

# A Review: Optimization of Energy in Wireless Sensor Networks

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**Abstract-** Wireless Sensor Networks have become an important research topic in last year. WSN is a collection of tiny, large number of densely deployed sensor node; these sensor nodes are smart, effective which is very powerful and versatile networking where traditional wired and wireless networking is unable to deploy. These sensor nodes have limited transmission range, processing and storage capabilities as well as their energy resources. Routing protocols for wireless sensor networks are responsible for maintaining the energy efficient paths in the network and have to ensure extended network lifetime. In this paper, we propose a new approach to provide multiple routing paths using an Ant Colony Optimization (ACO) algorithm. Ant Colony Optimization based routing algorithms have been proposed to solve the routing problem trying to deal with these constrains. This paper will find an energy efficiency path in the WSNs using a method is based on Ant Colony Optimization (ACO) algorithms, aiming to minimize the consumption of power, improve fault tolerance, and length the network lifetime. We conclude that the proposed protocol effectively extends the network lifetime with less consumption of energy in the network.

**Keywords-** Wireless sensor network, Ant colony optimization, Routing, Network lifetime

## I. INTRODUCTION

The popularity of Wireless Sensor Networks (WSN) are increasing day-by-day in recent years due to the advances in low power wireless communications, information technologies and electronics field. The wireless sensor networks are based on the cooperation of a number of tiny sensors and which are depending upon four parts: sensor (motes), processor, transceiver, and battery. The Sensor get information from surrounding area and processor change the analog information into digital information. These sensors sense and detect various environmental parameters such as temperature, pressure, air pollution etc. They are also deployed in monitoring of agriculture, smart homes, structures, passive localization, tracking etc. Then transceiver transmits the converted data to the base- station directly, or through neighboring sensor. The development of low-cost,

low-power, a multifunctional sensor has received increasing attention from various industries. Sensor nodes or motes in WSNs are small in size and are sensing capability, connecting and processing data while communicating with other nodes connected in the network, via radio frequency (RF) channel.

Routing is a challenging issue in WSNs due to the inherent characteristics that distinguish these networks from other Wireless networks like mobile ad hoc networks or cellular networks. The large amount of sensor nodes and Constraints in terms of energy, processing, and storage capacities requires careful management of resources. Due to such differences, many algorithms have been proposed for the routing in WSNs.

These routing mechanisms have taken into consideration the inherent features of WSNs along with the application and architecture requirements. The task of finding and maintaining routes in WSNs is nontrivial since energy restrictions and sudden changes in node status (e.g., failure) cause frequent and unpredictable topological changes.

In this paper an adaptation of Ant Colony Optimization (ACO) technique is demonstrated for network routing. This approach belongs to the class of routing algorithms inspired by nature's complex adaptive systems. Ant Colony Optimization (ACO) is a combinatorial optimization framework that reverse-engineers and formalizes the basic mechanisms at work in a shortest-path behavior observed in ant colonies. Ants in a colony are able to converge on the shortest among multiple paths connecting their nest and a food source. The driving force behind this behavior is the use of a volatile chemical substance called pheromone. While locating food, ants lay pheromone on the ground, and they also go in the direction where the concentration of pheromone is higher. This mechanism allows them to mark paths and subsequently guide other ants, and let good paths arise from the overall behavior of the colony.

## II. WIRELESS SENSOR NETWORK ARCHITECTURE

The Number of sensor nodes are form sensor network to produce high-quality information about their environment. The functionalities like sensing, processing, transmission, location finding, power consumption etc. are available in each of the nodes. Their main objectives are making discrete, local measurement about phenomenon surrounding these sensors, forming a wireless network by communicating over a wireless medium, and collect data and rout data back to the user via sink (Base Station). The sink (Base Station) communicates with the user via internet or satellite communication. It is located near the sensor field or well-equipped nodes of the sensor network. Collected data from the sensor field routed back to the sink by a multi-hop

infrastructure less architecture through the sink. Phenomenon is an entity of interest to the user to collect measurements about. This phenomenon sensed and analyzed by the sensor nodes. The user is interested to gathered information about specific phenomenon to measure/monitor its behavior.

Figure 1 shows the architecture of a typical Wireless Sensor Network with the components of a sensor node.

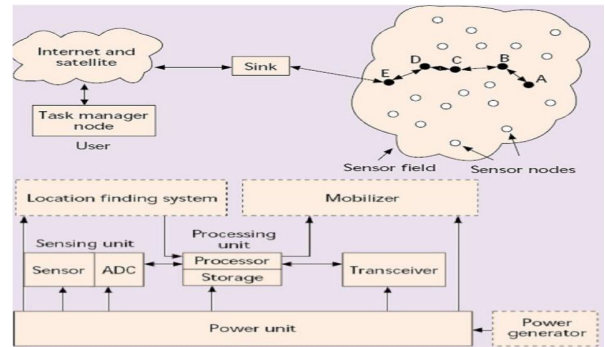


Figure 1. Sensor node and WSN Architecture

## III. ANT COLONY OPTIMIZATION (ACO)

Ant Colony Optimization is one kind of algorithm which is inspired by swarm intelligence (Dorigo & Stützle, 2004). An ant will leave pheromones for other ants when finding the food. Some ants will follow the pheromone to find the food, but some other ants will find a shorter path and also deposit their pheromone. Eventually, the shortest path from nest to food source will be found. Inspired by the activity of ants in nature, the prototype of the ACO System was built by Dorigo to solve intelligence optimization problems. Since then, Dorigo and other researchers have been working on ACO system and extending the system. They have already proposed Ant Colony System (ACS) and MAX-MIN Ant System (MMAS) which both are metaheuristic algorithms (Dorigo & Socha, 2007). ACO algorithms focus on global search, but their local search is not so efficient. This inefficiency may cause increased consumption of power if there are a large number of paths after the first global search. Compared to

other algorithms, single ACO may have a poor performance when the number of nodes is large. Lim, Jain and Dehuri (2009) have already found that ACO with local search can perform well on some complex problems. Therefore, an improved Ant Colony Optimization which combined with local search is proposed for solving this complex optimization problem. There are two general methods of local search: genetic local search and simulated annealing. The results of two hybrid Ant Colony Optimization algorithms will be compared to the original ACO algorithm and other routing results, to determine whether ACO combined with local search is more effective or not.

*A) AS (Ant system algorithm):*

Ant System (AS) was the first (1991) ACO algorithm. Its importance resides mainly in being the prototype of a number of ant algorithms which have found many interesting and successful applications. Three AS algorithms have been defined, which differ by the way pheromone trails are updated. These algorithms are called ant-density, ant-quantity, and ant-cycle. In ant-density and ant-quantity ants deposit pheromone while building a solution, while in ant-cycle ants deposit pheromone after they have built a complete tour.

*B) ACS (Ant Colony System):*

ACS was the first algorithm inspired by real ant's behavior. The merit to introduce the ACO algorithms and to show the potentiality of using artificial pheromone and artificial ants to drive the search of always better solutions for complex optimization problems. In ACS once all ants have computed their tour (i.e. at the end of each iteration) AS updates the pheromone trail using all the solutions produced by the ant colony. Each edge belonging to one of the computed solutions is modified by an amount of pheromone proportional to its solution value. At the end of this phase the pheromone of the entire system evaporates and the process of

construction and update is iterated. On the contrary, in ACS only the best solution computed since the beginning of the computation is used to globally update the pheromone. As was the case in AS, global updating is intended to increase the attractiveness of promising route but ACS mechanism is more effective since it avoids long convergence time by directly concentrate the search in a neighborhoods of the best tour found up to the current iteration of the algorithm.

ANTS algorithm within the ACO frame-work has two mechanisms:

i. Attractiveness

ii. Trail update

- The attractiveness of a move can be effectively estimated by means of lower bounds (upper bounds in the case of maximization problems) on the cost of the completion of a partial solution. In fact, if a state  $\iota$  corresponds to a partial problem solution it is possible to compute a lower bound on the cost of a complete solution containing  $\iota$ .
- A good trail updating mechanism avoids stagnation, the undesirable situation in which all ants repeatedly construct the same solutions making any further exploration in the search process impossible. Stagnation derives from an excessive trail level on the moves of one solution, and can be observed in advanced phases of the search process, if parameters are not well tuned to the problem. The trail updating procedure evaluates each solution against the last  $k$  solutions globally constructed by ANTS. As soon as  $k$  solutions are available, their moving average  $z$  is computed; each new solution  $z$  is compared with  $z$  (and then used to compute the new moving average value). If  $z$  is lower than  $z$ , the trail level of the last solution's moves is increased, otherwise it is decreased.

$$\Delta\tau_{i,j} = \tau_0 \cdot (1 - z_{curr} - LB/z - LB)$$

Where  $z$  is the average of the last  $k$  solutions and  $LB$  is a lower bound on the optimal problem solution cost.

#### IV ROUTING ALGORITHM IN WSNS

Suppose the ant is randomly placed on node  $i$ , the probability of an ant  $k$  choosing the next adjacent node  $j$  is as depicted in Equation 6. And the pheromone table helps to choose the next neighbor in the process.

$$P_{ij} = \frac{[\tau(i,j)]^a \cdot [\eta(j)]^b}{\sum_{\forall \in M_k} [\tau(i,j)]^a \cdot [\eta(j)]^b} \quad \text{If } j=M_k$$

$$0 \quad \text{otherwise}$$

where

$P_{ij}$  = probability of packet going from node  $i$  to  $j$ ,

$\tau(i,j)$  = pheromone level in the table of node  $i$  for node  $j$ ,

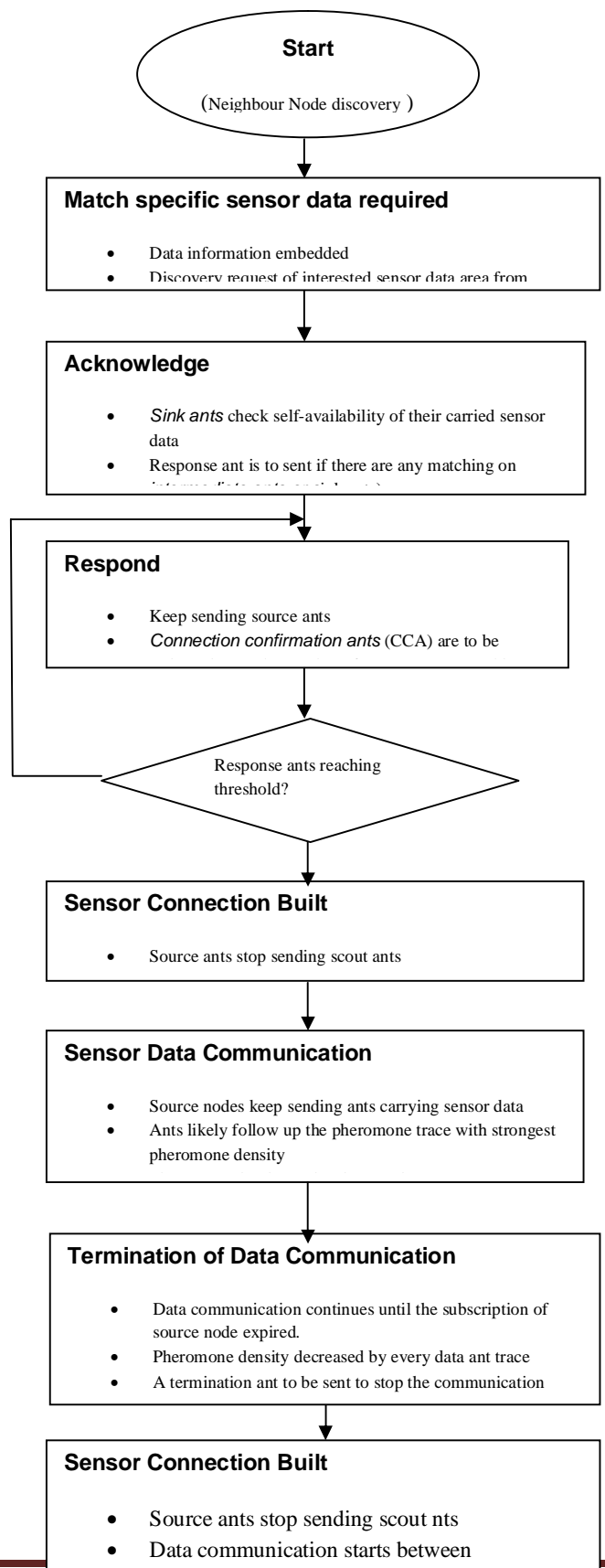
$\eta(j)$  = energy level of node  $j$ ,

$M_k$  = identifier of every visited node,

$a$  = parameter that denotes pheromone level,

$b$  = parameter that denotes energy level heuristics.

Two categories of ants are in use, they are termed as forward ants and backward ants. We adopted this concept from the relating work of ant algorithm routing such as T-ant, antNet and EEABR. We further develop the definitions as used in the literature. The forward ants are defined as the ants that are sent from the source. The forward ants will carry the information such as (1) the required sensor type, (2) the sensor region of interest, (3) the data rate and (4) the time period of the interest. More details can be seen in table I where both categories of ants are described in functions. Parameters and variables formatted in the packet of the experiment are described here in Table I. The header and data are carried by each packet. The packet is sent from source node, taking the form as backward and forward ants.



*Figure 2. Flowchart of the proposed algorithms for the routing scheme of WSNs*

#### V. CONCLUSIONS

In this paper, Ant routing algorithm performs well for symmetric networks with good success rates and energy efficiency. However, for denser networks the loss rate becomes high with the decrease in success rate and energy efficiency. Furthermore, if the network does not have a symmetric path, the algorithms do not work well as the ant wanders wastefully for searching the destination. In the near future, improvisations in ant routing algorithm will be implemented along with comparisons with other learning based algorithms.

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