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Study of QOS Parameters Using OFDM Based PHY

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Abstract— Quality of Service calls for consistent network data delivery and give some level of assurance for better network performance. In this work, details about the quality of service at the physical layer of wireless local area network (WLAN) IEEE 802.11, which uses OFDM technique, is studied. This study is based on simulation of IEEE 802.11 physical layer for QOS performance parameters. OFDM technique has been widely used in systems which use high data rates as IEEE 802.11 which is up to 54Mbps. OFDM increases the robustness against frequency selective fading or narrowband interference.

The Quality of Service has been widely studied for MAC layer of IEEE 802.11, but study of OFDM based IEEE 802.11 physical layer for QOS parameters has been done in this work. Different graphical data is generated to study QOS performance parameters. A separate simulation for OFDM and plotting of the graphs is also done to study its aspects.

Index Terms— QOS, OFDM, IEEE 802.11, Physical Layer, Throughput, Delay, Error Rate.

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1 Introduction

Wireless communication is seeing the greatest of developments in the present scenario. There are different protocols that deal with it. In this work, the study of QOS parameters at OFDM based PHY of WLAN standard IEEE 802.11 is done.

QOS is the performance of the network as seen by users. Quality of service is particularly important for the transport of traffic with special requirements. QOS technologies give following benefits:

- Building blocks for business multimedia and voice applications used in campuses.
- Helping network providers to establish service-level agreement with network users.
- Allowing or enabling network resources to be shared more efficiently.
- Manage voice based & multimedia traffic in such a way that it receives highest priority, maximum badwidth and minimum delay.

OFDM is used greatly in WLAN application using BPSK, QPSK, 16QAM and 64 QAM. Thus an OFDM based WLAN specification named IEEE 802.11 is studied at the physical layer for QOS parameters.

The QOS parameters (throughput, delay and error rate)at physical layer of OFDM based IEEE 802.11 has been studied because of the lack of built-in mechanism to support real time services which makes it difficult to gaurentee QOS services. QOS at the MAC layer has been developed by the task group IEEE 802.11e. Such works are still underway at physical layer, though link adaptation techniques have been done throughout the decade.

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2 Technical Overview

2.1 Quality of Service

QOS is the assurance of better performance of the network as seen by users. For quantitative, study of QOS, complete insight into some of the network related aspects has to be considered, such as avialability, throughput, delay, jitter, error rate. Quality of service provides different priority to different applications, users, or data flows.

Most QOS mechanisms can be classified into three catagories:

- Service differentiation (MAC)
- Admission control (MAC)
- Link adaptation (PHY)

The QOS parameters which will be studied in this work will be:

- Throughput: In communication networks, throughput is the rate of successful message delivery. There has been instance when the users sharing the same network resourse don't get the required bit rate (max throughput) for real time traffic.
- Delay: It is different from throughput as the delay is built over time though throughput remains normal. It can also be called latency. Delay is the time, longer than normal, taken by each packet to reach destination.
- Error Rate: The packets are sometimes corrupted due to noise & interference. This causes error in the packet. It is found heavily in wireless communication.

2.2 Orthogonal Frequency Division Multiplexing

OFDM has been highly accepted for WLAN IEEE 802.11, HIPERLAN, and Mobile Multimedia Access Communication. OFDM is the method encoding digital data over multiple carrier frequencies. A number of closely spaced orthogonal sub carrier sub-carrier signals are used to carry data on several parallel data streams. Each sub carrier is modulated with the conventional modulation schemes (QPSK, QAM) at a low symbol rate, maintaining data rates similar to conventional single-carrier modulation schemes. The carriers in OFDM are so arranged that the sidebands of the carriers overlap and still no interference is obtained. Thus the condition is called orthogonality. It can be described as the carriers being linearly independant (i.e. orthogonal), if the carrier spacing is a multiple of 1/T, where T is the symbol period.

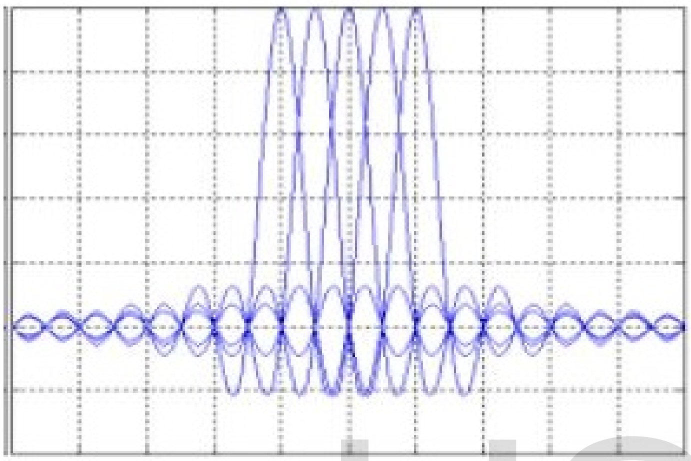

Fig. 1. Spectra of OFDM. Note that at the centre frequency of each carrier there is no crosstalk.

Key advantages of OFDM are given below:

- Efficient use of spectrum as it allows overlapping.
- Due to dividing of a single channel into narrow band sub-channels, OFDM is resistant to frequency selective fading.
- Free from ISI and IFI due to use of cyclic prefix.
- Channel equalization becomes simpler.

2.3 IEEE 802.11

It is a set of media access control (MAC) and physical layer (PHY) specifications for implementing wireless local area network computer communication. 802.11 family consists of half-duplex over the air modulation techniques that use the same basic protocol. 802.11 face serious challenges in meeting the demands of multimedia traffic due to lack of built in quality of service support. IEEE 802.11e has been developed to provide QOS at the MAC layer.

There are various task groups which are developed with different specification. The basic task groups are given in Table 1. Some important details about 802.11 are given below:

- 802.11 b/g/n(2.4) utilize 2.400-2.500 Ghz band,one of the ISM bands.
- 802.11 a/n use a more heavily guarded 4.915-5.825 Ghz band.
- 2.4 Ghz band is divided into 14 subchannels spaced 5 Mhz apart.
- 5 Ghz band is divided into 52 sub-carriers, out of which only 48 carry actual data.

There are 4 alternative physical layer technologies specified by IEEE 802.11.They are given below:

- Diffused infrared operating at 1 Mbps
- DSSS operating at 1 or 2 Mbps (microwave transmission)(ISM band at 2.4 Ghz)
- FSSS operating at 1 to 2 Mbps (microwave transmission)(ISM band 2.4 Ghz)
- OFDM operating at 1.5 to 54 Mbps(at 5.8 Ghz)

TABLE 1
802.11 TASK GROUPS

802.11 Task Groups	Frequency (GHz)	Bandwidth (MHz)	Allowable MIMO Stream	Data Rate Per Stream (Mbits/s)	Modulation
a	5	20	1	6, 9, 12, 18, 24, 36, 48, 54	OFDM
	3.7				
b	2.4	20	1	1, 2, 5.5, 11	DSSS
g	2.4	20	1	6, 9, 12, 18, 24, 36, 48, 54	OFDM, DSSS
n	2.4/5	20	4	7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2	OFDM
		40		15, 30, 45, 60, 90, 120, 135, 150	

3 LITERATURE SURVEY

Different transmission rates are achieved in 802.11 by different modulation schemes in PLCP header of the PHY layer. The rate adaptation technique and signaling mechanism are left open because they change depending on many types of channel condition.

There are many link adaptation algorithms which change the rate of transmission according to some factor. The metrics for link adaptation algorithm include SNR, received power level, transmission acknowledgements etc.

Various authors proposed different algorithms for rate adaptation. Some works are given below:

a) Efficient Rate Adaption Algorithm (ERA) [7]: ERA makes use of such scheme that quickly discovers losses and recovers them. ERA uses fragmentation mechanism of IEEE 802.11. ERA starts transmission at an intermediate rate and then quickly converges to most appropriate rate. It is the first scheme that has differenciated losses and reduced collision without use of RTS/CTS.

b) Loss Differenciated Rate Adaptation (LDRA) [8]: It first transmits the frame, if frame loss occurs; LDRA retransmits it at a basic rate. If the second transmission is successful, the loss is due to channel fading, otherwise collision. This

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strategy is particulary good for low SNR transmissions.

c) Robust Rate Adaptation (RRA) [9]: It requires the use of RTS/CTS after frame loss to avoid further collision due to hidden terminal. RRA uses RTS to remove collision; it does not reduce its rate of transmission even if the loss is due to channel fading, it changes the rate at the end of transmission window.

d) Collision-Aware Rate Adaptation (CARA) [10]: It is designed to handle collisions without use of RTS/CTS frames under good conditions. Under unfavourable conditions if the RTS frame is also lost, the frame loss is inferred to be due to collision. Thus what CARA does is, it uses RTS/CTS to reduce collisions.

e) Sender Based Rate Adaptation (BARA) [11]: BARA only monitors beacon frames from base stations or peer stations. Thus, it adapts the received signal strength (RSS) of beacon frames. Rate of other frames is inferred from ongoing transmission. Since beacon frames are mandatory for IEEE 802.11 transmission, the rate obtained from them will be fairly precise.

4 Simulation Results

This section consists of simulation of OFDM for 16 & 64 QAM and then plotting graph for BER. The next simulation is for IEEE 802.11 with adaptive bit rate procedure and plotting of graphs for QOS parameters throughput, delay and error rate.

4.1 Simulation of OFDM

The simulation of OFDM is done using MATLAB 8.1. The basic transmitter & receiver of OFDM is given in figure 2 and figure 3.

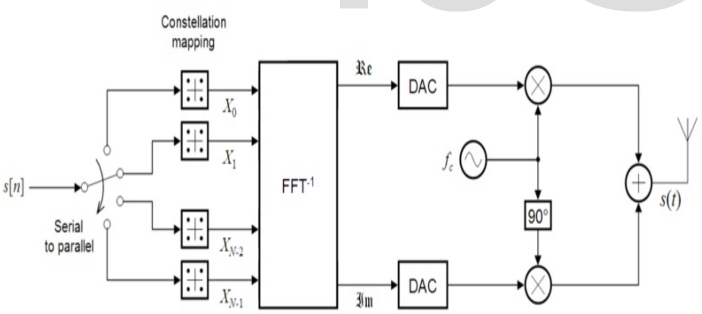

Fig. 2. OFDM Transmitter

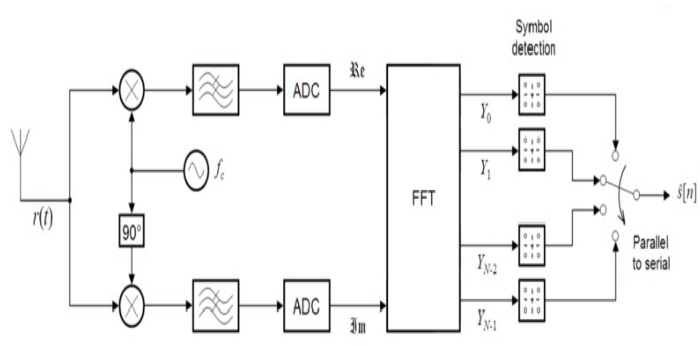

Fig. 3. OFDM Receiver

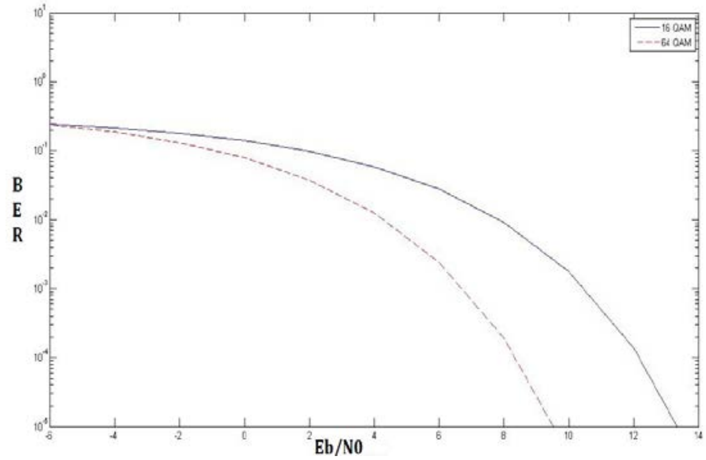

Fig. 4 BER Plot for 16 & 64 OFDM. Can be seen that the BER decreases with increase in SNR and that the BER of 64 OFDM is less than 16 OFDM.

The simulation for OFDM for 16 QAM & 64 QAM is done and the following graph given in figure 4 for bit error rate has been obtained.

4.2 Simulation of IEEE 802.11

The model shows an end-to-end baseband model of the physical layer of a wireless local area network (WLAN) according to the IEEE 802.11a standard. The model supports all mandatory and optional data rates: 6, 9, 12, 18, 24, 36, 48, and 54 Mb/s. The model also performs adaptive modulation and coding over a dispersive multipath fading channel, whereby the simulation varies the data rate dynamically.

The system shown in the model performs the following steps:

- Generation of random data at a data rate which varies with simulation.
- Coding, interleaving and modulation by one of the several schemes specified by the standard.
- OFDM transmission using 52 data subcarriers, 4 pilots, 64-point FFTs, and a 16-sample cyclic prefix.
- PLCP preamble modeled as four long trainingsequences.
- Dispersive multipath fading channel.
- Receiver equalization & viterbi coding

The reverse of this is performed at receiver.

Fig. 5. Simulation model for IEEE 802.11

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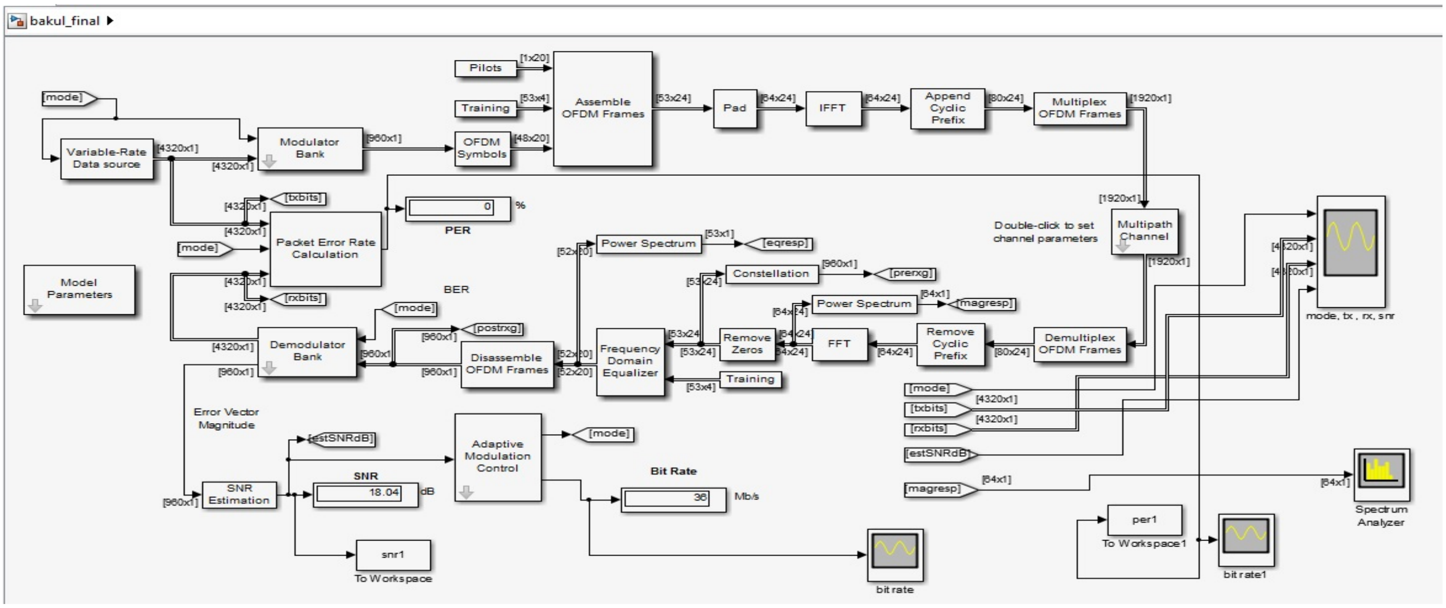
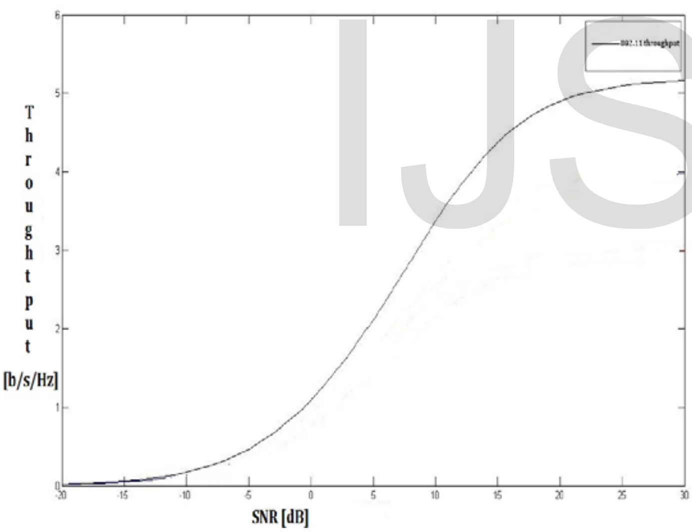


The graphs have been plotted for QOS parameters namely-throughput, delay and error rate. The graphs are given below:Fig. 6. Throughput of 802.11.



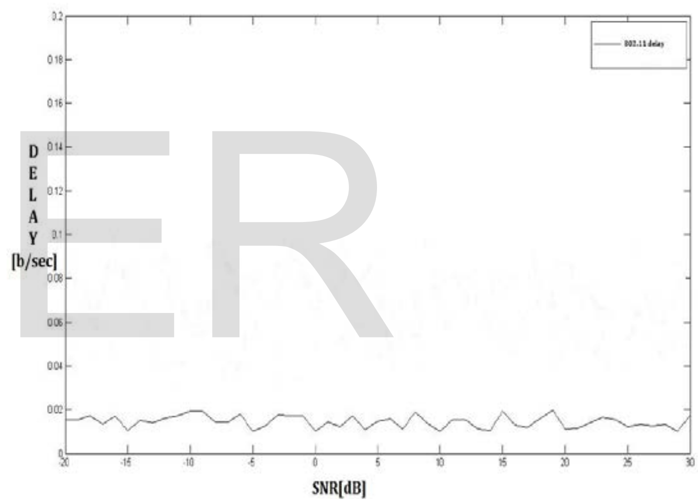
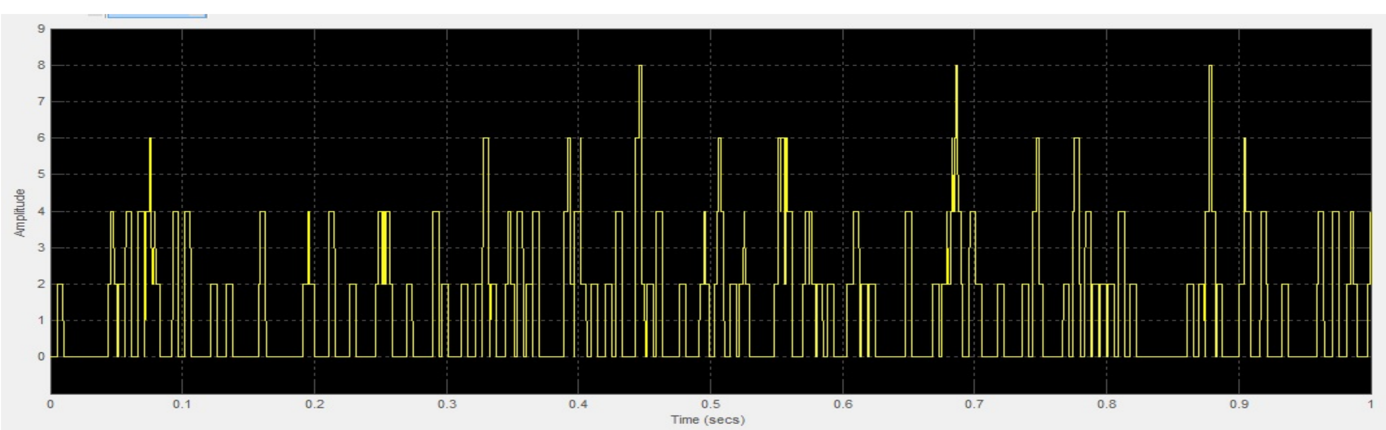


Fig. 7. Delay of 802.11. Delay levels remains low

Fig. 8. PER of 802.11. Levels of error remain low, mostly zero.



5 Infrences From The Graph

The simulation for IEEE 802.11 PHY has been done. The graphs for throughput, delay n error rate have been plotted. The inferences are given in the table below:

TABLE 2
INFRENCES FROM THE GRAPH

S.No	Simulation done for	Conclusion from graphs obtained	Status of Conclusion on the basis of QOS
1	Throughput	The throughput increases with increase in SNR	Positive
2	Delay	The delay levels are very low as they should be	Positive
3	Error rate	The packet error rate is very low.	Positive

6 Conclusion And Future Scope

The WLAN has become the need of the hour. It has made the world a smaller place. But this has increased the real time traffic on WLAN. For an uninterrupted, secureand timely service QOS parameters have to be met. Further alogorithms have to be developed which not only changes rate of transmission on the basis of losses of data packet but also on the basis of throughput and delay.

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