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Performance Analysis of OFDM Based Cognitive Radio Network under Channel Uncertainty

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Abstract:
The main objective of this project is to MIMO is paired up with OFDM to improve the performance of wireless transmission systems. The performance of an OFDM system high. Noise will be reduce high level. Measure the capacity and SNR value. High data rate wireless communication. Multiple antennas are employed both at the transmitting as well as receiving end. The performance of an OFDM system is measured, consider multipath delay spread, channel noise, Rayleigh fading channels and distortion. In this paper, bits are generate and then mapped with modulation schemes such as QPSK. Then, the mapped data is divided into blocks of 120 modulated data where a training sequence of the data is inserted both at the beginning and ending parts of the block. The equalization is used to determine the variation to the rest of data. Therefore, the capacity is increased by transmitting different streams of data through different antennas at a same carrier frequency. Any inter symbol interference (ISI) produced after the transmission is recovered by using spatial sampling integrated with the power allocation. Furthermore, the performance measure by SISO, MIMO, SIMO, MISO using power allocation.TO Calculation of power allocation of OFDM signal using to Calculation of power allocation of OFDM SISO signal, Calculation of power allocation of OFDM MISO signal, Calculation of power allocation of OFDM SIMO signal and Calculation of power allocation of OFDM MIMO signal. The Experimental results show between graphical representing. The compare all graph and plot the Comparison chart.

1. Introduction

Orthogonal Frequency Division Multiplex (OFDM), essentially identical to Coded Orthogonal Frequency Division Multiplexing (COFDM) and Discrete Multi Tone (DMT) modulation, is a Frequency Division Multiplexing (FDM) scheme used as a digital Multi Carrier Modulation (MCM) method.

Orthogonal Frequency Division Multiplexing (OFDM) is a method of Digital Modulation in which a signal is split into several narrow band channels at different frequency. The OFDM technology was first conceive in the 1960s and 1970s during the research into minimizing interference among the channels near each other in frequency.

The main idea behind the OFDM is that since low-rate modulations are less sensitive to multiparty, the better way is to send a number of low rate streams in parallel than sending one high rate waveform. This can be exactly done in OFDM. The OFDM divid the frequency spectrum into sub-bands small enough so that the channel effects are constant (flat) over a given sub-band. Then a classical IQ modulation (BPSK, QPSK, M-QAM, etc) is sent over the subband. If design correct, all the fast changing effects of the channel disappear as they are now occurring during the transmission of a single symbol and are thus treated as flat fading at the received.

A large number of closely spaced orthogonal sub carriers are used to carry data. The data is divid into several parallel data stream or channel, in one for each sub carrier. Each sub carrier is modulated with a conventional modulation scheme such as Quadrature Amplitude Modulation (QAM) or Phase Shift Keying (PSK) at a low symbol rate. The total data rate is to be maintain similar to that of the conventional single carrier modulation scheme with the same bandwidth.

The primary advantage of the Orthogonal Frequency Division Multiplexing (OFDM) systems over the single carrier schemes is its ability to cope with several channel conditions like attenuation of high frequencies in a long copper wires, narrow band interference and frequency selective fading due to multiparty fading without complex equalization filters.

Orthogonal Frequency Division Multiplexing (OFDM) is a multiplexing technique that became more popular in the recent years due to the development of Digital Signal Processors (DSPs) that can handle its heavy digital processing requirement. The OFDM system is being implemented in Broadband Wireless Access Systems as a way to overcome wireless transmission problems and improve bandwidth. OFDM is used in wireless digital radio, TV transmission, particularly in Europe, also used in wireless Network. The European Telecommunications Standards Institute (ETSI) HiperLAN/2 standards.

Orthogonal Frequency Division Multiplexing (OFDM) system is a Multi-Carrier Modulation (MCM) scheme in which many parallel data streams are transmitted at the same time over a channel, with each transmitted only a small part of total data rate.

With OFDM a high-speed digital messages divided into a large number of separate carrier waveform. The receiver system reconstructs the message from the separate carrier. The technique is a coding and transport scheme comparable to the way that Code Division Multiple Access (CDMA) is a coding scheme.
The word orthogonal indicates that there is a precise mathematical relationship between the frequencies of the carriers in the system. In a normal frequency division multiplex system used many carriers are spaced apart in such a way that the signals can be receive using conventional filters and demodulator. In such receiver, guard bands are introduced between the different carriers and in the frequency domain, which results in a lowering of spectrum efficiency.
If the dot product of two deterministic signal is equal to zero, these signal are said to be orthogonal to each other. Orthogonally can also be viewed from the stand point of stochastic processes. If the two random processes are uncorrelated then both are orthogonal to each other. If the random nature of signals in a communication system is known, then the probabilistic view of orthogonally provides an intuitive understanding of the implications of orthogonally in OFDM .
An Orthogonal Frequency Division Multiplexing (OFDM) carrier signal is the sum of a number of orthogonal sub-carriers, with base band data on each sub-carriers being independently modulated commonly by using some type of QAM or PSK. The composite base band signal is typically used to modulate a main RF carrier .
The Orthogonal Frequency Division Multiplexing (OFDM) systems has been popularly developed for the Wideband Digital Communication Systems, whether wireless or over copper wires, used in the applications such as Digital Television (D-TV), Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), Broadband Internet Access and Wireless Networking

1.1. OFDM Transmitter
The block diagram of Orthogonal Frequency Division Multiplexing (OFDM) transmitter is shown in the figure 1.

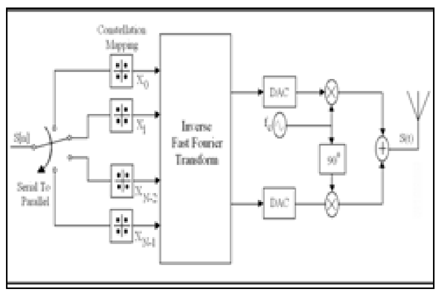

Figure 1: Block Diagram of OFDM Transmitter

S[n], a serial stream of binary digits is the input to the Orthogonal Frequency Division Multiplexing (OFDM) transmitter. By inverse multiplexing, the serial stream of binary digits is converted into N parallel streams, as any programmable ICwill take the input parallel. The N parallel streams are converted into the state space components by using modulation techniques like Quadrature Amplitude Modulation and Phase Shift Keying .
Quadrature Amplitude Modulation is a combination of simple Amplitude Modulation and simple Phase Modulation, which helps to transmit more data over the same bandwidth as that of simple Amplitude Modulation alone or Phase Modulation alone. Hence, QAM increases the efficiency of transmission of the data for radio communication systems.
Phase Shift Keying is a digital modulation scheme that conveys the data by changing or modulating the phase of the reference signal or the carrier waveform. PSK uses a finite number of phases each assigned with a unique pattern of binary digits. The various forms of the Phase Shift Keying are Binary Phase Shift Keying , Quadrature Phase Shift Keying , 8-Phase Shift Keying and 16-Phase Shift Keying.
An Inverse Fast Fourier Transform (IFFT) is computed on each set of symbols, given a set of complex time-domain samples. The time-domain samples are then quadrature mixed to pass band in the standard way. The real and imaginary component are first converted to the analog domain by using Digital-to-Analog Converters . The analog signals are then used to modulate cosine and sine waves at the carrier frequencies, fc respectively. These signals are then summed up to give the transmission signal, S(t) .

1.2. OFDM Receiver
The block diagram of Orthogonal Frequency Division Multiplexing (OFDM) receiver is shown in the figure 2.
The received signal, r(t) is the input to the Orthogonal Frequency Division Multiplexing (OFDM) receiver.
The received signal is quadrature mixed down to baseband signals by using cosine and sine waves at the carrier frequencies, fc.
The frequency of the base band signal is equal to twice that of the carrier frequency i.e., 2fc, so Low Pass Filters (LPFs) are used to attenuate the frequency which is greater than the carrier frequency, fc.

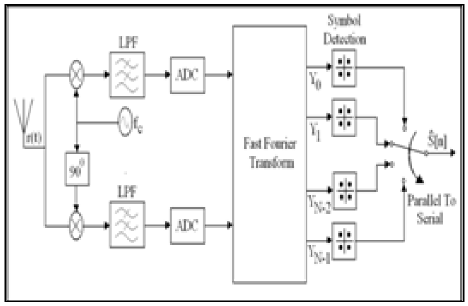

Figure 2: Block Diagram of OFDM Receiver

The baseband signals are then sampled and digitized by using Analog-to-Digital Converters. A forward Fast Fourier Transform (FFT) is used to convert back into the frequency domain. The frequency domain signal are then converted to N parallel stream, each of which is converted to a binary stream using an appropriate symbol detector. The binary streams are then recombine into a serial streams, which is an estimated to the original binary stream at the transmitter.

1.3. Problem Description

In the existing method for this project is that SISO is paired up with OFDMA to improve the performance of wireless transmission system single antenna are employed both at the transmitting as well as receiving end. The performance of an OFDMA system is measured, consider multipath delay spread, channel noise, Rayleigh fading channels and distortion. In this paper, bits are generate and then mapped with modulation schemes such as QPSK. But here SISO only user only benefit so only I apply this those performance will applying MIMO system also.

2. Power Allocation

Bandwidth is the difference between the upper and lower frequencies in a continuous set of frequencies. It is typically measure in hertz, and may sometimes refer to pass band bandwidth, sometime to base band bandwidth, depending on context. Pass band bandwidth is the difference between the upper and lower cut off frequencies of, for example, a band pass filter a communication channel or a signal spectrum. In case of a low-pass filter or base band signal, the bandwidth is equal to its upper cut off frequency.

A key characteristic of bandwidth is that a band of a given width can carry the same amount of information, regardless. where that band is located in the frequency spectrums. For example, a 3 kHz band can carry a telephone conversation whether that band is at base band (as in your POTS telephone line) or modulated to some higher frequency.

In the field of antennas, two different methods of expressing relative bandwidth are used for narrowband and wideband antennas. For either, a set of criteria is establish to define the extents of the bandwidth, such as input impedance, pattern or polarization.

Per cent bandwidth, usually used for narrow band antennas is used defined

As $$\%B = \frac{f_H - f_L}{f_c} = 2\frac{f_H - f_L}{f_H + f_L} \qquad 4.1$$

The theoretical limit to present bandwidth is 200%, which occurs for . $f_L = 0$.

Fractional bandwidth or Ratio bandwidth, usually used for wideband antennas, is defined as $B = f_H / f_L$, and is typically presentin the form of $B:1$. Fractional bandwidth is used for wideband antennas because of the compression of the percent bandwidth that occurs mathematically with percent bandwidths above 100%, which corresponds to a fractional bandwidth of 3:1.

$$\text{If } \%B - 2\frac{f_H - f_L}{f_H + f_L} - p\%,\ B - \frac{200+p}{200-p}. \qquad -4.2$$

Multiple-input and multiple-output, or MIMO, is the use of multiple antennas at both the transmitter and receiver to improve communication performances. It is one of several forms of smart antenna technology. Note that terms input and output refers to the radio channel carrying the signals, not to the devices having antennas.

MIMO technology has attracted attention in wireless communication, because it offers significant increases in data throughput and link range without additional bandwidth or increased transmit power. It achieve this goal by spreading the same total transmit power over the antennas to achieve an array gain that improve the spectral efficiency (more bits per second per hertz of bandwidth) or to achieve a diversity gain that improve the link reliability (reduced fading). Because of these properties of MIMO is an important part of modern wireless communication.

2.1. Noise Interfiring in Transmitting Channel

In telecommunications and computer networks, a communication channel or channel, refer either to a physical transmission medium such as a wire, or to a logical connection over a multiplex medium such as a radio channels. A channel is used to convey an information signal, for example a digital bit streams, from one or several senders (or transmitters) to one or several receiver. A channel has a certain capacity for transmitting information, often measure by its bandwidth in Hz or its data rate in bits per second.

Communicating data from one location to another requires some form of pathway or medium. These pathway called communication channel use two types of media: cable and broadcast. Cable or wire line media use physical wires of cables to transmit data and information. Twisted-pair wires and coaxial cables are made of copper and fiber-optic cable is made of glass.
In information theory, a channel refers to a theoretical channel model with certain error characteristics. In this more general view a storage device is also a kind of channel, which can be sent to (written) and received from (read).
Noise affects communication by somehow altering the message. In a very basic models of communication, a message has to pass from the receiver to the recipient through a channel.
Noise is something that interferes with the transmission of the message through the channel. An easy way to think of this picture static on TV. The static is the noise that interferes with the transmission of the TV program through the channel of your cable box or satellite dish. This make it difficult to understand the message sent by the TV program; you may not hear what someone on TV say correctly, and so misinterpret what they says for example.
Noise doesn't necessarily have to be something external that affect the channels. It can also be something internal to the recipient that affects how they receive the message. An example of this someone is in a bad moods. Being in a bad mood makes you more likely to interpret other people's messages as negative or hostile; the noise of your emotion affects how you see what they're trying to communicate.
Communication noise refers to influences on effective communication that influence the interpretation of conversation. While often looked over, communication noise can have a profound impact both on our perception of interactions with others and our analysis of our own communication proficiency.
Three type of noises. there are external, internal, and semantic.
External noise: External noise can be considered factors outside of a person that distracts them during communication. Typically it is the sight, sound, smell, texture, and environmental factor.

- Internal noise: Internal noise can be one's thoughts or feelings that interfere with communication. Or in many cases, daydream, feeling tried, and illness.
- Semantic noise: Reactions aroused unintentionally by symbols or words causing the listener to abruptly focus on an unrelated topic. In many cases the main reasons of this occurrence is a poorly developed speech, in terms which the presenter did not fully understand or most likely underestimated the intellectually or the feeling of the audiences. Most common forms of this noise are discriminatory remarks, red flag words, and controversial symbol.

3. Calculating the Signal Range

Signal-to-noise ratio (often abbreviated SNR or S/N) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. It is defined as the ratio of signal power to the noise power. A ratio higher than 1:1 indicate more signal than noise. While SNR is commonly quote for electrical signals, it can be applied to any form of signal (such as isotope levels in an ice core or biochemical signal between cells).

- Amplitude modulation(AM): Channel signal-to-noise ratio is given by

$$(\mathrm{SNR})_{\mathrm{C,AM}} = \frac{A_c^2(1+k_a^2P)}{2WN_0} \qquad 4.3$$

Where W is bandwidth and ka is modulation index
Output signal-to-noise ratio (of AM receiver) is given by

$$(\mathrm{SNR})_{\mathrm{O,AM}} = \frac{A_c^2k_a^2P}{2WN_0} \qquad -4.4$$

- Frequency modulation(FM): Channel signal-to-noise ratio is given by

$$(\mathrm{SNR})_{\mathrm{C,FM}} = \frac{A_c^2}{2WN_0} \qquad -4.5$$

Output signal-to-noise ratio is given by

$$(\mathrm{SNR})_{\mathrm{O,FM}} = \frac{A_c^2k_f^2P}{2N_0W^3} \qquad -4.6$$

For *n*-bit integer with equal distance between quantization levels (uniform quantization) the dynamic range (DR) is also determined.
Assuming a uniform distribution of input signal value, the quantization noise is a uniformly distributed random signal with a peak-to-peak amplitude of one quantization level, making the amplitude ratio $2^n/1$. The formula is then:

$$\mathrm{DR_{dB}} = \mathrm{SNR_{dB}} = 20\log_{10}(2^n) \approx 6.02\cdot n \qquad 4.7$$

This relationship is the origin of statements like "16-bit audio has a dynamic range of 96 dB". Each extra quantization bit increases the dynamic range by roughly 6 dB.
Assuming a full-scale sine wave signal (that is, the quantizer is designed such that it has the same minimum and maximum values as the input signal), the quantization noise approximates a saw tooth wave with peak-to-peak amplitude of one quantization level[8] and uniform distribution. In this case, the SNR is approximately

$$\mathrm{SNR_{dB}} \approx 20\log_{10}(2^n\sqrt{3/2}) \approx 6.02 \cdot n + 1.761$$ -4.8

Peak Signal-to-Noise Ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in term of the logarithmic decibel scale.
PSNR is most commonly used to measure of quality of reconstruction of loss compression codes (e.g., for image compression). The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression codes, PSNR is an *approximation* to human perception of reconstruction quality. Although a higher PSNR generally indicates that the reconstruction is of higher quality, in some cases the reverse may be true. It has to be extremely careful with the range of validity of this metric; it is only conclusively valid when it is used to compare results from the same codec (or codec type) and same content.
PSNR is most easily defined via the mean squared error (*MSE*). Given a noise-free $m \times n$ monochrome image I and its noisy approximation K, *MSE* is defined as:

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$ -4.9

The PSNR is defined as:

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \end{aligned}$$ -4.10

3.1. Output Signal

The simulations are performed under the scenario given. An OFDM system of N = 64 subcarriers is assumed with M = 5 relays. The values of Ts, Δf, and σ2 are assumed to be 4μ seconds, 0.3125 MHz and 10−6 respectively. The channel gains are outcomes of independent Rayleigh distributed random variables with mean equal to 1. All the results have been averaged over 1000 iterations.
In the simulations, Optimal and Sub-optimal algorithms apply the dual decomposition technique presented and the proposed method presented in respectively. Additionally, SNR algorithm refers to the method by which the subcarriers and users are selected according to the signal to noise ratio values; while in Random, the subcarriers are matched and assigned randomly. For both SNR and Random, the powers are evaluated by solving with the known t j, k and π (j, k, m).
The achieved capacity of the optimal and sub-optimal schemes vs. the interference constraint. The solid lines plots the case when PS = PRm= 0 dBm while the dashed ones when PS = PRm= 20 dBm. The achieved capacity is compared with that when only one of the interference or power constraint is applied. The interference (power) only performance forms an upper bound for that with both constraints. To that end, the performance of the optimal solution under both constraints has three different regions. Considering the case of PS = PRm= 0 dBm, the three region could be explained as follows: 1) if Ith≤ −35 dBm, the performance is equal to that of the interference only case. The limited effect of the power constraints comes from the small value of the allowed interference since only a small quantity of the available power can induce the maximum allowed interference. 2) IfIth≥ −20 dBm, the performance is equal to that of the power only case. The system in this region performs like a non-cognitive one since the available power budgets cannot induce the maximum allowed interference threshold. 3) If−35 <Ith≤ −20 dBm, in this region both power and interference constraints are affecting the optimization problem. Optimal solution performs close to the upper bound formed by the interference and power only curves. The same observations can be applied on the case of PS = PRm= 20 dBm but with different ranges of the regions.
To more clarify the different regions, Figure. 3 plots them optimal achieved capacity for different interference and power constraints. By fixing one of the constraints, one can see that the achieved capacity increases with the other up to certain point. After this point, the change of the constraint value does not affect the achieved capacity. This is can be justified –as described above- by working in the non-cognitive regions or in the regions in which the interference limit can be reached by only a small part of the available power budgets.
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3.2. Calculation of power allocation of OFDM signal

Figure 3: Power allocation in MIMO-OFDM

3.3. Calculation of power allocation of OFDM SISO signal

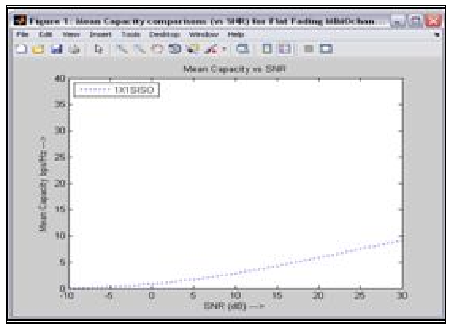

Figure 4: power allocation of OFDM SISO signal

3.4. Calculation of power allocation of OFDM MISO signal

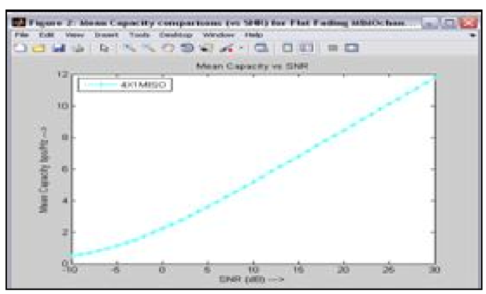

Figure 5: power allocation of OFDM MISO signal

3.5. Calculation of power allocation of OFDM SIMO signal

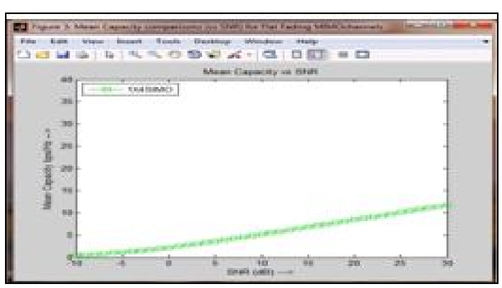

Figure 6: power allocation of OFDM SIMO signal

3.6. Calculation of power allocation of OFDM MIMO signal

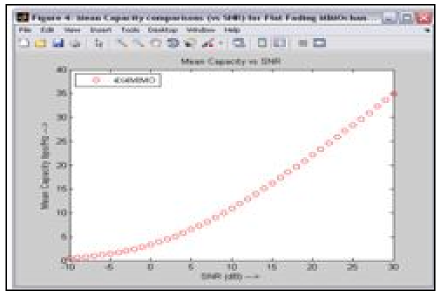

Figure 7: power allocation of OFDM MIMO signal

3.7. Comparision chart

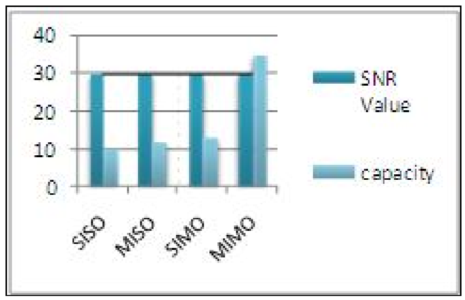

Figure 8: Comparision chart

Value	Capacity
30	10
30	12
30	13
30	35

Table 1: SNR

4. Conclusion

This project focuses on high data rate wireless communication due to such benefits as inter symbol interference free transmission, high spectral efficiencies, and reduced equalization complexity.QPSK Modulation is sent over the sub band. Each sub band is called OFDM traffic channel. Each traffic channels is assigned exclusively to one user at any time . So only here finding the SNR and CAPACITY of multiuser system here we finding the SISO, SIMO, MISO, MIMO systems SNR and CAPACITY value will be analyzing using power allocation. The Experimental results show between graphical representing.

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