An Extensive Literature Review on MIMO OFDM System

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Abstract-In this review paper we presented the study of orthogonal frequency-division multiplexing and multiple-input multiple-output (MIMO) area units the key experience for today's world. A multiple input multiple output experience will considerably increase data rate and spectrum potency while not occupying any further information measure. To the algorithms of detection area unit studied at that: Zero-Forcing (ZF) technique, most probability (ML) technique, QR decomposition with M-algorithm most probability technique (QRM-MLD), Minimum Mean sq. Error (MMSE) technique and (SD) Sphere decryption technique. The study shows that the most effective doable signal technique is higher to alternative signal strategies on bit-error-rate (BER) presentation. The BER presentation in an exceedingly related to MIMO-OFDM state of affairs of the strategies are studied. The capability of the ST coded OFDM system are often redoubled by increasing the quantity of ST coded OFDM terminals at the transmitter. Study justify that the ST coded multiple transmit and multiple receive antenna OFDM system as ST coded MIMO-OFDM system.

Keywords:- Channel Estimation, MIMO-OFDM, multipath propagation; MMSE.

I. INTRODUCTION

The performance of such systems was intensively studied in the last years. For example in [6] a simulation model of OFDM-MIMO system based on Space-Time Block Coding (STBC4) is built and analyzed with BER performance of the system for different number of transceiver antennas under different channels considering different modulation modes. In [3] the authors compare Alamouti Space Time Coding with MR Combining by calculating the BER for different SNR using MATLAB. The study of MIMO-OFDM wireless communication system shows better performance when Alamouti STC technique has been used for transmit diversity. In [1] a MIMO-OFDM system performance is simulated by using MATLAB and the study show that better performance can be achieved with more antennas. In [7] the performance of MIMOOFDM system employing QAM is analyzed. The author concluded that this is a good technique to be used for next generation wireless systems. In [2] MIMO system with different equalization schemes Zero Forcing (ZF) equalizer and MMSE which aid in the elimination of Inter Symbol Interference (ISI) thus improving overall performance were compared to analyze the BER of the designed system. The MMSE equalizer clearly had a better performance over the ZF equalizer in the region of about 3 dB. This helps in nullifying the effects of ISI thus improving overall performance. In [5] the performance of MIMO OFDM are evaluated on the basis of BER and Mean Square Error (MSE) level.

MIMO SYSTEM

Generally, multipath propagation would cause channel fading, which is regarded as a harmful factor to wireless communication [3]. Though, research shows that in a MIMO system, multipath transmission can be favorable to the wireless communication. Multiple antennas (or array antennas) and multiple channels are used in the transmitter and receiver of MIMO system [3]. In the transmitter, the serial data symbol stream after the necessary space-time processing is sent to the transmit antennas, and then transmitted to the receiver. In the receiver, the received data symbols are recovered through a variety of space-time detection technologies. In order to guarantee effective separation of the various sub-data symbol streams, the antennas must be separated with a sufficient distance (usually more than half a carrier wavelength) in order to prevent too much correlation between the received signals at the different antennas [3]. Fig.1. shows a MIMO system.

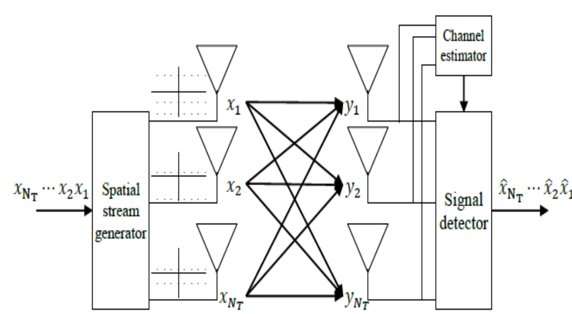

Fig. 1: MIMO system

As shown in Fig.2, signals are transmitted by antennas, and after propagating over the wireless channel such as the urban channel, they are received at the receive antennas. Each receiving antenna receives a superposition sum of the signals from the transmitting antennas.

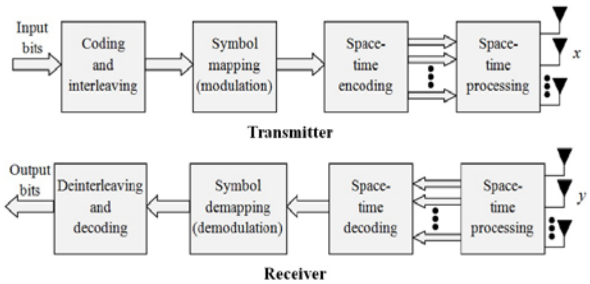

Fig.2: MIMO Transmit and Receive System Block Diagram.

Multiple-Input Multiple-Output

During the past decades, MIMO technology [9] has attracted attention in wireless communications, since it offers both of spatial diversity and multiplexing gain without requiring additional bandwidth or transmits power [3].

Properties of MIMO transmissions

Spatial diversity can be negotiated in two different ways according to the number of transmitted data streams.

$$d = \lim_{SNR \to +\infty} \frac{log[P_b(SNR)]}{\log(SNR)}$$

Even if the BER is a largely used criterion, this indicator has a major drawback: it depends on the modulation scheme that is used to transmit the data. To avoid this dependence, another criterion is often used in this context: the outage probability. The outage probability *pout* stands for the probability that the mutual information (*I*D) of the transmission is less than a given spectral efficiency (*R*),

$$P_{out} = P_r[ID < R]$$

Limitations of MIMO transmissions

MIMO transmissions induce an additional cost due to the installation of multiple antennas on the terminals. Moreover, an additional processing time is required to process several emitted and/or received signals.

$$\gamma = \frac{c}{f_c}$$

OFDM

OFDM is a multi-carrier modulation. In OFDM, the channel is divided into a number of orthogonal sub-channels and the high speed data signal is converted into parallel low speed sub-streams [3]. Those sub-streams are modulated on each sub-channel to be transmitted. Fig. 3 shows the basic processing in an OFDM system.

OFDM is effective against frequency selective fading and Inter Symbol Interference (ISI) [3].

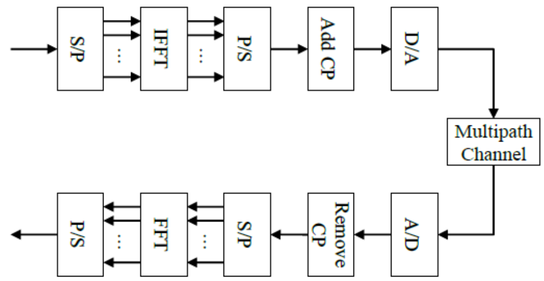

Fig.3: OFDM system

Since orthogonal sub-carriers are using as sub-channels, the spectral efficiency has been greatly improved. Wireless data services are asymmetric, such that the transmission capacity requirement of downlink is greater than of uplink. While using OFDM, the number of sub-channels can be adjusted flexibly to meet the different rate of downlink and uplink transmission [3]. OFDM can be jointly used with other access methods that improve the reliability of signal transmission in physical layer [6].

Generally, in OFDM, a certain length of the guard interval (GI) should be added and it overcomes the ISI when the duration of GI is greater than the maximum multipath delay spread of the radio channel. Typically the GI is filled with a cyclic prefix (CP) [3].

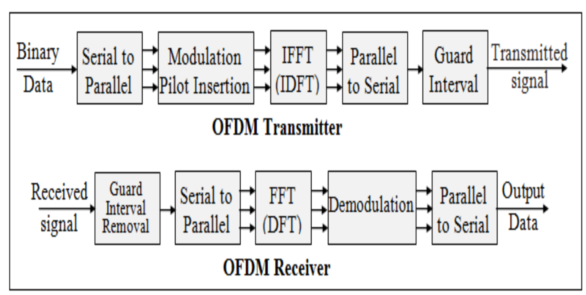

Fig. 4: OFDM Transmit and Receive System Block Diagram.

II. SYSTEM MODULE

It shows a block diagram of the MIMO-OFDM construction. From the time when a MIMO indication approach, *NT* dissimilar indication be transmitted concurrently above *NT* × *NR* transmission paths and each of those *NR* received signals is a combination of all the *NT* transmitted signals and the deform noise. on behalf of now deliberate on against to the single-input single-output (SISO) synchronization that compose complicated the system design concerning to channel estimation and symbol detection due to the hugely increased number of be in command of channel. Therefore chain flow from apiece antenna endure OFDM Modulation. The Alamouti STBC scheme has full transmitted diversity gain and low complexity decoder with the encoding matrix represented. [5]

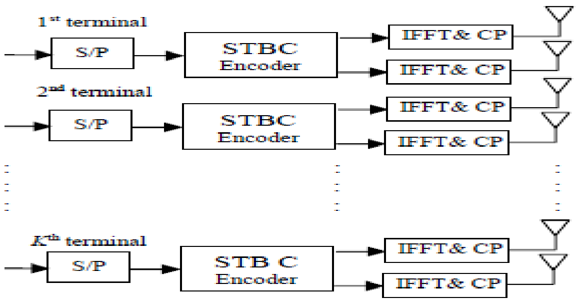

Fig. 5: Space-time block coded MIMO-OFDM transmitter

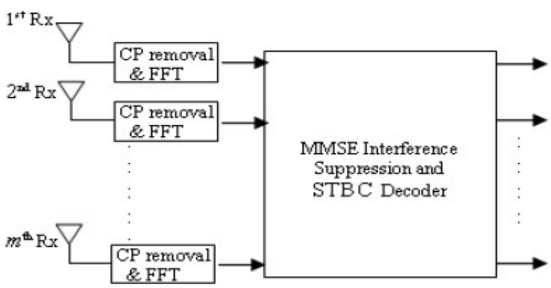

Fig.6. Space-time block coded MIMO-OFDM receiver

Linear Signal Detection

Linear signal location just treats craved stream from target transmit reception apparatus as signs and all other transmitted signs would be regard as impedances [6]. Impedance signals from other transmit radio wires are minimized or invalidated when the craved sign was identified [6]. The impact of the channel is altered by a weight framework such that [6]

$$\tilde{x} = \left[\widetilde{x_1}\widetilde{x_2} \ldots \widetilde{x_{N_T}}\right]^T$$
$$= Wy$$

That is the symbol detected is given by a linear combination of the received signals [6]. The standard linear detection algorithms include ZF detection and MMSE detection.

ZF Detection

Zero-Forcing detection is low complexity linear detection algorithm that gives the estimate of as [6]: x

$$\tilde{x}_{ZF} = W_{ZF}y = x + (H^H H)^{-1}H^H z = x + \tilde{z}_{ZF}$$

The detector thus forces the interference to zero. The matrix nullifying the interference is [6]

$$W_{ZF} = (H^H H)^{-1}H^H$$

Thus the processed noise is $\tilde{z}_{ZF} = W_{ZF}y = x + (H^H H)^{-1}H^H z$ [6].

Here means the Hermitian transpose operation. ZF recognition calculation is a direct discovery calculation since it acts as a straight channel isolating diverse information streams to perform deciphering freely on every stream, hence wiping out the multi-stream obstruction [6]. The disadvantage of ZF discovery is hindered BER execution because of clamor improvement [6]. The added substance white Gaussian clamor (AWGN) loses its whiteness property it is improved and corresponded over the information streams [8]. As the SNR builds, ZF arrangement turns out to be more prone to concur with the ML arrangement vector [8].

MMSE Detection

MMSE finder gauges the transmitted vector **x** by applying the direct change to the got vector **y**. It figures out the appraisal **x** $MMSE$ of the transmitted image vector **x** as [6]:

$$\begin{aligned}\tilde{x}_{MMSE} &= W_{MMSE}\, y = (H^H H + \sigma_z^2 I)^{-1}H^H y \\ &= \tilde{x} + (H^H H + \sigma_z^2 I)^{-1}H^H z \\ &= \tilde{x} + \tilde{z}_{MMSE}\end{aligned}$$

MMSE weight matrix $\mathbf{W}_{MMSE}$ is to expand the post-detection signal-to-interference plus noise ratio (SINR) [6]. And MMSE collector requires the factual data of noise $\boldsymbol{\sigma_z^2}$. MMSE detectors balances the noise enhancement and multi-stream interference by minimizing the total error [6]. Its BER performance is superior to ZF detection due to mitigating the noise enhancement.

ML Detection

ML identification ascertains the Euclidean separation between the got signal vector and the analysis of all conceivable transmitted sign vectors with the given channel **H**, and finds the one with the minimum distance [6]. and finds the one with the base separation [6]. Let C and NT signify an arrangement of sign star grouping image focuses and various transmit reception apparatuses, individually. At that point, ML recognition decides the assessment of the transmitted sign vector as [6]

$$\hat{x}_{ML} = arg \min_{x \in c^{N_T}} \|y - Hx\|^2$$

When compares to the ML metric. The ML strategy accomplishes the ideal execution as the greatest a posteriori (MAP) location when all the transmitted vectors are just as likely [14]. On the other hand, its many-sided quality increments exponentially as balance request and/or the quantity of transmit radio wires increments [14]. The obliged number ofML metric calculation is $|C|^{N_T}$, that is, the multifaceted nature of metric figuring exponentially increments with the quantity of with the number of antennas even if this particular method suffers from computational complexity.

III. LITERATURE REVIEW

In the year of 2014 Sahrab, A.A.; Marghescu, I.,[1] Investigated the Multiple-Input Multiple-Output (MIMO) systems offer considerable increase in data throughput and link range without additional bandwidth or transmit power by using several antennas at transmitter and receiver to improve wireless communication system performance. At the same time, Orthogonal Frequency Division Multiplexing (OFDM) has becoming a very popular multi-carrier modulation technique for transmission of signals over wireless channels. OFDM eliminate Inter-Symbol-Interference (ISI) and allows the bandwidth of subcarriers to overlap without Inter Carrier Interference (ICI). A MIMO-OFDM modulation technique can achieve reliable high data rate transmission over broadband wireless channels. This research deals with the analysis of a MIMO-OFDM system by using a MATLAB program. The performance of the system is evaluated on the basis of Bit Error Rate (BER) and Minimum Mean Square Error (MMSE) level.

In the year of 2014 Lei Wang; Zhongping Zhang,[2] presented the study of Linear precoding techniques are widely used in emerging MIMO-OFDM standards such as 3GPP LTE and WiMAX. These involve mapping a variable number of streams of transmit data symbols to the transmit antennas using precoding matrices selected from a pre-defined set on the basis of channel state information (CSI) fed back from the receiver. Previous work on these schemes and on selection of precoding matrices has assumed that linear detectors are used, but these cannot exploit the full receive-end diversity when multiple streams are transmitted. This research presents an adaptive precoding scheme using maximum likelihood (ML) detection with a precoder selection scheme based on minimum BER. It shows that full diversity can be achieved, and that a significant gain is available over adaptive linear precoding using linear detection, over antenna selection, and over spatial multiplexing.

In the year of 2011 Riera-Palou, F.; Femenias, G.,[3] proposed a novel receiver structure based on soft information for linearly preceded MIMO-OFDM systems. The architecture combines an MMSE-based front end with an iterative technique based on maximum likelihood detection (MLD) in a structure that exhibits two very attractive features. Firstly, it can fully exploit the diversity benefits of spreading the information symbols in the space and frequency domains by optimally estimating them. Secondly, and under the realistic assumption of the presence of a cyclic redundancy check (CRC) mechanism, the far more computationally demanding MLD component needs only be used when the MMSE front end has failed. Simulation results reveal that the MLD iterative mechanism adds only a negligible amount of computations to the simple MMSE detector while significantly improving its performance.

In the year of 2011 Yavanoglu, A.; Ertug, O.,[4] The study of wireless communication systems in indoor environments require high data rates and high transmission qualities especially for multimedia applications in WLAN (Wireless Local Area Network) systems. The support of high data rate MIMO spatial-multiplexing communication in OFDM-WLAN systems conforming to IEEE802.11n standard requires the use of compact antennas with low correlation ports. In this research, higher-order space-multimode diversity stacked circular microstrip patch uniform linear arrays (SCP-ULAs) are proposed for use in WLAN systems. The performance analysis of higher-order modal SCP-ULA is presented in terms of modal correlation, ergodic spectral efficiency and average BER by using both maximum-likelihood (ML) and suboptimal zero-forcing (ZF) and minimum mean-squared error (MMSE) MIMO detectors.

In the year of 2010 Riera-Palou, F.; Femenias, G.,[5] Investigated on a technique to adapt the frequency diversity order in a multicarrier multiantenna system. In particular, this study focuses on the combination of group-orthogonal code-division multiplex OFDM (GO-CDM OFDM), a multicarrier technique that has been shown to outperform conventional OFDM, with spatial multiplexing. Assuming a maximum likelihood detector (ML) is used at the receiver, the proposed method is shown to be effective in estimating the instantaneous channel rank, allowing the system to be dynamically configured to achieve the maximum diversity order while keeping computational complexity as low as possible. This technique can be a useful enhancement for those systems that are required to operate in a wide variety of scenarios subject to a tight computationl/power budget (e.g. mobile terminals), thus precluding them from using a worst-case designed solution.

In the year of 2010 Riera-Palou, F.; Femenias, G.,[6] The study of considers the use of precoding in MIMO-OFDM systems based on deterministic channel state information at the transmitter (CSIT). The proposed technique combats subcarrier fading using a linear spreading of the source information in the spatial and frequency domains. Unlike previous works, it is assumed that the receiver does not necessarily has to rely on linear processing, allowing in this way more powerful receiver strategies. In particular, it is shown that a detector based on the maximum likelihood (ML) criterion brings along important performance benefits. Different spreading strategies are evaluated in terms of their performance and ML detection complexity. It can be observed that spreading the information and optimising the system over a group of subcarriers (rather than on a per subcarrier-basis or all subcarriers together) extracts virtually all the diversity the wireless channel can provide while remaining computationally feasible. Simulation results are presented within the context of the new WLAN standard IEEE 802.11n in order to illustrate the practicality of the proposed technique.

In the year of 2008 Karami, E.; Juntti, M.,[7] Investigated on a joint detection and decoding algorithm is proposed for the spatial multiplex multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) channels. In the spatial multiplexed MIMO-OFDM channels, if enough cyclic prefix (CP) at least equal to the channel length is used, inter symbol interference is completely canceled and consequently spatial multiplexing interference (SMI) is the main limiting factor on the performance [4]. Optimum SMI cancellation is more complex for practically usage. In this research, a novel technique is proposed to approach to the performance of the optimum algorithm in much lower complexity. The proposed algorithm is based on a modified soft partially parallel interference cancellation (SPPIC) technique where, in each iteration, a part of the SMI proportional to the probability of the correct estimation in the last iteration, is cancelled. The output of this soft joint detector is fed to a turbo decoder. In the first iteration of the decoding, the probability of the correctness is calculated approximately assuming the correct estimation for other sub-streams in the last iteration and in the next iterations, it is updated using the output LLR of the turbo decoder. The proposed modified SPPIC algorithm is simulated and compared to the minimum mean square of error (MMSE), interference free case (lower bound), and SPPIC algorithms for 4 states frac12 turbo code in 4times4 MIMO OFDM channel assuming Micro cell Winner channel model considering 64 and 512 sub-carriers. Bit error rate (BER) and frame error rate (FER) are considered as comparison criteria and it is shown that the performance of the new algorithm is much better than MMSE algorithm and is very close to the interference-free lower bound.

In the year of 2007 Bin Yang; Ping Gong; Shaopeng Feng; Hanfeng Zhang; Yonghua Li; Weiling Wu,[8] The study of a spatial multiplexing and diversity joint transmit structure for MIMO-OFDM system where space-frequency block coding (SFBC) is used over all spatial multiplexing layers to obtain both space diversity and frequency diversity gain. Authors have derived a Monte Carlo probabilistic data association (PDA) detector to get a better bit error rate (BER) performance compared to generic PDA detector. Computer simulation results show that the proposed detector can reduce the intersymbol interference (ISI) greatly, and improve the system performance significantly while the computation complexity has been lower to a proper lever.

IV. PROBLEM FORMULATION

The first challenge concerns MIMO correspondences framework utilizes different receiving wires of both transmitting end and getting end, the information throughput and the range usage can become exponentially to meet the prerequisites of high transmission rate, high transmission execution and high information throughput, MIMO enhances interchanges framework execution by full utilization of space differences. Then, OFDM has been broadly considered in the educated community and industry. OFDM is a productive multi-bearer transmission innovation. It changes over rapid serial information streams to moderately low transmission rate of images on a gathering of sub channels by serial/parallel transformation. In OFDM, each subcarrier is orthogonal to one another. In recurrence space, the reactions of the sub channels cover. In this manner OFDM can give a higher range usage than typical recurrence division multiplexing framework.

V. CONCLUSIONS & FUTURE SCOPE

We have studied MIMO-OFDM framework. The sign location for the proposed MIMO-OFDM plan is taking into account MMSE and ZF obstruction wiping out strategies took after by ML deciphering. The execution of the MIMO-OFDM plan has been studied with diverse number of clients and gets receiving wires over multipath blurring channels. The execution of the MIMO-OFDM plan with ST and SF square codes are additionally broke down. A RLS based versatile channel estimation strategy is proposed for MIMO-OFDM frameworks. The channel estimation system is not so much complex but rather more data transfer capacity proficient than the already proposed channel estimation techniques.

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