Implementation of Customer Protection Device (CPD) in FTTH-EPON

Mohammad Syuhaimi Ab-Rahman† Siti Rahayu Hassan† Siti Asma Che Aziz† and Kasmiran Jumari†

Computer & Network Security Laboratory, Department of Electrical, Electronic & System Engineering, Faculty of Engineering & Build Environment, Universiti Kebangsaan Malaysia, 43600 Bandar Baru Bangi, Selangor, Malaysia.

Summary

This paper presents a solution to a technique for automatic protection and restoration switching in conjunction with a capability for intercommunications between customers in a passive optical network. Protection switching against fiber breaks is carried out using an additional device in the immediate split coupled with an ADSL-copper wire from the CO through ACS for control and monitoring purposes. Customer protection device (CPD) comprises of programmable optical switches will be employed at the customer end, just before the ONU to ensure continuous service delivery to customers. The principle mechanism of CPD is based on smart drop protection scheme (SDPS) proposed in earlier paper. Two types of failure conditions in the drop region of tree topology in EPON network are also explained.

Key words: FTTH, PON, protection switching, restoration

1. Introduction

Automatic identification technologies have been used to reduce the time and manpower to online monitoring and failure detection in optical access network. Currently FTTH has become one of the hottest technologies implemented in PON application. FTTH-PON offer many advantage such as large capacity, and allows the triple play services (data, voice, and video) to end users [1]. Passive optical networking (PON) technology in the other hand is considered the best optical access networking technique to provide higher and flexible quantities of bandwidth to customers [2, 3]. Protection against equipment failures and fiber breaks is crucial for continuous service delivery to customers. However, until recently, providing protection for the access path has not generally been concluded.

All transmissions in a PON are performed between Optical Line Terminal (OLT) and Optical Network Units (ONU). Therefore, in the downstream direction (from OLT to ONUs), a PON is a point-to-multipoint network, and in the upstream direction it is a multipoint-to-point network. The OLT resides in the local exchange (central office), connecting the optical access network to an IP, ATM, or SONET backbone. The ONU is located either at the curb (FTTC solution), or at the end-user location (FTTH, FTTB solutions), and provides broadband voice, data, and video services. The fiber is dedicated to each user in the access network which is called a point-to point (PTP) network.

For PON applications, equipment failure at either OLT or ONU can be easily remedied by having a backup unit in the controlled environment. However, for any fiber cut, it would take a relatively long time to perform the repair. Therefore, it is highly desirable to have survivable PON architectures with protection switching against any fiber cut. One of the crucial spot of protection and mechanism is in the drop region that is the area between the splitter and ONU; especially in the immediate split region.

Access control system (ACS) being the other intelligent device proposed in i-FTTH is focusing on providing survivability through the RSA against failure by means of dedicated and shared protection that is applied in PON. ACS is used to monitor the status of the working and restoration fibers. ACS recognized the types of failure and sent the activation signal to the related optical switch according to the activated protection mechanisms [4].

2. Protection architecture at the Immediate Split

Many studies of protection switching are focusing on the switching in the ONU itself. Some are concentrating at protection switching in conjunction with LAN emulation; whereby an automatic-protection-switching (APS) mechanism against distribution fiber breaks in passive optical networks (PONs) is carried out at the customer premises (ONU) by monitoring the distribution fiber using the traffic that is transported among the customers in PON. Here, the LAN data are used to monitor the state of distribution fiber and switching to the protected path is performed at each ONU independently and the protection scheme enables the protection of services to each ONU

Manuscript received March 5, 2009
Manuscript revised March 20, 2009

can be carried out on customer's demand and does not affect the operation of other ONUs [5].

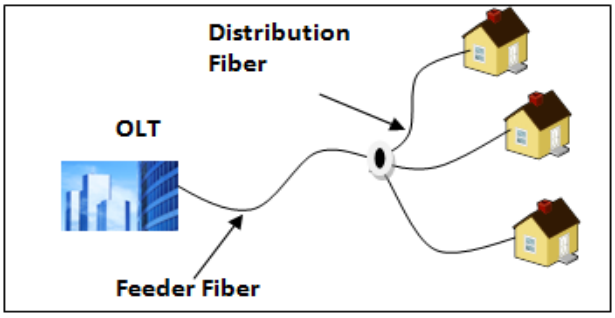

Fig. 1 FTTH-PON with tree topology

Two architectures of fiber access network are considered in this paper. As shown in Figure 1, the three architectures are point to point architecture, active star architecture, and passive star architecture [6]. The transmission in a PON is performed between an optical line terminal (OLT) installed in a CO (or remote terminal) and an optical network unit (ONU) placed at the customer residence or in a building. The OLT is active equipment. It corresponds to the demarcation point between the access network and the metro backhaul network. In case of dense urban, the tree architecture seems more suitable whereas bus architecture can be considered in case of rural area [7].

The left-hand side of the distribution fiber or 'drop region' of Figure 1's diagram is called the intermediate split while the right-hand side region; nearly to the houses is what we called the immediate split.

3. Smart Drop Protection Schemes

Smart Drop Protection Schemes (SDPS) is employed to implement the protection device by using the 2x1 and 2x2 optical switch used to reroute the signal to the protection line when failure occurs in the working line. The route depends on the restoration mechanism that is activated according to the types of failure. The two optical switches allocated in the transmission line in between ONU and the splitter. The first optical switch is used to switch the signal to protection line at local transmission or switch to protection line at transmission line nearby. The second optical switches (in the immediate split) will switch the signal in protection line back to the original path before sending it to the local ONU. For dedicated path protection, a working path and an end to-end backup path is established, and resources are assigned to it at connection set up time. The hardware design and its implementation at the immediate split will be discussed in the last section.

The mechanisms of protection in FTTH-PON access network in breakdown condition is shown in Figure 2. Purple arrow represents the mechanism of dedicated protection in FTTH access network when there is breakdown occurs at working line. When the failure is detected in working line, protection mechanism will be activated and convert the optic signal direction to the protection line. The purple arrow shows the protection mechanism as dedicated protection. In linear protection PON-FTTH scheme, each ONU is connected to splitter output terminal by two fibers; working line and protection line through two optical switches that is controlled by Access Control System (ACS).

3.1 Condition 1

Figure 2 depicts the failure is detected in working line, protection mechanism will be activated and convert the optic signal direction to the protection line. The purple arrow shows the protection mechanism as dedicated protection.

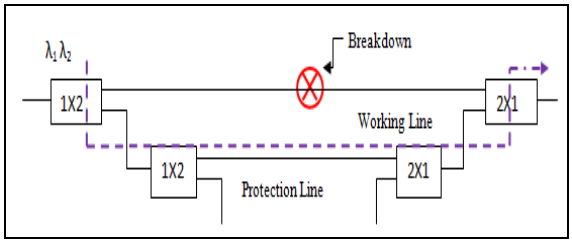

Figure 2 Breakdown at working line and signal diverted to the protection line.

3. 2 Condition 2

Figure 3 shows the shared protection scheme when breakdown occurs in both line in working line and protection line. Shared protection scheme will be activated and optic signal will convert the route to neighbor line protection as depicted in blue arrow.

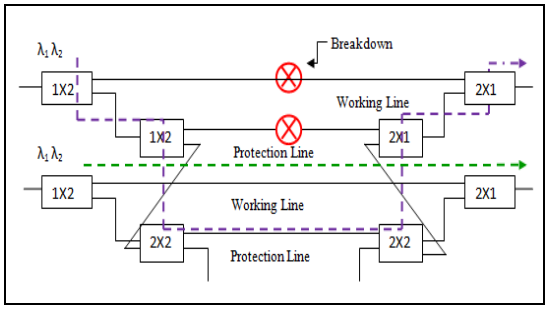

Figure 3 Breakdown at working line and protection line. Signal diverted to the neighbor protection line.

4. Customer Protection Device (CPD)

Here in this paper, FTTH-EPON is somehow upgraded to more cost-effective with capability of providing continuous service to the customer by having the access control system (ACS) with its multifunctional characteristic mentioned in earlier paper. On top of that, we introduce another special device; a customer protection device (CPD) that will give value-added to the network hence providing ease to the customers to perform a fast self-restoration at their own place. Figure 4 below shows the location of CPD in the whole system of i-FTTH network. ACS with Ethernet integrated is using the operating wavelength 1625nm for failure detection control and in-service troubleshooting.

At the customer end, another smart device called Customer protection device (CPD) is introduced to further enhance the level of network's reliability and security. This survivable device must be employed at each user before their ONU and it will focus on the protection scheme at the drop region. In the case of any breakdown in the working line, the protection mechanism will use the neighbor line protection in order to provide the alternative path for the working line.

The monitoring signal section in ACS is responsible for sensing fault and its location whereas generation of activation of signal is sent by activation section in ACS. The activation signal will trigger this device to activate switching mechanism inside the device by means of microprocessor instructions. The switching mechanism is referring to the two types of failure conditions in previous section.

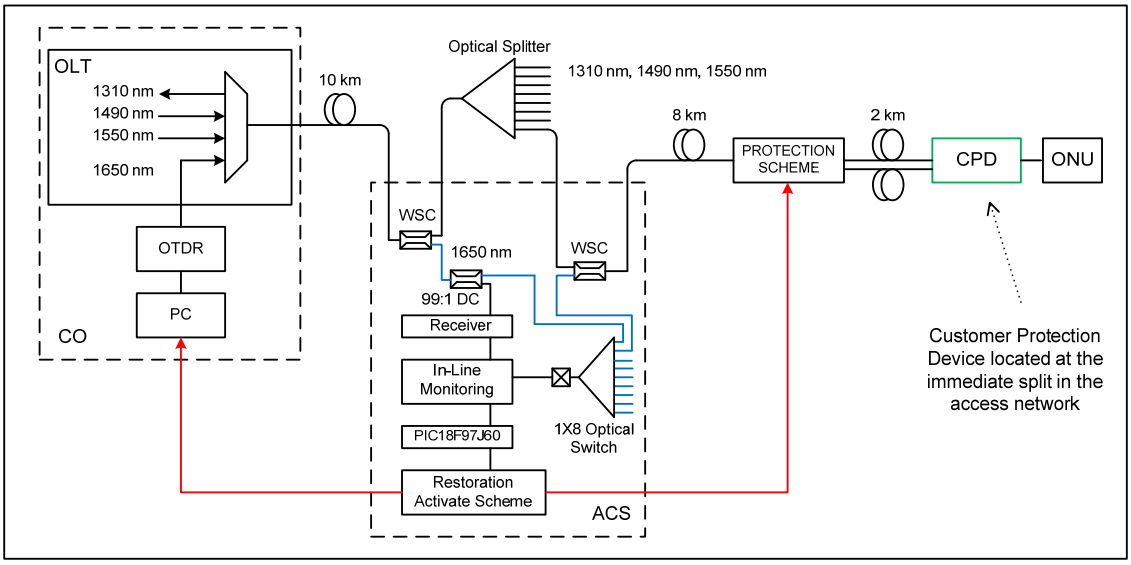

Figure 4 Employment of the CPD in the intelligent FTTH system network

4.1 Hardware Design

CPD comprises of optical switch module and a microcontroller controlled for switching. The device utilizes a microcontroller to handle the switching of polarization voltage +5V and -5V so as to direct the 2 sets of optical switch routing. As proposed in the restoration scheme in FTTH-EPON mechanism, CPD device has a total of 3 inputs and 2 outputs; as shown in Figure 5.

Optical switching delivers strong values in FTTH networks by reducing the cost. One of the advantages of using optical switching comes from operating manual operations. The installation and service activation measurements tests can be performed automatically from the device itself. If customer lose service it is critical to locate and restore the fault as quickly as possible. Optical switching can reduce the time to locate and restore from hours to minute. Hence, switch speeds is also important for protection switching.

A PIC18F97J60 microcontroller (Microchip Technology Inc., Chandler, AZ) is the chosen microcontroller due to its Ethernet integrated feature and full implementations of both Media Access Control (MAC) and Physical Layer transceiver (PHY) modules. Besides that, PIC18F97J60 has low power consumption, reprogrammable flash memory, and low cost. The microcontroller is placed into a socket to allow for removal and reprogramming when changes of 'on' and 'off' is desired. In addition, the 5V regulator and capacitor in the interfacing circuit allow for

the connection of an unregulated DC power supply or a 9V battery to power the circuit.

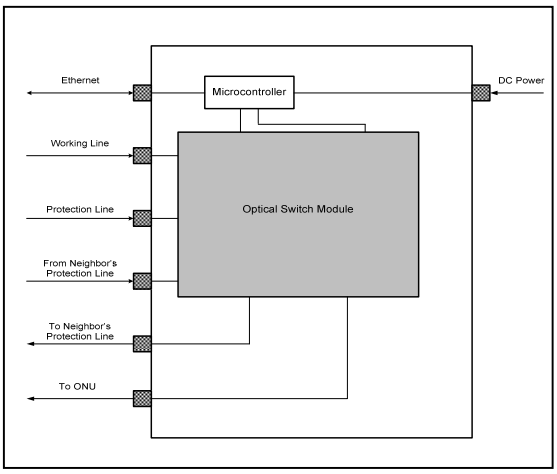

Figure 5 Diagram of CPD hardware circuit design

5. Conclusion

We have proposed the implementation of customer protection device (CPD) based on smart drop protection scheme (SDPS) used in passive optical network for FTTH protection and restoration. The SDPS mechanism will ensure the data flow continuously due to breakdown occur in the network and instantly repair operation. The protection mechanism for tree based optical switch will have capability to divert the signal onto protection line according to the types of failure condition and location of failures in access network. The programmable CPD is a real solution with simple, safe, and flexible characteristic to increase the survivability and security to the end users of FTTH-EPON.

Acknowledgement

This research activity had been conducted in Computer & Network Security Laboratory, University Kebangsaan Malaysia (UKM). The authors would like to thank the Ministry of Science Technology and Innovation (MOSTI), for sponsoring this research through National Science Fund (NSF) 01-01-02-SF-0493.

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Mohamad Syuhaimi Ab-Rahman received the B.Eng, M.Sc and PhD degrees in electrical, electronic and system from Universiti Kebangsaan Malaysia, Malaysia, in 2000, 2003, 2007 respectively. He joined the Institute of Micro-Engineering and Nanoelectronics (IMEN) in 2003. He is currently a senior Lecturer in Universiti Kebangsaan Malaysia (UKM), Selangor, Malaysia. He is also an associated research fellow of IMEN since 2006. His current research interests are in the area of photonic networks and optical communication technologies such as optical security nodes, device fabrication, photonic crystal, laser technology, active night vision, plastic optical fiber, fiber to the home, fiber in automotive and optical code-division multiplexing. The current and interest project is development of survivability and smart network system for customer access network then can be called as an intelligent Fiber-to-the-Home (*i*-FTTH), collaborated with Ministry of Science, Technology and Innovation (MOSTI) of the Government of Malaysia.

Siti Rahayu Hassan received the B.Eng. in Electronic Engineering from University of Manchester Institute of Science & Technology (UMIST), Manchester, United Kingdom in 2001. She is currently an assistant lecturer in Universiti Industri Selangor. She is doing an M.Sc degree in Electrical, Electronics and System department at Faculty of Engineering and Built Environment, UKM particularly in Computer and Network Security Research Group, UKM. Her research area is in FTTH network and its survivability.

Siti Asma Che Aziz graduated from UKM with a B.Eng in Electrical and Electronics Engineering. In October 2008 she joined as a researcher in Computer and Network Security Research Group, UKM. Currently she is doing an M.Sc degree in Electrical, Electronis and System department at Faculty of Engineering and Built Environment, UKM. Her interest is in optical communication and FTTH network.

Kasmiran Jumari is a professor in the Faculty of Engineering and Built Environment, UKM. He received his B.Sc. and M.Sc. in Physics and Instrument Design from UKM and University of Aberdeen in 1976 and 1978, respectively. In 1985, he holds a Ph.D. degree in Electronics from University of Kent. His research is in the area of security system, intrusion detection system, signal processing, image processing and computer communications networks. Currently, he is also hold a position as an associate research fellow in Institute of Space Science (ANGKASA), UKM