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Improvement of TDM-PON Upstream Bandwidth Utilization Adopting Two Wavelengths

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Abstract

Two types of wavelengths are used for EPON ONU to increase the upstream bandwidth utilization. Bandwidth loss from Guard time and MPCP protocol can be removed by overlapping two consecutive packets from ONUs equipped with different wavelengths. Performance estimation and testbed results are presented.

1 Introduction

EPON is now deployed in several nations for commercial purpose, which will initiate broadband convergence network [1]. Current EPON system has 1 Gbps bandwidth for both up and down transmissions [2]. However, the current systems can't utilize the full bandwidth, especially for the upstream, due to guard time and MPCP protocol. The bandwidth loss reaches up to 40% in the worst case. GPON, which is very promising especially in Europe and North America, requires very tight physical specification in its implementation. It specifies LD on/off time of 25 ns and while this parameter is 60~100 ns for EPON, which hinders cost reduction [3].

In this study, we propose to use two types of wavelengths at the ONU site to solve the above problems. About half of the ONUs are equipped with wavelength #1 while the other half with wavelength #2. If these two different wavelengths are sent in turn toward OLT, they don't interfere with each other and can obtain enough guard time while maximizing the bandwidth utilization.

2 Principles of the Proposed Scheme

Fig. 1 illustrates the proposed two upstream wavelength PON (2W-PON) architecture. Each ONU is equipped with one of these wavelengths so that the two wavelengths are evenly used among ONUs. MPCP protocol orders different wavelengths are sent in turn from ONU site with part of the packets from consecutive ONUs being overlapped in time. Each wavelength is detected by two receivers at the OLT and then packets are realigned by adjustment logic. Details of the adjustment logic are shown in Fig. 2. Preambles of each packet are delimited. Then, the payload parts are buffered and multiplexed. Although this architecture needs additional receiver module at the OLT, it increases the upstream bandwidth efficiency by up to 40%. Furthermore, it lessens the requirements of OLT receiver and ONU transmitter, which can lower the total cost.

3 Performance analysis

Performance is calculated for the proposed 2W-PON and existing 1W-PON system. Considering all sources of bandwidth loss with 1W-PON, including LD on/off time, receiver settling time, preamble, MPCP operation time and so forth, 35 μsec interval is inserted between consecutive ONU's windows. 10 Mbytes buffer, 16 ONUs with 8 ONUs have the same wavelength, self-similar traffic and 2 msec cycle time are assumed for the simulation. Fig. 3 shows that the throughput of the 1W-PON becomes 0.7, that is, 700 Mbps. For 2W-PON system, however, this time gap between time slots can be removed by overlapping windows, and the result shows that the throughput approaches 0.97. The reason that the value is a bit less than 1.0 comes from the truncated window size by the DBA algorithm. Even this small loss can be compensated by overlapping larger part considering the vacancy occurring from the truncation. Fig. 4 compares delays for two PON systems. While 1W-PON shows sharp increase at the load of 0.35, the limited scheme of 2W-PON doesn't have this slope until load 0.6.

4 Testbed Operation Results

Fig. 5 shows transmission test using a testbed. ONU blocks and an OLT adjustment part are emulated on FPGA chips. Preambles with one wavelength are sent before the transmission by the other wavelength is not finished yet. The OLT output shows a realigned packet stream with preamble parts stripped off.

Conclusion: 2W-PON is suggested to increase the EPON upstream bandwidth utilization. It is expected to lower the tight physical constraints of GPON. Implementation architecture and the test results are provided, which shows its validity.

5 References

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

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

3. Kwangok Kim, et. al, "Standards and Transition of GPON Technologies", Weekly Technology Transition, 2006.2.8.

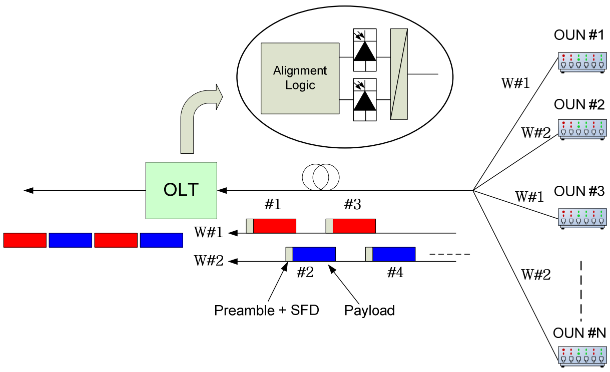

Fig. 1 Proposed 2W-PON structure

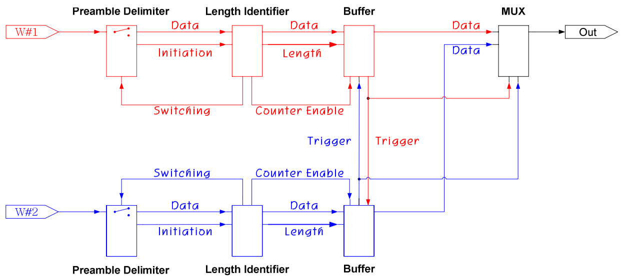

Fig. 2 Receiver Logic of OLT

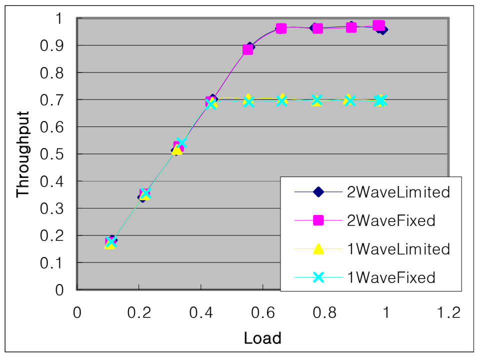

Fig. 3 Throughput comparison with conventional EPON

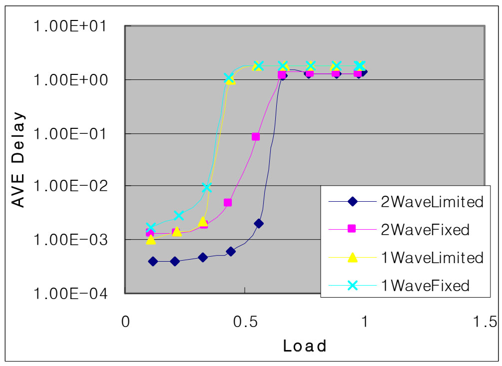

Fig. 4 Delay comparison with conventional EPON

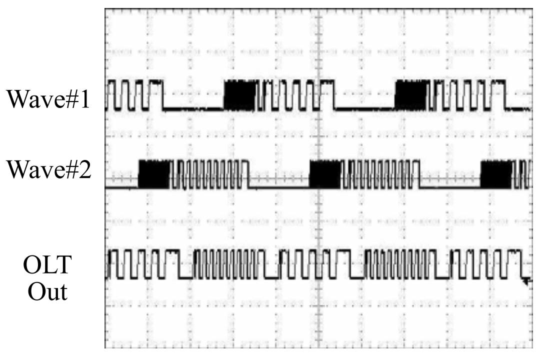

Fig. 5 Upstream transmission on the testbed