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Application of Two Upstream Wavelength In Fairness and Priority Environments

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Abstract

When two wavelengths are used for PON ONUs, upstream bandwidth utilization can be made very efficient. If wavelengths are not evenly distributed, however, fairness among ONUs is violated. To deal with this problem, a fairness algorithm is suggested. Wavelengths asymmetry can be introduced on purpose to provide different priorities among ONUs. Algorithms and simulation results are presented for both cases.

1 Introduction

EPON is a very economic way to implement FTTH system. After its standardization by IEEE[1], deployment of EPON system is on the rise[2]. Current GEPON is specified to have 1 Gbps bandwidth for both upstream and downstream transmissions. However, the upstream utilization is not good due to guard time and MPCP protocol. Therefore, two-upstream-wavelength EPON system is being considered. ONUs are classified into two groups and different wavelengths are assigned. When different wavelengths are sent in turn, parts of them can be overlapped, obtaining higher bandwidth utilization.

If wavelengths are evenly distributed among ONUs, performance will be fair among ONUs. If this condition is not met, however, the ONU group with more ONUs in it will have lower performance. An algorithm to remove this unfairness is proposed in this study. The asymmetric wavelength assignment can be used by operators to serve different service level agreements (SLA). Performance difference among ONUs is analyzed in this priority environment.

2 Principles of the Proposed Algorithm

Fig. 1 illustrates the proposed two upstream wavelength PON (2W-PON) architecture. Each ONU is equipped with one of these wavelengths. When wavelengths are evenly distributed MPCP protocol orders that different wavelengths are sent in turn from ONU site with part of the packets from consecutive ONUs being overlapped in time. Packets are realigned by adjustment logic. Fig. 2 and Fig. 3 show the case when wavelength distribution is not even. For fairness each ONU is assigned once during one cycle in Fig. 2. Fig. 3 shows the opposite case, where multiple time slots are given to an ONU in one cycle to provide better priority.

3 Performance analysis

Performance is calculated for the proposed 2W-PON under several asymmetric conditions. Total 16 ONUs, 2 msec cycle time, 10 Mbytes ONU buffer size and self-similar traffic are assumed for the calculation [3]. Considering all sources of bandwidth loss including LD on/off time, receiver settling time, preamble, MPCP operation time and so forth, 35 μsec interval is assumed between consecutive ONUs using the same wavelength. Guard time is removed for consecutive ONUs transmitting different wavelengths. Fig. 4 shows that the throughput is reduced for asymmetric distribution in fairness condition, which is attributed to the increased guard time. Delay for 12:4 ratio shows sharp increase at load 0.4 while this value is shifted to load 0.6 for 8:8 ratio as in Fig. 5.

Throughput for priority condition is calculated separately for the two wavelengths. P#1 in Fig. 6 indicates the wavelength which services fewer ONUs while P#2 for more ONUs. Throughput in this figure is the total amount for the ONUs in each group. Throughput is proportional to the number of ONUs for lower load. As load is increased, however, P#2 saturates while P#1 continues to increase. The added throughput of P#1 and P#2 decreases as asymmetry grows in priority condition. It is occurred by the reduced window size for each ONU since ONUs with P#1 are assigned more than once in one cycle and this value increases with higher asymmetry. Better performance with P#1 is more apparent in delay as illustrated in Fig. 7.

Conclusion: Similar throughput and delay are found in fairness condition although the total performance is degraded for asymmetric wavelength distribution. This asymmetry can be used for SLA when operated by a priority algorithm.

4 References

1. IEEE 802.3ah standard, approved June 24, 2004.

2. Craig Matsumoto, "Korea Goes Big on High", www.light reading.com, Jan. 08, 2007.

3. Sudhir Dixit, *IP OVER WDM*, pp. 249-261, John Wiley & Sons, 2003.

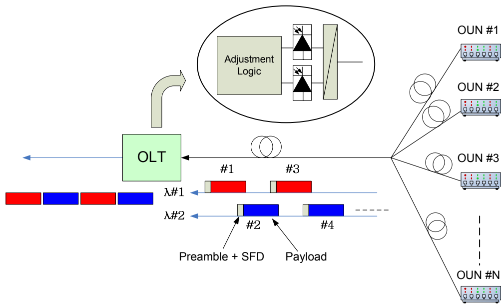

Fig. 1 Proposed 2W-PON structure

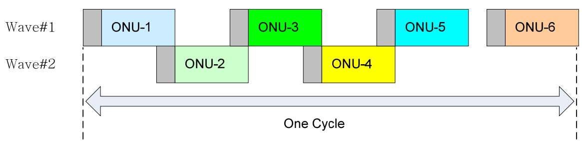

Fig. 2 Time slot assignment for fairness condition

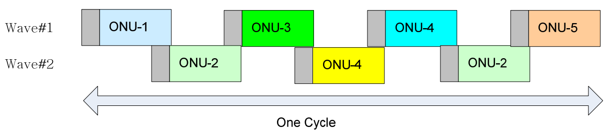

Fig. 3 Time slot assignment for priority condition

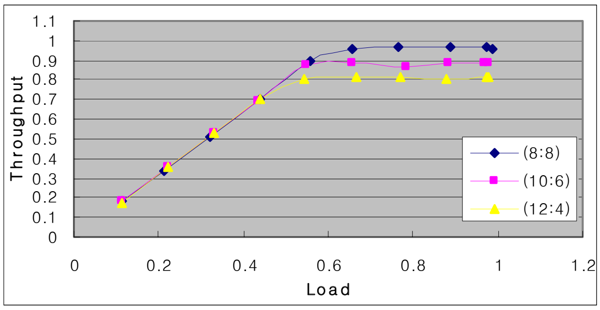

Fig. 4 Throughput for fairness condition

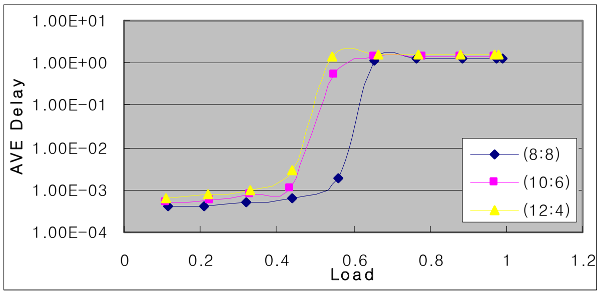

Fig. 5 Average delay for fairness condition

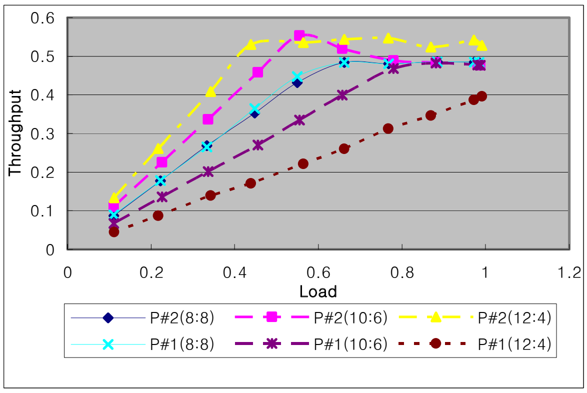

Fig. 6 Throughput for priority condition

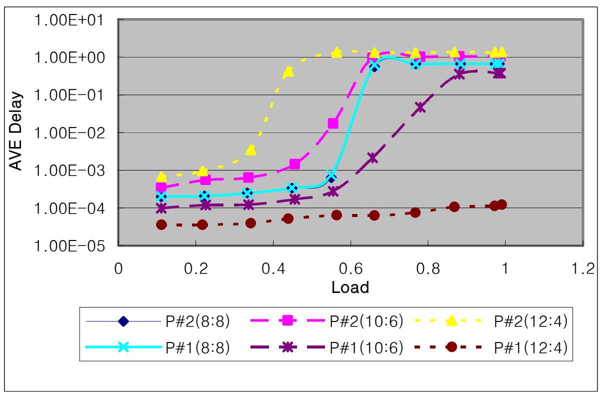

Fig. 7 Average delay for priority condition