Multipartition DBA Method on GPON

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***Abstract*—The majority of the optical fiber access network is currently dominated by Gigabit Passive Optical Network (GPON) technology, which is able to provide various services on the network. Dynamic Bandwidth Allocation (DBA) is used for control the upstream bandwidth on GPON. This DBA method alocates an unused timeslot for another Optical Network Termination (ONT) with a particular priority and set the maximum permitted frame length to be transmitted in order to get equal opportunities in data delivery. We proposed Multi partition DBA that divides time cycle into four groups. Simulation was conducted to compare the performance of Multi Partition DBA with two different schemes. This method improved the total delay performance since the number of partitions resolved the idle period and made DBA computation time more effectively.**

Keywords—GPON, DBA Mechanism, Bipartition, Multi Partition

I. Introduction

Broadband services are becoming the need of today's modern society. Internet traffic increased 51% when compared with total popolation in the world [1]. It means that communication with large bandwidth capacity is a must. GPON is widely applied because of the capacity and the cost of infrastructure development are relatively cheaper compared to previous technologies.

GPON is a point to multipoint optical network which does not have an active element in the distribution network. As seen in Figure 1, there are three main parts of GPON infrastructure that is Optical Line Terminal (OLT) placed in central office, multiple ONT, and Optical Distribution Network (ODN).

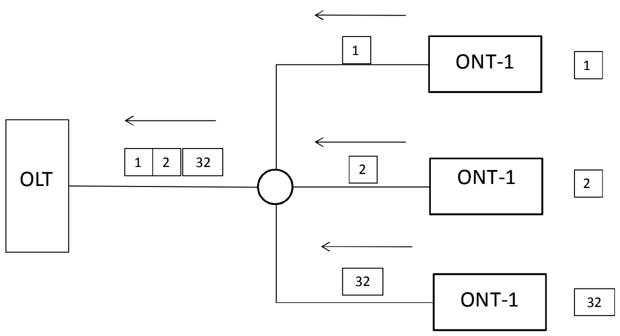


Figure 1. Upstream communication principle of GPON

In downstream transmission, OLT sends broadcast frames and each ONT selectively receive frames that have been addressed to it. In upstream transmission, it uses Time Division Multiplexing Access (TDMA) to prevent collisions between frames. Each ONT sends frames based on bandwidth allocation from OLT.

DBA algorithm is used by GPON to regulate the use of the upstream bandwidth. This setting can be done in static or dynamic modes [2]. This DBA algorithm relates to the GPON Transmission Convergence (GTC) frames. In downstream, GTC frames contain bandwidth map and payload for entire ONTs. Each ONT searches information that related to it and sends the upstream data based on the bandwidth map. In this process, the upstream data is queueing and residing on Traffic Container (T-Cont) based on the traffic types. There are five types of T-Cont, they are T-Cont 1, T-Cont 2, T-Cont 3, T-Cont 4, and T-Cont 5 [3].

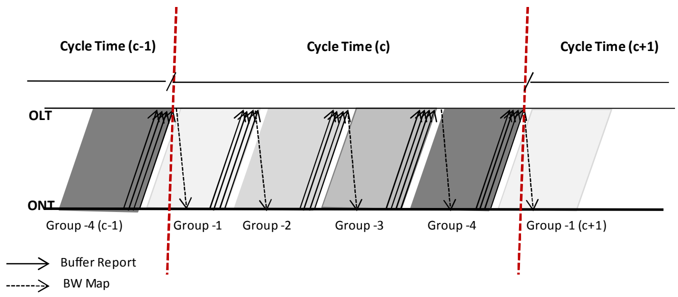
The DBA GPON utilized fix cycle time due to the framing of GTC. OLT gathers the request bandwidth from each ONT that are sent for one cycle time. Before OLT allocates timeslot to each ONT, the checking of queuing data amount from the previous cycle time should be done. In DBA method, OLT calculates and allocates bandwidth fairly for all ONTs.This way causes the idle period between OLT and ONTs. The DBA hot issues are such as how to reduce idle period and to improve the upstream bandwidth utilization.

A lot of researchers have been working on DBA GPON to obtain the upstream bandwidth usage more efficiently. Hwang et al, proposed Waited-based DBA method to improve utilization of upstream bandwidth by resolving the idle time period and the queueing state incositency [4].Turna et al, developed half cycling DBA according to the load of upstream traffic, that are offline DBA for high load traffic and online DBA for low load traffic [5]. Hwang et al dividing the cycle of transmission time in half and arrange distribution of bandwidth dynamically on two different groups, first algorithm is based on class of service while the second algorithm is based on the number of ONTs [6]. In this paper we proposed multi partition DBA that adopted from [6,7] by dividing ONTs into four groups based on the number of ONTs.

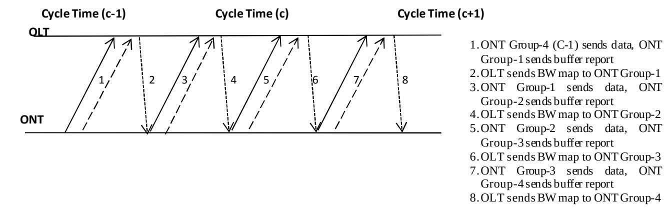
The rest of this paper is organized as follows. Section II present the proposed multi partition DBA, section III present the result discussion, and follows with conclusion in section IV.

II. MULTI PARTITION DBA

In this section, we develop multi partition DBA as the concept seen in Figure 2 (a) & (b). The network components to be simulated consist of OLT and 32 ONTs that are divided into four groups, those are ONT 1 – 8 as Group-1, ONT 9-16 as Group-2, ONT 17-24 as Group-3, and ONT 25-32 as Group-4. The duration of DBA computation time for each group are the same. When OLT calculates the bandwidth map for Group-2, the Group-1 sending the data. As soon as Group-1 finished sending data, Group-2 sending data while OLT calculate bandwidth map for Group-3.



(a)



(b)

Figure 2. Multi partition DBA

This multi partition concept then implemented in DBA algorithm based on previous method [6,7] as seen in Figure 3 below.

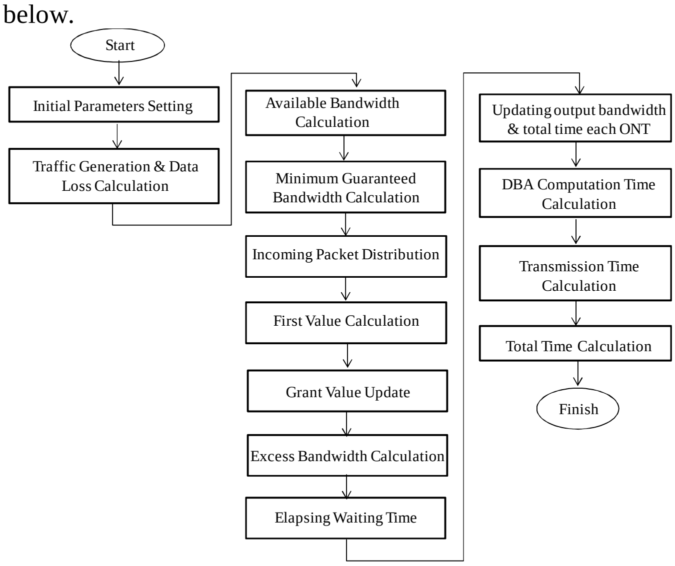


Figure 3. Flowchart multi partition DBA

The bandwidth allocation algorithm for multi partition DBA cooperates with calculated available bandwidth, limited bandwidth allocation and excess bandwidth reallocation. These three steps apply for four groups of ONTs.

Available Bandwidth, B_{all} for all groups in one cycle time can be calculated as (1) :

$$B_{all} = S \times (T_{max} - N \times T_g) \quad (1)$$

Where S is OLT link capasity, Tmax is the maximum cycle time, N is the number of ONT, and Tg is Time Guard. Minimum guaranteed bandwidth (Bmin) can be found by distribute the available bandwidth for amount of ONTs [1]

$$B_{min} = B_{all} / N \quad (2)$$

Predictive value (ΔP) of bandwidth requirement for differentiated T-Cont is express in the following equation (3)

$$\Delta P^{T2} = HC^{T2} \times (Twaiting / c) \quad (3)$$
$$\Delta P^{T3} = R^{T3} - HC^{T3}$$
$$\Delta P^{T4} = R^{T4} - HC^{T4}$$

where HC^{T} represent average bandwidth requirements of the history 10 cycle of each T-Cont of ONT and R^{T} represents bandwidth requirement of each T-Cont. If ΔP for T-Cont 2 and T-Cont 3 is a positive value, the forecast value should be updated to obtain the new bandwidth requirement, otherwise, there is no need to update

First Value is sent from OLT to ONT in the form of a grant message simultaneously with downstream data transmission. The First Value (F^{T}) can be found by comparing the Predictive Index (P^{T}) with Minimum Bandwidth (B_{min}). Predictive Index is the sum of predictive value with bandwidth requirement for each T-Cont in ONT [1].

$$P^{T} = R^{T} + \Delta P^{T} \quad (4)$$

$$F^{T2} = Min\,(B_{min}, P^{T2}) \quad (5)$$
$$F^{T3} = Min\,(P^{T3},\ B_{min} - F^{T2})$$
$$F^{T3} = Min\,(P^{T4},\ B_{min} - F^{T2} + {}^{T3})$$

If P^{T} is smaller than B_{min}, the limited bandwidth from OLT is the same as the predicted bandwidth. Otherwise, the granted bandwidth for ONT is B_{min} .

Excess bandwidth (B_{excess}) from the lightly loaded ONT may still be present after limited bandwidth allocation. B_{excess} is redistributed among the heavily loaded ONTs. If there were remaining bandwidth, it can be retained for the next group to enhance the bandwidth efficiency [1].

$$B_{excess} = \sum_{j \in L} (B_{min} - \sum_{T\epsilon\{T2,T3,T4\}} P^{T}) \quad (6)$$
$$B_{remain} = B_{excess} - \sum_{j \in H\,(} \sum_{T\epsilon\{T2,T3,T4} P^{T} - B_{min}$$

Total delay from all process is calculated by the formula below :

$$t_{Total} = t_{Waiting} + t_{DBA} + t_{Transmission} + t_{Propagation} \quad (7)$$

where $t_{Waiting}$ is waiting time, t_{DBA} is DBA computing time, $t_{Transmission}$ is length of time required by ONTs to wait for data packet to be sent, and $t_{Propagation}$ is time required by ONT to send information over optical fiber. The time required by OLT to calculate bandwidth requirement from ONT and sending bandwidth map to each ONT called DBA Computing Time. Calculation of transmission time is obtained by dividing amount of traffic with bandwidth allocation provided by OLT. The propagation time is the same for all scenarios to make it easier to observe the other calculation, by dividing the distance between OLT with ONT with the speed parameter of light.

III. RESULT DISCUSSION

In this simulation, the distance from ONTs to the OLT is assumed up to 20 km. Each ONT has a finite buffer of 10 Mbit. The traffic input is generated by random for three types of traffic with two different schemes. The schemes are Bi partition and Multi partition DBA with two different traffic proportions of T-Cont s : 602010 and 053055. For example, as seen in Table 1, 053055 Bipart denote the simulation for Bipartition DBA with 5% T-Cont 2, 30% T-Cont 3, and 55%T-Cont 4.

Tabel 1
Traffic Proportion of Simulation Scenarios

Scenario	Number Of Partition	TCont-2	TCont-3	TCont-4
053055 Bipart	2	5%	30%	55%
053055 Multipart	4	5%	30%	55%
602010 Bipart	2	60%	20%	10%
602010 Multipart	4	60%	20%	10%

The system performance of Multi partition DBA is compared by Bi partition DBA [6] in term of total time based on two schemes as seen in Table 2.

Table 2.
Simulation result for delay

Simulation Scenario	$T_{DBA\ Comp}$ (s)	$T_{waiting}$ (s)	$T_{transmission}$(s)	$T_{propagation}$ (s)	T_{total}(s)
602010multipart	0,0062913	0,0018721	1.268,251046	0,0021333	1.268,283174
053055multipart	0,0330248	0,0095278	1.281,671045	0,0021333	1.281,686704
602010bipart	0,0039978	0,0018477	1.412,688368	0,0021333	1.412,725374
053055bipart	0,0281226	0,0137192	1.421,542141	0,0021333	1.421,564285

Simulation result show that multipartition DBA can improve 11% for average total delay performance for both scenarios. This is because the addition of the number of partitions can resolve the iddle period and makes DBA Time more effective which will reduce the total delay.

Figure.4 shows delay comparison of Bipartition DBA with Multipartition DBA for two different traffic proportions.

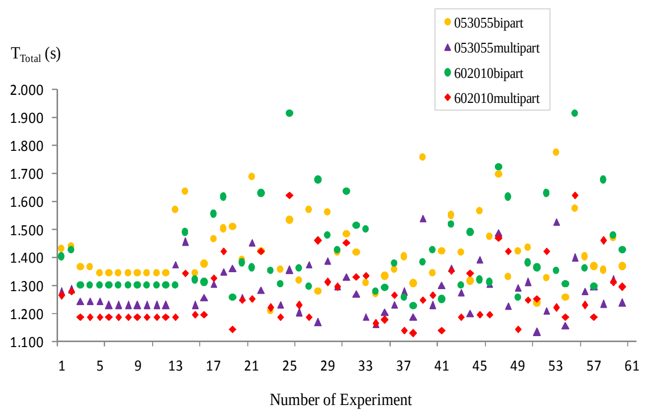


Figure 4. Total time of bipartition DBA and multipartition DBA for 2 traffic proportion

The DBA computing time of multipartition shows better performance for traffic proportion 602010 than 053055 as seen in Figure 3.2. The improvement is average 5,2 for multi partition and 7,03 for bi partition. In second scenario where is proportion of T-Cont -2 higher, the performance is same between multipartition and bipartition.

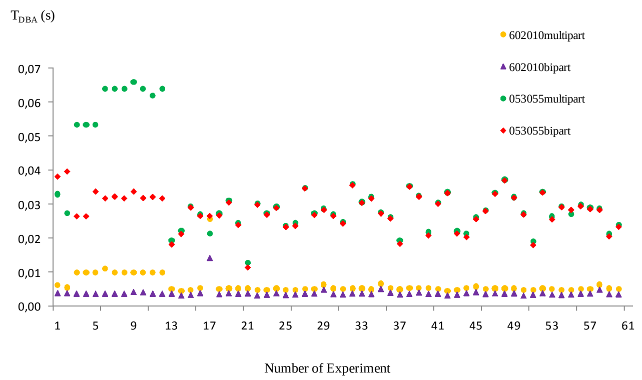


Figure 5. DBA Time of Bipartition DBA and Multipartition DBA for 2 traffic proportion

Waiting time for multi partition, as seen in Figure 6, is slightly lower than bipartition for higher proportion of T-Cont 2, but get better for other scenario in bigger T-Cont 4 proportion. The greater proportion of T-Cont 2 will make waiting time becomes longer. The reason is that available bandwidth must be allocated for T-Cont 2 first, so if traffic load of T-Cont 2 is getting higher, the available bandwidth cannot afford , and the allocated bandwidth for T-Cont 3 and T-Cont 4 must wait for remaining unused bandwidth from T-Cont 2. For first scenario, Twaiting for multi partition and bipartition show better performance.

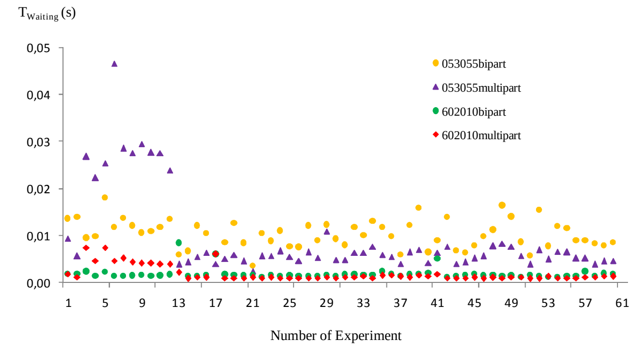


Figure 6. Waiting Time of Bipartition DBA and Multipartition DBA for 2 traffic proportion

The length of time required by ONTs to wait for data packet to be sent is namely transmission time. This calculation is obtained by dividing amount of traffic with bandwidth allocation provided by OLT.

Figure 7 shows that in traffic proportion 602010, the performance of transmission time each partition, for both Multi Partition & bipartition are better than 053055 for average 4% and 7%, but if it is compared between partition, the performance of Multi Partition 11% under bipartition for first scenario and 10% better for second scenario. This result is depend on proportion of T-Cont 2. If proportion of T-Cont 2 is bigger, then the waiting time is getting worst for Multi Partition DBA.

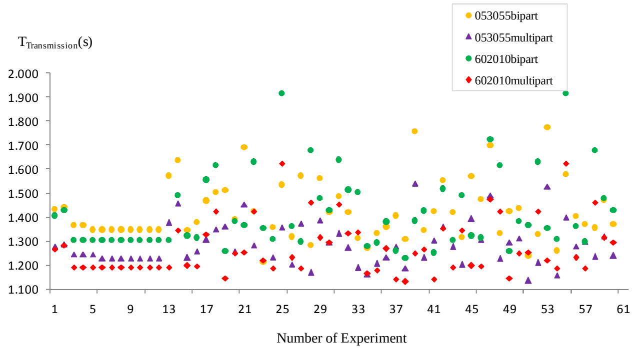


Figure 7. Transmission Time of Bipartition DBA and Multipartition DBA for 2 traffic proportion

Propagation Time is time required by ONT to send information over optical fiber. Propagation time is set to be same for all scenarios to make it easier to observe the other calculation, by dividing the distance between OLT with ONT with the speed parameter of light.

IV. CONCLUSIONS

The simulation performed on DBA models by modification the number of partition and two traffic proportion scenarios. Based on simulation result, it could be concluded that modification on Bipartition DBA improved the performance of total delay because it could reduce idle time on DBA computating time.

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