Hexagonally Sectored Routing Protocol For Wireless Sensor Networks

Abin John Joseph[1] U.Hari[2]
Department of ECE
SRM University
Tamil Nadu, India

Abstract

The key issue in the study of wireless sensor network is the reduction in the energy consumption and thereby increasing the lifetime of the network. This paper presents a sectored approach based on LEACH. The entire network is divided into hexagonal sectors. Sectoring ensures a uniform distribution of cluster heads throughout the entire network. Cluster head selection is done on the basis of weight calculated for each node. This ensures the load balance in the network, which in turn helps in prolonging the lifetime of the network. Weight is calculated on the basis of residual energy and degree of each node. Simulation results show that this scheme reduces the energy consumption, balances the load and as a result increases the network lifetime.

1. Introduction

Wireless sensor networks consist of a number of nodes which can be used in a variety of applications such as environmental monitoring, industrial monitoring, military and many other fields [1]. Each node consists of a sensing unit, a data processing unit and communication unit. These nodes uses the energy from a battery and it will be very difficult to recharge the battery once the nodes are deployed. So energy efficiency becomes the very important design goal of the sensor network so that the lifetime of the network can be maximized.

Clustering is an excellent method which can be used for topology generation. Energy efficiency and network topology scalability are some of the advantages of clustering [2]. LEACH(Low Energy Adaptive Clustering Hierarchy) is an efficient clustering protocol for wireless sensor networks[3]. In LEACH protocol, nodes elect between themselves as cluster heads with some probability. Remaining nodes join these cluster heads and form the clusters. But LEACH needs massive improvement against the non uniform distribution of cluster heads [4]. Also cluster head selection should take into account the remaining energy of node and the number of neighbouring nodes for better performance. Sectoring is an excellent technique to solve the problem of non uniform distribution of cluster heads. Sectoring ensure every part of the sensor network is covered by cluster heads if every sector contains a cluster head.

Our paper propose Hexagonal Sectored Shortest Path Routing Algorithm(HSSPRA) which allows clusters to be formed with nodes from different sectors so that every non CH node can join the nearest CH irrespective of which sector they belong to. This will result in minimum energy usage for the transmission of data from member nodes to CH and thus result in better energy efficiency. Cluster head selection is done with the help of a weight equation which takes into account the remaining energy and degree of the node. This helps in load balance.

The remaining part of the paper is organized as follows. Section II deals with the structure of the algorithm. The energy consumption model of the network is discussed in section III. Then the simulation and its result analysis are followed in section IV. Finally, concluding remarks are given in section V.

2. Proposed cluster based scheme

HSSPRA is similar to LEACH and is divided into a number of rounds. Certain assumptions are made for this approach. The BS is located away from the network. All the nodes in the network are homogenous. All nodes have equal energy at the start. All nodes have their positions fixed and cannot move. The position of BS is also fixed. All nodes know the location of every node and BS.

2.1 Sectoring

Sectoring is done by BS. Optimum number of sectors is found out by the BS depending on the size of the network. Equal hexagon shaped clusters are formed. BS will give a sector ID to each node which is permanent. Sectoring is only done once in

the network and is permanent throughout the lifetime of the network.

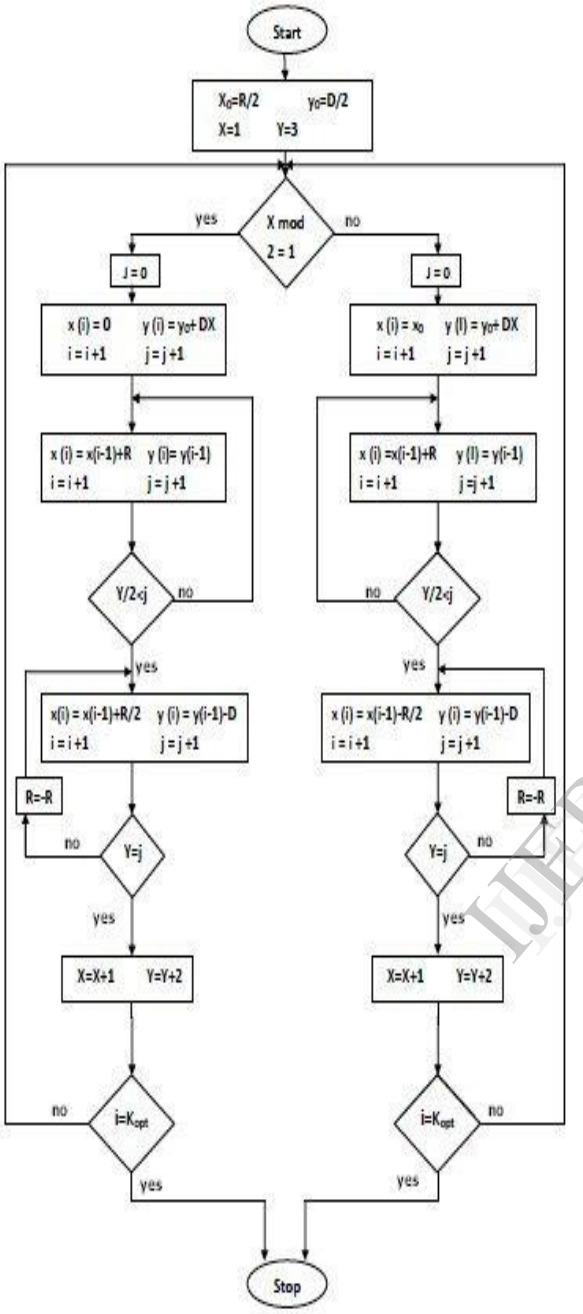


Fig. 1. Flow chart for specifying centre of hexagons

2.2 Cluster Head Selection

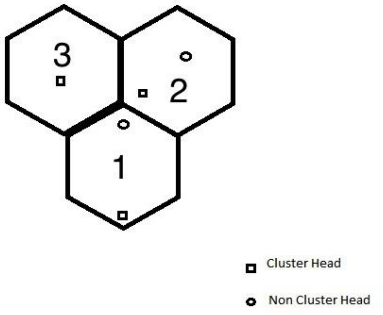
Sectoring rectifies the problem of uneven distribution of CH in the network. For load balance a weight equation is used. Weight equation uses the remaining energy degree of nodes in the sector. Weight is calculated by each node at the start of every round. Nodes having the same sector ID compare the weight with each other and the node having highest node is selected as the CH.
Weight equation is given by

$$W_i = \frac{D_i}{D_{avg}} \cdot \frac{E_i}{E_{avg}}$$

Where D_i is the degree of the node, D_{avg} is the average degree of nodes in a sector, E_i is the energy of a node and E_{avg} is the average energy of nodes in a sector at the start of a round.

2.3 Cluster Formation Phase

The major problem with cluster formation based on sector ID is that the CH may be at a corner of the sector and there may be a CH in the adjacent sector which may be nearer for the member node as shown in the figure



For the member node in sector 1, CH in sector 2, is nearer than CH in its own sector. If the member node selects the CH in its own sector as its CH for the round, the energy used by it will be more than required. To solve this problem after CH is selected the non CH nodes will choose the nearest CH based on the received signal strength. The steps involved in the cluster formation phase are

1) When a node is selected as CH, it broadcasts a message in the network saying that it has been selected as a CH for the current round.
2) After all the non CH nodes have received this message, each non-CH node selects the nearest CH using received signal strength, and sends a JOIN request to that cluster head.
3) The CH will send an ACK message and also the assigned TDMA slot.
4) After this, all member nodes start to transmit data to CH in its assigned TDMA time slot.
5) After receiving the data from all the member nodes, the CH will aggregate this data and transmits it to the BS via multihops using other CHs in the direction of BS.

2.4 Flowchart

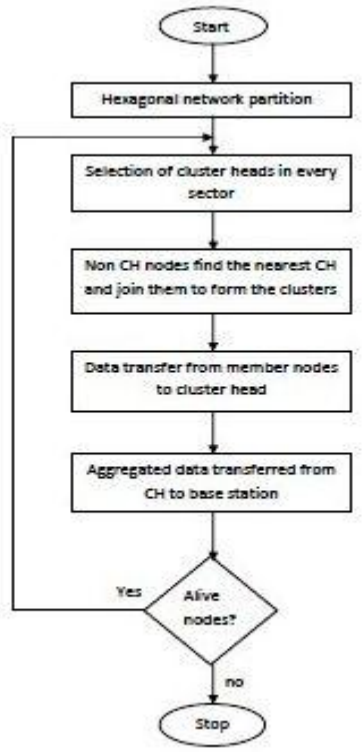


Fig. 3. Flow chart for the organizing scheme

3. Energy Consumption

The energy consumed by a node to transmit k bits of data for a distance of 'd' is given by

$$E_{TX}(k,d) = E_{elec} * k + (E_{fs\text{-}amp)*}k*d2 \quad (1)$$

The energy consumed by a node to receive k bits of data is

$$E_{RX}(b) = E_{elec}*k \quad (2)$$

where E_{elec} is the circuit energy consumption per bit. $E_{fs\text{-}amp}$ is the transmitter amplifier energy for free space.
The energy used by CH to aggregate the data received from member nodes is

$$Eagg\ (Ni, k) = Ni * k * E_{DA} \quad (3)$$

where Ni is the number of member nodes in a cluster and E_{DA} is the energy required for aggregation per bit.

4. Simulation

The simulation is done in MATLAB. The optimal number of sectors for the field of size 200 x 200 is found out to be 9. In this simulation part, we evaluate the performance of LEACH, HSWA and HSSPRA. The simulation parameters are shown in table below.

Table 1. Simulation parameters

Parameter	Value
Network coverage	200m x 200m
BS location	100m , 220m
N	100
Initial Energy	1J
E_{elec}	50nJ/bit
E_{fs}	10pJ/bit/m^2
E_{mp}	0.0013pJ / bit/m^4
d_o	87m
E_{DA}	5nJ/bit
Data packet size	4096 bits
Control packet size	200 bits

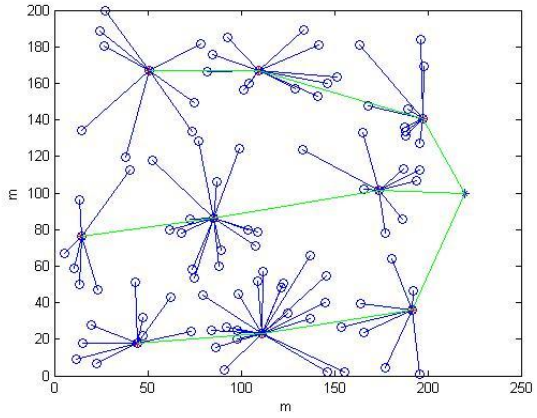


Fig. 4. HSSPRA protocol deployed network

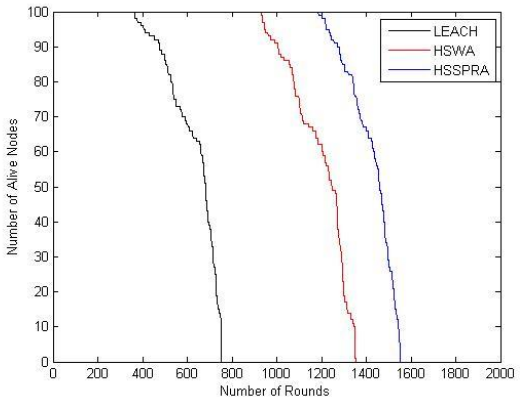


Fig. 3. Number of alive nodes

The network life time is shown in the Fig. 5. which shows the simulation results of LEACH, HSWA and HSSPRA. In HSWA protocol, the non cluster head nodes selects the cluster head in its own sector. But in HSSPRA, the non cluster head nodes selects the nearest cluster head irrespective of its sector id. Simulation results shows that HSSPRA gives a better energy efficiency than HSWA and LEACH protocol.

5. Conclusion

We proposed an equal hexagonal sectoring algorithm that enables the nodes to transmit data to the BS using clustering approach. This paper uses the remaining energy and position of nodes for cluster head selection. Also the shortest path is selected while the non cluster head nodes the cluster head. These considerations greatly enhance the energy efficiency of the network and provide load balance thereby increasing the network lifetime.

References

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