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SELF-DEPLOYMENT IN WIRELESS SENSOR NETWORKS USING ANT COLONY OPTIMIZATION METHOD

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ABSTRACT

Viable organization of the sensor nodes in Wireless sensor system is the most important purpose of worry as the performance and lifetime of any system relies on upon it. With the propelled research, the sensor nodes could automatically deploy all alone (Self-organization) using some of the existing techniques. Greedy Perimeter Stateless Routing (GPSR) is one of the location based routing technique which helps the small, cheap and resource constrained nodes to render the routing function without the need of complex calculations and gigantic amount of memory space during the procedure of self-deployment and thereby creating amazing transmission of the required data. In any case, now and again it neglects to discover a route from the source to a destination or in other words discover a route that is longer than the shortest path. In this paper, we propose a self- deployment plan utilizing the Ant Colony Optimization (ACO) that assurance data conveyance and discover a route very close to the ideal route regardless of the possibility that the system contains nodes with different transmission ranges and enhance the lifetime of sensor nodes. The execution of the proposed strategy is assessed utilizing delay, throughput, energy and delivery ratio of the information packets. The self-deployment scheme utilizing ACO demonstrates an improvement in energy and throughput by 3.74% and 4.45% respectively than the GPSR method.

Keywords: wireless sensor network, sensor nodes, self-deployment, greedy perimeter stateless routing, ant colony optimization.

1. INTRODUCTION

Wireless sensor networks (WSN) has turned into the most critical method for providing solutions for different entangled applications. Sensor nodes in WSN's are battery controlled devices with constrained communication, handling, detecting and capacity limit. To guarantee a safe and powerful transmission of information in a system these sensor hubs nodes to organized in the best way possible. Some of the time the position of the sensor nodes are not pre-figured out which permits random deployment in the out of reach areas. Along these lines the sensor networks protocols or algorithms must have self-organizing capacity [1].

Random deployment is a non-uniform arrangement where the uniformity is accomplished by making a few or all nodes mobile. Self-deployment is a uniform procedure of moving the randomly deployed nodes to stable locations all alone to accomplish great coverage and to extend the system life time [2, 3].

One of the cases for the deployment of the sensor nodes by considering the Localization is by utilizing GPS enabled sensors. Greedy Perimeter Stateless Routing (GPSR) also takes a shot at a similar principle. The Rectangular co-ordinates of the positions of the sensor nodes after the deployment can be calculated. These insights will be useful for the calculation of the routing function and aides in deciding the shortest Route feasible for the transmission of information [4].

There are a few shots for the Greedy calculation to fail at a particular node and along these lines the information keeps on pushing ahead in the system by provoking the Perimeter mode [5]. At the point when this occurs there are chances of finding a route that is longer than the shortest path. We need to eliminate this to diminish energy consumption. To target the above mentioned issue we propose the new approach of Ant Colony Optimization (ACO).

The explanation behind the noteworthy performance of the proposed ACO algorithm than the current GPSR calculation is as follows:

- ACO modifies the control packets compared to GPSR

The control packet overhead in ACO is much lower than GPSR. GPSR indicates steady control packet overhead withstanding the topology changes. Then again ACO's control packet changes as topology changes, which implies that ACO adjusts to the network topology and produces just required control packets [6].

- ACO uses Dynamic Network Topology

The key idea of ACO is to utilize the estimated unwavering quality of sensor information for topology estimation [7]. This property enhances the exactness of the subsequent topology. ACO is Robust and versatile to dynamic changes in the environment and different sorts of issues has been solved by utilizing ACO. In this way ACO is ideal for our work on the grounds that the topology of our network may powerfully change because of failure or addition of sensors.

- ACO considers Major parameters in the region of the network

ACO considers the significant system parameters and improves them to give most extreme network lifetime.

- ACO makes the most shortest path effortlessly and applies to each one of the nodes

Ant Colony Optimization (ACO) conversely with GPSR finds a route near the optimum route regardless of the possibility that the network contains nodes with

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various transmission ranges and enhances the lifetime of sensor nodes.

2. LITERATURE SURVEY

In [8] the sensor network deployment techniques were fundamentally arranged into two-on the basis of Region of interest and numerical approach. These are additionally grouped into deterministic, random and self-deployment; Genetic algorithms (GAs), Computational Geometry, Artificial Potential Field (APF) and Particle swarm optimization (PSO).

The authors in [9] have introduced a self-deployment calculation for mobile sensor networks to be used as a part of complicated indoor environments with obstacles represented to as certainty grids. Every node is repulsed to move with virtual drive conviction esteem to the certainty value and the network spreads out to take the deployment action. In spite of the fact that the network picks up a relatively good coverage, the coverage rate is low and node oscillation is additionally anticipated to be tackled. The authors in [10], proposed an anti-partition self deployment algorithm by planning the virtual repulsive force between nodes, the movement equation and the virtual attracting-field in the detecting region. This algorithm actualizes node self-deployment, as well as wipes out the scope for coverage holes and network partition which disturb traditional algorithm in meager network [26-29].

Another adaptable, adaptive heuristic system has been proposed in [11] which move the sensor nodes to enhance the target coverage in light of the nearby data. The outcome investigation was done in comparison with an optimization model that gives the optimal solution in terms of coverage, a genetic based approach that works in a centralized way and virtual forces based technique. The outcomes were sufficiently reasonable within the sight of obstructions too. In this paper [12], a localized self-deployment plot- Obstacle Avoidance Target Involved Deployment Algorithm (OATIDA) was proposed in view of the idea of potential field theory and relative neighborhood graph (RNG) to cover predefined targets at the same time keeping up association with the base station. In [13], they had the notion of trending innovation GPS introduced. A strategy has been acquainted which aims to investigate localization utilizing GPS equipped anchor nodes that are dropped and arbitrarily scattered inside the deployment region. After initial arrangement, the anchor nodes communicate its position utilizing signal bundles which will be again utilized by other nodes to restrict themselves. Along these lines the confinement happens. Improvement need to done in picking the anchor's position in view of the geometry [27].

While considering the Heuristic algorithms we have a portion of the accompanying methodologies which have as of now managed the idea of self- deployment [26]. The authors [14], needed to address two issues: the outline of an ideal position of heterogeneous sensor nodes and the self-arrangement of those nodes from arbitrary state to the ideal state through smart sensor development. Subsequently, ideal arrangement algorithm was first created taken after by the Swarm insight (SI) based sensor development methodology to achieve the ideal situation state has been proposed. The creators of [15] proposed a dynamic deployment algorithms using harmony search and examined its execution with some variations.

As we are planning to give insights about the superiority of the ACO over GPSR let us give some knowledge about GPSR as a localization protocol.

2.1 Self-deployment using Greedy Perimeter Stateless Routing (GPSR) localization algorithm

One of the important necessities for the sensor deployment is localization. It is a procedure to process locations of wireless gadgets in a network. The essential goal of localization is to decide the location of the target in a network made out of expansive number of inexpensive nodes thickly deployed in the region of interests to gauge certain phenomenon [16].

In this segment an overview of the well-known GPSR routing protocol that has a place with the classification of geographic protocols [4] is given. We have utilized this algorithm for localization in our work to discover the area of the sensor nodes which will be useful for the routing to happen efficaciously.

GPSR protocol provides all nodes with their neighbor's positions: occasionally, every node transmits a signal to the communicate MAC address, containing just its own particular identifier (e.g., IP address) and geological position [17].

This algorithm has two techniques for transferring packets forward - Greedy forwarding and Perimeter forwarding [4].

A. Greedy forwarding strategy

Greedy algorithm endeavors to pick node closest to the destination node from its neighbors as the following hop. If the separation to the goal from the neighbors of a node is shorter than the separation from the node itself then the packet advances to that neighbor. Along these lines the packets get forwarded to achieve the last destination. Something else, when the node finds that its own particular separation to the destination is the shortest path compared with the other separations between all its neighbors and the destination node, the node runs into a Local Minimum Problem or void issue in Greedy forwarding stage. At this point GPSR goes into second mode: Perimeter Mode.

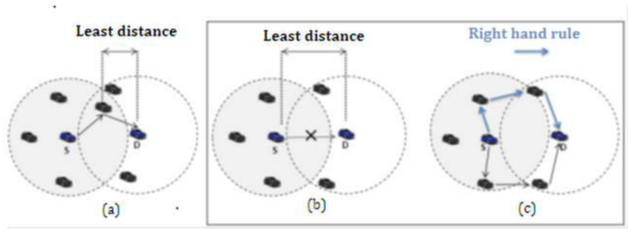

Figure-1. A typical illustration for forwarding packets. a. Greedy forward. b. Greedy failure c. Perimeter forward.

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B. Perimeter stateless strategy

This strategy depends on the right hand thumb rule. This rule is to traverse the graph. It expresses that if a packet arrive at x from y, the following edge navigated is the following one successively counter clock wise about x from edge (x, y).

For example, consider the Figure-2 [18], the forwarding path according to the right hand rule is x->u->m->n->d.

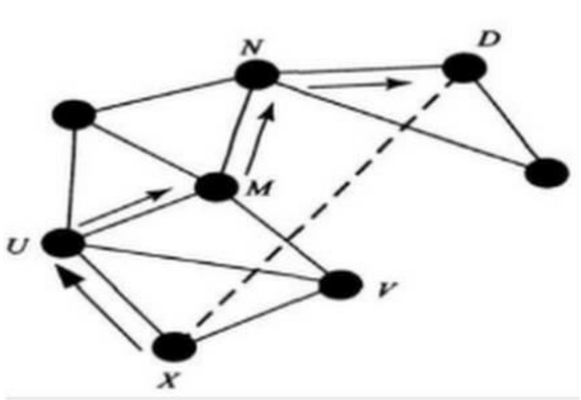

Figure-2. Perimeter forwarding instance.

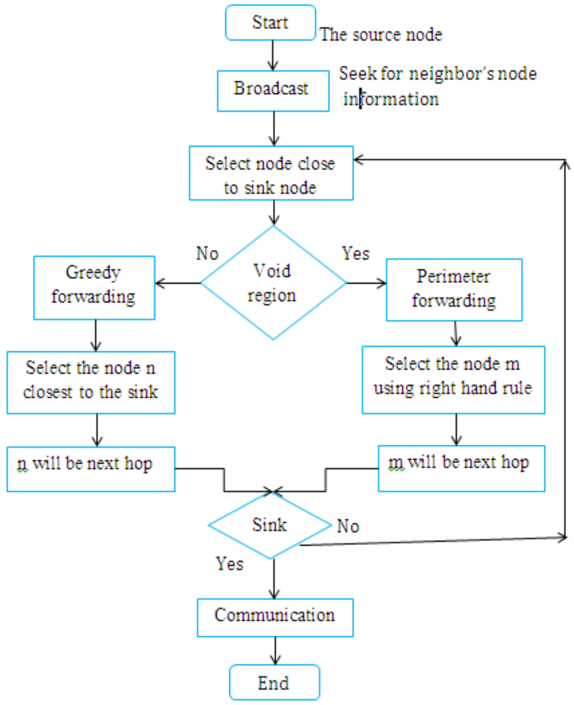

Figure-3. GPSR flowchart.

C. Steps involved in localization

The distance / angle estimation stage includes measurement systems to appraise the position related parameters between the nodes. Along these lines, the paper likewise calculated both distance and angle between every one of the nodes utilizing GPSR with the accompanying mathematical calculations.

Given the two points (x1, y1) and (x2, y2), the separation d between these points is given in Eq1, [19]

$$d = \sqrt{(x2 - x1)^2 + (y2 - y1)^2} \quad (1)$$

The Position calculation comprises of algorithms to calculate the coordinates of the obscure node with respect to known anchor nodes or neighboring nodes. The localization algorithm all in all determines how the data concerning distances and positions are controlled so as to permit most or every one of the hubs of a WSN to estimate their position.

D. Drawbacks of GPSR algorithm

As per the [20], it was found that GPSR has low computational complexity. High energy efficiency with void flooding, Path length equivalent to most brief Euclidean separation and has no loop routing. Regardless of the previously mentioned points of interest the calculation has a few disadvantages as taking after.

- Perimeter forwarding path is always long, and most cases it is not the best guiding choice as it is not able to discover optimal path.
- It is a not a self-learning algorithm.
- Each time you send packets, the face routing algorithm ought to be executed unavoidably
- Single path will make the node energy being likely going to be exhausted.

The results are processed and graphs have been generated for Delay, Throughput, Delivery Ratio and Energy in correlation with the proposed strategy. In this manner to conquer these inconveniences a superior technique is been proposed in next segment.

3. PROPOSED ACO ALGORITHM FOR SELF-DEPLOYMENT PROBLEM

Ant colony optimization (ACO) is populace-based metaheuristic algorithms that can be used to find discover surmised answers for troublesome optimization issues The crucial thought of ACO [21] is taken from the conduct of ants. At in the first place, each ant crosses the area in self-assertive way while examining for nourishment leaving a synthetic substance in its way. This chemical is called pheromone which is the preface of neighborhood information at each node. The amount of

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pheromone deposited depends upon the amount of ants on that path and length of that path. The shorter path will get higher measure of pheromone. The most recent ants will take a path which has higher pheromone obsession and will also brace the path they have taken. It is a masses based scan technique used for handling various combinatorial issues.

This behavior can be used for networking. A network can be viewed as directed graph imitating the path taken by ants. Ant packets can be utilized as a part of place of ants. The synthetic substance "pheromone" can be supplanted by the likelihood at every node. The pheromone trails in ACO be useful as dispersed, numerical information which the ants use to probabilistically create answers for the issue being comprehended and which the ants adjust in the midst of the algorithm's execution to mirror their pursuit encounter [22].The pheromone is an volatile substance so it ought to be altered or refreshed at entry of every ant packet.

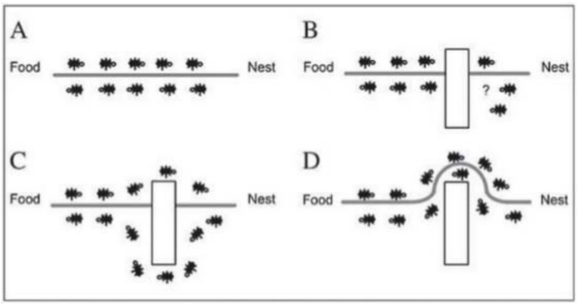

Figure-4. A. Ants in pheromone trail between nest and food; B. obstacle interruption; C. Ants finds two paths; D. a new pheromone trail is found along the shortest path.

A. Network model

Remembering the ultimate objective of making our algorithm more global, our network model assumes that the sensor nodes are discretionarily circulated in a rectangular locale. Meanwhile, we make taking after presumptions for sensor center points: (1) the fundamental energy of all hubs is the same. (2) Each node can get the information of its neighbor nodes. (3) The amount of nodes in the framework is huge.

- In past work utilizing GPSR algorithm, the procedure of self organization happens once for one simulation period yet in proposed work alongside algorithm usage a Protocol is suggested keeps running at times of equivalent time. In every period, the nodes push toward new destinations so as to expand the coverage and the connectivity bit by bit [23, 24, 25].

B. Working of ACO

This fragment outlines well-ordered technique for working principle behind fundamental ACO.

Each node represents a point or vertex in the graphical problem.

Line joining two nodes or vertices is known as edges.

Step 1: Random Deployment

At first the source will communicate ant packets over the framework. Each of the paths is haphazardly distributed with pheromone concentration at first.

Step 2: Generation of the solution set.

As examined before countless number of ants begins haphazardly from random nodes and they stroll through random path along these lines building up each of their own set of solutions. Each of their own solutions is produced in view of the constraints given.

Step 3: Node selection

The choice of the following node from the current node is based on a given probability function. The choice additionally depends on the pheromone associated with edge in the network. Each move of the ant can be considered as a part of Markov chain on the grounds that the probability of move depends just on the current value and not on the previous value.

Step 4: Estimation of the probability for the node selection.

The probability of choosing next node 'j' from current node 'i' is given by Eq. (2) [19]

$$P_{ij} = \frac{[\tau_{ij}]^{\alpha} * [\eta_{ij}]^{\beta}}{\sum_{k \in N_i} [\{\tau_{ik}\}^{\alpha} * \{\eta_{ik}\}^{\beta}]} \tag{2}$$

Here, α and β are control parameters

τ_{ij} Represents the pheromone concentration with the edges

η_{ij} Represents the heuristic information (Obtained based on experience).It is equal to $1/dij$ where dijis the distance between two nodes

N_i Represents the set of Nodes

P_{ij} Represents the probability of node j to be selected by ant coming fromnodei

Analysis

Based on the values of the parameters the probability function can analyzed as below:

- If α=0, the probability is purely based on heuristics. Nodes close to each other are chosen. Behaves same like greedy algorithm.
- If β=0, probability is based on pheromone concentration. Sometimes can lead to localized search space.

Step 5: Pheromone update

Once all the ants travels through each node, each ant packet received by any node updates the pheromone (local information), as in Eq. (3) [19], on the basis on residual energy.

$$\tau_{ij}(t+1) = (1-\rho).\tau_{ij}(t) + \sum_{k=1}^{m} \Delta\tau_{ij}{}^{k} \forall (i,j) \tag{3}$$

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Where, ρ is pheromone evaporation rate to avoid accumulation of pheromones

$$\Delta\tau_{ij}{}^{k}(t) = \begin{cases} \frac{1}{L_k} \\ 0 \end{cases} \quad (4)$$

$\Delta\tau_{ij}{}^{k}(t)$ represents the amount of pheromones that need to be added or subtracted to the path travelled by the ant k and it is calculated as Equation (4) [19] and hereL_k is the total length of the ant's k tour.

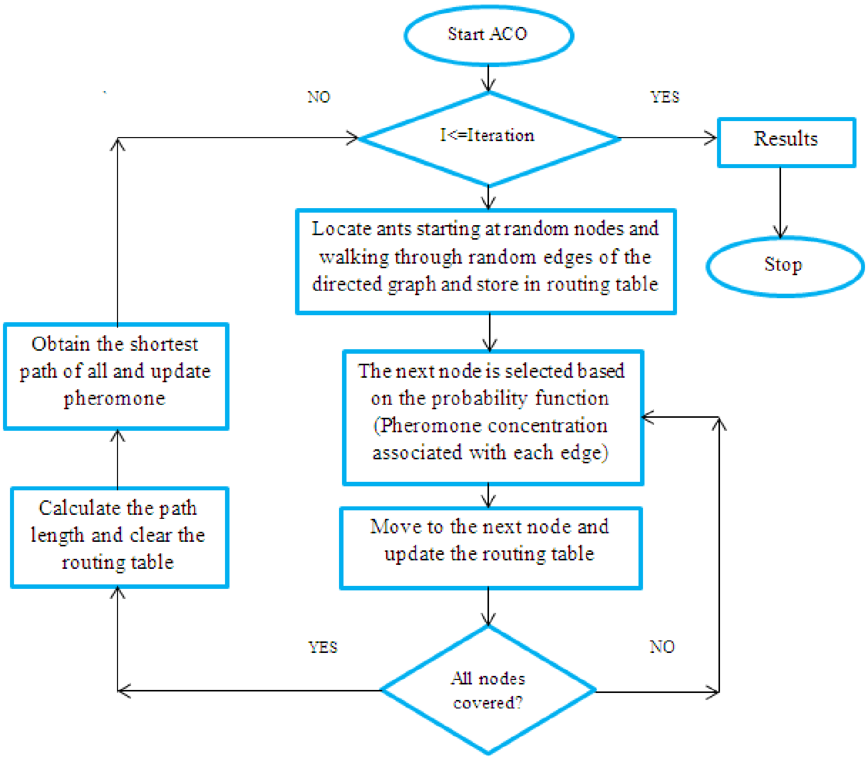

Figure-5. Flow Chart of ACO algorithm.

C. Observations

a) If the total length of the path travelled by ant k is very much lesser compared to the path travelled by all other ants then $\Delta\tau_{ij}{}^{k}(t)$ for the ant k is going to be very much higher compared to all other ants? This high value $\Delta\tau_{ij}{}^{k}(t)$ is added with the path travelled by the ant k as in Eq. (3). This result in a high amount of pheromones in the path travelled by the ant k compared to all other ants.

b) In this manner the algorithm proceeds. With each iteration a suitable value of $\Delta\tau_{ij}{}^{k}(t)$ is added to the paths travelled by each of the ants.

c) In due course of time a path with high concentration of pheromones is considered to be the optimal path for the given self deployment problem.

4. RESULTS AND DISCUSSIONS

In this section we assess the performance of each algorithm based on the following metrics, namely, Energy consumption of the network, Delay in the network, Packet Delivery ratio and Throughput of the network. Both the current and proposed algorithm are experimented utilizing NS2 (Network Simulator) on Intel Core i5 processor with 2.40GHz CPU and 4GB RAM. It is accordingly conceivable to demonstrate the relative outputs of each of the considered parameters. These graphs (Figures 6, 7, 8, 9) demonstrate a comparison between the three algorithms. The first algorithm is only a normal routing of the nodes with AODV (Ad Hoc On-Demand Distance Vector) without utilizing the GPSR protocol. Second algorithm which is highlighted in Red is using the GPSR scheme. In conclusion, the proposed ACO algorithm is represented to with Green chart.

Energy efficiency is a major concern in wireless sensor networks as the sensor nodes are battery-operated devices. Because of these energy constraints, the life time of a WSN is likewise restricted. In this manner, it is very important to limit the energy consumption in each node and prolong the life time of the network. As appeared in Figure-6, it is evident that the scheme planned using ACO exhibits best results demonstrating less energy consumption of sensor nodes in the WSN. Among GPSR and Algorithm without GPSR, the energy of the nodes in GPSR is decreased by 27.24% as compared to the one without GPSR. However, the proposed ACO algorithm improves the energy consumption of the nodes by 3.74%

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and 29.97% than GPSR and without GPSR methods respectively.

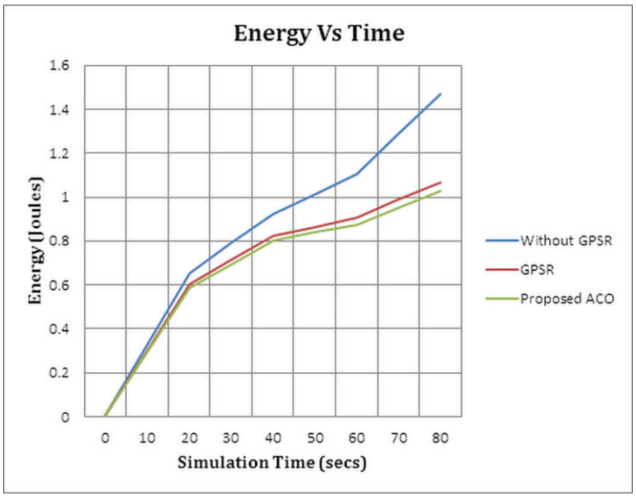

Figure-6. Energy consumption for various algorithms.

End-to-end delay refers to the time taken for a packet to be transmitted over a network from source to destination. The estimation for the delay is done by using the following equation

Average end to end delay

$$= \frac{\{\text{time(last packet received)} - \text{time(packet sent)}\}}{\text{total packets received}}$$

Which implies that the for a decent network the time difference between the packet received and the packet sent should be as low as would be prudent. In this manner same as the energy consumption, Figure-6 delay also should be very low for a network to effective. It is unmistakably appeared in Figure-7 that proposed algorithm exhibits best results demonstrating less delay in the network. Among GPSR and Algorithm without GPSR, the delay in the network using GPSR is reduced by 29.59% when contrasted with the one without GPSR. In any case, the proposed ACO algorithm improves the network delay by 3.67% and 32.17% than GPSR and without GPSR methods, respectively.

The ratio of packets that are effectively delivered to a destination contrasted with the quantity of packets that have been sent out by the sender is defined as Packet Delivery Ratio.

$$\text{Packet delivery ratio} = \frac{\text{received packets}}{\text{generated packets}} *$$
100(Expressed as percentage)

The greater the proportion, more are the number of packets received when contrast with packets generated, more packets received more is the data sent to destination which is the essential of any system. It is consummately delineated in Figure 8 that proposed algorithm displays best outcomes indicating better Delivery Ratio for the network. Among GPSR and Algorithm without GPSR, the delivery ratio of the network using GPSR is expanded by 3.61% as compared to the one without GPSR. However, the proposed ACO algorithm enhances the network's packet delivery ratio by 3.49% and 7.23% than GPSR and without GPSR methods, respectively.

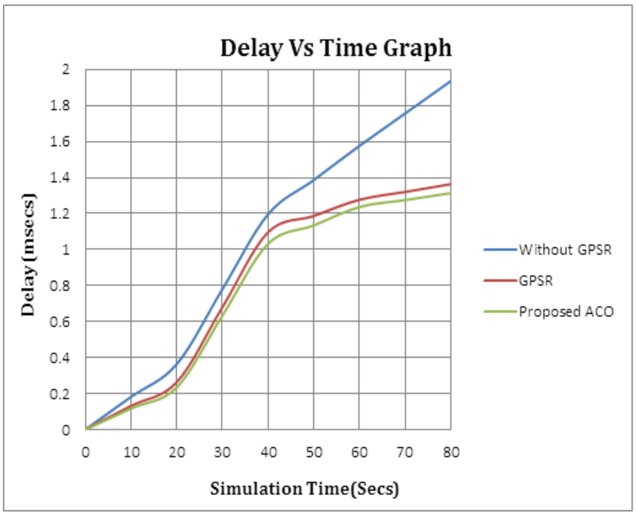

Figure-7. End to end delay for various algorithms.

Figure-8. Packet delivery ratio for various algorithms.

For calculating Throughput, we need to store the quantity of bytes received by the sink. We use the bytes attribute to access the bytes received. The number of bytes received is multiplied by 8, divided by sample time, and then divided by 1000000 which achieves MBits/s.

$$\text{Throughput} = \frac{\{\text{bytes received} * 8\}}{\text{time} * 1000000}$$

It is evident from the Figure-9 that proposed algorithm exhibits best results demonstrating better Throughput for the system. Among GPSR and Algorithm without GPSR, the throughput of the network using GPSR is increased by 14.56% as compared to the one without GPSR. Be that as it may, the proposed ACO algorithm enhances the network's throughput by 4.45% and 19.66% than GPSR and without GPSR methods, respectively.

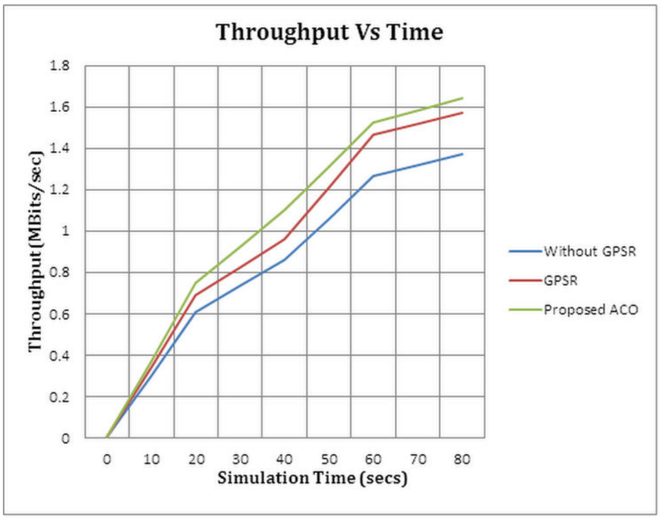

Figure-9. Throughput for various algorithms.

CONCLUSIONS

In this paper we concentrated the target coverage of a randomly deployed mobile sensor network. The algorithms such as GPSR and ACO have been analyzed and implemented for the self-deployment issue in wireless sensor networks. Among the three schemes considered proposed algorithm had minimum energy and delay, highest delivery ratio and throughput. With ACO implementation the network becomes dynamic considering all the significant parameters reasonable to get to an optimal path among all the shortest paths. Along these lines the most recent work of the Ant Colony Optimization (ACO) has addressed the self-deployment effectively and with this the convergence is guaranteed, but time to convergence is questionable. In addition to this paper the presence of obstacles between the sensor nodes need to be considered. Henceforth as a piece of our future work, we will address the certainty of the time convergence of the algorithm and the impact of the obstacles/hindrances on the performance of the Wireless Sensor Network.

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