Protection route Mechanism for Survivability in FTTH-PON Network

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Summary

This paper described the proposed protection route mechanism and simulation of protection mechanism model in order to achieve survivability in PON-FTTH. Due to large transport capacity achieved by the network, failures which occur cause huge losses of data and greatly influence upon a large number of users over a wide area. Therefore, the survivability of the whole network has to be examined more seriously. Then the smart and intelligent system of FTTH is expected to be a key element which provides centralized monitoring, survivability and instantly maintenance of FTTH customer access network.

Key words: FTTH, PON, protection, failure

1. Introduction

Fiber-to-the-home (FTTH) technology represents an attractive solution for providing high bandwidth from the central office to residences and to small- and medium-sized businesses. FTTH is cost-effective because it uses a passive optical network (PON). What makes FTTH even more interesting is the ease of network testing, measuring and monitoring. These systems follow the same basic principles as standard fiber networks, enabling the use of much of the same gear for installation and maintenance. The development of the single mode optical fiber, with its almost unlimited bandwidth, opened the door to massive deployment of long-haul and metropolitan point-to-point fiber-optic networks. The use of fiber-optic cable rather than copper cable allowed significant reductions in equipment and maintenance costs, and dramatically increased quality of service (QoS). Many corporate clients now have access to point-to-point fiber-optic services [1]. During the construction of an FTTH network, part of the testing occurs at the outside-plant level. This is when the distribution fibers need to be tested, as they are one of the last fiber links before the customer premises. When using OLTS-based methods, it is important to follow the manufacturer's instructions to set the optical return loss (ORL) sensitivity of the test set and to reference the source and the power meter. Once this is done, testing can begin. The ORL measurement is crucial when dealing with high power such as analog video transmission [2]. FTTH is a network infrastructure that is capable of supporting not only the services the cable operators can offer today, but also the services that will be offered in the future. There are many FTTH technologies that could be used to deploy in the field. We can classify FTTH technologies into two groups. One is AON (Active Optical Network) which is a cheap solution, but it includes active devices in the field causing high maintenance and operation cost [3].

FTTH is simply the 100 percent deployment of optical fiber in the access network. It is commonly deployed in two specific configurations. In the first one, fiber is dedicated to each user in the access network. This is called a point-to point (PTP) network. In the second, one fiber is shared (via a power splitter) among a set number of users, typically between sixteen and thirty-two. This is called a passive optical network (PON). There are advantages and disadvantages to the deployment of PTP and PON networks based on financial, bandwidth, and component considerations.[4] PONs are characterized by the "splitting" of the optical fiber one or more times in the field, resulting in the sharing of the optical fiber among multiple users. The fiber in a PON is typically shared by sixteen to thirty-two users. Hence the bandwidth of the fiber originating at the CO/HE is shared among a group of users. The splitting of the network is accomplished by an optical splitter. These splitters can split the fiber one to thirty-two times and, by their nature, introduce inherently high losses in the network. Therefore, their use is limited because of the power budget considerations of the network. A PON will have less optical reach than a PTP network, which does not use splitters. Typically a PON is capable of reaching subscribers 20 kilometers (km) from the original transmitter, which will cover 98 percent of the population. A single 1x32 splitter has less loss than 1x2 and 1x16 or 1x4 and 1x8 cascaded splitters or any combination of 1x16, 1x8, 1x4 and 1x2 splitters in the network [4]. PON technology has three commercialized schemes which are E-PON, G-PON(Gigabit PON) and WDM-PON. The structural strength of E-PON and G-PON is that they use

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two wavelengths that are shared by users. Statistical multiplexing performance is viewed as the most critical performance factor as users share the same bandwidth. E-PON which transports point to multipoint while preserving Ethernet frame format, connects to 32 ONTs (Optical Network Terminals). G-PON which is using GEM (generic encapsulation method) framing connects to 64 ONTs.PON that includes only passive devices in the field. Thus it can avoid the problems of AON, but its deployment cost is a litter higher. Instead of AON technology, PON technology is mainly used to deploy FTTH access network in Korea.[5]

Among the several kinds of optical network architecture, passive branched optical fiber networks have been shown to meet the needs of narrow band customers and to satisfy future upgrading requirements**.** After the installation of such networks, it is important to be able to locate any fiber link faults. A particular problem in this regard is that a fault occurring at one of the branched fibers must be located without affecting the service to other customers. To solve this problem, it is essential to use a wavelength different from the communication wavelength for fault location [6].

2 . PON Architecture Design

Active and passive are two commonly used FTTH architectures for FTTH deployment. Active Architecture is also called as Pont 2 Point (P2P) and Passive Optical Network (PON) architecture is called Point to Multi Point (P2M). Choice of active or passive architectures for deployment depends on the type of services to be delivered, cost of the infrastructure, current infrastructure and future plans for migrating to the new technologies [7]. PON is a point to multipoint (P2M) network. Each customer is connected into the optical network via a passive optical splitter, therefore, no active electronics in the distribution network and bandwidth is shared from the feeder to the drop. The advantage of FTTH PON is the fact that they use purely optical passive components that can withstand severe and demanding outside plant environment conditions without the need to consumer energy between in the central office exchange and the customer premises.

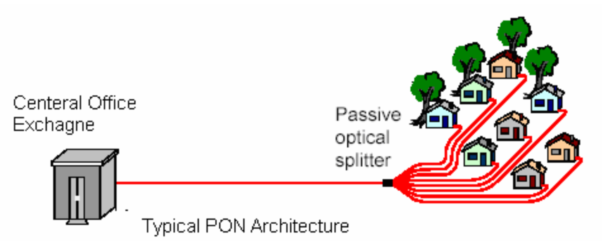


Figure 1 FTTH PON architecture design

The Optical Line Terminal (OLT) is the main element of the network and it is usually placed in the Local Exchange and it's the engine that drives FTTH system. Optical Network Terminals (ONTs) are deployed at customer's premises. ONTs are connected to the OLT by means of optical fiber and no active elements are present in the link.

3 Survivability in PON-FTTH

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). If the breakdown is the detected in drop section, ACS will recognize the related access line by the 3% tapped signal that is connected to every access line. The activation signal is then sent to active the dedicated protection scheme. But if fault is still not restored, the shared protection scheme will be activated. The monitoring signal section is responsible for sensing fault and its location whereas generation of activation of signal is sent by activation section in ACS.

So, this research was proposed to implement the protection scheme by using the optical switch which is used to switch 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 are allocated in the transmission line in which both ONU and splitter are located. A 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 will switch the signal in protection line back to the original path before sending it to the local ONU.

When the failure occurs in the working line, the first optical switches will switch the signal to the local protection line and the second optical switches will be activated simultaneously to switch the signal back to the transmission line. The restoration scheme is referred to dedicated protection similar to that deployed in ring configuration. The interruption in both working and protection lines need the shared protection scheme to be activated. The first optical switches are activated directly but the second optical switch is activated by sending the activation signal utilizing the adjacent protection line by ACS.

4. Protection Scheme Proposed

Figure 2 shows the mechanisms of protection in FTTH-PON access network in breakdown condition. 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.

5. FTTH based design for simulation

The FTTH based network design was modeled and simulated using the Optisystem CAD program by Optiwave System, Inc. Simulation aims to determine parameter value for each component used in FTTH based on proposed protection mechanism and to verify the Error rate for the network. The optical switch can be simulated using this software to see the output value produced for the FTTH based system and it will be compared with the network system. Figure 3 shows the PON-FTTH design proposed to do the simulation. In this simulation, a transmitter that consists of pseudo random bit sequence generator (PRBS) at 1.25 Gbps, NRZ with symmetric rise time and fall time of 0.05 bit was chosen. In this model, an optical switch is used for optical protection and was placed between splitter and ONUs. For the simulation, the optical switch considered in no insertion loss produced to provide ideal condition as well.

The two optical fibers were connected between the transmitter and 1:8 bidirectional splitter (18km) using a bidirectional optical fiber also the other one was linked between splitter and ONUs (2km) by using single mode fiber (SMF). In the downstream direction, at the OLT, two wavelength channels which are 1550nm and 1480nm are multiplexed and transmitted in optical fiber (18km) to the bidirectional splitter. In the upstream direction the 1310nm wavelength was transmitted and it consists of pseudo random bit sequence generator (PRBS) at 1.25 Gbps. Thus, in normal operation the downstream and upstream wavelength travelled through a transmission distance of 20km between OLT and ONUs. The receiver is a PIN photodetector with -25 dbm from the simulation result. The specifications of components in this model are tabulated in table 1 above.

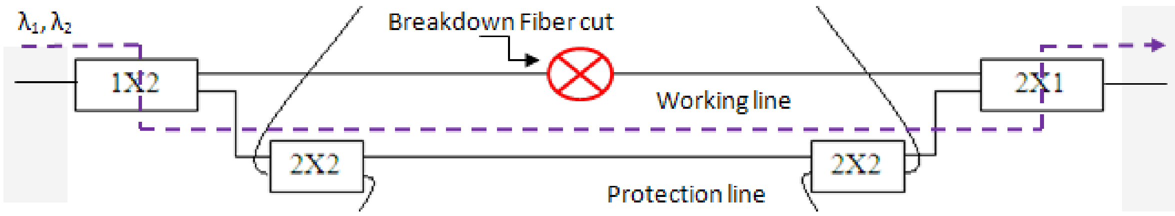


Figure 2 Breakdown occur at working line and signal diverted to the protection line.

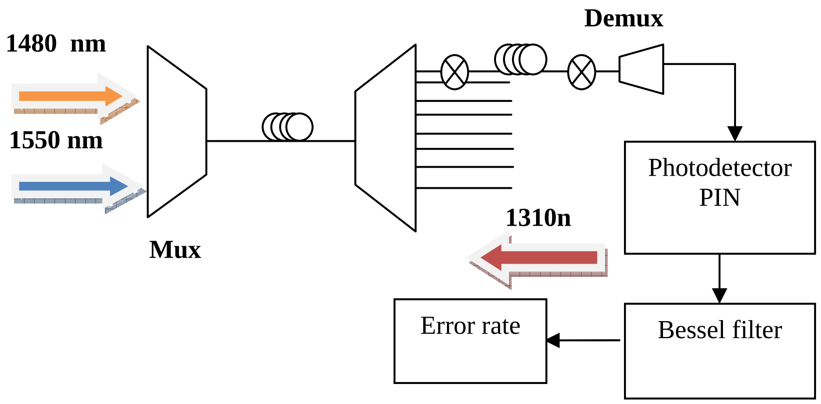


Figure 3 The PON-FTTH network in downstream and upstream direction

Table 1: Simulation parameters

Component	Parameter type	Value
PBRS Generator	upstream Bit rate (Gbps) downstream Bit rate (Gbps)	1.25 1.25 (symmetrical)
Electrical Generator	Rise time/ Fall time	0.05 bit
Light source	Downstream wavelength(nm) Upstream wavelength (nm)	1480, 1550 1310
Modulator	Modulation format	NRZ
Multiplexer/Demultiplexer	Insertion loss (dB)	0.5
Bidirectional Splitter (1:8)	Insertion loss (dB)	5
Circulator bidirectional	Insertion loss (dB)	1
Bidirectional optical fiber	Attenuation constant (dB/km)	0.25
SMF (2km) 16 numbers	Attenuation constant (dB/km)	0.25

5.2 Simulation Results

Our results were obtained by observing bit error rate, eye diagram, optical power levels. Simulation results obtained that minimum BER of 10^{-15}. The length of fiber segment connecting the ONU used as 20km. Figure 5 presents eye diagram of a) received downstream for 1550 nm wavelength b) received downstream for 1480nm c) received upstream for 1310 nm wavelength.

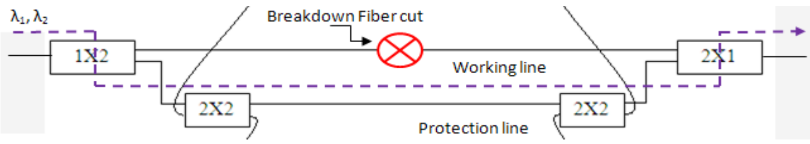
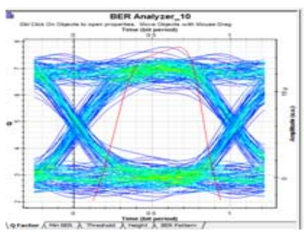
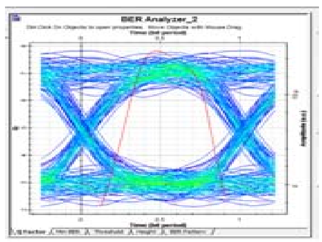


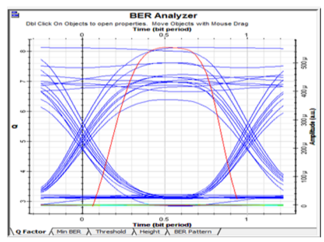
Figure 4 Breakdown occur at working line and optic signal diverted to the protection line



Max Q Factor = 7.78739
Min BER = 3.40237 e -15



Max Q Factor = 7.82702
Min BER = 2.48908 e -15



Max Q Factor = 8.12445
Min BER = 2.6341 e-017

(a) Downstream 1550 nm (b) Downstream 1480nm (c) Upstream 1310 nm

Figure 5 eye diagrams with Max Q factor and min BER value for upstream and downstream direction

6.0 Conclusion

We presented the design, model and simulation results for versatile, resilient passive optical network for Fiber to The Home protection application. To achieve desired network survivability, the different protection schemes are proposed. Employing the optical switch for 1x2 and 2x2 type will ensure the network to restoration scheme since it cover for dedicated and shared protection. Moreover, the downstream and upstream traffic performance has also been measured.

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