International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.4, No.10, October 2015 DOI:10.15693/ijaist/2015.v4i2.315-320

Data Collection Based Hybrid Compressive Sensing in Wireless Sensor Networks

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Abstract*-Hybrid compressive sensing (CS) can reduce the number of data transmissions and balance the traffic load throughout networks. To maximize network lifetime in Wireless Sensor Networks (WSNs) the paths for data transfer are selected in such a way that the total energy consumed along the path is minimized. Hybrid CS method was proposed to reduce the number of transmissions in sensor networks. The Hybrid Compressive Sensing which uses a clustering method in wirelesssensor networks.The sensor nodes are organized into a clusters. Within a cluster, the sensor nodes are transmitting data to cluster head (CH) without using CS. CHs use CS to transmit data to sink. An analytical model that studies the relationship between the size of clusters and number of transmissions in the hybrid CS method, the aim is to find the optimal size of clusters that can be lead to minimum number of transmissions. A centralized clustering algorithm based on the results obtained from the analytical model.

***Keywords:*Compressive sensing (CS), energy efficiency, sensor nodes, wireless sensor networks(WSN).**

I.INTRODUCTION

The research of the wireless sensor networks (WSN) has garner increasing attention owing to its technical importance in widespread applications, such as monitoring and surveillance in the military, civil industries, home automation and control the traffic field. In general, theWSN using a communication method has a multi-hopping, by which messages are transmitted through a sequence of sensor nodes (SN).

A WSN consists of a number of sensor nodes and devices that collaborate with each other have a common task such as environment monitoring, object tracking, etc., and report the collected data through wireless sensor interface to a sink node.

The energy efficiency of data gathering is one of the most important issues in the wireless sensor networks (WSNs). It has been tackled form various aspects in the beginning of WSNs, and includes the energy conserving sleep scheduling, topology control.Since the beginning of WSNs, which include among the others, energy conserving sleep scheduling, topology control, mobile data collectors, and data aggregations. where the first threeapproaches (and many others) focus on the efficiency ofnetworking techniques and that transport of the sensory data, dataaggregation directly aims to significantly reducing the amountof data to be transported, and it hence complements the otherapproaches and toachieve energy efficient of data collection for WSNs.

In large WSNs sensor nodes are often grouped into clusters. Clustering is essential for sensor network applications where a large number of ad-hoc sensors are deployed for the sensing purposes. In each and every sensor node starts to communicate and connect in data transmission in the network, the great data congestion and collisions will be experienced. Clustering method is used to overcome this problem. In clustered networks, some sensor nodes are elected as cluster heads (CHs) for each cluster created. Sensor nodes form in each cluster transmits their data to the respective CH and the CH aggregates the data and forwards them to a centralbase station. Clustering facilitates for efficient utilization of the limited energy of sensor nodes and hence extends the network lifetime. Although sensor nodes in clusters transmit messages over a short distance (within clusters), more energy is drained from CHs due to message transmission over long distances (CHs to the base Station) compared to other sensor nodes in the cluster.Many clustering algorithms are used in various frameworks. These algorithms are mostly heuristic in nature and aims at generating the minimum number of clusters such as that any node in any cluster is at most d hops away from the cluster head. Most of these algorithms have a time complexity of $O(n)$, where n is the total number of nodes. The demand time synchronization among the nodes, which makes them suitable only for the networks with a small number of sensors.

The clustering algorithm proposed for the aims at maximizing the network lifetime and efficient energy, but it assumes that the each node is aware from the whole network topology, which is usually impossible for wireless sensor networks which have a large number of nodes. Many of these clustering algorithms are specifically designed with an objective of generating stable clusters in environments with mobile nodes. But in a typical wireless sensor network, the sensors' locations are fixed and the instability of clusters due to mobility of sensors.

Shortest Path Tree (SPT) is described as at the initial stage, calculate the distance between the sensor nodes and sink according to the strength of signal. After the cluster heads are selected, the cluster heads present to all sensor nodes in the network that they are the new cluster heads. Once the sensor nodes receive the advertisement, then they calculate the distance between the cluster head and themselves, then add the distance into the set of cluster heads distance *H,*

$$H = \{di - j \mid i, j \text{ are cluster heads}\};$$

Each cluster head calculates the shortest distance to sink with Prim algorithm then sends data to sink along the optimal path.

II. RELATED WORK

To achieve a capacity gain over the baseline transmission scheme and the delay also reduced**.** The compression technique is used for compress the heavy amount of data in the network. To reduce transport load, conventional compression techniques are usually used to exploit the correlation among sensor data so that less data can be delivered to the sink without sacrificing the salient information. Compressive sensing (CS) provides a promising solution in a more efficient manner for the data gatheringproblem in WSNs, which attempts to reduce sensor data traffic over the network through collecting far fewer measurements than the number of original sensor data. The capacity and delay of datagathering with CS in WSNs. When a sink collects *M* random measurements for a snapshot, it forms a reconstruction of the snapshot. Time is divided into time slots with a fixed length t = b/w seconds. Each node takes one time slot to transport a reading to its one-hop neighbour. The capacityof data gathering *C* is the maximum rate at which the sink can receive a snapshot, i.e., the maximum rate at which the sink can receive all the nb bits of data generated by sensor nodes during a time duration T. When multi-sinks are present in the network, the capacity of data gathering is the maximum total data rate of all the data gathering sessions [2].

A novel classification of schemes that are based on the interaction between the communication subsystem and the sensing subsystem on a single sensor node. They are interested in collaborative target tracking instead of single node tracking. In fact, WSNs are often a dense nature, and redundant data that can be received from multiple sensors help at improving tracking accuracy and reducing energy consumption by using limited sensing and communication ranges. They show that energy-efficiency in a collaborative WSN-based target tracking scheme can be achieved via two classes of methods: sensing-related methods and communication-related methods. These two classes can be related to each other via a prediction algorithm to optimize communication and sensing operations. By self-organizing the WSN in trees and/or clusters, and selecting for activation the most appropriate nodes that handle the tracking task, the tracking algorithm can reduce the energy consumption at the communication and the sensing layers [3].

A new algorithm based on approach for energy-aware routing in wireless sensor networks, can reduce energy consumption and increase the network lifetime in wireless sensor networks. Energy-aware routing algorithm forms energy-balanced clusters and distribute energy consumption equally. This algorithm has used from fuzzy neural network for clustering and section of cluster head nodes among other nodes. Energy consumption happens in three domains: sensing, data processing (including AD/DA and digital signal processing), and communications. The sensing, signal processing parts operate at low sequential and consume less than 1mW. This is over an order of extent less than the energy consumption of the communication part. Communication/data processing exchange between sensor nodes but more local processing implemented by one sensor node in order to enlarge the lifetime of the WSN. That energy efficient routing determination is more important than simple shortest path routing. Several strategies are prevalently employed for power aware routing in WSNs that Minimizing the energy consumed foreach message [4].

The clustering algorithm is a solution to reduce energy consumption. It can be helpful to the scalability and network life time. However, the problem of unbalanced energy dissipation is an important issue in cluster based WSNs. Cluster heads are selected based on node deployment information, Residual energy, node degree and their distance from the base station. The PDKC is to cover the whole network by having the constant number of cluster heads; each node becomes a member of only one cluster. In the clustering algorithms, there are two kinds of communications, intra-cluster and inter-cluster communications. In intra-cluster, since the distance between CH and sensors are too short, the commutation is established by one or at most two hops. In inter-cluster communication the distance between CHs and BS. Multi-hop communication between a data source and a data sink is usually more energy efficient than direct transmission. [5].

A novel greedy matching pursuit algorithm (GMP) that complements the well-known signal recovery algorithms in CS theory and prove that GMP can accurately recover a sparse signal with a high probability. It provides a CS based problem formulation for target counting and localization, and prove that the product of the measurement matrix and the target decay matrix obeys RIP with a high probability. The target counting/positioning in sensor networks were mainly focused on three directions: (1) Binary-sensing based approaches position targets by assuming that a sensor reports value ′1′ if one or more targets are detected in its sensing range and ′0′ otherwise. (2) Topological integration based approaches aim to obtain the expectedtarget count in sensor networks. (3) Clustering based approaches are designed to identify multiple non-overlapping clusters, each of which contains one or more targets. The objective is to count the number of targets in each cluster. [6].

III ANALYSIS OF HYBRID COMPRESSIVE SENSING

Hybrid Compressive Sensing is the combination of tree structure and the clustering method in WSN.The two levels of transmissions in clustering method using the hybrid CS: intra-cluster transmissions that do not using the CS technique and inter-cluster transmissions that uses CS technique. The data size in inter-cluster transmissions is the same data in intra-cluster

transmissions. Reducing the number of transmissions can be effectively reducing the energy consumption of sensor nodes. For intra-cluster transmissions, the sensor nodes transmit their data to the CH following the shortest path routing (in terms of numberof hops). For inter-cluster transmissions, construct a minimal cost (in terms of number of hops) tree that connects all CHs to the sink and transmit the data projections along this tree.

The main aim is to reduce the number of retransmission for data collection in the wireless sensor networks. Compressive sensing is used to reduce the energy consumption of all sensor nodes and improve the network lifetime and energy efficiency.

Hybrid Energy Efficient Distributed Clustering(HEED) is a multi-hop clustering algorithm in Wireless Sensor Networks. CHs are selected based on the two important parameters: residualenergy and intra-cluster communication cost.Residual energy of each node is used to probabilistically choose the initial set of CHs, as commonly done in other clustering schemes. In HEED, Intra-cluster communication cost reflects the node level or node’s propinquity to the neighbour and is used by the nodes in deciding to join the cluster. Low cluster power levels promote an increase in the spatial reuse while high cluster power levels are required for inter-cluster communication and span two or more cluster areas. HEED provides a uniform CH distribution across the network and better load balancing. However, awareness of the entire network is needed to determine the intra-cluster communication cost. HEED is a distributed clustering scheme in which CH nodes are picked from the deployed sensors. HEED considers a hybrid of energy and communication cost when selecting CHs. Unlike. Only sensors that have a high residual energy can become cluster-head nodes. For a given sensor’s transmission range, theprobability of CH selection can be adjusted toensure inter-CH connectivity.

In HEED, each node is mapped to accurately one cluster and can directly communicate with its CH. The algorithm is divided into three phases: 1. Initialization phase: The algorithm sets an initial percentage of CHs among all the sensors. This percentage value is used to limit the initial CH announcements to the other sensors. Each sensor sets its probability of becoming a cluster head. 2. Repetition phase: During this phase, everysensor goes during several iterations to findsthe CH that it can transmit to the leasttransmission power (cost). If there is no CH,the sensor elects itself to be a CH and sends anannouncement message to its neighbours informingabout the change of status. Finally, eachsensor doubles value and goes to the nextiteration of this phase.

3. Finalization phase: During this phase, each sensor makes as a final decision on its status. It either picks the least cost CH or pronounces itself as CH. HEED enables well distributed cluster heads across the network. Several iterations involved in cluster formation in HEED can lead to overhead cost.

A.Challenges for Clustering Algorithms

Clustering schemes is an important role in WSN; these can effectively improve the network performance. There are several key limitations in WSNs that clustering schemes must consider.

1. Limited Energy: Wireless sensor nodes are smallsize battery operated sensors, so they have limited energy storage. It is not practicable to recharge or replace their batteries after exhaustion. The clustering algorithms are more energy efficient compared to the direct routing algorithms. This can be achieved by balancing the energy consumptionin sensor nodes by optimizing the cluster formation, periodically re-electing CHs based on their residual

energy, and efficient intra-cluster and inter-cluster communication.

2. Network Lifetime*:* The energy limitation onnodes results in a limited network lifetime fornodes in a network. Clustering schemes help toprolong the network lifetime of WSNs by reducing the energy usage in the communication within and outside clusters.

3. Secure Communication*:* The ability of a WSN to provide secure communication is ever more important when considering these networks for military applications. The self-organization of a network has a huge dependence on the application it is required for an establishment of secure and energy efficient intra-cluster and inter-cluster communication is one of the important challenges in designing clustering algorithms since these tiny nodes when deployed are unattended to in most cases.

4. Cluster formation and CH selection*:* Clusterformation and CHs selection are two of the important operations in clustering algorithms. Energy wastage in sensors in WSN due to direct transmission between sensors and a base station can be avoided by clustering the WSN. Clustering further enhances scalability of WSN in real world applications. Selecting optimum cluster size, election and re-election of CHs, and cluster maintenance are the main issues to be addressed in designing of clustering algorithms. The selection criteria to isolate clusters and to choose the CHs should maximize energy utilization

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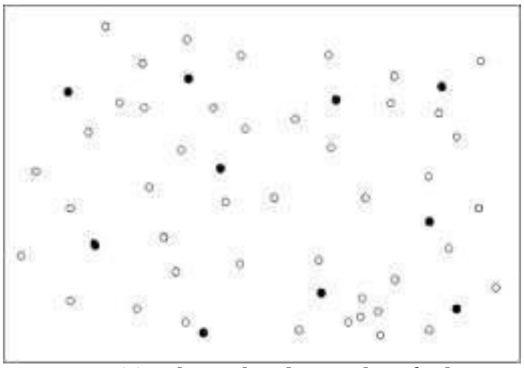
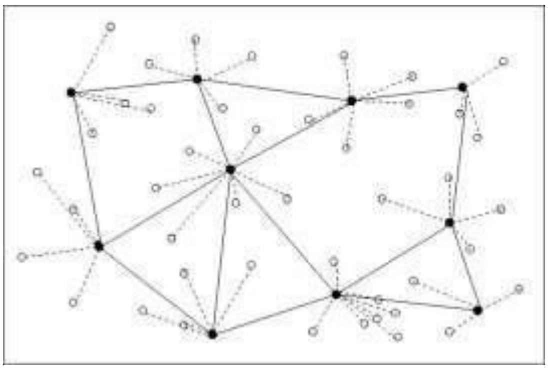


(a) Cluster heads are identified



(b) Cluster heads are connected

Fig: 1 Cluster Head Formation

5. Data Aggregation*:* Data aggregation eradicates duplication of data. In a large network there are often multiple nodes sensing similar information. Data aggregation allows differentiation between sensed data and useful data. Many clustering schemes providing data aggregation capabilities must carefully select a suitable clustering approach.

B.Clustering Process

Clustering is a division of data into groups of similar objects. Each group, called cluster, consists of objects that are similar between themselves and dissimilar to objects of other groups. In other words, the goal of a good document clustering scheme is to minimize intra-cluster distances between documents, while maximizing inter-cluster distances (using an appropriate distance measure between documents). A distance measure (or, dually, similarity measure) thus lies at the heart of document clustering. Clustering is the most common form of unsupervised learning and this is the major difference between clustering and classification. No super-vision means that there is no human expert who has assigned documents to classes. In clustering, it is the distribution and makeup of the data that will determine cluster membership.

Clustering is an effective topology control approach in WSNs which can increase network scalability and lifetime. Sensor node clustering is a very important optimization problem. In order to maintain a certain degree of service quality and a reasonable system lifetime, energy needs to be optimized at every stage of the system operation. A clustering scheme can effectively prolong the lifetime of wireless sensor networks by using the limited energy resources of the deployed sensor nodes efficiently.

C. Distributed Clustering

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 advertisementmessages to sensor nodes to invite sensor nodes to join their respective clusters.

The clustering formation procedure involves the election of a cluster head (CH) node in each cluster, in order to coordinate the cluster nodes. The cluster head is responsible for getting the measured values from its cluster's nodes, aggregating them and sending the aggregates to the sink(s) through other cluster heads.

The clustering protocol is distributed, where nodes make autonomous decisions without any

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centralized control, and energy-efficient, avoiding the fast energy depletion of sensor nodes and the excessive communication cost in terms of retransmitted messages.

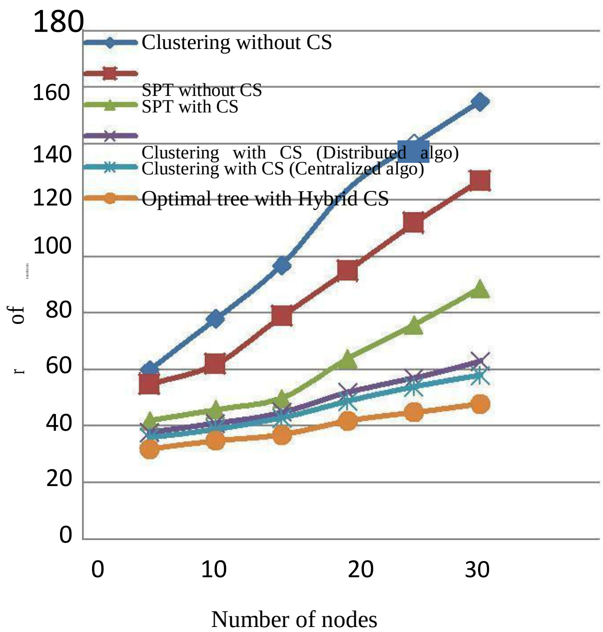
D. Centralized Clustering

The centralized algorithm, the sink node has the full knowledge of the network topology. The sink will divide the sensor nodes into clusters, choose a CH for each cluster, and construct a backbone tree that connects all CHs to the sink. After computing the clustering, the sink can broadcast the clustering information to all sensor nodes and start data collection subsequently.

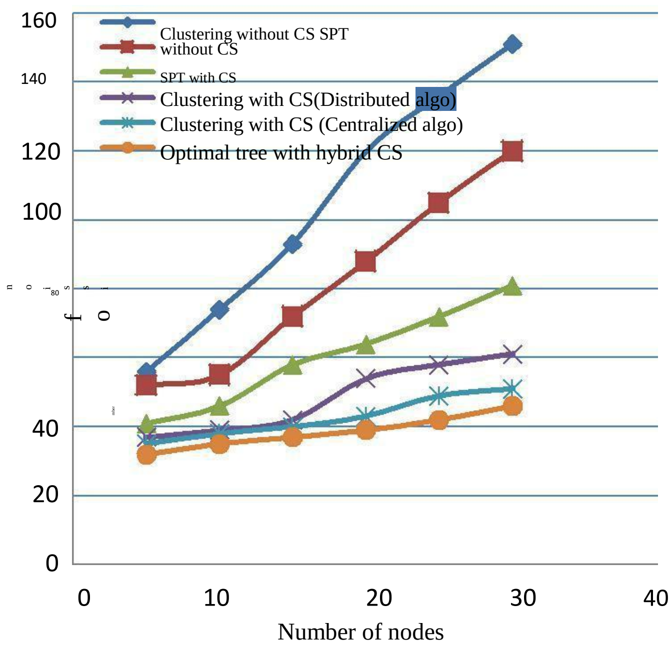
To reduce energy consumption, clustering techniques have been suggested. These techniques organize the nodes into clusters where some nodes work as cluster heads and collect the data from other nodes in the clusters. In a clustered network, the communication is divided into intra and inters cluster communication. The intra-cluster communication is from the nodes inside a cluster to the head. The inter-cluster communication is from the heads to the data center (sink node). The energy efficiency of a clustered sensor network depends on the selection of the heads.

IV. PERFORMANCE EVALUATION

The reduction ratio of transmissions of our method compared with other methods. As show in Fig. 1(a), when the compressive ratio is 5, our method reduce the number of transmissions compared with clustering without CS and shortest path tree without CS when the number of nodes is 30, compared with shortest path tree with hybrid compressive sensing method.

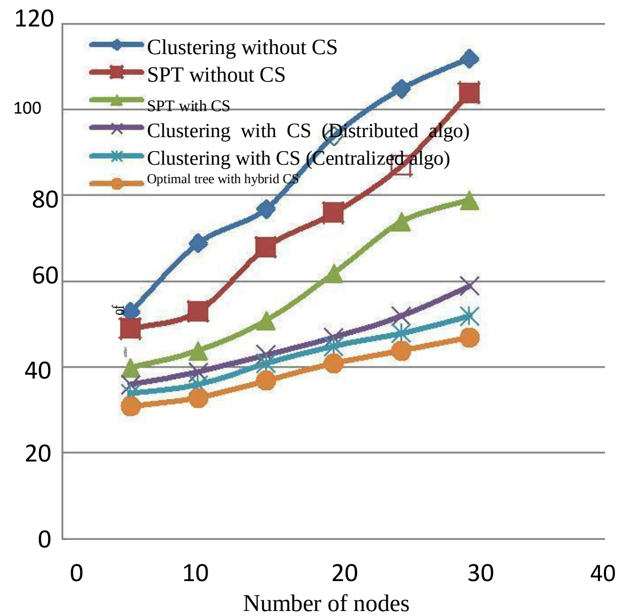


(a) The compressive ratio is 5



(b) The compressive ratio 10

In Fig. 1(b) & (c) when the compressive sensing ratio is 10 and 15. To reduce the number of transmissions compared to the clustering without CS and shortest path tree without CS using the 30 nodes in the sensor networks



(c) The compressive ratio 15

Fig. 2. The number of transmissions of data collection methods. The reduction ratio of clustering with hybrid CS compared with other methods.

ENERGY EFFICIENCY:

Table 1. Energy Efficiency

METHODS	COMPRESSIVE RATIO 5	COMPRESSIVE RATIO 10	COMPRESSIVE RATIO 15
Clustering without CS	41.6 %	44.6 %	47.1 %
SPT without CS	45.4 %	48 %	51 %
SPT with Hybrid CS	59.6 %	60 %	62.5 %
Clustering with CS (Distributed)	65.7 %	67.5 %	69.4 %
Clustering with CS (Centralized)	69.4 %	71.4 %	72.5 %
Optimal tree with Hybrid CS	73.5 %	75.7 %	78.1 %

V. CONCLUSION

In this paper we used hybrid CS used to design a clustering based data collection method, used to reduce the data transmissions in wireless sensor networks. The information on locations and distribution of sensornodes is used to design the data collection methodin cluster structure. Sensor nodes are organized intoclusters. Within a cluster, data is collected transmit to thecluster heads by the shortest path routing; at the clusterhead, data is compressed by usingCS technique. The projections are forwarded to thesink node following a backbone tree. First we proposed ananalytical model that studies the relationship betweenthe size of clusters and the number of transmissions inthe hybrid CS method, in order to find the optimalsize of clusters that can lead to minimum number oftransmissions. Inthat case we proposed a centralized clusteringalgorithm based on the results obtained fromthe analytical model. Finally, present a distributedimplementation of the clustering method. Extensivesimulations confirm that our method can reduce thenumber of transmissions significantly. When the numberof measurements is tenth of the number of nodesin the network, the simulation results show that ourmethod can reduce the number of transmissions compared with clustering method withoutusing CS.

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