Protection Switching against Failure in Distribution Region

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Summary

Protection and restoration mechanisms have been applied in backbone networks, but access networks are not considered significantly in the scope of survivability. In this paper, we propose a cost effective protection scheme for a novel tree-based EPON architecture in distribution region. The protection scheme is capable of fault detection within 2 ms, assuring zero packet loss with the assisting of Access Control System. The Optisystem CAD Software product of Optiwave Inc was used to investigate the system performance and to roof the system feasibility in four failure conditions.

Key words:
EPON, protection, restoration, mechanism, ACS, fault detection, distribution region.

1. Introduction

Fiber connections directly to the consumer have always been viewed as attractive due to their presumed longevity (an unpowered fiber network versus a powered copper network), lower operational costs, and tremendously larger bandwidth compared to copper twisted pair. FTTP gives the service provider to branch out being a single service delivery company to participate in various consumer activities with potentially attractive revenue streams, ranging from communications, to entertainment, to information. It has long been thought that fiber's very significant bandwidth would open the way to new applications by the consumer, but it is only recently with the advent of the Internet and the expansion of copper based broadband that this vision may become reality. Ethernet based Passive Optical Network (PON) technology is emerging as a viable choice for the next-generation broadband access network [1-2]. EPON is a PON that carries Ethernet traffic. EPON FTTH consists of a single, shared optical fiber connecting a service provider's central office to a passive coupler, which is located not more than 19km away from the central office (CO). The passive coupler is positioned not more than 1 km from residential customers, in order to minimize fiber usage. Each customer receives a dedicated short optical fiber but shares the long distribution trunk fiber [3]. One of the recently-introduced standards applicable to fiber-tothe- home (FTTH) networks is the IEEE 802.3ah Ethernet in the First Mile (EFM) standard, also known as EPON (Ethernet passive optical network), or GEPON (Gigabit Ethernet Passive Optical Network) [4].

PON which is point-to-multipoint fiber, with no active elements in the signal's path. All transmissions in a PON are between an Optical Line Terminal (OLT) and Optical Network Units (ONUs). Traffic from an OLT to an ONU is called 'downstream' (point-to-multipoint) and traffic from an ONU to OLT is called 'upstream' (multipoint-to-point). Two wavelengths are used normally 1310 nm for the upstream transmission and 1490 nm for the downstream transmission. In the downstream direction (OLT to User), are broadcasted by the OLT and extracted by their destination ONUs based on their media access control (MAC) address [5].

The downstream signal from OLT is broadcasting for each ONU, and the upstream signal from each ONU needs the multiple point control protocol (MPCP) mechanism to arrange the uplink. When a fiber link between the OLT and ONU is broken (or cut) due to the environment effect, the affected ONU will become unreachable to the OLT [6]. The motivation of passive optical technology in the access space is to provide a cost-efficient transport mechanism to end-users, which is interference-free, bandwidth-elastic, and distance independent between premises and head-end. The general PON topology consists of single mode fiber linking the network optical line terminal (OLT) and the optical network unit (ONU), and the ONU with the optical network terminating unit (NT) with a fiber link that can be (depending on type of fiber) up to 40 km or longer; such distance providing service to all loop lengths.[7]

In this paper we proposed the restoration architecture that can be applied in FTTH EPON especially in drop region (optical splitter to ONU). Any failure occurs in this region will be switched the traffic to the alternative path according to the types of failure. Failure in single working line will divert the signal to protection fiber that bundled together in one single cable. But if

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failure occurs on cable (both fiber damage) has to switch the signal to the other alternative protection line of neighbour connection. The first restoration scheme named as linear protection and the latter is shared protection. Both scheme proposals on survivability have aimed on ensuring the traffic flow continuously from OLT to ONU. This can be done by wisely and well planned on fiber installation during FTTH deployment.

However, although protection of access networks is required to ensure survivability, few studies on protection mechanisms have been achieved. The most commonly deployed protection architectures are 1:1 and 1+1.[8] Figure 1 shows the 1:1 protection scheme. There are two types of 1:1 protection. In the first type, a dedicated protection path is required, but the protection path is allocated to carry low -priority traffic, called extra traffic, under normal circumstances. In the second case, the protection path is not used at all during normal operation, and can simply be used when failure occurs in the working path. In this paper we are proposed to use the second case of 1:1 protection scheme according to the traffic prioritization. High priority traffic is transmitted on the primary path whereas the best effort traffic is diffused on the backup path. In case the primary path breaks, the high priority traffic is transferred to the backup path.

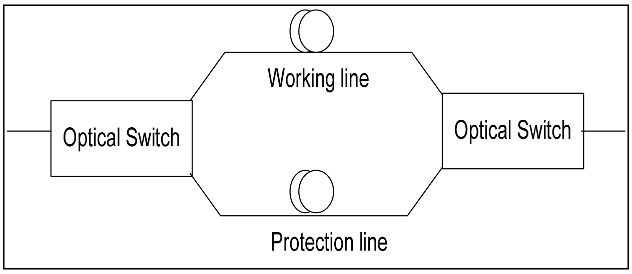

Figure 1 1:1 protection schemes

2. 1:1 Protection Route Mechanism

Survivability in network system will provide the protection and restoration architectures and it continued services in the presence of failures. Protection switching or restoration is the mechanisms used to ensure survivability. The survivability will add redundant capacity, detect faults and automatically re-route traffic around the failure. So the mechanism of restoration for the system was designed to meet the network specification. For our FTTH based design, downstream optic signal with λ_1 = 1480 nm and λ_2 = 1550 nm wavelength will be transmitted from central office (OLT) through the feeder region. Then the optic signal λ_1 and λ_2 will enter the drop region after passing through the optical splitter. So, the optic signal will be divided into 8 route signal in the drop region. In this paper we will discuss on four failure condition when every failure will use a different number of optical switch. The mechanism protection will have four type of restoration scheme. 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 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.

3. Simulation Results for Four Types of Failure Condition

Receiver sensitivity and dynamic range are the minimum acceptable value of received power needed to achieve an acceptable BER or performance. Receiver sensitivity takes into account power penalties caused by use of a transmitter with worst-case values of extinction ratio, jitter, pulse rise times, optical return loss, receiver connector degradations, and measurement tolerances. The receiver sensitivity does not include power penalties associated with dispersion or with back reflections from the optical path. These effects are specified separately in the allocation of maximum optical path penalty. Receiver have to cope with optical inputs as high as -5dBm and as low as -30dBm. Figure 2 represents the measured downstream and upstream dynamic range in dB in four conditions which is in normal condition A, condition B, condition C, condition D are 25.2 dB, 28.2 dB, 28.9 dB and 32.5dB respectively. Failure at condition D gives the highest value of dynamic range since the failure condition uses eight numbers of optical switch to perform the protection and restoration scheme to the network.

Table 1 Simulation parameters used in the simulation

Component	Condition A	Condition B	Condition C	Condition D
Transmitted Power (dBm)	0	0	0	0
PBRS generator (Gbps)	1.25	1.25	1.25	1.25
Demultiplexer Loss (dB)	0.5	0.5	0.5	0.5
Multiplexer Loss (dB)	0.5	0.5	0.5	0.5
Bidirectional Splitter (1:8) Loss (dB)	3	3	3	3
Circulator bidirectional (dB)	2	2	2	2
Bidirectional optical fiber Loss (dB)	0.25x20	0.25x20	0.25x20	0.25x20
Optical Switch Loss (dB)	1.2x2	1.2x4	1.2x6	1.2x8
Total Loss (dB)	25.8	28.2	28.9	32.5

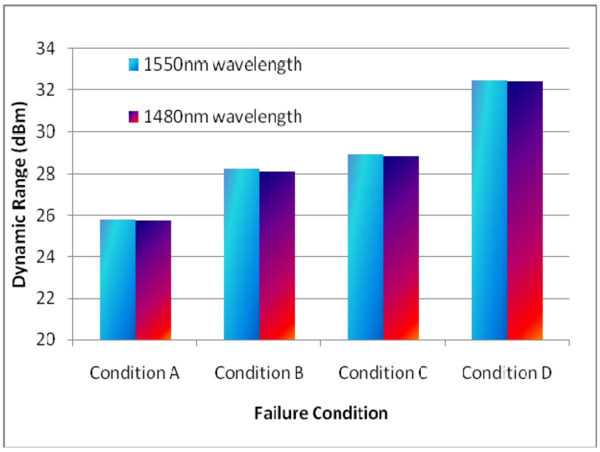

Figure 2 Dynamic range (dB) calculated of downstream and upstream traffics at four failure conditions observed.

So, in our design we proved the system in all four type condition can be implemented using sensitivity -34 dBm. Figure 9 shows the maximum Q factor calculated for four types of condition. The values can be accepted and above the minimum requirement which is 6 (~ BER = $1x10^{-9}$).

CONCLUSION

This paper described the protection scheme included with simulation approached in four failure conditions. In this paper, protection scheme mechanism proposed comprise of 4 different type of condition that require the optic signal to pass through the different number of optical switch. Due to different type of breakdown occur in optic signal route, and then the protection mechanism is differing to each other. For every type of protection mechanism, we employ the dedicated protection and shared protection. According to the three conditions, for the condition A, condition B and condition C the protection route will involve in two, four, and six numbers of optical switch respectively. The survivability of EPON is necessary to provide seamless services and ensure network reliability. Single failure in the line connected will activate dedicated protection while shared protection is activated when both fiber (working and standby fiber) are breakdown. The BER characteristics were measured at 1.25 Gbps and no degradation was observed, as confirmed by a comparison of these simulation results with those obtained from systems without restoration element.

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