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Energy Efficient Ant Colony Optimization based Routing Protocol for Wireless Sensor Networks

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Abstract

ACO(Ant Colony Optimization) is proved to be better technique for many applications. State of the art techniques about application of ACO for routing in wireless sensor networks (WSN) have been published in many articles. This is proved to be energy efficient as well as better in performance. In this paper we are proposing an algorithm for ACO based routing in which routing decision is based ACO pheromone parameter as well as remaining energy of the WSN node. Results of implementation show that proposed method is more energy efficient.

Keywords: ACO, Energy Efficient Routing, WSN, MANET.

Introduction

Swarm intelligence (SI) is becoming widely used to solve computational problems. Ant Colony and on fish schooling/bird flocking highly attracted the interest of researchers. Artificial Bee Colony (ABC) is the one which has been most widely considered on and applied to solve the real world problems. Ant Colony Optimization (ACO) is a Meta heuristic for solving tough optimization problems. The stimulating source of ACO is the pheromone track laying and following behavior of biological ants, which make use of pheromones as a communication medium. ACO is based on indirect communication within a colony of ants, through pheromone trails. The pheromone trace in ACO serves as information, which the ants use to probabilistically construct solutions to the problem being solved and which the ants become accustomed during the algorithm's execution to reflect their search experience. [1]

Literature review

Satisfying the stringent quality of service (QoS) requirements of multimedia transmission in a resource-constrained sensor network environment places new issues to routing in WSN. As result, optimal energy and application-specific QoS aware routing for WMSNs has gained considerable research attention recently. In [2], current state-of-the-art in energy-efficient routing techniques for WMSNs is surveyed with the highlights of the performance issues of each strategy.

In [3], a new protocol called Equalized Cluster Head Election Routing Protocol (ECHERP) is proposed. This protocol pursues energy conservation through balanced clustering. ECHERP models the network as a linear system using the Gaussian elimination algorithm, then calculates the combinations of nodes that are probable cluster heads in order to increase the network lifetime. This protocol is efficient in terms of network lifetime when evaluated against other well-known protocols [3].

In WSN, it is significant to reduce communication overhead by using routing protocol because the energy of the sensor node is limited. Existing cluster-based routing protocols faces the problem of random selection of a cluster head and they have a low reliability for data communication due to the not consideration of node communication range. Control overhead is greatly increased during constructing clusters. In [4] a new energy-efficient routing protocol is proposed to solve above problems using message success rate. In [4] cluster head selections are based on node connectivity and devise cluster maintenance algorithms. To guarantee data communication reliability, authors used message success rate to select a routing path. To reduce data communication overhead, authors used only the information of neighboring nodes [4].

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Hot spots in a wireless sensor network come into view as locations under heavy traffic load. Nodes in hot spot quickly eat up energy resources, leading to interruption in network. This problem is widespread for data collection in which Cluster Heads have a intense load of gathering and routing data. The routing load on CHs in particular deepens as the distance to the sink decreases. To equilibrium the traffic load and the energy utilization in the network, the cluster head should be alternate among all nodes and the cluster sizes should be cautiously determined at diverse parts of the network.

[5] Proposes a distributed clustering algorithm called Energy-efficient Clustering that establish suitable cluster sizes depending on the hop distance to the sink, while attaining estimated equalization of sensor node lifetime and reduced energy consumption[5].

The efficiency of these networks is highly dependent on routing protocols directly affecting the network life-time. Clustering is one of the most accepted techniques in WSN routing. In [6] a novel energy efficient clustering mechanism, based on artificial bee colony (ABC) algorithm, is proposed which results into improved the network life-time. ABC algorithm, imitate the foraging behavior of natural honey bee swarms, has been successfully used in clustering techniques [6].

In [7], author deal with virtual network embedding Problem with objective to map virtual networks in the network with minimum physical resources utilization while fulfilling its required QoS in terms of bandwidth, power processing and memory. This minimizes the reject rate of requests and maximizes returns for the substrate network service provider. In view of the fact that the problem is NP-hard and to deal with its computational inflexibility, a novel scalable embedding approach called as VNE-AC based on the Ant Colony Optimization is proposed in [7].

In [8] authors developed a routing method to control the picker congestion that challenges the traditional assumption regarding the narrow-aisle order picking system. A new routing algorithm based on Ant Colony Optimization (ACO) for two order pickers (A-TOP) with congestion consideration is proposed. A-TOP realizes the shortest total selection time in most instances and performs fine in dealing with the congestion. The impacts of warehouse structure, size, and pick to walk time ratio on A-TOP and system performance are comparatively better. A-TOP can become accustomed to diverse warehouse configurations [8].

The capacitated arc routing problem (CARP) is ambassador of many practical applications, and in order to widen its scope, an extended version of this problem that entails together total service time and fixed investment costs. [9] Proposes a hybrid ant colony optimization algorithm (HACOA) to solve case of the extended CARP. This method is characterized by the utilization of heuristic information, dynamic parameters, and confined optimization techniques: Information about Arc cluster and Arc priority, are obtained constantly from the solutions domain to direct the subsequent optimization. The adaptive parameters relieve the burden of select initial values and make superior and robust results. Local optimization uses two-opt heuristic to improve the overall system performance in the proposed algorithm [9].

One of the key concerns in WSN is routing due to the mobility of the nodes. In WSN, the difficulty increases due to various characteristics like dynamic topology, time varying QoS requirements, limited energy etc. QoS routing plays key role for providing QoS in wireless sensor networks. The biggest challenge in this kind of networks is to find a path between the communication end points satisfying user's QoS requirement. Nature-inspired algorithms such as ant colony optimization (ACO) algorithms have shown to be a good technique for developing routing algorithms for MANETs. In [10] a new QoS algorithm for mobile ad hoc network has been proposed. The proposed algorithm [10] combines the idea of Ant Colony Optimization (ACO) and Optimized Link State Routing (OLSR) protocol to identify multiple paths between source and destination nodes [10].

Dynamic traffic routing (DTR) refers to the process of redirecting traffic at junctions in a traffic network resultant to the developing traffic conditions as time progresses. [11] Considers the DTR problem for a traffic network as a directed graph, and deals with the mathematical facet of the resulting optimization problem from the viewpoint of network theory. Networks have thousands of edges and nodes, resulting in a considerable and computationally complex DTR optimization problem. Ant Colony Optimization (ACO) is chosen as the optimization method to solve problem in [11]. The standard ACO algorithm is not capable of solving the routing optimization problem therefore a new ACO algorithm is developed to attain the goal of finding the best distribution of traffic in the network [11].

The key differences of wireless sensor networks with other networks are limited energy resources and relatively low processing capabilities. Therefore, running power and reducing energy utilization are of great significance in these networks. In [12] presented a method for Wireless sensor network routing which can be more effective concerning the criteria of path length, delay and sensor node energy for the quality of service. The proposed method in [12] is used ant colony–based routing algorithm and local enquiry to find optimal routes. A fuzzy inference system was also used to decide the route superiority [12].

Ant colony optimization (ACO) is a probabilistic method used for solving complex computational problems, such as discovery of best routes in networks. It has been confirmed to perform better than simulated annealing and Genetic Algorithm (GA) approaches for solving dynamic problems [13]. ACO algorithms can rapidly adapt to real-time changes in the system. [13] Propose an ACO-based algorithm to work out the dynamic any cast routing as well as wavelength assignment problem in wave length routed optical networks.

Proposed system

In proposed system we use forward Ants and Backward ants to discover routes to destination. Along with pheromone as in traditional ACO, we make use of remaining energy for deciding probability of next node selected. Following paragraph explains it in mathematical way.

Let N is set of nodes in system, N= {n_1, n2,...,n_n} in system,
Let Assume P(i) is probability of node n_i to forwards forward ant as well as data is $p(i) = 0.5$, Initially
Let PH (i) is pheromone value of node n_i , Initially PH(i)=0 for all i=0 to n.
When Backward ant travels through node n_i,
PH(i)= PH(i) +∝, where ∝ is constant.
Let Routing table R, maintained at each node, Routing entry,
r (i) ={ ni , RE (i), PH(i) }
$Where\ \ ni \in N,$
RE (i) = Remaining Energy of node n_i,
PH (i) = Pheromone value of node n_i
Now Probability p(i) of selecting n_i as next node for Forward_Ant as well as data is

$$p(i) = \frac{PH(i) + RE(i)}{Max(PH) + Max(RE)}$$

Above probability is calculated periodically, giving equal priority to shortest path (PH) and energy RE (i), leads to energy efficient algorithm.

Implementation and results

Proposed system is implemented using OMNeT++ simulator and compared with [14]. Simulation parameters used as shown in table.

Parameters	Value
Network Area	500 × 500
MAC Protocol	Bypass MAC
No of Nodes	20
Packet Rate	1 packet per Second
Simulation Time	1000 seconds

Table 1 Simulation Parameters

Fig. 1 shows Energy consumption in both protocols along with time. From Figure it is clear that proposed model consumes less energy as compared to [14].

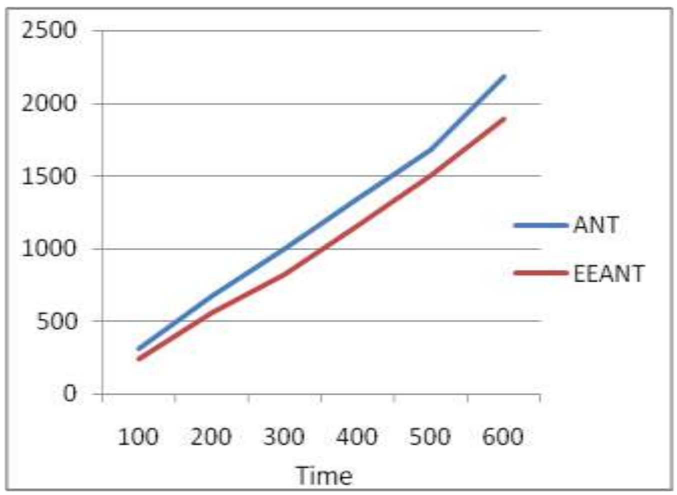

Fig. 1. Energy Consmsion Vs Time

Conclusion

Energy Utilization is very critical factor is designing routing protocol in WSN. In this paper we proposed routing algorithm using Ant Colony Optimization (ACO) with probability of route selection based on pheromone and remaining energy. Through simulation result we proved that proposed method is more energy efficient.

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