A Compressive Sensing Technique For Effective Transmission in Super Sensor Based Wireless Sensor Network

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Abstract
Energy efficient data transmission is a critical issue for battery powered Wireless Sensor Networks (WSNs). Thus making transmission and energy-efficient protocol design a crucial disputing problem. In this, paper we proposed a super sensor (clustering) method that uses Hybrid Compressive Sensing (HCS) technique with K-hop connectivity ID super sensor algorithm (K-CONID). We first proposed a mathematical method that analysis the intercourse between the size of super sensor and number of data transmission, Hybrid compressive sensing technique which reduces the total number transmission by compressing the data transmitted between super sensor head (CH) to the sink and modes transmit data to CH without CS. K-CONID algorithm is proposed to efficiently minimize the number of super sensor formed in the HCS network. Wide computer simulation confirm that our method can provide the efficient data transmission.

Keywords
Wireless Sensor Network, Compressive Sensing, K-CONID, Reelection

I. Introduction

In battery powered wireless sensor network, energy conservation is an important task. Sensed data is transferred through multihop method. Since the motes has limited energy and computing ability, so it's necessary for power consumption. In event sensing process the data is transferred as the energy, by continuously sensing the environment, the motes transmit large number of data to the sink. So number of data transmission increases drastically. To reduce the number data transmission there are many methodology exist. The new technology called hybrid compressive sensing [1] provides new frontiers for data gathering in the wireless sensor network. Hybrid Compressive Sensing (HCS) technique can reduce the number of data transmission and balance the traffic load during entire process.

The HCS method is improved version of compressive sensing (CS) [3] method. The previous method of compressive sensing worked on tree method. Due to the weakness of tree method such as absence of traffic load balancing, still problem exist. So we uses the hybrid compressive sensing technique on optimum super sensor method. In super sensor method the number of sensor motes are connected to the single sensor motes which act as super sensor head (CH), it have the capable to handle the data gathering and effectively transfer the collected data to the sink. These collections of mote in the super sensor called super sensor.

In order to collect the data in HCS method uses two modes of operations: (1) transmission within super senor (2) Inter super sensor transmission. In transmission with in super sensor, the motes within the super sensor (super sensor) transmits the data without compression technique. In inter super sensor transmission method, the super sensor head forward the gathered data to the sink by using compressive sensing method [1].

In previous method ignored about the reelection and scalability of the hybrid compressive sensing method. In our paper we proposed to provide the efficient reelection method and K-CONID method to provide scalability and adaptability of network.

II. Compressive Sensing

Compressive sensing technique can recover data from far fewer measurements than traditional methods use. In conventional compression sensing technique uses the correlation between the encoding side and explicit data communication among the motes. The basic idea of compressive sensing method in super sensor is working as. Fig 1. Consider the system has N number sensor motes within the super sensor.
Let α denote the small vector of actual data gathered at the super sensor head (CH). Let the vector α has N number of elements, one for each sensor motes with in the super sensor. Vector α can be represented as α=Ψs, where Ψ is an N×N transform basis, and s is a vector of coefficients. If there are at most k (K×N) nonzero elements in s, x is called k-sparse in the domain. When k is small, instead of transmitting N data to the sink, we can send a small number of projections of α to the sink, that is, y =ϕα, where ϕ is an M×N (M≪N) random matrix (called the measurement matrix) and y is a vector of M projections. At the sink mote, after collecting y, the original data α can be recovered by using l_1-norm minimization.
In data collection without using CS, the sensor motes close to the tree leaves relay packets for other motes, but the motes close to the sink forwards much more packets. By using compressive sensing method in data collection, every motes needs to transmit M packets for a set of N data items. So total number of transmission is MN which still large in size. HCS method uses compression only on CH and motes within the super sensor transmit the data without compression [1].

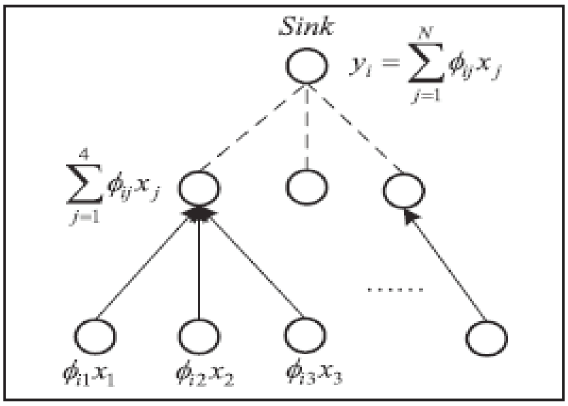

Fig. 1: Data Gathering in HCS Method

Also the previous work ignored the location and motes dispersion of motes in the network. Motes dispersion will provide the details to reduce the data transmission.

Adaptive data gathering method can provides the reconstruction of sensed data to achieve the local adaptive sparsity [3]. The received data is evaluated by utilizing successive reconstructions, the relation between the error and measurements. Also internal error and external events are differentiated by their features. It achieves 8dB SNR gain with moderate increase of complexity.

III. Super Sensor Structure

Fig 1. The process inside the super sensor can be categorized into three stages they are:

- Event discovering
- Analysing data
- Data compression
- Data transfer

A. Event Discovering

Event discovering is the process of detecting the environment changes and transmitting the data in the form of energy to the super sensor head (CH). At the leaf motes transmit the data without using compression

B. Analyzing Data

Data analyzing done at the Super sensor head. Super sensor head receives the data from all the super sensor member at different time periods. Sink provides the TDMA method for collecting the data to avoid the overhead and collusion.

C. Data Compression

Here the data is compressed based on the data received from the super sensor member and it take the vector of the total data compress the data with mote ID. Vector of data uses the non-zero element of the original data. (i.e.) it transmit only the present changes in data and avoids the non-change data. Hybrid compressive sensing method uses the relation between the previous data and current data received from the motes. Transmit only the changes in the data and combined with the mote ID.

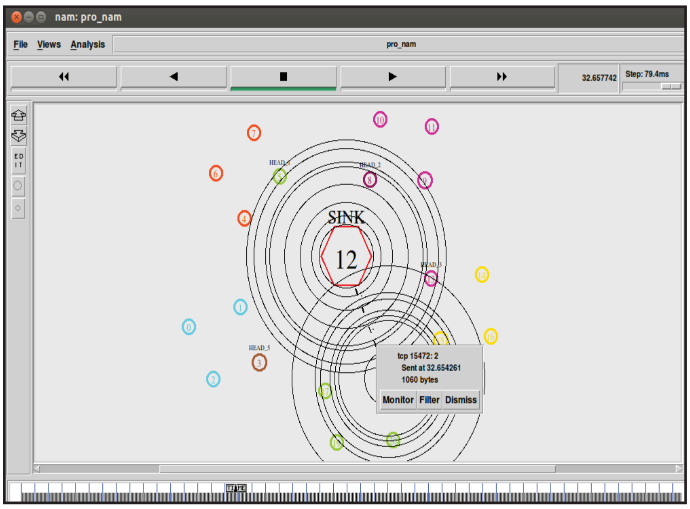

Fig. 2: CS Data Transmitted From the Super Sensor Head to the Sink

D. Data Transfer

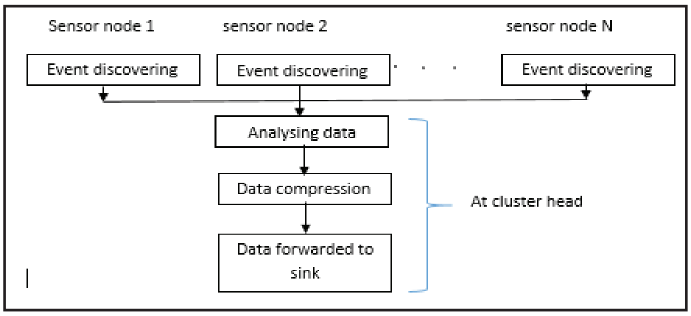

Fig. 3: Process in HCS Super Sensor Method

The compressed data is transmitted to the sink via back bone tree structure. Backbone tree structure follows the minimum spanning tree method (MTS). MTS method which select the lowest cost path to reach the sink with minimum energy requirement [6].

IV. K-hop Connectivity ID Super Sensor Algorithm (KCONID)

It combines two super sensor algorithms: the Lowest- ID and the Highest-degree heuristics. In order to select super sensor heads connectivity is considered as a first criterion and lower ID as a secondary criterion. Using only mote connectivity as a criterion causes numerous ties between motes

On the other hand, using only a lower ID criterion generates more super sensors than necessary. The purpose is to minimize the number of super sensors formed in the network and in this way obtain dominating sets of smaller sizes. Super sensors in the KCONID approach are formed by a super sensor head and all motes that are at distance at most k-hops from the super sensor head.

At the beginning of the algorithm, a mote starts a flooding process in which a super sensor request is send to all other motes. In the Highest-degree heuristic, mote degree only measures connectivity for 1-hop super sensors. K-CONID generalizes connectivity for a k-hop neighborhood. Thus, when k = 1 connectivity is the same as mote degree.

Each mote in the network is assigned a pair did = (d, ID). D is a mote's connectivity and ID is the mote's identifier. A mote is selected as a super sensor head if it has the highest connectivity. In case of equal connectivity, a mote has super sensor head priority if it has lowest ID. The basic idea is that every mote broadcasts its super sensor decision once all its k-hop neighbors with larger super sensor head priority have done so.

V. Analysis on the Optimal Super Sensor Size

There are N sensor motes uniformly and independently distributed in a rectangle sensor field. Such a deployment can be modeled as a Poisson point process. Let λ denote the density of the underlying Poisson point process. The number of sensors located in a region with the area of A, N(A), follows the Poisson distribution with mean of λA, i.e., $N(A) \sim Poi(\lambda A)$. The assumption of uniform sensor distribution has been widely used in the performance analysis of large-scale wireless sensor networks [21-24]. There is a sink mote s located at the corner of the sensor field. We assume the coordinates of s are (0, 0), as shown in fig. 3. This is because the sink is usually placed outside of the sensor field for easy installation. Our analysis can be easily modified to suit the cases that the sink is not located at the corner of the field. We assume that the transmission range of sensor motes is r.

That is, any two sensors whose Euclidian distance is within r can communicate with each other. The sensor field is partitioned into small grids of size a × a as shown in fig. 3. The edge length a of a grid is set to so that any two motes in a grid are within the transmission range of each other. Our purpose is to divide the sensor field into super sensor-areas, such that motes can be organized into super sensors.

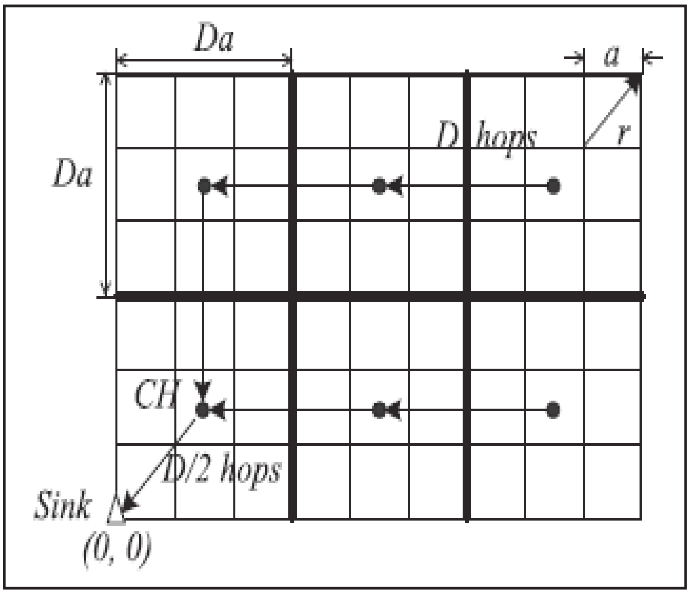

Fig. 4: The Sensor Field is Partitioned Into Small Grids of Size a × a

Suppose each super sensor-area is a square of size Da ×Da. All motes in a super sensor-square form a super sensor as shown in Fig. 3. The largest feasible value D_{MAX} is

$$D_{MAX} = \sqrt{\frac{N}{\lambda a^2}}.$$

The value of D lies in the interval D_{MAX}, and it will be determined later through our analysis. Given the Poisson distribution with density there are sensor motes in each super sensor on average. Thus, the sensor field has N super sensors on average.

In our hybrid CS method with the super sensor structure, the data transmission from the sensor motes to the CH does not use CS. The sensor motes within a super sensor transmit their data to the CH via the shortest path routing. We assume the CH is located at the center of the super sensor-square, which is the case that produces the minimum number of transmissions to collect data within the super sensor when motes are uniformly distributed.

Our main motto is to reduce total number of transmissions of the HCS method in super sensor, which is the sum of the intra super sensor transmissions and inter super sensor transmissions. That is,

$$T = T_{intra} + T_{inter}$$

Where, T_{intra} is the number of intra super sensor transmission, T_{inter} is the number of inter cluster transmission in the network. Which reduce by calculating the optimal super sensor member [1].

VI. Reelection

Super sensor schemes may cause the super sensor structure to be completely rebuilt over the whole network when some local events take place, e.g. the movement or "die" of a mobile mote, resulting in requirement of some super sensor head re-election (re-super sensor). This is called the ripple effect of re-super sensor. In other words, the ripple effect of re-super sensor indicates that the re-election of one super sensor head may affect the structure of many super sensors and arouse the super sensor head reelection over the network [6]. Thus, the ripple effect of re-super sensor may greatly affect the performance of upper layer protocols.

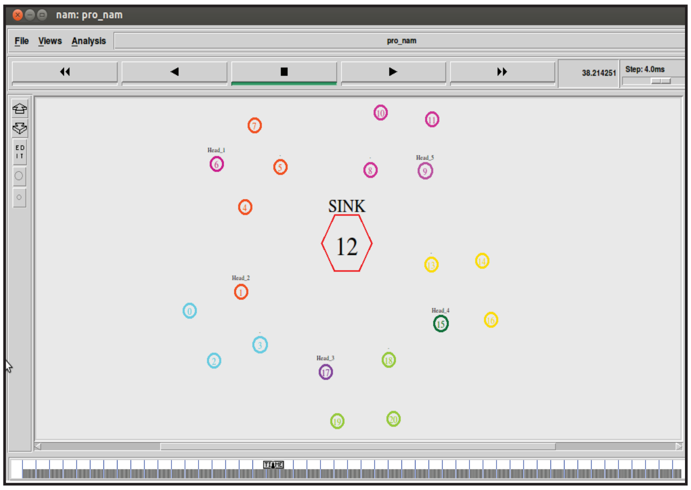

Fig. 5: Reelection of Cluster Head Based on Energy

In addition, most schemes separate the super sensor into two phases, super sensor formation and super sensor maintenance, and assume that mobile motes keep static when super sensor formation is in progress. This is because for the initial super sensor formation of these schemes, a mobile mote can decide to become a super sensor head only after it exchanges some specific information with its neighbors and assures that it holds some specific attribute in its neighborhood. With a frozen period of motion, each mobile mote can obtain accurate information from neighboring motes, and the initial super sensor structure can be formed with some specific characteristics. However, this assumption may not be applicable in an actual scenario where mobile motes may move randomly all the time.

VII. Simulation Results

NS-2 simulation results gives the energy consumption of the hybrid compressive sensing technique. Fig 3 shows the energy consumption of the super sensor network based on hybrid compressive sensing method. At the cluster setup phase the energy consumption is increased due to the handshaking process between the sensor motes and cluster formation process. After the communication phase the number of transmission is reduced, so the energy required for the compressed data at the CH is reduced and maintained art constant level.

Fig 6. Shows the throughput analysis of the compressed data transmission. Throughput is the number of data deliverd to the sink. By using the TDMA and reelection method which reduces the packet delay and packet dropping ratio due to the collusion between the data. The TDMA method is used to schedule the channel time for each nodes with in the cluster to reduce the data collusion and avoid the packet dropping.

ISSN : 2348-0033 (Online) | ISSN : 2249-4944 (Print)

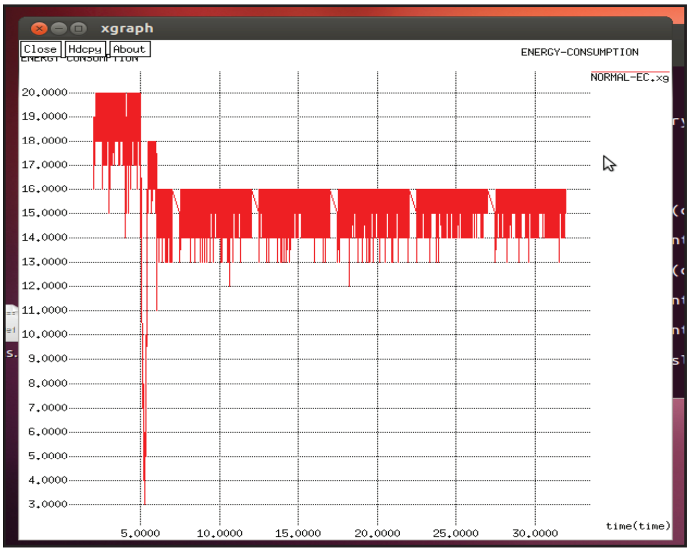

Fig. 6: Energy Consumption of the HCS Based Supersenor Network

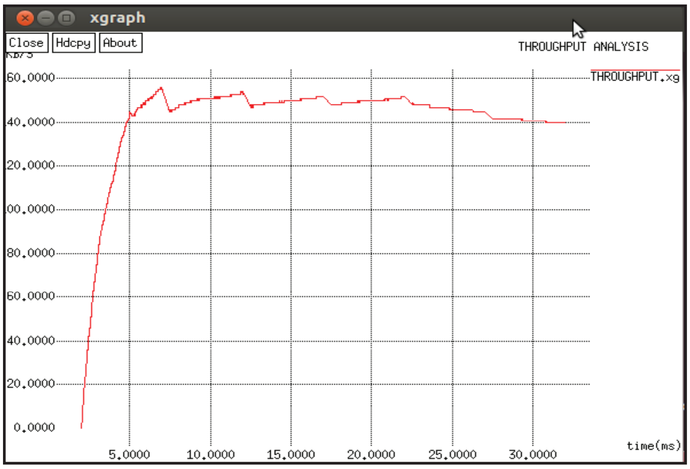

Fig. 7: Throughput of the Data Transmission

Fig. 7 shows the throughput results throughput is still increases by using the multi input methodwhich allows two super sensor head can transmit the data at same time, which doesn't affect the data throughput.

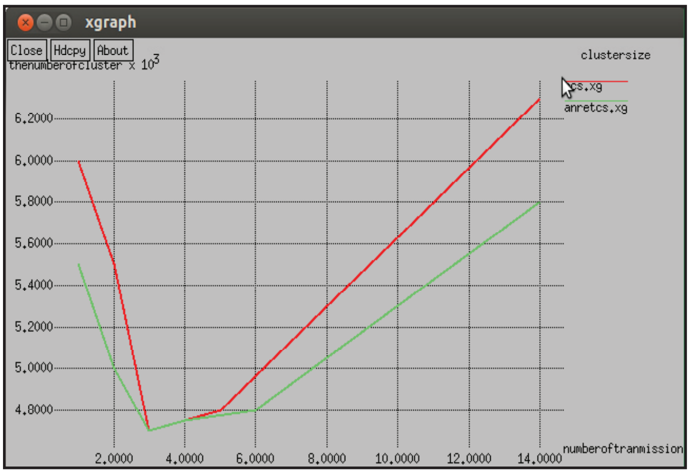

Fig. 8: The Number of Transmission With and Without Optimum Super Sensors

Fig. 8 explains about the how the number of transmission differs from the optimum size of super sensor using centralized super sensor algorithm and to the analytical results derived from the equations.

VIII. Conclusion

The In this paper. We used hybrid CS and K-CONID to design a super sensor-based data collection method, to reduce the data transmissions in wireless sensor networks. The information on locations and distribution of sensor motes is used to design the data collection method in super sensor structure. Energy based Reelection method can be used to reconstruct the super sensor even after the super sensor is destroyed due to the physical problem in the network. Sensor motes are organized into super sensors. Within a super sensor, data are collected to the super sensor heads by shortest path routing; at the super sensor head, data are compressed to the projections using the CS technique.

The projections with the node ID are forwarded to the sink following a backbone tree. We first proposed an analytical model that studies the relationship between the size of super sensors and number of transmissions in the hybrid CS method, to find the optimal size of super sensors that can lead to minimum number of transmissions. Then, we proposed a centralized super sensor algorithm based on the results obtained from the analytical model. Finally, we present a distributed implementation of the super sensor method. Master and slave technique is used to collect the motes which came out from the super sensor due to signal coverage like problems and rejected motes are form a new super sensor. So which reduces the rejection of motes.

Extensive simulations confirm that our method can reduce the number of transmissions significantly. When the number of measurements is 10th of the number of motes in the network, the simulation results show that our method can reduce the number of transmissions by about 60 percent compared with super sensor method without using CS. Meanwhile, our method can reduce the number of transmissions up to 30 percent compared with the data collection method using SPT with the hybrid CS. Even for the nonhomogeneous networks in the irregular sensor field, our method can significantly reduce data transmissions compared with these data collection methods.

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