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Protection Techniqueusing Multifunctional Optical Switch to Overcome Failure in Long ReachPONSystems

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Abstract:**Survivability Scheme against failure is proposed in the Passive Optical Networks (PON) architecture.A restoration schemes is focused in scattered residence architectures and it is applied in the tree and ring topologies by means of a protection unit called User End Protection Unit(UEPU). Protection technique is implemented with aMultifunctional Optical Switch (MOS)and it is installed before Optical Network Unit (ONU) in PON.MOS is applied in Wavelength Division Multiplexing (WDM) PON system and investigated for (i) without failure scenario and (ii) with failure scenario. The results shows that the receiver sensitivity obtained is -38 dB which is 3dB better than the traditionalProtection method.**

Index Terms: **light Path (LP), Passive Optical network (PON), User EndProtection Unit (UEPU), Optical Network Unit(ONU)**

I. INTRODUCTION

The Telecommunications industry have reachedfar implications for our lifestyles. An optical network provides a common infrastructure over which a variety of services can be delivered. These networks are also increasingly becoming capable of delivering bandwidth in a flexible manner where and when needed. Fiber transmission technology has evolved over the past few decades to offer higher and higher bit-rates on a fiber over longer and longer distances. This tremendous growth in bandwidth is primarily due to the deployment of optical fiber communication systems.

This paper highlights on the restoration scheme and its types for FTTH with a Passive Optical Network(PON). The issue against failure is focussed on PON architecture. Received power at each node for different topologies is analysed.Cost effective protection is made for hybrid PON with significant improvement in resilience , which makes a low cost design[1],[2].

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Maximum nodes to be implemented in topologies and to determining the maximum power output of each optical node. Receiver Sensitivity plays a key role in determining the maximum number of nodes. Number of nodes can be increased or decreased by varying receiver sensitivity. This paper also focuses on variation of coupling coefficient on ring path so as to vary the number of nodes in the ring. Capacity management technique to improve network performance by providing link protection in advance [3],[4].

Analyzes the insertion of booster at the OLT to increase the performance of the network. SOA amplifies the input signal to increase the number of users.Physical layer impairments were been considered in WDM optical networks. End to end path protection algorithm were introduced with impact of four wave mixing in optical networks[5],[6].

A protection scheme for a novel tree based for intermediate split structure (ISS) in the drop region section is implemented.Investigates design methods of protection schemes in survivable WDM networks using the path protection p-trail in order to provide better capacity efficiency by eliminating the rigidness of the protection structure of the well-accepted protection scheme, the failure independent path protection (FIPP) pre-conFigd protection cycle (p-cycle)[7],[8].

This paper investigates design methods of protection schemes in survivable WDM networks that use preconFigd protection structures (p-structures) in order to provide different quality-of-recovery (QoR) classes within 100% resilient single-link protection schemes.[9],[10].A novel logic decision unit in conjunction with a power monitoring unit is implemented in the OLT to enable the intelligent protection switching in more practical operation scenarios[11],[12].

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2. DESIGN METHODOLOGY

Appearing at the customer end (drop region), is a smart device called a User EndProtection Unit(UEPU); introduced to further enhance network reliability and security. If there is a fiber breaks in light path, the protection mechanism uses neighbouring line protection to provide an alternative path for the Light Path(LP). Our linear protection scheme (topology tree) suggests that only a passive optical network using a single port at the central office (central office, CO) to provide n number of users in 1: n ratio of the optical part. The split ratio can be adjusted from 2 to 64. However, the ratio of 32,16, or 8 is usually used. PON uses WDM to multiplex data stream to be carried in a single fiber.

In the proposed protection scheme, UEPU routes can be classified into three failure orders. (i)Failure Order 1 is characterised by the detection of one fiber fault in a light path linefiber. In this case, the optical signal is routed to the neighbouring line for protection and returned to the User End. In Failure Order 2 (i.e., two fiber faults detected in a sequence line), neighbouring-line protection is used as a restoration route to return the optical signal to the original path. Similarly, in Failure Order 3 (i.e., three fiber faults), the optical signal finds a standBy neighbouring- line protection to use the alternative protection path. Fig 1 shows the route of failure order1, order2 and order3 in user end.

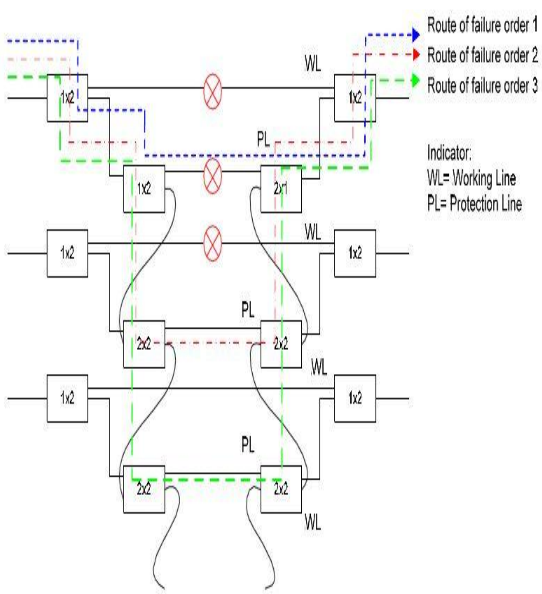

Fig 1Route of Failure order1, 2, and 3 in User End

Multifunctional Optical Switch Design

A basic 2×2 switch contains two inputs and two outputs and exhibits two switching states as follows one is the "straight" state, which is also known as the bar state, and the other is the "swap" state, which is also known as the cross state. A new switching configuration is proposed through an MOS that implements an optical matrix switch for the selection of an optical propagation route between three input and output ports. Optical switch matrices, as key components in the optical communication systems, are the signal routing modules in the optical layer. As for this work, the design of the matrix switch consists of fifteen 2×2 electro-optical switches arranged in a unique manneras shown in Fig. 2 to increase the number of signal routes, maximum 8 routes with good bit-error-rate BER characteristics. The MOS architecture also consists of power splitters and combiners at the input and output ports. The addition of power splitters and power combiners is to fit the MOS into *i*-FTTH network layout.

MOS ARCHITECTURE

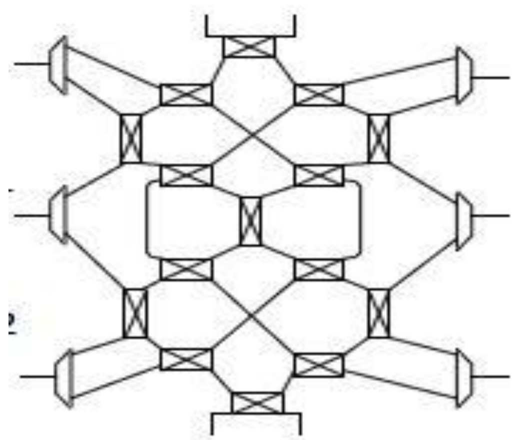

Fig 2
MOS Architecture

The Routes available for rerouting capability offered by MOS device is being classified according to number of optical switches involved in the route. Insertion loss of a single switch is counted as 1.2 dB. Here we compare performance of MOS for three conditions of routing which are (i)Condition A: Route involving 3 switches, (ii) Condition B : Routes involving 4 switches and (iii) Condition C: Routes involving 5 switches. The conditions are discussed as follows

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Condition A: Route involving 3 switches.

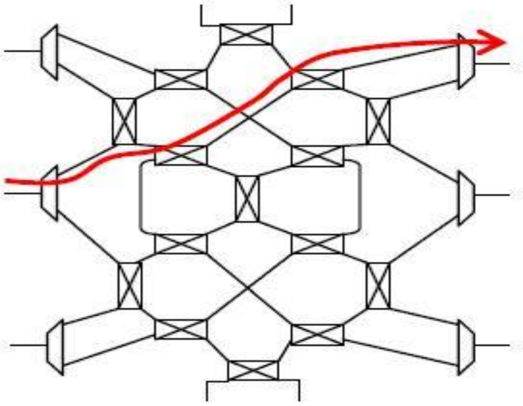

Fig 3. Condition A. Route involving 3 switches

Condition B : Routes involving 4 switches

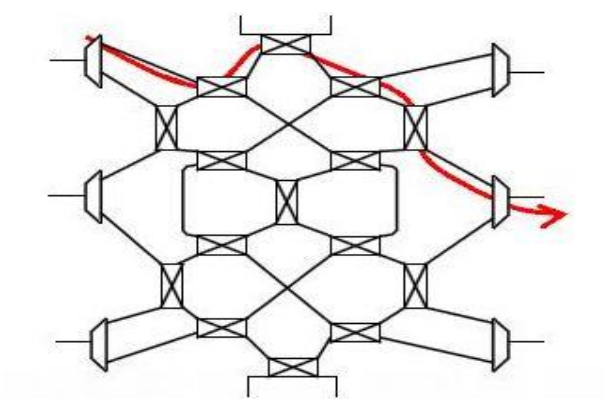

Fig 4. Condition B : Routes involving 4 switches

Condition C: Routes involving 5 switches

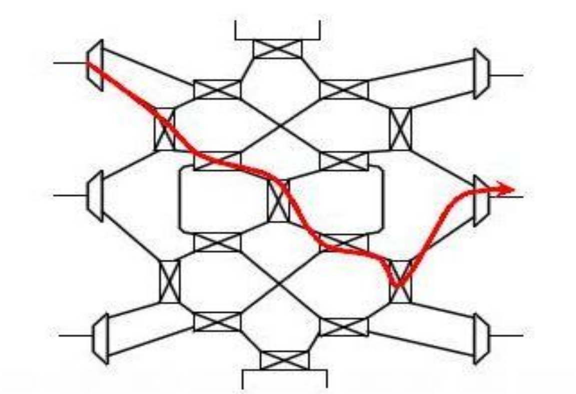

Fig 5. Condition C: Routes involving 5 switches

Simulation model for MOS architectures

Signal routing plays an important role in restoration mechanisms in case of failures. If we have a failure in one possible route it is possible to maintain the signal by letting it pass through another possible path. Simulation of routing the signal usingMOSand compare performances of three failure conditions.

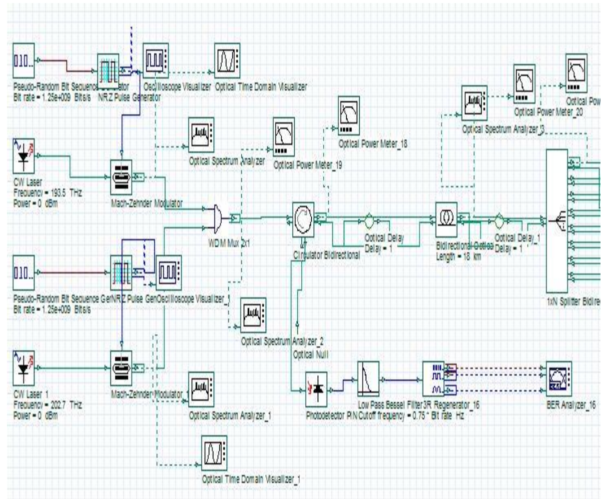

Fig 6.Simulation model for Transmission Unit

Two optical fibers were connected between the transmitter and a 1:8 bidirectional splitter (18 km) using a bidirectional optical fiber; one of the fiber was also linked between a splitter and ONUs (2 km) using a single-mode fiber (SMF). In the downstream direction at the OLT, two wavelength channels with frequencies of 1550 nm and 1480 nm were multiplexed and transmitted over the optical fiber (18 km) to the bidirectional splitter. In the upstream direction, the transmission wavelength was1310 nm. Fig 6 display the simulation model for MOS system at the optical Line Terminal (OLT).

The simulation aimed to verify the feasibility of the system and investigate the performance of the proposed protection-route mechanism based on the GPON architecture. For the simulation modelling, the proposed GPON design contained eight ONUs with a transmission distance of 20 km between the OLT and ONUs. The 1480 nm and 1550 nm downstream signals and the 1310 nm upstream signal exhibited 1.25 Gb/s direct modulation in the test access network, and the output power of the 1480 nm and 1310 nm lasers was 0 dBm. Fig 7 display the simulation model for MOS system at the optical network termination (ONT).

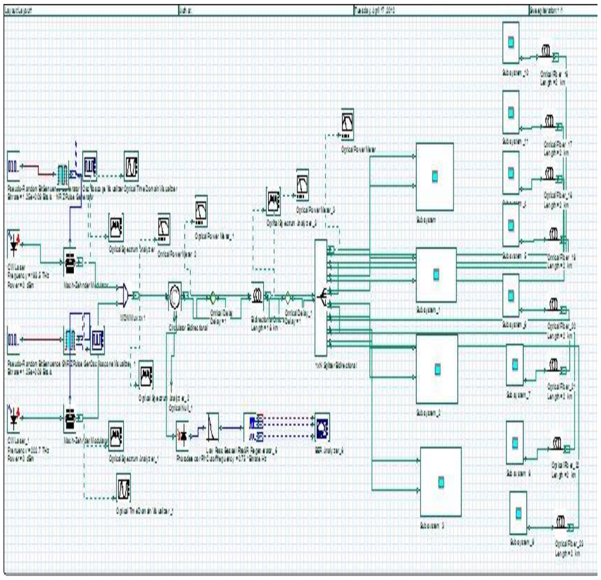

Fig 7.Simulation model for network termination having MOS

The BER performances were measured using a 1.25 Gb/s non-return-to-zero (NRZ) pseudorandom binary sequence (PRBS) with a pattern length of 2^31-1 for the downstream traffic between the OLT and the eight ONUs. The specifications of the components appeared in the MOS model system are listed with their values in Table I. Results were basically obtained by observing BERs, eye diagrams, optical power levels, and dispersionlevels..

Specifications ofMOS Model

Component	Parameter Type	Value
PRBS Generator	Up/Down stream Bit Rate (Gbps)	1.25
Electrical Generator	Rise time/Fall time	0.05 bit
Laser Source Wavelength(nm)	Upstream	1480,1550
	Down stream	1310
Mach Zehnder Modulator	Modulation Format	NRZ
Multiplexer/ Demultiplexer	Insertion loss(dB)	0.5dB
Bidirectional splitter(1:8)	Insertion loss(dB)	3
Circulator Bidirectional	Insertion loss(dB)	1
Bidirectional Optical fiber	Attenuation Constant (dB/km)	0.25
Optical Switches	Insertion loss(dB)	1.2
Power Combiner/ Splitter	Insertion loss(dB)	1
Optical Fiber	Distance	10-100 km

Table I: Specifications of MOS Model

4. RESULTS AND DISCUSSION

Simulation Results for MOSModel:

InMOS Model the receiver sensitivity needs to be adjusted to -38dBm for much better signal and longer length.But for the traditional model the receiver sensitivity of -35 dBm is enough to sustain the signal . The eye diagram for MOS in the downstream transmissions is obtained to be at -38dBm sensitivity.

Maximum Q factor vs Distance

The study also includes the distance analysis when OMS is being simulated using the sensitivity of -38 dBm. MOS has reported that in order to perform protection and restoration scheme up to order 3,an optimum receiver sensitivity value of -35 dBm was chosen for a 20km network of 8 users. If we need to increase the length, the sensitivity should be increased too to ensure good receiver performance.Fig 8 shows the Maximum Q factor vs length for -35 dBm sensitivity for OMS for downstream signal of 1550nm.

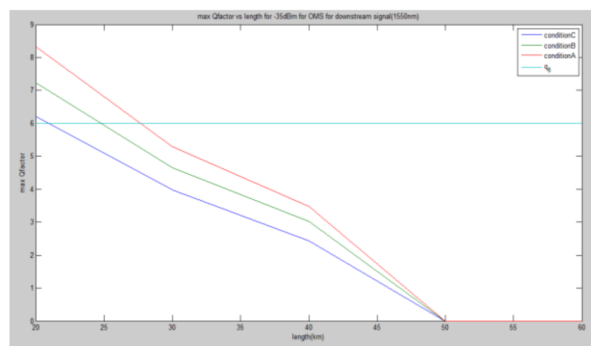

Fig8 Maximum Q factor vs length for -35 dBm sensitivity for OMS for downstream signal of 1550nm

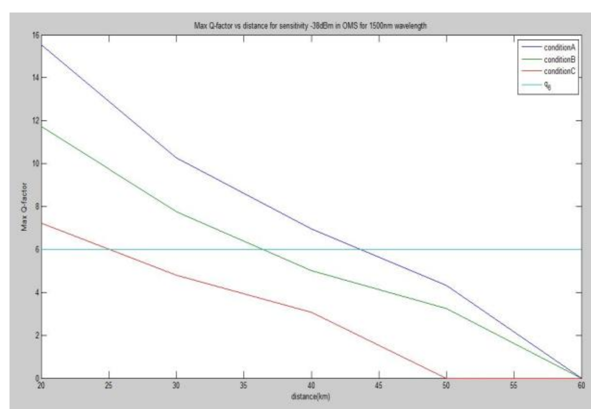

Fig 9Maximum Q factor vs length for -35 dBm sensitivity for OMS for downstream signal of 1480nm

Fig 9 shows the Maximum Q factor vs length for -35 dBm sensitivity for OMS for downstream signal of 1550nm.The OMS is capable to have a maximum fiber length of 28 km at condition A, 25.5 km at condition B and 21.5 km at condition C. In OMS, different class of failure order implies the different number of switches employed in different condition. A much longer fiber distance can be achieved when receiver sensitivity -38 dBm is considered. Maximum distance for condition A is now 43 km, 36 km for condition B and 24.5 km for condition C.

Output power vs distance for OMS for the three failure conditions

Km	**Condition A (dB)**	**Condition B (dB)**	**Condition C (dB)**
20	-31.085	-36.473	-38.352
30	-33.085	-38.473	-40.352
40	-35.085	-40.473	-42.352
50	-37.085	-42.473	-44.352
60	-39.085	-44.473	-46.352

Table II Output power vs distance for OMS for the three failure conditions

Table II shows the distance vs output power obtained for three failure conditions. At 20km min power obtained to be for condition C and max power obtained for condition A. Similarly for other distances also. It shows that for condition C no of switches more which increases the losses. ThereforeS use optical amplifiers to compensate it.

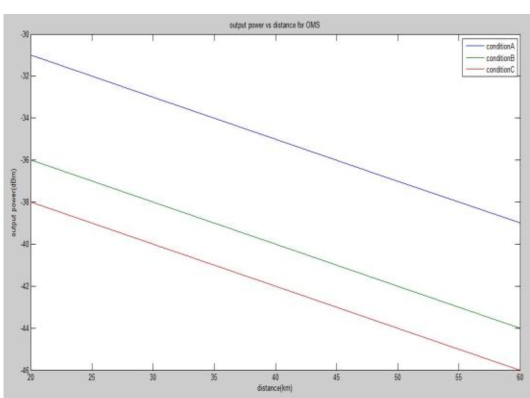

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Fig 10.Output power vs distance for OMS for the three failure conditions

Fig 10 shows a straight decrement line when the fiber line is increased for the three failures condition in MOS protection network when a lower sensitivity is implied (-25dBm). The highest ouput power obtained by the normal condition for every increasing unit of distance. Failure order 3 has the least output power at higher fiber length. Reachability of maximum distance is also depends on the sensitivity used; for example in order to achieve distance more than 20km for failure order 3, a higher sensitivity should be used for the entire protection network. At 40km, output power obtained by Condition C is significantly higher.

5. CONCLUSION

The WDM PON network is being simulated investigated and analyzed for failure conditions and a technique is proposed to provide an protection by means of tree network and ring network.For zero fault condition the ONU closer to the common splitter receivers almost same power and same Q -Factor. The far ONU receives less power. The ONU from common optical splitter have the common characteristics of variation of output power for increasing distances. Q factor determines the maximum achievable distances for the nodes to be placed, so that a signal could be reached during failure conditions. The obtained maximum achievable distances can be increased by increasing the sensitivity value at the receiver. The receiver sensitivity is changed by changing the thermal noise value. We have estimated the maximum achievable distance for different coupling ratio's and different sensitivity. It shows that the distances increases for higher sensitivity.

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