A Dynamic Bandwidth Allocation Protocol in WDM-PON with Loop-back scheme

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Abstract — **In this paper, we propose a dynamic bandwidth allocation in wavelength division multiplexing based passive optical network (WDM-PON) with loop-back scheme. A loop-back approach is to replace the transmitter in the ONTs with a reflective modulator, which uses part of the downstream light as the source for the upstream. We can utilize this scheme to share the cost of components in a PON. We present dynamic bandwidth allocation algorithm to *maximize network efficiency*.**

Keywords — **Wavelength Division Multiplexing, Passive Optical Network, Dynamic Bandwidth Allocation**

1. Introduction

In the past few years, a number of advanced optical components have been deployed in the backbone network. Optical amplifiers such as EDFA, SOA are now being widely deployed to increase the supported span, and trunk connections of 10Gbps have become a commercial reality. In addition, the wavelength division is being exploited to increase the link capacity toward hundreds of gigabits. Due to these recent evolutions, the cost of the advanced components can be expected to drop as they mature and higher volumes are requested. Hence, it is now worthwhile to evaluate how these technologies can contribute to the future architectures of the access network.

Passive Optical Network (PON) technology has been considered as the most promising solution in terms of supporting broadband service, low cost, and data centric passive optical network are the sharing of fiber between the optical line termination (OLT) and the remote node, producing a tree or multiple star structure, and the centralized control of the network at the central office or OLT. Both upstream traffic from the optical network terminals (ONTs) and downstream traffic from the core network are routed through the OLT, the resources of which are shared between the ONTs. The single-wavelength OPN is well established for use in the access network, and upgrading to multiwavlength systems is a natural progression. There are two broad approaches to implementing WDM over passive optical networks. The first involves the use of tunable receivers and tunable transmitters at the customer end, thus allowing reconfiguration of the network according to demand. The second uses fixed transmitters and receivers, giving a set wavelength to a group of ONTs[1].

In previous PON proposal[2], they proposed a PON architecture that combines advantages of WDM-PON with the cost-sharing features of the traditional PON. In the architecture, a single laser is shared among all N bidirectional links, while each ONT provides its upstream signal by over-modulating a portion of the downstream light. That is, they used loop-back scheme sending upstream traffic at ONT.

In this paper, we propose a dynamic bandwidth allocation in wavelength division multiplexing based passive optical network with loop-back scheme. In addition, we investigate a frame transmission with downstream and upstream simultaneously. The basic concept of WDM-PON with loop-back scheme is described in section 2. Then we provide a detail description of the dynamic bandwidth allocation over WDM-PON with loop-back scheme in section 3. In section4, we present simulation using OPNET and result that show the improvement of network efficiency of the proposed dynamic bandwidth allocation. Finally, a conclusion is drawn in the section 5.

2. WDM-PON with Loop-back scheme

A loop-back approach is to replace the transmitter in the ONTs with a reflective modulator, which uses part of the downstream light as the source for the upstream. We call this architecture as LPB-PON. The architecture is shown in figure 1. It may be observed that each node has a unique wavelength assigned to it through the remote node using a wavelength router, typically an arrayed waveguide grating(AWG).

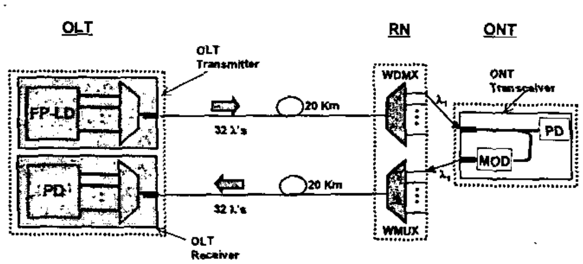

Figure 1. LPB-PON arbiterture

At the central office(OLT), there is a tunable which acts as the downstream source pulses are sent sequentially to each ONT[3]. A frame sent from the OLT to each ONT. That consists of two parts ; a data part, wherein data is transmitted by the OLT, and a return traffic part, wherein no data is transmitted but the OLT laser is left turned on. It is shwon in figure 2. Each ONT is provided with an exteral modulator. During the return traffic part of the frame, the ONT uses the odulator to modulate the ligth signal from the OLT. LPB-PON architecture avoids the need for having a laser at each ONT. Instead, each ONT has an external modulator.

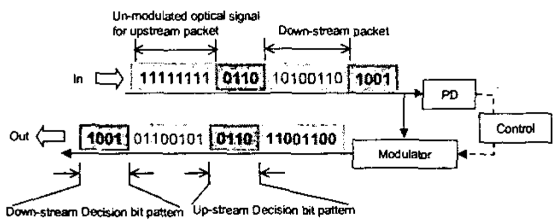

Figure 2. Frame transmission in LPB-PON

3. Dynamic Bandwidth Allocation in LPB-PON

We believe that a PON based on polling, possesses the best quallities, such as dynamic bandwidth distribution, use of a single downstream and a single upsteam wavelength, ability to provision a fractional wavelength capacity to each user, and ease of adding a new user.

To support to maximize network efficiency in LPB-PON achitecture, we propose dynamic bandwidth allocation as shown figure 3. It is similar to IPACT for EPON[4]. It is suggested by a scheme for in-band signalling that allows using a single wavelgnth for both downstream data and control message transmission. However, we extend this algorithms to WDM-PON, and we can support bandwidth dynamically according to how many upstream bandwidth allocation gives.

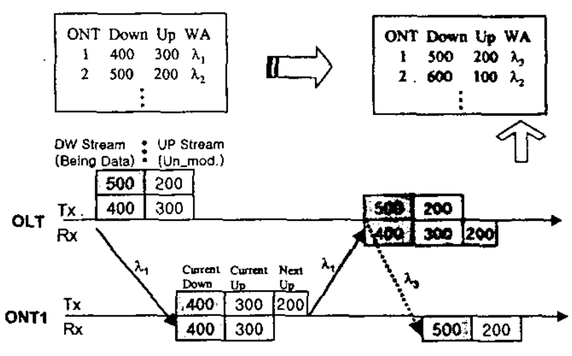

Figure 3. Dynamic Bandwidth Allocation protocol in LPB-PON

Figure 4 is shown the flow-gram of dynamic bandwidth allocation between OLT and ONT. At first, when an ONT wants to regist or is working, the ONT sends a registration request to an OLT through unmodulated optical signal come from OLT. Then, the OLT transmits downstream data and unmodulated optical signal for upstream in a single wavelength, symmetrically. In the ONT, it sends ONT's queue information with upstream data to the OLT. It also transmits downstream and upstream, symmetrically. After receiving queue information from ONT, the scheduler in OLT can decide the ratio of downstream bandwidth and unmodulated bandwidth for upstream in a single downstream wavelength. OLT can transmit dynamic up and downstream bandwidth to ONT.

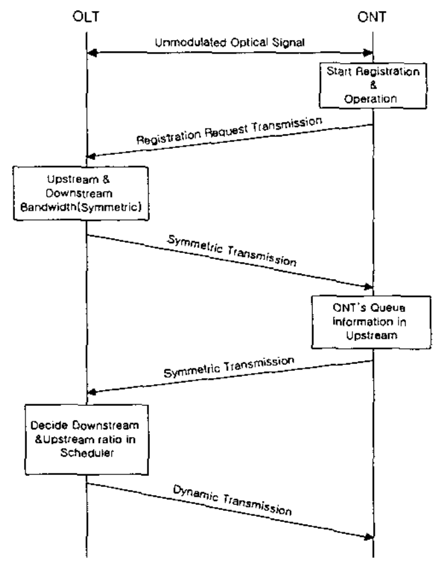

Figure 4. Dynamic Bandwidth Allocation flow-gram in LPB-PON

4. Simulation Results

To validate the proposed scheme, we performed computer simulations using OPNET simulator. Next figure 5, 6 illustrate operational process models of OLT and ONT in LPB-PON.

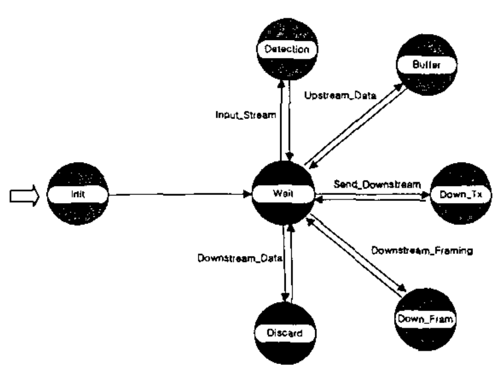

Figure 5. Operational process model of OLT

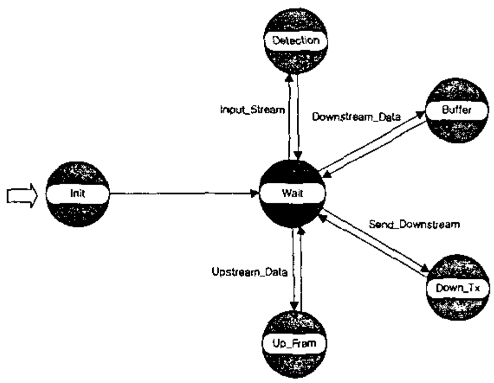

Figure 6. Operational process model of ONT

We consider a LPB-PON architecture with 16 ONTs connected in a tree topology. However, we just analyze one ONT's performance, because each ONT has a unique wavelength assigned to it through AWG. That is, it is point-to-point network. The channel speed is considered to be 1 Gbps and maximum frame size is 250Kbyte that is set to 2 msec in 1Gbps link. For upstream traffic model considered here, we used the ON/OFF source model that is the most popular one. In addition to the performance of an ONT in the DBA scheme over LPB-PON, we also present the performance of the ONTs in the Fixed Bandwidth Allocation (FBA) scheme for comparison. In FBA scheme, the ONT transmits fixed downstream bandwidth and upstream bandwidth symmetrically. In case of 1Gbps link, downstream bandwidth is 500Mbps and upstream bandwidth is 500Mbps.

We compare the improvement in queuing delay when DBA is used. Figure 7 shows the queuing delay of FBA and DBA. When the traffic load is low, the packet delay value of FBA is not differ from that of DBA. However, as upstream traffic load is larger near to 1, the delay of FBA increases much more than that of DBA. The reason is that the DBA algorithm allows large bandwidth allocation when upstream data is increase.

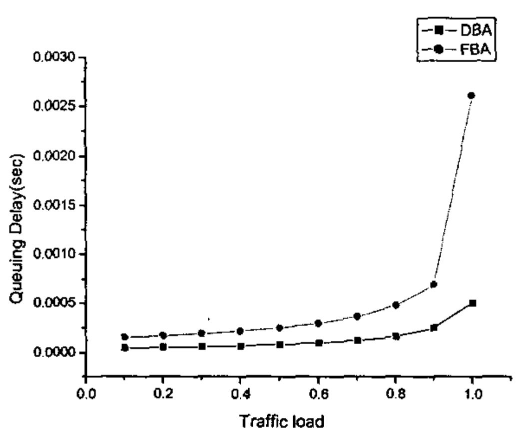

Figure 7. Comparison between FBA and DBA in LPB-PON

5. Conculsion

In this paper, we propose a dynamic bandwidth allocation in LPB-PON. A loop-back approach is to replace the transmitter in the ONTs with a reflective modulator, which uses part of the downstream ligth as the source for the upstrea. We present dynamic bandwith allocation algorithm that transmits ONT's queue information in upstream bandwith. This scheme provides better efficiency than the fixed bandwidth allocation.

Acknowledgement

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REFERENCES

[1] John M. Senior, Michael R. Handley, Mark S. Leeson, "Developments in Wavelength Division Multiplex Access Networking," IEEE Communications Magazine, December 1998, pp. 28-36

[2] J. J. Frigo et al., "A wavelength division multiplexed passive optical network with cost-shared components", IEEE Photon. Tech. Lett., vol. 9, no. 8, Aug. 1997, pp. 1770-1772.

[3] R. Ramaswami, K. N. Sivarajan, Optical Networks-A practical perspective, Morgan Kaufmann, 2001.

[4] G. Kramer, B. Mukherjee, G. Pesavento, "IPACT : A Dynamic Protocol for an Ethernet PON(EPON)", IEEE Communications Magazine, Feb. 2002, pp. 74-80.