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A Review on : Resource allocation and Routing in MIMO-OFDM Systems

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Abstract— MIMO and OFDM communication systems are one of the prominent technology that is preferred for performing wireless communication now a days. It facilitates the users to communicate at a high capacity which relies upon propagating surroundings. In recent wireless communication trends the resource allocation is one of the major issues. The efficient resource allocation can enhance the system's performance. In recent years various researchers represented the resource allocation in MIMO system and some of them are defined in this work. The objective of this study is to provide an overview to the concept of resource allocation in MIMO networks. The scheduling of various assignments is represented in this study by considering an example of MIMO network. This work also represents the routing and resource allocation in MIMO.

Keywords—MIMO (Multiple Input Multiple Output), Resource Allocation, Scheduling, Routing.

I. INTRODUCTION

Wireless mode of communication and mobile communication systems are significant communication technology of the current era and affect the all parts of the world with socially and economically. The recent status of wireless communication facilitates an expansion of application in comparison to what it was initially. The merging of internet and mobile communication has become a drastic change in communication field as it gives birth to new radio access technology by enhanced coverage area, capacity and latency.
Wireless communication is measured to be one of the rapidly growing parts of the communication technology. Mobile communication faces [1,2].
In last few years, the Cellular communication systems have significant growth. With the help of ordinary techniques and invention of new methods that can attain high bit rates, the increasing demands of end users can be easily attained. Upcoming generation of wireless communication network needs to support the application that require high bit rate like video transmission, voice transmission etc. Mainly there are two types of technologies that have obtained the wide interest to obtain the high bit rates in upcoming generation of wireless network are as follow: first one is Multiple-Input Multiple-Output (MIMO) systems that use more than one antenna at transmitter unit and also at the receiver unit and second one is Orthogonal Frequency-Division Multiplexing (OFDM). Due to frequency selective fading and multipath propagation the bit rates are affected and also various problems are arises like noise and ISI. With the help of Multiple Input Multiple output system in wireless communication system has resulted in improved capacity of transmission [3,4,5]. MIMO uses multipath transmission system and that's why it is beneficial in cellular communication networks. Large numbers of end users can be accommodated simultaneously in one BTS with the help of spatial multiplexing technique.

OFDM is a technology which is meant for 4G implementations. It is a wireless broadband technology with high bandwidth normally up to 20MHz. Thus it supports greater than 1Gbps data transfer rate.
In modulation, Information is mapped onto the variation in frequency, Phase and amplitude of a signal. Multiplexing is used for allocating the users in given bandwidth. OFDM is an approach which is the mixture of modulation and multiplexing.. In this the resources are shareable i.e. shared by the data sources. It uses modulation techniques.
OFDM is a digital multicarrier modulation scheme which enhances the single sub carrier modulation by using the concept of multiple subcarriers within the same individual channel. It follows the concept of FDM. In this various stream

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of information are added to the various channels which have parallel frequency [6,7].
Features of OFDM:

- Less sensitive to time synchronization errors.
- Provides the SFN i.e. Single Frequency Network.
- Robust against fading and ISI i.e. Inter Symbol Interference.

MIMO stands for Multiple Input and Multiple Output. MIMO system has many advantages as compare to single to single antenna communication. It is used as transmission and receiver equipment for wireless radio communication. It includes multiple transmitter and receiver antenna. Multiple antennas cause Variation in data rate.
MIMO has two features:

- Spatial Diversity: In this, same information is transferred over the independent fading channels to oppose fading.
- Spatial multiplexing- In this, each spatial channel carries independent information thereby, increasing data rate of system.

Development at physical layer can help in improving the capacity of data transmission in wireless transmission system. Orthogonal Frequency Division Multiplexing (OFDM) is widely used technique in static digital subscriber links. This technique is integrated with Multiple Input Multiple output technique, so multiple antennas are used at both transmitter end and receiver end. The limitation on the data transmission capacity in wireless networks has been removed by using the MIMO system and also it overcome the problems of fading that encountered by the information signal over the channel [8,9,10]. The big challenge is that the practical implementation of MIMO based wireless communication system in those channels where fast fading is present. The major thing need to be considered is that to design a system that is observable as well as controllable. It is necessary to develop a observable design for communication system so that the proper radio network measurements can be obtained along with the appropriate signaling. Now, it is also important to develop a controllable system so that interference can be eliminated from the required information signal. The Multiple Input Multiple Output system has been actually presented as single-user point-to-point method to increase the efficiency of spectrum by accommodating large number of users simultaneously with the help of multipath scattering technique. [11,12,13] Moreover, one this kind of related technique is also called as SDMA (Spatial Division Multiple Access). This method has already described about the probability of utilizing the space system to accommodate various users simultaneously in limited spectrum.

1.1 Scheduling

Let's define an assignment for a MIMO network which poses the above properties of network. The vector v is defined as

$$v = [v_1 \dots \dots \dots \dots v_l] \quad (1)$$

Where $v_x \in \{0,1\} with\ v_x = 1$
The vector depicts that the link x is active during allocation of v. Whereas the set of assignments is depicted by $\bar{v}$. The size of $\bar{v}$ is the main issue which exist while performing optimal scheduling in MIMO systems. [14] The rate of data transmission through link x in MIMO at the time of assignment v is denoted as

$$R(v,x) = \begin{cases} R_x \ if\ V_y = 0 \ for\ all\ y \in \aleph(x) \\ 0 \ otherwise \end{cases} \quad (2)$$

R (v,x) is a complex function which is modeled with binary relationship as defined in above equation. In equation (2) $\aleph(x)$ stands for a set of links. R_x is used for nominal data rate over maximum data rate x which can be achieved by applying various techniques such as water filling method. [15,16] The set of conflicts links can be represented by using the following formulation:

$$y \in \aleph(x) \quad (3)$$

if the data rates of at least one link is lesser than the threshold value η. Let us consider that the data rate of link x be R_x^y when the both links are active then in such case the conflict set corresponding to link x is developed by using the given equation

$$y \epsilon \aleph(x) if\ R_x^y < \eta R_x^y \ or\ R_y^x < R_y \quad (4)$$

Here R_x^y and R_y^x is evaluated by using methods such as GP and QN etc. the value of threshold is pre-defined by the user in order to ignore the interference. A schedule is defined as a convex combination of assignments. A scheduler is a vector

$$\{a_v, v \in V\} \quad (5)$$

Here in above equation $a_v \geq 0\ and\ \sum v\ a_v \leq 1$.
a_v is used to define that the assignment v is used. [17,18] The average data rate generated by the scheduler for link x is $\{a_v\} is\ \sum v\ a_v R(v,x)$

1.2 Routing

Routing in MIMO based network is defined as which channel is used to transmit the data packets from sender to receiver. Let Φ as a set of simultaneous sessions and in which this notation is used to show the pair of source and destination node in the network. The traffic demand is denoted by d_Φ is transferred from source node which is denoted by Φ_s to destination node which is represented as Φ_d through collection of routes [19,20].

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r_x^{Φ} is a notation which is used for representing the data rate linked with x and also define $O(n)$ and $I(n)$ to represent the set of links that are connected to nodes in the network. If the node n is elected as relay node for Φ^{th} flow, then the following equation is used:

$$\sum_{x \in O(n)} r_x^{\Phi} - \sum_{x \in I(n)} r_x^{\Phi} = 0 \quad (6)$$

If the node is elected as destination node for Φ^{th} flow, then the following formulation is used [25]:

$$-\sum_{x \in I(n)} r_x^{\Phi} = -d_{\Phi} \quad (7)$$

1.3 Resource Allocation

In this work the issue of resource allocation in MIMO system is addressed to determine the scheduling, routing and power control etc. Generally, the motive of resource allocation is to enhance the throughput of the system in order to accomplish peer to peer traffic demand [21, 22, 23].

In order to clarify the concept of resource allocation, let us consider an example where there is a MIMO network which is comprised of n number of MIMO nodes and l MIMO links. The MIMO nodes are transceivers and all the nodes in the network perform communication via similar channel [24,25].

The issue of resource allocation is defined by using the following formulation:

$$max\beta$$

$$\sum_{x \in O(n)} r_x^{\Phi} = \beta d_{\Phi}, n \; defines \; the \; source \; of \; \Phi \quad (8)$$

$$\sum_{x \in O(n)} r_x^{\Phi} - \sum_{x \in I(n)} r_x^{\Phi} = 0 \; , here \; n \; depicts \; the \; relay \; of \; \Phi \quad (9)$$

$$-\sum_{x \in I(n)} r_x^{\Phi} = -\beta d_{\Phi} \; here \; n \; depicts \; the \; destination \; of \; \Phi \quad (10)$$

$$\sum_{\{\phi \in \Phi\}} r_x^{\Phi} \leq \sum_{v \in V} \alpha_v R(v,x) \; for \; link \; x \quad (11)$$

$$\sum_{v \in V} \alpha_v \leq 1, 0 \leq for \; every \; v \in V \quad (12)$$

II. RELATED WORK

Protocol based method for spectrum allocation

The Multiple-Input Multiple-Output technique in wireless transmission system has shown high level improvements in offering the high level of spectral efficiency in wireless system with mesh topology. The cross layer technique had been represented in [1] in order overcome the problem related to spectrum allocation along with the issue related to power management for multiple input multiple output based communication network with mesh topology. Moreover, the communication system in which number of nodes are more than ten then it was observed that the computations become complex in the network. The main objective of this research work was to generate optimum technique that was comprised of Protocol based method; Protocol with Actual based Method along with the Sequential technique, in order to overcome obstructions in spectrum allocation in all the MIMO based communication systems. As compared to all, the protocol with actual technique can be used to balance the operational efficiency with the complexity in computation. This technique comprised of two phases. In first phase, the protocol based technique was implemented, that uses the iterative based technique in order to overcome the issues related to interference in multiple input multiple output communication links. Now the second phase was to calculate the exact rate of output for the set of variables assigned in first phase. Various numerical researches had been conducted to analyze the operations of the proposed techniques.

Resource Allocation

Paper [2] has presented a new technique for integrated resource allocation that had been combined with the grouping of dynamic users, multiple cells cooperation and resource block assignment for one carrier-FDMA uplink in virtual Multiple Input Multiple Output system. In the beginning, the grouping technique for dynamic multi-cell users by using the least mean square equalization and adaptive modulation technique had been created to minimize the bit errors. After this, a new technique had been developed to solve the problem related to the increasing the rate of output. In this problem resource allocation comprised of cell selection, grouping of dynamic users along with Radio Block pattern allocation. In addition to this to make the computational process simpler specifically where large number of users and radio blocks are present, in [2] an optimum Hungarian iterative paradigm had been proposed and this paradigm was based on user and resource division so that the issues related to disintegration of large scale problems into small groups can be resolved, so that the solution can be obtained near to ideal one and computational complexity had been also reduced. The results obtained after simulation had proved that the presented paradigm for joint resource allocation along with grouping technique for dynamic multi-cell users was optimum. The efficiency was measured in terms of Bit error rate.

Significant research works and various improvements have been taken place in last few years and in the field of multiple user MIMO system. Various communication techniques along with encryption methods was created in order to utilize the spatial dimensions in order to obtain the transmission of various individual data streams at the same point of time and reusing the identical radio resources. The optimum operation of these methods was totally dependent on the features of channels and elimination of interference. In case where the count of receiving units is greater than the count of transmitting antennas, then in this case the selection of user played vital role to take advantages from multiuser diversity and complete gain from the multiplexing can be obtained. The complete operation of proposed MU-MIMO systems can be considered as complex integrated multiple aimed optimization problem as various variables and features need to perform efficiently and this had included various number of users, antennas, spatial signaling, rate and power assignment, and transmission methods. The main aim of this research work was to provide brief overview related to different techniques that can achieve the above mentioned integrated optimization work in downlink of Multi User MIMO transmission systems [4].

technique along with various numbers of antennas can be an optimum approach for upcoming wireless communication system to achieve the high capacity of data transmission in downlink, in this the main concern of research was optimum assignment of resources that can be helpful in increasing the efficiency of operation and can provide good quality of service to end users. This paper had examined the operation of the above mentioned cooperative OFDMA systems in practical situation. The architecture of transceiver unit was presented in this paper, in order to minimize the intermixing of frequencies from transmitter as well as receiver unit. The operation of the system was analyzed by measuring the parameter of the system that is Signal to Interference and Noise Ratio (SINR), this parameter is evaluated and analyzed so that it can be verified that the operation of system is optimum or not. Because of remaining level of interference among subcarrier frequencies of transmitter and receiver unit, it was observed that the cooperation technique had undergone the degradation in efficiency of operation. But as compare to various other techniques, this paradigm was comparatively good. In addition to this, many paradigms used for assignment of current sources and restricted to the unicast form of system. This paper had reviewed the dynamic resource assignment technique that was comprised of OFDMA system with large number of antennas. The efficiency of multicast system was differentiated with the unicast system [7].

Orthogonal Frequency Division Multiple Access (OFDMA) The system comprised of both MIMO and Orthogonal Frequency Division Multiplexing (OFDM) can easily obtain the high capacity transmission of data and somewhat this transmission capacity also dependent on propagation surrounding. The main focus of this research work was efficient allocation of resource in MIMO-OFDM based system by implementing the water-filling paradigm. The water filling paradigm was used to assign the power resource so that the capacity of transmission in the channel can be improved. The information transmission capacity of the system was improved significantly. The Channel was considered as flat fading channel and analysis and differentiation was done between 2×2, 2×3, 3×2 and 4×4 MIMO-OFDM based systems and water-filling paradigm was implemented to assign the power. After analysis it was observed that the MIMO OFDM based system was optimum then the SISO – OFDM based system [8].

In this research work, the downlink operation Multiple Input Multiple Output based cellular system that can accommodate various users with different value of QoS as per required by the end user. This research work had presented the resource assigning paradigm that can improve the system operation efficiency by implementing the optimum capacity technique. Two types of techniques were used for proper assigning of resources and these techniques were as follow: first one is the Frame Allocation Algorithm (FAA), this paradigm was comprised of dynamic time assigning for transmission of beam generated. In this algorithm all the users are assigned with unique slot with different length depending on the channel parameters of active users in all the data frames. The second paradigm was Power Allocation Algorithm (PAA), this paradigm helped in maintaining the efficient power control in spatial division multiple accessing techniques. In this approach the resource assignment is done with the help of power assignment and in this long duration averages of channel parameters for all the active users was considered [9].

Energy Utilization

In last few years, the large amount of energy utilization in the wireless communication systems had resulted in the universal concerns all over the world. Therefore, the efficient utilization of energy has resulted in one of the main topics to concern about in the present wireless transmission system. In [3] the efficient utilization of energy while allocating the resources in LTE i.e. long term evolution technique in cellular communication system. In this research work both MIMO systems with Orthogonal Frequency Division Multiple access techniques that can be used in radio access networks and resource blocks for disintegrated sub-channel allocation was considered in this paper to implement it in LTE technique. Specifically, a problem was considered in which joint resource block allocation and power assignment need to be optimized in order improve the energy utilization quantify in terms of “bits-per-Joule” metric, and it was measured in terms of per-user QoS. In the beginning it was shown that problem of resource allocation in such a way that there should be

optimum energy utilization was transformed into a more tractable identical problem through which the fractional aim optimum energy utilization can be obtained. By using the Lagrange dual technique, the Radio blocks allocation can be decoupled with the assignment of power to various sub channels with the help of dual decomposition method, this will significantly simplifies the integrated Radio block allocation, and resolves the equivalent problem with the help of dual optimization technique. In addition to this, a paradigm was presented that was simple to perform computations and can execute the quality of service aware energy efficient resource assignment effectively. After performing the Simulation the results were obtained had shown that the presented paradigm can improve the utilization of energy and also provide high bit rate of transmission to the end users. In addition to this, with the help of MIMO-Orthogonal Frequency Division Multiplexing Access technique and Radio Block assignment methods was also considered in the propose paradigm. The presented technique can be easily implemented n Long term evolution technique.[3]

Channel Estimation

This paper was divided into two sections and here the second part was considered in which hybrid channel estimation and resource assignment problem in Multiple Input Multiple Output systems along with noisy channel was considered with partial CSI. In this paper the transmitter end was correlated with the multiple input multiple output channels along with the block fading, here each block is disintegrated into two phases: first one is training and second one is data transmission phase. This research work had extended the results obtained from one user in part I to various numbers of access channels. While transmitting the information, an iterative paradigm was presented in order to overcome the problem related to assignment of resources effectively like time, power as well as spatial dimensions. The proposed paradigm changes the parameters of end users and for this the round robin scheduling was used. Specifically the paradigm renews the training values and data transmission factors of end user, and it happens when the remaining users are static and this was occurred in such a way that the maximum output should be obtained in multiple user access channel; and this paradigm repeats itself by implementing the round robin scheduling. At last, the simulation had been performed and the results obtained were showing that the results in both the parts of paper were optimum. [6]

III. CONCLUSION

The present scenario demands the high data rate to support the newly introduced applications. This can be achieved with the help of multiple input multiple output technique (MIMO). MIMO is widely used form of communication which facilitates the users to perform data transmission with higher capacity. Multiple-Input Multiple-Output technique in wireless transmission system can help in achieving the high level improvements in offering optimum spectral utilization in wireless system but it also suffers from the problem of resource allocation. The issue of resource allocation with scheduling, routing is concluded in this study with an objective to enhance the performance of the system by increasing the throughput of the system. The effective resource allocation can be achieved by using various techniques such as water filling algorithm for power allocation.

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