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Computation of Various QoS Parameters for FiWi Access Network

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Abstract

Fiber wireless (FiWi) access network is one of the broad band access networks used to support multimedia applications and interactive services. However minimum QoS needs to be maintained by the network. In this paper a method has been proposed to compute the various network parameters such as packet delivery ratio (PDR), average delay and network throughput for a FiWi network, to ensure minimum QoS. This approach may be proved very useful in computing these parameters comprehensively for any algorithm related with research issues of FiWi network like ONU placement, survivability, energy efficient algorithms etc.

Peer-review under responsibility of organizing committee of the ICISP2015

Keywords: FiWi Network; QoS; Throughput; Average Delay; Packet Delivery Ratio

1. Introduction

Different Internet services are provided with the help of different types of access network configurations and related standards. The network configuration may be in terms of optical network, wireless network (WLAN, WiMax), and fiber wireless access network (FiWi) [1-5]. Network performance depends on advantages and disadvantages offered by the network, which depend on network characteristics. The optical network offers higher bandwidth, better stability but at higher cost whereas wireless network provides its services at relatively lower cost but its bandwidth is limited due to congestions. FiWi combines the benefits offered by optical and wireless network, and provides high speed network performance at low cost with desired QoS.

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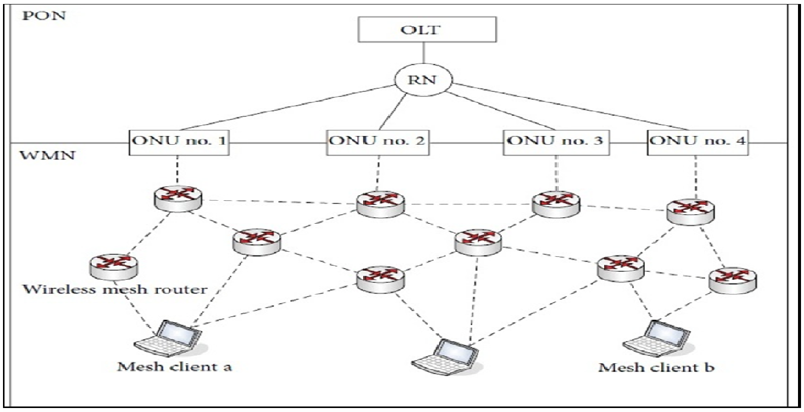

Fig. 1. Architecture of a FiWi network[9]

Fig. 1 shows the architecture of a FiWi network[6-8], which consists of optical back end and wireless front end. The back end consists of tree topology whereas wireless front end have mesh topology. The mesh topology has self-healing property whereas tree topology has the problem of sever failures. The back end consists of optical network unit (ONU), optical line terminal (OLT) and remote node (RN). The ONU acts as an interpreter between wired signals and wireless signal. Remote node works as a switch between multiple ONUs to route the traffic in different geographical sections. The OLT is the centralized office where the whole data is feed into the internet backbone. Front end consist of wireless routers located near the user in different geographical areas. These wireless routers communicate with backbone through ONUs. The user can access internet services via. wireless routers and ONUs.

The QoS of any network and services offered by it, depends on network characteristics. In order to evaluate QoS of a network, we need to measure various network parameters such as network throughput, average delay, packet delivery ratio, blocking probability etc. Various authors propose different algorithms to evaluate all these parameters in a FiWi network. The author in[10] evaluated delay among successive packet transmission for wireless front end for a FiWi network. In this algorithm author periodically check wireless links state. All links are assigned a weights according to the expected delay incurred in transmission process. A link with minimum delay will be assigned minimum weight. From these minimum delay paths (which are also known as DARA paths) author chooses optimum path to transmit the data, which have least delay among all DARA paths. To modify DARA in terms of increased survivability and failure awareness, the author proposes RADAR ("Risk-And-Delay Aware Routing) algorithm[11]. RADAR protects front end from different types of failures and also reduces successive packet delay among different users more effectively. Y. Liu *et al.*[12] calculate average hop counts, which is defined as average distance between a pair of routers or a router to ONU. The average hop count should be chosen such that the chances of packet failure should be least to reduce network recovery cost. The authors also calculated TBLF (Total length of back up fiber) as network parameter to minimize the overall network cost in terms of backup fiber used. To further improve the network performance, Y. Liu *et al.*[13] consider recovery delay as one of the network parameter along with TLBF and proposes SBR (Sharing backup radio) and SPR (Shortest protection ring) algorithm. In this algorithm authors reduces TLBF required for backup ONUs, by selecting shortest ring path available between all the backup ONUs. Along with this author also reduces recovery delay, which is defined as the time required to transfer affected traffic from a faulted segment to a healthy neighbour segment. The placement of ONUs is also an important concern for the designing of an optimal FiWi network. In[14] authors proposed an algorithm for ONU placement, in which they concentrate on network throughput and wireless hop count for different wireless routers and number of ONUs. They place ONUs in the network in such a way that overall wireless hop count will be minimized without interrupting any traffic demand. Y. Li *et al.*[15] proposes a FiWi network which supports inter ONU communication and evaluates network throughput and end to end delay as the network parameters. The author proposes a novel

WDM/ TDM PON architecture and for ensuring inter ONU communication by suggested decentralized dynamic bandwidth allocation (DBA) protocol. This algorithm aims to reduce end to end delay and to increase overall network throughput. In[16] author study the network throughput gain for FiWi network and compared it with that of wireless mesh network.

The papers discussed so far evaluate various network parameters according to the need of proposed algorithm (handling any of the key issues of FiWi). However no author suggested a comprehensive evaluation of different network parameters such as PDR, average delay and network throughput, in their paper. Hence this paper presents a generalized and basic approach to evaluate various network parameters of a FiWi network. This approach may be used with all the works presented so far for evaluation of PDR, average delay and network throughput.

2. System Model

FiWi network is modeled into L×L geographical area. Total N numbers of wireless routers are randomly deployed in the network. According to routers, ONUs are placed in the network in such a way that each router communicates to its primary ONU. OLT is placed in the center of network and all ONUs are connected to OLT through a link. For computation of network parameters, first we generate connections randomly, among all possible source-destination pairs of wireless routers. The path of connection may be pure wireless mode or wireless-optical-wireless mode. In pure wireless mode the connection is establish between source and destination through multiple wireless routers. In wireless-optical-wireless mode the connection establish between source and destination through source wireless router, source primary ONU, OLT, destination primary ONU and destination wireless router. A link between any source and destination pair is assumed to be failed, if it is being used by another source and destination pair, otherwise connection will be established. According to failed and successful connections we find following network parameters.

- Packet Delivery Ratio: It is the ratio of successful received packet to that of total packets in the network. The PDR for the given FiWi network is calculated as:

  Let T_C be the total connections in the network, F_C and S_C be the failed and successful connections, where

  $T_C = N (N-1)/2$ and $S_C = T_C - F_C$. Then PDR is given by Eq. (1)

$$PDR = \frac{S_C}{T_C} \tag{1}$$

- Average Delay (E_{delay}): The average time required by a packet to travel the network from source to destination is referred as average delay. To calculate it, let T_B be the number of bits transmitted by each wireless router, with M transmission rate in Mbps. Then $E_{delay}$is given by

$$E_{Delay} = T_B \times S_C \times W_H \times T_R \tag{2}$$

  Where, W_H is total number of wireless hops required in the network and T_R is time required for transmission of single bit.

- Network Throughput (N_T): It is the number of successful packets reception in a unit time interval. Network throughput is measured in bits per second. It is given by

$$N_T = \frac{S_C}{E_{Delay}} \tag{3}$$

3. Simulation Settings and Steps for Computation of Performance Parameters

This section explains the computation of network parameters for a randomly given FiWi network. For finding network parameters, the algorithm is executed in following steps:

(i) Network Deployment: A FiWi network has been constructed in 100 × 100 square geographical area. Number of wireless routers, varying from 20-50, are randomly deployed in the network. According to number of wireless routers, required number ONUs are placed in the network. Simulation is performed which is based on C/C++ software. The FiWi network shown in Fig. 2 consists of 50 wireless routers and 5 ONUs. OLT is placed in the center of the network. Each wireless router is supposed to transmit 1 packet, consist of 1000 bits when a link is established. The transmission rate is 10 Mbps, so 10^{-7} seconds are required to transmit 1 bit.

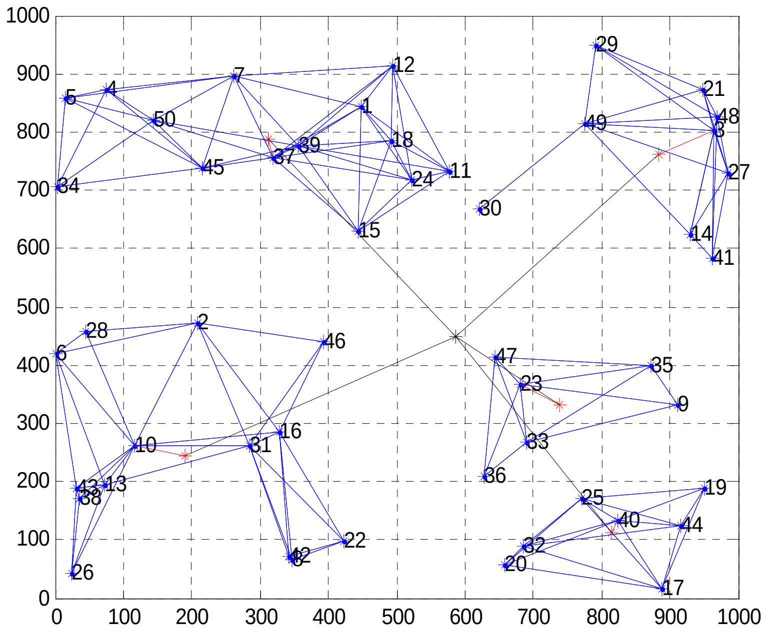

Fig. 2. Modeled FiWi network

(ii) Connection Generation: With the help of developed code, number of connection requests are generated randomly according to T_C = N (N-1)/2. Fig. 2 consists of 50 wireless routers and hence generated requests are 1225.

(iii) Computation of successful connections, failed connections and hop counts: With the help of developed code, successful and failed connections are calculated. It is assumed that a connection fails only when link is busy.

(iv) Computation of Performance Parameters: PDR, average delay and throughput are computed with the help of equations 1, 2 and 3 respectively.

4. Simulation Results & Discussion

Simulation results in form of performance parameters have been shown in this section. Fig. 3 shows packet delivery ratio vs. number of wireless routers for the given network. From Fig. we can see that with increase in number of wireless routers in the network, PDR also increases.

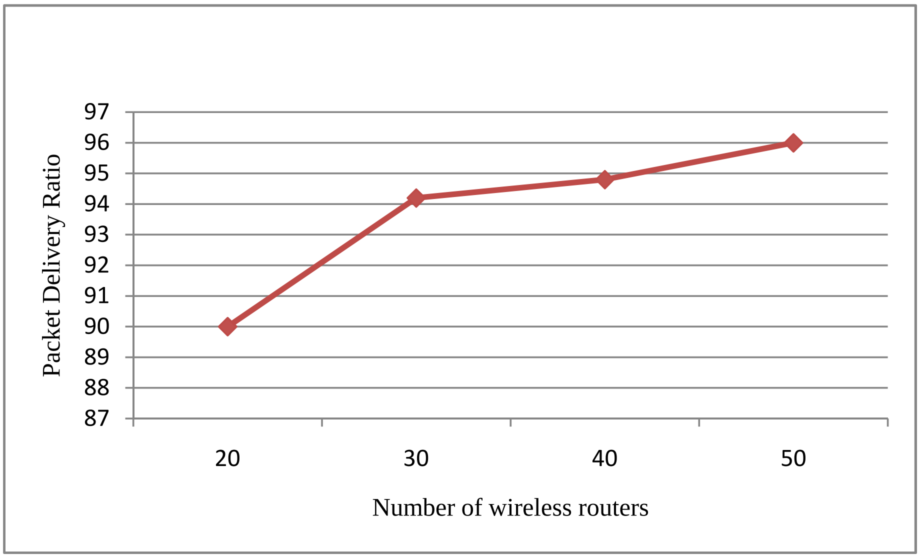

Fig. 3. Packet delivery ratio vs. Number of wireless routers

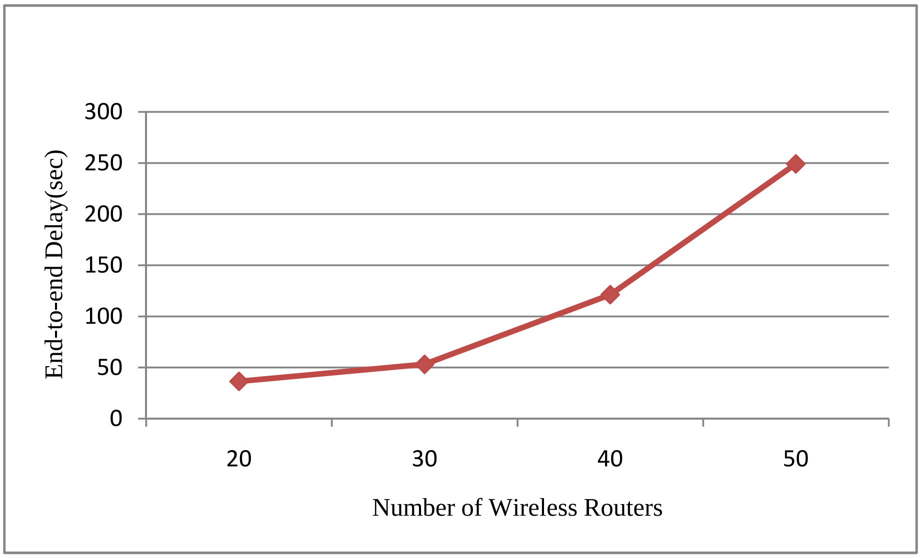

Fig. 4. Average delay vs. Number of wireless routers

This happens, because as we increase wireless routers, source-destinations pairs also increases. Since each wireless router transmits 1000 bit, total received data bits are also increased. However rate of increase in PDR decreases because source-destinations pair and link failure rate also increases. Fig. 4 shows the average delay vs. number of wireless routers. As number of routers increases in the network, total number of wireless hops also increases in the network. Consequently more delay is experienced by the network, since for same network area more number of routers is deployed.

Fig. 5 shows the network throughput vs. number of wireless routers. As number of routers increases in the network, more connections are generated hence more links become busy, which results in increased number of connection failures. This degrades the successfully received packets in the network per unit time, resulting in decrease in network throughput.

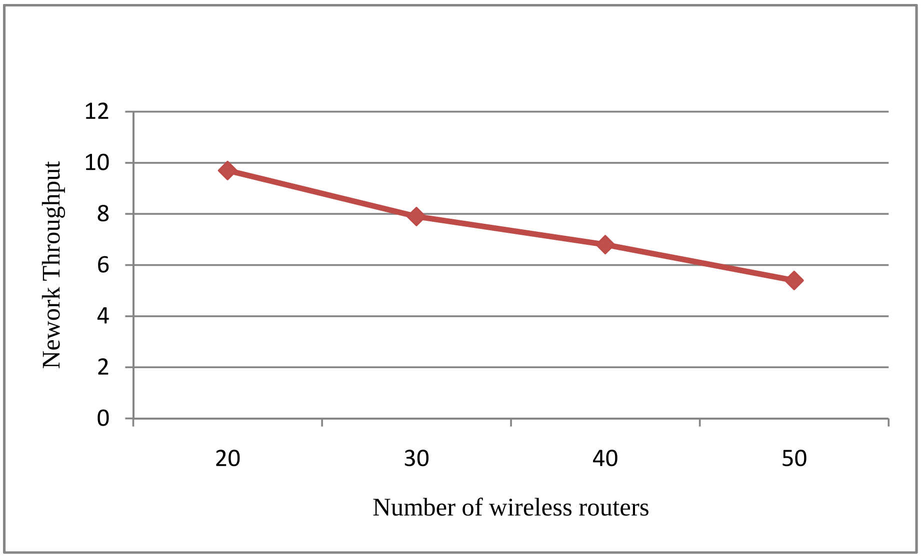

Fig. 5. Network throughput vs. Number of wireless routers

5. Conclusion& Future Scope

In this paper, different network parameters such as packet delivery ratio, average delay and network throughput are evaluated in a very simple and effective way, for a randomly deployed FiWi network. In the literature revived so far, no such work is available, which is computing these parameters comprehensively for FiWi network. Therefore this approach is very much attractive for computation of these parameters dealing with any of the research issues of FiWi network. In future more parameters may be evaluated by further expansion in the proposed work.

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