ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 10, March 2016

ENERGY PRESERVATION USING DUAL MOBILE SINK ROUTING IN CLUSTER FORMATION FOR WIRELESS SENSOR NETWORK

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Abstract: Energy consumption may reduce the lifetime of the network. Thus it is considered as the major problem in Wireless Sensor Network. In the existing system, Single Mobile Sink was used for collecting the aggregated data's from the Cluster Head. In the proposed system, Multiple Mobile Sink nodes are considered for gathering data from the Cluster Head (CH) and each cluster contain only one CH. The Cluster Formation is done using K-Means Algorithm.If the energy of the present Cluster Head becomes low then automatically the node with highest energy will be selected as the Cluster Head and the Cluster Head does not remains constant. The Mobile Sink Node visits the Cluster Head as a hostile and collect the data's from the allocated Cluster Head. The sensor nodes present in the Cluster 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 problem, Weighted Rendezvous Planning (WRP) is projected thereby every nodes present in the network is appointed a weight equivalent to its hop distance from the BS. Localization of node is included in which movement of the sink node is tracked by all the nodes.

Index Terms: Wireless Sensor Network, Cluster Head (CH), K-Means algorithm, 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 lifetimegreatly depends upon the energy consumption of the sensor nodes. In WSN, Data Aggregation and Collection is considered as an 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 theBase 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 organisation, thesensor 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 highly 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

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Available online at www.ijartet.com
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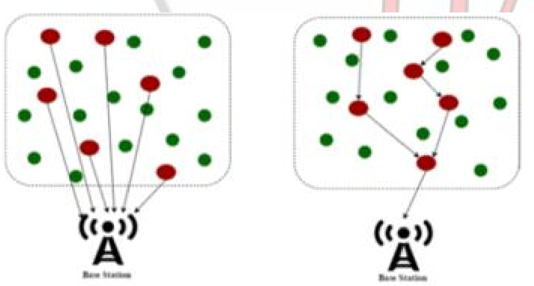
present in the network because some sensor nodes are not available to communicate with the BS. [8]

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.



Sensor Node   Relay Node

Figure 1(a) Single-Hop Network   Figure 1(b) Multi-Hop Network

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

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 Base Station may be large and the Cluster Head may consume lot of energy. In order to reduce the consumption of energy, an intermediate node called Mobile Sink 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's simultaneously to a single SenCar by using the technique Multi-User Multi-Input and Multi-Output (MU-MIMO).

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 packets 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 and each Cluster contains single Cluster Head that 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 [1] Gedik B., Liu L. and Yu P. S. proposed an adaptive sampling approach for data collection in sensor networks. One of the most prominent and comprehensive ways of data collection in sensor networks is to periodically extract the raw sensor readings. This way of data collectionthis enables complex analysis of data, which may not be possible with in-network aggregation or query processing.ASAP, which is evaluated as an adaptive sampling approach was developed for energy efficient periodic data collection in sensor networks. The main idea behind ASAP is to use a dynamically changing subset of the nodes as samplers such that the sensor readings of the sampler nodes are directly collected, whereas the values of the non sampler nodes are predicted through the use of probabilistic models that are locally and periodically constructed. ASAP is effectively used to increase network lifetime while keeping the quality of the collected data high. The ASAP approach consists of three mechanisms namely sensing driven-cluster construction was used to create clusters within the network such that nodes with close sensor readings are assigned to the same clusters. Correlation-based sampler selection and model derivation were used to determine the sampler nodes and to calculate the parameters of the probabilistic models that capture the spatial and the temporal correlations among the sensor readings as needed. Adaptive data collection and model-based prediction were used to minimize the number of messages used in the network to extract the data's.

In [6] Ma M. and Yang Y. discussed about an energy-efficient data gathering mechanism for large-scale multihop sensor networks. A mobile data observer, called SenCar, which could be a mobile robot or a vehicle equipped with a powerful transceiver and battery, works like a mobile base station in the network. Christo Ananth et al. [10] discussed about Reconstruction of Objects with VSN. By this object reconstruction with feature distribution scheme, efficient processing has to be done on the images received from nodes to reconstruct the image and respond to user query. Object matching methods form the foundation of many state- of-the-art algorithms. Therefore, this feature distribution scheme can be directly applied to several state-of-the-art matching methods with little or no adaptation. The future challenge lies in mapping state-of-the-art matching and reconstruction methods to such a distributed framework. The reconstructed scenes can be converted into a video file format to be displayed as a video, when the user submits the query. This work can be brought into real time by implementing the code on the server side/mobile phone and communicate with several nodes to collect images/objects. This work can be tested in real time with user query results. The moving planning algorithm can be used in both connected networks and disconnected networks. In addition, SenCar can avoid obstacles while moving.

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 uniform random deployment. This problem may leads 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 [15] Zhao M., Ma M. and Yang Y. focused on Efficient data gathering with mobile collectors and space-division multiple access technique in Wireless Sensor Networks. A mobile collector called SenCar work like mobile base stations and collect data from associated sensors via single-hop transmissions so as to achieve uniform energy consumption. SDMA technique was also applied for data gathering by equipping each SenCar with multiple antennas such that distinct compatible sensors may successfully make concurrent data uploading to a SenCar. To investigate the utility of the joint design of controlled mobility and SDMA technique, a single SenCar was deployed in WSN. The aim of the paper was to minimize the total data gathering time, which consists of the moving time of the SenCar and the data uploading time of sensors, by exploring the trade-off between the shortest moving tour and the full utilization of SDMA. This problem is referred as mobile data gathering with SDMA, or MDG-SDMA. Integer Linear Program (ILP) was formalized and a heuristic algorithm was proposed. Region-Division and Tour-Planning (RDTP) algorithm was proposed, in which data gathering time was balanced among different regions.

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 tradeoff between energy saves and data gathering latency in mobile data gathering by exploring a balance between the relayhop 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. DUAL 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.

When the multiple Mobile Sink emerge from the Base Station they split the network according to the mobile sink number and the mobile sink collect the data's only from the allocated area. Thus Multiple Mobile Sink will not approach same Cluster Head at a time. The Beacon Frame is

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transmitted from the Mobile Sink to the Cluster Head to verify the network condition and check whether the data's are ready for transmission. AOMDV routing protocol is used to determine the routes for transmitting the data packets. The location of the mobile sink is traced by the sensor nodes present in the network.

The packet delivery between the Cluster Head and the Base Station get increased. Transmission of Beacon frame reduces the packetloss. Single-Hop transmission reduces the energy consumption and increase the throughput. By the usage of multiple Mobile Sink Node the Network Lifetime gets increased. 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 information about the data which are involved in the transmission is stored in the Data Unit. After the collection of data's are 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 route is calculated by using WRP algorithm. The Routing table incorporates the combination of the available Routes and the shortest routes through which the Mobile Sink travels.

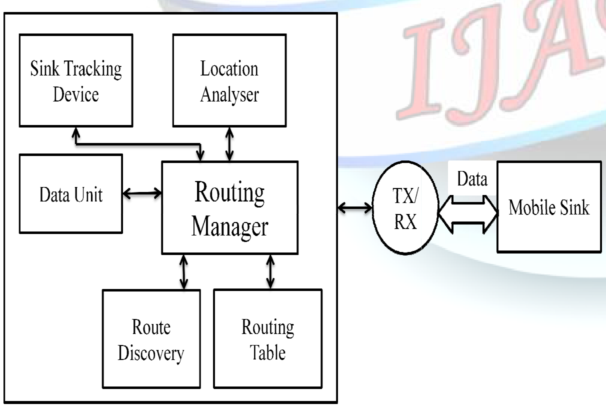

Fig 2 Architecture

Before the travel of the Mobile Sink starts, which Mobile Sink should move to which Cluster Head is instructed using Location Analyzer. 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 Managermanages 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 n 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.

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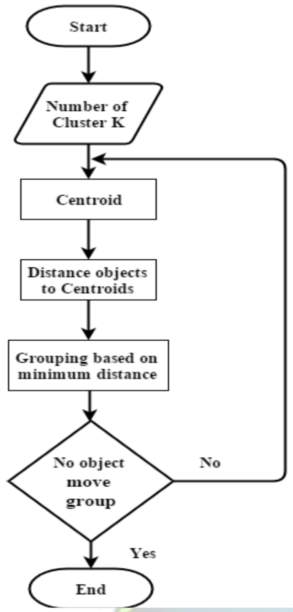

Fig 3 K-means flowchart

K-Means Algorithm Steps

Let X = {$x_1, x_2, x_3, \ldots, x_n$} be the set of data points and V = {$v_1, v_2, \ldots, v_c$} be the set of centers.

1) Randomly select *'c'* cluster centers.
2) Calculate the distance between each data point and cluster centers.
3) Assign the data point to the cluster center whose distance from the cluster center is minimum of all the cluster centers
4) Recalculate the new cluster center using

$$v_i = (1/c_i) \sum_{j=1}^{c_i} (x_i)$$

Where c_i represents the number of data points in the i^{th} Cluster.
5) Recalculate the distance between each data point and new obtained cluster centers.
6) If no data point was reassigned then stop, otherwise repeat from step 3.

B. Cluster Head Selection

Initially all the nodes will contain equal amount of energy. Thus there occurs random selection of Cluster Head. All the Cluster Member presents in the Cluster communicate with the CH in a single-hop fashion. If the Cluster Head Energy gets drain, then the node with the highest energy is considered as the Cluster Head. The Cluster Formation and Cluster Head selectionbelongs to Set-Up phase in Clustering technique.

C. Mobile Sink Node

The multiple mobile sink nodes collect the data packets 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. 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

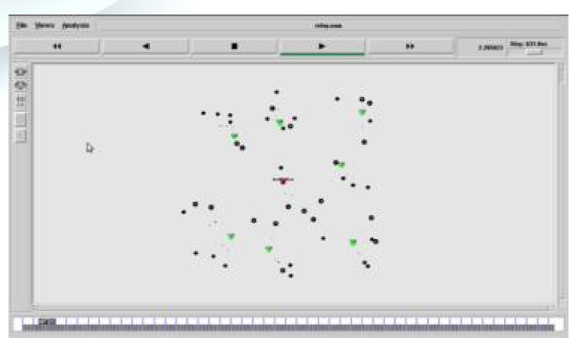

Fig 4 Creation of Nodes and Data transfer

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ISSN 2394-3785 (Online)
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International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
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Fig 4 represents creation of nodesand 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's 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.

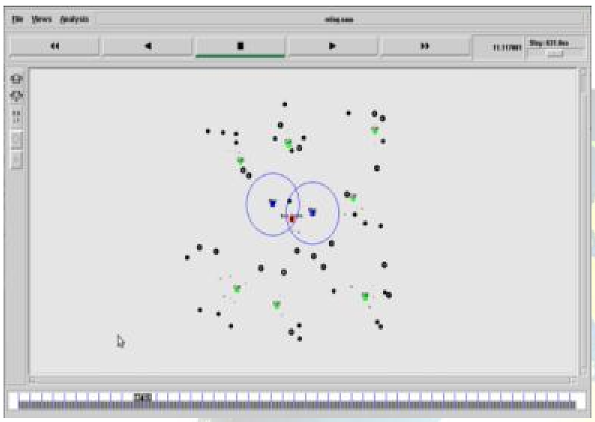

Fig 5 Emergence of Multiple Mobile Sinks from the Base Station

Fig 5 represents the emergence of multiple Mobile Sinks from the Base Station. The nodes 51 and 52 are considered as Mobile Sink. The Cluster Heads which are nearer to the Base Station are selected by the Mobile Sinks for gathering the aggregated data's. 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.

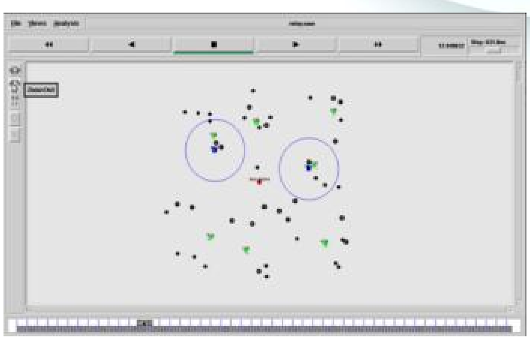

Fig 6 Mobile Sinks 1 and 2 visit the nearest Cluster Head 27 and 41

Fig 6 represents the Mobile Sinks 1 and 2 gathering data's from the Cluster Heads. Mobile Sink 1 gathers the data from the Cluster Head 41 and Mobile Sink 2 gathers the data from the Cluster Head 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.

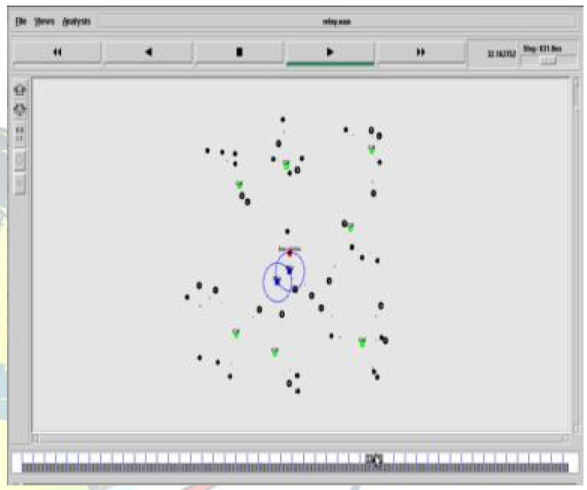

Fig 7Arrival of Mobile Sinks to the Base Station

Fig 7 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's to the Base Station. The multiple Mobile Sink visits all the Cluster Head in a single stretched manner. The delay for delivering the data's are reduced and the Cluster Head energy will not be drain quickly.

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ISSN 2394-3785 (Online)
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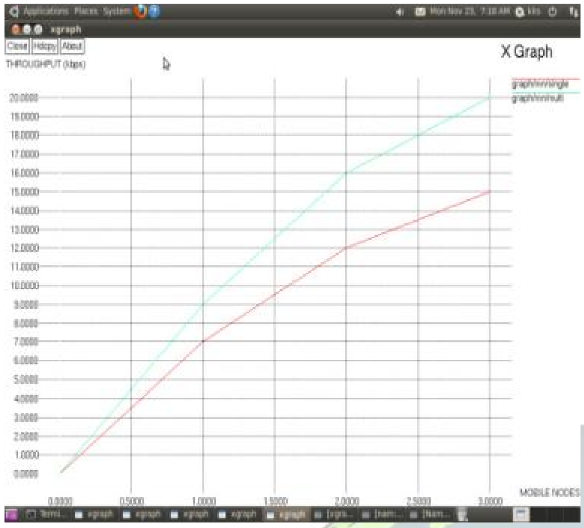

Fig 8 Comparison of Throughput

Fig 8 represents the comparison of throughput for both single Mobile Sink and multiple Mobile Sinks. Mobile nodes are plotted along x-axis and throughput is plotted along y-axis. The throughput gets increased by the usage of multiple Mobile Sinks when compared to the usage of single Mobile Sink. The throughput depends upon the number of mobile nodes used in the network.

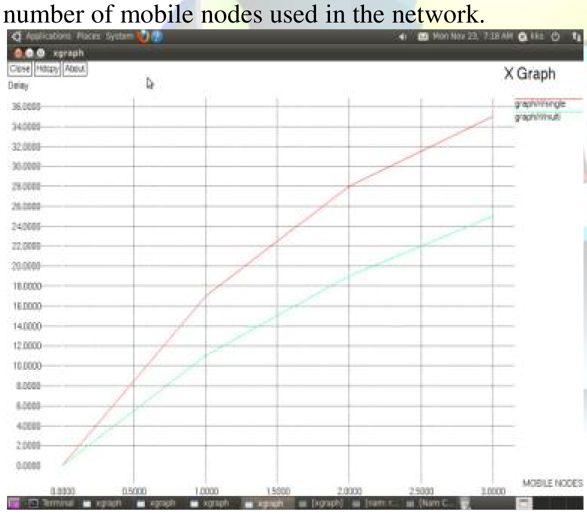

Fig 9 Comparison of Delay

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.

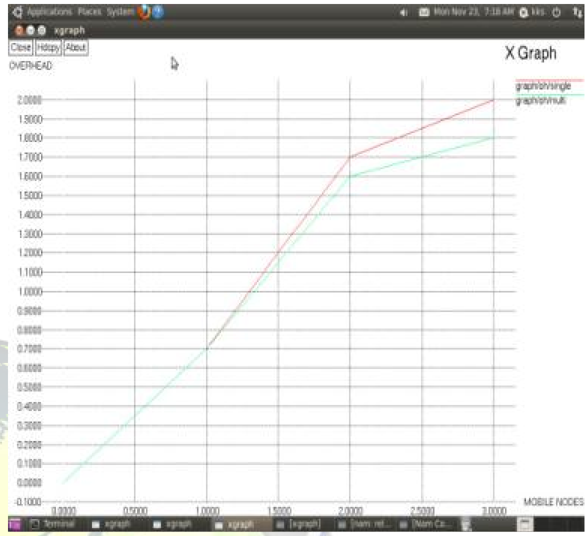

Fig 10 Comparison of Overhead

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

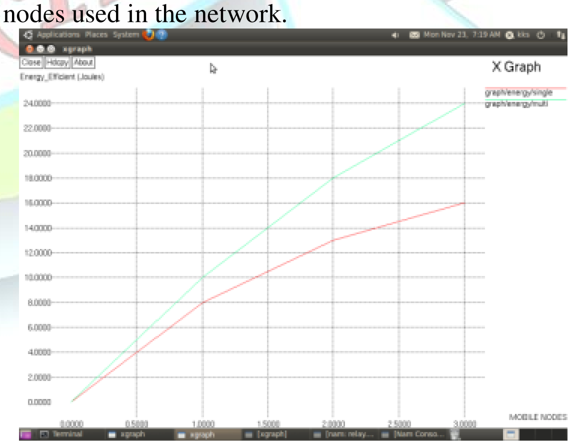

Fig 11 Comparison of Energy Efficient

Fig 11 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 network lifetime. 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's 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.

In the enhanced future work, for each round of data gathering, the Cluster Head gets changed and every Cluster Member will be activated as Cluster Head during data collection. The Cluster Head selection is done using Highest Energy First algorithm. The node with highest energy will be selected as Cluster Head. The energy of the Mobile Sink may drain due to large amount of data gathering. The aim of the project is to save energy and speed up the data transmission. Thus Back-Up sensors and speed Mobile Sink may also be another consideration for collecting the data and to achieve high energy efficiency. The speed Mobile Sink also reduces the delay of the data packets.

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Vol. 3, Special Issue 10, March 2016

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