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An Improved Energy Efficient Clustering algorithm for Mobile-Sink based Wireless Sensor Networks

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Abstract

The unique characteristic of the wireless sensor network is the limited battery of the nodes in the network. To save their batteries, the nodes in the network are usually clustered into groups, with the member nodes forwarding data to the sink via their cluster head. The sink in the network can be mobile or fixed. To support sink mobility, it is crucial to provide means to reach the mobile sink node. Since frequent location updates from mobile sinks can generate excessive energy consumption of sensors, routing strategies handling sink mobility should provide efficient ways for the tracking of sinks in order to keep all sensor nodes updated for the future data reports. This paper presents a data collection scheme using the mobile sink. The performance of the network has been analyzed on the basis of packet delivery ratio, throughput and routing overhead. These parameters have shown an improvement over the existing scheme.

Keywords: WSN, clustering, sink mobility, throughput, overhead

Introduction

In a wireless sensor network, sensors are dispersed in the field and communicate with each other wirelessly. However, sensor nodes work on battery with limited supply of energy. Furthermore, computational power of a sensor is also weaker as compared to the sink nodes. A sensor node uses energy from the battery and when a sensor node runs short of the energy, it stops granting any services such as sensing, data processing or data communication. When this happens, sensor is declared as "dead". The node is thus removed from the network topology. The lifetime of a sensor network is defined as the time interval from its deployment to the time a "critical" number of sensor nodes die, making the network unusable. Therefore, the lifetime of a sensor node depends greatly on the battery power. A small section of "dead" sensor nodes can directly affect the entire lifetime of the network and thus lead to a great loss in the network because of routing path's reallocation and stoppage of sensing and reporting the events in the environment. Therefore, in order to extend the lifetime of the network and guarantee the robustness of the sensor network, efficient energy consumption and energy conservation are of great significance in wireless sensor networks while designing and deploying networks for practical purposes.

The performance of the network is another important issue. In various environments, wireless sensor network systems are needed to be highly sensitive to the change in some ambient situations like the temperature of the reactor in a nuclear power plant and require immediate response to the phenomenon or events within that environment. Hence, the guarantee of the successful data delivery and fastness of the data processing and data transmission plays a crucial role in providing reliable sensing services. Some of the wireless sensor networks deploy a mobile sink to collect data from the sensor nodes as an approach to conserve their energies. It is agreed that a sink node is a powerful device with unconstrained energy supply and computational capacity. However, the following characteristics of sinks may critically influence the operations [8] of communication in sensor networks. During the network lifetime, the sink can be stationary or mobile. In some cases, mobility inferred by the application, e.g. sinks are integrated with other mobile devices such as mobile phones carried by mobile users, [8] in some others mobility ensures efficient data collection, the sinks move during the data gathering. To support sink mobility, it is crucial to provide means to reach the mobile sink node [9]. Since frequent location updates from mobile sinks can generate excessive energy consumption of sensors, routing strategies handling sink mobility should provide efficient ways for the tracking of sinks in order to keep all sensor nodes updated for the future data reports. Section II represents the brief survey about the data collection approaches in wireless sensor networks using mobile sinks. Proposed work to improve the data collectionhas been represented in Section III with the results shown in Section IV.

Literature Survey

T.H. Feiroz Khan [2016] proposed design and implementation of a strategy to regulate load while also improving the energy efficiency of the network. Each node has a threshold level of the load beyond which if there is inflow of data then the node automatically sends an MC_REQ requesting for aid from the mobile collector (MC). Based on the requests received from all the nodes, the MC estimates the most suitable position to move to among a bunch of static WSNs deployed to monitor and agricultural area. Simulations show the efficiency of the proposed MCER protocol [1].

Qi Liu et. al., [2016] proposed an Improved Grid-based Load-balanced Routing Method for WSN with Single Controlled Mobile Sink. They proposed a grid-based load-balanced routing method (GLRM) that aims to use a controlled sink to achieve load-balance in a non-uniform distributed network. Cell-header election of each cell is based on three parameters, i.e. the number of data packets that nodes need to relay, the Euclidean distance to the mid-point of cells and residual energy of each node, respectively. The GLRM also considers other factors that waste battery power, such as packet collision [2].

Nagamanaret. al., [2015] Energy Efficient Clustering Scheme has been used to control the flooding for information gathering with many mobile sinks. The Cluster Head (CH) was elected using the parameter, residual energy. While data collection, the Mobile Sink (MS) moves from one CH to another CH the MS will be flooded to the selected member of the group. Therefore, this scheme was used to find optimal routes to MS location and reducing the path reconfiguration procedure thus increase the network lifetime. However, links may fail due to mobility of sink and it does not maintain reliability due to node failure [3].

Ayesha Hussain Khan et. al., [2015] proposed the concept of joint sink mobility in the wireless sensor networks. The density of the network is calculated and the mobile sink nodes are moved accordingly, one to the highly dense regions and one to the highly sparse regions. In addition, to ensure timely communication with the nodes, which are far away from the sink node, the authors have proposed the concept of clustering those nodes so that far away nodes do not have to wait for their turn to communicate with the sink node. Instead, they can send their data to the cluster head and cluster head can forward the aggregated data to the sink node. The scheme has shown to outperform the M-LEACH in terms of stability period, throughput and network lifetime. [4]

Sonalvermaet. al., [2015] propose an energy smart routing protocol (ESRP) for WSNs with mobile sinks. The first sink proactively constructs a grid structure. A path along grid points is paved from a sink to the source for forwarding queries and disseminating data. For choosing each grid sensor node, a cost function is applied to serve each respective crossing point and to handle grid node failure. Based upon this grid, we develop novel methods for handling multiplicity and movements of sinks by creating an expected mobility zone in sensor field to ensure continuous data delivery from source nodes to sink or sinks [5].

In the energy- constrained wireless sensor networks (WSNs), the clustering algorithms for WSNs with a static sink frequently suffers from uneven energy consumption problems, where cluster heads (CHs) further away from sink consume more energy in a singlehop communication, with the CHs sending its data directly to the sink. In order to solve such problem, the authors in [6] have proposed a Distributed Energy-efficient Clustering Algorithm for mobile-sink based WSNs, where the sink moves around the target area with a fixed path and speed. The proposed clustering algorithm, binds each sensor node with a CH via single or multi-hop communication, where a CH transmit its data packet to the sink when distance between them is minimal. Thus, the controlled movement of the sink around the network helps in balancing the energy consumption of the sensor networks. The experimental results demonstrate the efficiency of their proposed algorithm over the existing state-of-the-art algorithms in terms of different metrics like, network lifetime, energy consumption, etc.

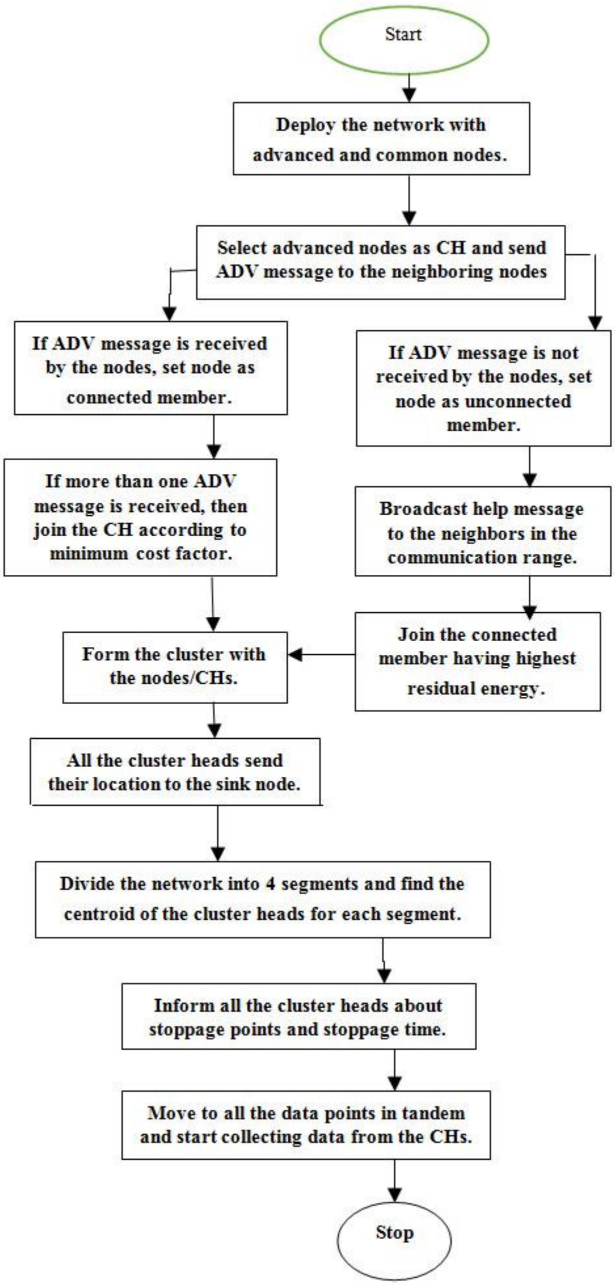
Jenq-ShiouLeuet. al (2015) forwards a new regional energy aware clustering scheme by means of isolated nodes for WSNs, called Regional Energy Aware Clustering with Isolated Nodes (REAC-IN). An appropriate clustering algorithm for aligning sensor nodes can increase the efficiency of energy in WSNs. However, clustering requires an extra overhead like cluster head selection, assignment and cluster construction. CHs are selected based upon weight in REAC-IN. Weight is found according to the remaining energy of each sensor node and the regional average energy of all sensors in each cluster. Inappropriately designed distributed clustering algorithms can cause the nodes to become isolated from CHs. These isolated nodes communicate with the sink by consuming excess amount of energy. To extend the lifetime of the network, the regional average energy and the distance between sensors and the sink are used to determine whether the isolated node sends its data to a CH node in the previous round or to the sink. [7]

Proposed Work

The first phase will be the selection of the cluster head. In this work, some of the nodes are assumed equipped with longer batteries as compared to other nodes. These nodes are advanced nodes. Therefore, initially the advanced nodes having high energy will be selected as cluster heads. Once the heads have been selected, they will be opting for the formation of the clusters with their neighboring nodes. Every node will join the cluster head which is nearest to it.

Next is the data collection phase by the mobile sinks from the cluster heads in the network. For this, the network will be divided into four halves and the sink node will move to the centroid of the cluster heads in each of the half one by one. In each part of the network, the sink node will stay for a predefined period so that data transmission between the cluster heads and sink node becomes more effective.

Flow Chat of Work



Results

The The performance of the network was analyzed based on three parameters namely packet delivery ratio, throughput and routing overhead in the network.

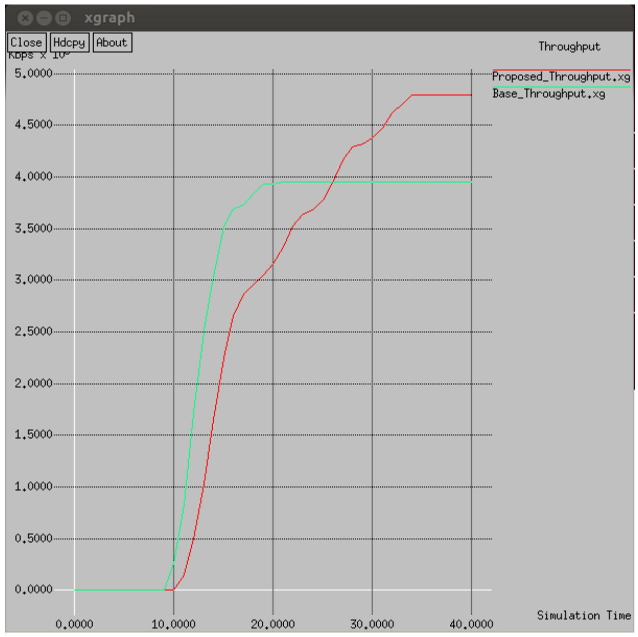


Fig. 1: Comparison of Throughput

The above graph shows the throughput values obtained for both the schemes. Throughput defines the amount of data received at a node per unit of time. While the value of throughput for the proposed scheme was at approx. 4796 Kbps, the same parameter showed the value of 3948 Kbps. Thus, it shows that proposed scheme gives better throughput in the network.

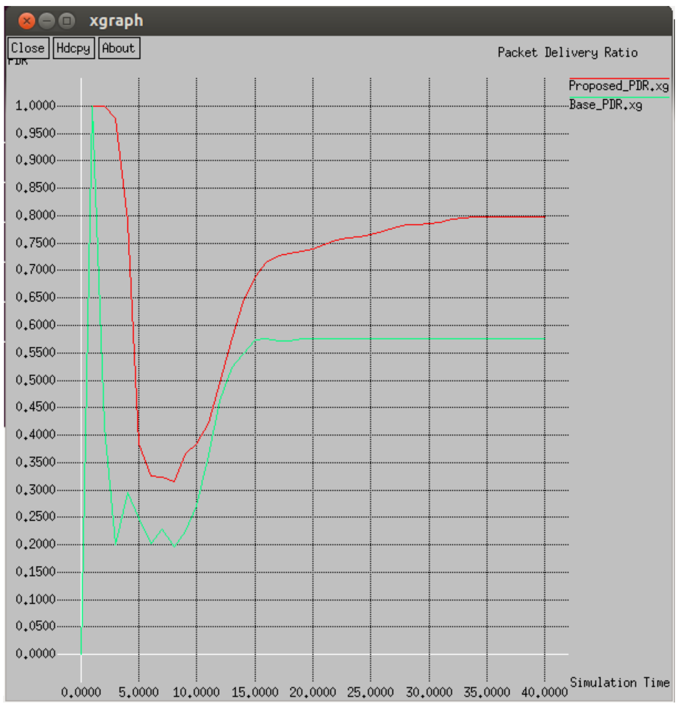


Fig. 2: PDR comparison

The above graph shows the comparison for the packet delivery ratio for both the schemes. It is defined as ratio of number of packets received to the number of packets sent in the network. It reflects percent of the packets successfully delivered in the network. Just like throughput, this parameter also showed higher values for the proposed scheme as compared to the existing scheme. The value for the proposed scheme was at 0.80 or 80 percent and for existing scheme; it was at 0.57 or 57 percent.

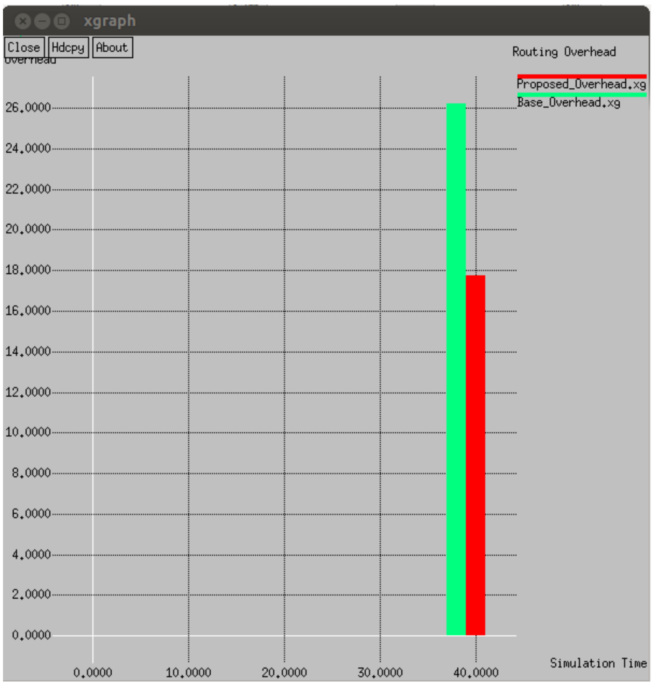


Fig. 3: Routing Overhead Comparison

It reflects how many number of control messages are required to be sent in the network so that data messages can be received. This parameter should be less for the better performance of the network. For the proposed scheme, the routing overhead was approx. 18 while for the existing scheme it was 26. Therefore, it reflects that network has performed better with the proposed scheme.

Conclusion

The proposed work aimed at improving the data collection procedure using the mobile sink node. When the data collection was performed with the mobile sink moving within the network, it reduces the communication distance between the cluster head and the sink node. Therefore, the shortening of the communication distance leads to increase in the values for the throughput and the packet delivery ratio.

In future, this work can be compared against various other schemes related to mobile sink data collection approach to check its efficiency. In addition, this work can be extended to include various security measures against hello flood attacks (the attack to which the clustered wireless sensor network is easily prone to).

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