

A Position Based Energy Efficient Clustering In WSN

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Abstract: Wireless Sensor Network (WSN) consists of several tiny and low-power sensors which use radio frequencies to perform distributed sensing tasks. Minimizing the energy consumed while ensuring the connectivity of a network is an important issue to be addressed in WSNs because the batteries powering the sensors may not be accessible for recharging. Clustering in WSNs is an effective technique for prolonging the network lifetime. In this project, we first propose a clustering technique in WSNs named energy-efficient homogeneous clustering then second part is route optimization technique in clustered WSNs. The first parameter to select the cluster head is an energy-efficient homogeneous clustering periodically selects the cluster heads according to their residual energy and the secondary parameter is the utility of the sensor to its neighbours. A route optimization technique in clustered WSNs among obstacles uses the shortest path algorithm. In this way, the selected cluster heads have equal number of neighbours and residual energy that reduces the average hop count, packet delay and energy-consumption of WSNs.

Keywords: WSN; Energy Efficient Clustering; Homogeneous Clustering

I. INTRODUCTION

A. WIRELESS SENSOR NETWORKS

A wireless sensor network (WSN) consists of sensor nodes capable of collecting information from the environment and communicating with each other via wireless transceivers. The collected data will be delivered to one or more sinks, generally via multi-hop communication. The sensor nodes are typically expected to operate with batteries and are often deployed to not-easily-accessible or hostile environment, sometimes in large quantities. It can be difficult or impossible to replace the batteries of the sensor nodes. On the other hand, the sink is typically rich in energy. Since the sensor energy is the most precious resource in the WSN, efficient utilization of

the energy to prolong the network lifetime has been the focus of much of the research on the WSN. The communications in the WSN has the many-to-one property in that data from a large number of sensor nodes tend to be concentrated into a few sinks. Since multi-hop routing is generally needed for distant sensor nodes from the sinks to save energy, the nodes near a sink can be burdened with relaying a large amount of traffic from other nodes.

Sensor nodes are resource constrained in term of energy, processor and memory and low range communication and bandwidth. Limited battery power is used to operate the sensor nodes and is very difficult to replace or recharge it, when the nodes die. Energy conservation and harvesting increase lifetime of the network. Optimize the communication range and minimize the energy usage, we need to conserve the energy of sensor nodes. Sensor nodes are deployed to gather information and desired that all the nodes works continuously and transmit information as long as possible. This address the lifetime problem in wireless sensor networks. Sensor nodes spend their energy during transmitting the data, receiving and relaying packets. Hence, designing routing algorithms that maximize the life time until the first battery expires is an important consideration. Designing energy aware algorithms increase the lifetime of sensor nodes. There are other objectives like scalable architecture, routing and latency. In most of the applications of wireless sensor networks are envisioned to handled critical scenarios where data retrieval time is critical, i.e., delivering information of each individual node as fast as possible to the base station becomes an important issue. It is important to guarantee that information can be successfully received to the base station.

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance, such networks are used in many industrial and consumer

applications, such as industrial process monitoring and control, machine health monitoring. The WSN is built of nodes from a few to several hundreds or even thousands, where each node is connected to one several sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting.



Figure 1: Wireless Sensor Networks

SINK: A wireless sensor network (WSN) typically consists of a sink node sometimes referred to as a base station and a number of small wireless sensor nodes. The data collected by the sensor nodes are forwarded to a sink node.

BASE STATION: The *base stations* act as a gateway between sensor nodes and the end user as they typically forward data from the WSN to a server.

B. CHARACTERISTICS

The main characteristics of a WSN include

- ✓ Power consumption constrains for nodes using batteries or energy harvesting
- ✓ Ability to cope with node failures
- ✓ Mobility of nodes
- ✓ Communication failures
- ✓ Heterogeneity of nodes
- ✓ Scalability to large scale of deployment
- ✓ Ability to withstand harsh environmental conditions
- ✓ Ease of use
- ✓ Power consumption

C. CLUSTERING IN WIRELESS SENSOR NETWORKS

a. CLUSTERING

Clustering in wireless sensor networks (WSNs) is the process of dividing the nodes of the WSN into groups, where each group agrees on a central node, called the cluster head, which is responsible for gathering the sensory data of all group members, aggregating it and sending it to the base station.

A variety of protocols have been proposed for prolonging the life of WSN and for routing the correct data to the base station. When the battery power at a sensor node expires, the sensor node discontinues its operations in the network.

Therefore, preserving the battery power of the individual sensor nodes is one of the primary concerns. The leader of cluster coordinates the communication among the cluster members and manages their data. Cluster heads randomly and periodically rotate over all the nodes to ensure battery power for all the sensor nodes. Cluster-based routing in WSNs is to achieve the network scalability and management, which maximizes the lifetime of the network by using local collaboration among sensors. In a clustered WSN, every cluster has a cluster head (CH). CHs periodically collect, aggregate, and forward data to the sink. Minimising the energy consumed while ensuring the connectivity of a network is an important issue to be addressed in WSNs because the batteries powering the sensors may not be accessible for recharging often.

D. EHC AND ROT TECHNIQUES

An Energy-efficient Homogeneous Clustering (EHC) technique in WSNs, that selects the CHs to connect a network. EHC is a distributed technique, where sensors make local decisions on whether to join a network as a CH or to a member of a cluster. The decision of each sensor or cluster head is based on their residual energy and its neighbouring CHs. The goal of a route optimization technique is to achieve a path from the source to the sink and also to achieve the goal at a minimum cost, i.e. shortest path in terms of hop counts among obstacles.

E. PROBLEM STATEMENT

The work mainly deals with ensuring the connectivity of network because batteries may not be recharged easily, due to this the network lifetime will also be decreased. In order to improve the life of the network there is a need to introduce a concept called clustering and send the packet information to the node which has higher energy. Thereby the life of the network is increased.

F. SCOPE OF THE PROBLEM

Scope of the project is to prolong the network lifetime through aggregating data at the cluster heads. Clustering methods in WSN lead the sensor nodes to be organized into small disjoint groups, where each cluster has a coordinator referred as CH and sub-coordinator named as gateway (GCH). In this cluster based approach the sensors do not need to communicate directly with BS. Instead, the CHs are responsible to organize cluster members and send the data collected within the cluster to the BS.

G. THESIS

CHAPTER 1: Introduction to the wireless sensor networks, Clustering in WSN, EHC and ROT techniques.

CHAPTER 2: Describes about the literature survey.

CHAPTER 3: Explains about the Position based energy efficient clustering in wireless sensor networks.

CHAPTER 4: Explains the Implementation and testing part

CHAPTER 5: Focuses on the results, analysis and their conclusions.

CHAPTER 6: Explains about Project conclusion and Future work.

II. LITERATURE SURVEY

J.-S. Lee AND W.-L. Cheng [1], proposed a fuzzy-logic-based clustering approach with an extension to the energy predication has been proposed to prolong the lifetime of WSNs by evenly distributing the work load. Fuzzy clustering algorithms use fuzzy logic for blending different clustering parameters to select cluster heads. To overcome the defects of LEACH, authors proposed to use three fuzzy descriptors (residual energy, concentration, and centrality) during the cluster-head selection. In every round, each sensor node forwards its clustering information to the base station at which the CHs are centrally selected. However, this mechanism is a centralized approach. In addition to the residual energy, the expected residual energy (ERE) has been introduced to act as a fuzzy descriptor during the on-line CH selection process. In order to estimate the ERE, the expected energy consumption (EEC) is required. The EEC would be quickly calculated via an off-line trained neural network model. The proposed approach adopts the LEACH architecture with an extension to the energy predication based on the ERE, and thus the approach is named LEACH-ERE. This paper considers network applications in which sensor nodes are deployed randomly in order to continuously monitor the environment.

The information collected by sensor nodes is sent to a base station located outside of the deployment field. Each sensor nodes can operate either in sensing mode to monitor the environment parameters and transmit it to the associated CH or in CH mode to gather data, compress it and forward to the base station. Energy is a major factor in designing WSNs. To achieve the energy efficiency, many clustering algorithms are proposed and LEACH is the representative one. LEACH uses the probability model to distribute the concentrated energy consumption of the CHs. However, it depends on only a probability model and the energy efficiency is not maximized. A fuzzy logic-based clustering approach based on LEACH architecture with an extension to the energy predication has been proposed for WSNs, namely LEACH-ERE. The main objective of algorithm is to prolong the lifetime of the WSN by evenly distributing the workload. To achieve this goal, mostly focused on selecting proper CHs from existent sensor nodes. LEACH-ERE selects the CHs considering expected residual energy of the sensor nodes.

Z. Ha, J. Wu, J. Zhang, L. Liu, and K. Tian [2], proposed a General Self-Organized Tree-Based Energy-Balance routing protocol (GSTEB) which builds a routing tree using a process where, for each round, BS assigns a root node and broadcasts this selection to all sensor nodes. Subsequently, each node selects its parent by considering only itself and its neighbours information, thus making GSTEB a dynamic protocol. In GSTEB the network collects information periodically from a

terrain where each node continually senses the environment and sends the data back to BS. General Self-Organized Tree-Based Energy-Balance routing protocol (GSTEB) which builds a routing tree using a process where, for each round, BS assigns a root node and broadcasts this selection to all sensor nodes. Subsequently, each node selects its parent by considering only itself and its neighbours information, thus making GSTEB a dynamic protocol.

The main aim of GSTEB is to achieve a longer network lifetime for different applications. In each round, BS assigns a root node and broadcasts its ID and its coordinates to all sensor nodes. Then the network computes the path either by transmitting the path information from BS to sensor nodes by having the same tree structure being dynamically and individually built by each node. Therefore a better balanced node is achieved when compared with the protocols mentioned earlier. GSTEB is a self organized protocol it only consumes small amount of energy in each round to change the topography for the purpose of balancing the energy consumption.

M. Tarhani, Y. S. Kaviani, and S. Siavoshi [3], SEECH: Scalable energy efficient clustering hierarchy protocol is designed for hierarchical WSNs. In SEECH, the base station (BS) collects information about the logical structure of the network and residual energy of SN. With these information, BS does efficient clustering. Finally, SEECH is compared with LEACH-C protocol. In hierarchical routing architecture, SNs self configures them for the formation of cluster heads. This protocol is BS assisted i.e. this protocol utilizes a high-energy BS to set up clusters and routing paths, perform randomized rotation of cluster heads, and carry out other energy-intensive tasks. The foundation of SEECH lies in the realization that the BS is a high energy node with a large amount of energy supply. Thus SEECH utilizes the BS to control the coordinated sensing task performed by the SNs. In SEECH the following assumptions are considered.

- ✓ A fixed BS is located far away from the deployment area.
- ✓ The SNs are energy constrained with a uniform initial energy allocation.
- ✓ The SNs are equipped with power control capabilities to vary their transmission range.
- ✓ Each SN senses the environment at a fixed interval and send the sensed data to the BS.
- ✓ All SNs are immobile.

The radio channel is supposed to be symmetrical. Moreover, it is assumed that the communication environment is contention and error free. Each SN has the ability to monitor its residual energy. The SN are geographically grouped into clusters and capable of operating in two basic modes:

- ✓ The cluster head mode
- ✓ The sensing mode

But in SEECH, the base station first collects information about the logical structure of the network and residual energy of each node. With this global information BS does cluster formation better in better way. In WSN, nodes sense the data and send this sensed data to the cluster head (in case of hierarchical routing) or directly to the base station according to the TDMA (time division multiplexing access) given by cluster head or base station respectively. But this TDMA

schedule will be failed if there will no synchronization of the clocks of all the nodes. So this can be another research area where this can be considered. So in future, time synchronization can be applied to SEECH.

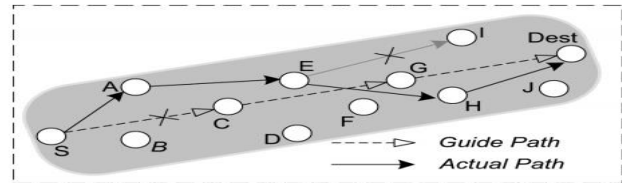
P. T. A. Quang and D.-S. Kim [4], The proposed Enhancing real-time delivery of gradient routing protocol combining on demand Multi hop information based multipath routing (OMLRP) and a gradient based network for achieving optimal path and reduces energy consumption. The network lifetime is prolonged up to 82% when adopting both OMLRP and gradient based network. OMLRP provides the least routing overhead which is most suitable to real time data delivery. In this paper, on demand acquisitions of neighbourhood information is used to find the optimal routing paths that reduce the message exchange overhead. It optimizes the number of hops for packet forwarding to the sink node which gives a better solution for energy consumption and delay. THVR algorithm was introduced to reduce the deadline miss ratio that uses geographic information that provide optimal path to forward packets to the destination. OMLRP offered on demand acquisition of neighbourhood information around data forwarding paths. It reduces the message exchange overhead than THVR. By combining OMLRP and a gradient based network, the optimal path and energy efficiency is achieved. This paper combined these two approaches for achieving optimal reliable routing.

A Gradient-Based Network Setup Gradient Based Network Setup take the minimum hop count and remaining energy of a node while routing data from source node to the sink. The optimal route is established autonomously, the scheme is composed of three sections discussed 1) Gradient setup It can optimize the transmission energy and reduce the energy consumption of each node to prolong the network lifetime. In this sink broadcasts a packet which contains a counter set to 1 initially. After receiving a packet, the receiving node sets its height equal to the counter in the packet and increases the counter by 1, then forwards the packet. 2) Height calculation the sink sets its height to 0. The heights of other nodes are equal to the smallest number of hops to the sink which is reduced the routing overhead because it select the minimum hop to involve the routing. 3) Data forwarding approach each node calculates joint parameters for forwarding the packets to sink. A node compares with its joint parameters to neighbouring nodes and selects a neighbour to relay its packets to the sink.

An energy efficient optimal gradient based routing protocol is proposed which is combination with OMLRP and a gradient based network that is achieved through optimal routing path and reduces energy consumption of sensor nodes. That the EEOGRP used gradient routing and look ahead algorithm within an elliptic region for achieving good performances with respect to energy efficiency and routing overhead compare to other two protocols like OMLRP-4hop and THVR. In addition, the EEOGRP reduced the computational complexity and enhances the energy efficiency of the sensor nodes by selecting optimal path and also provides effective routing that increase network lifetime.

J. Niu, L. Cheng, Y. Gu, L. Shu, and S. K. Das [5], The proposed R3E: Reliable reactive routing enhancement increase

the resilience to link dynamics for WSNs/IWSNs. R3E was designed to enhance existing reactive routing protocols to provide reliable and energy-efficient packet delivery against the unreliable wireless links by utilizing the local path diversity.



Example of the guide path.

Figure 2.1: R3E process in WSN

The source node broadcasts a data packet, which includes the list of forwarding candidates (helper nodes and the downstream guide node) and their priorities. Those candidates follow the assigned priorities to relay the packet. Each candidate, if having received the data packet correctly, will start a timer whose value depends on its priority. The higher the priority, the shorter is the timer value. The candidate whose timer expires will reply with an ACK to notify the sender, as well as to suppress other contenders. Then, it rebroadcasts the data packet toward its downstream link. If no forwarding candidate has successfully received the packet, the sender will retransmit the packet if the retransmission mechanism is enabled.

Disadvantage: Due to data broadcasting there are more node has to work unnecessarily.

H. Lu, J. Li, and M. Guizani [6], Secure and efficient data transmission for cluster-based proposed for Secure and Efficient transmission of data over the network a new protocol called SET has been proposed which is used with the help of IBS and IBOOS scheme. In this scheme time stamp is being added for BS to node and leaf node to CH communication. The SET IBS has a protocol initialisation stage prior network deployment and operating in rounds. The main idea of SET IBS and SET IBOOS is to authenticate the encrypted data which are efficient in key management and applying key management for security.

Initially it is identified that Clustering mechanism in WSN makes it possible for network scalability and hence decrease the energy consumption through aggregation of data. Clustering also enhances the system performance. To the existing protocols SET-IBS and SET-IBOOS made an enhancement in terms of energy consumption and overhead data transmission. The paper also highlights the differentiation among various Cluster based protocols. In order to overcome security threats, Homomorphic encryption and Digital Signature are added to guarantee more security and reduction in computation cost. Added advantage, these two Enhanced protocols can now be used in real time application or sophisticated applications in some context like Military domains and Health sectors.

M. J. Handy, M. Haase, and D. Timmermann [7], The author proposed Low energy adaptive clustering hierarchy with deterministic cluster-head selection for reducing the power consumption of wireless sensor network. The operation of LEACH is divided into rounds. Each of these rounds consists of a set-up and a steady-state phase. During the set-up

phase cluster-heads are determined and the clusters are organized. During the steady-state phase data transfers to the base station occur.

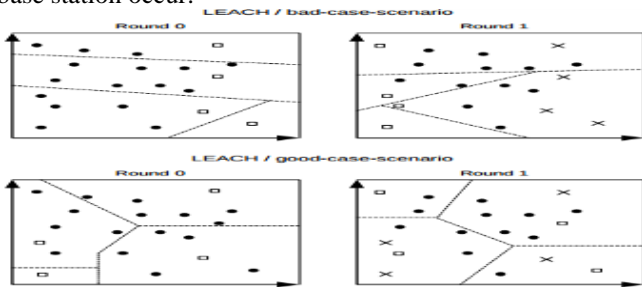


Figure 2.2: LEACH process

LEACH collects data from distributed micro sensors and transmits it to a base station. LEACH uses the following clustering-model: Some of the nodes elect themselves as cluster-heads. These cluster-heads collect sensor data from other nodes in the vicinity and transfer the aggregated data to the base station. Since data transfers to the base station dissipate much energy, the nodes take turns with the transmission – the cluster-heads rotate. This rotation of cluster-heads leads to a balanced energy consumption of all nodes.

Disadvantage: This work cannot provide the maximum life time for network

B. Karp and H. T. Kung [8], GPSR: Greedy Perimeter Stateless Routing for Wireless Networks, the authors proposed the present Greedy Perimeter Stateless Routing, a novel routing protocol for wireless datagram networks that uses the positions of routers and a packet's destination to make packet forwarding decisions. GPSR makes greedy forwarding decisions using only information about a router's immediate neighbours in the network topology.

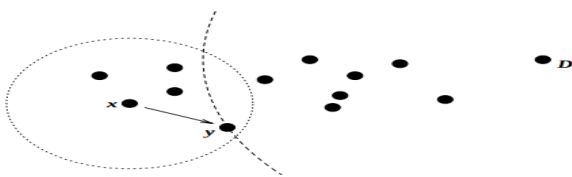


Figure 2.3: GPSR process

Greedy Perimeter Stateless Routing, GPSR, and routing algorithm that use geography to achieve small per-node routing state, small routing protocol message complexity, and extremely robust packet delivery on densely deployed wireless networks. GPSR generates routing protocol traffic in a quantity independent of the length of the routes through the network, and therefore generates a constant, low volume of routing protocol messages as mobility increases, yet doesn't suffer from decreased robustness in finding routes.

III. A POSITION BASED ENERGY EFFICIENT CLUSTERING IN WIRELESS SENSOR NETWORKS

A. CLUSTERING IN WIRELESS SENSOR NETWORKS

Energy efficient homogeneous clustering prolongs the lifetime of sensor networks. Energy efficient Homogeneous

Clustering (EHC) is used which selects the Cluster Head (CH) among the cluster based on the value of residual energy and utility of sensor to its neighbour. In a clustered WSN, every cluster has a cluster head (CH). EHC technique in WSNs, selects the CHs to create a connected network. Where sensors make local decisions on whether to join a backbone network as a CH or to a member of a cluster. The decision of each sensor is based on their residual energy and an estimate of how many of its neighbouring CHs will benefit from it being a CH. CHs periodically collect, aggregate, and forward data to the sink.

We propose a Route Optimization Technique (ROT) in clustered WSNs among obstacles. ROT forms an energy-efficient path between the CHs selected by EHC technique and the sink. ROT uses Dijkstra's shortest path algorithm. Using these techniques energy consumption and hop count are reduced and they are also used to improve the network lifetime.

B. LOCAL MINIMUM PROBLEM

Several geographical routing protocols have been proposed in recent years to address the local minimum problem in WSNs. Most of the existing solutions for the local minimum problem use perimeter routing technique (PRT). By the PRT, when greedy forwarding fails at a local minimum, i.e., no neighbours closer to the sink, packets tend to be routed along the hole boundaries. The Greedy Perimeter Stateless Routing (GPSR) uses greedy forwarding and switches to perimeter routing mode when a local minimum problem is reached. The right-hand rule is used in the perimeter routing mode, where packets are forwarded along the edge counter clockwise on the face of a planar graph. In WSNs, packets are typically routed from sensors to a sink. When a sensor recognizes itself as a local minimum, it asks its neighbour sensors to mark itself as a hole sensor. Data packets are sent to non-hole sensors when possible.

Hole Bypassing Forwarding (HBF) protocol address the hole diffusion problem in WSNs. The HBF protocol models a hole using a virtual circle whose radius is adjustable within a certain range and is calculated on a per-packet basis. The information associated with the virtual circle is used for selecting an anchor point to bypass the hole in order for a packet to reach a particular sink sensor. Nguyen et al. presented a novel routing protocol named Greedy Forwarding with Virtual Destination (GFVD) strategy. The basic idea is that during the transmission of a packet, a new destination called virtual destination is put in place when the packet is forwarded to a stuck sensor. The abstracted holes protocol uses a distributed convex hull algorithm to achieve a constant path stretch with lower communication and storage overhead.

C. ROUTING IN A CLUSTERED WSN

In wireless sensor networks, building efficient and scalable protocols is a very challenging task due to the limited resources and the high scale and dynamics. Geographic protocols, that take advantage of the location information of nodes, are very valuable for sensor networks. Geographic

routing is a routing principle that relies on geographic position information. It is mainly proposed for wireless networks and based on the idea that the source sends a message to the geographic location of the destination instead of using the network address.

Wireless Sensor Network originated as a battlefield surveillance application. Earlier routing protocols did not require point to point communication. Nowadays, the field has been growing with new potential in industrial, health and other monitoring applications and so is the need for more efficient routing algorithms. Wireless sensors have limited memory and they are battery-powered when deployed in the real world. Hence, memory and power consumption are the two typical challenges faced by wireless sensor network programmers. For data-centric point to point wireless sensor network applications efficient routing of data packets is a challenge. Geographic routing algorithms have been proposed for wireless sensors to effectively address this issue. Geographic routing protocols scale better for ad hoc networks mainly for two reasons:

- ✓ There is no necessity to keep routing tables up-to-date and
- ✓ No need to have a global view of the network topology and its changes.

Therefore, geographic routing protocols have attracted a lot of attention in the field of routing protocols.

a. NETWORK MODEL

Sensor nodes are randomly distributed in the sensing field. In wireless sensor network the nodes are static and fixed. The sensor nodes sense the information and then send to the server. If the source node sends the packet, it will send through the intermediate node. The nodes communicate only within the communication range. So, we have to find the node's communication range.

A network consists of N sensors, deployed at random uniformly in a FoI among obstacles. The sensors are stationary and powered by the batteries. We assume the binary disc communication model in which a sensor, denoted by s , can communicate with other sensors within the disc of radius C centered at s , denoted by $A(s,C)$, where $|A(s,C)| = \pi C^2$. Thus, C denotes the communication range of s . Two sensors i and j can communicate with each other directly and are known as neighbours if the Euclidean distance between them is not more than C . The number of neighbouring CHs of a CH is said to be the CH degree. In this paper, the lifetime of WSNs is the time from the start of the network operation to the death of the first sensor in the network. The lifetime of WSNs is divided into rounds to balance the energy consumption among sensors. Each round consists of two phases: decision phase and working phase. At the beginning of a round, all sensors participate in the decision phase to form a clustered WSN using the EHC technique. In the working phase, the sensory data from the sensors in a cluster are transmitted directly to their CH which then aggregates and forwards data to other CHs, which en-route to the sink using ROT.

D. ENERGY - EFFICIENT HOMOGENEOUS CLUSTERING

Clustering (EHC) technique in WSNs that selects the CHs to create a connected backbone network. EHC is a distributed technique, where sensors make local decisions on whether to join a backbone network as a CH or to a member of a cluster. The decision of each sensor is based on their residual energy and an estimate of how many of its neighbouring CHs will benefit from it being a CH. We give a distributed technique where CHs rotate with time, demonstrating how localized sensor decisions lead to a homogeneous connected global topology. The sensor which has the highest value of the residual energy becomes the CH. During the reformation of clusters, the cluster head is changed along with the members affiliated to it. Clustering provides resource utilization and minimizes energy consumption in WSNs by reducing the number of sensor nodes that take part in long distance transmission. In WSN the primary concern is the energy efficiency in order to extend the utility of the network. In this section, we first propose EHC technique and then describe its properties.

- ✓ EHC Description: EHC works in the following two steps to form a clustered WSN:

a. INITIAL CLUSTER HEAD ELECTION

The goal of this step is to elect the CHs in a distributed manner. Let P be the probability that the expected number of CH-candidates for a round is k of N sensors in ψ . The probability that there are at least one CH-candidate in the region $A(i,C)1-e^{-k|A(i,c)|/|\psi|}$ is with high probability. The probability P is therefore given by

$$P = k/N, \text{ where } 1 - e^{-k|A(i,c)|/|\psi|} \geq 0.99 \geq 1,46|\psi|NC^2 \quad (1)$$

The probability P is either stored in each sensor off-line or can be sent by the base station initially at the time of deployment. At the beginning of each round, sensor i picks a random number in $(0, 1)$. If the random number is less than P , then sensor i is a CH-candidate. With this mechanism, approximately k of N sensors are elected as CH-candidates. The random number does not depend on the previous round. Note that if a sensor i elects to become a CH-candidate, i broadcasts an advertisement message $CH_{adv}(i, E_i, n_i)$ to inform other sensors of its availability, where E_i and n_i are the residual energy and the list of neighbouring CHs of irrespectively. Advertisement contention occurs when multiple CH-candidates advertise at the same time. To resolve the contention, we use a randomized back-off delay. The randomized back-off delay for a CH-candidate i is denoted by

$$\text{Delay}_{i} = (E_{init} - E_i / E_{init} + R) \times T \quad (2)$$

where E_{init} , R , and T are the initial energy of sensors, a random number in $(0, 1)$, and the round-trip delay for a small control packet, respectively. The randomized back-off delay assures that a CH-candidate with higher residual energy among its neighbours will have higher probability to become a CH. The choice of delay_{i} is a reasonable method for evenly consumption of energy of the sensors while preventing additional overhead. The CHs elected in this step are denoted

by Initial CHs (ICHs). The pseudo code for initial cluster head election is given by Procedure 1.

Procedure 1: Initial Cluster Head Election

Input: $i, N, C, E_{init}, E_i, T, |\Psi|$;

Output: ICH, p, n_i ;

Step1: Set $n_i \leftarrow \{\phi\}$;

Step2: Set $n_{min} \leftarrow 100$;

Step3: Set $p \leftarrow \{\phi\}$;

Step4: Pick random numbers R and R_1 in $(0,1)$;

Step5: if $P \leq R_1$ and expire of $delay_{i1}$ and $n_i = \phi$ then

Step6: Broadcast a $C_{adve}(i, E_i, n_i)$ message;

Step7: if receive $C_{adve}(j, E_j, n_j)$ message from ICH j then

Step8: Add ICH j in neighbour list n_i ;

Step9: if $|n_j| \leq n_{min}$ then

Step10: $n_{min} \leftarrow n_j$ and $p \leftarrow j$;

b. CONNECTED NETWORK FORMATION

We elect more CHs to ensure that the CHs can form a connected network, since ICHs are not connected. A Non-Cluster Head sensor (NCH) is elected as a CH, denoted by Gateway CH (GCH), if two or more neighbouring ICHs are not connected. In the rest of the paper, a CH represents either a GCH or ICH. Preference is given to the NCHs which have higher amount of residual energy and maximum number of neighbouring CHs. Lemma 1 shows that a NCH has maximum five neighbouring ICHs. We estimate the randomized back-off delay to resolve the advertisement contention for selecting GCHs. The randomized back-off delay for a NCH i is denoted by

$$delay_{2i} = (E_{init} - E_i/E_{init} + 5 - |n_i|/5 + R) \times |n_i| T \quad (3)$$

Thus, a NCH with the higher residual energy and a number of neighbouring ICHs will be elected as a GCH with high probability among neighbouring GCH-candidates.

If a NCH I wants to associate with a CH j , where j has a minimum CH degree in n_i , i sends an associate message (denoted by $Casso(j, i, n_i)$) to j and receives a subsequent confirmation message (denoted by $Cconf(i, j, n_j)$) from j . A NCH updates information of neighbour i whenever it receives $Cconf(j, i, n_i)$ message from i . The pseudo code of this step is given by Procedure 2.

c. PROPERTIES OF EHC TECHNIQUE

First property of a clustered WSN is that all sensors are clustered. Line 10 in Procedure 2 illustrates that an isolated sensor will become a CH. Therefore, each sensor in WSN is either a CH or a member of a cluster. All CHs are connected is the second property of connected WSNs. Line 14 in Procedure 2 shows that if a sensor has two or more neighbouring ICHs, which are not connected, the sensor will become a GCH. Third property in a connected clustered WSN is that each NCH has exact one CH. Line 17 in Procedure 2 describes that each NCH allows to associate with only one CH.

Procedure 2: Connected Network Formation

Input: $i, p, n_i, N, C, E_{init}, E_i$;

Output: GCH;

Step1: if i is a CH then

Step2: if receive $Casso(i, j, n_j)$ message from a NCH j then

Step3: Send $Cconf(j, i, n_i)$ message to j ;

Step4: if receive $Cadve(j, E_j, n_j)$ message from a GCH j then

Step5: Add j in neighbor list n_i ;

Step6: Send $Cconf(j, i, n_i)$ message to j ;

Step7: else

Step8: if expire of $delay_{2i}$ then

Step9: if $|n_i| = 0$ then

Step10: Broadcast $Cadve(i, E_i, n_i)$;

Step11: else if $n_i = 1$ then

Step12: Send $Casso(j, i, n_i)$ to a CH $j \in n_i$;

Step13: else

Step14: if CHs in n_i are not connected then

Step15: Broadcast $Cadve(i, E_i, n_i)$;

Step16: else

Step17: Send $Casso(p, i, n_i)$ message to $p, p \in n_i$;

Step18: else

Step19: if receive $Cadve(j, E_j, n_j)$ or $Cconf(l, j, n_j)$ then

Step20: Add CH j in neighbour list n_i ;

Step21: if $|n_j| \leq n_{min}$ then

Step22: $p \leftarrow j$ and $n_{min} \leftarrow n_j$;

Maximum degree of a CH in EHC is eleven. Procedure 1 shows that ICHs are not directly connected with each other. The degree of a ICH is therefore the number of neighbouring GCHs. Consider a GCH M as shown in Fig. 1(a). We assume the ICHs Q and R are not connected. The Euclidean distances between M and Q , M and R , and Q and R are denoted by c, b , and a , respectively. If M is connected with Q and R , then $0 \leq \{b, c\} \leq C < a$. To estimate the maximum number of ICHs surrounding M , we take the minimum value of the angle $\angle RMQ = \cos^{-1}(b^2 + c^2 - a^2/2bc)$. Substituting a, b , and c , the angle $\angle RMQ > \pi/3$, i.e., the maximum number of neighbouring GCHs of a ICH is five.



Figure 3.1: CH and ICH communication

The maximum degree of a GCH is the number of neighbouring CHs. Fig. 1(b) shows a scenario where ICHs P, Q , and R are not connected. We assume the Euclidean distances between P and Q , P and R , and Q and R are denoted by c, b , and a , respectively. If GCHs M and N are connected with P, Q and P, R , respectively, then $0 \leq \{b, c\} \leq 2C < a$. To estimate the maximum number of GCHs surrounding P , we take the minimum value of the angle

$\angle RPQ = \cos^{-1}(b^2 + c^2 - a^2/2bc)$. For $0 \leq \{b, c\} \leq 2C < a$, the angle $\angle RPQ > \pi/6$, i.e. The maximum number of neighbouring CHs of a GCHs is therefore eleven. The maximum degree of a CH is therefore eleven.

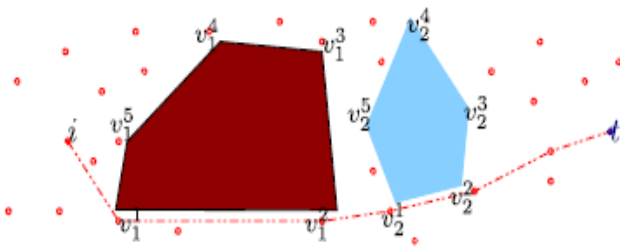


Figure 3.2: ROT process

- Step5: Apply DSP algorithm on the SP as Ids;
- Step6: Send data to the next ID using GF;
- Step7: else
- Step8: Send data to t using GF;
- Step9: else
- Step10: Send data to t using GF;

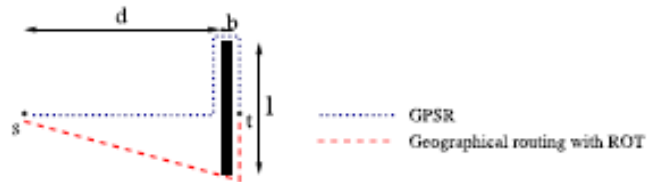


Figure 3.3: Geographic routing with ROT and GPSR

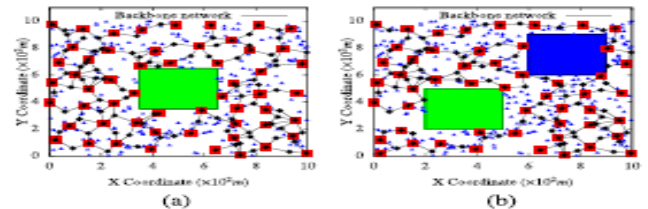


Figure 3.4: Clustered WSN among obstacles

E. ROUTE OPTIMIZATION TECHNIQUE (ROT)

The goal of a route optimization technique is to achieve a path from the source to the sink but we also want to achieve the goal at a minimum cost, i.e. shortest path in terms of hop counts among obstacles. Most of the literature on routing in WSNs does not have any special treatment for the obstacles in a FoI. ROT in clustered WSNs that optimizes the path length during data transmission without any extra overhead. We consider m obstacles in $_$, where $m \geq 0$. Each sensor knows about its location. Let view-vertices $V = \cup_{i=1}^m V_i$, where $V_i = \cup_{j=1}^n v_j^i$ is a set of view-vertices of an obstacle i , $1 \leq i \leq m$ and $n > 0$. The view-vertices of all the obstacles are stored in each sensor initially at the time of deployment or can be updated by the sink.

a. ROT DESCRIPTION

In the early phase of ROT, a backbone network is constructed using the proposed EHC, where a sensor is a CH or a member of a cluster. Consider a source CH i and a sink t . Before I send data to the sink t , it identifies the obstacles between t and itself. If there is no obstacle, I forward data to t using geographic forwarding (GF). Otherwise i finds a shorter path (SP) to t , denoted by $i \rightarrow t$, through the view vertices of obstacles using Dijkstra's shortest path (DSP) algorithm. i sets the view-vertices along SP as the intermediate destinations (IDs). When data reach the nearest CH of a ID, denoted by j , ROT reruns between j and t to find a new SP. The pseudo code of ROT is described in Procedure 3.

b. PROPERTY OF ROT

Due to the obstacles in the FoI, the path generated in the literature can deviate far from the shortest path. The Euclidean distance between source i and sink t is $d + b$. A $b \times l$ rectangular shaped obstacle separates i and t such that t is behind the obstacle. The path shrink reduces the energy consumption during routing the sensory data and therefore prolongs the life time of WSNs, stability, and delay.

Procedure 3: Route Optimization Technique

Input: clustered wsn, v_i^j, v_j^i ;

Output: SP;

Step1: if i is a source then

Step2: Set $|ID| \leftarrow \{\phi\}$ and send data to the associate

CH;

Step3: else if i is the nearest CH to ID or $|ID| = \phi$ then

Step4: if there exist obstacles for it then

The following experiments conducted with ns 2.34 simulator to illustrate the motivation of ROT. An obstacle of size $300m \times 300m$ is located at $(500, 500)$ as shown in Fig.4(a). The average path length using GPSR on EHC is 21 hops and GPSR on ROT and EHC is 17 hops. The path shrink is therefore 19.04%. Similarly, the path shrink is 21% when two obstacles are located in the FoI as shown in Fig. 4(b).

F. PARAMETERS OF CLUSTERED WSN

- ✓ **AVERAGE HOP COUNT:** The hop count refers to the number of intermediate devices through which data must pass between source and destination. Each time packets are passed to the next device, a hop occurs. Hop count is therefore a basic measurement of distance in a network.
- ✓ **ENERGY CONSUMPTION:** Energy consumption means consumption in energy or power. It can be concluded that when EHC is not used, all the sensors remain active to provide the routing for a short duration. This is because a geographical routing without route optimization technique requires more number of the average hop count for routing the packets.
- ✓ **PACKET DELIVERY RATIO:** The packet delivery ratio of a flow is the ratio of the number of packets that are received by the sink over packets submitted to the network by the source.
- ✓ **DELAY:** Delay is the measurement of the time for the packet to reach its destination beyond the described time.
- ✓ **LIFETIME:** In EHC, only CHs remain active to provide the routing and therefore prolongs the lifetime of WSNs. Power consumption should be minimized since it determine the lifetime of network.

IV. IMPLEMENTATION AND TESTING

This chapter explains about the implementation part and testing.

A. HARDWARE AND SOFTWARE REQUIREMENTS

a. HARDWARE REQUIREMENTS

System	:	Pentium IV a pair of 4 GHz
Hard Disk	:	20 GB
Monitor	:	15 VGA colour
RAM	:	256 MB

b. SOFTWARE REQUIREMENTS

Tools	:	network simulator version-2
Os	:	Linux
Languages	:	C++
Front End	:	TCL (Tool Command Language)

B. INTRODUCTION REGARDING NS2

We implemented DIDRIP protocol in Network Simulator (Version 2), widely called as NS2, is solely an occasion driven simulation tool that is used in learning the dynamic behavior of wireless and wired networks. Simulation of wired, wireless network functions and protocols (e.g. routing algorithms, TCP, UDP) may be done in NS2. In general, NS2 provides users with the simplest way of specifying such routing protocols and simulating their corresponding working models. Due to its flexibility and standard nature, NS2 has gained constant quality within the networking analysis community since its birth in 1989. There are two programming languages used in NS2. One is OTCL and another one is C++. C++ is used for detailed protocol implementation and in general for such cases where every packet of a flow has to be processed. For instance, if we want to implement a new queuing discipline, then C++ is the language of choice than OTCL, on the other hand, it is suitable for configuration and setup. OTCL runs quite slowly, but it can be changed very quickly making the construction of simulations easier. In ns2, the compiled C++ objects can be made available to the OTCL interpreter. The simulator supports a class hierarchy in C++ (the compiled hierarchy) and a corresponding hierarchy within the OTCL interpreter (interpreted hierarchy). We use object oriented tool command language as front end language or simply to write programs to generate a network scenario. One of the reasons is that it is simple and easy to code.

a. SIMULATION APPROACH

Simulation is a process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behaviour of the system and/or evaluating various strategies for the operation of the system.

Simulation is widely-used in system modelling for applications ranging from engineering research, business analysis, manufacturing planning, and biological science experimentation, just to name a few. Compared to analytical modelling, simulation usually requires less abstraction in the model (i.e., fewer simplifying assumptions) since almost every possible detail of the specifications of the system can be put into the simulation model to best describe the actual system. When the system is rather large and complex, a straightforward mathematical formulation may not be feasible. In this case, the simulation approach is usually preferred.

b. MOTIVATION FOR SIMULATIONS

- ✓ Complex eventualities may be simply tested
- ✓ Cheap doesn't need expensive instrumentation
- ✓ Results may be quickly obtained
- ✓ Various types of ideas can be tested in exceedingly smaller time duration
- ✓ Controlled experimental conditions can be verified
- ✓ Debugging is very simple.

c. NS2 PROGRAMMING STRUCTURE

- ✓ Network simulator is used to
- ✓ Create the event hardware
- ✓ Turn on tracing
- ✓ Create network topography
- ✓ Create transport connections
- ✓ Generate traffic
- ✓ Test errors
- ✓ Create the event hardware

d. INSTALLATION OF NS2

Installation of Ns2 has following steps. First we need to install ubuntu 10.04, and then update all the things in that. How to update means go to the top menu, system-Administration-update manager

Step: 1

-Open the terminal. For this Go to Application-Accessories-Terminal (or press Ctrl+alt+T)

-Then paste the following command

sudo apt-get install build-essential autoconf automake libxmu-dev gcc-4.3

Step: 2

Then u need to some files. So For this, open the Ns-allinone2.34 folder on the desktop, in that open folder OTCL1.13. In that folder, u need to modify the following files.

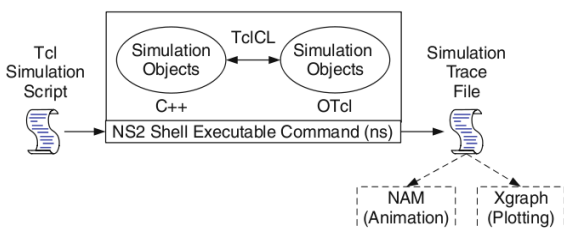


Figure 4.1: NS2 Structure

✓ *MODIFY MAKEFILE.IN FILE*

In this file, u need to replace CC= @CC@
With CC= gcc-4.3
To replace this press ctrl+H.
Then save the document.

✓ *MODIFY CONFIGURING AND CONFIGURE FILES*

In these two files u need to modify. Means u need to replace ld -shared with gcc -shared. For replacing ctrl+H then one dialog box will come. Then save the document.

Step: 3

Open the ns-allinone2.34 folder which is present on the desktop,

Then press ctrl+L. Then copy the path on the address bar.

Step: 4

Then open Terminal and do the following.

Type \$cd "paste the path here" without quotes and press enter.

Then

Type ./install

Then wait for some time, finally if successfully installed, it will display a message as "for Related Posts". Otherwise some problems might have occurred.

Step: 5

Then execute the following command in the Terminal

```
$ gedit ~/.bashrc
```

Then one document will be opened automatically.

Then delete all the content in that document and paste the following code in it.

```
# LD_LIBRARY_PATH
```

```
OTCL_LIB=/home/programmer/ns-allinone-2.33/otcl-
```

1.13

```
NS2_LIB=/home/programmer/ns-allinone-2.33/lib
```

```
X11_LIB=/usr/X11R6/lib
```

```
USR_LOCAL_LIB=/usr/local/lib
```

```
export
```

```
LD_LIBRARY_PATH=$LD_LIBRARY_PATH:$OTCL_LI
```

```
B:$NS2_LIB
```

```
:$X11_LIB:$USR_LOCAL_LIB
```

```
# TCL_LIBRARY
```

```
TCL_LIB=/home/programmer/ns-allinone-
```

```
2.33/tcl8.4.18/library
```

```
USR_LIB=/usr/lib
```

```
export TCL_LIBRARY=$TCL_LIB:$USR_LIB
```

```
# PATH
```

```
XGRAPH=/home/programmer/ns-allinone-
```

```
2.33/bin:/home/programmer/ns-allinone-
```

```
2.33/tcl8.4.18/unix:/home/programmer/ns-allinone-
```

```
2.33/tk8.4.18/unix:/home/programmer/ns-allinone-
```

```
2.33/xgraph-12.1/
```

```
NS=/home/programmer/ns-allinone-2.33/ns-2.33/
```

```
NAM=/home/programmer/ns-allinone-2.33/nam-1.13/
```

```
export PATH=$PATH:$XGRAPH:$NS:$NAM
```

Then after doing this, press Ctrl+H and replace the following.

```
/home/programmer/ns-allinone-2.33
```

Replace this with

```
/home/your system name/Desktop/ns-allinone-2.34
```

And in that document, at the 2nd line from the last, put 1.14 instead of 1.13

And at the 3rd line from the last, make the change as ns-2.34 instead of ns-2.33

Then save the document and close it.

Step: 6

Then finally copy the following command into the Terminal

```
"sudo ln -s /home/programmer/ns-allinone-2.33/ns-2.33/ns/usr/bin/ns"
```

After pasting it into the Terminal, just make the following modifications and then press Enter.

Make 2.33 as 2.34

And in the place of "programmer" in that command, just type your system name. Then the command should be like this.

```
"sudo ln -s /home/ur system name/Desktop/ns-allinone-2.34/ns- 2.34/ns/usr/bin/ns"
```

Then press Enter.

It will ask for password, enter the password.

Step: 7

Then finally type "ns" in the Terminal and press Enter.

Then "%" symbol will be displayed.

Then it was successfully installed. Otherwise some problems might have occurred in the installation process.

Step: 8

Then finally execute the following command in the Terminal

```
Type "sudo apt-get install xgraph" and press enter.
```

It shows finished installing Network Simulator.

CREATING THE TOPOLOGY

To be able to run a simulation scenario, a network topology must first be created. In ns2, the topology consists of a collection of nodes and links and it is wireless mesh topology.

Before the topology can be set up, a new simulator object must be created at the beginning of the script with the command:

```
Set ns [new Simulator]
```

The simulator object has member functions that enable creating the nodes and the links, connecting agents etc. All these basic functions can be found from the class Simulator. When using functions belonging to this class, the command begins with "\$ns", since ns was defined to be a handle to the Simulator object Nodes.

CREATING NODES

New node objects can be created with the command:

```
set n0 [$ns node]
```

```
set n1 [$ns node]
```

```
set n2 [$ns node]
```

```
set n3 [$ns node]
```

The member function of the Simulator class, called "node" creates four nodes and assigns them to the handles n0,

n1, n2 and n3. These handles can later be used when referring to the nodes.

The network simulator machine is an event-driven machine. There are presently four schedulers on the market within the machine, every one of that is enforced and employing a totally different information structure: an easy linked-list, heap, calendar queue (default), and a special kind known as “real-time”.

For tracing information or to get the output in NS2 two temporary files are generated in NS2. They are nam file and trace file. Nam file is employed to store the temporary information regarding nam window, and trace file is employed to trace the network surroundings.

V. RESULTS

We have tested our simulation output with NS2 simulator and we got a two type of results, one is NAM, and X graph. We compared the results by using GPSR, EHC and ROT techniques, and TREE-BASED Protocols.

In order to evaluate the GPSR, EHC and ROT techniques, and TREE-BASED methods the network setup was executed by increasing the range between nodes i.e.130, 150, 180, 210 and 250 nodes.

The number of nodes considered for evaluation purpose is mentioned below by considering different cases.

Case 1: Considering the nodes in WSN with 130mts coverage area

Case 2: Considering the nodes in WSN with 150mts coverage area

Case 3: Considering the nodes in WSN with 180mts coverage area

Case 4: Considering the nodes in WSN with 210mts coverage area

Case 5: Considering the nodes in WSN with 250mts coverage area

Case 6: Comparison of graphs by considering coverage area with 130, 150, 180, 210 and 250.

On each case for each of the protocol in GPSR, EHC and ROT techniques, and TREE-BASED methods the performance of each protocol was executed with respect to the following parameters.

PACKET DELIVERY FRACTION: This is defined as the ratio of the number of packets received at the destination and the number of packets sent by the source.

DELAY: This is defined as the average time taken for a packet to be transmitted from the source to the destination

HOP COUNT: The hop count refers to the number of intermediate devices through which data must pass between source and destination. Each time packets are passed to the next device, a hop occurs. Hop count is therefore a basic measurement of distance in a network.

ENERGY: Energy consumption means consumption in energy or power. It can be concluded that when EHC is not used, all the sensors remain active to provide the routing for a short duration. This is because a geographical routing without route optimization technique requires more number of the average hop count for routing the packets.

And finally overall picture of performance of each protocol is depleted considering all cases respectively in case 6.

A. OVERVIEW

The number of nodes which taken by the different coverage areas.

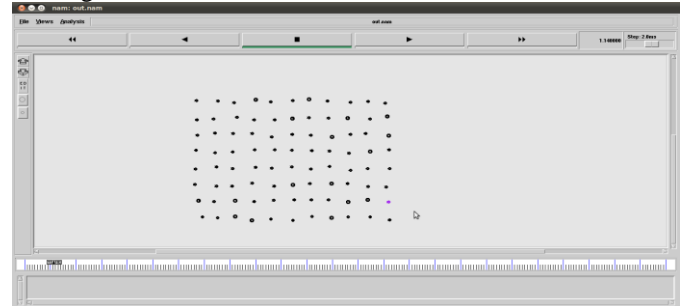


Figure 5.1: Initial nodes setup

The above figure represents the basic deployment of sensor nodes with source and destination by the coverage areas. In the figure purple colour node represents the destination, the black colour nodes represent the sensor nodes.

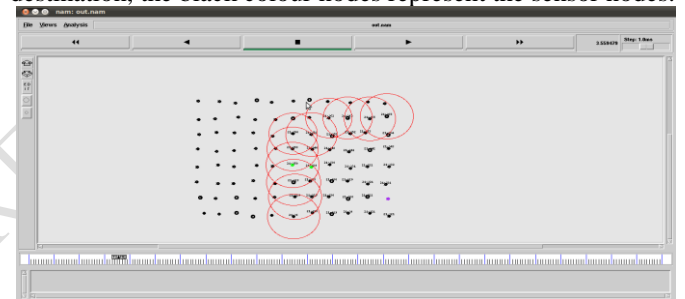


Figure 5.2: Initial message sharing to every node in GPSR method

In the above figure Hello message is sharing. By sharing the message only the nodes can know whether the neighbour nodes are working or not and the availability of base station.

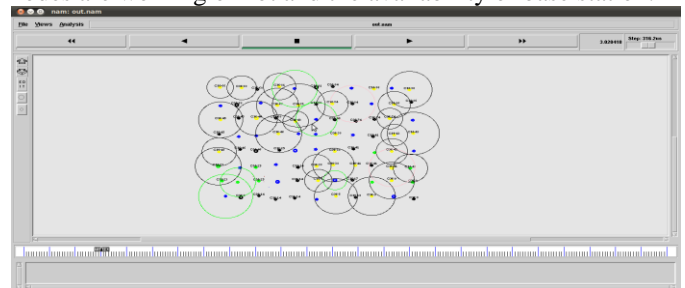


Figure 5.3: Initial message sharing to every node in EHC and ROT

In the above figure Hello message is sharing. By sharing the message only the nodes can know whether the neighbour nodes are working or not and the availability of base station.

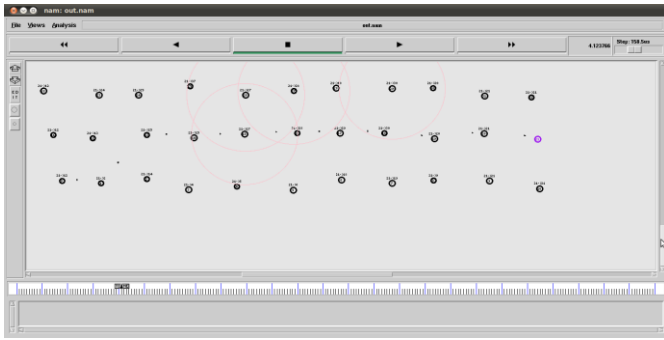


Figure 5.4: Data transferred by considering GPSR method

The above figure represents that what are the nodes neighbour or near to destination through that communication process will happen and the packets are transferred from source to destination. If no failure occurs, this method is the best one.

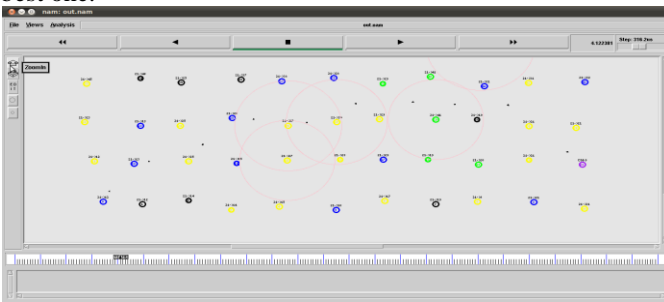


Figure 5.5: Data transferred by considering EHC and ROT technique

The above figure represents that what are the nodes neighbour or near to destination through that communication process will happen through that the packets are transferred from source to destination. If no failure occurs, this method is the best one. It provides less hop count and gives high performance.

In the above figure the Blue colour nodes represents Cluster heads and the Yellow colour represents the Gateway CHs. The green colour nodes represents the nodes participating in information collection.

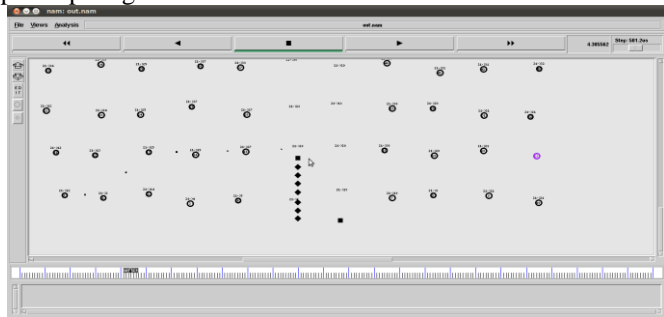


Figure 5.6: Loss of packets in GPSR method

The above figure shows the route is failed and the obstacle is occurred. By the failure of nodes the data loss is occurred.

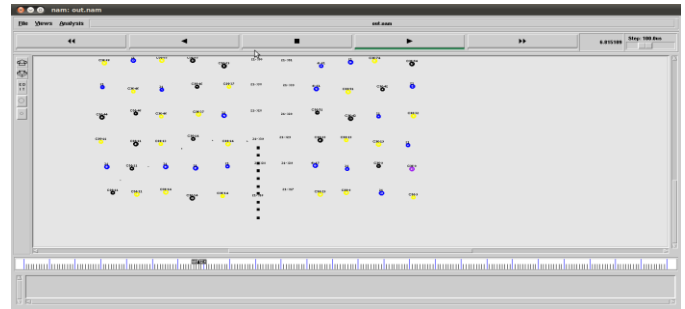


Figure 5.7: Loss of packets in EHC and ROT technique

The above figure represents the route is failed and the obstacle is occurred. By the failure of nodes the data loss is occurred.

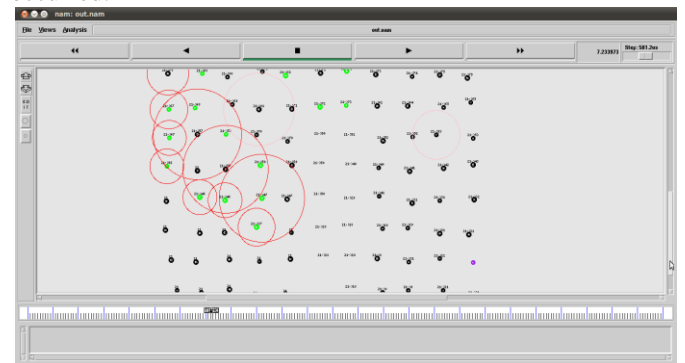


Figure 5.8: Resetting data in GPSR method

In the above figure it identifies the failure by sharing the message and it resets the data and has to send by choosing the alternate path.

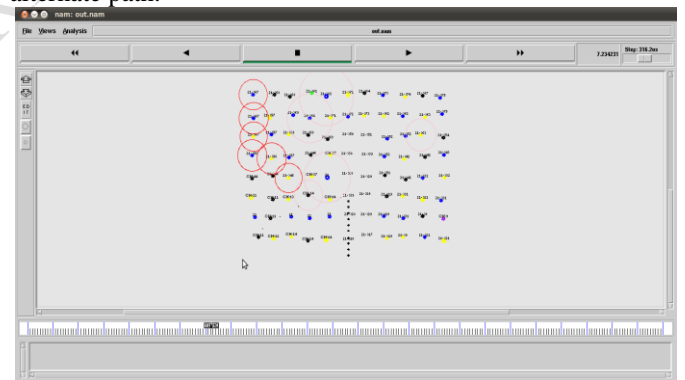


Figure 5.9: Resetting data in EHC and ROT

In the above figure it identifies the failure by sharing the message and it resets the data and has to send by choosing the alternate path.

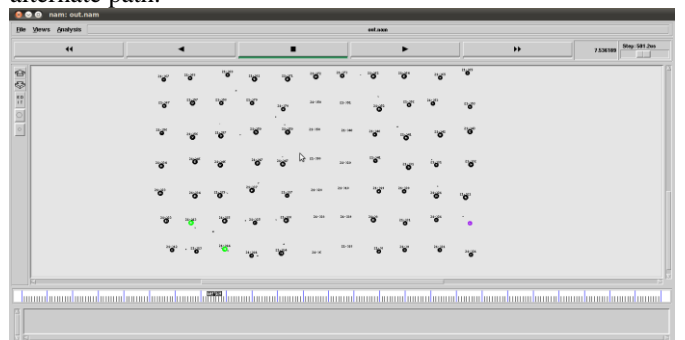


Figure 5.10: Data forwards through alternate path in GPSR method

The above figure represents the alternate path has been chosen with less hop count and delay with that the packets will move to the destination without any obstacles.

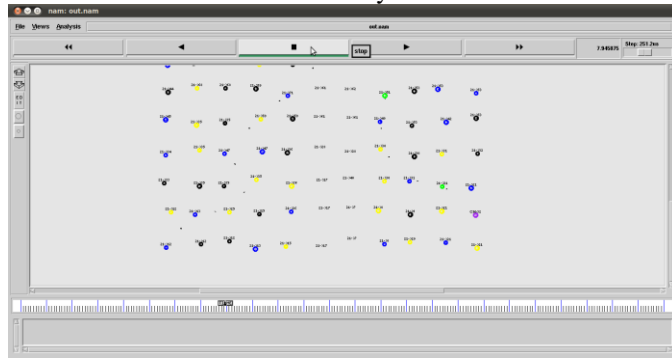


Figure 5.11: Data forwards through alternate path in EHC and ROT

The above figure represents the alternate path has been chosen with less hop count and delay with that the packets will move to the destination without any obstacles.

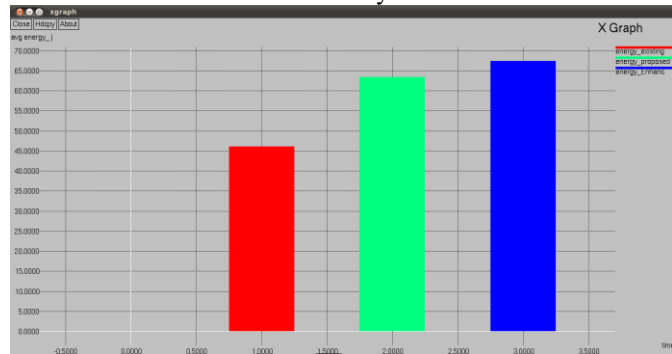


Figure 5.12: The above graph is the comparison graph shows the Energy

The above graph represents Energy by taking Time (in Sec) on X-axis and shows the energy consuming (Joules(KJ))on Y-axis.



Figure 5.13: The above graph shows the comparison graph for Lifetime

The above graph represents the Lifetime by taking number of obstacles on X-axis and life time on Y-axis. By comparing with GPSR, EHC and ROT techniques contains more lifetime.

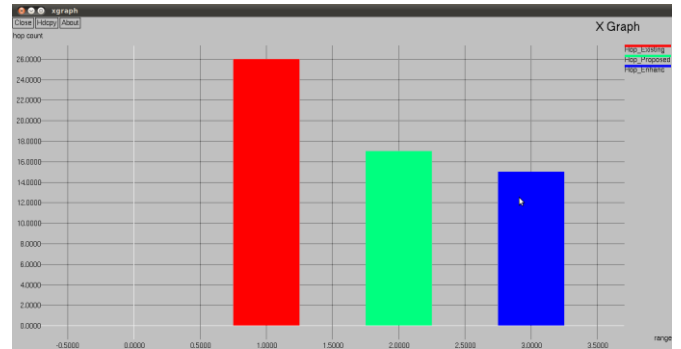


Figure 5.14: The above graph shows the comparison graph for Hop count

The above graph represents the Hop count by taking Communication range (in mts) on X-axis and Average Hop count on Y-axis.

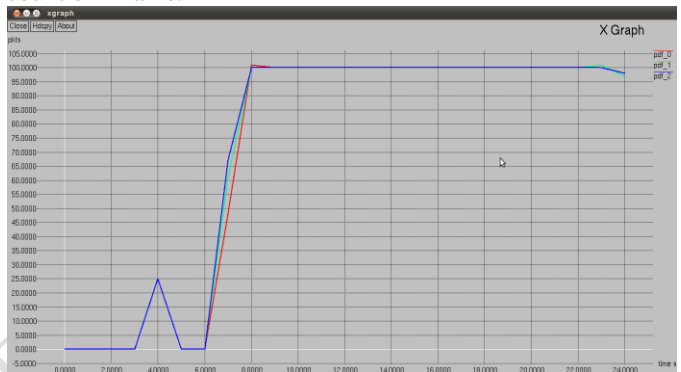


Figure 5.15: The above graph shows the comparison graph for packet delivery

The above graph is the comparison graph for packet delivery fraction which showing the time on X-axis and number of packets on Y-axis. By comparing with GPSR system the proposed EHC and ROT techniques and the enhancement Tree based protocol achieves better packet delivery.

CONSIDERING THE NODES WITH 130 MTS COVERAGE AREA

In this case we have considered the nodes by 130 mts coverage area.

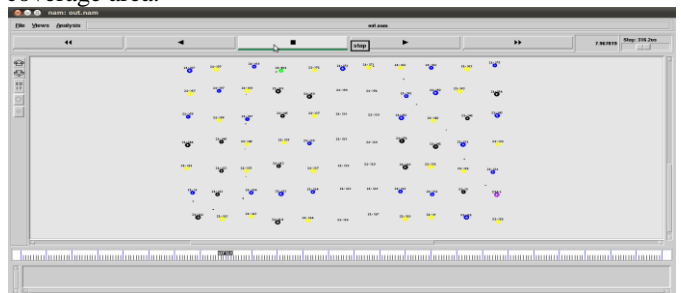


Figure 5.16: Data transferred from Source to destination in 150mts coverage area

In the above figure, from the nodes which are neighbour to destination through that communication happen then the packets transfer from source to destination without any obstacles.

CONSIDERING NODES WITH 150 MTS COVERAGE AREA

We constructed nodes with 150 mts coverage area between nodes.

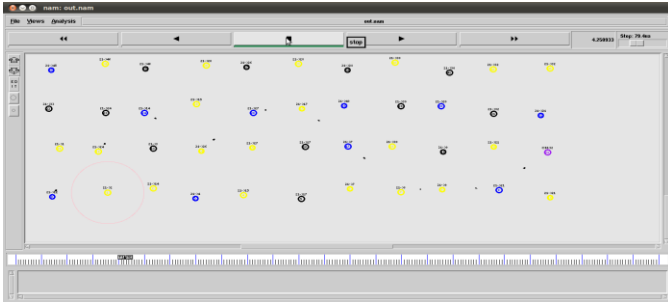


Figure 5.17: Data transferred from Source to destination in 150 mts coverage area

In the above figure, what are the nodes neighbour to destination through that communication is going to happen and the packets transfer from source to destination, if there is no failure occurred this method is the best one.

CHOOSING NODES WITH 180 MTS COVERAGE AREA

We constructed nodes with 180 mts coverage area between nodes.

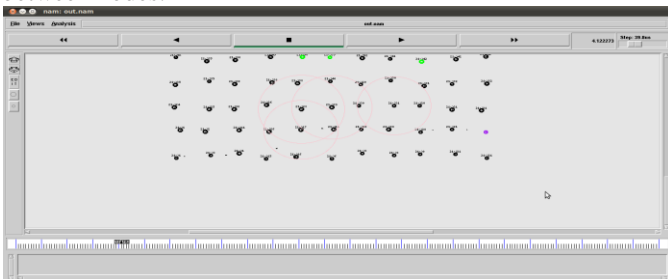


Figure 5.18: Data transferred from Source to destination in 180mts coverage area

In the above figure, what are the nodes neighbour to destination through that communication is going to happen and the packets transfer from source to destination, if there is no failure occurred this method is the best one.

CONSIDERING NODES WITH 210 MTS COVERAGE AREA

We constructed nodes with 210 mts coverage area between nodes.

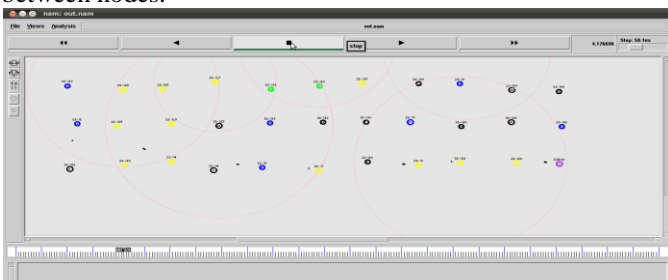


Figure 5.19: Data transferred from Source to destination in 210mts coverage area

In the above figure, what are the nodes neighbour to destination through that communication is going to happen and the packets transfer from source to destination, if there is no failure occurred this method is the best one.

CONSIDERING NODES WITH 250 MTS COVERAGE AREA

We constructed nodes with 250 mts coverage area between nodes.

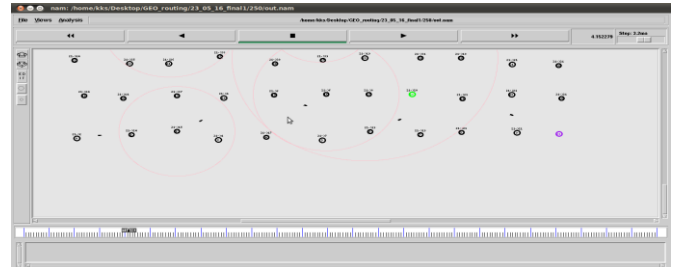


Figure 5.20: Data transferred from Source to destination in 250mts coverage area

In the above figure, what are the nodes neighbour to destination through that communication is going to happen and the packets transfer from source to destination, if there is no failure occurred this method is the best one.

B. DELAY TABLE

Coverage area	GPSR	EHC and ROT	Tree based
130	0.245197	0.160357	1.141831
150	0.150205	0.140569	0.12201
180	0.13345	0.11255	0.10308
210	0.1311	0.09365	0.07493
250	0.13105	0.10302	0.0656

Figure 5.2: Delay table for GPSR, EHC and ROT, and Tree based protocol

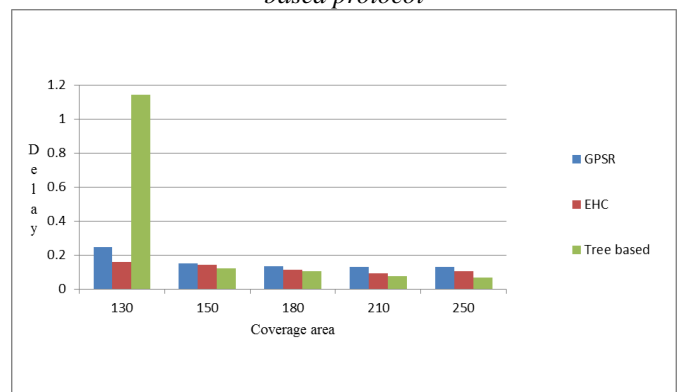


Figure 5.21: Delay Graph

Figure 5.21 shows the Delay graph for GPSR, EHC and Tree based methods. In the graph X axis represents coverage area of nodes and Y axis represents Delay, the blue line represents GPSR, the red line represents EHC and green line

represents Tree based enhance protocol. The Delay is decreased by using Tree based enhance protocol.

C. ENERGY TABLE

Coverage area	GPSR	EHC and ROT	Tree based
130	46.0117	63.3949	67.4171
150	66.14	71.49754	71.49752
180	72.463	73.4828	75.9469
210	70.6124	77.9702	82.4594
250	70.5859	75.985	84.4985

Figure 5.3: Energy Table for GPSR, EHC and Tree based methods

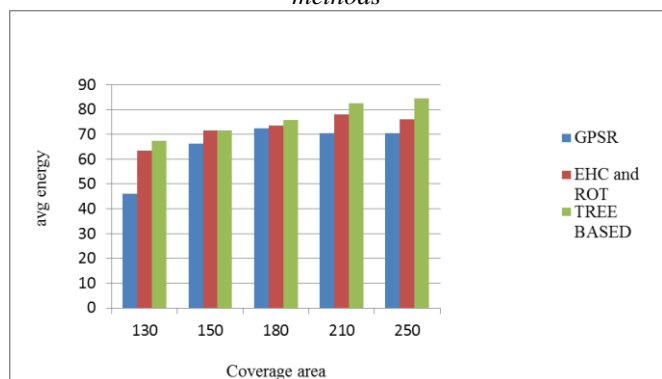


Figure 5.22: Energy Graph

Figure 5.22 shows the Energy graph for GPSR, EHC and Tree based methods. In the graph X axis represents coverage area of nodes and Y axis represents average energy, the blue line represents GPSR, the red line represents EHC and green line represents Tree based enhance protocol. The Energy is increased by using Tree based enhance protocol.

D. HOP COUNT TABLE

Coverage Area	GPSR	EHC and ROT	Tree Based
130	26	17	15
150	16	14	12
180	13	12	11
210	14	10	8
250	14	11	8

Figure 5.4: Hop count table for GPSR, EHC and Tree based methods

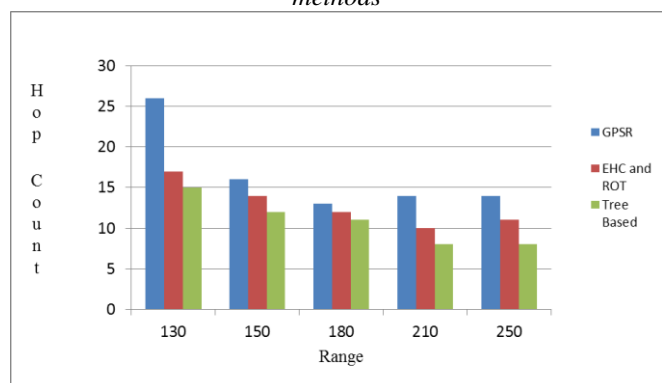


Figure 5.23: Graph for Hop count

Figure 5.23 shows the Hop count graph for GPSR, EHC and Tree based methods. In the graph X axis represents coverage area of nodes and Y axis represents Hop count, the blue line represents GPSR, the red line represents EHC and green line represents Tree based enhance protocol. The Hop count is decreased by using Tree based enhance protocol.

E. LIFETIME TABLE

Coverage area	GPSR	EHC and ROT
130	45.45	71.42
150	55.45	75.75
180	90.5	93.985
210	85.034	113
250	84.7458	103.734

Figure 5.5: Lifetime table for GPSR and EHC methods

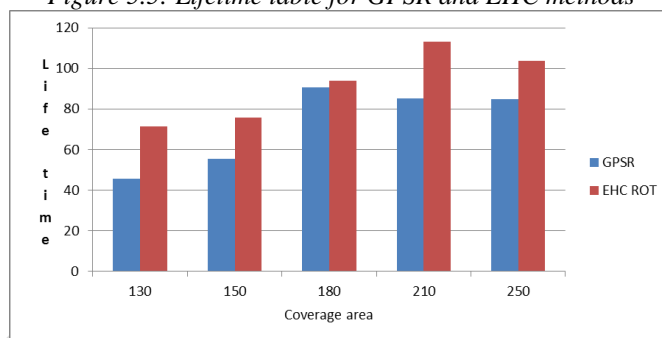


Figure 5.24: Life time Graph

Figure 5.24 shows the Life time graph for GPSR, EHC and Tree based methods. In the graph X axis represents coverage area of nodes and Y axis represents Lifetime, the blue line represents GPSR, the red line represents EHC protocol. The Lifetime is increased by using EHC protocol.

VI. CONCLUSION AND FUTURE WORK

By introducing the concept of clustering we found that the life of network got increased thus the quality of service has also increased. We mainly focused on energy-efficient clustered WSNs to prolong the lifetime of WSNs. We also proposed a technique to optimize the routing path among obstacles in clustered WSNs. We simulated the performance of the proposed EHC and ROT and the enhanced Tree Based protocol for different network scenarios and demonstrated that the energy consumption and average hop count in WSNs are reduced due to the clustering of sensors and optimization of routing path, hence the lifetime of WSNs is increased. The parameters tested for the quality of the service are hop count, packet delay, time and energy.

In future work, we would like to focus on applying a Fuzzy logic algorithm for route optimization.

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