PERFORMANCE ANALYSIS OF IEEE WLAN 802.11a IN PRESENCE OF DIFFERENT FEC

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Abstract

IEEE 802.11a, Wireless Local Area Network (WLAN), is a wireless broadband technology, which is used as substitute of wired Ethernet as well as in public hot sport wireless network because of its higher data rates compared to cellular mobile networks. In order to provide higher data rate and to mitigate the effect of fading caused by wireless channel IEEE 802.11a uses Orthogonal Frequency Division Multiplexing (OFDM) as a transmission scheme, which based on multicarrier modulation technique. The physical layer (PHY) of 802.11a is simulated with the help of MATLAB to investigate its performance in presence of different Forward Error Correction codes (FEC), over AWGN (Additive White Gaussian Noise) channel. Bit error rate (BER) performance has been observed with respect to Signal to Noise Ratio (SNR). It is found that IEEE WLAN 802.11a perform better in presence of RS code as compared to CC code.

Key words: AWGN, WLAN 802.11a, BER, OFDM, PHY, RS, CC, FEC

1.Introduction

WLAN is a wireless broadband technology that utilizes radio frequency (RF) to transmit and receive data through air interface. It is basically used as substitute of wired Ethernet as well as in public hot sport wireless network, because of its higher data rates compared to cellular mobile networks today [1].

The first WLAN standard is IEEE 802.11 WLAN which operates in 2.4 GHz frequency spectrum with data rate up to 2 mbps, now IEEE 802.11 WLAN has a variety of standards such as 802.11a, 802.11n, 802.11b and 802.11g, with operating frequency Spectrum of 5 GHz (first two) and 2.5GHz (last two) with data rate up to 54 mbps, 140 mbps, 11 mbps and 54 mbps respectively [2,3,4].The 802.11a standard alphabetically seems to be first but both 802.11a and 802.11b were rectified at same time, in spite of high data rate 802.11a has never been commercially popularbecause of its operating frequency spectrum of 5 GHz which made it more expensive andcomplicated to fabricate as compared to 802.11b.where WLAN 802.11g and WLAN 802.11n are rectified version of 802.11b and 802.11a respectively.

Now days with the increasing number of user and hotspots the need of high bandwidth on short distances emerges, which again made WLAN 802.11a a global subject of talk between communication engineers [1].This paper is focused on the PHY of WLAN 802.11a, in this research work PHY of 802.11a has been simulated and evaluated in presence of different FEC Spectrum Access

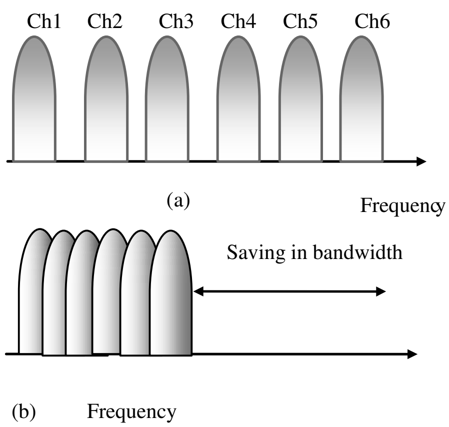

Figure1 Concept of the OFDM signal: (a) conventional multicarrier technique, and (b) orthogonal multicarrier modulation technique.

The paper is organized as follows: System model and OFDMA description is given in section 2. A brief overview of FEC is presented in Section 3. Simulation parameters and results are provided in section 4, finding of this research work is concluded in section 5.

2.802.1a PHY Layer System Model Overview

The IEEE 802.11a standard physical layer is based on OFDM modulation, which includes OFDM modulation and subcarriers allocation. [2-11-12] .

A. *OFDMA*

OFDM is a subset of frequency division multiplexing in which a single channel utilizes multiple sub-carriers on adjacent frequencies [5]

In addition the sub-carriers in an OFDM system are overlapped to maximize spectral efficiency. Ordinarily, overlapping adjacent channels can interfere with one another. However, sub-carriers in an OFDM system are precisely orthogonal to one another. Thus, they are able to overlap without interfering [6]-[13], as a result, OFDM systems are able to maximize spectral efficiency without causing adjacent channel interference, which is shown in Fig.1. In order to obtain the orthogonality the subcarrier frequencies should be spaced by a multiple of the inverse of symbol duration The mathematical representation of OFDM is described below:

Consider a data sequence $(_0, _1, \ldots, _{-1})$where each is complex number $^= +$. The result of DFT operation on vector$\{2\}_{=0}^{-1}$isvector $=$ $(_0, _1, \ldots, _{-1})$ of N complex numbers with

$$S_n = \sum_{n=0}^{N-1} 2 d_n \, e^{-j\left(\frac{2\pi n}{N}\right)}$$

$$= 2\sum_{n=0}^{N-1} 2 d_n \, e^{-j\left(\frac{2\pi f_n t_n}{N}\right)} m = 0,1,\ldots N-1 \quad (1)$$

Where $f_n \triangleq {}^{n}/_{n\Delta t}$ (2)

$\triangleq \Delta$(3)

AndΔ is an arbitrarily chosen interval. The real part of S has components

$$Y_m = 2 \sum_{n=0}^{N-1} (a_n \cos 2\pi f_n t_m + b_n \sin 2\pi f_n t_m) \quad (4) \quad , m = 0, 1, \ldots N-1$$

If these components are applied to a low pass filter at time intervals , a signal is obtained that closely approximates the frequency division multiplexed signal as:

$$y(t) = 2 \sum_{n=0}^{N-1} (a_n \cos 2\pi f_n t + b_n \sin 2\pi f_n t), 0 \le t \le N\Delta t \quad (5)$$

In order to recover the modulated data, a DFT with twice the sampling rate is employed. This is necessary since only the real part of the modulated signal in transmitted. Therefore, the DFT operates on 2N samples

$=$ $(\Delta/2)$ (6)

$$Y_m = 2 \sum_{n=0}^{N-1} (a_n \cos 2\pi nk/2N + b_n \sin 2\pi nk/2N) \sum$$

$,k=01, \ldots, 2-1$ (7)

The result of the DFT operation is then

$$x_l = \frac{1}{2}\sum_{k=0}^{2N-1} Y_k\, e^{-j\left(\frac{2\pi lk}{2N}\right)} = \begin{cases} 2a_{0,} \quad l = 0 \\ a_l - jb_l, l = 1,2,\dots,N-1 \\ irrelevent\ , l > N-1 \end{cases} \quad (8)$$

The original data $_1$and $_1$ can then be extracted as the real and imaginary part of (except at =0)[7]. Since the sinusoidal components of the parallel input are time limited, they have a $\left[\frac{sinf}{f}\right]^2$ shaped power spectrum. This special shape ensures that as long as the components are samples at the right instance, the neighbouring components have zero contribution. This orthogonal nature of the OFDM symbols helps prevent ICI.

B. Simulation Model

For performing analysis, simulations model shown in figure 2 is used, each block of the model is developed using MATLAB coding. This model is based on WLAN standard 802.11a [2].

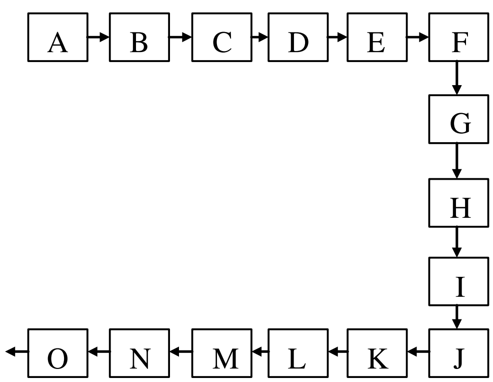

Figure 2 IEEE WLAN 802.11a Physical

The different blocks, shown in Figure 2 are explained below.

- First block denoted by A is random input generator, it generate the random binary data according to required data rate. 24 and 72 are the number of required bits in our model.
- Block B performs channel coding according to specified type like RS or CC for our model.
- Block C represents the interleaver, the output data symbols of block B is interleaved by it. The data symbols are written in the interleaving block in column order, then once the block is full; the symbols are read in row order and transmitted.
- Block D represents the modulator. Where 16QAM is the modulation type used in our simulation.
- Blocks E perform the serial to parallel (S/P) conversion.
- Inverse Fourier (IFFT) is performed by block F, where the IFFT size of model used is 64. It converts the frequency domain data set into samples of the corresponding time domain representing OFDM subcarrier. This same operation is responsible for keeping the orthogonality condition.
- Cyclic prefix is added by block G.
- Parallel to Serial (P/S)conversion is dome to make signal ready for transmission by block H
- Block I is channel □ Block J performed S/P conversion.
- This block K removes the cyclic prefix.
- Block L perform FFT to recover the signal.
- Block M performs P/S conversion
- Demodulation take place in block N
- Block O represent the deinterleaver, it deinterleave the output of the demodulator
- Decoding takes palace in block P. And final output data is obtained.
- At last the bit error rate of system is calculated.

3. FORWARD ERROR CORRECTION (FEC)

A. Convolution Code (CC)

It is only mandatory FEC code for 802.11a, Convolution encoder consume stream of information bits and convert it into a stream of transmitted bits, using shift register band, where the ratio of information bits to output bit generated is code Rate , k is the input bits received, m is the number of memory register [9].

B. Reed-Solomon Code (RS)

RS code is considered to be the special case of BCH codes [10]. It is capable of correcting and detecting both random and burst errors which makes it much more desirable for FEC. These codes are specified as (,) with bits per symbols. This means that the encoders takes k

data symbols of bits each, appends (−) parity symbols and produce a code word of n symbols each of m bits. The error correcting capability is = −/ 2[9]. RS code is much effective for code with very long block length, as it tend to average out the random errors, which make it suitable for use in random error correction.

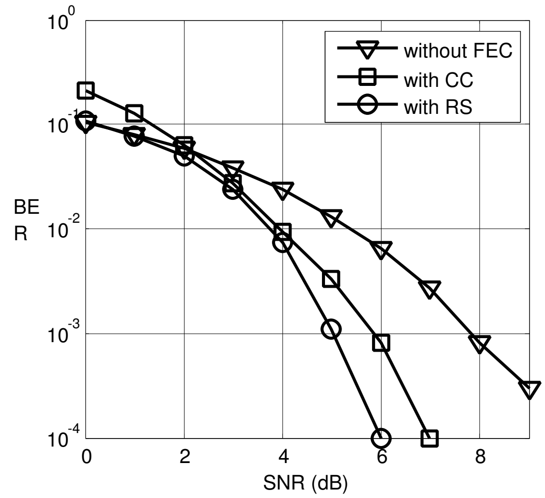

Figure 3. BER performance of 802.11a with different FEC

3. Simulation parameters and results

In this section the simulation parameters and result obtained by simulation is discussed.

A. *Simulation parameters:*

Parameter	Value
Nominal Channel Bandwidth, BW	20 MHz
N_{SD}:Number of data subcarriers	48
N_{SP}:Number of pilots subcarriers	2
N_{ST}:Number of total subcarriers	$52(N_{SD}+N_{SP})$
∇_f:Subcarrier frequency spacing	0.3125MHz)
T_{FFT}: IFFT/FFT period	3.2 µs $(1/\nabla_f)$
T_{GI} :GI duration	0.8 µs $(T_{GI}/4$
T_{SYM}: Symbol interval	4.0 µs$(T_{GI}+T_{FFT})$
NFFT: FFT size	64

Table 1 Simulation parameters

Here Table 1 shows the simulation parameters of WLAN 802.11a as prescribed by IEEE [2].

B. *Simulation Results:*

Table 2BER performance of 802.11a with different FEC

SNR	BER for CC	BER for RS	Without coding
0	0.2095	0.1061	0.1060
1	0.1260	0.0782	0.0805
2	0.0623	0.0495	0.0583
3	0.0275	0.0236	0.0381
4	0.0093	0.0074	0.0239
5	0.0033	0.0011	0.0129
6	0.0008	0.0001	0.0064
7	0.0001	0.0000	0.0027
8	0.0000	0	0.0008
9	0	0	0.0003

Figure 3 shows SNR vs. BER plot for CC, RS and without FE. From above figure 3 and table 2, it has been observed that performance of RS coding is better than CC. At BER 10^{-3}RS coding provide gain of 1 and 4 as compared to CC and without FEC scheme.

5. Conclusion

In this paper IEEE 802.11a PHY layer is simulated and performance curves and tables are concluded. It has been observed that, RS coding is better than CC.

6. References:

[1] Lat koski P., Janevski T., Popovski B., “Modelling and simulation of IEEE 802.11a wireless local area networks using SDL” in *MELECON* 2006, Page(s): 680 – 683.

[2] Wireless LAN Medium Access Control and Physical Layer Specificat ion, IEEE 802.11a.

[3] Wireless LAN Medium Access Control and Physical Layer Specificat ion, IEEE 802.11b.

[4] Wireless LAN Medium Access Control and Physical Layer Specificat ion, IEEE 802.11g.

[5] Shinsuke Hara, RamejeeParasad, *Multicarrier Techniques for 4G Mobile Communication* , London, Arrech House, 2003.

[6] YE (Geoffrey) Li, Gordon L.Stuber (Eds.), *Orthogonal Frequency Division Multiplexing for Wireless Communications*, United State of America: Springer, 2006.

[7] J. Armstrong. “New OFDM peak-to-average power reduction scheme”. In *Proc. IEEE Veh. Technol. Conf. (VTC)*, vol. 1, pages 756–760, May 2001.

[8] Digital Communications Fundamentals and Applications, 2nd edition, Singapore: Pearson Education, 2001.

[9] Digital Communications Fundamentals and Applications, 2nd edition, Singapore: Pearson Education, 2001.

[10] Robert H.Morelos-Zaragoza, The Art of Error correcting Coding, Canada: JOHAN WILLEY & SONS, LTD, 2003.

[11] Suong H. Nguyen, Hai L. Vu, and Lachlan L. H. Andrew, “Performance Analysis of IEEE 802.11 WLANs with Saturated and Unsaturated Sources” IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 61, NO. 1, JANUARY 2012

[12] Anil Mathew, Nithin Chandrababu, Khaled Elleithy, Syed Rizvi “Interference Of 802.11B WLAN and Bluetooth: Analysis and Evaluation” International journal of Computer Networks & Communications (IJCNC), Vol.2, No.3, May 2010.

[13] Lachhman Das Dhomeja1, Shazia Abbasi1, Asad Ali Shaikh1, Yasir Arfat Malkani “Performance Analysis of WLAN Standards For Video Conferencing Applications’” International Journal of Wireless & Mobile Networks (IJWMN) Vol. 3, No. 6, December 2011.