Joint Power Allocation and Beam Forming for Energy-Efficient Multi-Way Multi-Antenna Relay Networks

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Abstract

The joint design of user power allocation and relay beamforming in relaying communications, in which multiple pairs of single-antenna users exchange information with each other via multiple-antenna relays in two time slots. All users transmit their signals to the relays in the first time slot while the relays broadcast the beamformed signals to all users in the second time slot. The aim is to maximize the system's energy efficiency (EE) subject to quality-of-service (QoS) constraints in terms of exchange throughput requirements. The multi-way relaying strategy consists of one multiple access phase and multiple broadcast phases. We jointly design relay beamforming matrices and users' linear processing receivers in the broadcast phases to maximize the minimum signal-to-interference-and-noise ratio (SINR) under the relay power budget. the MRC receiver leads to a local maximum for the original joint optimization problem, while the ZF receiver has the computational advantage with a lower complexity.

Keywords – *Energy Efficiency, Multiple antenna, MRC receiver, ZF efficiency*

I. INTRODUCTION

A wireless networks is a kind of computer network which connects the numerous network nodes by means of a wireless data connections. Various telecommunication networks, enterprises and home utilize the method of wireless networks and thus eliminating the need of cables which is much costlier. These network nodes exchange data and are implemented by using the radio communications in the physical layer of ISO-OSI model. Both the wired and the wireless technologies have some merits and demerits. In a wireless network, a remote device can be connected via wi-fi. The wireless network often works in two different modes such as ad-hoc mode and infrastructure mode[1]. The various user components such as PDAs, tablets, smartphones and laptop computers communicate and exchange information between each other without the access points in a peer-to-peer manner. Also in case, where a small impulsive network is to be created in a meeting for sharing the files ad-hoc mode is normally preferred and it is less expensive. However this mode cannot be employed for larger networks due to various security issues such as access control and MAC filtering techniques.

The wireless access points are used to communicate the user devices with each other and also with the wired network in the infrastructure mode. The infrastructure mode is mostly preferred in the networks for its flexibility and ease of use mainly due to the two major components such as wireless devices and the access point. This topology can be used to form larger networks that cover larger distance and incur high complexity.

The access point functions like a base station between the devices and transmits signals among them. The access points are merely a detached device that connects with the wired network and acts as a bridge between the wired and the wireless devices[3]. The number of access points in an application may vary depending upon the number of users, the environment, its range and also the bandwidth required by them. In case if the bandwidth is shared, and the users sends multimedia files then additional access points are installed.

II. RELATED WORKS

Different authors done the research by using the different techniques and algorithms.

H. H. M. Tam. In the initial case, the objective is non-concave and it has a non-convex feasible set; whereas in second, a non-concave and a non-smooth objective were present. To overcome such problems, a new algorithm was proposed. This utilizes a convex quadratic program by means of repeated iteration was designed. Due to the increase in the objective value.

Alessio Zappone**.** A fractional problem taxonomy is analyzed here. With the occurrence of numerous fractional problems, a common resolution method was designed to tackle the complexity and the convergence problems. Hence, to solve these issues a theoretical and algorithmic framework was proposed. A signal model is also designed to tackle various issues such as one-hop, multi-hop, small-cell, multi-cell, cognitive radio systems and device-to-device systems.

Christopher M. Kellett. The users exchange data in the multiway relay channel through a relay. The capacity region for multiway relays is proposed. It is the responsibility of the finite fields to handle the inputs and the outputs of the channel. Using the decode-forward and coding method, the highest value of the capacity region is obtained. The data which is transmitted and received in the channel is at different rates.

Trung Q. Duong. In this work, a load balancing technique is combined with interference management methods are used. The small cells in the downlink is employed with the macrocell. The limited backhaul capacity which exists in each base station is also considered here. The users in these networks are not diverted to any base stations as it has only a limited backhaul capacity. The scheme is combined with traffic offload and transmits power allocation to achieve QoS of the users.

Ben Liang. A multi-antenna relaying combined with amplification between the transmitter and the receiver with single antenna power constraints was proposed. In order to reduce the high antenna power budget for the received signal to noise ratio, an optimal relay processing scheme was introduced. By means of transmit beam formers in the source and the receiver beam formers in the destination, focus is made on the single antenna source and destination.

III. SYSTEM ARCHITECTURE

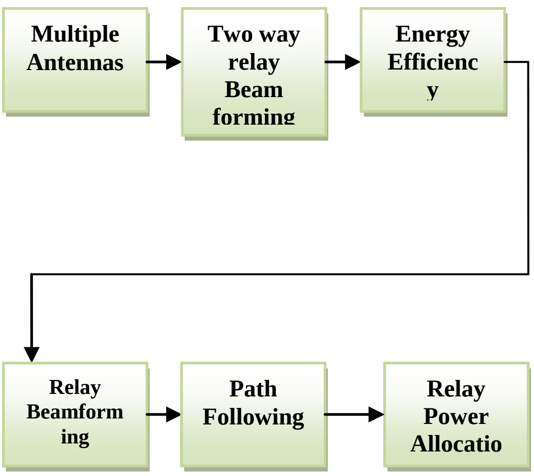

Fig 3.1 Architecture Diagram

The proposed system utilizes the combined features of single antenna and two-way relay techniques. This combined effort aims to maximize the energy efficiency which is subjected to users QoS constraints[5]-[6]. The users QoS constraints are satisfied enough with energy maximization and throughput maximization else it causes service discrimination. These users QoS constraints are not addressed properly when the problem is non-convex. Eventhough the non-convexity of the QoS constraints is identified, finding the feasible points is computationally difficult.

The architectural diagram of the proposed work is explained in Fig.3.1. The information is received from multiple antennas which acts as a source and it is performed a two-way relay beam forming process. The energy efficiency and the QoS constraints are analyzed and it is then fed into the relay beam forming techniques. In order to address the energy efficiency maximization. This proposed method addresses only a simple quadratic optimization technique. Apart from this, a new path following computing procedure is also proposed to address the energy maximization problem.

IV. PROPOSED WORK

The proposed problem is designed with K-cell HetNet such that in the downlink of the HetNet one large cell consists of numerous small cells. To limit the radio spectrum signals, a universal frequency reuse is exploited. Without affecting the generality, the large cell in the base station is marked as BS1 and the remaining base station with multiple small cells is marked as BSK_1,BSK_2,….BSK_g.

The small base station which is connected with the backhaul link is transmitting the signals at a very low capacity. Each base station consists of a backhaul link which includes the traffic from the reverse link for its serviced users' from the network to that of the base station by means of a 'Point of Presence' (PoP)[7]. An optical fibre link is used to connect the PoP to the core network. The capacity of the optical fibre link is assumed to be greater when compared to the sum of all the links from the PoP to all the base stations. Since the capacity of the fibre optical link is higher, the PoP of the link capacity of the main network is eliminated in the proposed method. Also, the traffic from the control plane is also neglected.

A. Two-way Relaying

The wireless two way relay channel exchange evidence by means of a relay node. The upper bound of the size is fixed by smearing a cut-set theorem. This upper bound is achieved by SNR region using numerous entree separated regions for uplinks after the finish nodes to the relay

B. Energy Efficiency

Various methods such as two-way relaying, one-way relaying, and two-way relaying with user static equal power allocation have been in practice to achieve the energy efficiency in the networks. Among these, the two-way relaying outperforms well when compared to one-way relaying and two-way relaying with operator equal power allocation.

C. Relay Beam forming

To enhance the sampling rate, a relay beamforming is designed from the transmitter to the receiver by means of network and energy constraints in the relay and at the receiver respectively. The optimization problem tends to be more constrained on the quadratic problem (QCQP). Hence to solve the optimization problem, a solution based on reduction is proposed. This quadratic problem is converted into a new program which is semi-definite.

D. Joint Optimization

Two specific problems namely quantization and white noise model to overcome the quantization errors were proposed. In the first case, how the performance of the system is optimized by efficiently allocating the resources is considered. Since the problem is non-convex it can be solved easily.

E. Path-following algorithms

Here, the proposed algorithm computes a solution set in the particular direction. These are not enough to follow the same direction C or sometimes close to it[8]-[9]. However they are loosely bounded but it follows with a nearest node of that direction . This highly eliminates the duality measure and makes the value to zero. Next, a point is computed by measuring the duality measure of two values say X and Y and the transmitted power may be either small or equal to Y .The algorithms generate iterate values such as (xk,)k sk) . From the devised direction, a pairwise products is computed and said to be not identical.

$$\frac{1}{\mu}\|XSe - \mu e\| = \frac{1}{\mu}\left\| \begin{bmatrix} x_1 s_1 \\ \vdots \\ x_n s_n \end{bmatrix} - \left(\frac{x^T s}{n}\right) e \right\|.$$

V. PERFORMANCE EVALUATION

A clustering based LEACH protocol which operates in a single hop mode between the cluster head and the base station is exploited. The sensor nodes which involve in the communication process compete for the ability to act as a cluster head for a particular round[10]. The cluster head also consists of sensor nodes which also compete for its ability to participate in the communication process by broadcasting their residual energy to the neighbouring candidates. The node with high residue energy will act as a cluster head. Hence all the participating nodes communicate with the neighbouring node and find the residue energy. Suppose if a node does not find another node with high residue energy, then that node becomes the cluster head.

A) Analysis of experiment

The received signals in the channels and their appropriate equations are derived[3]. The Rayleigh fading is assumed in the proposed method and it is modeled by an independent Gaussian random variables which is circular and symmetric in nature. These have a zero mean and a unit variance value. Apart from these, the background noise values are also normalized.

Various experiments have been conducted by comparing the throughput with the relay power budget. The results show a significant improvement in case of K=2 and K=3 during OPOW over OW analysis.

M_{sum} N_{max}	0	5	10	15	20
2,1,8	13.27	10.34	6.71	7.23	5.18
2,2,4	20.34	11.01	8.11	7.32	5.12
2,4,2	18.23	13.42	11.34	5.42	7.15

TABLE 4.1 Table of Iterations of Algorithm 1 with K = 2

The simulation results obtained for K=2 is f(1; 8); (2; 4); (4; 2)g. The throughput value is compared with the relay and the values are compared against one –way, two-way and two-way with users' fixed power allocation.

However, when the transmit power is high, the energy efficiency is dominated by the actual transmit power. The energy efficiency is maximized by minimizing the transmit power, and it is saturated beyond a threshold value. When the transmit power is saturated, the energy efficiency and the sum throughput also gets saturated accordingly.

Experiments are conducted with varying the power budget and the total number of antenna given for a relay and observed that the configurations having the less relays are more superior to the one which has more relays. Also, the configuration having less relays attain high throughput.

VI. CONCLUSION

The proposed method aims to reduce the SINR ratio by means of combining two approaches such as the matrices values in the processing relay and the vector values of the processing receiver side. This occurs in the broadcast phase for each and every individual user for the power budget present in the relay.

To overcome the optimization problem, an iterative optimization approach is proposed by combining the aforementioned two approaches. The MRC and the ZF receivers are combined in the receiver design as two different sub problems. The solution obtained is in the closed form. A local optimized solution and a sub-optimal solution is achieved by means of MRC and ZF receivers respectively. The performance of the receiver is highly improved by combining the successive interference cancellation method.

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