

Recent Advances in Wireless Communication through Implementation of OFDM-MIMO System

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Abstract-- Wireless communication was conventionally implemented using Single Antenna at Transmitter and Single Antenna at Receiver. But this has the disadvantage of low spectral efficiency, low link reliability, medium data rates and the problem of frequency selective fading. This problem can be solved by using OFDM-MIMO Systems. The advantage of OFDM-MIMO system is that it has the capacity of overcoming the frequency selective fading problem, high spectral efficiency, and low computational complexity. Orthogonal frequency division multiplexing (OFDM) is, it can transmit multiple Signal at a same time as is different from FDM Where selected frequency is allotted to each signal slots to be transmitted. This improves data rates in Wireless communication. OFDM may be combined with antenna arrays at the transmitter and receiver to increase the diversity gain and to increase the system capacity on time-variant and frequency-selective channels, resulting in a multiple-input multiple-output (MIMO) configuration. MIMO means multiple antenna at Transmitter and multiple antenna receivers side. This improves the capacity to overcome frequency selective fading. Thus OFDM combined with MIMO results in increased data rates and increased efficiency. In these proposed paper, system transmits a single signal using transmit diversity (TD) after that relay selection (RS) is done using Decode-and-forward (DF) protocol and Amplify-and-forward protocol (AF) and signal is transferred towards the receiver.

Index Terms- AF, DF, MIMO, OFDM, Relay selection (RS), Transmit diversity (TD).

networks, power line networks, and 4G mobile communications.

1. INTRODUCTION

As the number of user in mobile communication ever increasing, it has become the major concern of mobile network. In mobile network, to extend coverage area, data rate, quality of service etc. is a major problem. Efficient mobile communication system requires significant performance in mentioned parameter. These rising demand of user cannot be fulfilled without further extending the existing system. In these respect, the paper below provide desirable characteristic well suited for mobile network application. In these proposed theory, we discuss OFDM, MIMO Systems and how these system transmit a single signal using transmit diversity concept, after that relay selection using Decode-and-forward (DF) protocol and Amplify-and-forward protocol, and the signal is sent towards receiver.

2. OFDM

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 communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, DSL Internet access, wireless

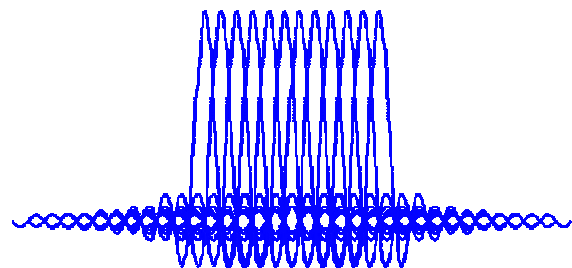


Fig 1. A Simple OFDM

OFDM is a specialized FDM, the additional constraint being: all the carrier signals are orthogonal to each other. In OFDM, the sub-carrier frequencies are chosen so that the sub-carriers are orthogonal to each other, meaning that cross-talk between the sub-channels is eliminated. This greatly simplifies the design of both the transmitter and the receiver; unlike conventional FDM. The orthogonality also allows high spectral efficiency, with a total symbol rate near the Nyquist rate for the equivalent baseband signal. Almost the whole available frequency band can be utilized. OFDM generally has a nearly 'white' spectrum, giving it electromagnetic interference properties with respect to other co-channel users.

OFDM requires very accurate frequency synchronization between the receiver and the transmitter; with frequency deviation the sub-carriers will no longer be orthogonal, causing inter-carrier interference (ICI) (i.e., cross-talk between the sub-carriers). Frequency offsets are typically caused by mismatched transmitter and receiver oscillators, or by Doppler shift due to movement. While Doppler shift alone may be compensated for by the receiver, the situation is worsened when combined with multipath, as reflections will appear at various frequency offsets, which is much harder to correct. This effect typically worsens as speed increases and is an important factor limiting the use of OFDM in high-speed vehicles. In order to mitigate ICI in such scenarios, one can shape each sub-carrier in order to minimize the interference resulting in a non-orthogonal subcarriers overlapping. For example, a low-complexity scheme referred to as WCP-OFDM (Weighted Cyclic Prefix Orthogonal Frequency-Division Multiplexing) consists in using short filters at the transmitter output in order to perform a potentially non-rectangular pulse shaping and a near perfect reconstruction using a single-tap per subcarrier equalization. Other ICI suppression techniques usually increase drastically the receiver complexity.

MIMO can be sub-divided into three main categories, precoding, spatial multiplexing or SM, and diversity coding.

Precoding is multi-stream beam forming, in the narrowest definition. In more general terms, it is considered to be all spatial processing that occurs at the transmitter. In (single-stream) beam forming, the same signal is emitted from each of the transmit antennas with appropriate phase and gain weighting such that the signal power is maximized at the receiver input. The benefits of beam forming are to increase the received signal gain, by making signals emitted from different antennas add up constructively, and to reduce the multipath fading effect. In line-of-sight propagation, beam forming results in a well-defined directional pattern. However, conventional beams are not a good analogy in cellular networks, which are mainly characterized by multipath propagation. When the receiver has multiple antennas, the transmit beam forming cannot simultaneously maximize the signal level at all of the receive antennas, and precoding with multiple streams is often beneficial. Note that precoding requires knowledge of channel state information (CSI) at the transmitter and the receiver.

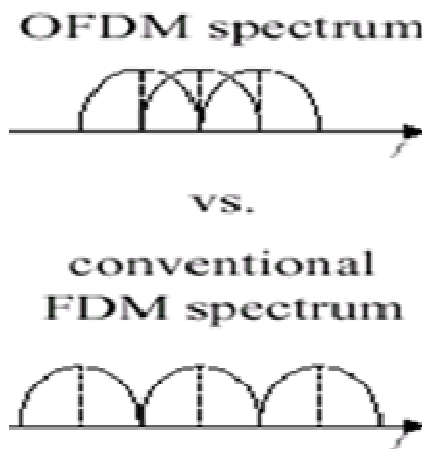


Fig.2 OFDM vs. FDM

3.MIMO System

Multiple-Input Multiple-Output (MIMO) technology is a wireless technology that uses multiple transmitters and receivers to transfer more data at the same time. All wireless products with 802.11n support MIMO, which is part of the technology that allows 802.11n to reach much higher speeds than products without 802.11n.

Spatial multiplexing requires MIMO antenna configuration. In spatial multiplexing, a high rate signal is split into multiple lower rate streams and each stream is transmitted from a different transmit antenna in the same frequency channel. If these signals arrive at the receiver antenna array with sufficiently different spatial signatures and the receiver has accurate CSI, it can separate these streams into (almost) parallel channels. Spatial multiplexing is a very powerful technique for increasing channel capacity at higher signal-to-noise ratios (SNR). The maximum number of spatial streams is limited by the lesser of the number of antennas at the transmitter or receiver. Spatial multiplexing can be used without CSI at the transmitter, but can be combined with precoding if CSI is available. Spatial multiplexing can also be used for simultaneous transmission to multiple receivers, known as space-division multiple access or multi-user MIMO, in which case CSI is required at the transmitter. The scheduling of receivers with different spatial signatures allows good separability.

Diversity Coding techniques are used when there is no channel knowledge at the transmitter. In diversity methods, a single stream (unlike multiple streams in spatial multiplexing) is transmitted, but the signal is coded using techniques called space-time coding. The signal is emitted from each of the transmit antennas with full or near orthogonal coding. Diversity coding exploits the independent fading in the multiple antenna links to enhance signal diversity. Because

there is no channel knowledge, there is no beam forming or array gain from diversity coding. Diversity coding can be combined with spatial multiplexing when some channel knowledge is available at the

parameters which we have used in this project. It includes different parameters mentioned in fig below. The system consists of input where we provide input waveform. These input waveforms are randomly

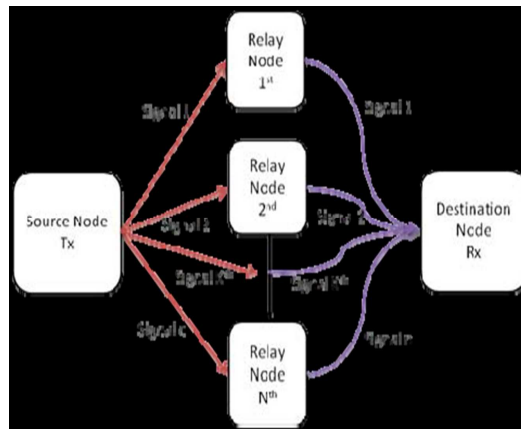


Fig 3. A Simple. diagram for MIMO System

transmitter interference then use serial to parallel convertor then use serial to parallel convertor. Then use FFT and one bit equalizer to minimize error then use signal demapper and parallel to serial convertor to get original signal. Thus obtain improved performance we design OFDM MIMO system.

4.OFDM-MIMO

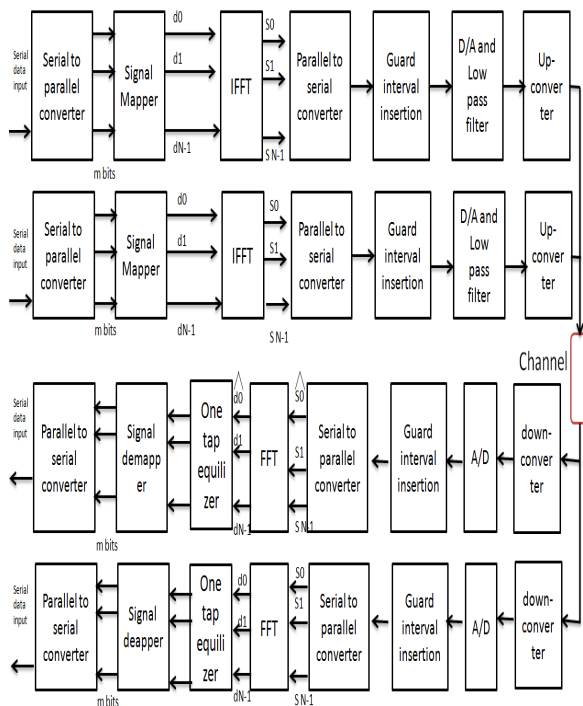


Fig 4.Block diagram of OFDM-MIMO system

Let us estimate the output of OFDM –MIMO System in various stages. In fig 5 we have shown the

selected bit patterns which is to be transmitted towards Receiver. It is followed by interleave where it is mixed with pilot carriers. The function of this interleaving is that the signal should not overlap with one another and the signal should be securely transmitted to the other side of the transmitter.. Then we add Preamble to the transmitted Signal .The preamble is the bit pattern which are inserted in front of the transmitted sequence. The output is shown in fig 8.and fig 9.We have shown the channel estimation of OFDM and the Received signal that is received at Receiver side, which seems as replica of transmitted signal. At the receiver side as shown in block diagram the operations performed are exactly reverse of that at the transmitter side. That means the interleaving done at the transmitter is removed., The signal is demapped and the original signal is obtained . However it is seen that received signal has lees bit error rate as compared to transmitted.

This difference in BER is further explained in Graphical user Interface of the OFDM as shown below in Fig 11.The GUI of OFDM is Plotted against BER and E_b/N_o . E_b/N_o is the energy to the noise ratio of the OFDM signal .The figure shows the Mean square error rate and the average error rate .It is clearly seen that the mean square error rate is always less than average bit error rate. The figure shows greatly reduction in BER as compared to conventional system which consist of single Antenna at transmitter and single antenna at Receiver. Compared to Conventional System, MIMO has greatly improve the performance of the system.



Fig 5. Parameter Of OFDM-MIMO

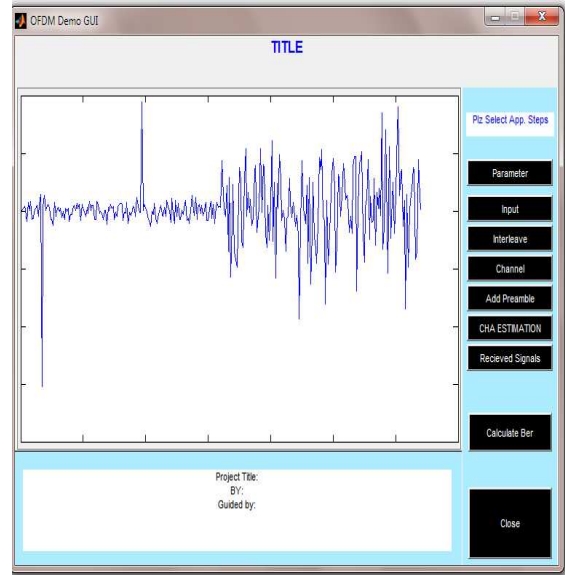


Fig8:Add Preamble

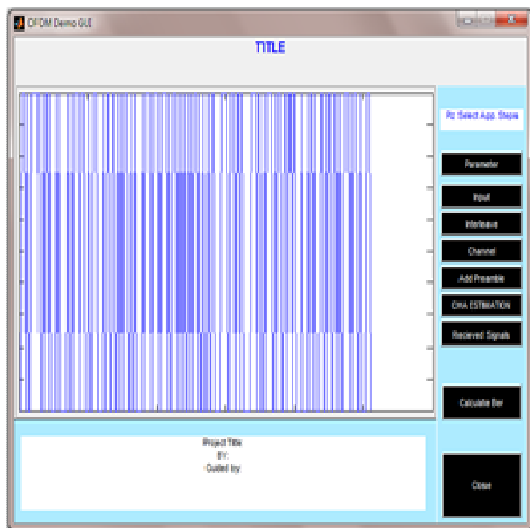


Fig6. Input Of OFDM-MIMO

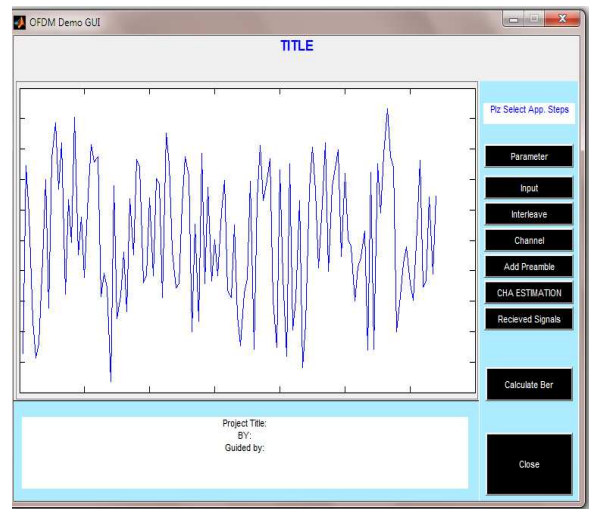


Fig 9. Channel Estimation Of OFDM-MIMO

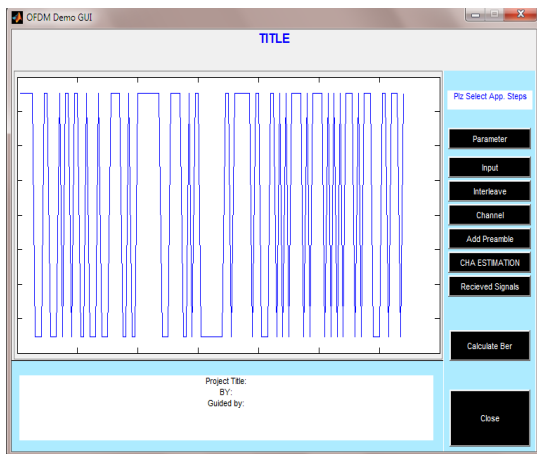


Fig 7. Interleave Of OFDM-MIMO

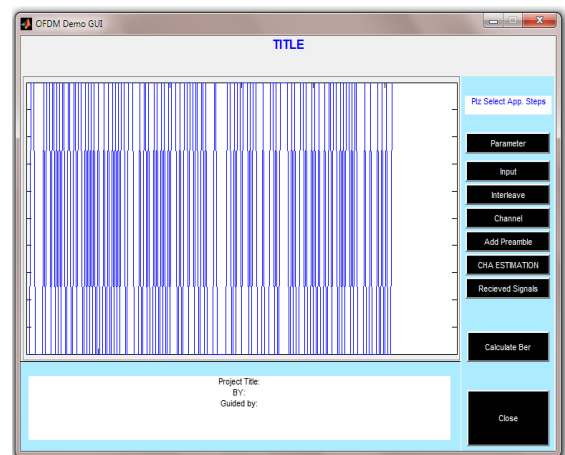


Fig 10.Received Signals Of OFDM-MIMO

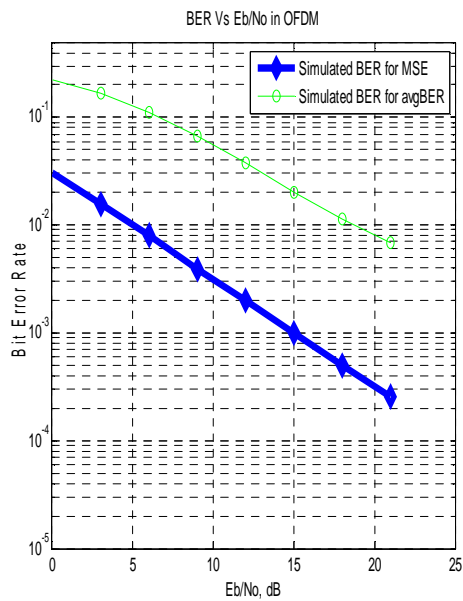


Fig 11..Simple GUI OF OFDM

5. MIMO using Relay Selection

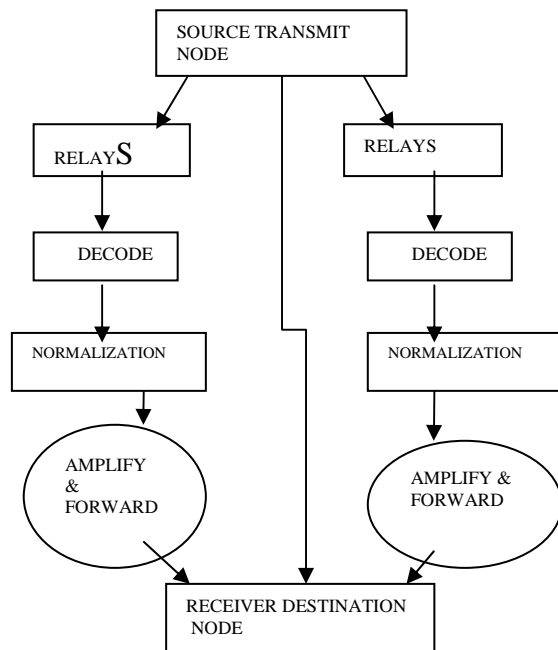


Fig 13 .MIMO using relay selection

As the number of user in mobile communication ever increasing, it is the major concern of mobile network. To extend coverage area, data rate, quality of service etc. is a major problem of mobile network. Many project system discuss circumvent the need for exhaustive searching and increases the speed of convergence having low complexity and having high gain. Near-far problem is common in wireless

communication systems. MIMO system enable to increased spectral efficiency. This can be achieved using relays which is demonstrated below.

Source transmitter transmits multiple signals to increase efficiency then at relay node these signals are analysed using DF and AF protocol. From relay node transmit signal further to the receiver. Amplify and forward (AF) in which first amplify the received signal from the source node and forward it to the destination station. Decode and forward (DF) in which first decode the received signal from the source node and forward it to the destination station. AF happens to be first to the DF. RS improves the performance of conventional TDS as shown in fig 13 above.

6. System and Data Model

The source and destination nodes each have N_{as} forward and N_{ad} backward antennas, respectively, and the relay nodes have N_{ar} forward and backward antennas with N_r intermediate nodes. N_{as} data streams are transmitted in the system, and each is allocated to the correspondingly numbered antenna at the source node. The protocol operation of Decode and forward ,Amplify and forward is explained below.

6.1.Decode-and-Forward

The signal that is received at the first phase at the destination and n^{th} relay for i^{th} symbol are given by following equation.

$$r_{sd}[i] = H_{sd}[i]As[i]Ts[i]s[i] + \eta_{sd}[i] \quad (1)$$

$$r_{srn}[i] = H_{srn}[i]As[i]Ts[i]s[i] + \eta_{srn}[i]. \quad (2)$$

The structures $H_{sd}[i]$ and $H_{srn}[i]$ are the $N_{ad} \times N_{ad}$ source-destination and $N_{ad} \times N_{ar}$ source-nth relay channel matrices, respectively. The quantities $\eta_{sd}[i]$ and $\eta_{srn}[i]$ are the $N_{ad} \times 1$ and $N_{ar} \times 1$ vectors of zero mean additive white Gaussian noise at the destination and nth relay, respectively, whose variances are σ_{sd}^2 and σ_{srn}^2 and autocorrelation matrices $\sigma_{sd}^2 I_{N_{ad}}$ and $\sigma_{srn}^2 I_{N_{srn}}$. The $N_{as} \times 1$ transmits the data at the transmitter side. At the nth relay, the output of the reception and interference suppression procedure is denoted $Z_{rn}[i]$, and the decoded symbol vector is given by

$$S_m[i] = Q(Z_{rn}[i]) \quad (3)$$

where $Q(\cdot)$ is a general quadrature-amplitude-modulation slicer. The $N_{ad} \times 1$ second-phase received signal at the destination is the summation of the N_r relayed signals, yielding

$$r_{rd}[i] = \sum_{n=1}^{N_r} H_{rnd}[i]A_{rn}[i]T_m[i] \hat{S}_m[i] + \eta_{rd}[i] \quad (4)$$

where \mathbf{H}_{rd} is the n th relay–destination channel matrix, and $\mathbf{A}_r[i]$ is the n th relay transmit power allocation matrix that proves the total transmit power of the second phase is unity. The summation of (4) can be expressed in a more compact form given by

$$\mathbf{r}_{rd}[i] = \mathbf{H}_{rd}[i]\mathbf{A}_r[i]\mathbf{T}_r[i]^T \hat{\mathbf{s}}[i] + \boldsymbol{\eta}_{rd}[i] \quad (5)$$

The final received signal at the destination is then formed by stacking the received signals from the relay and source nodes to give

$$\mathbf{r}_d[i] = \begin{bmatrix} \mathbf{r}_{sd}[i] \\ \mathbf{r}_{rd}[i] \end{bmatrix} \quad (6)$$

6.2. Amplify-and-Forward

$$\mathbf{r}_{rd}[i] = \mathbf{H}_{rd}[i]\mathbf{A}_r[i]\mathbf{T}_r[i] \mathbf{r}_{sr}[i] + \boldsymbol{\eta}_{rd} \quad (7)$$

where $\mathbf{r}_{sr}[i] = [\mathbf{r}_{Tsr1}[i] \ \mathbf{r}_{Tsr2}[i] \ \dots \ \mathbf{r}_{TsrN_r}[i]]^T$ can be interpreted as the AF equivalent of $\hat{\mathbf{s}}[i]$. Expanding (7) yields

$$\mathbf{r}_{rd}[i] = \mathbf{H}_{rd}[i]\mathbf{A}_r[i]\mathbf{T}_r[i]\mathbf{H}_{sr}[i]\mathbf{A}_s[i]\mathbf{T}_s[i]\mathbf{s}[i] + \mathbf{H}_{rd}[i]\mathbf{A}_r[i]\mathbf{T}_r[i]\boldsymbol{\eta}_{sr} + \boldsymbol{\eta}_{rd} \quad (8)$$

8. Simulations

In this section, we presented the simulations of OFDM in terms of GUI of OFDM. This has shown improved performance of the system as compared to conventional system. In Fig.10, we consider the BER convergence performance of the proposed algorithms and compare them against systems with exhaustive TDS, no TDS and random TDS. The gains achieved by the proposed algorithms are also highlighted by their significantly better performance than the random TDS scheme.

9. Conclusion

In this paper we have presented the OFDM system with MIMO system for improved performance of the system. We observed the spatial diversity and transmit diversity with relay selection algorithms for DF and AF, to further improve the data rates. We have proved that BER reduces down for MIMO system compared to conventional system. We compared conventional system with Present MIMO system

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