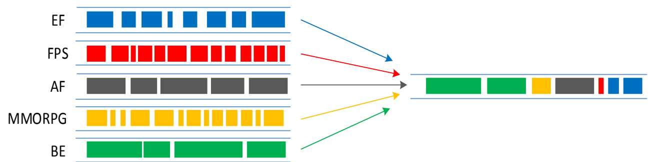

Fig. 2. Proposed queue scheduling in upstream direction.

B. OLT Architecture and Operation

Basically, in the EPON architecture, OLT has the main role in both data transmission directions either in downstream direction by the data broadcasting towards the ONUs, and operation, synchronization, timeslot allocation in the upstream direction. After receiving the traffic by the OLT, traffic classifier will classify the incoming traffics in terms of different rules, then forward to the individual queues. It will send the game traffics to the game controller engine module. This module consists of packet processing unit, microprocessor unit, and queue scheduling unit. Packet processing unit extracts required information and checks duplicated packets to keep one of them. Microprocessor unit is the processing power of the game controller engine, which is different from the OLT processor unit. Queue scheduling in this module is used for managing, queuing, and buffering the game traffics (i.e., FPS and MMORPG). Since game servers periodically send updates or other information to the all players, OLT will check the arriving packets and keep one of the duplicated packets. Afterward, OLT will assign the unique LLID, which would be accepted by all connected ONUs. Thus, the OLT can save bandwidth by sending the single copy broadcast (SCB) to the ONUs in downstream direction. The game controller engine module is a programmable module that can be changed and modified by the service providers. The OLT diagram illustrated in Fig. 3.

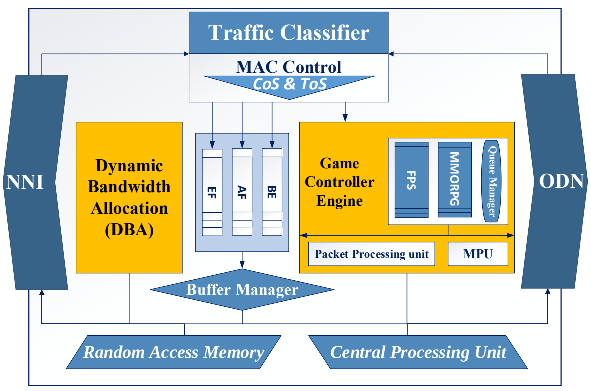

Fig. 3. Detailed ONU diagram.

C. Game DBA Scheme

DBA scheme can be categorized as online and offline. In the online model, once the OLT received the REPORT message from an ONU, the DBA calculates the timeslot window based on the requested REPORT message information from the ONU. Therefore the OLT sends the GRANT message towards the related ONU. In this model the OLT do not need to wait for receiving the REPORT message of all other ONUs. However, the OLT's control on channel transmission time will be reduced, which represents low performance of the fairness jitter, especially in highly load traffics. In the offline model, the OLT will calculate the transmission cycle time for each ONU and send the GRANT messages to all ONUs after gathering all REPORT messages from the ONUs. It takes advantage of fairly bandwidth allocation and leads to idle period problem, which can be

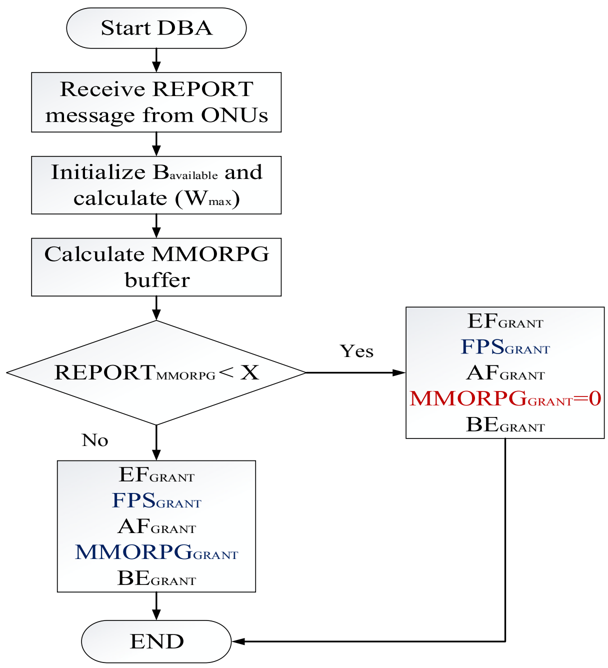

Fig. 4. Proposed Game DBA scheme.

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modified by using the prediction-based mechanism. In the proposed Game DBA scheme, the offline model is used as shown in Fig. 4. Therefore, the Game DBA will be executed as soon as the OLT received all REPORT messages. It will initialize the available bandwidth ($B_{available}$), then calculates the maximum transmission window (W_{max}) of each ONU. In the next step, if M_{RT} is MMORPG's incoming bitrate and T_{Th} is the boundary delay that MMORPG can tolerate. The boundary delay (T_{Th}) is less than 100*ms* [9]. Then the number of bits (*X*) accumulate in T_{Th} is

$$X = \frac{M_{RT}}{T_{Th}}$$

Therefore, whenever the ONU send REPORT message, the $MMORPG_{GRANT}$ is expressed as Eq(1):

$$MMORPG_{GRANT} = \begin{cases} 0 & if \quad REPORT_{MMORPG} < X \\ DBA-GRANT & Otherwise \end{cases} \quad (1)$$

Where $REPORT_{MMORPG}$ is the reported queue length of MMORPG traffic by the ONUs and *X* is the number of bits.

The DBA allocates transmission cycle time via OLT to the EF, FPS, AF, MMORPG, and BE, respectively to improve the quality of game service, if $REPORT_{MMORPG}$ was greater than or equal to *X*. Otherwise, the OLT holds the MMORPG traffics to pass the other types of traffic (i.e., EF, FPS, AF, BE), via the MMORPG transmission cycle times. Note that the MMORPG players do not sense these applied delays on the MMORPG traffics.

IV. Performance Evaluation

In this section, the QoS of proposed architecture will be analyzed in terms of the mean packet delay, packet loss and system throughput. We have modeled our system using OPNET simulator with an OLT, which is connected to the 32 ONUs. The downstream and upstream channel bitrate between OLT and ONU is set to 1Gbps. The distance is uniform over the range of 10 to 20*km* from OLT to ONUs, and the channel coding is 8B10B. Each ONU has 10Mb

TABLE I
Simulation Parameters

Parameter	Value
Number of ONUs	32
Downstream/Upstream link capacity	1*Gbps*
OLT-ONU distance (uniform)	10-20*km*
ONU buffer size	10*Mb*
Maximum transmission cycle time	1*ms*
Guard time	10*µs*
Control message length	0.512*µs*
AF and BE packet size (*byte*)	Uniform (64, 1518)
EF packet size (*byte*)	Constant (70)

buffer size. This model generates highly burst AF and BE traffics with Hurst parameter of 0.7. The packet size is uniformly distributed between 64 to 1518 bytes. The high-priority traffic, i.e., Expedited Forwarding (EF) traffic (e.g., voice) is modeled using Poisson distribution with fixed packet size (70*bytes*). The Server packet size of the FPS and MMORPG genres are in the range of 5 to 300 bytes, and 4 to 636 bytes, respectively. The client packet size of those genres would be ranged in 15 to 110, and 1 to 154, respectively. Finally, the simulation result will be compared with the original interleave polling with adaptive cycle time (IPACT) DBA. The simulation scenario is summarized in table I.

We have run three scenarios with different traffic proportions. Scenario 1 (i.e., G-11414) is set to 10%, 1%, 40%, 1%, and 48% for EF, FPS, AF, MMORPG, and BE, respectively. The traffic proportion of scenario 2 (i.e., G-13434) is represented such as 10%, 3%, 40%, 3%, and 44% to the EF, FPS, AF, MMORPG, and BE, respectively. The third scenario (i.e., G-15454) is set to EF, FPS, AF, MMORPG, and BE with 10%, 5%, 40%, 5%, 40%, traffic proportion respectively.

A. Mean Packet Delay

Generally in each ONU the arrival packets from the user's side will be sent to the related queues, which have different priority queue (PQ). In this paper we have used the proposed PQ with five different priorities. EF has the first priority in both, conventional PQ and proposed PQ. Therefore, the EF packet delay will be satisfied same as the IPACT. Fig. 5 shows the FPS packet delay of the scenario 1, 2, and 3. The packet delay of these scenarios is almost same and under 2*ms*. The reason is the proposed PQ in which FPS game packets have separated from the BE queue and located to the second priority queue. Thus, FPS packet delay is

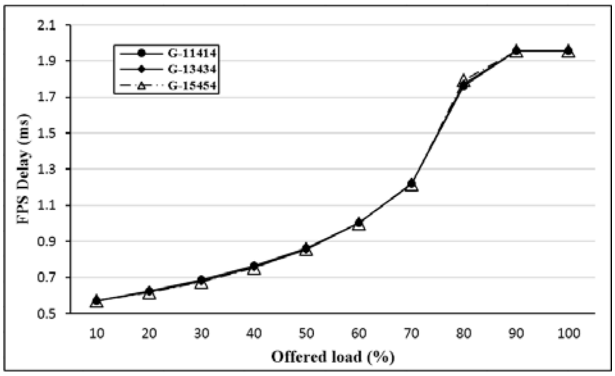

Fig. 5. FPS packet delay.

significantly improved compared to BE packet delay. In the proposed PQ, AF has the third priority. Hence, the packet delay of the AF traffic hardly increased for the scenario G-15454 and scenario G-13434 from 80% up to 100%, but it

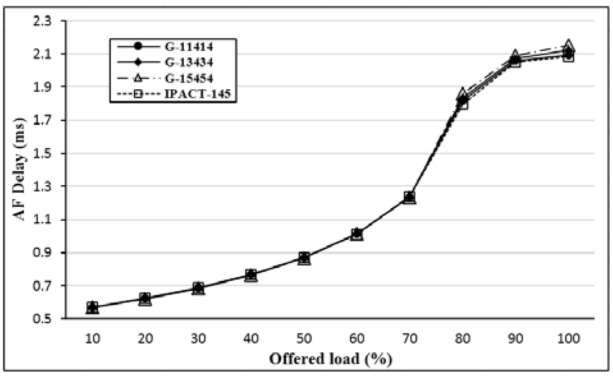

Fig. 6. AF packet delay.

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is still under 2.2ms as shown in Fig. 6.

Figure 7 depicts the MMORPG packet delay in terms of traffic load. The MMORPG traffic is also separated from BE traffic. As shown in this figure, the delay of scenario G-13434 and G-15454 are suddenly increased from the 90% and reach to the same value in 100%, which is under 31*ms*. The delay of scenario G-11414 in 100% is less than the other scenarios. Despite keeping the MMORPG traffic for some cycle, the MMORPG delay is considerably improved in all scenarios compared with BE delay. As illustrated in Fig. 8, the BE delay in 90% and 100% is slightly increased in comparison of IPACT.

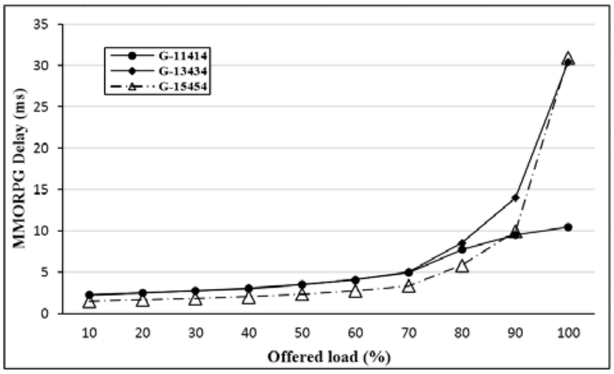

Fig. 7. MMORPG packet delay.

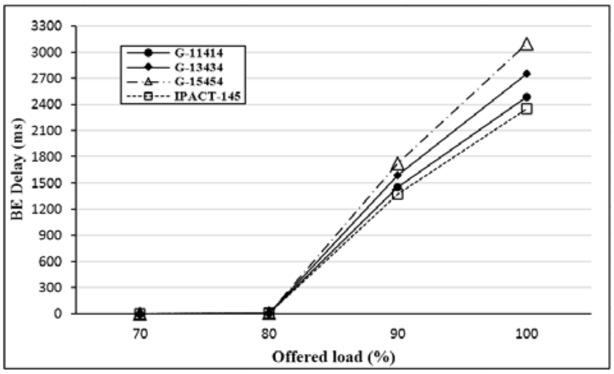

Fig. 8. BE packet delay.

B. Packet Loss

By using the new queue scheduling in the proposed mechanism, there is no packet loss for the FPS and MMORPG game genres. In the conventional queue scheduling, these game genres were part of the BE traffic which had packet loss in highly load (i.e., 90%, and 100%).

Figure 9 shows the BE packet loss in which we can see scarcely grow of scenario 1, 2, and 3, compared with IPACT, respectively. Figure 10 illustrates system throughput in terms of offered load. This figure represents exiguous improvement of scenario G-15454.

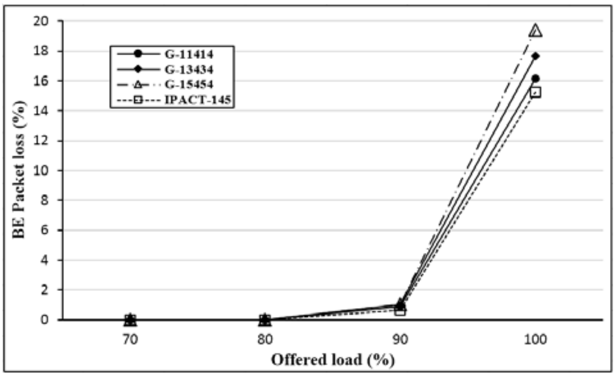

Fig. 9. BE packet loss ratio.

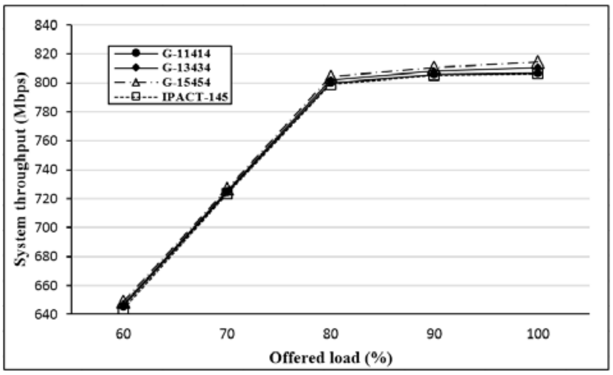

Fig. 10. System throughput in terms of offered load.

V. Conclusion

This paper has introduced an enhanced EPON architecture, a new queue scheduling mechanism was proposed to queue the FPS and MMORPG traffics separately, and a game dynamic bandwidth allocation (Game DBA) to allocate bandwidth to FPS and MMORPG and guarantee an overall QoS metrics based on the games requirements. The proposed Game DBA is capable to apply delay on the MMORPG traffics for some cycle with non-sensitive impact on player's behavior. Simulation results showed that the proposed queue scheduling and Game DBA have improved the quality of FPS and MMORPG games service, as well as overall quality of service (QoS) in EPON architecture.

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