Performance Comparison of FFT & Dwt Based OFDM with Alamouti Encoding Over Reyleigh Fading Channel

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Abstract: ***This examines the enactment of wavelet based on MIMO OFDM systems and also compare with the performance of FFT based MIMO OFDM. Wavelet based OFDM has more advantages compare to the FFT based OFDM. There is no necessity for cyclic prefix, more flexibility and optimal resolution. Wavelets want existed suitably in almost absolutely the arenas of wireless communication schemes with OFDM which is a durable applicant for next peers of wireless scheme. Simulation created examination will be jumble-sale to simulate the double multicarrier schemes, DWT with Haar mother construction multicarrier in addition the predictable OFDM, less than the consequence of taking multiple antennas scheme, by BPSK modulation schemes in Rayleigh fading channel. Established on the bit error rate presentation to the transmission ability by using Alamouti's algorithm, the DWT constructed multicarrier scheme was establish to be higher to the predictable OFDM scheme.***

Keywords: MIMO-OFDM, FFT, DWT, Rayleigh fading channel, BPSK, Alamouti's algorithm

1. Introduction

OFDM technique has been adopted as the standards in the several high data rate applications, such as Europe DAB/DVB (Digital Audio and Video Broadcasting) system, high-rate WLAN (Wireless Local Area Networks). OFDM system transmits information data by many sub-carriers, where sub carriers are orthogonal to each other and sub-channels are overlapped so that the spectrum efficiency may be enhanced. OFDM is a combination of modulation and multiplexing. Multiplexing generally refers to independent signals, those produced by different sources. So it is a question of how to share the spectrum with these users. In OFDM the question of multiplexing is applied to independent signals but these independent signals are a sub-set of the one main signal. In OFDM the signal itself is first split into independent channels, modulated by data and then re-multiplexed to create the OFDM carrier.

OFDM signals are typically generated digitally due to the difficulty in creating large banks of phase lock oscillators and receivers in the analog domain. Figure 1 shows the block diagram of an OFDM system.

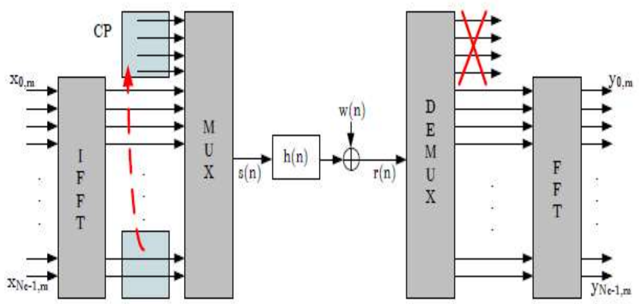

Figure 1: Model of an OFDM system

The enactment of ripple (otherwise called as wavelet) based Multi-user MIMO OFDM systems and also compare with the performance of FFT based MIMO OFDM. Wavelet based OFDM has more advantages compare to the FFT based OFDM is not needed for cyclic prefix, flexibility and optimal resolution. Wavelets want to exist suitably in almost absolutely the arenas of wireless communication schemes with OFDM which is a durable applicant for next peers of wireless scheme. That is third generation of partnerships project (3GPP) networks. Simulation created examination will be jumble-sale to simulate the double multicarrier schemes, DWT with Rayleigh Fading and Racian fading channels constructed multicarrier in addition the predictable OFDM, less than the consequence of taking multiple antennas scheme, by BPSK also QPSK as dual modulation schemes in additive white Gaussian noise channel (AWGN). Established on the bit error rate presentation to the transmission ability by using Alamouti's algorithm, the DWT constructed multicarrier scheme was establish to be higher to the predictable OFDM.

In this project, we focused on the two transmit (Tx) / one receive (Rx) antenna, and two Tx / two Rx antenna configuration. We evaluated the performance of FFT MIMO OFDM and DWT MIMO OFDM system on the basis of MIMO technique through an AWGN channel is existed [1]. Alamouti's coding is applied in both FFT MIMO OFDM system and DWT MIMO OFDM system is proposed in this paper. In OFDM realization, CI code spreading/de-spreading operation and carrier allocation/de-allocation are separately processed by simple IDWT/DWT type operation. We simulated these systems with both the AWGN and Rayleigh fading channels.

Space time block coding technique (STBC) is used to develop the diversity performance of the MIMO-OFDM system. Space time block coding can accomplish transmit diversity also power gain deprived of give up the bandwidth.

That paper is shared into three foremost sections: section II will give details of conventional FFT based MIMO-OFDM, section III will give to in detail for DWT based MIMO-OFDM, and the bit error rate (BER) section of mutually transformed platforms.

2. Alamouti's Code

Alamouti invented the simplest of all the STBCs designed for a two-transmit antenna system and has the coding matrix:

$$C_2 = \begin{bmatrix} c_1 & c_2 \\ -c_2^* & c_1^* \end{bmatrix},$$

Where * denotes complex conjugate.

It is readily apparent that this is a rate-1 code. It takes two time-slots to transmit two symbols. Using the optimal decoding scheme discussed below, the bit-error rate (BER) of this STBC is equivalent to $2n_R$-branch maximal ratio combining (MRC). This is a result of the perfect orthogonality between the symbols after receive processing, there are two copies of each symbol transmitted and n_R copies received.

3. Implementation of FFT&DWT

3.1 Based MIMO OFDM

The main reason that the OFDM technique has taken a long time to become a prominence has been practical. It has been difficult to generate such a signal, and even harder to receive and demodulate the signal.

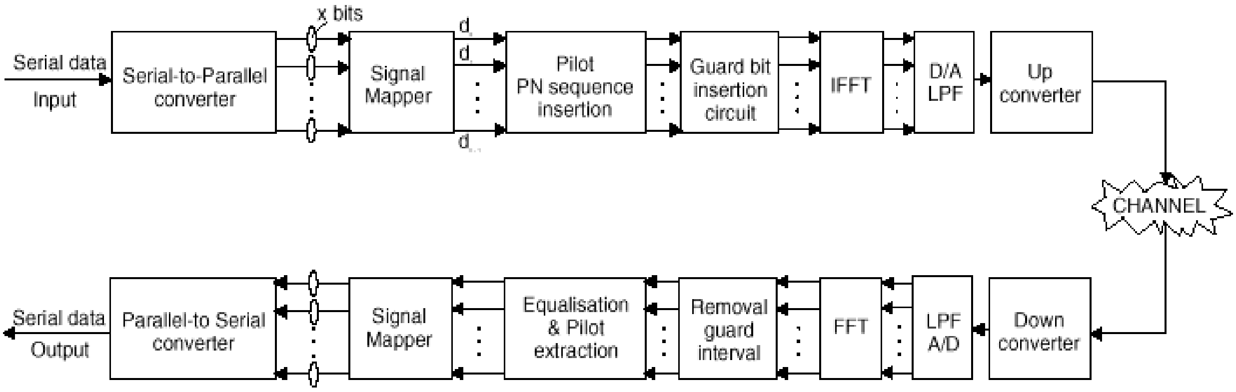

Figure 2: Block diagram of an OFDM system using FFT, pilot PN sequence and a guard bit insertion

The hardware solution, which makes use of multiple modulators and demodulators, was somewhat impractical for use in the civil systems. The ability to define the signal in the frequency domain, in software on VLSI processors, and to generate the signal using the inverse Fourier transform is the key to its current popularity. The capacity of an interference channel can be made to be the same as the channel with no interference. In this paper, we analyze the performance of

$$x[n] = \frac{1}{\sqrt{N}} \sum_{i=0}^{N-1} X[i] x^{j\frac{2\pi i n}{N}}$$

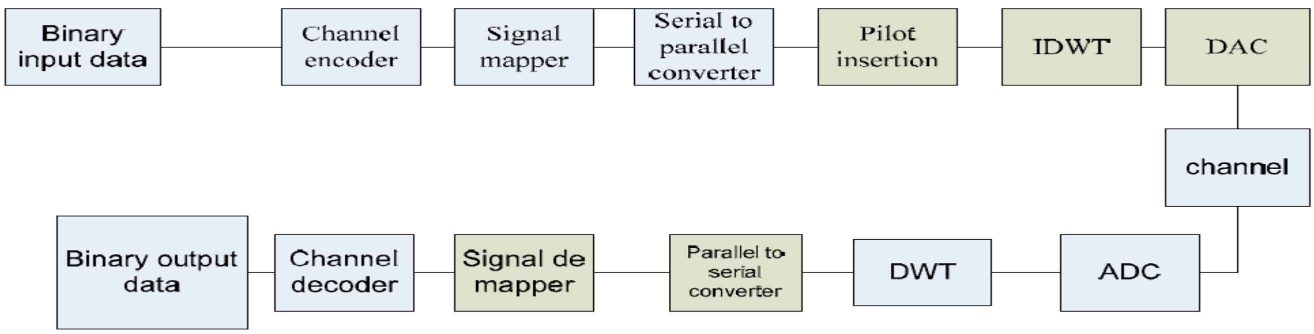

Figure 3: Block diagram for wavelet based OFDM Rayleigh Fading Model

A wireless radio channel whose delay spread is less than symbol period and the signal bandwidth is less than the coherence bandwidth where the channels are correlated, can appropriately be modeled as Rayleigh fading which assumes that a received multipath signal contains infinite or large number of arrival paths at the same time whose gain are statistically independent and no dominant path.

$$(r_k) = \left(\frac{r}{\sigma^2} e^{\left(-\frac{r^2}{2\sigma^2}\right)} \quad 0 \le r \le \infty \right)$$

Rayleigh distribution model is often used for fading signal with infinite or large number of arrival paths at the same time whose gain are statistically independent and no dominant path[4]. The phase component of the channel gain is Gaussian distributed.

2.1 Rician Fading Model

Fading causes the signal to become diffuse. The K-factor parameter, which is part of the statistical description of the Rician distribution, represents the ratio between the power in the line-of-sight component and the power in the diffuse component. The ratio is expressed linearly, not in decibels. While the Average path gain vector parameter controls the overall gain through the channel, the K-factor parameter controls the gain's partition into line-of-sight and diffuses components. This paper specifies the K-factor parameter as a scalar or a vector. If the K-factor parameter is a scalar, then the first discrete path of the channel is a Rician fading process (it contains a line-of-sight component) with the specified K-factor, while the remaining discrete paths indicate independent Rayleigh fading processes (with no line-of-sight component).

If the K-factor parameter is a vector of the same size as Discrete path delay vector, then each discrete path is a Rician fading process with a K-factor given by the corresponding element of the vector. The Doppler shift(s) of line-of-sight component(s) and Initial phase(s) of line-of-sight component(s) parameters must be of the same size as the K-factor parameter.

$$f(x) = \left\{ \frac{x}{\sigma^2} I_0\left(\frac{mx}{\sigma^2}\right) \exp\left(-\frac{x^2+m^2}{2\sigma^2}\right) \quad x \geq 0 \right.$$

Where:
- σ is the standard deviation of the Gaussian distribution that underlies the Rician distribution.
- $m^2 = m_I^2 + m_Q^2$, where m_I and m_Q are the mean values of two independent Gaussian components. I_0 is the modified 0th-order Bessel function of the first kind given by

$$I_0(y) = \frac{1}{2\pi}\int_{-\pi}^{\pi} e^{y\cos t}\,dt$$

Discrete Wavelet Transform is planned as high presentation digital signal processing method for procedure in applying multicarrier modulation. The block diagram proposal of multicarrier transceiver arithmetical system constructed on DWT is shown in Fig. 5. The system project include of an inverse discrete wave-let transform (IDWT) as modulator at the transmitter as well as a discrete ripple transform (DWT) as demodulator at the side of receiver. The foremost plus the essential modification among the conventional OFDM as well as DWT multicarrier scheme is the elimination of the cyclic prefix blocks in the transmitter otherwise in the receiver parts .

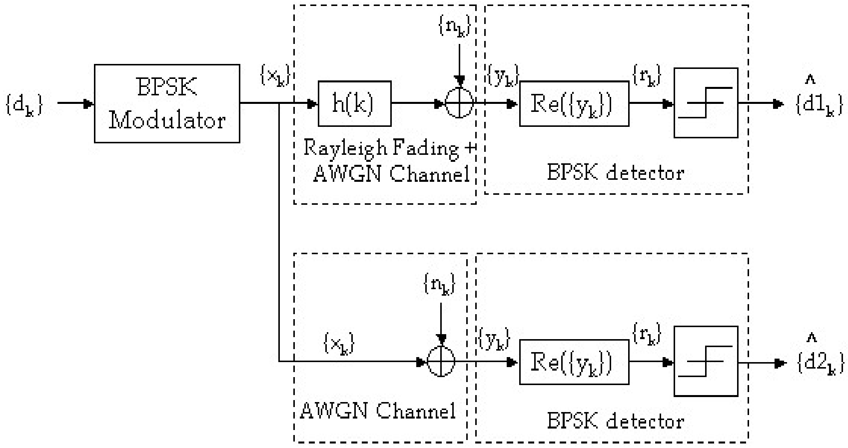

Figure 4: BPSK modulation over Rayleigh and AWGN channel

MIMO-DWT based OFDM have many number of antenna both the transmitting and receiving side. This is the interesting area in OFDM system. To increases the throughput of the data, to increases the data link range without the need for additional bandwidth, to improve the spectral efficiency, to achieve the diversity gain and reduce the multipath fading effect.

2.2 Flow Chart

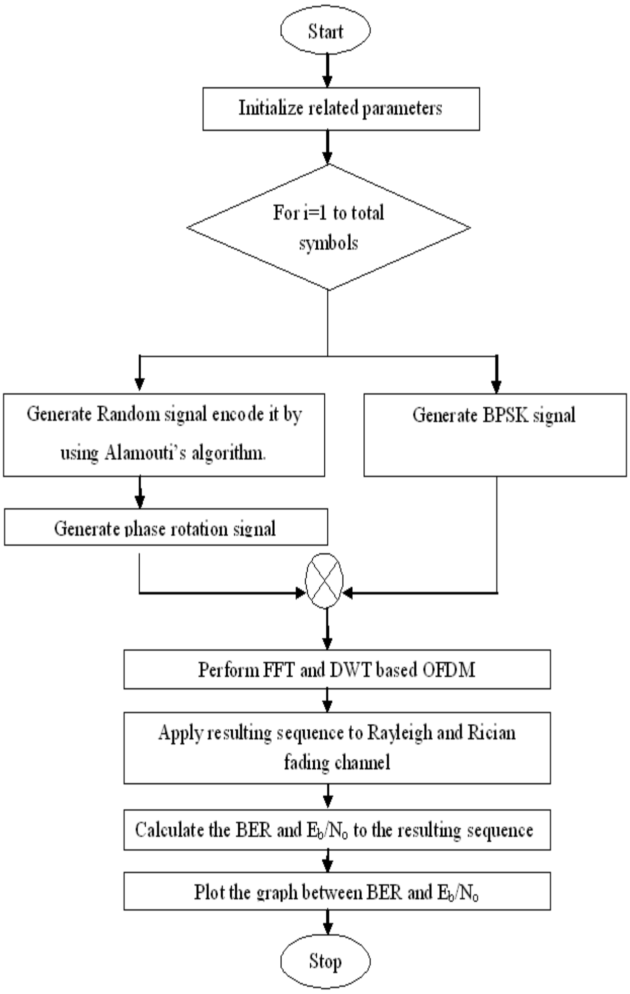

Figure 5: Flow chart of performance analysis between FFT-based OFDM and DWT-based OFDM by using Rayleigh

4. Results

In this section the computational comparison analysis between FFT based OFDM and DWT based OFDM is provided. Few works have been proposed in the recent years that compare the performances of wavelet and FFT based OFDM systems focusing on effects of noise, error performances, and computational complexity, etc.

3.1 Performance Analysis of FFT-OFDM and DWT-OFDM

Simulation variables and their matrix values are shown in Table I. The number of samples for the subcarriers N is 512 and the number of samples for the symbols *ns* is 1000. Data is similar between FFT and DWT OFDM in all parameters except the multiplexed one.

The simulation result shows the comparison of the FFT based OFDM and DWT based OFDM by using Rayleigh fading channel. However, this yields longer time of running the simulations. Some of the simulation parameters related to this figure are: the OFDM symbol period To = 9 ms, the total simulation time $t = 10 \times To = 90$ ms, the sampling frequency fs = 71.11 kHz, the carriers spacing ΔN = 1.11 kHz and the bandwidth $B = \Delta N \times 512 = 71.11$ kHz. Thus, the simulation satisfied the Nyquist criterion where $fs < 2B$. Both platforms used the same parameters. It is interesting to observe that the DWT-OFDM symbol is less in term of the mean of amplitude vectors as compared to FFT-OFDM. The mean of FFT is 1.4270, whereas, the mean of DWT is -9.667E-04. This is due to the fact that zero - padding was performed in the DWT (transmitter) system model. As a result, most samples in the middle of DWT-OFDM symbol is almost zeroes. The DWT-OFDM performance can be observed from Figure 6. It is shown that DWT is superior to FFT. It outperforms FFT and DWT by about 4 dB at 0.0111 BER.

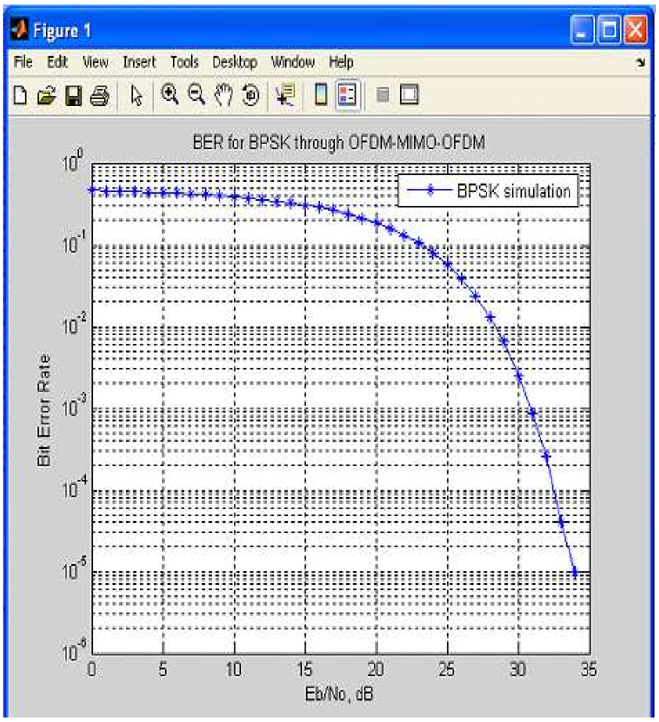

Figure 6: Shows that BER of BPSK through FFT-MIMO-OFDM

The effects of varying different parameters were observed while doing BER (Bit Error) Analysis for a Rayleigh Fading Channel. At first, the diversity order was varied, keeping the channel type (Rayleigh), Modulation type (PSK) and Modulation order fixed. When the diversity order was increased, it was seen that the BER decreases faster with increasing SNR (Signal to Noise Ratio).

Since diversity of MIMO-OFDM essentially means the number of independent fading propagation paths, it is good to have a higher order of diversity so that the same signal can be sent a number of times which would lead to a better reception at the receiving end.

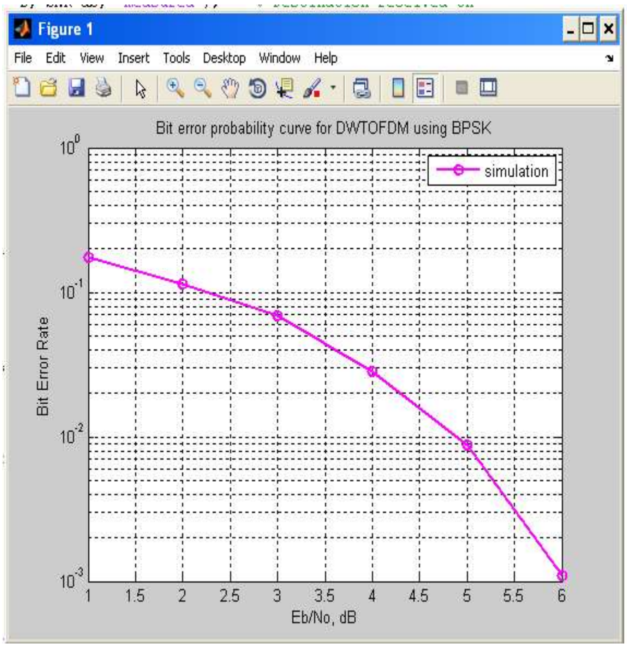

Figure 7: Shows that BER of BPSK through DWT-MIMO-OFDM

The WOFDM system given in Figure is simulated using MATLAB new version, considering a multiuser environment with and users. The wanted user data stream is first BPSK modulated and then level 3 wavelet decomposition is done in this approach with a valid wavelet function. Hence the low-pass and high-pass decomposition filter coefficients are ([0.7071, 0.7071] and [0.7071,-0.7071]), whereas reconstruction filter coefficients are ([0.7071, 0.7071] and [-0.7071,-0.7071]).

BER comparison of DWT and FFT based MIMO OFDM in Rayleigh fading channel

Table 1: Shows that BER comparison of DWT and FFT based MIMO OFDM in Rayleigh fading channel

SNR in dB	BER	
	DWT based MIMO OFDM	FFT based MIMO OFDM
0	0.4639	0.4635
4	0.4346	0.4457
8	0.4138	0.4135
12	0.3437	0.3620
16	0.2596	0.2881
20	0.1504	0.1891
24	0.0486	0.0806
28	0.0043	0.0132

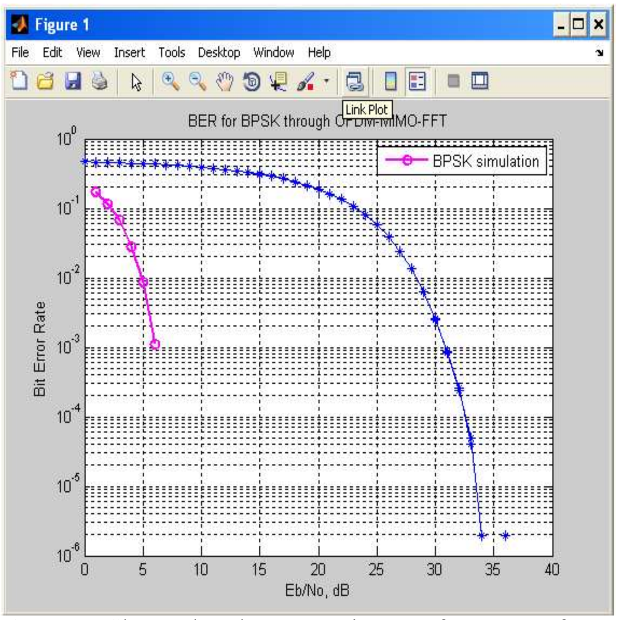

Figure 8: Shows that the comparison performance of FFT based OFDM and DWT based OFDM

AWGN (Additive White Gaussian Noise) channel model is one in which the only impairment is the linear addition of wideband or white noise with a constant spectral density. It is present even in complete vacuum or free space and does not account for the phenomena of fading, frequency selectivity or any other form of interference. A comparison was done between AWGN and Rayleigh Fading in terms of the BER. Initially, when the SNR is zero, the corresponding values of BER for Rayleigh Fading and AWGN are same. With increasing SNR, the gap between Rayleigh and AWGN gradually keeps increasing. Rayleigh Fading always takes into account the phenomenon of AWGN, so the AWGN is partially responsible for the BER value in Rayleigh Fading. It is not possible to avoid AWGN in any fading channel. AWGN is the ideal channel with no fading so we get best performance where as coming to practical scenario (considering fading) Rayleigh channel is considered. So BER performance of MIMO OFDM system in AWGN channel is always better than Rayleigh.

Table 2: Shows that BER comparison of in AWGN and Rayleigh fading channel for DWT based MIMO OFDM

SNR in dB	DWT based MIMO OFDM	
	BER in Rayleigh	BER in AWGN
0	0.4639	0.3339
4	0.4346	0.2466
8	0.4138	0.1404
12	0.3437	0.0401
16	0.2596	0.0034
20	0.1504	0
24	0.0486	0
28	0.0043	0

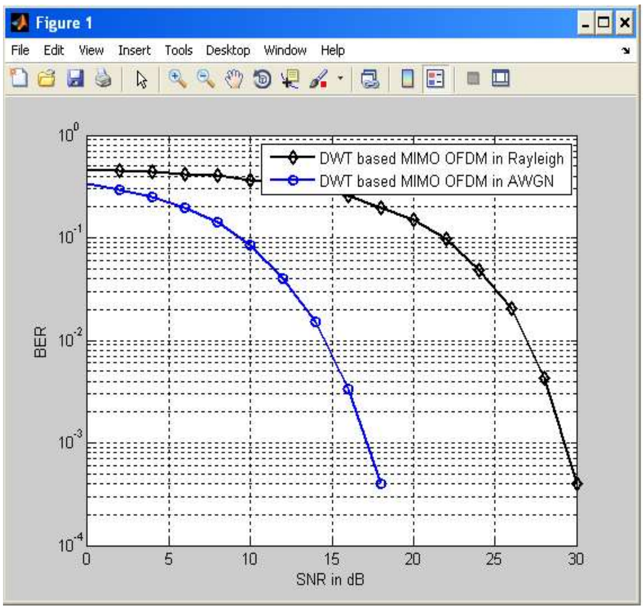

Figure 9: BER comparison of in AWGN and Rayleigh fading channel for DWT based MIMO OFDM

Table 3: Shows that BER comparison of DWT and FFT based MIMO OFDM in Rician fading channel

E_b/N_0 in dB	BER	
	DWT based MIMO OFDM	FFT based MIMO OFDM
0	0.1598	0.4711
4	0.1010	0.4629
8	0.0554	0.4612
12	0.0238	0.4352
16	0.0060	0.4191
20	0.0013	0.4082
24	0.0001	0.3808
28	0	0.0816

The DWT-OFDM performance can be observed from Figure. It is shown that DWT is superior to FFT. It outperforms FFT and DWT by about 12 dB at 0.4114 BER over Rician fading channel.BER comparison of DWT and FFT based MIMO OFDM in Rician fading channel. The DWT-OFDM performance can be observed from Figure 9. It is shown that DWT is superior to FFT. It outperforms FFT and DWT by about 12 dB at 0.4114 BER over Rician fading channel.BER comparison of DWT and FFT based MIMO OFDM in Rician fading channel. The bit error rate of FFT is 0.4352, whereas, the bit error rate of DWT is 0.0238 at 12 dB E_b/N_0.. BER comparison of DWT and FFT based MIMO OFDM in Rician fading channel.

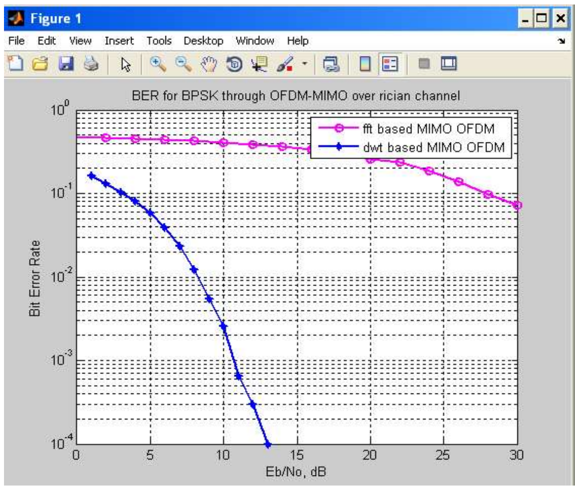

Figure 10: Shows that the comparison performance of FFT based OFDM and DWT based OFDM over Rician fading channel

A comparison was done between FFT based MIMO-OFDM and DWT based MIMO-OFDM over Racian Fading in terms of the BER. Initially, when the SNR is zero, the corresponding values of BER for FFT based MIMO-OFDM and DWT based MIMO-OFDM are little bit different. With increasing SNR, the gap between gradually keeps FFT based MIMO-OFDM and DWT based MIMO-OFDM increasing.

AWGN (Additive White Gaussian Noise) channel model is one in which the only impairment is the linear addition of wideband or white noise with a constant spectral density. It is present even in complete vacuum or free space and does not account for the phenomena of fading, frequency selectivity or any other form of interference. A comparison was done between AWGN and Rayleigh Fading in terms of the BER. Initially, when the SNR is zero, the corresponding values of BER for Rayleigh Fading and AWGN are same. With increasing SNR, the gap between Rayleigh and AWGN gradually keeps increasing.

5. Conclusions

In this paper, introduces an effective implementation of wavelet packet transform instead Fourier transform in multi-carrier communication considering practical cases. Wavelet based analysis is more immune to impulse and narrowband noises than conventional Fourier based OFDM system, also improves spectral efficiency and saves transmission power. It is found that DWT based OFDM system performs better than FFT based OFDM without putting any restriction on the number of antennas we are using at the base station as well as at the receiver ends. Simulation approaches using MATLAB for wavelet based OFDM, particularly in DWTOFDM as alternative substitutions for Fourier based OFDM are presented. Conventional OFDM systems use IFFT and FFT algorithms at the transmitter and receiver respectively to multiplex the signals and transmit them simultaneously over a number of subcarriers. The system employs guard intervals or cyclic prefixes so that the delay spread of the channel becomes longer than the channel impulse response. It is found that the DWT-OFDM platform is superior as compared to others as it has less error rate.

References

[1] R. Asif, R. A. Abd-Alhameed, O.O. Anoh and Y.A.S. Dama "Performance Evaluation of DWT-FDM and FFT-OFDM for Multicarrier Communications Systems using Time Domain Zero Forcing Equalization" International Journal of Computer Applications (0975 – 8887) Volume 51– No.4, August 2012.

[2] Md. Mahmudul Hasan "Performance Analysis of Wavelet Based Multiuser MIMO OFDM" World Academy of Science, Engineering and Technology International Journal of Computer, Information, Systems and Control Engineering Vol: 7 No: 3, 2013.

[3] Nilesh Chide, Shreyas Deshmukh, Prof. P.B. Borole "Implementation of OFDM System using IFFT and FFT" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 , Vol. 3, Issue 1, January -February 2013, pp.2009-2014.

[4] B.Monisha, M.Ramkumar, M.V.Priya, A.Jenifer Philomina, D.Parthiban, S.Suganya, N.R.Raajan. "Design and Implementation of Orthogonal Based Haar Wavelet Division Multiplexing For 3GPP Networks" (*ICCCI* -2012), Jan. 10 – 12, 2012.

[5] N. Manikanda Devarajan, Dr. M. Chandrasekaran "A Survey on OFDM Systems based on Wavelets" International Journal of Scientific & Engineering Research, Volume 5, Issue 2, February-2014 ISSN 2229-5518.

[6] J. A. C Bingham, "Multicarrier modulation for data transmission: An idea whose time has come", IEEE Communication Magazine, vol. 28, no. 5, (1990), pp. 5-14.

[7] Anfal Ali Alansari "MIMO-OFDM SYSTEM PERFORMANCE ANALYSIS BASED ON DWT" International Journal of Advanced Science and Engineering Technology On line ISSN 2225-9686; Print ISSN 2225-9678 Vol.3, No.1 (2013) pp (214- 220).

[8] J. A. C Bingham, "Multicarrier modulation for data transmission: An idea whose time has come", IEEE Communication Magazine, vol. 28, no. 5, (1990), pp. 5-14.

[9] B. G. Negash and H. Nikookar. "Wavelet-Based Multicarrier Transmission Over Multipath Wireless Channels", IEE Electronics Letters, vol. 36, (2000) October, pp. 1787-1788.

[10] C. V. Bouwel, J. Potemans, S. Schepers, B. Nauwelaers and A. V. de Capelle, "Wavelet Packet Based Multicarrier Modulation", Proc. IEEE Benelux Symposium on Communications and Vehicular Technology, Leuven, Belgium, (2000) October 19.

[11] A. R. Lindsey, "Generalized Orthogonally Multiplexed Communication via Wavelet Packet Bases", Ph.D. Thesis, Ohio University, (1995).