Bandwidth Optimization in Ethernet Passive Optical Network

[1]Pankhuri Dogra, [2]Mandeep Kaur
[1,2]Rayat Bahra University, Mohali, Punjab, India

Abstract
When the data is transferred over the network, packet delivery is one of basic requirement of the network but there are many major causes that can result packet loss over the network. Due to this there is requirement of some methodology that can reduce the packet loss. Advancement of PON technology with proper utilization of bandwidth and reduction of delay can overcome this problem. In this paper we proposed a model which can increase bandwidth upto 30%.

Keywords
CO, PON, WDMA, SCMA, TDMA, WAN, LAN, DBA, ONU, OLT etc.

I. Introduction
The quick development of the Internet access and services such as the IP video delivery and voice over IP is accelerating demand for broadband access. While most of the broadband services around the world are delivered through the copper access network, optical access technology has been commercially available for several years and is being deployed in large amount in some countries [7]. The rapid growth in both use and size of computer networks has arouse a new interest for increasing the networks capabilities to transport more traffic with higher speed. Over recent years, optical communication networks have been deployed widely across the globe. With excessesive bandwidth offerings of optical networks in metropolitan and Wide Area Networks (WANs), there still exists a restricted access between Local Area Networks (LANs) and the service provider's networks. This has a reflective impact on the design of next-generation optical network architectures and technologies. Optical fibres are widely used in telecommunications, since they allow sending large amounts of data at a great distance and having higher bandwidths (data rates) than other forms of communication. They are the transmission medium par excellence to be immune to electromagnetic interference and because signals travel along them with less losses. This transmission mode allows the transport of a multitude of information, used for applications such as broadband Internet, telephone and cable television, through more effective signals than copper wires.
There are two major set of fibre-based technologies to be deployed in the access networks. One is active optical networks and other is passive optical networks (PONs). The former depends on active components in the subscriber loop (from CO to users) and in PON, there is no active device in the signals path between CO and subscribers. High capacity feature of multi-access optical networks with comparison to other access network technologies like cable, DSL and wireless access is the main motive of passive optical network exploitation [8].
The Passive Optical Network is one of the most extensively deployed access networks due to its exclusive benefits, including transparency against data rate and signal format as well as high data rates and reliability [9]. The PON is type of access network which based on Optical Fibre. It is designed to make available unlimited bandwidth to the subscriber. A Passive Optical Network uses a passive optical splitter to divide the signal towards individual subscriber.
Due to passive interconnection of nodes, and shared medium among users, a multiple access scheme is required to avert collision. In all networks, multiple access schemes are accomplished by resource sharing in either of space, the time, the frequency, or the code domains. The four basic multiple access techniques that have been broadly investigated and applied to current optical fibre networks are comprised of, wavelength Division Multiple Access (WDMA), Subcarrier Multiple Access (SCMA), Time Division Multiple access(TDMA) and Code Division Multiple Access (CDMA) schemes [10]. Multiple access optical networks grasp best of both optical and electrical worlds, i.e. the routing and transport from optics and buffering and processing from electronics.There are four type of PON-based technologies namely Broad band PON (BPON), Ethernet PON (EPON), Gigabit PON (GPON), APON.

II. Literature review
Extensive research work in the area of achieving optimization in Passive Optical Network has been reported over the past few years which focused on reducing delay, bandwidth allocation and various approaches to achieve better optimized network performance.
Dixit et al. [1] presented a new dynamic bandwidth allocation (DBA) algorithm for service differentiation that meets the service-level agreements (SLAs) of the users. They proposed the MDAWS and the DAGS algorithm for the high-priority and the medium-priority traffic classes, respectively, which improve the jitter performance of both the traffic classes. The proposed DA algorithms not only impart a high jitter performance but also achieve a high through- put. The proposed algorithms achieve a centralized delay distribution for both the high- and medium-priority traffic class, whereby the variance of the delay is almost load independent. The proposed DA algorithms also achieve a high throughput of 96%. The algorithms implement centralized QoS control and thus make it more interoperable and efficient. The paper also proposes the concept of DP for SLA awareness where the ONUs with different delay-bound requirements are polled according to their needs, accomplishing the delay requirements of the prioritized traffic classes while increasing throughput.
Suzuki et al. [2] discussed a new dynamic bandwidth allocation (DBA) method for long-reach passive optical networks that can minimize the upstream latency. The OLT allocated grant with REPORT and GATE intensive EM-DBA for short-distance ONUs, and at the same time it run the predictive DBA for long-distance ONUs. With the predictive DBA, an OLT allocates a grant for ONUs depending on the estimated bandwidth for upstream transmission with the values of the transmission requests in REPORTs. The predictive DBA can be run with a short cycle in spite of the message exchange cycle based on the RTT. This allows long-distance ONUs to have the chance to transmit in a shorter allocation cycle. This has no impudence on the latency of short-distance ONUs even if they coexist with long-distance ONUs.

Maier et al.[3] explained a passive optical network (PON) polling mechanism for services that require low-latency performance, which achieves delay performance gains reaching 57%. This is done by decoupling the in-band report messages from the upstream data transmission time window and scheduling them individually in order to arrive without delay before a grant is to be transmitted from the optical line terminal (OLT). They analyze the details of this mechanism and provide discrete event simulation results to support the analysis. They accentuate that the proposed mechanisms maintain a statistical multiplexing approach (as opposed to a fixed window TDM approach), need only firmware upgrades at the OLT, can be rolled out on a per- ONU basis and come only at the cost of one extra guard time per ONU being polled in this way.

Nair et al. [4] described a routing scheme for OBS networks that reduces the burst loss probability of individual bursts and at the same time achieves the routing goal of maximization of the minimum unutilized bandwidth of links in the network. All OBS nodes periodically swap their scheduler-state information, and hence all nodes learn the topology of the network along with the tenure states of each link. Based on this information the end-to-end wavelength availability states of the routes are calculated, and bursts are then routed through the path that is likely to give minimum loss. The scheme can be applied in both source-routing and hop-by-hop-routing modes with provision for deflection routing in each mode. The performance of the proposed scheme is analyzed through simulation and found that it reduces the loss rates significantly.

Liem et al. [5] proposed a generic QoS-aware interleaved dynamic bandwidth allocation (QA-IDBA). The QA-IDBA can function adaptively bi-partitioned interleaved scheduling with QoS-based predictive limit bandwidth allocation (QP-LBA) and excess bandwidth reallocation (EBR) with the residual bandwidth compensation scheme to remove the idle period, enhance QoS, and effectively diminishes high-priority traffic delay and jitter. Simulation results show that our proposed algorithms can put up the growth of ONUs and achieve better overall superiority of system performance even if the high-priority traffic is increasing from 20%, 40%, and 60%.

Doyle et al. explained a novel protection mechanism which, by distributing the load produced by a node failure over the network, can significantly minimize the overall protection capacity required. They then present a practical FTTP deployment scenario based on their protected LR-PON architecture for a European country. The problem is modelled using integer linear programming, and the optimization results, obtained using a real dataset provided by a national operator, show that a small number of metro/core nodes can provide protected connection to FTTP users. By applying a detailed cost model to the outcome of the optimization, they are able to show that their LR-PON deployment strategy, which decreases the overall protection capacity, rather than just minimizing fibre distances in the LR-PON, can significantly reduce costs.

Cui et al. [6] developed the closed-form expression of the registration throughput to evaluate the random-delay based protocol. They show that an optimal discovery-window size can be determined by maximizing the registration efficiency. They study the performances of the registration protocol in Ethernet passive optical networks (EPONs). In each registration process, the newly-connected optical network units send their request without any scheduling which may cause collisions and lower the registration success probability. Thus, a random-delay based registration protocol has been defined in the IEEE 802.3av standard to prevent collisions. Our analytical results indicate that the random delay introduced in the protocol is helpful to improve the registration efficiency when the number of ONUs is large, or if all ONUs are clustered. However, the throughput enhancement by random delay is marginal if there is only a small number of evenly distributed ONUs in the vicinity of EPON.

III. Revised Model for Bandwidth Allocation

We have presented dynamic bandwidth allocation (DBA) model to effectively and fairly allot bandwidth between end users. We augmented the bandwidth allocation model to support QoS in a differentiated services framework. Due to the bursty nature of Ethernet traffic some ONUs might have less traffic to transmit while other ONUs needs more than Bmin. For this reason we develop a model to provide bandwidth. This model is also better to support differentiated services: a crucial requirement for a converged broadband access network with heterogeneous traffic. The overall goal of bandwidth allocation is to effectively and efficiently achieve fair scheduling of timeslots between ONUs in EPON networks.

Various symbols used in this model are explained as:
Number of ONUs
Transmission speed of PON
Guard time
The granted bandwidth
Minimum granted bandwidth
Excessive bandwidth allocated to ONU
Total excessive bandwidth
Total granted cycle
Now according to [11] we have (3.1) (3.2)
Where K is the set of heavily loaded ONU
from [12] can be expressed as given in equation (3.3)
Further solving the equations (3.3) and (3.1) we get equation (3.4) as Equation (3.4) can be taken as the proposed mathematical model. From this equation we can observe that allocated bandwidth is inversely proportional to the number of ONU. should always be greater than product of number of ONU and guard bandwidth. is added to provide excess bandwidth to the heavily loaded ONUs.

IV. Results and Discussion

In Bandwidth Allocation model we have discussed the bandwidth allocation for different ONUs. We augmented the bandwidth allocation model to support QoS in a differentiated services framework. It has been shown that strict priority-based bandwidth allocation, under our assumptions for traffic behaviour, will result in an unexpected behaviour for certain traffic classes (light-load penalty) and we suggested the use of appropriate queue management with priority scheduling to alleviate this problem. Bandwidth varies according to various parameters. Variation of some of these are presented as below

Fig. 1 shows the variation of bandwidth with time cycle, the parameters used are given in Table 1.

Table 1: Parameters Used for Variation of Bandwidth Allocation

Parameters	Values
Tcycle	2ms
Tg	1ms
R	0.5Mb/s

It is evident from the response of cycle time that with the increase of time cycle the bandwidth initially takes a curve shape and then increases linearly. Fig. 2 shows the variation of bandwidth with the transmission speed. The values of the parameters are: Tcycle=2ms; Tg=1ms; R=0.5Mb/s. From the graph we can conclude that as the transmission speed of PON increases, the allocated bandwidth also increases.

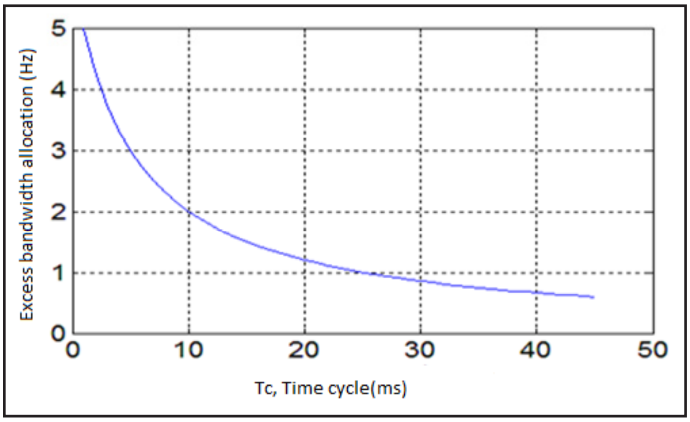

Fig. 1: Bandwidth Allocation V/s Cycle Time

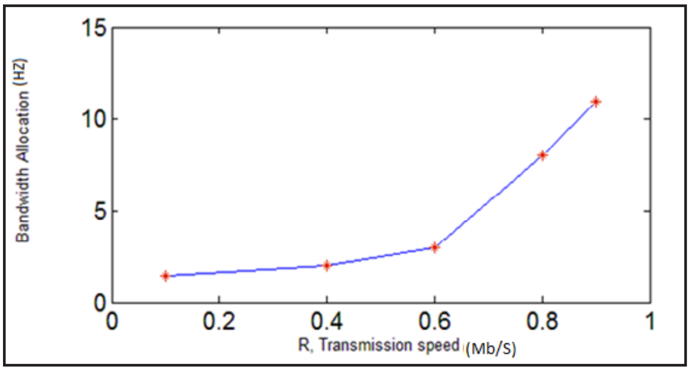

Fig. 2: Bandwidth V/s Transmission Speed

In Excess Bandwidth Allocation-I model we have explained about the excess bandwidth requirement of ONUs. The proposed excess bandwidth depends on total excess bandwidth, requested bandwidth and the maximum time cycle. These dependencies are presented here with the help of simulation results. Figure.4.3 presented the variation of excess bandwidth with maximum time cycle. The Parameters used are shown in table 4.2.

V. Conclusion

The presented work has been done on the analysis and improvement of Passive Optical Network. A mathematical model have been proposed to achieve the optimization of Bandwith Allocation goal. In the mathematical model variation of bandwidth is shown with different parameters. It shows that bandwidth increase with the increase of transmission speed. Bandwidth is improved upto 30%.

References

[1] Abhishek Dixit, Bart Lannoo, Goutam Das, Didier Colle, Mario Pickavet,“Dynamic Bandwidth Allocation with SLA Awareness for Qos in Ethernet Passive Networks”, Journal Optical Communication Network, Vol. 5, No. 3, 2013.

[2] Daisuke Murayama Noriyuki Oota, Ken-Ichi Suzuki, Naoto yoshimoto,“Low-Latency Dynamic Bandwidth Allocation for 100 km Long-Reach EPONs”, Journal Optical Communication Network, Vol. 5, No. 1, 2013.

[3] Tomaz Berisa, Martin Maier,"Low Latency Polling for Passive Optical Network”, IEEE Communication Letters, Vol. 17, No. 6, 2013.

[4] Subhrabrata Choudhury, Vivek Nair, A.K. Mal,“Routing Scheme for OBS Network”, Journal Optical Communication Network, Vol. 4, No. 10, 2012.

[5] I-Shyan Hwang, Jhong-Yue Lee, K. Robert Lai,“Generic Qos-Aware Interleaved Dynamic Bandwidth Allocation in Scalable EPONs”, Optical communication Network, Vol. 4, No. 2, 2012.

[6] Qingpei Cui, Tong Ye, Tony T, Lee, Wei Guo,“Throughput and Efficiency of EPON Registration Protocol”, Journal of Lightwave Technology, Vol. 30, No. 21, 2012.

[7] C. Lin, Ed.,“Broadband Optical Access Networks and Fibre-to-the Home; Systems Technologies and Deployment Strategies”, 2006.

[8] R. Low,“What’s next after DSL-passive optical networking?”, Journal of communications Network, Vol. 4, pp. 1, pp. 49-52, 2005.

[9] M.Rad, H.A. Fathallah, L.Rusch,“Fibre Fault PON Monitoring using Optical Coding: Effects of Customer Geographic Distribution”, IEEE Transaction Communication, Vol. 58, pp. 1172-1181, 2010.

[10] Kramer, Glen; Mukherjee, Biswanath, Pesavento, “Ethernet PON (ePON): Design and Analysis of an Optical Access Network”, University of California, 2000.

[11] Chadi M. Assi, Yinghua Ye, Sudhir Dixit, Mohamed A.Ali,“Dynamic Bandwidth Allocation for Quality-of-Service Over Ethernet PONs”, IEEE Journal on Selected Areas in Communication, Vol. 21, No. 9, 2003.

[12] Jiajia Chen, Biao Chen, Sailing He,“A Novel Algorithm for Intra-ONU Bandwidth Allocation in Ethernet Passive Optical Networks”, IEEE Communication Letters, Vol. 9, No. 9, 2005.

Pankhuri Dogra received her B.Tech Degree in ECE from GGS College of Modern Technology Kharar. She was a Lecturer of ECE in Longowal Polytechnic & Pharmacy College Derabassi for two years and seven months. Presently, she is pursuing M.Tech (ECE) from Rayat & Bahra Institute of Engineering & Bio-Technology, Kharar, Punjab, India