Route Prediction in Wireless Sensor Networks using Markov Model

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Abstract— **In Wireless Sensor Network (WSN), well known problems are routing problem has been briefly analyzed to enhance the network life time of WSN. In clustering, cluster head(CH) is responsible to send data via other CH nodes to the base station. This tends to create situation known as nodes are die earlier. To increase the node aliveness in the network, energy consumption of each sensor node should be reduced in the network. To decrease the energy consumption of energy proper selection of relay nodes is required. In this project, We are devising a algorithm for relay nodes selection. For the selection of relay nodes (routing) we are using markov model which is used to predict route on the basis of current state of next-hope towards the base station. The algorithm is checked in terms of no. of rounds vs remaining energy in the network with existing algorithm multi criteria decision model routing and leach.**

Keywords— **Markov Model, Clustering, Routing, Energy**

I. Introduction

A. *Wireless Sensor Networks*:

A wireless sensor network of spatially distributed sensors (it may be random or predefined position)to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and pass its collected data to each other towards the base station. Distribution of sensor node is may be random or predefined location. Generally two types of sensor nodes are used (1) homogeneous (all node have equal capabilities) and (2) heterogeneous (All nodes are not alike, some nodes have different capabilities). The requirement of wireless sensor networks was emerged by military applications such as battlefield surveillance and many more. Today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

B. *Clustering:*

Cluster analysis or clustering is the task of bunching a set of senor nodes in a way that sensor in the same group (called a cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters). In wsn sensor nodes which have shorter distance to the near CH are in the same group. Its main task is to collect the data from the target area and pass it to the CH. After that CH forward the collected information towards the base station.

Cluster formation itself is not one particular algorithm, but the general problem to be resolved. It can be achieved by various algorithms that differ significantly in their notion of what constitutes a cluster and how to effectively find them. Popular notions of clusters are groups with shortest distances with the cluster members, areas of the data space is dense, intervals or particular statistical distributions.

Therefore clustering is a multi-objective problem. The suitable clustering algorithm and parameter settings (including values such as the distance function to use, a density threshold or the number of expected clusters) depend on the individual data set and intended use of the results. Cluster analysis as such is not an automatic task, but an iterative process of knowledge discovery or interactive multi-objective optimization that involves trial and failure. It will often be necessary to modify data pre-processing and model parameters until the outcome achieves the required properties

C. *Routing*

To select the relay node between source to destination is known as routing. In wireless sensor node due to improper selection of the next-hope node in the communication increases the energy consumption and reduce the network lifetime. Routing is the one of the major issue in the wireless sensor network to solve the major issue many of the algorithms is devised but these existing algorithm lacking in consideration of selection parameters such as energy and distance to the base.

Contribution in this paper as follows (1) Markov-based routing protocol with Multiple selection parameters to provide the relay node selection solution for communication between the cluster head and Base station, (2) Experimental analysis of our algorithm by comparing with other routing algorithms. The Markov model and amplification model are discussed in Section 2. The Markov based routing algorithm is discussed in detail in Section 3. Simulation analysis with some routing algorithms is shown in Section 4. Paper is concluded in last section

II. Preliminaries

A. *Energy Consumption Model*

Sensor node reduces it energy to transfer data to the sink. The energy model that is used in the network that decreases the energy in different operation such as transmission, reception, sensing and aggregation

Equation1 shown below is for total energy consumption in transfer L bits of packet at distance dm, where Eelec is the energy required per bit in transmit circuitry and Eamp is the energy required in amplification process

$$E_{TX}(L, dd) = E_{elec} * L + E_{amp} * L$$

Equation2 shown below is for total energy required in receiving L bits of packet

$$E_{Rx} = E_{elec} * L$$

Equation3 and Equation4 is shown below for energy required in amplification, where Efs is energy required when free space model is used (i.e. distance shorter then threshold value) and Emp is energy required when multi-path fading channel model is used (i.e. distance more than threshold value).

$$E_{amp} = E_{fs} * d_w^2$$

$$E_{amp} = E_{mp} * d_w^4$$

Equation5 is shown for the amount of energy required in aggregation, where Eda is aggregation energy and *N* is the no. of members belongs to that cluster-head *CH*

$$E_{aa}(CH,M) = M * eda$$

Equation6 is shown below represents energy required in transmitting *L* bits of packet for *non CH* to the *CH*

$$E_{non-CH} = E_{Tx}(L, d_{non-CH})$$

Equation7 is shown below for the total energy required of *CH* Node.

$$E_{CH} = M * E_{Rx}(L) + M * E_{da} + E_{Tx}(L, d_{CH-BS})$$

B. Markov Model

It is used to predict future state on the basis of current state like consumer purchase the car then what is the next chance to buy the same car instead of other. Similar theory applicable the wireless sensor node also in which when next relay select to relayed the data to the base station than what is the chance to select the same relay instead of other relay node. Markov model has decision parameter to select the future state like as previous example of experience of purchase car is the decision parameter. Similarly in WSN residual energy of relay and distance is the decision parameter for the future selection of relay node
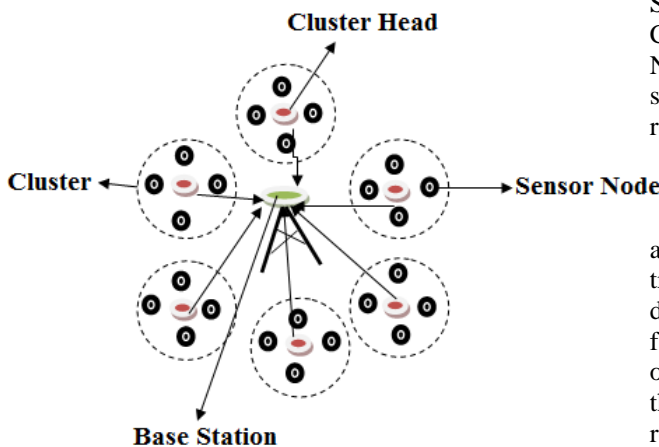

Fig: Communication between CH to BS

III MARKOV MODEL BASED ROUTING IN WIRELESS SENSOR NETWORKS

To decrease the energy consumption and to improve the network lifetime for the sensors in wireless sensor network, routing algorithm in wireless sensor network is devised. It is centralized routing algorithm. It makes global decision to predict the next-hope. We have used Markov model to predict the next-hope on the basis of current state of availability of sensor nodes in its range

A. Set-up Face

The goal of the setup phase is to form the clusters and select the cluster head. For the formation of cluster Basic leach protocol is used and cluster head selection mechanism shown in the algorithm.

Proposed Algorithm

Data: ;
Energy of Next-hope Sensor Node towards the BS;
Distance to the Next-hope;
Distance from Next-hope to BS;
Result: Routing Path from CH to the BS
initialization;
while *No Updation next-hope selection* **do**
    read current State of the Sensor Node;
    Apply Markov Model to analysis Sensor Node;
    if *Better Position is found* **then**
        Update the next-hope routing list in routing table;
    else
        Fix next-hope list and Start Communication;
    end
end

Algorithm 1: Next-hope selection in Wireless Sensor Network

Initialization:

In the initialization phase , next-hope relay list taken as input in its communication range in Markov Model
Representation of CH:
Set of cluster head are represented by cluster head node id C=(CH_{i},CH_{2},CH_{3},CH_{4}.....CH_{n}). Relay Node nodes is assigned to the cluster head in which have shortest distance from all the cluster head and energy of relay is greater than average residual energy of the network.

Cluster head updation:

In the initial round , all CH have the same energy but after some rounds CH and sensor depletes its energy in transmission, receiving and aggregation.In that case distance between next-hope and bs is useful to take decision for the selection. After some rounds cluster head is selected on the basis of markov model which have energy greater than the average residual energy and distance between relay node to the base station is minimum
position updation:
update the selected next-hope routing list in routing table until the desired condition meet.

B. Steady State Face

[9]After the formation of cluster, TDMA schedule is assign for the data communication process. Initially all the sensor node sends sensing data, position and residual energy information to the CH as per the assign schedule of TDMA. CH shrinks the information and combines into the single signal then send to the BS or to the nearest CH towards the BS (when CH node communicating indirectly via other CH nodes instead of directly). Due to the impact of compression process on non-CH node as well as CH node, amount of information is reduced. After the completion of the round, set-up face and steady state face repeated.

On the basis of received information (position and energy) of the sensor nodes, the routing structure is created that is already discussed in the setup face.

After the creation of routing architecture, BS broadcast CLU-ROU-IND message to the entire sensor nodes. When the non-CH sensor nodes received CLU-ROU-IND message then it sends sensing data, position and residual energy to the CH node as per assign schedule of TDMA.

In the cluster, when all of the information is received at the CH, the CH node performs aggregation to the received information and combines them into the single signal SEN-INF-RSP.

This CH node SEN-INF-RSP message is send to the nearest connected CH towards the base station or directly to the base station if it is directly connected to the base station. Reformation of the cluster is begins when CH node doesn't received the signal from the non-CH node. Thus, the calculation overhead only depends on formation of the cluster and selection of the CH node within the cluster.

IV. EXPERIMENTAL ANALYSIS:

To show the performance of proposed algorithm residual energy of CH is analyze. if the residual energy is more then network will sustain to the longer duration, it increases the network lifetime.

A. Residual Energy:

It is the energy left after some communication rounds. IF distance between sensor node and CH is less , it will consume less energy otherwise it will consume more energy.

B. Simulation Environment:

For the simulation analysis , experiment is performed in matlab and java-8.0. In which three test cases is analyzed. First when base station placed at the center, second when base station placed at the corner and third when base station placed outside the network. Parameters taken as input are initial energy of all sensor node is 2j, network size is 200*200, number of nodes 200 and all the nodes are homogeneous(means all node have same configuration).

C. Base station placed at the center

When Base station placed at the center , it is observed that performance of LEACH is lowest due to no parameter is taken to select the cluster head and CH communicate directly with the base station
. Performance of MCDM[10] Routing is better then leach due to parameters energy and distance to the sink is taken for selection of relay and communication is by relay nodes.

Finally performance of proposed better then both algorithms due to energy, distance to BS and distance to next-hope all are taken as input for the selection of relay nodes in routing path. Result is shown in figure2

D. Base station is placed at the corner

When Base station placed at the corner, performance of LEACH and MCMD routing depletes energy rapidly as compare to proposed algorithm as shown in figure 3. This is fact that due to CH dies in LEACH and MCDM routing earlier as compare to the proposed mechanism

E. Base station placed outside the WSN

When Base station placed at the outside the network, performance of LEACH and MCDM depletes energy rapidly as compare to proposed algorithm as shown in figure 4. This is fact that due to CH in LEACH and MCDM routing dies earlier as compare to the proposed mechanism

To improve the performance of case 2 and case 3 , optimization in routing can be used like PSO-routing, GA-Routing or nature inspired techniques
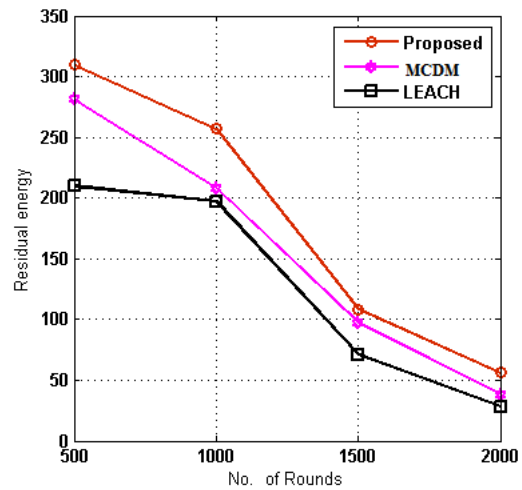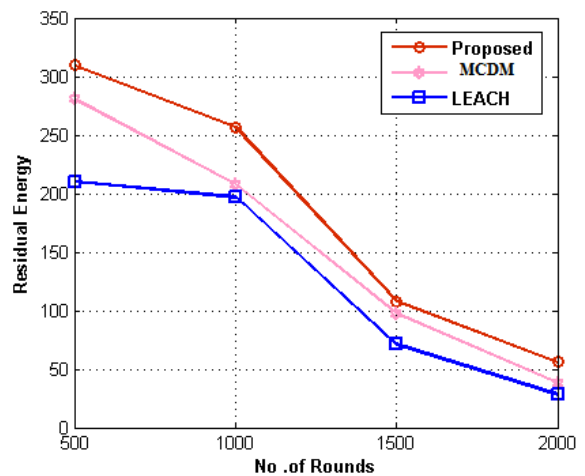

FIG 2: BASE STATION PLACED AT THE CENTER

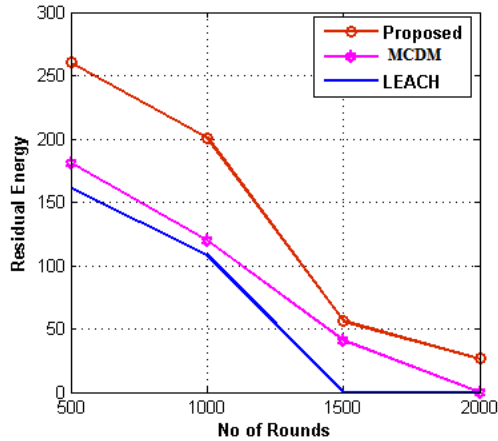FIG3: BASE STATION PLACED AT THE CORNER

FIG 3: BASE STATION PLACED OUTSIDE THE NETWORK

V CONCLUSIONS

In multi-hop inter cluster communication, relay traffic increases at CH and consumption of energy is much more in CH's to sink node via relay nodes. Therefore, CH dies earlier. In this paper, routing algorithm in wireless sensor network algorithm is devised to reduce the energy consumption in network by proper selection of next-hope relay. In order to achieve the objective workload markov model is used by taking energy and distance as a input criteria. Hence performance of network increases as BS goes outside the network as compare to other routing algorithm. So, instead of direct communication indirect communication is useful. In future we are going to implement security with routing mechanism to improve the performance

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