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Proposing Novel Schema for Downstream Using Multiple OLTs in EPON System

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Abstract

The paper proposes a new schema for downstream using multiple OLT mechanisms in EPON system. In the proposed mechanisms a new DBA algorithm is used, so-called CDBA-Controlled Dynamic Bandwidth Allocation, this controls the assigned bandwidth for each OLT. We proposed an architecture which also comforts the system reliability; in case of network failure another OLT will be able to recover the system in a short period of time. It also allows the unused bandwidth of one OLT to be used by the other OLT. In the future, companies can provide their services without deploying another PON.
Keywords: multimedia services, passive optical network, multi-optical line terminal, EPON, controlled dynamic bandwidth allocation.

1. Introduction

Network operators have already started the deployment of the new multimedia services such as video-on-demand (VoD), high-definition television (HDTV), peer-to-peer (P2P) live video streaming and IPTV. By the predictions of Cisco, these markets will grow exponentially in the next few years [1]. The development of aforementioned multimedia services will represent 80 percent of the global consumer traffic by 2015 [2]. The financial investments that are needed for updating the infrastructures to support those services put more pressure on the operators who need to recover the investment within a very short period of time. On the other hand, clients are more demanding and require better services at lower costs. Therefore, competition among operators is becoming increasingly strong. For each new service that is being introduced, one of the main questions is: what is the best way of serving both the client and the operator needs?

The biggest issues of the companies in the future that will provide video-on-demand, P2P and other on demand services will be the cost of the equipment and the provision of high quality services at low costs for the users.

In VoD services, large varieties of contents are available to the customers who are not supposed to access the same content in the exact same instant and broadcasting information is no longer a solution. Contents are requested on demand, and user experience and network performance are affected by both the user traffic profiles variability and the video server location. Great number of users requesting videos and video servers far from customer's access network would result in long waiting delays and a bad experience for a user, which might not find this new service very interesting.

Network operators are facing the challenge of carrying the large data-centric traffic with tighter timing and Quality-of-Services (QoS) requirements for expanding upon the existing network infrastructures [3]. In the access network domain, Ethernet Passive Optical Networks (EPONs) are regarded as one of the best solutions for the access networks due to its simplicity, high data rate, and low-cost [4]. An EPON consists of an Optical Line Terminal (OLT) located in the Central Office (CO), a feeder fiber, Passive Splitter (PS) and Optical Network Units (ONUs). The OLT connects a group of related ONUs over point-to-multipoint topologies to deliver broadband packets, and it also reduces costs relative to maintenance power. In addition, the Optical Liner Terminal (OLT) has the entire channel bandwidth to broadcast the control data packets and messages to each Optical Network Unit (ONU) because of the directional properties of the splitter.

In EPON system, the data sent from OLT toward ONUs are split at a passive splitter and simultaneously broadcasted to each of ONUs. It should be noted that each ONU receives all downstream traffic designated to not only itself but also every other ONU. In another way, we can say that the data received by non-destination ONUs is discarded. In the upstream transmissions from the ONUs to the OLT, a polling technique is used as a multiple access technology to allow the ONUs to share the same optical line. The ONUs are assigned by time slots, and they are allowed to transmit data only during the assigned time slots. Despite all the advantages of EPON, there are still many challenges in providing multimedia services in the EPONs. It might be about how the network operators can guarantee the Quality of Service (QoS) while achieving sufficient profits and revenues. More video content will be sent over unicasts, which will increase the bandwidth and due to the evolution from HDTV formats towards super HD and ultra HD and 3D formats the demands of the bandwidth are even higher [2]. Providing higher capacities than the existing PONs will not solve all the existing problems. There must be a proper infrastructure to provide the protection to this new high capacity network. So far, to our knowledge not so many papers discuss the downstream in EPON systems: mostly papers are concentrated in the upstream but, however, the present-day users care more about the downstream because of growing on demand for services, and users need more and more traffic.

In this paper, we propose a new architecture of PON that has multiple OLTs. All OLTs are connected to each other with a cable, and they all are also connected to the Core Network thus assuring the network confidence. In case of network failure, another OLT will be able to recover the system in a short period of time. The proposed architecture can be used to solve another important problem of the network. Nowadays, only a one vendor can provide services to the users connected to the PON network [5, 6, 7]. It means that the users have no freedom to choose one from multiple service providers and services such as VoD, IP television, HDTV and IP telephony are differed from vendor to vendor. Moreover, the proposed architecture can make new possibilities for the users who like online gaming and sharing files. Using this network, the companies which are going to provide their own services over the same PON system, as well as the users can trek from one service provider to another according to their preference. The proposed architecture can also support not only local-traffic redirection but also provide better QoS, particularly for P2P video-streaming.

Figure 1 shows the proposed architecture that can efficiently support P2P multimedia services. The main purpose of this paper is to design an architecture that will be reliable for the next generation optical networks, and the internet providers can easily provide P2P VoD services. The providers can deliver their own services in the same PON system using the proposed network architecture. The rest of the paper is organized as follows: Section II introduces the related works with the existing bandwidth allocation algorithms for single-OLT PON system. Section III introduces new DBA Schemes for downstream transmission. In Section IV, the system performance is evaluated by simulation results. Section V discusses the lost or wasted bandwidth and Section VI concludes our paper.

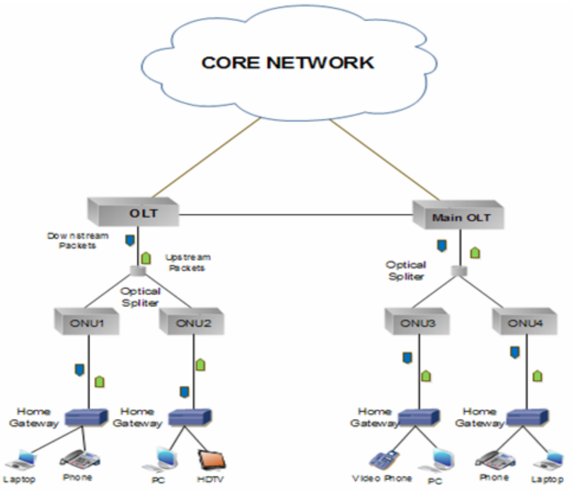

Fig. 1. Proposed Architecture

2. Related Works

In PON systems an important factor is the Dynamic Bandwidth Allocation; each ONU's upstream bandwidth is decided by assigning time slots specified by the OLT in a unit time [8]. In general, the bandwidth allocation algorithms have a main impact in minimizing latency, meeting quality of service guarantees, improving the fairness and requirement of buffer size in upstream direction. Bandwidth allocation algorithms can be classified into two main groups; the first one is called dynamic bandwidth allocation (DBA) and the second one - fixed bandwidth allocation (FBA) algorithms. The performance of EPON by using a fixed bandwidth allocation algorithm is studied well, where all traffics are considered to a single class [9]. As it is shown in Figure 2 the scheme is very simple and continuously grants the maximum window to all ONUs. As a matter of fact the cycle time Tcycle is constant for all kinds of traffic loads.

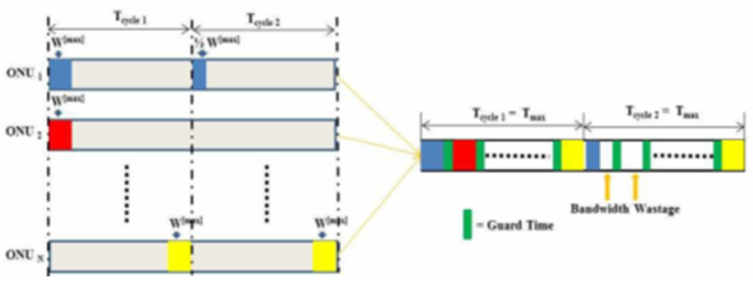

Fig. 2. Fixed Bandwidth Allocation Scheme

The main disadvantage of this algorithm is that the light loaded ONUs will under-utilize their allocated bandwidth leading to enlarged delay to other ONUs and finally deteriorate the throughput and bandwidth utilization of the system. DBA is suitable for burst traffic such as VoIP and FTTHs and they can provide flexible bandwidth sharing of allocation among the users. So far different types of DBA algorithms have been developed to improve the bandwidth utilization and to adopt the current demand of vast traffic.

Figure 3 shows the LS bandwidth allocation scheme. Meanwhile the granted window is based on the requested window, the cycle time Tcycle is variable. As it is shown in the figure, the cycle time for the first cycle is Tcycle1= Tmax, because every ONU requests for maximum bandwidth W [MAX]. On the other hand, cycle time in the second cycle is Tcycle2= T_{MAX}- T_S, here, T_S is the cycle time saving due to light-loaded ONUs. The main advantage of this scheme is that it reduces the bandwidth wastage by granting smaller bandwidth to the light-loaded ONUs. Nevertheless, one limitation of this algorithm is that it makes Tcycle too small, which will result in lower bandwidth utilization because of constant guard time for every two successive ONUs.

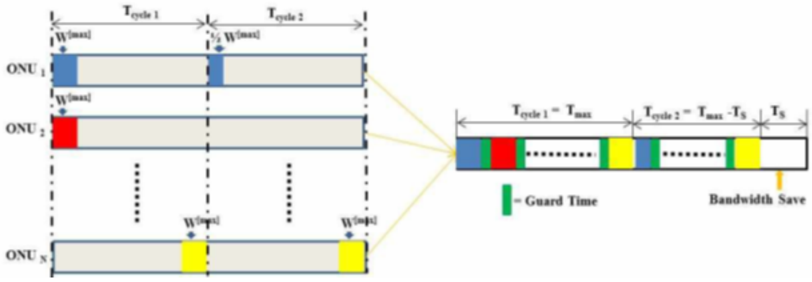

Fig. 3. Dynamic Bandwidth Allocation scheme

These DBA algorithms are proposed only for the single-OLT PON and should require a guard time between every two consecutive ONUs to avoid data overlapping. Due to this guard time, some bandwidth wastage problem is observed.

3. Bandwidth Adjustment Approach Among Multiple OLTs

As it is already known in a single-OLT system, a number of ONUs share the upstream bandwidth while a single OLT utilizes complete downstream bandwidth. Thus, the bandwidth allocation algorithms have evolved only for allocating the upstream bandwidth among ONUs. Multi-OLT PON architecture is a rather complex architecture than the current single-OLT PON. In our proposed multi-OLT passive optical network architecture several OLTs need to share the downstream bandwidth. Since the proposed architecture already has multi-OLTs, thus in this state the downstream bandwidth allocation scheme is needed, too. The present Fixed Bandwidth Allocation (FBA) is not suitable for flexibly maintaining bandwidth among the multiple OLTs. The FBA is suitable only for architectures with a single OLT with several ONUs. FBA will always provide a fixed percentage of bandwidth, which means a huge waste of capacity when traffic generations of the OLTs are far different from the estimated values. Hence, in this paper a new DBA is proposed, so-called Controlled Dynamic Bandwidth Allocation (CDBA) scheme for the downstream transmission. We named it Controlled Dynamic Bandwidth Allocation because it guarantees the assigned bandwidth for each OLT and it also allows the unused bandwidth of one OLT to be used by the other OLTs. Hence, it can increase the efficiency of the proposed architecture without losing the unused bandwidth. The amount of delivery is limited so that the assigned bandwidth at each OLT is controlled. Figure 4 shows the algorithm of CDBA.

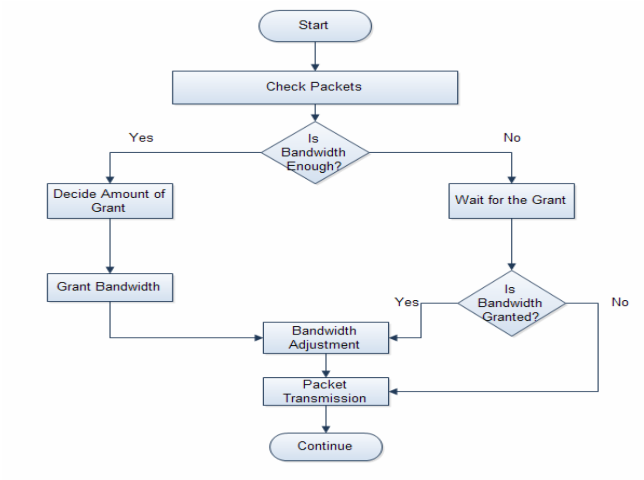

Fig. 4. Algorithm of Controlled DBA

4. Performance Evaluation

Table I. System Parameters

Parameter	Value
Number of OLTs in the system	2
Number of ONUs in the system	16 or 32
Downstream/upstream link capacity	1Gbps
OLT-ONU distance	10-20 km
Buffer size	10 MB
Maximum transmission cycle time	2*ms*
Guard time	5μs
Computation time of DBA	10μs
Control message length	0.517μs

The system model is set up in OPNET simulator with 2 OLTs and 16 or 32 ONUs. Table I shows the system parameters used in the study. The distance from OLT to ONU is 10-20 km, the downstream and upstream link capacities are equally 1 Gbps and each ONU has 10 MB of buffer size. In the simulation the maximum transmission cycle time is 2 *ms* with 5μs of Guard time.

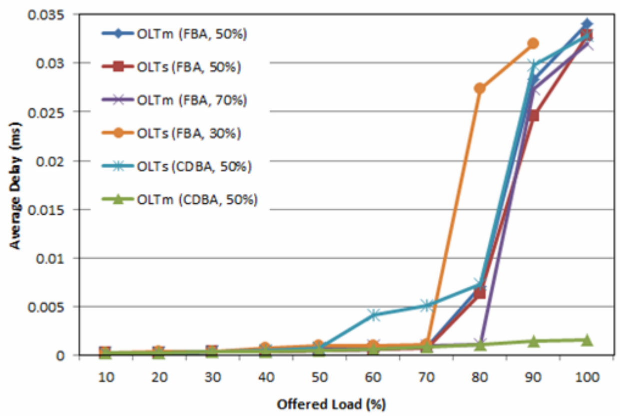

Fig. 5. Downstream delay with assigned bandwidth ratio of 30%-70%

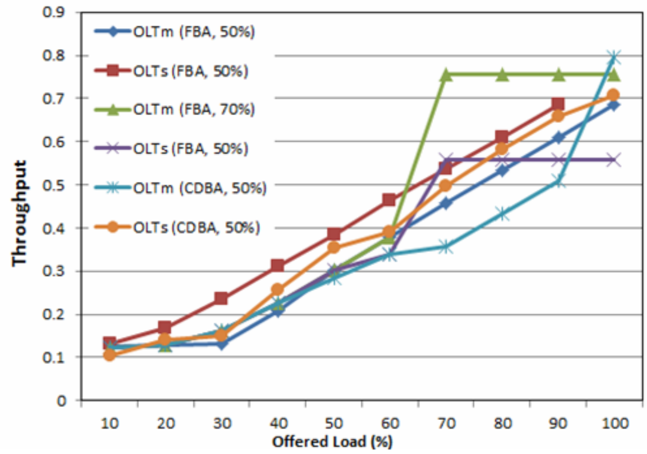

Fig. 6. Downstream throughput with assigned bandwidth ratio of 30%-70%.

Figure 5 and figure 6, accordingly, show the downstream delay and downstream throughput with the assigned bandwidth ratio. In the downstream performance the OLTm through FBA with 50% indicates an average delay of OLTm. We can clearly see that the CDBA facilitates OLTs and also guarantees the quality of service for OLTm. Moreover, in our proposed architecture we can also save the bandwidth in the feeder fiber.

5. Lost Bandwidth

An imprecise bandwidth allocation results in wasteful resource allocation. The imprecise bandwidth allocation means that the OLT is assigning too much or too little bandwidth in terms of the requested bandwidth to ONUs. When the system traffic load is too high and is greater than 50%, the lost bandwidth is reduced because there is no more available bandwidth which can be granted to the ONUs. Figure 7 shows the lost bandwidth ratio versus the total number of the traffic loads. The simulations are completed for the proposed CDBA and DBA_VOD.

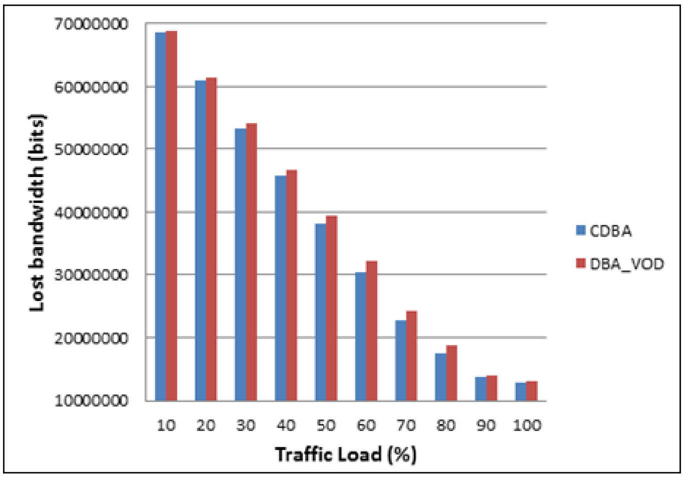

Fig. 7. Lost bandwidth ratio with traffic Load

The simulation results show that in the proposed architecture the lost bandwidth is reduced, when the traffic load is greater than 50%. Additionally, it is scalable to large-size mesh access networks and achieves higher network survivability, faster recovery and reliability.

6. Conclusion

The paper proposes a novel scheme for downstream using multiple OLTs in EPON systems. In future the internet providers can use the proposed architecture for providing their own services without deploying another PON. Using this network, the internet providers which are going to deliver their own services over the same PON system, as well as the users can trek from one service provider to another according to their preference. It provides protection facilities as well. Moreover, they can deliver video-on-demand, P2P and other on demand services: their biggest issues which are the cost of the equipment and providing high quality services at low costs for the users can be finally solved. In the paper new DBA Schemes are introduced for downstream transmission. The new DBA algorithm is one of the key factors to let the providers deliver their individual services in P2P VoD systems. The simulation results show that the proposed multi-OLT EPON system saves the unused bandwidth in case of network failure, and if OLT fails or feeder fiber damages, another OLT will be able to recover the system in a short time: it can also accommodate 3% more traffic load than the single-OLT PON without suffering any congestion and is cost-effective. At last the CDBA and DBA_VOD ratio is quite good, which is the main aspect of saving the lost bandwidth while providing multimedia services through multi- OLT EPON systems.

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Հոսքի ուղղությամբ նոր սխեմայի առաջարկություն EPON-ում բազմաթիվ OLT-երի օգտագործմամբ

Դ. Բեյբության

Ամփոփում

Հոդվածում հոսքի ուղղության համար առաջարկված է նոր սխեմա EPON համակարգում՝ բազմակի OLT մեխանիզմներ օգտագործելու միջոցով: Առաջարկված մեխանիզմներում օգտագործվել է նոր դինամիկ թողունակության բաշխման (ԴԹԲ) ալգորիթմ, այսպես կոչված՝ կառավարվող դինամիկ թողունակության բաշխում (ԿԴԹԲ), որը վերահսկում է հանձնարարված թողունակությունը յուրաքանչյուր օպտիկական գծի տերմինալում (ՕԳՏ): Մենք առաջարկել ենք այնպիսի կառուցվածք, որը նաև ապահովում է համակարգի հուսալիությունը. ցանցի խափանման դեպքում մեկ այլ ՕԳՏ-ն ի վիճակի կլինի կարճ ժամանակահատվածում վերականգնել համակարգը: Այն թույլ է տալիս նաև մեկ ՕԳՏ-ի չօգտագործած թողունակությունը օգտագործել մեկ այլ ՕԳՏ-ով: Ապագայում ընկերությունները կկարողանան առաջարկել ծառայություններ՝ առանց լրացուցիչ պասիվ օպտիկական ցանցի տեղադրման:

Предложение новой схемы для потока передачи с использованием множественных терминалов оптических линий в пассивной оптической ETHERNET сети

Д. Бейбутян

Аннотация

В статье предложена новая схема для потока передачи с использованием механизмов множественных терминалов оптических линий (ТОЛ). В предложенных механизмах использован новый алгоритм Распределения Динамической Пропускной Способности (РДПС), так называемая контролируемая РДПС, которая контролирует заданную пропускную способность для каждого ТОЛ. Мы предложили архитектуру, которая также обеспечивает надежность системы: в случае обрыва сети другой ТОЛ будет в состоянии восстановить систему за короткий промежуток времени. Она также позволяет использовать невостребованную пропускную способность одного ТОЛ другим. В будущем компании могут предложить свои услуги без установления дополнительных Пассивных Оптических Сетей (ПОС).