Performance Analysis of Energy Dissipation in WSNs Using Multi-Chain PEGASIS

Mukesh Prajapat[#1], Dr. N.C. Barwar[*2]

[#] *M.E. Scholar, Department of Computer Science & Engg.,M.B.M. Engineering College, J.N.V. University, Jodhpur, India*
[*] *Assoc. Prof., Department of Computer Science & Engg.,M.B.M. Engineering College, J.N.V. University, Jodhpur, India*

Abstract— In wireless sensor networks, sensor nodes have limitation of energy so the lifetime of the networks is very important design factor.There are proposed many routing protocols for the wireless sensor networks recently. One of these protocols, the PEGASIS (Power-Efficient GAthering in Sensor Information Systems) protocol is a chain-based routing scheme that are proposed for reducing energy consumption of communication in the networks. In general, the PEGASIS protocol give twice or more performance in comparison with the LEACH (Low Energy Adaptive Clustering Hierarchy) protocol. The chain-based routing schemes construct the chains for routing path. The chain-based routing schemes use the concept of multi-hop routing. The proposed approach divides the single chain into multiple parts. It decreases the network overhead due to fewer numbers of nodes in chains. Minimization of data delivery delay is also an important requirement to improve network performance. In the proposed method nodes are divided in several regions and different chains are made for each region, it reduces the delay between nodes to BS, hence energy load is distributed uniformly among the chains. Overall performance analysis is measured in terms of network lifetime in terms of Sum of Remaining Energy (Joule) with number of rounds. We compare the LEACH, PEGASIS and proposed method with respect to 15J, 20J, 25J and 30J Energy, Where initial energy level of nodes are 0.5J. Proposed method is found to be 20% better at performance than PEGASIS and 72% than LEACH.

Keywords— *Wireless sensor network, PEGASIS, Multi-Chain PEGASIS, Energy dissipation, Number of dead nodes and Rounds, LEACH.*

I. INTRODUCTION

Wireless sensor networks are set of hundreds or thousands of micro sensor nodes that have capabilities of sensing, establishing wireless communication between each other and doing computational and processing operations. In fact,
These sensor nodes sense their environment and can provide information about environments which are far from us via wireless communications. These networks have many applications and appeals but because of their limitations of energy and bandwidth, actual applications of them are difficult. Since to achieve these capabilities, we must use many numbers of these micro sensor nodes, the cost for these nodes should be very low. The energy of nodes is depending on the power which is embedded in nodes, so we always have the limitation for the cost and the size of the nodes. There are many energy efficient protocols designed for wireless sensor networks ([1], [2]). When sensor networks are considered, those data routing

algorithms can maximize the system lifetime for the different method. In this paper, we propose a new method for reducing the energy consumption in the nodes routing. This energy reduction will cause changes in some of the other dependent parameters such as delay. Among the hierarchical protocols, Low-Energy Adaptive Clustering Hierarchy (LEACH) [3] and Power Efficient Gathering in Sensor Information Systems (PEGASIS) [4] are the most famous. PEGASIS avoids the formation of clusters and allows a single node in the chain, to forward data to the BS [5]. An energy efficient network organisation scheme for WSN is proposed in this paper. In the context of chaining scheme, the proposed method divides the single chain into the multi-chain. The proposed method uses the characteristics of energy division among the multiple chains instead of single chain. We simulate our new method using MATLAB R2014a software and simulation result demonstrates that the proposed model achieves less energy consumption compare to LEACH and PEGASIS.

The rest of the paper is organised as follows. Section II reviews different chain based protocol and related work. Section III presents a proposed model. Section IV gives comparative analysis of proposed method with existing LEACH and PEGASIS protocol.

II. RELATED WORK

In the recent years many energy efficient routing protocol has been proposed some of the major protocols are given below.

A. LEACH Protocol:

LEACH [6] is the First and most popular energy-efficient hierarchical clustering algorithm for WSNs that is used for reducing power consumption. LEACH is based on data aggregation technique that combines the original data into a smaller size of data that carry only meaningful information to all individual sensors. LEACH divides the a network into several cluster of sensors, which are constructed by using localized coordination and control not only to reduce the amount of data that are transmitted to the sink, but also to make routing and data dissemination more scalable and robust.

LEACH uses a randomize rotation of high-energy CH(Cluster Head) position rather than selecting in static manner, to give a chance to all sensors to act as CHs and avoid the battery depletion of an individual sensor and die quickly. LEACH uses single-hop routing where each node can transmit directly to the cluster-head and the sink.

Therefore, it is not applicable to networks deployed in large regions. While LEACH helps the sensors within their cluster dissipate their energy slowly, the CHs consume a larger amount of energy when they are located farther away from the sink.

B. PEGASIS Protocol:

The key idea of PEGASIS is organize all sensors to being a data chain for data transmission and reception. The data from one node to another node make data aggregation and sent by leader to BS.PEGASIS assumes that all nodes know global location of sensors and use greedy algorithm to form chain. An upstream node on chain searches next hop node in networks that do not participate in chain formation and chooses the closest node as its child node. After formed data chain, the end chain node begins to send data. Each node aggregates data from child node with its own data in order to come into being a new data packet. Then, send the new data to parent node. Every node on chain repeat the same operation till the data reaches to leader node. Since this chain computation is done once, followed by many rounds of data communication. When a node dies, the chain is reconstructed in the same manner to bypass the dead node.

Alternatively, the BS can compute this chain and broadcast it to all the sensor nodes. We used random 100-node networks for our simulations. We placed the BS at a far distance from all other nodes. For a 100m x 100m plot, our BS is located at (50, 50).For constructing the chain, we assume that all nodes have global knowledge of the network and employ the greedy algorithm. Chain construction in PEGASIS protocol is shown in Fig.1 Gathered data moves from node to node, get fused, and eventually a designated node transmits to the BS. Nodes take turns transmitting to the BS so that the average energy spent by each node per round is reduced. Building a chain to minimize the total length is similar to the travelling salesman problem, which is known to be intractable. In PEGASIS each node will receive and transmit one packet in each round and be the leader once every 100 rounds. With our simulation experiments, we found that the greedy chain construction performs well with different number of nodes and random node placements.
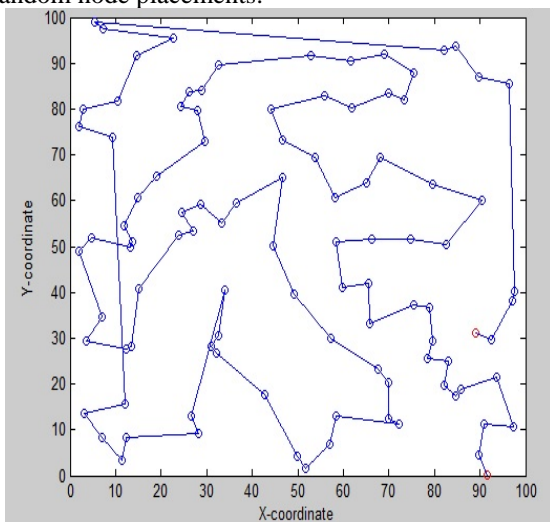
Data Aggregation: For gathering data in each round, each node receives data from one neighbour, fuses with its own data, and transmits to the other neighbour on the chain. Note that node i will be in some random position j on the chain. Nodes take turns transmitting to the BS, and we will use node number i mod N (N represents the number of node) to transmit to the BS in round i. Thus, the leader in each round of communication will be at a random position on the chain, which is important for nodes to die at random locations. The idea in nodes dead at random places is to make the sensor network robust to failures. The node which is dead during communication that node be bypassed in reconstructing in chain.

C. Chain-Based Routing Scheme

The BS is located far away from sensor nodes. In the wireless communication, an energy consumption increases in proportion to square of the transmission distance [7]. If the number of transmitting data to the BS is decreased, the total energy dissipation is decreased. The minimum transmission-energy is saving energy for signal amplifying [8, 9]. The head node has responsibility to transfer data of every sensor nodes to the BS. Only the head node communicates with the BS so this scheme can save energy dissipation. Energy-efficiency has been focused from different aspects, like, energy conserving sleep scheduling, topology control and data aggregation [10].

III. PROPOSED WORK

We propose Multi-chain PEGASIS protocol for reduction of energy consumption in WSNs. It is the modified version of PEGASIS. Proposed method is found to be 20% better at performance than PEGASIS and 72% than LEACH.

A. Chain Formation in proposed protocol

In multi chain PEGASIS the chain formation is same as the PEGASIS except in multi-chain PEGASIS nodes are distributed in four regions and each region contain a separate chain[11] i.e. 100 nodes area is divided in each 25-25 nodes. Chain construction of proposed model is shown in Fig.2

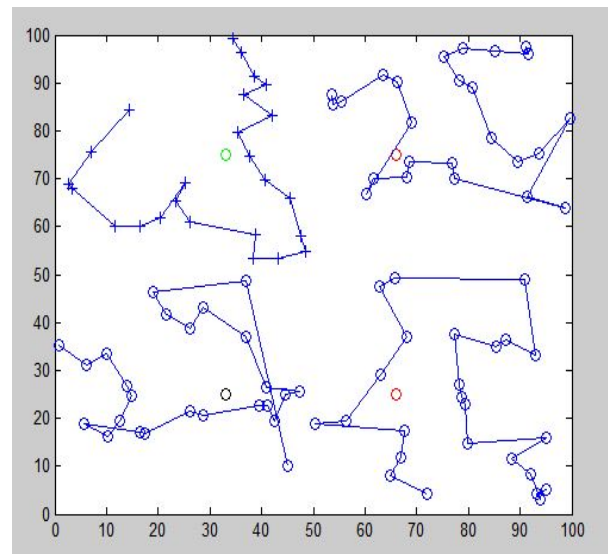Fig. 1 Chain Construction in PEGASIS protocol

Fig. 2 Chain Construction in Proposed protocol

- Sink find the far node by comparing the distances of all nodes from itself in first region.
- The chain construction is start from end node which is far from the sink.
- The end node finds the most near neighbor and makes the chain between end node and nearer node.
- Each node finds the distance between itself and the nearest node not connected in chain and connect it with the same method which mention above.
- The same procedure of chain formation is applied in all four regions.

B. Energy Cost

The following equations used to calculate transmission cost and receiving cost for a k-bit message and a distance d are:

- Transmission cost:
$$E_{TX}(k, d) = E_{TX\text{-elec}}(k) + E_{TX\text{-amp}}(k, d) \quad (1)$$

- Receiving cost:
$$E_{RX}(k, d) = E_{RX\text{-elec}}(k) \quad (2)$$

- Data Aggregation cost: Data aggregation cost is calculated based on fusion of all data at a node of k-bit message
$$E_{DA}(k) = E_{DA\text{-elec}}(k) \quad (3)$$

IV. SIMULATION AND COMPARATIVE ANALYSIS WITH EXISTING PROTOCOLS

To evaluate the performance of the multi-chain PEGASIS protocol it has been simulated in 100 node network and the nodes are randomly distributed in a 100m* 100m square. In this model, a radio dissipates the energy in sending or receiving 1bit: *Eelec* = 50nJ/bit. Nodes having initial energy is *E* = 0.5J/Node**.** In order to show the performance of the protocol it is simulated using MATLAB R2014a. The results are shown under and comparison between them.

A. Parameter Used:

The following parameters used for simulation of proposed and existing protocol.

TABLE I. PARAMETERS USED FOR SIMULATION

Rounds	2000
Network Size	100m*100m
Number of Nodes	100
Base Station Location	PEGASIS:(50,50) Proposed:(33,25),(33,75),(66,25), (66,75)
Initial Energy of Nodes	0.5J
Packet Size	2000bits

B. Comparison between proposed model, LEACH and existing PEGASIS protocols:

We simulate the protocol for determine the Sum of Remaining Energy of nodes per round in proposed, LEACH and PEGASIS protocol. We compare the results of protocols based on above parameters mention in *Table I*.
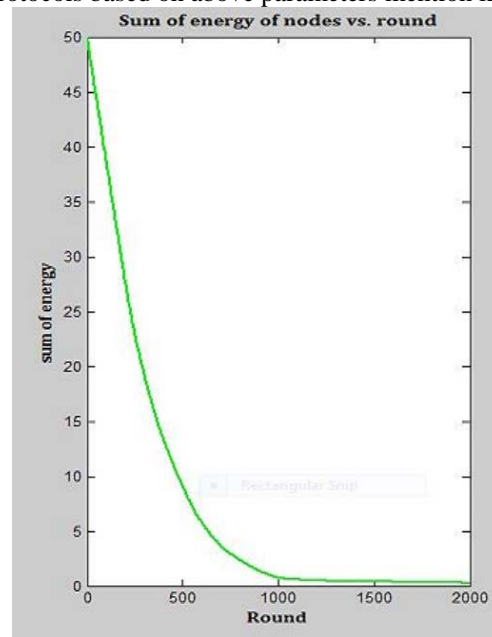

Fig. 3 Sum of Energy v/s Number of Rounds in LEACH protocol

From Fig.3 We observe that initially, sum of energy of all nodes are 50J, as rounds are increases energy is consumed
Leach protocol up to 477 rounds residual energy are 15J,20J Residual energy remain left until 307 rounds,25J Residual Energy up to 241 rounds and 30J energy up to 201 rounds.
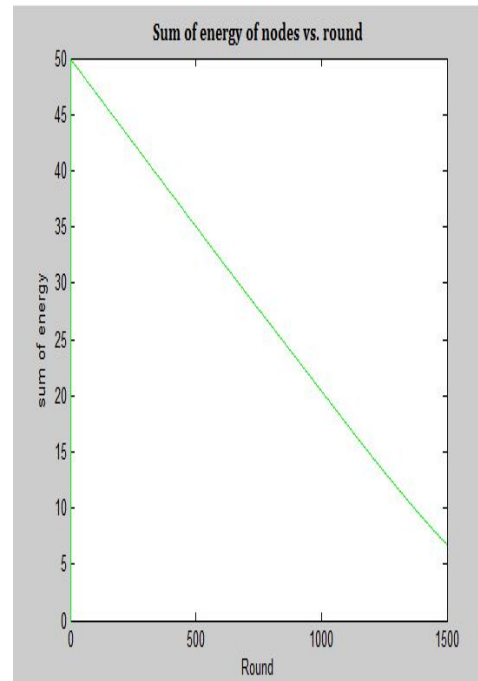

Fig. 4 Sum of Energy v/s Number of Rounds in PEGASIS protocol

We can seen from Fig.4 that in PEGASIS protocol up to 1193 rounds residual energy are 15J,20J Residual energy remain left until 1007 rounds,25J Residual Energy up to 830 rounds and 30J energy up to 664 rounds.
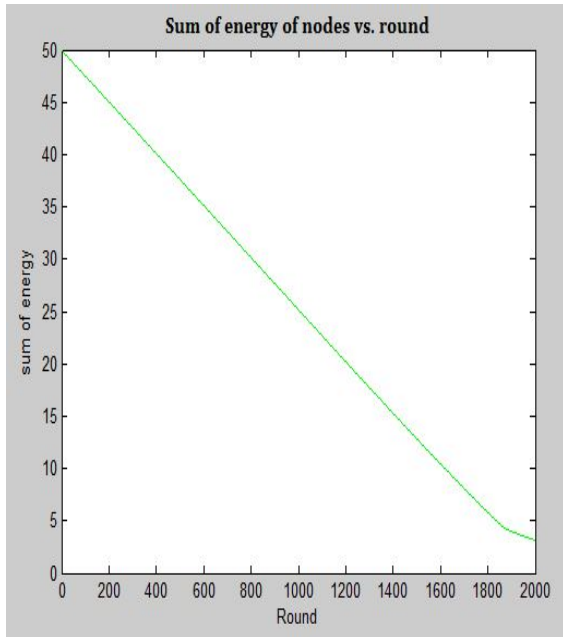
Fig. 5 Sum of Energy v/s Number of Rounds in Proposed protocol

From Fig.5 we observe that in proposed protocol up 1406 rounds residual energy are 15J,20J Residual energy remain left until 1183 rounds,25J Residual Energy up to 997 rounds and 30J energy up to 817 rounds..

TABLE II. SUM OF ENERGY OF NODES PER NUMBER OF ROUNDS

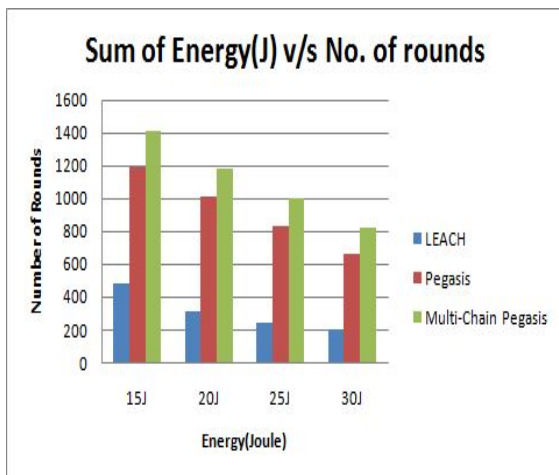|	15J	20J	25J	30J
LEACH Protocol	477	307	241	201
PEGASIS Protocol	1193	1007	830	664
Proposed Method	1406	1183	997	817

Fig. 6 Comparative Analysis of Sum of Remaining Energy in Nodes v/s Number of Rounds in Proposed method, LEACH and PEGASIS protocol

We can observe from Fig.6 that proposed algorithm give better performance than existing PEGASIS and LEACH protocol. It gives overall performance 20% better than PEGASIS and 72% than LEACH.

V. CONCLUSIONS

The paper proposes a multi-chain PEGASIS routing approach for increase lifetime of sensor networks in terms of Remaining energy per number of rounds by using of multi-hop concept. Our scheme achieves balance of energy dissipation among the chains unlike of a single chain in PEGASIS. We proved performance of our scheme by using simulation on MATLAB R2014a. This proposed approach gives better performance than existing PEGASIS and LEACH protocol in terms of energy consumption.Proposed model approximate 72% more efficient than LEACH and 20% than PEGASIS.

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