

Performance Evaluation of IEEE 802.11g System under Different Channels Condition

حساب الأداء لمنظومة IEEE 802.11g تحت مختلف ظروف القناة

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Abstract:

This paper studies one of the most widely deployed Wireless Local Area Networks (WLANs) based on IEEE 802.11g standard. The IEEE presented the IEEE 802.11g standard for providing higher data rates up to 54 Mbps at the 2.4 GHz frequency band. However, the simulation results obtained with varying channel conditions represented by typical models are indicative of the performance of OFDM in different environments. The channel adaptation process essentially captures the propagation characteristics of a typical WLAN-enabled office ranging from a small room to a large open space. MATLAB has been chosen as the modeling tool because of its flexibility and mathematical simulation capabilities. The results show that certain channels are better than others and will help in evolving a signal power benchmark for effective communication.

Keywords: OFDM, 802.11g, Performance Analysis, Simulation, MATLAB.

1. Introduction

The multicarrier system is very important modulation technique which provides high resistance against symbol interference under high bit rate transmission condition. Orthogonal Frequency Division Multiplexing (OFDM) system is a very popular version from multicarrier communication systems

which is used in many modern communication standards because it can be implemented efficiently and easily using fast Fourier transform (FFT) with a simple equalizer.

The first OFDM scheme dates back to 1966 when Chang published his pioneering work on the synthesis of band-limited orthogonal signals for multi-channel data transmission [1], The first milestone came about in 1971 when Weinstein and Ebert [2] used a Discrete Fourier Transform (DFT) to perform baseband modulation and demodulation in the receiver. The Inter Symbol Interference (ISI) can instead be eliminated by adding a guard interval at the cost of power loss and bandwidth expansion [3]. Another milestone in OFDM came about in 1980, when Peled and Ruiz solved the orthogonality problem by introducing a cyclic extension, more commonly referred to today as Cyclic Prefix (CP) [4].

The rapid increase in popularity for this scheme is due to the fact that it allows the available channel bandwidth to be used very efficiently. OFDM also enables very high data rate transmission to be achieved. Multicarrier OFDM systems also offer a greater degree of robustness against communications channel perturbations such as frequency selective fading and multipath fading effects, which are often prevalent with both fixed and mobile wireless transceivers. If the transceiver is moving, either in a car or being carried by a person, fading effects may degrade the received signal. OFDM offers extra protection against fading effects using the frequency diversity properties of OFDM and methods used to share the transmission data over multiple frequencies.

One of the most popular versions of OFDM systems today is the IEEE 802.11 wireless local area network standard, commonly referred to as “WiFi” (Wireless Fidelity). This paper focuses on the performance of IEEE 802.11g system based on OFDM (orthogonal frequency division multiplexing) using modeled transmitter and receiver. We investigate the

performance analysis through computer simulations over various modulations like BPSK, QPSK, 16-QAM and 64-QAM

The rest of this paper organized as follows: section 2 discusses OFDM system architecture .Some of IEEE 802.11g specifications represented in section 3.The Simulation results are represented in Section 4. Finally, Conclusion will be presented in section 5.

2. OFDM System architectures

The fundamental principle of OFDM is the use of overlapping subcarriers to modulate parallel data streams. This makes OFDM much more bandwidth efficient than the conventional non-overlapping multicarrier technique [5]. The subcarriers in OFDM systems need to be orthogonal, so that they do not interfere with each other. The fast Fourier transform (FFT) technique is employed to derive a set of orthogonal subcarriers .By modulating low rate data streams onto these subcarriers, OFDM system can ensure flat fading condition on each subcarrier [6].

Fig. 1 is the block diagram of an OFDM system. First, the binary data is mapped into symbols using a specific modulation scheme, such as QPSK or 16QAM. Then, the symbol stream is converted in N parallel symbol streams by means of a serial to parallel (S/P) converter. Inverse fast Fourier transform (IFFT) is applied onto the symbol streams, for OFDM modulation. A parallel to serial (P/S) conversion is done further, and a cyclic prefix (CP) extension, or guard interval, is added to each OFDM symbol. The CP is inserted to prevent inter-symbol interference (ISI) between adjacent OFDM symbols, and inter-carrier interference (ICI) between adjacent subcarriers. Finally, the OFDM signal is transmitted after carrier modulation. The OFDM receiver chain begins with the carrier demodulator. After CP removal and S/P conversion, the FFT operation is performed. A further P/S conversion is needed to obtain original symbol stream. The symbol demapping module is used to estimate the

transmitted binary data. For a detailed description of OFDM systems, readers are referred to [7].

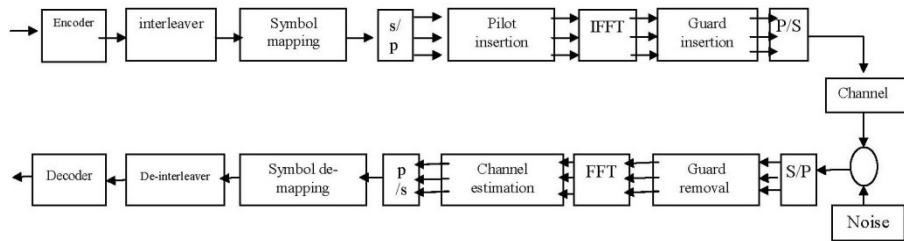


Figure 1: Block Diagram of the OFDM Systems

3. Some of IEEE 802.11g Specifications

The IEEE 802.11g is an interface between the MAC layer and wireless media, specifically designed for OFDM modulation. The IEEE 802.11g utilizes the unlicensed 2.4 GHz band [8], to transmit frames at data rate up to 54 Mbps, enabling multimedia transmissions over WLAN networks. The IEEE 802.11g uses 52 subcarriers that can be modulated with BPSK, QPSK, 16QAM or 64QAM, depending upon the channel conditions. The forward error correction (FEC) is implemented through convolutional coding with the coding rate of 1/2, 2/3 or 3/4. As a result, the different transmission modes with multiple data rates are supported by the system as shown in Table I.

Mode	Data rate(mbps)	Mod.	Cod. rate (R)	Coded bits per subcarrier	Coded bits per OFDM symbol	Data bits per OFDM symbol
1	6	BPSK	1/2	1	48	24
2	9	BPSK	3/4	1	48	36
3	12	QPSK	1/2	2	96	48
4	18	QPSK	3/4	2	96	72
5	24	16QAM	1/2	4	192	96
6	36	16QAM	3/4	4	192	144
7	48	64QAM	2/3	6	288	196
8	54	64QAM	3/4	6	288	216

TABLE (I) RATE-DEPENDENT PARAMETER

The schematic diagram of the IEEE 802.11g is shown in Fig. 1. First, the data for transmission is scrambled to prevent long runs of 1s and 0s in the input data. The scrambled data then input to a convolution encoder. The encoder consists of 1/2 rate coder and subsequent puncturing process to obtain 2/3 or 3/4 rate (if necessary). The coded data is interleaved in order to prevent error bursts from being input to the convolution decoding process in the receiver. After interleaving, pilot bits are inserted. The data stream is OFDM modulated to create IEEE 802.11 bursts and mapped onto 48 subcarriers, whereas, the pilot bits are mapped onto 4 subcarriers. At the receiver, inverse processes are used to recover the transmitted data and deliver them to the higher layer [5].

The relevant timing-related parameters for IEEE 802.11g are listed in Table II. The pilot subcarriers are uniformly distributed over the bandwidth of interest. We assume that there is perfect timing and carrier synchronization (there is no frequency offset). This assumption is idealistic because exactly these two factors limit the performance of OFDM systems. Moreover we assume that the channel estimation performed with the training is perfect, i.e. the channel is perfectly known at the data subcarriers in both amplitude and phase.

Table II: Timing Related Parameters in IEEE 802.11g

Parameter	Description	Value
N_{SD}	Number of data subcarriers	48
N_{SP}	Number of pilot subcarriers	4
N_{SP}	Number of subcarriers total	$52(N_{SD} + N_{SP})$
ΔF	subcarrier frequency spacing	0.3125 MHz (=20 MHz/64)
T_{FFT}	IFFT/FFT period	$3.2 \mu s (1/\Delta F)$
$T_{PREAMBLE}$	PLCP preamble duration	$16 \mu s (T_{SHORT} + T_{LONG})$

T_{SIGNAL}	GI duration	$0.8\mu\text{s}(T_{\text{FFT}}/4)$
T_{GI}	Training symbol GI duration	$1.6\mu\text{s}(T_{\text{FFT}}/2)$
T_{GI2}	Symbol interval	$4\mu\text{s}(T_{\text{GI}}+T_{\text{FFT}})$
T_{SYM}	Symbol interval	$4\mu\text{s}(T_{\text{GI}}+T_{\text{FFT}})$
T_{SHORT}	Short training sequence duration	$8\mu\text{s}(10 \square T_{\text{FFT}}/4)$
T_{LONG}	Long training sequence duration	$8 \mu\text{s}(T_{\text{GI2}}+2\square T_{\text{FFT}})$
Slot time σ	length of time marked off by two instants	$9 \mu\text{s}$
SIFS	Short inter frame Space duration	$10 \mu\text{s}$
DIFS	data inter frame space duration	$28 \mu\text{s}$
PLCP Header H	Physical Layer Convergence Protocol duration	$24 \mu\text{s}$
PHY_I	Physical Data Rates	6Mbps....54Mbps
CW_{min}	continuous waveform duration	15 slots
ACK	Frame acknowledgement duration	$24 \mu\text{s}$

4. Simulation Results

This section considers IEEE802.11g system as underlying OFDM model. It utilizes 20 MHz bandwidth with 64 subcarriers. Fig.1 shows the block diagram of the baseband system model which simulated by writing a MATLAB program.

The performance of the IEEE802.11g system is evaluated under AWGN, flat Raleigh fading channels, and channel B described in Table III.

Figures 2-7 have shown the performance of OFDM system under different environment conditions without or with Equalizers. In Fig. 2 the performance of OFDM system under AWGN is shown and will be used as a reference in this study.

As shown in Figs. 3 and 4 the OFDM system cannot be operated correctly in the presence of fading channel without using an equalizer process.

On the other hand, Figs. 5 and 6 show the performance of the OFDM system in the presence of fading channel using frequency domain equalizer (FEQ); Fig. 5 shows the performance of the OFDM system with using FEQ under flat Rayleigh fading channel condition, and in Fig. 6 shows the performance of the same system under channel B condition. From these figures one can see the FEQ is successfully deleted the channel effects with loss of approximately 2dB in equalization process where bit error rate (BER) assumed equal to 10^{-2} . However, Figs. 5 and 6 are approximately identical which proves the perfect performance of FEQ in such channel conditions. Finally, Fig. 7 shows the effect of FEQ on the constellation of OFDM signal transmit over different channels.

Table III: Standard Channel models for IEEE 802.11 System [9]

Environment	Description
A	Typical office environment for NLOS condition with 50ns rms delay spread.
B	Typical large open space and office environment for NLOS condition and 100ns rms delay spread.
C	Typical large open space environment for NLOS condition and 150ns rms delay spread.
D	The same as environment C, but for LOS condition. A 10dB spike at zero excess delay has been added, resulting in rms delay of about 140ns.
E	Typical large open space environment for NLOS condition and 250ns rms delay spread.

5. Conclusion

This paper compares the performance of IEEE802.11g in terms of bit error rate under varying condition and the figures show certain channels are better than others and will help in evolving a signal power benchmark for effective communication.

الملخص:-

حساب الأداء لمنظومة IEEE 802.11g تحت مختلف ظروف القناة

يدرس في هذا البحث واحدة من اهم شبكات الاتصال اللاسلكي وهي IEEE 802.11g والتي قدمت كمنظومة نقل بيانات بمعدل عالي يصل الى 54 Mbps عند تردد حامل 2.4 GHz. على كل حال, نتائج المحاكاة تم الحصول عليها لاداء المنظومة تحت ظروف مختلفة لقناة النقل. وان عملية تكييف القناة تمثل توليد نموذج لشبكة لاسلكية في ابعاد تتراوح من غرفة صغيرة الى مساحة مفتوحة كبيرة. وقد تم اختيار بيئة "MATLAB" لتمثيل المنظومة لمرونته وقدرته الرياضية العالية. وقد بينت النتائج ان قنوات معينة هي افضل من غيرها وهذا سيساعد في تطوير مؤشر لطاقة الاشارة للحصول على اتصال فعال.

7. References

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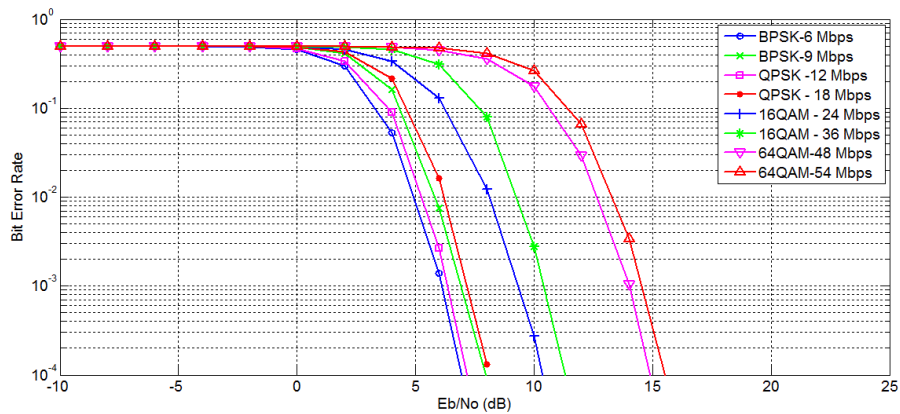


Figure 2: Simulation of the 802.11 OFDM systems under AWGN only without any equalization

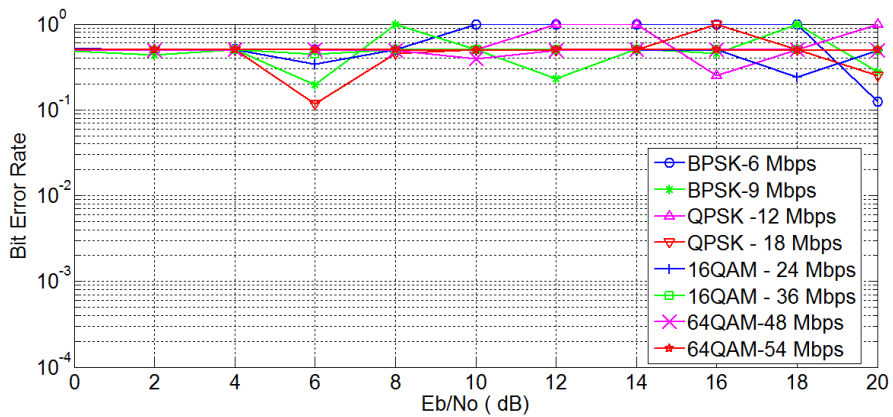


Figure 3: Simulation of the 802.11 OFDM systems under flat Rayleigh fading channels + AWGN without any equalization.

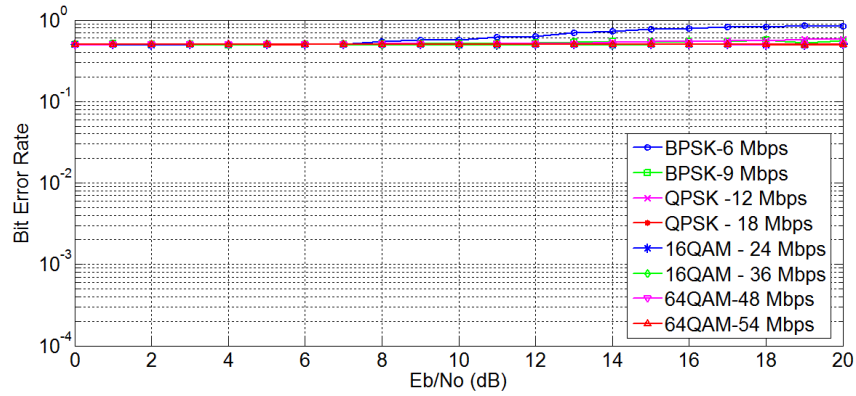


Figure 4: Simulation of the 802.11 OFDM systems under channel B + AWGN without any equalization.

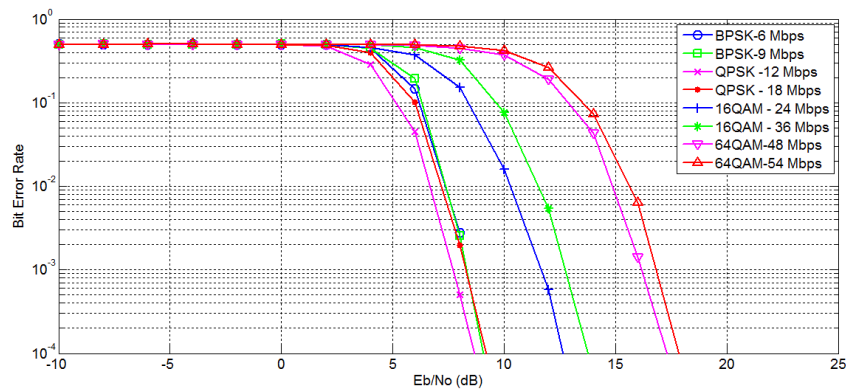


Figure 5: Simulation of the 802.11 OFDM systems under flat Rayleigh fading channels + AWGN with using FEQ.

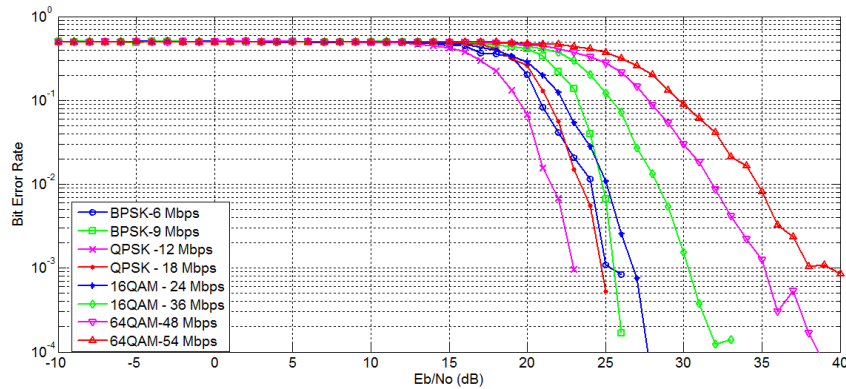


Figure 6: Simulation of the 802.11 OFDM systems under channel B + AWGN with using FEQ.

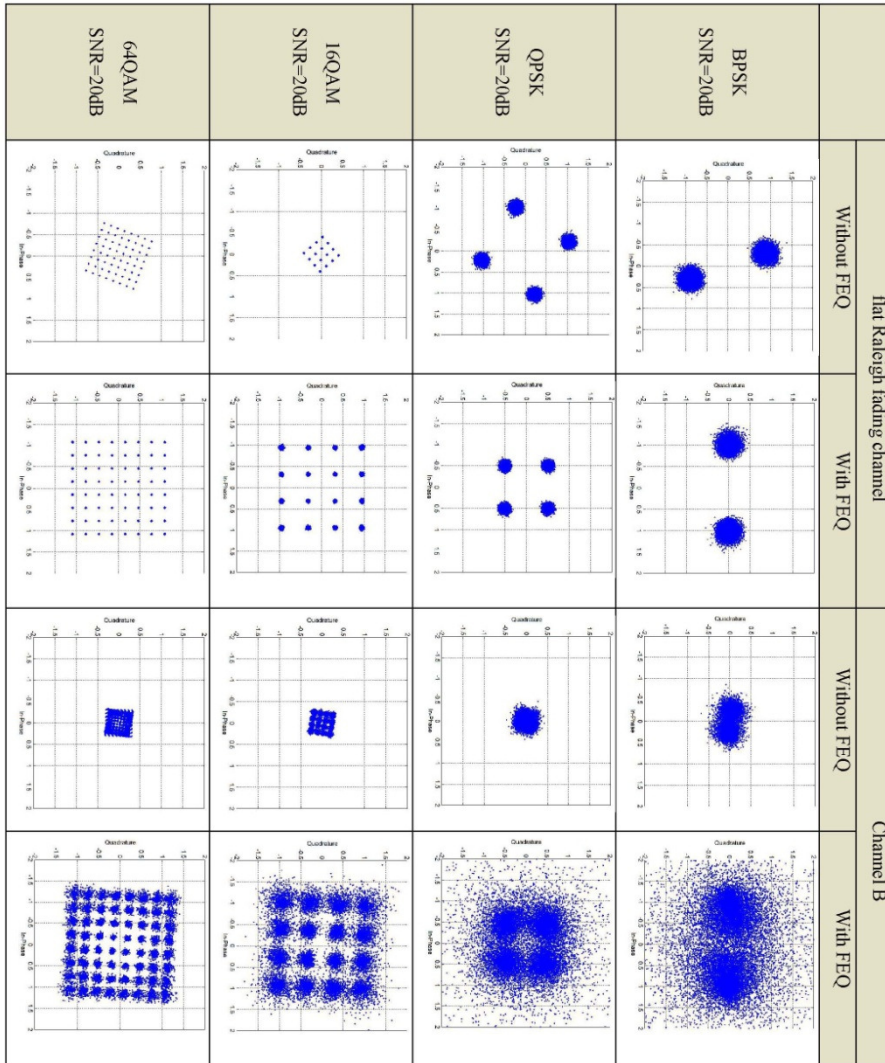


Figure 7: FEQ effects on constellation of OFDM signal transmit over channels