Energy Efficient Routing Protocol for Wireless Sensor Network

A Dissertation Submitted

By

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Under the guidance of

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ABSTRACT

LEACH was the first most Routing Protocol used clustering concept in Wireless Sensor Networks. In LEACH protocol nodes are deployed randomly. Hence sometime clusters size varies from iteration to iteration. Cluster heads are selected according to their probability. The transmission residual energy is an unconsidered factor which effect the cluster heads performance in the network. Sometimes few nodes which are deployed at corner of sensor field are unable to register themselves among any cluster head due to its limited transmission range.

To overcome these limitations, Energy Efficient Hybrid Routing Protocol is proposed which use the concept of GA to elect cluster head. To bind corner nodes GSA approach is applied. GSA gives us best solution among all the possible solutions.

Proposed algorithm select cluster heads by evaluating different parameter of nodes like transmission energy level, distance from base station, pervious number of counts to be select as cluster head. All these parameter helps to elect more appropriate node to become a cluster head.

Those nodes which are deployed at corner of sensor fields may have useful information. A nearby node is select by evaluating its fitness function. After finding next node corner nodes sends its data to base station by multi-hop routing path.

The main advantage of proposed approach is it helps to select more appropriate cluster head. Better quality of cluster heads improve the network life time, energy consumption, reduce the packet delay time.

ACKNOWLEDGMENT

First of all I feel great pleasure in acknowledging my deepest gratitude to my revered guide and mentor, **Mr. Ravi Kant Sahu**, Professor, Computer Science and Engineering Department, Lovely Professional University, under whose firm guidance, motivation and vigilant supervision I succeeded in completing my work. He infused into me the enthusiasm to work on this topic. His tolerant nature accepted my shortcomings and he synergized his impeccable knowledge with my curiosity to learn into this fruitful result.

I would sincerely thank **Mr. DALWINDER SINGH**, Head, Computer Science and Engineering Department who suggested many related points and is always very helpful and constructive.

Words are inadequate to express my heartfelt gratitude to my affectionate parents who have shown so much confidence in me and by whose efforts and blessings I have reached here.

I find it hard to express my grateful to the Almighty in words for bestowing upon me his deepest blessings and providing me with the most wonderful opportunity in the form of life of a human being and for the warmth and kindness he has showered upon me by giving me life's best.

I wish to express heartiest thanks to my friends and colleagues for their support, love and inspiration.

Date: **Anjali Singhal**

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DECLARATION

I hereby declare that the dissertation proposal entitled **Energy Efficient Routing Protocol for Wireless Sensor Network** submitted for the M. Tech. Degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

Date:

Anjali Singhal

Registration No: 11301849

CERTIFICATE

This is to certify that **Anjali Singhal** has completed M. Tech. dissertation proposal titled **Energy Efficient Routing Protocol for Wireless Sensor Network** under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of the dissertation proposal has ever been submitted for any other degree or diploma.

The dissertation proposal is fit for the submission and partial fulfilment of the conditions for the award of M. Tech. Computer science and Engineering.

Date:

Signature of Advisor

Name: Ravi Kant Sahu

UID: 16920

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Chapter 1
INTRODUCTION

The field of wireless communications and miniature electronics have allowed the development of low-power, low-cost, multifunctional and tiny sensor nodes. These nodes are composed of equipment's that are responsible for sensing, data-processing and communicating. A collection of such sensor nodes, when scattered in one area, gathers data from their proximate environments and coordinate it to execute a certain task. Thus, this collection of sensor nodes can be referred to as a wireless sensor network (WSN). Some application areas of WSN are health, military and security. For example, the functional data information about a patient can be monitored remotely by a doctor using WSN. This is more convenient for the patient, it allows the doctor to have better understanding about the patient's current condition. Sensor networks can also be used for detecting foreign chemical agents in the air and the water. They help in identifying the type of object, concentration and location of pollutants. The wireless sensor networks will provide the end user with intelligence and a better understanding of the environment.

The basic goals of WSN as following

- To determine the values of physical variables at a given location like temperature of storage room.
- To detect the occurrence of events like how many time temperature drops below 30 degree.
- To estimate parameters of the detected event or events what's the current temperature
- To classify a detected object
- To track an object.

Ad-hoc Network: It is a collection of self-configured mobile nodes which communicate with each other by using radio waves. If no direct link established between two nodes then multi-hop routing is followed. For e.g. Vehicular Ad-hoc network. In Ad-hoc network vehicles moves randomly, GPS is used to find the location, according to current location information route are established.

Table 1.1 WSN vs Ad-hoc network

Factors/ Issues	**WSNs**	**Ad-hoc network**
Routing	Fixed	Dynamically changed
Failure rate	High	Low
Mobility of nodes	No	Yes
Central Controller	Yes	No
Deployment of population	Densely deployed	Sparsely deployed
Communication range	Short	Long
Number of nodes deployed	Very large	Not many
Identification (ID)	Not unique	Unique ID by its MAC address
Communication	Broadcast	Point-to-point
Memory	Limited	High
Power	Limited	Not an issue

1.1 The major components of Wireless Sensor Network

- **Sensors Field**: It is an area in which sensor nodes are deployed.
- **Objects**: Objects are the particle with in the network from which nodes sense the information that may be living thing or non-living.
- **Sink**: It is also a type of sensor node which performs the special task of receiving, processing and storing data from other sensor nodes. In case of clustering protocol this node is responsible for data aggregation and thus reduces the energy consumption.
- **Base Station**: It is a centralized control point within the network used to abstract information from the wireless network and transmits the control information back to the network nodes.

- **Sensor Nodes**: Sensor nodes are those sensors which are responsible for gathering information by sensing and routing and then sending this information back to a sink or base station. The WSN nodes varying from few to several thousand nodes which are connected to each other by direct or indirect way.

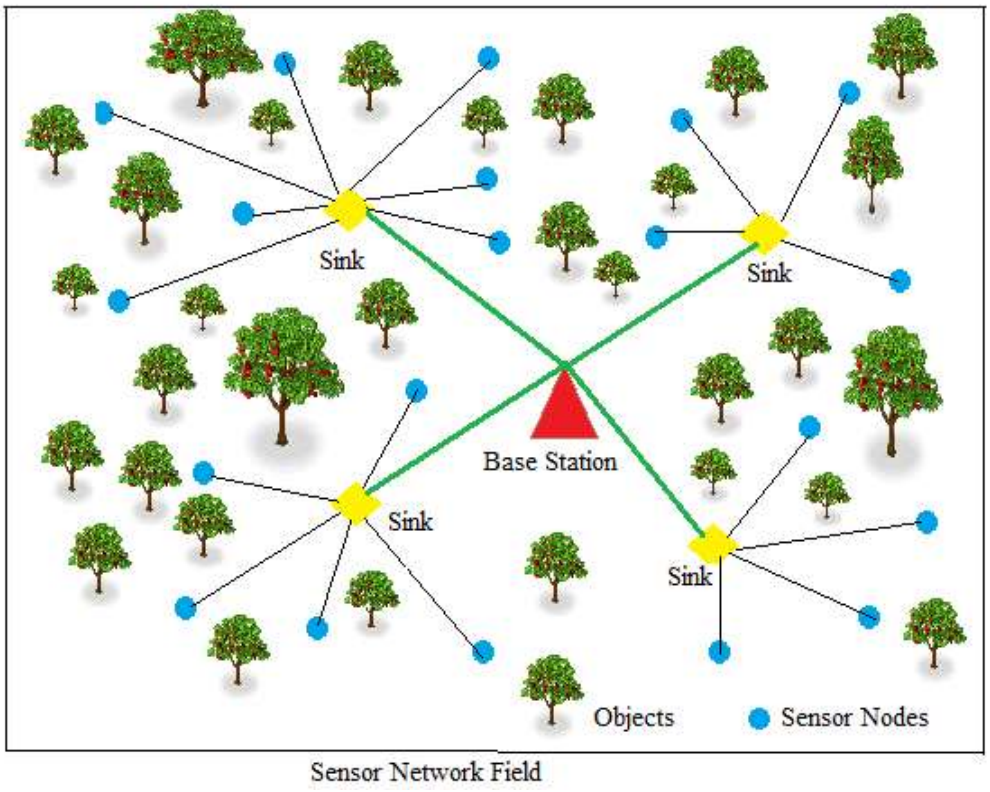

Fig. 1.1 Wireless Sensor Network Model

1.2 Wireless sensor nodes some basic components

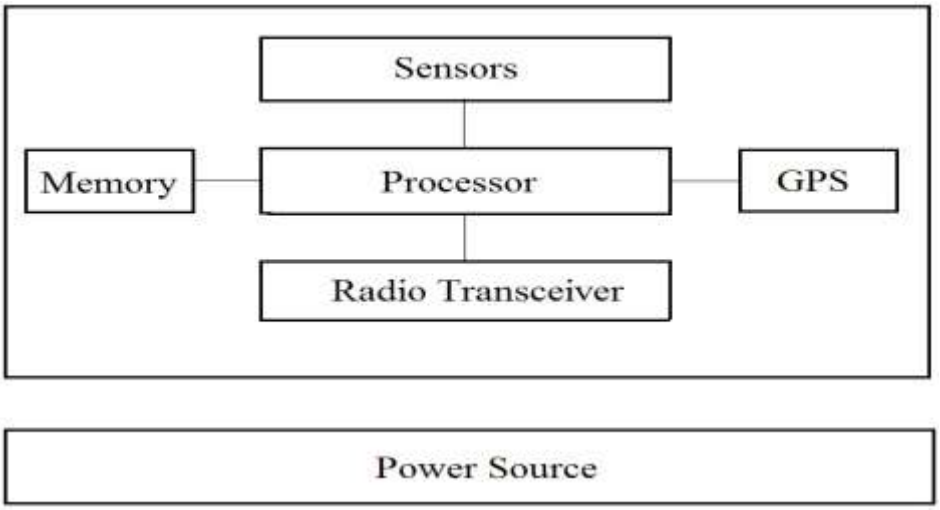

Fig. 1 2. Basic Components of sensor Nodes

The block diagram of a basic components of sensor nodes is presented in Figure 2. It is made up six basic components:

- **Sensors**: It provide information gathering abilities from the physical world by converting physical phenomena to electrical signals. It is made up of two sub-components: sensors and simple to advanced converters (ADCs). There are two type of sensors: simple sensors or computerized sensors. Also there exists a mix type of sensors that measure ecological parameters, such as temperature, light intensity, applied force, sounds, locations, and so forth.

- **Processor**: The processing unit mainly provide a computation capability to the sensor node. It consists of a small microprocessor, through which every other component is managed and controlled such as execution of routing protocols, create routing tables and signal processing algorithms on the gathered information. The main four processing states can be identified in a microprocessor: off, sleep, idle and active. In sleep state, the CPU unit and most internal peripherals are turned off, and can only be activated by an external interrupt (event). In idle state, the CPU unit is still inactive, but other peripherals components are active.

- **Memory:** It is a storage unit on sensor nodes which store information about routes, working condition, node identification number etc. Two different kinds of memory are the used on-chip memory of a microcontroller and Flash memory (off-chip). Mostly flash memory are used due to cost and storage factor.

- **GPS:** In wireless communication, to track the exact location position of senescing devices, we required a Global Positioning System. GPS provides current location in formation and helps us to track weather sensor nodes are present inside the network or outside.

- **Radio Transceiver**: It is a basic unit in wireless communication which allow nodes to communicate with their neighbour nodes and outside the world. Radio transceiver present on both ends (sender/receiver). It transmits digital data over short range radio channel. There are several factors that affect the performance of radio transceiver: type of modulation scheme used, radio range, data rate, transmit power and the network life time.

- **Power Sources:** One of the most important component of sensor node is power sources, performance of sensors usually dependent on battery power. Sensor nodes are generally tiny, light weighted and cheap, the size of the battery is limited. AA batteries stores 2.2 to 2.5 Ah at 1.5 V. Sensor nodes may have a lifetime of months to years, since the battery replacement is not an easy task in large network. So, limited capacity of power source required energy efficient operation to perform varies tasks and improve network life time.

1.2 Wireless Sensor Network Communication Architecture and protocol stack

WSN Architecture followed by base station as well as sensor nodes. This model combines integrates data with network protocols, routing and power awareness, consumed power efficiently by wireless channel and endorses cooperative efforts of sensor nodes.
It consist of the number of layer as mention in below figure:

- **Physical Layer:** It should meet the requirements such as carrier frequency generation, signal detection, data encryption, frequency selection, modulation, transmission and receiving mechanisms.

- **Data Link Layer:** It should fulfil such requirements: medium access, multiplexing of data stream, error control, data frame detection, reliable point-to-point and point-to-multi-hop connections in the WSN. MAC layer present in data link layer responsible for collision detection and minimal power consumption.

- **Network** Layer: It is responsible for routing data information which received from the transport layer by searching most efficient path for transmission.

- **Transport Layer**: It plays vital role when sensor network intends to accessed through the outside internet and maintaining the flow of data.

- **Application Layer:** Its software depends on the deployment model of network and responsible for presenting all required information to the application and propagates query to lower level layers.

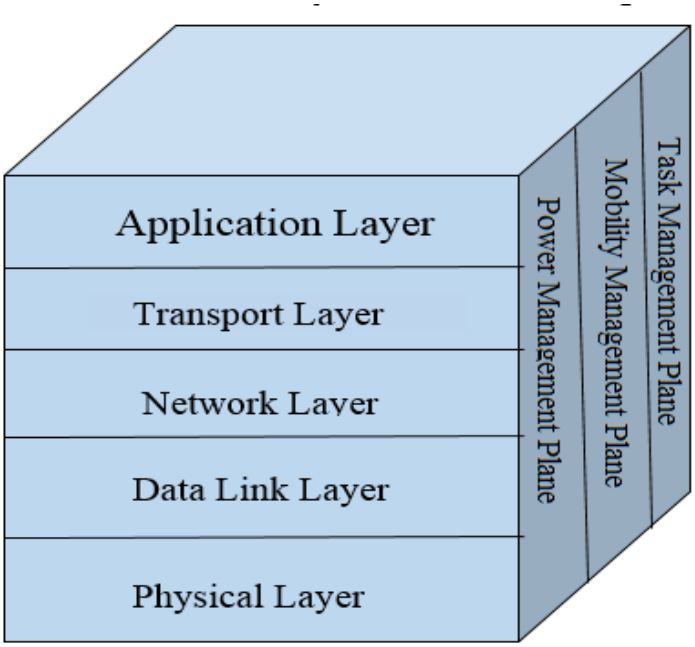

Fig 1.3. Wireless Sensor Network Communication Architecture Model

- **Power Management Plane:** It manages power utilization of sensor network.
- **Mobility Management plane:** It Maintain the node mobility information.
- **Task Management Plane:** It schedules and maintain the sensing activity and data forwarding process.

1.3. Network Characteristics

- **Dense node deployment**: Sensor nodes are densely deployed in the implementation field. The number of sensor nodes in network can be more than that in a ad hoc wireless network.
- **Battery-Powered:** Wireless sensor nodes are powered by battery energy. Sometimes they are deployed in hostile area where it is very challenging to change and recharge the batteries.
- **Save Energy and Computation Time:** Sensor nodes are capable to maintaining the limited use of energy, computation time and storage capacities.

- **Self-configuration:** Nodes are deployed randomly in the communication network without any sort of careful planning. Once deployed, nodes are configured automatically.

- **Frequent Topology changes:** Network topology changes frequently the reason being node failure, energy depletion, damage, channel fading.
- **No global identification**: In large sensor network it is impossible to build a global addressing scheme for each sensor network.

- **Application oriented:** According to the application requirement sensor nodes are deployed and designed.

- **Many to-one traffic pattern:** The data recognised by sensor nodes flow from multiple source nodes to a particular sink node, which flow in a many to one traffic pattern which is used in optimization techniques.

1.4. Network Design Primary Objectives

- **Small node size:** To decrease the cost and power consumption of sensor nodes in network topology.

- **Low node cost:** By decreasing the cost of sensor nodes directly reduces the cost of the wireless sensor network.

- **Low power consumption:** Batteries are used to powered sensor nodes with in network and it's difficult to change and recharged again and again theirs batteries, it is important to decrease the power consumption of nodes which directly effect on the network life time, hence network lifetime is prolonged.

- **Scalability of network:** Number of nodes in a network may vary from few to many. It is important to design the protocols which are automatically scalable according to different network sizes.

- **Security:** In most of the applications sensor nodes are organised in a hostile environment which makes them vulnerable. To provide security we need to introduce security mechanisms to prevent valuable information in the network or from illegal access of other malicious attacks.

- **Quality of Service Support:** Different applications requires different type of QoS in terms of delivery latency and packet lost ratio. QoS provides standards to our networks.

1.5. Network Design Challenges

The main network design challenges are as following

- **Limited energy capacity of sensor:** The sensor are powered by batteries, they have limited energy capacity. For example, in the battlefield, somewhere it is impossible to access the Wireless sensors nodes and to recharge their batteries due to deployment in hostile area. When the power of a sensor nodes reaches a certain threshold value, the sensor nodes will become some-what faulty and will not be able to function properly, which impact on the network performance.

- **Sensor locations:** In most of the WSN protocols assume that the sensors are either equipped with GPS receivers or by use of some other localization technique for learning about their locations.

- **Limited hardware constrain:** The limited hardware constraints facing many challenges in software and network protocol design for WSN. It high lights not only the energy constraint in sensor nodes, but other issues like the processing and storage capacities of the sensor nodes.

- **Massive and the random deployment:** The deployment of nodes in WSNs is application oriented and can either be pre-defined or random which affects the performance of the routing protocol.

- **Network characteristics and unreliable environment:** A WSN operates in a dynamic or an unreliable environment conditions. The network topology, which is defined by the sensors and the communication links between the sensors nodes and base station, changes very frequently either due to the sensor adding, deletion, node failures and the energy depletion.

- **Data Aggregation:** Sensor may produce significant amount of redundant information, similar type of packets from multiple sensor nodes can be aggregated to reduce the number of transmissions. Data information aggregation method can

be used to achieve energy efficiency and data transfer rate in a number of routing protocols.

- **Requirement of diverse sensing application:** WSN have a large range of diverse applications. No protocol can fulfil the requirements of all the applications. Therefore, the routing protocols should collect data to delivery and its accuracy so that the sink can gather the required knowledge about the physical phenomenon on the right time.

- **Scalability:** Routing protocols should be able to scale well within the network size. Sensor nodes may not essentially have the same capabilities in terms of sensing, energy, processing and particularly communication. Due to this communication links between sensor nodes may not be symmetric, specifically, a pair of sensors may not be able to communicate in both directions.

1.6 Routing Protocol

Wireless sensor networks, is a self-establishing multi-hop wireless network, which works as a decentralized system and it does not pose fixed infrastructures. Conventional routing protocols do not compatible with some of the sensor networks requirements: sensors have low battery power, limited memory, the routing tables grow up with the network size and do not support diffusion communication. This is the main reasons to build more an energy efficient routing protocol for WSNs.

The accountabilities of a routing protocol includes exchanging the routes information finding the feasible path to the destination based up on hop length, minimum power required, and lifespan of the wireless link, gathering information about the route path breaks, mending the broken paths information, consuming minimum processing power and bandwidth and utilizing minimum bandwidth.

1.5.1 Characteristics of Routing Protocols

- It should be specific to the application.
- It should be data centric.
- It should be capable to perform data aggregation function.

- It must optimally use network resources such as bandwidth, computation power, battery power and memory etc.
- It should be capable of providing certain level of QoS as application demanded by network.
- End to end delay must be less.
- The number of packets collisions should be minimum.

1.5.2 Classification of Routing Protocols

A WSNs might be have classified in four ways, routing path establishment, according to the network structure, protocol operation based protocol and initiator of communication. Routing protocols in WSNs may varies according to the application design of network.

- **Proactive protocols:** It evaluates all the possible routes before they are essentially needed them and store these route information in a routing table. Routing tables store in nodes memory unit. When a route changes, its information has to be propagated throughout the network and time to time sensor nodes required to update their routing table. WSN consist of thousands of nodes, it's very difficult for nodes to maintain huge amount of routing information due to limited memory size therefore proactive routing protocols are not well suit to WSN. Proactive protocols also called table driven routing protocols

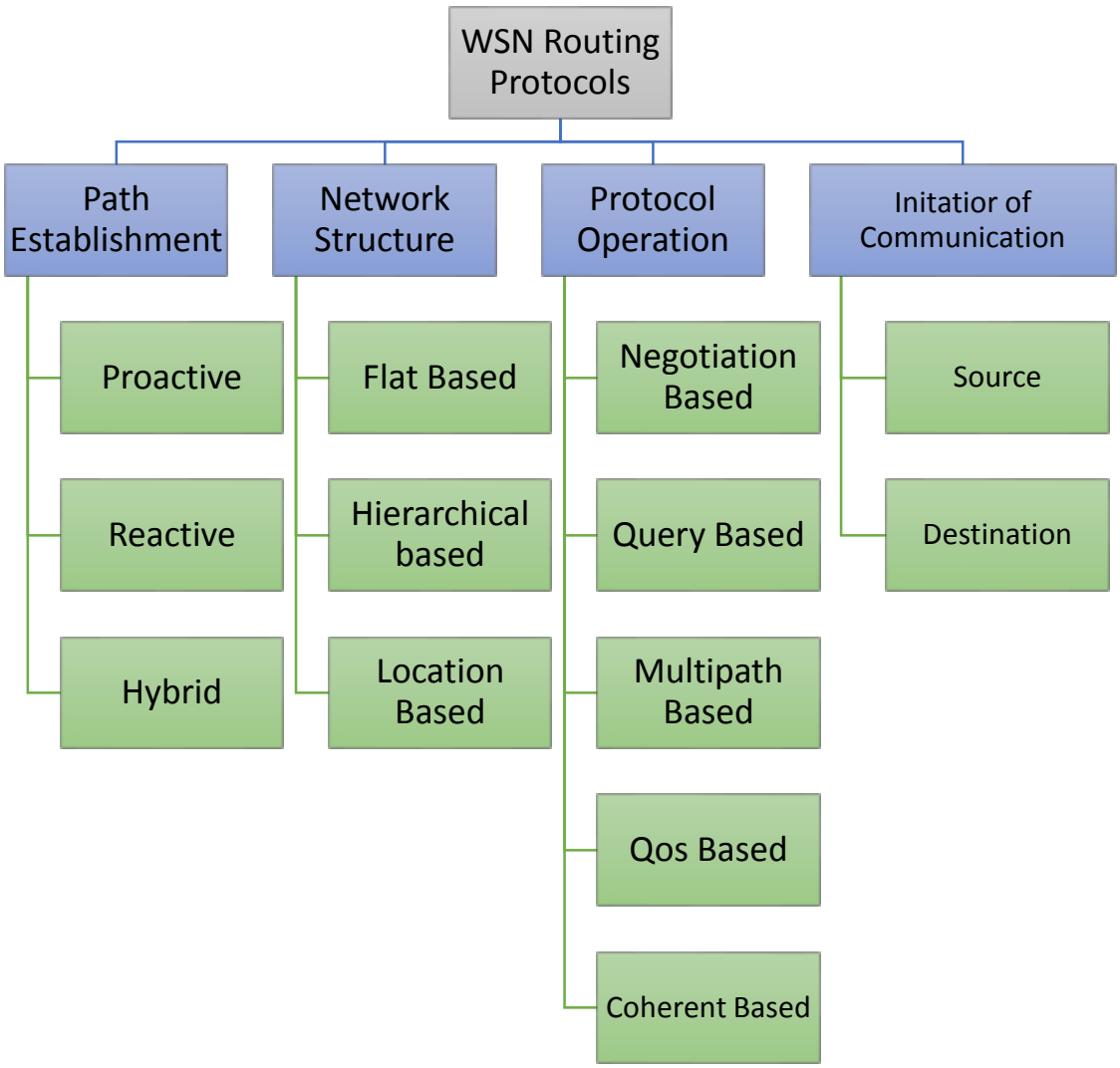

Fig. 1.4 Wireless Sensor Network Routing Protocols

- **Reactive protocols:** Protocols that falls under this type of category also called on-demand routing protocols, because they only compute routes when it is required**.** This type of routing protocols do not exchange routes information periodically.

- **Hybrid routing protocol:** It is the mixture of best feature of both proactive and reactive routing protocols.

- **Location based protocols:** Wireless sensor nodes are addressed by their own locations. The distance between two sensor nodes estimated depending upon the incoming signal strengths from the source nodes. Generally two different approach are used to track location, first is find the coordinate of the neighbouring node and other is through GPS. There is no addressing scheme for WSN like IP-addresses.

- **Hierarchical Protocols:** The main design concern for any WSN is scalability. Thousands of sensor nodes are present in the network. Sensor are not enough capable to communicate over large distance. To overcome this issue hierarchical approach is used. Hierarchical routing works in two layers, first one is used for clustering and other layer used for routing. The nodes having higher energy are used for processing and sending the information while the other nodes with low energy are used for performing the sensing activity near the target. It increases the network life time, energy efficiency, delay etc.

- **Flat-based Protocols:** No global identification number assign to nodes due to less number of nodes present in network field. Each node plays the same type role and number of sensor nodes collaborate to carry the task of sensing. Hence we also called it data centric routing, the sink node transmits queries packet to certain regions and wait for reply.

- **Coherent Protocols:** The local data handling on the nodes can be differentiate between the coherent (minimum processing) and the non-coherent (full processing) routing protocols. The data is forwarded to sink node after minimum processing like time stamping, duplicate suppression etc. when all source nodes sends their data to sink at same time , large amount of energy consumed. To overcome this problem limited number of source nodes sends data to sink node.

- **Multipath based Protocols**: It uses multiple paths rather than single path for improving the WSN performance. For example the fault tolerance can be improved by maintaining multiple paths between the source and sink. It increases the cost of energy consumption and generates more traffic. The alternate paths are kept alive by sending periodic signals.

- **Negotiation-based routing:** The negotiation based routing is done for eliminating the redundant data transmission. In this the communication decisions are made based on the sources available in the network scenario. The use of flooding of disseminated data information produces explosion and overlap between the send data, hence number of duplicate packets by nodes. This consumed more energy, battery power, communication power, memory etc. To overcome this problem negotiation based

routing protocol is used, Sink or next node sends a negotiation messages before transmission begins.

- **Query based protocols:** The destination sensor node propagates the query for data from a node through the network. A node having same data sends back reply message to the initiate's node. This sort of query used natural language and high level query language.

- **QoS-based protocols:** When the process of data transmission performed with the help of this routing, it balances the networks energy consumption and data quality through certain level of QoS metrics such as delay time, energy used or the bandwidth.

1.7 Leach Protocol

In this paper our main focus is on the hierarchical protocol LEACH. Clustering is a type of energy-efficient routing protocol that can be used by the nodes to transmit sensed data to the sink. We have described layered protocols in which a network is composed of several clusters of sensors as shown in above figure different cluster is shown by different colours, Cluster Head (CH), Base station (BS). CH is responsible for organising the data transmission events of all non CH nodes in its cluster. Nodes are arranged into a cluster. Each cluster have a cluster head that is responsible for transmitting nodes data to the base stations. Data travels from inter clustered layer to a BS. While, sends data from one node to another it takes one hop distance, if it sends data on large distance it takes multi-hop routing. It helps to transmit data information to the base station in faster manner. Clustering provides inherent optimization capabilities at the cluster heads

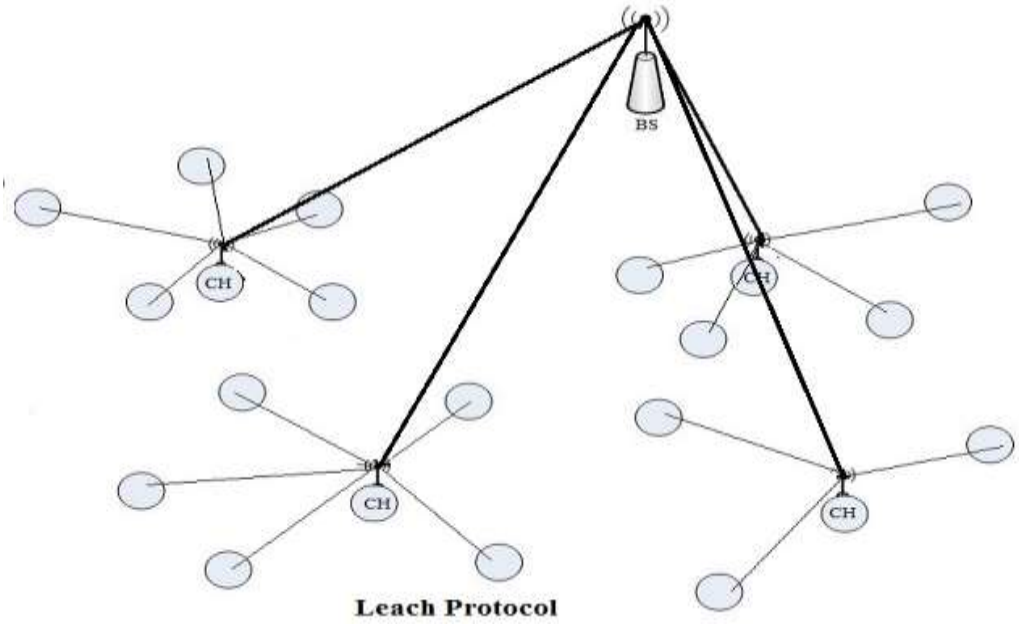

Fig. 1. 5. Hierarchical Protocol Network

LEACH Protocol is the first hierarchical routing protocol that has proposed for data fusion. Many hierarchical routing protocols improved based on LEACH protocol performance matrix. It is self-adaptive and self-organized protocol. LEACH use its round as unit, each round is made up of two stages (cluster set-up stage and steady stage), to reduce unnecessary energy costs, the steady stage must be much longer than the setup stage.

1.6.1 The design goal performed by Leach are as

- The Randomized rotation of cluster heads nodes selection and the corresponding clusters.
- The Global communication reduction by the use of local compression.
- The Localized co-ordination and control for cluster configure and operation.
- Lower energy media access control.
- Application specific data processing task.

1.6.2 Leach protocol Architecture

The Leach process is categorized into number of rounds and each of these rounds have mainly two different phases and these are known as:

Setup phase

- All the nodes are deployed randomly in the area
- Evaluated the nodes probability to become a cluster head by using

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

p is probability, r is number of round, where G is set of nodes that have not been CHs in the last 1/p rounds.

- The Advertisement of the cluster heads to its different individual cluster nodes.
- Transmission of the schedules plan that has been created during the setup phase.

Steady state

- The process of data aggregation within the separate clusters in the network.
- Compression of the sensed information that is sensed by the non-cluster head node into its different cluster head within the cluster range.
- Transmission of the aggregated data to the base station through all elected cluster heads

1.6.3 Advantages of LEACH protocols

It provides the best feature of scalability in the network by means of limiting most of the communication inside the different clusters of the network. Single-hop routing is possible from sensor node to cluster head and by this we are able to save the energy of the network. Distributiveness property within the cluster, where it distributes the role of CH to the other cluster members within the clusters. It does not require the information of the location of the sensor nodes in the net-work to create new clusters. It provides the dynamic clustering approaches. It is well-suited for the applications that needs constant monitoring of the environmental.

1.6.4 Disadvantages of LEACH protocol

It significantly relies on cluster heads rather than the cluster members of the cluster for having communication with the sink. It incurs additional overheads due to the process of cluster head changes in each iteration of the communication of information. There is no inter-cluster communication in the networks because the CHs can directly

communicate with the sink. This process requires high range of the transmission power in the network. In LEACH CHs are not at all uniformly distributed within the cluster that means the CHs can be located at the edges of the clusters. In LEACH, CH selection is a random process, which does not take into considerations the energy consumption of the different nodes within the cluster along with the CH into account and this leads to the reselection of CH as the same node in many simultaneous iteration of data processing in the network. It does not work well with the applications that requires large area of coverage along with the multi-hop inter-cluster communication.

1.8 Simulation of WSNs

Network Simulation like OPNET, NetSim, JSim, Matlab and NS2 can be used to simulation of wireless sensor network.

Conclusion

We have studied the basics of wireless sensor network, basic components required to construct sensor network and sensor node. Review the characterises of WSN, challenges faced while constructing network, objectives which we achieves.by constructing WSN. An architecture model defines the functionality of WSN layer structure. There are varies application in which WSN successfully work and reduce the computation overhead. The study of routing protocol gives the brief idea about classification of routing protocols. We also study a clustering base LEACH protocol, its architecture model, advantages and disadvantages. There are so many simulation tools which is use to deploy WSN virtually.

Chapter 2
REVIEW OF LITERATURE

2.1 Review of literature

Wireless sensor networks, is a self-establishing multi-hop wireless network, which works as a decentralized system and it does not pose fixed infrastructures. Conventional routing protocols do not compatible with some of the sensor networks requirements: sensors have low battery power, limited memory, the routing tables grow up with the network size and do not support diffusion communication. This is the main reasons to build more an energy efficient routing protocol for WSNs.

B. Wendi et.al (2004) proposed LEACH architecture of wireless sensor networks that developed the energy-efficient cluster-based routing protocol and media access together for particular application. The data aggregation techniques is used to attain good performance of network in terms network life time, latency rate and application observed quality.

Y. Jennifer et.al (2008) discussed the survey report is based on wireless sensor networks. The sensors are smaller, cheaper and intelligent device. For communication purpose we equipped it with wireless network. The design of a network depends on its significant applications and not just limited to military tracking, Environmental monitoring, surveillance, industrial machine monitoring

G.Ahmed et.al (2008) prosposed an algorithm for validate the cluster head selection in the leach protocol by using GA approach at base station side. Firsly cluster heads heads are create with the help of probility equation then base satation validates the particitaion of cluster heads in a particular round.

W. Lin et.al (2009) proposed clustering base routing protocol which used the concept of Ant Colony Optimization (ACO), which produces cluster of unequal size to balance energy consumption. It is a dynamic routing algorithm which finds path for data transmission on the bases of bio-logical ant's behaviour. Clusters those are close to BS have smaller size to increase the life span of network

R. Esmat et.al. (2009) discussed a new optimization algorithm based on Gravitation Search Algorithm (GSA). GSA is assembled on the bases of law-of-Gravity and the motion of mass interactions. Proposed approach follows the theory of Newtonian physics to compute search agents fitness function. Results shows the high performance of this algorithm by solving number of non-liner equations.

S. Muhammad et.al. (2012) proposed an energy efficient and scalable routing protocol based on artificial bee colony. The concept of multiple scouting and hierarchal network is used to transmits senesced data to base station .It improves the network life time and reduce the energy consumed by network. BCO fitness function computes the path and gives best global result

A. Bara'a et.al. (2012) proposed a Meta-heuristic clustering by using evolutionary algorithm has been proposed to improve the working of Leach protocol, prolong the network life time and energy consumption. A new fitness function is proposed that compares the two clusters properties and obtained results feather compare with other protocols like LEACH, SEP, HCR.

S. Aravindh. et.al (2012) proposed a combined hybrid algorithm approach is proposed in which ACO and GA (Genetic Algorithm) are used to find the shortest path. The paths generated by ant nodes are given input to GA. The GA finds the set of optimal possible routes by using selection, crossover and mutation process. The ACO concept is using to reduce the size of routing table. The worth of using GA is that it computes routes dynamically rather than making decision on the pre-computed route.

U. Hari et.al (2013) proposed approach is to minimize the energy consumption of network by using multi-hop routing process with using Dijkstra's shortest path algorithm is used for data transmission. Proposed algorithm use unequal size cluster concept with parameters like distance between nodes and base station , degree of nodes and results shows it improve networks life time and performance matrix.

N.K. Sharad et.al (2013) proposed a comparison paper on ACO, GA and SA approach by solving travelling salesmen problem. ACO gives better result in dynamic scenarios only for local optimization. With increases in number of iteration GA will provide better

solutions and provide global solution. SA algorithm consume more computation time. This paper concludes that GA gives over all better result than ACO and SA.

S. Haidar. et.al (2014) proposed highly conserved to extend the WSNs lifetime. One method is to deploy the multiple sinks, which are more capable nodes in comparison to sensors. These increased the area coverage and reduce the communication distance between sensors and sinks.

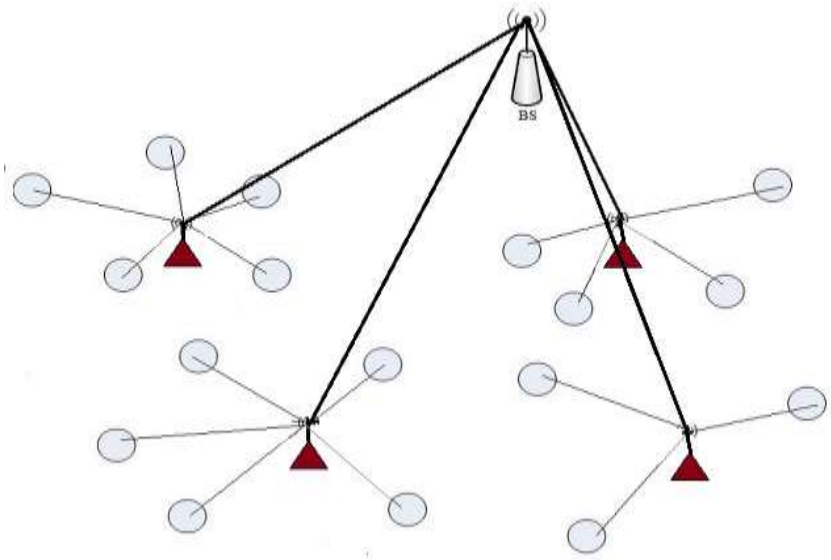

Fig. 2.1 Wireless sensor network with multiple sink

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This raises a problem which sensor should bind to which sink in order to avoid overloading on sinks. In this paper a Genetic Algorithm based approach was used to resolve the balancing problem. For future work in this paper we have to do more things like introduce the concept of non-exclusive nodes to neighbouring sensors, analysing the routing oath failure and path recovery solution in multi-hop approach

S.Tripti. et.al (2014) proposed a novel routing approach based on ACO algorithm in Wireless Sensor Networks on which LEACH protocol is applied, to route the data packets in sensor networks to maximize energy efficiency and to increase the network lifetime. They try to reduce the efforts used in sending the redundant data sent by the sensors which are very much close to each other in the sensor network. The performance of our proposed algorithm has been compared with the LEACH protocol and the

simulation results shows that the proposed approach provides optimized solutions in terms of efficient energy utilization and enhanced network lifetime.

Z.Haitao. et.al (2014) proposed a combined LEACH with Simulated Annealing and Genetic Algorithm approach to overcome the LEACH protocol drawback. The sensor nodes are deployed randomly in the sensor field. Initially the cluster heads were selected by SA and GA and then calculates the cluster centre of each cluster. If the average energy level of the member nodes in the cluster is higher than that of cluster head energy, it will become the new candidate cluster head; at last the candidate cluster heads becomes the cluster head according to their distance from the base station. Result shows that the proposed algorithm could improve the Energy Hotspot affected by the uneven distribution of cluster head in LEACH, Hence it can balance the WSN load balance and extend the network lifecycle.

B.Alakesh. et.al (2014) explain a brief introduction to routing protocol challenges in WSN along with some basic issues related to designing the routing protocols. The basic ordering of routing protocols in WSNs according to the most energy efficient protocol named LEACH describe with its advantages and disadvantages. They also high light on some of the improve version of LEACH protocol.

Conclusion

We have studied the basics of WSNs protocols LEACH in brief, LEACH is a hybrid energy efficient protocol which is based on clustering concept. There are so many optimized algorithms are proposed such as Dijkstra's, Ant Colony Optimization(ACO), Genetic Algorithm(GA), Gravitational Search Algorithm(GSA). These all techniques are used to improve varies issues of LEACH by formulating combined approach. Results shows how these techniques effect the performance and maximize the network lifetime by using optimal solutions.

Chapter 3
RESEARCH METHODOLOGY

3.1 Scope of the study

In this section we will discuss the review of literature. Literature survey helps us to identify the problem in previous work and highlights the area of improvement. In LEACH algorithm re-clustering process plays vital role. Each data gathering cycle is called as round. During each round a specific percentage of total nodes are elected as cluster heads. The different magnitude clusters may exit in the network at the same round. Each node get chance to become CH according to their probability to chosen as CH in particular round). It is possible that not a single node selects as CH and few of the nodes have to act as forced CH. Ignoring the residual energy, nodes location and other significant parameters is the main reason of CH failure Arbitrary cluster heads selection process while nodes have different energy. Effect the performance of cluster member nodes because they deplete energy after cluster head dead.

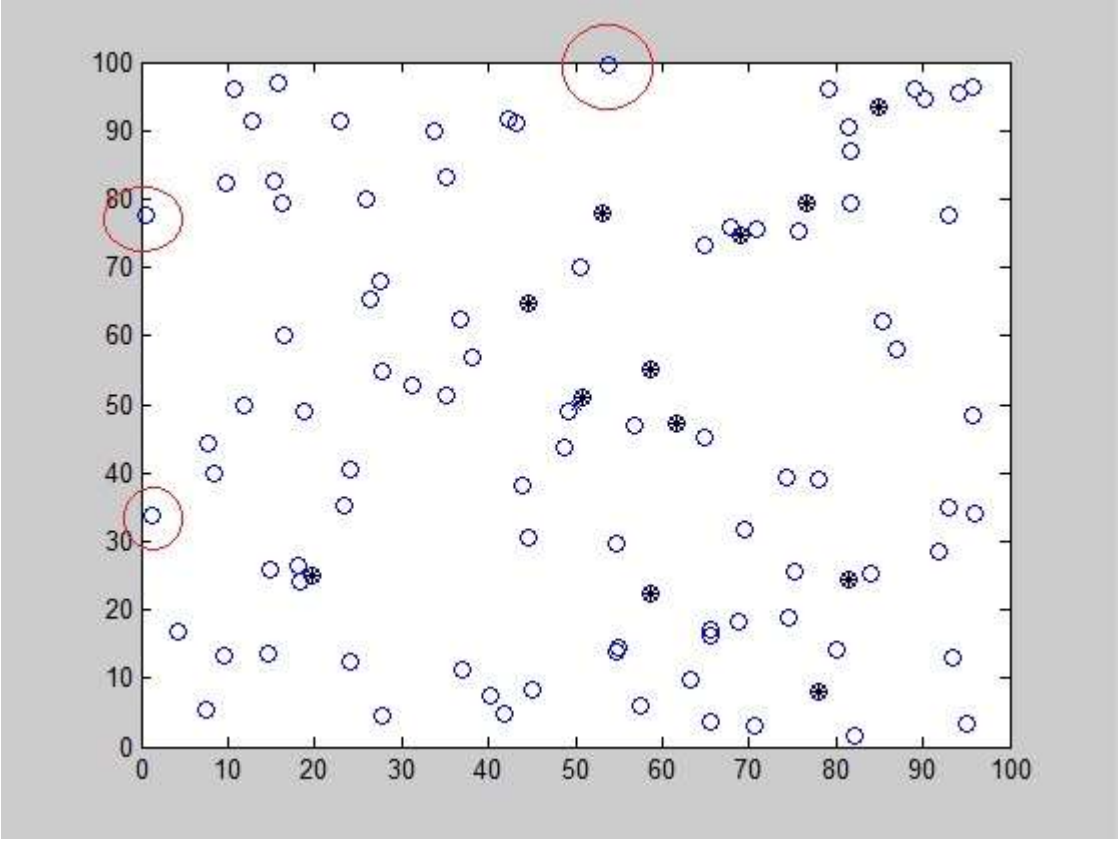

Fig. 3. 1 Nodes deployed at edge

Nodes are deployed randomly either in uniform or non-uniform fashion .Clusters are not uniformly distributed where some nodes may be placed at the edges of sensor field. Due to this reason their transmission range is limited hence not able to transmit their data to base station or register themselves under any cluster head. We need to bind them with other nodes so that we are to gather proper information and send to base station with the help of multi hop route.

Cluster heads energy level goes down more frequently as compared to other nodes. That's why leach is used re-clustering concept in every next round. There may be possibility of cluster head die in between when nodes are sending their data to cluster in this case we need to re- cluster with in an intra-cluster nodes. There are so many heuristic algorithms proposed which provide optimized solution to our problem Cluster head selection probability parameter also evaluated by using different techniques to improve the chances of a node to become a cluster head.

At the time of data aggregation cluster head fully loaded and need more energy to send the data. If we can use a multi-hop data transition process to reduce the energy consumption, average latency rate which automatically increase the network life time. Hence sensor nodes will able to send more data to base station which improves the packet delivery ratio.

3.1.1 Ant Colony Optimization

ACO algorithm in which sensor nodes act like artificial ants, opt their basic features like forward and backward path construction, pheromone values evaporation rate to evaluate the fitness function of node by using three functions self-adaption, cooperation and competition. After number of iterations a single optimized path is constructed.

Table 3.1 Difference between Natural Ants and Artificial Ants

Criteria	**Real Ants**	**Artificial Ants**
Behaviour of Pheromone Depositing	Pheromones are deposited when ants are moving in their forward and backward way	Pheromones are deposited only on the return path after an ant solution is constructed and evaluated
Pheromone Updating Amount	Pheromone trail is updated in some specific species only, with a pheromone value that depends on the quantity of the food source	Once a path has constructed by an ant, the pheromone trail of node is updated on its return path with an value that is inversely proportional to the path length stored in its memory
Environment-Tal constraints	It exist in real ant colonies, e.g. predation or competition with other colonies and the colonies level of protection	It does not exist in the artificial ant colonies.
Memory Capabilities	Real ants have no memory management capabilities	Artificial agents store the paths parameters in there memory and used it in retracting process. They also same parameters for determining the quantity of pheromone level
Return Path Method	Real ants use there pheromone value in there forward path to retrace their	No pheromone value is deposited by nodes on the forward path, nodes use the stored paths values from their memory to retrace their returning path
Evaporation Behaviour of Pheromones	It evaporate too slowly making it less significant for the merging with other ants	Evaporation values become more significant for the merging with other nodes

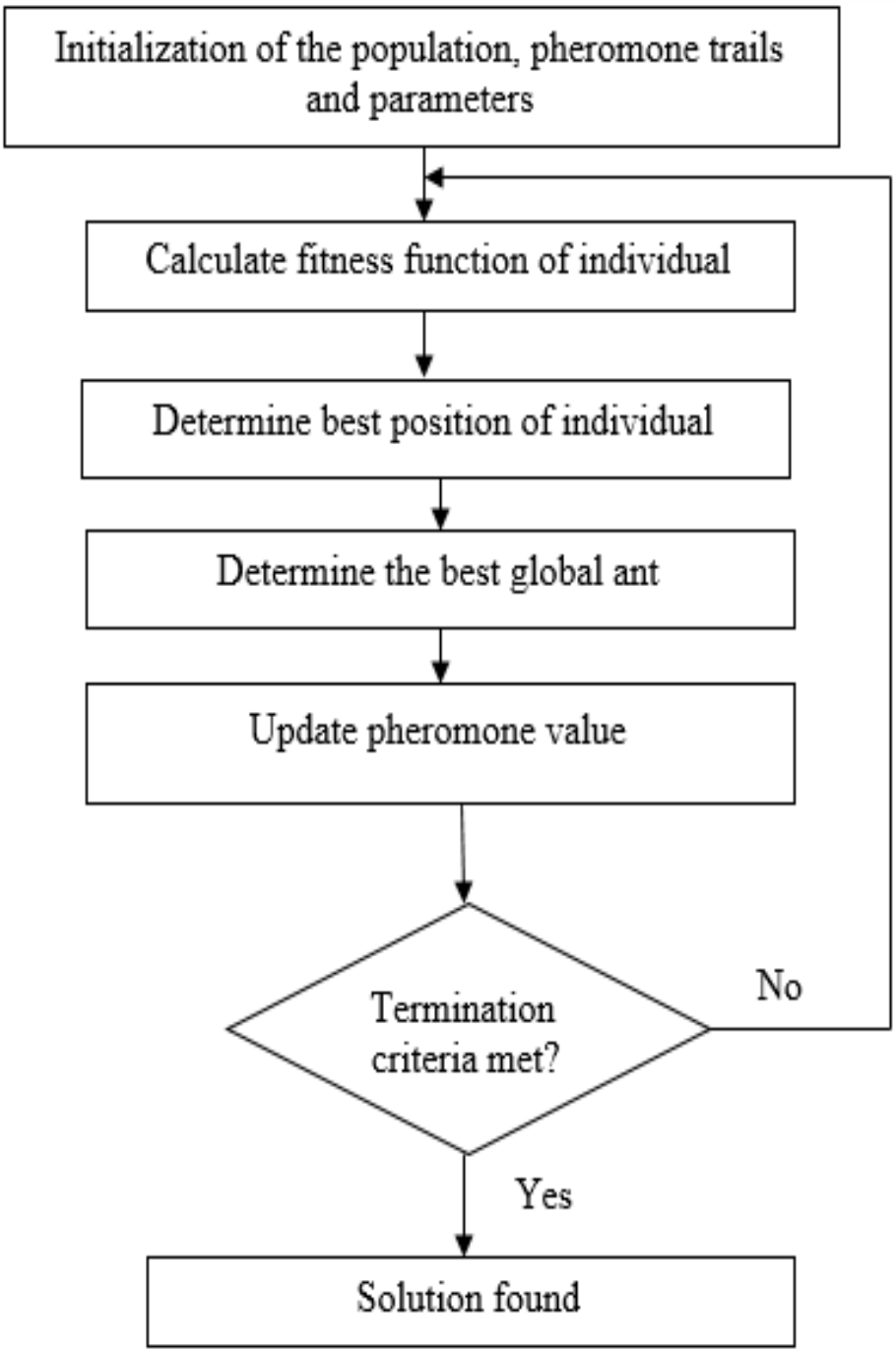

Fig 3.2 Ant colony optimization flow chart

3.1.2 Genetic Algorithm

In GA nodes initialize as pollution by opting genetic behaviour, best fitness function result is considered as best pollution, to calculate fitness value three steps (crossover, mutation, selection) are repeated for particular number of generations to find local solution. It is best in case when we have two options for a solution.

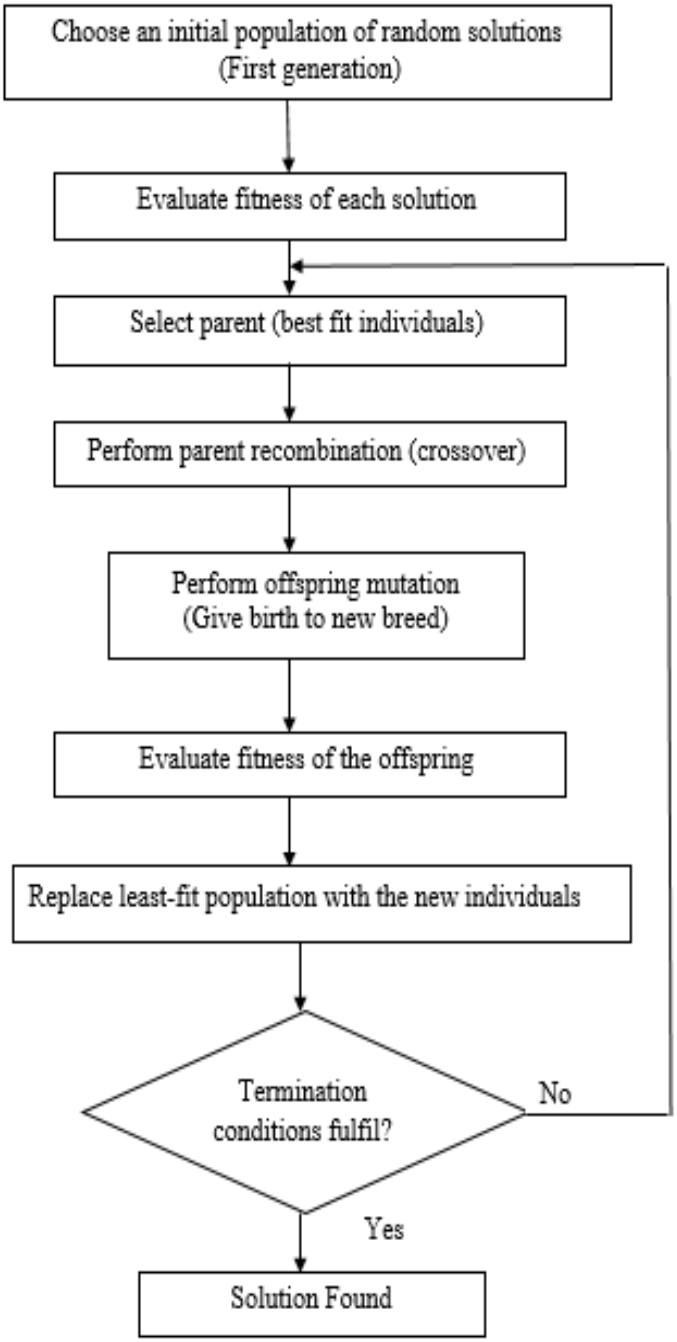

Fig. 3.3 Genetic Algorithm flow chart

Basic terminology used in Genetic Algorithm

- **Chromosome:** It is a set of genes that contains the solution in the form of genes. For e.g. 98150 is a chromosome value then 9,8,1,5 and 0 are its genes.
- **Population:** The total number of individuals or chromosome with same number of genes.

- **Fitness:** It is a value that assigned to an individual based on readiness of an individual to provide solution. Greater the fitness value, more appropriate solution will obtained.
- **Fitness function:** It is an application oriented objective function which assigns fitness value to the individual.
- **Crossover:** Taking two fit individuals and then perform intermingling process to generate new two individuals.
- **Mutation:** It is a process of changing a random genes in an individual value.
- **Selection:** The process of selecting individual to generate the new generation.

3.1.3 Gravitational Search Algorithm

GSA is a physical phenomenal based upon Law of Gravity and Law of Motion to find global optimized solution. Working of ACO and GSA is somewhat similar but computation functions are totally different. ACO selects one best solution among two different entities whereas GSA provide all over one best solution among population. The Gravitational Search Algorithm considered as an isolated system for small artificial world of masses which obeying the Newton Law of gravitation and motion.

Law of gravity

It state that each particle attracts every other particle and the gravitational force between two particles is directly proportional to the product of their masses and inversely proportional to the distance between them [10]

$$F = G\left(\frac{M_1 M_2}{R^2}\right)$$

G is the gravitational constant, M_1 and M_2 mass of two particles and R is the distance between these two particles

Law of motion:

The current velocity of mass is equal to the sum of the fraction of its previous velocity and the variation in the velocity. Variation in the velocity or acceleration of any mass is equal to the force acted on the system divided by mass of inertia [10] An acceleration is depend on force and its mass

$$a = \frac{F}{M}$$

F is force applied on an object, M is the mass, a is the acceleration

Fitness function computed from following equation

$$F_{ij}^{d}(t) = G(t)\left(\frac{M_{pi}(t) * M_{aj}(t)}{R_{ij}(t)+\in}\right)\left(x_j^d(t) - x_i^d(t)\right)$$

$F_{ij}^{d}(t)$ is the force acting on agent i from agent j at d^{th} dimension and t^{th} iteration. $G(t)$ is the computed gravitational constant at the same iteration while $\in$ is a small constant. $R_{ij}(t)$ is the Euclidian distance between two agents i and j at iteration t.

Best fitness function computed as follow

Minimization Problems

$$best(t) = \min fit_j(t) \qquad j\epsilon(1 \ldots \ldots . N)$$

$$worst(t) = \max fit_j(t) \qquad j\epsilon(1 \ldots \ldots . N)$$

Maximization problems

$$best(t) = \max fit_j(t) \qquad j\epsilon(1 \ldots \ldots . N)$$

$$worst(t) = \min fit_j(t) \qquad j\epsilon(1 \ldots \ldots . N)$$

$fit_j(t)$ represents the fitness values of the j^{th} agent at iteration t, best(t) and worst(t) represents the best and worst fitness at iteration t.

Computation of Gravitational constant (G)

$$G(t) = G_o e^{(\alpha/T)}$$

G_o and α are initialized at the starting, T is the total number of iterations.

Compute Masses of the agents

$$m_i(t) = \frac{fit_i(t) - worst(t)}{best(t) - wrost(t)}$$

$$M_i(t) = \frac{m_i(t)}{\sum_{j=1}^{N} m_j(t)}$$

Compute Accelerations of agents

$$a_i^d(t) = F_i^d(t)/M_{ii}(t)$$

Acceleration of the i^{th}agents at iteration t

$$F_i^d(t) = \sum_{j \in kbest, j \neq i} randF_{ij}^d(t)$$

$F_i^d(t)$ is the total force acting on i^{th}agents. Kbest is set of first K agents values with the best fitness value and biggest mass.

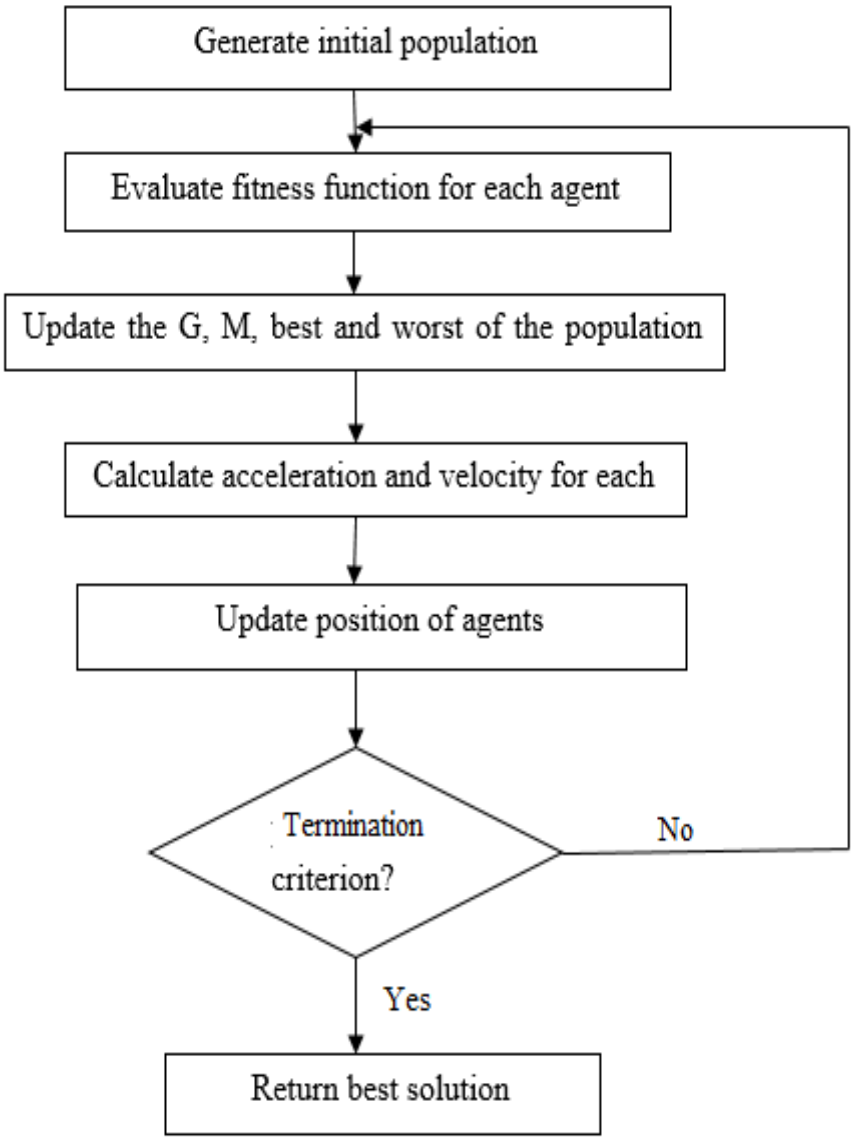

Fig. 3. 4 Gravitational Search Algorithm flow chart

3.1.4 Energy consumption model

WSN use an energy attenuation model depending on the distance value between two node (Sender and Receiver). The transmitter transmits k bits data to another node, d is the meter distance between two nodes.

The energy consumption calculation formula

$$E_{TX}\ (k,d) = \begin{cases} kE_{ele} + kE_{fs}\, d^2 & d < d_o \\ kE_{ele} + kE_{mp}\, d^4 & d \geq d_o \end{cases}$$

$$E_{RX}(k) = kE_{ele}$$

$$E_{DA}\ (k) = kE_{da}$$

E_{mp} is multi path length energy value for transmission data , E_{fs} is for fixed path length energy value for transmission, E_{da} is the energy consumption used to compressed data unit. E_{TX} is transmission energy of sender, E_{RX} is received energy of the receiver, $d_o$is the critical distance between two nodes.

3.2 Objectives of the study

- To increase the network longevity
- To bind all nodes that are out-off range or not registered under any cluster head due to non-uniform deployment
- To deploy an energy efficient hybrid algorithm.
- To computer cluster head election probability by using GA method.

3.3 Research Methodology

In pervious works firstly cluster heads selected randomly then a probability parameter is used to select cluster heads. In proposed work cluster heads are select with the help of GA process which give us more appropriate value of node to become a cluster head
There is one issue in Leach protocol when no node get chance to become a cluster head. GA approach also remove no cluster head formation issue. The major characterise

- GA approach search from a population of points rather than a single point.
- GA use probabilistic transition rules rather than non-deterministic rules.
- GA use application oriented objective functions rather than not derivatives or other previous knowledge.

- GA sets parameter according to application rather than using predefine parameters.

We also try to bind limited range edge node with the GSA approach the major characterise are following

- GSA proved us one best solution by evaluating overall force obtained by all particles rather than selecting best one from two particles
- GSA consume less memory as compare to others.
- Most of an optimization algorithms works on social behaviours while GSA inspired by a physical phenomenon of forces

Our proposed Methodology is divided in two parts setup phase and steady phase

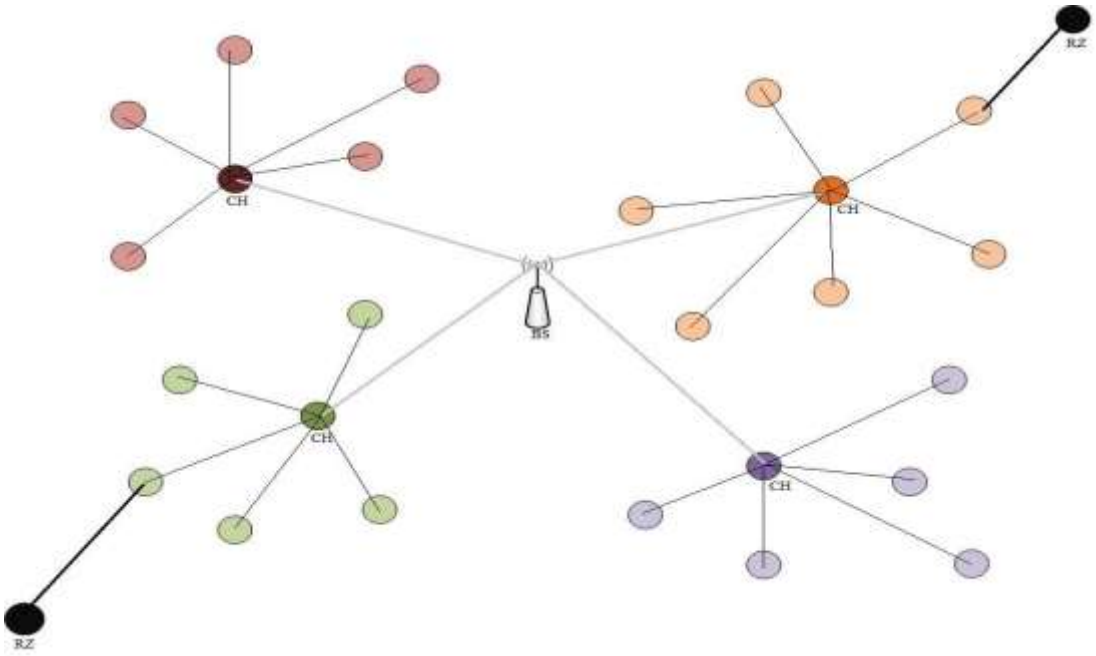

Fig 3.5 Proposed model of Wireless Sensor Networks

- BS is Base Station
- Four CH is selected Cluster Head in different clusters
- RZ either a node which is node in the range or not registered under any cluster

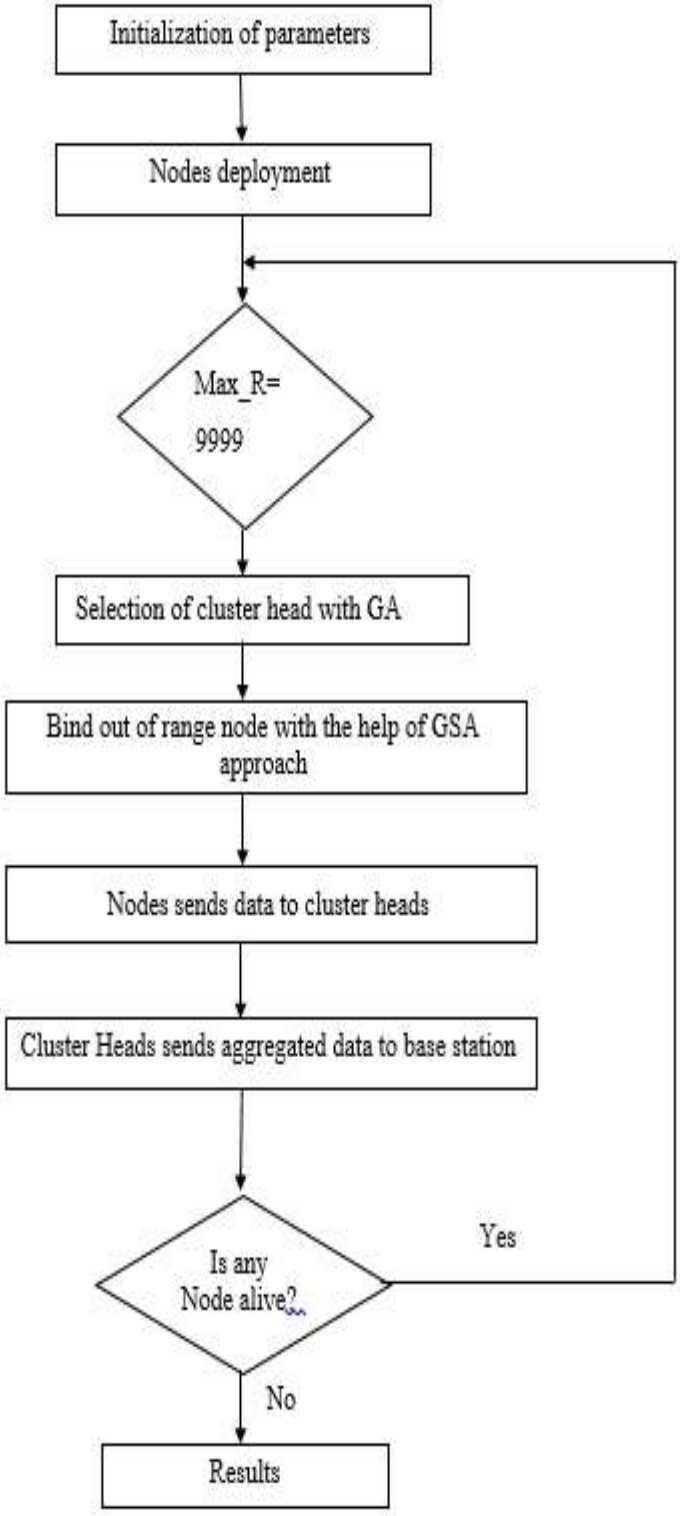

Fig 3. 6 Proposed Algorithm

Setup phase

- Sensor nodes and base station are deployed in the sensor field.
- Invitational parameters are provided to sensor nodes so that they can start working.

- Cluster head is selected with the help of GA and sends the information about cluster to the base station. The information from base station is sent back to all nodes so that they can select their cluster heads.
- If any node is found out off range (RON) and not able to register itself under any cluster head then the gravitational search approach is used to find the path. When RON finds next hop it will automatically bind with cluster head by using the multi-hop concept.
- After step up phase complication we establish a cluster head link with base station and base station also have information about all node id's and their respective cluster heads.

Steady Phase

Time division multi access (TDMA) principle is used. In cluster a fixed time slot is provided to non-cluster head sensor nodes for transmission their data to the respective cluster heads. Due to non-uniform distribution of nodes some cluster heads either nearby or far away from the base station they use multi-hop path. Cluster heads transmits their aggregate data to the base station. As a result, energy consumption by cluster heads gradually reduced and increased network life time

Conclusion

Packet delivery ratio, delay time, average throughput of network, average energy consumption and network durability improvement is the main concern of the study. Along this we also try to find the best combination of technique which improves the performance parameters of network wireless network with the help of this research methodology we are able to implement a hybrid routing protocol for wireless sensor network. Leach protocol limitation are overcome with this hybrid concept and result we get an energy efficient routing protocol which improve network life time, packet delivery ratio

Chapter 4
Results and Discussions

The proposed routing protocol is simulated using MATLAB tool. Experiments are performed on simulations with different numbers of sensor nodes uniformly distributed in a 100 m×100 m. Base station is located at position [75,100].

Table 4.1 Simulation Parameters

Max_round	No of Max Round	99999
ctrPacket_L	Length of packet that sent for nodes to CH	200 bits
Packet_L	Length of packet that sent for CH to BS	6400 bits
E_o	Initial energy of each node	0.5 nJ
E_{TX}	Energy for transferring of each bit (ETX)	50 nJ/bit
E_{RX}	Energy for receiving of each bit (ERX)	50 nJ/bit
E_{fs}	Energy of free space model	10e-12 J/bit
E_{mp}	Energy of multi path model	1.3e-15 J/bit
E_{DA}	Data aggregation energy	5e-9 J/bit

Performance parameters

Average Throughput: It is defined as the total number of packets delivered over the total simulation time (bites/sec.)

$$Average\ Throughput = \frac{\left(\frac{N}{t}\right)}{r}$$

Where N is the total number of packets delivered to base station, t is the total time taken by data packet to transmit over network, r is the total number of cycles.

Packet delivery ratio: It is defined as ratio of total packets received at base station to total packet generated by sender. We denoted it in %.

$$Packet\ delivery\ ratio = \frac{N}{n} * 100$$

Where N is the total number of packets delivered to base station, n is total number of packets transmitted by all nodes.

Network life time: The total number of nodes which are alive at end of all cycles of the algorithm.

Energy efficiency: It is the total energy consumed in delivering 1000 bits of data to the base station (j/Kbits).

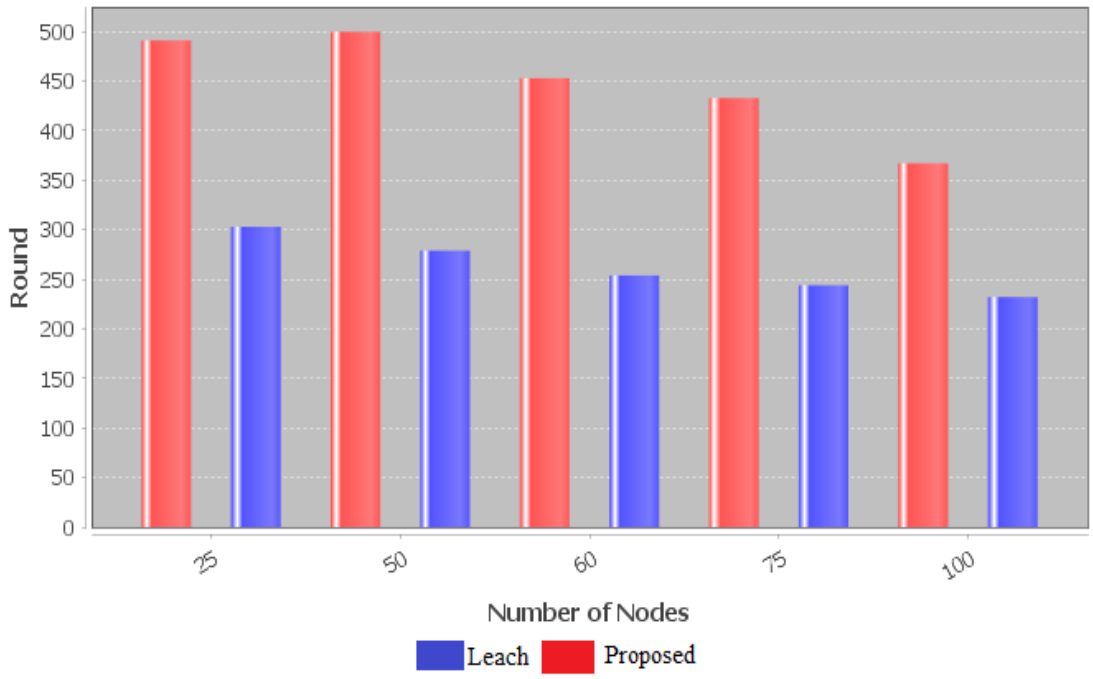

Fig 4.1 Number of rounds

Fig 4.1 shows that proposed approach improve the network life in terms of number of rounds. With the increases in life time nodes are able to send more data.

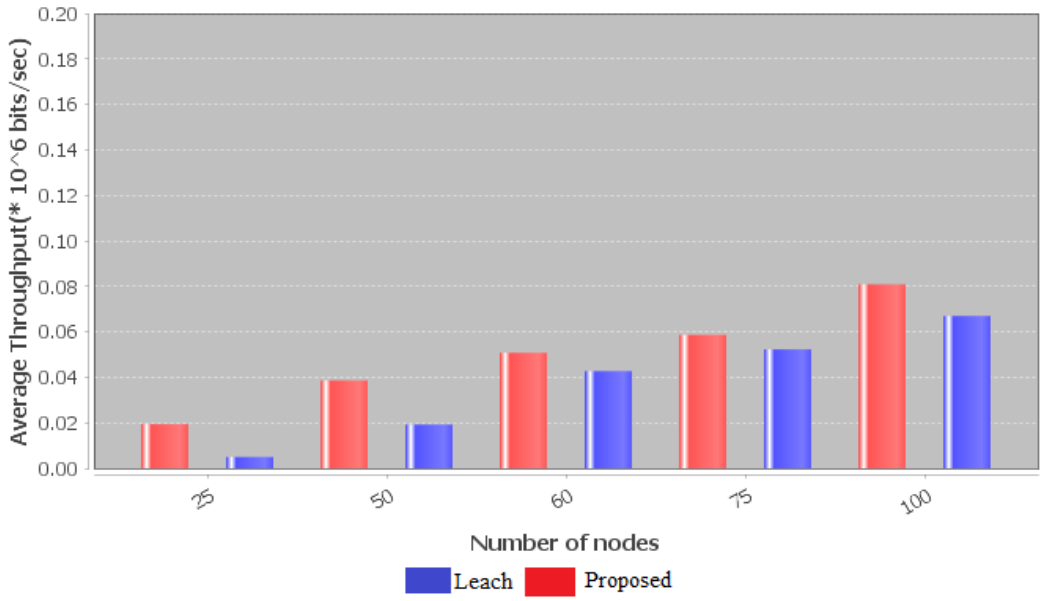

Fig. 4.2 Average throughput graph

Fig 4.2 shows that average throughput of network is improved because proper election of cluster head is performed. At the time of election cluster head distance and residual energy is considered

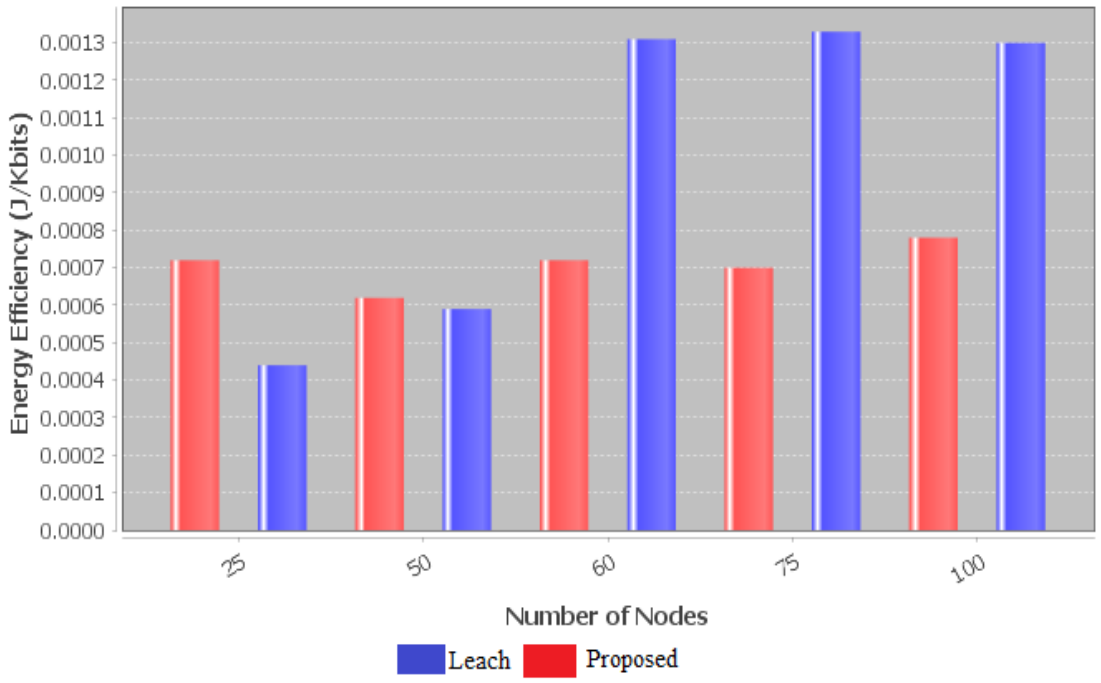

Fig. 4.3 Energy Efficiency graph

Proposer formation of cluster heads improves the network energy consumption show in fig 4.3. We analysis our result by running proposed algorithm for different number of nodes. In leach with increase in number of nodes more clustering needs to be performed. CH just elect on the basis of probability of node to become CH in particular round. But proposed algorithm use GA process to elect cluster heads. GA gives us better probability values than traditional Leach.

Re-clustering process change the cluster heads in each round. Hence different sizes of clusters found with an equal number of nodes. Therefore every cluster head have its own transmission range. Sometime in a particular round CH unable to maintain like with member node due to limited range. In fig 4.4 and fig 4.5 gives the rum time image of cluster formation. In case of fig 4.4 all nodes able to communicate with its CH but in case of fig 4.5 one node is out of range of its cluster head and not able to take participation in data transmission process.

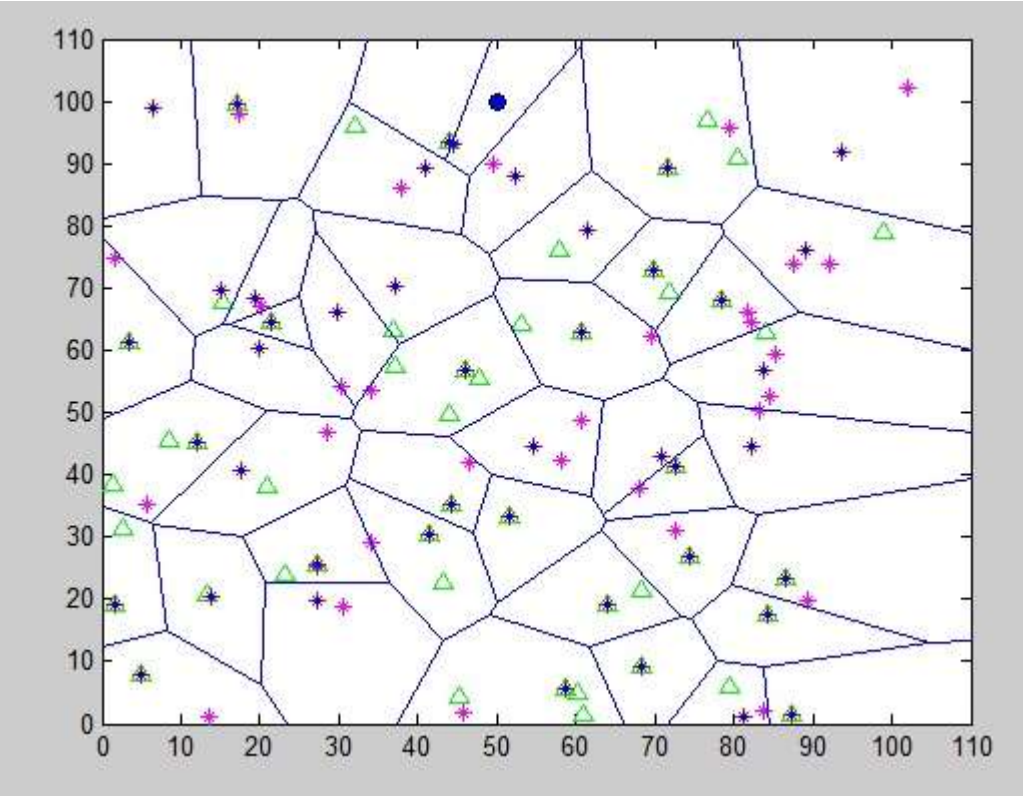

Fig 4.4. Dynamically re-clustering

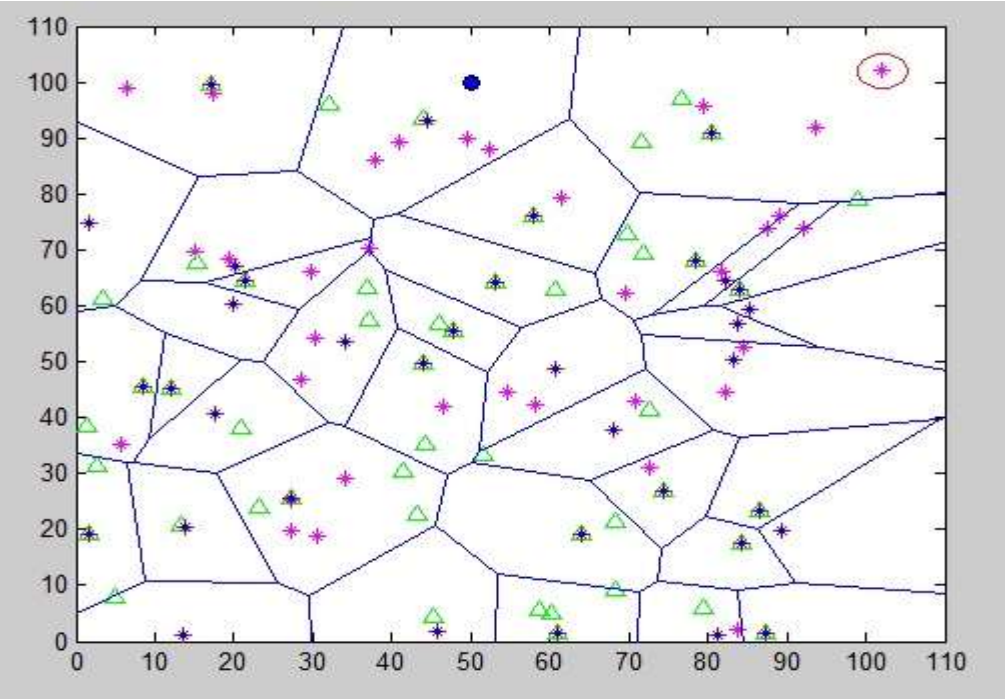

Fig. 4.5 Node out of range from cluster head

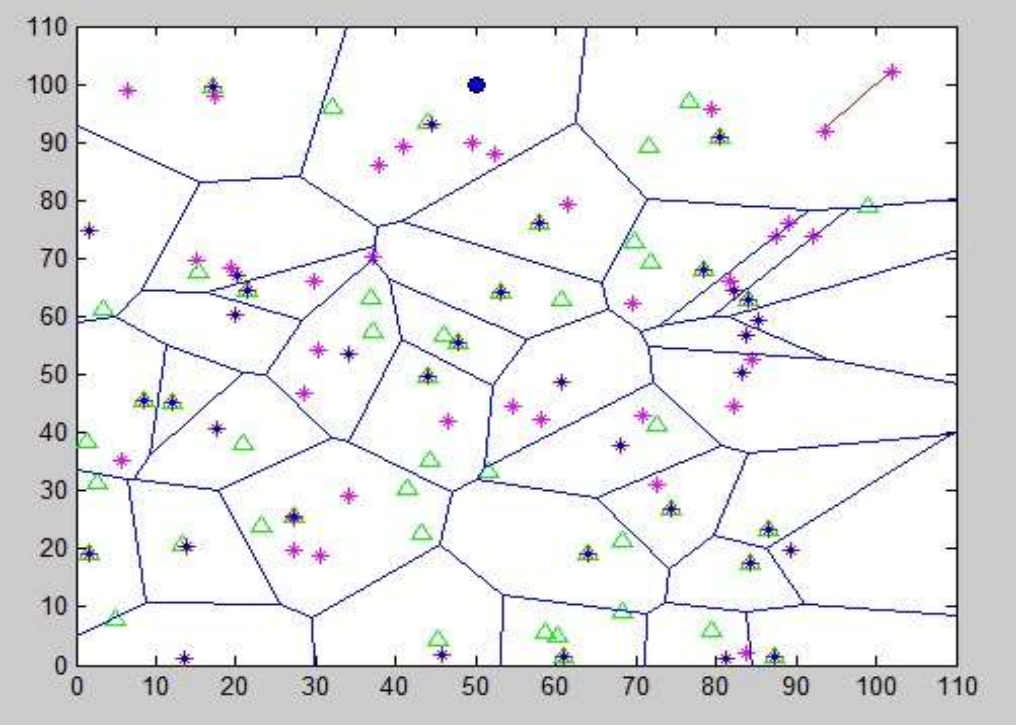

Fig 4. 6 Out of range node connection with nearby node

Proposed approach help us to bind this out of range node with its nearby nodes. Show in fig 4.6. GSA approach is used to create a multi-hop link between nearby node and out of range node.

Chapter 5
Conclusion and Future Scope

The LEACH protocol had some limitations like energy consumption, network life time, out of range sensor nodes, forcefully selection of cluster heads, and load on nodes. These type of limitations degrades the LEACH performance. To improve them a new Energy Efficient Routing Protocol is proposed. We studied number of optimization techniques some are based on local solution other on global solution. The rate of convergence of an algorithm is also a main factor through which we decided which technique we opt to find our solution. Re-clustering process plays vital role in leach protocol. During each round a specific percentage of total nodes are elected as cluster heads. CH elect according to their probability to chosen as CH in particular round. In proposed algorithm we elect cluster heads with the of GA approach. Hence number of parameters are used to make decision.

Nodes are deployed randomly either in uniform or non-uniform fashion .Clusters are not uniformly distributed where some nodes may be placed at the edges of sensor field. Due to this reason their transmission range is limited hence not able to transmit their data to base station. We bind them with other nodes.by gravitational search. GSA gives a global solution and consume less memory as compare to other techniques like ACO, ABC. Its convergence rate is also high. The results proves that proposed algorithm improves the network life span and energy consumption is less as compare to Leach protocol.

In future, we will try to balance the load of cluster heads. Because unequal size of cluster create load among cluster heads. Sometime every less nodes register themselves under any cluster head .To maintain balance between cluster heads a multi-hop approach will be proposed and try to improve the fitness function of GSA

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Appendix

Abbreviations

ACO	Ant Colony Optimization
ADC	Advanced Converters
BS	Base Station
CH	Cluster Head
CPU	Control Processing Unit
ETX	Energy of data transmission
ERX	Energy of data Receiving
G	Gravitational constant
GA	Genetic Algorithm
GPS	Global Position System
GSA	Gravitational Search Algorithm
IP	Internet Protocol
LEACH	Low Energy Adaptive Clustering Hierarchal Protocol
M	Masses of Agents
MCA	Multi Access control
NS2	Network Simulation tool 2
QoS	Quality of services
SA	Simulated Annealing
TSP	Travelling Salesmen Problem
WSNs/WSN	Wireless Sensor networks

Energy Efficient Routing Protocol for Wireless Sensor Network