Dynamic Deployment of Wireless Sensor Networks Using Enhanced Artificial Bee Colony Algorithm

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Abstract: ***Wireless sensor networks (WSNs) are an emerging technology that has potential applications in surveillance, environment and habitat monitoring, structural monitoring, healthcare etc. As the usage and development of wireless sensor networks increases, problems related to these networks are being discovered. Dynamic deployment is one of the main issues that directly affect the performance of wireless sensor networks. Determining the positions of the sensors is the main subject of sensor network deployment, which depends on the coverage of the interest area. Deployment is always a difficult task due to environmental influences that can trigger bugs. Deployment becomes harder when the sensor nodes are mobile. Particle Swarm Optimization (PSO) is a technique used for deployment of wireless sensor networks due to its simplicity and quality of solution. But PSO technique doesn't take into consideration the energy conservation of the wireless sensor nodes. PSO requires large amount of memories when there is more number of nodes. In this project, a new technique to deployment problem is proposed based on the artificial bee colony (ABC) algorithm which is enhanced for the deployment of sensor networks to gain better performance by trying to increase the coverage area of the network and energy consumption. The good performance of the algorithm shows that it can be utilized in the deployment of wireless sensor networks.***

Keywords: Artificial bee colony, wireless sensor networks, dynamic power allocation**.**

1. Introduction

Wireless sensor networks (WSNs) are networks of autonomous nodes used for monitoring an environment. WSNs are an emerging technology [1] that has potential applications in surveillance, environment and habitat monitoring, structural monitoring, healthcare, and disaster management. As the usage and development of wireless sensor networks increases, problems related to these networks are being discovered. Developers of WSNs face challenges that arise from communication link failures, memory and computational constraints and limited energy. Dynamic deployment is one of the main issues that directly affect the performance of wireless sensor networks and another challenge in this kind of networks is to find most efficient routing due to the changing topology and to reduce the energy consumption. Determining the positions of the sensors is the main subject of sensor network deployment, which depends on the coverage of the interest area.

It has been found that Artificial Bee Colony Optimization (ABCO) is a special kind of optimization technique having characterization of Swarm Intelligence (SI) which is highly suitable for finding the adaptive routing for such type of networks. ABCO is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs. ABCO algorithms are inspired by the behavior of bees in a bee colony which are able to find optimal connection of the bee colony with the source of food. ABCO routing algorithms use simple agents called forager bee and employed bee which establish optimum paths between source and destination that communicate indirectly with each other. ABCO is used because they are more robust, reliable, and scalable than other conventional routing algorithms.

As the topology of WSN is always changing and the processing power of node is weak, the location information of network is hard to be collected in time. Traditional routing algorithms, taking the flooding algorithm as an example, are unable to satisfy with the network requirements and even deteriorate the network performance seriously sometimes. To solve the problem, position based algorithms have been proposed. The availability of cheap instruments like GPS receivers for estimating the location of nodes in a network, many GPS based location determination routing algorithms researched in past years. In location-based routing algorithms it is assumed that a node is aware of its position, the position of its neighbors, and the position of the destination. The drawback of these algorithms is that they may fail in indoor ad hoc networks to find a route or they may find a non-optimum route in some situations.

The main technical challenge dealt in this paper is an energy efficient location based routing for WSNs. The approaches used for solving are ABCO routing, and location determination using RSSI.

So, in this paper we have proposed Artificial Bee Colony Optimization algorithm which finds nearly shortest paths, with the location information collected by Receiver Signal Strength Indicator (RSSI). We call this method as Enhanced Artificial Bee Colony Algorithm (EABC).

2. Related Works

The Deployment in wireless sensor networks are designed in such a way that they can with stand all the constraints of the wireless sensor networks like limited bandwidth, power, mobility etc. The requirements of the deployment methods are that they must be able to perform an efficient and effective mobility management.

2.1 Dynamic Transmission Power Control

Ghufran Ahmed *et al* [2] in their paper propose Dynamic Transmission Power Control (DTPC), which is a method for an efficient utilization of the energy resource and thus leads to an increase in lifetime. In DTPC the transmission range of each node is different from other and adjusted according to the current topology of the network. Network connectivity is the major factor in adjusting the transmission range of these nodes rather than RSSI. DTPC is being used in conjunction with GRACE which is a well-known power-aware protocol. The proposed transmission power control protocol results in greater network lifetime but it uses complex mechanism as it works based on topology.

2.2 Variable Power Broadcasting

Avinash Chiganmi *et al* in their paper proposes [3] Variable Power Broadcasting Based on Local Information for Source Dependent Broadcasting Protocols proposes several algorithms like EPABLO and EINOP that are effective in determining the most efficient transmission power for each broadcasting node. Typical broadcasting protocol uses fixed transmission power to cover the node irrespective of the distance so by reducing the transmission power enough to cover this node, energy expenditure would be reduced. Paper proposes some mechanisms based on local neighbourhood knowledge, and ensuring the overall network is still covered. The main goal was to make a better use of the available two-hop local neighbourhood information to achieve better energy utilization in covering the one-hop neighbours. This system failed to make better performance as it made use of neighbour nodes to establish a path.

2.3 Particle Swarm Optimization

Raghavendra V. Kulkarni *et al* [4] in their paper proposes Particle swarm optimization (PSO) which is a simple optimization algorithm. It has been applied to address WSN issues such as optimal deployment, node localization, clustering and data-aggregation. The paper outlines issues in WSNs, introduces PSO and discusses its suitability for WSN applications. PSO models social behaviour of a flock of birds. It consists of a swarm of s candidate solutions called particles, which explore an n-dimensional hyperspace in search of the global solution. PSO suits centralized deployment. Fast PSO variants are necessary for dynamic deployment. PSO can also limit network scalability. PSO requires large amounts of memory, which may limit its implementation to resource-rich base stations. Iterative nature of PSO can prohibit its use for high-speed real-time applications, especially if optimization needs to be carried out frequently.

2.4 Bee Colony Algorithm

Asma Sanam Larik proposed [5] Bee Colony Algorithms for Wireless Sensor Networks. The application of Bee Colony algorithms to solve the routing problems in Wireless Sensor Networks as well as MANETs is discussed. Fundamental concepts about the working of Bee Colony algorithm is self-organization and division of labour which are necessary and sufficient properties to obtain swarm intelligent behaviour. The agents in Bee Colony algorithms communicate indirectly through the stigmergy and provide positive feedback to a solution by collecting nectar from the food sources. The Self-organization relies on four basic properties

- Positive feedback
- Negative feedback,
- Fluctuations and
- Multiple interactions

The exchange of information among bees is the most important occurrence in the formation of collective knowledge. The most important part of the hive with respect to exchanging information is the dancing area. Communication among bees related to the quality of food sources takes place in the dancing area.

3. Observations

The primary goal in Wireless Sensor Networks is to efficiently establish one or more paths between two nodes so that they can communicate reliably. Unfortunately nodes in Wireless Sensor Networks are limited in energy and bandwidth. The unpredictable nature of Wireless Sensor Networks pose a wide range of challenges like efficient routing, load distribution, congestion avoidance, energy consumption, etc. Different deployment methods have been developed for Wireless Sensor Networks, some makes use of the bio-inspired algorithms and some makes use of dynamic transmission power. However most of these methods only attempt to solve one challenge i.e. effective deployment. None of them considers reduction in the energy consumptions. Hence there is a need to develop a unified method which considers effective deployment and reduced energy consumption which results in better network management. A family of routing algorithms has been proposed based on Artificial Bee Colony optimization (ABCO). Notably, one common feature of these protocols is they use of fixed transmission power. If nodes are allowed to adjust their transmission power to cover nodes that need to be covered only by minimizing the transmission power battery life can be prolonged. Some existing work on transmitting with variable transmission power and finding the most energy efficient transmission can be solved either using centralized algorithms where each node is equipped with knowledge of global network topology or distributed algorithms with local information. Many of these methods use GPS to find the distance between the nodes. Limiting factors like small size, limited computation power and energy source, the possible solution excludes use of GPS for identifying the distance between nodes.

4. Proposed Systems

The Enhanced Artificial Bee Colony (EABC) algorithm is a swarm intelligence method inspired by the intelligent foraging behaviour of honey bees, is used for the dynamic deployment problem of WSNs. The aim of the optimization technique is to maximize the coverage rate of the network. In the network's scenario, it is assumed that:

- The detection radii of the sensors are all the same (r).
- All of the sensors have the ability to communicate with the other sensors.

• All sensors are mobile.

In the EABC algorithm, the position of a food source represents a possible solution to the optimization problem and the nectar amount of a food source corresponds to the quality (fitness) of the associated solution. Therefore, the deployment of the sensors in the sensed area (each solution of the deployment problem) refers to a food source in the algorithm. The coverage rate of the network, i.e. the total coverage area, corresponds to the fitness value (nectar) of the solution. In the EABC model, artificial bee colonies, in which the goal of the bees is to find the best solution, comprise 3 groups of bees:

• Employed bees

They are associated with a particular food source which they are currently exploiting or are "employed" at. They carry with them information about this particular source, its distance and direction from the nest, the profitability of the source and share this information with a certain probability.

• Onlookers

A forager bee who tries to find a food source by means of the information given by the employed bee is called Onlooker.

• Scouts

A forager bee that looks for a food source by searching the environment randomly to exploit is called a scout.

In the proposed system first we initialise the network and the best paths are stored. After the best path has been stored the employed bees are send in order to find out the change in paths or any link breakages. The information gathered by Employed bee is analysed and then the onlooker bee is send to the nodes discovered by employed bees. The Onlooker bees collect the details of the nodes already visited. They give status of nodes. Depending on the information from the onlooker bees the best paths are determined. The Scout Bees perform random search for nodes.

In this system we have sensor nodes which are mobile and the shortest path is calculated by the nodes depending on the RSSI value, distance between the nodes, number of hopes between the nodes.

4.1 Calculation of RSSI

Suppose that RSSI $_{(i,j)}$ is a signal strength value, which was send from node j to node i, and measured from the node i. Then

$$RSSI_{(i,j)} = A - 10n \log (D_{i,j} / D_o) \quad (1)$$

When Do = 1m, the formula can be simplified as ,

$$D = 10^{(A - RSSI_{(i,j)} / 10n)} \quad (2)$$

The unit for RSSI $_{(I,j)}$ is dBm. D $_{I,j}$ is the actual distance between node i and node j. The radio parameter A is defined as the absolute value of the average power in dBm received at a close-in reference distance of one meter from the transmitter, assuming an omni directional radiation pattern.

The radio parameter n is defined as the path loss exponent that describes the rate at which the signal power decays with increasing distance from the transmitter

The parameters A and n can be estimated empirically by collecting RSSI data (and therefore path loss data) for which the distances between the transmitting and receiving devices are known. The typical value A is in the range [30.0, 50.0] with precision 0.5. A typical value for n is 2 to 4.

4.2 Enhanced Artificial Bee Colony Algorithm

Initialize Population Repeat

- Place the employed bees on their food sources
- Place the onlooker bees on the food sources depending on their nectar amounts
- Send the scouts to the search area for discovering new food sources
- Memorize the best food source found so far Until requirements are met

The search consists of three steps: moving the employed and onlooker bees onto the food sources and calculating their nectar amounts and determining the scout bees and directing them onto possible food sources. A food source position represents a possible solution to the problem to be optimized. The amount of nectar of a food source corresponds to the quality of the solution. Onlookers are placed on the food sources by using a probability based selection process. As the nectar amount of a food source increases, the probability value with which the food source is preferred by onlookers increases. The scouts are characterized by low search costs and a low average in food source quality. One bee is selected as the scout bee. The selection is controlled by a control parameter called "limit". If a solution representing a food source is not improved by a predetermined number of trials, then that food source is abandoned and the employed bee is converted to a scout.

5. Simulation Results

A wireless sensor network including 100 mobile sensors was simulated. The detection radius of each sensor was 8 m, the size of area was 1,000 m^2 , the colony size was 5, and the limit parameter for the scout was 100. The ABC algorithm was run with different numbers of iterations: 100, 500 and 1000 iterations. To observe the performance of the algorithm, each scenario was run 10 times, starting with random seeds. The average coverage percentage with different iteration numbers are given in Figure.1.

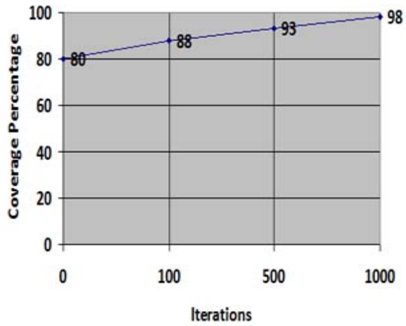

Figure 1. Coverage Percentage

As seen in Figure 1, the effective coverage area was improved considerably while the iteration number increased. The coverage rates were 88%, 93%, and 99% for 100, 500 and 1,000 iterations, respectively. It can be understood that the stability of the algorithm also increased with larger numbers of iterations. To highlight this improvement, the best dynamic deployments obtained by the ABC algorithm for each number of iterations are shown in Figure 2, Figure 3 and Figure 4 respectively.

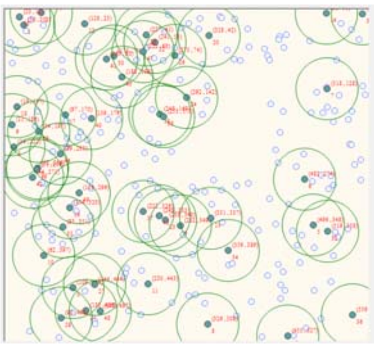

Figure 2. Best Coverage for 100 iteration

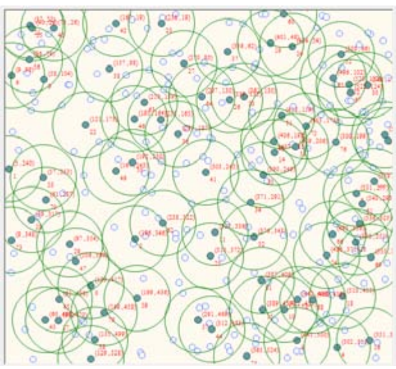

Figure 3. Best Coverage for 500 iteration

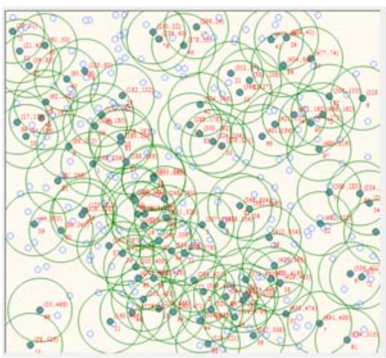

Figure 4. Best Coverage for 1000 iteration

5.1 NS2 Simulation Model

In our simulation; the channel capacity of mobile hosts is set to the same value:1.5 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. In our simulation, 30 mobile nodes move in a 1000 meters x 1000 meters region for 6 seconds simulation time. By Euclidian distance calculation distance of different node w.r.t to the RSSI value is determined. We assume each node moves independently with the same average speed. All nodes have the same transmission range of 250 meters. In our simulation, the speed is set as 5m/s. The simulated traffic is Constant Bit Rate (CBR).Simulation parameters are given below

Table.1 Simulation Parameters

Routing	EABC
Protocol	30
No Of Nodes	1000 m x 1000m
Area size	802 .11 b
MAC	250m
Radio Range	6 sec
Simulation Time	CBR
Traffic Source	512 KB
Packet Size	Random Way Point model
Mobility model	5 m/s
Speed	0.5 Joules
Initial Energy	

Performance comparison of different parameters are given below

i. Packet Delivery Ratio: The ratio of the data packets delivered to the destinations to those generated by the CBR sources. It specifies the packet loss rate, which limits the maximum throughput of the network. By considering location information also EABC achieves higher packet delivery ratio as shown in figure 5.

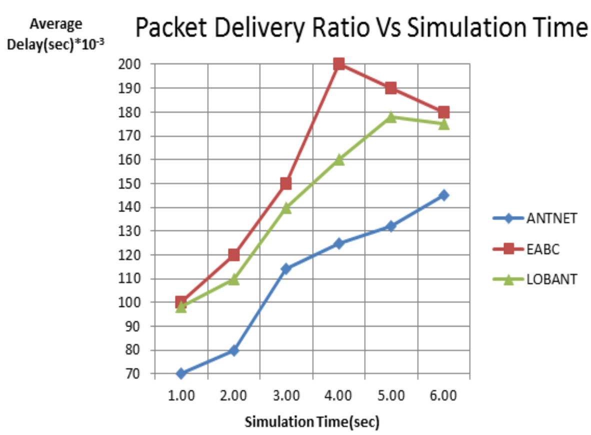

Figure 5. Packet Delivery Ratio Analysis

ii. End-to-end Delay:- This metric represents average end-to-end delay and indicates how long it took for a packet to travel from the source to the application layer of the destination. It includes all possible delay caused by buffering during route discovery latency, transmission delays at the MAC, queuing at interface queue, and propagation and transfer time. It is measured in seconds.

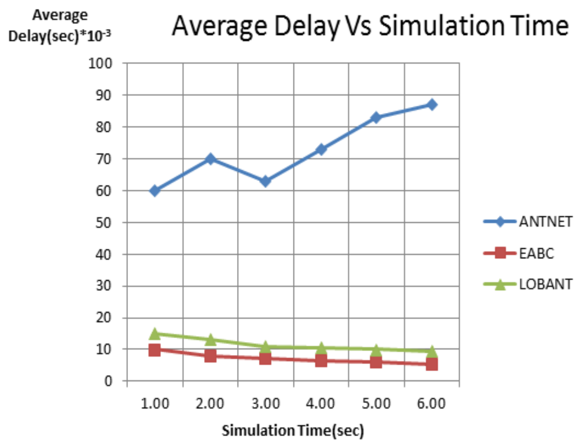

Figure 6. End to End Delay analysis

iii. Throughput**:-** Throughput is total packets successfully delivered to individual destination over total time divided by total time. When comparing the routing throughput by each of the protocols, EABC has the high throughput. It measures of effectiveness of a routing protocol. Figure 7 shows the throughput comparison graph.

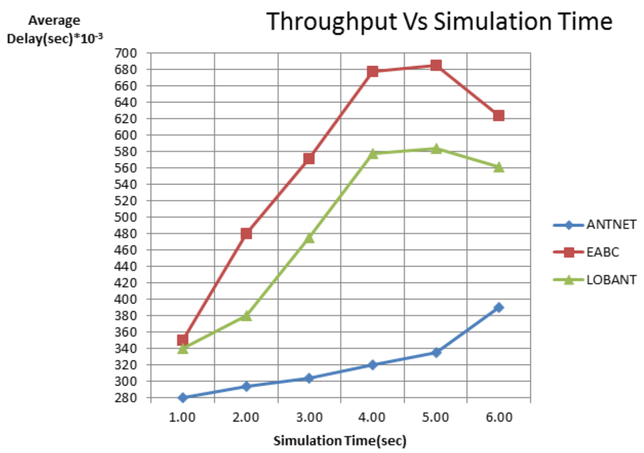

Figure 7. Throughput Analysis

6. Conclusion

Paper proposes an Enhanced Artificial Bee Colony Optimization Algorithm (EABC),which uses Received Signal strength to calculate the distance to consider as a routing metric. The use of location information as a heuristic parameter resulted in a significant reduction of the time needed to establish routes from a source to a destination which is important for a reactive routing algorithm. In this study, the Enhanced ABC algorithm is applied to the dynamic deployment problem in WSNs with mobile sensors. We can also apply the EABC algorithm for dynamic deployment of WSNs including not only mobile sensors but also stationary ones. The Energy Consumption is reduced and the coverage rate is increased. A probabilistic sensor detection model will be used to decide the effectively covered area.

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