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An Efficient Clustering Technique for Deterministically Deployed Wireless Sensor Networks

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***Abstract*-In wireless sensor networks the deployment of nodes is an important factor that affects all the aspects of system like coverage, connectivity, bandwidth, packet loss and lifetime of network. In this work, we propose a new clustering technique for enhanced lifetime of the network in deterministic deployment of the sensor network. The main aim of proposing this approach is to provide coverage with minimum number of nodes, enhance the life time of network, minimise packets from nodes to base station, and balance energy consumption. We propose two algorithms, first is a dynamic routing algorithm from a node to cluster head , it works with two parameters , number of nodes and battery level of nodes and second algorithm is an Energy Efficient Deterministic Cluster-Head Selection Algorithm (E^2DCH) for choosing the cluster heads. In this approach we continuously change position cluster head and move clusters in a deterministic manner so that we can enhance lifetime of the network. Analysis and simulation results demonstrate the correctness and effectiveness of our proposed algorithm.**

Key Words:*E2DCH, Clustering Technique, WSNs, Reduce Packet Loss*

1. INTRODUCTION

WSN is an organization of sensor nodes that interacts with each other remotely and is spread at random or manually over an area to check environmental or physical conditions [1, 2]. Wireless sensor network is also recognized as resource constraint wireless network. Normally WSNs have a huge number of sensor nodes and they have capacity to intercommunicate with one another and also can communicate to base station. The essential necessity for a sensor is low-cost nature. There are some issues like data rate of the network is also very low. WSNs have the ability to manage dynamic topology and handle with node failures [3, 4]. Wireless sensor networks (WSNs) have been applied for numerous applications it's include military surveillance, service monitoring and environmental monitoring. A sensor node is having a restricted sensing scope and also communicating range.

A wired sensor network is usually applied in industry and sensor node is very less intelligent. The sensors could be spread randomly in ruthless environments such as a battleground or it can be deterministically placed at defined locations. Wireless sensor network was first used 1990 for the commercial purpose. The sensors are coordinating among themselves to build a communication network like one multi-hop network or a hierarchical system with several clusters and cluster heads.

In this work, Sensor nodes are deployed deterministically so that it will cover the region with minimum nodes. Designing efficient deterministic topology and routing strategy for this topology which ensures minimum collision are the main objectives. We propose an Energy Efficient Deterministic Cluster-Head Selection Algorithm (E^2DCH) that continuously changes the cluster head positions by different movement strategies in such a fashion that all nodes will become cluster heads after some fixed time interval.

All nodes within a cluster send data to its respective cluster head by routing and then cluster head aggregates all the information and send fuse information to base station. So in fusion process, cluster heads consume large amount of energy. If we do not change cluster heads, then they will die earlier and it will affect the total lifetime of network. In order to enhance the lifetime of network it is necessary to adjust the positions of the cluster heads.

*Design Goal of propose scheme:*Our framework works on event detection approach. Limited power resources of sensor network should be focus while constructing a framework. There is some design goal:

Early Detection of event : The early minute's detection of an event in region is most important time duration for a successful system. In this we suggest a deterministic sensor network topology which will act as fast as possible if any event is sensed by sensor nodes.

Energy Efficiency- Sensor nodes have determined power resources, a wireless sensor networks should have a highly efficient energy consumption strategy. Sensor network are placed in harsh condition like, at volcano, hilly area or at forest, and they are battery operated, changing of battery in

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these types of circumstances is not always possible. So, the sensor node should have an efficient energy consuming strategy. In the energy efficiency we propose energy efficient routing protocol and cluster head selection protocol.

Forecast capacity: in the application like forest detection, radioactive monitoring spread the direction of event is very quickly and the fight against this issue requires fresh and accurate data. Values of event detected from critical zones should be propagated to the Base station within seconds. Base station accomplishes the necessary calculation for forecasting point of detection of event.

2. Deterministic Deployment Scheme

The deployment of sensors is a key consideration as it affects the performance of system. The deployment of sensor node is square grid. The key features of deterministic deployment are the following,

1-Sensor nodes should deploy in a specific fashion so that chances of data packet collision minimized.

2-In order to detect event as early as possible, the sensor nodes should effectively cover the region of interest. 3-Sensor node deploy such that it will cover whole region in minimum number of nodes.

2.1 *Network Architecture & Topology Design*

In our topology, we have deployed 8 secondary cluster head surrounding the single cluster head in a 3×3 square matrix and 36 total sensor nodes are deployed around this network. Nine sensor nodes are in each direction in 3×3 square matrix.

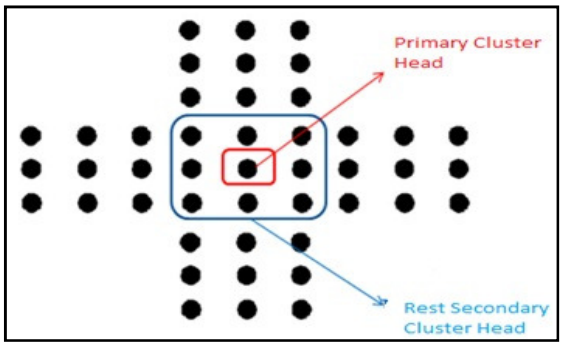

Fig 1 Proposed Topology

Assumptions of the topology are as follows:-

1. Nodes can take and transmit data to and from neighbouring nodes only.
2. The range of motes is set in such way that even neighbouring diagonal too is not allowed to take and transmit data from each other.
3. Primary base station has the authority to send data to any of node deployed in this topology.
4. Secondary cluster head are used to allocate the load equally amongst the boundary nodes. Benefits of this topology are following

Data fusion: in Data fusion several messages are aggregated to construct a single which leads to fewer messages overhead in the network. In our topology, each mote of a column sends a message to the next mote of its respective row if it finds concentration of gases or radioactive radiation is above than threshold. The next column motes, if the also find their surrounding concentration of gases or radioactive radiation is above than threshold, fuse their data in the message they received from the previous mote & then send to next node. In this way, data fusion takes place.

Balanced energy consumption: In our framework, sensor nodes sends regular information message to secondary cluster head to balance energy consumption. The secondary cluster head motes then forward the data to the main cluster head; in this way energy consumption is balanced in the node closer to cluster head.

Fewer messaging overhead: In our design, the motes send data to base station only when they find their surrounding concentration of gases or radioactive radiation is above than threshold else they do not send any data. So, only useful information is passed to base station.

Easy to expand: The complete network is very easy to expand and viewed as a unit cell and the complete area can be covered by combining these unit cells to make complete lattice.

Optimum utilization of base station range: in this topology we are utilizing the complete base station range. Since, the data can be send and receive from base station in all the direction so we are covering a greater amount of area comparing to our previous topology

Simple algorithm for best path: The maximum possible paths through which data packet can be transmitted are six. Due to this much less processing time is required by the sink in order to decide the best possible path for data transmission. Hence, the whole system gets speed up.

2.2 *Intra Cluster Communication Protocol*

All the nodes within cluster are synchronizing with cluster head before transmitting data. This approach uses sleep awake protocol for better energy management. If there is an event so we have to select a path by which we can transfer data continuously from node to base station. To find the best path we take Geometric Mean of the battery levels of different possible paths. Then we divide the Geometric Mean by number of nodes in path. The path with the highest Geometric Mean of Battery Level divided by number of nodes is elected as the Best path to gain the reliability of data transfer to the base station. Geometric mean divided by number of nodes will be high if all nodes of path have high battery level and the number of nodes in path is less therefore it will give a short and reliable path. If we use arithmetic mean rather geometric mean then it will not give

a consistent path. For example we have two paths first is four nodes with battery level 3,0,4,3 and the second is 4-nodes with battery level 2,2,3,3. The arithmetic mean for both paths is same but geometric mean for first path is 0 therefore it cannot be a reliable path and it is obvious because it contains a node with 0 battery level. In our proposed approach, maximum path from any node to cluster head are six and they are showing in fig 2. Cluster.The first node senses the event and sends it to next node. The other nodes wait till they receive a packet. When they receive they just send it to next hop. In this way the data packet is sent to the Cluster Head. If the Cluster Head receives any Danger Packet, then it will first finds out in which field the event has been occurred, then it will check which one of the node has detected the event. The Cluster Head will calculate the best path (considering two factors, Distance & Battery Level. It will broadcast the best path by encoding it into a packet and it will receive packets from sensor node which detected the event. If nodes receive an Alert Signal, then they wait for the Best Path signal from cluster head. The cluster head calculates the best path. The cluster head broadcasts the Best path by encoding it in a packet. Each node receives the packet & decodes it to check whether it is in path or not. . The nodes which are not in path run Timer of 15 min. & go to "SLEEP" state.

$$PathPerformance = \frac{GeometricMeanBatteryLevel}{NumberofNodes}$$

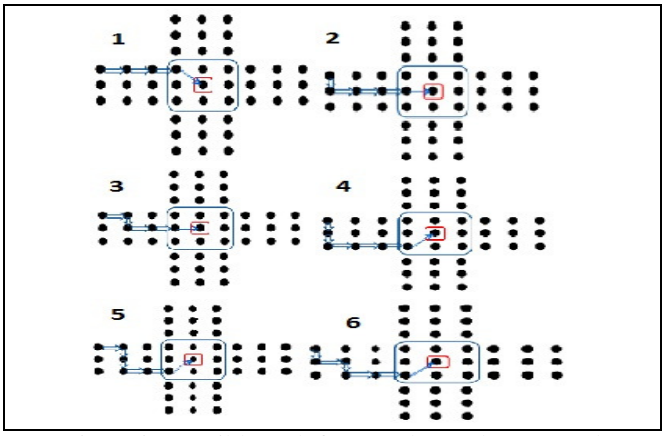

Fig2. Six Possible path from node to Cluster Head

2.3 Energy Efficient Deterministic Cluster Head Selection Algorithm (E^2DCH)

This section focuses on cutting the power consumption of wireless sensor networks. Here, we present a new approach to boost lifetime of sensor networks. Cluster Head consumes more energy as compared to other nodes, because it consumes energy for aggregation of data and for transmitting aggregated data to base station. In this approach we continuously change the position of cluster head and move topology in a deterministic manner enhancingthe lifetime of network. This algorithm ensures that after a particular time interval all nodes will become cluster heads. In our presented topology cluster head is positioned at the center. The algorithm for choosing cluster head is as following:

Input: Total number of Nodes N in a cluster

Output: After a particular time interval, all the nodes will become cluster heads in turn. Begin

1. Sensor nodes are deterministically deployed in a square grid. Nodes are grouped into clusters.
   Repeat step 2 to 5 for N/2 rounds
2. In the case of event detection, the nodes transmit data to their respective cluster heads which eventually gets transferred to the base station
3. Perform a right-shift on the position of all the cluster-heads
4. Now again data could be transferred as mentioned in step 2
5. Perform an Upward-shift on the position of all the cluster-heads
   End

3. THE SIMULATION FRAMEWORK

MATLAB has been used as a simulator in my thesis work .In our simulation the field of 18x18 dimensions has been taken and number of sensor nodes are 324. In this various parameters of node and their default values have been defined. Nodes are deployed in deterministic manner. Nodes are deployed at a fixed distance with each other. The vertical and horizontal coordinates of every sensor nodes must be preserved to calculate the energy dissipation in data transmission. In our simulation initially 4 full cluster and 8 partially cluster present. Each node has 0.5 joule energy. In our simulation we are using this value but we can assign any value. It is necessary that all sensor nodes must have equal energy earlier any action or event occurs. Sink has been placed corner of the field. Table 1 shows some detail about the energy consumption in numerous operations [5].

Operations	Energy Consumption
Electronics energy (Eelec)	50 nJ/bit
Amplifier energy (efs) (emp)	10 pJ/bit/m2 0.0013 pJ/bit/m4
Energy for data aggregation (EDA)	5 nJ/bit/signal

Table 1: Radio Characteristic

The packet format of message is shown in figure 3 [6]. There are three fields: header, information field and trailer. The header field generally contains the identification number of source and destination, packet sequence number, message type, in WSN header is of very few bytes. Data field contains data or control information depending upon the type of message and trailer contains the cyclic redundancy check bits.

Header	Information or Data	Trailer

Fig 3 Packet format of message

There are 4 full clusters and 8 partial clusters in each full cluster there are 45 nodes and cluster head present at middle of cluster. There are 4, three arm clusters and 36 present in each cluster. There are four clusters with 9 node in each also present. After every round clusters moves from their position because cluster head aggregate data and send it to another cluster head , it consume more energy, if we do not change position of clusters then cluster head will die early .

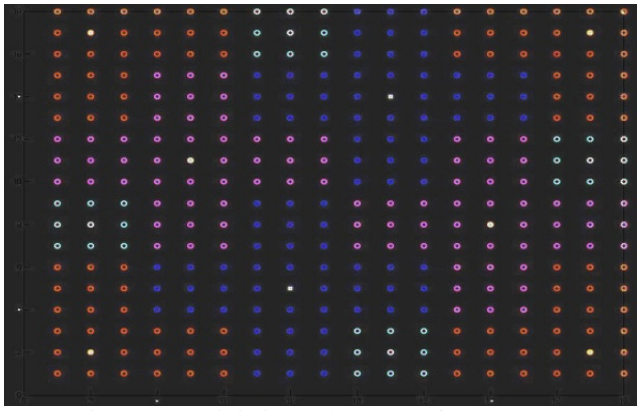

Fig 4 Deterministic deployment of 324 nodes

In fig 4 there are 324 sensor nodes deterministically deploy. Distance between two nodes is 1 m in x and y direction and diagonally and sensing range of each node is $\sqrt{2}/2$ m so it will cover whole area. There are some event generated in simulation and each event has some value. If a particular event in the range of one or more nodes then and its value greater then a threshold level than nodes will send packets to cluster head in multi-hop communication.

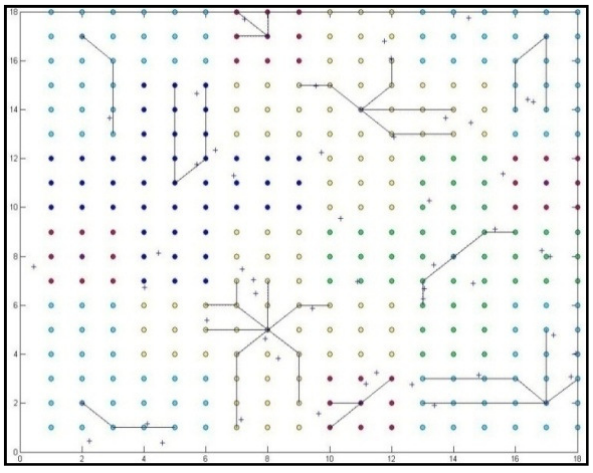

Fig5 Communication between nodes and cluster head

In fig 5 each sensor node sense values of event if event within its sensing range and its value is greater than some threshold then its send packet to its respective cluster head by intra cluster routing technique. Routing technique is according to proposed algorithm.

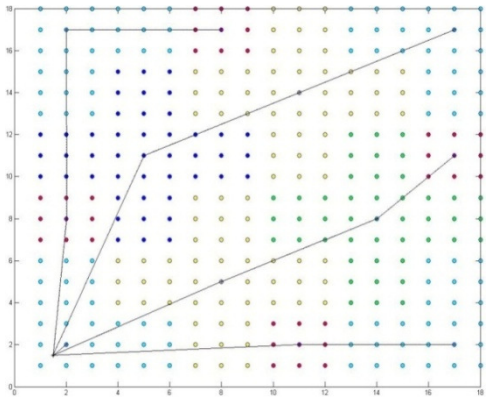

Fig 6: Cluster Heads transmit packet to base station

After getting values from nodes each cluster head aggregate data and send a value to Base station, it is showing in fig 6. Base station is placed at the corner of field. Cluster head send packet diagonally to next cluster head in a multi hop manner. Sink collect information from all the cluster head which got some thread from its node. After aggregating information sink know that all position where the events detected.

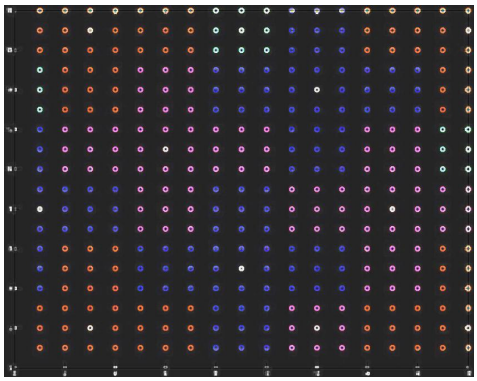

Fig 7: All Cluster Head shifted one position right

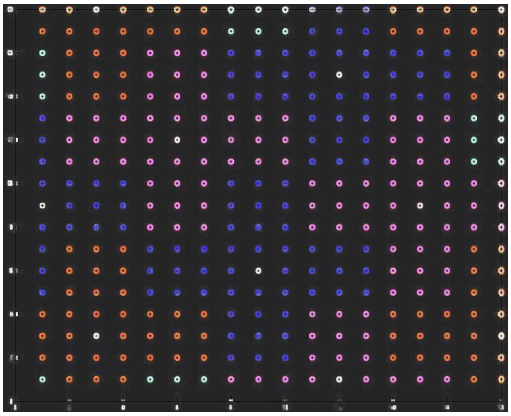

Fig 8All Cluster Head shifted one position upward

In next round entire structure shifted one position right as shown in fig 7 and then again node sense data and then transfer to respective cluster head and cluster head transfer data to base station. Then again entire structure shift one

position upward as shown in fig 8 and again node sense data and send to cluster head and cluster head send to BS. Then after entire structure shifted one position right and then one position upward. In our simulation after completion of 18 right shift and upward shift, means on 19th round structure will appear exactly same as 1st same as it appear in round.so we can say in 18 round all node will become cluster head.so it is a very energy efficient protocol, this protocol guarantees that all node will become cluster head. The energy of the node is computed after every transmission of data and check the available energy of the node. So that it is able to further participate in the operation phase of the network.

4. SIMULATION RESULTS

In this section we analysis the lifetime of proposed deterministic network. If any event detected then nodes always communicated with cluster heads. We have done two simulations with varying number of nodes. We have taken 2500 rounds in both simulations. In our first simulation we took 324 nodes in the beginning. After 2500 rounds, 112 nodes were alive as shown in figure 8. First node died at round number 1862.

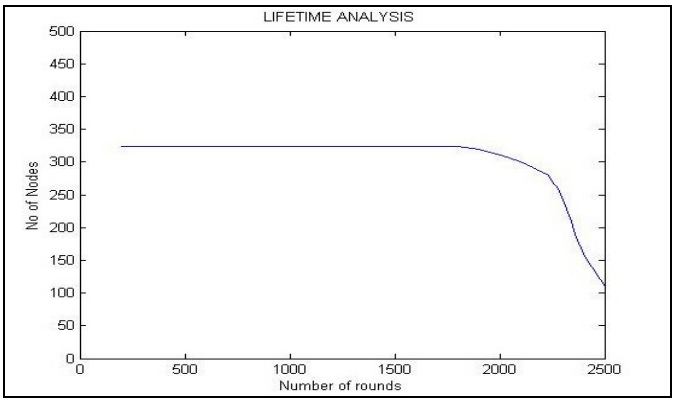

Fig 9.1 Lifetime of Network at n=324

In second simulation we took 400 nodes.The first node died at round number 1878 and after 2500 round 128 nodes were alive. Second simulation is shown in Fig. 91. and 9.2.

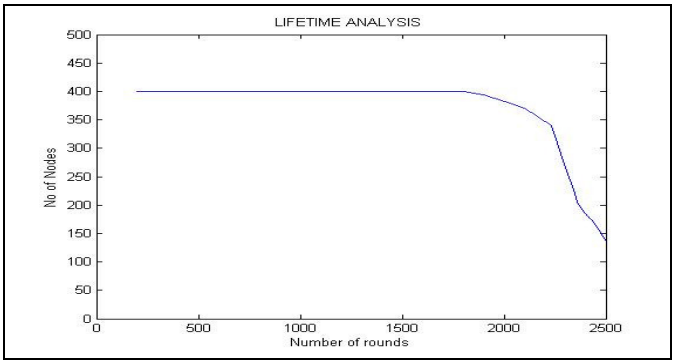

Fig 9.1 Lifetime of Network at n=324

5. CONCLUSION

We have proposed a unique strategy for the deterministic cluster head selection in wireless sensor network. We deploy nodes in deterministic manner and form a deterministic topology. Our routing algorithm is working on two parameters; number of hope count and residual energy of the nodes. This approach has been successful in achieve a good lifetime. We minimize the collision between packets and it aggregate data efficiently

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*Comparison:: In Square topology, a 3*3,4*4 or 5*5 square is chosen and these square are placed side by side resulting in a large square. Our proposed topology uses the concept of Square topology. One cluster of our topology contains five 3 * 3 squares four of which are placed around one as described in previous sections. So the routing algorithm suggested earlier can be applied. Hence we can say that our topology is an advanced version of Square topology.*

