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SCHEDULING ALGORITHMS IN PON: A SURVEY

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Abstract: Optical access networks are evolving as the next generation access networks for the broadband services, which provides higher data rates. Passive Optical Networks (PON) have emerged as a promising solution for the optical access networks due to cost efficient passive components. To provide good network access to the users a PON system must employ an efficient bandwidth allocation algorithm, which allocates the available bandwidth dynamically to the users. This paper describes the architecture, upstream operation, downstream operation and various DBA Algorithms proposed for the PON networks.

Keywords: Optical Fibre, PON, Dynamic Bandwidth Allocation (DBA), OLT, ONU.

1. INTRODUCTION

The growth of telecommunications has produced greatly increased capacity in backbone networks. The capacity of backbone networks has largely been grown with the tremendous growth of Internet traffic, but there has been little progress in the access network, the so-called last mile, where a bottleneck occurs between the backbone network and the high-capacity local area networks [1], [4].

At this stage of growth, the only effective solution to this last mile bottleneck is a universal fiber-based infrastructure that is accessible to all users belonging to a businesses or residences. A passive optical network (PON) is a point-to-multipoint optical network in which there is no active element in the path of signals from source to destination. This PON technology is viewed as an attractive solution to the last mile problem [2], [3], [4].

Fig. 1 shows the typical architecture of PON. We believe that this tree structure with single-wavelength TDM is an attractive solution. In traditional TDM solution, the Optical Line Terminal (OLT) assigns fixed time slots in upstream traffic for each Optical Network Unit

(ONU). Since ONUs has different distances to OLT, ranging has to be performed such that the gaps between slots are minimal [5].

The transmission of data packets from OLT to ONU is called as downstream transmission. The transmission of data packets from ONU to OLT is called as upstream transmission. As shown in fig.2 there is a passive optical combiner/splitter which combines the data traffic of different ONUs and transfer to the OLT during upstream data transfer and OLT acts as the broadcast during downstream data transfer [6].

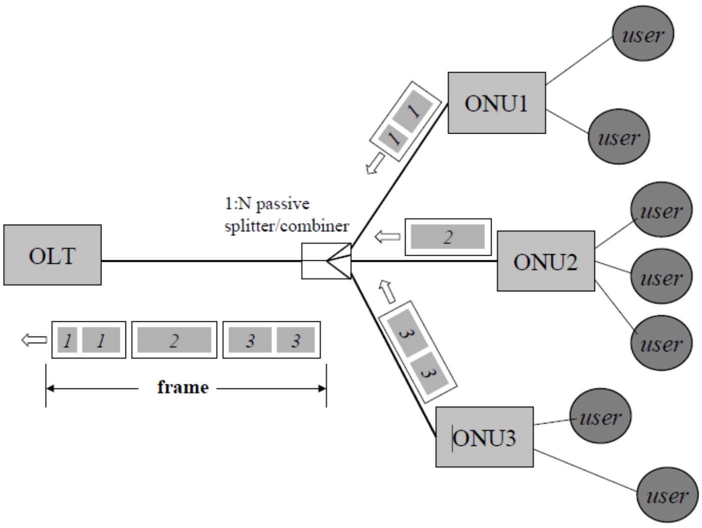

Figure-1 Architecture for PON with DBA for upstream traffic [5]

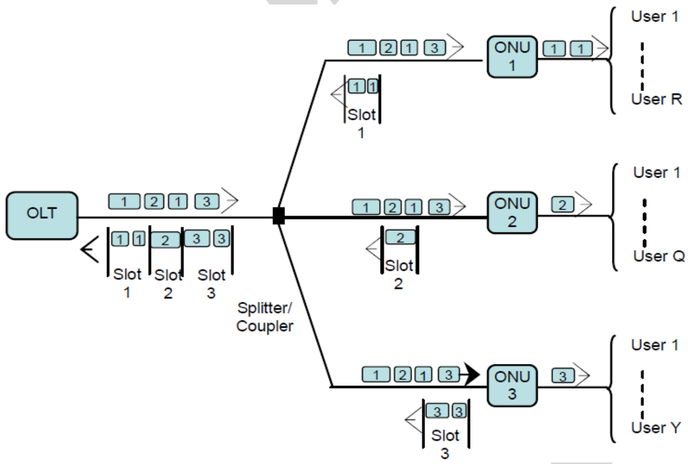

Figure-2 Upstream and Downstream Operation in PON [6]

2. SCHEDULING ALGORITHMS

In the today's world the internet users are increasing due to which the data rate requirements are also increasing day by day. Thus the amount of data traffic to be handled by the network is also increasing rapidly and hence, it is required to provide such a high data rate. So the allocation of the available bandwidth is one of the important factors that provide better

Quality of Service (QoS). The bandwidth allocation can be fixed and variable. Thus the bandwidth allocation algorithms are defined as Static and Dynamic algorithms.

But each ONU in a PON serve a small number of users only, causing variation in the bandwidth requirement. Assigning fixed bandwidth to each ONU would result in inefficient use of the bandwidth. So to efficiently utilize the bandwidth PON's assign bandwidth dynamically to the users according to their need. This need of the bandwidth is discovered by OLT by passively observing the traffic from the ONU and by sending reports as to state of its ingress queues.

To prevent interference and collision between the data in the upstream direction, a PON system must employ a MAC mechanism to provide the access to the shared upstream channel and at the same time to efficiently share the bandwidth of the upstream channel among all optical network units (ONUs). Scheduling Algorithms are the algorithms applied for MAC layer, which schedules the packets of different optical network units (ONUs) so as to achieve a better performance.

3. RELATED PREVIOUS WORK

N. Kumar et al. [29] explained that up to 64 users can share a PON port on an OLT, per-user cost of the OLT decreases as more users share the same port. Depending upon optical splitter placement, various portions of outside plant resources like fiber material and splicing costs may also be shared among multiple users. Further, they investigated Gigabit Ethernet Passive Optical Network in the presence of Forward Error Correction (FEC) techniques. They observed that value of quality factor lies in the range of 13 to 7dB and 20 to 7dB at 2.50 Gbps in absence and presence of FEC at transmission distance of 10 to 40 km in GEPON. They observed that in presence of FEC technique the achievable BER is 10^{-12} at bit rate 2.50 Gbps for 30 km respectively and concluded that forward error correction technique yields the highest value of quality factor and lowest BER in GEPON systems. B. Y. Kim et al. [30] explained that to satisfy the required bandwidth over a 20 km transmission distance, PON with a single-mode optical fiber was only practical choice to minimize the cost of implementing an FTTP solution. Further, they explained that WDM-PON provides point-to-point optical connectivity using a dedicated pair of wavelengths per user, while a TDM-PON appeared to be a satisfactory solution for current bandwidth demands, the combination of future data-rate projections and traffic patterns coupled with recent advances in WDM technology may result in WDM-PON becoming the preferred solution for a future fiber-based access network. R. Roy et al. [10] investigated the operation of an EPON based system in a DWDM environment which extended the concept of a multi-wavelength system from being merely a stack of independent PONs to that of a stack of a switched set of PONs. The functioning of the switching elements within the scope of EPON operation were investigated and qualitatively described. They presented the architecture of the Switched DWDM-EPON system. Emphasis was given to present an architecture which could be practically realized with minimum modifications to the existing EPON standards. The solution minimized the cost increase at the ONU site, instead increasing the associated complexity at the OLT site to distribute the cost addition over multiple users. They proposed cost-performance characterization of such a network which needed to be elaborated and can be useful in future. R. P. Davey et al. [28] described that G-PON supports a maximum logical reach of 60 km and a maximum logical split of up to 128, in practice most commercial systems conform to the class specification that allows a maximum optical loss budget of 28 dB: often this is used to deploy a split size of 32 and reach of up to 20 km. Similarly they explained that GE-PON specifies a maximum distance of 10 or 20 km. The concept of increasing the reach and/or split of PONs via intermediate equipment such as optical amplifiers has been of research interest. Recently research has focused on extending the reach of G-PON and GE-PON via mid-span optical amplifiers or transponders. Further, they described that by using semiconductor optical amplifiers deployed in an underground footway box to extend the physical reach of G-PON to 60 km and 128-way split.

Up until now, various scheduling algorithms and DBA algorithms have been proposed for PON networks. In [7], two adaptive scheduling algorithms for MAC in an EPON system are presented. These are longest-queue-first (LQF) and the earliest-packet-first (EPF) algorithm. It is shown through simulation results that the proposed scheduling algorithms can effectively improve the network performance in terms of packet delay compared with the most commonly-used round-robin (RR) scheduling algorithm. A fine scheduling algorithm was introduced for upstream bandwidth allocation in an Ethernet-based passive optical network by Biao Chen et al. [8]. The scheduling algorithm consisted of inter optical network unit (ONU) scheduler at the optical line terminal (OLT) and an intra-ONU scheduler at each ONU. In the inter-ONU scheduling, a GATE/REPORT approach was introduced to eliminate the unused remainders without transmission delay and maximize the utilization of bandwidth and the intra-ONU scheduler gave fair bandwidth allocation to the queues of different priorities for each user in a hierarchical and decentralized way. Numerical results have shown to fulfill various requirements of delay and throughput for the transmission of multimedia traffic for each end user. Another dynamic scheduling algorithm, termed hybrid granting protocol (HGP) was proposed by A. Shami et al. in [13]. This algorithm supports different QoS in EPON. Specifically, this dynamic scheduling algorithm minimizes packet delay and jitter for delay and delay-variation sensitive traffic (e.g., voice transmissions) by allocating bandwidth in a grant-before-report (GBR) fashion. This considerably improves their performance without degrading QoS guarantees for other service types.

In [11] N. Ghani et al. discussed that various dynamic bandwidth allocation (DBA) schemes have been developed using frame-based transmission, which largely focus on optical line terminal (OLT) capacity allocation amongst multiple optical node units (ONU). In this work, the further issue of intra-ONU bandwidth allocation is discussed and the inter/intra-ONU bandwidth allocation issue is treated under the broader packet scheduling framework. In [12] Y. Luo et al. discussed a new DBA algorithm and provided an overview of the upstream bandwidth allocation issue for multiservice access provisioning over EPONs, and proposed an algorithm for dynamic bandwidth allocation with service differentiation. Based on the multipoint control protocol (MPCP) and bursty traffic prediction, they showed that the algorithm enhances QoS metrics such as average frame delay, average queue length, and frame loss probability over other existing protocols. Another dynamic bandwidth allocation (DBA) algorithm, called per-slot DBA (PSDBA), is proposed to efficiently and fairly allocate bandwidth among multiple users with different requirements by T. Fan et al. in [14]. They discussed that the PSDBA algorithm is based on the multipoint control protocol (MPCP) and allocates bandwidth on a per-slot basis. It is also combined with queue management to support quality of services (QoS) in the design of an EPON system. Their results showed that the PSDBA algorithm outperforms a well-known DBA algorithm using a per-frame bandwidth allocation strategy.

4. CONCLUSION

In this paper, we have concluded that EPON are the future access networks. We discussed the standard architecture of Ethernet Passive Optical Networks (EPON) and functioning of OLT & ONUs in the upstream transmission as well as in downstream transmission. We then explained various scheduling algorithms and DBA algorithms being proposed by various authors.

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