PRIORITY-BASED CONGESTION TRUST AWARE ENERGY EFFICIENT ROUTING ALGORITHM (PCTA-EERA) IN WIRELESS SENSOR NETWORK (WSN)

R. TAMILARUVI,

Assistant Professor, Department of Computer Science and Engineering, Annamalai University, Annamalainagar, India. tamil2party@yahoo.com

D. SURESH,

Assistant Professor, Department of Information Technology, Annamalai University, Annamalainagar, India. deiveekasuresh@gmail.com

ABSTRACT: The significance of data packet transmission reliability is increasing as Wireless Sensor Network (WSN) is becoming more extensively utilized. It is essential that the protocols for routing the data packets are reliable and secure is accurate data packet delivery possible. The current cryptographic algorithms may not be used for WSN security due to WSN restrictions. In a while, the Trust Aware Energy Efficient Routing (TAEER) mechanism has developed as a benefit for successful packet transmission with higher security and may give effect with fewer resources. The TAEER system, however, suffers congestion due to a large demand for resources during the active period and a delay between the speed of data processing and transmission and the speed of incoming traffic. By causing buffer overflow, packet loss, increased latency, excessive energy consumption, or, worse still, the failure of the overall system, this may interfere with entire network. A Priority-based Congestion Trust Aware Energy Efficient Routing Algorithm (PCTA-EERA) is presented in this research using an improved fuzzy based trust management system as well as the Chaotic Weight Dragonfly Algorithm (CWDA). The data transmission has been classified into regular, on-demand, and emergency data for the prioritised routing process. Identifying the nearest nodes is done by neighbour discovery. CWDA serves as the Cluster Head in clustering (CH). For the objective of selecting a CH, node factors like node-to-base station distance, path loss, node weight, queue length, residual energy, link reliability, and node reachability have been taken into consideration. Malicious nodes have been detected through improved fuzzy based trust management in order to enhance the security. For successful packet transmission, Time Division Multiple Access (TDMA) scheduling had been being adopted. In terms of Packet Delivery Ratio (PDR), Energy Consumption, End to End Delay (E2E), Network Lifetime (NL), Transmission Rate (TR), and Average Remaining Round (ARR), the experimental findings demonstrate that the proposed system outperforms the existing system.

KEYWORDS: Wireless Sensor Network (WSN), energy efficiency, node trust, improved fuzzy framework, Chaotic Weight Dragonfly Algorithm (CWDA), and Time Division Multiple Access (TDMA).

1. INTRODUCTION

Wireless Sensing Network (WSN) has advanced rapidly over the years. This technology includes of low-power, high- and low-operating nodes, is the most significant. Nodes are the instruments which comprise a WSN. These nodes are fundamental to the data collection process and perform out numerous tasks. The node liable for gathering data is described as a source node and all data from all source nodes is kept on a single sink node. Because of its strong processing capabilities, the sink node is more potent than other nodes. The manner in which the sensor nodes could indeed monitor the data has been evaluated by the WSN. Utilizing ubiquitous sensors defined as sensor nodes, ecological phenomena more than a large area could be monitored [1]. These sensors are commonly distributed at random in the area. Examples for sensor networks include battlefield management, logistics and inventory control, energy conservation, medical monitoring, and emergency response networks. To keep functioning the WSN, a secure energy-efficient technique is needed [2].

Multiple sensors, processors, and Radio Frequency (RF) components are included in battery-powered WSN. The sensor nodes could indeed send their data to the base station or coordinator node [3]. As is common knowledge, a sensor node's valuable small size requires a tiny battery by a restricted energy usage [4]. WSN replaced the function of the particular macro sensor; it gained benefits over its own predecessors in terms of wider sensing range, fault tolerance, improved accuracy, and lower cost. It is also impossible to recharge or replace the battery in that situation.

The energy efficiency is considered to be an essential problem in designing protocol related toward the constraint and non-rechargeable energy of resources designed for the sensor nodes because it considerably impacts lifetime of sensor nodes. Therefore, a combination of nodes is essential for establishing various small groups known as clusters in order to enhance energy efficiency and reduce transmission delay. To ensure the scalability and predictability of performance in WSN, clustering has become essential [5]. Centralized clustering, distributed clustering, and hybrid clustering are the 3 types under which clustering can be classified. The clusters in the centralized clustering have such a fixed CH assigned to them. The cluster's final nodes function as member nodes. In a distributed network, the CH is not stable. Based on very few factors, the CH continues to move from node to node [6]. The term "hybrid clustering" relates to the clustering which incorporates distributed and centralized clustering.

Nodes are clustered based on the network's characteristics and purpose. The sensor nodes are grouped into clusters to reduce the energy consumption and data transmission time. Member nodes and the Cluster Head (CH) unique node make up clusters. The collected data can be advanced to the CH by member nodes. Another sensor node with more advanced powers than others is CH [6]. The CH is used to send the aggregated data to the sink or BS, which is a clustering benefit. As a result, the network's nodes are grouped into clusters for information processing and transmission, while lesser energy nodes are utilized for target event sensing. The data is then sent directly to a BS by CH. A key factor is making the best option for CH. As an outcome, the evolutionary algorithm is important in solving this issue due to its capability to adaptively solve complex issues in polynomial time. In accordance with the reviews, swarm intelligence-based evolutionary algorithms like Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Artificial Bees Colony (ABC), Firefly Algorithm (FA), Cuckoo Search (CS), and Bat Algorithm (BA), as well as genetic-based evolutionary algorithms are principally used for CH selection.

On the other hand, one of the significant issues to WSN applications is fault tolerance. Various studies have put forward by the fault-tolerant mechanisms which can minimize failure of WSN components and achieve acceptable data accuracy, reliability, and energy efficiency [7]. Congestion, security, and delay are extra important factors influencing routing paths. There has been frequently an overflow of transmitted data at the forwarder nodes that also results in transmission delay. In order to solve these problems, it could be useful to take the data packets priorities into account. This can maintain the congestion, security, delay, and energy usage at the same time as increasing the openness of the routing paths designed for emergency data.

Chaotic Weight Dragonfly Algorithm (CWDA) and Priority-based Congestion Trust Aware Energy Efficient Routing Algorithm (PCTA-EERA) was developed for WSN. Based on priority and quality measures, the CWDA improves the selection of the best routing path. PCTA-EERA priority-based routing, where the pick of the forwarding node takes energy, delay, and packet transmission rate into account. In the WSN model, it increases energy usage, decreases congestion and delays, and completes urgent transmission. In this case, the sensor nodes are gathered into a cluster, and the cluster leader is chosen using CWDA. An improved fuzzy system can identify malicious nodes. Lastly, packet transmission is carried out using fault-tolerant based routing. The paper is arranged as shown: Section 2 shows the reviews on routing and security mechanisms. Section 3 offers a PCTA-EERA mechanism for WSN. Section 4 depicts the results and Section 5 concludes the paper.

2. LITERATURE REVIEW

Various methods has been developed to increase efficiency by PDR, energy usage, end-to-end delay, Average remaining round, and other factors due to the WSN limitations. Managing trust-based energy efficiency and network congestion are the most important ways to increase energy efficiency. Figure 1 shows the classification of several congestion control protocols.

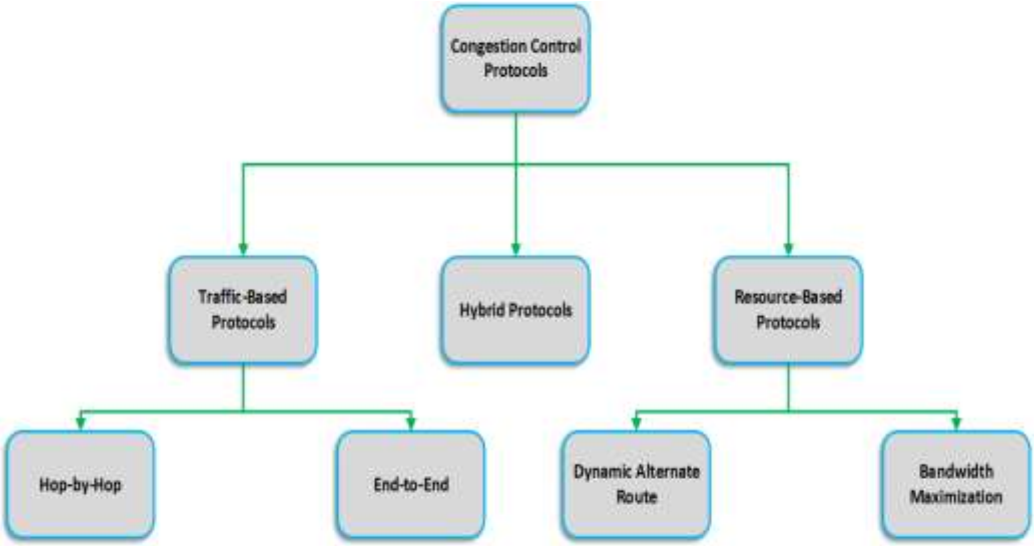

FIGURE 1: CLASSIFICATION OF CONGESTION CONTROL PROTOCOLS

For WSN security and energy effectiveness, Gong et al. [8] proposed a Secure and Energy Aware Routing Protocol (ETARP). ETARP provides an attempt to tackle WSN applications running in battlefield. The concept of utility is a new way toward concurrently allowed for route responsibility and energy consumption in the routing protocol. The Monte-Carlo method is employed in MATLAB simulations to conduct out the experimental evaluation. According to simulation, the proposed ETARP system is able to keep the similar security level at the same time as provided that better energy efficiency designed for delivery ratio when compared to the routing protocols namely AODV-EHA and Light-Weight Trust-Based Routing Protocol (LTB-AODV).

Liu et al. [9] introduced a Dynamic Duty Cycle (DDC) for delay minimization in WSNs. First, examine at the way network delay is affected by duty cycle. The DDC system is then developed to extend the nodes' active duration in non-hotspot regions. The likelihood that the forwarding node set stays awake increases with a higher duty cycle. As a result, a node's transmission latency and sleep delay both get reduced. Moreover, the performance is improved only using the nodes' remaining energy. Energy usage, NL, and E2E delay are used to measure performance. DDC scheme, transmission delay is minimized by 20–50% by Static Duty Cycle (SDC) scheme, NL is improved by >16.7% and the energy effectiveness by 15.30%–16.30%.

Mostafaei [10] created an algorithm based on the Reliable Routing Distributed Learning Automaton (RRDLA) to increase network efficiency when managing various QoS constraints. The initial, learning, transmitting, and retransmitting stages constitute the RRDLA. The development of the LA network and each LA's action set takes place in the first phase. During the learning period, a less amount of nodes by higher PDR are selected. The efficiency of the RRDLA algorithm as measured by: a) E2E; b) PDR; c) network lifetime; and d) the quantity of data transfers. E2E and energy efficiency are key things where RRDLA algorithm works better than the other state-of-the-art algorithms.

A Fuzzy based energy Efficient Multiple Cluster Head Selection Routing Protocol (FEMCHRP) to extend network lifetime and balance energy usage in WSN was designed by Rana et al. [11]. The clustering of nodes, CH nodes are selected which transmit all the information toward the Cluster Head Leader (CHL), are both steps in the routing process. CHL then transmit compiled info to the base station (BS). Fuzzy logic is used in the selection of CH and CHL, and the shortest energy route is selected using the Dijkstra Algorithm for data transmission. NL, energy dissipation, and residual energy are the three evaluation matrices used to evaluate the results. The simulation is performed using the MATLAB. Proposed routing protocol is more successful at extending NL, and balancing energy consumption.

Hamilton Energy-Efficient Routing Protocol (HEER) has been introduced for delay-aware and energy-efficient clustered protocol in WSN by Yi and Yang [12]. In the network setup phase, proposed system clusters are formed and link each cluster's members on a Hamilton Path for data transmission. This path is constructed using a greedy algorithm. Furthermore, MATLAB simulation was used to implement the HEER protocol and compare it to a number of cluster-based protocols, and chain-based protocols. Network performance and transmission delay are the evaluation measures. Comparison to the cluster-based protocols LEACH and LEACH-EE, HEER performed 66.50% and 40.60% more iterations in the simulation. Power Efficient Gathering in Sensor Information Systems

(PEGASIS) and Intra-grid-PEGSIS, 2 chain-based protocols were compared with HEER, which handled 21.2 and 16.7 times as many rounds, correspondingly.

In order to maximise energy efficiency in WSN, Wang et al. [13] created a clustering algorithm that chooses cluster heads using an improved Artificial Bee Colony (ABC), improved Ant Colony Optimization (ACO), and fuzzy C-means (FCM). All nodes have the same energy level during the network initialization phase, so the FCM clustering is optimized using the improved ABC algorithm to identify the best clustering. Finally, routing between the CH and the base station, an improved ACO-based energy-efficient routing algorithm is also introduced in WSN. Polling control method is introduced depending on idle nodes into intra-cluster communication in the stable transmission phase toward raise energy effectiveness and further enhance network throughput. MATLAB is used to evaluate the proposed protocol than the other methods. Experiments in simulation related to throughput, NL, total residual energy, and stability.

For energy-harvesting WSN, Ding et al [14] proposed optimising routing algorithm depending on COngestion COntrol (CCOR) gives sufficient maintenance of energy efficiency and congestion control. Queuing network model is introduced to determine the congestion degree of node. Based on node positions and packet service rates, the two functions link gradient and traffic radius are created toward CCOR algorithm. Finally, the link flow rates are used to divide the route selection probabilities for each path. Packet Loss, average routing hops, and energy usage of packets are used for results evaluation, and it is has been experimented by MATLAB. Based on the simulation results, the proposed method greatly reduces the rate of packet loss whereas keeping excellent energy efficiency.

A Priority-based Application Specific Congestion Control Clustering (PASCCC) was developed by Jan et al. [15]. It has been introduced to reduce energy usage and identify congestion in WSN. It incorporates the nodes mobility and heterogeneity to detect network congestion. By preserving threshold levels for different applications, PASCCC minimizes the duty cycle of each node. For CH to achieve coverage fidelity, a novel queue scheduling mechanism is presented by ensuring that the additional resources consumed by much distance nodes are used effectively. With existing techniques, PASCCC improved efficiency in terms of NL, energy consumption, data transmission, quality of data (QoD), and quality of service (QoS) metrics.

For WSN energy efficiency, Gholipour et al. [16] proposed a distributed traffic-aware routing scheme. The gradient-based routing model employing depth and traffic density is proposed followed by instructions on how to combine them to make dynamic routing decisions. The shortest cost path model-based gradient field is presented first, followed by the depth field. The gradient field should then be updated toward signify traffic information in every of the neighboring nodes. NS2 simulator, the proposed algorithm was evaluated by packet loss ratio, energy usage, and E2E delay. The proposed system can enhance network resource consumption, decrease needless packet retransmission, and greatly enhance WSN performance.

Support Vector Machines (SVM) and Genetic Algorithm (GA) were created by Gholipour et al. [17] to reduce energy consumption in WSN. WSN congestion results in packet loss, decreased throughput, and poor energy efficiency. The strategy determines the buffer utilization ratio and determines how congested the degree downstream node. The present node uses SVM to increase network throughput by adjusting the transmission rate to address the issue of congestion. Using GA, SVM parameters are tuned. Utilizing NS2 and MATLABR2013a, SVM is applied in a sensor network environment. Network Throughput (Receiving Packet Rate (RPR)), energy consumption, NL, Normalized Buffer Size, and E2E Delay are the performance evaluation measures. According to simulation findings, the proposed method increases throughput and NL under different traffic conditions whereas reducing energy consumption, packet loss, and E2E delay.

Gherbi et al [18] introduced a Hierarchical Energy-Balancing Multipath routing protocol (HEBM) for energy consumption in WSN. CH are optimally selected and correctly circulated over the area of interest allocated the member nodes success them by sufficient energy dissipation and appropriate load balancing. The performance evaluation metrics are Energy Consumption, NL, Fist Node Die (FND), Last Node Die (LND), Transmission Time, latency per packet, and Average number of clusters. It is simulated using is carried out through NS2 simulator. The proposed protocol is 41.70% when compared to DEEAC algorithm by FND, and 25.50% better than FEMCHRP by LND at the same time as preserving the standard data transmission delay.

3. PROPOSED METHODOLOGY

Priority-based Congestion Trust Aware Energy Efficient Routing Algorithm (PCTA-EERA) is presented using a Chaotic Weight Dragonfly Algorithm (CWDA), and improved fuzzy based trust management. The data transmission has been classified into regular, on-demand, and emergency data for the prioritised routing process. Identifying the nearest nodes is accomplished by neighbour discovery. In clustering, CWDA has been also introduced for Cluster Head (CH). In order to improve the security, malicious nodes are detected by improved fuzzy based trust management. Finally, TDMA scheduling has been introduced for successful packet transmission. The proposed system consists of network model, neighbor discovery phase, cluster formation, CH selection, trust management, Fault tolerant based routing, and Priority-based Congestion control. Figure 2 shows the overall proposed architecture.

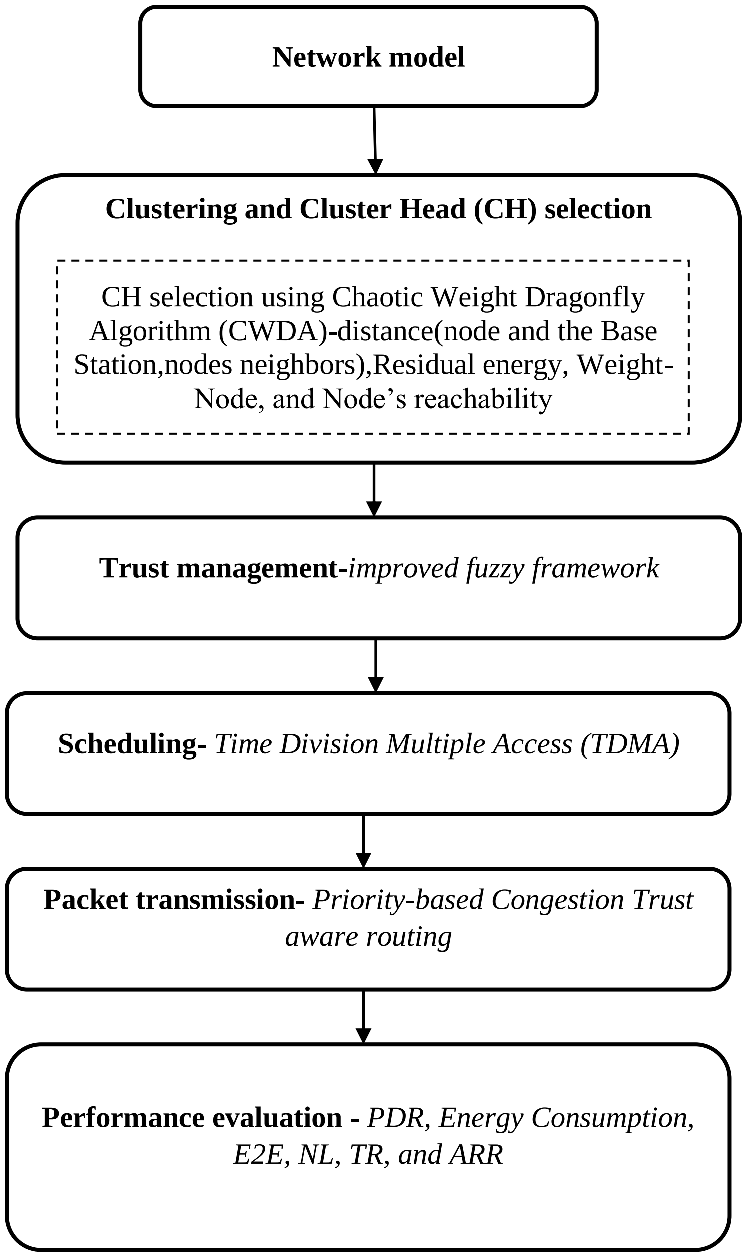

FIGURE 2: FLOW DIAGRAM OF THE PROPOSED WORK

3.1. Network Model

The network's nodes are dispersed throughout a square region, with the sides' lengths denoted by the letter "M". Suppose that every node have sufficient energy for communication mostly with BS as well as being able to accomplish this at diverse power levels. Inside the cluster range of the nodes, each and every one of the nodes might interrelate toward their neighbours in a single hop. It is understood with the purpose of at the beginning of every phase, each and every one nodes synchronized as a minimum. For the sake of simplicity, let's presume with the purpose of certain wireless transmission channel is safe. Assume with the purpose of it network's operational time is divided into rounds toward cluster formation occur at the start of every round and data collection, aggregation, and transmission toward the BS happening each and every one around.

3.2. Neighbor Discovery (ND)

In the initialization stage of WSN, Neighbors Discovery (ND) is crucial. It would be to gather as much data that you can regarding nearby nodes in order to provide self a stable platform for selecting neighbours. To exchange data and notify the chosen neighbours, messages of various types should be exchanged among the discoverer and adjacent nodes. The formation of a neighbour table indicates the end of the neighbourhood discovery. Each node sends a message by a Discov-neigh-msg. A timer called ts-discov is initiated has been discoverer transmits a Discov-neigh-Msg at the beginning broadcast. Once the discoverer has established a neighbour table and has amassed all acknowledgment (ACK) messages, the neighbourhood discovery is completed.

3.3. Cluster Formation and Cluster Head Selection

In this proposed work, distance based clustering is performed for cluster formation. CH selection is done by using Chaotic Weight Dragonfly Algorithm (CWDA). Understood these following equations (1-3) for selecting the CH,

$$\beta_1(i,j) = 1 - \alpha_1\left(1 - \frac{Dis_{BS,i}}{Dis_{BS,j}}\right) \tag{1}$$

where $Dis_{BS,i}$ − the distance among the node "i" to BS, $Dis_{BS,j}$: the distance among the BS to neighbor node "j".

$$\beta_2(i,j) = 1 - \alpha_2\left(1 - \frac{NW_i}{NW_j}\right) \tag{2}$$

here, NW_i-Node-weight of node i, NW_j −Node-weight of neighbor node j.

$$\beta_3(i,j) = 1 - \alpha_3\left(1 - \frac{Er_i}{Er_j}\right) \tag{3}$$

where Er_i-Residual energy of node i, Er_j-Residual energy of neighbor node j . Reachability r(i) of a node i is defined as follows,

$$r(i,j) = \alpha_4 \frac{1}{N\left(\sum_{j=1}^{j=N-1} dis_{ij}\right)} \tag{4}$$

where N is number of nodes, $dis_{ij}$is distance among node i and j. CH is defined as follows,

$$P_{CH}(i,j) = Max\left[1 - \sum_{i,j=1}^{n} \beta_1(\mathrm{i,j}), \beta_2(\mathrm{i,j}), \beta_3(\mathrm{i,j}), r(\mathrm{i,j})\right] \tag{5}$$

$P_{CH}(i,j)$- condition to be CH for node, α_1, α_2, α_3, α_4- constant coefficient 0 or 1.

DA has been developed using two different types of swarming behaviour in dragonflies: migration and hunting [19]. To locate the best CH and hunt preys, a hunting swarm of dragonflies travels in compact groups (clusters) over a constrained area. Dragonflies migrate in long groups in a single direction when they are engaged in a hunting swarm. This behaviour was taken advantage of mimic the clustering's global optimal CH selection [19]. Swarm members generally work together to find CH and to protect themselves from lower nodes. The steps for applying dragonfly insect swarming behaviour are as follows [20],

Separation is a technique that used flying dragonflies to avoid traffic between one another. It can be represented mathematically as an equation (6),

$$S_i = -\sum_{j=1}^{N} X - X_j \tag{6}$$

where X has been denoted as the current search agent, while X_i is represented as the jth neighbor node of CH(X). N has been denoted as the amount of neighbors nodes for packet transmission. Alignment refers to a method that adjusts an individual speed to the confined dragonfly swarm velocity vector. It is expressed by equation (7),

$$A_i = \frac{\sum_{j=1}^{N} V_j}{N} \tag{7}$$

where V_j has been denoted toward the j^{th} neighbor's node velocity vector.

Cohesion is a factor designed for present node position update of explore agents by the purpose of characterizes the need of search agents toward travel to CH. It is able to be specified by equation (8),

$$C_i = \frac{\sum_{j=1}^{N} X_j}{N} - X \tag{8}$$

Attraction indicates the attention of search agents toward travel in way of CH by energy efficient routing. The affinity of i^{th}node in the swarm move towards the energy efficient has been specified by equation (9),

$$F_i = F_{location} - X \tag{9}$$

where $F_{location}$ has been denoted toward the location of CH by energy efficient, and X has been denoted present member (node).

Distraction refers toward mechanism with the purpose of dragonflies goes after toward escape from enemy. The distraction of i^{th} dragonfly is computed by equation (10),

$$E_i = E_{location} - X \tag{10}$$

where $E_{location}$ is denoted as the present node location of the cluster members, and X is the node location of the present CH. To discover the best CH selection, DA describes a location vector and a step vector designed for every search agent in the swarm. The step vector of dragonflies is described as follows [19,20],

$$\Delta X_{t+1} = (sS_i + aA_i + cC_i + fF_i + eE_i) + w\Delta X_t \tag{11}$$

where *s*, *a*, *c*, *f*, and *e* is represented as the weights of separation (S_i), alignment (A_i), cohesion (C_i), attraction (F_i) and distraction (E_i) by i^{th} search agent. *w* is represented as the inertia weight. The obtained step vector (ΔX_{t+1}) by search agent X has been described as follows,

$$X_{t+1} = X_t + \Delta X_{t+1} \tag{12}$$

where *t* is represented as the current iteration. Chaotic map is introduced toward adjust the weight of dragonflies' movements by the optimization toward speed up the convergence rate and obtain enhanced the efficiency of Chaotic Weight Dragonfly Algorithm (CWDA).

Algorithm 1: Pseudocode of Chaotic Weight Dragonfly Algorithm (CWDA)

1. Initialize node locations of each and every one search agents in the swarm X_i(i = 1, 2,..., n)
2. Initialize step vectors of each and every one search agents ΔX_i(i = 1, 2,..., n)
3. While (termination criteria is not reached) do
   3.1. Estimate each and every one dragonflies' fitness by equation (5).
   3.2. Values of (F) and (E) has been updated
   3.3. Weight factors of swarm (i., e., w, s, a, c, f, and e) has been updated
   3.4. Find S, A, C, F, and E by equations (6-10)
   3.5. Step vector of search agent (ΔX_{t+1}) has been updated by equation (11)
4. End while
5. Return the best possible search agent

3.4. Trust management using improved fuzzy framework

The network security is damaged as a consequence of the conduct of malicious nodes. Consequently, the primary objective of this study is to improve network safety by recognizing faulty nodes. Fuzzy based trust management approach is employed for the detection of malicious nodes. The proposed fuzzy method considers the effective transmission rate, transmission time, packet loss ratio, and residual energy as design parameters. After evaluating each node's trust score, a threshold-based decision module is used. In this module, the trust score of nodes is evaluated to the cutoff threshold to assess if the node is malicious or not.

Fuzzy Inference System (FIS): Fuzzification, fuzzy rule base generation, fuzzy inference system, and defuzzification are the four stages which generally make up the fuzzy framework. Parameters are used as input for the fuzzy system toward establishes a trust score for every node (See Figure 3).

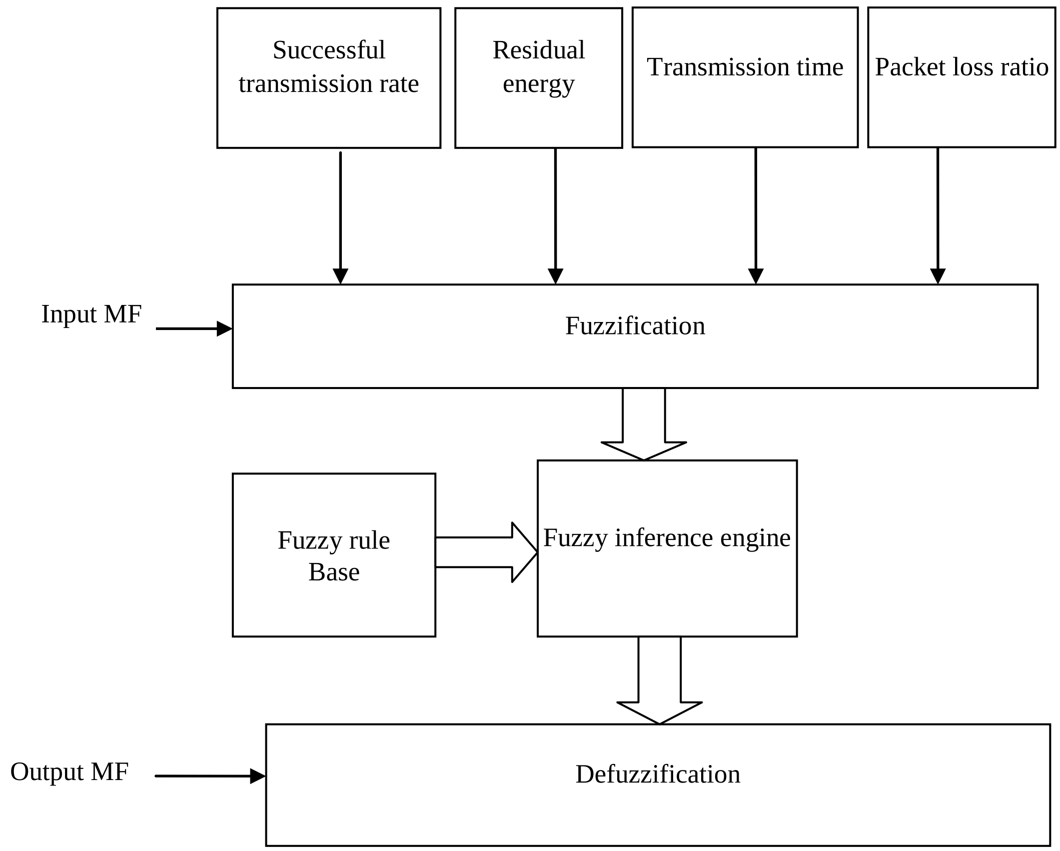

FIGURE 3: IMPROVED FUZZY FRAMEWORK

Fuzzifcation: At this step, input values that really are crisp are represented as fuzzy variables. The fuzzy framework is provided the parameters effective transmission rate, transmission time, residual energy, and packet loss ratio. The degree to which these values belong towards the linguistic membership values (0 and 1) in the supplied fuzzy membership functions is determined by the fuzzification of the input. Table 1 shows the fuzzy membership functions with node parameters as LOW (L), MEDIUM (M), and HIGH (H). Each point in the input space is mapped to a membership among 0 and 1 based on the Membership Function (MF), which is a curve. The Fuzzy model includes mixed triangular and trapezoidal MF to produce the desired results.

Fuzzy rule base generation: The rule design consists of various IF-THEN fuzzy rules. A set of fuzzy implication IF-THEN rules are used to represent the connection among the input and output.

Inference engine: The inference engine extracts the fuzzified inputs and converts these inputs into fuzzy output utilising IF-THEN rules, input and output fuzzy sets, and the fuzzified inputs as inputs. The fuzzy connective operator "AND" is the minimal operator for fuzzy rules that chooses the lower of the two related membership values. The output fuzzy membership function according to the smallest value created by linking the antecedents with such a "AND" is implemented for each rule, which method is the most popular. Each rule individual fuzzy set output is combined into an output fuzzy set to produce the total output.

Defuzzification (D): This stage includes converting a set of fuzzy values into crisp values. The MF of the input and output parameters should be modified for every iteration throughout to modify the fuzzy rule basis. Consequently, selecting the ideal combination of the variables is crucial. The method is appropriate for enhancing the Fuzzy model's default parameters. The methodology improves input values in a triangular form to achieve the desired result. It is essential for enhancing input numbers at the triangular MF.

3.5. Fault Tolerant Routing

Sensor nodes receive a time slot for data transmission through a TDMA schedule that is created by the CH. The control phase and the data phase constitute the TDMA super frame according to the TDMA frame structure model. Transmitting control packets like route request, route reply, and route update packets, utilize the control slots has been used in control phase. In the management phase, every node in the WSN is assigned a control slot. Data bits are transmitted during in the data phase, employing the data slots. When a fault in the system occurs during packet transmission, the algorithm searches for a solution to ensure that communication could indeed continue via the backup nodes. Each network node could indeed instantly communicate with other nodes inside the transmission range. By choosing the backup routes communication is reestablished when faults occur. Identify the suitable node in the cluster in the proposed task. Then choose following possible nodes for packet transmission if the node was previously selected as the CH. Likewise, look up the node state in the memory table; if it's failed, move on to the next node. A separate node can be selected as a backup node.

3.6. Priority-based Congestion Routing (PCR)

In this study, a new approach to preventing congestion in the transmission of key information is proposed that transmits essential packets to the sink by using shortest route possible. It is obvious that choosing the shortest path and changing the packet transmission rate are vital by critical data. To avoid congestion in the source node, the transmission rate must be reduced if the destination node has a high traffic capacity. Each node needs to be knowledgeable of the traffic situation affecting its neighboring nodes. To do this, each node adds its Awareness Information (AI) into the forwarding packets' header and distributes it. The routing paths, transmitted packets length and queue length are estimated by the congestion model. The usual waiting queue duration is set by the network utilization rate (ρ)) is described as follows:

$$QL = \frac{\rho^2}{1-\rho} \tag{13}$$

The queue length has been determined for every one of the data packets together the route for every hop, and the fitness function will employ the sum of all queue lengths. The fitness function might be written using the goal parameters to make it easier. It can be rewritten as follows,

$$f = W_E \times \left|1 - \frac{En_{total}(N_T)}{En_{max}}\right| + W_R \times \prod \left|1 - \frac{LinkR(N_T)}{LinkR_{max}}\right| + W_{PL} \times \left|1 - \frac{PL(N_T)}{PL_{max}}\right| + W_{QL} \times \sum \left|1 - \frac{QL(N_T)}{QL_{max}}\right| \tag{14}$$

where NT is denoted as the amount of nodes N in every iteration at specified time T at the same time as En_{max}, $LinkR_{max}$, $PL_{max}$and $QL_{max}$is denoted as the residual energy, link reliability, path loss and queue length. En_{total} is denoted as the total energy needed toward complete task. $W_E, W_R, W_{PL}, andW_{QL}$ is the node weight of residual energy, link reliability, path loss and queue length. It has been used to proposed algorithm for optimal selection of routes.

Link reliability: Link reliability among two nodes (a and b) ($LinkR_{ab}$), and it is described as follows,

$$LinkR_{a,b} = (1-\gamma)LinkR_{ab} + \gamma \frac{Tp_{succ,ab}}{Tp_{tot,ab}} \tag{15}$$

Here, $Tp_{succ,ab}$is denoted as the total amount of successfully transmitted packets among a and b nodes; γ is represented as the average weighting factor (0.4 for experimentation). $Tp_{tot,ab}$is described as the total amount of packets transmitted among a&b nodes by the numerous transmissions and retransmission for each and every one packets.

Path Loss Model: Measuring the amount of packets dropped throughout a transmission constitutes the way path loss occurs, which reliable data transmission occurs. Friis algorithm is employed for calculating path loss (PL) depending on the d-distance between two communicating nodes. It is described as follows,

$$PL = PL_{d_0} + 10p\log\left(\frac{dis}{dis_0}\right) + X_\sigma \tag{16}$$

Here, p is denoted as the PL exponent, $dis_0$is denoted as the reference distance, $X_\sigma$is denoted as the shadowing factor and $PL_{d_0}$is denoted as the PL in dB by dis_0.

Critical data transmission: The proposed system has to send emergency data in time without delay or packet loss during transmission. By selecting the free of conflict routing routes, this may be achieved. The following equation (17) must be employed to determine the patients' traffic priority so as to achieve this objective.

$$TrafficPriority = \frac{SensorthersholdReadings}{PacketCapacity \times GenerationTime} \tag{17}$$

The paths will be distributed according toward the sensor threshold values, which are able to be either high or low. The generation time specifies the time when the data was created, and it should to enclose a packet size higher than 0. The conflict-free distribution of paths along by resources to sensor nodes becomes achievable by this priority.

4. RESULTS AND DISCUSSION

Simulation results of proposed PCTA-EERA system, and existing methods has been carryout by this section. Once the simulation is starts then comparison has evaluated between methods like Trust Aware Energy Efficient Routing (TAEER), Distributive Energy Efficient Adaptive Clustering (DEEAC) [18], HEBM [18] and Fault Tolerance based Energy Efficient Routing (FTEER) by NS2 simulator. Additionally, employ 2 simulation situations. In the first scenario, 100 nodes are randomly and uniformly distributed throughout a 200 m x 200 m field. In the second case, 200 nodes are equally and randomly placed throughout an area via a size of 200 m x 200 m to investigate the results of methods. The PDR, Energy Consumption, E2E, NL, TR, and ARR performance assessment metrics have been determined.

4.1. Simulation Setup

Simulation parameters used in experimentation is clearly summarized in Table 1.

TABLE 1: SIMULATION PARAMETERS

Parameter	Values
Area	200m×200 m
Data packet size	4000 bits
Control packet size	512 bits
Number of sensor nodes	200
Initial energy	2J
Base station location	(50,50)
Distance d_0	87 m
E_{elec}	50nj/bit
Traffic type	CBR

4.2. Simulation Results

The performance comparison of PDR, Energy Consumption, E2E, NL, TR, and ARR values are clearly described in table 2-7. These six metrics simulation results are clearly plotted in the following figures 4-9.

TABLE 2: PACKET DELIVERY RATIO (PDR) COMPARISON OF ROUTING METHODS

Number of Nodes	Packet Delivery Ratio (PDR) (%)				
	DEEAC	HEBM	FTEER	TAEER	PCTA-EERA
50	55.62	62.49	78.58	84.44	86.15
100	62.18	67.84	80.20	86.56	90.27
150	68.92	73.51	82.45	88.11	92.66
200	74.19	78.70	84.74	90.50	94.15

TABLE 3: ENERGY CONSUMPTION COMPARISON OF ROUTING METHODS

Number of Rounds	Energy Consumption (J)				
	DEEAC	HEBM	FTEER	TAEER	PCTA-EERA
400	1.4539	1.1136	0.7174	0.4243	0.1683
800	1.4818	1.2517	0.7514	0.4592	0.1945
1200	1.5278	1.3572	0.9405	0.7249	0.3172
1600	1.9412	1.7339	1.1959	0.7353	0.4121

TABLE 4: END TO END DELAY (E2E) COMPARISON OF ROUTING METHODS

Number of Nodes	End to End Delay (E2E) (sec)

	DEEAC	HEBM	FTEER	TAEER	PCTA-EERA
50	0.9221	0.7758	0.5279	0.3893	0.1812
100	0.9619	0.8780	0.5672	0.4096	0.2457
150	0.9790	0.9381	0.6783	0.4157	0.2785
200	0.9998	0.9523	0.8584	0.6857	0.5514

TABLE 5: NETWORK LIFETIME (NL) COMPARISON OF ROUTING METHODS

Number of Nodes	Network Lifetime (NL) (rounds)				
	DEEAC	HEBM	FTEER	TAEER	PCTA-EERA
50	125	234	352	395	447
100	147	272	367	404	479
150	178	294	408	439	488
200	200	325	430	460	496

TABLE 6: TRANSMISSION RATE (TR) COMPARISON OF ROUTING METHODS

Number of Rounds	Transmission Rate (TR) (%)				
	DEEAC	HEBM	FTEER	TAEER	PCTA-EERA
400	55.45	60.57	76.42	79.44	86.73
800	57.89	65.82	79.89	83.51	90.42
1200	65.87	72.50	84.67	87.49	93.75
1600	72.50	76.71	87.74	90.58	96.46

TABLE 7: AVERAGE REMAINING ROUND (ARR) COMPARISON OF ROUTING METHODS

Number of Rounds	Average Remaining Round (ARR)				
	DEEAC	HEBM	FTEER	TAEER	PCTA-EERA
400	45	75	120	145	178
800	105	125	175	183	225
1200	155	225	255	278	351
1600	255	290	300	322	370

Packet Delivery Ratio (PDR): PDR is able to be computed as the ratio of total packets delivered by the total packets sent throughout the network about source node to the target node. The objective is for the largest number of data packets feasible to make it at the desired location. It is able to be expressed formally by equation (18),

$$\text{Packet Delivery Ratio (PDR)} = \frac{\sum TotalPacketsReceivedbyalldestinationnode}{\sum TotalPacketsSendbyallsourcenode} \quad (18)$$

Energy Consumption: The amount of energy required for sending or receive a message at a length of one unit over a distance of d. Equation (19) provides the amount of energy required for sending the k-bit messages over the distance d,

$$\mathrm{En_{Tx}}(\mathrm{K,d}) = KEn_{elec} + KEn_{amp}dis^2 \quad (19)$$

En_{elec} is denoted as the energy required for electronic circuits. En_{amp} is denoted as the energy required for amplification of transmitted signals between single and multi path models.

Energy consumption toward receive a packet of K bits, and it is described by Equation (20).

$$\mathrm{En_{Rx}}(\mathrm{K}) = KEn_{elec} \quad (20)$$

En_T is denoted as the total energy dissipated in the WSN throughout a round. It is described by Equation (21),

$$\mathrm{En_T} = \lambda[NEn_{DA} + 2NEn_{elect} + NEn_{fs}dis_{neigh}^2 + En_{amp}dis_{CHtoBS}^4 \quad (21)$$

where En_{DA} is denoted as data aggregation with respect to energy in each node, dis_{CHtoBS} is represented as the average distance among the CH and the BS, dis_{neigh} is denoted as the distance towards the subsequently node in the chain, λ is denoted as the total size of transmitted data, En_{fs} and En_{amp} is denoted as the transmitter amplifier model.

End to End Delay (E2E): E2E delay is described among the time a packet is generated at the sensor toward the time received by the sink. It is described by equation (22),

$$\text{End to End Delay} = \sum_{i=1}^{k} (OneHop_{Delay}(i) + C) \tag{22}$$

$$OneHop_{Delay} = Processing_{Delay} + Queuing_{Delay} + Channel_{Access_{Delay}} + Transmission_{Delay} + Propogation_{Delay} + Reception_{Delay} \tag{23}$$

Network Lifetime (NL): An important determining metric in WSN is network lifetime calculated as the period of time until the initial sensor energy runs out. In a traditional WSN, so every sensor node is set up to send data collected to the sink through the use of multihop communication.

Transmission Rate (TR): The amount of bits which may be transferred in a certain period of time relies on the transmission rate.

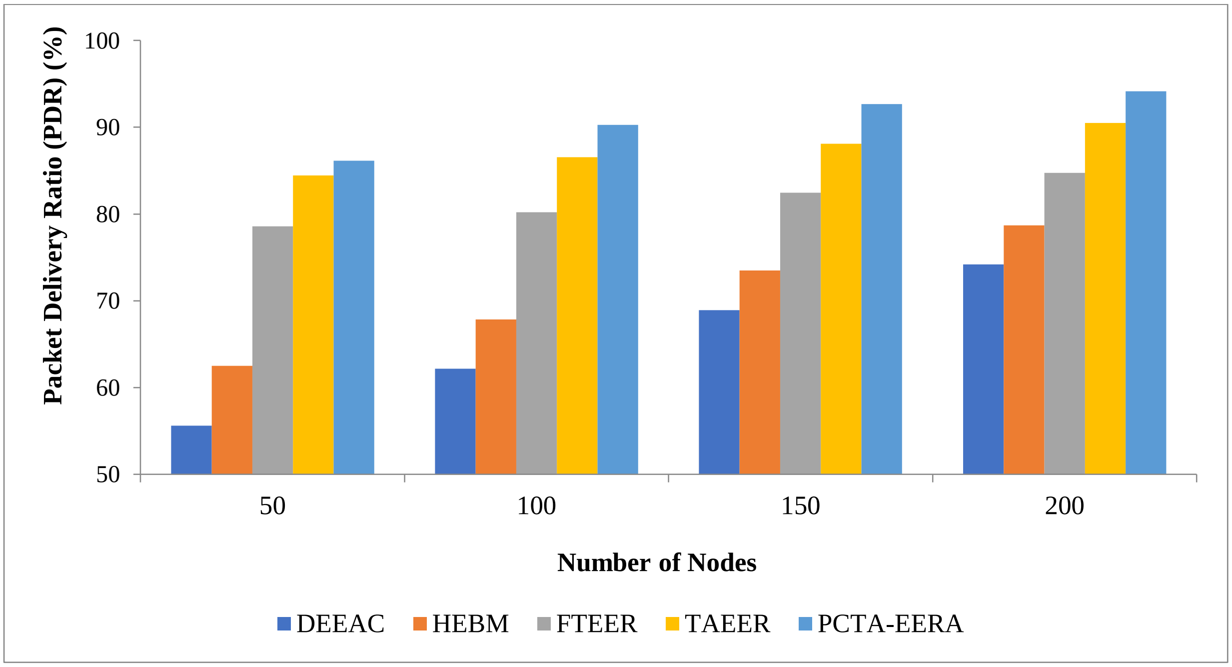

FIGURE 4: PACKET DELIVERY RATIO (PDR) vs ENERGY EFFICIENT ROUTING METHODS

Figure 4 shows the PDR comparison results of the PCTA-EERA and the other routing methods like TAEER, DEEAC, HEBM and FTEER. It shows that the proposed system has higher packet transmission than the existing models. PCTA-EERA approach gives improved PDR of 94.15%, other methods like TAEER, DEEAC, HEBM and FTEER has decreased PDR of 74.19%, 78.70%, 84.74% and 90.50% for 200 nodes. The number of nodes is increased PDR value of methods has been also increased. Table 2 illustrates the PDR results of the methods. The proposed methods have a significantly increased PDR when compared to other existing methods.

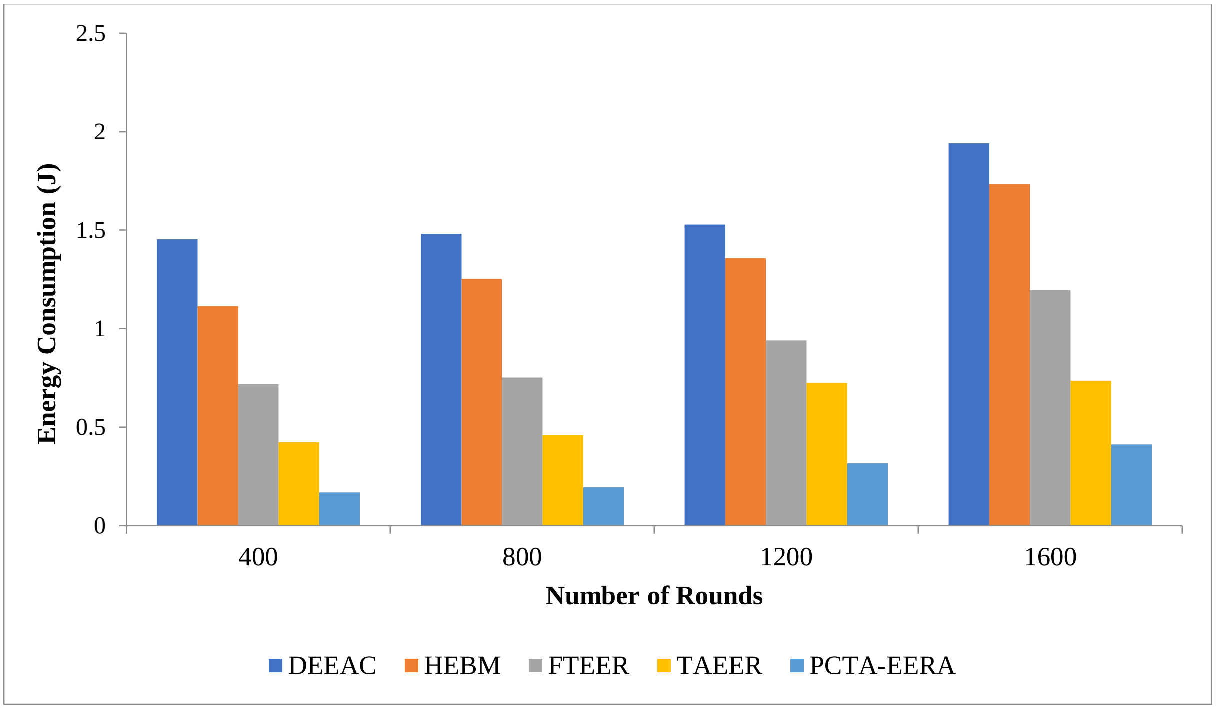

FIGURE 5: ENERGY CONSUMPTION VS. ENERGY EFFICIENT ROUTING METHODS

Figure 5 shows the energy consumption of sensor nodes with respect to TAEER, DEEAC, HEBM, FTEER and PCTA-EERA. Proposed system has lesser energy usage of 0.4121J, other methods like TAEER, DEEAC, HEBM and FTEER has higher energy usage of 1.9412J, 1.7339J, 1.1959J and 0.7353J for 1600 rounds. Table 3 illustrates the energy consumption results of routing protocols. PCTA-EERA makes use of multihop communication by inter-cluster and intra-cluster. It has lesser energy usage than the other routing protocols.

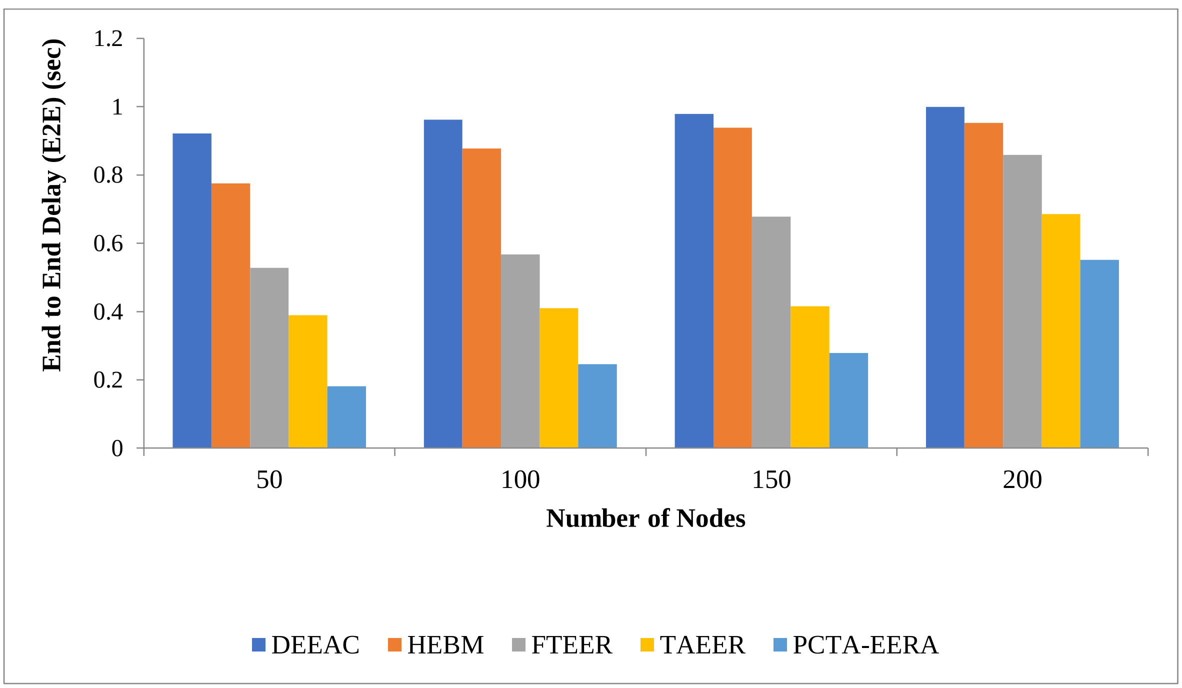

FIGURE 6: END TO END DELAY (E2E) VS. ENERGY EFFICIENT ROUTING METHODS

Figure 6 shows the E2E results of the PCTA-EERA and the existing routing methods like TAEER, DEEAC, HEBM and FTEER. E2E of proposed system is 0.5514 seconds, other methods like TAEER, DEEAC, HEBM and FTEER has increased E2E of 0.9998 seconds, 0.9523 seconds, 0.8584 seconds, and 0.6857 seconds for 200 nodes. The no. of nodes is increased E2E value of methods has been also increased. Table 4 illustrates the E2E results of the routing protocols.

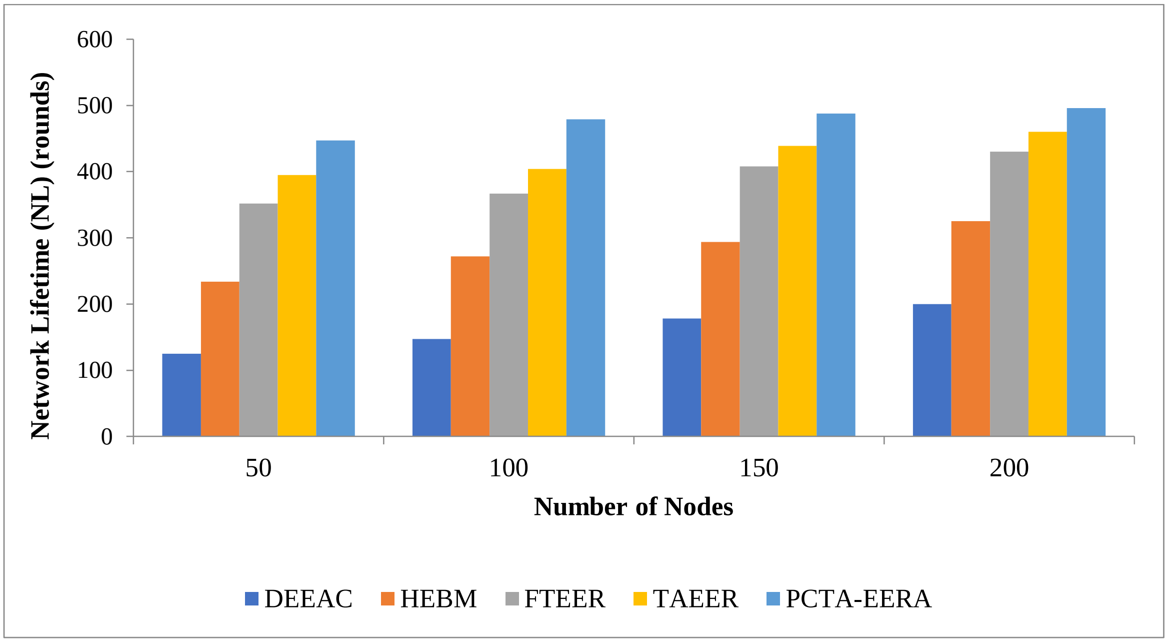

FIGURE 7: NETWORK LIFETIME (NL) VS. ENERGY EFFICIENT ROUTING METHODS

Figure 7 shows the NL results of the routing methods. It shows that the proposed protocol has a longer NL than other methods due to correct toward its energy preservation and smaller loss of packet transmission. Proposed approach has a higher NL of 496 rounds, other approaches like TAEER, DEEAC, HEBM and FTEER achieves lowest value 200 rounds, 325 rounds, 430 rounds and 460 rounds for 200 nodes. The number of nodes is increased; NL value is also increased. Table 5 illustrates the NL results of the routing protocols. The proposed methods have a considerably good NL compared to others.

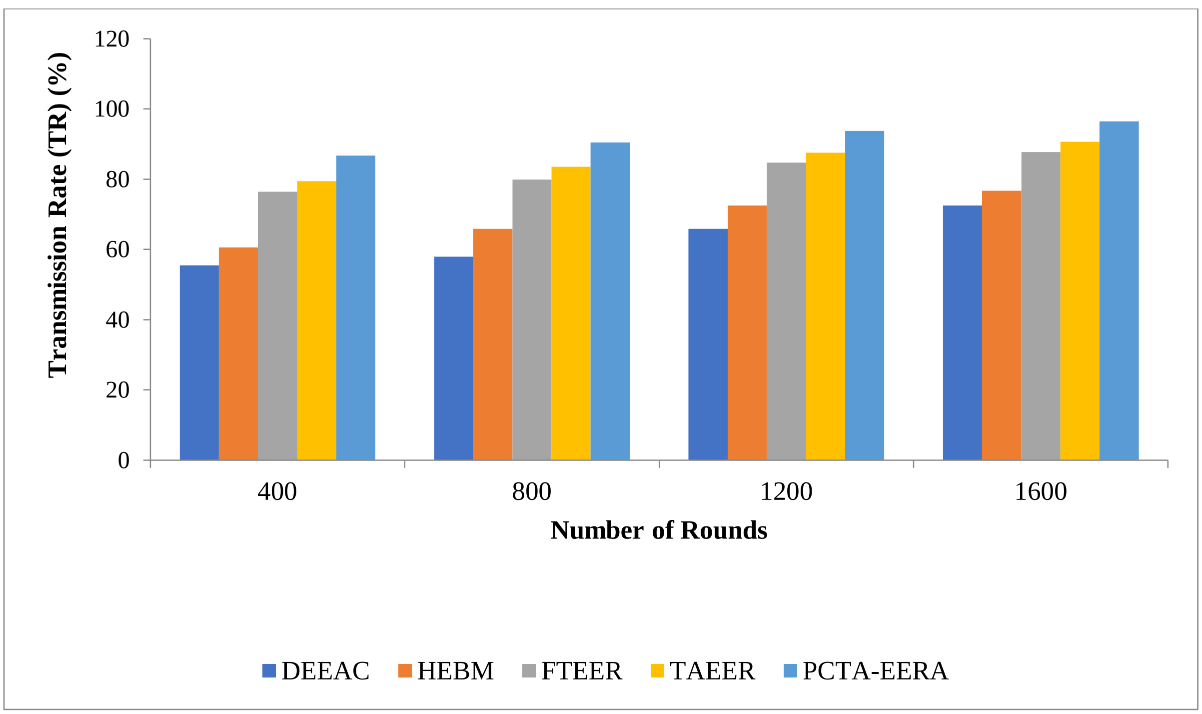

FIGURE 8: TRANSMISSION RATE (TR) VS. ENERGY EFFICIENT ROUTING METHODS

Figure 8 shows the results of PCTA-EERA and the routing models like TAEER, DEEAC, HEBM and FTEER in terms of TR. Proposed system has higher TR of 96.46%, other methods like TAEER, DEEAC, HEBM and FTEER achieve lowest value 72.50%, 76.71%, 87.74% and 90.58% for 1600 rounds (See Table 6). The number of rounds is increased; TR value is also increased.

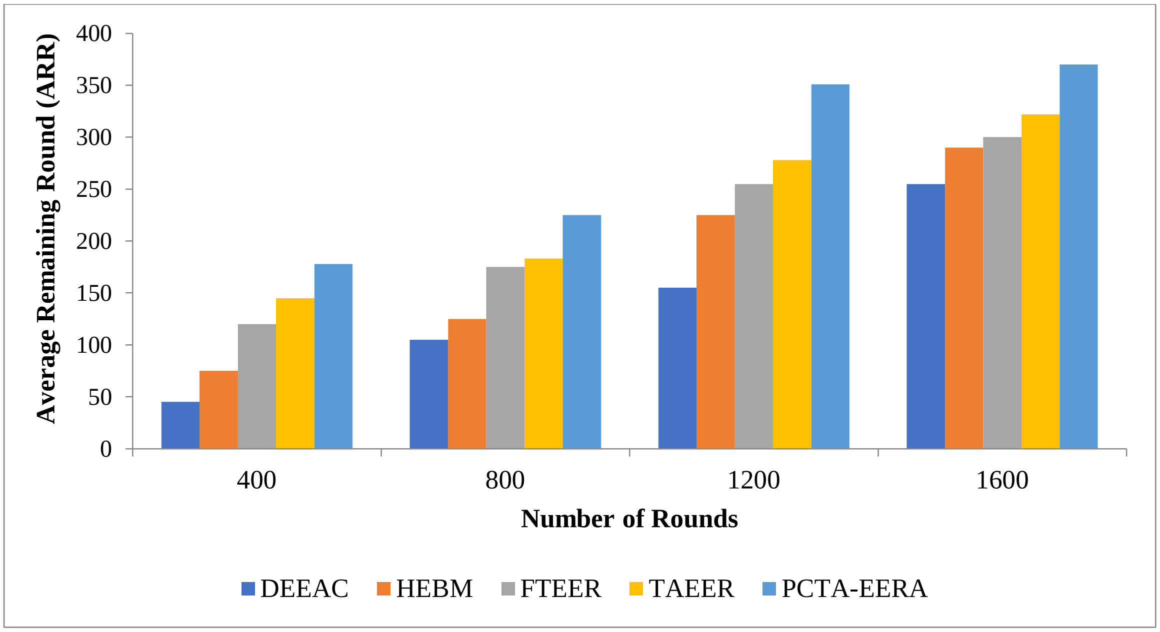

FIGURE 9: AVERAGE REMAINING ROUND (ARR) VS. ENERGY EFFICIENT ROUTING METHODS

Figure 9 shows the results of PCTA-EERA and the existing routing models like TAEER, DEEAC, HEBM and FTEER in term of ARR. It has an increase proposed approach in ARR which is 370, where as other existing approaches TAEER, DEEAC, HEBM and FTEER achieve lowest value 255,290,300 and 322 for 1600 rounds. The number of rounds is increased; ARR value is also increased. Table 7 illustrates the ARR results of the proposed PCTA-EERA and other existing routing protocols are TAEER, DEEAC, HEBM and FTEER. The proposed methods have a considerably good ARR compared to others.

5. CONLUSION AND FUTURE WORK

Numerous factors which include failure packet delivery to the receiver, network congestion, packet retransmission, delay in packet delivery to the sink, poor received signal intensity, among others help to higher consumption of energy. A Priority-based Congestion Trust Aware Energy Efficient Routing (PCTA-EERA) Algorithm is described using an improved fuzzy based trust management system and the Chaotic Weight Dragonfly Algorithm (CWDA). The PCTA-EERA study provides a congestion management protocol and divides the data into two groups: 1) critical data 2) non-critical data. CWDA optimized algorithm has been introduced for route optimization and congestion management has been also performed depending on the nodes' energy, distance, queue length, link reliability, and path loss while selecting the forwarding node. During this procedure, every node attaches it's AI in the header of the forwarding packets consequently precedes in the direction of broadcast data. The malicious nodes are identified via improved fuzzy based confidence management, which improves network security. Fault-tolerant routing and TDMA-based scheduling is proposed for effective packet transmission. Proposed approach works gives improved results in terms of PDR, Energy Consumption, E2E, NL, TR, and ARR. Additionally; attempt to improve the proposed technique by building a precise formula for queuing priority using a simple linear function.

REFERENCES

1. Jawhar, I., Mohamed, N., Al-Jaroodi, J. and Zhang, S. A framework for using unmanned aerial vehicles for data collection in linear wireless sensor networks. Journal of Intelligent & Robotic Systems, Vol.74, Pp.437-453, 2014.
2. Zivkovic, M., Bacanin, N., Zivkovic, T., Strumberger, I., Tuba, E. and Tuba, M. Enhanced grey wolf algorithm for energy efficient wireless sensor networks. Zooming innovation in consumer technologies conference (ZINC), Pp.87-92, 2020.

3. Mohanty, S.N., Lydia, E.L., Elhoseny, M., Al Otaibi, M.M.G. and Shankar, K. Deep learning with LSTM based distributed data mining model for energy efficient wireless sensor networks. Physical Communication, Vol.40, Pp.1-27, 2020.
4. Zhang, P., Xiao, G. and Tan, H.P. Clustering algorithms for maximizing the lifetime of wireless sensor networks with energy-harvesting sensors. Computer Networks, Vol.57, No.14, Pp.2689-2704, 2013.
5. Wang, T., Zhang, G., Yang, X. and Vajdi, A. Genetic algorithm for energy-efficient clustering and routing in wireless sensor networks. Journal of Systems and Software, Vol.146, Pp.196-214, 2018.
6. Shokouhifar, M. and Jalali, A. A new evolutionary based application specific routing protocol for clustered wireless sensor networks. AEU-International Journal of Electronics and Communications, Vol.69, No.1, Pp.432-441, 2015.
7. Jassbi, S.J. and Moridi, E. Fault tolerance and energy efficient clustering algorithm in wireless sensor networks: FTEC. Wireless Personal Communications, Vol.107, No.1, Pp.373-391, 2019.
8. Gong, P., Chen, T.M. and Xu, Q. ETARP: An energy efficient trust-aware routing protocol for wireless sensor networks. Journal of Sensors, Pp.1-10, 2015.
9. Liu, Y., Liu, A., Zhang, N., Liu, X., Ma, M. and Hu, Y. DDC: Dynamic duty cycle for improving delay and energy efficiency in wireless sensor networks. Journal of Network and Computer Applications, Vol.131, Pp.16-27, 2019.
10. Mostafaei, H. Energy-efficient algorithm for reliable routing of wireless sensor networks. IEEE Transactions on Industrial Electronics, Vol.66, No.7, Pp.5567-5575, 2018.
11. Rana, S., Bahar, A.N., Islam, N. and Islam, J. Fuzzy based energy efficient multiple cluster head selection routing protocol for wireless sensor networks. International Journal of Computer Network and Information Security, Vol.7, No.4, Pp.54-61, 2015.
12. Yi, D. and Yang, H. HEER–A delay-aware and energy-efficient routing protocol for wireless sensor networks. Computer Networks, Vol.104, Pp.155-173, 2016.
13. Wang, Z., Ding, H., Li, B., Bao, L. and Yang, Z. An energy efficient routing protocol based on improved artificial bee colony algorithm for wireless sensor networks. IEEE Access, Vol.8, Pp.133577-133596, 2020.
14. Ding, W., Tang, L. and Ji, S. Optimizing routing based on congestion control for wireless sensor networks. Wireless Networks, Vol.22, Pp.915-925, 2016.
15. Jan, M.A., Nanda, P., He, X. and Liu, R.P. PASCCC: Priority-based application-specific congestion control clustering protocol. Computer networks, Vol.74, Pp.92-102, 2014.
16. Gholipour, M., Haghighat, A.T. and Meybodi, M.R. Hop-by-hop traffic-aware routing to congestion control in wireless sensor networks. EURASIP Journal on Wireless Communications and Networking, Pp.1-13, 2015.
17. Gholipour, M., Haghighat, A.T. and Meybodi, M.R. Hop-by-Hop Congestion Avoidance in wireless sensor networks based on genetic support vector machine. Neurocomputing, Vol.223, Pp.63-76, 2017.
18. Gherbi, C., Aliouat, Z. and Benmohammed, M. An adaptive clustering approach to dynamic load balancing and energy efficiency in wireless sensor networks. Energy, Vol.114, Pp.647-662, 2016.
19. Song, J. and Li, S., 2017, Elite opposition learning and exponential function steps-based dragonfly algorithm for global optimization. In 2017 IEEE International Conference on Information and Automation (ICIA), pp. 1178-1183.
20. Elhariri, E., El-Bendary, N. and Hassanien, A.E., 2016, Bio-inspired optimization for feature set dimensionality reduction. In 2016 3rd International Conference on Advances in Computational Tools for Engineering Applications (ACTEA), pp. 184-189.