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A QoS Aware Three Way Point Rule based Fusion of Earth Worm and Deer Hunt Optimization Routing in Wireless Sensor Network

V. Bibin Christopher[1] · **R. Isaac Sajan**[2] · **T. S. Akhila**[3] · **M. Joselin Kavitha**[4]

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Abstract

Wireless Sensor Networks (WSN) have become one of the most demanding factors. The major problem in network-related QoS is obtaining a route that fulfils numerous constraints such as latency, throughput maximization, packet delivery ratio (PDR), network lifetime, connection quality, and minimum energy consumption. However, the route selection and QoS requirements need to be addressed in the WSN. To incorporate these issues, we proposed a Three Way Point Rule based Fusion of Earth worm and Deer Hunt optimization Routing (TREDHO) to provide quality communication in WSN. The model consists of setup stage and the communication stage. The setup stage contains network structure and node movement; the network structure is divided into small triangles. In the node movement phase, the route connection is based on movement and random factors. The communication phase consists of route discovery, the fusion of Earth worm and Deer Hunt optimization (EW-DHO) are used for optimal route selection by considering three way point rules. The packet is transmitted from the source node to the target depending on the estimated path. The effectiveness of TREDHO is estimated by comparing its performance with the state-of-the art method in terms of throughput, PDR, delay, energy consumption, and network lifetime.

Keywords Random way point · Dynamic routing · Node · Sink · Random factors · Movement factors

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✉ V. Bibin Christopher
bibinchristopher.v@yahoo.com

[1] Department of Computing Technologies, SRM Institute of Science and Technology, Chengalpattu, India

[2] Department of Computer Science and Engineering, Ponjesly College of Engineering, Nagercoil, India

[3] Electronics and Communication Engineering, Mar Ephraem College of Engineering and Technology, Elavuvilai, India

[4] Electronics and Communication Engineering, Marthandam College of Engineering and Technology, Kuttakuzhi, India

1 Introduction

With the rapid expansion of recent technology, wireless communication systems have made it possible to perform different applications related to the advent of WSN. Generally, WSN is a collection of cooperating and geographically distributed sensor nodes communicating with each other in relation to the availability of small size, low-cost and intelligent wireless devices [1, 2]. Recently, the WSN has attracted more attention in providing various applications such as disaster monitoring, health monitoring, industrial field, civilian and military security-based applications [3]. A systematical study of WSN protocols is very significant to evaluate the protocol performance based on several key parameters such as mobility model, route selection, and communicating pattern among others. However, the impact performance of routing protocol is necessary to enhance the Quality of Service (QoS) among the protocols for network parameters such as energy consumption, throughput, and packet delivery rate in WSN [4, 5].

Mobility support is an essential need for a large number of application in WSN. In this, the mobility of nodes attempts to change the speed and direction with the demand for high energy and high-speed localization services based on movements [13, 14]. At this point, there exist three types of mobility movement like controlled, pre-defined and random movement for a moving entity (sink/sensor node). In a controlled movement, the node movement is controlled by an external node for real-time scenarios. Then in pre-defined movement, the node moves in a specific path area with the reaching target point, speed and time. Lastly, the random movement describes that the node moves in a random area within the considered network level [15].

In the previous studies, researches mainly focused on routing with the support of different network topologies such as heterogeneous, homogeneous, random, mesh, multi-hop, and dynamic to improve the QoS communication from node to sink [6]. Based on different network topologies and distributed environment, the routing and forwarding decisions are easily managed by the self-collected nodes. This can be able to prolong the overall network longevity [7, 8]. From this point of view, several papers have appeared for analyzing various routing protocols such as mobility, trust, and multi-hop for data collection mechanisms [9]. In this, the Trust management system integrated with Dynamic Source Routing (TDSR) protocol involves two data packet headers such as RREQ (Route Request) and RREP (Route Reply) message to interrupt the network by discarding packets to the end of the process. But this protocol consumes high energy consumption [17]. Then in a centralized scheme, the relocating nodes used a clustering process to achieve coverage density based on node mobility. Thus the quality of communication is not sufficient to determine the route under consideration of other QoS parameters [18, 19]. Among these facts, the routing problem arises in energy consumption balancing and QoS requirements.

QoS aware routing in WSN has some issues like reduced life time of nodes, traffic intensity, and minimum energy consumption. Lack of resources, like energy and bandwidth, may cause nodes to cooperate less, which could result in worse QoS. Also, selecting a route between the nodes does not require a broadcasting control, this will cause network flooding due to the high energy consumption and huge overhead. So, establishing a routing path for energy balancing and increasing the network lifetime is a key challenge in the communication paradigm. However, the route selection and QoS requirements need to be addressed in the WSN. Hence, an efficient dynamic routing protocol with mobility support is required to improve the QoS in terms of throughput, latency, and PDR for WSN.

1.1 Contributions

The contributions of the proposed TREDHO are as follows,

- The route selection is designed by using random waypoint connection rules, which helps to increase the whole network life time and enhance the quality of communication.
- The mobility model is used for route connection based on two factors (random and movement factors), which improves the connectivity and reduce the congestion.
- A fusion of EWO-DHO is introduced to improve the searching process and better balance the exploitation and exploration ability.
- The EWO-DHO reduces energy usage by selecting the most efficient transmitting path.
- The network-related parameters such as PDR, throughput, delay, and energy consumption, regarding QoS are analyzed and compared with existing methods.

The paper is organized as follows: Sect. 2 deliberate the literature review about QoS based routing protocols for WSN. Section 3 describes the proposed scheme, the performance metrics is described in Sect. 4. Section 5 gives an assessment of proposed and existing, finally, the Sect. 6 is concluded.

2 Related Works

The main purpose of routing protocols is to decrease energy consumption by determining the most efficient path between source and destination. As a result, this has become a challenge to the researchers to develop an energy efficient routing protocol with better QoS parameters. Some of the related works associated with QoS based routing protocols for WSN are discussed in this section.

2.1 Energy Aware Routing

Dhanalaxmi et al. [20] introduced a node's trust values and fuzzy rules for energy aware routing protocol. This protocol perform based on trust estimation for each node in the network, ideal routing of packet, and balancing the energy for model by effective routing mechanism. This method performs secure routing without link failure, but it takes time for sending the packets. Hajiee et al. [21] offered an opportunity and routing algorithm based on trust. It contain two phases. Based on tolerance constant, the secure node is chosen in the first part and in the second part, opportunistic node is chosen from secure nodes to execute routing. This method increases the malicious nodes identification, which improves the performance of routing. This is not effective for routing with more sink. Loganathan et al. [22] offered an energy aware method based on re-scheduling and aggregation of data. The sensor nodes distributed in the sensing area are segmented into clusters. An aggregator node is existed in each cluster for the fusion of data. The data are send to sink through neighbor nodes, which are arranged in the similar communication range. This method decreases the energy consumption by selecting aggregator nodes, which increases the network lifetime. However, the QoS is not improved. Han et al. [23] introduced trust based and energy aware protocol by utilizing genetic algorithm for reducing energy consumption in the WSN. This method enhance the speed of finding attackers and choose efficient energy routes, but the complexity is high. Haque and Baroudi [24], introduced a Dynamic Energy Efficient Routing (DEER) protocol which is a type of reactive protocol to exchange the RREQ and RREP messages with QoS oriented routing in multihop WSN. The network considers specific nodes that have high residual energy to relay the data from source to destination and multiple constraints of delay, throughput and energy consumption. DEER approach consists of two phases: In the route determination phase, the individual nodes with remaining energy are selected as the best route to transmit the data. In a particular session time, the established links used new nodes to transmit the data and remove the failed nodes, when any adjacent relay node fails in the relaxation phase. However, the packet drop occurs because of long-distance transmission.

2.2 Multi-hop Routing

Rezaeipanah et al. [25] offered a multi-hop routing algorithm based on clusters. The K-means algorithm and open source development algorithm are used for clustering, and genetic algorithm are used for multi hop routing. This method increases the network lifetime. Shahbaz et al. [26] present fuzzy logic and the firefly algorithm for multipath routing in WSN. It contain three stages. Initially, the firefly algorithm is utilized to cluster the WSN in the first stage, and the routing is done between CH by using fuzzy logic in the second stage. Finally in the third part, the paths are retained, when a path is ruptured, the path finding route is restarted. This method enhances the life time of the network and end to end delay, but it has a high packet loss rate and energy consumption. Adnan et al. [27] introduced a clustering protocol based on fuzzy logic and multiple path transmission. Initially, consumption of energy is reduced by applying multi-hop communication. Then the cluster size nearer to BS is reduced to solve the energy hole problem by using a dissimilar clustering algorithm. Finally, the distribution of data between the CHs. This method consumes more time for routing. Alghamdi [28], presented an optimized route selection algorithm for effective communication between the two end-users in multihop WSN. This approach considers different parameters such as traffic intensity, distance, energy, bandwidth, and rank along with equal weights to improve the QoS. The extensive use of this approach is that the next optimal route is determined when the bit rate is varied during data transmission. Even though the initial route fails because of link failure. Hence, the approach ensures a QoS rout based on the considered parameters and achieves a high PDR. Jaiswal and Anand [29], mentioned an efficient routing protocol (ERP) to develop the QoS and network performance in WSN. This protocol determines the optimal path using three Optimality Factors (OF) such as traffic intensity of a hop node, reliability, and lifetime. Initially, the path finding procedure begins with the Path Exploration Request packet (PEReq) from the source node and is broadcast to the destination node only if the Path Exploration Reply packet (PEReq) acknowledgement is received. Also, the protocol adopts a data-centric routing technique to reduce the communication cost and updates the route based on OF in the routing table among multiple paths for IoT applications.

2.3 QOS Aware Routing

Mohana devi et al. [30] presented a QoS aware routing protocol based on combined cuckoo search and particle swarm optimization. These algorithms are used to cluster the sensor nodes in WSN, and they determines the optimal routes to the sink node by selecting the best CH based on distance from surrounding nodes and residual energy. It allows the source node to send data over numerous pathways at the same time, which reduces the time of data transmission. As a result, it considerably conserves sensor residual energy and minimizes network traffic. It doesn't enhance the lifetime of the network. Kalidoss et al. [31] introduced QoS aware trust and energy efficient secured protocol for routing in WSNs. This method determines the genuineness of nodes by an authentication method, which enhances the performance of routing. Shi et al. [32], designed a QoS aware Throughput Delay and Packet Loss (TDL) based routing protocol that schedules each node under Low Power Listening (LPL) modes independently in the WSN. This protocol computes a feasible path through a cross-layer approach to improve QoS performance and an optimized detection mechanism to identify the malicious attack. Also, a congestion degree measurement has been introduced to measure the node and link-level congestion based on queue length and sleep mode for each adjacent node. Furthermore, the decisions are determined by switching and parent node selection. Hence, the approach detects the attack accurately in the real-time practicable solution. Salari-Moghaddam et al. [33], presented a trust-based management system using the Enhanced Dynamic Source Routing protocol (EDSR) that provides a reliable path for each node by using neighbours trust to improve QoS in WSN. In this scheme, each node transmits an RREQ packet with a high trust value to reduce the energy when discovering the shortest path based on the number of hops. Here, only a trusted node will be preferred to access the destination. Using this approach, the untrusted nodes are avoided in the management system. However, no mechanism is predicted to reduce with the quality of communication among the trusted nodes. Shyamala et al. [34], introduced a cross-layered framework (CRF) that incorporates various methods for each layered OSI protocol stack in Mobile WSN (MWSN). The framework involves the application layer, network layer, MAC layer and session layer. In the layered protocol stack, the network parameters of delay and congestion are adjusted by network adaptive compress scaling to improve the packet generation rate in the application layer. The round trip time of Laplacian scaling is measured to control the outgoing packet generation rate at the session layer. Then adaptable redundant routing is conducted in the network layer, and lastly, cooperative forwarding is employed to adjust the communication for link failure nodes in the MAC layer. These cross-layer solutions maintain QoS with respect to PDR and ensure a fault tolerance for data transmission. Kumar and Thirukrishna [35], presented an Optimized Radio Energy Algorithm (OREA) that gives efficient data transmission between the node and sink with low transmission cost and high network life in homogenous WSN. This approach uses a transmission and reception energy model to initiate the components such as power amplifiers and radio electronics. Further, the clustering algorithm manages the node coordination through the Cluster Head (CH) and avoids connectivity degradation for each message. The evaluation of the approach considers two QoS metrics, such as PDR and traffic load, when compared with random and heterogeneous algorithms simulated on the MATLAB platform. However, route selection is not focused on data transmission.

From the above survey of numerous methods, it is clear that the WSN suffers degradation in its performance because of the different issues such as network-related QoS parameters (latency, throughput, PDR, connection quality, energy consumption, and network lifetime). The routing protocols are intended for static node/sink only. Also, selecting a route between the nodes does not require a broadcasting control, this will cause network flooding due to the high energy consumption and huge overhead. So, establishing a routing path for energy balancing and increasing the network lifetime is a key challenge in the communication paradigm. However, the route selection and QoS requirements need to be addressed in the WSN. To incorporate these issues, it is necessary to design a route selection and dynamic routing protocol that provides a minimum number of connections with improved QoS network parameters and route communication with the support of the node mobility model to improve QoS communication from source to destination.

3 Proposed Dynamic TREDHO Model

A TREDHO model is employed to provide quality communication based on the route selection in WSN. Here the network structure is divided into small triangles denoted as blocked triangles based on coverage area. The network model contains deployed nodes, sink, node movement model, factors (movement and random factors) and dynamic routing protocol. In the TREDHO model, the route connection between the two waypoints (initial position and final position) is determined based on random and movement factors. This factor information is collected from the neighborhood node position and saved in the routing table. Then the fusion of EW-DHO is used for finding optimal path by considering three way point rules (based on speed, distance, and traffic intensity).. The packet is transmitted from the source node to the target depending on the estimated path.

The TREDHO model scheme consists of two phases: Set up phase and Communication phase.

3.1 Set up Phase

The setup phase consists of network structure and node movement.

3.1.1 Network Structure

The network structure is divided into small triangles and is referred to as blocked triangles. The deployed nodes are dynamic, and positioned randomly in the network. Also, the sink is located at the upper part of the network to reduce the transmission distance. The network structure is shown in Fig. 1. Triangle grid covers huge volume of area than circular or square cell.

Initially, the network is divided into several triangles based on node's number. The triangle is a right angle triangle, so $Area\ ,\ A_{area} = \frac{p \times q}{2}$, where p and q are base and height of the triangle. Area of the network, $a = S_{id}^2$, a is the area of the square, S_{id} denotes the side.

$$Number\ of\ triangle\ ,\ H = \frac{a}{A_{area}} \tag{1}$$

3.1.2 Node Movement

In this phase, the blocked triangle structure is used to improve the path by generating waypoints around the triangle. A line drawn between the two waypoints (initial position and final position) is called a connection. The route connection is determined based on two factors: random factors and movement factors are employed to obtain the random waypoint. The movement factors involve Motion information, current speed, angular direction, and time. The random factors involves the next position and traffic intensity of a hop node. The movement factors and random factors improves the connectivity and

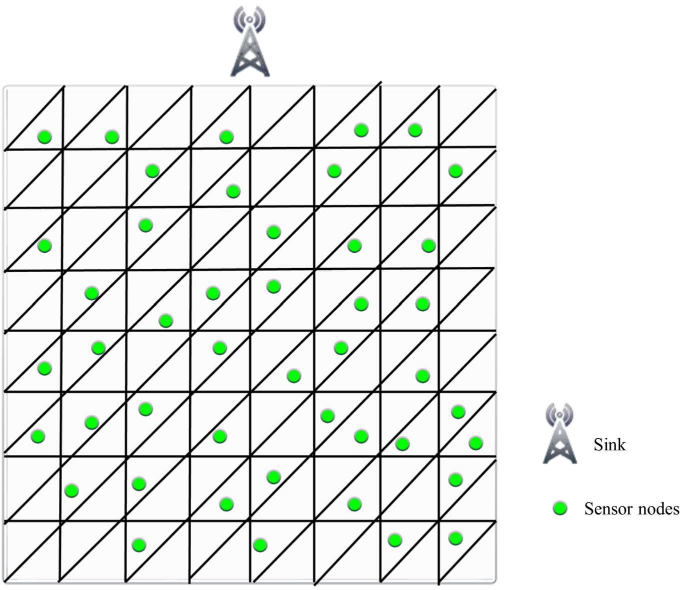


Fig. 1 Network structure

reduces the congestion. The random way point model includes the changes in nodes direction and speed. A mobile node starts from one position for a particular period, when this time expires it selects a destination randomly in the simulation area and the uniformly distributed speed i.e., max-speed and min-speed. By the arrival, it pauses for a certain time and starts the process again. In a random waypoint, the nodes are moved in a zigzag manner to reach the destination. The applications like military, sensors are used for monitoring the environment to detect objects in an area in which there are packet drops due to path failure. This leads to misdirection of routes and reduces the throughput of the network. For these situations, we use the random waypoint model by finding another route to the destination.

3.1.2.1 Motion information In the area to be observed, after positioning of node t the coordinate is (A_t^{now}, B_t^{now}); in the area to be observed after positioning of node y is (A_y^{now}, B_y^{now}). The Euclidean distance between node t and y is determined in Eq. (2).

$$D_{ist}(S_t^{now}, S_y^{now}) = \sqrt{(A_t^{now} - A_y^{now})^2 + (B_t^{now} - B_y^{now})^2} \tag{2}$$

From the above formula when $\left(D_{ist}(S_t^{now}, S_y^{now}) \geq D_G\right)$ it denotes the distance between two nodes is too nearer and the repulsive force is greater than the gravitational force, distance between two nodes is too far and the repulsive force is lesser than the gravitational force, $D_{ist}(S_t^{now}, S_y^{now}) < D_G$, where gravity plays an important role in this time.. The coordinate obtained by node t and y after calculation is (A_t^{new}, B_t^{new}), $and\,(A_y^{new}, B_y^{new})$.

when $D_{ist}(S_t^{now}, S_y^{now}) < D_G$,

$$A_t^{new} = A_t^{now} + \frac{H_t^{now}\left(A_t^{now} - A_y^{now}\right)\left[\left(D_G - D_{ist}\left(S_t^{now}, S_y^{now}\right)\right)\right]}{2\left(H_t^{now} + H_y^{now}\right)D_{ist}\left(S_t^{now}, S_y^{now}\right)}, \tag{3}$$

$$B_t^{new} = B_t^{now} + \frac{H_t^{now}\left(B_t^{now} - B_y^{now}\right)\left[\left(D_G - D_{ist}\left(S_t^{now}, S_y^{now}\right)\right)\right]}{2\left(H_t^{now} + H_y^{now}\right)D_{ist}\left(S_t^{now}, S_y^{now}\right)} \tag{4}$$

$$A_y^{new} = A_y^{now} + \frac{H_y^{now}\left(A_y^{now} - A_t^{now}\right)\left[\left(D_G - D_{ist}\left(S_t^{now}, S_y^{now}\right)\right)\right]}{2\left(H_t^{now} + H_y^{now}\right)D_{ist}\left(S_t^{now}, S_y^{now}\right)} \tag{5}$$

$$B_y^{new} = B_y^{now} + \frac{H_y^{now}(B_y^{now} - B_t^{now})[(D_G - D_{ist}(S_t^{now}, S_y^{now})]}{2(H_t^{now} + H_y^{now})D_{ist}(S_t^{now}, S_y^{now})} \tag{6}$$

When $D_{ist}(S_t^{now}, S_y^{now}) \geq D_G$,

$$A_t^{new} = A_t^{now} \tag{7}$$

$$B_t^{new} = B_t^{now} \tag{8}$$

$$A_y^{new} = A_y^{now} \tag{9}$$

$$B_y^{new} = B_y^{now} \tag{10}$$

where H_t^{now}, and H_y^{now} denotes current energy of node t and y. Initially the parameter and sensor node are placed randomly in the area to be monitored.

3.1.2.2 Current Speed, Angular direction, and Time Node speed is an important procedure for data transmission. If the mobile node moves faster, the time taken for the data transmission is less. Initially, every node is assigned a current direction and speed. In every interval of time, the node updates the current direction and speed. Especially, the kth instance value of direction and speed is estimated based on the value of direction and speed at the $(k-1)^{th}$ instance. The direction and speed are determined using Eq. (11) and (12).

$$T_k = \alpha \times T_{k-1} + (1-\alpha) \times T + \sqrt{1-\alpha^2} \times T_{l_{k-1}} \tag{11}$$

$$U_k = \alpha \times U_{k-1} + (1-\alpha) \times U + \sqrt{1-\alpha^2} \times U_{l_{k-1}} \tag{12}$$

where T_k and U_k denotes the mobile node new speed and direction at time interval k, T and U are constants which signifies the mean value of direction and speed as k-1 > infinity, where $0 < \alpha < 1$ is the tuning parameters utilized to change the randomness, and $T_{l_{k-1}}$, and $U_{l_{k-1}}$ are random variables.

The mobile node position is given by a time interval k, which is determined in Eq. (13) and (14).

$$l_k = l_{k-1} + T_{k-1} \times \cos U_{k-1,} \tag{13}$$

$$U_k = U_{k-1} + T_{k-1} \times \sin U_{k-1} \tag{14}$$

3.1.2.3 Traffic Intensity The behavior of forwarding a packet through a node during each round is determined by the traffic intensity. When more packets are sent to the node; less is the chance of a node to be chosen as a path node in consecutive rounds. This makes load balancing in the network by giving other unutilized nodes a chance to become path nodes, i.e., nodes with less packets sent and no packets ever transmitted may have this opportunity. Therefore, traffic load with respect to the distance of the sink is determined in Eq. (15).

$$t = \frac{\pi a^2}{\sqrt{\Delta A}} \tag{15}$$

where t denotes the traffic load with respect to sink, A signifies the coverage area in total distance, a denotes the certain distance (0,A). Traffic intensity at mean hop length f is determined in Eq. (16).

$$T_{raffic} = \frac{A^2 - a^2}{2af} \times o \tag{16}$$

where o denotes the traffic rate.

3.2 Communication Phase

The communication phase consists of route discovery. We introduce the EWA-DHO algorithm to optimize the optimal path for routing, we consider hunting prey phases to make the optimal path (destination node). The DHO [36] is good at completing entire test problems and is highly competitive and sensible when compared to other algorithms. But the DHO has some drawbacks, such as a high chance of failing into local optimum solution & also decreasing the speed of search. So, for an efficient search process, we combined EWA [37] with DHO. EWA-DHO is high in favorable region's searching ability and balancing exploration and exploitation ability. Thus, the overall design of fusion based EWA-DHO gives high accuracy in obtaining the optimal path (shortest path) for routing. Figure 2 shows the data transmission of packets.

The DHO main objective is to determine the best position for human to hunt deer. Some specific characteristics of deer make it harder for predators to hunt. They are excellent visual sense, superior smelling skill, and the ability to detect ultra-high-frequency sounds. The fitness is determined by considering speed, distance, and traffic intensity. To improve the search, the three rules (based on speed, distance, and traffic intensity) are updated to obtain the optimal route. The optimal data transmission route is discovered depending on the optimal fitness attained from the hunting activity.

Step 1: Population initialization.

The hunter's population is initialized and is represented in Eq. (17)

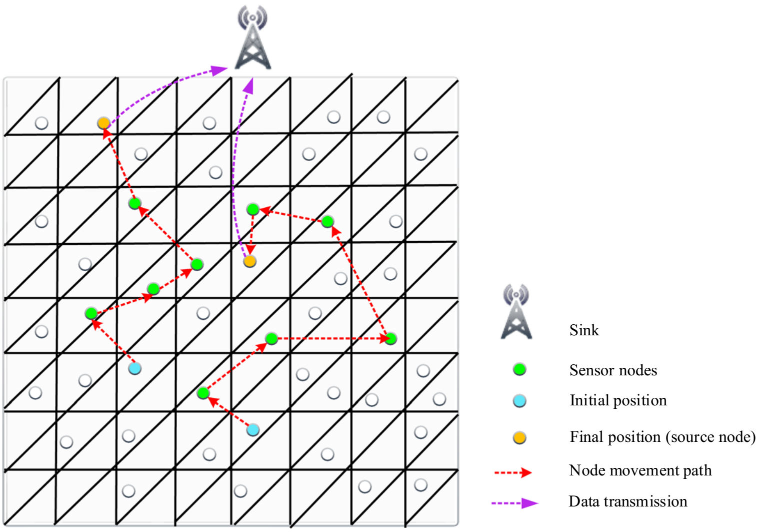


Fig. 2 Data transmission

$$W = \left\{W_1, W_2, \ldots\ldots..W_n\right\}; 1 < r \le s \tag{17}$$

where s signifies the number of hunters and r denotes the hunter's population.

Step 2: Fitness evaluation.

The fitness is determined based on three random way point rules by considering speed, traffic intensity, and distance.

$$Fitness = \begin{cases} P_2 \; if \; \left(Rule_1\left(P_1, P_2\right) = \min\left(distance, traffic\ intensity\right), \max\left(speed\right)\right. \\ P_1 \; if \; \left(Rule_3\left(P_1, P_3\right) = \min\left(distance, traffic\ intensity\right), \max\left(speed\right)\right. \\ P_2 \; if \; \left(Rule_2\left(P_1, P_2, P_3\right) = \min\left(distance, traffic\ intensity\right), \max\left(speed\right)\right. \end{cases} \tag{18}$$

Based on each node distance, speed, and traffic intensity, the fitness is calculated. The rules are depicted below.

This phase consist of a certain parameters in hello packets. The hello packets contain random factors and movement factors information such as motion information-$D_{ist}(S_t^{now}, S_y^{now})$, current speed-$T_k$, direction-$U_k$, and traffic intensity- T_{raffic}. The route finding process consists of three waypoints (P1, P2 and P3) for route selection. Each nodes in the network is white in color initially. This help to increases the whole network life time and enhance the quality of communication. The neighbor nodes is assigned as green in color.

R1: Consider waypoint P1 and P2 in the network, the P2 is changed to green color if any of the following condition are satisfies,

(i) $L\left[P_2\right] \subseteq L\left[P_1\right]$ and $T_k\left(P_2\right) < T_k\left(P_1\right)$.
(ii) when $T_k\left(P_2\right) = T_k\left(P_1\right), L\left[P_2\right] \subseteq L\left[P_1\right]$ and $U_k\left(P_2\right) = U_k\left(P_1\right)$
(iii) Rule signifies that $T_{raffic}\left(P_2\right) < T_{raffic}\left(P_1\right)$ and $L\left[P_2\right] \subseteq L\left[P_1\right]$ when $T_k\left(P_2\right) = T_k\left(P_1\right), U_k\left(P_2\right) = U_k\left(P_1\right)$.

(iv) $L[P_2] \subseteq L[P_1]$ and $D_{ist}(P_2) < D_{ist}(P_1)$ when $U_k(P_2) = U_k(P_1) T_{raffic}(P_2) = T_{raffic}(P_1)$, $T_k(P_2) = T_k(P_1)$.

where $L[P_1]$ denotes the closed path waypoint set of P1, $L[P_2]$ signifies the open path point set of way point P2. The above rule signifies that if the speed of waypoint P2 is smaller than waypoint P1, the direction of two way point is same and the distance is same. Where $L[P_2] \subseteq L[P_1]$ condition holds good in all cases indicating that node P2 is connected in the network.

R2: Consider two way points P1 and P3 in the network as marked neighbor of point P2. The P2's marker is changed to green if any of the condition satisfies,

(i) $L[P_2] \subseteq L[P_1] \cup L[P_3]$ but $L[P_1] \nsubseteq L[P_2] \cup L[P_3]$ and $L[P_3] \nsubseteq L[P_1] \cup L[P_2]$.
(ii) $L[P_2] \subseteq L[P_2] \cup L[P_3]$ and $L[P_1] \subseteq L[P_2] \cup L[P_3]$, but $L[P_3] \nsubseteq L[P_1] \cup L[P_2] L[P_1] \cup L[P_2]$, one of the condition holds
(a) $T_k(P_2) < T_k(P_1)$ or
(b) $U_k(P_2) > U_k(P_1)$ and $T_k(P_2) = T_k(P_1)$ or
(c) $U_k(P_2) = U_k(P_1), T_k(P_2) = T_k(P_1)$ and $T_{raffic}(P_2) < T_{raffic}(P_1)$
(d) $D_{ist}(P_2) < D_{ist}(P_1)$ and $T_k(P_2) = T_k(P_1), T_{raffic}(P_2) = T_{raffic}(P_1), U_k(P_2) = U_k(P_1)$.

This shows that waypoint P3 and P1 can be removed, if neither P1 nor P3 is not covered (shortest distance).

R3: Consider two way points P1 and P3 in the network. The P1 is changed to green if any of the condition satisfies,

(i) $L[P_1] \subseteq L[P_3]$ and $T_k(P_1) < T_k(P_3)$.
(ii) when $T_k(P_1) = T_k(P_3), L[P_1] \subseteq L[P_3]$ and $U_k(P_1) = U_k(P_3)$
(iii) Rule signifies that $T_{raffic}(P_1) < T_{raffic}(P_3)$ and $L[P_1] \subseteq L[P_3]$
(iv) $L[P_1] \subseteq L[P_3]$ and $D_{ist}(P_1) < D_{ist}(P_3), D_{ist}(P_1) = \min\{D_{ist}(P_3), D_{ist}(P_1),\}$

This shows that waypoint P3 can be removed and the P2 is connected in the network.

The initial position of the node sends hello packets to the next node based on the three random way point rules. The way point consists of random and movement factors. The node, which has high speed, minimum traffic intensity, high motion information, and direction towards the destination, receives the hello packets from the initial position, and this process continues until the hello packets are received by the sink.

Step 2: Position and wind angle initialization.

The location of deer and wind angle are significant parameters to find the hunter's optimal position. The circle is considered as search space. So the mathematical formula for computing wind angle is based on circle's circumference, which is given in Eq. (19).

$$\emptyset_j = 2\pi r \tag{19}$$

where r denotes the random number in the range from [0,1], j denotes the present iteration.

The deer position angle is given in Eq. (20).

$$\theta_j = \pi + \emptyset \tag{20}$$

Step 3: Propagation of Position.

The hunter's encircling behavior is mathematically represented in Eq. (21).

$$W_{j+1} = W^{lead} - R.b.\left|G \times W^{lead} - W_j\right| \tag{21}$$

where b denotes the random numbers that varies from 0 to 2, R and G denotes the coefficient vectors, which is determined in Eq. (22) & (23).

$$R = \frac{1}{4}\log\left(j + \frac{1}{j_{\max}}\right)c \tag{22}$$

$$G = 2.a \tag{23}$$

where the parameter C in the range of -1 and 1, a signifies the random numbers in the range [0,1].

Consider hunter's two positions; leader and successor position. A parameter is derived from the difference between the deer's visual angle and the wind angle, which aids in updating the position angle, which is given in Eq. (24).

$$d_j = \emptyset_j - p_j \tag{24}$$

The deer's visual angle is determined by using Eq. (25).

$$p_j = \frac{\pi}{8} \times r \tag{25}$$

The updated position angle is given in Eq. (26).

$$\theta_{j+1} = p_j + \theta_j \tag{26}$$

The position is updated for the hunter by taking the position angle, which is given in Eq. (27).

$$W_{j+1} = W^{lead} - b.\left|\cos\left(\theta_{j+1}\right) \times W^{lead} - W_j\right| \tag{27}$$

where b denotes the random numbers, W^{lead} signifies the search agent's leader position.

After updating the DHO solution, the EWA concept is used to carry out the following update procedure. The fitness evaluation is carried out for the complete solution, which is updated by DHO. The fitness evaluation selects the leader position from all of the solutions. The selected leader is updated by using the EWA, the weight factor is determined in Eq. (28).

$$T_f = \frac{\left(\sum_{u=1}^{z} W_{u,f}\right)}{Z} \tag{28}$$

$$W'_{u,f} = W_{u,f} + T_f * x \tag{29}$$

where z denotes the population's total number, $W_{u,f}$ denotes the u^{th} earthworm at position f, and x denotes the number selected at random from the Cauchy distribution.

Step 4: Termination process.

The location update is performed for all iterations until the ideal position is attained.

```
Pseudocode for EW-DHO algorithm
Input: Initialize the W population
Output: $W^{lead}$ is the ideal solution
Start
    While ()
        For all of the population's solutions
        Estimate the value of each solution's fitness.
       Update the d,p,b,R,G, and C values
         If (b<1)
           If |$Q \geq 1$|
               Update the location of the current hunters by utilizing Eqn. (20).
           Else
                Update the location of the current hunters by utilizing Eqn. (28).
          End if
          Else
               Update the location of the current hunters by utilizing Eqn. (27).
           End if
          End for
      Determine the fitness value of each solution.
      Choose the leader positions
      Update the position of leader by utilizing Cauchy mutation utilizing Eqn. (29)
       Calculate the fitness function
         If the current fitness less than the leader fitness
              Leader fitness is changed by current fitness
             Leader solution is changed by current solution
           End if
       j=j+1
   End while
   Return $W^{lead}$
Terminate
```

4 Experimental Result and Simulation Setup

The TREDHO model performance is tested in MATLAB platform by arranging 100 nodes in a simulation area of 100 × 100. The Table 1 shows the parameters for simulation. The population size is set as 100, the random variable varies from 0 to 2, the coefficient vector has a value between – 1 and 1, ‘a’ is in the interval of [0, 1] for DHO. The earthworm generation are set to 50, similarity factor = 0.98, constant = 0.9.

Table 1 Simulation parameters

Parameters	Values
Simulation area	100×100
Node mobility model	Random waypoint
Number of nodes	100
Sink position	(50, 50)
Communication range	16 m
Minimum speed	0.05 m/s
Maximum speed	0.3 m/s
Packet data maximum size	10 bytes
Initial energy of nodes	5 J
Packet transmission power	2 w
Packet receiver power	0.1 w
Simulation duration	1000

4.1 Performance Metrics

The TREDHO model performance is tested under throughput, delay, energy consumption, PDR, and network lifetime.

4.1.1 Throughput

This metric is utilized to measure the number of packets reached in the sink node at a particular time in the network.

4.1.2 Delay

It is stated as the packets transmitted from the initial position to destination in a period of time.

$$D = \sum_{i,j=1}^{k} \frac{R_{tj} - M_{ti}}{L} \tag{30}$$

where R_{tj} signifies the time of packets reached at node j, M_{ti} represents the time of packets sent from the node j, L denotes the number of connection between the initial and the final position.

4.1.3 Energy consumption

It is defined as the energy consumed in total during sending of packets by the network.

$$I_{ene} = \sum_{i=1}^{k} I_i \tag{31}$$

where I_{ene} denotes the energy, k denotes the number of utilized node, and I_i signifies the energy consumed by single node.

4.1.4 PDR

It is stated as the number of packets transmitted to the destination to the number of packets reached at the destination.

$$PDR = \sum_{i=1}^{k} \left(\frac{N_i}{E_i} \right) \tag{32}$$

where N_i denotes the number of received packets, E_i denotes the number of sent packets, k signifies the nodes.

4.1.5 Network Lifetime

It is the time taken for the death of first node because of the exhaustion of energy.

4.2 Performance Analysis

The proposed TREDHO model is compared with existing ERP [29], OREA [35], CRF [34], and DEER [24] with numerous metrics. The network-related QoS parameters are improved under two scenarios (varying the number of nodes and varying the speed of nodes) based on the following metrics such as, PDR, throughput, energy consumption, delay, and network life time.

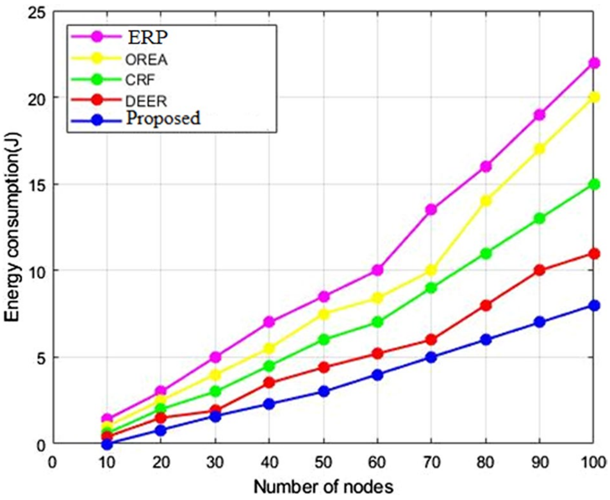


Fig. 3 Energy consumption analysis

4.2.1 Energy Consumption Analysis

The Fig. 3 shows the comparison of proposed TREDHO model performance and existing methods such as ERP, OREA, CRF, and DEER. The results shows that the energy consumed for our proposed TREDHO model is 5 J, when comparing with ERP, OREA, CRF, and DEER is 14 J, 10 J, 9.5 J, and 5.2 J for 70 nodes. However, the number of nodes increases, the consumption of energy also increases. When the network with 100 nodes is deployed, the ERP technique consumes more energy of 23 J among the existing method, but the proposed TREDHO model has the low energy consumption of 7 J. From the result it is obvious that the proposed TREDHO model has low energy consumption. This is due to the introduction of the EWO-DHO, which reduces energy usage by selecting the most efficient transmitting path.

4.2.2 PDR Analysis

The Fig. 4 demonstrates the analysis of the PDR of proposed TREDHO Model and existing ERP, OREA, CRF, and DEER methods. From the result, we can conclude that the packet delivery rate is increased in the proposed TREDHO model when comparing with existing ERP, OREA, CRF, and DEER methods. The values for our proposed TREDHO model is 96, when comparing with ERP, OREA, CRF, and DEER is 84.8, 85.1, 92.3, and 94.9 for 70 nodes. The values for our proposed TREDHO model is 85, when comparing with ERP, OREA, CRF, and DEER is 70, 71, 83.5, and 84 for 0.2 speed. It is evident from the result that the proposed TREDHO model have high packet delivery ratio. This is due to random factors and movement factors route connection, which improves the connectivity and reduce the congestion.

4.2.3 Throughput Analysis

The throughput analysis is given in Fig. 5 by comparing the proposed TREDHO model and existing ERP, OREA, CRF, and DEER methods. Based on the result, our proposed TREDHO model is 61, when comparing with ERP, OREA, CRF, and DEER is 30, 32, 44, and 53 for 70 nodes and the proposed TREDHO model is 40, when comparing with ERP, OREA, CRF, and DEER is 32, 33, 38.2, and 39.8 for 0.2 speed. It is clear that the proposed model outperform high throughput. As the existing methods are unable to transmit the packets due to congestion during the routing process. In the proposed TREDHO model, the three way point rule (based on traffic intensity, speed, and distance) is used, which gives congestion free data transmission, which reduces the packet loss.

4.2.4 Delay Analysis

The delay analysis is given in Fig. 6 by comparing the proposed TREDHO model and existing ERP, OREA, CRF, and DEER methods. The term “delay” refers to the time it takes a source node to send a packet to its final destination. Therefore, without delay, the data packet is transmitted. The existing methods such as ERP [30 s], OREA [20 s], CRF [17.2 s], and DEER [13 s] have higher delays than the proposed TREDHO model. The proposed TREDHO model takes less time to transmit the data packets than the existing

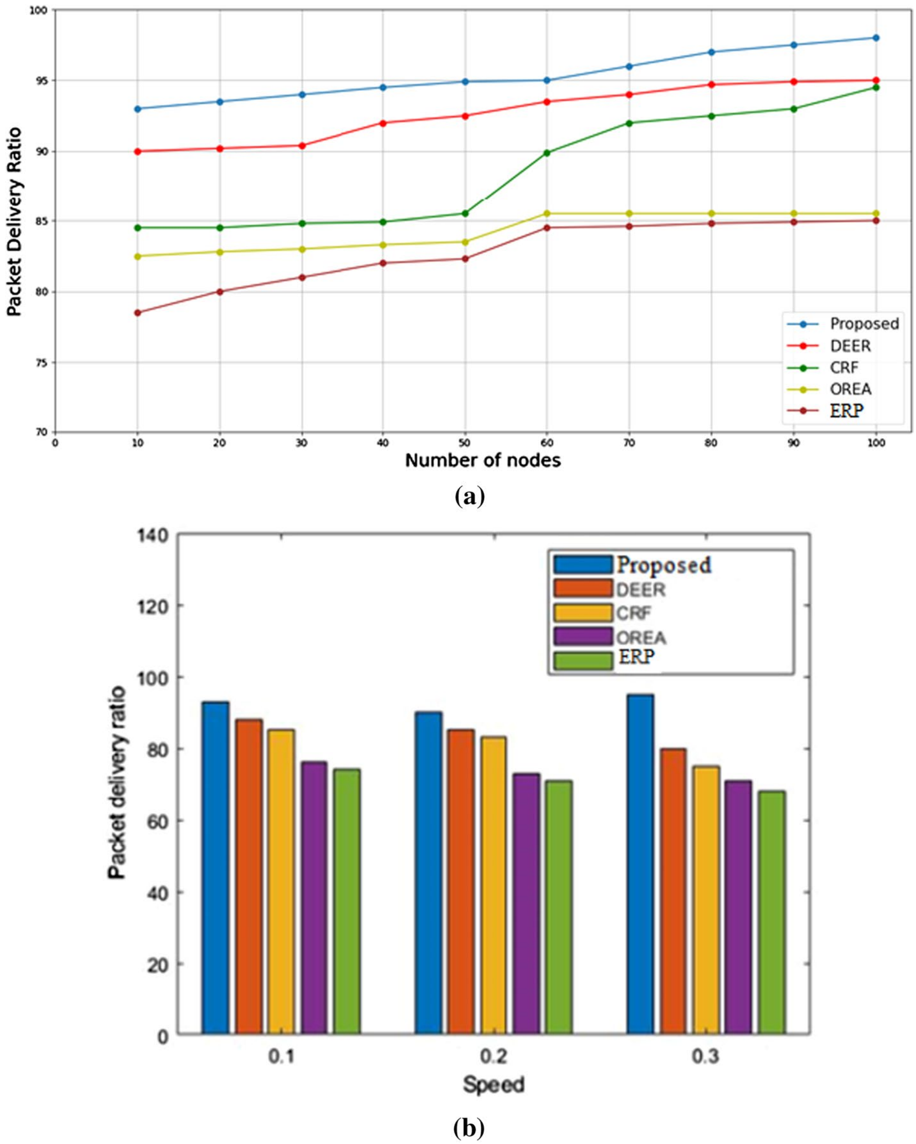


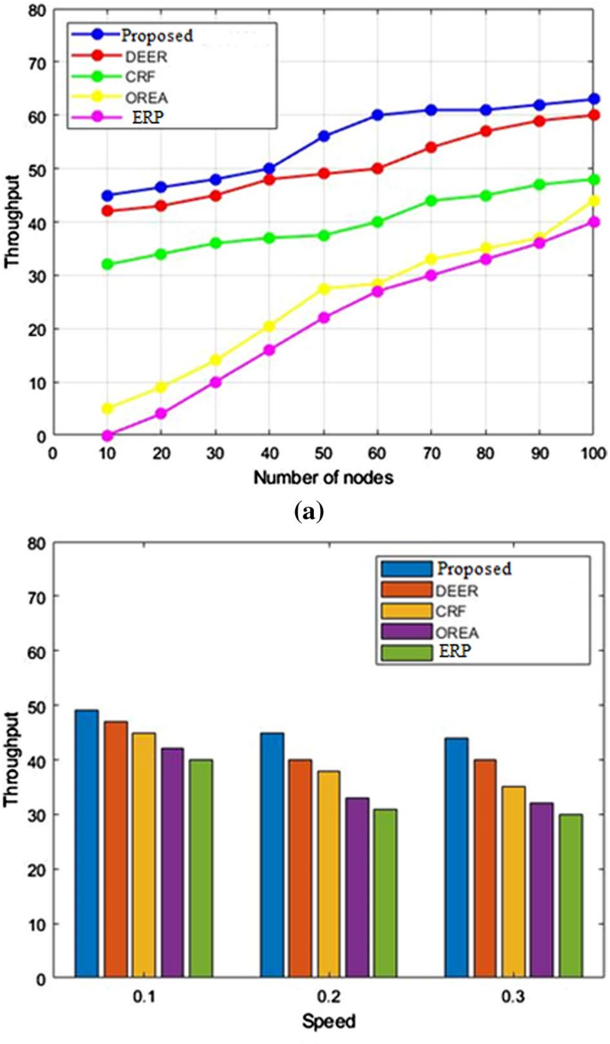
Fig. 4 (**a**) PDR versus number of nodes (**b**) PDR versus speed

methods. The existing methods have larger delay because of the connection failure. In the proposed TREDHO model, the transmission of data is faster because of the shortest and optimal route selection by the EW-DHO.

4.2.5 Network Life Time Analysis

The network lifetime is the time at which the initial node dies, which is illustrated in Fig. 7. From the analysis, it is cleared that our proposed TREDHO model attains high life time than

Fig. 5 (**a**) PDR versus number of nodes (**b**) PDR versus speed



(a)

(b)

existing ERP, OREA, CRF, and DEER methods. The values for our proposed TREDHO model is 1100 s, when comparing with ERP, OREA, CRF, and DEER is 420 s, 732 s, 744 s, and 1000 s for 70 nodes. When number of node increases, the network lifetime decreases in existing methods. But in proposed model, the number of node increases the network life time increases.

Fig. 6 Delay

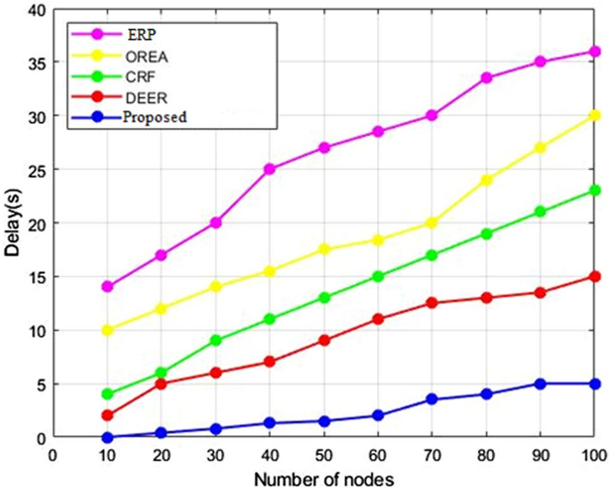
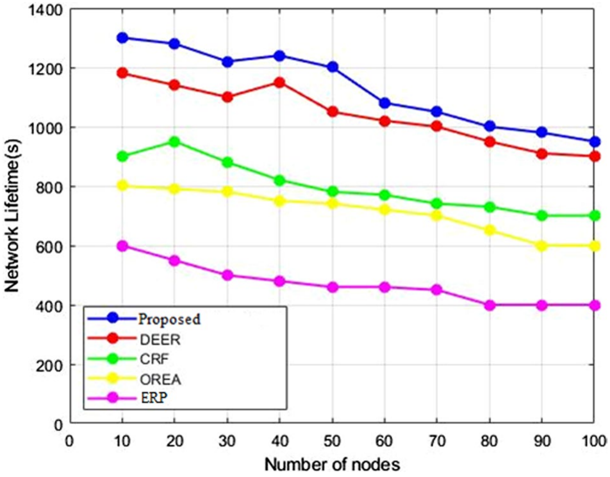


Fig. 7 Network lifetime analysis



5 Conclusion

This paper introduces a TREDHO model to provide quality communication without network flooding, with minimum energy consumption and delay. A dynamic routing protocol provides a minimum number of connections with improved QoS network parameters and route communication with the support of the node mobility model to improve QoS communication from source to destination. The TREDHO model sends data packets with high successful PDR, minimum delay, high network life time, high throughput, and low energy consumption. The values for our proposed TREDHO model: energy consumption is 5 J, PDR is 96%, throughput is 61%, delay is 4 s, network lifetime is 1100 s for 70 nodes, when comparing with ERP, OREA, CRF, and DEER. This work can be used in healthcare industry, where wearable equipment and advanced medical sensors are used by WSNs to provide real-time monitoring of patients' vital signs when they are within a healthcare institution, such as a hospital or their home. The multiple route request path lead to heavy control overhead. The future work may be done to overcome the accidental jamming.

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Declarations

Conflict of Interest Authors declares that they have no conflict of interest.

Consent to participate There is no informed consent for this study.

Consent for Publication Not Applicable.

Human and Animals Rights This article does not contain any studies with human participants and/or animals performed by any of the authors.

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V. Bibin Christopher was born in Kanyakumari, India, on April 5, 1985. He received his B.E. degree in Electrical Engineering from Anna University, Chennai in 2006. He received his M.E and Ph.D. degree in Computer Science and Engineering from Anna University, Chennai, India, in 2009 and 2021. Currently he is working as an Assistant Professor in SRM Institute of Science and Technology, Kattankulathur Campus Chengalpattu Dt., Tamilnadu, India. His current research interests include Wireless Sensor Networks, Mobile Computing, and Network Security.

R. Isaac Sajan was born in Kanyakumari, India, in 1984. He received his B.E., M.E, and Ph.D degrees in Computer Science and Engineering from Anna University, Chennai, India, in 2006, 2008 and 2021. Currently he is working as an Associate Professor in Department of Computer Science and Engineering, Ponjesly College of Engineering, Nagercoil, India. His-current research interests include Wireless Sensor Networks, Mobile Computing, Wireless Communications in general and Artificial Intelligence.

T. S. Akhila received the B.E. degree in Electronics & Communication Engineering, the M.E. degree in Embedded System Technology from Anna University, India, in 2009 and 2011 respectively. She is an assistant professor in Mar Ephraem College of Engineering and Technology, India. Her research interests are Wireless Sensor Networks, Wireless Communication and Embedded System.

M. Joselin Kavitha received the B.E. degree in Electronics & Communication Engineering, the M.E. degree in Communication System from Anna University, India, in 2008 and 2010 respectively. She is an assistant professor in Marthandam College of Engineering and Technology, India. Her research interests are Wireless Sensor Networks, Wireless Communication and VLSI Design.