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Performance Evaluation of Survivable Fiber-Wireless (FiWi) Access Network

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Abstract

FiWi support high speed transmission rate, hence any kind of failure may result in huge data loss. To prevent this, there is a requirement to design more survivable and reliable network. In FiWi networks there are two types of failures viz. ONU level failure and segment /OLT level failure. In the present work, to handle segment level failure, we propose an efficient algorithm viz. "Fully Mesh based protection scheme". In the proposed algorithm we connect backup ONUs from each segment in a fully mesh fashion. Simulation result shows that proposed algorithm improves network survivability in terms of reduced blocking probability.

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Keywords: Fiber-Wireless (FiWi) ; Survivability; Blocking probability; Ring Topology; Mesh Topology

1. Introduction

The explosive growth of bandwidth intensive applications is creating the need of lower cost, higher bandwidth and flexible networks. The example of existing access technologies are PON (Passive Optical Network) and WMN (Wireless Mesh Network). PON offers high bandwidth and better stability but it is limited by the use of expensive optical devices. WMN provides services in flexible manner but it is constrained by limited bandwidth.

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Therefore integration of technical merits of both PON & WMN networks results in a new technology, viz. "Fiber Wireless access network (FiWi)"[1-4]. FiWi offers flexibility to users to access broadband services with high data rate at lower cost.

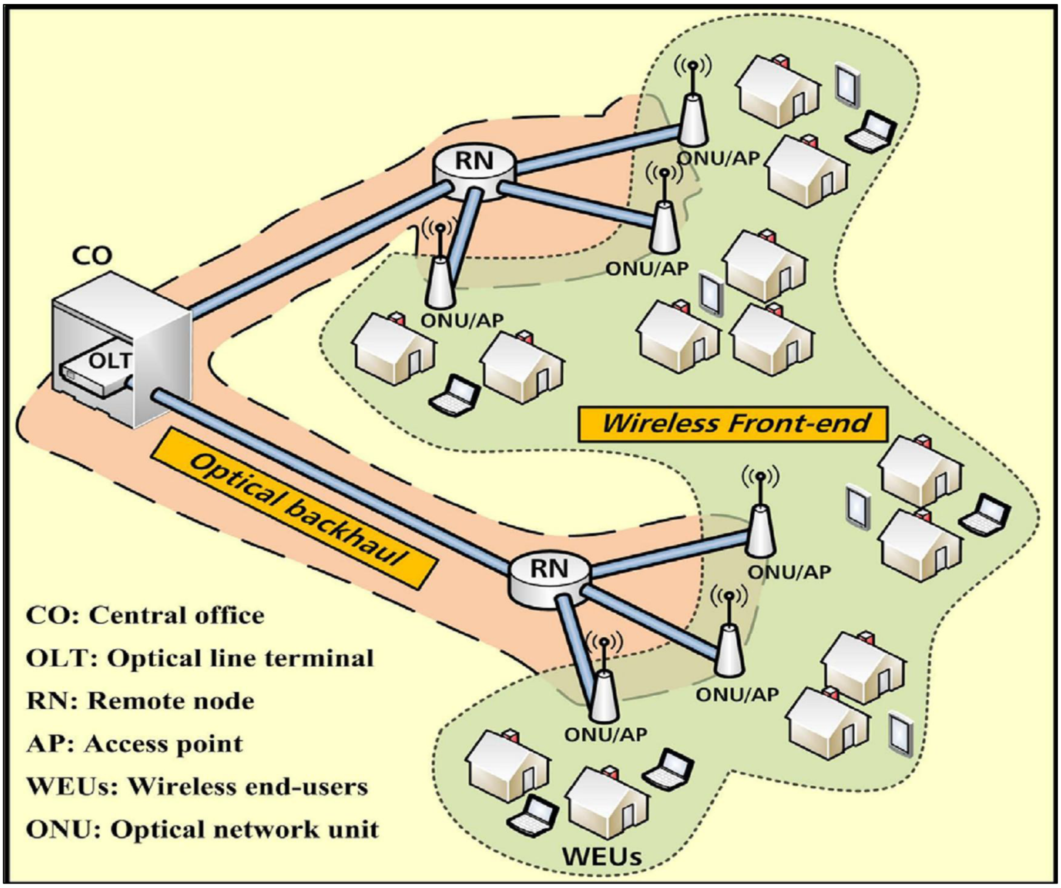

Fig. 1. FiWi architecture.[1]

In Fig. 1. , we show the architecture of FiWi network (a tree-mesh topology network). The network consists of two parts, one is front end which includes WMN and another is back end which includes PON. Front end consist of wireless routers and network users (located in different geographical areas), connected to each other in a mesh fashion. Whereas back end consist of optical cables connected to different ONU's (with a wireless gateway) in a tree topology format. In FiWi networks, these ONUs play very important role to establish FiWi network as it interface front end and back end by converting signal in wireless-optical-wireless format. FiWi is meant to provide high data rate, hence survivability of the network becomes a critical issue. The survivability[5-7] is defined as the ability of network to provide services even in presence of failure in the network. The failures in the network may occur either on front end or on back end. Because of the mesh structure, the front end exhibits self healing property, hence the chances of failures are less in front end. On the other hand, back end consist of tree topology which results in higher blocking chances due to less number of rerouting paths. So, the failures at back end are more severe than wireless front end. We can classify failures at the back end into two categories[8]: ONU level failure and segment or OLT level failure. The schematics of ONU level failure and OLT level failure are shown in Fig. 2. and Fig. 3. respectively.
In ONU level failure, one of the distribution fiber fails whereas in OLT level failure, feeder fiber fails which results in huge data loss in FiWi network.

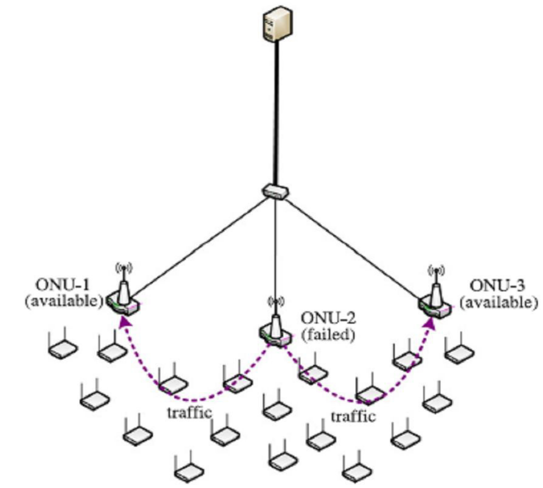

Fig. 2. ONU level failure. [9]

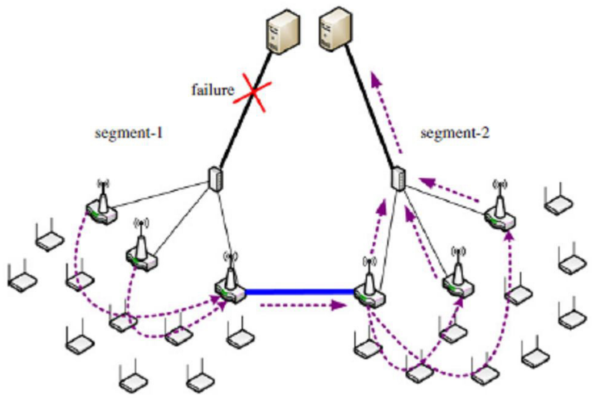

Fig. 3. OLT level failure.[5]

The rest of the paper is organized as follows: In Section 2 we summarize the previous work on survivability of a FiWi network and its related terminologies. In section 3, we discuss about the proposed work in detail and simulation results are shown in section 4. Section 5 concludes the work.

2. Related Work

As stated earlier that FiWi expected to support high data rate, hence survivability and average packet delay are the mandatory terms for concern. Various algorithms were proposed to increase the survivability level of FiWi networks.

The author in[10] proposes an algorithm which provides an efficient solution for protecting packet delay in the wireless front end. In this algorithm author predicts wireless link states periodically. After analyzing the links, author assign weights to each link according to the delay offer by them in such a way that minimum delay link will assigned by minimum weight. Now from these minimum delay paths author chooses optimum path to transmit the data, which reduces the delay efficiently. To modify DARA[10] in terms of increased survivability and failure awareness, the author proposes RADAR[11] ("Risk-And-Delay Aware Routing) algorithm. RADAR protects front end from different types of failures and also reduces successive packet delay among different users. Taiming Feng and Lu Ruan[12] propose an algorithm to protect FiWi against different failures and it is also more cost-effective than RADAR. This algorithm protects the network from different failures with minimum cost by heuristic solutions. The author considers some new assumptions other than RADAR to make the algorithm better. The author selects one of the ONUs randomly from each segment as a backup ONU and then deploys backup fiber among this backup ONUs. When a segment fails the traffic of that segment will transfer to its neighbor segment via backup fiber connected between them. Each segment will connect with at least one of the segment in the network. The OBOF[13] (optimizing back-up ONUs selection and backup fibers deployment) algorithm was proposed which is better than heuristic solution proposed in preceding algorithm in terms of cost-effective networks. The author also concerns on the optimum selection of backup ONUs because if we select backup ONUs in random fashion then it will results in increased retrieval cost to recover the affected traffic. The author implements the algorithm in two steps viz. Backup ONU selection and Backup fiber placement. Backup ONU from each segment is selected by SA (Simulated Annealing) algorithm whereas EGCE (Enhanced Greedy Cost Efficiency) algorithm is proposed to deploy backup fiber among backup ONUs from each segment. Author implements EGCE algorithm in two different ways; one is RBS (Remote Backup Segment) method which shows, how to use residual capacity of remote segments in an effective manner. Second is BLB (Bound on Length Backup-Optical-Path) method which limits the recovery time increase by RBS method during communication with remote segments. Author further carried his work to reduce the network cost by using graph theory and termed algorithm as "Auxiliary Graph Based Protection (AGP) algorithm[8]. In this algorithm author selects one backup ONU from each segment randomly and then deploy backup fiber among them in such a manner that each segment has one backup segment via backup ONU pairs. The algorithm works more efficiently than OBOF in terms of optimum path with least delay. The algorithm solves the problems of Maximum Protection Minimum Hops Number (MPMHN) and Maximum Protection Minimum Backup Fibers Length (MPMFL) more accurately and improves the network performance by reducing the fault chances. For survivable converged optical and data center networks author proposed an algorithm WRBR[14] (Wireless rerouting and backup radios). This algorithm protects FiWi against single segment failure by placing wireless routers and configuring backup radios in a cost efficient manner. The author allocates a primary ONU with several backup ONUs via backup radio paths. The allocation of backup ONUs and wireless backup routers in the network are done by mixed integer linear programming (MILP) and heuristic solution.

In the above mentioned work only single segment failure is considered. For multiple failures these algorithms will fail to serve. Therefore to protect the network against multiple failures, author propose Ring based Protection considering Multiple Failures (RPMF) [15] algorithm. The backup ONUs from each segment will connect to one another in a ring fashion via backup fibers. This architecture offers improved system performance, as it offers two optical paths for each segment to reroute the affected traffic. Y. Liu et. al.[16] proposes an algorithm which protects FiWi from different level of failures in the network. To protect network against ONU level failure, SBR (Sharing Backup Radios) algorithm is proposed, in which each ONU will connect to its partner ONU through a backup radio path. On the other hand to protect network from OLT level failure, SPR (Shortest Protection Ring) algorithm is proposed. The author implements SPR algorithm in two ways: Genetic algorithm and Backtracking method. By genetic algorithm clustering of segment is done and by Backtracking method shortest ring path is determined among various segments to connect backup ONUs.

Though these algorithms provide better solution in case of multiple failures but to further enhance network performance, we propose another solution viz. fully mesh topology based scheme.

3. The Proposed Scheme (Fully Mesh scheme)

After analysing the existing Ring solution for protection against multiple failures i.e. RPMF and SPR algorithms, we came to a conclusion that if both the backup optical paths fail simultaneously then that segment will completely detach from the network which results in huge data loss. Therefore to make a network more survivable we propose an efficient solution called Fully Mesh topology based protection scheme supporting multiple failures. The proposed solution provides better reliability, survivability and reduced blocking probability than the existing ring scheme. Let us compare the proposed work with the existing ring scheme in order to evaluate its performance. We consider four segments: – S_1, S_2, S_3, and S_4 which are connected to each other in ring and mesh fashion as shown in Fig. 4. and Fig. 5. respectively. When OLT level failure occurs in both schemes at segment S_1, then segment S_1 loses its connections with the OLT. To prevent the data loss in the segment, all the ONUs of segment S_1 transfers their traffic to the backup ONU through the wireless path. Then backup ONU transfers this traffic to neighbour segments as per the residual capacity available. Now, in case of ring scheme, we have two backup optical paths to reroute the traffic of the failed segment as shown in Fig. 4. If, coincidentally both neighbour segments do not have enough residual capacity to handle the traffic of the failed segment or backup fiber links fail simultaneously then the affected traffic will be blocked. But in mesh scheme besides the available paths in ring scheme, we provide an extra backup optical path connecting segment S_1 directly to segment S_3 which will result in reduced blocking probability of the traffic generated by the failed segment.

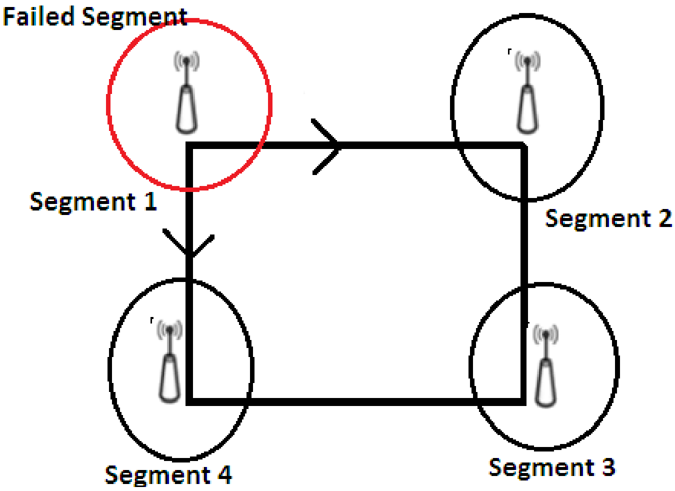

Fig. 4. Ring architecture.

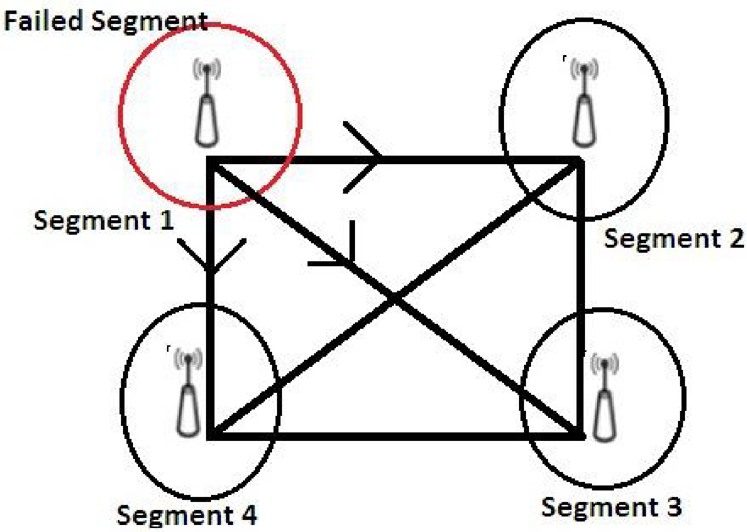

Fig. 5. Fully mesh architecture.

4. Simulation & Result analysis

To evaluate the performance of proposed scheme by simulation, following assumptions and parameter values are considered.

4.1 Simulation assumptions

- The traffic flows from user to Internet via WMN in front end and PON in back end.
- It is considered that the intermittent distance between two segments is not much less that they can make a wireless link among each other to reroute their traffic.
- It is considered that each segment has average equal capacity.
- We randomly select backup ONUs from each segment.
- We consider each backup fiber link with enough capacity to carry affected traffic.
- The traffic offered to the network is in random fashion.
- To calculate blocking probability, we inject 10000 packets in the network.
- The random traffic injected into each segment is about 10% to 90% of overall demand capacity of the network to calculate blocking probability at different traffic instances.
- The traffic of the failed segment will transfer to its neighbour segment according to the residual capacity of that segment.

4.2 Simulation results and analysis

To evaluate the performance of proposed scheme, we calculate blocking probability. Blocking probability is defined as the ratio of number of packets fails to reach the destination to the total number of packets injected in the network.

$$\text{Blocking probability} = \text{number of packets failed} / \text{total number of packets} \tag{1}$$

Fig. 6. shows comparison of blocking probability versus total variable traffic offered (in %) by the failed segment for both ring and mesh networks. It is clear from figure that for lower traffic (up to 60%) blocking probability will not varies too much. But as we move towards higher traffic demand (i.e. 70% to 90%) proposed scheme exhibits less blocking probability then existing solution. It is due to the fact that, proposed work offer an extra backup optical path which helps to reroute traffic more effeciently than existing solution. Hence mesh scheme outperforms then ring scheme in terms of reduced blocking probability and increased survivability for higher traffic demands.

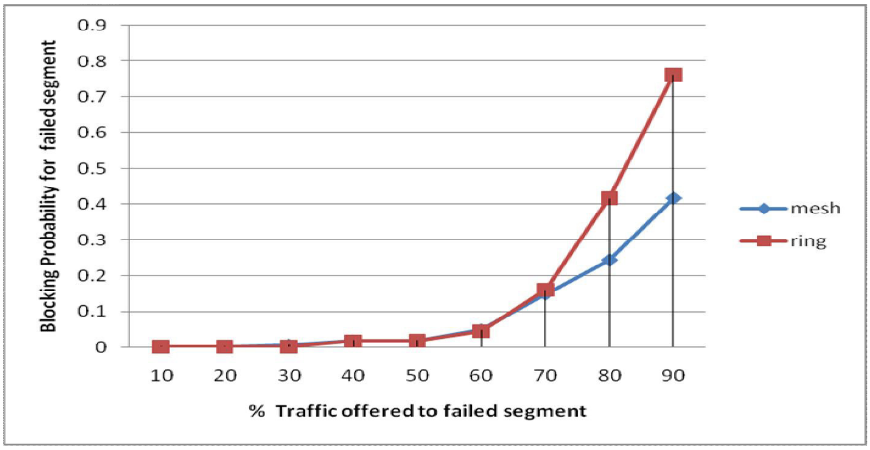

Fig. 6. Comparison of blocking probability versus traffic (in %)

5. Conclusion

As FiWi supports high data rate over the network, any component failure may results in huge data loss. Hence, there is a need to design a network which is more survivable and prevent such data loss. Therefore in this paper we concern mainly about the survivability of a FiWi networks. Although the proposed work has large fiber length due to mesh topology but it protects FiWi against multiple segment failure more effectively than existing ring solution. It is clear from results that at high traffic demand, the proposed algorithm exhibits less blocking probability than existing ring solution. Therefore for heavy traffic networks, proposed scheme shall be the ideal choice.

References

1. Shaddad RQ et al. Survey on access technologies for broadband optical and wireless networks. *Journal of Network and Computer Applications* 2014; 41:459–472.
2. Ghazisaidi N, Maier M. Fiber-wireless (FiWi) access networks: a survey. *IEEE Commun Mag* 2007; 47:160– 167.
3. Ghazisaidi N, Maier M. Fiber-wireless (FiWi) access networks: challenges and opportunities. *IEEE Network* 2011; 25:36–42.
4. Maier M, Ghazisaidi N, and Reisslein M. The audacity of fiber-wireless (FiWi) networks (invited paper). *In Proceedings ICST* 2008; 16–35.
5. Liu Y, Guo L, Gong B et al. Green survivability in Fiber-Wireless (FiWi) broadband access network. *Optical Fiber Technology* 2012; 18: 68-80.
6. Mohan N, Wason A, Sandhu P. Trends in Survivability Techniques of Optical Networks. *International Journal of Computer Science and Electronics Engineering* 2013; 1(2).
7. Lee S, Tan S, Wong E. Survivability evaluation of optimum network Node placement in a hybrid fiber-wireless access network. *In Proceedings IEEE PHO* 2011; 298–299.
8. Bhatt UR, Sarsodia T, Upadhyay R. Survivability of an Integrated Fiber-Wireless (FiWi) Access Networks. *In Proceedings ICICT* 2014; 243-248.
9. Liu Y, Guo L et al. Auxiliary graph based protection for survivable Fiber-Wireless (FiWi) access network considering different levels of failures. *Optical Fiber Technology* 2012; 18:430-439.
10. Sarkar S. A Novel Delay Aware Routing Algorithm (DARA) for a Hybrid Wireless Optical Broadband Access Network. IEEE Network 2008; 20-28.
11. Sarkar S, Yen H, Dixit S et al. RADAR: risk-and-delay aware routing algorithm in a hybrid wireless-optical broadband access network (WOBAN). *In Proceedings OFC* 2007; 1–3.
12. Feng T, Ruan L. Design of a Survivable hybrid Wireless Optical Broadband Access Network. *Journal of Optical Communication Network* 2011; 3(5):458-464.
13. Liu Y et al. Optimizing Backup Optical Network-Units Selection and Back fiber deployment in Survivable Hybrid wireless Optical Broadband Access Network. *Journal of Light wave Technology* 2012; 30(10):1509-1523.
14. Liu Y et al. Deployment of survivable fiber-wireless access for converged optical and data center networks. *Optical Switching and Networking*. 2014; 14(3):226-232.
15. Liu Y et al. Ring-based Protection Scheme for Survivable Fiber-Wireless (FiWi) Access Network Considering Multiple Failures. *In Proceedings ONS* 2012; 333-338.
16. Liu Y et al. Protection based on backup radios and backup fibers for survivable Fiber-Wireless (FiWi) access network. *Journal of Network and Computer Applications* 2013; 36:1057–1069.