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Efficient Allocation of Power Resource in OFDMA Systems with Diverse Modulation Techniques

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ABSTRACT: Of late there is an utmost need for providing higher data rate and better Quality of Service(QoS) for ever increasing number of users in wireless communication systems. The Orthogonal Frequency Division Multiplexing (OFDM) is one of the leading candidates for future wireless communication systems. This paper gives a brief introduction about OFDMA and discusses in depth about allocation of power resource to all the active users present in a cellular network in an optimum way using the Load Matrix approach. Load Matrix approach is used to calculate the average interference within the cells based on RoT (Rise over Thermal noise) and distribute minimum required SINR to each user thereby enhancing the Quality of Service (QoS) of the network. The approach is first experimented on a single carrier communication system and then it is extended to multi-carrier systems. This paper also deals with the performance of a communication link in terms of BER for various digital modulation techniques. From simulations it is observed that performance of QAM is better than QPSK in systems implementing OFDMA.

KEYWORDS: OFDMA, RoT, SINR, Resource Allocation, Load matrix approach, QPSK, QAM.

I.INTRODUCTION

In recent years high data rate techniques have gained considerable interests in communication systems. In a basic communication system, the data is modulated onto a single frequency. The available bandwidth is then totally occupied by each symbol. These kinds of systems can lead to Inter-Symbol- Interference. The basic idea of orthogonal frequency division multiple access(OFDMA) is to divide the available spectrum into several orthogonal sub channels as a result of which each narrow band sub channel experiences almost flat fading. It is a flexible multiple access technique that can accommodate many users with widely varying applications, data rates, and QoS requirements. Dynamic and efficient bandwidth allocation is possible using this technique. This technique also allows sophisticated time and frequency domain scheduling algorithms to be integrated in order to best serve the user population. OFDMA can be seen as either a modulation technique or a multiplexing technique. One of the main reasons to use OFDMA is to increase the robustness against frequency selective fading or narrow band interference.

Using multiple transmit and receiving antennas for communication system design has been the present and rapidly budding trend among various upcoming technologies being introduced in wireless communication to improve spectral efficiency and link reliability. Increase in bandwidth is generally required to meet the ever increasing demand for higher data rates, better Quality of Service, high network capacity. But owing to the fact of spectral limitations and expense of increasing the available bandwidth, use of multiple transmit and receive antennas for increasing the spectral efficiency provides the best possible alternative. It is proven that a multi-carrier system can improve the capacity of a communication system by a factor of minimum number of transmit and receive antennas. Multi-carrier systems in general are employed for two main reasons. They are to achieve Transmit Diversity and to form a multi-carrier communication model. Transmit diversity is based on space-time coding. Space-time coding enhances system performance and improves efficiency in a promising way. But, space-time coding becomes more complex with increase in bandwidth. Hence we opt multi-carrier system with space-time coding to reduce ISI caused due to multi path propagation. In this paper, multi-carrier systems with optimal utilization of power resource are modelled. In this paper the allocation of power resource in an OFDMA cellular system based on SINR and available power resource is outlined as Load Matrix approach. This concept has the facility to joint management of interference within a cell while allocating radio resources to users and this concept intakes Inter Cell Interference information. Next, using this Load

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Matrix approach the performance of a communication link in terms of BER is evaluated for various digital modulation techniques. This paper is organized into V sections where in section I gives introduction and allocation of power resource using Load Matrix approach is dealt with in section II. Section III gives about the system model that has been taken into consideration while results and discussion and conclusions are made in sections IV and V respectively.

LITERATURE SURVEY

Although, the studies and system based on the concept of orthogonal frequency division multiple access have been publishing since 1958, the most of the application using current form of OFDMA developed during 1980s and 90s. There is a lot of research on allocation of power resource in single carrier systems. Whereas this paper discusses efficient allocation of power resource in multi carrier communication systems with QPSK and QAM modulation techniques.

II. ALLOCATION OF POWER RESOURCE USING LOAD MATRIX APPROACH

Resource allocation is the greatest challenge in present day wireless cellular systems. The installation of multiple base stations to provide services result in certain phenomena that needs to be correctly addressed for proper operation of the wireless network. By power control, means the algorithms, protocols, techniques that are employed in a wireless network to dynamically adjust the transmit power of either mobile station or base station for reducing co-channel interference as co-channel interference limits the capacity of a cellular network. Assuming that systems are interference limited ,an optimized approach can be implemented to maximize the minimum SIR in the system and minimize the maximum SIR in system, thereby equalizing the SIR of all radio links. Although it provides an optimal solution ,this scheme is extremely hard to implement because the centralized controller has to dynamically keep track of all the links in the sysem and compute the transmit powers for each mobile terminal.Hence an efficient resource allocation is one of the greatest challenges in wireless cellular communication. The resource allocation schemes avoid the wastage of the resources by allocating resources to a mobile terminal over a short period of time and providing quality of sevice over wireless networks which is the most stressing point for service providers. The majority of current systems are interference limited rather than noise limited. Interference is part of every mobile cellular communications system, and it constitutes a limitation to both radio network capacity and Quality of service provided to users . Intercell interference is managed via averaging of the effects of multiple interferers. It is more effective in the uplink than in the downlink. Interference averaging also allows statistical multiplexing of bursty users, thus increasing system capacity.

The Load Matrix (LM) concept has the facility to joint management of interference within and between cells while allocating radio resources to users and this concept proposed intakes the inter-cell interference information into account in order to avoid RoT outage. Resource allocation is to allocate power and bandwidth to each user by calculating number of active users in the network .This is done by the Load Matrix approach. In a multi-cell system one of the main challenges in resource allocation is the control of Inter-Cell Interference. LM is a centralized scheduler, uses a database containing the load contribution of all active users in the network and it assigns radio resources to all active users in the network. The basic problem in the uplink scheduler is to assign appropriate transmission rate and time to all active users, resulting in maximum radio resource utilization across the network while satisfying the QoS requirements of all the users. The important factor in the resource allocation is the users transmit power. The constraints to be satisfied to implement Load Matrix approach for a network of M users and N cells are

Constraint1: This constraint states that the maximum user power $P_{i,max}$. For each active user i in the network, its transmit power P_i must be maintained in an acceptable region defined

$$0 \le p_i \le p_{max} \quad i \in \{1,\ldots,M\} \tag{1}$$

Constraint2: The total received power at base station should be kept below a certain threshold for all N base stations in the network. It uses Rise over Thermal noise (RoT) to represent the interference constraints.

$$RoT_j \le RoT_{target} \quad j \in \{1,\ldots,N\} \tag{2}$$

RoT_j is the total in band received power fixed target value to maintain uplink interference level at the base station j (BS_j) over thermal noise. The RoT_j for M active users in the network given below is used to estimate RoT of cells, can be written as

$$RoT_j = (N' + \sum_{i=0}^{M} p_i G_{ij})/N' \tag{3}$$

Constraint3: The signal to noise plus interference ratio required at the serving base station j if rate k is being assigned to the user to achieve a given frame error rate is $SINR_{target,k}$. For each user, depending on its channel type

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and speed, each rate k has a minimum required SINR called $SINR_{target,k}$. This constraint satisfies only by considering $SINR_{target,k}$ as SINR.

$$SINR_{i,j} \geq SINR_{target,k} \quad (4)$$
$$i \in \{1,., M\},\ k \in \{1,\dots,k\}$$

LM scheduling can be implemented in both centralized and decentralized strategies. In a centralized scheduling the entity assigns radio resources to all the base stations and subsequently to all the users in the network where as in decentralized scheduling each base station is implemented with identical LM scheduling. A centralized scheduler assigns radio resources to all the M users and N cells in the network, $LM_{i,j}$ is the load factor contribution by user i at BS_j defined as

$$LM_{i,j} = \frac{p_i G_{ij}}{\sum_{m=1}^{M} p_m G_{mj}} \quad (5)$$

Where G_{ij} is the channel gain from user i to BS_j averaged over scheduling period, N' is the thermal noise and P_i is the transmitted power. The $LM_{i,j}$ values stored in column j of LM database, RoT of cell j can be written

$$RoT_j = \frac{1}{1-\sum_{i=1}^{M} LM_{i,j}} \quad (6)$$

$SINR_{i,j}$ can be written as

$$SINR_{i,j} = \frac{p_i G_{ij}}{N'ROT_j - p_i G_{ij}} \quad (7)$$

The required transmitted power for user i at rate 'k' is

$$P_{i,k} = \frac{N' RoT_j}{G_{ij}} \cdot \frac{SINR_{target,k}}{1+SINR_{target,k}} \quad (8)$$

If above all constraints are satisfied then only power $P_{i,k}$ is acceptable and user i will be scheduled for transmission. Later, the LM elements are updated and RoT is calculated for each cell. The performance of the LM scheduling has the best RoT over other algorithms because this scheduler significantly reduces the probability of the RoT exceeding its target. The RoT is computed over a single carrier system. For modelling this approach in multi-carrier system a modified model of resource allocation called Multi Cell Load Matrix approach is used.

MULTI CELL LOAD MATRIX APPROACH

While modelling for a multi carrier communication system it has to be considered that the signal to interference ratio is affected distinctly in each carrier. Hence a single SINR is not optimal for allocation. To obtain optimization of power allocation in multi carrier system here a diverse approach of SINR based on bifurcated SNR and SIR is proposed. In this approach the signal to interference noise ratio is considered as a combination of original SNR and SIR defined by the equation.

$$SINR = \left(\frac{1}{SNR} + \frac{1}{SIR}\right)^{-1} \quad (9)$$

When $SNR = Po/\sigma_{bn}^2$ denotes background signal to noise ratio while $SIR = \frac{p_o}{\sum_{i=1}^{N_i} p_i}$ is the signal to interference ratio. By considering above term into SINR for conventional LM approach, the propose SINR gets modified as

$$SINR_{i,j} = \frac{p_i G_{ij}}{N'ROT_j - p_i G_{ij}} + \frac{p_o}{\sum_{i=1}^{Ni} p_i} \quad (10)$$

The required transmitted power for each user i at K^{th} carrier is defined as

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$$P_{i,k} = \frac{N'RoT_j}{G_{ij}} \cdot \frac{SINR_{target,k}}{1+SINR_{target,k}} \quad (11)$$

The allocable power to each user at Kth carrier is then defined as:

$$P_{alloc} = p_{i,k}\ ,\ \text{if SINR} < p_{i,k} \quad \text{else } p/k \quad (12)$$

where' k' is number of carriers allocated in a multi carrier system.

III.SYSTEM MODEL AND ASSUMPTIONS

To design a multi-carrier system for test evaluations a multi carrier system with four transmit and p ($p\geq4$) receive antennas is developed as shown in Fig.1.

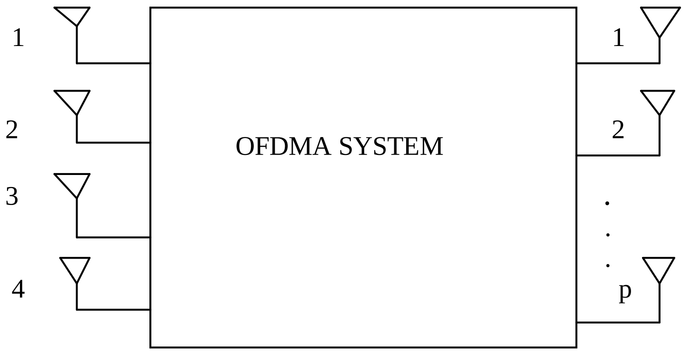

Fig.1 OFDMA System model

At one time of forwarding, data blocks were generated defined as, $\{b_i[n,k]:k=0,1,\ldots\}$ for i=1 and 2, is transformed into two different signals, $\{t_{2(i-1)+j[n,k]}:k=0,1\ldots j=1,2\}$ for i=1 and 2,respectively, through two space-time encoders. The signal for the i^{th} transmitting antenna is modulated by $t_i[n,k]$ at the k^{th} carrier of the n^{th} data block. The receiver signal at each receive antenna is the superposition of four distorted transmitted signals, which can be expressed as

$$r_j[n,k]=\sum_{i=1}^{4} H_{ij}[n,k]t_i[n,k] + w_j[n,k] \quad (13)$$

For j=1.........p

Where $w_j[n,k]$ denotes the additive complex white Gaussian noise at the j^{th} receiver antenna, and is assumed to be zero-mean with variance σ_n^2 and uncorrelated for different n's,k's, or j's. $H_{ij}[n,k]$ denotes the channel frequency response for the k^{th} tone at time n, corresponding to the i^{th} transmit and the j^{th} receive antenna. And during the transmission process, the signals are allocated with multiple power levels to transmit power effectively for optimal usage of this resource which is called 'resource allocation' and it is done basing on Load Matrix Approach which was discussed in the earlier sections of this paper.

IV RESULTS AND DISCUSSION

For the evaluation of the load matrix approach a communication system with a Rayleigh fading channel and different modulation schemes at the transmitter and the corresponding demodulation schemes at the receiver are considered. Simulations are carried out for a channel count of 3,5 taking into account the most efficient modulation schemes for OFDMA like QAM and QPSK. The system is validated for the SNR variation of -4dB to 14dB for an AWGN channel. The user's information of 1200 bits are considered for each user and a carrier frequency of 2GHz is considered in compliance with 3GPP, LTE model. The simulation observations for various modulation techniques under different channel conditions are shown in Fig.2-5.

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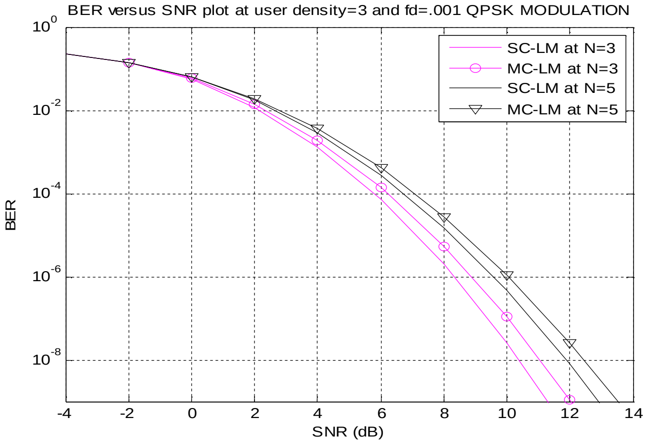

Fig.2 BER versus SNR plot at user density=3 and fd=0.001using QPSK modulation

Fig.2 is a plot between SNR and BER for both single carrier and multi carrier systems, for an user density=3 and fading factor (fd)=0.001 using QPSK modulation. It is clear that for QPSK modulation, with an increase in SNR there is a considerable decrease in BER which is due to the presence of multiple channels. The presence of multiple channels reduces SINR which acts as a base for allocating optimum power to each user and also as a platform for allocating more number of users in a given network. The BER for single carrier system is 0.02x10^{-6} and BER of 0.1x10^{-6} for multi carrier system at SNR=10 and N=3 is achieved.

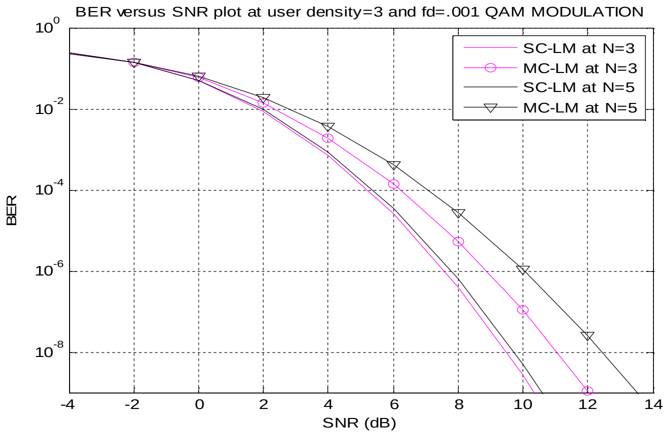

Fig.3 BER versus SNR plot at user density=3 and fd=0.001using QAM modulation.

Fig.3 is a plot between SNR and BER for both single carrier and multi carrier systems, for an user density=3 and fading factor (fd)=0.001 using QAM modulation. It is clear that for QAM modulation, with an increase in SNR there is a considerable decrease in BER which is due to the presence of multiple channels. The presence of multiple channels reduces SINR which acts as a base for allocating optimum power to each user and also as a platform for allocating more number of users in a given network. The BER for single carrier system is 0.001x10^{-6} and BER of 0.1x10^{-6} for multi carrier system at SNR=10 and N=3 is achieved.

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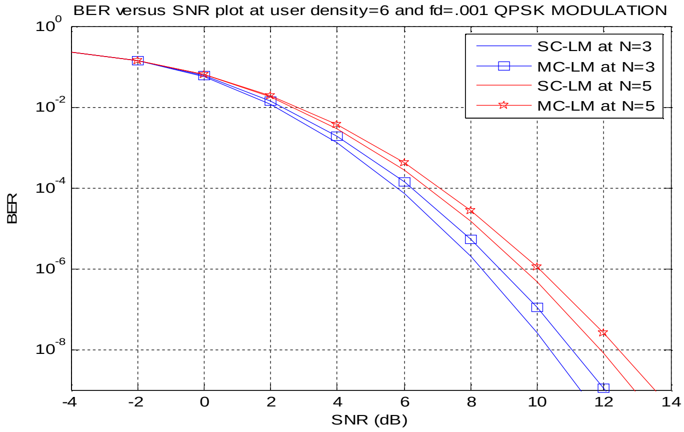

Fig.4 BER versus SNR plot at user density=6 and fd=0.001using QPSK modulation.

Fig.4 is a plot between SNR and BER for both single carrier and multi carrier systems, for an user density=6 and fading factor (fd)=0.001 using QPSK modulation. It is clear that for QPSK modulation, with an increase in SNR there is considerable decrease in BER which is due to the presence of multiple channels. The presence of multiple channels reduces SINR which acts as a base for allocating optimum power to each user and also as a platform for allocating more number of users in a given network. The BER for single carrier system is 0.02x$10^{-6}$and BER of 0.1x10^{-6} for multi carrier system at SNR=10 and N=3 is achieved.

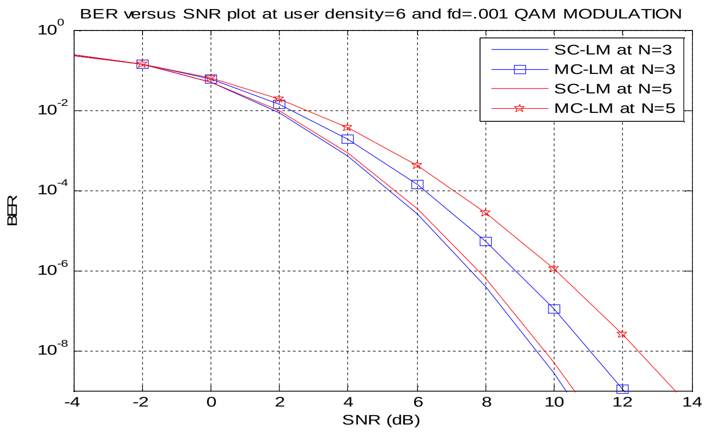

Fig.5 BER versus SNR plot at user density=6 and fd=0.001using QAM modulation.

Fig.5 is a plot between SNR and BER for both single carrier and multi carrier systems, for an user density=6 and fading factor (fd)=0.001 using QAM modulation. It is clear that for QAM modulation, with an increase in SNR there is considerable decrease in BER which is due to the presence of multiple channels. The presence of multiple channels reduces SINR which acts as a base for allocating optimum power to each user and also as a platform for allocating more number of users in a given network. The BER for single carrier system is 0.001x10^{-6} and BER of 0.1x10^{-6} for multi carrier system at SNR=10 and N=3 is achieved.

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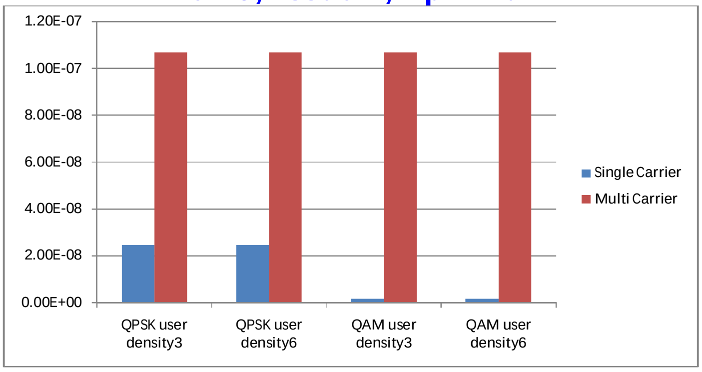

Fig.6 BER for single carrier and multi carrier at SNR=10 and N=3

Fig.6 compares the value of BER for single carrier and multi carrier with QPSK and QAM modulation techniques at SNR=10 and N=3. From simulations it is observed that almost equal BER is achieved at SNR=10 for multi carrier systems using QAM and QPSK modulation techniques. For single carrier systems BER using QPSK modulation technique is $0.02x10^{-6}$ and BER of $0.001x10^{-6}$ is achieved using QAM modulation technique. Thus QAM is better than QPSK for single carrier systems.

V. CONCLUSION

By adapting OFDMA it is made possible to cater the performance of future wireless communication systems. From simulation results it is observed that even if number of users are increased, by a corresponding increase in number of channels the BER can be reduced for an optimum SNR itself. This approach of Load Matrix decreases the required power to each user by reducing the SIR which in turn is due to the increase in number of channels considered thereby accommodating more number of users in the network. Thus the performance of Load Matrix approach for various channel cases is efficient. Implementation of OFDMA technology provides multi caller video conferences without any speech or video delay, watching HD videos without any buffering and online applications at a faster rate. OFDMA increases the capacity and QoS of the network thus overcoming the major drawback in present wireless communication systems. For single carrier systems BER using QPSK modulation technique is $0.02x10^{-6}$ and BER of $0.001x10^{-6}$is achieved using QAM modulation technique.

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