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CONCEPT OF DYNAMIC BANDWIDTH ALLOCATION AND SCHEDULING ALGORITHMS IN PASSIVE OPTICAL NETWORKS

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Abstract: - Passive optical network is a broadband access technology that provides a cost effective infrastructure between the server and the users. PON is a point-to-multipoint optical network that uses passive components like optical splitter/combiner that provides a path between the user and the server. The performance evaluation of the optical access network is an important factor and is measured in terms of Bit Error Rate (BER), packet delay, packet loss probability, interference etc. Scheduling algorithm, DBA algorithm, network topology and crosstalk interference are the various issues that affects the performance of an optical network. In this paper, we have surveyed various DBA Algorithms.

Keywords: - PON, Dynamic Bandwidth Allocation (DBA), Multi-Point Control Protocol (MPCP).

1. INTRODUCTION

With the Internet traffic doubling approximately every four months, there is a greater need for interoperable networks, facilitating, and making faster communications. The widest deployed Local Area Network (LAN) is Ethernet based, though the links between Local Area Networks and Metropolitan Area Networks (MAN), and Wide Area Networks (WAN) are utilizing different technologies. One of the best solutions to bypass the capacity problems of access networks is by using a Passive Optical Network (PON) [2].

Passive optical network (PON) technologies are expected as one solution for the full service access network (FSAN) because optical fiber can satisfy the increasing bandwidth demand driven by high-speed file sharing, videoconference, video on demand, and other high-speed services [1].

A passive optical network (PON) is a point-to-multipoint optical network with no active elements in the path of signals from source to destination. PON technology is viewed by many as an attractive solution to the last mile problem [20]. PON technology becomes even more attractive when it is implemented in association with Ethernet, a solution

commonly known as Ethernet over PON (EPON) [21-23]. The main advantages of EPON architectures are:

• Low costs: EPONs are based on cheap passive optical devices (splitters) and Ethernet cards;
• High bit-rate: current off-the-shelf optical Ethernet cards work at 1 Gbit/s or 10 Gbit/s;
• optimized for IP traffic: almost every IP packets generated in a LAN environment is encapsulated in an Ethernet frame [24].

PONs consists of two main types of end devices: Optical Line Terminals (OLTs) and Optical Network Units (ONUs) see figure-1. The OLT is connected to the ONUs with a feeder fiber that is subsequently split using a 1: N optical splitter/combiner to enable the ONUs to share the optical fiber. This is illustrated in figure-2. The transmission direction from OLT to ONU is referred to as downstream and operates as a broadcast medium. The transmission direction from the ONUs to the OLT is referred to as upstream [13].

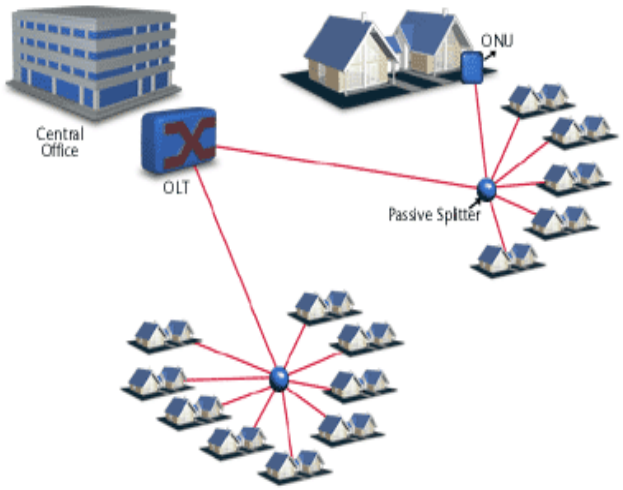

Figure-1 EPON architecture [24]

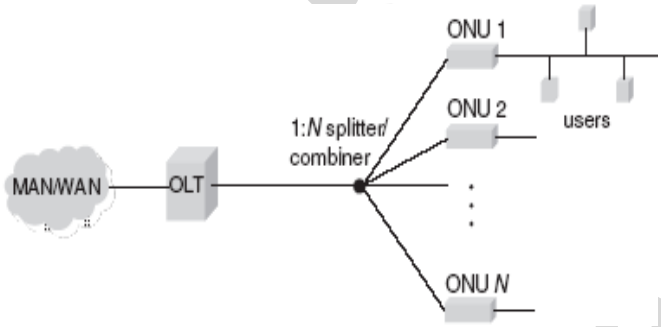

Figure-2 EPON architecture with one OLT, N ONUs, and a 1: N splitter/combiner [25]

The upstream signals propagate from ONU to OLT but are not reflected back to each ONU; therefore, the PON is not a broadcast medium in the upstream direction. In upstream direction the data from various ONU's is transferred to the OLT. So to avoid any interference, time division multiplexing (TDM) or wavelength division multiplexing (WDM) is used to combine the data from different ONU's. First generation PONs use wavelengths to separate the upstream and downstream channels but use TDM to avoid upstream transmission collisions between ONU's. Due to the topology of the PON, MAC protocols that rely on connectivity between all nodes cannot be utilized. A PON allows for connectivity from the OLT to all ONU's in the downstream and from each ONU to the OLT in the upstream (i.e., only the OLT has

connectivity to all nodes). This connectivity pattern dictates the use of a centralized MAC protocol residing at the OLT. This leads to a polling-based MAC, where the OLT polls ONUs and grants them access to the shared PON medium [13].

2. MULTI POINT CONTROL PROTOCOL

Multipoint control protocol (MPCP) supports OLT for the timeslot allocation. The protocol is based on two messages: one of which is GATE message which is sent from OLT to an ONU and transmission timeslot is allocated through it. The other one is REPORT message used for making request of desired bandwidth by looking at its buffer space that how much it is filled. The two other messages GATE and REPORT are MAC control frames and are processed by the MAC control sub-layer [4].

As we have two messages for MPCP, it has two operation modes: auto discovery and normal operation. In Auto discovery mode whenever a new ONU is connected to the system is detected by it and it also finds out the round-trip delay and MAC address of the newly connected ONU. In case of normal mode a request is transmitted through a GATE message destined to a particular ONU which contains the time when the ONU should start transmission and how long should it transmit? MPCP layer also maintain a clock. ONUs gets their required time slot by matching MAC address and will then adjust their local register with start time of the transmission and its length. When the GATE message is received by the ONU, the buffered data is transmitted along with the REPORT message [25].

3. DYNAMIC BANDWIDTH ALLOCATION (DBA) ALGORITHMS

There has been a dramatic increase in the amount of network data traffic due to rising number of internet users demanding increased data rates. So the allocation of the available bandwidth is one of the factors that provide better Quality of Service (QoS). The bandwidth allocation algorithms can be categorized as Fixed Bandwidth Allocation (FBA) and Dynamic Bandwidth Allocation (DBA) algorithms.

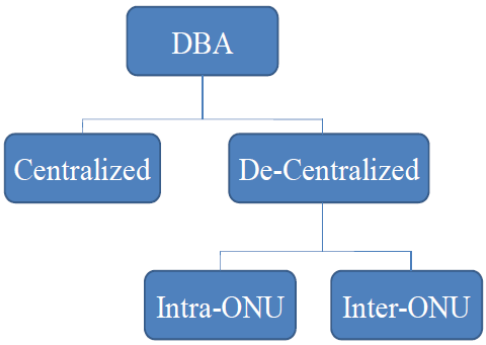

Figure-3 Framework for dynamic bandwidth allocation (DBA) algorithms for PONs [25]

Today almost all scheduling algorithms are dynamic in nature. We have made a survey of these proposed algorithms for PONs and these algorithms are used in the DBA module for the calculations of bandwidth. These DBA make it sure that there should be no collision in the upstream transmission and also have to ensure QoS issues, which include packet delay, queuing delay, packet loss. We have made a framework for the dynamic bandwidth allocation algorithms and PON shown in figure-3 [25].

We categorize DBA algorithms into different layers such that at first layer they can be divided into two: centralized and decentralized. The centralized approach is one which is completely an OLT based bandwidth allocation algorithm. Whereas in the decentralized approach the scheduling algorithm can either be run on the OLT side

or on the ONU side. In the second layer, we have then divided decentralized approach into two different types: Inter ONU scheduling and Intra-ONU scheduling [25].

4. LITERATURE SURVEY

J.W. Kim et al. [9] described an optimized ATM-PON based FTTH access network to provide residential subscribers with full services. They described the requirements of ATM-PON access network with considerations of services and PON specific layered functions. They also considered the major technical issues to realize the ATM-PON based FTTH access network economically. Gert Van der Plas et al. [8] presented an ATM-based Passive Optical Network (APON) that had been installed for a Video On Demand (VOD) trial on Bermuda. The field trial was based on a broadband network with an ATM-based Passive Optical Network in the local loop. An overview was given of the configuration of the network and of the operation of the VOD service. The basic principles of the operation of the APON access network were also presented. The research work conducted for Ethernet passive optical networks is compiled and classified in [13]. They examined PON architectures which provided meaningful and insightful presentations of the prior work on EPONs. Different Dynamic Bandwidth Allocation (DBA) algorithms and a survey of the existing approaches for supporting quality of service and fairness are also discussed in [13].

Thereafter various DBA algorithms were developed and some of them were modified in order to modify the bandwidth availability to the users. Quality-of-service (QoS) support in Ethernet Passive Optical Networks is of crucial concern and issue of intra-ONU allocation was discussed in [3]. The results of the paper confirm good performance for a wide range of input traffic classes and loads. In [6], the authors evaluated a simple modification of the bandwidth allocation algorithm called Multi Point Control Protocol (MPCP). The results, obtained showed that the modified algorithm outperform the original one in terms of maximum available bandwidth and packet wait time in upstream direction. Further improvement in multipoint control protocol (MPCP) was proposed in [10] by J. Zheng. The proposed algorithm uses the multipoint control protocol (MPCP) to arbitrate the transmission of multiple ONU's, and incorporates a dynamic bandwidth allocation (DBA) scheme that makes use of the excessive bandwidth of lightly loaded ONUs to meet the bandwidth demand of heavily loaded ONUs. Through simulation experiments, it is shown that the proposed algorithm can significantly improve the network performance in terms of packet delay, queue length, and throughput under high traffic load. Another DBA approach explained in [11] is based on a frame structure that is broadcasted downstream periodically. In this paper authors discussed a frame division method for supporting prioritized DBA for different traffic classes based on weights determined according to the traffic load and QoS requirement of each traffic class. The method was investigated through computer simulation for voice, video and data applications. The simulation results showed that it can properly allocate bandwidth to voice with little over-provisioned bandwidth while video can be efficiently prioritized at the expense of less support for data traffic. A fine scheduling algorithm was introduced for upstream bandwidth allocation in [5]. The scheduling algorithm consisted of inter optical network unit scheduler at the optical line terminal and an intra-ONU scheduler at each ONU. Numerical results have shown to fulfill various requirements of delay and throughput for the transmission of multimedia traffic for each end user. The performance of dynamic bandwidth allocation algorithms (inter-ONU Scheduling) and intra-ONU scheduling algorithms was analyzed in [14], and further investigation was done to find how a combination these algorithms can be implemented in EPON in order to efficiently support the transmission of multimedia

traffic and improve the performance of the low priority traffic at the same time. In another approach [19], it is being described that scalability of EPON which had become a limiting factor in realizing network architecture with large coverage and a high number of subscribers. A simple active remote node with a Media Access Control (MAC) forwarding scheme for an EPON network is proposed to achieve improved network performance and overcome bandwidth limitations arising from higher split ratios which works in conjunction with EPON protocols and did not modify the underlying functionalities of the network.

5. CONCLUSION

In this paper, we concluded that the Passive Optical Networks (PON's) are the access networks of next generation to meet the high bandwidth requirement of users. Here, we have discussed the PON architecture, MPCP protocol, classification of DBA and various DBA algorithms that are used to utilize the available bandwidth.

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