Fault Tolerance in Passive Optical Networks: A Survey

Authors
Saroj Saini¹, Ashok Kumar²

¹Department of Electronics and communication Engineering Ambala college of Engineering Applied Research Ambala, INDIA
²Department of Electronics and communication Engineering Ambala College of Engineering Applied Research Ambala, INDIA

Email- swtsanju98@gmail.com, ashokcalicut 1993@gmail.com

ABSTRACT
Passive optical networks play an important role in fiber access system in the world today. Time division multiplexing-passive optical network is a fast emerging architecture that uses only passive components. In wavelength division multiplexing, passive optical network each light path can carry a huge amount of traffic failure may damage the end user applications. Hence fault tolerance has an important issue on this network. In a survey Studies many architectures, protocols and techniques to remove or overcome failures in the access network. Also in this survey study, methods for recovering from channel failures, link failures and node failures. In this paper we discussed the performance of the survey. Survivability is a critical issue in a wavelength division multiplexing optical networks.

Keywords- PON, WDM, Fault Tolerance

I. INTRODUCTION
With the integration of Electronic and Communication technologies and the optical fiber communication techniques, Telecommunication networks are gives the fastest and high quality services to the users. Optical and Wireless networks are initially developed for many or different communication scenarios. Optical networks are mainly used for high bandwidth and long distance communication [1]. Optical fiber, becomes the dominated transport medium in the telecommunication systems because of its advantages in scalability, capacity, cost and reliability. Now a day’s optical fiber is the backbone of the networks [2].

Passive Optical Networks (PON)
In telecommunication networks passive optical networks plays an important role in that time. In which passive components are used. Because of its important they gained more attention in the industry world. It is developed by a single fiber, in which unpowered splitters are used to transmit signal to multiple end points. PON includes of a optical line terminal (OLT), optical network units (ONUs) and optical network terminals (ONTs)at the end point. It is a form of fiber optic access network. For Time Division Multiplexing Passive Optical Network(TDM-PON), a passive splitter is used in the optical distribution network (ODN). Each ONUs and ONTs are bust multiplexed in the time domain [3].

Wavelength Division Multiplexing (WDM)
WDM is the backbone of passive optical networks. The next generation transport networks called intelligent optical network that is a wavelength division multiplexing networks. They are based on passive optical components [4]. Definition,(Transmit the data in multiple streams, with the help of exclusive properties of fiber optics). In WDM , light path carry a huge amount of data, also they provided the capability to transfer
the whole data at high speed over large distance. In a single fiber independent signals are transmitted in different wavelengths. The wavelength determines the communication path by address of origin, destination or routing [5].

**Fault Tolerance**
In WDM, light path can carry a huge amount of traffic; failures may seriously damage end user applications. So, Fault tolerance is an important issue in the passive optical network world. The ability of network, which tolerates or handles the faults (failures), is called as fault tolerance. There are three main type of fault scenarios are, channel fault, link fault, node fault.

Channel Fault: This fault is occurred when two nodes are failed between on a link in a single channel. This fault can be recovered by routing using another spare of channel.

Link Fault: Fault occurred caused by a fiber cut. It can be recovered by a using separate protection fiber.

Node Fault: when the WADM node is failed in a system then node fault is occurred. It is complex scenario in all of three[6].

Mostly, common schemes are used to tolerate the faults (failures) i.e.:

Path protection
Path restoration

Path Protection: It provides a backup path or route to each circuit in the network deigning time. There are two types, first is Dedicated Path Protection, in which single back path provided that’s the way it is also called as 1:1 path protection. And the second is Shared Path Protection. Fig. 3 shows the protection switching. Path Restorations: It will provide an end to end backup route to the source and destination. When a fault occurs in the network, then path restoration is used. If no routes are found or available that’s means connection is failed [5] [6].

**Survivability**
It is a network capability which provided a continuous service even in the presence of faults. It is recovered the network from fault and is the most important requirement of the networks. On WDM networks the survivability had focused on the recovery from node failure or single link failure. This is a combination of two factors i.e.

It is easy to plan for a faulty one piece of a equipment at a time.

In optical networks, cable cuts are common.

**Organization of the Paper**
Section II describes the Literature Survey. Performance measurements which are based on a survey are given in Section III. Section VI concludes the paper. Future work explained Section V.
II. LITERATURE SURVEY

To reduce the traffic and Bandwidth efficiency in optical networks, Sub-OLT DBA in starring based EPON architecture was proposed by Z.D Shyu and I.s Hwang at 2013. It improves the delay and performance of the system between ONUs. The DBA operates on ring topology, where OLT control and dedicates time slots. The EF traffic of each ONU is sent by tree structure and AF and BF traffic of each ONU is transmitted by ring architecture [3]. Maged Abdullah Esmail, 2013 presents a survey of Physical layer monitoring techniques for TDM-passive optical network. Passive components are only used in between the customer and the center office in Time Division Multiplexed- Passive Optical Network (TDM-PON). For high service quality PON operators need a monitoring system for the physical layer. In TDM-PON, OLT transmits the downstream signals. It operates like a master of the network, the operation of the ONUS was controlled by OLT [18]. In 2012 RPR-EPON-Wimax network architecture for access and metro network [13] was described by Abdou Ahmed and Abdallah Shami. It is reliable due to the dependability of the RPR standard and the protection mechanism in the EPON. The group of Wimax include in the first end of the networks that are turned by the backhaul optical segments that rooted in the RPR ring network. To transfer the huge amount of data burst switching network are used. Paramjeet Kaur, 2012 proposed the fault tolerant algorithm for optimization of blocking probability in optical burst switching (OBS) network. The blocking probability of the network is improved then pervious algorithm which introduces by Hardeep Singh et.al in 2011 [15]. Lei Guo proposed a new heuristic algorithm called multi domain Hamiltonian cycle protection (MHCP) for blocking probability and less complexity, 2010. Proper link selections and to manage load balancing author also presents the link cost formulas. G. Ramesh and S. Sundara Vadivelu, 2009 proposed a reliable and fault tolerant routing algorithm for primary and backup paths in optical WDM networks. It will increase the throughput and performance of the channel [5]. In 2009, N. Correia was proposed joint wireless and optical survivability planning with efficient spectrum reuse. Multi radio WOBANs aimed at obtaining a fault tolerant network [1]. Avinash Karanth Kodi presents an optoelectronic architecture called as ND-RAPID for HPC system [9]. It will provide fault tolerance and improved the performance of the system via DBR. OTIS swapped network with a connected basis network able for the maximal fault tolerance property was proved by Weidong Chen. In [11] proposed the method for parallel path between OTIS network nodes. A survey on hybrid wireless – optical broadband – access network (WOBAN), 2007 Suman Sankar was explained. It is a promising architecture for future access networks [8]. The architecture for implementation called as SOME-BUS (Simultaneous Optical multiprocessor Exchange Bus) described in 2004 by Constantine Katsinis. It provided the recovery memory in each processing and fault tolerance. Network traffic was reduced and increase the processor utilization significantly [12]. Fault tolerance capability of three stages (input, middle or output stage) rearrangeable Clos network is analyzed in [14]. A new model and an efficient, fault-tolerant routing algorithm for Clos network presents by Yuanyuan Yang, 2004.
reliable and scalable architecture (CCN architecture) of IP based control plane of OTNS was proposed in 2002, Ramesh Nagarajan [10]. This is based on multiprotocol label switching (MPLS) protocols. In 2001 A. Nucci and B. Sanso, defined a new methodology for the design of fault tolerant logical topologies in wavelength routed optical networks [7] that supports both unicast and multicast IP datagram flows or exploit the wavelength division multiplexing. They also proposed a numerical approach called joint optimization. Complexity of previous disjoint optimization (HDAP algorithms) was overcome by joint optimization. Survivability[2], a very important issue in WDM networks. Dongyun Zhon and Suresh Subramaniam present a survey on survivability in optical network in 2000. In 1999, proposed a set of efficient algorithm for reliable or unreliable WDM network and new cost model for multiple point to point routing, multicast and multiple multicasting by Hong Shen [16]. Optical networks suffer with many faults, Ornan (Ori) Gerstel [6] presents the recovery schemes for failures (faults) i.e. channel fault, link fault and node fault in 1998.

### III. PERFORMANCE MEASUREMENTS BASED ON A SURVEY

**Blocking probability**: Difference between the numbers of total connection requests to number of blocked connection requests.

**Traffic**: It ceases when no. of users used a single network or no. of requests in a channel.

**Delay**: When transmitted data, then in receiving end it not receive at a given time. Then delay is occurring.

**Capability**

**Fast Failure Tolerance**

**Reliability**

The performance of the system or optical networks depends on these measurements. Different algorithms, architectures and techniques are used to improve the performance of passive optical networks.

**MHCP (Multi-Domain Hamiltonian Cycle Protection) algorithm**

In 2010 Lei Guo proposed this algorithm to overcome the Blocking Probability, Resource Utilization Ration and Complexity. This algorithm is based on the Protection mechanism. Path Protection and Shared Protection schemes are considered in Protection Mechanism. The protection mechanism depends on Hamiltonian Cycle. The Hamiltonian Cycle 1-2-3-4. Hamiltonian Cycle Links can be divided into On-Link and Straddling Link. If the On-Link failed it will be protected by the residual routes on Hamilton Cycle. In case of Straddling link fail, then it can be protected by another two routes. In a MHCP algorithm author presents the Local Hamiltonian Cycle (LHC) that is based on physical topology and Global Hamiltonian Cycle (GHC) based on the virtual topology. This topology is protected a multi-domains from inter-fiber link and intra-fiber link. Also in a multi domain optical network single fiber link failure can be tolerated by MHCP algorithm. Improve the performance of the network or blocking probability reduced by using the load balancing method in the paper. Also author compared the MHCP algorithm to MSP algorithm (Multi-domain Shared Protection). MHCP can provide the lowest probability, then MSP. Acc. In performance it will 40% better than MSP. Because of lower blocking probability MHCP had a good resource utilization ratio. MHCP contains a faster run time result is less complex, than MSP.

**Fault Tolerant Algorithm to Minimize the Blocking Probability**

In 2012 paramjeet Kaur presented a fault tolerant algorithm to minimize the blocking probability in optical burst switching network. Here we explain the steps which are defined in this paper.

**Step 1**: We select the optical burst network source and destination in which we want to transfer data.

**Step 2**: All routes are defined which are in between the source and destination.

**Step 3**: To find all paths which are possible from source to destination. Also apply the Dijkstra algorithm in which we consider the shortest path for transferring data. And also calculate the Candidate Distance for each node. Given below:
Candidate distance = distance from the solved node + length of arc  

Step 4: Next than arrange all the paths in increasing order from source to destination.  
Step 5: Select the shortest path.  
Step 6: Check fault on the selected path if the fault occurred on this path then select another path which is not faulty. If no fault occurs then calculate the blocking probability for each node. For calculating blocking probability it will use the Engset formula in eq.

\[ P_b(T, C, S) = \frac{C^T \left( \frac{C}{T} \right)}{\sum_{i=0}^{T} C^i \left( \frac{C}{T} \right)} \]

Here \( T \) denotes the traffic intensity, \( C \) denotes the number of circuits in group, \( S \) denotes the number of sources of traffic.  

Step 7: Then all calculating blocking probability for every path arrange in the increasing order. Which consider the minimum blocking probability select this path.  
Other parameters are used to reduce the blocking probability.  
No. of servers = No. of Users then Blocking probability is zero.  
Also increase the no. of servers, then blocking probability will be reduced.  
By using this algorithm blocking probability will be reduced up to 0.94.

A Fault Tolerant in Mechanism on Star-ring Based Ethernet Passive Optical Networks  

In 2013 Z.D Shyu, I.S. Hwang and I.C. Lin Proposed A fault tolerant mechanism on starring based on Ethernet passive optical network. To overcome the traffic or delay issues in the EF and AF this architecture is presented. In a tree topology data will be transmitted to a central node from the node. May causes a performance wastage. So improve or solve this issue by the sub-OLT proposed star-ring based EPON architecture. Control the traffic in the ring and provided the high reliability or low cost. To protect the link fiber and ring fiber from fault. This architecture is based on the tree topology structure and it transmitted the in a ring network at the speed of light. Here consider the Dynamic Bandwidth Allocation algorithm for a Sub - OLT and OLT in the star ring architecture and ring network can be designed by both ONU and Sub-OLT components. This architecture used the dual optical fiber that supported the backup for one another.  
In fault tolerance, the author proposed the protection mechanism featured in the ring architecture. It will detect the error and recovered this fault. DBA operates in a ring topology here it controls the OLT and time slot to report message by MPCP for EPON. In which report message and transmitted data by ONU. ONU can be exchanged with next or another ONU in a ring. DBA algorithm is used to secure the time slot for the next cycle. This is avoiding the data collision. In the tree structure EF and AF traffic transmitted of each ONU.

IV. CONCLUSION  
In optical WDM networks, since each Lightpath can carry a huge amount of traffic, failures may seriously damage the end-user applications. Hence, fault-tolerance becomes an important issue on these networks. The performance of any optical network can be measured on various parameters such as blocking probability, speed, cost, failure rate, etc. Various algorithms and techniques had been proposed to measure, control and improve all these parameters. But still a lot of improvements can be done on these techniques to achieve desired results.

VI. FUTURE SCOPE  
In optical networks, many failure issues these are very interesting topics for future work. In future Survivability is a critical issue in a WDM optical network. Joint optimization is now very large in term both
lost traffic and maximum congestion level. The performance of parameters will be better in the future, for example, blocking probability, capability, traffic and delay.

REFERENCE