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An Improved Energy-Efficient BBO-Based PEGASIS Protocol in Wireless Sensors Network

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ABSTRACT

The energy efficiency in the WSN is one of the very important Performance Indicator. Sensor network is a distributed event-based system that differs from traditional communication network. Sensor webs consisting of nodes with limited battery power and wireless communications are deployed to collect useful information from the field. PEGASIS (Power-Efficient Gathering in Sensor Information System) is chain based protocol which is used to construct chain of sensor nodes. In the proposed work BBO is implemented along with PEGASIS to get the shortest chain for every round. Moreover to construct chain, energy of each sensor has been taken into account to bring a balance of energy consumption between nodes. Compared with PEGASIS, this PEG-BBO gives better results. Simulation results show that proposed protocol significantly prolongs the network lifetime.

Keywords- BBO, Chain-based, PEGASIS, Routing protocol, WSN.

I. INTRODUCTION

1.1 WSN

Wireless Sensor Networks [1] with the characteristics of low energy consumption, low cost, distributed and self organization, have brought a revolution to the information perception. The wireless sensor network is composed of hundreds of thousands of the sensor nodes that can sense conditions of surrounding environment such as illumination, humidity, and temperature. Each sensor node collects data such as illumination, humidity, and temperature of the area. Each sensor node is deployed and transmits data to base station (BS). The wireless sensor network can be applied to variable fields. For example, the wireless sensor network can be used to monitor at the hostile environments for the use of military applications, to detect forest fires for prevention of disasters, or to study the phenomenon of the typhoon for a variety of academic purposes. These sensor nodes can self-organize to form a network and can communicate with each other using their wireless interfaces. Energy efficient self-organization and initialization protocols are developed. Each node has transmit power control and an omni-directional antenna, and therefore can adjust the area of coverage with its wireless transmission. Typically, sensor nodes collect audio, seismic, and other types of data and collaborate to perform a high-level task in a sensor web. For example, a sensor network can be used for detecting the presence of potential threats in a military conflict. Most of battery energy is consumed by receiving and transmitting data. If all sensor nodes transmit data directly to the BS, the furthest node from BS will die early [2]. On the other hand, among sensor nodes transmitting data through multiple hops, node closest to the BS tends to die early, leaving some network areas completely unmonitored and causing network partition. In order to maximize the lifetime of WSN, it is necessary for communication protocols to prolong sensor nodes' lifetime by minimizing transmission energy consumption, sending data via paths that can avoid sensor nodes with low energy and minimizing the total transmission power.

1.2 Architecture of WSN

After the initial deployment (typically ad hoc), sensor nodes are responsible for self-organizing an appropriate network infrastructure, often with multi-hop connections between sensor nodes. The onboard sensors then start collecting acoustic, seismic, infrared or magnetic information about the environment, using either continuous or event driven working modes. Location and positioning information can also be obtained through the global positioning system (GPS) or local positioning algorithms [3]. This information can be gathered from across the network and appropriately processed to construct a global view of the monitoring phenomena or objects. In general, the wireless sensor networks are deployed for monitoring at a large area so the wireless sensor networks need many sensor nodes. If the sensor node consumes all the energy, it is wasted. We do not consider to recharge and to reuse sensor node. Because of these reasons, the value of the sensor nodes must be inexpensive to practical use. Deployed in harsh and complicated environments, the sensor nodes are difficult to recharge or replace once their energy is drained. Mean while the sensor nodes have limited communication capacity and computing power. So how to optimize the communication path, improve the energy-efficiency as well as load balance and prolong the network lifetime has become an important issue of designing routing protocols for WSN. Hierarchical-based routing protocols [4] are widely used for their high energy-efficiency and good expandability. The basic idea of them is to select some nodes in charge of a certain region routing. These selected nodes have greater responsibility relative to other nodes which leads to the incompletely equal relationship between sensor nodes.

1.3 Routing techniques in WSN

Wireless sensor networks (WSN) consist of small nodes with sensing, computation, and wireless communications capabilities. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. Routing protocols in WSNs might differ depending on the application and network architecture. Overall, the routing techniques [5] are classified into three categories based on the underlying network structure: flat, hierarchical, and location-based routing. Furthermore, these protocols can be classified into multipath-based, query-based, negotiation based, QoS-based, and coherent based depending on the protocol operation. In flat networks all nodes play the same role, while hierarchical protocols aim to cluster the nodes so that cluster heads can do some aggregation and reduction of data in order to save energy. Location-based protocols utilize position information to relay the data to the desired regions rather than the whole network. LEACH (Low Energy Adaptive Clustering Hierarchy) and PEGASIS (Power-Efficient Gathering in Sensor Information System) are the typical hierarchical-based routing protocols. As an enhancement algorithm of LEACH, PEGASIS is a classical chain-based routing protocol. It saves significant energy compared with the LEACH protocol by improving the cluster configuration and the delivery method of sensing data. PEGASIS protocol is used in the proposed chain building process.

II. PEGASIS

The PEGASIS algorithm is based on the LEACH. The core conception in PEGASIS is to form a chain among all the sensor nodes so that each node can receive from and transmit to the closest neighbor. Gathered data moves from node to node, get fused, and eventually a designated node (cluster head) transmits to the BS [6]. Nodes take turns transmitting to the BS so that the average energy spent by each node per round is reduced. The method of Building a chain to minimize the total length is similar to the traveling salesman problem, which is known to be intractable. However, with the radio communication energy parameters, a simple chain built with a greedy approach performs quite well [7]. So, PEGASIS algorithm has some advantages as follow:

- Normal nodes only communicated with it's neighbor and every node will take data fusion in order.
- The distance of the connect nodes with each other have been shortened remarkably.
- Nodes take turns to be the cluster head, so it takes no energy.

III. Biogeography-Based Optimization

As name suggests, BBO is a population based global optimization technique developed on the basis of the science of biogeography i.e. study of the distribution of animals and plants among different habitats over time and space [8]. BBO results presented by researchers are better than other optimization techniques like Ant Colony Optimization, Particle Swarm Optimization, Genetic Algorithm and Simulated Annealing.

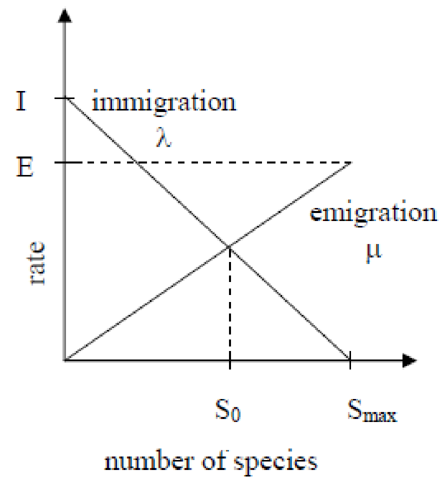

Fig. 1 Linear migration relationships for an island. The equilibrium number of species is S_0, at which point the immigration and emigration rates are equal.

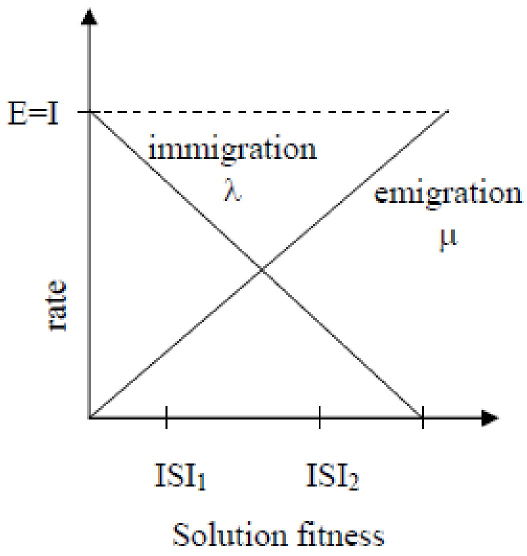

Fig. 2 Illustration of two candidate solutions to some problem using symmetric immigration and emigration curves. ISI_1 is a relatively poor solution and ISI_2 is a relatively good solution. ISI_1 has a high immigration and a low emigration rate, and ISI_2 has a low immigration and a high emigration rate.

Suppose that there is a problem and a population of candidate solutions that are represented as vectors. Further suppose that there is some way of assessing the goodness of the solutions. Good solutions are analogous to islands with a high ISI, and poor solutions are analogous to islands with a low ISI. Note that ISI is the same as "fitness" in other population based optimization algorithms. In biogeography, species migrate between islands. However, in BBO solution features (SIVs) migrates between islands. The migration probabilities are based on a curve similar to that shown in Figure 1, but for the sake of simplicity assume that all solutions (islands) have identical migration curves with E = I. Figure 2 illustrates the migration curves along with two solutions. ISI_1 represents a poor solution and ISI_2 represents a good solution. The immigration rate for ISI_1 will therefore be higher than the immigration rate for ISI_2, and the emigration rate for ISI_1 will be lower than the emigration rate for ISI_2. The migration rates of each solution to probabilistically share features between solutions is used. This can be implemented in several different ways, but in this paper we use the original BBO formulation, which is called partial immigration-based BBO [9]. In this approach, for each feature in each solution, we use the immigration curve to probabilistically decide whether or not to immigrate. If immigration is selected for a given solution feature, then the emigrating island is selected probabilistically. Fig. 3 is a conceptual description of one generation of this approach, where the notation yk(s) is used to denote the s^{th} feature of the k^{th} population member. Migration and mutation of the entire population take place before any of the solutions are replaced in the population, which requires the use of the temporary population vector w in Fig. 3.

```
Let y denote the population of solutions
w ← y (note that w is a temporary population vector)
For each island w_k
    For each SIV s
        Use λ_k to probabilistically decide whether to
        immigrate to w_k(s).
        If immigrating then
            Use μ to probabilistically select the
            emigrating island y_j.
            w_k(s) ← y_j(s)
        end if
        Probabilistically decide whether to mutate w_k(s)
    next SIV
next island
y ← w
```

Fig. 3 One generation of the partial immigration-based BBO algorithm. Y is the entire population of solutions, Y_k is the kth solution, and yk(s) is the sth feature of Y_k.

IV. Proposed Methodology

Methodology used in PEG-BBO for energy enhancement is described in the following steps:

Step 1: Initializing WSN parameter
Step 2: Deploying No. of Nodes
Step 3: Implementing PEGASIS Protocol
Step 4: Initialize BBO parameter for routing
Step 5: Defining Migration and Emigration rate
Step 6: Routing update with each round
Step 7: Checking Lifetime and Data Consumption
Step 8: Comparison with other methods

Table 1 System Parameters Value

Parameter	Value
Network size	100×100 m^2
Number of nodes	100
Base Station	(50,175)
Energy	0.5 J
Data packet	3000 bits
Transmission Energy	50*0.000000001 J
Receiving Energy	50*0.000000001 J

V. Results and Discussion

This paper uses Matlab as simulator to evaluate the performance of existing PEGASIS compared with PEG-BBO.

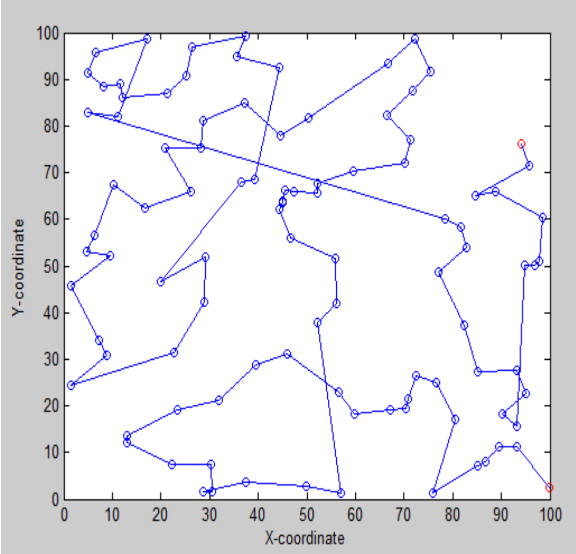

Fig. 4 Chain formed in PEG-BBO

Fig. 4 shows how chaining process in done using PEG-BBO. For every round this process is performed.

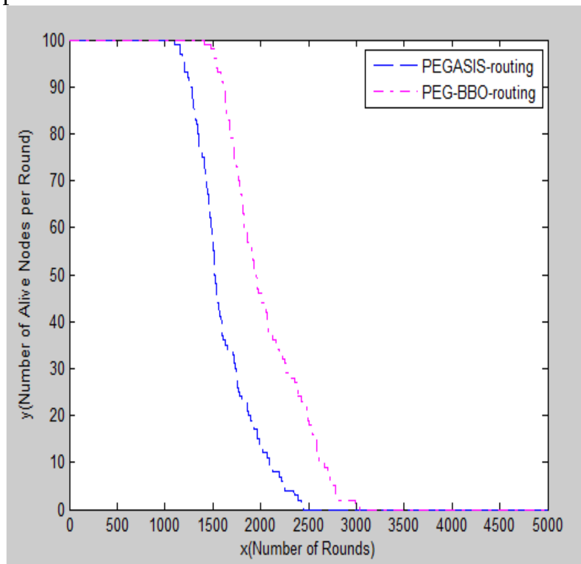

Fig. 5 Number of nodes alive over time

As shown in fig. 5 nodes alive in PEG-BBO is larger than PEGASIS hence PEG-BBO makes the system more energy efficient.

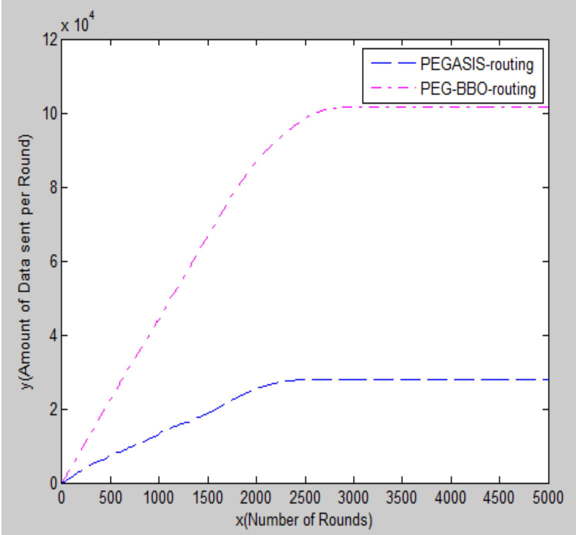

Fig. 6 Amount of data sent over time

As shown in fig. 6 as the no. of round increases more data is sent in PEG-BBO than in PEGASIS.

VI. Conclusion

In this paper, a routing protocol using BBO is presented to construct the chain of the PEGASIS protocol. BBO adopts a more reasonable method to build the chain and keep energy consumption balanced to further prolong the lifetime of WSN. The simulation results shows that PEG-BBO gives higher energy-efficiency and extending lifetime of network.

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