

Performance of OFDM in Time Selective Multipath Fading Channel in 4G System

Kratika Gupta

Department of Electronics & Communication
Sagar Institute of Research & Technology
Indore (M.P.), India
riyagupta180@yahoo.com

Pratibha Nagaich

Department of Electronics & Communication
Sagar Institute of Research & Technology
Indore (M.P.), India
Pratibha.nagaich@trubainstitute.ac.in

Abstract — A comprehensive description of 4G system has been discussed in this paper. With the explosive demand for higher data rate networks, OFDM has emerged as a key technology for 4G standards like 3GPP LTE, IEEE 802.16m WiMAX and IEEE 802.11n WLAN. In mobile radio communication, the fading channels generally exhibit both time-selectivity and frequency-selectivity. Orthogonal frequency-division multiplexing has been proposed to combat the frequency-selectivity, but its performance is also affected by the time-selectivity. In this paper, we investigate how various parameters, such as the number of carriers, the guard time length, and the sampling offset between receiver and transmitter, affect the system performance. Further, we determine the optimum values of the above parameters, which minimize the degradation of the signal-to-noise ratio at the input of the decision device. With its robustness to frequency selective fading, high spectral efficiency and ease of implementation by means of Discrete Fourier Transform (DFT), OFDM is a cutting edge technology for Broadband mobile wireless. Along with its compatibility with MIMO, OFDM is an attractive air-interface solution to meet the demands of 4G networks. In mobile environment, channel is subject to both time and frequency selective fading. Although OFDM is resistant to ISI resulting from frequency selective fades, but it is quite sensitive to time selective multipath fading. This time selective fading causes ICI thus degrading system performance. For a satisfactory performance of OFDM, it is imperative that the sub-carriers remain orthogonal to each other. The orthogonal behaviour of sub-carriers can be jeopardised due to two effects namely Carrier frequency offset, and Doppler spread. This paper reviews the methods to mitigate the deleterious effect of time selective multipath fading in 4G system.

Keyword- Fading channel, OFDM, performance optimization, Broadband Wireless Access (BWA).

1 INTRODUCTION

Since the soonest times, man has found it essential to communicate with others. To meet these requirements and to ensure high quality of service to users, the innovative BWA techniques being used today which connects Wi-Fi hotspots with each other and to other part of internet. This standard is based on multi carrier modulation (MCM) scheme. The broadband services can be categorized into two types; Fixed Wireless Broadband (FWB) and Mobile Broadband. The FWB provides services offered by the fixed line broadband on wireless platform and a competitive alternative to DSL or cable modem. The mobile broadband offers mobility. Thus the mobility is “the ability to keep ongoing connections engaged and active while moving at vehicular speeds”.

The Wimax communication standard incorporates OFDM for achieving better spectral efficiency and data rates which includes the medium access control (MAC) and physical (PHY) layers, of BWA. In OFDM, parallel narrow-band sub-carriers are used for long distance transmission. It provides good resistance to multipath and allows Wimax to operate in NLOS condition. As OFDM follows principle of orthogonality thus, serial-to-parallel transmitter converts the incoming high data stream into low-data stream, and then transmits each low data stream over an infrequent orthogonal carrier. The data rate of each transmitted stream is effectively reduced by a factor of N from the original data rate. By employing this strategy, OFDM extremely reduces inter symbol interference (ISI) by avoiding multipath in frequency-selective channels.

Usually, wireless communication systems are subjected to fading, there must be enormously high signal to noise ratios are required to achieve reasonable error probability. A major problem in such system is multipath fading in channels. Basically, the fading attributes multipath interference, delay, doppler spread and rapid fluctuations of amplitude, phases of radio signals over short interval of time. There are several parameters to objectively measure the performance of the system and the influence of nonlinearities of signal.

Let, $\{s_{n,k}\}$ with $E|s_{n,k}|^2 = \sigma_s^2$ be the complex symbols to be transmitted at the N^{th} OFDM block. The OFDM modulated signal can be represented by equation (1).

$$s_n(\mathbf{t}) = \sum_{k=0}^{N-1} s_{n,k} e^{j2\pi k \Delta f t} \quad 0 \leq t \leq T_s \quad (1)$$

Here, T_s is the symbol duration, Δf is sub channel space, and N is the number of sub channels of OFDM.

At receiving end, to demodulate the OFDM signal the symbol duration should be enough such that $T_s \Delta f = 1$. It is also known as orthogonal condition. Since, it makes $e^{-j2\pi k \Delta f t}$ orthogonal to each other for different value of k . Under orthogonal condition, the transmitted symbols $\{s_{n,k}\}$ can be detected at the receiver by equation (2).

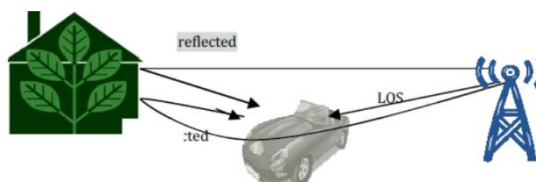
$$s_{n,k} = \frac{1}{T_s} \int_0^{T_s} s_n(t) e^{-j2\pi k \Delta f t} dt \quad (2)$$

Wireless communication is enjoying a fast growth period in history which is supported by the technology advancement. Such is the cellular concept developed by Bell Laboratories [1]. Mobile communication offers a full duplex communication using a radio to connect portable device to a dedicated Base station, which is then connected to a switching network and hence providing facilities for voice call and data exchange. The first generation of mobile communication, known as Advanced Mobile Phone System (AMPS), which was deployed in 1983 [1]. The second generation (2G) of mobile communication is known as Global System for Mobile communication (GSM) was deployed in the 1990s [1] provides 9.6kbps data rate. The International Telecommunications Union (ITU) developed a plan in 1995 [2] called International Mobile Telecommunication 2000 (IMT-2000) to implement a global frequency band [1, 3]. The third Generation system (3G) standard was deployed in 21st century (2000s) with data rate of 64kbps to 2Mbps. Soon after the launch of 3G, a collaborative group of standards organisation and telecommunication companies called Third Generation Partnership Project (3GPP) was formed for enhanced versions to the standard. Evolved from 3GPP standards in 2004 [4], is the Release 8 version, which is known as Long Term Evolution (LTE). 3GPP-LTE targets to support high data rate of 100Mbps for the downlink and 50Mbps for the uplink with achievements of low delay, higher data rate, flexible bandwidth and optimised radio access and cell

edge performance [5]. To achieve the above goals, data access and modulation technologies' having the popular consideration is based on Frequency Division Multiple Access (FDMA). For the Downlink, Orthogonal Frequency Division Multiple Access (OFDMA) is considered while Single Carrier Frequency Division Multiple Access (SCFDMA) is for the Uplink.

2 CHARACTERISTICS WIRELESS CHANNEL

In the last few decades, communication over a distance is focused and scalability of radio access technology is taken into an account, thus provides a great flexibility in network deployment options and offer better services. Due to use of broadband system which has high quality features new techniques emphasized with high transmission capability [1].



Wireless channel is an unguided channel and signals not only contain the direct Line of Sight waves but also a number of signals as a result of diffraction, reflection and scattering. This propagation type is termed Multipath [2] degrades the performance of the channel.

3 Additive White Gaussian Noise Channel (AWGN): The AWGN channel is a good model for the physical reality of channel, as long as the thermal noise at the receiver is the only source of disturbance [6]. The impairment this channel caused to signal is the addition of Gaussian distributed noise.

I. FADING CHANNELS

A. Nakagami-m channel

Rayleigh fading fails to describe long distance fading effect with appropriate accuracy. Thus Nakagami observed this fact and formulated a parametric gamma distribution-based density function to describe the experimental data. Fading occurs for multipath scattering with relatively larger time-delay spreads, with different clusters of reflected waves. This is the type of small scale fading. In any cluster reflected waves phase occurs random but the time delays are almost equal for all waves. As a conclusion the envelope of each cluster signal is Rayleigh function. The average time delay is supposed to differ between the clusters. ISI occurs by the clusters become higher if the delay time is remarkably outreached the bit period of digital data.

The PDF for this distribution is given by Nakagami (1960) as

$$p(x) = \begin{cases} \frac{2}{\Gamma(m)} \left(\frac{m}{\Omega}\right)^m x^{2m-1} e^{-\frac{mx^2}{\Omega}} & x > 0 \\ 0 & \text{otherwise} \end{cases} \quad (10)$$

Where, Ω is defined as $\Omega = E[X^2]$

and the parameter m is defined as the ratio of moments [12], called the fading figure

$$m = \frac{\Omega^2}{E[(X^2 - \Omega)^2]}, \quad m \geq \frac{1}{2} \quad (11)$$

The mean and the variance for this random variable are given by

$$E[X] = \frac{\Gamma(m + \frac{1}{2})}{\Gamma(m)} \left(\frac{\Omega}{m}\right)^{\frac{1}{2}} \quad (12)$$

$$VAR[X] = \Omega \left(1 - \frac{1}{m} \left(\frac{\Gamma(m + \frac{1}{2})}{\Gamma(m)}\right)\right) \quad (13)$$

B. Lognormal channel

This channel implies the distribution suitable for modelling the effect of shadowing of the signal due to large obstacles, such as tall building, in mobile radio communications. Some part of the signal lost due to absorption, reflection, diffraction, and scattering, thus shadowed channel designed. Suppose that a random variable Y is normally distributed with mean m and variance σ^2 . Let us define a new random variable X that is related to Y through the transformation $Y = \ln X$ (or $X = e^Y$). Then the PDF of X is

$$p(x) = \begin{cases} \frac{1}{\sqrt{2\pi\sigma^2}x} e^{-\frac{(\ln x - m)^2}{2\sigma^2}} & x \geq 0 \\ 0 & \text{otherwise} \end{cases} \quad (14)$$

For this random variable mean and variance are

$$E[X] = e^{m + \frac{\sigma^2}{2}} \quad (15)$$

4 Multi Path Fading Channels: An alternative class of channel used to model communication system is fading channels because mobile reception is harshly affected by multipath propagation which results in Fading or Inter-symbol Interference (ISI). In a wireless environment radio signals might arrive to the receiver by two or more paths in phenomenon known as multipath propagation. Multipath is caused by many factors such as Atmospheric ducting, ionosphere reflection and refraction. Phase shifting, destructive and Constructive interference are possible in a multipath environment [5]. This would result in Rayleigh Fading that affects the quality of the received signal after causing errors. Broadly, the fading phenomenon can be broadly classified into two different types: 1) large-scale fading and 2) small-scale fading. This is shown in Figure 2.



Figure2..Classification of multipath fading channel

This paper focuses on investigating the effect of fading in modern digital communication techniques such as orthogonal frequency division multiplexing (OFDM). It is because OFDM is most commonly used in modern mobile broadband wireless communication systems such as mobile WiMAX and long-term extension (LTE).

5 SIMULATION ENVIRONMENT AND PERFORMANCE METRICS

A. System Model

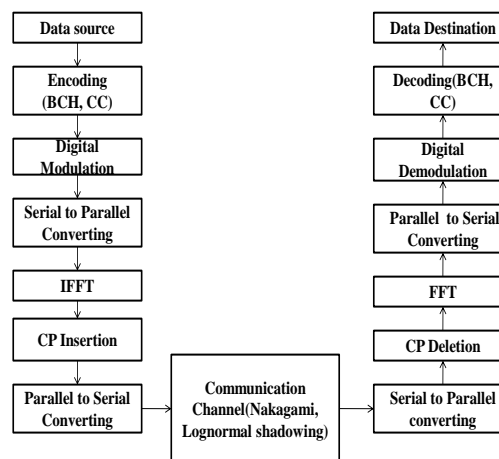


Figure2..Schematic block diagram of OFDM Communication System

B. Model description

The proposed WiMAX system is as shown in Figure 2. The input data sequence is generated and encoded using FEC encoding technique such as BCH and Convolution code [12]. Then, modulation is performing with BPSK. The output of this technique is real and imaginary value. Only real part is taken into consideration and processed to serial to parallel conversion block and after conversion data is sent to IFFT block to transform spectrum into time domain signal. Cyclic prefix is used to avoid inter symbol interference (ISI) which is one of the major drawback in multicarrier transmission. Then, data is converted parallel to serially and pass through different fading channels. And at the receiver side vice-versa process performs. The received data is then determined with original data & BER and loss of bit is numerate.

6 CONCLUSION

An extensive demonstration of OFDM system has been presented in this paper. The proposed system is tested under Nakagami and Lognormal shadowing channel with different coding techniques as BCH and Convolution code. It is concluded from the simulation that the OFDM system provides good reduced bit error rate, with BPSK modulation technique. We have estimated that BPSK gives better performance among the entire channels environment with BCH coding. Among both the channels Lognormal Shadowing channel using different coding technique under OFDM system provide better performance as calculated. Finally we can say that the performance of high signal to noise ratio channel is best to achieve optimum utilization of bandwidth. This paper reviews the methods to mitigate the deleterious effect of time selective fading and compares the simulation result of high Doppler spread with that of small Doppler spread.

7 REFERENCES

- [1] Intel corp., IEEE 802.16 and wimax: Broadband Wireless Access for Everyone, www.intel.com/ebuisness/pdf/wireless/intel/802.16-wimax.pdf, 2003.
- [2] Clint Smith and Daniel Collins, "3G Wireless Networks", 2nd edition, 2008.
- [3] Vivek K. Dwivedi and G. Singh, "Improved BER Analysis of OFDM Communication System on Correlated Nakagami-n Fading Channel", International Conference on Microwave, 2008.
- [4] Md. Ashrafal Islam, Riaz Uddin Mondal, and Md. Zahid Hasan, "Performance Evaluation of Wimax Physical Layer under Adaptive Modulation Techniques and Communication Channels", International Journal of computer Science and Information Security (IJCSIS), vol.5, No.1, 2009.
- [5] Ehab M. Shaheen and Mohamad El-Tanany, "BER Analysis of UWB Systems in the Presence of Narrowband Interference in Lognormal Mulyipath Fading Channel. IEEE transaction, paper ID 901726 2009.
- [6] Mukesh Kumar Mishra, Neetu Sood, and Ajay K Sharma, "Efficient BER Analysis of OFDM System over Nakagami-m Fading Channel", International Journal of Advanced Science and Technology (IJAST), vol.37, December 2011.
- [7] V. Jagan Naveen and K. Raja Rajeswari, "Generation of Nakagami Fading Signals with Arbitrary Correlation and Fading Parameters", International Journal of Future Generation Communication and Networking, vol.4, No.2, June 2011.
- [8] Khairi Ashour Hamdi, Senior Member, IEEE, "Analysis of OFDM over Nakagami-m Fading with Nonuniform Phase Distributions", IEEE Transactions on Wireless Communications, vol.11, No.2, February 2012.
- [9] M. Mirahmadi, Member, IEEE, A.Al-Dweik, Senior Member, IEEE, and A.Shami, Senior Member, IEEE, "BER Reduction of OFDM Based Broadband Communication Systems over Multipath Channels with Impulsive Noise", IEEE Transactions on Communications, vol.61, No.11, November 2013.
- [10] Ehab Salahat and Ibrahim Abualhaol, "General BER Analysis over Nakagami-m Fading Channels", IFIP Wireless and Mobile Networking Conference (WMNC), 2013.
- [11] Xuegui Song, Student Member, IEEE, Julain Cheng, Senior Member, IEEE, and Mohamed-Slim Alouni, Fellow, IEEE, "High SNR BER Comparison of Coherent and Differentially Coherent Modulation Schemes in Lognormal Fading Channels", vol.18, No.9, September 2014.
- [12] Bernard Skalar and Pabritra Kumar Ray, "Digital Communication: Fundamentals and Applications", Pearson, Edison 2, Jan.2009.
- [13] Proakis John G., Salehi M., - Communication System Engineering, Prentice Hall of India, Edition 2, 2005.
- [14] Orthogonal Frequency Division Multiplexing, U.S. Patent No. 3, 488, 4555, filed November14, 1996, issued Jan.6, 1970.
- [15] Vendee-Ramjee, "OFDM for Wireless Multimedia Communications".
- [16] Umesh Sharma, "Comparative Study of Digital Modulation Techniques in WIMAX", International Journal of Engineering and Innovative Technology (IJEIT), vol.2, No.2, August 2012.
- [17] Anuradha.R.Kondelwar, and Dr.K.D.Kulat, "BER Analysis of Proposed Wimax System in different channel Environments", International Journal of Emerging Technology and Advanced Engineering (IJETA), vol.2, No.9, September 2012.
- [18] Y. Wu and W. Y. Zou, "Orthogonal frequency division multiplexing: A multi-carrier modulation scheme", IEEE Transaction. Consumer Electronics, vol.41, no.3, pp. 392 399, Aug. 1995.
- [19] Mrityunjay Prasad Tripathi, Dr.Soni Changlani, Prof.Saiyed Tazin Ali, "Performance Comparison of M-PSK and M-QAM Modulations for WiMAX OFDM system under the Rayleigh Fading Channel", International Journal of Technological Exploration and Learning(IJTEL) , ISSN: 2319-2135, vol.3, no.2, April 2014.
- [20] N. C. Beaulieu and C. Cheng, "Efficient Nakagami-M Fading Channel Simulation," IEEE Transactions on Vehicular Technology, vol. 54,no. 2, pp. 413-424, 2005.
- [21] Prajoy Podder, Tanvir Zaman Khan, Mamdudul Haque Khan, M. Muktaadir Rahman, "BER Performance

- Analysis of OFDM-BPSK, QPSK QAM over Rayleigh Fading channel and AWGN fading channel", International Journal of Industrial Electronics and Electrical Engineering, vol.2, July 2014.
- [22] Amer.M. Magableh and Mustafa M. Matalgah, "Accurate Closed-Form Approximations for the BER of Multi-Branch Amplify-and-Forward Cooperative Systems with MRC in Rayleigh Fading Channel", WSEAS Transactions on Communications, vol.12, July 2013.
- [23] P.M.Shankar, "A Nakagami N-gamma Model for Shadowed Fading Channels", Wireless Pers Communication, Springer Science + Business Media, 2012.
- [24] M. Divya, Bit Error Rate Performance of BPSK Modulation and OFDM BPSK with Rayleigh Multipath Channel international Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 - 8958, Volume-2, Issue- 4, April 2013.
- [25] Allanki Sanyasi Rao, S. Srinivas, A New BER and SNR Calculations for MIMO System International Journal of Inventive Engineering and Sciences (IJIES) ISSN: 2319-9598, Volume-2 Issue-8, July 2014.
- [26] Md. Mejbaul Haque^{1,*}, Mohammad Shaifur Rahman¹ and Ki-Doo Kim², "Performance Analysis of MIMO-OFDM for 4G Wireless Systems under Rayleigh Fading Channel" International Journal of Multimedia and Ubiquitous Engineering Vol. 8, No. 1, January, 2013.

IJSER

IJSER