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Adaptive Resource Allocation using various Smart Antenna Techniques to maintain better System Performance

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Abstract*: *Smart antennas are capable of offering major contribution in improving system performance of orthogonal frequency division multiplexing (OFDM) systems. The OFDM is an air-link technology required for future wireless communication applications to address the technological challenges in fulfilling users demand. The adaptive resource allocation techniques in OFDM systems using smart antennas is an optimistic approach showing light towards developing various methods to improve spectral efficiency with required quality of service (QoS). However, fully adaptive techniques increase the challenges in designing the physical layer with minimum complexity. Now, the challenge is to investigate the possibility of achieving satisfactory system performance without increasing complexity at MAC layer of next generation OFDM systems. In this paper, methodology of designing a hybrid smart antenna system is proposed to achieve required QoS with minimum system complexity.

Index Terms*: *Adaptive resource allocation, Orthogonal Frequency Division Multiplex (OFDM), Quality of Service (QoS), Hybrid Smart Antenna.

I. INTRODUCTION

The main challenge in next generation wireless communication systems is to transmit high data rates using bandwidth efficient techniques. Bandwidth is the limited resource available. Hence, allocating the available resources adaptively is necessary to address the requirements of next generation challenges without costing much at system level. The improvement in the performance of the system is obtained by designing both MAC and physical layers simultaneously. OFDM is the most recommended radio-link technology, even for 5G, due to its ability to support diverse methodologies for time varying environment [1]. The usage of OFDM is globally acknowledged for high speed wireless communication applications. The OFDM is the backbone in building IEEE802.11a/g, and LTE for high data rate applications in terms of simultaneous transmission using many sub-carriers[2][8].

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Nowadays, using smart antenna methods in OFDM systems is considerably improving system performance at the cost of system complexity. Many techniques are proposed by the researchers to achieve required QoS with varying level of complexity. The smart antennas are used in two different modes: Adaptive and Switched-beam [3][4]. Obviously, adaptive smart antennas (ASA) have showed better performance over switched-beam smart antennas (SSA) due to their adaptability. However, ASA are more complex compared to SSA to implement. The successful functioning of adaptive smart antennas is depending upon the many issues related to adaptive beamforming, threshold level (CT) and channel estimation. Particularly, adaptive-beam-forming-algorithms (ABF) increase the computational implications due to their high processing requirements when used in the system. The adaptive beamforming may also increases the interference between the users due to spatial considerations. This introduces more complexity in MAC layer in achieving system performance more than the demand of some applications.

The applications involving voice as input are not demanding high system performance from user perspective. The applications like uninterrupted video streaming are required the support of high system performance with no limit on the system complexity. In this context, there is no need to increase system performance every time at cost of other parameters. These issues are required to be considered before proposing an adaptive antenna arrays in OFDM systems for an application. The patterns of switched-beam smart antennas are selected based on user spatial information whereas adaptive arrays consider all the users in the cell simultaneously in choosing the pattern irrespective of their locations. Hence adaptive arrays need strong channel estimation algorithms to have correct status of the channel. The, switched-beam antennas rely on the spatial-division of users and hence they do not increase complexity as much as that of adaptive antennas [4]. This idea invokes the possibilities of performance improvements with reduced system complexities[6].
This paper, adaptive resource allocation using various Smart Antenna Techniques to maintain better System Performance, discusses the performances of OFDM system with perfect smart antenna, hybrid smart antenna and switched-beam antenna for varying number of users. The perfect smart antenna is the adaptive antenna array (AAA) whereas hybrid smart antenna is the application-based combination of SSA and AAA.

The main objective of this paper is to propose various performance parameters for different combinations of SA in OFDM system[12][13].

II. ADAPTIVE RESOURCE ALLOCATION USING SMART ANTENNAS

The transmitter of OFDM system with provision for using SSA or HAS or AAA to accomplish adaptive resource allocation for different user data rates and chosen modulation technique is shown in Fig. 1.

The users with low and high data rates of different traffic are considered in order to evaluate the capability of adaptive resource allocation (ARA) in OFDM system for selected number of subcarriers and given modulation technique. For a user with voice data, few subcarriers are allocated and modulated with the scheme under test. The beamforming for the modulated data is performed using switched-beam antennas to reduce the complexity as the input voice is of low data rate[10]. For a user with multimedia data, more subcarriers are allocated to ensure high quality reception. For beamforming, adaptive antenna arrays are used to achieve better system performance to ensure expected QoS. The process of incorporation of different smart antenna techniques based on user demand ensures adaptive resource allocation in orthogonal FDM systems. The process is designed in frequency domain. The time-domain waveforms are obtained using IFFT modules. The channel estimation done to consider fading nature of the channel into the operation. The data is transmitted using smart antennas after adding cyclic prefix.

In receiver, the cyclic prefix are removed initially and converted back to frequency domain using FFT. The demodulation is performed to obtain data packets for analysis.

III. SIMULATION ALGORITHM

The steps for simulation of OFDM system[11] shown in Fig. 1 are summarized as follows:

Start:

1. *Generate data packets of different rates*
2. *Select the required number of subcarriers*
3. *Allocate bits*
4. *Perform beamforming based on data rates*
5. *Apply cyclic prefix*
6. *Perform OFDM modulation*
7. *Extract the signals*
8. *Perform OFDM demodulation*
9. *Receive the packets*
10. *Analyze the results*

End

IV. SIMULATION RESULTS

For the simulation of proposed model, the following cases of smart antenna are considered[5]:

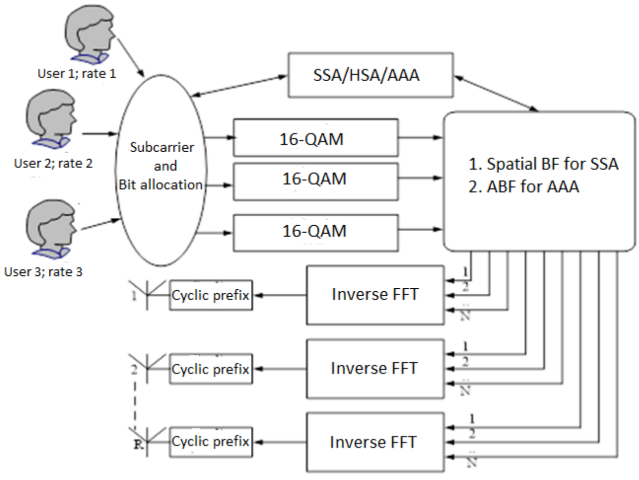

Fig. 1 Block diagram of OFDM transmitter with smart antnnas

1. Switched beam smart antenna with III beams
2. Hybrid smart antenna with III beams
3. Perfect smart antenna with III beams
4. Switched beam smart antenna with VI beams
5. Hybrid smart antenna with VI beams
6. Perfect smart antenna with VI beams

Number of users:	Upto 200
Number of subcarriers:	512
Adaptive modulation:	16 QAM
CSI:	Jake's model[9]
Maximum Doppler shift:	150Hz

The channel characteristics are assumed to be constant over OFDM symbol duration.

The parameters considered for the performance analysis are:

1. The user data traffic
2. Throughput
3. Average packet delay
4. Bit rate

These parameters are simulated against number of users.

The input of different users is taken to generate packets. Based on the input data rate, number of subcarriers are allocated. For voice input, two subcarriers are allocated with one-bit allocation. For video data, 32 subcarriers are allocated. The data is then modulated with quadrature amplitude modulation of 16 levels. The channel condition estimated using Jake's mode[9]l.

At the receiver demodulation is performed using coherent detector to get the output packets. The user data traffic, bit rate, average packet delay and throughput are plotted against the number of users. The simulation results are shown in Fig. 2, Fig. 3, Fig. 4 and Fig. 5.

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V. REULT ANALYSIS

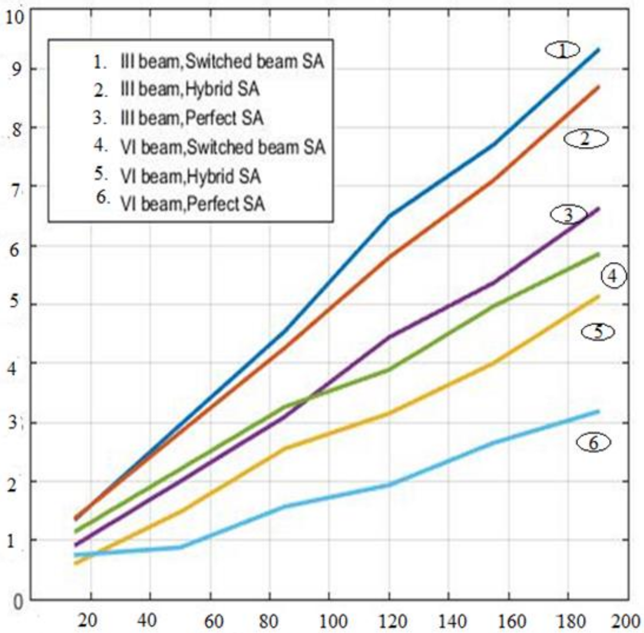

Fig. 2 Normalized user data traffic Vs Number of users

The proposed system is implemented by using MATLAB. The number of users is varied from almost zero to 200.

From Fig. 2, it is evident that the data traffic increases as the number of users in a cell increases. The maximum data traffic is observed for three beam antennas, compared to six beam antennas. As expected, adaptive array antennas are capable of decreasing the data traffic compared to switched beam SA. The performance of hybrid model lies between that of SSA and AAA.

From Fig. 3, high bit rate per user is required for three beam antennas. As number of beams increases required data rate per is user is decreased. It is also true for AAA. Adaptive array antennas (perfect antennas) require less bit rate per user compared to switched-beam antennas.

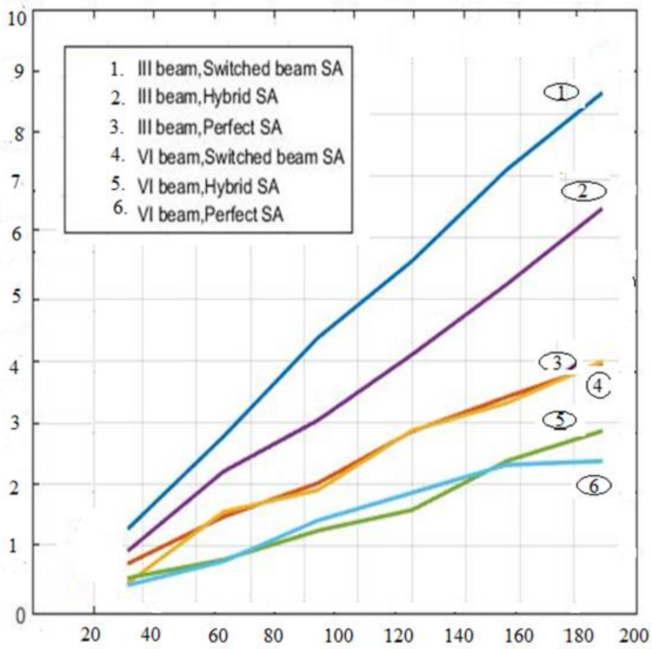

Fig. 3 Bitrate Vs Number of users

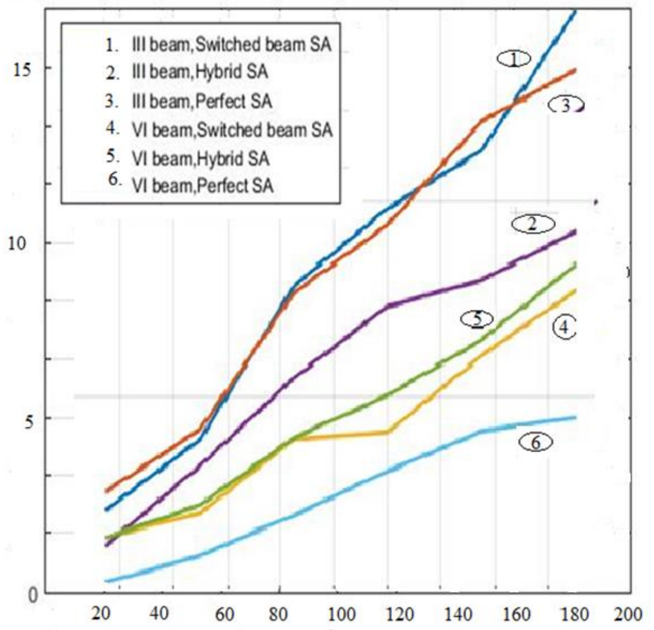

Fig. 4 Average packet delay Vs Number of users

The performance of hybrid model lies between that of SSA and AAA. Hence, hybrid SA is better than switched-beam smart antenna in performance and better than AAA in complexity.

From the simulation results, shown in Fig. 4, it is understood that average delay in packet transmission in three beam smart antennas is more than six beam smart antennas. For transmission using perfect antennas, the average delay is least of all the rest. But, hybrid antennas shows almost same delay as that of switched beam antennas. Hence, adaptive arrays are more suitable for high speed data transmission using OFDM systems.

The Fig. 5 shows that the throughput is almost same for smart antenna techniques irrespective of the number of users in a slow fading environment.

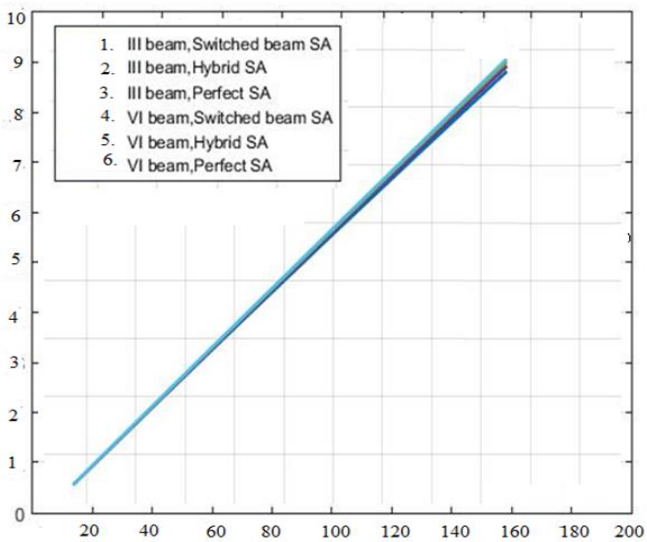

Fig. 5 Normalized packets transmitted Vs Number of users

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VI. CONCLUSION

The OFDM system with smart antennas is capable of increasing system performance in attaining required QoS. The proposed idea proves that hybrid smart antenna comprising of switched-beam and adaptive array is showing better performance than conventional OFDM system with acceptable complexity. The hybrid antenna is better in handling data traffic with lesser bit rate to produce a given throughput for a given number of users. The OFDM system with hybrid smart antenna is recommended for applications demanding transmission of voice data with real-time video streaming. This scheme is recommended over OFDM with adaptive antenna arrays as it provides acceptable performance with lesser complexity.

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