SC-FDMA System with Enhanced Channel Capacity using SVD and Eigen vectors

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***Abstract* - The growing demand on wireless communication service has created the necessity to support higher data rates for multimedia services. .As next generation wireless communication networks are expected to provide broadband multimedia services such as voice, web browsing, video conferencing etc. For high data rate achievement one must enhance the capacity of the wireless communication system. The capacity of a communication system can be enhanced by using OFDM system. OFDM is commonly used for communication system due to its high transmission rate and robustness against multipath fading So as to enhance the capacity of fading channels the OFDM system are combined to form hybrid system. Capacity is the measure of maximum information that can be transmitted reliably over a channel. In this paper, the comparison was done between the OFDM system and SCFDMA system, and the better results were obtained by SCFDMA system. The capacity was measured using both SVD decomposition method and Eigen vectors.**

***Index Terms* - OFDM (Orthogonal Frequency Division Multiplexing), Singular value decomposition, Water Filling Algorithm**

I. INTRODUCTION

As wireless multimedia applications become more widespread, request for higher rate of data is superior to usage of a broader transmission bandwidth. With an expanded transportation bandwidth, frequency discrimination of the channel becomes harsher and thus the difficulty of inter-symbol interference (ISI) eventually more severe. In a traditional single carrier transmission system, time concern equalization in the pattern of tap delay line refining is carried out to remove ISI. However, supposing wide band medium, the duration of the time domain filter to accomplish equalization becomes intensively large since it linearly increments with the channel response duration. The way to mitigate the frequency-selective fading seen in a wide band channel is to use a multicarrier technique which subdivides the entire channel into smaller sub-bands, or subcarriers. Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation scheme which utilizes orthogonal subcarriers to transmit information. In the frequency field, since the frequency range of a subcarrier is planned to be shorter than the coherence frequency range, every sub channel is observed as a flat fading medium which facilitates the channel equalization method. In the time concern, by dividing stream of data with high-rate into a sum of minor data rate streams that are transported in parallel, OFDM determines the difficulty of ISI in broad band transmissions [1]. But OFDM has its disadvantages: High peak-to-average power ratio (PAPR), high sensitivity to frequency offset, and a need for a robust or coded strategy to defeat spectral or spiritual nulls in the channel [2], [3].Single carrier frequency division multiple access (SCFDMA) which utilizes single carrier modulation at the transmitter and frequency domain equalization at the receiver is a method that has analogous performance and approximately the similar complete design as those of an OFDMA systems. SC-FDMA has drawn extreme attention as an interesting alternate to OFDMA; exclusively in the uplink transmissions where reduced PAPR considerably advantages the mobile extreme such as transmit power capability. Considering a time deviating channel, we require a basic algorithm that adaptively adapts transmit specifications for huge capacity. System capacity can be further enhanced by using water filling algorithm, singular value decomposition and many other techniques which considerably enhances the capacity of the wireless communication system. SVD (Singular Value Decomposition) scheme decouples the channel form in spatial concern. OFDM systems are best choice for increasing the capacity of wireless communication system because of characteristics like reduced ISI, reduced ICI (Inter carrier interference), optimized power consumption and easy transmission of symbol in time, frequency and space .In this we are focus on high rate of data for wireless transmission due to such advantages as inter-symbol interference (ISI) free communication, large spectral efficiency, and declined equalization complication. The paper depicts that OFDM and SC-FDMA system with SVD and Eigen vector and water filling algorithm. Moreover, the BER of both the systems has been improved by using Alamouti codes.

II. RELATED WORK

L. S et.al[1] had proposed the iterative water filling algorithm to enhance the channel capacity of MIMO OFDM system. The simulation had been carried out on MATLAB 2010a using different antenna arrangements over Rayleigh, Rician and Nakagami fading channels. Moreover bit error rate (BER) performance of MIMO OFDM system had been compared over different modulation schemes.

R. Hidayat et.al[2] had proposed channel estimation for spatial multiplexing was investigated for MIMO OFDM system. Pilot symbols were used to gather knowledge about the channel and attempt to evaluate it. The channel assessment located on pilot symbol is called pilot supported channel evaluation. In that research, Least Square (LS) mechanism was preferred for beginning channel estimation. Zero Forcing (ZF) algorithms were adopted to identify and isolate the obtained signal. The outcome shows that channel estimation promising better by enhancing SNR.

H. Deshmukh et.al[5] had implemented water filling algorithm for allocating power to the MIMO channels for enhancing the capacity of the MIMO network. The water filling algorithm had provided solution with the help of channel state information. The singular value decomposition and water filing algorithm had been employed to measure the performance of MIMO OFDM integrated system.

Md.Rahim et.al[11] had presented the singular value decomposition and water filling algorithm had been employed to measure the performance of MIMO OFDM integrated system. Therefore, the capacity was enhanced by transmitting dissimilar streams of data over distinct antennas at equal carrier frequency. Each Inter Symbol Interference (ISI) produced after the transmission was recovered by using spatial sampling integrated with signal processing algorithm.

H.Wang et.al[6] had proposed optimal cooperative water filling algorithm for power allocation in OFDM system. The transmitter first cooperates by sharing CSI (channel sate information) and then jointly optimizes power allocation in the metric of sum throughput, which could be modeled as a convex optimization problem. Based on the solution, the optimal cooperative power allocation algorithm was constructed, the structure of which could be explained as a cooperative water filling relative to the traditional water filling.

III. PROBLEM FORMULATION

Capacity is the measure of maximum information that can be transmitted reliably over a channel. Channel capacity enhancement is to increase the capacity of a channel in terms of power, bandwidth and complexity. It is enhancement in the data rate at which a signal is sent over a communication channel. As we need to minimize the energy consumed by the circuit and want to maximize the capacity of a system and that is possible only if we use OFDM system. OFDM is a famous wireless multicarrier communication scheme as it provides a great support for wired as well as wireless systems. The basic principle behind OFDM is to divide the high data rate stream into several numbers of subcarriers. Due to the lower data rate of subcarriers, the symbol rate is increased and thereby the dispersion caused by the multi path propagation is decreased [11]. The othogonality of all the subcarriers make the interference negligible. Many algorithms are conventionally used for channel capacity enhancement which gave efficient results. In the conventional techniques numbers of antennas were employed for transmitting and receiving different data stream bits which increased the system cost. Since, technique of OFDM has become old now, the problems of using this technique in channel capacity enhancement arose and the need of the hour is to overcome these problems using a different approach from the conventional systems so that the efficiency of the system can be increased. The conventional techniques were also disregarded because the capacity of MIMO systems also needed hike so that the problems faced in the earlier techniques can be overcome and a better and efficient system can be designed.

IV. OBJECTIVES

1. Capacity enhancement of MIMO OFDM system using multiple water filling approach.
2. To Extend or upgrade system from OFDM to SCFDMA.
3. Comparison between OFDM system and SCFDMA system channel capacity.

V. PROPOSED WORK

The capacity and coverage of Many Input Many Output Orthogonal Frequency Division Multiplexing schemes can be improved by operating a suitable radio resource distribution to select the feasible resources in a commercial way for multiuser atmosphere. For adequate distribution of the power to the MIMO carriers as well as to improve the capacity of the MIMO system by using water filling algorithm. The achievement of MIMO-OFDM has been calculated utilizing Singular Value Decomposition as well as water filling algorithm. With water-filling algorithm the capacity and SNR performance for system has also been displayed here for the approximate analysis. Distinct modulation methods are executed in this work for the authentication of performance of suggested scheme. In the previous enhancement techniques OFDM system was used in which MIMO capacity was enhanced using SVD decomposition in which the values were in the form of direct vectors. In the new proposed technique in place of OFDM system, SCFMDA system is used, and in the place of using SVD decomposition, the vector values are first sorted so that the allocation of power can be justified i.e. the lower values can be allocated the higher power. Sorting the values in a vector will also decrease the complexity of the system. In the new approach water filling algorithm is not used in OFDM systems but in SCFDMA systems and the values are taken in the form of Eigen vectors. This Eigen vector is then sorted for decreasing the complexity. The sorting of the vectors helps in allocating power according to the need, this saves power wastage and makes the system more efficient.

VI. OFDM

Second and third generation mobile systems are based on either TDMA or CDMA technologies. Although these technologies can theoretically be extended to next generation broadband wireless systems, practical implementation issues and complexities limit their acceptance. On the other hand, OFDM offers an easier solution and practical implementation. However, OFDM is not without its issues. OFDM has become a most favored technique for broadband wireless system due to susceptibility to signal dispersion under multipath conditions. Unlike other modulation techniques that operate symbol by symbol, OFDM transmits a block of data symbols simultaneously over one OFDM symbol. The time used to transport all subcarriers is known as an OFDM symbol and the subcarriers are modulated by the block of input data symbols. The baseband modulator transforms the input binary bits into a set of multi-level complex numbers that corresponds to different modulations formats such as BPSK, QPSK, 16- or 64-QAM. The forms of modulation scheme used generally rely upon the signal-to-noise equivalent of the received signal and the receiver capability to decode them accurately. The symbols whish are modulated and suddenly mapped to subcarriers. An inverse-FFT (IFFT) is used to convert the modulated sub-carriers in frequency domain to time domain patterns. It is feasible to have distinctive modulation schemes by multiple subcarriers, and it is absolutely beneficial in rough and time varying channel situations. In a broadband arrangement, the channel over its large system bandwidth is frequency selective; signifies the signal fading on every sub-carrier is separate. The interference constant on every subcarrier can also be distinctive and alter individually with time. It results in a distinctive Signal-to-Noise Ratio on each of the subcarriers. Hence, having a convenient modulation scheme on these subcarriers would help to increase the complete system throughput. OFDM system acquires an adaptation of modulation schemes to each of the subcarriers rely upon channel situations, and this is called Channel-dependent arranging. A cyclic prefix block imitates a fraction of the samples at the point of the time domain samples section (at the IFFT output) to the beginning. Since the DFT/FFT results are at fixed intervals in theory, replicating the samples to the introduction will create the signal steady. The duration of the cyclic prefix relies upon the channel delay spread, and is alternatively longer than the duration of the channel feedback. At the receiver side, the prefix portion of the symbol is removed away as it may consist of ISI from its former symbol. Hence, it removes the effect of ISI produced by the multipath signal propagation. Though, the prefix is responsibility in an OFDM system, as it does not conduct any valuable information.

a) OFDM to SC-FDMA

The main difference between OFDM and SC-FDMA transmitter is the DFT mapper. After mapping data bits into modulation symbols, the transmitter groups the modulation symbols into a chunk of N symbols. An N-point DFT converts these symbols in time field into frequency field. The frequency domain patterns are suddenly mapped to a fragment of M subcarriers where M is usually greater than N. Similar to OFDM, an M-bit IFFT is well-known to produce the time-domain segments of those subcarriers, which is followed by cyclic prefix, parallel to serial converter, DAC and RF subsystems.

b) Frequency Spread OFDM

Each data symbol is DFT transformed since averaging to subcarriers thus the SC-FDMA is named DFT-pre-coded OFDM. In a standard OFDM, every data type is transported on independent subcarrier. In SC-FDMA, numerous subcarriers transmit every information symbol due to mapping of the symbols’ frequency domain samples to subcarriers. As every data symbol is transmitting over numerous subcarriers, SC-FDMA proposes extensive gain or range of frequency gain in a frequency selective channel. Thus, SC-FDMA can be viewed as frequency-spread OFDM or DFT-spread OFDM.

VII. SC-FDMA MODULATION

It is a Single Carrier with Frequency Division Multiple Access technique (SC-FDMA), encouraging design for high rate of data uplink transmission and has been selected by 3GPP for it upcoming production of cellular system, named Long-Term Evolution. SC-FDMA is an altered scheme of OFDM with analogous throughput performance and complication. This is regularly observed as DFT-coded OFDM at this place time-domain data patterns are transformed to frequency concern through a discrete Fourier transform (DFT) since running through the basic OFDM modulation. Thus, SC-FDMA acquires all the benefits of OFDM over new well-known schemes like TDMA and CDMA. The major difficulty in continuing GSM TDMA and wideband CDMA to broadband schemes is the increment in complication including the multipath signal reception. The main advantage of OFDM, as is for SC-FDMA, is its robustness against multipath signal propagation, which makes it suitable for broadband systems.

SC-FDMA is a recent multiple access schemes that exploits particular carrier modulation, DFT extent orthogonal frequency multiplexing as well as frequency concern equalization. It has a analogous design and performance as OFDM. SC-FDMA is presently accepted for 3G LTE as the uplink multiple access strategy. The block diagram for SC-FDMA i.e. transmitter and receiver structure for SC-FDMA and OFDM system are given in Figure 7.1 and Figure 7.2. It is apparent from the figure that SC-FDMA transceiver has similar structure as a conventional OFDM system other than the addition of a distinct DFT block since subcarrier mapping. Hence, SC-FDMA can be treated as an OFDM structure along a DFT mapper.

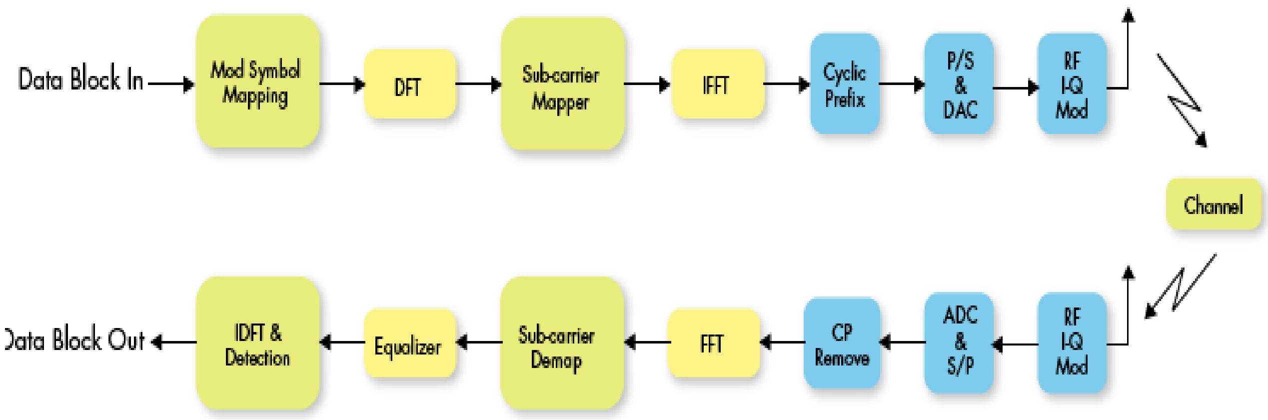

Figure7.1: SC-FDMA with transmitter and receiver

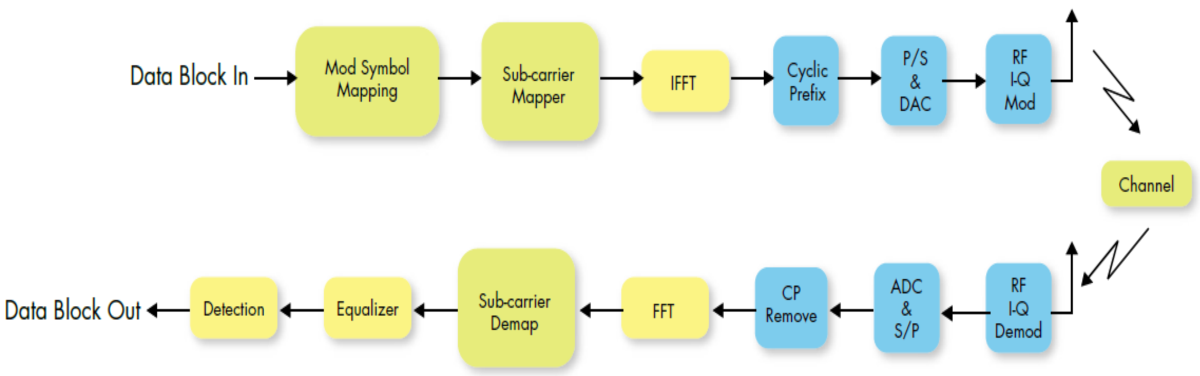

Figure 7.2: OFDM Transmitter and Receiver

VIII. CHANNEL CAPACITY

In this section we deals with the capacity behasvior of wireless MIMO and OFDM based spatial multiplexing systems in broad-band fading environments for the case where the channel is unknown at the transmitter and perfectly known at the receiver. The capacity of the channel is defined as the maximum of the mutual information between the input and the output over all distributions on the input that satisfy the power constraint. In order to achieve the highest channel capacity, when communicating over time-varying Rayleigh fading channels,

- the channel fading information must be known to both the transmitter and the receiver
- the transmitter adapts its transmission power and rate according to the channel state, allocates higher transmission power and rate when the channel condition is good, while reduces the power level and rate when the channel condition becomes worse, and no data rate when the channel SNR reduces to a certain value.

How fast can we transmit information over a communication channel?

Suppose a source sends r messages per second, and the entropy of a message is H bits per message. The information rate is $R = r H$ bits/second. One can possibly analyze that, for a given transmission system, as the information rate raises there will be increment in number of errors per second. The channel capacity of the system makes intuitive sense:

- As the bandwidth of the channel increases, it is possible to make faster changes in the information signal, thereby increasing the information rate.
- As S/N increases, one can increase the information rate while still preventing errors due to noise.
- For no noise, S/N goes to ∞ and an infinite information rate is possible irrespective of bandwidth.

Water filling is the solution of various optimization problem related to channel capacity. Water filling algorithm solves the problem of maximum mutual information between input and output of a channel. Water filling indicates a method by which the capacities for the spatial mediums are adapted depend on the channels growth. The channel with huge gain as well as signal to noise ratio is given more power. The data rate in each sub channel is related to the power allocation by Shannon's capacity formula $C = B \log(1 + SNR)$. Though, considering the capacity as a logarithmic function of power, the rate of data is commonly insensitive to the correct power distribution. The Capacity of a MIMO system is algebraic sum of the capacities of all channels and is given by the formula below

$$\text{Capacity} = \sum_{i=1}^{n} \log_2 (1+ \text{Power Allocated} * H)$$

we have to maximize the total number of bits to be transported.

SIMULATION RESULTS:

Comparison between OFDM & SC-OFDM System with SVD: The effect of water-filling algorithm is reflected in figure, which represents the capacity curve vs snr with different techniques.

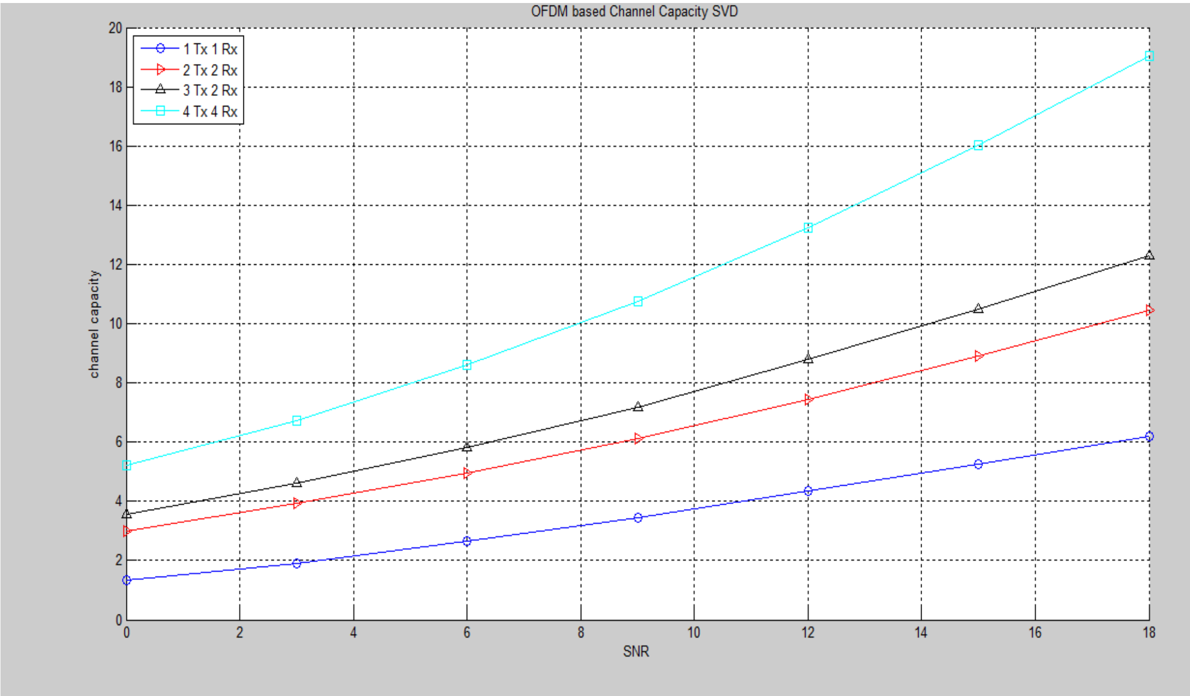

Figure1: OFDM based Channel Capacity vs SNR with SVD

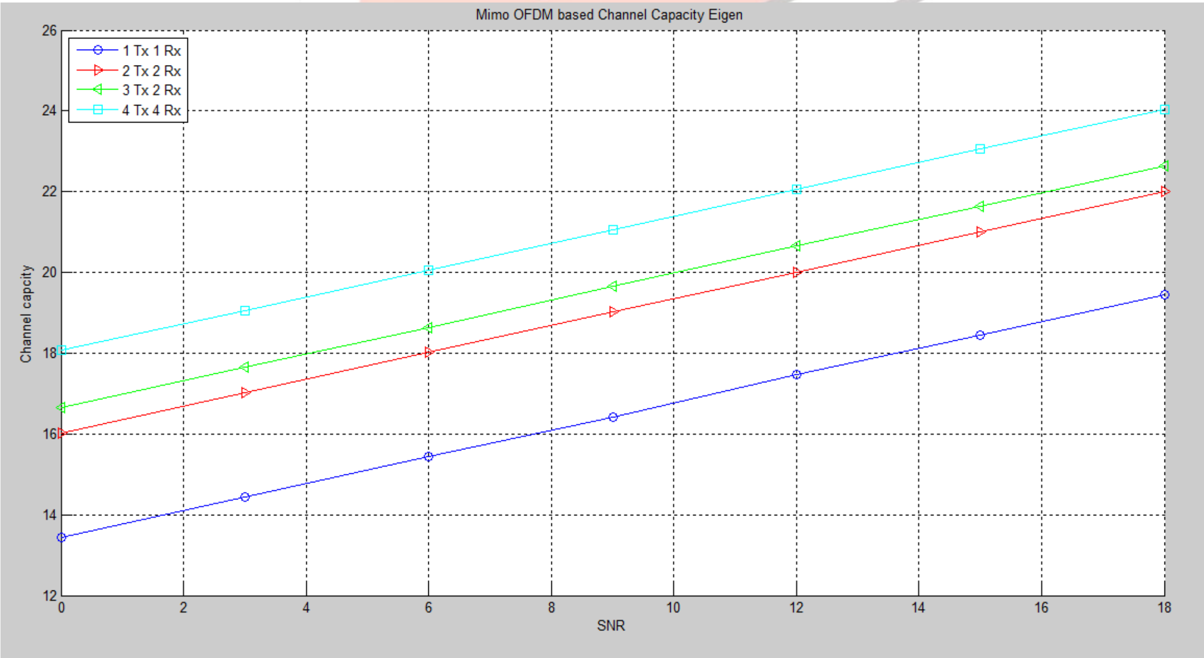

Figure2: OFDM based Channel Capacity vs SNR with Eigen vectors

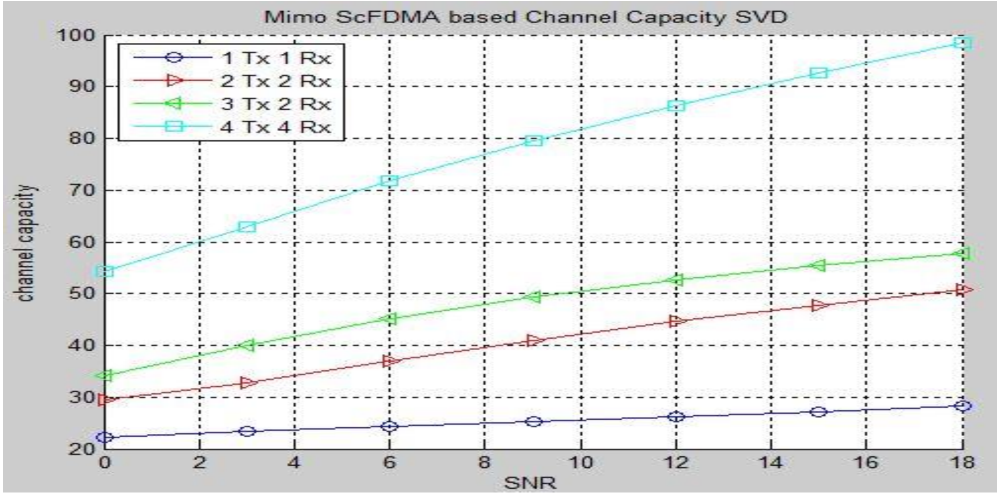

Figure3: SC-FDMA based Channel Capacity vs SNR with SVD

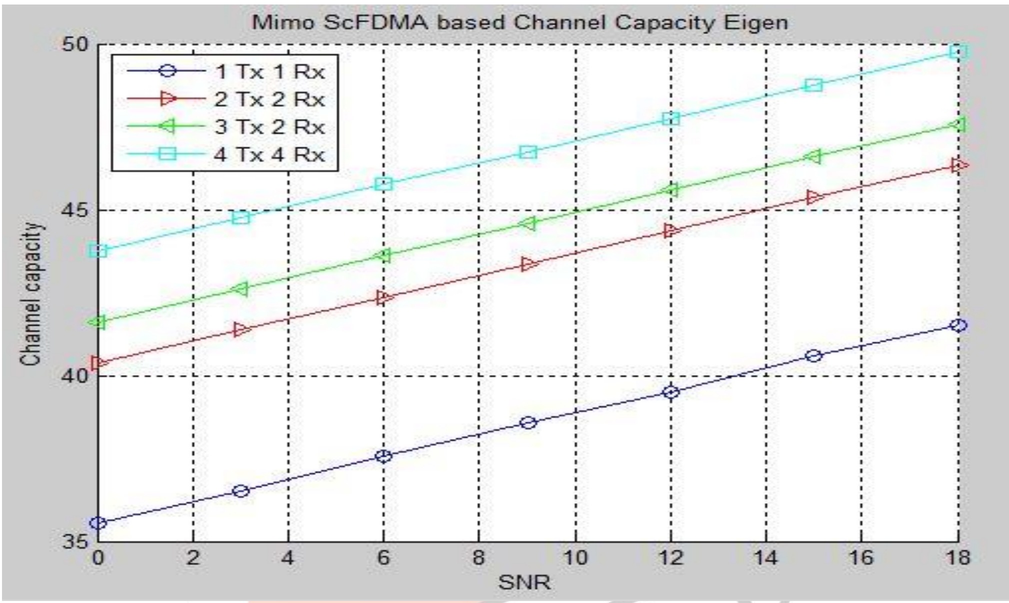

Figure4: SC-FDMA based Channel Capacity vs SNR with Eigen vector

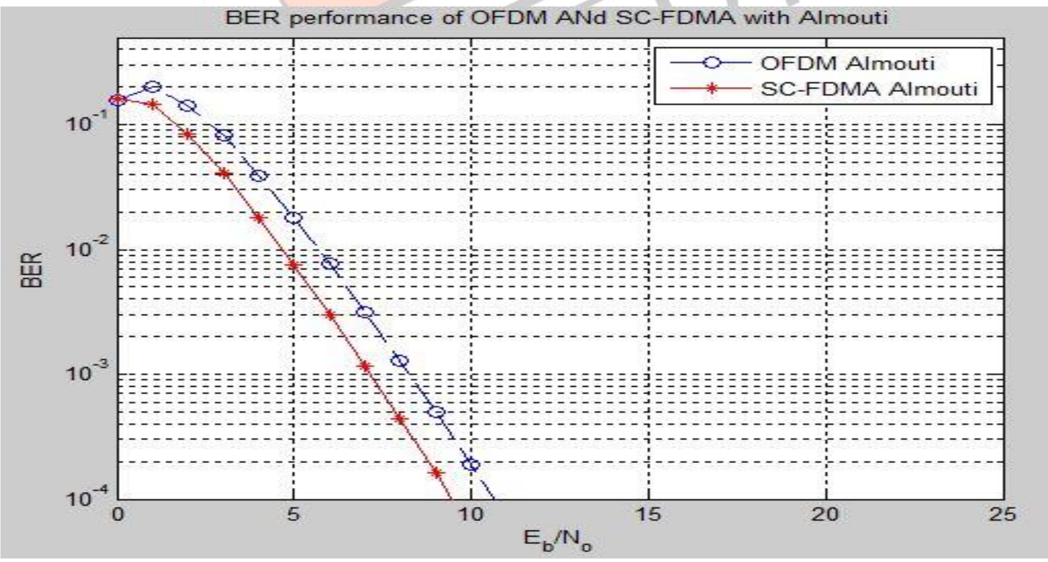

Figure 5: BER of OFDM and SC-FDMA vs SNR with Almouti

CONCLUSION

OFDM is an effective technique to combat multipath delay spread for wideband wireless transmission. In this paper, we concluded from the experimental results that the capacity enhancement with SCFDMA system is better than the capacity enhancement with OFDMA system. The comparison was done between the OFDM system and SCFDMA system, and the better results were obtained by SCFDMA system. The capacity was measured using both SVD decomposition method and Eigen vectors .Results were obtained using SVD decomposition method with the SCFDMA systems. Hence, it was concluded that the new technique in which channel capacity enhancement is done using SCFDMA system with SVD decomposition method yields better and efficient results than the conventional techniques.

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