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ROUTING BASED ON ANT COLONY OPTIMIZATION TECHNIQUE FOR ENERGY CONSERVATION

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ABSTRACT

Wireless Sensor Networks having no. of nodes with limited power are deployed to collect the useful, important information from the field. In WSNs it is difficult to collect the information in an energy efficient manner. The most important feature of a routing protocol, in order to be efficient for WSNs, is the energy consumption and the extension of the network's lifetime**.** Ant Colony Optimization, a swarm intelligence based optimization technique, is widely used in network routing. A routing approach relevant to an Ant Colony Optimization algorithm is proposed for Wireless Sensor Networks consisting of mobile nodes. Detailed descriptions and performance test results of the proposed approach are included. Simulation results show that proposed algorithm reduces the energy consumption.

KEYWORDS: Ant Colony Optimization, network routing.

INTRODUCTION

Recent trends in WSN routing have been towards strengthening existing approaches by considering more detailed network properties. The routing protocols play a very important role in selecting the relevant path for data transmission from the source to the destination efficiently. There are already many routing algorithms are available to find the shortest path and also to increase the output of the network. In this paper, we are proposing a routing algorithm which may be applied in small network structure with balanced node. The goal of every network routing algorithm is to direct the traffic from source to the destination maximizing the network performance.

The algorithm Ant Colony Optimization (ACO) based on the behaviour of the real ants which finding a shortest path from a source to the food. When ants searching for food source they deposits a chemical trails which is known as Pheromone. During foraging for food, ants communicate with this deposited trail of the pheromone. When food is discovered, ants return to the nest laying a trail to help the other ants who are still searching food source. The quantities of the pheromone during foraging and recruitment is different present on the path. Shorter path are expected to return earlier and hence increase the amount of pheromone deposit in its path at a faster rate than the ants following a longer path. This is because all the ants follow the same path that's why the pheromone is strengthen by every ant.

In this paper we have proposed new algorithm which is based on ACO algorithms for energy conservation by finding the minimum distance between base station and sensor node.

LITERATURE REVIEW

Algorithms for wireless sensor network do not offer some of the sensor networks requirements such as high power battery, memory, and the routing tables grow up with the network length and do not support diffusion communication. These are the main reasons why it is necessary to design new algorithms to improve energy efficiency. Sensor nodes have the ability to sense the environment nearby, perform simple computations and communicate in a small region. Although their capacities are limited, combining these small sensors in large numbers provides a new technological platform, called wireless Sensor Networks (WSNs). WSNs provide reliable operations in various application areas including environmental monitoring, health monitoring, vehicle tracking system, military surveillance and earthquake observation [1-2].

Although WSNs are used in many applications areas, they have several restrictions including limited energy supply and limited computation and communication abilities. These limitations should be considered when designing protocols for WSNs. Because of these considerations specific to WSNs, many routing schemes using end-to-end devices [3] are inappropriate for WSNs. In sensor networks, minimization of energy consumption is considered a major performance criterion to provide maximum network lifetime.

In addition, since channel bandwidth is limited, protocols should have capability of performing local collaboration to reduce bandwidth requirements [4].The basic method to transfer information from a sensor node to the base node is called flooding. In this method, information is disseminated by all the nodes as well as the base node. The broadcasting operation to all over the network requires too much node resources such as energy and bandwidth. Heinzelman et al. proposed SPIN family protocols that disseminate all the information in the network assuming that all nodes are potential base nodes [5]. However SPIN's data advertisement operation does not guarantee data delivery. In this respect multi-path routing protocols promise advantages. The use of multiple paths to transfer data to the base node enhances the reliability of WSNs.

Directed diffusion [6] is a candidate method for multi-path routing. However, directed diffusion may not be suitable for those monitoring applications which require periodic data transfers. The optimization of network parameters for a WSN routing process to provide maximum network lifetime might be considered as a combinatorial optimization problem. Many researchers have recently studied the collective behavior of biological species such as ants as an analogy providing a natural model for combinatorial optimization problems [7-10]. Ant colony optimization (ACO) algorithms simulating the behavior of ant colony have been successfully applied in many optimization problems such as the asymmetric traveling salesman problem [11], vehicle routing [12] and WSN routing [8,13,14].Singh et al. [15] proposed an ant based algorithm for WSN routings. However, this algorithm does not consider the main specifics of WSN structures, including issues related to energy.

Zhang et al. [16] proposed ant based algorithms for WSNs; their study includes three routing algorithms named SC, FF, and FP. The algorithms are successful with initial pheromone settings to have a good system start-up, but the SC and FF algorithms are not quite effective in latency, while providing better energy efficiency. Besides, the FP algorithm, while providing high success rates of data delivery, consumes much higher energy than the FC and FF algorithms. The Energy Efficient Ant Based Routing Algorithm for WSNs (EEABR) [17], based on a ACO metaheuristic, is another proposed ant based algorithm to maximize the lifetime of WSNs. The algorithm uses a good strategy considering energy levels of the nodes and the lengths of the routed paths.

Previously so many ant based routing algorithms built. Some of them are as follows: Ant-AODV (Ant Ad hoc on demand distance vector) [19] uses fixed number of ants going around the network in a more or less random manner, keeping track of the last n visited nodes and when they arrive at a node they proactively update its routing table.

ARA (Ant-colony based routing algorithm) [20] is a purely reactive scheme which uses forward ants and backward ants to create fresh routes from a node to a destination. ARA uses forward ants and backward ants to create fresh routes from a node to a destination. When routes to a destination D are not known at S, a forward ant is broadcast, taking care to avoid loops and duplicate ants. When a forward ant is received at an intermediate node X via node Y, the ant reinforces the link XY in X to route to all the nodes covered so far by the forward ant. When a forward ant is received at D, a backward ant is created which backtracks the path of the corresponding forward ant. At each node the backward ant is received, the link via which the backward ant is received is reinforced, like the forward ant does, for all nodes which have been visited by the backward ant. In ARA, data packets perform the necessary (positive) reinforcement required to maintain routes. When a path is not taken, it subsequently evaporates (negative reinforcement) and cannot be taken by subsequent data packets. Under the described scheme, amplification of topological and network fluctuations is not possible except under extreme conditions when routes break often.

PERA (Probabilistic emergent routing algorithm) [21] reactively establishes route to the destination using delay as the metric. Multiple paths are set up, but only the one with the highest pheromone value is used by data PERA uses broadcast forward ants as exploratory agents sent out on-demand to find new routes to destinations. Each ant holds a list of nodes that were visited while exploring the network, and since these ants are broadcast at each node, a forward ant can result in several backward ants sent by destination nodes in response to forward ants. This uncovers several routes for each forward ant sent, and at each node these multiple routes found to the destinations are maintained as probability values.

ANSI (Ant hoc networking with swarm intelligence) [22] deployed two types of ants namely; Local proactive ants and global reactive ants.

AntHocNet (ant-based hybrid routing algorithm) [23], a hybrid, stochastic approach to the routing problem in MANET. AntHocNet is a congestion-aware protocol which only finds routes on-demand, but once a route is established, the route is proactively maintained. This approach, argued by the authors to be more ant-like than other competing ant based protocols, will fail to reduce overheads in very high traffic/mobility scenarios, owing to the rate at which proactive ants are potentially unicast when the mobility increases. This is because in high mobility/traffic scenarios, routes get invalidated often and proactive activity has to increase appropriately to keep a valid view of the network for routing, thus increasing the load placed on the network.

AntNet [24] algorithm tries to manage both delay and energy concerns using the concept of ant pheromone to produce two prioritized queues, which are used to send differentiated traffic. But such approach can be infeasible in current sensor nodes due to the memory required to save both.

CHALLENGES IN NETWORK ROUTING

Due to various wireless network constraints, the design of routing protocols is very challenging for WSNs. There are several network design issues for WSNs, such as, energy, bandwidth, central processing unit, and storage.

The design challenges in sensor networks involve the following main aspects:

1. Limited energy capacity:

Since sensor nodes are battery powered, they have limited energy capacity. Energy poses a big challenge for network designers in hostile environments. Furthermore, when the energy of a sensor reaches a certain threshold, the sensor will become faulty and will not be able to function properly, which will have a major impact on the network performance.

2. Sensor locations:

Another challenge that faces the design of routing protocols is to manage the locations of the sensors. Most of the proposed protocols assume that the sensors either are equipped with global positioning system (GPS) receivers or use some localization technique to learn about their locations.

3.Limited hardware resources:

Sensor nodes have also limited processing and storage capacities, and thus can only perform limited computational functionalities. These hardware constraints present many challenges in software development and network protocol design for sensor networks.

4. Massive and random node deployment:

Sensor node deployment in WSNs is application dependent and can be either manual or random which finally affects the performance of the routing protocol. In most applications, sensor nodes can be scattered randomly in an intended area or dropped massively over an inaccessible or hostile region.

5. ***Network characteristics and unreliable environment:***

A sensor network usually operates in a dynamic and unreliable environment. The topology of a network, which is defined by the sensors and the communication links between the sensors, changes frequently due to sensor addition, deletion, node failures, damages, or energy depletion. Also, the sensor nodes are linked by a wireless medium, which is noisy, error prone, and time varying. Therefore, routing paths should consider network topology dynamics due to limited energy and sensor mobility as well as increasing the size of the network to maintain specific application requirements in terms of coverage and connectivity.

6. Data Aggregation:

Since sensor nodes may generate significant redundant data, similar packets from multiple nodes can be aggregated so that the number of transmissions is reduced. Data aggregation technique has been used to achieve energy efficiency and data transfer optimization in a number of routing protocols.

7. Diverse sensing application requirements:

Sensor networks have a wide range of diverse applications. No network protocol can meet the requirements of all applications. Therefore, the r outing protocols should guarantee data delivery and its accuracy so that the sink can gather the required knowledge about the physical phenomenon on time.

8. Scalability:

Routing protocols should be able to scale with the network size. Also, sensors may not necessarily have the same capabilities in terms of energy, processing, sensing, and particularly communication. Hence, communication links between sensors may not be symmetric, that is, a pair of sensors may not be able to have communication in both directions. This should be taken care of in the routing protocols.

ACO TECHNIQUE

This behaviour of real ant colonies is exploited to solve optimization problems. ACO is a meta-heuristic optimization technique. A heuristic approach for directing ones attention in learning, discovery, or problem solving. The research led to creation of more robust, general methods so that they may be applicable for solving various different problems. These more general and improved heuristic methods were called metaheuristics. Ant algorithms

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were inspired by the observation of real ant colonies. Ants are social insects, that is, insects that live in colonies and whose behaviour is directed more to the survival of the colony as a whole than to that of a single individual component of the colony. An important and interesting behaviour of ant colonies is their foraging behaviour i.e. how ants can find shortest paths between food sources and their nest [Dorigo et al., 1996]. Ants are capable of finding the shortest path from food source to their nest or vice versa by smelling pheromones which are chemical substances they leave on the ground while walking. Each ant probabilistically prefers to follow a path rich in pheromone. This behaviour of real ants can be used to explain how they can find a shortest path. The main idea is that it is indirect local communication among the individuals of a population of artificial ants. This indirect local communication between ant agents is called stigmergy. The core of ant's behavior is the communication between the ants by means of chemical pheromone trails, which enables them to find shortest paths between their nest and food sources.

A. Swarm intelligence (SI)

ACO is based on Swarm Intelligence which is the collective behavior of decentralized, self-organized systems, natural or artificial exhibited by animals or insects shown in figure 3.1. The expression was introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems. SI systems are typically made up of a population of simple agents or boids interacting locally with one another and with their environment. The inspiration often comes from nature, especially biological systems. The agents follow very simple rules, and although there is no centralized control structure dictating how individual agents should behave, local, and to a certain degree random, interactions between such agents lead to the emergence of "intelligent" global behavior, unknown to the individual agents. Natural examples of SI include ant colonies, bird flocking, animal herding, bacterial growth, and fish schooling. In principle, it should be a multi-agent system that has self-organized behavior that shows some intelligent behavior. The ant colony optimization algorithm (ACO) is a probabilistic technique for solving computational problems which can be reduced to finding paths. Many researchers had already implemented various routing algorithms on WSN for better performance.

B. The Social Insect Abilities

The search for food in ants is organized in part by chemical trails laid while searching for food source. During foraging for food, ants communicate with the aid of the pheromone laid on their way back to the nest. When food is discovered, ants return to the nest laying a trail to recruit nest mates to the food source. The difference between foraging and recruitment trails is attributed to different quantities of trail pheromone present on the path. Ants have been found to adapt to their environment and always find the most efficient path to their food source. The optimization of path behavior of ant is now widely used to motivate applications such as routing in WSN. The path from the nest to the food source at time, the ants find the food and bring it back efficiently, establishing a pheromone trail to it. When there is an obstacle in their path such that there is one part that is shorter than the other, the ants can choose either path with equal probability, hence having the same number of ants on both sides. The path that is shorter will allow ants to gather food quickly and strengthen the pheromone trail on the way back faster than the ants on the longer path, causing the other batch of ants to move with higher probability towards the trail that is stronger. As the process continues, it will be observed that all the ants will use the shortest path towards the food source.

V. SYSTEM OVERVIEW

By using proposed approach will increase Robustness, Reliability, Routing is easy, Energy compaction, energy efficiency, Easy to in finding optimal path, Load balancing .By using this methods for prolonging the lifetime of WSNs will overcomes issues of Topology Management, Device Control, Greedy Algorithm, Device Placement, Data Processing Routing in existing work.

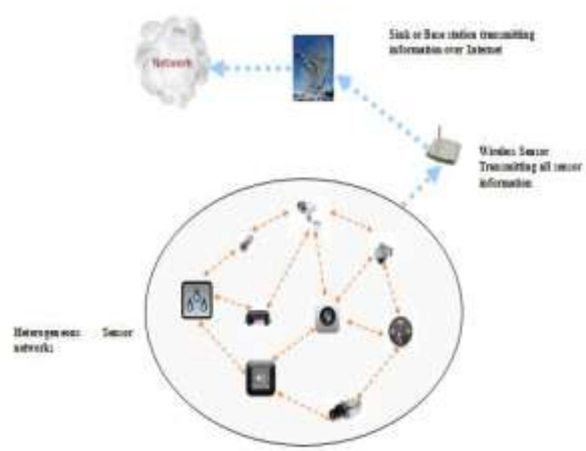

Fig. 1: System Architecture of existing WSNs

In our proposed system we have taken two sink as sink1 and sink2. Each consists of 3 sensor nodes. The initial target area of 300*750 taken and the sensor

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coverage range is 50meter and sink coverage is 100 meter taken.

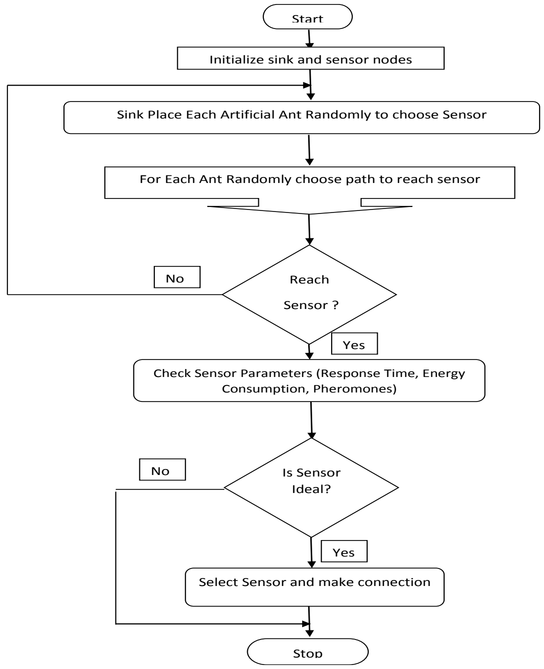
Initially Sink broadcasts the request message for receiving data from the sensor nodes. In response to the broadcasts message the sensor nodes who has data with them for transmission sends a positive acknowledgement towards the sink. Once the sink receives this acknowledgement message from respective nodes it calculates four parameters which are response time, distance, and pheromone value and consumed energy level. If the response time value is less than 60ms only then the connection is allowed. Basically the response time is decided from the distance coverage and the distance depends on pheromone value. Thus more impact is on response time for allowing the data connection to establish.

To evaluate the performance of proposed algorithm a simulated graphs consumed energy Vs iteration is presented in the results.

A. Algorithm

1. Initialize pheromone Trail in target area
2. Load the configuration (like sensor reader which contains the information about temperature, pressure information's) 3. Add the target area
4. Do While
5. Calculate the coverage distance between sensors, sink then
6. Find the distance then
7. Add all data to area starting from sensor to sink
8. While 9. Calculate all paths according to ACO algorithm then find optimized path
10. Update in ACO table by distance, coverage, sensors details 11. Do until (Each Ant Completes a round) – round Loop
12. Local Trail Update (all path calculation between sensor and sink) End Do End while Analyze round
13.Global Trail Update (shortest distance calculation updated) End Do
14. Finally shortest distance between sink and destination are calculated.
15. Repeat the same.

B. Flow Chart:



Performance Evaluation

Various performance metrics are used for comparing different routing strategies in WSNs. We have used the following:

- Response Time
- Energy consumed

VI. RESULTS AND DISCUSSION

This section of the paper discusses the simulation of the proposed routing algorithm and evaluates its performance. To evaluate the implementation of the proposed ACO routing, simulation was carried out in Java NetBeans 6.9 Framework, This software provides a high fidelity simulation for wireless communication and sensors with detailed communication between sensors and sinks. This demonstrates the increased WSNs lifetime.

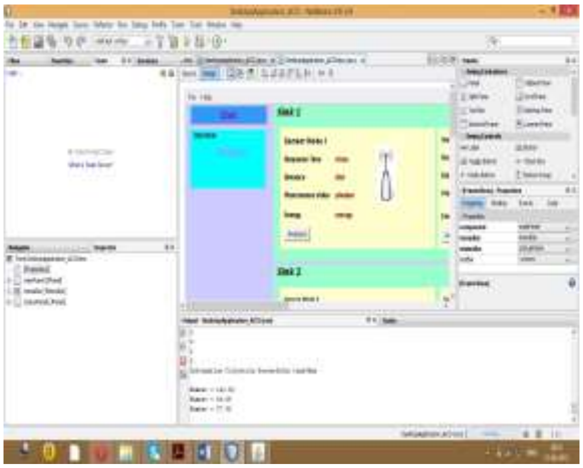


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Fig.2 Technical architecture for simulation in JAVA NetBeans 6.9

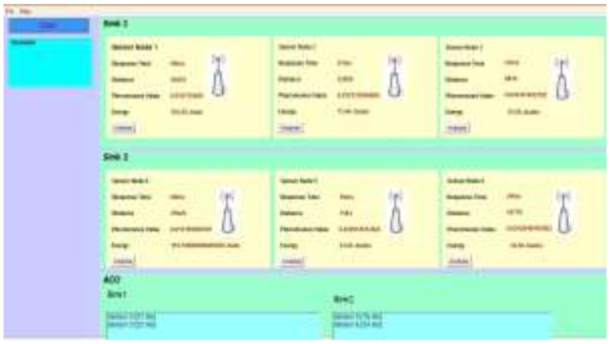

Fig.3 Parameters for selection of optimal distance: iteration 1

Fig.4 Parameter calculation for optimal path: iteration 2

Fig.5 Parameter calculation for optimal path: iteration 3

Fig.3 shows the parameters likes response time, distance, pheromone value and consumed energy for each single node in the sink1 and sink2. In the output ACO plane we can observed that only those nodes are connected to the sink which has the response time less than 60ms. The response time is calculated from the pheromone which is available on the path of 60ms. So in the ACO plane only sensor 2 and 3 are allowed to send data to sink1 and sensor 5 & 6 are allowed to send data to sink2. Same for iteration 2, 3 is shown in figure no. 4, 5 respectively.

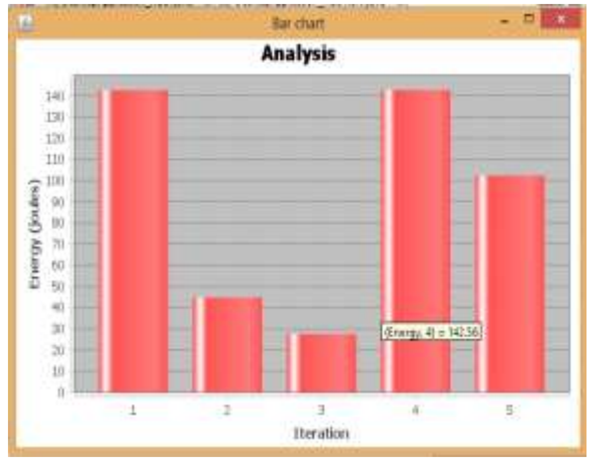

Fig.7 Bar chart of Energy conserved by node1

In figure 7. Energy conserved by node 1 for iteration 1 is 142J, for iteration 2 is about to 44J, for iteration 3 it consumed 27J and for iteration 4 & 5 it consumed 142J and 102J respectively. So for iteration 3 node 1 consumes less energy i.e. more energy is conserved by node 1 for iteration 3. So we can use that same distance used in iteration 3 to transmit the data to the sink1 and conserve the energy.

VII. CONCLUSION

In this paper, we presented a new algorithm based on ACO for maximizing the network lifetime and balance the node power consumption as long as possible. Based upon finding coverage, connectivity between the sensor and sink and followed by finding optimal path, the lifetime of sensor is maximized. In further enhancement we can use active/sleep mode in sensors. Finally the synchronization between sink take places and transmits al data's to destination. Extensive simulation result clearly shows that the proposed approach provides approximate, effective and efficient way for maintain and increasing the lifetime of wireless sensor networks

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