Ant-Based Routing Protocols

For Wireless Sensor Networks: An overview

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Abstract - *Routing in Wireless sensor network is very demanding task due to their inherent characteristics such as limited energy availability, low memory and reduced processing power. There are some recent advances in wireless sensor networks which are specifically designed for sensor networks where Efficient Energy awareness and power consumption is an important aspect. High efficient routing is an important issue in design of limited energy resource in Wireless sensor networks. Ant colony optimization (ACO) is one of the advanced routing protocols which describe specific protocol in wireless sensor network related to the efficient energy and power consumption. Inspiring by the promising performance of basic Ant based routing protocol. This paper proposes an Improved Energy Efficient Ant Based Routing (IEEABR) Algorithm in wireless sensor network which deals with the approach to increase Time Span of sensors and Efficient towards the Energy and Performance.*

***Key Words*: Wireless Sensor Network, Routing Protocols, Ant Based Routing, Energy Efficient.**

1 .INTRODUCTION

Wireless Sensor Networks (WSN) is a network of number of tiny sensor nodes. Sensor node consists of Processor, Sensor, Transceiver and Battery. The sensor nodes are followed by Battery which is non-rechargeable and performs operation using processor and transceiver. WSNs are used in many applications but they have several restrictions including limited energy supply, limited process time and communication abilities. These limitations are considered while constructing any protocol in wireless sensor networks.

Ant colony optimization is one of the proposed algorithm in which an improved energy resources are used to minimize the limitations over the basic proposed algorithm. Due to improvement in low power wireless communication and low power analog and digital communication, the sensors nodes has received a demand in wireless sensor networks. The topology of sensor network changes very frequently and some time they are not in fever of protocols.so the energy and power requirement can be increased [1].

As sensor nodes are limited in power consumption and acting capacities, the performance of sensor node may vary. There are so many routing topologies except ant colony protocol which carries a work for sensor nodes. But basic ant colony protocol is convenient. We proposed the Low Power Requirement and Energy Efficient protocol as Improved Energy Efficient Ant Based Routing Protocol (IEEABR). The basic method to transfer information from a sensor node to base is called as Flooding. In this method, information is spread around all the Nodes and to the Base Node also [9].

Ant Colony Optimization (ACO) algorithm is based on the behaviour of real ants. While moving some forward ants finds there path for destination and remaining ants follow the path of forward ants. In the same way, the sensor nodes are considered as ants and search there path. The minimum path i.e. shortest path to be chosen and followed until the destination doesn't occurred. These sensor nodes are relevant to each other and efficient over the energy consumption [3].

1.1 Routing Protocol in WSN

A Routing Protocol specifies how routers communicate with each other. In the same manner, how the sensor nodes are communicating between themselves is the routing protocol. Routing Algorithm specifies the path of the sensor nodes. It travels or share the information first among immediate neighbors and then throughout the network. In this way sensor nodes gain knowledge of the topology of the network.

Due to presence of sensor nodes, WSN present unique characteristics in ad hoc network. As the ad hoc network controls the sensor nodes to travel among network, in the same manner the ant colony algorithm decide the way for sensor nodes to communicate between them in a whole network. Ant Colony Algorithm is better option for this improvement in wireless sensor networks. This paper proposes An Improved Energy Efficient Ant Based Routing (IEEABR) Algorithm having a comparison with Basic Ant Routing Protocol (BABR) [3].

1.2 Types of Routing Protocol

1) On-Demand (Reactive) Routing

On Demand Routing (ODR) is designed to be used in partially frame network where hub router maintains a link to multiple

sub routers. In on demand routing protocol, the number of routers can lead to network blocking.
Example: Ad hoc on demand Distance Vector
Dynamic Source Routing

2) Table Driven (Proactive) Routing

It keeps Routing tables updated at each node and which update it periodically. The routing procedure is based on these updated routing table data. In these protocols, each node keeps the best next hop node information for all destinations in the network [8].
Example: Link State Algorithm
Distance Vector Algorithm

Basic examples of proactive algorithm: Basic Ant Based Routing Algorithm, Energy Efficient Ant Based Routing Algorithm, Improved Energy Efficient Ant Based Routing Algorithm.

1.3 Basic Ant Based Routing Algorithm (BABR)

The simplest way to describe the Ant Colony concept in WSNs is to put the concept of Basic Ant Colony Algorithm (BABR).The implementation of this algorithm is as follows:

1) A Forward ant is launched to source node whose task is to find a path up to the destination.
2) Consider each node as r, at any node where the forward ant is launched which chooses the next node until the destination node is not occurred.
3) As the ants move forward to reach up to the destination, the Routing table is get updated after reaching every node.
4) Forward ants calculate the all values of routing table of all parameters and keep it updated after every node.
5) By reaching the destination node, forward ant converted into backward and starts there reverse travelling to update its new routing table.
6) After reaching the backward ant to source node, the routing table is get updated and the ant is at initial position.
7) The destination computes the forward as well as backward path from routing table and shows the result of both the travelled path.
8) This shows the Basic Routing Algorithm of Ant Based Protocols to travels the ant in both forward and reverse path and to put update the routing table time to time [2][7].

1.4 Energy Efficient Ant Based Routing Algorithm

Energy Efficient Ant Based Routing Algorithm (EEABR) is the improved version of Basic Ant Based Routing Algorithm (BABR). Basic Ant Algorithm considers study only about the path followed by forward and reverse path but Energy Efficient Ant Algorithm put its concept with the help of considering the energy parameter.

In BABR Algorithm, ants moved in both the direction and update the path followed in Routing table. In any one direction of flow of ant, ant considers the previous node i.e. last visited node to update the table. While travelling in both the direction and to update the table two times, it requires more memory to store the data of routing table [3][8].

In BABR Algorithm, sensor nodes must communicate between each other i.e. between the last visited node and current node. So it requires more memory to store data of routing table. In EEABR Algorithm, this memory requirement concept is handle properly to lay down the memory wastage and build the efficient algorithm. As these algorithm put the concept of requirement of large memory for basic ant based routing algorithm, it proposes the new efficient algorithm which include the concept of Energy. Energy Efficient means not exactly related to the energy concept but to put the relevant algorithm in favor of energy and memory [1].

In EEABR Algorithm, the last two visited node are saved as visited node and not considered for next move of ant. Energy is important parameter to be considered and implement in this algorithm. The quality of a given path should be measured on the basis of number of nodes in the path. For improving the quality and efficiency of algorithm, one should consider the number of nodes and path followed by the ants. On the basis of path and visited nodes, the efficiency of code is to be considered. More relevant and efficient algorithm is practically possible. By comparing Energy Efficient Algorithm with Basic Ant Algorithm, it has better energy efficiency and storage capacity [2].

1.5 Improved Energy Efficient Ant Based Routing Algorithm

Ant Colony Optimization is the colony of Artificial Ant that travels through wireless sensor networks to search Shortest and Energy Efficient path between the source nodes to destination node to maximize the Lifetime of sensor nodes. However it is inspired from natural behavior of ant colonies [3]. In our paper we present the Improved Energy-Efficient Ant Based Routing Algorithm (IEEABR) which is more relevant and efficient than other algorithms i.e. BABR and EEABR. Basic Ant Colony algorithm and Energy Efficient Ant Based algorithm had some disadvantages and that can be reduced and which can increase processing time by Proposed IEEABR Algorithm.

In this Algorithm, consider the available power of node and the energy consumption of each path as efficient for routing selection. It improves the memory usage, power consumption, processing ability, Battery life, utilizes the self-organization, dynamic optimization capability of ant colony system to find the shortest as well as Energy Efficient Path from the source node to destination node. It avoids the use of nodes on optimal path and increases the lifetime of network while preserving the network connectivity. Energy Efficient is an important issue in wireless sensor networks so as to minimize the utilization of the power on visiting the every node 1. [4][1]

In our proposed algorithm, the destination node is specified. The forward Ant is directly sent to the destination node from the source node where it is initiated. Routing Table saves the information of neighboring nodes, which will not save the information related to all nodes which reduced the size of boundary table as well as the memory required for sensor nodes. At each node the new memory is created and deleted which keeps the information of previous and present node as well.

Each memory record saves the previous node, forward node and identification of the present node. It also updates the time out values of present visiting nodes. When every forward ant reaches to its next node then routing table saves its identification and while leaving that visited node, it eliminates the updated data from routing table. When it reaches to the destination node then backward ant is created and traveled by the same path as that of the forward ant until the source node occurred. When it gets reached to the source node, the traversing of forward as well as reverse ant gets completed [6].

2. ALGORITHM

1. Initialize the routing tables with a uniform probability distribution;

$$P_{ld} = \frac{1}{N_k}$$

Where P_{ld} is the probability N_k of jumping from source node to destination node. This is done to reflect the previous knowledge about the network topology.

2. At a given time after network topology update, a Greater probability values is assigned to the neighboring nodes that simultaneously could be destination in process for d∈N_k then the initial probability in the probability distribution table of k is given by;

$$P_{dd} = \frac{9N_k-5}{4_{Nk^2}}$$

Also, for the rest neighboring nodes among the neighbors for which m is not equal to d, and $m \in N_k$ will then is:

$$P_{dm} = \frac{4N_{k-5}}{4N_k^{\,2}}, \text{ if } N_k > 1$$
$$= 0 \quad , if \quad N_k = 1$$

3. At regular intervals of time from every network node, a forward ant k is launched with the aim to find a path until the destination. Where the number of ants lunched at each node is limited to k*5 for network congestion control. The identifier of every visited node is saved onto a memory M_k and carried by the ant. Where k is any network node having a routing table will have N entries, one for each possible destination and d is one entry of k routing table N_k is the set of neighbouring nodes of k, P_{lk} is the probability with which an ant or data packet in k, jumps to a node l $1 \in N_k$, when the destination d, d(d≠k) Then, for each of the N entries in the node k routing table, it will be nk values of Pld subject to the condition [1]:

$$\sum l \in N_k \, P_{ld} = 1; \; d=1\ldots\ldots N.$$

4. Forward ants' selects the next hop node using the same probabilistic rule proposed in the ACO met heuristic:

$$P_k(r,s) = \frac{[\tau(r,s)]^{\alpha}.[E(s)]^{\beta}}{\sum_{\mu \in M_k}[\tau(r,\mu)]^{\alpha}.[E(s)]^{\beta}} \quad s, M_{k,€}$$

Where $P_k(r,s)$ is the probability with which ant k chooses to move from node r to node s, τ is the routing table at each Node that stores the amount of pheromone trail on connection (r,s). E is the visibility function given by $\frac{1}{c-e_s}$ (c is the initial energy level of the nodes and es is the actual energy level of node s), and α and β are parameters that control the relative importance of trail versus visibility. The selection probability is a trade-off between visibility (which says that nodes with more energy should be chosen with high probability) and actual trail intensity (that says that if on connection (r, s) there has been a lot of traffic then it is highly desirable to use that connection.

5. When a forward ant reaches the destination node, it is transformed to a backward ant which mission is now to update the pheromone trail of the path it used to reach the destination and that is stored in its memory.

6. Before backward ant k starts its return journey, the destination node computes the amount of pheromone trail that the ant will drop during its journey:

$$\Delta\tau = \frac{1}{c - \left[\frac{E_{min}-N_j}{E_{av}-N_j}\right]}$$

Where C is the initial energy of the nodes, E_{min} E_{av} are the minimum and average energy respectively of the path traversed by the forward soldier as it moves towards the hill, N_j represent the number of nodes that the forward soldier has visited. The idea behind the calculation of $\Delta\tau$ is that, it brings optimized routes, since it is a function of the energy level of the path, as well as length of the path. For example, a path with 10 nodes can have the same energy average as path with 4 nodes. Therefore, it is important to calculate the pheromone trail as a function of energy and number of nodes as against the number of nodes as it used in other ACO [1].

7. When the backward ant reaches the node where it was created, its mission is completed and the ant is eliminated.

8. Else, if it fails to reach the node where it was created, i.e. when a loop is detected, immediately the ant is self-destroyed.

By performing this algorithm for several iterations, each node will be able to know which are it best neighbours to send a packet towards a specific destination [1][4][5].

9. Whenever there is a link failure, an automatic update is made on the routing tables in case of a node n loses its link lnm with its neighbour node m. It is assumed that if an ant is in n, the probability Pdm, to a destination d through node m, is distributed uniformly between the remaining Nk-1 neighbours for the entry d in the routing table of n. Pdm=0, during a link lnm failure, hence it is not possible to travel from k to m for arrival to d. Hence, new probability values after link lnm failure is introduce as Pdl, and the probabilities will be proportional to their relative values before the failure instead of forgetting what it has learned until the moment of the failure and is updated according to algorithm as;

$$P_{dl} = P_{dl} * (1 + Z)$$

$$Z = \frac{P_{dm}}{1 - P_{dm}}$$

$$P_{dm}, P_{dm} = 0$$

3. FLOW CHART

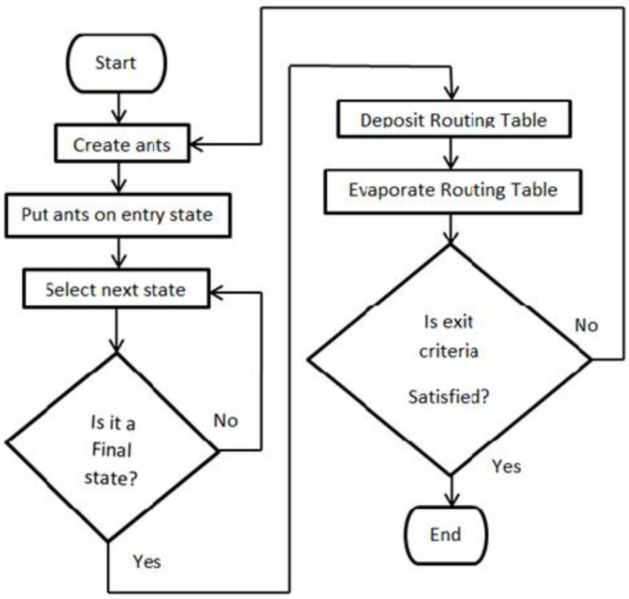

Fig 1- Flow Chart of Algorithm

4. SOFTWARE DESIGN

4.1 ROUTING TABLE

Routing Table keeps the information of current node and visited node in it. It requires the information of visited node as well as the present node to update the data into the routing table.

For updating the data and to put refresh the routing table following is the formula proposed in our paper.

$$\tau(r,s) = (1 - \rho) * \tau(r,s) + [\frac{\Delta\tau}{\emptyset B d_k}]$$

Basic node creation using ant colony optimization is as follows. In this basic ant algorithm nodes are created and shortest is determined to reach up to the destination node from source node

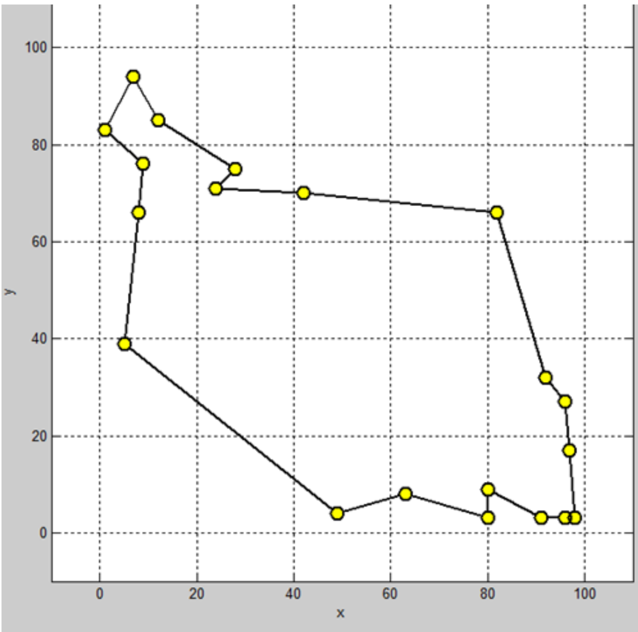

Fig 2- Basic Node Creation

4.2 PARAMETER DEFINE

Latency: The time delay of an event sent from the source node to the destination node (seconds).

Success rate: It is a ratio of total number of events received at the destination to the total number of events generated by the nodes in the sensor network (%) [1].

Energy consumption: It is the total energy consumed by the nodes in the network during the period of the experiment (Joules).

Energy efficiency: It is a measure of the ratio of total packet delivered at the destination to the total energy consumed by the network's sensor nodes (Kbits/Joules).

5. CONCLUSION

Routing in wireless sensor networks has attracted a lot of attention in the recent years and introduced unique challenges compared to traditional data routing in wired networks. Wireless sensor networks consist of large sets of resource-constrained nodes. The design of effective, robust, and scalable routing protocols in these networks is a challenging task. On the other hand, the relatively novel domain of swarm intelligence offers algorithmic design principles, inspired by complex adaptive biological systems that well match the constraints and the challenges of WSNs. Therefore, a number of routing protocols for WSNs have been developed in the last years based on ACO principles. Our proposed algorithm is the advanced set of algorithm in Ant Colony optimization to put the effective and efficient algorithm in area of sensor networks. Here we proposed our Improved Energy Efficient Ant Based Routing Protocol with some parameters to make our algorithm effective.

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