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A TWO-WAY RELAY TRANSMISSION IN CODED MIMO-OFDM USING DELAY DIVERSITY SCHEME

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ABSTRACT:

In wireless communication, Two-way relays can enhance coverage, throughput, and reliability of wireless systems; it has attracted intense research interest in the past decades. Performance review shows that Full-Duplex relay system outperforms well than the traditional relay systems, due to its capability to double the spectral efficiency. The Self-interference (SI) releasing from the Full-Duplex (FD) node's transmission to its own reception has the detrimental effect on the performance of FD relay communication. Delay diversity (DD) MIMO-OFDM in amplify-and-forward (AF) two-way relay system is proposed, where one relay forwarding link, one direct source to destination link and residual self-interference (RSI) are taken. The required cyclic prefix (CP) length is evaluated and an appropriate Amplify and Forward (AF) relay protocol in the full-duplex relay MIMO-OFDM system is proposed. To provide spatial diversity, the direct source-to-destination link and the AF relay link can be combined. To convert the spatial diversity to channel frequency diversity that is further exploited by using the bit-interleaved coding by DD MIMO-OFDM scheme. The performance of Bit Error Rate (BER) for the proposed system is proved by simulation results.

1. INTRODUCTION:

Relay-assisted communication has been undergoing vast development in both industry and academia in recent years. The attractive benefit of relaying is the utilization of cooperative diversity to combat channel fading and boost communication reliability. By receiving, re-transmitting, and processing radio signals, low-cost solution energy efficiency is offered by relay networks to increase coverage of wireless connections. The Amplify and Forward (AF) protocol outperform the Delay and Forward (DF) equivalent in terms of shorter processing problems is the Self-Interference (SI) and less computational demand which results from the parallel transmission and reception at the same frequency. The strong SI looped back at the relay node from the transmitter can easily decreases the throughput of a full-duplex relay system. For SI suppression techniques, a substantial amount has been paid. The physical isolation of the relays transmits and receive antennas, the instance, or sufficiently large separation or space between transmit and receive antennas should be taken to partially remove the SI. Experiment reports show that by employing both interference and isolation cancellation techniques at least 110dB of SI can be suppressed. However, the SI can be minimized by suppression techniques, and residual self-interference still poses a problem in reality. Residual SI management is a necessary requirement in the designs of all full-duplex relay networks.

2. MOTIVATION:

The tremendous benefits a wireless technology brings along, most networks, local or otherwise, are not only adopting it but also evolving with it. The wireless technology offers, among others, lower cost, easier installation and mobility - a flexibility that no fixed network can offer. Consequently, it is expected that the reliability of data is uncertain due to error nature of wireless channels caused by fading and multipath. The goal for reliable data transmission is that received information is as close as possible to the transmitted data themselves. Hence, various techniques have been developed to deal with and help to improve the reliability of data over wireless channels. Among them, an interleaved MIMO-OFDM is considered to be an efficient and fairly simple technique that easily improves the reliability of a wireless full-duplex network. The benefits of relays are exploitation of the co-operative diversity to conflict channel fading to boost the communication performance by improving diversity of signal by relay communication with delay diversity where each relay introduces a certain time-delay to a signal before forwarding. And residual self-Interference (RSI) cancellation is done by loopback interference.

3. EXISTING SYSTEM:

A detailed study of the effect of phase noise from the oscillators on cancellation is presented in when independent oscillators are used in up-conversion and down-conversion. Shared oscillator can reduce the phase noise effects and improve the cancellation performance by 25 db. In this case, the difference between the phase noise at transmit and receive chains depends on the delay that the self-interference signal experiences. A frequency-domain method to compensate such phase noise is proposed in and a time-domain phase noise estimation technique is developed. The limiting factor of these methods is that they consider the intended signal as additive noise, which reduces the estimation accuracy. In the following, once an initial estimate of the channel coefficients is obtained, we propose a ML estimate of the phase noise affecting both the self-interference and intended signals, which avoids the drawback of considering the intended signal as Additive noise.

4. LITERATURE REVIEW:

In a Two-way or Full-duplex relay transmission system self-interference (SI) is the major issue because two-way communication takes place in the same frequency band. SI is a phenomenon where receiver performance gets degraded by unrelated emissions at the same frequency to a desired signal. To mitigate this Self-interference many techniques are proposed but with those techniques, the BER performance, and system performance, degrades. So in this project, instead of mitigating self-interference, it is taken as a signal rather than noise, using amplify and forward relay.

Power allocation is the major concern for a wireless communication system. So optimum power allocation is executed individually between subcarriers or all subcarriers acquire equal power. Different sections of power can be allocated to source node subcarriers and relay node subcarriers respectively. So, different survey papers that use different algorithms has studied and obtained the knowledge about the operations done by the algorithms. The following research on papers gives key idea about the survey done.

A. Masmoudi and T. Le-Ngoc [5] have proposed A Maximum likelihood technique to mitigate the self-interference (SI). This approach jointly estimates the intended channels and self-interference (SI), which is exploiting by its own known transmitted symbols, both undetermined data symbols, and known pilot from the other intended transceiver. The Maximum Likelihood (ML) solution is obtained by maximizing the ML function under the assumption of Gaussian received symbols, where complete cancelation of SI takes place, which reduces the system performance.

Y. Li et al [6] has solved an optimal allocation of power problem by using two steps with four scenarios is considered for this two-way relay system. Energy efficiency optimization required to consider individual connection (link) fairness into account. A Max-Min Energy-Efficiency Optimal Problem (MEP) to ensure fairness among link sin terms of energy efficiency in OFDMA systems is investigated. In particular, maximize the energy efficiency subjected to the rate requirements; transmit power, and subcarrier assignment limitations of the plight (worst-case) link. Because of the non-smooth and mixed combinatorial features of the formulation, on low complexity sub-optimal Algorithms design by using the Lagrangian dual decomposition and generalized fractional programming theory is evaluated.

Yi Liu, Xiang-Genxia, and Hailin Zhang [7] have proposed a two-way relay with the amplify-and-forward (AF) protocol in full-duplex asynchronous cooperative network is considered. For the cases without and with cross-talks, respectively the two distributed space-time coding methods are proposed. In the first case, each relay receives the signal sent through the cross-talk link. The practical cross-talk cancellation in this network shows that the cross-talk interference cannot be removed properly. For this reason, space-time codes are designed by employing the cross-talk signals instead of removing them. In other case, the self-coding is noticed individually through the signals by the two relay nodes form a space-time code and the channel loop at each relay node. The possible cooperative diversity of both cases is analysed and to gain complete co-operative diversity some conditions are presented. Simulation results prove the theoretical analysis.

T. Himsoon, W. Su and K. J. R. Liu [8] have proposed a Differential AF relay to mitigate self-interference with DPSK modulation. By combining signals efficiently from both direct and relay links, a higher-level performance compared to direct transmissions with either coherent detection or differential detection is proposed. An exact BER formulation and its easy bounds for a case of optimum-combining cooperation system with Differential M-ary Phase-Shift Keying (DMPSK) signal. The major drawback is it is controlled by phase of the modulation so the exact BER performance is difficult to analyse.

5. METHODOLOGIES:

Several alternatives of cyclic delay diversity (CDD) and delay diversity (DD) techniques can be adapted to utilize the frequency diversity [9]–[10]. To minimize errors/drawbacks of previous techniques and optimize the data speed, delay diversity coded MIMO-OFDM, amplify and forward relay are proposed. In which multiple antennas are used at source (transmitter), relay and destination (receiver). In the context of full-duplex relay systems, by using

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OFDM and DD the spatial diversity offered by the source and relay transmits antenna which are located differently can be exploited. In the relay network, the required processing delay at amplify and forward (AF) relay node provides a natural accumulation of delay spread. This delay spread could be completely exploited to provide more ability to the relay system.

5.1. Interleaved OFDM:

Interleaved OFDM, it has a higher code rate than OFDM. OFDM enhances the code rate without increasing the number of subcarriers and without bandwidth expansion but with a moderate increase in computational complexity and delay.

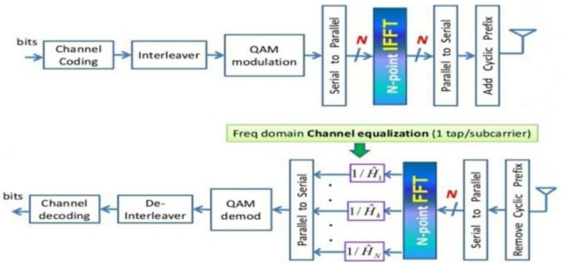

Figure.1: Block Diagram of Interleaved OFDM

Channel coding is a process of detecting and correcting bit errors in digital communication systems. Channel coding is performed both at the transmitter and receiver. At the transmit side, channel coding is referred to as encoder, where parity bits (extra bits) are added with the data before modulation. On the receive side, channel coding is mentioned to as a decoder. During transmission, channel coding enables the receiver to detect and correct errors if they occur due to fading, noise, and interference.

lnterleaver has been used in communication systems to combat burst errors introduced due to fading channel. lnterleavers are categorized based on their design methods, complexity, interleaving properties and their suitability for given application. Interleavers are divided into three main types, namely non- random, random and algebraic interleavers.

Quadrature Amplitude Modulation (QAM) is a process of combining two amplitude-modulated signals into a single channel, thereby doubling the effective bandwidth. QAM signal have two carriers, one signal is called the Q signal, and other is called I signal, each having the same frequency but differing in phase by 90 degrees.

A conversion process in which the stream of data elements received all at once is converted and sent as a stream of data at 1-bit at a time. To perform the QAM modulation (in the transmitter) and demodulation (in the receiver) of the channels, OFDM uses a much systematized algorithm of the FFT. By convention, they decided to use the FFT in the receiver and the IFFT in the transmitter. The complex conjugate of the product is used in the IFFT. To compute Discrete Fourier-Transform (DFT) of a sequence, or its inverse (IDFT), a fast Fourier transform (FFT) algorithm is implemented. Fourier analysis transforms a signal from its original domain (usually time or space) to the frequency domain and vice versa.

The concept behind the OFDM cyclic prefix (CP) is quite straight forward. The cyclic prefix performs two main functions.

1. CP provides a guard interval to eliminate inter-symbol interference from the previous symbol.
2. For modelling the linear convolution of a frequency-selective multipath channel as circular convolution, CP is repeated at the end of the symbol. This in turn may transform to the frequency domain via a discrete Fourier transform (DFT). This approach indulges simple frequency-domain processing, such as equalization and channel estimation. The cyclic prefix (CP) is created so each OFDM symbol is precedent by a copy of the end part of that same symbol.

5.2. Delay Diversity:

Cyclic-Delay Diversity (CDD) is similar to delay diversity. The only difference is that cyclic-delay diversity applies cyclic shifts, rather than linear delays and operates block-wise, to the different antennas. Thus, CDD is significant to block-based transmission schemes such as OFDM and DFT-Spread-OFDM. In OFDM, a cyclic shift of the time-domain signal resembles a frequency-dependent phase shift, Similar to delay diversity; this will create artificial frequency selectivity as seen by the receiver.

5.3. MIMO – OFDM:

The combination MIMO-OFDM is beneficial since OFDM enables support of more antennas and larger bandwidths since it simplifies equalization dramatically in MIMO systems. By adopting Multiple-Input Multiple-Output (MIMO) and Orthogonal Frequency-Division Multiplexing (OFDM) technologies, indoor wireless systems could reach data rates up to several hundreds of Mbits/s and achieve spectral efficiencies of several tens of bits/Hz/s, which are unattainable for conventional single-input single-output systems. The enhancements of data rate and spectral efficiency come from the fact that MIMO and OFDM schemes are indeed parallel transmission technologies in the space and frequency domains, respectively. MIMO-OFDM when generated OFDM signal is transmitted through a number of antennas in order to achieve diversity or to gain higher transmission rate then it is known as MIMO-OFDM.

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Efficient implementation of MIMO-OFDM system is based on the Fast Fourier Transform (FFT / IFFT) algorithm and MIMO encoding, such as Alamouti Space Time Block coding (STBC), the Vertical Bell-Labs layered Space Time Block code VBLASTSTBC, and Golden Space-Time Trellis Code (Golden STTC) [3]. OFDM has been adopted for various transmission systems such as Wireless Fidelity (WIFI), Worldwide Interoperability for Microwave Access (WIMAX), Digital Video Broadcasting (DVB) and Long-Term Evolution (LTE).

The OFDM system assigns subgroups of subcarriers to each user. With thousands of subcarriers, each user would get a small percentage of the carriers. In a modern system like the 4G LTE cellular system, each user could be assigned from one to many subcarriers. In LTE, subcarrier spacing is 15 kHz. Using a 10-MHz band, the total possible number of subcarriers would be 666. In practice, a smaller number like 512 would be used. If each subscriber is given six subcarriers, we can place 85 users in the band. The number of subcarriers assigned will depend on the user's bandwidth and speed needs. Combining OFDM with multiple input multiple output (MIMO) technique increases spectral efficiency to attain throughput of 1 Gbit/sec and beyond, and improves link reliability.

6. SYSTEM MODEL:

In this section, figure: 2 illustrates the system model where a two-hop relay accommodated communication with multiple antennas at the source node; destination node and relay node are considered. This system gives parallel communication at the relay node simultaneously. The streams of data symbols are transmitted by the source node via two ways (the direct source to-destination link, and the two-hop relay link). At the relay node, the signal from the source node is amplified and then forwards the signal to the destination node by using amplify and forward algorithm.

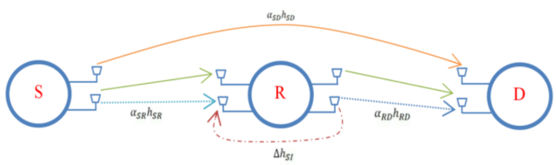

Figure.2: System Model

The transmitted signal at the relay node loops back the interference with the signal received. The determination of relay node is to redirect the signals from a source transmitter to destination receiver. Full-duplex relays exploits Simultaneous Transmit and Receive (STAR) such that source-relay and relay-destination links share one physical channel can be more sophisticated than simple on-channel repeaters.

Small-scale fading and path losses are considered in modelling the relay system. The path coefficients; α_{SD} (from source to destination node), α_{SR} (from source to relay node), α_{RD} (from relay to destination node) are positive constants. Because of small propagation distance, assume that the loop back interference has no path loss.

Relay system has three quasi-static frequencies flat communication channels; namely, the source-to-relay channel h_{SR}, the relay-to-destination channel h_{RD} and the direct source-to destination channel h_{SD}. In this paper, single tap channels, i.e., h_{SR}, h_{RD}, h_{SD} are assumed with zero mean and unit variance. At relay node, for all associated channels there is no channel-state information. But the mean power of residual self-loopback channel is estimated by the relay node. The mean power of residual self-interference is looped back as a reference (i.e., loopback information is fed to source node) to add CP with proper length.

In the i-th time slot the signal x(i) is transmitted by source node with average symbol energy $E\{|x(i)|^2\} = 1$ and average transmit power is,

$$P_s = \gamma P. \tag{1}$$

Where $\gamma\epsilon(0,1)$ is the power allocation factor, P is the total power consumption of relay system.

The relay receives $r(i)$ signal while transmits signal $t(i)$ concurrently with an amplification factor β. The signal at the relay node consists of transmitted signal by source node, the loopback interference and the received noise. Therefore, the signal at the relay is represented by,

$$r(i) = \sqrt{P_s}\alpha_{SR}h_{SR}x(i) + \Delta h_{SI}t(i) + n(i) \tag{2}$$

Where n(i) is Additive White Gaussian Noise (AWGN) at the relay node receive antenna, that has zero mean and average variance $E\{|n(i)|^2\} = \sigma_R^2$. The relay can amplify the signal and forward that signal with a power of

$$P_r = (1-\gamma)P \tag{3}$$

To normalize the received signal power by multiplying an amplification factor to re-transmit the received signal the amplification factor is given by,

$$\beta = \frac{\sqrt{P_r}}{\sqrt{P_s\alpha_{SR}^2 + P\sigma_{SI}^2 + \sigma_R^2}}$$

$$\beta = \frac{\sqrt{(1-\gamma)P}}{\sqrt{\gamma P\alpha_{SR}^2 + P\sigma_{SI}^2 + \sigma_R^2}} \tag{4}$$

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In above equation, the denominator of β is used for normalizing the signal in equation (2).

The transmitted signal is a delayed version of $\tau \geq 1$ symbols due to relay processing delay at relay node. The signal transmitted by the relay node is given by,

$$t(i) = \begin{cases} 0 & \text{for } 0 \leq i \leq \tau \\ \beta r(i-\tau) & \text{for } i \geq \tau \end{cases} \tag{5}$$

For without loss of the interference Cancellation in full-duplex relay network takes a processing delay of one symbol period the transmitted signal at the relay can be exhibited by the summation of infinite echo terms of the signal at the relay node.

$$t(i) = \beta \sum_{j=1}^{\infty} (\Delta h_{SI}\beta)^{j-1} * (\sqrt{P_s}\alpha_{SR}h_{SR}x(i-j) + n(i-j)) \tag{6}$$

The above equation can be expressed as,

$$t(i) = \beta \sum_{j=1}^{J} (\Delta h_{SI}\beta)^{j-1} \sqrt{P_s}\alpha_{SR}h_{SR}x(i-j) + \bar{n}(i) \tag{7}$$

Where $\bar{n}(i)$ is given by,

$$\bar{n}(i) = \beta \sum_{j=J+1}^{\infty} (\Delta h_{SI}\beta)^{j-1} \sqrt{P_s}\alpha_{SR}h_{SR}x(i-j) + \beta \sum_{j=1}^{\infty} (\Delta h_{SI}\beta)^{j-1}\, n(i-j) \tag{8}$$

The signal received by the destination can be represented as,

$$y(i) = \sqrt{P_s}\alpha_{SD}h_{SD}x(i) + \alpha_{RD}h_{RD}t(i) + n(i) \tag{9}$$

Where η(i) denote the AWGN (zero mean and average variance $E\{|n(i)|^2\} = \sigma_D^2$.)

By substituting (7) in above received signal expression (9), the signal received can be rewritten as,

$$y(i) = \sqrt{P_s}\alpha_{SD}h_{SD}x(i) + \sqrt{P_s}\alpha_{SR}h_{SR}\alpha_{RD}h_{RD} \sum_{j=1}^{J} (\Delta h_{SI})^{j-1}\beta^{j} x(i-j) + \bar{n}(i) \tag{10}$$

Where η(i) is the identical noise and is given by $\eta(i) = \alpha_{RD}\, h_{RD}\, n(i) + \eta(i)$.

6.1. Source Node Implementation:

A circulate of un-coded statistics bits are fed to Binary Convolutional Code (BCC) encoder and output of the encoder is a flow of coded bits are then separated into K segments c(k)m of bN bits, k = 1,2…..K. Each segment is interleaved by a block interleaver.

$$h = [\sqrt{P_s}\alpha_{SD}h_{SD}, \alpha_{RD}h_{RD}h_{RSI}(0), \alpha_{RD}h_{RD}h_{RSI}(1), \ldots, \alpha_{RD}h_{RD}h_{RSI}(J-1)]^T \tag{11}$$

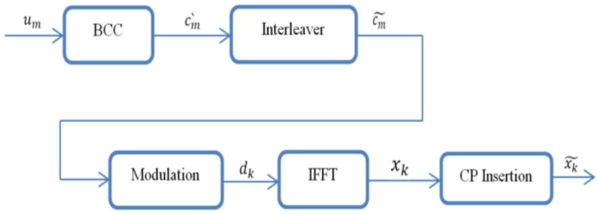

Figure.3: Signal processing at Source node

To form a single bit stream c_m, all these K bit interleaved sequence are concatenated. Then these c_m bits are merged into b-bit segments. By using gray labelling these b-bit segments are mapped onto 2^b-ary modulation symbols. The modified data codes are separated into blocks with length N. The data d_k for the K-th block is given by,

$$d_k = [d_k(0), d_k(1), \ldots\ldots, d_k(N-1)]^T \tag{12}$$

Where $d_k(n)$ is the n-th image in the k-th block. Frequency statistics block dk is changed into time area information block x_k by implementing N-point IDFT, which is represented by,

$$x_k = F_N d_k$$

$$x_k = [x_k(0), x_k(1), \ldots\ldots, x_k(N-1)]^T \tag{13}$$

For the Delay Diversity, the transfer hub needs to transmit the cyclic delayed form of the squares transmitted at the source hub. Be that as it may, the transfer generally is a repeater and just rehashes the sign it gets from the source hub. To understand the transmission of cyclic delayed information square requires the determination of both a legitimate CP length at the source hub and a period delay at the hand-off hub.

Presently at articulation (10), where the signal y(i) at the destination hub is the straight convolution of the transmitted sign x(i) at the source and the virtual multipath channel h with delay spread of J images. Obviously a CP with least length of J images is required at the source hub, If the direct convolution of the transmit signal x(i) and the multipath channel h is changed over into a round convolution of the transmit information square x_k and the multipath channel h. Accordingly, the CP length L_{CP} in the full-duplex AF hand-off framework is required to be more noteworthy than or equivalent to the quantity of loopback multipath, which is given by,

$$L_{CP} \geq J \tag{14}$$

In CP the k-th block $\widetilde{x_k} \in C^{(N+L_{CP})*1}$ is articulated by prepending L_{CP} CP codes to each of the data block x_k, which is specified by,

$$\widetilde{x_k} = [x_k(N - L_{CP}), \ldots\ldots, x_k(N - 1), x_k(0), x_k(1), \ldots\ldots, x_k(N-1)]^T$$

$$\widetilde{x_k} \triangleq [\widetilde{x_k}(0), \widetilde{x_k}(1), \ldots\ldots, \widetilde{x_k}(N + L_{CP} - 1)]^T \qquad (15)$$

Where the information symbols and CP are re-denoted by $\widetilde{x_k}(i)$ indexed from 0 to N +L_{CP} -1. $\tilde{x}$ Is communicated consecutively via the transmit projection at the source node.

6.2. Relay Node Implementation:

During the transmission of the k-th CP prepended hinder at source hub, the hand-off stores each got image aside from the last one and re-transmits at its transmit reception apparatus in the up and coming time allotment with an intensification factor. The transfer doesn't advance the last received image in light of the fact that the up and coming schedule opening is apportioned to transmit the image for next transmission square. The unmistakable consideration has been paid to the transmission of the underlying image and the gathering of the last image in each square.

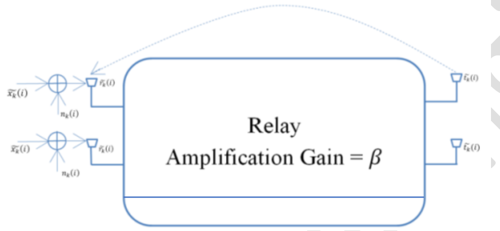

Figure.4: Signal Processing at Relay Node

In the first time allotment of each square, in light of the fact that the transfer is required to delay its transmission to expand the quantity of multipath in the identical coursed channel lattice at the goal and the channel h_{SD} has just one tap, to set the principal image transmitted in each square to be zero, which is likewise the handling delay of τ = 1. In this way, the transmitted images during the k-th square can be,

$$\widetilde{t_k} = \begin{cases} 0 & \text{for } i = 0 \\ \beta\widetilde{r_k}(i-1) & \text{for } i = 1, 2, \ldots\ldots, N + L_{CP} - 1 \end{cases} \qquad (16)$$

Where r_k, is the gotten signal at i-th time-allotment (0 < i < N + L_{CP} – 2). The vital delay at the hand-off hub really gives the delay decent variety CP addition, evacuation and furthermore transferring convention at the first and last schedule openings, delay assorted variety is at last changed into the multipath assorted variety at the destination. Since the sign got at the hand-off is the blend of the sign transmitted from the source hub, the loopback impedance from the transmitter of the transfer and the added substance noise, $\widetilde{r_k}(i)$ can be given by,

$$\widetilde{r_k}(i) = \begin{cases} \alpha_{SR} h_{SR} \widetilde{x_k}(i) & \text{for } i = 0 \\ \alpha_{SR} h_{SR} \widetilde{x_k}(i) + \sum_{j=\max(1,i-J+1)}^{i} h_{RSI}(i-j)\widetilde{x_k}(j-1) + \widetilde{n_k}(i) & \text{for } i - 1, 2, \ldots, N + L_{CP} - 1 \end{cases} \qquad (17)$$

In above equation by defining $n_k(i)$, i = 0, 1,…..,N +L_{CP} -1, to be complex Gaussian with variance σ_R^2 and zero mean, $\widetilde{n_k}(i)$ represents the overall additive noise,

$$\widetilde{n_k}(i) = \begin{cases} \sum_{j=0}^{i} (\Delta h_{SI}\beta)^{i-j} n_k(j) & \text{for } i = 0, 1, 2\ldots J \\ \sum_{j=0}^{i} (\Delta h_{SI}\beta)^{i-j} n_k(j) + \sum_{j=0}^{i-J-1} (\Delta h_{SI}\beta)^{i-j} \alpha_{SR} h_{SR} x_k(j) & \text{for } i = J+1, \ldots, N+L_{CP}-1 \end{cases} \qquad (18)$$

Since the data image $x_k(N-1)$ has just been contained in the CP divide and has been sent by the hand-off hub, which gets the last image in the k-th transmission square yet doesn't transmit, which won't annihilate the flowed structure in the time space proportional channel-framework after the CP expulsion later. In the wake of sending the sign in the last image span, the transfer hub clears the whole put away sign. The hand-off handling is summed up in the accompanying Algorithm 1.

Algorithm 1: AF Relay Processing

OFDM symbol k=0, 1, 2 …
if i=0 then
$\widetilde{t_k}(0) = 0$
$\widetilde{r_k}(0) = \alpha_{SR} h_{SR} \widetilde{x_k}(0) + n_k(0)$
end if
for i=1, 2… N+L_{CP}-1 do
$\widetilde{t_k}(i) = \beta\widetilde{r_k}(i-1)$
$\widetilde{r_k}(0) = \alpha_{SR} h_{SR} \widetilde{x_k}(i)$
$+\sum_{j=\max(1,i-J+1)}^{i} h_{RSI}(i-j)\widetilde{x_k}(j-1)$
$+\widetilde{n_k}(i)$
if i=N+L_{CP}-1 then
Clear the stored signal
end if
end for

6.3. Destination Node Implementation:

The general behaviour of relay transmission, where acknowledged signal model applies here without loss of generality, consider the first lump where the acknowledged signal at time slot i, i =N + L_{CP} - 1, is given by,

$$\widetilde{y_k}(i) = \sqrt{P_s}\alpha_{SD} h_{SD} \widetilde{x_k}(i) + \sqrt{P_s}\alpha_{SR} h_{SR} \alpha_{RD} h_{RD} \sum_{j=1}^{J} (\Delta h_{SI})^{j-1} \beta^j \widetilde{x_k}(i-j) + \widetilde{n_k}(i) \qquad (19)$$

The k-th received block y_k includes N +L_{CP} symbols,

$$\widetilde{y_k} = [\widetilde{y_k}(0), \widetilde{y_k}(1), \ldots\ldots, \widetilde{y_k}(N + L_{CP} - 1)]^T \quad (20)$$

The first L_{CP} symbols of y_k are the CP images and they are expelled at the goal hub as indicated by (19). After the CP evacuation, the data images stayed from the immediate way, i.e., the first term from (19) are $\tilde{x}(L_{CP})$, $\tilde{x}(L_{CP}+1)$, …, $\tilde{x}(N + L_{CP} - 1)$, i.e., x(0), x(1), …, x(N-1) the data codes continued from the second term from (19), corresponding to the link $\sqrt{P_s}\alpha_{SR}h_{SR}\alpha_{RD}h_{RD}\beta$ are $\tilde{x}(L_{CP} - 1)$, $\tilde{x}(L_{CP})$, …, $\tilde{x}(N + L_{CP} - 2)$, i.e., x(N - 1), x(0), …, x(N - 2) and so forth, the information codes continued from the (J+1)th term from (19), corresponding to the path $\sqrt{P_s}\alpha_{SR}h_{SR}\alpha_{RD}h_{RD}(\Delta h_{SI})^{j-1}\beta^j$ are $\tilde{x}(L_{CP-J})$, $\tilde{x}(L_{CP-J}+1)$, …, $\tilde{x}(N + L_{CP-J}-1)$, i.e., x(N -J), x(N-J +1), …, x(N -J -1). One can see from the above investigation, all the first information codes x(0), x(1), …, x(N - 1) are remembered for each way in the got signal (19).

Subsequently the CP exclusion by $y_k \epsilon$ C^{Nx1} the received signal is,

$$y_k = \widetilde{H_k} x_k + \widetilde{\eta_k} \quad (21)$$

Where $\widetilde{H_k} \in C^{NXN}$ is a circulant framework and its first segment is the virtual multipath divert h in (12) padded by N-J-1 zeros, i.e., $[h^T, 0\ldots 0]^T$ and $\widetilde{\eta_k}$= $[\widetilde{\eta_k}(L_{CP})\ldots \widetilde{\eta_k}(N + L_{CP} - 1)]^T$ is the added substance Noise. Changing the got sign to the recurrence space by actualizing the N-point DFT on y_k,

$$z_k = F_N^H y_k$$

$$z_k = H_k d_k + v_k \quad (22)$$

Where

$$H_k = F_N^H \widetilde{H_k} F_N$$

$$\mathrm{H_k = diag(H_k(0), H_k(1), \ldots, H_k(N-1)} \quad (23)$$

After de-planning, the interleaved coded bit succession $\widetilde{c_m}$ is gained. At that point we get the coded bit grouping $\widehat{c_m}$ by passing $\widetilde{c_m}$ through the de-interleaver π^{-1}. The gauge of the un-coded bit succession $\widehat{u_m}$ is gotten by disentangling the coded grouping $\widehat{c_m}$. Following the structure rules of BICM [23], the full decent variety request of two can be accomplished on the blunder execution of $\widehat{u_m}$.

6.4. Power Allocation:

For the comparative transfer arrange, in the event that it is half-duplex, choosing the force distribution factor γ =0.5 so P_s =γ P = P/2, P_r = (1− γ) P = P/2 s normal. For the full-duplex system, self-obstruction is the extra way. The uniform force designation may not yield great execution. Another methodology is to adjust the transmit power P_s and the transfer power P_r under an absolute aggregate force imperative which is centring to balance the normal direct channel fluctuation and the normal remaining self-impedance channel change. Since $E\{|h_{SD}|^2\}=E\{|h_{SR}|^2\}=E\{|h_{RD}|^2\}=1$, λ_{SD} is the general normal direct channel change and the general normal most grounded hand-off channel fluctuation $\lambda_{Relay,1}$ spoken to as,

$$\lambda_{SD} = \gamma P \alpha_{SD}^2 \quad (24)$$

$$\lambda_{Relay,1} = \gamma P \beta^2 \alpha_{SR}^2 \alpha_{RD}^2$$

$$\lambda_{Relay,1} = \frac{\gamma(1-\gamma)P^2\alpha_{SR}^2\alpha_{RD}^2}{\gamma P\alpha_{SR}^2+\sigma_{SI}^2+\sigma_R^2} \quad (25)$$

Let $$\lambda_{SD} = \lambda_{Relay,1} \quad (26)$$

The power distribution aspect γ is denoted by

$$\gamma^* = \frac{P\alpha_{SR}^2\alpha_{RD}^2 - \alpha_{SD}^2(\sigma_{SI}^2+\sigma_R^2)}{P\alpha_{SR}^2(\sigma_{SD}^2+\sigma_{RD}^2)} \quad (27)$$

The proposed power-assignment strategy adjusts the force quality of the immediate connection channel with the most grounded hand-off channel and in this manner this force distribution technique can give close to ideal execution.

6.5. Algorithm for full-duplex MIMO-OFDM relaying:

The study of full-duplex MIMO-OFDM relaying in the following aspects:

1. A thought of using leftover SI as a helpful sign as opposed to Noise. The remaining Self-Interference (SI), the immediate connection, and transfer interface coefficients are by and large demonstrated as a virtual multi-way channel at destination, which is an original thought for the full-duplex MIMO-OFDM hand-off framework and encourages completely using the leftover SI as a helpful sign part.
2. The important CP length at the source hub is given. In the event that progressively remaining SI is displayed as the virtual multi-ways at the goal, an increasingly broadened CP is required.
3. A Block-based AF transfer convention to understand the Delay Diversity MIMO-OFDM at the goal hub. With the assistance of this convention, the full-duplex hand-off connection can go about as an assorted variety branch to give improved vigor to full duplex transfer framework.
4. A piece interleaved coded MIMO-OFDM is utilized to gather the delay-decent variety request of two in the AF hand-off framework.
5. The force distribution issue for a full-duplex hand-off correspondence framework with an absolute whole force imperative on the source and transfer transmission powers. Reproduction results show that

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the proposed power distribution performs better than equivalent force designation.

7. SIMULATION RESULTS:

The error probability performances of the proposed Delay Diversity MIMO-OFDM scheme in full-duplex relay system are analysed by MATLAB Simulation. OFDM symbols with 1024 subcarriers. The length of Cyclic Prefix is L_{CP}= 16 if no other Cyclic Prefix lengths declared. The convolution code rate-1/2 with Viterbi decoding is used with 8000 information bits, (133, 171) generating matrix in octal format, and constraint-length 7. Convolutional code has a free distance d_{free} = 10.

Parameters	Specifications
No. of subcarriers	1024
Pilot frequency	4
Cyclic prefix length	16
Channel length	4
Channel Model	AWGN
No. of Transmitters	2
No. of Receivers	2
Modulation Technique	QPSK, 16-QAM, 64-QAM

Table.1 System Parameters

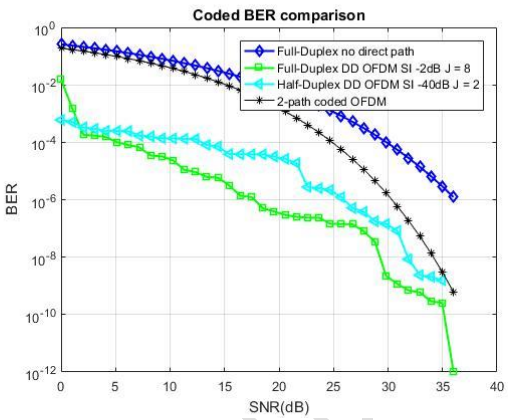

Figure.5: Coded-BER comparison of full-duplex MIMO-OFDM without the source to-destination link, full-duplex DD MIMO-OFDM, 2-path coded OFDM, and half-duplex OFDM.

The Viterbi algorithm with trace length 64, Interleaver with 32×64 block interleaver coded bits to avoid delay requirement and to initialize Viterbi decoding at the receiver side interleaving is evaluated within a single OFDM symbol. The path losses are assumed as $\alpha_{SD}^2 = 0.2, \alpha_{SR}^2 = 0.8, \alpha_{RD}^2 = 1$. The path loss coefficients such that $\alpha_{SD}^2 < \alpha_{SR}^2 < \alpha_{RD}^2$, since this relation generally applies to the realistic urban radio propagation scenario. Other possible path loss coefficients will also provide very similar simulation results if this relation $\alpha_{SD}^2 < \alpha_{SR}^2 < \alpha_{RD}^2$ is satisfied.

The power allocation factor γ can be calculated. With the above given pass loss coefficients, γ = 0.83 is used for proposed power allocation scheme. The signal-to- noise ratio (SNR) at relay and destination node are denoted by SNR_R and SNR_D respectively. A coded bit error rate (BER) comparison of four cases: The first two proposed full-duplex DD MIMO-OFDM scheme with $\sigma^2_{SI}/\sigma^2_{RD}$=−40 dB and J =2, and with $\sigma^2_{SI}/\sigma^2_{RD}$ =−2 dB and J = 8, respectively. The third case is full-duplex MIMO-OFDM without the source to destination link, and the next one is the direct source to destination coded MIMO-OFDM transmission through a two-path channel with [0.8, 0.2] power delay profile, which is known as “2-path coded OFDM”. The last curve is the half-duplex counterpart.

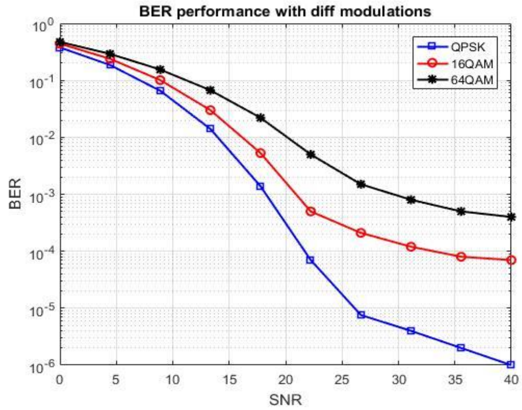

Figure.6: Coded BER versus SNR_D with SNR_R =25 dB.

The coded BER performance of proposed DD MIMO-OFDM scheme is demonstrated in Fig: 5.3. $\sigma^2_{SI}/\sigma^2_{RD}$ =−40 dB. The SNR_R is fixed at 25 dB. The modulations techniques are QPSK, 16-QAM and 64-QAM. The Outage Probability vs. SNR for Proposed system is illustrated in figure: 6 wherein as increase in SNR reduces the Outage Probability, which indicates exponential reduction in power.

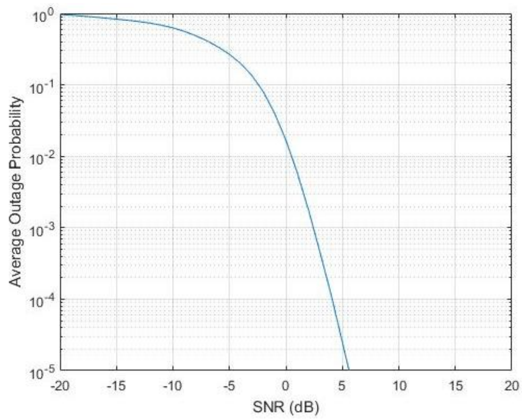

Figure.7: Outage probability of Full-duplex DD MIMO-OFDM

The power allocation method is employed in this simulation. Error floors appear in the high SNR range due to the fixed SNR, (i.e., SNR_R, at the relay) on all three curves.

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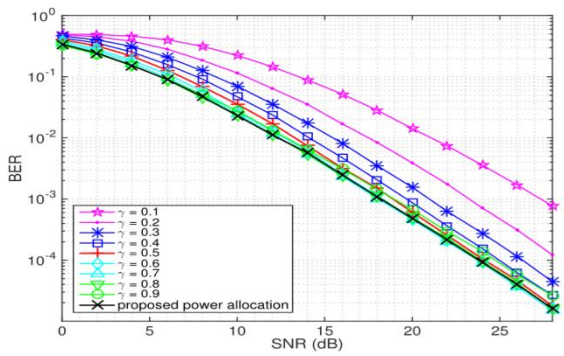

Figure.8: BER comparison of different power allocations with factor γ (from 0.1 to 0.9) including the proposed power allocation method.

The above figure: 8 give the BER comparison for different power allocations for factor γ with proposed power allocation method. With step size 0.1 the allocation factor γ is expelled from 0.1 to 0.9. The BER curves for γ = 0.7 and γ = 0.8 gives the best performance. The proposed allocation method has the near optimal performance and the curve represents a very close to the curves with best BER performance.

7. CONCLUSION:

In this paper, one DD MIMO-OFDM scheme in full-duplex relay communication systems with one source node, one relay node, and one destination node are considered. The full-duplex relay system can be equivalently transformed into a two-antenna DD system by adding CP with an appropriate CP length. To improve the qualitative behaviour of the system, In-band full duplex mode is implemented, that allows for parallel transmission and reception at relay node.

Thus a block based delay diversity MIMO-OFDM transmission scheme can exploit the frequency diversity. The error probability performance is analysed by comparing Coded BER of full duplex MIMO-OFDM without the source to destination link, full-duplex DD MIMO-OFDM, and half-duplex OFDM. Therefore, the simulation result verifies that full-duplex delay diversity with no direct link between source (transmitter) and destination (receiver) shows the better BER performance.

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