

Enhancement of Quality of Service in Fi-Wi Networks

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Abstract: Fiber-Wireless (Fi-Wi) efficiently combines both wireless and optical networks that can change future of broadband services. In Fi-Wi Networks, Fiber given to the end user is cost efficient and also improves overall QoS of system. Combining two separate technologies leads to inept data transmission, which adversely affects the QoS. By using DBA (Dynamic bandwidth allocation) techniques we can make sure that the QoS of system is improved. Dynamic Bandwidth allocation is done using WDM (Wavelength Division Multiplexing). In this paper using software simulations, we have made the performance evaluation of QoS parameters such as Bit Error Rate (BER), Quality factor and Jitter in Fi-Wi Networks.

Keyword: Fi-Wi (Fiber-Wireless), WDM (Wavelength Division Multiplexing), QoS (Quality of Service), BER, JITTER.

I. INTRODUCTION

Fi-Wi Networks for future broadband access services look promising as it takes the advantage of both Optical and Wireless technologies. Fi-Wi Network is most cost efficient and very flexible to the end users [1]. Wireless communication is done using IEEE 802.11e [2], but the disadvantage of wireless communication is it cannot accommodate many users unless it has backhaul network which offer huge bandwidth such as optical network. Optical Network can meet all the demands of the users, such as to accommodate many users and provide them with huge bandwidth [3.] Fi-Wi system which integrates both optical and wireless technologies seems to be the best possible solution for future broadband services. In this paper we concentrate on Fi-Wi network comprising of Wireless devices such as Access points, STA (Stations) and Optical devices like Optical Network Unit (ONU), OLT (Optical Line Terminal) which are used in interface of WLAN and PON Networks. Here a group of ONU's are connected to OLT. Downlink and Uplink Transmission of all ONU's is controlled by OLT [4]. DBA using WDM improves QoS and also makes the PON (Passive Optical Network) reconfigurable based on user demands. SR (Status Reporting) DBA and TM (Traffic Monitoring) DBA [5] and are two algorithms used to improve Bit Error Rate, Quality factor and Jitter of overall Fi-Wi Network. We make the performance evaluation of QoS parameters using both the DBA algorithms with the help of MATLAB and OPTISYSTEM Software. This paper is organized as follows: Section 2 describes the implementation of Wireless and Optical Networks in detail. Section 3 describes the interface of both WLAN and PON Networks which is done using Matlab Optisystem Co-simulation. Section 4 explains implementation of two DBA algorithms. Section 5 contains the corresponding results.

II. CREATING WLAN IN MATLAB AND PON IN OPTISYSTEM

In WLAN there are group of Moving Stations (STA) under each Access point (AP) and group of Access points under a

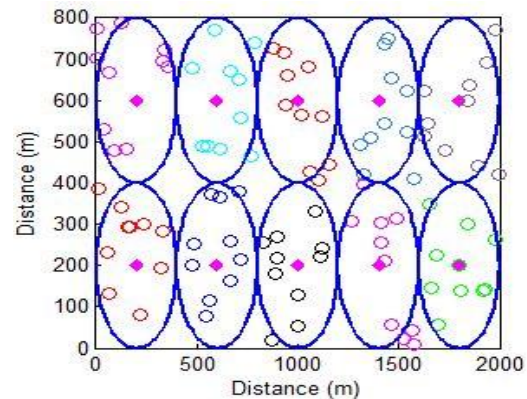


Fig 1 Representation of AP and STA under each ONU

single ONU. It forms the hierarchy of WLAN network. Fig 1 show the representation of ONU. Following symbols represents APs and STAs in network

- ◆ Access Point
- Station

Each AP covers a area of radius 200m. STAs which over 200m and lesser than $200\sqrt{2}$ m has very low SNR value, applicable for those STA which doesn't lie inside circle in Fig1. All the STAs are given random locations and the distance between each AP is 400 meters. ONUs are varied each time, a sample illustration of 10 ONUs in a location which remain under an OLT is shown in Fig 2

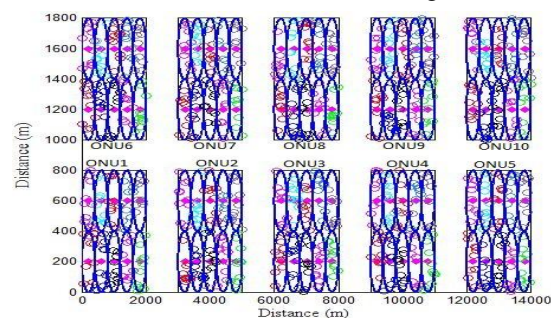


Fig 2 Representation of APs, STAs, ONUs under OLT

A. Wireless Channel

In wireless communications line of sight doesn't happen every time and even signal starts fading along its transmission path. We introduced Rayleigh fading effect in this wireless network. DPSK modulation and demodulation techniques are adopted for transmissions between STA and AP. In general every information between moving stations and Access Points is transmitted only in 1's and 0's. All the Moving Stations (STA) negotiate the QoS parameters like no of bits, bit rate, SNR value. Based on these parameters AP calculates transmission Opportunity (TXOP) [2]. Now STA are required to transmit its data in TXOP period. When no other station is utilizing the channel the Access Point sends message to the Moving Station to utilize the channel for sending its data.

B. SNR Estimation

As distance between AP and STA increase received signal power decreases and noise power increases. Based on the distance between AP and STA we estimate SNR and add introduce AWGN noise accordingly.

C. Encoding and Decoding

For transmission of control information such as no of bits, SNR, bitrate we introduced Encoding and Decoding techniques. The Information needed to be transmitted is converted into is converted into ASCII code (always of length 8 bits) which include start and end delimiters. After conversion the information is passed through wireless channel. Now the Received bits after demodulation are converted from ASCII values to character values.

D. TXOP Calculation

Using Encoding and Decoding techniques QoS parameters like no of bits are known to Access Point. According to IEEE 802.11 Standards Frame length is 2346 bytes. No of frames is given as No of Frames= (No of Bits)/ (Frame length) TXOP= (Frame length * No of Frames)/ (Bit Rate) Now the Calculated TXOP is sent to Moving Stations Using the same Encoding and Decoding techniques

E. Transmission of Data

For each Moving Station a certain no of bits are transmitted through channel. AP knows how many no of bits STA is going to send (as initially control information is exchanged) Receiver (Access Point) checks if all the bits are received Data at each ONU is collected and stored in bin files these files are used as source to transmit data to OLT (Optical Line Terminal).

F. Bit Error rate Calculation

For each ONU data from each Access point is received and appended to bin file. Data generated initially is stored in bin files. So now comparing both files we can calculate the no of bits changed when transmitted through ONU. Bit Error Rate of every Moving Stations calculated and used at end to compute overall BER.

G. PON Network

Passive Optical Network gives fibre to the end user. It can be defined at FTTC (Fiber to the Curb), FTTH (Fiber to the Home), FTTB (Fiber to the Building) depending on where it terminates. PON consists of OLT and a number of

ONU are connected to it. The Network consists of Transmitter, Optical fiber and Receiver. The Transmitter section consists of User Defined Bit Sequence pulse Generator, Return to Zero (RZ) or Non Return to Zero (NRZ). CW Laser generates a continuous wave optical signal. We use Mach Zender Modulator which is an intensity modulator having 3db Couplers connected by two wave guides of same length. In receiver section a PIN photo detector converts optical to electrical, a data recovery block to get received binary bits and a signal visualize to view received bits. ONU is constructed using above described elements. Optical Fibre acts as a channel between Transmitter and Receiver. Losses in optical cable like Attenuation, Dispersion and Nonlinear effects are taken into consideration. A detailed view is given in Fig 3

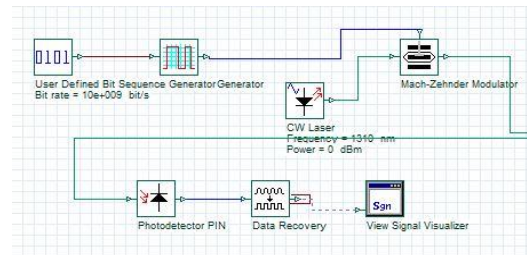


Fig 3 ONU designed in Optisystem 12

III. MATLAB OPTISYSTEM CO-SIMULATION

The interface of WLAN and PON is done with the help of Matlab Optisystem Co-simulation. Matlab at each instance invokes Optisystem to fetch results. Steps involved in Matlab Optisystem Co-simulation are:

1. Prepare the Passive Optical Network layout of Optisystem.
2. Write script for each component of PON layout of Optisystem in Matlab.
3. Script of Various Parameters like attenuation, length of Optical Fiber cable and for other components is also written in Matlab.
4. During Simulation Matlab calls the Optisystem software and simulates the required OSD file.
5. The Results generated from Optisystem are imported to Matlab

Now using DBA techniques we can make sure that the QoS is enhanced.

IV. DBA ALGORITHMS

In Static Bandwidth allocation methods upstream data channel is limited [6]. This results in blockage of all the traffic at ONU resulting in low performance. To overcome these disadvantages DBA are introduced. DBA are implemented based on amount of data being generated at user end. Two algorithms are implemented to ensure better QoS in Fi-Wi networks.

- (i) Status Reporting (SR) DBA
- (ii) Traffic Monitoring (TM) DBA

In SR DBA [7], based on amount of data generated at ONU accordingly bandwidth is allocated. All the data received at each ONU is collected, a REPORT frame is send by each ONU to OLT. OLT collects REPORT frames then calculates and allocates bandwidth for every ONU in the network. A GATE frame is send to ONU by OLT having information about amount of bandwidth and also as an indication to start transmission.

All these calculations are done in Matlab, bandwidth of each channel is changed accordingly in Optisystem through Matlab. Bandwidth of WDM channel is varied from 5GHz to 95GHz, based on size of data at each ONU Bandwidth is allocated. Wavelengths of each upstream channel are varied from 1306nm to 1318nm with spacing of 0.8 nm (100GHz). Bitrate is 1 Gbps. Fibre length, attenuation and other parameters are varied to estimate BER at different conditions.

In TM DBA OLT continuously monitors the traffic that is being sent by ONU. It always compares received traffic with previous traffic, if greater increases bandwidth in steps else vice versa. If difference is high then step always will be high. Both these algorithms are used to avoid congestion at ONUs. In TM DBA bandwidth is varied from 5 GHz to 95 GHz. ONU sends idle frames if no traffic is received at ONU. The pseudo code for TM DBA is given below

```

D = prev_data - pres_data
If(D => 0)
    If(D>0 && D<=a)
        pres_BW = prev_BW + factor(a)
    else if(D>a and D<=b)
        pres_BW = prev_BW + factor(b)
else
    if(D<0 && and D>=a1)
        pres_BW = prev_BW - factor(a1)
    if(D<a1 && D>=b1)
        pres_BW = prev_BW - factor(b1)
end

```

Range of parameters a,b,a1,b1 varies always with the amount of incoming data at each ONU. For more accurate results decrease range and increase parameters. Function factor() computes the bandwidth based on difference of traffic at each instance.

V. RESULTS

In this section, we evaluate both the algorithms with the results we achieved through simulations in Matlab and Optisystem. We primarily concentrated on three parameters to show the performance of both the algorithms. In the WLAN network we created moving stations, under each AP upto 10 STAs, and under each ONU upto 10 APs. ONUs are varied from 1 to 14 and 1 OLT serves all these ONUs. In optical communication eye diagram help to know the system performance at the receiver end. QFactor, Bit Error rate and Jitter are calculated from eye pattern in Optisystem. Based on the simulation we performed Quality factor is always high in SR DBA. In Fig 4 on varying the number of ONUs QFactor is calculated

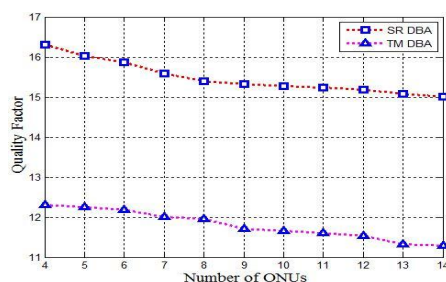


Fig 4 QFactor of SR and TM DBA on varying ONUs

A comparison is made on average QFactor, Jitter, BER of SR DBA and TM DBA varying ONUs form 1 to 14 as shown in Table 1

TABLE I
Comparing QFactor, BER, Jitter in SR and TM DBA

Algorithm	QFactor	BER	Jitter
SR DBA	15.4792	5.4360e-039	0.0300
TM DBA	11.7862	1.0750e-011	0.0255

Jitter is termed as the difference between correct timing of the received bit and the timing detected by the system. It is generally undesirable and should be as low as possible. In both SR and TM DBA jitter is very low but TM DBA is considered to be the best. A comparison of jitter is made on both algorithms shown in Fig 5

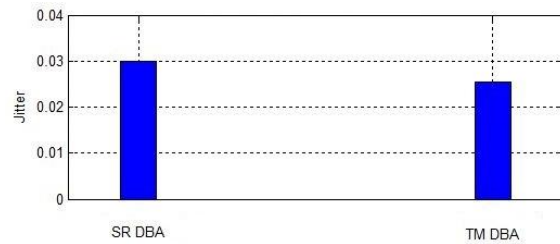


Fig 5 Comparison of Jitter in SR DBA and TM DBA

VI. CONCLUSION

Fi-Wi is the combination of high capacity passive optical network with mobility wireless network creates a perfect platform for all the future applications and networking services. While merging these technologies it is always important to ensure QoS. In this paper we have shown how to implement DBA algorithms and showed their impact in getting low bit error rate, jitter and high Quality Factor. Using the results we derived it helps to decide particular algorithm based on application.

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