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An Energy Efficient vMIMO based Routing & Topology construction framework for WSNs

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Abstract: In the recent times virtual Multiple Input Multiple Output (VMIMO) has been conceptualized to achieve energy efficiency in the field of wireless communications. It gained the attention of many researchers as data gathering and fusion has become one of the most prominent issues in Wireless Sensor Networks (WSNs). The MIMO network is defined considering a group of sensor nodes participating in transmitting and receiving data packets over a WSN. Although configuring a WSN with multiple transmitters and receivers consumes very less amount of power during long term data transmission but it increases the sensor node in built circuitry power thus the energy optimization models are required to be considered. Due to the circuitry complexity and difficulty of integrating separate antenna, virtual MIMO concepts are applied in wireless sensor networks (WSNs) for energy efficient communication to save energy and increase reliability in case of channel and signal fading. This paper introduces energy efficient VMIMO based routing and topology construction model which has been further integrated into centralized and distributed topology construction for WSNs. The proposed method also implements an energy efficient routing using static and dynamic access points. The performance evaluation of the proposed model shows the effectiveness with respect to various existing operational parameters.

Keywords: Energy Efficiency, Virtual MIMO, Static Access Point, Mobile Access Point, Wireless Sensor Networks

I. INTRODUCTION

Although main power consumption term in a traditional wireless systems is due to the energy required for actual transmissions, this may not be the case in an energy-limited wireless sensor network. In fact, in some cases it is the circuit energy needed for receiver and transmitter processing that is dominant. Thus, in designing energy efficient techniques for such sensor networks one should consider both circuit and transmission power consumption terms. Multiple-input-multiple-output (MIMO), or multiple antenna, communication is one of the techniques that has gained considerable importance in wireless systems during recent years.

However, a drawback of MIMO techniques is that they could require complex transceiver circuitry and large amount of signal processing power that may lead to large power consumptions at the circuit level. Thus, in evaluating the applicability of MIMO techniques to energy-limited wireless sensor networks, we need to take into account the circuit power consumption as well as the transmit power consumption. Moreover, physically implementing multiple-transmit or receiver antennas on a small, energy-limited sensor might not be realistic. This makes direct application of dual antenna MIMO techniques in wireless sensor networks impractical.

However, as reported in [1] it is possible to implement MIMO techniques in wireless sensor networks without physically having multiple antennas at the sensor nodes via cooperative communications techniques. As reported in [1] and [2] such distributed MIMO techniques can offer considerable energy savings in cooperative wireless sensor networks even after allowing for additional circuit power, communications and training overheads. The use of distributed communications in wireless sensor networks allows for energy savings through spatial diversity gains. Cooperative transmission and/or reception of data among sensors is known to diminish the per-node energy consumption (the main constraint of sensor systems), increasing network lifetime. The original work of [3] set up the relaying scenario of Gaussian channels when supported by one relay node, showing capacity gains when properly allocating power. This result was the baseline for the proposed cooperative network in [4], where the relay node is considered another network user. The necessary extension of this result to multiple relay channels has been recently carried out by [5], setting up the first information theoretic approach to cooperative multi-hop transmission.

A large number of protocols and methods are proposed for energy efficient communications in WSNs. In this paper, we would like to investigate cooperative virtual MIMO that provides energy efficient communication by sharing the transmission and reception of information. In virtual MIMO, multiple senders and receivers participate in long-range communication to improve data reliability in fading channels. The performance of virtual MIMO in WSNs depends on the structure of network layer and data link layer. There are several approaches for implementing virtual antenna array in WSNs. Although the core implementation of virtual antenna array or co-operative transmission lies on physical layer, there is deep dependency on the higher layers (network and data link) to implement this issue. In a cognitive network framework,

the network components can modify the operational parameters to respond to the needs of particular environment. We propose a cluster based virtual MIMO cognitive model with the aim of changing operational parameters (constellation size) to meet the optimum design.
In this paper propose new virtual MIMO-based cooperative communications architecture for energy-limited wireless sensor networks. The paper is organized as follows Section II discusses about the recent studies towards energy efficient digital pre distortion techniques which is followed by problem statement in Section III. Section IV discusses about proposed system followed by discussion of algorithm implementation in Section V. Section VI discusses about the result analysis followed by conclusion in Section VII.

II. BACKGROUND

In recent years, virtual MIMO has attracted a growing interest because of its energy efficiency in large field of networks. In virtual MIMO network, a group of sensors cooperate to transmit and receive data. Although the participation of multiple transmitters and receivers in a transmission saves significant energy in long-range communications, the increase in the number of transmitters and receivers also increases the circuitry power consumption. As a result, the energy optimization techniques have to be adapted with the environment. Due to the circuitry complexity and difficulty of integrating separate antenna, virtual MIMO concepts are applied in wireless sensor networks (WSNs) for energy efficient communication to save energy and increase reliability.

The energy-efficient data gathering problem in sensor networks has been extensively investigated using the traditional communication scheme (SISO). For many monitoring applications with a periodic reporting pattern, a tree-based topology was adopted due to its simplicity and energy efficiency, which were two important factors to consider in resource-constrained networks. The work constructed a topology for data gathering with fusion based on the SISO and MISO modes. Another work adopted VMIMO to improve energy-efficiency of data gathering with fusion in a cluster-based wireless sensor network. Generally speaking, the above works largely ignored the impact of topology structures on the energy consumption of VMIMO-based data gathering, and did not consider the joint optimization of topology construction and VMIMO communications.

The use of distributed communications in wireless sensor networks allows for energy savings through spatial diversity gains. Cooperative transmission and/or reception of data among sensors is known to diminish the per-node energy consumption (the main constraint of sensor systems), increasing network lifetime. The original work of [3] set up the relaying scenario of Gaussian channels when supported by one relay node, showing capacity gains when properly allocating power. This result was the baseline for the proposed cooperative network in [4], where the relay node is considered another network user. The necessary extension of this results to multiple relay channels has been recently carried out by [5], setting up the first information theoretic approach to cooperative multi-hop transmission. The specific relationship between spatial diversity of cooperative networks and the decrease of transmit power is studied for single relay and multi relay channels in [6] and [7], respectively. Furthermore, the importance of optimal resource allocation in the relay channel is analysed in [8]. Therein, the impact of optimum time and power allocation in half-duplex relay networks is shown. In this project we propose a clustered cooperative multi-hop sensor network that implements cooperative transmission and reception of data among cluster nodes, with the aim of reducing power consumption in VMIMO systems.

To propose a novel and energy-efficient data gathering method using VMIMO for wireless sensor networks. We studies energy-efficient data gathering in wireless sensor networks using VMIMO. We define the joint VMIMO and data gathering (VMDG) problem, which is NP-hard. We also propose a distributed method called D-VMDG as an approximation algorithm. This algorithm first constructs a tree-like topology by taking the unique features of VMIMO into account. Then, an energy-efficient routing protocol based on dynamic programming is proposed for each node on the constructed topology. The joint VMIMO and data gathering (VMDG) problem is to select a set of cooperative node pairs, construct a VMIMO-aware topology and perform VMIMO-aware routing on the topology, so that all nodes will send their sensor data to the base station with VMIMO transmissions. The optimization objective of this problem is to minimize the total energy consumption of data gathering for wireless sensor networks.

This project proposes a novel and energy-efficient data gathering method using VMIMO for wireless sensor networks. We first define the joint VMIMO and data gathering (VMDG) problem, and formally prove that this problem is NP-Hard. As the problem is difficult to solve optimally due to its high computational complexity, we propose a distributed and heuristic algorithm called D-VMDG, which consists of two steps. The first step selects a set of cooperative node pairs and constructs a tree-like topology by taking the unique features of VMIMO into consideration. Then, an energy-efficient routing protocol based on dynamic programming is proposed for the constructed topology. Our theoretical analysis shows that the proposed algorithm can achieve a constant approximation guarantee for the VMDG problem with respect to the optimal performance. Our simulation results illustrate that the proposed D-VMDG algorithm decreases the energy consumptions by about 81 and 36 percent compared with the well-known MDT [6] and MIMO-LEACH [9] algorithms respectively.

III. LITERATURE REVIEW

This section briefly summarizes related works about data gathering and VMIMO, respectively. The research of using MIMO technology in wireless sensor networks first began in 2004 and currently there are some scholars have started working at some of the challenging issues. Literature [2] analyzed the extra energy cost of the communication among cooperation nodes and achieved the total energy consumption in cooperative MIMO-based wireless sensor network. The experimental results show that, even in considering the additional traffic load, collaborative MIMO communications mode still save more energy than SISO communications mode. Literature [3] analyzed the performance of MIMO-based wireless sensor network in the case of the same channel interference. Literature [4] analyzed the diversity gain and multiplexing gain provided by MIMO and proposed the method of using different gains methods in MIMO according to different application requirements.

Some researchers dedicated to study the challenging issues for WSNs using collaborative MIMO, such as how to select collaboration nodes, synchronization, routing and so on. Literature [5] proposed a cooperative node selection algorithm. Each node selects the node from its neighbors as its cooperation node which has the smaller ratio of its transmission energy consumption to its residual energy.

Taking into account the similarity of characteristics of collaborative MIMO and clustering WSN, literature [6] proposed using cooperative MIMO techniques in cluster-based wireless sensor networks, which select collaboration nodes from cluster-heads to form collaborative MIMO.

In order to reduce the total energy consumption in the network, literature [7] proposed a method of optimizing the transmission rate and the size of cluster at the same time. However, the algorithms proposed based on the same assumption, that is, nodes are densely distributed in the network to ensure cluster-heads find enough cooperative nodes. In practice, with the running of network, some nodes could run out of the network for failing or being blocked due to lack of power or have physical damage or environmental interference. When the network deployment becomes sparser but the amount of information to be transferred is huge, the collaboration nodes could consume more energy than the normal nodes, which aggravates the energy imbalance in the network. Though some protocols use the method of shortening the period of clustering to solve the problem, frequent clustering could waste more energy. In view of the above insufficiency, the paper proposes a dynamic collaborative virtual MIMO based routing protocol (DCVM).

Islam et al. [15] proposed an energy efficient cooperative technique for a WSN where selected numbers of sensors are used to form a MISO structure wirelessly connected with a DGN. The selection of nodes is based on a selection function which is a combination of channel condition, residual energy, inter sensor distance in a cluster and geographical location. Data are sent by the sensors to a DGN using a multihop transmission. Here we are concentrating our design on the final hop where sensors transmit their data to the DGN. A mathematical model is developed to get the selection function. Zhao et al. [2] address an essential issue in WSNs by introducing the mobility and MIMO capability to the data sink in order to optimize the system performance. Specifically, the mobile sink moves along a pre-determined path and collects data packets at some polling stations. Finally, author theoretically analyze the performance of mobile data gathering in a WSN enhanced by MIMO support, and also investigate its efficiency by simulation experiments. The results demonstrate that the proposed mechanism can greatly improve the system throughput and energy efficiency with minimum additional overhead.

Zhao et al. [6] proposed a three-layer framework for mobile data collection in wireless sensor networks, which includes the sensor layer, cluster head layer, and mobile collector (called SenCar) layer. The framework employs distributed load balanced clustering and MIMO uploading techniques, which is referred to as LBC-MU. The objective is to achieve good scalability, long network lifetime and low data collection latency. At the sensor layer, a distributed load balanced clustering (LBC) algorithm is proposed for sensors to self-organize themselves into clusters. Extensive simulations are conducted to evaluate the effectiveness of the proposed LBC-MU scheme. The results show that when each cluster has at most two cluster heads, LBC-MU can reduce the maximum number of transmissions a sensor performs by 90% and the average number of transmissions by 88% compared with the enhanced relay routing scheme. It also results in 25% shorter average data latency compared with the mobile collection sch- - eme with single-head clustering.

Madi et al. [7] considered two precedes (max-dmin and P-OSM) for closed-loop MIMO systems are considered. Energy-efficient cooperative schemes are proposed for these precedes based on a quantification of the feedback information. The results show that these MIMO precedes-based cooperative schemes can provide a significant energy efficiency compared to a space-time block codes-based cooperative schemes, even after using additional steps required in transmission. Jayaweera et al. [8] proposed a virtual multiple-input multiple-output (MIMO) communications architecture based on vertical Bell Laboratories layered space-time (V-BLAST) receiver processing is proposed for wireless sensor networks (WSNs). This scheme does not require transmitter-side node cooperation unlike previously proposed virtual MIMO schemes. The energy and delay efficiencies of the proposed virtual MIMO scheme are derived for networks with both single- and multiple-antenna data gathering nodes (DGNs). Numerical results show the significant energy savings offered by the proposed method. These results also indicate that rate optimization over transmission distance is not essential as in virtual MIMO systems based on Alamouti scheme.

Zhao et al. [18] consider data gathering in wireless sensor networks (WSNs) by utilizing multiple mobile collectors and spatial-division multiple access (SDMA) technique. It focus on the problem of minimizing the maximum data gathering time among different regions, which consists of two parts: the data uploading time of the sensors in this

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region and the moving time of the associated SenCar on a tour. We refer to this problem as data gathering with multiple mobile collectors and SDMA, or DG-MS for short, and formalize it into an integer linear program. We then propose a region-division and tour-planning algorithm to provide a practically good solution to the problem. Simulation results demonstrate that the proposed scheme significantly outperforms other non-SDMA or single mobile collector schemes by efficiently shortening and balancing the data gathering time among different regions.

IV. PROPOSED METHOD

This paper proposes a novel and energy-efficient data gathering method using VMIMO for wireless sensor networks. We first define the joint VMIMO and data gathering (VMDG) problem, and formally prove that this problem is NP-Hard. As the problem is difficult to solve optimally due to its high computational complexity, propose a distributed and heuristic algorithm called D-VMDG, which consists of two steps. The first step selects a set of cooperative node pairs and constructs a tree-like topology by taking the unique features of VMIMO into consideration. Then, an energy-efficient routing protocol based on dynamic programming is proposed for the constructed topology.

Figure 4.6 flowcharts for the proposed system. I.e. Construction of topology and energy efficient routing. In this section, we define the joint virtual MIMO and data gathering (VMDG) problem. There are ‘n’ wireless nodes randomly distributed in a planar field. We assume that each node u knows its position denoted by (Xu; Yu). Each node is equipped with an antenna, and can adjust its transmission power arbitrarily. Form this method we can optimize the power at both the transmitter and receivers sides. So we can achieve better routing method to solve power optimization problem. The below flow chart demonstrates the proposed system model system.
The VMIMO topology is constructed using both centralized and distributed systems. In centralized method all the sensor nodes sends the data to the cluster head. Then each cluster head send the collected data to the sink node. In distrusted system, each and every sensor nodes transmit the collected data to the sink node as well as neighboring node. In this case, if any data loss happens also, the sink node collects the original data through the other nodes. There is no loss of data will happen. But energy consumption will increase. Then, by using the VMIMO-energy efficient routing techniques we can reduce the power consumption in the network.

In this method developed two type of routing method. Firstly, Mobile access point and second is Static access point. In mobile access point the collector will collected all the data form the cluster head. That is the mobile AP will move to each and every cluster head and it will collected all the in the cluster head, then it will reach the sink node. But in the case of static AP, each and every sensor node and cluster head have a separate static point. This static point will help to transmit the data form sensor node to sink node.

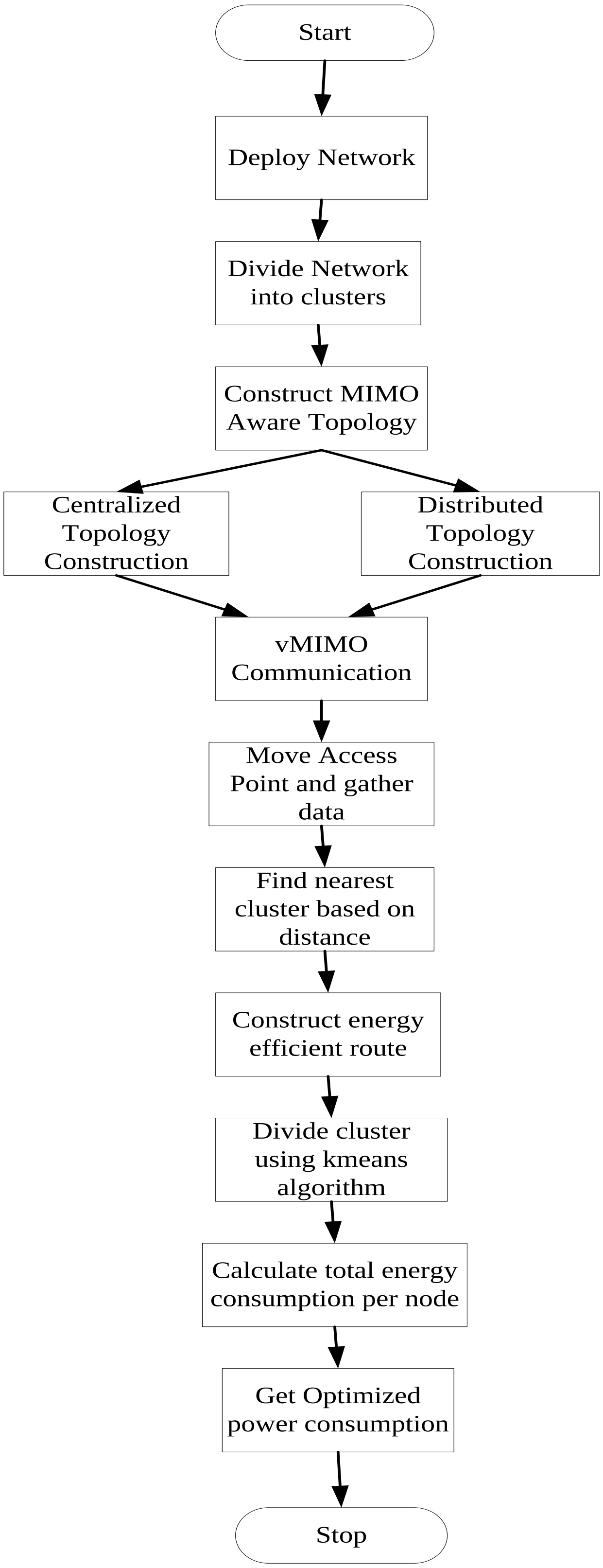

Figure 4.6 flow chart for the proposed system

V. RESULTS AND DISCUSSION

This section presents the numerical results to demonstrate the energy efficiency of the proposed algorithm. We select two types of topology construction and two types of routing method. One is centralized and distributed topology constructions. In the routing we considered a Mobile AP and Static AP techniques. This constructs the minimum-energy topology for data gathering under the SISO communication mode using the Dijkstra algorithm. The MIMO-LEACH algorithm, which implements the data gathering using VMIMO on a cluster structure.

The reason for choosing these algorithms is two-fold. One is to show the energy efficiency of VMIMO communication by comparing with the optimal algorithm using the traditional approach. Second, we compare with the LMIMO algorithm to show the performance improvement due to the constructed VMIMO topology used by our algorithm. This is implemented using Matlab tool.

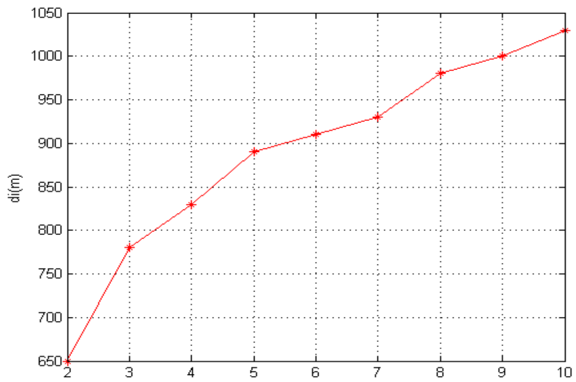

Fig. 6.9 plot for delay for proposed system

Fig. 6.9 shows the comparison of delay parameter for proposed system with LEACH algorithms. In this graph we can observe that, the delay obtained in proposed method is very less than the LEACH algorithm. This shows that our proposed method is very fast compared to LEACH in order to send the data form sensor nodes to sink node. As the number of cluster size increases, the delay will also decreases in our proposed system.

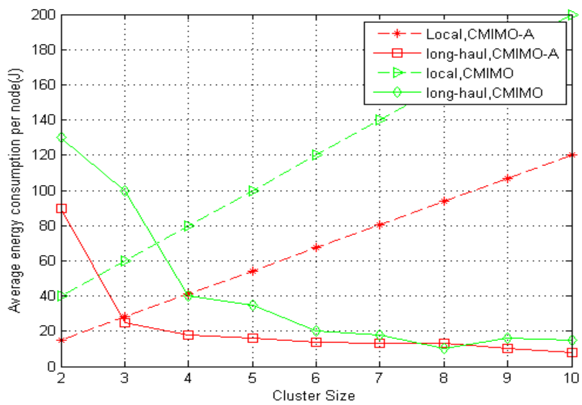

Fig. 6.10 Comparison of Avg. Energy consumption per node for proposed method with LEACH

Fig. 6.10 shows the comparison of Avg. Energy consumption per node for proposed method with LEACH. Here we can observe that as the number of cluster size increases, the Avg. Energy consumption per node will also decreases in our proposed system. This shows that our proposed system reduces the power in both transmitter and receiver systems.

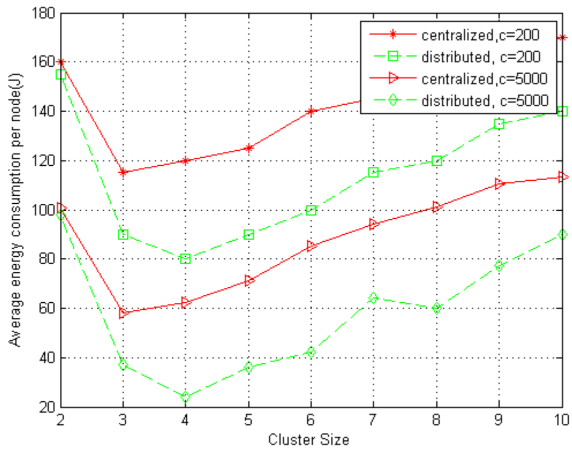

Fig. 6.11 Static AP vMIMO-EE-Routing constructed

Fig. 6.11 shows the comparison of Avg. Energy consumption per node for proposed method with centralized and distributed system. Here we can observe that as the number of iterated topology increases, the Avg. Energy consumption per node will also decreases in our distributed system compared to centralized system. This shows that our proposed system reduces the power in both transmitter and receiver systems.

VI. CONCLUSION AND FUTURE DIRECTION

In this work proposed a centralized and distributed VMIMO Topology Construction topology to introduce cooperative diversity in multi-hop wireless sensor networks. We proposed that, within every network cluster, all sensor nodes cooperate to transmit and receive data to take advantage of the diversity gain that arises when exploiting virtual-MIMO communications between clusters. To build up the virtual MIMO channel, we assumed a time division, decode-and forward multi relay channel composed of a broadcast channel and a space-time coded MIMO channel. To construct an energy aware multi antenna reception protocol we proposed a selection diversity technique. The joint optimization of the time assignment for the time-division channels and the power allocation was decoupled into the cluster-to-cluster link optimization.

REFERENCES

[1] Hongli Xu; Liusheng Huang; Chunming Qiao; Weichao Dai; Yu-e Sun, "Joint Virtual MIMO and Data Gathering for Wireless Sensor Networks," in Parallel and Distributed Systems, IEEE Transactions on , vol.26, no.4, pp.1034-1048, April 1 2015.

[2] Miao Zhao; Ming Ma; Yuanyuan Yang, "Mobile Data Gathering with Multiuser MIMO Technique in Wireless Sensor Networks," in Global Telecommunications Conference, 2007. GLOBECOM '07. IEEE, vol., no., pp.838-842, 26-30 Nov. 2007.

[3] Islam, M.R.; Jinsang Kim, "Energy efficient cooperative MIMO in wireless sensor network," in Intelligent Sensors, Sensor Networks and Information Processing, 2008. ISSNIP 2008. International Conference on, vol., no., pp.505-510, 15-18 Dec. 2008.

[4] Miao Zhao; Yuanyuan Yang; Cong Wang, "Mobile Data Gathering with Load Balanced Clustering and Dual Data Uploading in Wireless Sensor Networks," in Mobile Computing, IEEE Transactions on , vol.14, no.4, pp.770-785, April 1 2015.

[5] Valli, R.; Dananjayan, P., "Utility based power control with different deployment schemes in virtual MIMO Wireless Sensor

Network," in Advances in Engineering, Science and Management (ICAESM), 2012 International Conference on , vol., no., pp.417-422, 30-31 March 2012.

[6] Miao Zhao; Yuanyuan Yang, "A framework for mobile data gathering with load balanced clustering and MIMO uploading," in INFOCOM, 2011 Proceedings IEEE , vol., no., pp.2759-2767, 10-15 April 2011.

[7] Madi, G.; Vrigneau, B.; Poussard, A.-M.; Vauzelle, R., "Cooperative MIMO precoders for energy-efficient transmission in wireless sensor network," in Signal Processing Conference, 2011 19th European , vol., no., pp.784-788, Aug. 29 2011-Sept. 2 2011.

[8] Jayaweera, S.K., "V-BLAST-Based Virtual MIMO for Distributed Wireless Sensor Networks," in Communications, IEEE Transactions on , vol.55, no.10, pp.1867-1872, Oct. 2007.

[9] Medhi, N.; Sarma, N.; Mira, A., "Cooperative MIMO in wireless sensor networks with mobile sensors for cooperativeness and data aggregation," in India Conference (INDICON), 2012 Annual IEEE , vol., no., pp.251-256, 7-9 Dec. 2012.

[10] Jayaweera, S.K., "An energy-efficient virtual MIMO architecture based on V-BLAST processing for distributed wireless sensor networks," in Sensor and Ad Hoc Communications and Networks, 2004. IEEE SECON 2004. 2004 First Annual IEEE Communications Society Conference on , vol., no., pp.299-308, 4-7 Oct. 2004.

[11] Pillutla, L.S.; Krishnamurthy, V., "Minimum Energy Data Gathering in Correlated Sensor Networks with Cooperative Transmission," in Communications, 2007. ICC '07. IEEE International Conference on , vol., no., pp.3623-3628, 24-28 June 2007.

[12] [12] Wei Liu; Kanru Xu; Pan Zhou; Yi Ding; Wenqing Cheng, "A Joint Utility-Lifetime Optimization Algorithm for Cooperative MIMO Sensor Networks," in Wireless Communications and Networking Conference, 2008. WCNC 2008. IEEE, vol., no., pp.1067-1072, March 31 2008-April 3 2008.

[13] Islam, M.R.; Jinsang Kim, "Estimation of velocity and training overhead constraints for energy efficient cooperative technique in Wireless Sensor Network," in Advanced Communication Technology, 2008. ICACT 2008. 10th International Conference on , vol.2, no., pp.1115-1120, 17-20 Feb. 2008.

[14] Li Wang; Yuhan Dong; Xuedan Zhang, "Throughput maximization transmission scheme for virtual MIMO in clustered wireless sensor networks," in Wireless Communications and Networking Conference (WCNC), 2013 IEEE , vol., no., pp.3632-3636, 7-10 April 2013.

[15] Islam, M.R.; Jinsang Kim, "On the use of selection function in cooperative MISO at wireless sensor network," in Intelligent Sensors, Sensor Networks and Information Processing, 2008. ISSNIP 2008. International Conference on , vol., no., pp.139-144, 15-18 Dec. 2008.

[16] Liu Danpu; Zhang Kailin; Ding Jie, "Energy-efficient transmission scheme for mobile data gathering in Wireless Sensor Networks," in Communications, China , vol.10, no.3, pp.114-123, March 2013.

[17] Guo, S.; Yang, Y.; Wang, C., "DaGCM: A Concurrent Data Uploading Framework for Mobile Data Gathering in Wireless Sensor Networks," in Mobile Computing, IEEE Transactions on , vol.15, no.3, pp.610-626, March 1 2016.

[18] Miao Zhao; Yuanyuan Yang, "Data Gathering in Wireless Sensor Networks with Multiple Mobile Collectors and SDMA Technique Sensor Networks," in Wireless Communications and Networking Conference (WCNC), 2010 IEEE , vol., no., pp.1-6, 18-21 April 2010.