Overloaded Spread spectrum OFDMA in indoor environment (More Interleaving)

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***Abstract*—**Progress of mobile communication technology is related to the invention or any changes in latest Radio Access Technique which can meet the requirements of the user by enhancing the capacity. The main objective of this paper is to enhance spectral efficiency and hence average throughput of the system using OFDM based multiple access technique. Here we have chosen Overloaded Spread spectrum OFDMA. We have observed that for 24% overloading approximately 33% rise in Spectral efficiency.

Keywords*—overloaded; spread spectrum; indoor; interleaving; Spreading gain (SG)*

I. INTRODUCTION

Latest trend in the wireless communication is because of increasing need of end users to access faster INTERNET even in higher mobility condition. Currently, we are getting data-rate more-than 100 Mbps in case of wire-line system with copper or fiber based solution. With increasing number of mobile phone users, which exceeded 4th billion landmark at the end of 2008 [1], it's necessary to go beyond the currently available technologies and provide user all the services they demand with sufficient quality of service, with maximum data rate. "It is always dangerous to put any limit on the increasing data rate" and hence we have to look into future generation wireless systems i.e. beyond 4G.

II. SPREAD SPECTRUM OFDMA

A. Motivation

In this Spread Spectrum-Orthogonal Frequency Division Multiple Access (SS-OFDMA), a symbol to be mapped on a carrier is instead spread over spreading gain amount of carriers. This gives the advantage of frequency diversity and hence even channel condition is not good for certain carriers, symbol mapped can be decoded easily. Hence this kind of technique gives benefit of OFDMA and CDMA. Depending on correlation properties, system performance of Spread Spectrum OFDMA varies. Hence, receiver has to use Multiuser Detection techniques to mitigate interference.

B. Fundamentals of Overloaded Spread Spectrum OFDMA

One of the merits of CDMA based technique is Soft Capacity i.e. it can be overloaded with certain degradation in probability of error. Overloading is term used in Cellular CDMA technique. Generally, CDMA allocates every sequence of length N to maximum N number of users i.e. $N = T/T_c$ is the processing gain or spreading gain of CDMA. Where, T: Symbol Duration and T_c: Chip Duration. If less than N number of users is allocated using chip sequence of length N, then system is called Underloaded System. In this case, Orthogonality of the codes is not violated and hence their performance is not affected. When Number of users exceed N, system is Overloaded. So, in this case, it is necessary to assign more number of sequences than the spreading factor. Hence, the sequences become no more orthogonal and in effect, it increases the Multiple Access Interference (MAI). This kind of scheme makes system performance worse.

In literature, different approaches are described to mitigate this effect of overloading and hence enable more number of users to share bandwidth simultaneously. Several approaches include the use of Multi User Detection (MUD) at Base Station [14] has shown CDMA Overloading performance using Iterative Interference Cancellation Receiver. Several approaches [15] also suggest use of Orthogonal Codes such as Quasi Orthogonal Sequences (QOS) and Orthogonal Gold (OG) Codes can enhance system performance.

Recently, OFDMA based access technique is been dominant and suitable for multi-path environment. For next generation wireless network, we can still think about combination of CDMA and OFDMA. One of these kinds of technique which is used in 3GPP-LTE standard is SC-FDMA [11]. It consists of DFT spreading which enables the Code Division Multiplexing of the symbols. This Concept of Overloading in CDMA can be extended further to OFDM based access technique to increase the capacity. This can be possible using different kinds of spreading codes, such as OG Codes or QOS. These Codes must have very little or no performance degradation as compared to under loaded system and should possess good correlation properties. Further, it is also necessary to use a Multi Stage Detector [16] for the interference cancellation. Keeping all this in mind, performance of this new scheme is evaluated using Rayleigh channel in the indoor environment and each user data is interleaving and transmitted (Low interleaving).

III. TRANSCEIVER DESCRIPTION

One of the advantages of Overloaded OFDMA is, it increases the capacity of OFDM system in proportion to the increase in amount of Overload. Also, Symbols are spread over carriers' equivalent to the amount of spreading gain. So it also brings in advantage of Diversity Gain. . But, this novel Access technique has to deal with PAPR issue as it mainly depends on kind of spreading sequences we are using [17].

Fig 1(a) and Fig 1(b) shows the Transmitter and receiver block diagrams of Overloaded SS-OFDMA in More Interleaving Localized Access (MILA) case. In this case at the transmitter side interleaving is done over all the users data i.e., U *M * L number of bits together, as shown in Fig 1(a) where L is the number of bits per symbol and M is the number of symbols sent by each of the U users. At the receiver each user will receive all the users data (U*M*L number of bits) that were broadcast by the transmitter, and De-interleave them. Out of U*M*L bits each user takes only M*L bits of his data and drops the other bits. Hence Complexity involved is more in More Interleaving Localized Access (MILA) case compare to Low Interleaving Localized Access (LILA) case.

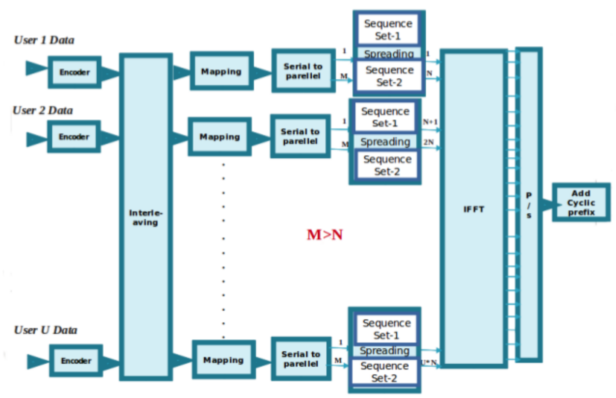

Fig 1(a) Transmitter Block diagram

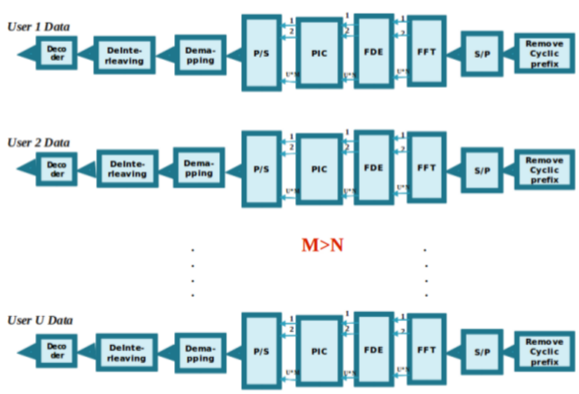

Fig 1(b) Receiver Block diagram

A. *BER performance*

Fig. 2(a) shows the BER performance of Overloaded Spread spectrum OFDMA for BPSK modulation, Fig. 2(b) shows the BER performance of Overloaded Spread spectrum OFDMA for QPSK and Fig 2(c) for 16QAM with complex scrambling OCDMA/TDMA codes The performance is done in Rayleigh channel for HDIC receiver with spreading gains 32,128 and 256 with ECC 1/2 in indoor and outdoor case respectively(FFT size = 2048).Results shows that there is a degradation in SNR requirement with overloading similar to Low Interleaving Localized Access(LILA) case. But BER performance improves compare to Low Interleaving Localized Access (LILA) due to More Interleaving gain among the user's data. This degradation is more for higher modulation. This is because, as we increase the number of symbols in set-2, interference increases with that respect. Hence makes performance worse. 32,128 and 256 with Error Correction Coding (ECC) 1/2 in indoor and outdoor case respectively (FFT size = 2048). Results show that there is degradation in SNR requirement with overloading. This degradation is more for higher modulation. This is because, as we increase the number of symbols in set-2, interference increases with that respect. Hence make performance worse. As we increase the SG, performance improves because Cross-correlation decreases as we increase the Spreading gain.

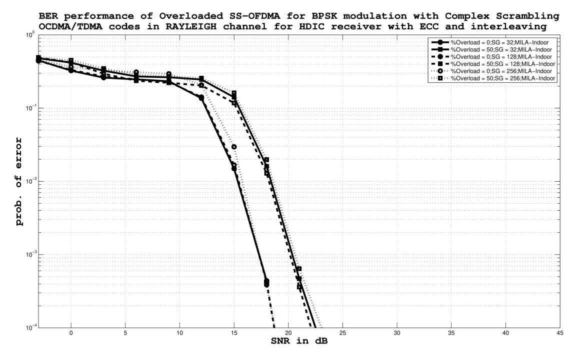

Fig 2(a) BER performance of Overloaded Spread spectrum OFDMA for BPSK modulation

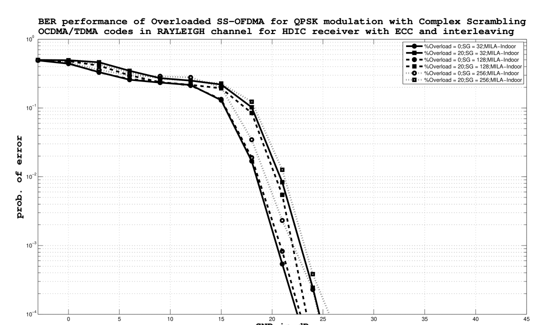

Fig 2(b) BER performance of Overloaded Spread spectrum OFDMA for QPSK modulation

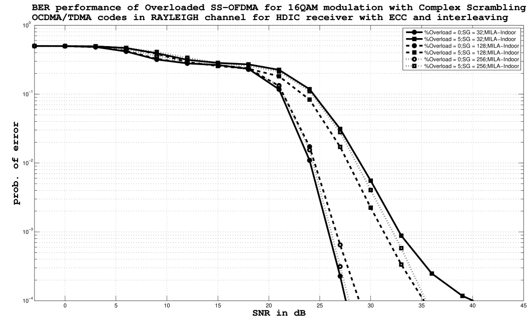

Fig 2(c) BER performance of Overloaded Spread spectrum OFDMA for 16-QAM modulation

B. Analytical Model for Throughput performance

Following equation gives normalized throughput which depends on SNR of the system,

$$\text{Throughput} = C/W = \log_2 (1+SNR)$$

Where, C is capacity, W is system Bandwidth. Hence C/W, which is nothing but normalized throughput which can be a measure of number of bits per second that can be transmitted over a Hz of bandwidth or in other words, number of bits that can loaded in a symbol of duration and SN R is signal to noise ratio at the receiver.

Also, if P e is the probability of erroneously received symbols then again we can express Throughput relation as [6]

$$\text{Throughput} = (1\text{-}P_e)Lr\ (1+ [\text{Percent Overload}/100]\ )$$

Where, L is number bits carried over a symbol, r is rate of error control coding and Percent Overload is amount of overload applied. Thus we can say, for approximately, zero probability of error, Throughput is more than no overload case by amount of percentage overload applied.

C. Conclusions

(i) BER performance

The following Table 1.1 shows the SNR in dB requirement at BER 10^{-2} for different modulation with Complex Scrambling OCDMA/TDMA codes for Spreading Gains 32,128 and 256 with ECC 1/2.

Observation: With the increase in SG the BER performance improves for different modulation.

ii)Throughput performance

The following Table 1.2 shows the SNR requirement to achieve the maximum throughput for different modulation with Complex Scrambling OCDMA/TDMA codes for Spreading Gain 32 with ECC 1/2(for BER>10^{-2} throughput is taken as zero).

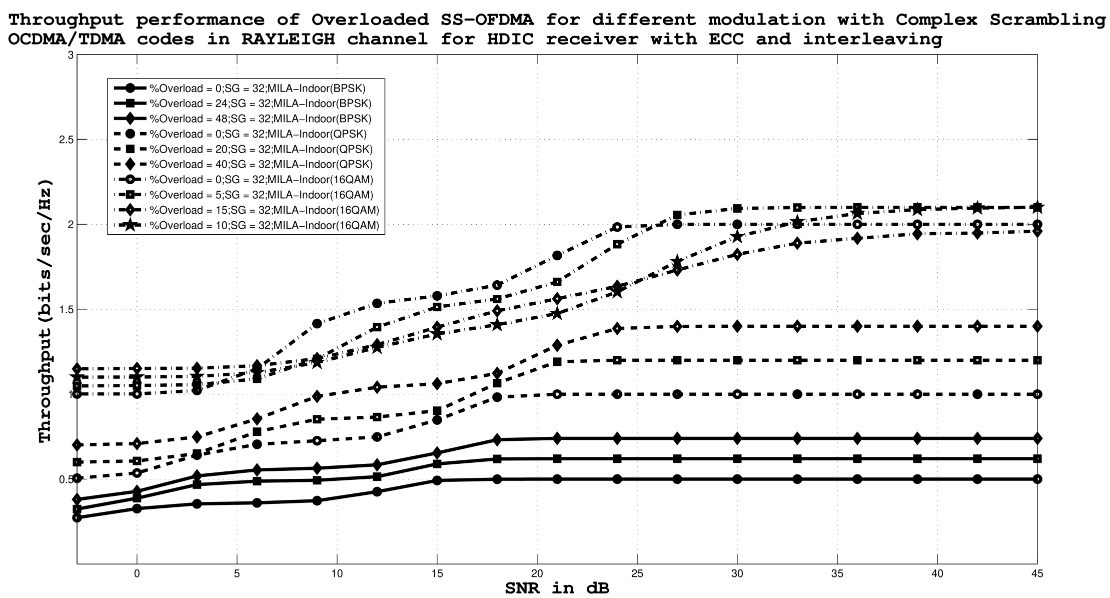

Fig 3: Throughput Performance of Overloaded SS-OFDMA in Outdoor scenario with More Interleaving

Table 1.1. SNR requirement of Overloaded SS_OFDMA for SG 32,128,256 in MILA indoor Scenario

BPSK						QPSK						16-QAM					
0% Overload			5 % Overload			0% Overload			5 % Overload			0% Overload			5 % Overload		
32	128	256	32	128	256	32	128	256	32	128	256	32	128	256	32	128	256
15.3	15.4	115.7	18.4	18.2	18.6	18.5	18.6	19.4	20.8	20	21.2	24.1	25	24.3	29	27.8	28.6

Table1.2 SNR requirement of Overloaded SS-OFDMA to achieve maximum Throughput in MILA indoor scenario

BPSK			QPSK			16-QAM		
0%	24%	48 %	0%	20%	40%	0%	5 %	10 %
18. 8	20. 6	21	20. 9	23. 6	26. 8	26. 7	33	

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