ENERGY OPTIMIZATION BY GRID CLUSTERING IN WIRELESS SENSOR NETWORKS

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---ABSTRACT---

Wireless sensor networks contain small network sensor nodes that are connected without wires with each other.They are used now a day in order to monitor borders, pressure, temperature, weather forecasting.These sensor nodes need rechargeable battery for the power supply.So the main drawback of these networks is that they have limited power supply.As these sensor nodes areused at borders where battery backup are limited, due to which energy is consumed.So to optimize energy, clustering is used in wireless sensor networks to increase the network lifetime of sensor nodes.This paper consists of grid clustering for the energy optimization of sensor nodes.In this grids are further divided into small grids in order to reduce the energy consumption.Size of grid is directly related to the transmission range of the node.So as the size decreases the transmission range also decreases this in turn conserves the energy.

Keywords-*Cluster, Energy Efficiency, Grid clustering, Network lifetime, Wireless sensor networks*

I. Introduction

A wireless sensor network consists of small sensor nodes that are capable of sensing an environment around them.WSN contains large number of low cost sensing nodes.These nodes sense data, aggregate data and then transfer it to the base station.In wireless sensor networks clustering is used as there are multiple sensor nodes exist between the sources and sink nodes.Clustering divides the large area into smaller groups.Clustering is used in order to arrange the same type of sensor nodes together. Same types of nodes are placed at one cluster.Each cluster thus has some number of sensor nodes.Every cluster has a leader known as Cluster Head.Cluster communicates with each other through theseCH (cluster head).Each cluster has one CH.All sensor nodes within a cluster transfer there sensed data to the CH.CH (cluster head) aggregate data and then communicate with other cluster CH to transfer data(1).CH as collect data, aggregate it and transmit it to other CH.This process consumes energy and results in the energy depletion as compare to the other nodes.CH near the sink consumes more energy and results in decline of the network lifetime.So the CH near the sink optimizes energy in order to increase the network lifetime(2).We should not overburdened the CH near the sink.Sensor nodes are also prone to failure due to the harsh environment.This failure degrades the network lifetime and overall performance of the network.In order to save energy and to increase network lifetime routing protocols are used or in WSN large numbers of routing and clustering algorithms areused. There are many routing protocols such as LEACH, DWECH (3)etc.Fig.1 show the architecture of sensor nodes. In this paper we use grid based clustering to optimize the energy. The sensor field is divided into small grids. In this CH communicate with base station in single hop and through other CH with multi hop(4).Other sensor node communicate with CH in same grid with single hop. SinceCH have to collect data and aggregate it and then transmit the data to the base station. The CH selection is done in order to maintain the energy level whenever its energy falls below threshold value. In this virtual CH also selected to avoid frequent execution of CH election process(4).

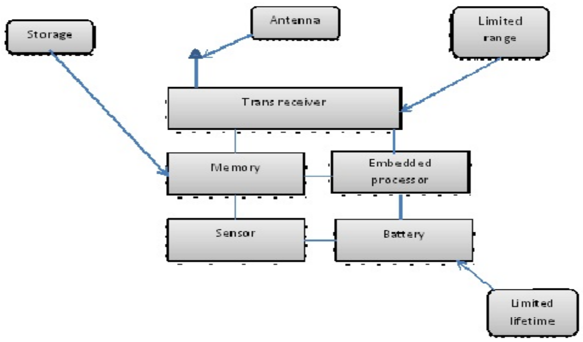

Fig.1 Architecture of sensor node

II.Related Work

Many clustering and routing algorithms have been developed in order to conserve energy and toincreases the network lifetime.Younis et al. proposed energy efficient protocol(5), which selects the cluster head periodically according to their residual energy. Grid based clustering algorithm organizes sensor nodes in such a way that if node does not perform any work it go into sleep mode and thus conservesenergy. Optimal grid size is taken in order to minimize energy.Fig.2 shows the wireless sensor network and how the data is transmitted from source node to sink node.

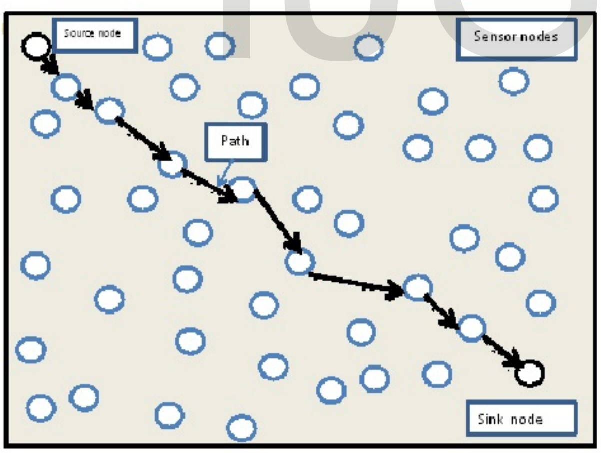

Fig.2Wireless sensor network

III.Proposed Work

The main aim of our algorithm is to increase the network lifetime by energy efficient protocol. The sensor field is divided into small equal sized grid like cluster. Every cluster have sensor nodes and one cluster head (CH).This CH communicate with the other sensor nodes and collect data then it communicate with other cluster CH and transmit data to the base station by multi hop(6).CH is selected on the basis of their residual energy. If the residual energy of CH falls below thresholdvalue, CH election message passed. Thenodes which have more residual energy become next CH. TheCH nodes nearer to sink consume more energy. Sothe area nearer to the sink divided into small grids. As the grid is optimized the energyis also conserve. Here the grid size, d is equal to the transmission range, r.So as the grid size decreases transmission range also decreases, due to which energy is conserved and it increases the network lifetime.The grid size d and transmission range, rare proportional equal to each other.Fig3 show that how the grid nearer to the sink is further divided.

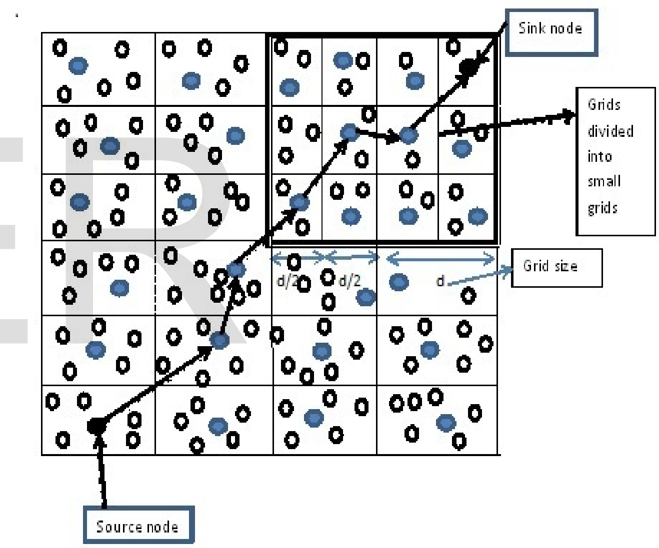

Fig.3 Grids further divided into small grids

IV.System Model

As we assumed that sensor nodes are deployed randomly in the given area(7)-(8).The location of the sensor node and the base station is known. We assumed that sensor nodes are static. As nodes are used randomly, the energy is dropped. So, various energy efficient protocols are used to increase the network lifetime. We assume that whole area is divided into small cluster. Each cluster have cluster head (CH).The size of the cluster is d, and the transmission range,r is used to transmit the data from one cluster to another. In the proposed model we assume that two cluster heads are at a maximum

ISSN 2229-5518

distance of less than r, the diagonal distance between two CH is r/2 meters. It is done so that connectivity is maintained between the nodes. Here data is sensed by sensor nodes. The whole operation is divided into rounds. In each round data is sensed and gathered at CH then CH transmit this data to the other CH. This process continues unless the energy dissipated. As the energy dissipated the message of selection of CH passes. Now the new CH selected and rounds started again. TheTDMA scheduling is used in order to avoid collision among the data transmitted by various sensor nodes to the CH(9).Data aggregation process is done at CH so it manages TDMA scheduling(10). As CH aggregated the transmitted data then it transmit this data to next CH by hop. During transmission of data between CH the CDMA scheduling is used .It avoids the collision when data is transmitted between clusters.

1.1Network Model

Here we take assumption that every sensor node contains information regarding to its residual energy and distance of its neighbor sensor nodes(11).In this data gathering operation done in rounds. In every round sensor nodes sense data and transmit them to the CH.CH aggregate data, it discard data which is not in use and redundant. Here all communication is done on wireless networks. Two nodes are connected by wireless networks if they are within the same range of communication.

1.2 Energy Model

Energy model that we use is a radio model(12).Here distance depends on the transmitter and receiver; it uses multipath channel and free space. If distance is less than threshold value d_0, free space model (fs) is used else multipath model (mp) is used.Suppose E_{elec} is the energy required by the circuit and e_{fs} and e_{mp} is the amplifier energy (E_{amp}).Thus the energy required for transmitting k-bit of message over d distance is calculated as(13):

$$E_{TX}(k, d)=E_{elec}*k+E_{amp}*(k,d)$$

$$E_{TX}(k,d)=\begin{cases} E_{elec}*k+k\,(e_{fs})d^2 & , d<d_0 \\ E_{elec}*k+k(e_{mp})d^4 & ,d>d_0 \end{cases}$$

The energy required for receiving data of k-bit is calculated as:

$$E_{RX}*k=E_{elec}*k$$

Here E_{elec} is the energy consumed for various operations such as coding, modulation, spreading schemes, filtering.Thismodel is simple model. On the other hand, radio wavepropagation model is very difficult to model.

V.Clustering

In wireless sensor networks the sensor area is partitioned into cluster. Each cluster has sensor nodes of same nature. Cluster formation in wireless sensor networks give good scalability and conserve energy. Geographic coordinates are used in clustering and routing(14).Dividing large area into small grids conserve the energy so grid based clustering is used in wireless sensor networks in order to conserve energy(15).The main problem in clustering is how to find the optimal grid size. For that we divide the whole area into small grids. Clusteringhas basically two phases:

A.Initialization phase

In this we divide the whole sensor area into small grids of size d.On the basis of transmission range grids are constructed. Forcomputing grid size we take transmission range, r of the sensor nodes and d x d we the size of the grid. This division makes sure that CH connect with its neighboring CH placed at any corner of the grid and even diagonally. If CH placed at the corner then it consists of worst case scenario so we connect with CH which is nearer to the centroid of the grid.

B.Set-up phase

Here we emphasis on the selection of CH. Firstly, within a cluster we compute the average distance between sensor nodes. Here we select the CH which has high residual energy.

1.1Cluster/Grid formation

It is the initialization phase where our main concentration is on the selection of grid size. Inthis sensor nodes are divided into equal size grids of size d. Here we take transmission range,r of the sensor nodes.Fig.4 show the grid construction. Grid size is calculated as(16):

$$r^2= (2d)^2+ (2d)^2$$
$$r^2=8d^2$$

Thus, grid size $d=r/2\sqrt{2}$

The CH is selected which is nearer to the centroid of the cluster. Asthe CH, which is located at the corner of cluster contains worst scenario. Here transmission range, ris directly proportional to the grid size, d.So as the size decreases the transmission range also decreases. Thus,we emphasized mainly on the small grid size. In the same cluster the homogeneous sensor nodes are placed. Each sensor node has data regarding its residual energy and distance from other nodes. Source node and sink node are connected by these sensor nodes. The optimal path is choosing when data is transmitted from source to sink node.

Following figure show the relation between the grid size d and transmission range r.

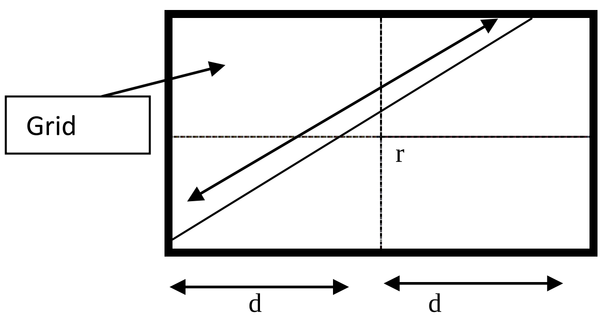

Fig.4 Grids construction

1.2Cluster headselection

Our next step after the formation of cluster is selection of cluster head (CH).Each cluster have number of sensor nodes so as to communicate with other cluster we have to select the CH so that it communicate with other cluster CH. These CH transmitted data to the base staion.CH gather data from the sensor nodes and aggregate it and remove the unwanted and redundant data. Then CH communicates with other CH and transmits data to it.Every sensor nodes randomly selected as a CH.CH selection depends on the residual energy of the sensor node. If the CH residual energy falls below threshold value then next sensor node is selected as CH whose value is equal to the threshold value.Back offtimer is used in order to compete for the CH selection by the sensor nodes.

1.3Cluster headrotation

When CH performs operations it consumes energy. So to maintain the energy of cluster head, CH rotation is performed.CH rotation is done in a manner such that energy level is maintained for transmission of data. Sensor nodes consume energy while performing any operation such as data transmitting and gathering. If we let this work done by one sensor node then energy depletes at a faster rate and also the work is not done in efficient way. So to provide smooth functioning of the sensor nodes CH rotation is done with in a cluster and sensor node which has sufficient residual energy is selected as next CH. In grid based clustering if residual energy E_r of a CH fall below threshold energy E_{t},,then CH pass message of cluster head selection to other nodes. Thenodes which have greater residual energy compete for this process.CH calculate the candidacy factor CFfor every sensor node n:

$$CF=d_c/E_r$$

Here d_c= distance from the centroid of the cluster

Node is selected as next CH if its CF value is low. As the relation between CF and E_r is inversely proportion so as the value of CF is minimum the value of E_r is maximum. This implies that node which is nearer to the centroid of the cluster has more residual energy and it is the next CH. During selection of CH energy is consumed more so some virtual CH's also selected in order to decrease the value of CF.

1.4Role of cluster head in data aggregation and routing

Sensor nodes sense data and then transmit it to the CH using one hoprouting.CH then collect data and aggregate it.It removes the redundant data and only required data is transmitted to the next basestation by multi hop routing.CH selects the next hop CH from its 8 neighbor by greedy strategy.CH_1 selects the next CH_2 as the CH_2 has lesser distance from the sink node.

VI. Simulation

In this we calculate the performance of a proposed grid based clustering algorithm by simulation in MATLAB 7.5.0 on Intel i5 core processor on the platform Microsoft Window 7 ultimate. Define firstly the parameters of the simulation. In this we see the effect of various factors such as transmission range, network size and number of nodes. Table 1 defines the simulation parameters.

VII. Performance

Simulation of this algorithm is done in MATLAB For this we take network size of 200*200 square meter area, number of nodes with in this area is 300,grid size we take is 100m and transmission range 150m.Other parameters are shown in Table 1.We simulate this algorithm by dividing grid nearer to the sink node. As the load of transmission is maximum at sink node thus dividing grid size further minimizes the energy consumption.Section V explains the working of CH in a wireless sensor networks. The performance of network area depletes as the CH transmission energy lower down.

Table 1

Simulation parameters

Parameter	Value
Network Size	200 x 200
Number of nodes	300
Grid size	100m
Initial energy	1 J
Packet Size	1000 bits
Transmission Range	150m
E_{elec}	50nJ/bit
e_{fs}	10pJ/bit/m^2
e_{mp}	0.0015pJ/bit/m^4

So continuous rotation of CH is done after some interval.CH collects data from source node and transmit it to the sink node.Fig.3 show that how we divide the area nearer to the sink node.

Following scenarios generated after this:

1.1Effect of grid size on transmission range

Transmission range is the range of transmitting data between nodes. When we transmit data from one node to another node energy depletes. As in wireless sensor networks battery place an important role.So energy consumption is essential feature in wireless sensor networks. In order to do that various energy efficient algorithms are made.

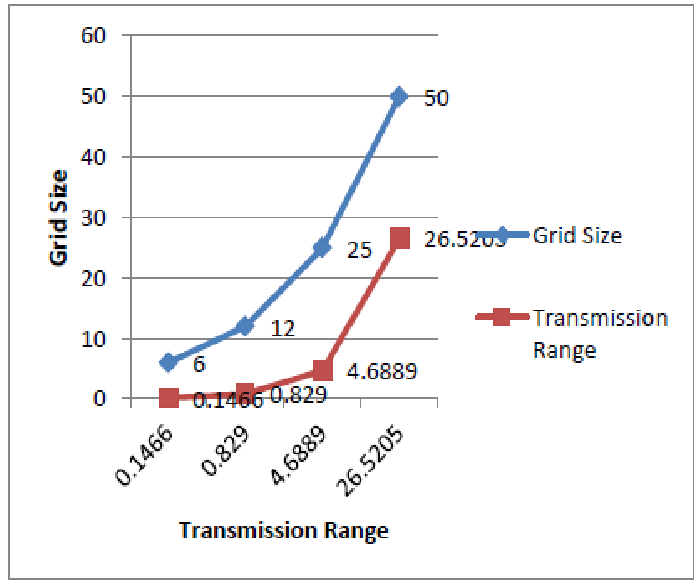

Fig.5 Relation between Transmission Range and Grid Size

In Fig.5 relation between transmission range and grid size is shown .We see that as the grid size decreases the transmission range also decreases. Asthe transmission range decrease the energy is optimized.

VIII.Conclusion

Optimizing grid size conserve energy during transmission of data between nodesdue to which energy of nodes is conserved. As the energy of nodes conserved the whole network energy is conserved.Thus dividing the grid size furtherlower down the transmission range which in turn minimize the energy consumption. This algorithm of dividing grid intosmaller size further nearer to the sink optimizes energy consumption. As the load nearer to the sink is maximum, so we further divide the area nearer to the sink. Asthe transmission range and grid has proportional relationship so as the grid size decreases the transmission range also decreases. Simulation result shows that our algorithm performs better in variousscenarios. As the energy is conserved the battery is optimized and it increases the network lifetime.

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