QUERY PROCESSING IN SENSOR NETWORK

J.Sophia[1], M.Ponmathi[2], K.Gandhimathi[3]
Assistant Professor, Idhaya Engineering College for women

Abstract—Virtual multi-input multi-output (MIMO) or vMIMO is becoming an attractive technology to achieve spatial diversity in wireless networks without using additional antennas, and to reduce power consumption by cooperation among multiple nodes. As data gathering is one of the most important operations in many sensor network applications, this paper 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. Our theoretical analysis shows that D-vMDG can achieve an approximation ratio of O (1). Our simulations show that D-vMDG decreases the energy consumption by 81 and 36 percent compared to the well-known MDT and MIMO-LEACH algorithms respectively.

***Keywords*—Data gathering, virtual MIMO, energy efficiency, wireless sensor networks**

I. INTRODUCTION

Wireless sensor networks (WSNs), consisting of such nodes in a self-organized manner, have been widely used to monitor the physical world for a long period. Typical applications include habitat monitoring [1] and ancient building maintenance [2]. Such applications usually require a large number of battery-powered sensor nodes to be deployed in a target field, and each sensor node periodically produces a small amount of data and reports to base stations or remote users for continuous surveillance.

An essential operation in surveillance applications is to collect the sensed information from sensor nodes and transmit it to a base station or control center for complex processing, which is referred to as data gathering. There are two main categories for this kind of communication scheme. One is with data fusion, and the other is without data fusion. Though data gathering with fusion can decrease power consumption of wireless communication by reducing traffic loads, this mechanism is not suitable for some applications requiring detailed information about the monitored Field, such as real-time video from each wireless camera or historical data by each wireless node. In this paper, we consider data gathering without fusion, and study how to reduce power consumption for data gathering without fusion. For simplicity, data gathering without fusion is abbreviated as data gathering in the rest of this paper.

As battery power is a critical resource in such wireless sensor networks, many algorithms and protocols aim to decrease the energy consumption. In wireless transmissions, signal fading of wireless channels increases power consumption. Recently, spatial diversity is shown to be an effective way to cope with signal fading and reduce power consumption in wireless networks. Generally, spatial diversity can be achieved by employing multiple transceiver antennas at each node, such as a MIMO system. However, it may be impractical, in terms of required footprint, to equip each wireless node (especially a tiny device) with multiple antennas [3]. To achieve spatial diversity with only one antenna on each node, the vMIMO mechanism [4] has been introduced, and it has become an efficient way to reduce power consumption [5]. There are four different modes of vMIMO, single-input single-output (SISO), single-input multi-output (SIMO), multi-input single-output (MISO) and multi-input multi-output (MIMO), respectively.

Though earlier works [3], [6], [7] have pioneered the research on data gathering using the vMIMO technology, there are three main limitations we aim to overcome. First, the work in [6], [7] used the vMIMO transmission on a fixed topology. However, it would be more beneficial if, in conjunction with the use of vMIMO, one constructs a suitable topology and designs energy-efficient routing protocol for data gathering. Second, the works in [3], [6] did not fully explore the advantages of vMIMO since only the SISO and MISO com-munication modes were employed. Finally, none of the works in [3], [6], [7] obtained any approximate performance guar-antee for the data gathering problem in sensor networks.

This paper proposes a novel and energy-efficient data gathering method using vMIMO for wireless sensor net-works. 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 [8] and MIMO-LEACH [7] algorithms respectively.

The rest of this paper is organized as follows. In Section 2, we discuss related works on data gathering. Section 3 describes the systm design and rest of the section describes vMIMO model and defines the vMDG problemand a distributed algorithm is proposed for vMDG, and the approximation factor is also analyzed. We conclude the paper in Section 7.

II. RELATED WORKS

This section briefly summarizes related works about data gathering and vMIMO, respectively.

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 net-works. In fact, a number of studies had investigated tree construction for data gathering under the traditional communication scheme. In general, the traditional methods usually performed short-range transmission instead of long-range transmission to reduce the energy cost of data gathering in wireless sensor networks.

Recently, virtual MIMO transmission has become a promising technology for next-generation wireless net-works. This technology has been applied to save the energy consumption of multi-hop routings .Moreover, data gathering using vMIMO has also been studied. The work in performed vMIMO transmission on a cluster structure. As LEACH was an efficient cluster construction protocol, Yuan et al proposed a vMIMO scheme for LEACH clusters, namely MIMO-LEACH, which is hereafter referred to as LMIMO for short. An approach that combined vMIMO and data gathering with fusion was presented in [8], which analyzed the effect of long-haul distance on the energy efficiency of wireless transmissions.

III. SYSTEM DESIGN

A.SYSTEM ARCHITECTURE

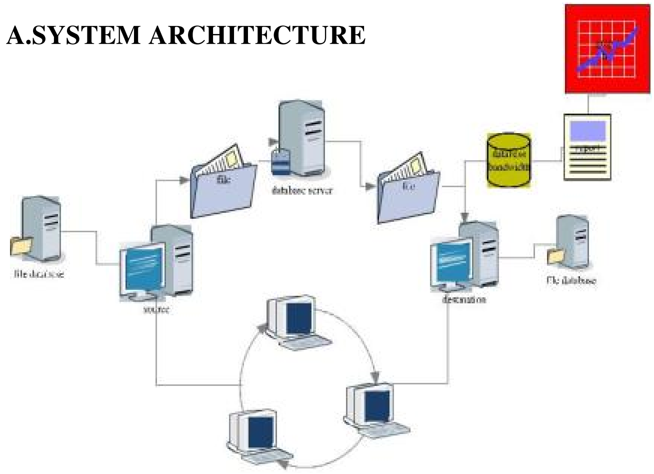


Fig 1:System Architecture

Fig 1 Describes that database connect to the source and the files in database are connecting to destination by the user login. Hence the nodes are created and text files are transmitted by node to destination. Then the bandwidth and capacity of the nodes are calculated. Finally the total files are merged and graph values are noted

B.MODULE DESIGN

1. FILE

This module the user can select any files to choose for transmitting from selected source node to destination nodes using a particular path that can be calculated using a greedy algorithm.

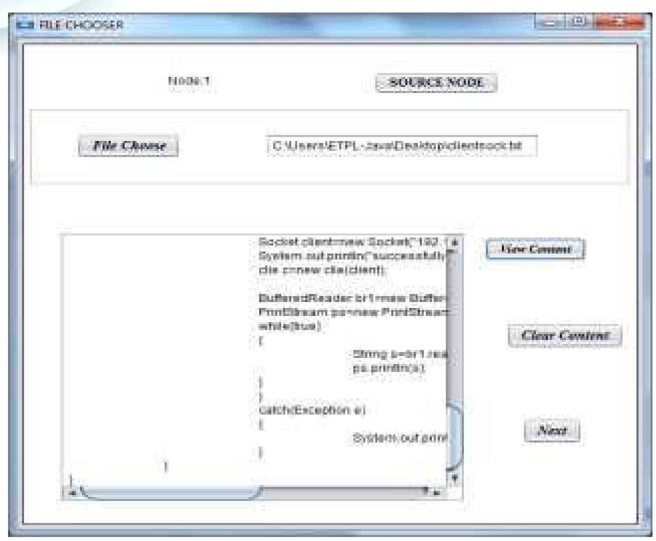


Fig 2 Choosing the File

2. FORWARDING

This module the path can be selected using a greedy algorithm to transmit a file from source to destination. To receive a file from one to another users. This module can be used as an intermediate to transmit files.

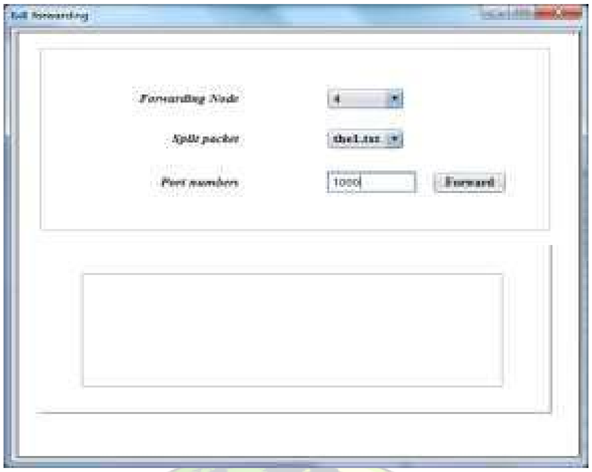


Fig 3 Forward file from one node to another

3. DISTRIBUTED

This module the distributed algorithm can be used to find the shortest path or greedy path to transmit a file from one node to another node using an intermediate node or forwarding path and also used to calculate the delay for the process time.

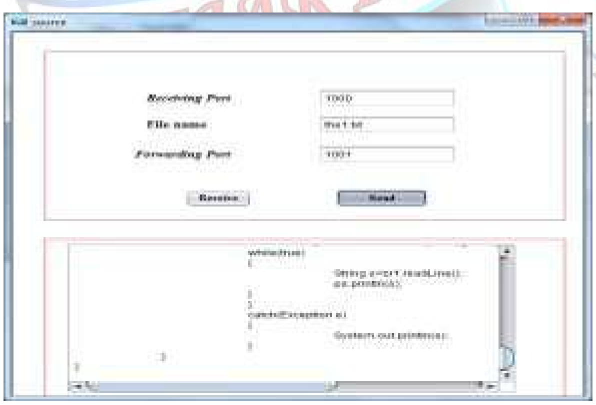
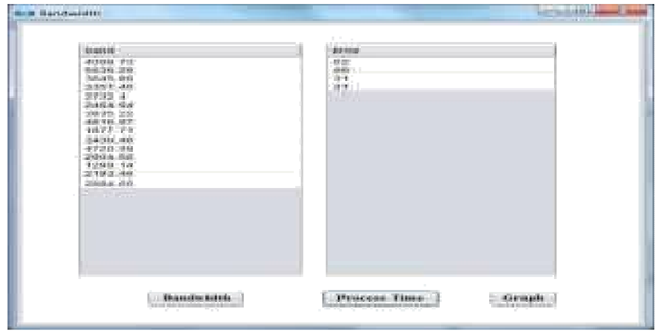


Fig 4 Finding Shortest path

4. BANDWIDTH

This module the Bandwidth of transmitting the files from source node to destination node can be calculated using the Distributed algorithm. Then the delay and process time of the both averages can be calculated as a result data in it.



ALGORITHM DESCRIPTION

Phase 1:Distributed MDT construction

Broadcast a message loc(u,Xu,Yu)to local neighbors after a delay;
On receving a loc(u,x,y)message from node v
W(u,v)=pu,v;//minimum transmission power
Each node constructs a local minimum Dijkstra tree(LMDT);
Using the BellmanFord algorthim forMDT construction,denoted by T;
Each node unow knows the parent v=P(u)and its children;

Phase 2:Modify t and partner Selection

Finished=false;
The base station first sends a dct(0,0)message to neighbors(children)
On receving the pts(u,v)message from nodev
Send a dct(1,v)message to children nodes//node v as the partner
Finished=true;
On the receving the dct(p-nodepair,p-id)from its parent node v
For each link lu,w(to every child node on T)
If(P-nodepair=0) Wu,v=1/2Pu,w+Pu,v-rPu,v-P{u,w},v;
Else
t=p-id;
Wu,w=1/2Pu,w+Pu,v-Pu,w-min{P{u,w},v,P{u,w},t,P{u,w},{v,t}};
Select a link lu,w with the maximum weight If(Wu,w>0 for the selected link)
Transmit a pts(w,u)message to node w
Select node w as the partner
Send adct(1,w)message to all other children nodes(except w)
Else
Send a dct(0,0)message to all children nodes(including w)

IV. JOINT VIRTUAL MIMO AND DATA GATHERING PROBLEM

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. We make four important assumptions for problem definition.

First, it is assumed that the network is synchronized. Despite some concerns over the infeasibility of the MIMO mode due to lack of simultaneous synchronization, some works have shown that a small synchronization error didn't greatly decrease the performance of vMIMO transmission.

For example, Nguyen et al. analyzed that the performance degradation increased with the synchronization error and the number of cooperative transmission and reception nodes. However, the cooperative MIMO system was rather tolerant for small ranges of synchronization Error and the degradation was negligible for synchronization error range as small as 0.2Ts, where Ts was the symbol period. The previous work [10] has shown that the variance of the synchronization error is not more than, where s is the maximal variance of the Link delay and c is the sampling interval. As a result, given the parameters Ts and s, the synchronization error can be bounded by adjusting the parameter c. As a result, it is reasonable to assume perfect time synchronization among the network.

Second, this paper assumes that transmission collision can be avoided. Since our focus is not on MAC protocols, we neither discuss channel access, nor explicitly consider collisions in the problem definition. In general, MAC protocols based on adaptive modulation can be used, and in particular, the MAC protocol proposed in [10] which uses a variable-length energy-minimizing TDMA scheme for interference avoidance, can also be used. Third, this work ignores the cost of sharing the control information for vMIMO transmission in the data gathering.

This assumption is based on the following reasons. First, the control packet is relatively short compared with the data packet. Second, the proposed algorithm will construct a tree. Most of the links in this tree are not long (in terms of geometric distance). Accordingly, the energy consumption of additional data exchange procedure will not greatly impact the energy consumption of vMIMO comunication.

Fourth, we will consider vMIMO involving two (2) nodes at most based on the following rationale. In [28], Sajid et al. have given two conclusions by simulations. First, the SIMO, MISO and MIMO modes are more energy-efficient compared with the SISO mode. Second, in many cases, the 2X2 mode is much more energy-efficient than 1X1 (SISO), 3X3 (MIMO) and 4X4 (MIMO) modes. In addition, if more nodes cooperate with others in vMIMO transmission, the management of the cooperative nodes will also become more complex [5]. Therefore, this paper studies the cooperation among (at most) two nodes for vMIMO. Accordingly, the vMIMO transmission includes four different communication modes, SISO (1 X 1), SIMO (1 X 2), MISO (2 X 1) and MIMO (2 X 2) respectively. In the SIMO, MISO and MIMO modes, the transmitter or receiver sides may contain two nodes. For convenience, two nodes in one transmitter or receiver side will be referred to as a cooperative node pair.

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. More formally, the Vmdg

V. DISTRIBUTED ALGORITHM FOR THE VMDG PROBLEM

As the vMDG problem is NP-Hard, this section proposes a distributed heuristic algorithm D-vMDG with a constant approximation factor for this problem. We will first give a brief overview of the proposed algorithm, and then describe two main steps in detail. Finally, we will analyze the approximation performance and complexity of the proposed algorithm.

Algorithm Overview

Under the traditional scheme, the Dijkstra algorithm can construct a spanning tree, called Minimum Dijkstra Tree or MDT, which is rooted at the base station and contains the "shortest" path for all other nodes in a given network. This is the optimal topology for data gathering under the SISO communication mode, as it determines the energy-minimum routing from each sensor node to the base station under this mode. However, due to special features of the vMIMO transmission, MDT is no longer optimal for the vMDG problem and thus needs to be modified.

The proposed D-vMDG algorithm consists of two main steps, topology construction and route selection, respectively, and has two sub-algorithms, one for each step. In the first step, a sub algorithm called vMIMO-aware Topology Construction (or vMTC) builds up a tree-like topology modified from MDT. In the second step, another sub-algorithm called vMIMO-based Energy-efficient Routing (or vMER) will perform the route selection for each node using dynamic programming, taking all communications modes of vMIMO into consideration.

VI. Distributed vMIMO Topology Construction

In this section, we present a distributed vMIMO-aware topology construction algorithm called vMTC. The algorithm, which mainly consists of two phases, first constructs a MDT and then modifies it while taking the unique features of vMIMO communications into consideration. For Convenience, we describe the proposed vMTC algorithm for Node u as follows.

Phase 1:

Under the SISO communication mode, two Nodes are connected if their distance is not more than the Maximum communication range. Given an arbitrary topology G and a node u, the connected nodes are its one-hop neighbors, denoted by N^G (u). First, each node u locally broadcasts its location message loc(u,X_u,Y_u) with a maximum transmission power (using well-established reliable broadcast protocols that may rely on retransmissions with random backoff for example). On receiving a location message loc(v,X_v,Y_v) from node v, node u determines the Euclidean distance of link lu;v, and computes its weight as w(u.v)=$p_{u,v}$, the minimum power consumption through this link under the SISO communication mode. Note that, the localization information is used to compute the distance between two nodes. As a result, the energy consumption per bit can be derived,After collecting the neighboring information, each node u will construct a Local minimum Dijkstra tree (LMDT) as in [9], then obtain a connected neighbor set. As shown in [9], LMDT contains MDT, i.e., MDT subset of LMDT. This process of constructing LMDT before constructing MDT can decrease the number of transmission links to be considered, and accordingly, Reducing the message complexity in the subsequent construction of the MDT topology. After a short delay, the base station will start the BellmanFord algorithm [8] to construct a MDT, denoted by T. More specifically, each sensor node maintains a local variable PER, which denotes the minimum energy consumption from this node to the base station. The BellmanFord's method runs repeatedly in iterations until a MDT topology is constructed. In each iteration, each sensor node broadcasts it's PER information to its local neighbors. On receiving the energy information, each sensor node will update the PER information. If the PER's value is decreased, this node will select the transmitter as its parent node in the MDT. This topology preserves the energy minimum path from each sensor node to the base station under the SISO mode.

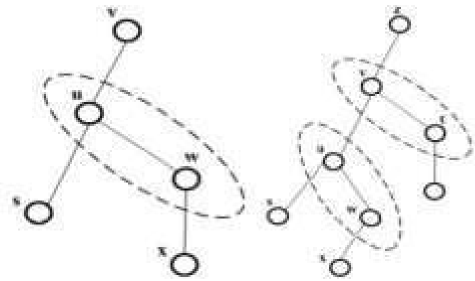


Fig. 2. Illustration of the *dct()* message and link weight assignment.

Phase 2: Modify T (i.e., the MDT constructed in Phase 1) into a vMIMO-aware topology by forming partners. After the MDT construction process, each sensor node u knows the parent node p (u) and its children node set cns(u) (if any) in tree T. To simplify the network management and our presentation, two sensor nodes u and v will be considered as a cooperative node pair if and only if link lu,v belongs to tree T. Moreover, node u (or v) is called the partner of node v (or u). Note that the base station will not select a partner for vMIMO transmission.

At the beginning of Phase 2, the base station broadcasts a detection message dct containing two parameters, denoted by dct (p-node pair, p-id), to its children nodes in tree T. For the base station, both parameters will be set to 0. In general, the first (binary) parameter p-node pair is set to "0" to indicate That the parent side contains only one node, and"1" to Indicate that the parent side is a node pair, i.e., two nodes. For example, in the case of the detection message sent by Node v in Fig. 2a, this parameter will be set to 0. On the Other hand, in Fig. 2b, when node v (which has already selected node t as its partner node) sends a detection message, it will have p-node pair set to 1. The second parameter "p-id" represents the ID of the parent node's partner, and is set to 0 if the parent node has no partner (i.e., when p node pair is 0). Note that, while node v may select node u (instead of node t), or none of the two as its partner, nodes u and t, being the sibling to each other on the tree T, will not select each other as a partner in the algorithm, for node u and node t are not connected in the tree. On receiving dct(p-nodepair, p-id) from node v, node u will follow two different processes based on the value of the parameter p-nodepair.

Case (a) where p-node pair=0. In this case, the parent side of node u only contains one node, which is v, as shown in Fig. 2a. Each connected link lu,w will be assigned a weight, which approximately denotes the amount of the power reduced (or saved) due to cooperation between node u and node v. This amount of saved power is estimated as follows: under the traditional scheme (i.e., the SISO mode), for each packet from the child node of node u, node u will need to transmit at power pu,v to reach node v. For each packet from the child node of node w, node u and node w will cost $p_{w,u} + p_{u,v}$ to reach node v. Thus, the expected energy consumption of two nodes is $1/2p_{w,u} + p_{u,v}$ per packet. With vMIMO, there are two sub-cases. The first sub-case is that the child side of node u (e.g., node s in Fig. 2) will transmit a packet to node u. After node u forwards the packet to its partner w, two nodes cooperatively transmit to node v using the MISO communication mode. The energy consumption by nodes u and w is $p_{u.w} + p_{\{u,w\}v.}$

VII. CONCLUSION

This Project describes vMIMO is an efficient way to save power and energy in wireless communication. This paper has studied the energy-efficient data gathering problem with vMIMO communication for wireless sensor networks. We have defined a new optimization problem called joint vMIMO and data gathering (vMDG), and designed a distributed algorithm D-vMDG, which consists of vMIMO-aware topology construction and vMIMO-aware energy efficient route selection. The theoretical analysis has shown that the proposed algorithm can achieve an approximation performance. Our simulations have shown the high energy efficiency of the proposed algorithm

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