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Designing WLAN System with Adaptive Modulation and Coding over Dispersive Multipath Fading Channel

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Abstract: In the past decade there has been a steady growth in development and implementation of Wireless Local Area Network and Remerged as in the largest sector of the telecommunication industry. Wireless Local Area Network (WLAN) provides connectivity, mobility, and much higher performance and achievable data rate. WLAN is a new medium of a access technology in the Local Area Network (LAN) world. Mostly WLAN applications are used in public sectors such as airports, banks, hotels, offices, city centres because of the flexibility of the people. Orthogonal Frequency Division Multiplexing (OFDM) has been adopted by IEEE 802.11's standard as a transmission technique for high data rate in WLANs. Now IEEE 802.11 standard has been expanded to a family of WLAN standards. 802.11a and 802.11g both are used Orthogonal Frequency Division Multiplexing (OFDM) but operate in different frequency bands. It is shown that 802.11a provides high speed throughout the entire coverage area and long term solution however it does not provide better solution in most cases as compared to IEEE 802.11g. Matlab Simulation model of WLAN based on IEEE 802.11a using different modulation and demodulation techniques such as BPSK, QPSK and QAM to analysis the best performance of IEEE 802.11a with implementation of OFDM. Furthermore, the results show that the performance is improved significantly by adding convolutional coding with Viterbi decoding, and thus highlights the importance of Forward Error Correction (FEC) coding to the performance of wireless communications systems.

Keywords: WLAN, OFDM, BER, FEC.

I. INTRODUCTION OF WIRELESS LAN

A Wireless LAN (WLAN) is a wireless computer network that links two or more devices using wireless communication to form a Local Area Network (LAN) within a limited area such as a home, school, computer laboratory, campus, or office building. This gives users the ability to move around within the area and remain connected to the network. Through a gateway, a WLAN can also provide a connection to the wider Internet. Most modern WLANs are based on IEEE 802.11 standards and are marketed under the Wi-Fi brand name.

A WLAN can be either an extension to a current wired network or an alternative to it. WLANs have data transfer speeds ranging from 1 to 54 Mbps, with some companies offering proprietary 108Mbps solutions. A WLAN signal can be broadcast to cover an area ranging in size from a small office to a large campus. Most commonly, a WLAN access point provides access within a radius of 65 to 300 feet. It should be noted that the IEEE 802.11 are the standards that most of the modern wireless LANs are based on. WLAN types includes:

(a). Private home or small business WLAN: A home or business WLAN employs one or two access points to broadcast a signal around a 100- to 200-foot radius. You can find equipment for installing a home WLAN in many retail stores.

(b). Enterprise class WLAN: An enterprise-class WLAN employs a large number of individual access points to broadcast the signal to a wide area. The access points have more features than home or small office WLAN equipment, such as better security, authentication, remote management.

II. SYSTEM MODEL OF WIRELESS LAN

The Transmitter encoding process of 802.11 physical layer is described in the block schematic below.

(a). Preamble Generation: Preamble part consists of Short Training Field (STF) and Long Training Field (LTF).

(b). Header Generation: Generating the signal field bits and apply encoding and interleaving on these signal bits. Then this encoded data is mapped into frequency domain, and pilot and guard bits are inserted. Then this signal is again converted into time domain.

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(c). Data Generation: The message to be transmitted if it is not already in bits then the same is converted first to ASCII; then it is pre-pended with an appropriate MAC header and a CRC32 is added. Once this is done number of OFDM symbols need to be derived based on length and modulation-code rate. This is used for generating OFDM symbols for the DATA as mentioned below for each symbol.

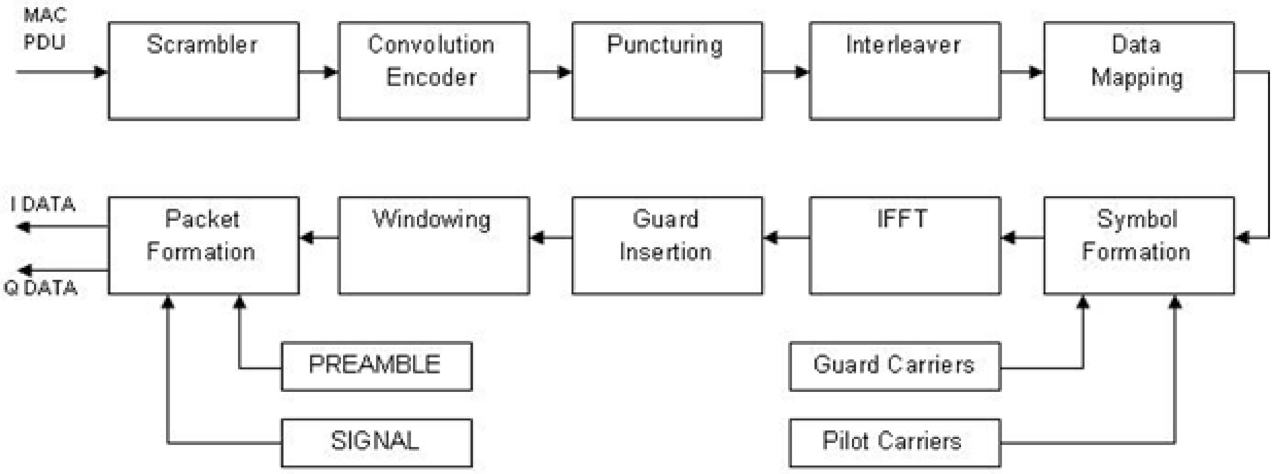

Figure 1. Block Diagram of Transmitter of Wireless LAN.

Combine these symbols in the order which includes preamble, Header and data symbols, hence the packet is formed to be transmitted. The receiver consists of all the blocks reverse of the transmitter except it will have front end synchronization modules for time offset, frequency offset and channel impairment correction. This is shown in the figure below. This is achieved using preamble pattern. After this is done header is decoded as the modulation-code rate is known i.e. BPSK 1/2. Based on header information viz. rate and length data is decoded and passed on to the MAC layer for further processing.

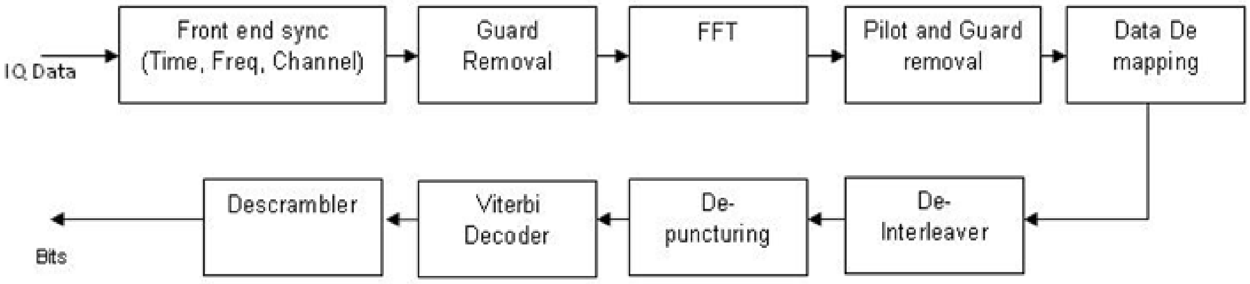

Figure 2. Block Diagram of Receiver of Wireless LAN.

III. IEEE 802.11 STANDARD FOR WIRELESS LAN

Recently, Wireless Local Area Networks (WLANs) have become very popular because of the convenience they offer. Instead of sharing a common wired medium as in the conventional LANs, WLANs share the radio spectrum which is rather scarce. Efficient techniques and appropriate technologies are required to make the optimum use of the spectrum so that WLANs support the data rates and services as available in today's conventional LANs. With the advances in radio technology, it is now possible to support high data rates in WLANs. IEEE has launched a family of radio LAN standards viz. IEEE 802.11. Over the years many versions of IEEE 802.11 standard such as 802.11a, 802.11b…802.11g have been developed. These standards are widely accepted both by the industry as well as the users. 802.11a operates at 2.4GHz RF frequency and supports data rate up to 54Mbps. There are other popular standards in the 802.11 family 802.11b, 802.11g and 802.11n. 802.11b operates at 2.4GHz and supports data rate up to 11 Mbps, where in DSSS (Direct Spread Sequence Spectrum) and CCK (Complementary Code Keying) modulation schemes are employed. 802.11g operates at 5GHz and supports both 11a and 11b standards.
WLAN frame structure consists mainly PLCP Preamble, Signal (Header) part and Data Part. PLCP preamble field, composed of 10 repetitions of a "short training sequence" and two repetitions of a "long training sequence" preceded by a Guard Interval (GI). Header part consists of 24 bits which is always BPSK modulated. Header part contains Rate (modulation-code rate) and length (Unit of OFDM symbols) of the Data part. In WLAN, one symbol consists of 64

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point FFT. It consists of 48 data carriers, 4 pilot carriers, 1 DC and rest of the carriers are used as guard carriers. The 11a standard defines modulation-code rate table as mentioned below, based on data rate various physical layer configuration is made.

Table 1. Different Data Rates Supported by WLAN Standard.

Data Rate Mbits/s	Modulation	Coding Rate	Coded Bits per Subcarrier	Coded Bits per OFDM Symbol	Data Bits per OFDM Symbol
6	BPSK	1/2	1	48	24
9	BPSK	3/4	1	48	36
12	QPSK	1/2	2	96	48
18	QPSK	3/4	2	96	72
24	16-QAM	1/2	4	192	96
36	16-QAM	3/4	4	192	144
48	64-QAM	2/3	6	288	192
54	64-QAM	3/4	6	288	216

IV. WIRELESSLAN PERFORMANCE ANALYSIS

Simulation of Wireless Local Area Network (WLAN) system is done in Simulink tool of MATLAB. The simulation results are plotted in term of the performance of Wireless LAN system that is Bit Error Rate (BER). First the Wireless LAN system is analyzed with different modulation schemes at different data rates. The modulation Schemes namely BPSK, QPSK, 16-QAM and 64-QAM are analyzed and the Bit Error Rate (BER) of Wireless LAN system with these interleaving schemes is calculated to check the system performance. Analysis was done by observing the simulation result and tabulating the analysis results to make it more convenient to be read. In the performance analysis of Wireless LAN system the transmitted signal, received signal, scatter plots and bit error rate of the systems are analyzed.

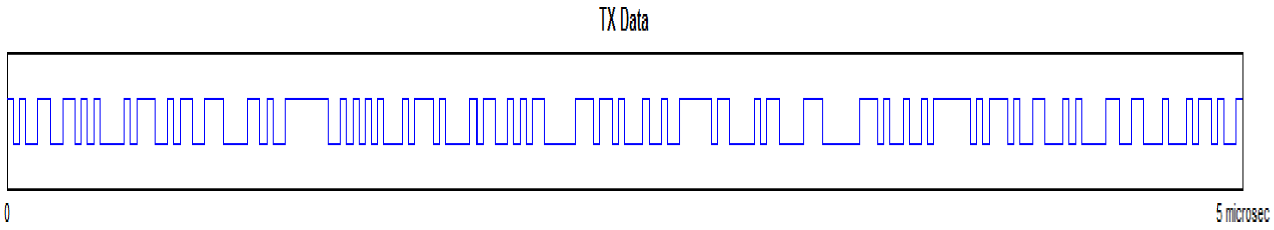

Figure 3. Transmitted Signal of Wireless LAN.

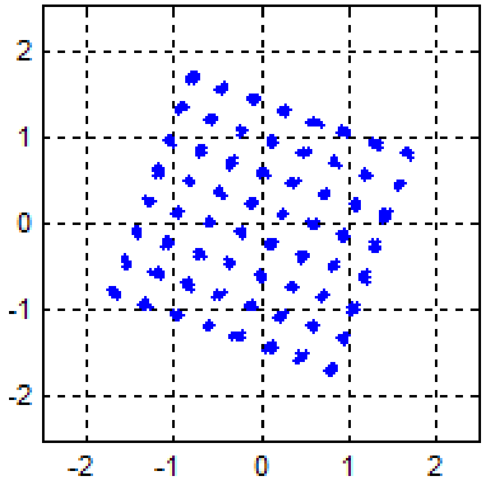

Figure 4. Constellation Diagram of Unequalized Signal of Wireless LAN.

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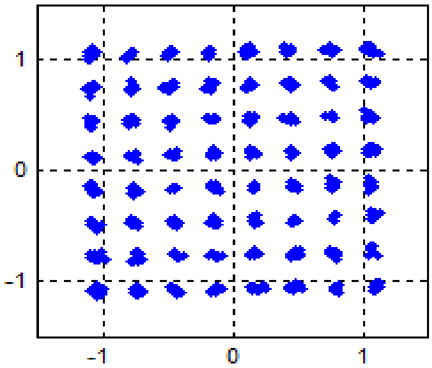

Figure 5. Constellation Diagram of Equalized Signal of Wireless LAN.

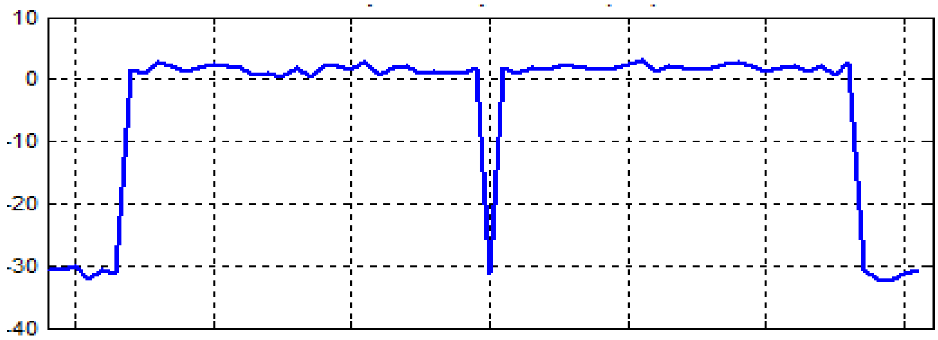

Figure 6. Power Spectrum of Received Signal of Wireless LAN.

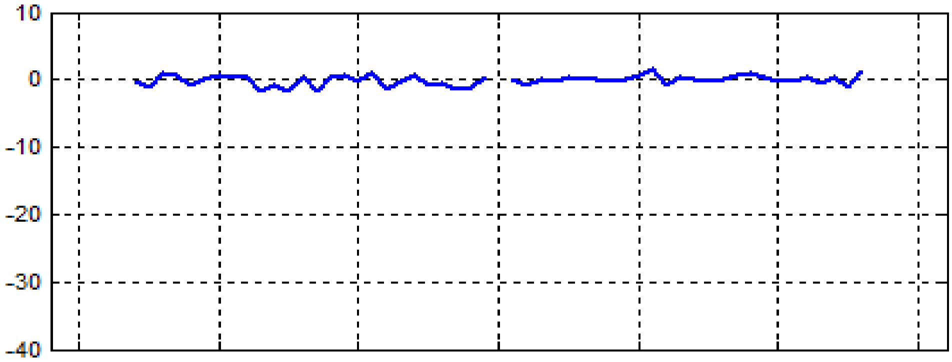

Figure 7. Power Spectrum of Equalized Signal of Wireless LAN.

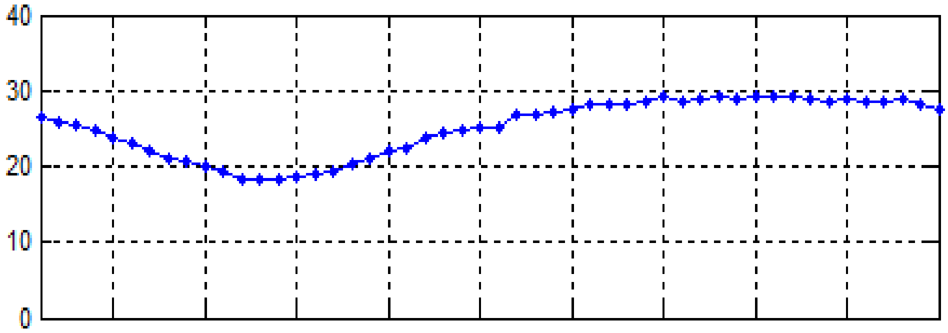

Figure 8. SNR Plot of Wireless LAN.

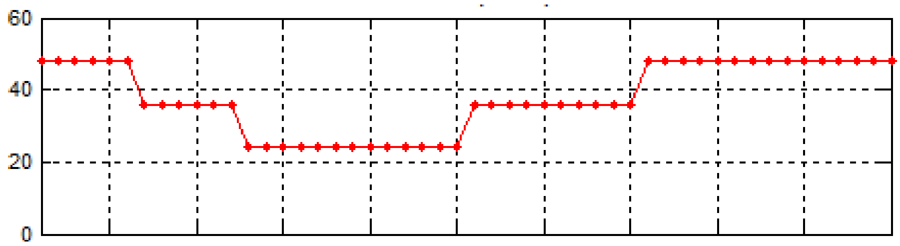

Figure 9. Bit Rate (Mb/s) Plot of Wireless LAN.

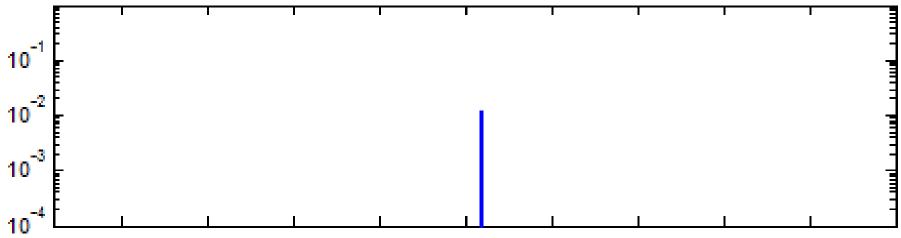

Figure 10. BER (per packet) Plot of Wireless LAN.

The Figure shows the transmitted and received signal of Wireless LAN system. To plot these signals spectrum scope is used. The Spectrum Scope block computes and displays the periodogram of the input. From the plot of transmitted and received signal it is clear that the received signal is so much distorted as comparison to transmitted signal due to channel.
The Scatter Plot Scope displays constellation diagram of a modulated signal, to reveal the modulation characteristics, such as pulse shaping or channel distortions of the signal. The scatter plot also shows the strength of the signal at any point in the coverage area.
The simulation results are plotted in term of the performance of Wireless LAN system that is transmitted, received signal. Now the Bit Error Rate (BER) of Wireless LAN system is analyzed. The BER is calculated with error rate calculation block. In this block the transmitted and received signals are compared to calculate the BER.
The Error Rate Calculation block compares input data from a transmitter with input data from a receiver. It calculates the error rate as a running statistic, by dividing the total number of unequal pairs of data elements by the total number of input data elements from one source. This block can be use to compute either symbol or bit error rate, because it does not consider the magnitude of the difference between input data elements. If the inputs are bits, then the block computes the bit error rate. If the inputs are symbols, then it computes the symbol error rate.

Table 2. BER of Wireless LAN.

Bit Error Rate	0.2548
Total Error Bits	2.139e+006
Total Bits	8.396e+006

V. CONCLUSION

In the present scenario, massive growth in wireless and mobile communications, the emergence of multimedia applications as well as high-speed Internet access and the deregulation of the telecommunications industry are the key drivers towards a new demand for radio-based broadband access networks. The telecommunication companies designed many multiple access technologies for occupying maximium number of users without changing the frequency bandwidths. One of these systems called Wireless Local Area Network shall provide high-speed communications between mobile terminals and various broadband infrastructure networks by using Orthogonal Frequency Division Multiple Access. As the number of users increases the complexity of system increases.
So Wireless LAN system is designed to withstand with interference and fading in communication channel. Channel coding and Interleaving is needed for a system in order to sustain in any type of environment especially in multipath fading channel. By observing the results it is found that when Block Interleaver is used with Convolutional Encoding under the influence of AWGN channel the BER is less than the other interleaving schemes. From transmitted signal and received signal of the Wireless LAN it is clear that in case of block interleaving the distortion is very less. Similarly the scatter plot shown better signal strength in case of equalized signal. So, It is concluded that by using frequency domain equalization the equalized signal gives better performance for power spectrum, constellation plot and gives minimum bit error rate.

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