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Comparison of the Performance of Mimo Multi-Carrier Code Division Multiple Access and Multi Carrier Code Division Multiple Access Signal in Fading Channels

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Abstract: This paper gives the effectiveness measures of the comparison of the MIMO MC CDMA and MCCDMA modulation technique for wireless radio applications. MIMO is checked as a modulation technique for telephony communication system. A comparative study of MIMO MC CDMA and MC CDMA a variant of MC is done with the CDMA technology for the same application. The study will provide bird eye view of MIMO and CDMA for communication engineering. It was found by study that MIMO performs extremely well, providing a very high tolerance to multipath delay spread and channel noise. This paper attempts to assess wireless communications channels and propose techniques to improve the performance of modern wireless communications. Hence from a strategic perspective, an analytical study into the comparison of performance of MIMO Multi Carrier Code Division Multiple Access (MIMO-MC-CDMA) and multicarrier code division multiple access signal in frequency selective fading channel, the channel bandwidth is the main theme of this paper; from which the problems that may affect the communications link are highlighted and measures to counterbalance and alleviate multi path fading are proposed and investigated.

Key words: MIMO · Code Division Multiple Access (MIMO-CDMA) · Wireless communication

INTRODUCTION

Nowadays, Multi-Carrier Code Division Multiple Access (MC-CDMA) is the most promising candidate for the air interface downlink of the *4th* Generation mobile radio systems. MC-CDMA combines the robustness of MIMO Multiple Input Multiple Output (MIMO) modulation with the flexibility of CDMA [1]. Where Multiple Input Multiple Output (MIMO) communication systems is done by using several antennas at the transmitter and at the receiver, inherit space diversity to mitigate fading effects. When the channel is not known at the transmitter, taking benefit of the transmit diversity requires methods such as space-time coding which uses coding across antennas and time [2]. For example, Space-Time Block Coding (STBC), as proposed by Alamouti in [3] and Tarokh in [4], provides full spatial diversity gains, no inter symbol interference and low complexity ML receiver if transmission matrix is orthogonal. Moreover with STBC, only one receives antenna can be used, leading in that case to MISO (Multiple Input Single Output) systems. In [5, 6 and 7], A major problem in wireless communications which prohibits high data rate transmission is the effect of multipath fading. Fading is caused by constructive or destructive interference produced when different versions of the transmitted signal arrive at the receiver through different paths having different time delays, attenuations and phases. Frequency selective fading is one type of channel where inter symbol interference (ISI) is created due to time dispersion of the transmitted symbols within the channel. ISI causes significant performance degradation and for this reason in order to achieve high data rates, technologies that perform wellunder fading channels have to be used.Multicarrier code division multiple access (MC-CDMA), a technology _rstproposed in [8-11] and thoroughly overviewed in [12-14], performs well under frequency selective channels. It permits multiple users to access the wireless channel simultaneously by modulating and spreading their input data signals across the frequency domain using different spreading sequences. MC-CDMA combines the robustness to multipath fading accomplished by orthogonal frequency division multiplexing (OFDM) [15, 16], with the enhanced frequency diversity. In this paper, we compare the result

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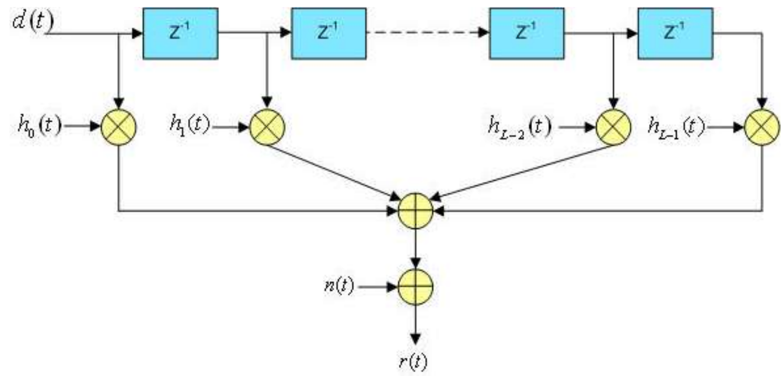

Fig 1: Tapdelaylinemodel

of MIMO using MC CDMA and the result just with multicarrier CDMA. For this comparison, the results are evaluated over Rayleigh fading channels.

Multipath Channel Model: A general multipath channel model is presented in [17]. In this model the impulse response of the time varying multipath channel is a function of time. The variable time represents the time that the channel changes when the receiver travels with a constant velocity over a short distance. The variable denotes the channel multipath delay. The multipath channel delay axis is divided into equally spaced segments, called the excess delay bins and the excess delay bin width signal that arrives at the receiver it should be noted that the signals received within the l-the bin are represented by a single multipath component with time delay width. The baseband impulse response of the multipath channel is modeled by the summation of all multipath components that arrive at the receiver with different attenuations, phase shifts and time delays.in Figure 1. In this model, each multipath component arrives at the receiver. Figure 1: shows a Tap delay line model.

In mobile radio channels with non line-of-sight (NLOS), the Rayleigh distribution is usually used to model the received envelope of individual multipath components at specific time instants.

Fading Channels: Fading is caused by constructive or destructive interference between different versions of the transmitted signal which arrive at the receiver at different times. There are different types of fading which are defined according to the relationship between the transmitted signal parameters (such as bandwidth, symbol period, etc.) with respect to the channel parameters (such as r m s delay spread, Doppler spread). Time dispersion due to multipath delay spread causes the transmitted signal to experience either at or frequency selective fading.

Flat Fading: The received signal undergoes at fading channel conditions when the wireless channel contains constant gain and linear phase response within a bandwidth which is much greater than the signal bandwidth (i.e. By >> Bs). In other words, if a change in the channel gain occurs, this will cause a constant amplitude and linear phase change of the transmitted signal bandwidth. In the time domain, at fading describes a channel where the symbol period of the transmitted signal is much larger than the multipath delay spread of the channel (Td). This approximates the fact that multipath channel impulse response has no excess delay.

Frequency Selective Fading: A signal propagates through a frequency selective fading channel only when the channel keeps a constant gain and linear phase response over a bandwidth which is smaller than the signal bandwidth (i.e. Bc < Bs). In other words, the spectrum of the transmitted signal has a larger bandwidth than the coherence bandwidth of the channel. In the time domain, the channel impulse response has a multipath delay spread larger than the symbol period (> Td) and this causes multiple versions of the transmitted signal to appear at the receiver. These versions have different gains and phase hence the detected signal is distorted. Frequency selective fading channels [13] induce inter symbol interference (ISI) due to time dispersion of the transmitted symbols by the channel. Frequency selective fading channel can be modeled with the tap delay line shown in Figure 1.

where hl(t) denotes the channel gain for the l-th tap at time t and delay because deep fades to the received symbols (the channel for that symbol period has small value). These symbols cannot be detected correctly and this significantly degrades the system performance. For this reason, techniques to overcome fading are very important.

Diversity Techniques: Diversity techniques are used to combat the multipath fading and to improve the overall system performance. Diversity is implemented by transmitting multiple versions of the same signal at different times, frequencies or spatial.

Code Division Multiple Access (CDMA): The major technologies include the FDMA, TDMA, CDMA and OFDMA systems. In FDMA, distinct frequencies are assigned to different users so as to access the channel concurrently. TDMA allocates different timeslots to different users in order to access the spectrum together on the same frequency band. FDMA and TDMA technologies have mostly used in first and second generation (1G & 2G) cellular systems as well as WLANs. On the other hand, CDMA techniques are currently used in third generation (3G) cellular systems. In CDMA, each user is assigned a distinct spreading sequence that spreads the incoming data over a large bandwidth. In this way, different users can access the available spectrum at the same frequency band and time slot. The two main CDMA techniques for providing multiple access are frequency hopping (FH) and direct sequence (DS).

Multi Carrier Code Division Multiple Access (MC- CDMA): MC-CDMA signi_es the combined system of OFDM and CDMA technologies. MC-CDMA was _rst proposed in [10, 11, 18] and thoroughly reviewed in [12, 14].

This technique permits multiple users to access the wireless channel simultaneously by modulating and spreading their input data signals across the frequency domain using di_erent spreading sequences. MC-CDMA combines the robustness to multipath fading of OFDM with the multi-user spectrum access of CDMA [19].

Multicarrier and Multiple Access Systems: Multicarrier systems [20] convert a serial high-rate data stream into multiple parallel low-rate sub streams, each modulated on a different subcarrier. Since the symbol rate on each subcarrier is much less than the serial data stream symbol rate, the e_ects of multipath delay spread, i.e. ISI, are significantly decreased. This research is mainly focused on two multicarrier technologies and these are OFDM and MC-CDMA. Multiple access (MA) [21, 22] systems allow multiple users to access the wireless radio spectrum simultaneously. The wireless spectrum is a scarce resource therefore a wireless system has to allocate simultaneously the available amount of channels to multiple users in order to achieve higher system capacity. There are various techniques available for attaining multiple access and these include frequency division multiple access (FDMA), time division multiple access (TDMA), CDMA and OFDMA.

Multiple Input Multiple Output (MIMO): MIMO system [23, 24] is a scheme based on multiple transmitting and multiple receiving antennas which can achieve very high data rates in rich multipath and scattering environments without increasing the transmission bandwidth or the total transmitted power of the system. The point-to-point MIMO channel of four transmit (Nt = 4) and four receive (Nr = 4) antennas is depicted in Figure 2: 4x4 MIMO channel. MIMO techniques realize high data rates through spatial multiplexing and increase the spectral efficiency of the system in rich scattering environments by providing spatial diversity. In addition, the MIMO system capacity increases linearly with the number of transmit-receive antenna pairs. This explains the reason why a great interest has raised for spatial multiplexing architectures.[25] Figure 3 shows the MIMO MC-CDMA transmitter.

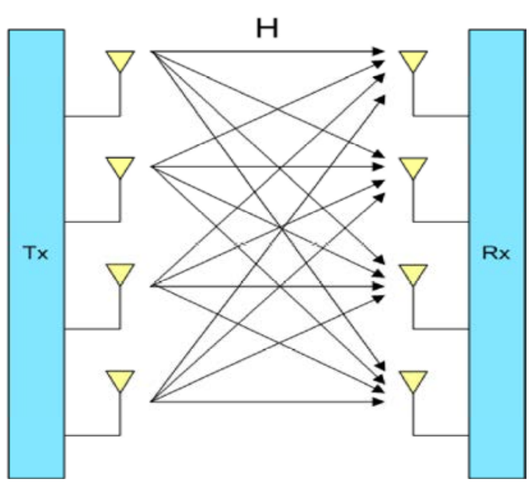

Fig 2: 4x4 MIMO channel

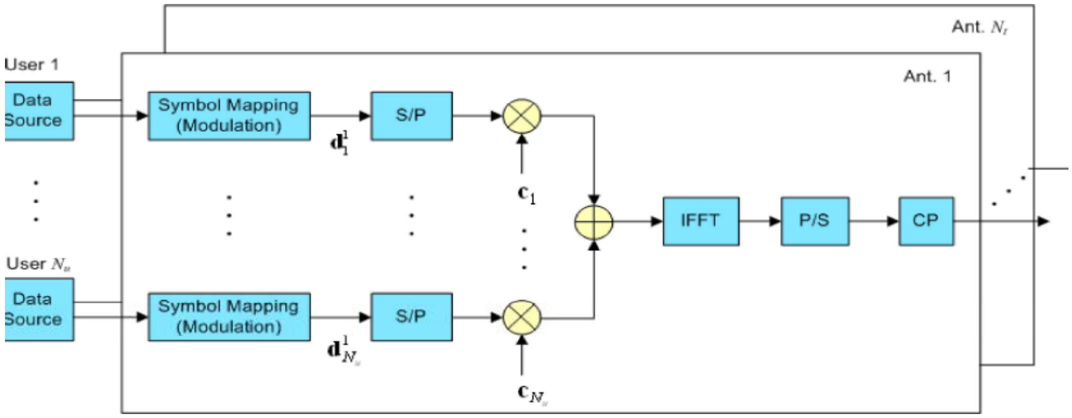

Fig 3: MIMO MC-CDMA transmitter [25]

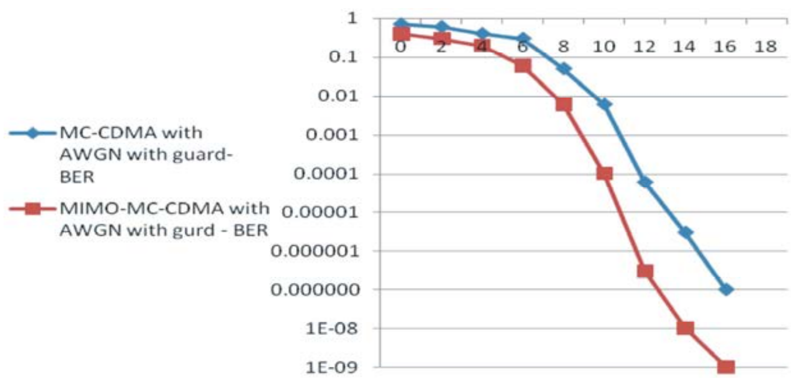

Fig 4: Comparison between the performance MIMO MC CDMA and MC CDMA with AWGN and using guard interval

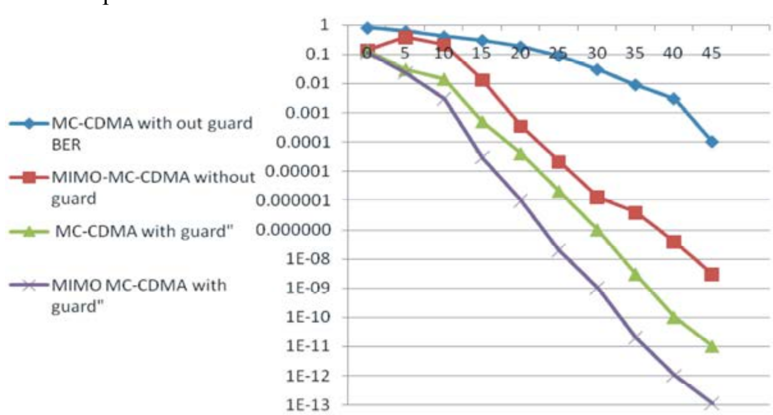

Fig 5: Comparison between the performance MIMO MC CDMA and MC CDMA with Rayleigh fading and with and without guard interval

Simulation Results: In this paper, the performance of the proposed comparison between MIMO MC CDMA and MC CDMA system is valuated through Monte Carlo simulation. On the X access shows the S/N ratio and on Y access shows the BER. The performance of MIMO MC CDMA and MC CDMA system in AWGN shows that at 10 dB the BER for MC CDMA is 0.008 but for MIMO MC CDMA the BER is 0.0001, this means that the performance of MIM MC CDMA is better in 3 dB than the Performance of MC CDMA system in AWGN channel. In other words to achieve the BER 0.0001 for MC-CDMA we need the Signal to noise ratio of 13 dB but for MIMO MC CDMA to achieve the same BER 0.0001 we need the signal to noise ratio to be 10 dB only as shown in Fig 4.

Fig-5 compares the performance of MIMO MC CDMA and MC CDMA system in Rayleigh fading channel. On the X access shows the S/N ratio and on the Y access shows the BER, The performance of MIMO MC

CDMA and MC CDMA system in Rayleigh channel shows that to achieve the BER for MIMO MC CDMA without guard is 0.001, we need 18dB but for same BER MC CDMA with out guard period the signal to noise ratio is 42 dB. For MIMO MC CDMA with guard band to achieve the same BER 0.001 we need 13dB only. Also for MC-CDMA with guard period we need the Signal to noise ratio of 17 dB comparing with MIMO MC CDMA to achieve the same BER 0.0 01 we need the signal to noise ratio to be 13 dB only as shown in Fig.

This means that the simulation results for MIMO MC DCMA with guard period is much better than the results MC CDMA with the same period guard in 4dB difference.

CONCLUSION

In this paper a Comparison of BER performance between MIMO MC CDMA and MC CDMA with AWGN and Rayleigh fading with and with out guard interval has been proposed. The simulation results shows that the BER of the MIMO MC CDMA system is better than the performance of the MC CDMA system and is more suitable with 4GHz mobile system, this is because the MIMO MC CDMA uses a carrier frequency in multibands.

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