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ENHANCEMENT OF HIGH DATA RATES IN WIRELESS COMMUNICATION NETWORKS USING MIMO-OFDM TECHNOLOGY

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ABSTRACT

Wireless communication systems require high transmission speed, improvement in spectral efficiency, and increasing speed and robustness. Orthogonal frequency-division multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wideband digital, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, DSL broad band internet access, wireless networks, and 4G mobile communications By using Multiple input and multiple output (MIMO) i.e. multiple antennas at the transmitter and multiple antennas at the receiver, the spectral efficiency will increase. For broadband communications, OFDM turns a frequency selective channel into a set of parallel flat channels, which significantly reduces the receiver complexity. In this paper, we applied Space-Time Coded Multiple-Input Multiple-Output OFDM (STC MIMO- OFDM) concept for spreading the transmitted symbols. In the proposed systems, a multidimensional diversity, including time, frequency, space and modulation diversities, can be used, resulting in better bit error performance in AWGN channel for with and without padding as well as for with and without convolution coding.

KEYWORDS: OFDM, STC, MIMO, BER, PER, AWGN.

INTRODUCTION

The growth of mobile communications, wireless Internet access and multimedia applications has produced a strong demand for advanced wireless techniques. The challenges for wireless communication designs come from the detrimental characteristics of wireless environments, such as multipath fading, Doppler Effect, co-channel interference, and intentional jamming in military communications and ITS. There is a rising need for high data rate [1] [2] [3] [4] [5] [6] [8], in wireless communication.

As user's demands exceed the capacity of wireless networks, operators are forced to find ways to improve the network capacity and throughput in order to provide an acceptable level of service. There is tremendous technological growth towards exploiting the bandwidth of a system. Particularly, in the wireless domain, 60 GHz RF band has lots of promise which can offer a bandwidth of 5 GHz. Now we are thinking of a system which can serve the purpose of communication in ITS application. A

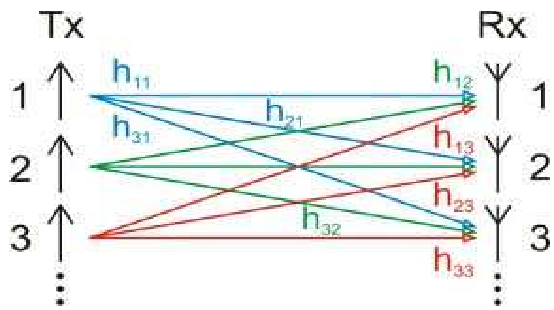
Communication model is based on the principle that any change in the signal after transmission is eliminated to recover the original signal at receiver and avail a reliable communication.

The approaching Fourth generation (4G) mobile communication systems are projected to solve still remaining problems of 3G (third generation) systems and to provide a wide variety of new services, from high quality voice to high-definition video to high-data-rate wireless channels. 4G is MAGIC—Mobile multimedia, anytime anywhere, [9].As a promise for the future, 4G systems, that is, cellular broadband wireless access systems have been attracting much interest in the mobile communication arena. The 4G systems not only will support the next generation of mobile service, but also will support the fixed wireless networks. The features of 4G systems might be summarized with one word-integration. There are actually three major objectives which the 4G technologies to fulfill- Continuous connectivity, Data rate of 100 MBPS at user terminal and Other services like ITS to deploy. CALM [10], continuous communication for vehicles, is a new World Standard for ITS operation. It includes Millimeter wave radar, GPS, 2G air interface to support ITS activities.

OFDM-MIMO IN WIRELESS COMMUNICATION

Various schemes that employ multiple antennas at the transmitter and receiver are being considered to improve the range and performance of communication systems. By far the most promising multiple antenna technology today happens to be the so called multiple – input multiple-output (MIMO) system. Increasing the number of MIMO transmitters and receivers however holds even greater potential. In doing so MIMO takes the advantages of the various reflections seen by the receiver. STC is one of the techniques used in MIMO, which spatially multiplexes multiple independent data streams transferred simultaneously within one spectral channel of bandwidth. OFDM-MIMO (STC) can significantly increase data throughput as the number of resolved spatial data streams is increased. A MIMO channel is a wireless link between M transmits and N receive antennas. It consists of MN elements that represent the MIMO channel coefficients. The multiple transmit and receive antennas could belong to a single user modem or it could be distributed among different users.

The later configuration is called distributed MIMO and cooperative communications. Statistical MIMO channel models offer flexibility in selecting the channel parameters, temporal and spatial correlations. MIMO channel simulation tools are implemented based on these models. Several statistical MIMO channel models were proposed in [6] and [7].Both models introduced spatial correlation by multiplying a matrix of uncorrelated random variables by a square root of a covariance matrix and both are based on similar assumptions. However, they differ in their approach. Fig.1 shows conceptual diagram of existing technology, smart antenna system and MIMO channels respectively.



Y=Hx+n

MIMO SYSTEM MODEL

The input /output a relation of a narrow band single-user MIMO wireless link is modulated by a complex baseband vector notation:Y=HX+ n …..(1). Where H is the channel matrix and n is the additive white Gaussian noise (AWGN) vector at a given instant in time channel noise. Furthermore, as a commonly used structure for the MIMO system, shares some basic modules with our general multiple antennas.

$$Y = \begin{bmatrix} y_1 \\ y_2 \\ y_N \end{bmatrix} \quad \text{.........(1)} \;;$$

$$n = \begin{bmatrix} n_1 \\ n_2 \\ . \\ . \\ n_N \end{bmatrix}$$

$$H = \begin{bmatrix} h_{11} \text{.....} h_{1M} \\ h_{21} \text{.........} h_{2M} \\ h_{N1} \text{.........} h_{NM} \end{bmatrix} \quad \text{...(3)}$$

$$X = \begin{bmatrix} x_1 \\ x_2 \\ . \\ . \\ x_M \end{bmatrix} \quad \text{...(4)}$$

The time-varying channel impulse response between the j^{th} (j = 1.2..........M) transmit

antenna and the i^{-th} (j= 1.2 ....N) receive

antenna is denoted as hi. j(ι,t) This is the response at time t-ι. The composite MIMO channel response is given by the N x M matrix H(ι,t) with

$$H(\tau,t) = \begin{bmatrix} h_{1,1}(\tau,t) & h_{1,2}(\tau,t) \ldots\ldots & h_{1,M}(\tau,t) \\ h_{2,1}(\tau,t) & h_{2,2}(\tau,t) \ldots\ldots & h_{2,M}(\tau,t) \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ h_{N,1}(\tau,t) & h_{N,2}(\tau,t) \ldots\ldots & h_{N,M}(\tau,t) \end{bmatrix}$$

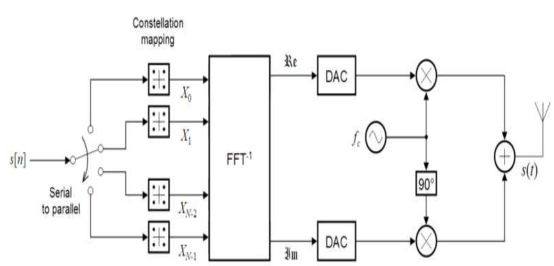
The Vector refered to as $h_{1j}(\tau,t)$ $h_{2j}(\tau,t)$ ……. $h_{Nj}(\tau,t)$ the spatio-temporal signature induced by the j th transmit antenna across the receive antenna

MIMO SYSTEM CHANNEL CAPACITY

To mitigate the problem of fading which is due to multipath propagation, diversity techniques were developed. Antenna diversity is a widespread form of diversity. Information theory has shown that with multipath propagation, multiple antennas at both transmitter and channels that operate simultaneously, on the same frequency band at the same total radiated power. Antenna correlation varies drastically as a function of the scattering environment, the distance between transmitter and receiver, the antenna configurations, and the Doppler spread. This representation is also known as spectral (bandwidth) efficiency. MIMO channel capacity depends heavily on the statistical properties and antenna element correlations of the channel. Representing the input and output of a memory less channel with the random variables X and Y respectively, the channel capacity is defined as the maximum of the mutual information between X and Y: receiver can establish essentially multiple parallel .

EXPERIMENTAL SET UP

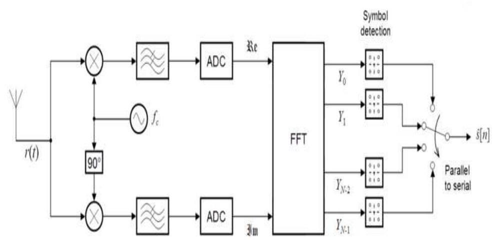
Transmitter and Receiver system in MIMO-OFDM is shown in Fig. 2(a) and Fig 2(b). OFDM is a multicarrier transmission technique, which divides the available spectrum into many carriers, each one being modulated by a low data rate stream. Each subcarrier is orthogonal to each other, meaning that cross-talk between the sub-channels is eliminated and inter-carrier guard bands are not required which significantly reduces the receiver complexity.



2 (a): Block diagram of OFDM-MIMO (STC) Transmitter System.

In current 802.11 systems without MIMO (Multiple Input Multiple Output) there is a single RF (Radio Frequency) chain on the wireless device. Multiple antennas use the same hardware to process the radio signal. So only one antenna can transmit or receive at a time as all radio signals need to go through the single RF chain. In MIMO there can be a separate RF chain for each antenna allowing multiple RF chains to coexist. The various parameters on which the simulation followed by analysis for Fig.2 (a) and Fig 2(b) are: Modulation techniques: BPSK, QPSK. Number of FFT points: 256 and 1024 (with and without interleaving),

Convolution code rates: R1/2 and R3/4, Channel Models: AWGN.

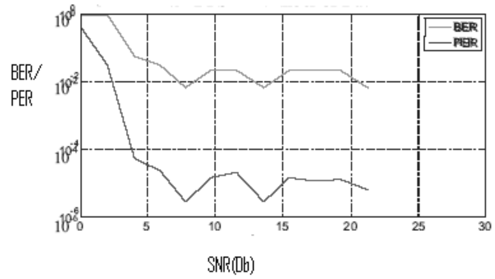


2 (b): Block diagram of OFDM-MIMO (STC) Receiver System.

In current 802.11 systems without MIMO (Multiple Input Multiple Output) there is a single RF (Radio Frequency) chain on the wireless device. Multiple antennas use the same hardware to process the radio signal. So only one antenna can transmit or receive at a time as all radio signals need to go through the single RF chain. In MIMO there can be a separate RF chain for each antenna allowing multiple RF chains to coexist. The various parameters on which the simulation followed by analysis for Fig.2 (a) and Fig 2(b)are: Modulation techniques: BPSK, QPSK. Number of FFT points: 256 and 1024 (with and without interleaving), Convolution code rates: R1/2 and R3/4, Channel Models: AWGN.

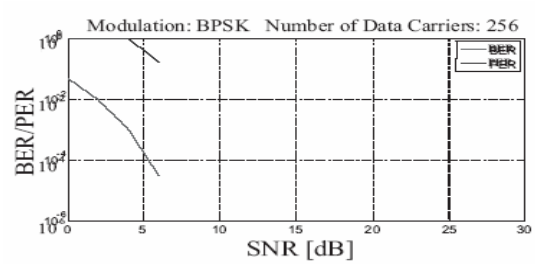
SIMULATION AND PERFORMANCE ANALYSIS OF OFDM-MIMO (STC) SYSTEMS

Performance analysis has been done for the proposed system based on MATLAB simulation. In communication systems, information bits are typically grouped into a frame or packet format and transmitted to a receiver. The received packets may be lost or include errors because of a noisy channel for transmitting the data. The packet error rate (PER) is the percentage of received packets that include an error. PER in a coded system depends on the ratio of the bit energy to noise spectrum density (SNR), the FEC code rate , ARQ scheme and the packet size. Bit Error Rate (BER) is the fundamental parameter to access the quality of any digital transmission and quality measurement of recovered data. Using FFT approach as the number of subcarrier increases the better is accuracy due to higher number of points. Hence data rate will also increase.



i) In comparison with three modulation schemes by varying receiver elements and keeping the transmitter elements initially fixed, for the case of with and without padding for BPSK and QPSK modulation, as SNR increases BER and PER improves. So data rate increases as shown in fig.3, which is mainly due to its receiving diversity technique.

Fig.3: Performance of a BPSK modulation for without padding and without coding. Parameters: No. of FFT points= 256; Modulation = BPSK; Channel = AWGN, Tx elements=2 and Rx element =2. Modulation: QPSK, Number of data carriers: 256



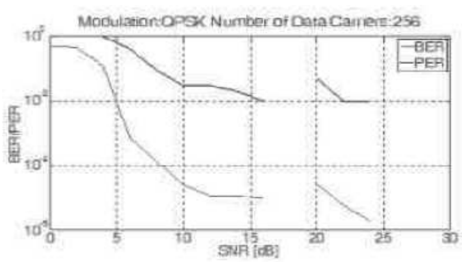


Figure: 3

Fig.4: Performance of a QPSK Modulation for with Padding Parameters: No. Of FFT Points = 256; Modulation =QPSK; Channel = AWGN, Tx Elements=2 And Rx Element =2, Code Rate=1/2.

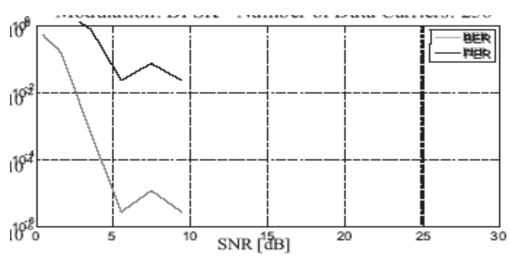


Figure: 4

ii) For with coding OFDM-MIMO (STC/MRC) system overall performance of all modulation techniques is much better than without coding. Modulation: BPSK, Number of carriers: 256

Fig.5: Performance of a BPSK modulation for without padding Parameters: No. of FFT points = 256; Modulation = BPSK; Channel = AWGN, Tx elements=2 and Rx element

=2, coding rate=3/4 Figure : (5)

Fig.6: Performance of a QPSK modulation for without padding Parameters: No. of FFT points = 256; Modulation = QPSK; Channel = AWGN, Tx elements=2 and Rx element =2, coding rate=3/4 Figure : (6)

iii) The overall performance of BPSK for OFDM MIMO(STC) system can improve for higher values of FFT points but the performance of QPSK almost remain constant .The overall performance for both with coding ,without padding and with coding ,with padding1024 FFT points is better than 256 FFT points in case of QPSK modulation as depicted in Fig.3,4 and Fig.7 - Fig.10.

Fig.7: Performance of a BPSK modulation for without padding Parameters: No. of FFT points = 1024; Modulation = BPSK; Channel = AWGN, Tx elements=2 and Rx element =2.

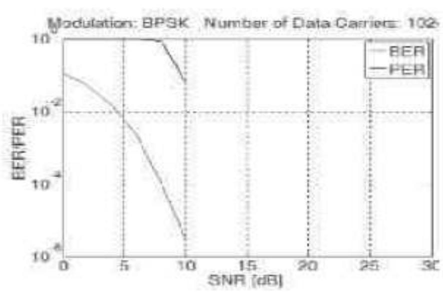


Figure: 7

Fig.8: Performance of a QPSK modulation for without padding Parameters: No. of FFT points =256; Modulation = QPSK; Channel = AWGN, Tx elements=2 and Rx element =2.

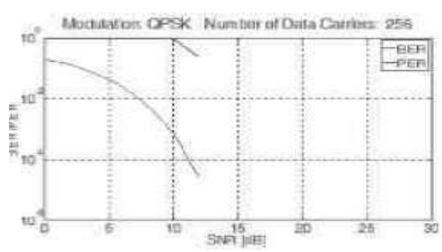


Figure: 8

Fig.9: Performance of a QPSK modulation for without padding Parameters: No. of FFT points = 1024; Modulation = QPSK; Channel = AWGN, Tx elements=2 and Rx element =2.

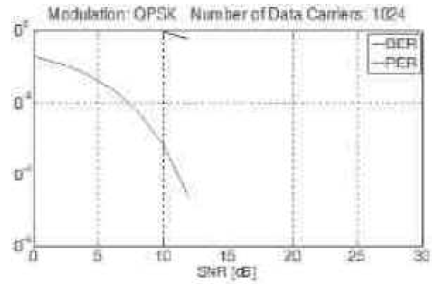


Figure: 9

Fig.10: Performance of a QPSK modulation for without padding Parameters: No. of FFT points = 1024; Modulation = QPSK; Channel = AWGN, Tx elements=2 and Rx element =2, Code rate =1/2.

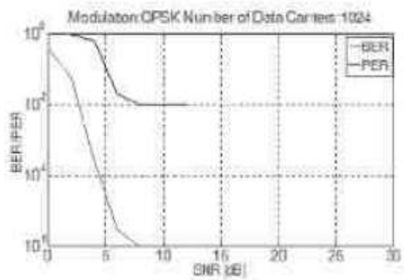


Figure: 10

CONCLUSIONS

From the performance, with different antenna configurations and propagation conditions the proposed MIMO-OFDM (STC) gives potentially higher spectral efficiency because no orthogonal transmitted signals and received co-channel signals are separated by decor relation (processing algorithm) due to multipath. It is understood that both MIMO technology and wider bandwidth channels will be required to reliably satisfy the higher throughput demands of next generation applications. The result shows that proposed system fare capable of improving bit rate and maximizing throughput efficiency without increasing total transmit power or required bandwidth with STC processing at the receiver .

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