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Performance Evaluation of LTE based System Parameters using OFDM in Indoor and Outdoor Environment

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Abstract

Background/Objectives: OFDM is a wireless broad band technology employed in 4G wireless system. OFDM is the Frequency Division Multiplexing (FDM) modulation technique used for sending a group of signals simultaneously over a channel. OFDM divides the signal into a number of narrow signals which are sent at various frequencies to the receiver. **Method/Analysis**: Long Term Evolution is a 4G technology used for both indoor and outdoor environments. LTE is able to produce higher data output rates and reduce the cost of delivering a megabyte of data. The outside sources of interference, design and configuration of the LTE network may reduce the spectrum efficiency and results in low data output rates for users and high costs for network operators. LTE will be deployed to provide multimedia services for mobile and portable scenarios. **Findings/Applications:** This paper concentrates on correlating SNR to the performance of LTE in indoor and outdoor environments. An average throughput and a consistent performance are observed more frequently in outdoor areas when compared to indoor areas. A comparison of indoor and outdoor parameters is shown by simulating in MATLAB.

Keywords: 4GTechnology, Indoor-outdoor, LTE, MATLAB, OFDM, SNR

1. Introduction

Wireless positioning system for Mobile Stations (MS) is achieving significance during the past decade very rapidly. The MS positioning requirements are used to improve fraud detection, e-marketing, fraud detection, location-based services and applications. In addition to these improvements, mobile network functions like handovers would have an advantageous performance if accurate positioning information were available. This is because, it is necessary to improve wireless positioning Nowadays, there is a good accuracy in wireless positioning, in good atmospheric conditions, by using GPS and GNSS or the Galileo system in Europe. The accuracy of these systems worsens with weak channel conditions, or even disappears in indoor locations. This is because they need atleast4 satellites with good signal strength reaching the receiver that communicate with the satellites at low carrier-to-noise ratios.

The SoO classification is sometimes controversial, and some do not include cellular systems into SoO class, arguing that many cellular systems, such as Long Term Evolution (LTE), have already signals specifically optimized for positioning. OFDM technique under study is to achieve better wireless positioning performance. Although there are higher sensitivity receivers and other improvements to reach better results.

Firstly, OFDM is seriously affected by synchronization errors. Moreover, the OFDM signal with good dynamic range requires RF amplifiers with a good PAPR. The presence of carrier frequency offset makes OFDM more sensitive than single carrier systems because of Discrete Fourier Transform (DFT)[1].

1.1 OFDM

The OFDM technique consists of transmitting N complex data symbols over N narrow and orthogonal subcarriers.

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These subcarriers can be superposed without interfering thanks to being orthogonal, which means that there is no Inter-Carrier Interference (ICI) when the receiver is synchronized. The mentioned subcarriers are chosen narrow enough so they can be considered as belonging to flat regions, and they can be easily equalized to correct the errors at the receiver. Moreover, the transmission rate is higher due to the parallel subcarriers sending information at the same time. The next step is to see how the OFDM signal is built. According to the Figure 1, the serial data stream composed with N complex data symbols goes throw a serial to parallel converter to split the stream into N parallel channels. The separation between adjacent.

Channels is Df, which results in a total bandwidth of N·Df. After that, the data transmitted in each channel is modulated by doing the Inverse Fast Fourier Transformation (IFFT). Then, these N channels are combined with a parallel to serial converter (S-P) to form the N samples of OFDM. At the output of the parallel to serial converter (P-S), a Guard interval is introduced at the starting of the symbol, which is called Cyclic Prefix (CP). The reason of doing this is to avoid the Inter-Symbolic Interference (ISI) between two consecutive OFDM symbols. The CP usually is the copy of the last Ncp samples inserted where said symbol starts. After the CP insertion, the OFDM symbol is formed by N + Ncp samples[2,3].

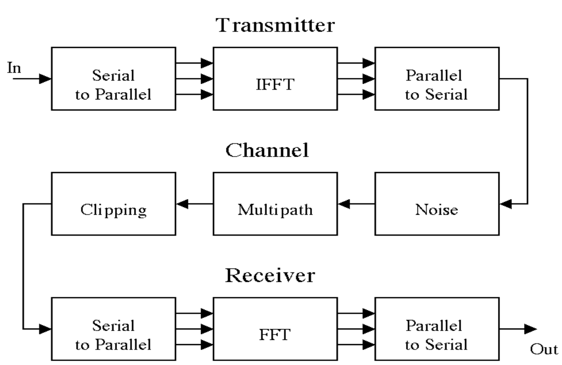


Figure 1. Block diagram of OFDM.

The Figure 1 shows the block diagram of OFDM. It consists of various different blocks like parallel to serial and serial to parallel converters in transmitters and receivers. The inputted serial binary data is converted to parallel data using a serial to parallel converter and applied simultaneously to an IFFT device. An IFT converts the frequency domain into time domain data. IFFT is used for OFDM to generate samples of a waveform with phase shift frequency components. Later the OFDM signal is created by the parallel to serial (P-S) block by outputting the time domain samples sequentially. The effects of multipath, noise and slicing is analyzed through the channel simulation. Random data is added to the transmitted signal and noise is simulated by this additional process. The attenuated and delayed copies of the transmitted signals involve multipath simulation in the addition process to the original base band signal. This simulates the problem in WC when the signal propagates on multiple channels. The amplifier saturation which is a major practical problem is addressing by slicing in OFDM with high PAPR.

1.2 LTE - Long Term Evolution

Based on GSM/EDGE and UMTS/HSPA networks LTE is a derived wireless standard for high-speed communication in data terminals and mobile phones. The 3GPP (third generation partnership project) developed this standard and Release 8 document series specified this standard, with small improvements. LTE is the upgradation of carriers for both GSM and UMTS networks. The usage of different frequencies and multi band phones indicate that LTE can be used in different countries for only the phones which have these features. The Commercially available LTE doesn't satisfy the technicality of 4G wireless services with respect to the document series of 3GPP release 8 and 9 and the requirements set by ITU-R organization. The differentiation between the WiMAX advanced and LTE advanced is specified by ITUr and presented true 4G technologies. With the advancements in IC technologies the LTE has to increase its speed and capacity which is achieved by the use of different DSP processors and modulation techniques. The other technical issue in LTE is to redesign and simply the network architecture for IP based system. The LTE wireless interface operates on a separate radio spectrum different from 2G and 3G networks[4].

LTE Advanced, is the advanced version of LTE being standardized in March 2011. In the year 2013 the services of LTE advanced were started. The standard uplink and downlink rates of LTE are 75Mbps and 300 Mbps respectively providing a transfer latency less than 5ms. LTE systems are able to manage fast-moving mobiles, multicast and broadcast streams can also be supported. The operating parameters supported by LTE are carrier bandwith ranging from 1.4MHz to 20 MHz, FDD and TDD duplexing techniques[5].

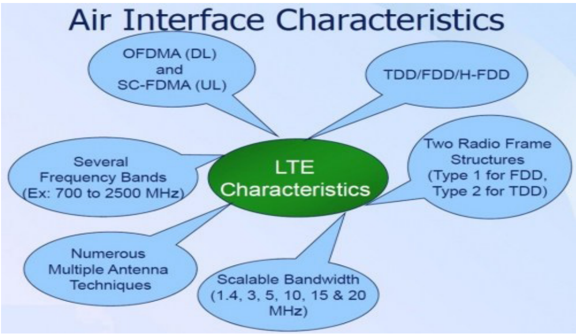


Figure 2. Characteristics of LTE.

Table 1. Basic LTE parameters.

S.No	Parameter	Description
1	Frequency range	UMTS FDD and TDD bands
2	Duplexing	FDD, TDD half duplex FDD
3	Channel bandwidth	1.5, 3, 5, 10, 15,20 MHz etc
4	Modulation schemes	PSK, QAM etc
5	Multiple access schemes	SC-FDMA, OFDM
6	Peak data rate	Uplink: 75 Mbps, downlink: 150 or 300 Mbps

The Table 1 lists some of the basic parameters of LTE like duplexing, frequency range, channel bandwidth, modulation, multiple access schemes, data rates etc. These requirements are covered by using OFDM, MIMO and multi-level modulation schemes. OFDM is suitable for the enhancement of data-rates and capacity which compiles the increasing demand of mobile services around the world. In addition, it is well known that OFDM offers a high performance in multipath environments that characterize the mobile wireless systems.DFT/IDFT, namely the Fast Fourier Transform (FFT) and its inverse (IFFT) is normally used on OFDM implementations[6].

2. Methodology

The performance evaluation is done by quantifying the BER performance by simulating some SM schemes in different spectral efficiencies on LTE channels. An assumption is made that multi path channels are statistically independent and all the transmission schemes have same signal power. Along with this time and frequency synchronization are also assumed.

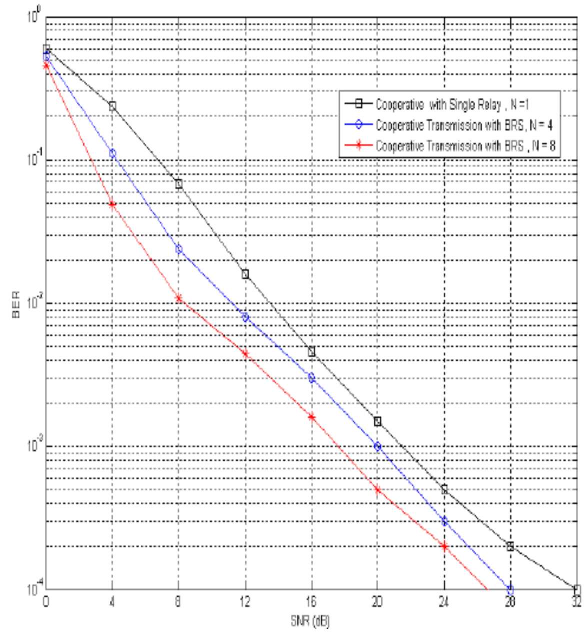


Figure 3. BER versus SNR for the 3 bits/s/Hz transmission scheme.

2.1 First Generation

1G technology was first used in analog communication, switching technology, and aws used for voice communication and was not applicable for data communication.

2.2 Second Generation

2G (or **2-G**) is an abbreviation for second-generation. **Advantages of 2G over 1G are as follows:**

1. Digital encryption was done in phone conversations
2. These systems are more bandwidth efficient.
3. These systems started the data services for mobiles like SMS text messages, MMs etc.

as the messages are encrypted no receiver can receive and unable to read it.

Analog radio signals were used in 1G networks while digital radio signals were used in 2G networks. The successors of 2G are some of the following technologies like 2.5G, 2.75G, 3G, and 4G.

2.3 Third Generation

The 3G is an enhancement of 1G and 2G technologies. the third generation is more advantageous when compared to the previous technologies.

The third generation mobile technology based on wide band wireless network fulfilling the International

Mobile Telecommunications-2000(IMT-2000) specifications by the International Telecommunication Union.

Advantages of 3G:

1. More reliable, secured and bandwidth is high
2. Enhanced multimedia services.
3. Overcrowding problem solved, etc

Disadvantages of 3G:

The disadvantages of 3G include

1. High power consumption
2. High cost
3. Close base stations are required etc

2.4 Fourth Generation

4G is the successor of 3G.

Advantages of 4G:

1. High voice quality
2. Easy access to internet
3. High bandwidth
4. Video calling, conference calls, etc. are possible
5. 4g is almost 10 times faster than 3G

Disadvantages of 4G:

1. Data prices for consumers are high
2. Device support for consumers force them to buy a new one, etc

3. Experimental Results

Here some parameters are worked out and they are calculated based on the system performance referring to signal to noise ratio, symbol error rate etc.

The rate at which information or data transmitted over a given bandwidth in a communication system is called Spectral **efficiency or spectrum efficiency.** In a digital communication system the spectral efficiency is calculated in terms of *bit/s/Hz*. It is ratio of maximum throughput to bandwidth in hertz of a communication channel. Spectral efficiency can also be calculated in bits per symbol equivalent to bits per channel use.

constellation is derived from the Latin "constellatus," set with stars; from "com-," together, and "stellare," to shine; stella, a star. A constellation is a group of stars, which might form a pattern or shape within a specific area of the sky and is often named after people, animals or objects. There are 88 constellations whose boundaries were established in the late 1920ís and published in 1930 by the International Astronomical Union. Constellations are best seen when they are at their highest point in the night sky, which is called the culmination of the constellation. The culmination dates are listed for all 88 constellations.

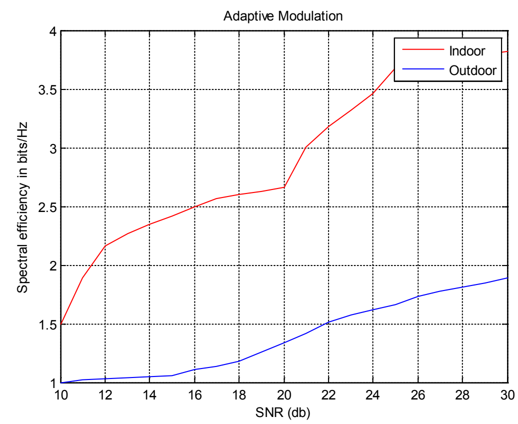


Figure 4. Adaptive modulation.

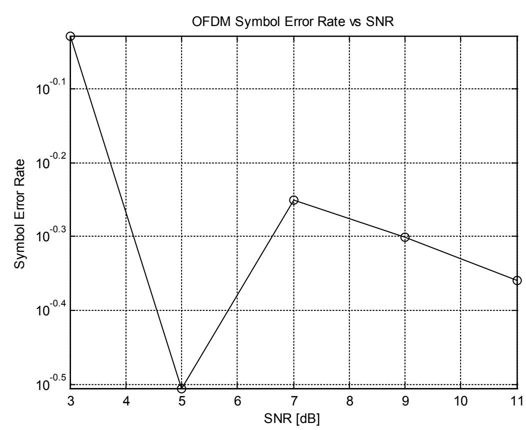


Figure 5. SNR vs SER.

Another parameter to be measured is **Signal-to-noise ratio.** The ratio of signal power to noise power is called as S/N ratio. It is generally expressed in decibels. is a measure used to compare the signal level to noise level. It is defined as the ratio of signal power to the noise power, often expressed in decibels. When this ratio is greater than 0db (i.e., more than 1:1) indicates that more signal than noise. ASK and FSK systems need more transmission power for a given probability of error compared to PSK. Synchronous carrier detection of PSK signals is required and it is more complex and expensive, therefore DPSK systems are preferred. The PSK systems have a bandwidth efficiency of 1bps/Hz.

A sequence of symbols(waveforms) si(t) of equal duration T are transmitted where each symbol(waveform) is selected from a set of M. Normally b = log2 (M) bits per symbol are allowed to transmit. A set of symbols whose real and imaginary parts of the complex baseband signal are amplitude modulated. This is known as Quadrature Amplitude Modulation (QAM).

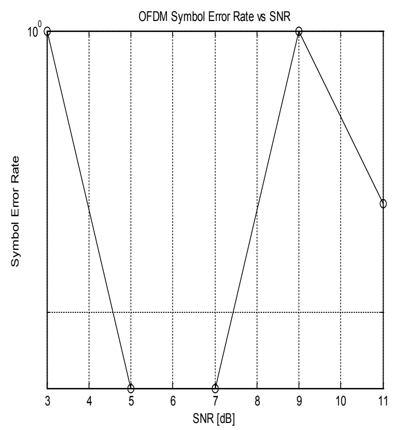


Figure 6. Indoor PSK.

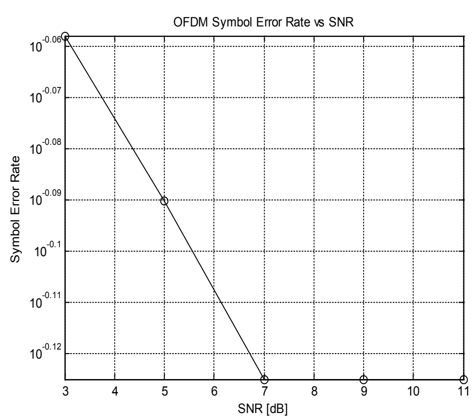
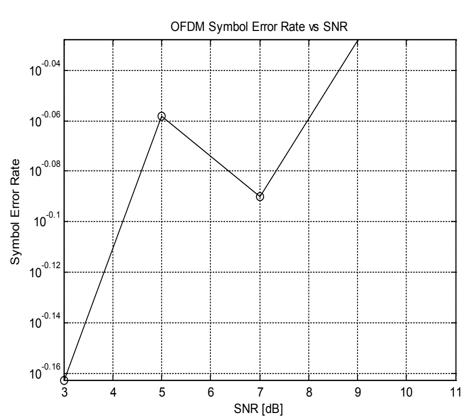


Figure 7. Outdoor PSK.



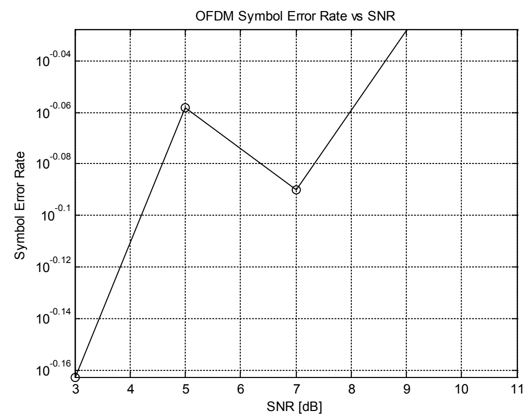


Figure 8. Indoor QAM. Figure 9. Outdoor QAM.

Very often cyclic prefix is used along with modulation in multipath fading channels for retaining the properties of sinosoids. Sinusoidal signals are generally Eigen functions of LTI systems. A sinusoid of infinite duration may be an Eigen function if the channel is assumed to be LTI. Practically it may not be obtained because real signals are always time limited. rarely used in combination with modulation to retain the sinusoids' properties in multipath fading channels. Generally sinusoidal signals are Eigen Functions of LTI systems. Therefore, if the channel is assumed to be linear and time-invariant, then a sinusoid of infinite duration would be an Eigen function. Practically, it may not be obtained, as real signals are always time-limited.

4. Conclusion

In this paper, the performance evaluation of LTE based system parameters using OFDM in indoor and outdoor environment was simulated and measured SINR and spectral efficiency throughput with different scenarios while varying number of users. It is found that indoor PSK and outdoor PSK, indoor QAM and outdoor QAM throughput varies significantly.

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