ETHERNET PASSIVE OPTICAL NETWORK (EPON) EDUCATIONAL MODULE FOR ENGINEERING POSTGRADUATE STUDENTS

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ABSTRACT

The most effective solution to cope with the ever increasing bandwidth demands is by using Ethernet Passive Optical Network (EPON). Thus, there are needs in introducing an EPON subject for Engineering Postgraduate students. However, since networking is a subject that is not easy to visualize, the lack of means to illustrate or convey the EPON network causes an apparent lack of interest amongst engineering students towards the discipline. In order to overcome these problems, a need to develop an educational module for the EPON system is seen. In this paper, an EPON testbed is proposed together with a friendly graphical user interface (GUI) as a tool for the postgraduate engineering subject to better understand the protocol and the bandwidth allocation studies of EPON. The details of the testbed and the preparation stages to make it an educational module are also demonstrated together with results to assist engineering postgraduate students to better understand the subject matters.

Keywords: EPON, Educational module, Testbed, Peripheral interface controller, Graphical user interface, C programming.

1. INTRODUCTION

The number of people who rely on the Internet on a daily basis keeps on increasing as the number of new multimedia applications such as internet protocol (IP) television (TV) and voice over IP (VoIP) increases. The phenomenal success of the Internet has created new challenges. As of June 2012, more than 2.4 billion people or over a third of the world's human population have used the services of the Internet (Miniwatts Marketing Group, 2012). The sudden increment in the

Internet traffic patterns and applications caused congestion in the local loop between a customer and the local exchange. In order to overcome this problem, Ethernet passive optical network (EPON) is seen as one of the most suitable technologies at the moment as the devices are ubiquitous from the home network all the way through to regional, national and worldwide backbone networks, implementation of EPONs can be highly cost-effective. Thus, there are needs in introducing an EPON subject for Engineering Postgraduate students.

Up to now, the teaching of EPON is taught in Data Network Architecture and Electronics subject that is performed using conventional techniques. Majority lecturers use written course notes combined with formal lectures. Despite of the evidence that experiments help students in their learning, we rarely heard about laboratory or teaching experiments in EPON. Since networking is a subject that is not easy to visualize, the lack of means to illustrate or convey the EPON network causes an apparent lack of interest amongst engineering students towards the discipline.

In order to overcome these problems, a need to develop an educational module for the EPON system is seen. The purpose of developing such testbed is most importantly to stimulate postgraduate students using new technologies so that it is more interesting for them to study and to develop a testbed that allows the visualization of how a protocol or algorithm in a network works. Otherwise, the concept may be difficult for the postgraduate students to grasp.

This paper proposes an EPON educational module in which its outcome is to create a successful teaching-learning experience for the postgraduate students through which the students have better visualization on the concept of EPON and better understanding on the protocol and other algorithms. The rest of the papers are arranged as follows. Section 2 discusses on the related work. Section 3 explains in details on the educational module with the main function being discussed in Section 4. The conclusion and future work is elaborated in Section 5.

2. RELATED WORK

The EPON study are normally done using simulations (Radzi *et al.*, 2010), but simulation method is not able to capture the nuances and non-linear effect of a real network. In order to study the dynamics of EPON, a testbed is required. At the moment, the EPON testbed is designed either using application-specific integrated circuit (ASIC) (Kim *et al.*, 2007) or field-programmable gate array (FPGA) (Bin *et al.*, 2006).

ASIC is an integrated circuit (IC) customized for a particular use, rather than intended for general-purpose use. It uses a hardware description language (HDL), such as Verilog or VHDL, to describe the functionality of ASICs. The disadvantage of ASIC is that it is not cost efficient and thus, FPGA is preferred.

The FPGA is an IC designed to be configured by a customer or a designer after manufacturing. It can be used to implement any logical function that an ASIC could perform, but the ability to update the functionality after manufacturing offers advantages for many applications. Similar to ASIC, FPGA also runs on HDL, which is a complex language that describes a concurrent circuit and must contort itself to achieve sequential execution. Since FPGA itself is already an extremely complex chip, it is less suitable for research purposes. This is because every time the DBA

algorithm or protocol is changed, the board needs to be fabricated and thus adds up the cost and the time needed for the fabrication makes the research process slower.

Peripheral Interface Controller (PIC) is considered as a more suitable approach to be used for research purposes in order to develop a testbed for EPON platform. It is one of the advanced microcontrollers developed by microchip technologies that integrate all types of advanced interfacing ports and memory modules. The reason PIC is being used in this study is because PIC is simpler as it uses C programming. Besides that, it is more cost effective and faster to develop as compared to FPGA.

3. THE DESIGN AND DEVELOPMENT OF THE EDUCATIONAL MODULE

An EPON system typically consists of an optical line terminal (OLT), multiple optical network units (ONUs), a passive optical splitter (POS) and optical fiber. The block diagram of EPON testbed is shown in Figure 1, where the OLT is connected to the ONUs via a 1:8 optical splitter through a 20 km single mode fiber with fixed connector/physical contact (FC/PC) connector. The OLT and all the ONUs are also connected to a computer via RS-232 cable. The computers are equipped with a platform to monitor the frames coming in and out called as a Protocol Test Platform (PTP).

Figure-1. Block diagram of EPON testbed
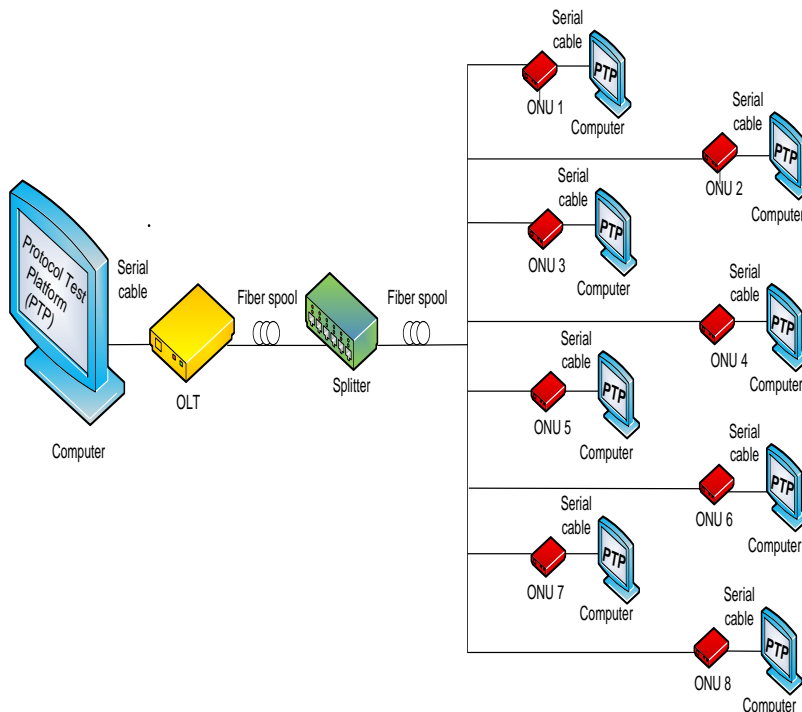
In this educational module of EPON proposed, the OLT and ONUs are developed in house by Significant Technology Sdn. Bhd. (SigTech) and the inside view of the board can be seen in Figure 2 (a) and (b) respectively. PIC24FJ128GA010 microcontroller is used as the processor in the OLT and ONU boards. The transceiver used for OLT is Eoptolink GTR-3052H-49 that has a wavelength

of 1550 nm, whereas for ONU is GTR-2032H that has a wavelength of 1310 nm (Eoptolink). The receiver used for both OLT and ONUs are Maxim MAX 232 (Semiconductor), which is chosen due to its simplicity as it contains the necessary drivers and receivers in one package. It is used to adapt RS-232 signal voltage levels to transistor-transistor logic (TTL).

Figure-2. The inside view of) OLT and b) ONU
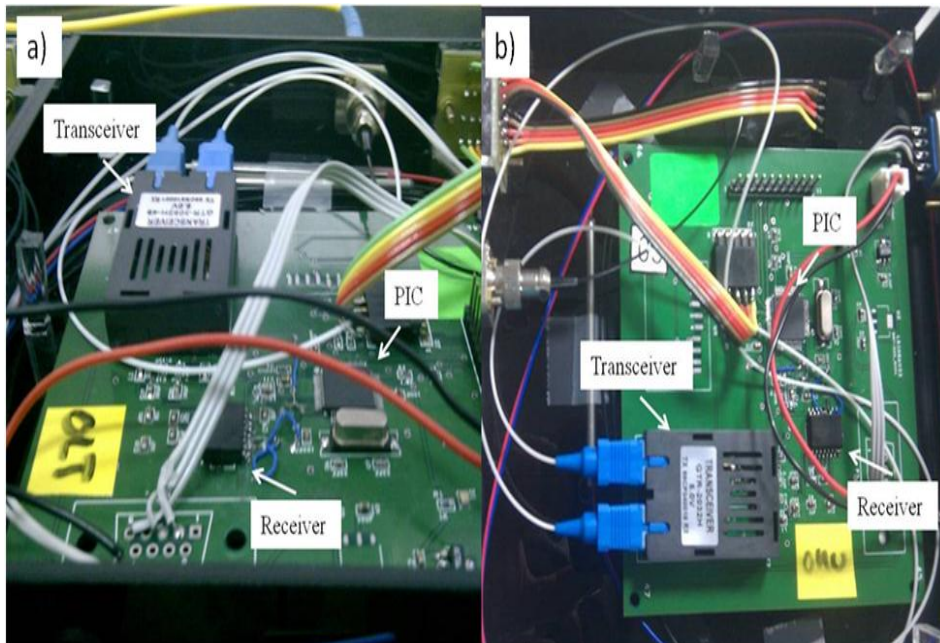
The OLT and ONU use a PIC microcontroller as the processor because it is simpler to design, more cost effective and easily reconfigurable. It contains the firmware for the OLT and ONUs that can be programmed by using a PIC debugger hardware. The firmware equips the EPON testbed with the platform to perform protocol and bandwidth allocation testing. The basic EPON protocol, which is Multi Point Control Protocol is already designed and burned in the OLT and ONU. Engineering postgraduate students can study the rest of the protocol and the bandwidth allocation algorithm with a simple programming designed using Mikro C language. PICkit 2 Debug Express is used to program the firmware of the microcontroller. It consists of a PIC microcontroller programmer device and a MPLAB Integrated Development Environment (IDE) software for programming. The compiler used is MPLAB IDE integrated with C30 microchip. This firmware is loaded inside the OLT or ONU by first converting them to HEX file before burning them inside the OLT or ONU. It is as easy as using your thumbdrive to transfer a file. In order to monitor the effects of the system after the changes of the protocol or algorithm is done, PTP is proposed in every computer connected to the OLT and ONUs. PTP is a graphical user interface (GUI) software that is designed using Microsoft Visual Basic and can be seen in Figure 3. It is essential in capturing the GATE and REPORT messages so that the performance parameters such as throughput, delay and fairness can be observed in a user friendly interface. PTP is also used to

generate the DiffServ traffic that can be used for bandwidth allocation studies. The DiffServ traffic is designed based on the source code for NS-2 software.

Figure-3. PTP
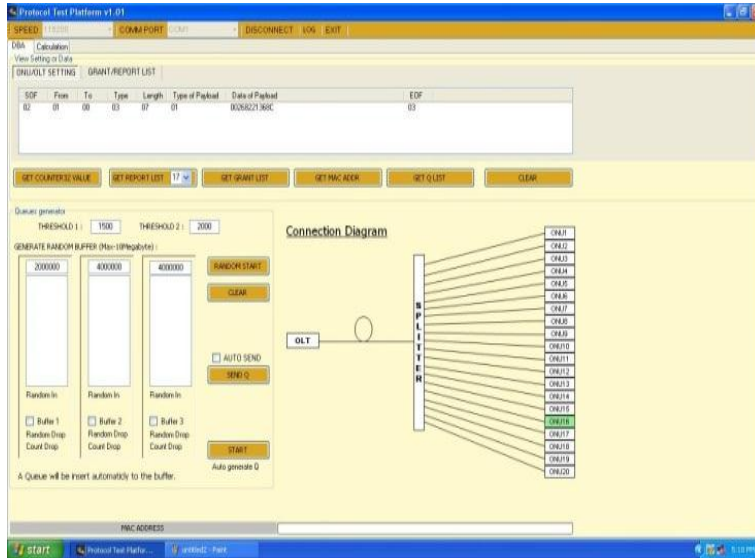
4. MAIN FUNCTIONS OF THE EDUCATIONAL MODULE

In this section, the main functions of the educational module are summarized. They are divided into three groups, namely the hardware, firmware and PTP.

4.1. Hardware

The educational module can be used to study on the environment of the EPON system. The number of ONUs can be varied as high as 20 ONUs. The length of the fiber can also be varied as long as 20 km. The effects of these variations are not able to be observed using the simulation method and more interesting to be learned as compared to the conventional text book method. A sample graph on the effect of fiber length towards the bandwidth utilization is shown in Figure 4.

Figure-4. Effects of fiber length towards bandwidth utilization
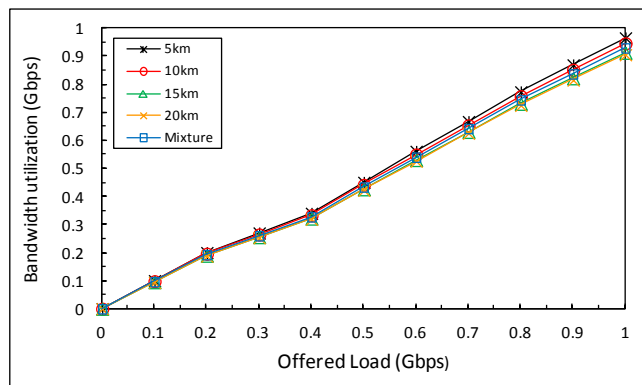
4.2. Firmware

The firmware of the OLT and ONU can be reconfigured to perform the protocol and bandwidth allocation studies. The configuration can be easily done using Mikro C programming and can be easily burned by using PICKit, which works similarly with transferring files using your thumb drive. This makes the changes of any protocol and bandwidth allocation studies to be done repeatedly and in an instant. A sample graph of different allocation algorithms towards the bandwidth utilization is shown in Figure 5.

Figure-5. Effects of different algorithms towards bandwidth utilization
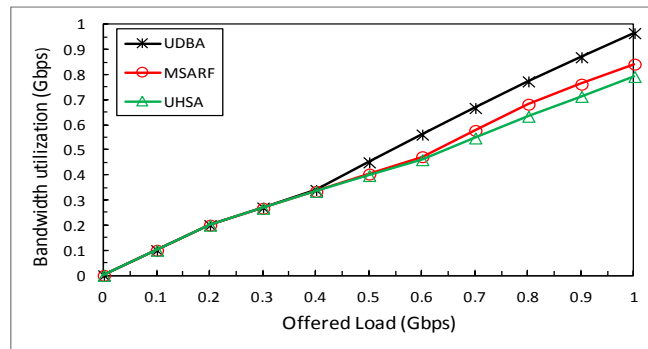
4.3.   PTP

PTP is used to generate DiffServ traffic, which can be varied to see their effects towards a certain algorithm. Besides that, it shows the GATE and REPORT messages of EPON system, which eases up the analyzing process. The process of EPON system when there are changes done in the hardware and firmware can also be observed in a user friendly manner using PTP.

5.   CONCLUSION AND FURTHER WORK

For teaching and learning, EPON studies usually involve the conventional textbook method in which the protocol and bandwidth allocation studies of EPON is not easy to be visualized. In the EPON educational module proposed, the real hardware that made up EPON system can be observed and studied. The firmware can easily be configured to test the variation of protocols and algorithms and the result can easily be observed by the PTP software. This way, EPON subject matters become more interesting to be learned and more easily be understood. Future work will be based on making the traffic injected in the hardware to be real traffic as opposed from random traffic generated by the PTP.

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