Achieving Enhanced Life-time of Wireless Sensor Network using

Dual Hop Clustering Algorithm Over Leach Protocol

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Abstract- *Development of low cost, low power and small size sensors has taken importance due to recent advancement in electronics technology. Hundreds and thousands of these sensors are deployed in wireless sensor network according to the requirement of network application. Wireless sensor network (WSN) is one of the evolving technologies. Sensor nodes are able to monitor physical environment, compute and transmit this information to core network. These sensors should communicate with each other and also for external Base station.*

WSN offers a wide-range of applications, some of these are environmental monitoring, industrial sensing, infrastructure protection, battlefield awareness and temperature sensing. A wireless sensor node is a popular solution when it is difficult or impossible to run a mains supply to the sensor node. A sensor node will have a transceiver antenna, a control unit and a power unit with which it performs a continuous surveillance of a geographical area in which it is deployed. A node dies off when its battery power is depleted as its battery power is limited. Network becomes inactive till most of the nodes die off. A vast number of researchers are working on increasing the network lifetime. There is a base station or sink to which the nodes transmit the sensed data and is not constrained in power.

Keywords-- Leach, Dual hop, Clustering ,WSN

I. INTRODUCTION

Wireless sensor networks (WSNs) are large collections of small sensor devices that can be an effective tool for collecting data from various environments. Each sensor sends its data to Base Station (BS), and finally BS sends these data to end user. Clustering is considered as an effective approach to provide better data gathering and scalability for large sensor networks.

Clustering is an efficient method for providing better data aggregation and scalability for Wireless Sensor Networks. WSN's have less performance due to obstacle presence. In this project LOCODO algorithm is simulated in this project which clusters sensors based on their geographic locations. LOCODO algorithm detects an obstacle locally using message communication among neighbouring sensors of the obstacle and sensors detecting obstacles use the LOCODO rule to send data.

Massive and random placement of sensor nodes on a monitored field renders node communication a difficult task to be achieved. Interference, congestion, and routing problems are possible to arise at any point in such networks. Routing challenges in WSNs stem from the unique characteristics of these networks, such as limited energy supply, limited computing power, and limited bandwidth on the wireless links, which impose severe restrictions on the design of efficient routing protocols. According to theory , a
number of routing challenges and design issues like, among others, node placement and energy consumption, can affect routing process in WSNs.

Thus, topology control, in conjunction with routing challenges, becomes an important issue that has to be carefully considered in order to achieve proper network operation. Generally, congestion control algorithms in WSNs employ two methods in order to control and avoid congestion . The first method is called traffic control and the second resource control. Algorithms that employ the traffic control method, adjust the rate with which sources inject traffic to the network in order to control congestion. On the other hand, resource control algorithms, employ redundant nodes, which are not in the initial path from source to sink, in the process of forwarding data. Thus, algorithms that employ this method do not control the data rate of the sources but the paths through which the data flows. According to studies traffic control algorithms are not affected by different node placements, while according to the same studies resource control algorithms are significantly affected.

Different node placements create a variable number of paths which are important for the proper operation of these algorithms. Placement of nodes in Wireless Sensor Network (WSNs) is often massive and random. Permitting all nodes to transmit concurrently without any control will result in high interference, high energy consumption, and reduced network lifetime.

1.2 Problem Definition

Clustering is an efficient method for providing better data aggregation and scalability for Wireless Sensor Networks. Various applications of WSNs has caused that factors decreasing their performance such as obstacle presence have been investigated. In routing algorithms particularly clustering algorithms, there has not been much attention toward this factor. Without using GPS and complicated localization methods, LOCODO algorithm clusters sensors based on their geographic locations. In this paper, we added the detection and avoidance of obstacles to LOCODO algorithm. Our approach detects an obstacle locally using message communication among neighboring sensors of the obstacle. Moreover, sensors detecting obstacles use the right hand rule to send data.

1.3 Previous Approach

A wireless sensor network (WSN) often contains hundreds or thousands of sensor nodes equipped with sensing, computing, and communication devices such as short-range communication devices over wireless channels. These nodes may be distributed over a large area; e.g., WSNs can do area monitoring for some phenomenon of interest. In such an application, the main goal of the WSN is to collect data from the environment and send it to a sink node. The previous approach does not take route into consideration which is efficient in terms of energy, power consumption and route discovery time.

1.4 Wireless Sensor Network

A wireless sensor network is a collection of sensor nodes organized into a cooperative environment. Each sensor node is capable sensing physical parameters like atmospheric pressure, temperature, humidity etc. and also capable of processing the sensed data. The nodes communicate wirelessly and often self-organize after being deployed in a working environment.

The innovative advancement in Wireless Sensor Networks made it conceivable to use in observing and control of Agriculture parameters in rural area. Because of uneven regular conveyance of rain water, it is exceptionally essential for agriculturists to screen and control the desired distribution of water to the crop field or as per the necessity of the crop. There is no perfect irrigation technique available which may be suitable for every climate condition, soil structure and mixture and variety of crops cultures. It is observed that farmers need to manage enormous money because of misfortune in wrong forecast of climate and incorrect irrigation method to crops. In this paper with the development in remote sensor gadgets, it is possible to use them for automatic environment monitoring and controlling the parameters of agriculture.

II. EXISTING SYSTEMS

Network protocols must be designed to achieve fault tolerance in the presence of individual node failure while minimizing energy consumption. In addition, since the limited wireless channel bandwidth must be shared among all the sensors in the network, routing protocols for these networks should be able to perform local collaboration to reduce bandwidth requirements.

LEACH (Low Energy Adaptive Clustering Hierarchy) is one of the frequently used protocol in wireless sensor networks. There are lot of variants in this protocol and each have their own advantages and disadvantages compared to their counter-parts. LEACH is one of the first hierarchical routing Protocols used for wireless sensor networks to increase the life time of network.

Only cluster-head can directly communicate to sink and member nodes use cluster-head as intermediate router in case of communication to sink. Cluster-head collects the data from all the nodes, aggregate the data and route all meaningful compress information to Sink. Because of these additional responsibilities Cluster-head dissipates more energy and if it remains cluster-head permanently it will die quickly as happened in case of static clustering. LEACH tackles this problem by the idea of randomizing rotation of cluster-head to save the battery of individual node.
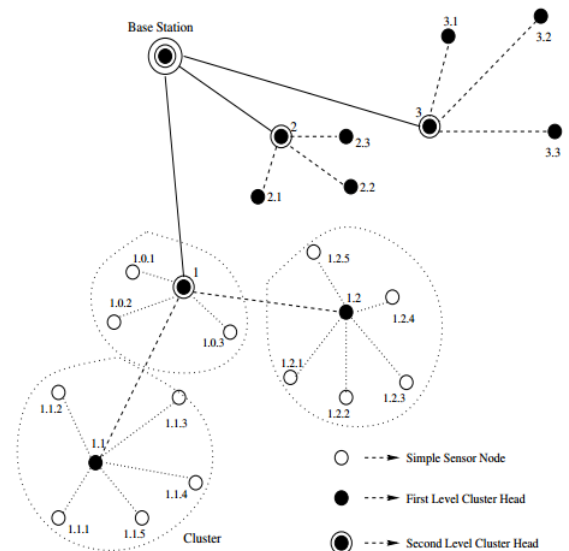

Figure 2.1: LEACH Architecture

There are lot of variants of LEACH protocol viz., MODLEACH , LEACH-SC, MULTIHOP LEACH , TEEN , PEGASIS .Some nodes elect themselves as a cluster-head independently from other nodes.
These nodes elect themselves on behalf Suggested percentage P and its previous record as cluster-head. Nodes which were not cluster-head in previous 1/p rounds will generate a number between 0 to 1 and if it is

less than threshold T(n) then nodes become cluster-head. Threshold value is set through this formula.

$$T(n) = \begin{cases} \dfrac{P}{1-P*(r \bmod \frac{1}{P})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

Where G is set of nodes who have not been cluster-head in previous 1/p rounds, P= cluster head percentage, r =is current round. The node becomes cluster-head in current round, it will be cluster-head after next 1/p rounds.

In LEACH-SC, a new method is used to choose cluster heads, i.e. an ordinary node A will choose a cluster head which is the closest to the center point between A and the sink. The simulation results show that compared with LEACH, LEACH-SC protocol can greatly reduce the overall network energy consumption, balance the energy consumption among the sensors extend the lifetime of the network.

With MULTI HOP LEACH protocol the information is transmitted from cluster head (CH) to base station (BS) node through single hop communication no matter the distance between BS and CH. Energy consumption will be more if distance is far. This M-LEACH protocol modifies LEACH allowing sensor nodes to use multi-hop communication within the cluster in order to increase the energy efficiency of the protocol.

MODLEACH gives maximum network life time amongst all protocols. This due to limiting number of transmissions (concept of soft threshold) along with efficient cluster head replacement mechanism that preserve energy globally and multi power level for inter and intra cluster communication.

 In MODLEACH, number of transmissions are confirmed only when a pre-described change in sensed data is achieved. This limits number of transmissions to preserve residual energy of a sensor node (numbers of transmissions are inversely proportional to energy of sensor node).TEEN had the main features viz.,
1. Critical data w.r.t time reaches the user almost instantaneously. So, this scheme is eminently suited for time critical data sensing applications.

2. Message transmission consumes much more energy than data sensing. So, even though the nodes sense continuously, the energy consumption in this scheme can potentially be much less than in the proactive network, because data transmission is done less frequently.

The main idea in PEGASIS is for each node to receive from and transmit to close neighbours and take turns being the leader for transmission to the BS. This approach will distribute the energy load evenly among the sensor nodes in the network. We initially place the nodes randomly in the play field, and therefore, the i–th node is at a random location. The nodes will be organized to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm starting from some node. Alternatively, the BS can compute this chain and broadcast it to all the sensor nodes.

III LITERATURE SURVEY

I have carried out an exhaustive research on LEACH routing protocol and its variants.

3.1 LEACH

This is one of the most preferred routing protocols for wireless sensor network. The parameters of this protocol are used as a benchmark by most of the researchers. Concept of dynamic clustering is used in LEACH according to which sensor nodes self-organize themselves into clusters at the start of each round. This will avoid a single cluster head to lose energy every time. When clusters are created each node autonomously decide whether it can be a cluster.

The outcome of calculation in LEACH a threshold, T(n), and if a random number generated by all node (except previous round cluster head) is less then T(n), the node is selected as the cluster head. Selecting an appropriate cluster head can save power for the whole ad hoc wireless network. Generally, cluster head election for mobile ad hoc network is based on the distance to the centroid of a cluster, and the closest one is elected as the cluster head; or pick a node with the maximum battery capacity as the clusterhead.

The other member nodes of a cluster periodically send their sensed data to the cluster head and rest all other time. Each node decides its cluster by comparing received signal strength of advertisement message sent by elected cluster nodes in each round.

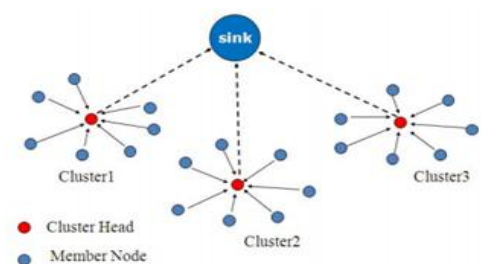LEACH routing protocol makes wireless sensor network scalable and robust.

Figure 3.1 : Clustering Technique in LEACH

3.1.1 DISADVANTAGES OF THE LEACH PROTOCOL

Although LEACH protocol prolongs the network lifetime in contrast to plane multi-hop routing and static routing, it still has problems. The cluster heads are elected randomly, so the optimal number and distribution of cluster heads cannot be ensured. The nodes with low remnant energy have the same priority to be a cluster head as the node with high remnant energy. Therefore, those nodes with less remaining energy may be chosen as the cluster heads which will result that these nodes may die first. The cluster heads communicate with the base station in single-hop mode which makes LEACH cannot be used in large-scale wireless sensor networks for the limit effective communication range of the sensor nodes .

3.2 LEACH SC

In this variant of LEACH , a non-cluster node joins itself with the cluster head. Cluster head is nearest to the midpoint between itself and the base station. Thus this protocol avoids flow of data in one direction far from the sink station during the data transfer from a node to the cluster head and as the data always flows towards the base station . This protocol saves more energy compare to its similar variants.

3.3 MODLEACH

The latest in LEACH protocol is MODLEACH . It uses dual transmission mode for data transfer depending on the distance between cluster member and cluster head or cluster head and base station.In each transmission energy of the transmitting node reduces by a factor f, which is evaluated using formula:

$$F = (ETX+EDA)*4000+EM*4000*(dist*dist)\alpha$$

where ETX is Transceiver idle state energy, EDA is data aggregation energy (which is zero for a intra cluster transmission), EM is energy mode constant it is ten times high in long distance communication as compared to a short distance one, dist is the distance between the **sender and the receiver and α is a constant with a value** of 1 in case of low power mode and 2 for high power mode.

3.4 MULTIHOP LEACH

This is another variant in which cluster heads will not transmit aggregated data directly to the base station but through other cluster heads and they choose the path with lowest hop count.

This M-LEACH protocol modifies LEACH allowing sensor nodes to use multi-hop communication within the cluster in order to increase the energy efficiency of the protocol. This work extends the existing solutions by allowing multi-hop inter-cluster communication in WSNs in which the direct communication between CHs or the sink is not possible due to the distance between them. Thus, the main innovation of the solution proposed here is that the multi-hop approach is followed inside the cluster and outside the cluster. CHs can also perform data fusion to the data receive, allowing a reduction in the total transmitted and forwarded data in the network.
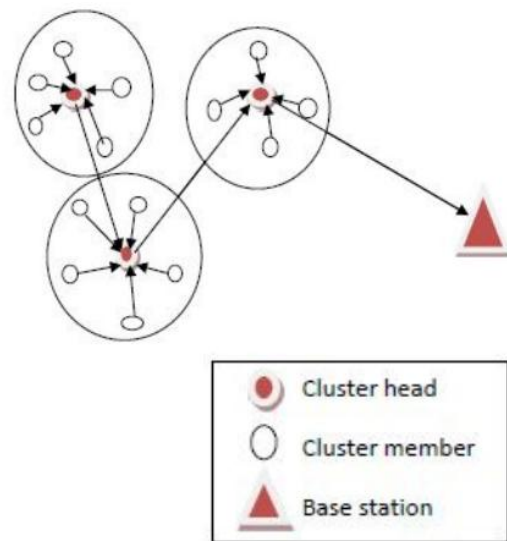

Figure 3.4 : Cluster Head and Base Station set up

There are some imminent dis-advantages of multi-hop protocol as they are Combined with the extra computations CHs perform, they end up consuming energy faster than the other nodes.

3.5 TEEN : Threshold sensitive Energy Efficient sensor Network protocol

This is one of the latest variant of LEACH protocol. This protocol is quite different from traditional functionality of LEACH protocols , as this is   is an event driven protocol. This introduces a new idea to avoid power drain by sending sensed data only when some event is triggered in the network.

TEEN has two different kinds of thresholds viz., soft threshold and hard threshold.

Hard Threshold (HT): This is a threshold value for the sensed attribute. It is the absolute value of the attribute beyond which, the node sensing this value must switch on its transmitter and report to its cluster head.

Soft Threshold (ST): This is a small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit.

Hard threshold is a globally set value whereas soft threshold is chosen adaptively by a cluster by cooperating with other clusters. Even though this is one of the most energy efficient protocol, there is catch , as this protocol cannot be implemented in scenarios where periodic report of sensed data is the need and this has to be passed to the sink because sensors nodes only switch on their communication module (radio transmitter) **when some event occurs. TEEN protocol's simulation results to outperform LEACH .**

3.6 PEGASIS : Power Efficient Gathering in Sensor Information System

This protocol deals with the aggregated data obtained from CHs. With this protocol the aggregated data from CHs is transferred to the single cluster head which is nearest to the base station. The main idea in PEGASIS is for each node to receive from and transmit to close neighbors and take turns being the leader for transmission to the BS. This approach will distribute the energy load evenly among the sensor nodes in the network. We initially place the nodes randomly in the play field, and therefore, the i –th node is at a random location. The nodes will be organized to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm starting from some node. Alternatively, the BS can compute this chain and broadcast it to all the sensor nodes.
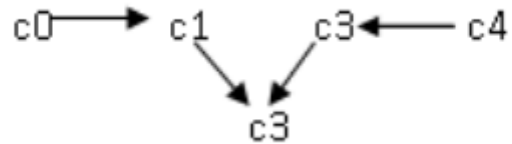

Figure 3.6: Chain Clustering in PEGASIS

Power Efficient Gathering in Sensor Information System has achieved 100% to 300% more power efficiency then LEACH protocol. But the main draw back is that the single cluster connecting to the base station (sink) has to wait for data from other clusters as a result of which a considerable delay is introduced. In our case cluster c2 is such an example.

IV. THE PROPOSED WORK

My research is aimed to improve the lifetime of network and for this I need to have nodes alive till maximum number of rounds are completed as per LEACH ideology. Here I have assumed that the nodes are power difficient and they are supplied with a fixed amount of initial energy goes to zero the node becomes dead permanently when their battery power is completely drained. Parallely base station is supplied with   power continously.

 Additionally, the nodes are kept static and they are deployed in the area of $100 \times 100 m^2$ randomly. The base station is placed at the center of the target region i.e. in the co-ordinate (50,50) as previous studies have proven that we get maximum network lifetime in average scenario for a random organized nodes.

For comparison I have kept the number of nodes as 50 and the value of percentage of clusters (p), from the LEACH is 0.1. This means that in every round 0.1% of the total number of nodes will be cluster heads or CH. I have combined the power saving schemes from of the existing clustering protocols along with my idea of dual hop data transfer scheme.

Research on LEACH protocols pointed out that the nodes need less power to transfer their data within the cluster to the cluster head and need high power while communicating with base station or with other cluster heads if cluster head selection criteria is minimum distance, assuming that the low power transmission amplification energy is less than that of high power to an extent of ten times.

Following the above criterion the communication type is classified into two types based on the source and target of nodes :

1. Intra cluster.

2. Inter cluster or cluster head to base station.

I am designing the proposed algorithm such that the member nodes in a cluster which only needs to do intra cluster communication requires transmission energy ten times less than that needed for other two types of communication. This I would like to term as the Dual mode transmission power. If the distance between the sender and the receiver is less than d0, we can use the low power transmission otherwise it will switch to high power transmission.

The threshold d0 is set equal to square root of the ratio between high and low transmission mode energy. Next as I explained the thresholds can be applied for saving power, but applying thresholds restricts producing periodic data. LEACH has a imminent drawback of losing energy as in every round the nodes need to re-cluster themselves as a new cluster head comes to existence.

Therefore I have applied the hard thresholding scheme in such a way that if the cluster head exhaust away half of its initial energy then we encourage the re-clustering to save energy.

 So with an aim of improving the network lifetime, I have incorporated a whole new concept of transmitting aggregated data from the cluster head to the base station in two low power hops to save energy, rather than using one single high power hop to the base station. The data is sent from one cluster head to another cluster head within a distance, less than d0 from itself and also the receiver cluster head should have a distance less than d0 from the base station.

This idea is based on the phenomenon that if we use alternating power transmissions, routing of data using two low power hops is more energy saving than using a single hop high power transmission. The figure below suggests the various power saving schemes used in this proposed scheme.

Figure 4.1:Overview of proposed scheme

Module 1: "Dualhop transfer to the base station"

 This is the setup phase where dual hop hierarchical network is setup which comprise of several cluster heads and base station. The network parameters are explained in the subsequent sections. As explained earlier we supply intial energy to the cluster nodes and the base station is supplied with continuous power.

Module 2: "Thresholding to avoid repeated re-clustering"

In this module we define the threshold values for the cluster heads. Threshold decides if a node has to be re clustered or not. This strategy places a vital role in the architecture to improve the performance and efficiency of the overall network.

Module 3: "Dual transmission power node"

This is the crux of my algorithm where the transmission mode is defined. Inter cluster communication and intra cluster communication are the two modes used here. This module is the more differential part compared to other variants of LEACH and other existing mulithierarchical wireless sensor network architecture.

Module 4: "Core LEACH protocol"

In the final phase, based on the output of above modules , the LEACH protocol is applied for network communication.

IV. DESIGN AND IMPLEMENTATION

4.1 MULTICASTING UISNG ZONE STRUCTURE BASED ALGORITHM LEEACH

There are increasing interests and importance in supporting group communications over Mobile Ad Hoc Networks (WSNs). Example applications include the exchange of messages among a group of soldiers in a battlefield, communications among the firemen in a disaster area, and the support of multimedia games and teleconferences. With a one-to-many or many-to-many transmission pattern, multicast is an efficient method to realize group communications. However, there is a big challenge in enabling efficient multicasting over a WSN whose topology may change constantly. *Conventional* WSN multicast protocols [3]–[8], [28] can be ascribed into two main categories, tree-based and meshbased. However, due to the constant movement as well as frequent network joining and leaving from individual nodes, it is very difficult to maintain the tree structure using these conventional tree-based protocols (e.g., MAODV [3], AMRIS [4], MZRP [5], MZR [28]). The mesh-based protocols (e.g., FGMP [6], Core-Assisted Mesh protocol [7], ODMRP [8]) are proposed to enhance the robustness with the use of redundant paths between the source and the destination pairs. Conventional multicast protocols generally do not have good scalability due to the overhead incurred for route searching, group membership management, and creation and maintenance of the tree/mesh structure over the dynamic WSN.

1.In a general network, when a node p[i] wants to send a message to a far away node p[d], one that is not its , attaches the index d of the destination process to the data message sends data (d) to its neighboring node p[g].

2. When node p[g] receives the message data (d), it also forwards the message to its neighbor p[h] and so on.

3. Forwarding the data (d) message continues until the data (d) message finally arrives at its destination p [d].

4. Given the ultimate destination, to which of its neighbors p[i] (node) should forward the message. The task of determining this is known as routing.

4.2 Routing Definition

Routing is the task of determining the best neighbors to which data (d) message is to be forwarded, given the ultimate destination d of the message. Routing is usually performed by providing each process in a network with a table called its routing table.The routing table of the node p[i] lists each possible ultimate destination d the best neighbor to which p[i] forwards every data (d) message.

4.3 Common problems of Routing Tables
1. The routing table has one entry for each possible ultimate destination in the network. Because each process is a possible ultimate destination, the number of entries in a routing table in a given network equals the number of processes in that network. Hence in a network with large number of processes, routing tables are large.

2. These tables need to be updated periodically to reflect any change in the network topology. To update its routing table, each process may exchange additional message with other processes in the network.

3. The routing tables need to be updated whenever mobile ultimate destination changes its location within the network. The mobility of ultimate destination requires that each routing table in the network be augmented with extra information. It also requires that each process in the network exchange additional messages with other processes in the network.

These problems are addressed in the various routing protocols. In this project hierarchical *routing* is *designed to address this issue.*

4.4 ARTIFICIAL HIERARCHICAL PARTITIONED STRUCTURE OF NETWORK

In this algorithm, the network processes are partitioned according to an Artificial hierarchical structure with the sole purpose of reducing the number of entries in the routing tables. The *process and nodes* represent the same.
Consider a network where the processes are partitioned into m regions.

The processes in each region in turn partitioned into n districts. Each district has r processes.

In this network each region i and each district j is connected in the following sense:

a.   For each of two processes p and q in region i, **there is a sequence of processes p.0,p.1.....p.r** such that p is p.0 and q is p.r and for every k,0 ≤ k < r, p.k & p.k+1 are nhbrs in the region.

 b. For each of the two processes p and q in district j , **there is a sequenc of processes p.0,...p.s such that p is p.0 and q is p.s and for each k,   0 ≤ k < s, p.k and p.k+1 are nhbrs in district j.**

Each process in this network is uniquely identified by three identifiers i, j and k. i indicates the region to which process belongs, j indicates the district in region i, to which process belongs and k indicates the process in district j in region i.

4.5 CONCEPTUAL METHODOLOGY OF HIERARCHICAL ALGORITHM

1.   The processes in this artificial hierarchical partitioned network constitute a process array with three indices as follows: process p[i:0..m-1, j:0..n-1, k:0..r-1]
2.   In this network, when a data message is to be sent, the three identifier of its destination process are attached to the message before the message is sent.
3.   When a data(x, y, z) message arrives at the process, the process uses its routing table and the triple (x, y, z), which determines the message destination to determine the best neighbor to which message is forwarded.
4.   The routing table of each process p[i, j, k] consists of three arrays named rgn, dstr and prs.
5.   Array rgn determines the best for reaching a destination process whose region is other than i.
6.   Array dstr determines the best nhbr for reaching a destination process whose region is i, but whose district is other than j.
7.   Array prs determines the best nhbr for reaching a destination process whose region is i, & whose district is j but the process is other than p[i, j, k] itself.

4.6 ADVANTAGE OF HIERARCHICAL ALGORITHM

Total number of entries in the three arrays rgn, dstr, prs in one process is m + n + r. It is quite less than m x n x r which is the total number of entries in the flat Routing table.

4.7 HIERARCHICAL ROUTING ALGORITHM

The three arrays are declared in process p[i, j, k] as follows

inp rgn : array [0.. m-1] of N

dstr : array [0..n-1] of N

 prs : array [0..r-1] of N

where N is an input of triples (i', j', k') such that p[i', j', k'] is a nhbr of p[i, j, k]

When data(x, y, z) msg is received by a p[i, j, k], the triple (x, y, z) of msg .Destination is compared with triple (i, j, k) of receiving process:

 If $x \neq i$, then msg is fwded to p[rgn[x]].

 If $x = i$, but $y \neq j$ then the msg is fwded to p[dstr[y]]

 If $x = i$, $y = j$ but $z \neq k$ then the msg is fwded to p[prs[z]]

 If $x = i$, $y = j$ & $z = k$ then the msg has already arrived at its ultimate destination p[i, j, k].

Process p[i, j, k] in the hierarchical routing protocol can be defined as follows.

Next figure gives the details of Hierarchical Routing Algorithm. The RTMSG is the part of Hierarchical Routing Algorithm and is given as shown in Fig 6.3. RTMSG stands for how the Hierarchical routing algorithm routes the message

```
process  p[ i: 0..m-1, j:0..n-1, k:0..r-1]

inp  N  :  set{ (i, j, k)/p[i', j', k'] is a nhbr of p[i, j, k]}
     up  :  array[N] of boolean
     rgn :  array[0..m-1] of N
     dstr :  array[0..n-1] of N
     prs  :  array[0..r-1] of N

var   x :  0..m-1,
      y :  0..n-1,
      z :  0..r-1

par   g :  N

begin

  true →
    {generate a data(x, y, z) msg & route it}
    x, y, z  : =  any, any, any
    RTMSG
 □ rcv data(x, y, z) from p[g] →
    { route the received data (x, y, z) msg }
    RTMSG

end
```

Figure 4.7: Hierarchical Algorithm Details

```
RTMSG

If  x ≠ i ∧ up[rgn[x]] →
   send data(x, y, z) to p[rgn[x]]
□ x ≠ i ∧ ~up[rgn[x]] →
  { non-reachable destination} skip
□ x = i ∧ y ≠ j ∧ up[dstr[y]] →
   send data(x, y, z) to p[dstr[y]]
□ x = i ∧ y ≠ j ∧ ~up[dstr[y]] →
  { non-reachable destination} skip
□ x = i ∧ y = j ∧ z ≠ k ∧ up[prs[z]] →
   send data(x, y, z) to p[prs[z]]
□ x = i ∧ y = j ∧ z ≠ k ∧ ~up[prs[z]] →
  { non-reachable destination } skip
□ x= i ∧ y = j ∧ z = k
   { arrived at the destination} skip
fi.
```

Figure 4.8: RTMSG Algorithm Details

As shown in *Fig 4.8* , N indicates the set which contains information all nodes which are present in the network, Up is an array which can be either true or it can be false it will be true if and only if both the links between the links are UP. Rgn indicates the region identifier of the node. Dstr indicates the district identifier of the node. Prs indicates the node itself.

There are two actions which the node should perform

1. Whenever the node receives packet from the other node it routes the message using RTMSG algorithm.

2. The node which is not in transmitting mode will form the data and sends the packet using RTMSG algorithm

3. At any point of time a node can perform only one action either sending or forwarding the packet.

4.8 RTMSG (ROUTE THE MESSAGE ALGORITHM)

The RTMSG algorithm is the part of Hierarchical algorithm

1. When the destination node is *not in the same region* (i.e x not equal to i) and the link is *up* then the packet is sent directly to some node in the corresponding region.

2. When the destination node is *not in the same region*(i.e x not equal to i) and the link is *down* then the packet cannot be send.

3. When the destination node is *in the same region* (i.e x = i) and node is *not in the same district* (i.e y is not equal to j) and the link is *up* then the packet is sent directly to the some node in the corresponding district .

4. When the destination node is *in the same region* (i.e x = i) and node is *not in the same district* (i.e. y is not equal to j) the link is *down* then the packet cannot be send.

5. When the destination node is in the *same region* (i.e x=i) and *same district* (i.e y=j) and the *destination node is different* (i.e z is not equal to k) and the *link is Up* then the packet is send to the destination node .

6. When the destination node is in the *same region* (i.e x=i) and *same district* (i.e y=j) and the *destination node is different* (i.e z is not equal to k) and the *link is Down* then the packet cannot be send .

7. When the destination node is in the *same region* (i.e x=i) and *same district* (i.e y=j) and the *destination node is reached* (i.e z = k) and then the packet has reached the destination .

4.9 Node Deployment Algorithm –LOCODO Algorithm

Node Deployment Algorithm is the algorithm which is responsible for positioning the mobile stations and the base stations (cluster heads) in each zone.

4.10 Cluster Formation Algorithm –LOCODO Algorithm

In this algorithm, the network nodes are partitioned according to an artificial hierarchical structure with the sole purpose of reducing the number of entries in the routing tables. The entire network is divided into partitions like regions and districts.

Zone Formation algorithm divides the entire are into multiple zones. Each Zone having a set of nodes in its zone. This is the algorithm which is responsible for deploying the nodes. The entire area is divided into zones with each zone bounded with the limits with some xmin and xmax. The y region is bounded within the limits ymin and ymax. Each zone is allocated a set of nodes.
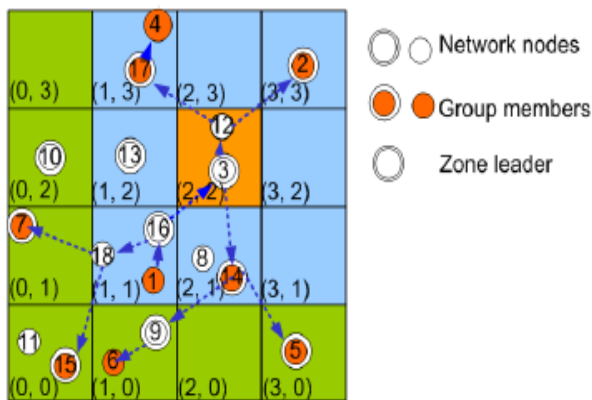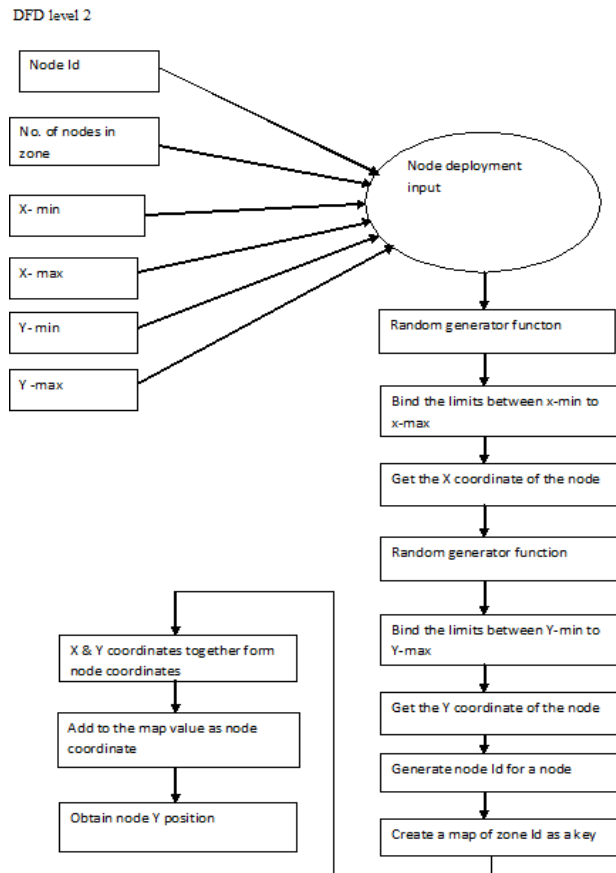
Figure 4.9 : Zone Formation Figure

Figure 4.10: Cluster Formation Algorithm

4.11 Cluster Head Election Algorithm-LOCODO Algorithm

The zone leader algorithm first finds out the centered co-ordinates of the multiple zones. The set of nodes in each zone is taken and the position of each of the node. The node which will have the minimum distance with respect to center of the zone becomes the cluster Head.

4.12 Route Discovery Algorithm

Steps for the LOCODO Algorithm

Fig shows the information about route discovery process if it is Non-Obstacle Aware

1. Source Node & Destination Node are inputs

2. Check whether the source and destination in same zone. If Yes Communication happens directly.

3. If Source Node & Destination Node are not in same zone. Then check whether source node is zone leader. If source node is Zone Leader then add to route. Otherwise find the zone leader of

the source node then add the source node to route and then zone leader of source node to route.

4. Check whether destination node is zone leader then destination node is added to route. Find the destination zone leader and add to route and then add destination node to route.

V. CONCLUSION

Wireless sensor networks (WSNs) are large collections of small sensor devices that can be an effective tool for collecting data from various environments. Each sensor sends its data to Base Station (BS), and finally BS sends these data to end user. Clustering is considered as an effective approach to provide better data gathering and scalability for large sensor networks.

Clustering is an efficient method for providing better data aggregation and scalability for Wireless Sensor Networks. WSN's have less performance due to obstacle presence. In this project LOCODO algorithm is simulated in this project which clusters sensors based on their geographic locations. LOCODO algorithm detects an obstacle locally using message communication among neighboring sensors of the obstacle and sensors detecting obstacles use the LOCODO rule to send data

VI. FUTURE WORK

1. The network routing algorithm can be future improved by bringing into picture the concept of Friendship Routing by forming the friendship routing which can be used to deliver packets to the destination.

2. The network lifetime and processing time can be taken as the future parameters.

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