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Research Article

Reduction of Power using new ACO (Ant Colony Optimization) in Wireless Sensor Network

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Abstract

Wireless Sensor Networks is one of the most researching topic and rising area now days. Wireless sensor network (WSN) technology has provided the availability of small and low-cost sensor nodes with capability of sensing various types of physical and environmental conditions, data processing, and wireless communication. WSN have become popular due to its wide range applications. Power optimization is the main problem constraint in WSN and this limitation combined with a typical deployment of large number of nodes has added many challenges to the design and management of wireless sensor networks. The energy of battery is limited in Wireless sensor Networks. This paper propose an energy efficient routing algorithm inspired from nature scheme, its implementation and validations are also described in this paper. The new ACO based routing algorithm is used to find the minimum route of nodes in wireless sensor networking the basis of pheromone updating. The simulations results show that our method boasts undoubtedly a number of attractive features, including power consumption, throughput, and latency performance have been improved.

Keywords: *Power Consumption, nACO (new Ant colony optimization), Wireless Sensor Network, Pheromones.*

1. Introduction

A sensor network is composed of a large number of sensor nodes, which are densely deployed either inside the phenomenon or very close to it. The position of sensor nodes need not be engineered or pre-determined. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities. Another unique feature of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fitted with an on-board Instead of sending the raw data to the nodes responsible for the fusion, sensor nodes use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data. The widely used field of Wireless Sensor Network (WSN) technology is in military surveillances for the coded messages as well as better in environmental monitoring, health monitoring and also can be used in earthquake observation.

In every new technology it is needed that the technology should be of low cost as well as it needs low power operation, if we talk about the WSN technology, it satisfies all above criteria because it is totally a wireless system in which many nodes operate on limited batteries while satisfying given throughput and delay requirement.

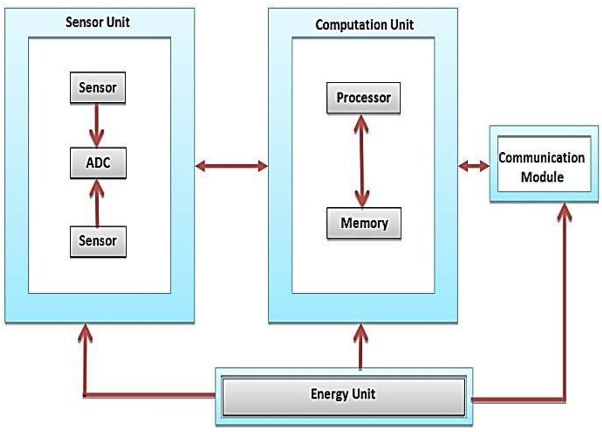

Figure 1 :- Architecture of sensor node

Sensor nodes can be used for continuous sensing, event detection, event ID, location sensing, and local control of actuators. The concepts of micro-sensing and wireless connection of these nodes promise many new application areas. We categorize the applications into military, environment, health, home and other commercial areas. It is possible to expand this classification with more categories such as space exploration, chemical processing

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and disaster relief. The remainder of the paper is organised as follows: Section II detail of Ant colony optimization. Section III reviews the background of the new scheme initiated by the swarm behaviour. Section IV presents the new routing algorithm details including algorithmic steps, and its implementation details. Simulation results of the new algorithm are presented in Section V. As a validation experiment, the performance analysis shows the efficiency of our proposed routing scheme that potentially to small sized networks in WSNs. Finally, we emphasises the contribution of this paper and future work.

Ant Colony Optimization

ACO algorithm is a probabilistic technique for diminished to discover good paths through graphs.

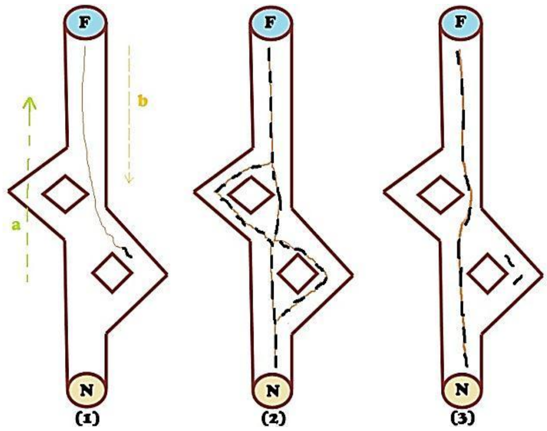

Figure 2:- Travels of ant

The original idea comes from observing the exploitation of food resources among ants, in which ants' individually limited cognitive abilities have collectively been able to find the shortest path between a food source and the nest.

- The first ant finds the food source (F), via any way (a), then returns to the nest (N), leaving behind a trail pheromone (b)
- Ants indiscriminately follow four possible ways, but the strengthening of the runway makes it more attractive as the shortest route.
- Ants take the shortest route, long portions of other ways lose their trail pheromones.

Application and Advantages of ACO

The application of ACO are routing in telecommunication network, travelling salesman, graph Colouring, Scheduling, Constraint satisfaction. The advantages of ant colony optimization are inherent parallelism, Positive Feedback accounts for rapid discovery of good solutions, efficient for Traveling Salesman Problem and similar problems, Can be used in dynamic applications (adapts to changes such as new distances, etc)

Proposed New Ant Colony biological model

Proposed nACO Algorithm

This new routing system is based on metaphor of ant food foraging behaviour. Basically the ant colony optimization is a probabilistic technique for reducing to finding best paths though graphs.

This technique is inspired from behaviour of aunts in searching paths for food in colony. They are inspired from the behaviour of aunt for routing in wireless and wired mobile environments. In addition, Stutzle and Hoos proposed MAX-MIN ant system, namely MMAS; it is an improvement version of ACO. MMAS differs from standard ACO in that

1. Only the best ant adds pheromone trails

2. The minimum and maximum values of the pheromone are explicitly limited. Agassounon proposed interesting work based on ACO to solve information retrieval and resource allocation issues.

ACO algorithms can be applied to find the near-optimal multihop routing path in mobile ad hoc networks, namely AntHocNet, the experimental results indicate AntHocNet algorithm outperforms the other popular Ad hoc On-Demand Distance Vector Routing (AODV) algorithm in conditions of delivery and end-to-end delay ratio. Related problems such as load-balance and routing in computer networks are also investigated in the work by Hsiao et. al, by use of ACO[9]. In sum, performance comparisons between ACO-based algorithm and other routing algorithm show better performance by use of ACO metaheuristics.

The most important feature of ACO metaheuristic is inspired from the stigmergy, stigmergy is a mechanism of indirect coordination between agents. The proposed algorithm, called nACO, especially for WSNs, each packet are regarded as an individual ant, communicating with each other via pheromone values stored in each wireless sensor node's pheromone table. There are main three steps are of the proposed nACO algorithms for the routing scheme of WSNs. The steps include
(1) Generate local solutions based on the path selection probability
(2) Pheromone update
(3) Decision making.

This new Ant colony optimization technique is a reliable, nature-inspired called nACO.

Routing Algorithm In WSN

Suppose the ant is randomly placed on node x , the probability of an ant m choosing the next adjacent node y is as depicted in Equation . And the pheromone table helps to choose the next neighbour in the process.

$$Pxy=\frac{[T(x,y)]^{a}\cdot[E(y)]^{b}}{\sum_{u\in Im}[T(x,y)]^{a}\cdot[E(y)]^{b}} \text{ if } y\notin Im$$

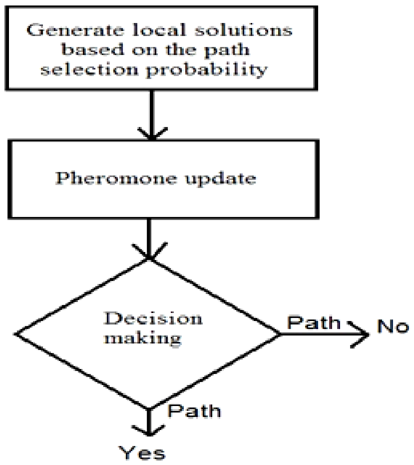

Figure 3 : - Process of nACO

0 otherwise

Pxy = probability of packet going from node x to y,
T(x,y) = pheromone level in the table of node x for node y
E(y) = energy level of node y
Im = identifier of every visited node,
a = parameter that denotes pheromone level,
b = parameter that denotes energy level heuristics.

Description of Data Structures in C++ syntax

In this section, we describe how the pheromone table, ant table and multi-hop counters are described in C++ syntax as below.

1. Pheromone Table
Typedef unordered_map<unsigned short, Double>PheromoneTable;

2. Ant Table for node
Struct AntType //structor of Ant Node Table
{
Double antID;
Unsigned short previousNode;
Unsigned short nextNode;
}
Typedef unordered_map<unsigned short,….>AntNode Table

3. Multi-hop Ant Searching Mode
Typedef unordered_map<unsigned short, Unsigned short>multiHopSearching;

Pheromone Update

Finding a suitable node, pheromone plays an very important role. In this new algorithm, only pheromone along our successfully recorded paths is intensified, instead, pheromone in those incomplete paths evaporates. The pheromone increases and reductions will influence the searching process in next iteration. We adopt the conventional ACO pheromone update rule as: Intensify pheromone: an absolute amount of pheromone $\Delta T^m x.y > 0$ is added to the existing pheromone values on the paths completed by k -th ant

$$\Delta T^m x.y = \frac{S}{Z\min(k)} \; if\ (x,y) \in Wm$$
$$0 \qquad if \notin Wm$$

Where Wm are the paths having been travelled by m-th ant. S is a constant.

Evaporate pheromone

pheromone on the edges of incomplete traversing paths is reduced in order to minimize the chances of being selected by other ants.

$$Tx,y = (1-\varrho)\times Tx,y \qquad \text{u}x,\ y\in[1:52]$$

Where $\varrho \in [0, 1]$ is the pheromone evaporation rate. Tx,y is the current pheromone density on the trail t(x,y).

Mutate pheromone update process

In order to increase the convergence speed of the algorithm, we combine the mutation parameter into our pheromone update rules, where the concept of threshold is also involved. The mutation parameter in our algorithm is partly based on Best-worst Ant Colony Algorithm (BWACA) as well as Max-min Ant system.

Simulation

Min- Hop algorithm is most commonly used for routing label witched Path. Many routing protocol are adopted the nature of this algorithm. So we compare our proposed algorithm from min-hop algorithm is very reasonable. In both algorithms same metrics are to be applied. There are following parameter matrices using in simulation.
1- Power Consumption
2- Latency
3- Throughput

Power Consumption (PC) measured as

$$PC = \frac{(TP/NN) - IPPN}{\text{Number of packets receive}} \quad \ldots\ldots \text{Eqn. 1}$$

PC-Power Consumption
TP- Total Power
NN-Number of Nodes
IPPN- Idle Power per Node

Latency (L) is calculate by the difference between time received and time sent describe in eqn 2

L = TR-TS……………….Eqn. 2
TR=Time received
TS= Time sent

Throughput (TP) is the quantities of packets, it is the ratio between Packet sent by source and packets received by sink node.

TP = PSS/PRS …………..Eqn. 3
PSS - Packets Sent by Source
PRS - Packets received by sink

Figure 4 and Figure 5 shows the comparison view of power consumption and latency exhibited by different node density levels. Figure shows, the number of nodes is small than not make a considerable impact on the power consumption and latency. When the participated nodes increasing till 220, power peak occurs, and new routing algorithm proposed in nACO consume less 1/3 power than min hop algorithm through the similar curve trends is observed.

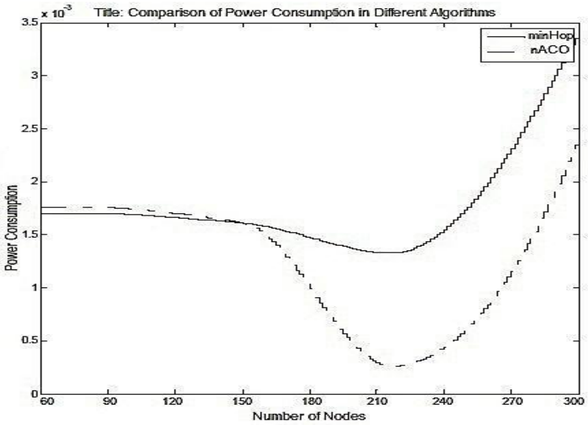

Figure 4 : -Comparison of Power Consumption of Ant Population Levels

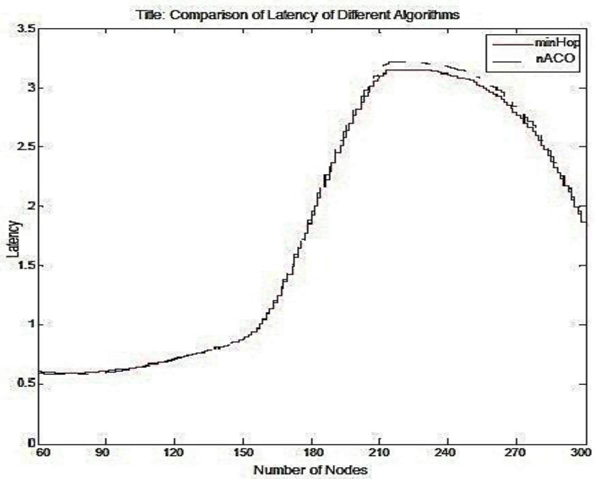

Figure 5 : -Comparison of latency between Two Algorithms

Results are more significant for the large number of nodes. Figure 5 shows, impact of latency for algorithm are trivial, and new ACO algorithm produces the less than latency than the min hop. Nodes are increases till 220, there are very less difference between min hop and new nACO Algorithm. The New nACO algorithm is more effective and more impressive from traditional ACO.

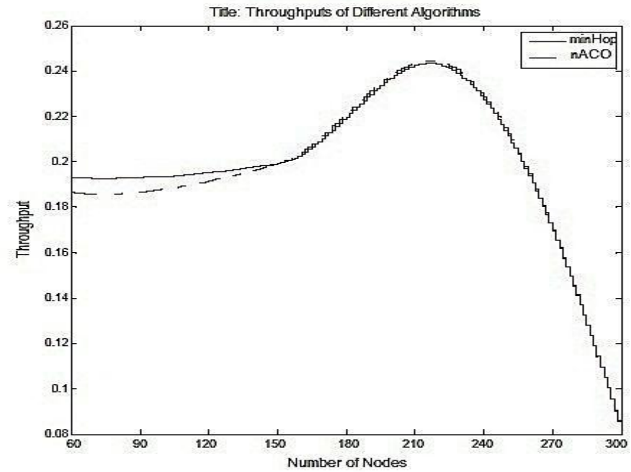

Figure 6 : -Comparison of Throughputs between Two Algorithms

The proposed new nACO shows as a good improvement in Power consumption, latency and throughput.

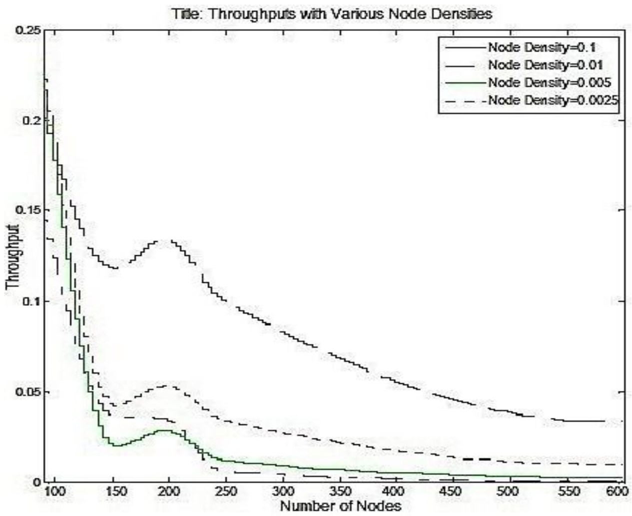

Figure 7 : -Throughputs with Various Node Densities

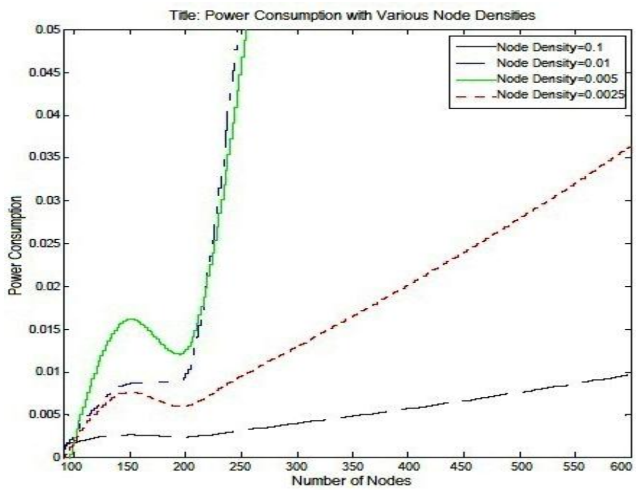

Figure 8 : -Power Consumption with Various Node Densities

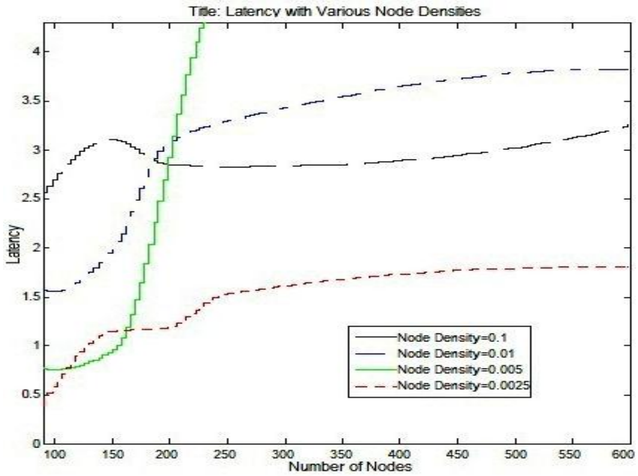

Figure 9 : -Latency with Various Node Densities

Figure 7, 8 and 9 shows the impacts of various node densities towards power consumption, latency and throughput. Shows in figure, there is revealed effect on the efficiency of different node densities, it is not a linear connection. The minimum power consumption is remarked for few optimal node densities.

Equally, the density is 0.005, it comes to the latency in Figure 9 and throughput in figure 7, when the min latency occurs, but when the density is 0.1, maximum latency occurs. Same case is also for throughput.

When the network has 100 nodes, the min power consumption, max throughput, and min latency appears to start occurrence.

The current good results are well conformity with the required network size less than 200.

Conclusion and Future Works

In this paper, we propose a new algorithm model, nACO, which is very effective for communication from source node to destination node. The results are more impressive for the power consumption, latency and throughput point of view. A reliable, nature-inspired routing algorithm called nACO. for sensor networks is presented. The algorithm is partly based on the efficient Max-Min algorithm and it is suitable for flexible structure of wireless sensor networks. This new routing scheme performs generally not worse than other standard routing algorithm, and in some occasions, it outperforms than min-hop algorithm.

For future work we performed more comparisons work with others wireless sensor network routing algorithms, and validate the best parameters for proposed algorithm under different environment for networking industries.

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