Reducing Chain Complexity using Honey Bee Optimization in Wireless sensor network

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Abstract- **In Wireless Sensor Network, due to the power restriction of nodes, efficient routing is very important in order to save the energy of sensor node and to enhance the lifetime of the network. In this paper, a new protocol i.e. O-PEGASIS (Optimized PEGASIS) has been designed to reduce the complexity of chain in PEGASIS. A new approach has been used to overcome the problem of PEGASIS by using the Honey bee optimization technique. The results of new protocol i.e. O-PEGASIS have been compared with PEGASIS and EAPHRN. Simulation results show that the lifetime of O-PEGASIS is better as compared to PEGASIS and EAPHRN. Throughput has been increased in the O-PEGASIS since no sensor nodes die for the first 130 rounds but in case of PEGASIS and EAPHRN, sensor nodes die for the first 14 rounds and 49 rounds respectively. Thus, the proposed protocol is more energy efficient as compared to chain based protocols i.e. PEGASIS and EAPHRN.**

Keywords – WSN, chain, routing, PEGASIS, lifetime, EAPHRN, Honey bee optimization.

I. INTRODUCTION

In the recent years, there is vast increase in the researches related to Wireless Sensor networks because of its applicability in various areas such as health, safety, agriculture, medical field and industrial automation [1][2]. WSN consists of hundreds of wireless sensor nodes that are limited in energy and one of the major challenges in wireless sensor network is to increase the network lifetime [3]. Various routing protocols have been designed in WSNs that differ on the basis of network architecture and application [4]. On the basis of network structure, routing protocols are classified into flat network routing, hierarchical routing and location based routing. On the basis of protocol operation, routing protocols are classified into negotiation-based routing, multi-path routing, query based routing, Coherent based routing and QoS based routing [4][5].

The rest of the paper is organized as follows. In section II, chain based routing protocols i.e. PEGASIS and EAPHRN

that have been considered for analysis is reviewed. In section III honey bee optimization technique has been discussed. System and energy model is discussed in section IV. The design and implementation of proposed protocol is detailed in section V. Section VI manifests simulation environments, parameters and results. Conclusion and future work remarks in section VII.

II. CHAIN BASED ROUTING PROTOCOLS

Various chain based routing protocols that have been considered for analysis are PEGASIS and EAPHRN.

PEGASIS (Power Efficient Gathering in Sensor Information System) is one of the chain based hierarchical routing protocol where all the sensor nodes are organized into chain using the greedy algorithm. Here, every wireless sensor node communicates with the nearest neighbor and receives the sensing information. The aggregated data is passed to the designated leader and finally forwarded to the base station. Even though PEGASIS involves all the sensor nodes in order to balance the network but still there are some flaws in this approach. Firstly, for real time applications and large sensing field, unacceptable data delay time is introduced due to a single long chain. Secondly, redundant transmission path results into wastage of the network energy. Thirdly, single chain leader sometime becomes a bottleneck [6].

EAPHRN (Energy Aware PEGASIS Based Hierarchical Routing) is a chain based routing protocol in which node does not connects to the next closest node but connects to a random node that is not far than the Distance Threshold (DT). The procedure of this protocol is categorized into two phases i.e. Chain Setup phase and Leader election phase. The advantage of this protocol is that it saves energy and maintains energy consumption balance in WSN [7].

III.   HONEY BEE OPTIMIZATION

In this section, foraging behavior of honey bee optimization and its algorithm with flow chart has been discussed.

A   Foraging behavior of Honey Bee Optimization

A honey bee colony extends themselves over long distances in multiple directions in order to achieve large number of food sources. The foraging process starts in a colony by sending the scout bees to search for the promising flower patches. There is a random movement of scout bees from one patch to another. When the scout bees return to the hive, they found a patch which is measured above a certain quality threshold and deposit their pollen or nectar and then they move to the dance floor to perform the waggle dance. The waggle dance is for colony communication and it contains the information of flower patch i.e. the direction in which the patch is found, distance of flower patch from hive and its quality fitness. This information is useful for sending the bees to the flower patches without using maps. The waggle dance enables the colony to determine the fitness of various patches according to the food quality and amount of energy required to harvest it. After the waggle dance, the scout bee moves back towards to the flower patch with other bees i.e. follower bees that were waiting inside hive.

Then more follower bees are sent to the more promising patches which allow the colony to gather the food more efficiently and quickly. The bees monitor the food level while harvesting from the flower patch. This is important to decide the next waggle dance when they return to hive [8][9].

B   Honey Bees Optimization Algorithm

Honey bee algorithm performs random search along with the neighborhood search for both functional and combinatorial optimization. The main aim of this algorithm is to find an optimal solution by the honey bees' natural foraging behavior. Here, various parameters are required in general i.e. scout bees (n), selected sites in visited sites (m), stopping criteria, best sites in selected sites(e), initial patch size that includes the size of the network and its neighborhood, bees for selected sites, bees for (m-e) sites.

Bees are randomly placed in a space and then the evaluation of bees fitnesses is done. Now, the bees with highest fitnesses are the selected bees and the bees that visit the sites are selected for the neighborhood search. Now for the selected sites, recruit bees and evaluate fitnesses. Fittest bees from each patch are selected. Remaining bees are randomly assigned in search space and then their fitness is evaluated. The steps are further repeated until the stopping criterion is met. The bees' algorithm is used in various applications such as data clustering, pattern recognition in neural networks, engineering optimization, image analysis etc [8][9].

IV.   THE SYSTEM AND ENERGY MODELS

A   System Model and Assumptions

System model of WSN as shown in Fig. 1 consists of one Base Station (sink) and large number of immobile wireless sensor nodes. Wireless sensor nodes are deployed uniformly in a target area in order to monitor the environment continuously.

The assumptions regarding the wireless sensor nodes and wireless sensor network are as follows:-

1.   Base station is located far away from the geographical region where sensors are scattered randomly.
2.   After deployment sensors as well as base Station are stationary. Fig.1 illustrates such a network as an example.
3.   Wireless sensor nodes are homogeneous and they have the same capabilities.
4.   Each and every node is under the coverage of Base Station and also under the coverage of other nodes.
5.   Amount of transmission power can vary with respect to distance to the receiver.
6.   Each and every wireless sensor node can reach directly to the base station.
7.   Data is transmitted periodically from wireless sensor node to the Base station which is at remote location.
8.   Links are bi-directional.
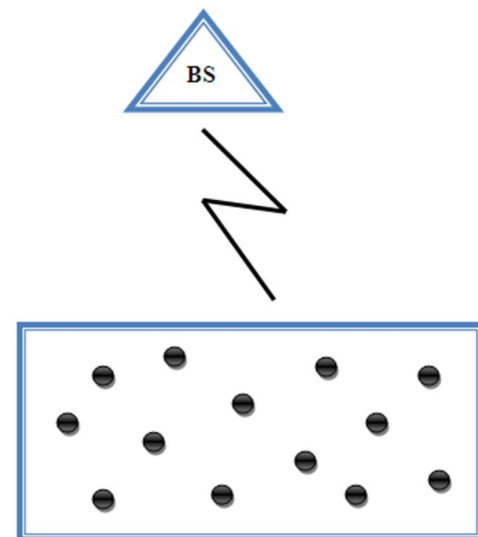9.   Transmitted packets have the same size.

Fig. 1: Typical Wireless Sensor Network Topology[7]

B   Energy Model

The energy that is dissipated in order to run the transmitter as well as receiver with Eelec=50nJ/bit. For the transmitter amplifier, energy is given as Eamp=100pJ/bit/m2. Radios have the power control and they can also expend the required minimum energy in order to reach the desired recipients. In order to avoid the reception of unintended recipients, radios can be turned off.

For k-bit message and distance d, the transmission and receiving costs can be calculated by the following equations:-

For transmitting:-

$$ETx(k,d)= ETx\text{-}elec(k)+ETx\text{-}amp(k,d) \qquad - \qquad (1)$$

$$ETx(k,d)= Eelec*k+Eamp*k*d^2 \qquad - \qquad (2)$$

For receiving:-

$$ERx(k)=ERx\text{-}elec(k) \qquad - \qquad (3)$$

$$ERx(k)=Eelec*k \qquad - \qquad (4)$$

EDA which is the energy of aggregation of data is 5 nJ/bit/signal.

V. PROPOSED ALGORITHM USING HONEY BEE OPTIMIZATION

The main aim of the proposed protocol is to design a chain based hierarchical routing protocol that is optimal in terms of network life time and energy efficiency. The idea is to find an optimized chain using honey bee technique.

The procedure of proposed protocol is divided into main phases:-

1. Initialization of parameters
2. Field initialization
3. Random deployment of sensor nodes
4. Deployment of sink
5. Chain formation using greedy algorithm (Initialization of HBO i.e. Honey bee Optimization)
6. Optimization of distance parameter using Honey bee technique
7. Data transmission of all rounds
8. Computation of number of rounds of communication w.r.t dead nodes
9. Power Computations
10. Comparison of results of the proposed protocol with PEGASIS and EAPHRN in terms of number of rounds of communication

100 sensor nodes are initialized in the network size of 1000 x 1000 and the location of Base Station is set to (995, 995). The field is initialized into 100 virtual regions in order to deploy the wireless sensor nodes uniformly. Chain is initially formed using greedy algorithm in which the node is connected to the next immediate node and honey bee optimization is initialized. The nutrient function or the parameter to be optimized is the distance parameter. In honey bee approach, 1000 bees are initialized and for each bee, fitness value according to nutrient function is computed. Then the step size or the positions of bees' are altered and then again the fitness value is computed. If the new fitness value of bee is greater than the previous fitness value then the new bee is the last best bee otherwise previous one is the last best bee. Now, the last best bee moves to the hive and performs the waggle dance i.e. employs other bees by sending its own information. The procedure is repeated for number of iterations. Further the data transmission takes place in which the first nodes sends its data to the next node, the next node aggregates the data with its own data and send it to the other node and so on. At last the aggregated data is sent to the Base Station. The number of rounds of communication w.r.t dead nodes has been computed. Then the power computations are done where energy of each sensor node is initialized as .5J. Energy being dissipated to run the transmitter as well as receiver and energy of data aggregation are initialized as 50nJ/bit and 5nJ/bit. Data packet size is specified as 2000 bits. Energy required transmitting and sending the data as mentioned in equations 1 and 2 are computed. At last, the results of proposed protocol have been compared with the PEGASIS and EAPHRN.

VI. PERFORMANCE EVALUATIONS

A   Simulation Environment

The simulation has been run on computer system and the tool used for simulation and evaluating the proposed work is MATLAB. MATLAB is a high performance and technical language that performs visualization, computation, data analysis and programming where problems as well as solutions are represented and expressed in mathematical form.

The simulation tool and the computer system parameters are illustrated in Table I.

Table I The simulator and the computer system parameters

Parameters	Value
Simulator	MATLAB 2011b
System Model	Acer Extensa 4630Z
CPU	Pentium (R) Dual-Core CPU @ 2.00 GHz
RAM	2.93 GB RAM
Operating System	Microsoft Windows XP Professional

B   The Simulation Environment Parameters

For simulation, 100 wireless sensor nodes are randomly deployed in a 1000m x 1000m geographical region.

The simulation environment parameters are illustrated in Table II.

Table II The simulation environment parameters

Parameters	Value
Network Size	1000m x 1000m
Base Station Location	(995, 995)
Nodes	100
Initial Energy	0.5 J
Eelec	50nJ/bit
EDA	5nJ/bit
Data Packet size	2000 bits

C   The Simulation Operation

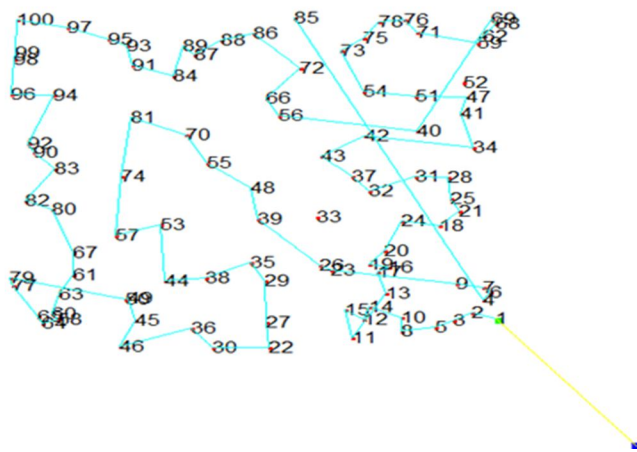The simulation in Fig. 2 shows the optimized chain using honey bee approach of O-PEGASIS.

Fig.2: The Proposed Protocol's chain construction phase with the simulation scenario

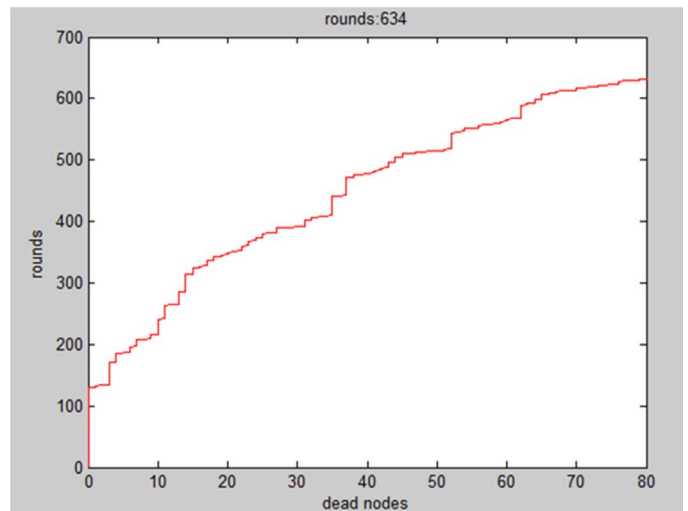Fig. 3 represents the graph of number of rounds of communication w.r.t. dead nodes of O-PEGASIS.

Fig. 3: Simulation of number of rounds of communication w.r.t. dead nodes

D   Simulation Results

The simulation results are in terms of rounds against the number of dead nodes as shown in Table III.

Table III Simulation results in terms of number of rounds against number of dead nodes

Percentage of dead nodes	Number of Rounds/PEGASIS	Number of Rounds/ EAPHRN	Number of Rounds/ O-PEGASIS
1%	14	49	130
10%	68	164	216
25%	116	232	374
50%	170	332	514
75%	216	416	623

According to the results of simulation, the proposed protocol i.e. O-PEGASIS is more energy efficient as compared to PEGASIS as well as EAPHRN as shown in Fig. 4.
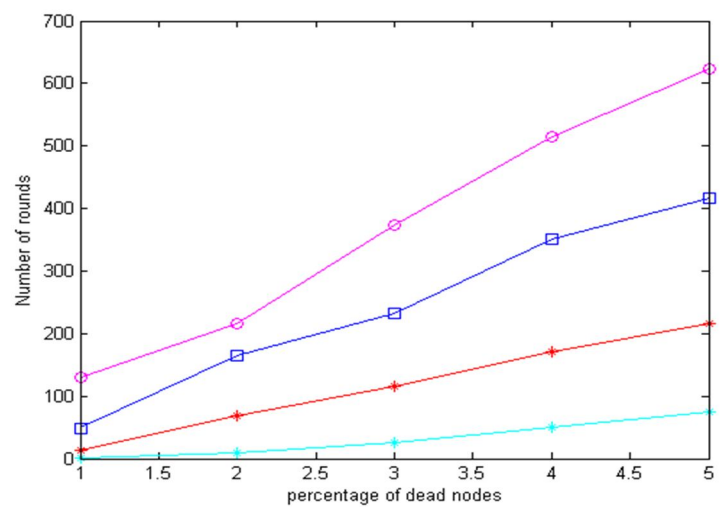
Fig.4: Column chart of the simulation comparison

VII. CONCLUSION AND FUTURE WORK

A new hierarchical routing protocol has been proposed for Wireless sensor networks that attempt to enhance the lifetime as well as throughput of Wireless sensor network. The efficiency of the proposed protocol i.e. O-PEGASIS has been evaluated in MATLAB 2011b and it has been shown in simulation results that the proposed protocol has solved the chain complexity of PEGASIS and also has shown better results as compared to EAPHRN. In the proposed protocol i.e. O-PEGASIS, chain complexity is reduced by using honey bee optimization approach and is more efficient in energy saving. In simulation, number of rounds of communication against the dead nodes lost by the network of O-PEGASIS has been computed which is better than both PEGASIS and EAPHRN. In future, the work can be extended by reducing the complexity of chain further by optimizing the energy parameter along with the distance parameter or the nutrient function can be changed.

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