

A Decentralized Clustering Algorithm Using Gossip Technology with Distributed Implementation in Compressive Sensing

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ABSTRACT: Compressive sensing (CS) can reduce the number of data transmissions and balance the traffic load throughout networks. However, in CS method the number of transmissions for collecting a data is still large. We proposed a hybrid method using CS to reduce the number of transmissions in sensor networks. The previous scheme uses CS method on routing trees. We propose a clustering method that uses hybrid CS for sensor networks. The sensor nodes are grouped into clusters. Within a cluster, nodes transmit data to cluster head (CH) without using CS. CS is used in CH to transmit data to sink. The relationship between the size of clusters and number of transmissions in the hybrid CS method can be studied by using an analytical model which helps us to find the optimal size of clusters that can lead to minimum number of transmission. Finally, we present a distributed implementation of the clustering method. Extensive simulations show that hybrid CS method can reduce the number of data transmissions significantly.

KEYWORDS: Wireless Sensor Network, Compressive Sensing, Data Collection, Clustering

I. INTRODUCTION

Wireless Sensor Networks (WSN) is composed of a hundreds or thousands of micro sensor nodes, which are randomly deployed either inside the phenomenon or very close to it. The micro sensor nodes have capabilities of sensing, establishing wireless communication between each other and doing computational and processing operations. The position of sensor nodes need not be engineered or pre-determined. This allows random deployment in inaccessible terrains or disaster relief operations [1]. In spite of the several applications of WSNs, these networks have numerous restrictions, e.g., limited energy supply, limited computing power, and limited bandwidth of the wireless links connecting sensor nodes. The main aim of WSNs is to perform data communication and to extend the lifetime of the network by using energy management approaches. The communication protocols have significant impact on the overall energy dissipation of these networks. Based on our findings that the conventional protocols of direct transmission, minimum-transmission-energy, multi-hop routing, and static clustering may not be optimal for sensor networks. [2]. Considering the limited battery power capability of an individual sensor, a sensor node can able to sense very small area, so a wireless sensor network has a large number of sensor nodes organize in very high density which reasons for precise problems such as scalability, redundancy. Reducing the amount of data communication by removing unnecessary sensed data and by means of the energy-saving link would save large amount of energy, therefore the lifetime of the WSNs gets increased [3].

Sensor networks have a wide variety of applications and systems with vastly varying requirements and characteristics. The sensor networks can be used in Military environment, Disaster management, Habitat monitoring, Medical and health care, Industrial fields, Home networks, detecting chemical, Biological, radiological, nuclear, and explosive material etc. Especially in environment monitoring system the sensor node need to collect data continuously and data is transmitted to the sink using multiple hops [2]. It has become an important issue in sensor network to reduce the number of data transmissions. A compressive sensing method is used to reduce the number of data transmissions and it manages the

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network without traffic [3]. In data gathering method without using CS, the node which is close to the tree leaves send only fewer packets but the node which is close to the sink has to send more packets. So an hybrid method is used, in which the node close to the leaf node does not uses a CS to send an data but the node close to the sink uses an CS to send data [4].

The previous schemes use clustering method on routing trees. When compared to the tree method, the clustering method has more advantages such as fault tolerance and traffic load balancing. Here we use CS on clustering method. Here the nodes are grouped into clusters. Within a cluster a node does not uses CS to transmit data to CH but the CH uses CS to transmit data to sink. But here an issue is to determine how big a cluster should be. If the cluster size should be large then the number of data transmissions will be large to collect data from sensor nodes and if the cluster size is small then the number of clusters will be large and data collected by the CH will be large.

II. SURVEY OF COMPRESSIVE SENSING TECHNIQUE USING CLUSTERING METHOD

The compressive sampling scheme is applied to sensor data gathering for large scale wireless sensor networks [5]. This will provide more knowledge to the research in both compressive sampling applications and large-scale wireless sensor networks. Data gathering sensor networks are used in many applications like infrastructure and habitat monitoring. Here a more number of sensor nodes are deployed and sensor readings are spatially correlated. The successful deployment of sensor nodes in such large sensor network faces two main challenges. 1. Effective global communication cost & 2. Energy consumption load balancing. In general the data transmissions are occurred through multiple hops from node to sink. The proposed compressive data gathering is able to reduce global scale communication cost without doing computation or transmission control and also the load is an important characteristic and it is capable of extending the lifetime of the entire sensor network. If the sensor readings are not clear in any known domain and it is not in proper order then compressive data gathering cannot achieve capacity gain. The compressive data gathering is not suitable for small scale networks when the capacity gain is small.

The data stream model is used in many applications like numerous types of data, including telephone records, Web documents, and clickstreams [6]. Here a data stream is send only in ordered sequence of points from $x_1; \dots; x_n$ and that must be accessed in order and that can be read only once or a small number of times. Each reading of the sequence is called a linear scan or a pass. The data stream may be customer click streams, telephone records, large sets of Web pages, multimedia data, financial transactions, and observational science. These data sets are too large to fit in main memory and are typically stored in secondary storage devices. Hence in this data streams it will send the next data streams only if it can remember the data that is stored in secondary storage. Linear scans are very cost-effective and also it is very difficult to access the data. Here running time will be very high. In application like intrusion detection or target monitoring it will provide more mistakes. In case of speed e.g. clustering web search results it appears quick and job is not good.

In wireless sensor network clustering is a standard method for achieving efficient and scalable performance. Clustering algorithms generates a number of disjoint clusters that satisfy some criteria [7]. In this we formulate some clustering problem that aims at generating overlapping multihop clusters. Overlapping clusters are used in many sensor network applications like inter-cluster routing, node localization, and time synchronization protocols. In order to solve overlapping clustering problem we use randomized and distributed multihop clustering algorithm (KOCA). KOCA aims to connect overlapping clusters that cover the entire sensor network with a specific average overlapping degree. The results show that KOCA produces approximately equal-sized clusters, which allow distributing the load evenly over different clusters. KOCA is scalable and the constant time of an network time terminates due to formation of cluster.

LEACH is one of the hierarchical protocols. Hierarchical routing is used to reduce energy consumption by doing data aggregation and fusion in order to reduce the number of transmission to the base station [8]. The main idea of the leach is to form an cluster based on the received signal strength and use cluster head as router to the sink. This enhances energy consumption and also the transmission done only by the cluster head. In Leach, the node transmit data directly to cluster head and therefore to the base station. There are two types of phase. They are set up phase and steady state. In set up phase there will be an advertisement phase and cluster set up phase. At advertisement phase the cluster head inform its

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neighbour that it become cluster head. At cluster set up phase the member node inform cluster head that they become a member node to the cluster with join packet. In the steady state phase there will be schedule creation and data transmission. The role of being a CH is rotated periodically among the nodes of the cluster in order to balance the load. The rotation is performed by getting each node to choose a random number “T (n)” between 0 and 1. A node becomes a CH for the current rotation round if the number is less than the following threshold

$$T(n) = \frac{p}{1 - p * \left(r \bmod \frac{1}{p} \right)} \quad : \text{if } n \in G$$

$$T(n) = 0 \quad : \text{Otherwise}$$

(1)

Eqn.1 shows the threshold value. Where p is the desired percentage of CH nodes in the sensor population, r is the current round number, and G is the set of nodes.

III. CLUSTERING METHOD FOR EFFICIENT DATA TRANSMISSION USING HYBRID COMPRESSIVE SENSING

In this we propose a clustering algorithm based on the analytical model and to avoid the number of transmission using a hybrid compressive sensing. Here the sensor nodes are grouped into clusters. Within the clusters the node transmits data to the cluster head without using any compressive sensing. But the cluster head uses a compressive sensing technique when it transmits data to the sink. First we propose an analytical model that studies the relationship between the size of the cluster and number of transmissions aiming to find the optimal size of the cluster that can lead to minimum number of transmissions. Then we propose a centralized clustering algorithm based on the result obtained from the analytical model. In order to transmit the data efficiently we are going for LEACH-C protocol [8]. LEACH-C provides an efficient clustering configuration algorithm, in which an optimum cluster head is selected with minimization of data transmission energy between a cluster head and other nodes in a cluster.

Figure.1 shows block diagram of efficient data transmission using clustering method. In LEACH-C, the base station receives information about residual node energy and node positions at the set up phase of each round. The received data can compute an average residual energy for all nodes. The nodes with less than average energy are excluded in selection of cluster heads. Among the nodes that have more than average energy, cluster heads are selected with use of the simulated annealing algorithm. The base station sends all nodes a message of the optimum cluster head IDs (Identifiers). The node, the ID of which is the same as the optimum cluster head ID, is nominated as a cluster head and prepares a TDMA schedule for data transfer. Other nodes wait for the TDMA schedule from their cluster heads. The LEACH-C solves the problem of uncertainty on the number of cluster-head at each round in LEACH. Hence LEACH-C provides more advantages such as it can reduce the number of data transmission, provides low communication cost, maintaining traffic load and also fault tolerance and finally the energy consumed by the sensor node is low.

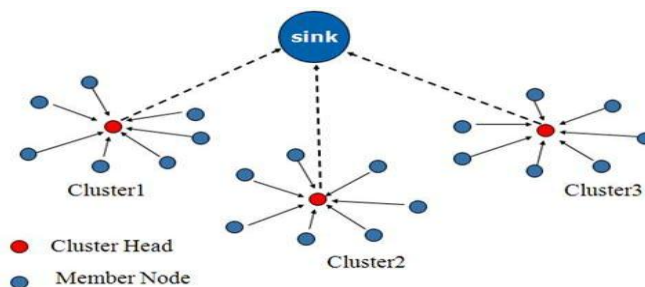


Fig.1 Block diagram of efficient data transmission using clustering method

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A. DISTRIBUTED IMPLEMENTATION

This section presents a distributed implementation of clustering method. We assume that

1. Every sensor node knows its geographic location. This location information can be obtained via attached GPS or some other sensor localization techniques.
2. The sink knows the area of the whole sensor field, but does not need to know the location information of all sensor nodes.

This is a reasonable assumption, since in most applications of the sensor networks the sink usually knows the area that has sensors deployed for surveillance or environmental monitoring. In our distributed algorithm, the sink divides the field into C cluster-areas, calculates the geographic central point of each cluster-area and broadcasts the information to all sensor nodes to elect CHs. The sensor node that is the closest to the center of a cluster-area is selected to be the CH. The CHs then broadcast advertisement messages to sensor nodes to invite sensor nodes to join their respective clusters.

B. CLUSTER HEAD ELECTION

The sensor node that is the closest to the central point will become the CH. Since the sensor nodes do not know who is the closest to the central point of a cluster- area, and we do not know if there is a sensor node falling into the close range of the central point, we let all nodes within the range of Hr from the center be the CH candidates of the cluster, where r is the transmission range of sensors. The value of H is determined such that there is at least one node within H hops from the central point of a cluster. To elect the CH, each candidate broadcasts a CH election message that contains its identifier, its location and the identifier of its cluster. The CH election message is propagated not more than $2H$ hops. After a timeout, the candidate that has the smallest distance to the center of the cluster among the other candidates becomes the CH of the cluster. In the extreme case that no sensor node falls within H hops from the central point so that there is no CH for this cluster-area, the nodes in this cluster-area accept the invitation from neighboring CHs and become members of other clusters. Thus, no node will be left out of the network.

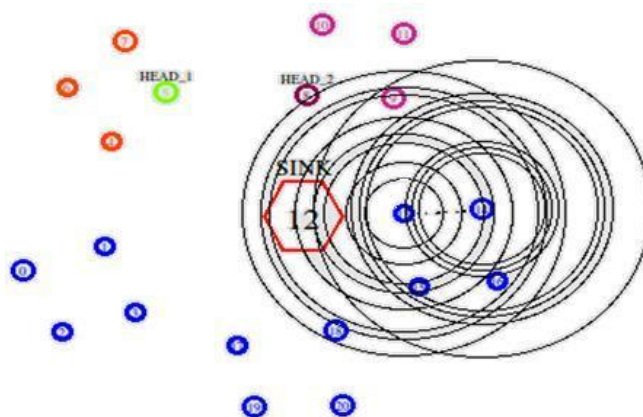


Fig.2 Efficient data transmission using clustering method

Figure.1 shows that the nodes are grouped into clusters and each node sending RTS and CTS to each other node. The node which has a high energy will become a cluster head. The cluster head collect data from its group node without using compressive sensing but the cluster head uses compressive sensing technique when it sends data to the sink.

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C. RE-ELECTING CLUSTER HEAD

After a CH send data to the sink we are going to reelect the cluster head for next data transmissions. While sending a data the cluster head can lose its energy. So we are going to reelect the cluster head for further transmissions.



Fig 3. Reelecting cluster head

D. K HOP CONNECTIVITY

The K hop connectivity is mainly used to avoid the data loss. In a network some of the node has a high energy and some has low energy [21]. While transmitting a data the node which has low energy can able to drop the data. In k hop connectivity the cluster node which has low energy will send its node to the cluster head which has high energy by sending RTS and CTS. The node goes to the cluster which has high energy and shares its data and return back to its original position.

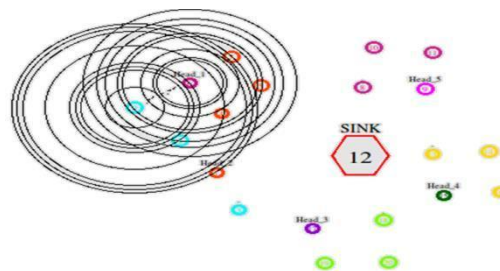


Fig 4. K-HOP connectivity

E. MASTER AND SLAVE

Inorder to conserve energy and for effective data transmissions in mobile adhoc networks we are going for master and slave techniques [22]. There are two types of nodes, master (clusterhead) and slave (member). The node within a cluster can able to move outside from its specified range. so the nodes which come outside from its range will form a cluster and again it selects a cluster head to transfer data. Hence there will be no data loss. The master node is the head node so the master node alone connect to the sink and slave node is a member node and hence there is no direct link to the sink. so the slave node had to use master node to send data to the sink.

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Fig 5.Master and Slave

F. MIMO

MIMO is used to send the multiple data to the sink [21]. In previous we use SISO that will send a single data to the sink. But in MIMO the cluster heads collects data from its node and sends the data simultaneously.

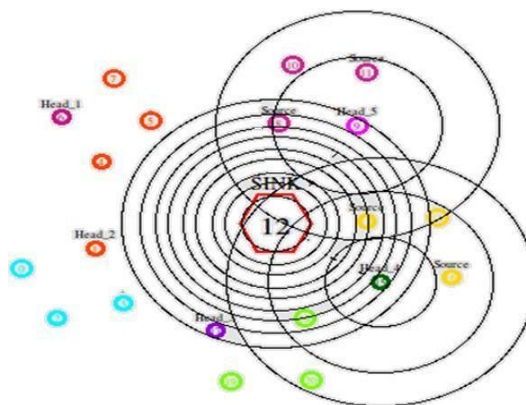


Fig 6.MIMO

IV.RESULTS AND DISCUSSION

The Network Simulator version 2.0 (NS2) simulation of the proposed approach is done to evaluate the performance. The lifetime of a wireless sensor network is constrained by the limited energy and unbalanced network load. To improve the lifetime of the wireless sensor networks it is very important to have high energy efficiency and balancing network load.

Performance metrics: The performance of the proposed protocol is compared with LEACH protocol. The performance is evaluated mainly according to following metrics.

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1. DELAY RATIO

It is average delay taken by the nodes during data transmission.



Fig 7. Delay ratio comparison

Fig.7 shows that the comparison of delay ratio. While using centralized (LEACH protocol) the packet delay ratio is high. In decentralized protocol the delay ratio is low.

2. THROUGHPUT

It is the number of packets successfully received by the receiver during the data transmission.

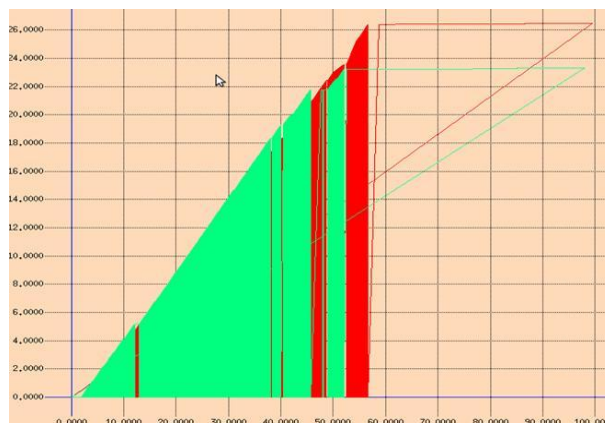


Fig 8. Throughput comparison

Fig.8 shows that the comparison of throughput. Throughput ratio is high in decentralized protocol and it is low in centralized protocol.

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3. PACKET DELIVERY

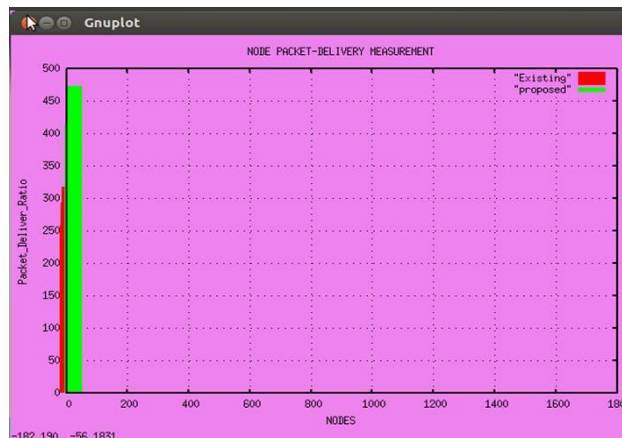


Fig 9.comparison of packet delivery

Fig. 9 shows that the comparison of packet delivery. In centralized protocol the packet delivered to the sink is very low and packet delivery is high in decentralized protocol.

4. PROTOCOL WORKING FREQUENCY

It shows that how the proposed protocol was efficiently working than the other existing protocols.



Fig.10. Protocol working frequency comparison of Routing Protocols

V. CONCLUSION

The NS2 simulations show that when the data collected by sensors is strongly correlative, the proposed protocol outperforms LEACH. Hence this clustering method which uses a hybrid compressive sensing can reduce the number of data transmissions.

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