Orthogonal Frequency Division Multiplexing for Mobile Communication: An Overview

Amin ul Haq, Prof. Adeel, Noor Khan, Amir Shehzad, Ihsan Ilahi Jan, Waseem Khan, Junaid Khan, Muhammad Ishfaq Ahmad Khan, Abdul.Sattar and Usman

Gandhara University of Sciences, Peshawar, Pakistan

***Abstract*– This paper investigates the effectiveness of Orthogonal Frequency Division Multiplexing (OFDM) as a modulation technique for wireless radio application. Orthogonal frequency division multiplexing has numerous exclusive properties which erects it particularly well suited to grip the challenging ecological/environmental circumstances experienced by mobile wireless data application. It was originated that OFDM performs extremely well compared with CDMA providing a very high forbearance to multipath delay spread, peak power clipping and channel noise. Also it endows with a high spectral efficiency.**

***Keywords*–** Mobile Communication, Analysis, Multiplexing and Efficiency

I. INTRODUCTION

One of the anticipated Third/3rd generation telecommunication systems is a widespread/universal mobile telecommunication system (UMTS), which endeavors to grant a more supple data rate, a privileged/higher aptitude/capacity and additional compactly integrated services as compared to the second generation mobile. The majority 3rd generation mobile phone system are utilizing Code Division Multiple Access or comprehensive Time Division Multiple Access by improving flexibility of service obtainable but CDMA was brought into being to execute scantily/poorly/badly in solitary cellular system and elevated Inter user interference. Numerous techniques, with aspire of perking up/progressing cell capacity, endowing with multipath exemption/immunity, suppleness, lofty lenience to peak power clipping and channel noise and also supplying a lofty spectral efficiency embraces Orthogonal Frequency Division Multiplexing.

OFDM consent various users to convey in an owed/allocated band by subdividing the offered Bandwidth into various carriers called tones. They are jam-packed greatly nearer/closer jointly than standard FDM. This guides to OFDM providing high spectral efficiency.

A. Introduction to CDMA

It is a spread spectrum technique that exploits neither frequency channel as in frequency division multiple access (FDMA) nor time slots as in time division multiple access (TDMA). CDMA technology was formerly invented/developed by military during World War-II.

Various properties that have prepared Code Division Multiple Access useful are:

- Signal trouncing and noninterference with accessible systems
- Anti-jam and intervention refutation
- Information security
- Precise ranging.
- Manifold User Access
- Manifold Tolerance

B. Indispensable Transmitter of CDMA

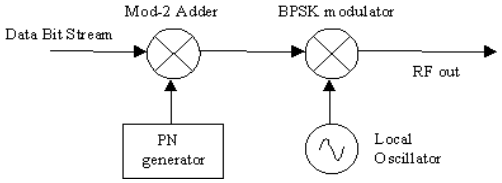

Fig. 1: CDMA Transmitter

In CDMA (Fig. 1), narrow band message is multiplied by hefty bandwidth signal i.e. a pseudo random noise code (pseudo random code) also called Walsh code. These pseudo random codes are orthogonal for extrication the multiple users on identical channel. These are supported through or by Walsh matrix, which is a square matrix with binary elements (1 or0 called chips) and dimensions that are power of two.

$$W_{2n} = \begin{pmatrix} W_n & W_n \\ W_n & W_n \end{pmatrix}$$

The Walsh codes are orthogonal, which means the dot product of any two rows is zero, while for every two rows unerringly partially the number of bits will be equivalent and half will not.

At beneficiary/receiver, the conveyed/transmitted signal is recuperated/recovered by associating the revived signal with inventive pseudo random code utilized by the broadcaster/transmitter. Nevertheless, all additional signals

which are un-correlated to pseudo random code spreading befall further spread.

II. ALLIED PROBLEMS

CDMA main weak points are:

- Elevated interuser interference in repeal link.
- Stumpy single cell capacity.
- Great Bit Error Rate for multipath exemption/immunity, peak power clipping and channel clatter/noise.

The Above problems are able to be argued by utilizing simulation outcomes for Code Division Multiple Access technique as shown:

A. Amount of Consumers in a Cell vs. BER

Reverse/Overturn link of The BER for a Code Division Multiple Access system boosts as further clients exercises the similar cell. Fig. 2 shows the BER anticipated based on amount of clients. The outcome/result is for a secluded cell with no meddling from adjoining/adjacent cells, no multipath upshots/effects, no channel shattering/noise. None of these consequences would deteriorate the BER.

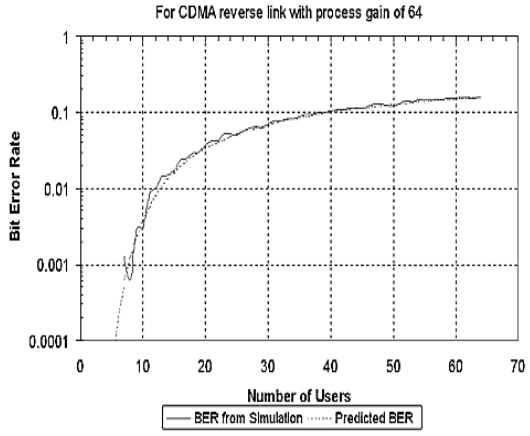

Fig. 2: BER vs. Number of users in cell

Fig. 2 shows that BER turns into drastically hefty if the number of users is larger than 8. Consequently it is understandable that the inter-user interference in reverse link is weak point in CDMA.

B. Imperviousness (Multipath)

Bit Error Rate Vs Multipath hinder spread for Code Division Multiple Access reverse/overturn link. The noise just because of multipath pilots to amplify in the sum of intervention seen or viewed by every user, & therefore mounting the acknowledged BER. From Fig. 3 it can be taken under consideration that the BER is basically dreary for impediment spread of larger than one chip time (0.8 microsecond) which to be supposed as the imitated signal befalls uncorrelated. In Fig. 3, the multipath stoppage/delay spreads guides to augment in equivalent amount of clients in the cell as it increases the sum of interference seen by receiver.

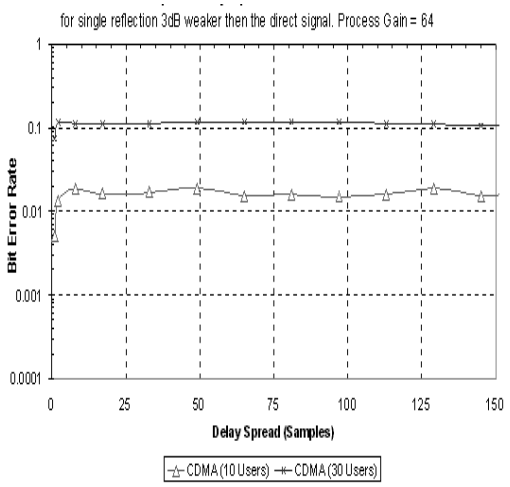

Fig. 3: Bit Error Rate Vs Multipath delay/hindrance spread for Code Division Multiple Access reverse/overturn link

C. Peak Power Clipping

Incase the transmission technique is lenient to peak power clipping, and then it allocates the signal to be clipped. This clipping of signal diminishes the peak to RMS signal power ratio therefore allowing/permitting the signal power to be amplified for the sized Transmitter. Fig. 4 shows outcome of peak power clipping on mutually/both the overturn/reverse & forward links for Code Division Multiple Access.

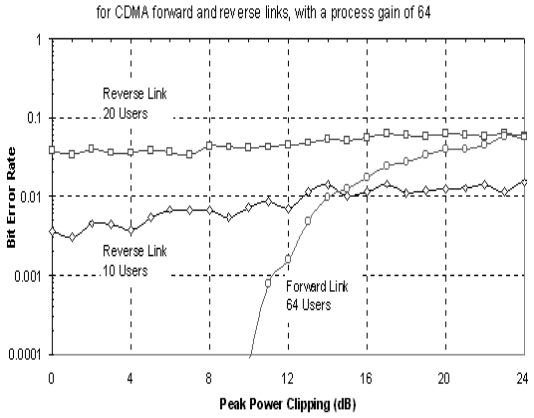

Fig. 4: Peak power clipping outcomes

Clipping Peak power for the overturn/reverse link is furthermore liable to be miniature as only ever transpire due to misrepresentation in the base station receiver a glowing premeditated receiver is improbable to cause momentous clipping of the signal. The forward/frontward link shows important clipping to the spreader/transmitter. The Bit Error Rate is little for peak power clipping of less than 10dB, on top of which the orthogonal character of Walsh code utilized commences to crumple.

D. Channel Clattering

Code Division Multiple Access noise recital of reverse/overturn link is shown in Fig. 5 just because of lofty;

altitude of inter-user intervention the accumulation of channel noise guides/leads to only a steady grow in the Bit Error Rate. The Bit Error Rate of the lines (10 clients, 20 clients and 30 clients) reaches roughly. The similar Bit Error Rate at the Signal to Noise Ratio of 0dB. The Bit Error Rate is very dreadful for further than 10 clients despite the consequences of the channel Signal to Noise Ratio, therefore creating 20 or 30 clients impracticable. For 10 clients the Bit Error Rate befalls superior than 0.01 at roughly a Signal to Noise Ratio of 14dB, which is highest Bit Error Rate that be able to be on the whole tolerated for voice communication.

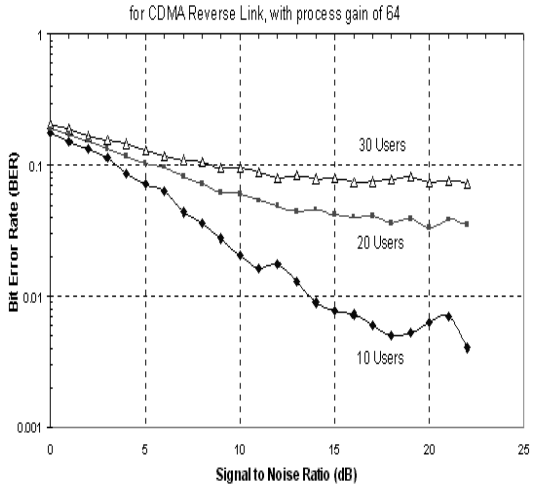

Fig. 5: BER Vs Single to noise ratio

III. CONSTRUCTIVE FOR MOBILE COMMUNICATION

OFDM embodies a different system-design approach. It can be deliberated of as a blend of modulation and multiple-access systems/scheme/plans that segments or fragments a communications channel in that kind of technique that a lot of clients can carve up it. While TDMA segments are according to time and CDMA segments are according to spreading codes, OFDM segments are according to frequency. It is a technique that segregates the spectrum into a number of likewise spaced tones and carries a segment of Clients information/record on each and every tone. A tone can be considered of as a frequency, greatly in the identical approach that each and every key on a piano represents/embodies a unique frequency.

Orthogonal Frequency Division Multiplexing can be seen as an outline of frequency division multiplexing (FDM); On the other hand, OFDM has a vital particular property that each tone is orthogonal with all other tone. FDM characteristically needs there to be frequency guard bands among the frequencies so that they do not obstruct each other. Orthogonal Frequency Division Multiplexing permits the spectrum of each and every tone to overlie, and because they are orthogonal, they do not obstruct with each other. By permitting the tones to overlie/overlap, the large quantity of spectrum compulsory is decreased. Orthogonal Frequency Division Multiplexing is a modulation technique in that it facilitates client data to be modulated onto the tones by adjusting the tone's phase, amplitude or both. In majority all fundamental form, a tone may possibly be there or immobilize to point out a 1or0 bit of information; however either PSK & QAM is typically employed. OFDM system takes a data stream & gashes it into N parallel data streams, each at rate 1/N of the original rate. Each & every stream is then mapped to a tone at a distinctive frequency pooled together utilizing the IFFT (inverse fast Fourier transform) to capitulate the time-domain waveforms to be transmitted. Note that the crest/peak of each tone corresponds to a zero point or level or null for every other tone.

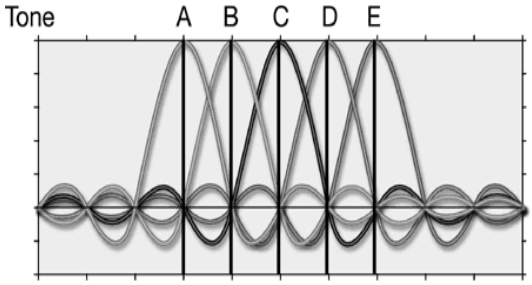

Fig. 6: Tones for OFDM

Hence each user can be assigned a prearranged number of tones when the information to send, or otherwise a user can be assigned an erratic amount of tones based on the sum of information that they ought to send. The work/assignments are controlled or restricted by the media access control (MAC) layer, which plans the resource assignments based on client demand.

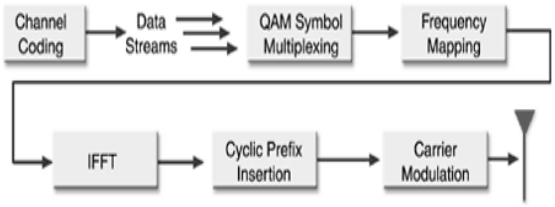

Fig. 7: OFDM transmitter chain

The adding of security/guard time, called a cyclic prefix. The channel can be prepared to act as if the transmitted waveforms guarantee orthogonality, which effectively thwarts one sub carrier from prying with another. The cyclic prefix is truly a replica of the last segment of data symbol affixed/joined to the front of the symbol all through guard interval as in Fig. 8.

Multipath grounds tones and deferred imitations of tones to disembark at the beneficiary or receiver with some delay/hindrance spread. This guides to misalignment among sinusoidal which have to be aligned be orthogonal. The cyclic prefix permits the tones to be realigned at the receiver, therefore regaining orthogonality.

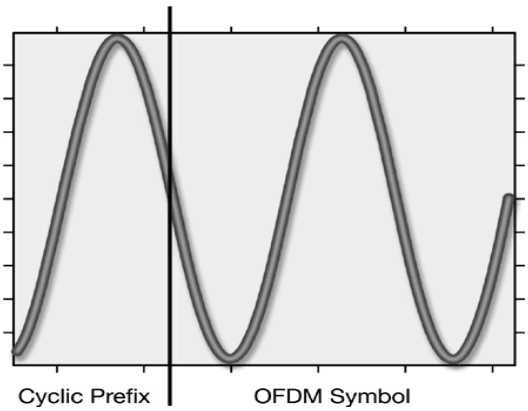

Fig. 8: Cyclic Extension of Sinusoid

IV. VIRTUES OF OFDM OVER CDMA

The explanations & simulated results of both access techniques i.e., CDMA &OFDM. They can be compared as:

- By constructing sluggish parallel data streams, the bandwidth of the modulation symbol is efficiently decreased, hence coherence B.W of channel decreases.
- Appropriate selection of system parameters such as the number of tones & tone spacing can greatly reduce or eliminate ISI.
- Switching or exchanging frequencies following each symbol time, the fatalities just because of frequency selective/discerning fading are diminished.
- Every carrier in an OFDM signal has a very narrow bandwidth i.e., 1KHZ, thus resulting symbol rate is low results in signal having a high tolerance to multipath delay spread (e.g. >100microsec)
- CDMA has originated to act upon poorly in a single cellular system with each cell only allowing 7-16 simultaneous user in a cell compared with 128 for OFDM.(this was for a 1.25MHZ B.W. and 19.5 Kbs user data rate
- OFDM noise performance was found to depend exclusively on modulation technique used for modulating each carrier of signal. The bare minimum SNR for BPSK ~ 7dB,~12dB for QPSK and ~ 25dB for 16PSK

V. CONCLUSIONS

This paper highlights the inimitable design defy faced by mobile data systems that result from the vagaries of the ruthless wireless channel. The ample & speckled service profiles that are facilitated through data communications & the protocols such as TCP/IP (transport control protocol or internet protocol), with the certainty of wireless links. Orthogonal Frequency Division Multiplexing has been exposed to deal with such sort of tests/challenges and to be a key facilitator of a system design that can endow with high performance mobile data communication. Also OFDM is able-bodied positioned to congregate the sole stipulation/demands of mobile packet data traffic. OFDM was brought into being to perform very well compared with CDMA.OFDM was found to allow up to 2-10 times more users than CDMA in a single cell & from 0.7-4 times more in multicellular environment.

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