IMPROVE ENERGY EFFICIENCY USING MULTIPLE MOBILE SINK ROUTING AND DYNAMIC CLUSTER HEAD SELECTION FOR WSN

N. Jeenath Shafana¹, G. Aravind Swaminathan², V.PerathuSelvi³, C.Vinola⁴

¹PG Student, ²Associate Professor, ³,⁴Assistant Professor

Email id: shafanajeenath@gmail.com
1, 2, 3, 4 Department of CSE, Francis Xavier Engineering College

ABSTRACT: The main factor consider for reducing the network lifetime is Energy Consumption. This is considered as a major problem in WSN. In the Existing system, Single Mobile Sink was considered for gathering the data from the Cluster Head. In the proposed system, Multiple Mobile Sink nodes are considered for collecting the data from the Cluster Head. The entire Cluster contains only one Cluster Head. By using K-Means algorithm, the Cluster formation takes place. The CH is selected as dynamic in nature i.e. the selected CH frequently changes for each round. Initially CH is identified in the network in random manner and in further rounds the nodes with highest energy is selected as the current CH. The CH selection is done by using Energy-LEACH algorithm. The Cluster Member transmits the data to the Cluster Head in a Single-Hop fashion. Finding the unique shortest path is considered as a problem in WSN. To overcome the above problem, Weighted Rendezvous Planning (WRP) is projected. WRP increase the network lifetime and reduce energy consumption when compared with the existing system. The speed of the Mobile Sink is maintained as constant, in order to reduce the packet loss. The simulation based performance evaluation is performed and analyzed.

Index Terms: Wireless Sensor Network (WSN), Cluster Head (CH), K-Means algorithm, Energy-LEACH (E-LEACH), Weighted Rendezvous Planning (WRP), Mobile Sink Node.

I. INTRODUCTION

Wireless Sensor Network (WSN) usually consists of collection of sensors and mobile nodes in large numbers with the presence of power transceiver. [¹] WSN is composed of randomly deployed sensor nodes and they are placed around the Base Station or Sink [²]. The power transceiver effectively used for gathering data’s from various applications like civil application, environment monitoring, etc and finally, transmit the data’s to the Base Station (BS).

The Wireless Sensor Networks life time greatly depends upon the energy consumption of the sensor nodes. In WSN, Data Aggregation and Collection is considered as a most important and necessary to save the energy and to prolong the network lifetime. [³] Energy consumed by each sensor node is done in two major ways: sensing the field and routing the data to the Base Station or Static Sink. [⁴] The deployed sensor nodes are left unattended then it is difficult to recharge (or) replace the battery. After the sensor nodes present are grouped into autonomous organization, the sensor nodes near the BS deplete in their batteries much faster than other nodes. [¹⁷] Due to the depletion of energy, the network lifetime is not guaranteed. The Energy consumption is considered as critical factor because of limited power supply.

Performance of the Wireless Sensor Network mainly depends on the lifetime of the network and energy conservation. To achieve high scalability, prolong network lifetime and energy efficiency, the Cluster-Based scheme is considered instead of Flat topology. [³]

The similar sensor nodes are grouped into clusters called Cluster Member and they are considered as the Lower Layer of the network. The Cluster Head is selected as the higher layer to collect the sensing data from the Cluster Member and transmit it to the Base Station. [⁶, ¹⁴]

Clustering process involves the following four steps: [⁷]

1. Data Point Representation
2. Data Point Similarity Measurement
3. Clustering into Clusters
4. Data Abstraction (if needed)

The presence of the static sink introduces some problems regarding the energy consumption and network lifetime. The static sink may not be able to gather the information from all the sensor nodes present in the network because some sensor nodes are not available to communicate with the BS. [⁸]

To reduce the defect caused by the static sink, mobile sink was proposed. It has been proven that the mobility of the sink gives tremendous improvement in energy efficiency, network lifetime, throughput, scalability etc. [⁸]

The mobile sink called as mobile data collector is considered as a mobile robot or vehicle equipped with a powerful battery, large memory and transceiver. The mobile sink traverse the network, collects the sensed data from the Cluster Head from the nearby Clusters and return the
collected data’s to the Base Station. Since the mobility sink is used, it can traverse close to all the Clusters present in the network in a planned manner to prolong the network lifetime. \[9, 12\]

For example, in the wild environment the radio-tagged zebras and whales are used as mobile nodes and in the urban area, the public transportation vehicle such as buses and trains are considered as the mobile nodes. \[6\]

In WSN the data transmissions are done in two ways namely Single-Hop Transmission and Multi-Hop Transmission. \[10, 13\] Figure 1a represents Single-Hop Transmission and Figure 1b represents Multi-Hop Transmission. The data’s are transmitted as Single-Hop within the Cluster Formation.

![Figure 1(a) Single-Hop Network](image)

![Figure 1(b) Multi-Hop Network](image)

In Single-Hop network, the data is transmitted from the source to the Static Station or Base Station which consists of only single-hop between them as shown in Fig 1 (a). If the nodes are present close to each other then the energy consumption by the sensor nodes gets reduced. Thus the nodes present in the Clusters will communicate with the Cluster Head in a single-hop fashion.

In Multi-Hop network, when the distance between the nodes is large and the communication between the nodes is takes place through the number of intermediate nodes placed in the network. The distance between the Cluster Head and the BS may be large and the CH may consume lot of energy. In order to reduce the consumption of energy, an intermediate node called Mobile Sink Node is placed between them and the Mobile Sink will collect the aggregated data’s and transmit it to the Base Station.

In the existing work, \[17\] a three-layer Framework (Sensor Layer, Cluster Head Layer and Mobile Collector (or) SenCar Layer) was considered.

At the Sensor Layer, the sensors are Self-Organized into Clusters. Multiple Cluster Head (CH) was generated for each Cluster and to balance the load Dual Data Uploading (DDU) concept was considered. At the Cluster Head Layer, the Multiple Cluster Head will work together with each other and they perform energy saving inter-cluster communication. At the Mobile Collector (or) SenCar Layer, two Cluster Head will load the data simultaneously to a single SenCar by using the technique Multi-User Multi-Input and Multi-Output (MUMIMO).

The usage of single mobile sink will consume lot of energy and take lot of time to reach the Clusters. In order to reduce the energy consumption, multiple mobile sink is considered. The multiple mobile sink first traverses the location of the Clusters present in the network and finds the position of the Cluster present close to the Base Station. The data forwarding path from the Cluster Head to the Mobile sink depends on the mobile Sink current position.

Routing has two parts: route discovery and packet forwarding. \[11\] Route discovery means discovering the routes between the nodes and packet forwarding is forwarding the data through the discovered paths. AOMDV (Ad-hoc On-demand Multipath Distance Vector) routing protocol is taken into consideration for multiple sink routing.

This paper is summarized as follows:

- Find the set of Clusters using K-Means algorithm. Each Cluster contains single Cluster Head and they are dynamically selected. The CH’s are visited by the mobile sink. The objective is to minimize the energy consumption and increase the network lifetime by reducing the Multi-Hop transmission from Cluster Member (CM) to the Cluster Head (CH) and consider Single-Hop fashion.
- WRP is a heuristic method that finds a nearest travelling path. Based on the Hop distance WRP allocates a weight to each sensor nodes present in the network. The CH at minimum distance will be assigned with highest weight and the CH with Highest weight will be assigned to the MS for data collection.
- Positions of the mobile sink node are traced by all the nodes present in the network.

II. RELATED WORK

In [4] Lee E., Park S., Yu F. and Kim S.-H. focused on the data gathering mechanism with local sink in geographic routing for the Wireless Sensor Networks. Most existing geographic routing protocols on sensor networks concentrates on finding the ways to guarantee data forwarding from the source to the destination, and not many protocols concentrate on gathering and aggregating data in a local and adjacent region. The data generated from the sources are often redundant and highly correlated. Gathering and aggregating data from the region in the sensor networks is important and necessary to save the energy and wireless resources of sensor
nodes. Thus the concept of local sink was introduced. The local sink is a sensor node in the region, in which the sensor node is temporarily selected by a global sink for gathering and aggregating data from sources in the region and delivering the aggregated data to the global sink. Data funneled technique was considered and by using this technique the border nodes with shortest distance from the global sink are selected as local sink. Single local sink model was used for determining the optimal location of the single local sink because the buffer size of the local sink is limited and the deadline of the data is constrained. Single local sink is capable of carrying out many sources in a large-scale local and adjacent region. The multiple local sink extension was also considered. This mechanism improves the energy efficiency, data delivery ratio and reduces the deadline miss ratio.

In [11] Xu K., Hassanein H., Takahara G. and Wang Q. proposed relay node deployment strategies in heterogeneous Wireless Sensor Networks. In a heterogeneous Wireless Sensor Network (WSN), Relay Nodes are adopted to relay data packets from Sensor Nodes to the Base Station. The deployment of the Relay Nodes can have a significant impact on connectivity and lifetime of a WSN system. The first discussion is based on the biased energy consumption rate problem associated with unique random deployment. This problem may lead to insufficient energy utilization and shortens the network lifetime. To overcome this problem, two random deployment strategies was proposed and they are lifetime-oriented deployment and hybrid deployment. The lifetime-oriented deployment is also called as weighted random deployment. The network is divided into two regions i.e. one region is far away from the Base Station and another region is close to the Base Station. The former solely aims at balancing the energy consumption rates of Relay Nodes across the network, thus extending the system lifetime. However, this deployment scheme may not provide sufficient connectivity to Sensor Nodes when the given number of Relay Nodes is relatively small. The latter reconciles the concerns of connectivity and lifetime extension. Both single-hop and multihop communication models are considered. It provides guideline for efficient deployment of Relay Nodes in a large-scale heterogeneous WSN.

In [16] Zhao M. and Yang Y. addresses a Bounded relay hop mobile data gathering in Wireless Sensor Networks. In order to maximum energy saving at sensor nodes, intuitively, a mobile collector should traverse the transmission range of each sensor in the field such that each data packet can be directly transmitted to the mobile collector without any relay. However, this approach may lead to significantly increased data gathering latency due to the low moving velocity of the mobile collector. It was observed that data gathering latency can be effectively shortened by performing proper local aggregation via multihop transmissions and then uploading the aggregated data to the mobile collector. In such a scheme, the number of local transmission hops should not be arbitrarily large as it may increase the energy consumption on packet relays, which would adversely affect the overall efficiency of mobile data gathering. The trade-off between energy saves and data gathering latency in mobile data gathering by exploring a balance between the relay-hop count of local data aggregation and the moving tour length of the mobile collector was studied. A polling-based mobile gathering approach was proposed formulate it into an optimization problem, named Bounded Relay Hop Mobile Data Gathering (BRH-MDG). Specifically, a subset of sensors was selected as polling points that buffer locally aggregated data and upload the data to the mobile collector when it arrives. When sensors are affiliated with these polling points, it was guaranteed that any packet relay is bounded within a given number of hops.

The disadvantages of the existing system are the Sensor nodes present on the path of the network quickly drain in their energy and cluster heads will inevitably consume large amount of energy when compared to other sensors due to handling intra-cluster Aggregation and inter-cluster data forwarding.

III. MULTIPLE MOBILE SINK ROUTING IN WSN FOR ENERGY PRESERVATION

To overcome the disadvantages of the existing system, Multiple Mobile Sink is considered for gathering the data’s from the Cluster Head and transmit it to the Base Station. Single Cluster Head is generated for each Cluster in random manner by using K-Means algorithm and the Cluster Member transmit the data’s to the Cluster Head in Single-Hop fashion. Weighted Rendezvous Planning is a valid intensive technique used to find the nearest optimal travelling path. WRP is the process of assigning weights to the Cluster Head by considering the Hop Distance that they need to transmit. By using Load balance Scheme the Multiple Mobile Sink will not approach same Cluster Head at a time. The Beacon Frame is transmitted from the Mobile Sink to the Cluster Head to verify the network condition.

Single-Hop transmission reduces the energy consumption and increase the throughput. By the usage of multiple Mobile Sink Node the Network Lifetime gets increased. The speed of the Mobile Sink is maintained to reduce packet loss. Finally the performance is improved and energy efficiency is achieved.

Figure 2 represents the System architecture. The Mobile sink acts as an intermediate node between BS and Cluster Head. The nodes present in the network are grouped into clusters using K-Means algorithm and the CH is selected in dynamic manner using E-LEACH algorithm. The
information about the data which are involved in the transmission is stored in the Data Unit. After the collection of data is done by the Cluster Head, the Mobile Sink involved in data collection from the Cluster Head. The routes involved in the network are found and the shortest route among the available route is calculated using WRP algorithm. The Routing table incorporates the combination of the available Routes and the shortest routes through which the Mobile Sink travels.

Before the travel of the Mobile Sink starts, which Mobile Sink should move to which Cluster Head is instructed using Location Analyzer. Constant speed for the Mobile sink is considered to reduce packet loss. If the MS moves in high speed then the data gathered from the CH are relatively small. If the MS moves in low speed the CH need to wait for long time. The position of the Mobile Sink Node is traced by all the nodes present in the Network by the usage of Mobile Sink Tracking Device. It is used to avoid the arrival of the Multiple Mobile Sink node to the same Cluster Head for data collection. The Routing Manager manages all the modules involved in the process.

A. Cluster Formation

In this module, to achieve high energy efficiency sensor nodes that are present in the network are grouped into Clusters. The main idea of clustering concept is to reduce the occurrence of network traffic from sensor node to sink and improve the energy consumption. Here the sensor nodes are located in the region in static manner. For Cluster Formation, K-Means Clustering Algorithm is considered.

K-Means Algorithm

K-Means is considered as simplest unsupervised learning algorithms that solve a well-known clustering problem as shown in Fig 3. The main aim of K-Means clustering algorithm is to partition n observations into k clusters and each observation belongs to the cluster with the nearest mean value. This algorithm has a close relationship with the K-Nearest Neighbor classifier which is a popular machine learning technique. Through a certain number of Clusters it is easy to classify the given data set.

The idea of K-Means is to define k centers for each cluster. These centers should be placed carefully because different locations cause different result. Consider each point belonging to a given set of data’s and associate it to the nearest center. In the proposed system, each cluster contains single Cluster Head.

B. Cluster Head Selection

The CH is selected as dynamic in nature i.e. the selected CH frequently changes for each round. Initially all the nodes will contain equal amount of energy. Thus the CH is identified in the network in random manner and in further rounds the nodes with highest energy is selected as the current CH. The CH selection is done by using Energy-LEACH algorithm.

E-LEACH Algorithm

LEACH algorithm is a hierarchical protocol in which the nodes transmit the data to the CH, and the CH’s aggregate the data and forward it to BS. To improve the network lifetime E-LEACH algorithm is considered. The CH is selected as dynamic in nature. In each round, the nodes with highest energy are selected as the current CH.

C. Mobile Sink Node

The multiple mobile sink nodes collect the data from the Cluster Head and transmit it to the Base Station. The Mobile sink nodes are emerged from the Base Station and they contain buffers to store the collected data’s. When the buffer value reaches zero or the buffer becomes full, then the stored data’s are transmitted to the Base Station. During pause time, the mobile sink sends a Beacon Frame to the neighboring Cluster Head in order to check the network condition. This
module belongs to Steady State Phase in Clustering technique.

D. Speed of the Mobile Sink

Constant speed for the Mobile Sink is considered to reduce packet loss. If the mobile sink node moves in high speed then the data gathered from the CH are relatively small. If the mobile sink node moves in low speed then the CH need to wait for long time for the arrival of the sink node. Thus the speed of the mobile sink node should not be high or low.

E. Scheduling the Mobile Sink Node

Scheduling the mobile sink is the process of planning how the mobile sink nodes operate. Weighted Rendezvous Planning (WRP), a heuristic method used to finds a near-optimal travelling path for the mobile sink, such that it minimizes the energy consumption of sensor nodes. WRP assigns a weight to Cluster Head (CH) based on the hop distance. The CH at minimum distance will be assigned with highest weight and the CH with highest weight will be assigned to the MS for data collection. After reaching the BS, the multiple Mobile sink communicates with each other in order to verify whether they both do not visit the same Cluster Head during data collection.

IV. RESULTS AND COMPARISON

Fig 4 Creation of Nodes and Data transfer

Fig 4 represents creation of nodes and data transfer between the nodes placed in the network. The nodes that are placed in the network are grouped into clusters. K-means algorithm is used for Cluster Formation and each cluster contains one Cluster Head. The 50th node is considered as Base Station. The data are transmitted from the Cluster Member to the Cluster Head in a single-hop fashion. The nodes present near the Base Station transmit the data’s directly to the Base Station. Initially all the nodes will contain equal amount of energy. Thus the CH is selected in the network in random manner.

Fig 5 Dynamic CH selection

Fig 5 represents the occurrence of frequent changes in the selected CH. For CH selection E-LEACH algorithm is used. The selected CH is dynamic in nature i.e. in each round; the nodes with highest energy are selected as the current CH.

Fig 6 Mobile Sink’s Emerge from the BS

Fig 6 represents the emergence of multiple Mobile Sinks from the Base Station. The nodes 51, 52 and 53 are considered as Mobile Sink. The Cluster Heads which are nearer to the Base Station are selected by the Mobile Sinks 1 and 2 for gathering the aggregated data. If the BS needs the data from a particular CH alone, then MS3 is used to gather the data only from that CH alone. By using WRP algorithm the shortest path is determined. Before the travel of the Mobile Sink node starts, which Mobile Sink node moves to which CH is instructed using Location Analyzer.

Fig 7 MS’s 1, 2 visit the nearest CH 26, 27 and MS 3 visit the CH 32

Fig 7 represents the Mobile Sinks 1, 2 gathering data from the Cluster Heads 26, 27. While collecting the data from the current CH, the nearest CH from the current CH is found.
and the network condition of the nearest CH is verified. The calculated data are stored in the buffer and moved to the nearest CH. The Mobile Sink 3 gathers data from the Cluster Head 32. The BS needs the data from the CH 32, so the Mobile Sink 3 moves to that CH alone for gathering the data.

![Fig 8 Arrival of Mobile Sinks to the Base Station](image)

Fig 8 represents the arrival of the Mobile sinks to the Base Station. After collecting the data from the Cluster Head, the Mobile Sinks deliver the data to the Base Station. The multiple Mobile Sink visits all the Cluster Head in a single stretched manner. The delay for delivering the data is reduced and the Cluster Head energy will not be drain quickly.

![Fig 9 Comparison of Delay](image)

Fig 9 represents the comparison of delay for both single Mobile Sink and multiple Mobile Sinks. Mobile nodes are plotted along x-axis and delay is plotted along y-axis. The delay gets reduced by the usage of multiple Mobile Sinks when compared to the usage of single Mobile Sink. The delay depends upon the number of mobile nodes used in the network.

![Fig 10 Comparison of Energy Efficient](image)

Fig 10 represents the comparison of energy efficiency for both single Mobile Sink and multiple Mobile Sinks. Mobile nodes are plotted along x-axis and energy efficient is plotted along y-axis. The energy efficient gets increased by the usage of multiple Mobile Sinks when compared to the usage of single Mobile Sink. The energy efficient depends upon the number of mobile nodes used in the network.

V. CONCLUSION AND FUTURE WORK

In the proposed system, Multiple Mobile Sinks is used for data gathering between the Cluster Head and the Base Station to improve the energy efficiency and to prolong the lifetime of the network. The Cluster Head need not wait for long time for the arrival of the Mobile Sink node. Thus the delay of data packets gets reduced. The Cluster Head gather the data from the Cluster Member in a single stretched manner. By the usage of Multiple Mobile Sink, the Communication Overhead is reduced. Location awareness Multiple Mobile sinks is considered and the sensor nodes present in the Cluster must keep track of the position of the Mobile Sink Node. WRP algorithm is used to determine the shortest distance from the Cluster Head to the Base Station depending upon the Hop distance and the Mobile Sink will travel in the detected shortest path. The speed of the Mobile Sink is considered in order to reduce the packet loss.

In future work, if the Mobile Sink node energy drain, then automatically the back-up sensor is used to replace the energy drained Mobile sink with another new Mobile sink.

REFERENCES


