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On

Improved Threshold Sensitive Stable Election Protocol in Heterogeneous WSN using Genetic Algorithm

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By

SUNIL KUMAR BISAIYA

Roll No. – 2K13/CSE/30

Under the esteemed guidance of

DR. S.K. SAXENA

Department of Computer Science and Engineering

Delhi Technological University

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Dr. S.K. SAXENA
Project Guide
Dept. of Computer Science and Engineering
Delhi Technological University
Bawana Road, New Delhi-110042

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Sunil KumarBisaiya

Roll No.2K13/CSE/30

M.TECH

E-mail: sunil.bisaiya@gmail.com

ABSTRACT

We present an approach for heterogeneous wireless sensor network of three types of nodes with different energy levels namely advance nodes, intermediate nodes and normal nodes.The WSN network is created using Genetic Algorithm.The energy efficiency can be improved by the proposed approach through Multiple Cluster Heads. The mobile sink node and mobile sensor nodes can directly reach cluster heads and collect data from it. Mobile sink reduces the

energy consumption arises due to routing of data to the static sink, Cluster Head or Base Station. Only sink moves to collects data from cluster head. The cluster head selection is based on highest residual energy. After aggregation of data, sink moves to collect data from cluster head directly whereas in static sink case, data is sent in multiple hops to sink from cluster head. Path of sink node is optimized to reach the cluster heads. Mobility of sink via shortest path reduces delay of data delivery. So with sink mobility scheme achieves energy optimization than without sink mobility.

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LIST OF SYMBOLS AND ABBREVIATIONS

SN	Sensor Node
WSN	Wireless Sensor Network
BS	Base Station
ADC	Analog-Digital Converter
TDMA	Time Division Multiple Access
QoS	Quality of Service
UPS	Uninterrupted Power Supply
PDA	Lack of Cohesion in Methods 4
TSEP	Threshold Sensitive Election Protocol
SEP	Stable Election Protocol
ETSSEP	Enhance Threshold Sensitive Stable Election Protocol
CH	Cluster Head
AODV	Number of Attributes and Methods
LEACH	Low-energy adaptive clustering hierarchy
EEHC	Energy Efficient Hierarchical Clustering
H-HEED	Heterogeneous -Hybrid Energy Efficient Distributed
TDEEC	Threshold Distributed Energy Efficient Clustering
DEEC	Distributed Energy Efficient Clustering
EDEEC	Enhanced Distributed Energy Efficient Clustering
DEEAC	Distributive Energy Efficient Adaptive Clustering
ELBSEP	Energy Level Based Stable Election Protocol
EELBCRP	Energy-Efficient Level Based Clustering Routing Protocol
UCEESEP	Unequal Clustering Energy Efficient Stable Election Protocol
LEACH-C	Low-energy adaptive clustering hierarchycentralized clustering
EEHC	Energy efficient heterogeneous clustered scheme
CDMA	Code Division Multiple Access
DD	Degree of Dependency
E_0	Initial Energy
N	Number of Nodes

K	Bit of Data
M	Dimension of Network Region
P	Probability
T	Threshold
E_{elec}	Energy Dissipated per bit to Run the Transmitter or the Receiver
E_{fs}	Energy Dissipation in free space model
E_{amp}	Energy Dissipation in Multipath Fading model
E_{DA}	Energy Dissipation in Data Aggregation
α	Factor for Advance Node
β	Factor for Intermediate Node
b	Fraction of Intermediate Nodes
m	Fraction of Advance Nodes
P_{opt}	Optimal Probability
R	Total Rounds
r	Current Round
d_{toBS}	Average Distance between the Cluster Head and the Base Station
d_{toCH}	Average Distance between the Cluster Nodes and the Cluster Head
k	Number of Clusters
K_{opt}	Optimal Number of Cluster
MS	Mobile Sink

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CHAPTER ***1***

INTRODUCTION

1.1 WIRELESS SENSOR NETWORK

With the advance of technology, computers can be built in small size while still maintaining the capability of data processing and communication. A good example is the wireless sensor platform. A typical sensor node usually has a size close to a coin or even smaller, including the battery. It integrates the computing system, the radio component and the sensing units together on a single tiny platform.Due to the low cost of SNs, WSNs have become most popular [1]. It is more viable for variety of real life applications. In WSNs each SN has capability to sense the data, perform some computation on that data and communicate to other nodes. Once SNs are deployed in the network, they can keep operating until their energy depletes. WSNs can be used in variety of applications such as military programs, forest monitoring, land slide detection, water monitoring, agriculture, structural monitoring etc [2][3]. Architecture of WSNs for various applications is shown in fig 1.1.

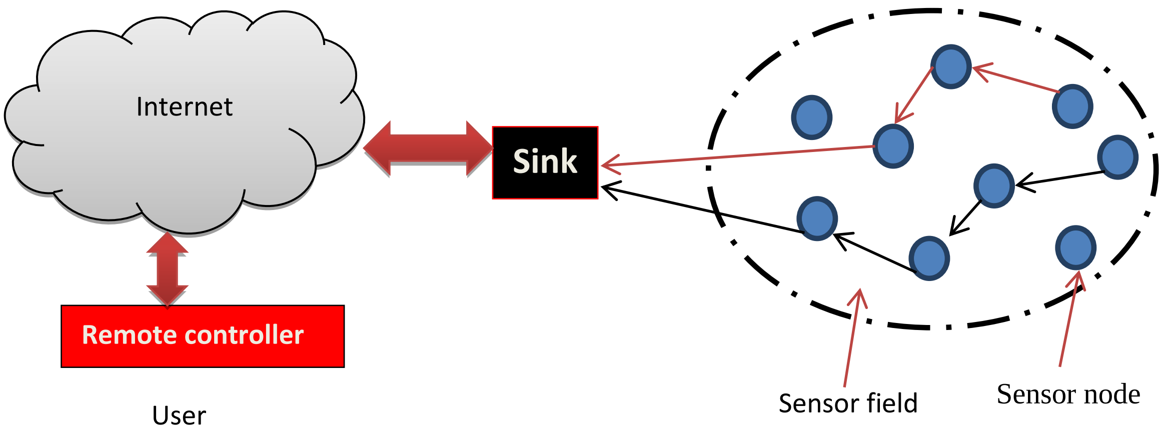

Figure 1.1: Architecture of Wireless sensor network

In WSNs, large numbers of SNs are deployed to sense an object because single sensor is not capable of sensing the whole environment; therefore all the nodes have collaborate with each other to provide full functioning of these networks. SNs are able to assemble and configure themselves which is more powerful and helpful property in creating the network. In most of the existing algorithms to save energy, SNs communicate only to the local peers rather than directly to the BS. WSNs can have different infrastructure for different applications [1]. Wireless sensors network are multi-hop ad-hoc wireless networks without any backbone infrastructure. Small, inexpensive, intelligent, disposable sensors with low-power can be deployed in large numbers, in environments like home to hostile and possibly inaccessible environments like disaster areas or battlefields. They can be deployed manually by hand, or randomly by, for instance, dropping it by an aeroplane. Every sensor is capable of mobile communication and has different level of intelligence for processing signals and transmitting data. This makes wireless sensor network highly adaptable so that it can be deployed in almost all environments. The sensor nodes can be used for collecting data from a faraway place and sending back to the sink or base station via multiple hops. These types of features allow wireless sensor networks to have great potential in various applications like environment monitoring, surveillance and target tracking, etc. [3]. For example, number of SNs can be used for monitoring chemical plants that automatically form wireless network and informs to the BS at any leak [2][3].They can also reconfigure themselves to track the poisonous gases and find the location of leak. Deployment cost of wireless SNs is minimal as compared to the wired nodes. They can be added simply to extend network. In addition to reduce the installation costs, WSNs can easily adopt the changes in the environment. As a result, it is more efficient than the wired network. Adaptation mechanism for these changes can respond to network for different modes of operations. Generally, when people think about the wireless devices they think of items such as mobile phones, laptops, personal digital assistants etc which costs hundreds of dollars and depends on the existing infrastructure. While WSNs use small low-cost devices for many applications and they doesn't depend on any fixed infrastructure [16]. The common participants of WSNs are: (i) *sources* that generate data of the task, (ii) *intermediate data* that forwards data generated by other nodes and can make additional application and (iii) *sink node* from which users access the network and where the data are received [1].

1.2 SYSTEM ARCHITECTURE OF SENSOR NODES

WSNs are made of large number of SNs which are deployed in the wide area. All SNs within a WSN can communicate to each other directly or via other nodes. In WSNs there is sink node which can be one or more nodes among all nodes. All SNs perform sensing and send their sensed data to sink node directly or through other nodes as intermediate nodes. A component based operating system called TinyOS [1] is used to run wireless devices. In TinyOS event based programming is used and they used efficient component model. There is tight coupling between hardware and software in TinyOS so they optimize system. TinyOS is very flexible to build application specific modules. It can be used for generalized architecture. Single CPU is used for application and protocol processing. A sensor node consists of some components such as sensing unit, analog to digital convertor, small memory, processing unit, transceiver [1] etc as shown in fig 1.2

- **The sensing unit** senses and converts the signal from analog to digital via the Analog-Digital Converter (ADC).
- **Theprocessingunit**processes and stores the data. It is the core of the sensor node and is responsible for the management of the whole platform.
- **The communication unit** transmits and receives data to and from the network.
- **The power unit** provides the energy for other units. Batteries are the most common power sources for the sensor platform.

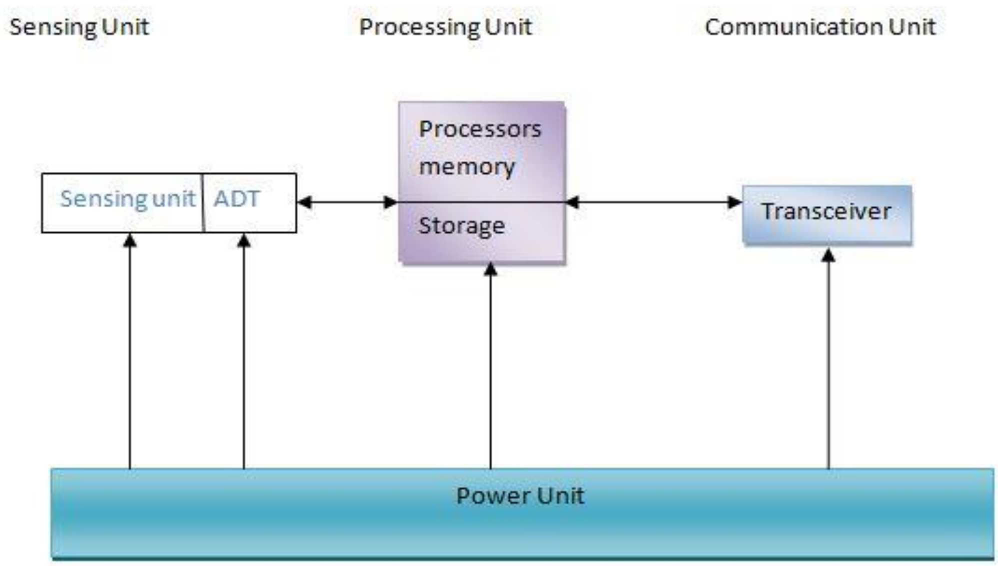

Figure 1.2: Typical components of a sensor node

Sensor node sense the data using sensing unit. Data generated by sensing unit is analog data. After generating analog signal, sensing unit sends it to analog to digital convertor. ADC converts analog signal into digital signal and also informs to sensing unit what to do. ADC sends this digital data to memory where sensor node can store them. Each sensor node has a processing unit where they can perform simple computation. After computation sensor nodes send their data through its transceiver to other nodes [1].

1.3WIRELESS SENSOR NETWORKS ARCHITECTURE ISSUES

Routing protocols performance depends on the architecture model of WSNs [1][20]. Different architecture constraints have been considered for WSNs based on the applications. In this section we are considering the architectural issues which are as follows:

i. **Security implementation:** Security is a very important parameter for the applications such as battle field monitoring. When we design a sensor network for such applications, security is a major concern. Hence protocols working in these applications should be secure [22].

ii. **Energy consideration:** In WSNs, after the deployment of SNs, it is almost impossible to change their battery. Hence consumption of energy should be less in route selection and transmission of data. Since transmission power of nodes is directly proportional to the square of distance of transmission hence multi-hop transmissions should be used rather than direct transmission. But multi-hop transmission have overhead of management of route. For high density networks, direct transmission is efficient whereas for large scale networks with low density, multi-hop transmission should be preferred [30].

iii. **Data aggregation:** In WSNs several SNs generate redundant data for same object. In that case, similar packets can be aggregated to reduce transmission overhead. In data aggregation, redundant information are discarded by using several techniques such as suppression, max-min etc. These techniques of aggregation can be used by the aggregator SNs to reduce data size. The energy consumed in such calculations is much less in comparison to transmission [35].

iv. **Node deployment:** It is important to deploy SNs in efficient manner in WSNs. It is based on the application and affects routing. For example, some applications require movement of nodes while others require static nodes. Nodes can be static or mobile on the basis of application requirements. In case of static nodes, nodes are placed manually and routing is performed on the basis of it. While in the case of mobile nodes, they form self organizing networks [31].

v. **Data delivery models:** In WSNs, data delivery model can be query based, event driven, TDMA (time division multiple access) based or hybrid on the basis of applications. In query based data model, data transmission takes place when query is generated. In event driven model, when any event occurs, transmission of data takes place. While in the TDMA based model, data are transmitted periodically. Some applications require hybrid model for data transmission [11].

vi. **Node capabilities:** Depending on applications, SNs can perform sensing, transmission and reception of data. SNs can also work as aggregators and relay nodes to forward data of other nodes [31].

vii. **Network dynamics:** In WSNs, three main components are SNs, sink nodes and objects or phenomena. SNs are used to perform sensing in its range. Sink nodes are the nodes from which user receives information. Objects or phenomena are those, which are to be sensed [1].

1.4WIRELESS SENSOR NETWORK CHALLENGES

WSNs are used for various applications and environments and for effective application of WSNs [2], we need good and efficient protocols. In designing efficient protocol, there are several challenges which should be understood. These challenges are as follows:

I. **Resource constraints:** The most important constraints of sensor networks are limited battery-power of SNs. Lifetime of SNs directly depends on its power supply. So energy consumption of nodes is very important issues in designing the protocols. Limited bandwidth and limited memory are also other constraints of WSNs. SNs are capable of simple calculations, so this issue should also be considered in designing of protocols [1].

II. **Fault tolerance:** SNs can fail due to lack of energy or physical damages. Protocols that are working in the WSNs must accommodate these changes. The failure of some nodes shouldn't affect the overall network operation. This is called reliability or fault tolerance issue. For example if we take the case of routing protocols then a good routing protocol should find an alternate route to overcome node failure problem [1].

III. **Scalability:** In most of the applications, number of SNs is of the order of thousands, millions or more. Hence the protocols working in WSNs should be scalable and are capable of working for such a large number of nodes. They should be able to work for such high density networks and density of network can vary according to the application requirements [6].

IV. **Quality of Service (QoS):** In some applications of WSN, sensed data are required within certain amount of time otherwise data become useless. These applications are very time critical. For these applications time is a QoS parameter [22][26].

V. **Security:** In some applications of WSNs, security is very critical parameter. In WSN applications, effective adjustment should be achieved between secure data transmission and limited communications bandwidth. While in the traditional networks the focus is on the maximum throughput [22].

VI. **Production costs:** WSNs are made of large number of SNs. To justify the cost of whole sensor networks, cost of single node should be considered. Sensor network is not cost justify if the cost of network in establishment is more as compare to traditional sensors. Cost of sensor networks should be kept low [26].

VII. **Hardware Constraints:** Each sensor node is made of four units such as: sensing unit, processing unit, transceiver unit and power unit. They can have additional component on the basis of applications such as power generator, location finding system and mobility etc. Sensing unit can also be divided into two parts such as: sensor and analog to digital converter. Sensor senses the object and generate analog signal which is converted into digital signal by analog to digital converter then forwarded to processing unit. Processing unit associated with a small memory and capable some simple calculations. The task of transceiver unit is to connect nodes to other nodes. There is one important component called power unit which is supported by power scavenging unit. There are other units which depend on applications.

1.5 CATEGORIES OF SENSOR NETWORK APPLICATIONS

There are many applications of sensor networks but they can be broadly classified into three fields such as: object tracking, security monitoring and environment monitoring which are as follows:

i. **Object tracking:** WSNs are used for tracking objectsthrough a region of space. Many times we need to track the location of objects. We can control system attacks by tracking the object through last check points. While using these systems, it is not possible to find the objects current location. For example, when any shipment passes through a routing center, UPS scan them through scanning its barcode. But if shipment not passes through any routing centre, system breaks down. To track shipment, it is necessary to pass them through routing center while it is impractical to pass shipment through all checkpoints [2][3].

   Objects can be tracked by tagging a small sensor node in network. In WSNs, sensors are deployed in the environment and these SNs are deployed to sense RF messages of the objects. These SNs are used to announce the presence of device. When any object moves through these locations it will be tracked by these SNs. A database can be maintained to store the information of the tracked object relative to the known locations. It is possible to track the object using this system and find the current location. In object tracking, system topology changes as object moves through the network. During nodes movement it should keep in mind that the connectivity of network is maintained. In nodes movement, only some SNs moves while other nodes remain static to maintain the connectivity of network. Additionally, SNs track continuously as object moves from one location to another. Network should be able to detect the presence of new nodes.

ii. **Security monitoring:** In security monitoring, SNs are placed at fixed locations in WSNs. SNs continuously monitor the environment to detect any anomaly. In this, sensor networks do not collect any data. Each node senses in its range and transmit information only when any security violation occurs. System should consist of reliable communication and immediate alarm messages. It is very important that each

SN works correctly. If any node in WSNs fails due to any reason, it shows security violation which should be reported. In security monitoring, nodes are arranged such that they are able to know the status of each other. In security monitoring, each node is assigned a time slot during which it has to inform, if any security violation occurs. The topology used for security monitoring is different from the topology used in data collection [2][22].

Each node transmits data of its descendent in collection tree. To do this, it is necessary that tree should be wide and short. The optimal configuration for security network should have linear topology which forms Hamiltonian cycle. Power consumption of each node depends on how many children it has. Today's security system is checked once in an hour and evenly distributed the cost of checking nodes. Energy consumed should be minimalin checking. Most of the energy is consumed in signaling the alarm when any security violation occurs.

If any security violation occurs, nodes should communicate to BS immediately. Data communication has direct impact on the performance of application. Users want that alarm should respond quickly in case of failure. To do this, each node should forward data quickly from its neighbors. In security networks, data are more important than cost of energy consumption because alarm activations are rarely needed. In fire system, alarms would very rarely signal. In one time alarming, significant amount of energy is deducted. Higher energy consumption will be achieved if we are reducing the transmission latency. In security network, large amount of energy is spent in checking the working of system and should be ready to alarm announcements. While actual data transmission requires very less energy.

iii. **Environment monitoring:**In environment monitoring, SNs are deployed in the environment and sense environment periodically. When researchers want to collects data through the environment then WSNs are one of the best solutions for it. Environment can be sensed for long time and seasonal trends by scientists. The SNs should be placed at their positions and data should be collected regularly. In this application category of WSNs, there is a large number of SNs for continuously sensing the environment and transmitting their sensed data to BS that stores those information using traditional methods. WSNs lifetime should be long and SNs require very low data rates. All SNs are evenly distributed within the environment. After deployment, SNs discover the topology of the network and selects shortest route to transmit their data. Nodes in the WSNs use some routing strategy to find the shortest route [2][3].

In environment monitoring, SNs can also develop their own routing strategies to select shortest or optimal route but it is not mandatory. Typically, we use tree based topologies where each routing tree has high capability root node called sink. Each child SN transmits sensed data to its parent node until data is reached to the sink node. If the tree has large depth then the nodes which are at the upper level will deplete their energy very quickly, as a result they die soon. Interval between transmissions can be of the order of minutes. Typically SNs transmission interval value is between 1 to 15 minutes. In environment monitoring, typical parameters for sensing are temperature, pressure, humidity, light intensity etc which do not change quickly. The sensed data can be delayed for varying period of time and it doesn't affect the network performance. Hence, the interval of transmission can be settled according to the application. The data are needed for future analysis. Each of the communication events should be scheduled to meet the lifetime requirements. The SNs can also be going into the sleep mode and they only wake up for sensing and forwarding data. There is need of precise schedule for the effective communication events.

Nodes can fail as time passes due to less amount of energy. So nodes' energy should be periodically checked. Researchers can learn more about the environment monitoring and can add additional sensing points. Reconfiguration is not efficient and represents more energy losses. The important characteristics of WSNs for environment monitoring are long lifetime of network,static topology, less synchronization overhead and low data rates. To improve network efficiency data transmission can be delayed.

iv. **Hybrid networks:** Generally, application requires all three categories scenario. For example for a problem of vehicular tracking network needs alarm monitoring system and data collection system. If network doesn't have any object then it performs as alarm monitoring. Each SN senses in its range for object and if object is detected alarm will be activated and the entire network then works as the data collection system. Then SNs transmit their sensed data periodically to the BS for tracking an object. Hence, due to this network behavior, it is required to produce single architecture for all three application scenarios [3].

1.6 POTENTIALAPPLICATIONSOF WIRELESS SENSOR NETWORK

Wireless sensor networks are useful in many areas such as agriculture, industry, military and security.

i. **Area monitoring:** It is very common application of WSNs. In this application, SNs are deployed in the region to monitor environment. For example, in military application, SNs detect enemy intrusion. SNs, after sensing the events, report to one of the BS. Then BS takes an appropriate action (sends a message through internet or satellite) [2][3]. WSNs can use various range of sensor networks to detect moving vehicle, human etc.

ii. **Air pollution monitoring:** WSNs can also be used to monitoring pollution in air. Several cities (London, Stockholm etc) are using WSNs to monitor concentration of dangerous gases for citizens [2][3].

iii. **Forest fire detection:** It is a very important application of WSNs. SNs is deployed in the forest to detect fire. SNs, used in the forest, can sense temperature, humidity and gases that are produced by fire. Since early detection of fire is also crucial for fire fighters. With the help of SNs we are able to know when fire is started and how it is spreading [2][3].

iv. **Greenhouse monitoring:** WSNs can be used to control the temperature and humidity inside the greenhouses. When temperature or humidity within the greenhouse goes below predefined level then greenhouse manager notifies it via short text messages or email [2].

v. **Landslide detection:** WSNs are used to detect landslides. SNs can detect changes in the parameters to detect the landslide and movements of soil. With the help of SNs, it is possible to detect occurrence of landslide before it happened [3].

vi. **Military application:** In the battle field, the network should be fault tolerant;self organized and secure [22]. The SNs should be able to do following services:

- Monitoring forces, equipment and ammunitions
- Inspection of opposing forces
- Target monitoring
- Battlefield surveillance
- Chemical, nuclear and biological attack detection
- Damage assessment

vii. **Machine health monitoring:** WSNs can be used in maintenance of machinery condition. It creates new functionalities and effective cost savings. In wireless system we can add significant amount of SNs according to the need while in the wired network it is limited [1][3].

viii. **Water monitoring:** Many times, we need to sense waste water in industry. WSNs is very useful in that case. Using wireless sensors, we can monitor industrial devices[2].

ix. **Landfill ground well level monitoring and pump counter:** WSNs can be used to monitor different water levels within ground well. SNs sense the level of water and send this information to the central data logging system. Central data logging system stores that information, performs calculation or can notify to personnel when they need it [2].

x. **Agriculture:** It is the most common application of WSNs. WSNs are very useful for farmers in maintenance of wiring in critical environment. Using SNs, gravity feed water system can be monitored. Tanks and water tank levels can be measured using wireless devices (such as wireless sensors) that send the sensed information to the central controller. We can reduce the wastes and increase the efficient use of water by using irrigation automation [2].

xi. **Structural monitoring:** Using WSNs, we can monitor movements of objects within the building and on the flyovers, bridges, tunnels etc. With the help of SNs, we can remotely monitor assets. It also helps in collecting data daily while using traditional way. We collect data only weekly or monthly [2].

1.7 MOBILE SENSOR NETWORK

The participants of WSNs are sink nodes, source nodes and intermediate SNs. Sink nodes can be external elements or SNs that interact with the network. For example, sink can be PDAs, gateways to other networks or laptops in the networks [1].

i. **Single hop and multi-hop network:** In single hop network, all nodes are communicating to other nodes directly as shown in fig 1.3. Due to constraints such as attenuation, interference, obstacles or other factors, direct communication is not possible between source nodes and sink nodes. As a result data can be lost. Hence we have to retransmit data due to which more energy is lost [4].

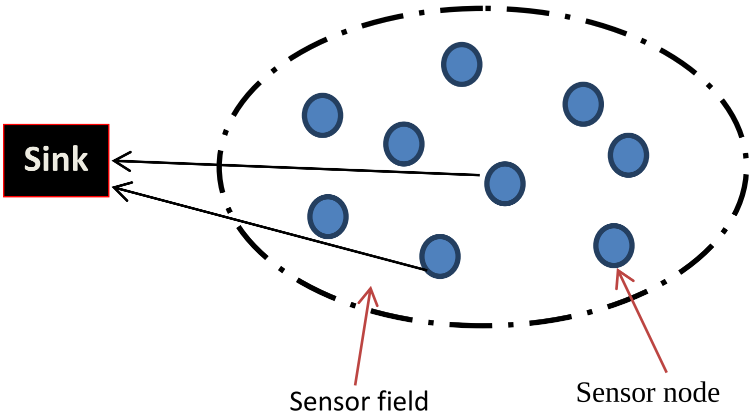

Figure 1.3: Single hop transmission

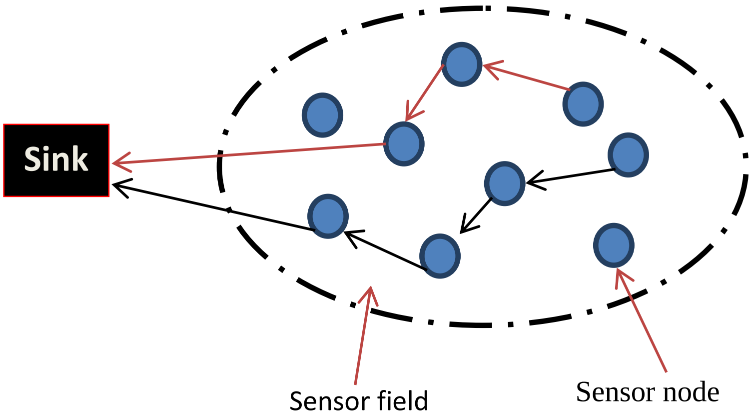

Figure 1.4: Multi-hop transmission

While in the multi-hop network, data transmission takes place through several intermediate nodes. In multi hop network, if data is lost between any pair of nodes then only nearest node retransmit data. Hence, there is less consumption of energy as compared to the single hop network [4].

ii. **Mobility WSNs:** Wireless network offers capability of mobility [4]. As a result nodes and objects in the WSNs can moves from one place to another. There are three types of mobility in the WSNs as follow:

a) **Node mobility:** Wireless SNs have capability of mobility[37]. Sensor node can move from one location to another according to requirement. In object tracking, when objects move, sensor node can also move to track them to some distant. WSNs are self configurable and flexible due to mobility of nodes [4].

b) **Event mobility:** One of the most common applications of events generation is tracing of object. In this application, events (objects) are moving from one location to another location and we have to track them. WSNs are more effective to track such objects [8].

c) **Sink mobility:** Sinks are locations or nodes from which user wants information. Sink can be any node which can move or remain static according to the application needs [24][39].

1.8 MOTIVATION

A wireless sensor network (WSN) consists of inexpensive power constrained sensor nodes collecting data from the sensing area and transmits data towards the base station in a synergetic way. The basic goal of wireless sensor network is to enhance the node lifespan, stability period and throughput of network. The wireless sensor network nodes are restricted by energy, storage capacity, and computing power. So clustering is used to improve lifetime and stability. The many protocols were proposed to efficiently use the battery power to extend the lifetime of the wireless sensor network. The existing Threshold Sensitive Stable Election Protocol (TSEP) is not efficient as it does not consider energy parameter in threshold parameter. The efficient routing protocol in a cluster plays an important role in energy saving and stability of the cluster and its nodes. Stability aware Enhance Threshold Sensitive Stable Election Protocol (ETSSEP) is proposed for heterogeneous wireless sensor network. It is based on dynamic changing of cluster head election probability. It selects cluster heads on the basis of residual energy level of nodes and minimum number of clusters per round. The multiple cluster association based system is contributed to the proposed ETSSEP scheme. The nodes that are neighbors of multiple clusters, divides the data and send it to multiple clusters heads.The mobile sink node and mobile sensor nodes can directly reach cluster heads and collect data from it. Mobile sink reduces the energy consumption arises due to routing of data to the static sink, Cluster Head or Base Station. Path of sink node is optimized to reach the cluster heads. Mobility of sink via shortest path reduces delay of data delivery.

1.9 OBJECTIVE

- To enhance the lifetime of the node, stability period and throughput of network through proposed clustering protocol.
- To analyze the performance in heterogeneous wireless sensor network.

1.10 EXISTING SYSTEM

TSEP is also a reactive routing protocol and it has three different levels of energies. Cluster head (CH) selection is done by threshold value, due to three levels of node heterogeneity and being reactive network routing protocol, it produces increased stability period and network lifetime.

Limitation: It is does not consider the energy levels of the nodes for the cluster head (CH) selection during threshold calculation.

1.11 PROBLEM STATEMENT

The efficient routing protocol in a cluster plays an important role in energy saving and stability of the cluster and its nodes. The existing system is threshold sensitive stable election (TSEP) protocol which does not consider the energy levels of the nodes for the cluster head (CH) selection, during threshold calculation and CH is still probability based in TSEP protocol.

1.12PROPOSED SYSTEM

Nodes are created using Genetic algorithm. ETSSEP is a cluster based reactive routing protocol with three level of heterogeneity. For three levels of heterogeneity, nodes with different energy levels are: advance nodes, intermediate nodes and normal nodes. The energy of advance nodes are greater than all other nodes and a fraction of nodes which have more energy than normal node and less energy than advance nodes are called intermediate nodes, while rest of the nodes are called normal nodes. Intermediate nodes have β times more energy than normal nodes, advance nodes have α times more energy than normal nodes and we assume that $\beta = \alpha/2$. In ETSSEP the total energy distributed over different types of nodes is computed as:

The clusterheadis elected by checking the probability of each node. The probabilities of different types of nodes for electing a cluster head in case of three level of heterogeneity. The m is the proportion of advance nodes to the total number of nodes n, and b is the proportion of intermediate nodes of the total no of nodes n. Initially, each node can become a cluster head with a certain probability. Nodes that are elected to be cluster head in the current round cannot be cluster head in the same epoch. When cluster head selection is done another parameter threshold is taken into consideration. Each node generates a random number between 0 and 1, if generated value is less than the threshold than the node will become clusterhead. In the proposed approach, have adjusted the value of threshold for selection of the clusterhead, based on the ratio of residual energy of the node and average energy of the network and optimal number of clusters per round. So, only the node with the highest energy will become the clusterhead.

- It dynamically changes cluster head election probability.
- It improves throughput and network lifetime of the network.
- The mobile sink node and mobile sensor nodes can directly reach cluster heads and collect data from it.
- Mobile sink reduces the energy consumption arises due to routing of data to the static sink, Cluster Head or Base Station. Only sink moves to collects data from cluster head.
- The cluster head selection is based on highest residual energy. After aggregation of data, sink moves to collect data from cluster head directly whereas in static sink case, data is sent in multiple hops to sink from cluster head. Path of sink node is optimized to reach the cluster heads.
- Mobility of sink via shortest path reduces delay of data delivery. So with sink mobility scheme achieves energy optimization than without sink mobility.

1.13 CONTRIBUTION

Genetic Algorithm: The genetic algorithm[42]that is derived from the ideas of natural selection and natural genetic.It works on a population of possible solutions is being used to create the WSN. Each individual in the genetic algorithm populationrepresents a possible solution. Some individuals are selected based on the fitness value. And then, genetic algorithm imitatesthe nature genetic process, crossover, to exchange some of these individual genetic data randomly to generate the offspring.By repeating these processes until the best genes, which have the fittest capability, are obtained. Each individual may represent one or more chromosomes with an associated fitness value and population

Multiple Cluster Heads: Stability aware Enhance Threshold Sensitive Stable Election Protocol (ETSSEP) is proposed for heterogeneous wireless sensor network. It is based on dynamic changing of cluster head election probability. It selects cluster heads on the basis of residual energy level of nodes and minimum number of clusters per round. The multiple cluster association based system is contributed to the proposed ETSSEP scheme. The nodes that are neighbours of multiple clusters, divides the data and send it to multiple clusters heads.

MS (Mobile Sink): Mobile Sink [39][40]traverse through the entire WSN to collect data from the sensor nodes.The route between source and MS is though multi-hop but the path is dynamic since the MS keeps changing its position[36]. The usage of mobile sink in the wireless sensor networks reduces the energy consumption of the nodes and to prevent the formation of energy holes in wireless sensor networks The mobile sink based system is contributed to the proposed ETSSEP scheme.

CHAPTER 2

LITERATURE REVIEW

This chapter presents the literature review related to the cluster based routing in different type of routing algorithm. The review of research works that aimed to reduce the energy consumption so increase the network lifetime, throughput.

2.1 PROACTIVE V/S REACTIVE ROUTING

One of the most popular methods to distinguish ad hoc network routing protocols is based on how routing information is acquired and maintained by mobile nodes. Using this method, mobile ad hoc network routing protocols can be divided into proactive routing, reactive routing and hybrid routing.

A proactive routing protocol is also called "table driven" routing protocol. Using a proactive routing protocol, nodes in a mobile ad hoc network continuously evaluate routes to all reachable nodes and attempt to maintain consistent, up-to-date routing information. Therefore, a source node can get a routing path immediately if it needs one.

In proactive routing protocols, all nodes need to maintain a consistent view of the network topology. When a network topology change occurs, respective updates must be propagated throughout the network to notify the change. Most proactive routing protocols proposed for ad hoc networks have inherited properties from algorithms used in wired networks. To adapt to the dynamic features of ad hoc networks, necessary modifications have been made on traditional wired network routing protocols. Using proactive routing algorithms, nodes proactively update network state and maintain a route regardless of whether data traffic exists or not, the overhead to maintain up-to-date network topology information is high.

Reactive routing protocols for ad hoc networks are also called "on-demand" routing protocols. In a reactive routing protocol, routing paths are searched only when needed. A route discovery operation invokes a route-determination procedure. The discovery procedure terminates either when a route has been found or no route available after examination for all route permutations.

In a mobile ad hoc network, active routes may be disconnected due to node mobility. Therefore, route maintenance is an important operation of reactive routing protocols. Compared to the proactive routing protocols for ad hoc networks, less control overhead is a distinct advantage of the reactive routing protocols. Thus, reactive routing protocols have better scalability than proactiverouting protocols in mobile ad hoc networks. However, when using reactive routing protocols, source nodes may suffer from long delays for route searching before they can forward data packets.

2.2ENERGY EFFICIENT ROUTING PROTOCOLS FOR WSNS

Various routing protocols have been proposed over the years still there is a scope of reducing energy consumption in routing [21]. The efficiency (in terms of control overhead) of one approach over the other depends to a large extent on the relative node mobility and traffic diversity. It may be noted that individual node speeds are irrelevant unless they affect the relative node speeds because path stability is primarily determined by relative node mobility; relative node mobility can be low even when nodes individually move at high speeds as with group movement scenarios. Traffic diversity measures the traffic distribution among nodes.

2.3 HIERARCHICALPROTOCOLS

Similar to other communication networks, scalability is one of the major design attributes of sensor networks. A single-tier network can cause the gateway to overload with the increase in sensors density. Such overload might cause latency in communication and inadequate tracking of events. In addition, the single-gateway architecture is not scalable for a larger set of sensors covering a wider area of interest since the sensors are typically not capable of long-haul communication. To allow the system to cope with additional load and to be able to cover a large area of interest without degrading the service, networking clustering has been pursued in some routing approaches.

The main aim of hierarchical routing is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication within a particular cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink. LEACH [22] is one of the first hierarchical routing approaches for sensors networks. The idea proposed in LEACH has been an inspiration for many hierarchical routing protocols.

2.3.1 LEACH

Low-energy adaptive clustering hierarchy (LEACH) [22] is one of the most popular hierarchical routing algorithms for sensor networks. The idea is to form clusters of the sensor nodes based on the received signal strength and use local cluster heads as routers to the sink. This will save energy since the transmissions will only be done by such cluster heads rather than all sensor nodes. Optimal number of cluster heads is estimated to be 5% of the total number of nodes. All the data processing such as data fusion and aggregation are local to the cluster. Cluster heads change randomly over time in order to balance the energy dissipation of nodes. This decision is made by the node choosing a random number between 0 and 1. The node becomes a cluster head for the current round if the number is less than the following threshold:

$$T(n) = \begin{cases} \dfrac{p}{1 - p * \left(r \, mod \, \frac{1}{p}\right)} & where\ n \in G, \\ 0 & otherwise, \end{cases}$$

Where, p is the desired percentage of cluster heads(e.g. 0.05), r is the current round, and G is the set of nodes that have not been cluster heads in the last 1/p rounds.

LEACH achieves over a factor of 7 reduction in energy dissipation compared to direct communication and a factor of 4–8 compared to the minimum transmission energy routing protocol. The nodes die randomly and dynamic clustering increases lifetime of the system. LEACH is completely distributed and requires no global knowledge of network. However, LEACH uses single-hop routing where each node can transmit directly to the cluster-head and the sink. Therefore, it is not applicable to networks deployed in large regions. Furthermore, the idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may diminish the gain in energy consumption.

Title: *An Energy Efficient Hierarchical Clustering Algorithm for Wireless Sensor Networks*
Author: *SeemaBandyopadhyay and Edward J. Coyle*

Energy Efficient Hierarchical Clustering (EEHC) is an another clustering protocol is EEHC which divides the network into a hierarchy of layers. The operations in EEHC are classified into the initial and the extended stages. In the initial stage, the data are gathered from regular nodes by the ClusterHeads. Then, the data are aggregated and transmitted to the ClusterHeads of the next layer. The operations are recursively repeated until the data reach the base station. In order to elect the ClusterHeads, a probabilistic algorithm, based on the node density in neighbouring of the node, is served. In the algorithm each node announces itself as a Cluster head based on its probability. Then, all the nodes that have received this announcement from the node by either direct or forwarded communication join the nearest Cluster head based on the signal strength. Also, there are some nodes that receive this announcement from none of the ClusterHeads in the neighbourhood of the node and elect themselves as new ClusterHeads. The authors present some analysis on the optimal values of clustering parameters and find the best ones, resulting in reduced energy consumption.

Advantages

- It improves the network lifetime and makes large-scales WSNs more scalable because of its hierarchical architecture.
- It reduces the energy consumption

Disadvantages

- The data aggregation in multi-layered clustering might increase the delay, because the data should be stored in intermediate nodes until other data arrive and then are aggregated and transmitted to the base station.

2.3.2HYBRID ENERGY EFFICIENT DISTRIBUTED PROTOCOL FOR HETEROGENEOUS WIRELESS SENSORNETWORK

The main requirements of wireless sensor network are to prolongthe network lifetime and energy efficiency. The Heterogeneous - Hybrid Energy Efficient Distributed

ProtocolforWireless Sensor Network has been proposed toprolong the network lifetime.In all nodes are assumedto be homogenous all sensor nodes are equipped with sameinitial energy. The impact ofheterogeneity in terms of node energy. The percentage of the node population is equipped with more energythan the rest of the nodes in the same network - this is the case ofheterogeneous sensor networks. As the lifetime of sensornetworks is limited there is a need to re-energize the sensornetwork by adding more nodes. These nodes will be equippedwith more energy than the nodes that are already in use, whichcreates heterogeneity in terms of node energy, leads to theintroduction of H-HEED protocol [7].

Advantages:

- Cluster selection to achieve load balancing.
- To improves the life time.

Disadvantages:

- Some Cluster heads, mainly which are near to the sink, might die earlier because these Clusters heads have very large workload.
- HEED suffers from a consecutive burden since it needs several iterations to form the clusters. Therefore due to several iterations lot of packets are broadcasted.

Title: *Energy Efficient Scheme for Clustering Protocol Prolonging the Lifetime of Heterogeneous Wireless Sensor Networks*

Author: *ParulSaini and Ajay K Sharma*

In many routing protocols have been proposed based on heterogeneity with main research goals such as achieving the energy efficiency, lifetime, deployment of nodes, fault tolerance, latency, in short high reliability and robustness. An energy efficient cluster head scheme, for heterogeneous wireless sensor networks is proposed, by modifying the threshold value of a node based on which it decides to be a cluster head or not, called TDEEC (Threshold Distributed Energy Efficient Clustering) protocol.

Advantages

- It is to use energy of sensor nodes more efficiently by changing threshold.
- It is better performance when compared to other protocol

Disadvantages

- When all cluster head dies the network become stable (dead), therefore all sensor nodes are not utilized. Due to this the network does not work till the death of last node.

Title: *On Performance Evaluation of Variants of DEEC in WSNs*

Author: *T. N. Qureshi, N. Javaid, M. Malik, U. Qasim and Z. A. Khan*

The performance of heterogeneous WSN protocols under three and multi level heterogeneous networks. It compare performance of DEEC, DDEEC, EDEEC and TDEEC for different scenarios of three and multilevel heterogeneous WSNs. Three level heterogeneous networks contain normal, advanced and super nodes whereas super nodes have highest energy level as compared to normal and advanced nodes. It discriminate each protocol on the basis of prolonging stability period, network life time of nodes alive during rounds for numerous three level heterogeneous networks. Each containing different ratio of normal, advanced and super nodes along with the multilevel heterogeneous WSNs.

Advantages

- The performance of EDEEC and TDEEC is better in all heterogeneous scenarios that contain variable heterogeneity in terms of lifetime. In terms of stability period, TDEEC is the best among all.

Disadvantages

- EDEEC and TDEEC have large instability period. On the other hand, by changing the heterogeneity parameters of the network, the performance of DEEC and DDEEC is greatly affected.

Title: *Distributive Energy Efficient Adaptive Clustering Protocol for Wireless Sensor Networks*

Author: *UditSajjanhar and PabitraMitra*

Adapting this approach, propose a Distributive Energy Efficient Adaptive Clustering (DEEAC) protocol. This protocol is adaptive in terms of data reporting rates and residual energy of each node within the network. A modification of the LEACHs stochastic cluster-head selection algorithm by considering two additional parameters, the residual energy of a node relative to the residual energy of the network and the spatio-temporal variations in the data reporting rates of a node relative to the network. Since DEEAC evenly distributes energy-usage among the nodes in the network by efficiently adapting to the variations in the network, optimal cluster-head selection saves a large amount of communication energy of sensor nodes.

Advantages

- The main goal of this algorithm is to choose nodes with high residual energy and greater hotness values as cluster heads.
- It increases the lifetime of the system.

Disadvantages

- This scheme is that the nodes will never communicate if the thresholds are not reached, hence the user will not get any data from the network and unable to know even if all the nodes die.

Title: *Energy Level Based Stable Election Protocol in Wireless Sensor Network*

Author: *Yogesh Mishra, AshishSinghadia and RashmiPandey*

The proposed ELBSEP as a reactive network routing protocol with three different levels of node heterogeneity. ELBSEP combines the best features of TSEP and energy level estimation method. Due to the concept of energy level based cluster head selection, hard and soft threshold value, three levels of node heterogeneity and being reactive routing network protocol ELBSEP produces increase in energy efficiency, enhanced lifetime of network and maximum throughput as shown in the simulation result. This protocol perform well in small as well as large geographical networks and best suited for time critical applications.

Advantages

- ELBSEP use ratio of current residual energy to initial residual energy so it balances the energy consumption among sensor nodes and enhances the network lifetime.

Disadvantages

- ELBSEP is not suitable where frequent information is received from wireless sensor network.
- ELBSEP is that if threshold value is not reached, the base station will not receive any information or data from sensor network and even all the sensor nodes of the network become dead, system will be unknown about this limitations.

Title: *An Energy Efficient Level Based Clustering Routing Protocol For Wireless Sensor Networks*

Author: *MeenakshiDiwakar and Sushil Kumar*

The sensor nodes equipped with limited power sources. Therefore, efficiently utilizing sensor nodes energy can maintain a prolonged network lifetime. One of the major issues in sensor networks is developing an energy-efficient routing protocol to improve the lifetime of the networks. The proposed system is a EELBCRP (Energy-Efficient Level Based Clustering Routing Protocol), a protocol for wireless sensor networks. Network partitioned into annular rings by using various power levels at base station and each ring having various sensor nodes. Also consider the residual energy of each node and distance from the base station of nodes as the principle of cluster-head election. The mathematical formula for election the cluster head is provided. The results are obtained in terms of three metrics- lifetime of the network, number of clusters and energy consumption of clusters heads.

Advantages

- It provides the energy consumption of cluster heads, numbers of clusters and network lifetime.

Disadvantages

- It is does not optimize the number of levels to efficiently consume the energy of all nodes and improve the network lifetime.

Title: *Unequal Clustering Energy Efficient Stable Election Protocol in Wireless Sensor Network*

Author: *SantoshAhirwar and PushprajTanwar*

UCEESEP as a reactive routing protocol is proposed where nodes with three different levels of energies. The concept of unequal clustering is used and cluster head selection is threshold as well as energy level based, due to three levels of heterogeneity and being reactive routing network protocol, it produces increase in energy efficiency and enhanced network lifetime. In the UCEESEP protocol will perform well in small as well as large sized networks and best suited for time critical applications.

Advantages

- UCEESEP perform well in small as well as large sized networks and best suited for time critical applications.

Disadvantages

- UCEESEP is not suitable where frequent information is received from wireless sensor network.

EEHC: Energy efficient heterogeneous clustered scheme for wirelesssensor networks

The impact of heterogeneity of nodes in terms of their energy inwireless sensor networks that are hierarchically clusteredthat a percentage of the populationof sensor nodes is equipped with the additional energy resources. Assume that the sensornodes are randomly distributed and are not mobile, the coordinates of the sink and the dimensions ofthe sensor field are known. Homogeneous clustering protocols assume that all the sensor nodes areequipped with the same amount of energy and as a result, they cannot take the advantage of the presenceofnode heterogeneity. Adapting this approach, introduce an energy efficient heterogeneous clusteredscheme for wireless sensor networks based on weighted election probabilities of each node to become acluster head according to the residual energy in each node [12].

Advantages:

- To scalability and efficientcommunication.
- In order to improves the lifetime.

Disadvantages:

- The major issuesin the design of routing protocol for WSN is energy efficiency due to limited energy resources of sensors.

Energy and Throughput of Hierarchical Routing Protocol Leachand Leach-C for WSNS: A Review

As power sources have limited power supply in WSNs anddue to the importance of sensing data, it should betransmitted periodically. Itanalyzed that the performance ofLEACH-C is better than LEACH protocol due tocentralized clustering algorithm approach. According to the equal time slot and equal amountof energy dissipation for both LEACH and LEACH-Cprotocol the more amount of data is received at the basestation in case of LEACH-C protocol.LEACH is the first hierarchical cluster based routingprotocol, distributed algorithm is used to form clusters innetwork area. For each cluster there is a cluster head nodewhich is responsible for data aggregation and sends theimportant data in its TDMA-Time Division MultipleAccessto the base station, where these data needed using CDMA-Code Division Multiple Access.Few numbers of nodes become the cluster head which actas the router to the base station [11].

Advantages:

- It is scalability and very efficient communication

Disadvantages:

- The cluster head selection is randomso it does not helpin account of less energy consumption and it cannot coverthe large area.

2.4SINK NODE IN WIRELSS SENSOR NETWORK

Title:*A Review on Data Collection method with Sink Nodein Wireless Sensor Network.*
Author:*SuchitaR.Wankhadeand NekitaA.Chavhan*

This review paper first shows theWSNs with sink node and their architecture then shows the comparative study of different sensor datacollection method and sink node data collection method it then decides which technique is efficient for thedata collection from the sensor nodes.

Every node in sensor network consist of three subsystem, firstsensor subsystem which sense environment, second processing subsystem which perform localcomputation on sensed data and third communication subsystem which is responsible for messageexchange.

Advantages:

- Sink node mobility.

Disadvantage:

- Sink node failure while data transmission.

Title:*Energy Efficient Multiple Mobile Sink and Interference Aware Path Selection in Wireless Sensor Networks*

Author :*P.Kanagara, T.Sasi*

They presented a paper on A WSN composed of a large number of sensor nodes deployed in a field. But the energy efficiency is an important problem. The usage of mobile sink in the wireless sensor networks reduces the energy consumption of the nodes and to prevent the formation of energy holes in wireless sensor networks. But in order to reduce the delay in some of the applications, in the existing method form a hybrid moving pattern is formed in which a mobile-sink node only visits rendezvous points (RPs), as opposed to all nodes. To address this problem, a heuristic called weighted rendezvous planning (WRP) is suggested whereby each sensor node is assigned a weight corresponding to its hop distance from the tour and the number of data packets that it forwards to the closest RP. But due to the single mobile the deadline of the packet is missed.

Advantages:

- The proposed method an innovative technique is introduced which is called Energy efficient Multiple Mobile Sink and Interference-Aware Path Selection (EEMMS-IPS) for placing multiple mobile sinks and reducing interference.

Disadvantage:

- Rendezvous points can leave some important sensor node's data.

Title:*Cluster Based Energy Efficient Sensory Data Collection With Mobile Sink*

Author :*G.Sunil and Mrs. D. Jasmine David*.

When a cluster node fails because of energy depletion we need to choose alternative cluster for that particular region. In periodical time each sensor node in the cluster should possess the next cluster head re-election based on energy to avoid node failure .The important factor of the network lifetime, most of the sensor nodes are present in an isolated urban fields to sensing the data in particular area.

Advantages:

- This paper addresses the problems of cluster node failure.

Disadvantage:

- There is no fixed probability of CH failure.

Title: *Flooding-limited and multi-constrained QoS multicast routing based on the genetic algorithm for MANETs*

Author: Yun-Sheng Yen Han-Chieh Chao, Ruay-Shiung Chang, AthanasiosVasilakos

This paper proposes a multi-constrained QoS multicast routing method using the genetic algorithm. The proposal will be flooding-limited using the available resources and minimum computation time in a dynamic environment.

Advantages:

- By selecting the appropriate values for parameters such as crossover, mutation, and population size, the genetic algorithm improves and tries to optimize the routes.

Disadvantages:

- Not efficient in network fluctuations and failures.

CHAPTER **3**

PROPOSED WORK

3.1 PROPOSED SYSTEM

The nodes are created using Genetic Algorithm[42]. In the proposed ETSSEP protocol, the sensor nodes are assumed to be static. The base station or sink is of high configuration, that contains high energy, enough memory and is deployed in a controllable place outside the network region. It is also assumed that all sensor nodes are capable of data aggregation, computing their own residual energy and finding their geographical location.

In the Wireless Sensor Network sensor nodes are deployed very densely. Thus many nodes of a small region can sense the same event and might want to send that redundant data through multiple paths [4], which leads to wastage of energy as well as congestion in the network that problem can be solved by grouping the nodes in a nearby location, called cluster and make a head node, called cluster head, among those nodes in that location. The cluster head node performs data accumulation and elimination of redundant data, sensed by the associate nodes and also transmits the aggregated data to the sink. The formation of clusters is initiated by the occurrence of events and the cluster head selection process is based on certain parameters like residual energy and the number of neighbouring nodes. This is followed by sensing of data, data aggregation by the selected cluster head and forwarding of the data to the sink following an energy efficient path.

3.2 ASSUMPTIONS

- All the SNs are time synchronized with respect to sink.
- All SNs are uniformly distributed within the sensor area.
- Each SN may have different energy level.
- Every SNoverhearsthe packets transmitted by the other nodes within a cluster.
- Sink node is static in nature and is placed in the centre of the sensor area.
- We start working with the environment in which all the node have same level of energy.
- After some time some of the nodes of the network have dissipated its energy and network automatically became the heterogeneous in nature.

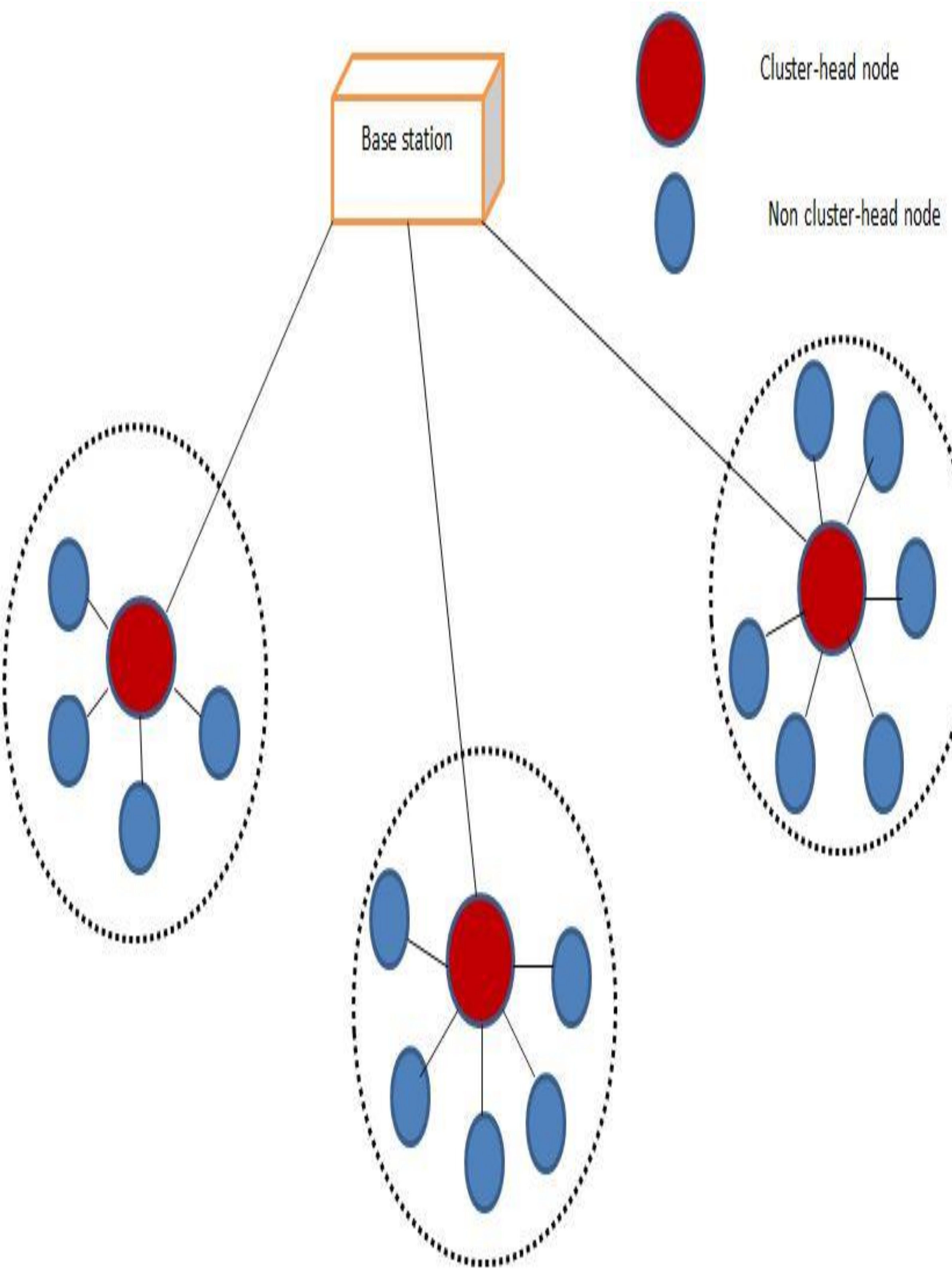

Fig3.1: Architecture of cluster based network

3.3

Our proposed enhanced threshold sensitive stable election protocol(proposed ETSSEP), has been designed to reduce energy consumption of SNs by reducingthe transmission of sensed data within a cluster using multiple cluster association. There are four phases in ourproposed scheme namely cluster formation, measurement of total energy using ETSSEP protocol,cluster head selection based on highest residual energy, Data Transmission to Cluster head.

3.3.1 CLUSTER FORMATION PHASE

Clusters are formed based on communication range, network width and height. Each node computes its cluster ID.For three level of heterogeneity nodes with energy levels are advance nodes, intermediate nodes and normal nodes.The energy of advance nodes are greater than all other nodes and a fraction of nodes which have more energy than normal node and less energy than advance nodes are called intermediate nodes, while rest of the nodes are called normal nodes.

3.3.2 MEASUREMENT OF TOTAL ENERGY USING ETSSEP

ETSSEP is a cluster based reactive routing protocol with three level of heterogeneity. For three levels of heterogeneity, nodes with different energy levels are: advance nodes, intermediate nodes and normal nodes. The energy of advance nodes are greater than all other nodes and a fraction of nodes which have more energy than normal node and less energy than advance nodes are called intermediate nodes, while rest of the nodes are called normal nodes.

Intermediate nodes have β times more energy than normal nodes, advance nodes have α times more energy than normal nodes.

Assume that $\beta = \alpha/2$. In ETSSEP the total energy distributed over different types of nodes is computed as:

$E_{adv} = n.m(1+\alpha)$

$E_{int} = n.b(1+\beta)E_0$

$E_{nrm} = n(1-m-b)E_0$

Then total Energy of the network

$E_{total} = E_{adv} + E_{int} + E_{nrm}$

$= n.m(1+\alpha)E_0 + n.b(1+\beta)E_0 + n(1-m-b)E_0$

$= n(1+m\alpha+b\beta)E_0$

Where,

m and b denotes the advance nodes and intermediate nodes fraction of total number of nodes n.

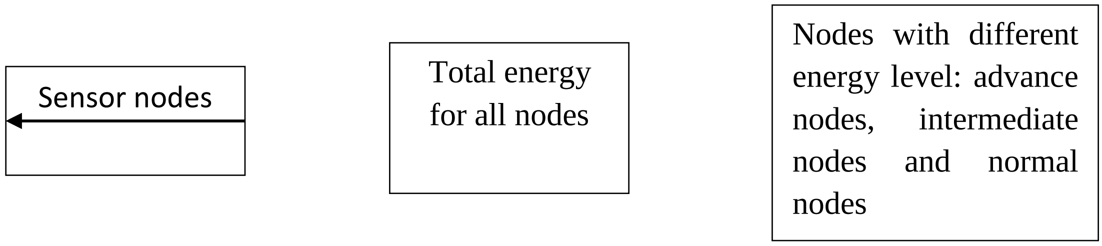

Fig 3.2: Total energy calculation model for ETSSEP

3.3.3 CLUSTER HEAD SELECTIONPHASE

The next phase of cluster head selection. In each round, the nodes of a cluster compete to become the cluster head. If the residual energy of node is greater than the threshold value then it becomes a candidate node of cluster head selection process. Threshold value can be defined as the minimum energy required in receiving data from all nodes, aggregating them, and sending that to a neighbour node. Every candidate node will calculate the competition bid for becoming a cluster head for itself.

In ETSSEP, the calculated probability depends on the residual energy of node and average energy of the network at round r. The average energy of network at round r is estimated as:

$$E(r) = \frac{1}{N} E_{total} (1 - \frac{r}{R})$$

Where,

r is the current round

N is total number of nodes

E_{total} is total initial energy of the heterogeneous network

R denotes the total rounds of the network calculated as:

$$R = \frac{E_{total}}{E_{round}}$$

The energy dissipated in the network in a particular round is denoted as E_{round}. So, the energy dissipated in current round is calculated as:

$$E_{round} = K(2NE_{elec} + NE_{DA} + kE_{amp}d_{toBS}^4 + NE_{fs}d_{toCH}^2$$

In the above equation, k is no of clusters, K is size of data in bits, E_{DA} is energy dissipation in data aggregation, D_{toBS} is the average distance between the cluster head and the base station, d_{toCH} is the average distance between the cluster nodes and the cluster head.

And E_{elec} is the energy dissipation per bit to run the transmitter or receiver, E_{fs} and E_{amp} is the energy dissipation in free space and multipath fading channel radio model respectively.

Now we have,

$d_{toBS}=0.765\frac{M}{2}$, $d_{toCH}=\frac{M}{\sqrt{2\pi k}}$

where M is dimension of the region M x M.

and optimal no cluster is calculated by using this formula:

$$K_{opt} = \frac{M}{d_{toBS}^2}\frac{\sqrt{N}}{\sqrt{2\pi}}\frac{\sqrt{E_{fs}}}{\sqrt{E_{amp}}}$$

3.3.4RADIO DISSIPATION MODEL:

Over the few last decades, energy conservation has been a major objective for WSN. Life of a wireless sensor depends on its battery life time. We use radio energy model is based on [15, 16] according to radio energy dissipation model illustrated in Fig.3.1, the energy expanded by transmitting K bit message over a distance d is given by:

$$E_{Tx}(K,d) = \begin{cases} K.E_{elec} + K.E_{fs} * d^2 & if\ d < d_0 \\ K.E_{elec} + K.E_{amp} * d^4 & if\ d \geq d_0 \end{cases}$$

Where E_{elec} is the energy dissipated per bit to run the transmitter or the receiver and d0 denotes the threshold distance and calculated as:

$$d_0 = \sqrt{\frac{E_{fs}}{E_{amp}}}$$

There are two different radio models which are used: the free space model (E_{fs})andthemultipath fading channel model (E_{amp}). The distance between the transmitter and receiveris d. If d is less than d_0, free space model is used; otherwise multipath fading channel isused. E_{Rx} is the energy dissipated for receiving K bits and calculated as:

$$E_{Rx}(K) = K.E_{elec}$$

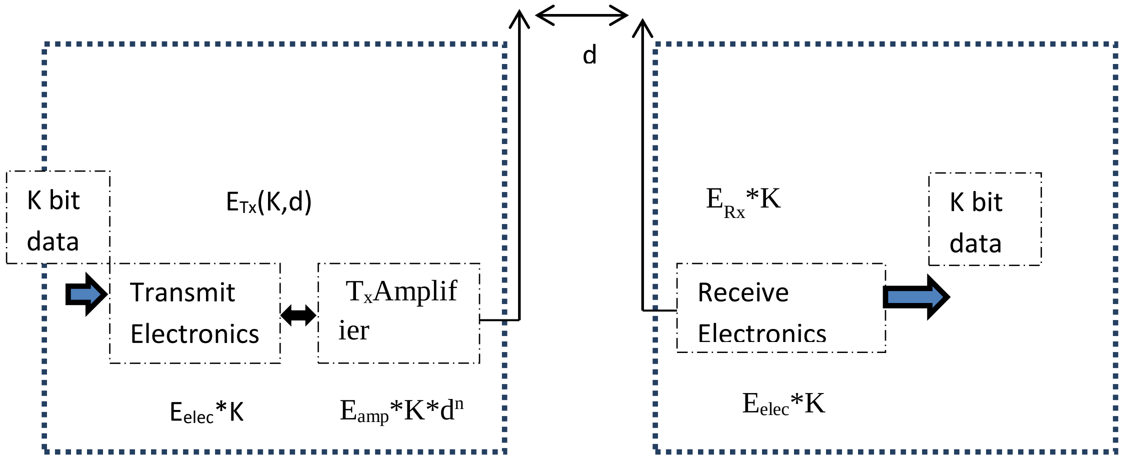

Fig.3.3: Energy dissipation model

The cluster head is elected by checking the probability of each node. The probabilities of different types of nodes for electing a cluster head in case of three level of heterogeneity are:

$$P_{int} = \frac{P_{opt}}{1 + m.\alpha + m.\beta}$$

$$P_{int} = \frac{P_{opt}(1 + \beta)}{1 + m.\alpha + m.\beta}$$

$$P_{adv} = \frac{P_{opt}(1 + \alpha)}{1 + m.\alpha + m.\beta}$$

Where,

m is the proportion of advance nodes to the total number of nodes n, b is the proportion of intermediate nodes of the total no of nodes n.

Initially, each node can become a cluster head with a certain probability. Nodes that are elected to be cluster head in the current round cannot be cluster head in the same epoch.

When cluster head selection is done another parameter threshold is taken into consideration. Each node generates a random number between 0 and 1, if generated value is less than the threshold than the node will become cluster head. In the proposed approach, have adjusted the value of threshold for selection of the cluster head, based on the ratio of residual energy of the node and average energy of the network and optimal number of clusters per round. So, only the node with the highest energy will become the cluster head.

The threshold is set as different types of nodes:

$$T(s) = \begin{cases} \frac{\mathrm{P}}{1 - \mathrm{P}\left(\mathrm{r} \mod \frac{1}{\mathrm{P}}\right)} * \frac{\text{Residual enegry of the node}}{\text{Average enegry of the network} * \mathrm{K_{opt}}} & \text{if } s \epsilon G \\ 0 & \text{otherwise} \end{cases}$$

$$T(s_{nrm}) = \begin{cases} \frac{\mathrm{P_{nrm}}}{1 - \mathrm{P_{nrm}}\left(\mathrm{r} \mod \frac{1}{\mathrm{P_{nrm}}}\right)} * \frac{\mathrm{E_r}}{\mathrm{E_{an}} * \mathrm{K_{opt}}} & \text{if } \mathrm{n_{nrm}} \epsilon G' \\ 0 & \text{otherwise} \end{cases}$$

$$T(n_{int}) = \begin{cases} \frac{\mathrm{P_{int}}}{1 - \mathrm{P_{int}}\left(\mathrm{r} \mod \frac{1}{\mathrm{P_{int}}}\right)} * \frac{\mathrm{E_r}}{\mathrm{E_{ai}} * \mathrm{K_{opt}}} & \text{if } \mathrm{n_{int}} \epsilon G'' \\ 0 & \text{otherwise} \end{cases}$$

$$T(s_{adv}) = \begin{cases} \frac{\mathrm{P_{adv}}}{1 - \mathrm{P_{adv}}\left(\mathrm{r} \mod \frac{1}{\mathrm{P_{adv}}}\right)} * \frac{\mathrm{E_r}}{\mathrm{E_{aa}} * \mathrm{K_{opt}}} & \text{if } \mathrm{n_{adv}} \epsilon G''' \\ 0 & \text{otherwise} \end{cases}$$

Where, G', G'' and G''' are the set of normal, intermediate and advance nodes. T_{nrm}, T_{int} and T_{adv} are the threshold applied to the population of normal nodes, intermediate nodes and advance nodes. Er is the residual energy of any node E_{an}, E_{ai} and E_{aa} is the average energy of normal node, intermediate node and advance node. K_{opt} is the optimal number of clusters per round. The cluster head is elected; it broadcasts advertisement to the nodes to form a cluster. After cluster formation, the sensor nodes in the cluster send their sensed value to the cluster head during their time slots. The cluster head receives all the data from sensor nodes and aggregate it before transmitting to the base station.

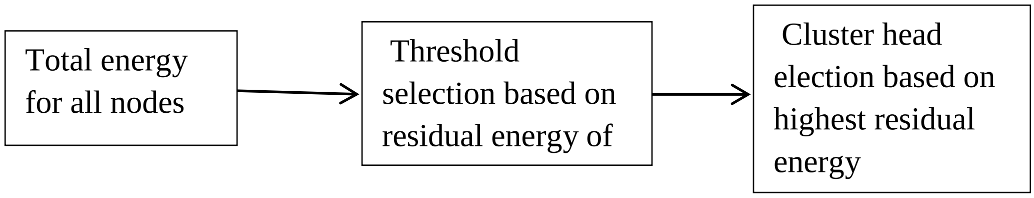

Fig 3.4: Cluster head election based on highest residual energy

3.3.5 MULTIPLE CLUSTER HEAD BASED DATA TRANSMISSION:

A node receives CH advertisement message from multiple clusterheads.It joins to the one which is closer to it and send join request message to the corresponding clusterhead(250 metres in our simulation). But data transmission is carried out with other Cluster Heads also based on degree of dependence.Cluster member sends data to cluster head based on dependency degree.

Dependency Degree = (Total distance from all the cluster head - Distance to each neighbor clusterhead) / Total distance all neighbor clusterhead.

Total packets are split and sent according to the percentage of dependency degree. While multiple cluster association maintains the balance energy consumption, so network life time is improved.

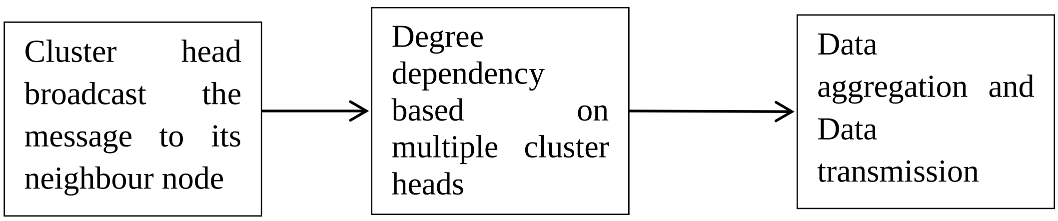

Fig 3.5: Data aggregation and transmission with Multiple cluster Association model

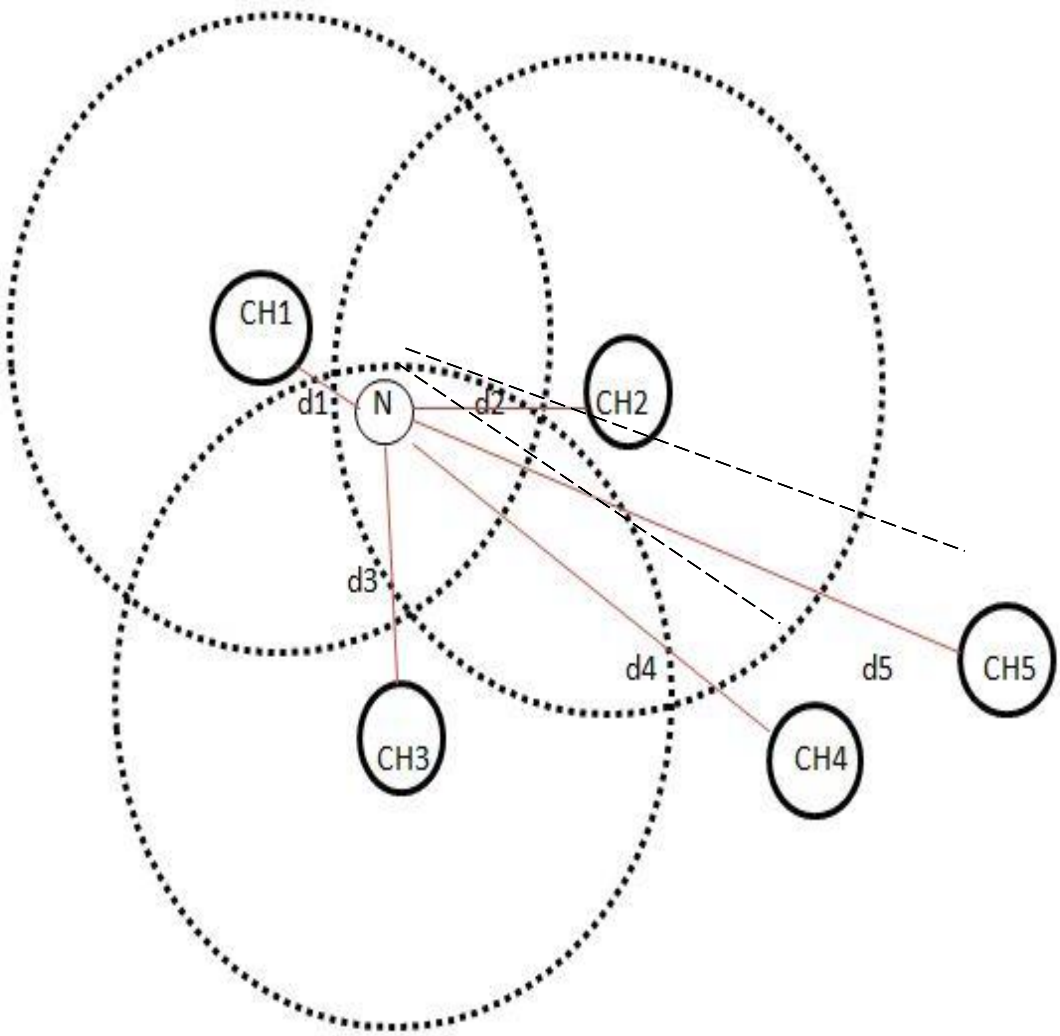

Figure 3.6: Degree of dependency based cluster head joining

Example:

In figure 3.4, Now if we calculate the dependency degree of the common node with the help of dependency formula then:

Dependency degree of common node from $dd_{CH1} = \frac{(d1+d2+d3+d4+d5)-d1}{(d1+d2+d3)}$

Similarly dependency degree from $dd////_{CH2} = \frac{(d1+d2+d3+d4+d5)-d2}{(d1+d2+d3)}$

And from $dd_{CH3}=\frac{(d1+d2+d3+d4+d5)-d3}{(d1+d2+d3)}$

If we consider that d3>d2>d1.

Then dependency degree of node from $dd_{CH1}>dd_{CH2}>dd_{CH3}$.

3.3.6 MOBILE SINK DATA GATHERING

Using mobile sinks, sensors could communicate with a sink when it gets closer, thus using shorter hop-by-hop data delivery paths. Mobile sinks can also change their location when the nearby sensors' energy becomes low. In this way, the set of sensors located near sinks change over time, the energy consumption is balanced, and the network lifetime is prolonged.
A sink node[37] has more resources in terms of power, computation, and mobility. Sometimes sensor nodes are grouped in clusters using various mechanisms and one of the sensors is selected as cluster head based on various criteria[41]. A cluster head manages the sensors in its cluster, gathers information from them, and forwards data to/from the sink[38]. The main objective of these algorithms is to design mechanisms that prolong network lifetime by employing mobile sinks to gather information from the sensors.

3.4BLOCK DIAGRAMOF PROPOSED WORK

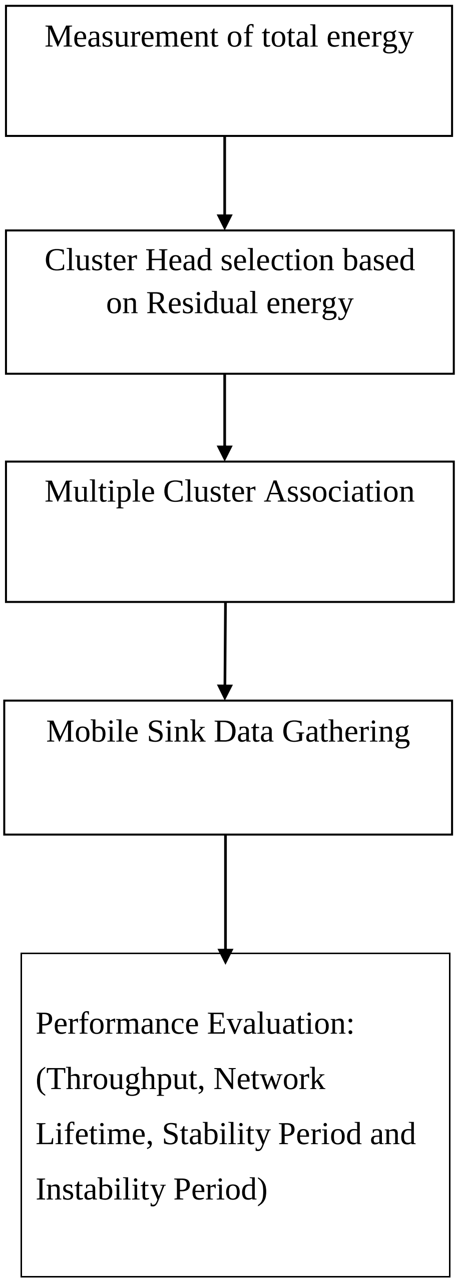

Fig 3.7: Block Diagram

3.5CASE STUDY:

3.5.1 SENSOR NODE DISTRIBUTION

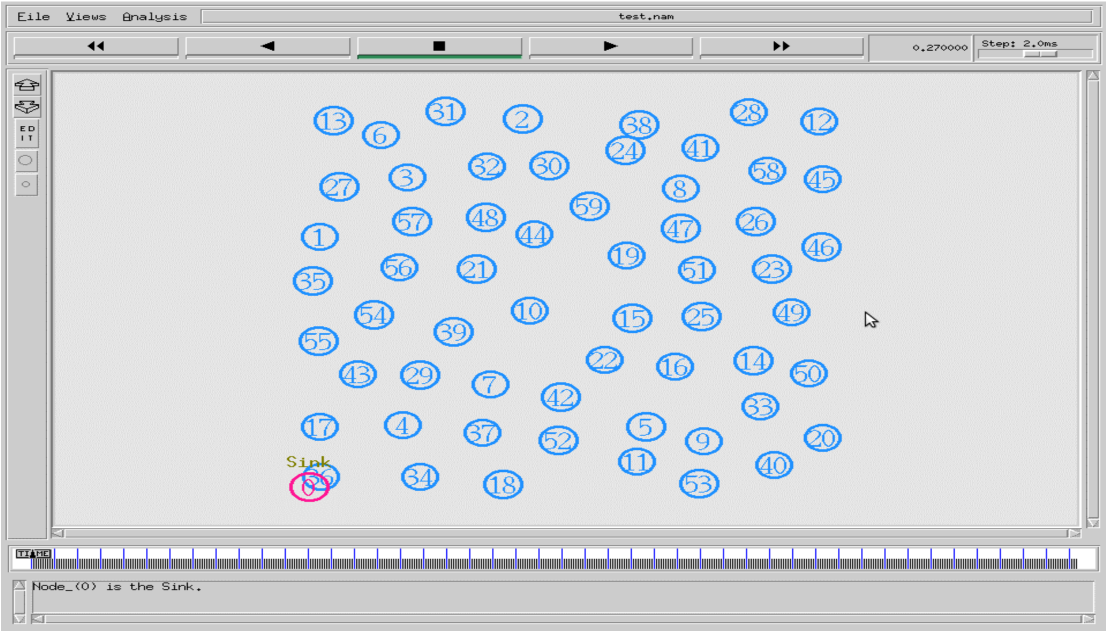

Fig 3.8: Sensor node distribution in the network

A network with 50 nodes is considered, and we assume here that node 0 as the base station and all other nodes as the common nodes. We initially consider that all the node in the network have same level of energy and after some time of simulation some of the nodes of the network lost its energy in dissipation and network automatically become the heterogeneous in nature.

3.5.2 CLUSTER FORMATION

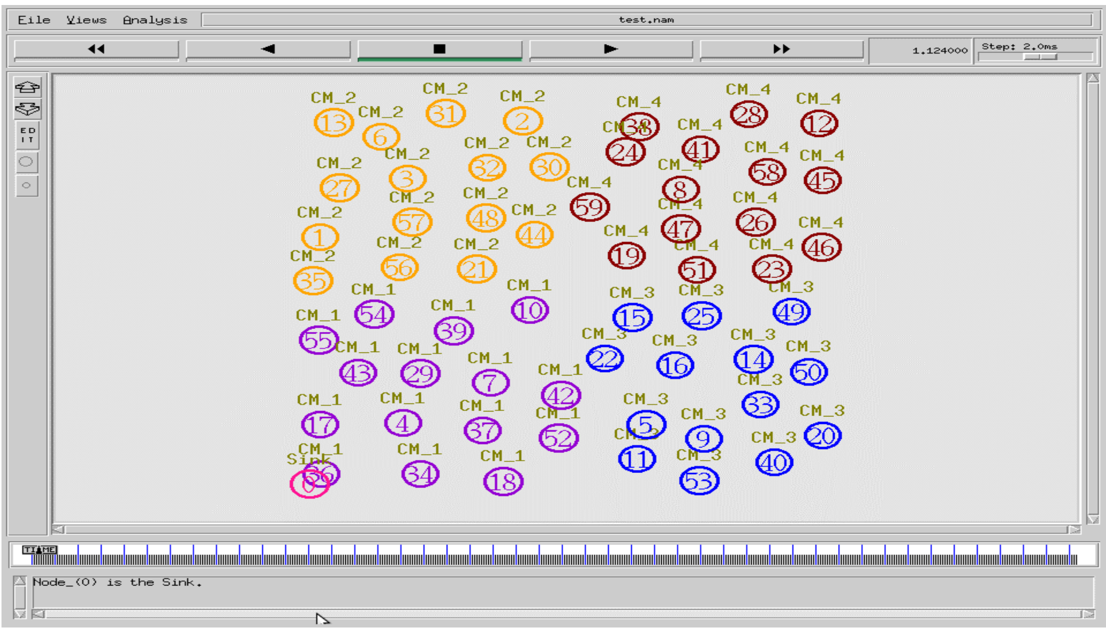

Fig 3.9: Cluster formation in the network

In the particular this network all the nodes divide itself in the 4 clusters based on communication range, network width and height.Clusters are formed based on communication range, network width and height.Each node computes its cluster ID

Result:

First Cluster Member

cluster_ID(1-1)=4,cluster_ID(1-2)=7,cluster_ID(1-3)=10,cluster_ID(1-4)=17

cluster_ID(1-5)=18,cluster_ID(1-6)=29,cluster_ID(1-7)=34,cluster_ID(1-8)=36

cluster_ID(1-9)=37,cluster_ID(1-10)=39,cluster_ID(1-11)=42,cluster_ID(1-12)=43,

cluster_ID(1-13)=52,cluster_ID(1-14)=54,cluster_ID(1-15)=55

Second Cluster Member

cluster_ID(2-1)=1,cluster_ID(2-2)=2,cluster_ID(2-3)=3,cluster_ID(2-4)=6,

cluster_ID(2-5)=13,cluster_ID(2-6)=21,cluster_ID(2-7)=27,cluster_ID(2-8)=30,

cluster_ID(2-9)=31,cluster_ID(2-10)=32,cluster_ID(2-11)=35,cluster_ID(2-12)=44,

cluster_ID(2-13)=48,cluster_ID(2-14)=56,cluster_ID(2-15)=57

Third Cluster Member

cluster_ID(3-1)=5,cluster_ID(3-2)=9,cluster_ID(3-3)=11,cluster_ID(3-4)=14,cluster_ID(3-5)=15,

cluster_ID(3-6)=16,cluster_ID(3-7)=20,cluster_ID(3-8)=22,cluster_ID(3-9)=25,cluster_ID(3-10)=33

cluster_ID(3-11)=40,cluster_ID(3-12)=49,cluster_ID(3-13)=50,cluster_ID(3-14)=53

Fourth Cluster Member

cluster_ID(4-1)=8,cluster_ID(4-2)=12,cluster_ID(4-3)=19,cluster_ID(4-4)=23,cluster_ID(4-5)=24 cluster_ID(4-6)=26,cluster_ID(4-7)=28,cluster_ID(4-8)=38,cluster_ID(4-9)=41,cluster_ID(4-10)=45,

cluster_ID(4-11)=46,cluster_ID(4-12)=47,cluster_ID(4-13)=51,cluster_ID(4-14)=58,

cluster_ID(4-15)=59

3.5.3 ENERGY BASED NODE HETEROGENEITY

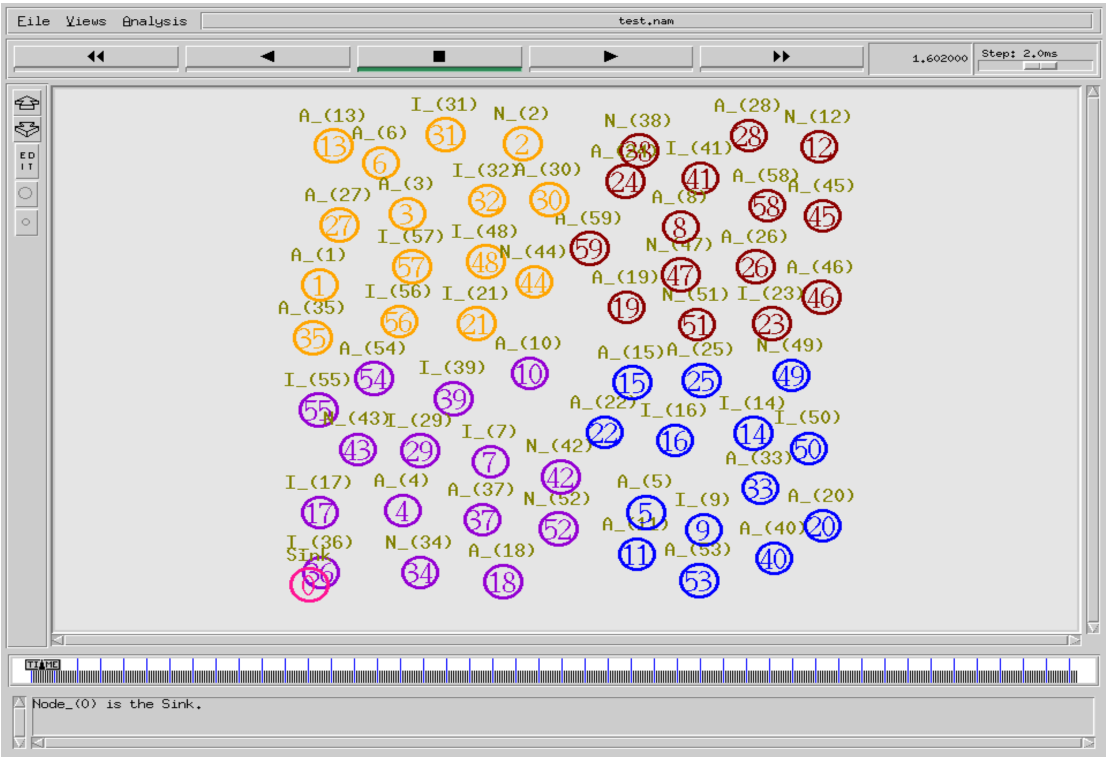

Fig 3.10: Energy based heterogeneity

For three level of heterogeneity nodes with energy levels are advance nodes, intermediate nodes and normal nodes.

The energy of advance nodes are greater than all other nodes and a fraction of nodes which have more energy than normal node and less energy than advance nodes are called intermediate nodes, while rest of the nodes are called normal nodes.

Result

NORMAL NODES ARE:

Normal Nodes(1) = 2,Normal Nodes (2) = 12,Normal Nodes (3) = 34,Normal Nodes (4) = 38

Normal Nodes (5) = 42,Normal Nodes (6) = 43,Normal Nodes(7) = 44,Normal Nodes (8) = 47,

Normal Nodes(9) = 49,Normal Nodes (10) = 51,Normal Nodes (11) = 52

INTERMEDIATE NODES ARE:

Intermediate Nodes (1) = 7,Intermediate Nodes (2) = 9,Intermediate Nodes (3) = 14,

Intermediate Nodes (4) = 16,Intermediate Nodes (5) = 17,Intermediate Nodes (6) = 21

Intermediate Nodes (7) = 23,Intermediate Nodes (8) = 29,Intermediate Nodes (9) = 31

Intermediate Nodes (10) = 32,Intermediate Nodes (11) = 36,Intermediate Nodes (12) = 39

Intermediate Nodes (13) = 41,Intermediate Nodes (14) = 48,Intermediate Nodes (15) = 50

Intermediate Nodes (16) = 55,Intermediate Nodes (17) = 56,Intermediate Nodes (18) = 57

ADVANCED NODES ARE:

Advance Nodes (1) = 1,Advance Nodes (2) = 3,Advance Nodes (3) = 4

Advance Nodes (4) = 5,Advance Nodes (5) = 6,Advance Nodes (6) = 8

Advance Nodes (7) = 10,Advance Nodes (8) = 11,Advance Nodes (9) = 13

Advance Nodes (10) = 15,Advance Nodes (11) = 18,Advance Nodes (12) = 19

Advance Nodes (13) = 20,Advance Nodes (14) = 22,Advance Nodes (15) = 24

Advance Nodes (16) = 25,Advance Nodes (17) = 26,Advance Nodes (18) = 27

Advance Nodes (19) = 28,Advance Nodes (20) = 30,Advance Nodes (21) = 33

Advance Nodes (22) = 35,Advance Nodes (23) = 37,Advance Nodes (24) = 40

Advance Nodes (25) = 45,Advance Nodes (26) = 46,Advance Nodes (27) = 53

Advance Nodes (28) = 54,Advance Nodes (29) = 58,Advance Nodes (30) = 59

3.5.4 CLUSTER HEAD SELETION BASED ON HIGHEST RESIDUAL ENERGY

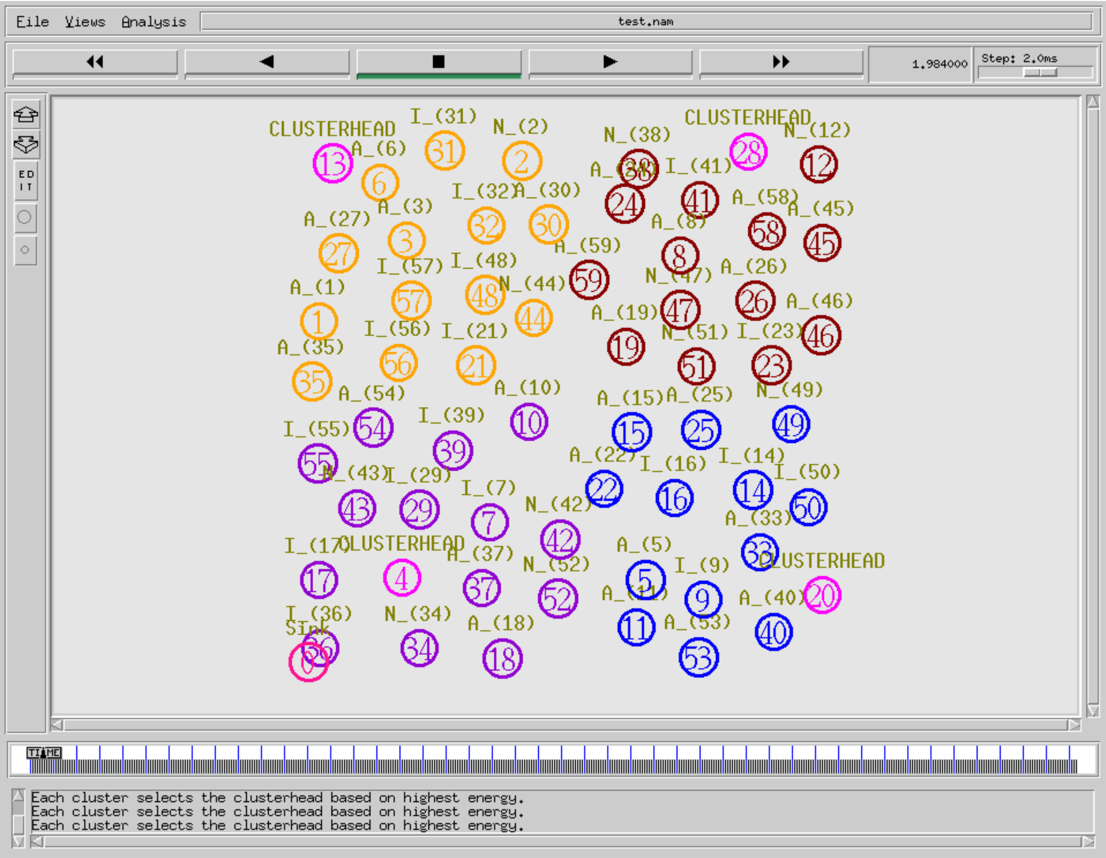

Fig 3.11: Cluster head Selection based on Highest Residual Energy

Each cluster selects the cluster head based on highest residual energy

Result

Alpha 0.5

Beta 0.25

m value = advance node count / total number of nodes

b value = intermediate nodes count / total number of nodes

Probability calculation

Probability of Normal nodes(Pnrm) = 0.075471698113207558

Probability of intermediate nodes(Pint) = 0.094339622641509441

Probability of advance nodes(Padv) = 0.11320754716981134

Residual Energy of Advance Nodes

Residual Energy of Advance node(1) = 0.627350

Residual Energy of Advance node(3) = 0.943783

Residual Energy of Advance node(4) = 0.959768

Residual Energy of Advance node(5) = 0.820110

Residual Energy of Advance node(6) = 0.786538

Residual Energy of Advance node(8) = 0.713844

Residual Energy of Advance node(10) = 0.868427

Residual Energy of Advance node(11) = 0.845641

Residual Energy of Advance node(13) = 0.984300

Residual Energy of Advance node(15) = 0.608564

Residual Energy of Advance node(18) = 0.791689

Residual Energy of Advance node(19) = 0.716688

Residual Energy of Advance node(20) = 0.974457

Residual Energy of Advance node(22) = 0.623649

Residual Energy of Advance node(24) = 0.944813

Residual Energy of Advance node(25) = 0.667846

Residual Energy of Advance node(26) = 0.890891

Residual Energy of Advance node(27) = 0.801415

Residual Energy of Advance node(28) = 0.986501

Residual Energy of Advance node(30) = 0.774583

Residual Energy of Advance node(33) = 0.931362

Residual Energy of Advance node(35) = 0.648544

Residual Energy of Advance node(37) = 0.646819

Residual Energy of Advance node(40) = 0.931850

Residual Energy of Advance node(45) = 0.917214

Residual Energy of Advance node(46) = 0.815413

Residual Energy of Advance node(53) = 0.703584

Residual Energy of Advance node(54) = 0.740501

Residual Energy of Advance node(58) = 0.798600

Residual Energy of Advance node(59) = 0.866582

Average Energy Calculation

Average Energy of Normal Nodes = 0.25006654545454543

Average Energy of Intermediate Nodes = 0.475651944444444436

Average Energy of Advance Nodes = 0.28539116666666664

Cluster head Selection

In Cluster Area 1

Advance Node Count (1-1) = 4

Advance Node Count (1-2) = 10

Advance Node Count (1-3) = 18

Advance Node Count (1-4) = 37

Advance Node Count (1-5) = 54

Swapping of Advance node(1-1) = 4

Swapping of Advance node(1-2) = 10

Swapping of Advance node(1-3) = 18

Swapping of Advance node(1-4) = 54

Swapping of Advance node(1-5) = 37

Advance node Cluster head(1) =4

In Cluster Area 2

Advance Node Count (2-1) = 1

Advance Node Count (2-2) = 3

Advance Node Count (2-3) = 6

Advance Node Count (2-4) = 13

Advance Node Count (2-5) = 27

Advance Node Count (2-6) = 30

Advance Node Count (2-7) = 35

Swapping of Advance node(2-1) = 13

Swapping of Advance node(2-2) = 3

Swapping of Advance node(2-3) = 27

Swapping of Advance node(2-4) = 6

Swapping of Advance node(2-5) = 30

Swapping of Advance node(2-6) = 35

Swapping of Advance node(2-7) = 1

Advance node Clusterhead(2) =13

In Cluster Area 3

Advance Node Count (3-1) = 5

Advance Node Count (3-2) = 11

Advance Node Count (3-3) = 15

Advance Node Count (3-4) = 20

Advance Node Count (3-5) = 22

Advance Node Count (3-6) = 25

Advance Node Count (3-7) = 33

Advance Node Count (3-8) = 40

Advance Node Count (3-9) = 53

Swapping of Advance node(3-1) = 20

Swapping of Advance node(3-2) = 40

Swapping of Advance node(3-3) = 33

Swapping of Advance node(3-4) = 11

Swapping of Advance node(3-5) = 5

Swapping of Advance node(3-6) = 53

Swapping of Advance node(3-7) = 25

Swapping of Advance node(3-8) = 22

Swapping of Advance node(3-9) = 15

Advance node Clusterhead(3) =20

In Cluster Area 4

Advance Node Count (4-1) = 8

Advance Node Count (4-2) = 19

Advance Node Count (4-3) = 24

Advance Node Count (4-4) = 26

Advance Node Count (4-5) = 28

Advance Node Count (4-6) = 45

Advance Node Count (4-7) = 46

Advance Node Count (4-8) = 58

Advance Node Count (4-9) = 59

Swapping of Advance node(4-1) = 28

Swapping of Advance node(4-2) = 24

Swapping of Advance node(4-3) = 45

Swapping of Advance node(4-4) = 26

Swapping of Advance node(4-5) = 59

Swapping of Advance node(4-6) = 46

Swapping of Advance node(4-7) = 58

Swapping of Advance node(4-8) = 19

Swapping of Advance node(4-9) = 8

Advance node Clusterhead(4) =28

CLUSTERHEAD(1)=4,CLUSTERHEAD(2)=13,CLUSTERHEAD(3)=20

CLUSTERHEAD(4)=28

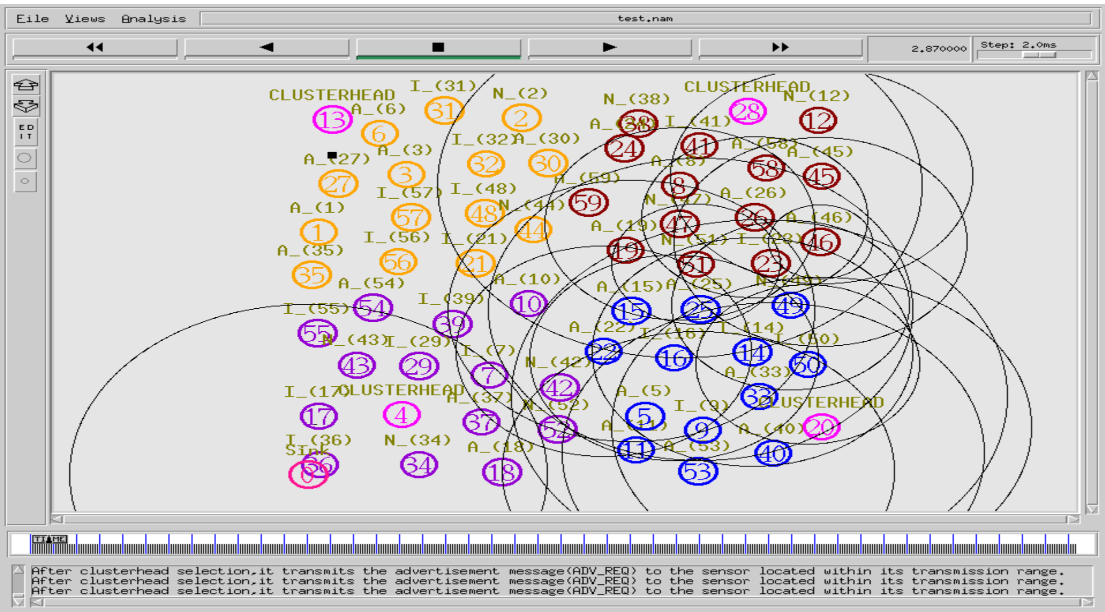

Figure 3.12: Message transmission after CH selection within its transmission range

After cluster head selection, it transmits the advertisement message to the sensor located within its transmission range.

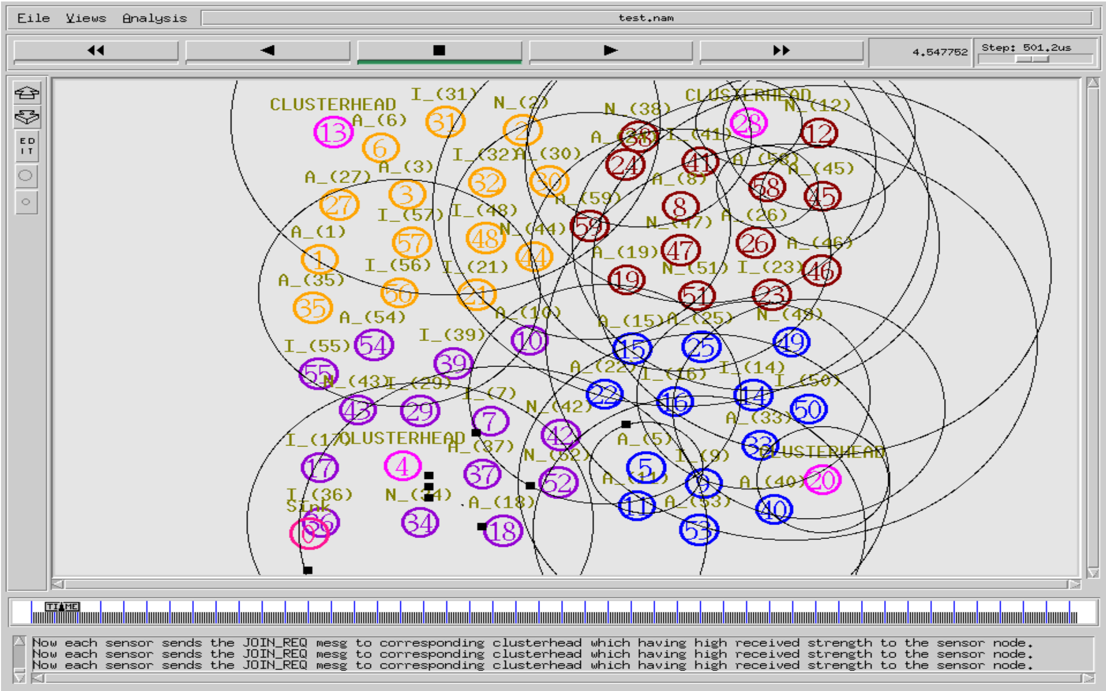

Figure 3.13: Sending Join request to CH of High Strength

Each cluster member send join request message to corresponding cluster head from which it received the signal with high strength.

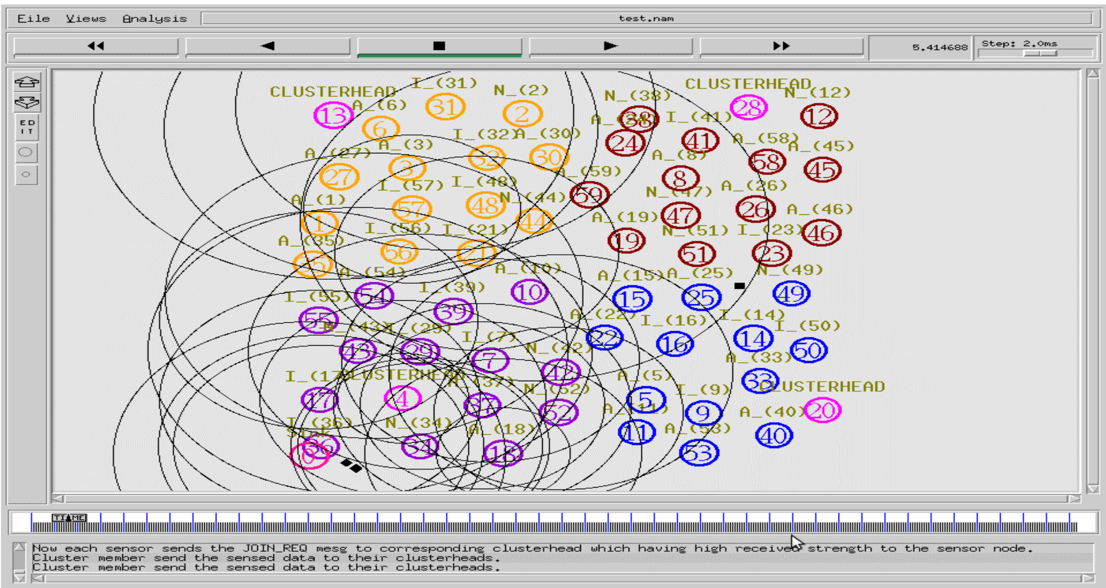

Figure 3.14: Data Transmission to CH of High Strength

Cluster member sends the sensed data to their clusterhead. Then cluster head aggregates all sensed data and waits to send it to sink.

3.5.5Data Gathering with Sink Mobility

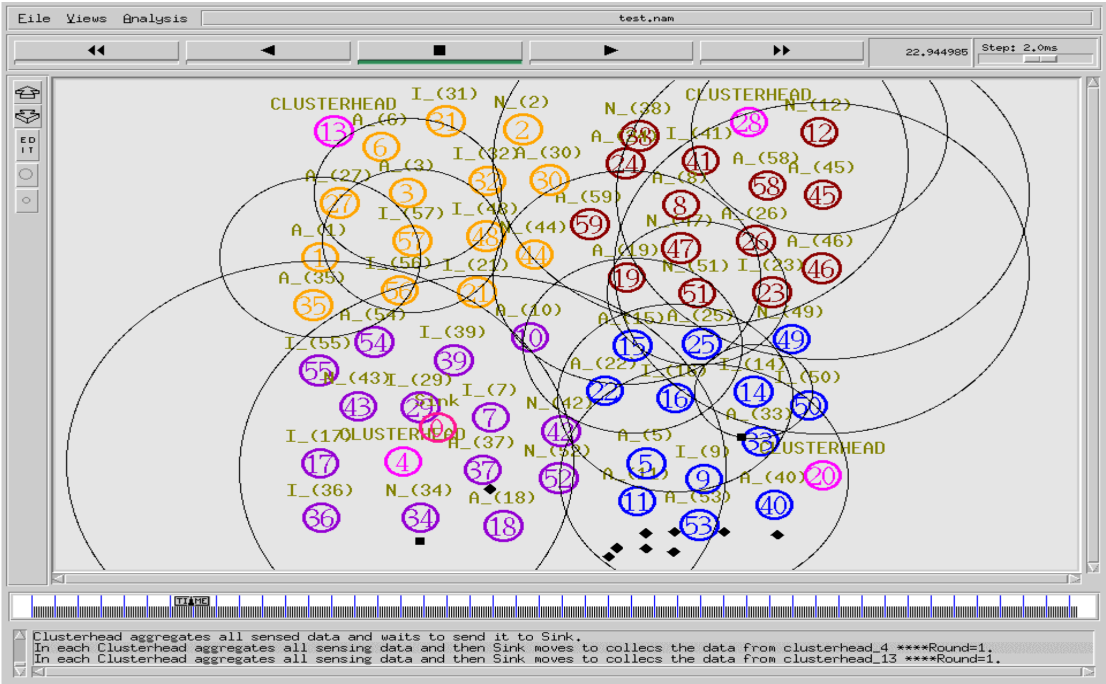

Figure 3.15: Data Gathering with Sink Mobility

Sink travel via optimal path and collects data. Once the mobile sink arrives at the clusterhead, it collects data from sensor nodes via the clusterhead.

Sink moves to collects data from cluster head 4.

Sink moves to collects data from cluster head 13.

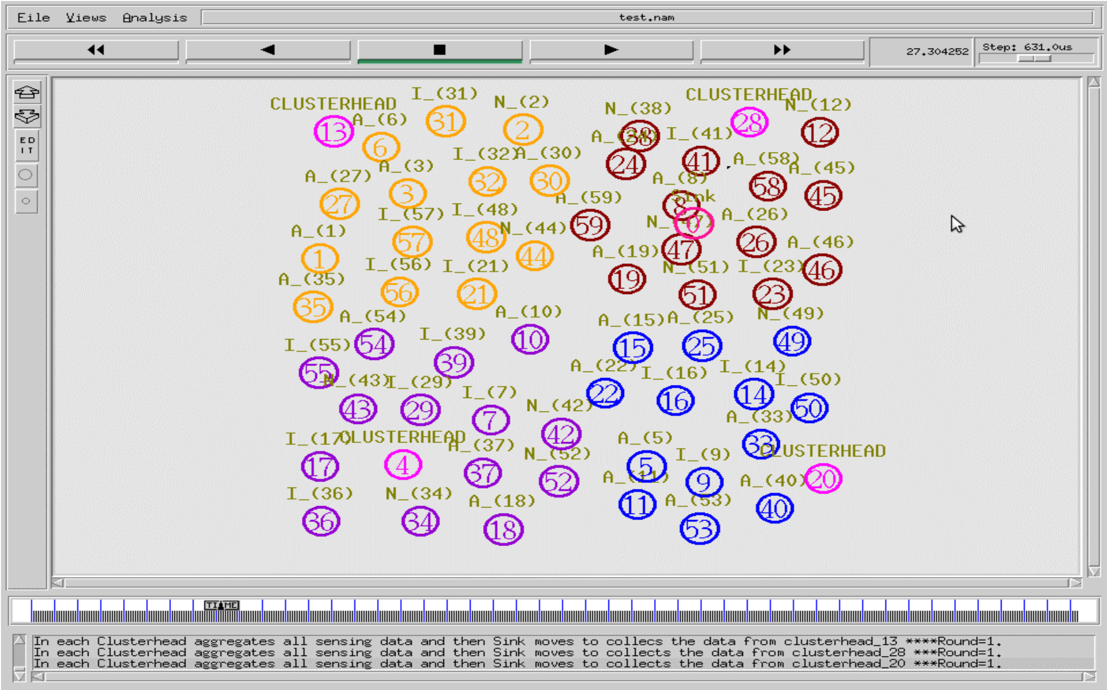

Figure 3.16 Sink moves to collects data from cluster head 28

Sink moves to collects data from cluster head 28.

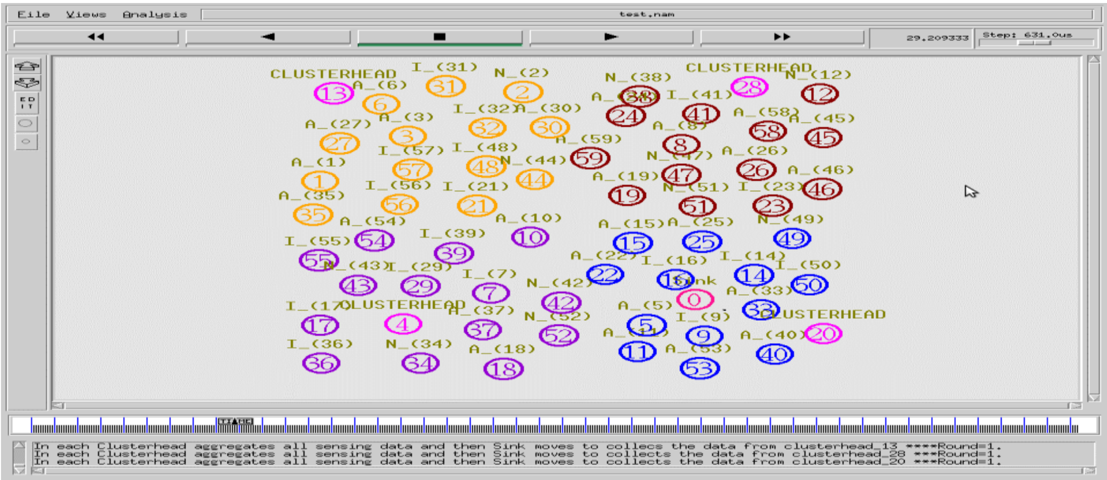

Figure 3.17 Sink moves to collects data from cluster head 20

Sink moves to collects data from cluster head 20.

3.5.6Data Gathering Without Sink Mobility

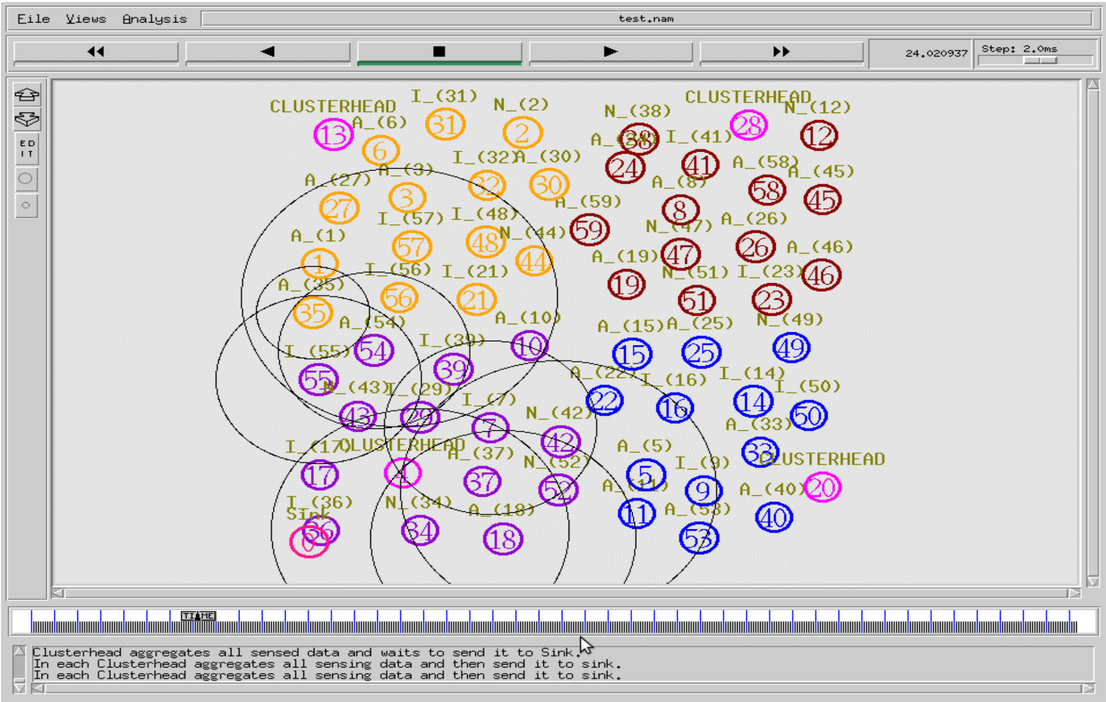

Figure 3.18:Data Gathering Without Sink Mobility

Cluster member sends the sensed data to corresponding clusterhead. Then, cluster head aggregates all sensed data and waits to send it to sink.

Then each cluster head sends aggregated data to sink.

CHAPTER **4**

SIMULATION RESULTSAND DISCUSSIONS

In this section we evaluate the performance of the proposed ETSSEP approach having Multiple Cluster Heads and ETSSEP. Proposed ETSSEP reduces energy consumption in SNs by reducing the transmission of sensed data within a cluster using multiple cluster heads. The main objective of this simulation study is to evaluate the performance of the proposed ETSSEP protocol. First we define simulation platform, simulation parameters and performance matrices used. After that we compare proposed protocol with existing protocol such as ETSSEP [6].The resultsconfirmtheefficiency of proposed protocol to deliverdata from source to sink.

In this chapter, it has been describing the system model and the simulation settings by following ways to define performance metrics on the basis of different scenarios by taking the different number of wireless sensor nodes and before describing the system model, introduce the simulation setting.

4.1INTRODUCTION

In this chapter, it has been describing the system model and the simulation settings by following ways to define performance metrics on the basis of different scenarios by taking the different number of wireless sensor nodes and before describing the system model, introduce the simulation setting.

4.2SIMULATION SETTING

4.2.1 Simulation Platform

We have chosen the NS2 [15] Simulator. NS2 is an object-oriented modular discrete event network simulator and provides infrastructure to writing simulations. It works on the basis of component (module) architecture for simulations.

4.2.2 Simulation Parameter

We assume a flat two dimensional field of area 500x500m^2 in which SNs are uniformly deployed. SNs are heterogeneous in term of their residual energy. While each SNs have same transmission range and sensing range. All node initially positioned at (0 m, 0 m), and after providing the mobility all the nodes deployed randomly in 500 m cross 500 m area.. We used the MAC protocol 802.11 and simulate the scheme for 150 seconds and on the basis of simulation results compare proposedapproach of sink mobility using ETSSEP protocol with ETSSEP protocol without sink mobility for the scenarios of varying number of rounds. Scenario is kept same for both protocols with same topology and energy. Totally 4 simulation runs are made by varying number of rounds as 1, 2, 3, and 4 Parameters such as network lifetime, stability period, instability period and throughput are computed and plotted as X graph..

The parameters used in simulation are shown in table 4.1.

Table 4.1: Simulation Parameters

SIMULATOR	Network Simulator 2
NUMBER OF NODES	Random
TOPOLOGY	Random
INTERFACE TYPE	Phy/WirelessPhy
MAC TYPE	802.11
QUEUE TYPE	Droptail/Priority Queue
ANTENNA TYPE	Omni Antenna
PROPAGATION TYPE	Tworay Ground
ROUTING PROTOCOL	AODV
TRANSPORT AGENT	UDP
APPLICATION AGENT	CBR
INITIAL ENERGY	1Joules
AREA	500 * 500
SIMULATION TIME	150seconds

4.3 PERFORMANCE MATRICES

We are using the following matrices for evaluating the performance of the proposed ETSSEP protocol and comparing its performance with ETSSEP protocol. These matrices are as follows:

4.3.1 Average Residual Energy of Network(E_a)

It can be defined as the average amount of energy consumed by each node for a particular task. Average energy consumption $E_a(r)$is calculated by using the equation 5.1.

$$E_a(r) = \frac{1}{N} * E_{total}(1 - \frac{r}{R}) \quad (5.1)$$

WhereE_{total}, r is the current round, R is total no of round, 'N' is the number of nodes.

4.3.2 Throughput

It is defined as the no. of packet send to the destination in per unit of time.

$$\text{Throughput (bits/s)} = \frac{\text{Total Data}}{\text{Data Transmission duration}}$$

4.3.3 Stability Period

Stability of the protocol is the time interval from the start of network until the death of first node is called stable region.

4.3.4 Instability Period

Instable period of protocol is the time from the death of first node until the death of last node also called the instable region.

4.4 SIMULATION RESULTS

4.4.1Network Lifetimecomparison graph of proposed ETSSEP approach v/s ETSSEP

When the number of rounds increased the network lifetime is decreased. The network lifetime of proposed ETSSEP approachand ETSSEP for the varying number of rounds is shown in fig. 4.1. As shown in fig. 4.1, for 2, 3 and 4 as the no of rounds is increases, the proposed with mobility scheme provides better network lifetime when compared to the existing without mobility scheme. We take 60 nodes for comparison.

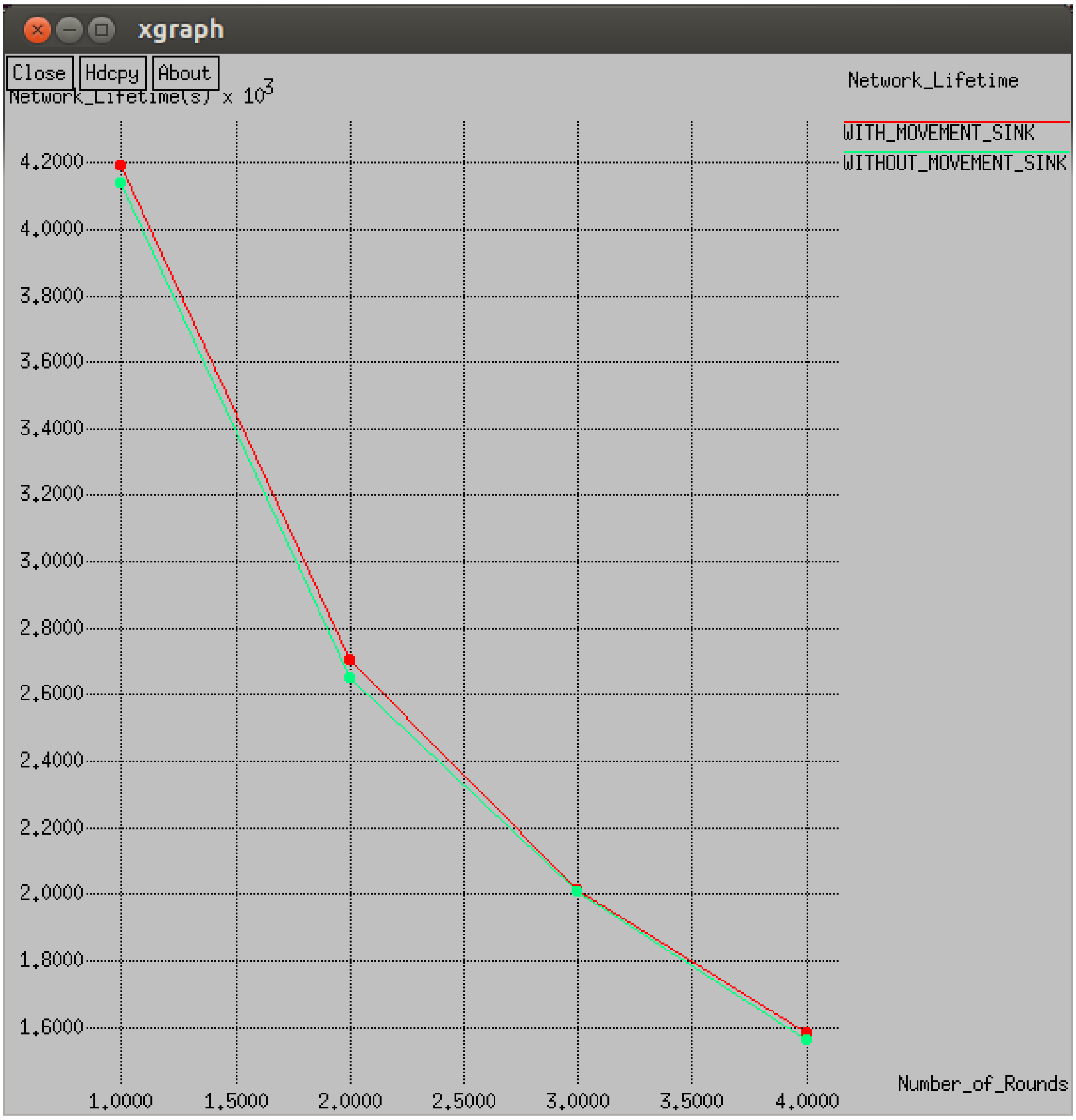

Fig.4.1:Network Lifetimecomparison of proposed ETSSEP approach v/s ETSSEP

4.4.2 Throughput comparison graph of proposed ETSSEP approach v/sETSSEP

When the number of rounds increased the throughput is increased. The proposed with mobility scheme provides better throughput when compared to the existing without mobility scheme. The throughput of the proposed ETSSEP is better than ETSSEP. The throughput of proposed ETSSEP and ETSSEP for the varying number of rounds is shown in fig. 4.7 As shown in fig. 4.7, for 2, 3 and 4 as the no of roundsis increases the throughput of the proposed ETSSEP with Sink Mobility is better than ETSSEP without Sink Mobility. We take 60 nodes for comparison.

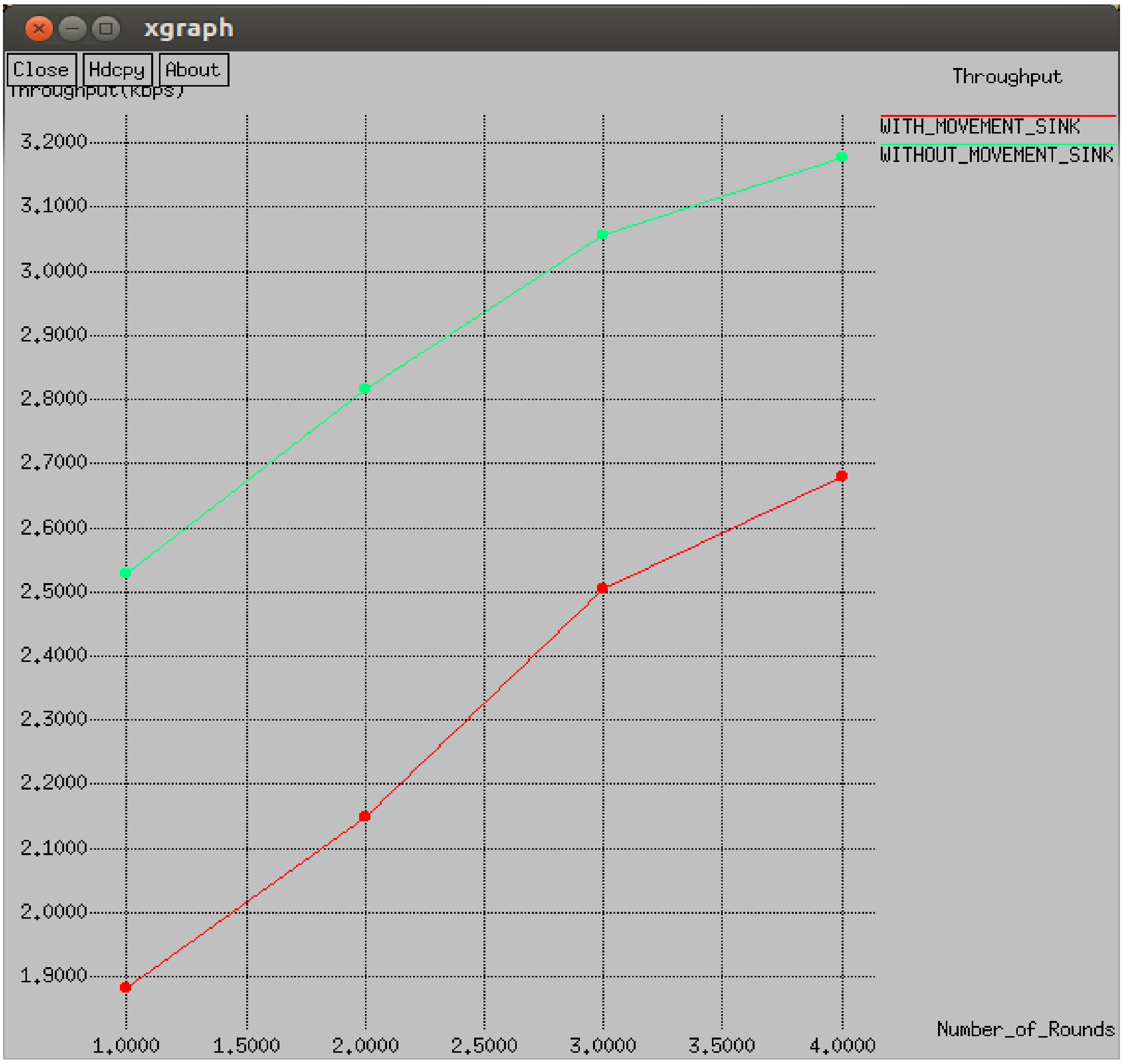

Fig. 4.2: Throughput comparison of proposed ETSSEP approach v/sETSSEP

4.4.3 Stability period comparison graph of proposed ETSSEPapproachv/sETSSEP

When the number of rounds increased the stability period is decreased. The Stability period of proposed ETSSEP and ETSSEP for the varying number of rounds is shown in fig. 4.7. As shown in fig. 4.7, for 2, 3 and 4 as the no of roundsis increases, the proposed ETSSEP with Sink Mobility and ETSSEP without Sink Mobility scheme provides similar performance.We here take 60 nodes for comparison.

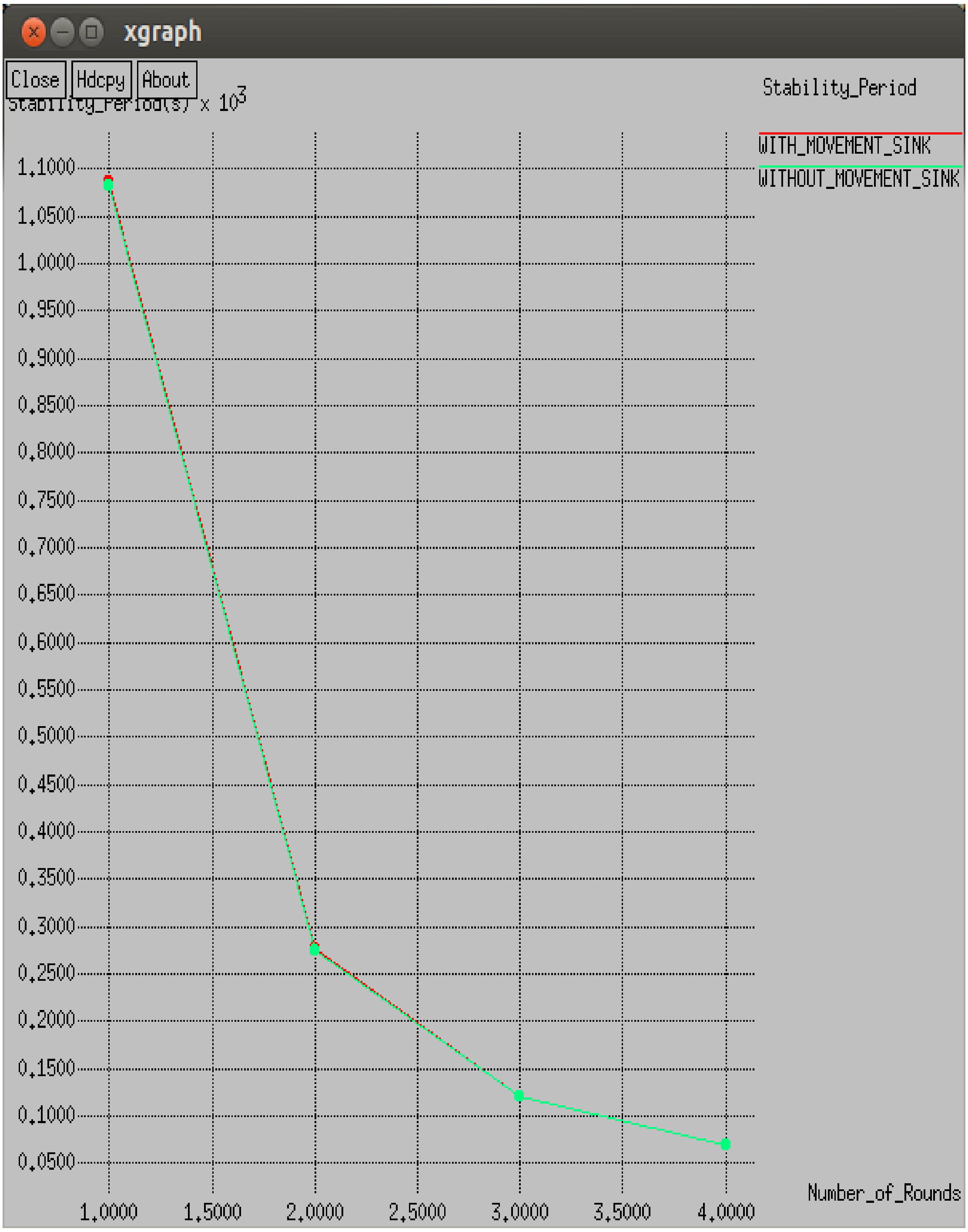

Fig.4.3: Stability period comparison graph of proposed ETSSEP approach v/s. ETSSEP

4.4.4 Instability period comparison graph of proposed ETSSEP approach v/sETSSEP

When the number of rounds increased the instability period is decreased. The instability period of proposed ETSSEP and ETSSEP for the varying number of rounds is shown in fig. 4.4. As shown in fig. 4.7, for 2, 3 and 4 as the no of roundsis increases, the proposed ETSSEP with Sink Mobility and ETSSEP without Sink Mobility scheme provides similar performance.We here take 60 nodes for comparison.

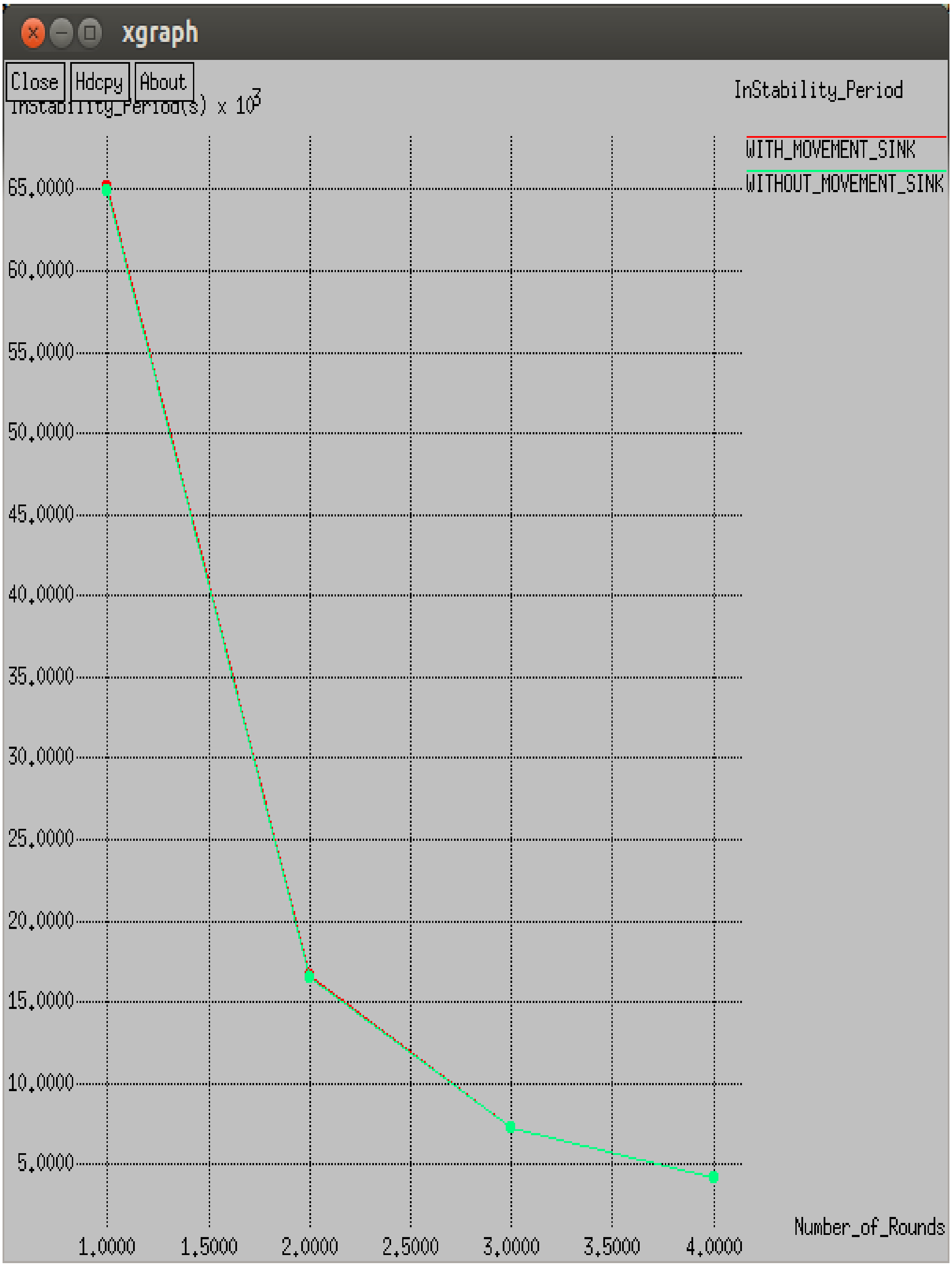

Fig. 4.4: Instability period comparison graph of proposed ETSSEP approach v/s ETSSEP

CHAPTER **5**

CONCLUSIONS AND FUTURE WORKS

5.1 CONCLUSIONS

The WSN network is created using Genetic Algorithm. ETSSEP is a reactive routing protocol where nodes considered with three different levels of energy.It is based on dynamic changing of cluster head election probability. It selects cluster heads on the basis of residual energy level of nodes and minimum number of clusters per round. The multiple cluster heads based data transmission technique is contributed to proposed approach in ETSSEP. Mobile Sink is being used for accumulating data from the Cluster Heads to be delivered to Base Station. It leads to increase in network life and throughput. We also evaluate and compare its performance with static sink WSN and WSN with random sink mobility. Our results show that the algorithm achieves better WSN lifetime compared to static sink case and random movement strategy. The usage of mobile sink in the WSN reduces the energy consumption of the nodes and to prevent the formation of energy holes in wireless sensor networks. In comparison with existing protocol it can be concluded that this protocol will perform well in small as well as large sized networks.

5.2 FUTURE WORKS

Our proposed ETSSEP protocol gives better and improved performance as compared to ETSSEP. If we adjust the mobility of sink according to the cluster head location and by increasing the level of nodes classification in term of energy level we would be able to improve the lifetime and throughput of the network. This makes thatin future, we would like to modify proposed scheme to handle some other issues such as mobility of sink nodes on Rendezvous Points in WSN. We would like to extend this work for handling different types of objects and mobile sinks.

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