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Analysis & Review Equalization & Channel Estimation for OFDM & CDMA

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Abstract— **Multi-carrier code division multiple accesses (MCCDMA) has been considered as a strong candidate for next generation wireless communication system due to its excellent performance in multi-path fading channel and simple receiver structure. However, like all the multi-carrier transmission technologies such as OFDM, the inter-carrier interference (ICI) produced by the frequency offset between the transmitter and receiver local oscillators or by Doppler shift due to high mobility causes significant BER (bit error rate) performance degradation in MC-CDMA system. Many ICI cancellation methods such as windowing and frequency domain coding have been proposed in the literature to cancel ICI and improve the BER performance for multi-carrier transmission technologies. However, existing ICI cancellation methods do not cancel ICI entirely and the BER performance after ICI cancellation is still much worse than the BER performance of original system without ICI.**

Index Terms— **MIMO-OFDM; cdma, BER; PAPR; Channel Capacity; Synchronization, Carrier offset**

I. Introduction

Wireless communication is the transfer of information over a distance without the use of electrical conductors or "wires". The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometers for radio communications). When the context is clear, the term is often shortened to "wireless". Wireless communication is generally considered to be a branch of telecommunications. It encompasses various types of fixed, mobile, and portable two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Other examples of include GPS units, garage door openers and or garage doors, wireless computer mice, keyboards and headsets, television and cordless telephones.

Multiple access schemes based on a combination of code division and OFDM techniques have already proven to be strong candidates for future 4G systems[11]. Several techniques have been proposed. The three most popular proposals are multicarrier (MC-) CDMA, multicarrier modulation with direct sequence (DS-) CDMA, and multitone (MT-) CDMA . In this thesis, I concentrate on MC-CDMA, a novel digital modulation and multi access scheme and a very promising technique for 4th generation cellular mobile radio systems [15]. MC-CDMA allows high-capacity networks and robustness in frequency selective channels [31]. The general block diagram [2] of a MIMO-OFDM system is given in figure 1.

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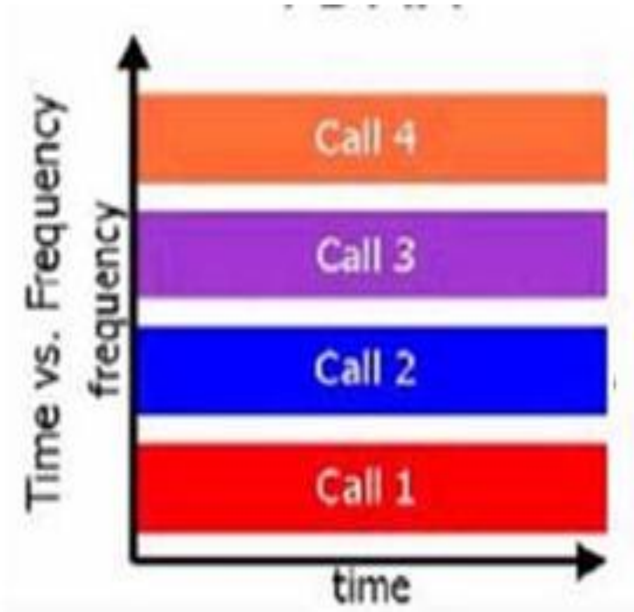

Fig.1. Frequency Division Multiple Accesses

CDMA is achieved by modulating the data signal by pseudo-random noise sequence (PN Code), which has a chip rate higher than the bit rate of the data. The PN code sequence is a sequence of ones and zeros (called chips), which alternate in a random fashion. Modulating the data with this PN sequence generates the CDMA signal. The modulation is performed by multiplying the data (XOR operator for binary signals) with the PN sequence.

II. Frequency Hopping Code Division Multiple Access (FH-CDMA)

FH – CDMA is a kind of spread spectrum technology that enables many users to share the same channel by employing a unique hopping pattern to distinguish different users' transmission. The type of spread spectrum in which the carrier hops randomly from one frequency to another is called FH spread spectrum. A common modulation format for FH system is that of M-ary frequency shift keying (MFSK) [29].

A major advantage of frequency hopping is that it can be implemented over a much larger frequency band than it is possible to implement DS- spreading, and the band can be noncontiguous. Another major advantage is that frequency hopping provides resistance to multiple – access interference while not requiring power control to prevent near – far problems. In DS – systems, accurate power control is crucial but becomes less effective as the carrier frequency is increased.

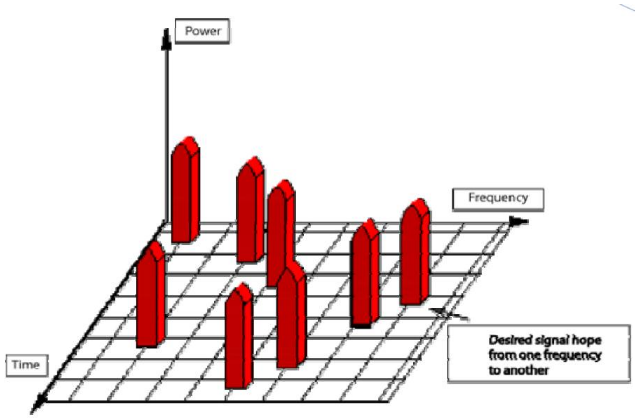

Fig-1.2 Frequency hopping

III. OFDM

Initially the development of CDMA was thought be adequate since it support a lot of user, low power, good coverage and capacity etc. As CDMA works by assigning a single code to each user, such codes can chosen to minimize interference between groups of receiver. This can be accomplished by choosing codes having the lowest cross correlation properties. One of the drawbacks of CDMA is the complexity of receiver that needs to be design. In addition, CDMA suffers from the near-far effect and self-jamming problem that result from poor synchronization. OFDM, a technique robust to frequency selective fading was then proposed .OFDM works by splitting the bandwidth into different sub carrier and orthogonal to each other. Since the spectrum of each carrier has a null at carrier frequency, this will result in no interference between carrier and overcomes the problem of overhead. OFDM has limited bandwidth, which result in low symbol rate, contributing to high tolerance to multipath delay spread since delay spread must be long to causes significant ISI [18][25]. Some of the problems associated with it are that it requires RF power amplifiers with high peak to average power ratio since it has noise like amplitude with large dynamic range. Beside OFDM is more sensitive to carrier frequency offset than single carrier systems.

IV. Delay Spread

In communications, the delay spread is a measure of the multipath richness of a channel. It measures the difference between the time of arrival of the first significant multipath component (typically the line-of-sight component) and the time of arrival of the last multipath component. It is mostly used in the characterization of wireless channels, but the same concept applies to any other multipath channel (e.g. multipath in optical fibers).

The delay spread can be characterized through different metrics, although the most common one is the root mean square (rms) delay spread.

V. Time Domain Spreading

Another way of combining multicarrier modulation with CDMA is the MC -DS-CDMA scheme that spreads the original user data stream in the time domain. As shown in Fig.2.14, the user data stream is first serial to parallel converted into N_c (the number of subcarriers) sub streams, each of which is time-spread and transmitted in an individual subcarrier. In other words, a block of N_c symbols are transmitted simultaneously. The value of N_c can be chosen according to the system design requirement. However, it is commonly assumed to be equal to the length of spreading code N which will also make the comparison with MC-CDMA easier .All the symbols are spread in the time domain using the same spreading code for a particular user. It is clear that this scheme achieves time domain diversity but no frequency domain diversity for each individual data symbols.

VI. MC-CDMA System

The previous chapter presented an overview of OFDM systems, the importance of cyclic prefix and the analysis of Inter Carrier Interference in OFDM. OFDM is an effective technique to combat the frequency selectivity of the channel. Code Division Multiple Access (CDMA) has been a strong candidate to support multimedia mobile services because it has the ability to cope up with the asynchronous nature of the multimedia traffic and can provide higher capacity as opposed to the conventional access schemes such as TDMA or FDMA. By employing Rake receivers CDMA systems can coherently combine the multipath components due to the hostile frequency selective channel. The processing gain due to spreading provides robustness to the multi-user interference. The use of conventional CDMA does not seem to be realistic when the data rates go up to a hundred megabits per second due to severe ISI and the difficulty in synchronizing a fast sequence. Techniques for reducing the symbol and chip rate are essential in this case [9].

VII. Simulation of Rayleigh Fading

For simulation purposes, it is sufficient to consider baseband but it might not be sufficient for hardware implementation purposes. Therefore, the channel simulation was not made at carrier frequency which is 3.4 Ghz, if that was done then spectrum would be considerably trivial as most information would contain zeros instead of doppler spectrum. The region where the gain is intensively negative dBs is known as deep fade. The distance between two deep fades is 44.1 ms, so there will be about 20 deep fades for 20 wavelengths. In other words, there will be three deep fades every 0.1s which is also depicted in figure. In the Fig.5.2, it can be seen that there are about 20 fades which correspond to 20 wavelengths.

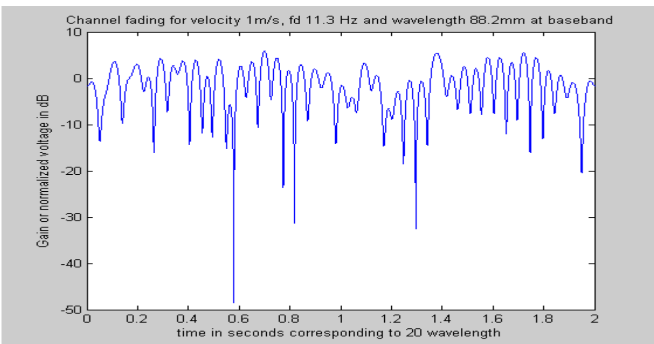

Fig-2 Channel fading for velocity 1 m/s and wavelength 88.2 mm at baseband TABLE I. Simulation Parameters for MIMO-OFDM System

A. Bit error rate (BER) Analysis A. BER Analysis of MIMO-OFDM System

A bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits. The definition of bit error rate can be translated into a simple formula:

BER = number of errors / total number of bits sent

If the medium between the transmitter and receiver is good and the signal to noise ratio is high, then the bit error rate will be very small - possibly insignificant and having no noticeable effect on the overall system However if noise can be detected, then there is chance that the bit error rate will need to be considered.

These include the optical driver, receiver, connectors and the fibre itself. Bit errors may also be introduced as a result of optical dispersion and attenuation that may be present. Also noise may be introduced in the optical receiver itself. Typically these may be photodiodes and amplifiers which need to respond to very small changes and as a result there may be high noise levels present. Another contributory factor for bit errors is any phase jitter that may be present in the system as this can alter the sampling of the data.

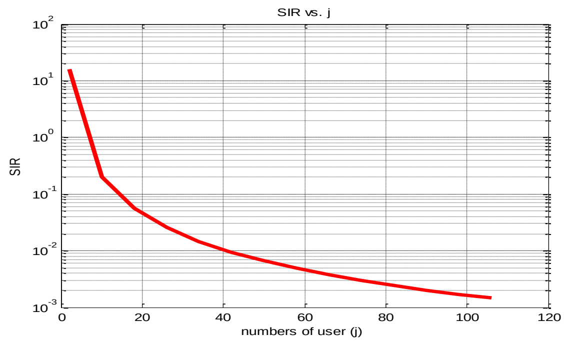

Fig 3 SIR vs. j

Signal to noise ratios and E_b/N_o are parameters that are more associated with radio links and radio communications systems. In terms of this, the bit error rate, BER, can also be defined in terms of the probability of error or POE. The determine this, three other variables are used. They are the error function, erf, the energy in one bit, E_b, and the noise power spectral density (which is the noise power in a 1 Hz bandwidth), No.

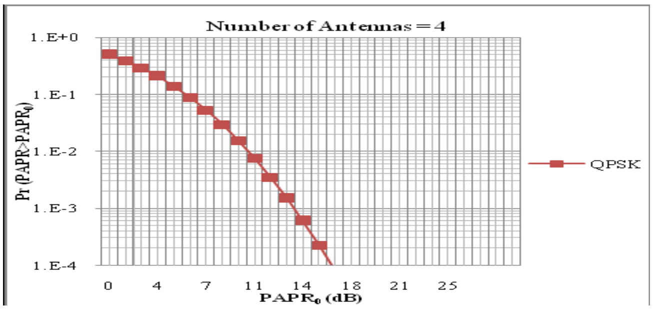

Figure 4. CCDF plot of MIMO-OFDM system for QPSK modulation scheme for Tx= 4

VIII. CONCLUSION

The "one technology fits all" approach will not suffice in the future competitive telecommunications market. Instead, operators will leverage the most appropriate technology for a particular application or service. Bluetooth will support the personal area network, NFC will enable mobile commerce, Wi-Fi will satisfy local area network connectivity, GPS will enable presence and location-based services, 2G and 3G cellular technologies will provide ubiquitous voice and broadband data services, and OFDM-based technologies will provide large amounts of bandwidth for backhaul, broadcast and broadband applications in "hot-zones." For most operators, 3G CDMA-based technologies will be more than sufficient for their voice and broadband data requirements for at least a decade. For those operators that require higher amounts of bandwidth, especially in high-traffic areas, OFDM based technologies offer certain economic benefits and will enable them to complement their services, features and coverage. In most instances, however, 3G CDMA will remain the leading and most economical platform for the delivery of mobile broadband services.

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