OFDM Application to Transmit Diversity MIMO System using Decode Forward & Amplify Forward Protocols for Relay Selection

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ABSTRACT

In present scenario, there is a need of improving our future wireless communication system, since system suffers from the problem 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 signals. The advantage of OFDM 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 a popular method for high data rate wireless transmission. 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. In these proposed paper system transmit 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.

General Terms

Wireless Communication ,Mobile Communication

Keywords

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

1. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) as become a useful technique for transmission of signals over wireless channels. OFDM can be used in combination with a Multiple-Input Multiple-Output (MIMO) transceiver to increase the diversity gain because the OFDM system provides numerous parallel narrowband channels. The sub-channels has very less frequency separation required to maintain orthogonally of their respective time domain waveforms. In wireless communication the signal is propagating from the transmitter to the receiver along number of different paths, referred as multipath. As the signal propagates power drops of due to path loss, macroscopic fading and microscopic fading. Thus, fading of the signal can be reduced by transmitting the signal through multiple independent fading paths and combining at the receiver. 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.

Spatial Multiplexing is used to improve the capacity of a MIMO system by transmitting data streams in time slots and frequency bands simultaneously from each transmit antenna ,and obtaining multiple data streams at the receiver using channel information about each path. 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 reducing the number of antennas at the transmitter or receivers side. This the performance can be further improved by using relays with relay selection protocols such as decode and forward and amplify and forward protocol[3]

In this paper we are discussing MIMO-OFDM with its graphical output, transmit diversity with relay selection algorithm for Amplify and forward , decode and forward protocol. we consider the BER convergence performance of the proposed algorithms and compare them against systems with exhaustive TDS, no TDS and random TDS.

2. MIMO-OFDM

The above paper is the block diagram of MIMO system for transmission and reception of the signal. This figure1 has multiple components which specifies the concept of MIMO system. In figure given below, we use two antennas. Two Serial to parallel encoder convert the complex data and are fed into the signal mapper. The OFDM modulator perform an IFFT followed by parallel to serial convertor .The guard interval eliminate interference between OFDM symbol. After that Digital to analog convertor convert signal into analog form. Then up-convertor convert a band of frequency from a lower frequency to a higher frequency. Above circuit for transmitter then relay selection algorithm will take place using amplify and forward and decode and forward algorithm. Then at the receiver down –convertor is used then that signal converted into digital form using A-D convertor. Then guard interval removal to minimize the interference 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 to obtain improved performance we design OFDM MIMO system.

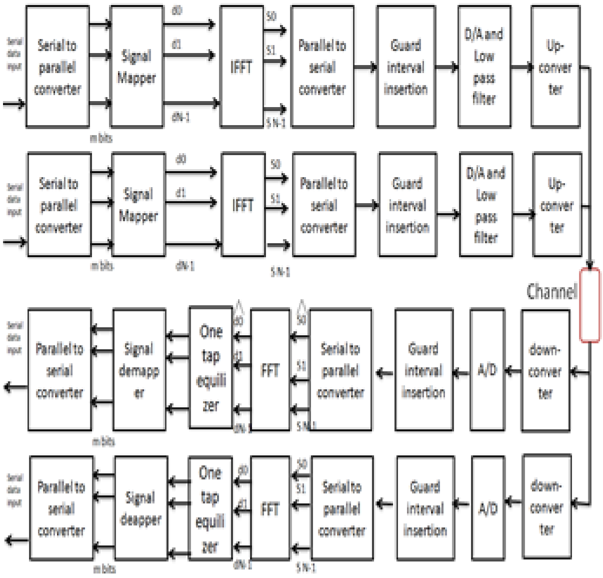

Fig 1.Block diagram of OFDM

3. SIMPLE GUI OF OFDM

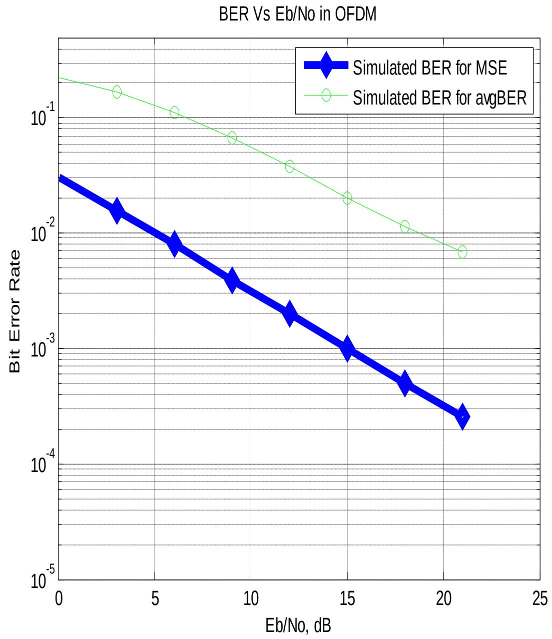

Fig.2 BER performance versus Eb/No

Figure shows the BER versus Eb/No performance of the proposed and conventional algorithms . Our aim of obtaining increased diversity and improved performance has been achieved. However ,due to use of linear receivers it is not possible to achieve the full receive diversity. This improvement obtained is the result of removing the transmission over poorer paths .The largest gains is seen in 5dB-15dB region and the gain reduces above this region.[9]

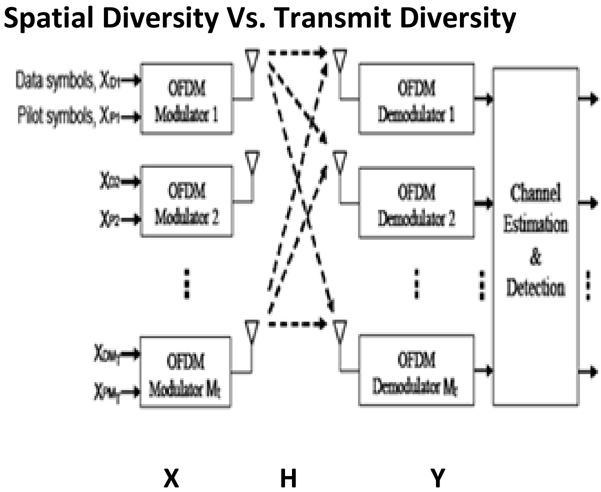

Fig 3.Transmission and reception in OFDM

As shown in fig3 ,the transmitter side consist of OFDM modulator with the inputs as data symbols and pilot symbols. This is nothing but the transmitter side of the OFDM-MIMO system.. The receiver side consist of OFDM demodulator followed by channel estimation and detection unit. This is the receiver side of the OFDM-MIMO system. The point to be discussed here is that how transmission between transmitter and receiver is done with improved capacity of MIMO link .This is achieved by using spatial diversity[8].

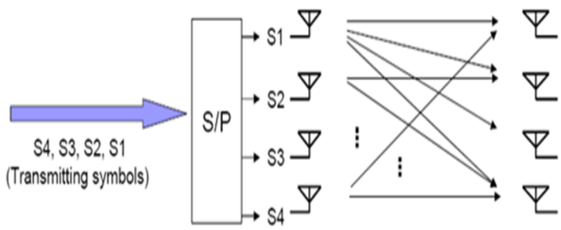

Fig.4..Spatial diversity description.

As shown in figure there are 4 symbols to be transmitted These are applied at the serial to parallel convertor .These 4 symbols at the transmitting side are splitted into 4 separate symbols and are then transmitted through different paths. . If these signals arrive at the receiver antenna array with sufficiently different spatial signatures and the receiver has accurate channel state information, it can separate these streams into parallel channels.

This concept has greatly improved the system performance by increasing the data rates, reducing the multipath fading which occurred due to signals having different angles as it pass over mountainous regions, hilly regions, and buildings. However the adaptivity of the link to the given signal have proved that the signal having low velocity users suits spatial diversity. However signal having high velocity user best suits transmit diversity. Spatial diversity provides wastage of some bandwidths which is not seen in transmit diversity. Hence for high velocity users which is seen in MIMO system , here at present we are discussing transmit diversity.

In conventional technology, single antenna use at both source and destination. But due to the multipath effect, electromagnetic field bounces off hills, canyons, buildings. Hence, signal reaching at the receiving antenna multiple times having different angle and cause problem such as fading, cut-off, intermittent reception. It causes a reduction in data rate and increased in number of error. Hence multiple antennas at both ends take advantageous effect. MIMO for wireless communication is an antenna technology in which multiple antennas at each terminal. The multiple antenna at each end is use to minimize the errors and optimize speed and data integrity. MIMO system enables to increased spectral efficiency for a given total transmit power. Multiple antennas at the both end of the system called multiple inputs and multiple outputs. Basically use to improve the efficiency and reliability of a system as compared to single input and single output system [13], [8]. Conventional method requires to provide larger bandwidth and having introduced with higher modulation types. MIMO technique having multiple numbers of antennas at both transmitter and receiver to improve the communication performance and higher data rate [5]. Diversity technique is used to improve the wireless link performance and received signal quality. There are various types of diversity such as time diversity, frequency diversity, space diversity, angle diversity, path diversity, polarization diversity, transmits diversity. In many systems additional antennas may be expensive or impractical at the remote or even at the base station. In these cases, transmit diversity can be used to provide diversity benefit at a receiver with multiple transmit antennas only. With transmit diversity, multiple antennas transmit delayed versions of a signal, creating frequency-selective fading, which is equalized at the receiver to provide diversity gain. Since transmit diversity with N antennas results in N sources of interference to other users, the interference environment will be different from conventional systems with one transmit antenna. Thus, even if transmit diversity has almost the same performance as receive diversity in noise-limited environments, the performance in interference-limited environments will differ

4. 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 analyzed 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 5 below.

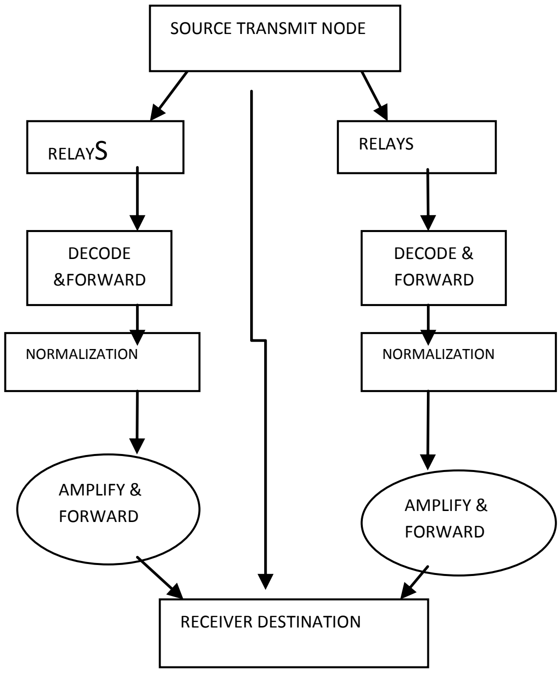

Fig5 .MIMO using relay selection.

5. 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.

5.1 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.[13]

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

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

The structures $H_{sd}[i]$and $H_{srn}[i]$ are the N_{ad} × Nad source–destination and N_{ad} × N_{ar} source—nth relay channel matrices, respectively. The quantities $\eta_{sd}[i]$ and $\eta_{srn}[i]$. are the N_{ad} × 1 and N_{ar} × 1 vectors of zero mean additive white Gaussian noise at the destination and nth relay, respectively, whose variances are $\sigma^2{}_{sd}$ and $\sigma^2{}_{srn}$ and autocorrelation matrices $\sigma^2{}_{sd}I_{Nad}$ and $\sigma^2{}_{srn}I_{Nsrn}$.. The N_{as}x1 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

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

where Q(·) is a general quadrature-amplitude-modulation slicer.

The N_{ad} × 1 second-phase received signal at the destination is the summation of the Nr relayed signals, yielding

$$r_{rd}[i] = \sum_{n=1}^{Nr} H_{rnd}[i]A_{rn}[i]T_{rn}[i]\hat{}s_{rn}[i] + \eta_{rd}[i] \quad (4)$$

where **H**r*n*d is the *n*th relay–destination channel matrix, and **A**r*n*[*i*] is the *n*th relay transmit power allocation matrix that proves the total transmit power of the second phase i s unity

The summation of(4)can be expressed in a more compact form given by

$$\mathbf{r}rd[i] = \boldsymbol{H}rd[i]\boldsymbol{A}r[i]\boldsymbol{T}\, r[i]\hat{}.\mathbf{s}[i] + \boldsymbol{\eta}rd[i] \qquad (5)$$

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

$$r_d[i] = \begin{bmatrix} rsd[i] \\ rrd[i] \end{bmatrix} \qquad (6)$$

5.2 Amplify-and-Forward

The following is the expressions for the destination's second-phase received signal:[13]

$$\mathbf{r}rd[i] = \boldsymbol{H}rd[i]\boldsymbol{A}r[i]\boldsymbol{T}\, r[i].\mathbf{r}sr[i] + \boldsymbol{\eta}rd \qquad (7)$$

where .**r**sr[*i*] = [**r***T*sr1 [*i*] **r***T*sr2 [*i*] . . . **r***T*sr*Nr*[*i*]]*T* can be interpreted as the AF equivalent of ˆ.**s**[*i*]. Expanding (7) yields

$$\mathbf{r}rd[i] = \boldsymbol{H}rd[i]\boldsymbol{A}r[i]\boldsymbol{T}\, r[i]\boldsymbol{H}sr[i]\mathbf{A}s[i]\mathbf{T}s[i]\mathbf{s}[i]+$$

$$\boldsymbol{H}rd[i]\boldsymbol{A}r[i]\boldsymbol{T}\, r[i].\boldsymbol{\eta}sr \quad + \boldsymbol{\eta}rd \qquad (8)$$

Where Hsr[i] = [HTsr1 [i]HTsr2 [i] . . . HTsrNr[i]]T , and Ar[i] normalizes the average transmit power of the second phase based on each relay's receive power. The received signals of the first and second phases can then be combined as in (6) to give rd[i].[13]

6. ANALYSIS

In this section, we analyze and discuss four major aspects of the proposed algorithms that shows their advantages over existing methods. The four areas covered are computational complexity, convergence, diversity gain, and feedback requirements[13].

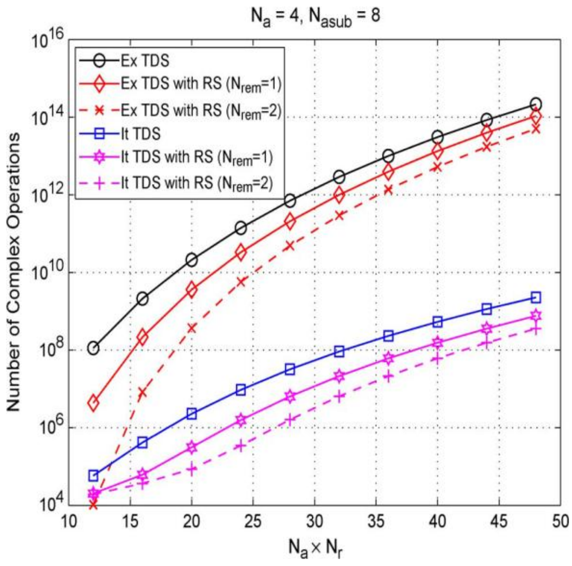

Fig 6. Computational complexity of optimal exhaustive (Ex) and proposed iterative (It) MMSE schemes.

6.1 Complexity

The iterative operation of the TDS algorithms shows complexity advantage over an exhaustive search of the entire set of solutions. These savings result from a vast reduction in the number of calculations at each time instant for each set considered compared to the exhaustive search. Performing RS in combination with the TDS algorithm improves both convergence and complexity. In Fig. 3, the computational complexity in terms of the (average) total number of complex multiplications and additions is given for the optimal exhaustive methods and the proposed DSA when optimal linear MMSE reception is used. For simplicity and conciseness, in this figure and throughout the remainder of this paper, *Na* is used to refer to the number of antennas at all nodes, where *Na* = *N*as = *N*ar = *N*ad. Thus there are substantial complexity savings from the use of the proposed algorithms over the exhaustive solutions; these are savings that increase with the number of relays and total antenna elements in the system. A second feature of importance are the savings made from introducing RS into the optimal exhaustive and proposed methods. These savings also increase with system size and confirm that those made by RS exceed the cost of its implementation

6.2 Feedback Requirements

A major advantage are their low feedback requirements. No precoding is required at the transmitting nodes, TDS lonely operates in the second phase, and all receptions are at the receiving nodes only require locally available CSI. Consequently, only the feedback of the TD selections to the relays is required. For RS, relay MSE information is required to be forwarded, which is a process that occurs during the training period. As covered earlier in this paper, TDS can be interpreted as discrete power control with one bit quantization, where the relative transmit power from each antenna is constrained to either 1 or 0. As a result, *N*ar feedback bits are required for TDS at each relay node and a total of *Nr* × *N*ar bits for the overall system, a figure that grows linearly with the size of the system. This increases system performance with low error rate.. In addition to this the impact on the capacity of the system is small as only a brieftime slot is required for transmission of the feedback information .However, the forwarding of the relay MSE information is subject to quantization, and it is, therefore, the number of quantization levels that determines the rate of the forwarded data. In this paper, a binary symmetric channel is used to model the feedback and feed forward channels, the quality of which is controlled by the probability of the error term, where $0 \leq pe \leq 1$.

6.3 Diversity

A significant benefit of multirelay MIMO systems is the Diversity advantage and spatial multiplexing gains . In this paper, receivers based on linear MMSE filtering have been used, and therefore, it is not possible to obtain the full diversity on offer unless so form of coding is implemented. The diversity advantage available to uncoded MMSE receivers can be maximized and the accompanying interference suppression is improved. The method of TDS and RS restricts the number of transmit paths used and therefore lowers the maximum diversity advantage. However, it enables the lower complexity MMSE-based techniques to increase their exploitation of the diversity at an SNR of interest by removing paths that bring little or no advantage to the cooperative transmissions of the first and second phase and dedicating increased transmit power over the remaining transmission routes.

6.4 Convergence

Considering the nature of the problems and algorithms presented in this paper, convergence is observed against the optimal exhaustive solution at each time instant. Due to the application of the proposed schemes in practical communications systems, we concentrate upon BER and squared estimation error as a measure of performance and convergence. Global convergence of the proposed algorithms is dependent on two assumptions: 1) the independence between the observations used for the objective function for the MMSE TDS and for the MMSE RS. . However, operation of TDS and RS and the practical difficulties of obtaining numerous independent observations under the system model are presented in this paper, the proof of convergence is intractable and, therefore, not guaranteed. Throughout the simulations presented in this paper and extensive experimentation, excellent steady-state convergence performance has been observed. Further support for this conclusion is presented in [1], where no convergence issues example, if a large initial step size is chosen for the TDS process and a small step size for the RS process, it is possible that the TDS process will become trapped in a state associated with a local minimum and therefore fail to converge to the exhaustive TDS with RS solution. Additional care has to be taken when studying the convergence of the schemes that feature adaptive reception. As previously mentioned, the step size of TDS and RS algorithms is fixed for the adaptive MMSE implementation to aid convergence of TDS and RS at large i and avoid becoming trapped in a non-optimal state. Although effective, the rate of convergence will still lag behind the optimal scheme due to not only the convergence of the LMS adaptive filter algorithms and the ensemble error but also the convergence of a total of four algorithms in parallel for TDS with RS.

7. 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.6, 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.[13]

8. 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. We discuss four major aspects of the proposed algorithms complexity, feedback requirement, diversity, convergence. Thus we have proved that MIMO OFDM is better than conventional system without TDS.

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