ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785
(ISRA), Journal Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

FiWi – FUTURE GENERATION BROADBAND ACCESS TECHNOLOGY

Uma Rathore Bhatt *

* Dept. of E&TC, Institute of Engineering & Technology, Devi Ahilya University, Indore, India

ABSTRACT

As today's generation is now became the slave of different internet services at every step of their life. Hence, different researches are carried out continuously since past decade to enhance the performance of existing broadband access networks. The networks which are technically advanced to provide internet services are Passive optical networks (PON), Wireless mesh networks (WMN) and Fiber Wireless Networks (FiWi). Among all Fiber-Wireless (FiWi) broadband access network is a promising access technology, because it integrates the technical merits of both PON and WMN networks such as higher bandwidth of PON and lower cost of WMN. Therefore FiWi provides services to user in "Anytime-Anyway fashion" with high capacity and low cost. Various issues are related to FiWi Network viz. ONU Placement, Survivability and Energy saving. ONU placement are related with, "how efficiently ONUs are place in the network to reduce the overall network deployment cost". Survivability related to "provide services to users even if the failure occurs in network". "How to save energy in FiWi network" is related to Energy saving issue. In this paper detail discussion of various issues of FiWi network is done.

KEYWORDS: FiWi, PON, WMN, ONU Placement, Survivability, Energy Saving.

INTRODUCTION

In recent years, there is an explosive growth in internet users which requires very high bandwidth for services. Generally user requires higher bandwidth and lower cost broadband access network which serves services in "Anytime-Anywhere" fashion. The Passive optical network (PON) is considered as a preferable solution due to its higher bandwidth and transmission stability. But the deployment cost of PON is very high due to the usage of optical devices and fibers. Alternative, Wireless mesh network (WMN) may be considered as a solution due to its better flexibility, low cost and easy deployment. But bandwidth of WMN is limited due to limited spectrum. Therefore various researchers of both fields came to combine the technical merits of both PON and WMN networks. As a result, a new technology is emerged and called as "Fiber-Wireless Access Network (FiWi)" [1-4] (Formerly "Wireless Optical Broadband Access Network (WOBAN)". FiWi provides user to access network at lower cost with higher bandwidth.

The advantages of FiWi network over other broadband access network are as follows:

(1) Compare to PON, FiWi can provide wider coverage and better flexibility by WMN front-end which reduces the deployment cost.

(2) Compare to WMN, FiWi can provide higher bandwidth capacity and better stability by PON back-end and also reduces packet loss and interferences.

Fiber Wireless (FiWi) network has the tree-mesh architecture as shown in Fig. 1. It has two ends, PON at back-end whereas WMN at front-end. In back-end, single Optical Line Terminal (OLT) drives various Optical Network Units (ONUs) via feeder fiber, distribution fiber and Remote Node (RN). From ONU a wireless gateway is connected through wire. In front-end, users are located at premises and buildings can connect to network through wireless routers. If user want to access internet first they sends packet to its nearby wireless router, router send packet to its primary ONU via wireless gateway. ONU send this packet to OLT via feeder fiber, distribution fiber and remote node. Finally OLT inject packet to internet backbone. In this fashion FiWi provides user to access network with higher bandwidth capacity and better flexibility.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785
(ISRA), Journal Impact Factor: 2.114

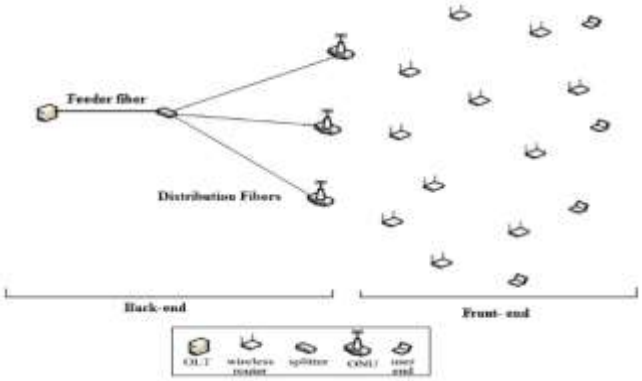

Fig.1. Architecture of FiWi Access Network [4]

Issues in FiWi Network

The issues which are related with FiWi networks are ONU Placement, Survivability and Energy Saving. [5]

1. ONU Placement

This issue related to placement of ONUs in the network. As discussed earlier ONU is the most important device in FiWi network since it provides communication between both ends. It also has the capability of transmitting and receiving optical as well as wireless signal and also convert optical signal to wireless signal and vice versa. Also the deployment cost of network depends on the number of ONUs in the network. Therefore, placement of ONUs is one of the issues in FiWi network. The ONUs placed in the network in such a way that with minimum number of ONUs all the user access internet services. Also ONU support both type of traffic i.e. internet as well as p2p traffic in FiWi network [6, 7]. Basically internet traffic originate from user end and goes to internet backbone whereas p2p traffic originates from one user and goes to another user. p2p may be routed through pure wireless path or wireless-optical-wireless path. In pure wireless path, traffic goes through wireless routers whereas in wireless-optical-wireless path the traffic first goes to primary ONU of the source user via wireless hop-way. ONU forward this traffic to OLT, OLT sends to all the ONUs of the segment. ONU decide whether they forward traffic or discarded based on the destination user address. Fig. 3 shows the routing from one router to another router in both paths. Router $r_{i\ wants}$ to communicate with router r_j then in pure wireless path it requires 5 hops whereas in wireless-optical-wireless path it only requires 4 hops.

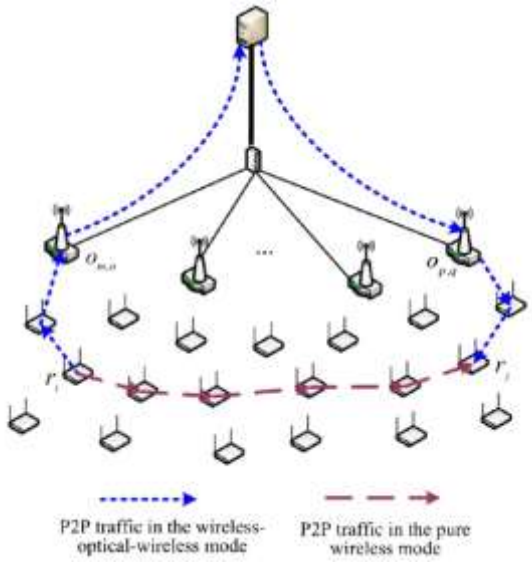

Fig.2. Illustration of routing for p2p traffic [6].

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785
(ISRA), Journal Impact Factor: 2.114

2. Survivability

As FiWi supports high data rate over the channel to provide fast internet services to the user, any failure in the network may results in huge data loss. To protect such loss of data, we have to make our network more survivable at lower cost. Survivability may be defined as "ability of any system to continue its function during and after any natural or man-made disturbance in the system".

The failure in the FiWi networks are categorized mainly in two parts: One is ONU level failure and another is segment level failure [8]. In ONU level failure which is caused due to failure of one of the distribution fiber cable in a segment which disconnects the corresponding ONU from the OLT. The traffic of that ONU will be transferred to nearby segments via multiple hops through wireless routers as shown in Fig 3. On the other hand, segment level failure is caused due to the failure of feeder fiber cable which disconnects the whole segment from the OLT. The traffic of faulted segment now transferred to its neighbor segment via backup fibers connected to backup ONUs from each segment as shown in Fig 4.

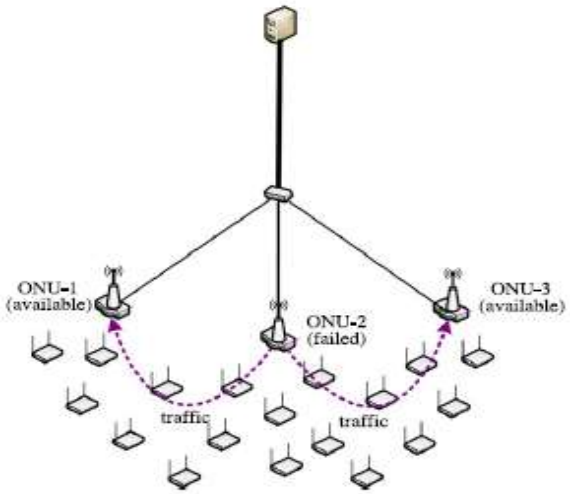

Fig.3. Protection from ONU level failure [8]

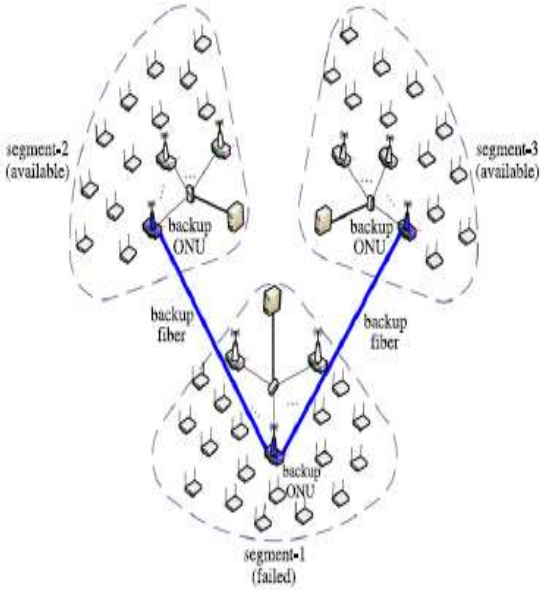

Fig.4. Protection from Segment level failure [8]

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785
(ISRA), Journal Impact Factor: 2.114

3. Energy Saving

Another important issue in FiWi is the saving of energy in FiWi network [5]. With the ever-increasing concern over the global warming and energy crisis, energy saving and emission reduction require more research attention i.e. to make a network which is more survivable and also economical in terms of power consumption. We can save energy in FiWi network by considering different energy saving criteria's on each ONU of a segment. If an ONU feels low traffic then it transfers its traffic to other ONU (depending on its residual capacity) and goes into sleeping mode by itself.

RELATED WORK

This section briefly discusses the related work done on various issues of FiWi network

1. ONU Placement

Suman Sarkar et. al. [9, 10] proposes various algorithms for ONU placement considering internet traffic only includes random approach, deterministic approach, greedy algorithm and simulated annealing (SA) algorithm. In all the algorithm first divide the network into multiple non-overlapping region i.e.in a grid, and then placed ONUs according to algorithms. In random approach place ONUs randomly in each region whereas in deterministic approach ONUs is placed in center region of each grid. But both these algorithm are not suitable in FiWi network due to proper connectivity and not suitable for non-uniform distribution of users respectively. In greedy algorithm author first place ONUs in center region of each grid and then on the basis of minimum distance, find primary ONUs of all the users. Simulated Annealing algorithm works in five stages which are: (1) Initialization, (2) Perturbation, (3) Cost Calculation, (4) Acceptance and (5) Update.

Sarkar also proposes primal model [11] for ONU placement considering internet traffic only. In this model they take more constraint with ONU placement which are user assignment, channel capacity and interferences etc. Author considers lower bound i.e. relaxes some constraint and upper bound i.e. takes all constraint. Lagrangean relaxation method used to solve the primal model for the lower bound and the upper bound of the optimization problem.

All the algorithms discussed so far considering only internet traffic but p2p traffic is the present need in network. Zeyu Zheng et. al. [7] gave an algorithm for ONU placement with the consideration of both types of traffic. They find the best position of ONUs in the network such that overall wireless hop count is minimized. For achieving this author uses Tabu search algorithm. This work remains untouched in minimizing the number of ONUs in the network. In author proposes LBOP algorithm [6] with the consideration of minimizing number of ONUs in the network. LBOP works in two stages: ONU placement and Load balancing. In ONU placement, first place ONUs in center region of each grid ant then minimize the number of ONUs in such a way that all the wireless router will communicates with remaining ONUs. In Load balancing, load balancing takes place among different ONUs.

U. Bhatt et. al. [4] propose hybrid algorithm considering both type of traffic. Hybrid algorithm works in two stages. In first stage, ONUs are place in the center region of each grid. Then author form the set of subordinate wireless routers under the wireless hop way and try to reduce the number of the ONUs in such a way that all the wireless router can communicate to at least one of the ONU. In the second stage with the help of genetic algorithm, author find the best location of remaining ONUs in their own grid followed by further reduction on number of ONUs.

2. Survivability

The author in [12] depicts an algorithm RADAR (Risk and Delay aware routing) which consider multiple failures like gateway failure, ONU failure and OLT failure. The algorithm maintains a risk list which was updated periodically to maintain a cumulative record of failure in the network, which also helps to reroute traffic on a failure. This algorithm helps to reroute traffic easily with less delay.

Taming Feng and Lu Ruan [13] proposes a new algorithm by making some modifications in RADAR to make the network more survivable. The author suggests heuristic solution for providing Maximum protection at minimum cost. They select one ONU from each segment randomly and named it as backup ONU and then connect backup ONUs of different segments with each other via backup fiber. This will help to reroute traffic of failed segment to nearby segment easily.

In [14] author proposes a new algorithm for protection of networks from segment level failure and abbreviate as OBOF (optimizing backup ONUs selection and backup fiber deployment). This algorithm is better than RADAR and algorithm in [13] in terms of optimization in backup ONU selection and protection level. OBOF works in two stages: one is selection of backup ONU in an optimized way and second is deployment of back fiber among them. Selection of backup ONU is done by the help of SA (Simulated Annealing) algorithm whereas for deployment of backup fibers, author suggest EGCE (Enhance greedy cost efficient) algorithm. EGCE algorithm is further divided into two stages: (1) RBS (Remote backup segment) method helps to utilize the residual capacity of remote segments and (2) BLB (Bound on length of backup optical path) method which

limits the recovery cost increased in RBS method. Author further carried his work to reduce to reduce overall network cost by using Graph theory used in network deployments and named as AGP (Auxiliary graph based protection) algorithm [9]. These algorithms suggest the most optimum way to reroute the traffic of failed segment to neighbor segment with minimum cost. They use MPMHC (Maximum protection with minimum hop count) concept to propose their algorithm.

The related work discussed ahead considers single segment failures in the network however if a number of segment fails simultaneously then above algorithms are not be the optimal solutions. So for handling multiple failures simultaneously author in [15] proposes Ring based protection scheme. This algorithm proposes to connect backup ONUs from each segment in a ring fashion to reroute affected traffic to neighboring segment. Author further improves the ring scheme by minimizing the ring size and fiber length with the help of Hamiltonian matrix method. This algorithm [16] considers both types of failures i.e. ONU level failure and Segment level failure. For ONU failure author suggest SBR (Sharing backup radios) algorithm whereas for segment level failure author proposes SPR (Shortest protection ring) algorithm. In SBR, each ONU is connected to a partner ONU within the segment via preset wireless path with the help of wireless radios installed on some of the wireless routers. On the other hand SPR works in two stages: (1) Segment clustering done by Genetic algorithm and (2) Backtracking method which helps to find the shortest ring path among various rings, which helps to reduce fiber cost and in turn overall network cost.

3. Energy Saving

X. Gong proposes dynamic energy saving algorithm for energy saving in FiWi network called Energy-saving Algorithm based on Sleeping Low-loaded ONUs (EASLO) [17]. In EASLO, author adds three functionalities for energy saving in each ONU viz. dynamic energy awareness, sleep/awake transferring and traffic re-routing. The working of dynamic energy awareness is used to aggregate the traffic as much as possible to high-load ONUs to increase the number of low-load and zero-load ONUs. Then traffic re-routing reroute the traffic into an ONUs which have enough capacity to handle the traffic. The sleep/awake transferring examine the traffic in ONU, if the traffic is lower than sleeping threshold than ONU put into the sleeping mode and if traffic suddenly increases then ONU in awakening state. In this way by adding this functionality in each ONUs, energy can save in FiWi network.

CONCLUSION

The paper considers future generation broadband access technology named as “FiWi” networks. FiWi provides services to the users in flexible manner. As it stated earlier that, FiWi is the combination of merits of both PON and WMN access network, hence it provides services to the users with high bandwidth at relatively lower cost. The paper also enlighten the issues of FiWi network i.e. ONU placement, Survivability and Energy saving. As a whole the paper describes the FiWi broadband technology in brief to understand FiWi in an easy manner.

REFERENCES

[1] N. Ghazisaidi and M. Maier, Fiber-wireless (FiWi) access networks: a survey, IEEE Commun. Mag. Vol. 47, pp. 160– 167, 2007.
[2] N. Ghazisaidi, M. Maier, Fiber-wireless (FiWi) access networks: challenges and opportunities, IEEE Network, vol. 25 pp. 36–42, 2011.
[3] U R Bhatt, N Chouhan, ONU placement in Fiber Wireless (FiWi) Network, Engineering (NUiCONE), Nirma University (2013) 1-6
[4] U. Bhatt, N. Chouhan, R. Upadhyay, Hybrid Algorithm: A cost efficient solution for ONU placement in Fiber-Wireless (FiWi) Network, Optical Fiber Technology, vol. 22, pp. 76-83, 2015.
[5] Y. Liu et al., Green Survivability in FiWi Access Network, Optical Fiber Technology, vol. 18, pp. 68–80, 2012.
[6] Y. Liu, et al., Load balanced optical network unit (ONU) placement in cost-efficient fiber-wireless (FiWi) access network, Optik - Int. J. Light Electron Opt., vol. 124, pp. 4594-4601, 2013.
[7] Z. Zheng, J. Wang, X. Wang, ONU placement in fiber-wireless (FiWi) networks considering peer-to-peer communications, in: Proc. of GLOBECOM, pp. 1–7, 2009.
[8] 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, vol. 18, pp. 430-439, 2012.
[9] S. Sarkar, H. Yen, S. Dixit, et al., Hybrid wireless-optical broadband access net-work (WOBAN): network planning and setup, IEEE J. Sel. Areas Commun. 26(August (6)) (2008) 12–21.
[10] S. Sarkar, B. Mukherjee, S. Dixit, Towards global optimization of multiple ONU placement in hybrid optical-wireless broadband access networks, in: Proceedings of COINNGNCON, pp. 65–67, July 2006.

[11] S. Sarkar, H. Yen, S. Dixit, et al., Hybrid wireless-optical broadband access network (WOBAN): network planning using Lagrangean relaxation, IEEE/ACM Trans. Network. Vol. 17 pp. 1094–1105, 2007.
[12] S. Sarkar, H. Yen, S. Dixit et al., RADAR: risk-and-delay aware routing algorithm in a hybrid wireless-optical broadband access network (WOBAN). In Proceedings OFC, pp. 1–3, 2007.
[13] T. Feng, L. Ruan, Design of a Survivable hybrid Wireless Optical Broadband Access Network. Journal of Optical Communication Network, vol. 3, no. 5, pp. 458-464, 2011.
[14] Y. Liu 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, vol. 30, no. 10. Pp. 1509-1523, 2012.
[15] Y. Liu et. al., Ring-based Protection Scheme for Survivable Fiber-Wireless (FiWi) Access Network Considering Multiple Failures, In Proceedings ONS, pp. 333-338, 2012.
[16] Y. Liu et. al., Protection based on backup radios and backup fibers for survivable Fiber-Wireless (FiWi) access network. Journal of Network and Computer Applications, vol. 36, pp. 1057–1069, 2013.
[17] X. Gong et. al., Dynamic energy-saving algorithm in green hybrid wireless-otical broadband access network, Optik, vol. 124, pp. 1874-1881, 2013.