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An Efficient Data Collection Method with Relocation of Mobile Node in Wireless Sensor Networks

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Abstract—In recent years, the Wireless Sensor Network (WSN) has been focused on many applications. The main task of the widely deployed sensor network is data collection. Energy efficiency is one of the studied challenges by the researchers. How to consume the energy while sensor nodes are sensing the event and again collected data back to the sink is one of the critical issues in WSN. In existing different energy efficient routing protocols are developed to increase the lifetime of sensor networks. In this paper, a new data collection method with relocation of mobile node is proposed to enhance the lifetime of WSN. The proposed method has a mobile data collector node. The mobile Data Collector Node (DCN) collects the data from the cluster heads and finally sends it to sink node. After the completion of some rounds, the mobile DCN will relocate based on residual energy of the each sensor nodes. After that the new mobile data collector collects the data from cluster head and gives it to sink node. The proposed method minimizes the energy consumption, traffic and also increases the lifetime. The simulation results show that the proposed method has better performance in terms of energy consumption, throughput and lifetime.

Index Terms—Data collection, energy consumption, mobile data collector, relocation, residual energy lifetime, wireless sensor networks.

1 Introduction

Wireless Sensor Networks (WSN) comprise of several sensor nodes which are distributed over a large environment and use batteries as an energy resource [1]. These sensor nodes are used to collect data from the environment, process that data into meaningful information and share that aggregated data over a communication link. The sensor nodes are equipped with limited amount of battery life and storage capacities [4]. Increasing the lifetime of sensor network is the main challenging problem in WSNs. Data aggregation is one of the main task of the deployed nodes (i.e. process of collecting the data)[10]. The main goal of data collection is to gather and aggregate the data in an energy efficient manner, thereby increasing the lifetime of sensor networks. Various energy-aware data gathering methods are developed so far. In recent years, the concept of mobility satisfies the increasing demand of many applications. Mobile Data Gathering is a technique that consists of one or more mobile elements roams over the sensing field to gather the data [6]. WSNs have been used in many applications such as medical, environmental, battle field, military, home and commercial applications etc [9] In this paper, an efficient data collection method with relocation of mobile node is proposed. The proposed method is implemented by using ns2 simulator. The result shows better performance in terms of energy, throughput and lifetime. Section 2 discuss about the existing techniques of the data collection method. The new data collection method is described in section 3. Results and discussion are discussed in section 4. Finally the conclusions are summarized in section 5.

2 Related Works

In this section, we discuss about the existing data gathering methods in WSNs. To improve energy efficiency in sensor networks, different techniques are available to gather the data. Using mobile elements to gather data has been widely used in now-a-days. As compared to static sensor nodes, mobile sensor nodes have numerous advantages. The existing data collection methods have been classified into three approaches namely topology, routing protocols, data aggregation methods etc.

2.1 Topology Based Approaches

In topology based approaches, there are several types of topologies such as flat, chain, tree, cluster that are used to gather data [12] .Chuan zhu at el [3] proposed Tree-Cluster-based Data-Gathering Algorithm (TCBDGA). This is a hybrid topology. The idea behind this method is some special nodes are named as sub rendezvous points. These special points are selected according to the traffic load of the node. After the construction of tree, the root nodes are described as rendezvous points. The mobile sink collects the data from both points at particular period. This algorithm reduces the hotspot problem and also improves the network lifetime.

Velmani and Kaarthick [13] have developed Velocity Energy-efficient and Link-aware Cluster Tree protocol (VELCT). In this paper, Data Collection Tree (DCT) is constructed based on cluster head position. The DCT has one data collection node. This node collects the data from cluster head and forwards the data to sink node. This algorithm gives better performance than existing algorithms in terms of energy, end-to-delay and also increases the network lifetime for large scale sensor networks Heidemann at el [14] designed Geographic adaptive fidelity. It is a location based routing protocol. GAF conserves energy by switching off the unnecessary nodes in the network without affecting the route.

2.2 Cluster Based Approaches

Manjeshwar at el [7] have designed a protocol Threshold sensitive Energy Efficient sensor Network protocol (TEEN). It is a hierarchal protocol. In this paper, first cluster is formed. After that CH sends two thresholds to the cluster members. There are hard and soft thresholds used. The hard threshold only allows the minimum possible value of sensor nodes to switch on the transmitter and collect data from CH. If there is no change or small change in attribute, the soft threshold reduces the number of transmission if the threshold values are not reached and the user does not receive the data correctly. Therefore TEEN does not applicable for periodic reports.

Zhu at el [15] described an efficient energy-aware Distributed Intelligent Data Gathering Algorithm (DIDGA). There are two phases, the first is cluster formation phase and second is path formation phase. The cluster head is selected based on which sensor nodes have more power. The mobile collector collects the data from the cluster head. A path formation optimization algorithm with ant colony algorithm is introduced for mobile collector to enhance the energy.

Chang at el [2] proposes Energy-Balanced Data Collection (EBDC) mechanism. To minimize the energy consumption, the mobile sink are used to move along the different paths with different sweep repetitions to collect the data. The number of sweep repetitions in each path is determined by how much each sensor node consumes energy when the mobile sink moves along the path.

Mottaghia at el [8] have combined the concept of mobile sink and rendezvous nodes with the LEACH algorithm to improve the performance of sensor networks. The rendezvous nodes are selected based on the mobile sinks distance. The proposed method reduces the energy consumption and also increases the lifetime of large sensor networks.

2.3 Data and Query Driven Approaches

Lee and park [5] have designed Predictable Mobility based Data Dissemination protocol (PMDD) .They constructed a virtual grid structure. The head of the grid forwards the queries and data to the sink. Each node in the grid knows the future location where the sink will move, so they can easily forward the data. This algorithm increases the data delivery ratio.

Shi at el [11] have proposed an efficient Data-Driven Routing Protocol (DDRP). This protocol combines random walk routing with data driven packet forwarding for the construction of data forwarding path. This protocol reduces the overhead of the route discovery.

3 Proposed Work

The proposed work consists of two phases. In first phase, selection of mobile data collector and cluster formation is performed. Then, the second phase is initiated to collect the data from the cluster head at certain rounds and relocation of mobile data collector is also carried out in this phase.

3.1 First Phase

In this phase, consider a large number of sensor nodes are randomly deployed in the sensing field. Before the selection of cluster head, beacon signal is used to find out the location and position of sensor nodes. Once the neighbor nodes are identified, cluster heads are chosen by using cluster head election algorithm. The selection of cluster head is based on threshold value. In this proposed work, the threshold value can be calculated in equation (1) by the multiplication of factors such as residual energy, total number of cluster members, coverage distance and speed of the sensor nodes.

$$Th_u = N_S \times C_D \times R_S \times S_N \qquad (1)$$

Where $Th_u$is the threshold value to select the cluster head , N_S is the number of neighbor sensor nodes, C_D is the coverage

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distance of the sensor nodes, R_S is the residual energy of the each sensor nodes and S_N is the speed of the sensor nodes. The node can be selected as cluster head in which nodes having the maximum number of cluster members and also having high residual energy. After the completion of cluster head selection, the mobile data collector node is selected.

3.2 Second Phase

In this phase, all the cluster members send their collected data to the cluster head. Then the mobile DCN collects the data from each cluster head and send it to sink node. This mobile data collector collects the data at certain rounds and however mobile DCN does not participate on sensing at this particular round. After certain rounds of data collection, the battery energy will drain out. So, the sensor network will die. To avoid this problem relocation method is introduced. The relocation of mobile data collector is based on residual energy of the sensor node.

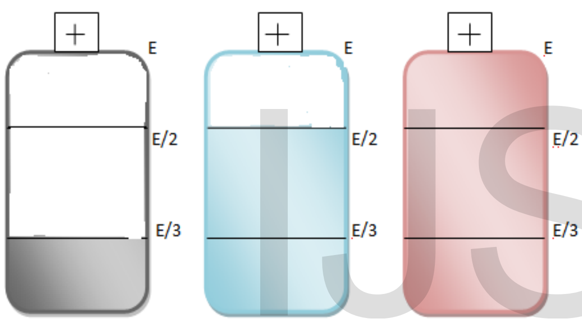

Fig.1 Residual battery energy

Fig 1 shows the residual battery energy of the sensor node. The sensor nodes which having high current residual energy collects data for large number of rounds. The selection of mobile DCN is finding out by the following cases. The battery energy value is full in initial stage, let E be the battery energy value. $r(v)$ denotes the current residual battery energy of the each sensor nodes. The residual energy of the sensor nodes can be calculated by the following cases. In this first case, the current residual battery energy lies between$0 \leq r(v) \leq E/3$. The sensor nodes in the first case have low energy, if we select the nodes in first case, the data collection rounds will low. In the second case, the current residual energy value between $0 \leq r(v) \leq E/2$. As compared to first case this case has little bit more residual energy. In the third case, $0 \leq r(v) \leq E$ the current residual battery is high. In our proposed method, after the completion of particular data collection rounds, the current residual energy is calculated. Based on the current residual energy, the new mobile DCN is selected. The new mobile DCN is again collecting the data from the cluster head. This process is repeated for lot of rounds.

3.3 Steps

(a) Initialize the deployment of sensor nodes with initial battery energy.
(b) Identify the neighbor node to form the cluster.
(c) Select the CH over the entire network.
(d) Select the mobile DCN.
(e) The mobile DCN collects data from CH.
(f) Compute the current residual energy of the mobile DCN.
(g) Compare initial battery energy with current residual energy.
(h) Select the new mobile DCN.
(i) Again new mobile DCN collects the data.
(j) Repeat the step from (f).

4 Results and Discussion

Our proposed method is simulated by using NS2 simulator. The following various parameters are assumed for simulation. First the sensor nodes are deployed over 700×700 m^2.The sensing range of each sensor node is 20m.The maximum packet size is 50 bytes. The velocity of the mobile node is 20m/s. The initial battery energy is 50 J. DSDV protocol is used for routing. Table 1 shows the simulation parameter for the proposed method.

TABLE 1
List of Simulation Parameters

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The selected mobile DCN collects the data from the CH. we have chosen two rounds for data collection in our simulation. After the collection of data, we compute the current residual battery energy and compare with the initial battery energy. Based on the current residual battery energy, mobile DCN will relocate and further new mobile DCN collects the data. Fig 2 shows the graph of number of nodes Vs energy consumption

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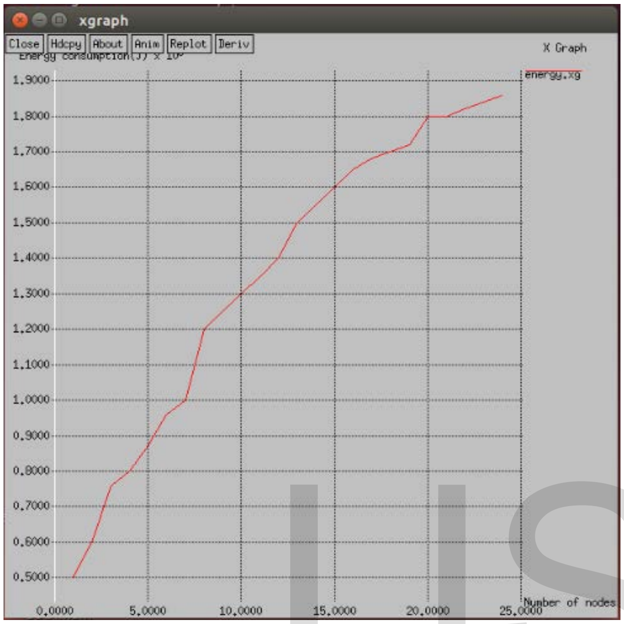

Fig.2 Number of nodes Vs energy

From the fig.2, we observed that energy consumption is reduced when more number of nodes is used for data collection because of the cluster head selection is based on threshold value, number of cluster members, coverage distance etc. Fig 3 shows the graph of energy consumption Vs lifetime. In our proposed system, the lifetime of the sensor network is increased because of the minimum energy consumption of the each sensor node. The node having high current residual energy has been selected as data collector. So, the data collection rounds also increased. From the graph, we observed that mobile DCN collects data upto 25 rounds if the sensor node consumes low energy.

Fig.4 shows the performance of throughput with respect to the energy of sensor node. From the graph it is observed that if the number of data collection round becomes more, the throughput also increases due to the low energy consumption and there are proportional to each other. Our proposed method increases the throughput and lifetime of the sensor networks. The hotspot problem is less in our method because; the mobile data collector is used for data collection. Our method reduces the delay and traffic of the sensor nodes because of only one mobile DCN can collect the data at particular round.

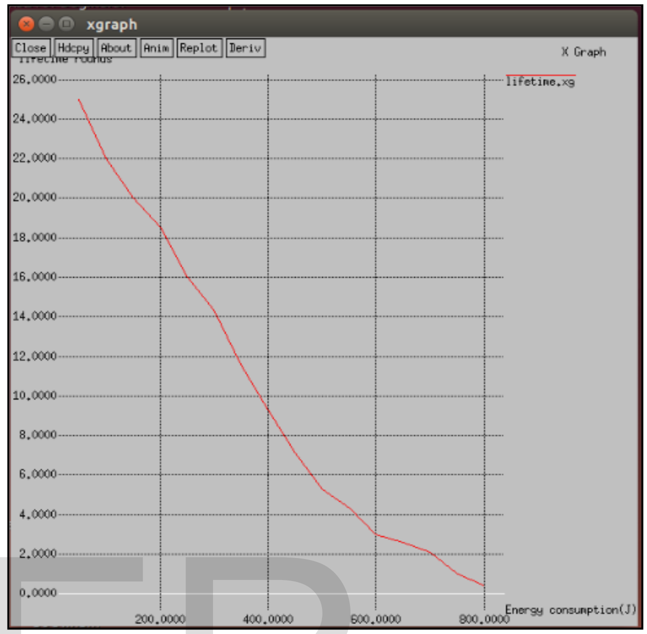

Fig.3 energy consumption Vs lifetime (rounds)

Simulation scenarios	Value
Sensing field region (m^2)	700×700
Number of nodes	22
Initial battery energy (*J*)	50
Velocity of mobile node (*m/s*)	10
Transmission range (*m*)	20

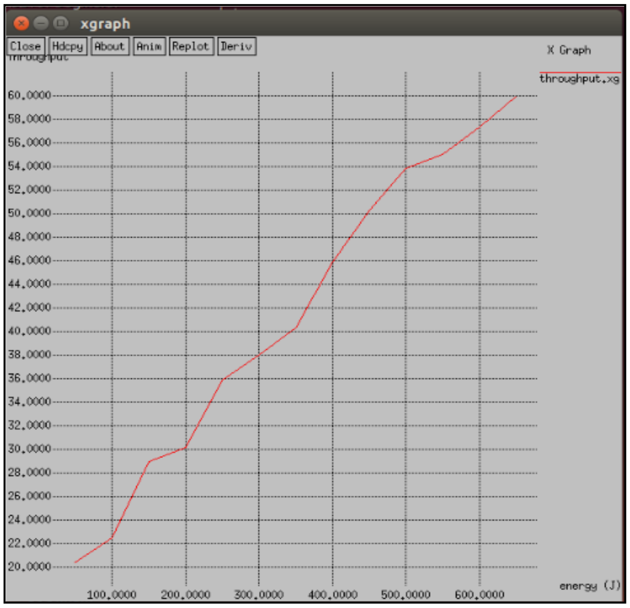

Fig.4 energy Vs throughput

5 Conclusion

In this paper, an efficient data collection method with relocation of mobile node is proposed to prolong the lifetime of the sensor networks. To increase the lifetime of networks, the energy consumed by each node must be low. The proposed method has mobile Data Collector Node to collect the data from cluster head. The selection of mobile DCN is based on current residual battery energy of the node and also the cluster head selection is based on threshold value, speed and coverage distance. The mobile DCN does not participate on sensing at this particular round. Our proposed method saves the energy of each node and reduces the delay, traffic and also prolongs the lifetime. Our simulation results show that our algorithm gives better performance in terms of energy, throughput and lifetime.

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