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Performance Analysis of Adaptive Modulation in OFDM Systems

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Abstract*— OFDM technology promises to be a key technique for achieving the high data capacity and spectral efficiency requirements for wireless communication systems. Different order modulations allows a wireless communication system to send more bits per symbol and thus achieve higher throughputs or better spectral efficiencies. So the use of adaptive modulation allows a wireless system to choose the best order modulation scheme depending on the channel conditions. Hence OFDM with Adaptive modulation (AOFDM) is implemented. In AOFDM, adaptive transmission scheme is employed according to channel fading condition to improve the performance. The performance metrics such as Bit Error Rate, Signal to Interference plus Noise Ratio are to be considered. Based on Signal to Interference plus Noise Ratio threshold value, modulation schemes are varied according to the environmental conditions. The adaptive OFDM is simulated and it provides better performance when compared to OFDM with fixed modulation schemes.
Keywords*— Adaptive modulation, Orthogonal Frequency Division Multiplexing (OFDM), Bit Error Rate (BER)

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a special form of multi-carrier transmission technique in which a single high rate data stream is divided into multiple low rate data streams. These data streams are then modulated using subcarriers which are orthogonal to each other. In this way the symbol rate on each sub channel is greatly reduced, so that the effect of intersymbol interference (ISI) due to channel dispersion in time caused by multipath delay spread is reduced. To reduce ISI further, guard interval can be inserted between OFDM symbols. Cyclic prefix is added to the OFDM symbols inorder to maintain the orthogonality between the subcarriers. The main advantages of OFDM are its multipath delay spread tolerance and efficient spectral usage by allowing overlapping in the frequency domain. Another significant advantage is that the modulation and demodulation can be done using inverse Fast Fourier Transformation (IFFT) and Fast Fourier Transformation (FFT) operations, which are computationally efficient[3]. But the disadvantage of this is, each subcarrier is attenuated individually under the frequency-selective and fast fading channel. The channel performance may be highly fluctuating across the subcarriers and varies from symbol to symbol. If the same fixed transmission scheme is used for all OFDM subcarriers, the error probability is dominated by the OFDM subcarriers with highest attenuation resulting in a poor performance. This problem can be mitigated if different modulation schemes are employed for the individual OFDM subcarriers [2]. On the other hand, Shanon's theorem also suggests that the spectral efficiency in terms of bits/s/Hz can be increased with the received signal-to-interference-plus-noise power ratio (SINR). Adaptive modulation is a technique to control the number of loadable bits per unit time, per unit bandwidth according to the SINR. Therefore OFDM with adaptive modulation is an opportunistic throughput enhancement technique [10].The contents of this paper are as follows. We will explain the system model of AOFDM, Architecture and types of AOFDM are described in section II. The AOFDM system performance depends on certain factors. They are described in section III. Simulation results are shown in section IV. Finally we will give the conclusions and results in section V and VI respectively.

II. SYSTEM DESIGN

In this paper, Sub band adaption algorithm is used in order to reduce the complexity of the individual subcarrier adaption procedure. The switching thresholds for various modulation schemes in this algorithm are investigated in [5]. All subcarriers in an AOFDM symbol are split into blocks of adjacent subcarriers referred to as subbands. A mode selector is present in both the transmitter and the receiver. It is used to select the appropriate modulator type. The same mode is employed for all subcarriers of the same subband.[10]. The choice of the modes to be used by the transmitter for its next OFDM symbol is determined by the channel quality estimate of the receiver based on the current OFDM symbol. In order to estimate the channel, pilot symbols are inserted with the data samples. Perfect channel estimation is assumed in this paper. The channels quality varies across the different subcarriers for frequency selective channels. The received signal at any subcarrier can be expressed as,

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$$R_n = H_n X_n + W_n \qquad (1)$$

where H_n is the channel coefficient at any subcarrier, X_n is the transmitted symbol and W_n is the Gaussian noise sample.[11]. Total subcarriers size considered for the proposed work is 2048, sub band size is 4 and each subband has 512 subcarriers.

A. AOFDM Architecture

The goal of adaptive modulation is to choose the appropriate modulation mode for transmission, given the local SNR, in order to achieve good trade-off between spectral efficiency and overall BER. The Block diagram for OFDM system with adaptive modulation is as shown in Fig.1.

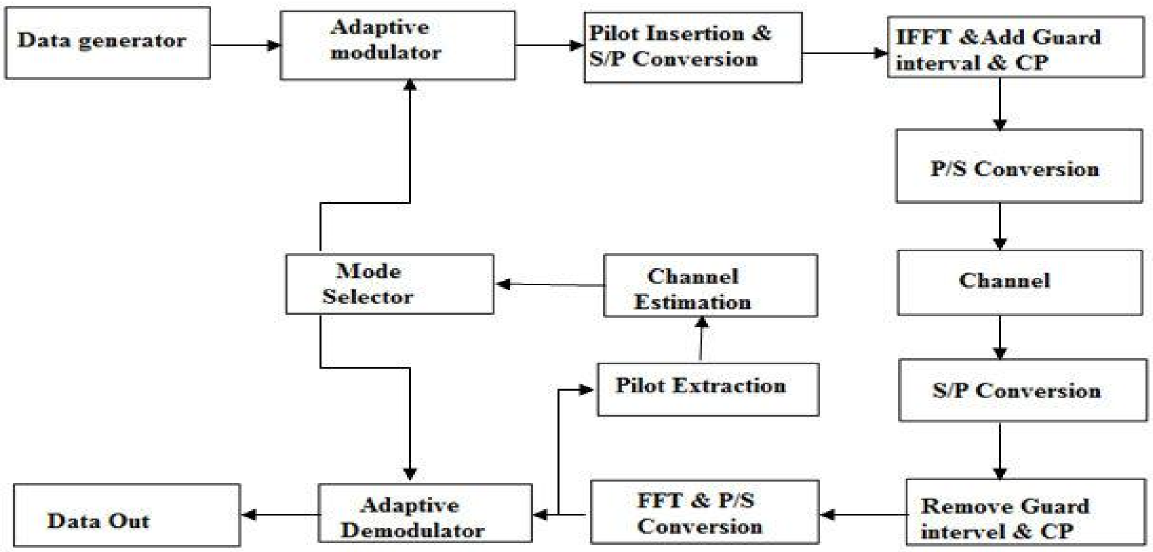

Fig.1 Block diagram of AOFDM

At transmitter, the data is generated with the help of data generator. Adaptive modulator block consists of different modulators which are used to provide different modulations. The switching between these modulators is done by mode selector which chooses the appropriate modulation. An inverse Fourier transform (IFFT) converts the frequency domain data set into samples of the corresponding time domain representation of this data. Cyclic prefix are then added. Then, the parallel to serial block creates the OFDM signal by sequentially outputting the time domain samples. Then these time domain samples up converted and are transmitted to the channel.

At receiver, the received signal is down converted and then the cyclic prefixes are removed. FFT is applied to have frequency domain signals. Adaptive demodulator does the reverse of modulator. Then the data is extracted from the demodulator. The pilot symbols are extracted for channel estimation. The channel estimator is used to estimate the average instantaneous SINR for the whole channel from these pilot symbols of previous OFDM frame. Estimated SINR is sent to the mode selector in the transmitter by the feedback channel. Then the mode selectors present in the transmitter and receiver compares the estimated value of SINR with threshold value and the selects the appropriate modulator demodulator pair for the next OFDM frame [4]. As per the physical layer specification of LTE, proposed work used three types of modulation schemes (QPSK, 16QAM, 64QAM) [6].

B. Adaptive Modulation Methods

The communication system performance depends upon the modulation level or order M of the particular modulation scheme. As modulation order M increases, system throughput performance improves and BER performance degrades. Adaptively selecting the modulation mode for the scheme will lead to better BER performance with considerable system throughput performance. There are three different types of modulators present in the transmitter and also three different types of demodulators present in the receiver. There are two types of adaptive modulation methods [5]. They are,

Adaptive modulation without transmission blocking

Adaptive modulation with transmission blocking

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C. Adaptive modulation without transmission blocking

In this method, transmissions are allowed for all channel conditions. The mode selector in the transmitter and receiver compares the estimated value of SINR with threshold value and adapts its modulation scheme based on Table -I. This threshold values are obtained from the observation of fixed modulation schemes and also from [5].

TABLE-I
SWITCHING THRESHOLD FOR ADAPTIVE MODULATION WITHOUT TRANSMISSION BLOCKING

Mode Number	Modulation	Threshold(dB)
1	QPSK	SINR<21
2.	16QAM	21≤SINR<26
3.	64QAM	SINR≥26

D. Adaptive Modulation With Transmission Blocking

The mode selector in the transmitter and the receiver compares the estimated value of SINR with threshold value and adapts its modulation scheme for the current OFDM frame based on Table-2 for all sub bands [5]. The modulation scheme selected by mode selector is employed for all subcarriers of the same subband. Data transmissions in the subbands are blocked when they are found deep faded based on estimated SINR. Hence it is called Adaptive modulation with transmission blocking [2].

TABLE-II
SWITCHING THRESHOLD FOR ADAPTIVE MODULATION WITH TRANSMISSION BLOCKING

Mode Number	Modulation	Threshold(dB)
0.	No Transmission	SINR<10
1.	QPSK	10≤SINR<21
2.	16QAM	21≤SINR<26
3.	64QAM	SINR≥26

III. AOFDM SYSTEM PERFORMANCE

The performance of AOFDM highly depends on the accurate channel estimation at the receiver and the reliable feedback path between that estimator and the transmitter on which the receiver reports channel state information (CSI). In order to assure a high-quality implementation the next steps must be followed:

A. Channel Quality Estimation

The transmitter requires an estimate of the expected channel conditions for the next transmission interval. Since this knowledge can only be gained by estimation from past channel quality estimations, the adaptive system can only operate efficiently in an best quality estimation scenarios. Because if the estimated channel SNR is deviated more from the actual channel SNR, this results poor BER performance. So the proposed work uses comb type pilots for this estimation.

B. Parameter Adaptation

The choice of the appropriate modulation mode to be used in the next transmission is made by the mode selector in the transmitter,

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based on the switching threshold algorithm. In this paper SINR based adaption is done. This SNR threshold is such that it guarantees a BER below the target BER.

C. Feedback Mechanism

Once the receiver has estimated the channel SNR, it has to feed back the selected mode to the transmitter in order that the adaptation can be performed. However, the challenge associated with adaptive modulation is that the mobile channel is time varying, and thus, the feedback of the channel information becomes a limiting factor. Therefore, the assumption of a reliable feedback channel is necessary in order to achieve an accurate performance of the AOFDM scheme.

IV. SIMULATION RESULTS AND DISCUSSION

In this simulation, the performance of adaptive modulation is investigated in terms of throughput and BER. To highlight the advantages of adaptive modulation, comparison is made with fixed modulation system. OFDM with fixed modulation schemes Vs OFDM with adaptive modulation schemes are employed. Table-III shows the simulation parameters considered.

TABLE III
SIMULATION PARAMETERS

PARAMETERS	VALUE
No. of bits	1008(QPSK),2016(16QAM) ,3024(64QAM)
No. of complex data	504
No. of pilots	8
Pilot type	Comb
Cyclic prefix	36
Symbol time	71.3µsec
Guard time	66.6µsec
IFFT size	2048
No. of sub carriers	2048
Modulation types, Mode Numbers	QPSK(1),16QAM(2), 64QAM(3), No Transmission(0).
Amount of bits considered	10^4 bits
Subcarrier spacing	15kHz
Carrier Frequency	2GHz

A. BER Performance

Adaptive modulation performs better than fixed 16QAM and 64QAM modulation which is shown in Fig.2. Because this scheme

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requires less SNR for better BER performance. In this simulation, the SNR values have been chosen from 1dB to 25dB. Also, after 26dB adaptive modulation without transmission blocking gives more spectral efficiency since it uses 64QAM scheme.

B. Throughput Performance

The Table-IV shows comparison of different mode selection possibilities. If we observe the case1 and case3, case3 has two blocked subbands and case1 has only one blocked subband. But both the cases require two OFDM symbol to transmit all the bits (i.e. Spectral efficiency is same for both the cases). Because case1 has two subbands that choose lower order modulation schemes, while case3 has two subbands that choose higher order modulation schemes. Also case4 requires only one OFDM symbol to transmit all the (12096) bits by choosing higher order modulation scheme in all the sub bands. Hence spectral efficiency can be improved by using adaptively choosing the modulation scheme.

C. Spectral Efficiency Calculation

Total Bandwidth=N*B_N =30MHz
71.3**µ**sec=12096bits Then,1 sec=170Mbits
Spectral efficiency=5bits/sec/Hz (upper limit)
Spectral efficiency=1bits/sec/Hz(lower limit)
Data rate---42Mbps to 170Mbps

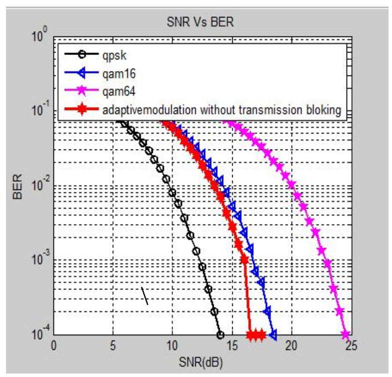

Fig.2 SNR Vs BER performance

TABLE-IV MODE SELECTION AND AMOUNT OF OFDM SYMBOL

CASES	MODE SELECTION FOR SUBBAND 1,2,3,4 Respectively				NO.OF BITS FOR ONE OFDM SYMBOL (=Sb1+Sb2+Sb3+Sb4) (based on each subband mode)	NO. OF OFDM SYMBOLS NEEDED TO TRANSMIT ALL 12096 BITS
1.	3	0	2	1	(3024+0+2016+1008)=6048	12096/6048=2
2.	1	1	0	1	(3*1008)=3024	12096/3024=4
3.	0	0	3	3	(2*3024)=6048	12096/6048=2
4.	3	3	3	3	(4*3024)=12096	12096/12096=1

V. CONCLUSION

In this proposed work, OFDM with Adaptive modulation is discussed in detail. Focus has been placed on two types of Adaptive modulation, without transmission blocking type, with transmission blocking type. A better switching algorithm is used to improve the BER performance. This algorithm utilizes the average value of the instantaneous SNR of the subcarriers as the switching parameter for various modulation schemes. Based on this algorithm, the two types of adaptive modulation schemes are simulated.

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OFDM with fixed modulation schemes are also designed to compare the performance. The results shows that, Adaptive modulation gives better BER performance than the fixed 16QAM and 64QAM modulation schemes and also it gives the idea of increasing the spectral efficiency even though subbands are in deep fading condition.

VI.FUTURE WORK

As a forthcoming work, interpolation methods can be investigated in detail for the best channel estimation. Then, it is possible to get the good spectral efficiency and BER performance with AOFDM systems.

REFERENCES

[1] Arne Svensson, Fellow IEEE, "An Introduction toAdaptive QAM Modulation Schemes for Known and Predicted channels", Proceedings of the IEEE, Vol.95, No. 12, December 2007.

[2] A.Sohail and M.N.Jafri, "Adaptive OFDM over Frequency Selective and Fast Fading Channel Using using Blockwise Bit Loading Algorithm International Conference on Wireless and Optical Communication Networks, pp. 1-4, July 2007.

[3] CharanLangton,"Orthogonal Frequency Division Multiplexing",by Intuitive Guide to principles of communications www.complextoreal.com

[4] Irving Kalet, "The Multitone Channel", IEEE Transactions on Communications, Vol. 37, No. 2, February 1989.

[5]J.Faezah,K.Sabira,"Adaptive Modulation for OFDMSystems",International Journal of Communication Networks and Information Security (IJCNIS) Vol.1,No.2, August 2009.

[6] "LTE in a Nutshell: The Physical Layer", White paper by Tele system Innovations Inc, 2010.

[7] K.M.hadi, R.Tripathi and K.Kant, "Performance of Adaptive Modulation in Multipath Fading Channel", The 8th International Conference on Advanced Communication Technology, ICACT, vol. 2, pp. 1277-1282, February 2006.

[8] L.Hanzo, S.X.Ng, T.Keller and W.Webb, "Quadrature Amplitude Modulation: From Basics to Adaptive Trellis Coded, Turbo Equalized and Space-Time Coded OFDM, CDMA and MC-CDMA Systems", 2nd Edition, pp. 1085 - 1105 John Wiley Sons Ltd – IEEE Press, 2004.

[9] M.Mahmoud, Allam S.Mousa, "Channel Estimation based in Comb-Type Pilots Arrangement for OFDM System Over Time Varying Channel", Journal of Networks, Vol. 5, No. 7, July 2010.

[10] M-X Chang and Y.T. Su, "Model-based channel estimation for OFDM signals in Rayleigh fading", IEEE Transaction on Communications, vol. 50, no.4, pp.540-544, April 2002.

[11] Md. Tanvir Hasan, "Improvement of Bit Error Rate (BER) of Adaptive Orthogonal Frequency Division Multiplexing (AOFDM) Systems under Rayleigh Fading Condition by using Convolution Coding", International Journal of Scientific &Engineering Research Volume 3, Issue 5, May-2012

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