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A Novel Energy Aware Clustering Mechanism with Fuzzy Logic in MANET Environment

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Abstract
A Mobile Ad Hoc Networks (MANETs) comprises of the vast range of devices such as sensors, smart phones, laptops and other mobile devices that connect with each other across wireless networks and collaborate in a dispersed fashion to offer network functions in the absence of a permanent infrastructure. The Cluster Head (CH) selection in a clustered MANET is still crucial for lowering each node's energy consumption and increasing the network's lifetime. However, in existing clustering mechanism trust of the all nodes are presumed those causes increased challenge in the MANET environment. Security is a crucial factor when constructing ad-hoc networks. In a MANET, energy consumption in route optimization is dependent on network resilience and connectivity. The primary objective of this study is to design a reliable clustering mechanism for MANETs that takes energy efficiency into account. For trusted energy-efficient CH in the nodes, a safe clustering strategy integrating energy-efficient and fuzzy logic based energy clustering is proposed to address security problems brought about by malicious nodes and to pick a trustworthy node as CH. To improve the problem findings Bat algorithm (BAT) is integrated with Particle Swarm Optimization (PSO). The PSO technique is inspired because it imitates the sociological characteristics of the flock of the birds through random population. The BAT is a metaheuristic algorithm inspired by microbat echolocation behavior that uses pulse average with global optimization of the average path in the network. Hybrid Particle Swarm Optimization (HPSO) and BAT techniques are applied to identify the best route between the source and destination. According to the simulation results, the suggested Fuzzy logic Particle Swarm Optimization BAT (FLPSO-BAT) technique has a minimum latency of 0.0019 milliseconds, with energy consumption value of 0.09 millijoules, maximal throughput of 0.76 bits per sec and detection rate of 90.5% without packet dropping attack.

Keywords: - MANET, cluster head, particle swarm optimization, trust stage, trust threshold.

I. INTRODUCTION

A Mobile Ad Hoc Network (MANET) is self-configured network for establishment of the mobile router those are linked towards wireless network those without access point [1]. The each mobile device is self-constrained and free of gadgets and arrange in the manner in consideration point of view. The MANET's nodes share the network structure and medium for wireless communication varies irregularly and dynamically [2]. Because nodes in a MANET are allowed to migrate to any location, communication links are often broken. The MANET applications decide the number of nodes and density of nodes [3]. MANET has led to new scenario for the wireless sensor communication to withstand data and device network [4].

There are still some design flaws and obstacles to address with many applications. The movement of the nodes exhausts the remaining energy to a great amount due to their dynamic nature. Furthermore, reduced energy dissipation in the network increases the lifetime of the nodes and, as a consequence, the network's lifespan [5]. When a link between nodes fails, energy is squandered needlessly. Because it is necessary to attain greater throughput by prolonging the nodes' lifetime in terms of residual energy, this energy consumption has an influence on network performance. Therefore, we propose a solution for prolonging the network's lifetime by reducing routing energy usage [6]. To extend the network's lifetime, the mobile nodes may be aggregated into clusters, which is a viable technique for improving network stability and scalability.

The procedure of electing a cluster head (CH) is to choose a node inside the cluster to serve as the cluster's leader. The Cluster Head is in charge of the cluster's information. This data provides a list of the cluster's nodes as well as the route to each of them [7]. The CH's job is to communicate with all of the cluster's nodes. CH, on the other hand, must be able to connect with nodes from other clusters, either directly or via the relevant CH or gateways. In this paper, a cluster-based routing scheme for MANET is suggested in order to increase network longevity [8].The availability of MANETs, which have each node serving as a router and a constantly changing topology, is not always guaranteed. The route between two nodes is likewise not guaranteed to be free of malicious nodes. Wireless connections between nodes are very vulnerable to link assaults. In MANETs, resource constraints may have an impact on security quality [9]. It is necessary to execute certain encryption and decryption operations while doing excessive calculations. The vulnerabilities and characteristics support the development of a security solution that includes authentication, confidentiality, integrity, non-repudiation, and availability.

To do this, we will need a method that ensures security at each tier of the protocol. To circumvent the limitations of single route routing, multipath routing systems have been created in recent years. There are various pathways between a source and a destination. Multipath techniques provide various advantages, including better bandwidth usage, reduced end-to-end latency, faster throughput, and longer network life. In addition, it has the capability of load balancing traffic by routing it across several pathways. It reduces network congestion and provides route failure prevention [10].To reduce energy consumption, a clustering concept with CH selection is still a critical method to extend the network's lifespan. In addition, the trustworthiness of the nodes in ad hoc is an important issue for security. When designing ad-hoc networks, security is a major consideration. Consuming energy in route optimization is dependent on network resilience and connectivity in a MANET. The primary objective of this study is to design a safe and efficient method of clustering MANETs to conserve energy. To address the security issues caused by hostile nodes and ensure that only a reliable node is chosen as CH, a trust-based energy-efficient technique based on the integration of fuzzy logic clustering was developed. To identify the optimal problem with identification of best solution Bat algorithm (BAT) is integrated with Particle Swarm Optimization (PSO).

The remainder of this paper will be organized in the following manner: Section II begins with a discussion of similar works. Section III defines the suggested novel fuzzy logic-based energy-aware secure clustering. Section IV discourse the simulation results. Section V presented the overall conclusion of the developed scheme.

II. RELATED WORKS

MANETs have a wide range of applications, including military applications, temperature sensor units, transportation and industrial sectors, health monitoring systems, and smart agriculture. The MANET has grown so widely utilized in recent years that it is now vital to offer secure and reliable efficient communication between the nodes in the network even when they are not physically linked. Because of the large amounts of data generated by business customers, energy economy and network optimization are becoming more important. The consumption of network bandwidth has increased in tandem.

N. Veeraiah *et al*. [11] constructed a hybrid model for trust based security scheme for cat slap single algorithm for improving routing in MANET. Initially, clustering with fuzzy is enables and CH is selected under direct, indirect and recent trust scheme. Value nodes were located using trust thresholds. The suggested hybrid protocol determines the optimum paths depending on latency, performance, and connectivity within this route. K. Vinoth Kumar *et al*. [12] offered a WSN security scheme for Data Aware Routing Protocol is a unique approach for high data collecting that achieves a balance between energy and security schemes. The proposed method's security model has two stages: Optimal Cluster Head (OCH), which monitors the behavior of the Cluster Head and cluster members. The second step improves the security-based energy-efficient model by encrypting and decrypting energy measurements. Energy Efficient Clustering with Secure Routing Protocol (EECSRP) in MANET was proposed by M.Selvakumar et al. [13] using hybrid evolutionary algorithms (EAs). The EECSRP method groups nodes together and selects optimal routes to ensure data is transmitted between them in a reliable and low-power manner. The EECSRP approach is divided into two parts. The cluster head selection and cluster assembly procedure are carried out in the first stage, employing the niche mechanism and the monarch butterfly optimization method. Following that, in the second step, β-hill climbing based on the grasshopper optimization algorithm is implemented for identification of the best path within the MANET.

There are two phases to the suggested routing protocol, which was introduced by K.Karthick et al. [14] as a mobility-aware routing protocol for MANET employing a hybrid optimization (MARP-HO) algorithm to improve the quality of data broadcasting. The clustering procedure consists of two stages: creating clusters and choosing a cluster leader. To begin, we perform energy-efficient clustering with the help of the improved animal migration optimization (IAMO) method. Then, we get numerous restrictions from each cluster member, including their energy usage, received signal strength, mobility, and cooperation level. As a result of the obtained constraints, the node costs of all cluster members were determined, with the node with the highest cost being designated as the CH. Second, we apply the IACO method (improved ant colony optimization) to determine the best route between two points. Abdali T-AN *et al.* [15] introduced an energy-aware location-aided routing (EALAR) based on the effective ad hoc network system with routing developed through integration of the particle swarm optimization (PSO) and mutation process into the traditional location-aided routing (LAR) protocol. All essential performance indicators based on consideration of packet delivery ratio (PDR), overhead, end-to-end latency and energy consumption, to improve routing protocol performance.

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Quy Vu Khanh & Le Anh Ngoc [16] proposed an approach for low-energy routing integrated with the routing metric for estimation of hop count and energy of the nodes, measurements to determine an appropriate path. Simulation findings reveal that compared to current protocols, the proposed protocol improves network longevity and performance.U. Srilakshmi [17] proposed Genetic Algorithm with Hill Climbing (GAHC). Finding the optimum multipath route using a GA-Hill Climbing algorithm. The modified fuzzy C-means method used density peak to choose cluster heads (CHs) based on consideration of recent, direct and indirect trust values. In addition, the calculation assumes the trust nodes are computed based on threshold value of nodes. However, the anticipated hybrid protocol features through aggregation for estimation of connection, latency and throughput determine the optimum route.

Energy aware on demand routing protocol for MANETs was proposed by R. Prasad and P. S. Shankar [18]. The protocol provides a cost-effective means of routing packets across a MANET, with the potential to extend the network's useful life under certain routing conditions. Energy efficient routing in a MANET simply builds paths among the mobile nodes and protocol activities so long as there is power in the network. When a mobile node goes into sleep mode, the protocol lowers or turns off its transmit and receive power. Simultaneously, it monitors the network possible communication medium. Jubair, M.A. *et al.* [19] proposed a new bat optimized link state routing protocols to increase the MANET's energy efficiency. In both the MANET optimized link state routing (OLSR) and the BAT, signal transmission and reception are used to identify the path. These similarities led to the development of BOLSR, which estimates the best route between two nodes based on their energy dynamics. The technique should focus on routing security. S Alghamdi *et al.* [20] proposed a meta-heuristic-based optimal load-balancing energy-efficient routing protocol based on cuckoo search. Based on each node's remaining energy, the proposed protocol uses cuckoo search to find the most efficient route. Ad hoc load balancing of the Multipath Distance Vector protocol and the Ant Hoc Net routing protocol were all examined and compared in terms of their energy-conscious modifications. The emphasis of this strategy should be on energy efficiency. Table 1 shows the summary of the existing works.

Table 1. Summary of existing approaches

References No	Published Year	Methodology name	Benefits	Difficulties
[11]	2021	Hybrid fuzzy clustering, cat slap single-player algorithm (C-SSA).	Provide secure energy efficient routing	Delay at cluster head selection
[12]	2020	Security based Data Aware Routing Protocol (SDARP)	Secure energy efficient routing	Energy issues
[13]	2021	Energy-efficient clustering with secure routing protocol (EECSRP) with hybrid evolutionary methods (EAs)	Provide secure energy efficient routing	Need to focus on more no of attacks
[14]	2021	MANET hybrid optimization mobility aware routing protocol (MARP-HO).	Energy saving	Security issues
[15]	2020	Energy-aware location-aided routing (EALAR)	Energy efficiency	Need to focus on attacks
[16]	2021	A saving energy routing protocol	Less energy consumption routing	Security issues
[17]	2021	Genetic Algorithm with Hill climbing (GAHC) protocol	Provide energy efficient routing	Need to focus on more security attacks
[18]	2020	The protocol for demand with the energy aware routing	Energy efficient routing	Security
[19]	2019	BOLSR, a new protocol,	Provide energy efficient routing	Security issues in routing
[20]	2021	For optimal load balancing and energy efficiency, a meta-heuristic-based cuckoo search is implemented.	Energy efficient multipath routing	Security

In contrast to earlier work, we suggested an optimized energy-aware secure clustering protocol. This research uses a fuzzy inference approach for energy-efficient and secure clustering. PSO defined as the optimization technique for estimation of the particles swarm inspired value for flocking and behavior of birds. It finds the optimum answer by moving across an N-dimensional search space. The BAT Algorithm is one of the optimizations and arithmetic intelligence algorithms. This work is based on a theory inspired by microbat echolocation behavior. Hybrid Particle Swarm Optimization (HPSO) and BAT ideas are applied to identify the best route between the source and destination.

III.THE PROPOSED SECURE OPTIMIZATION ROUTING ALGORITHM

The major aim this paper is to improve the routing and security in the communication with improved energy efficiency. Additionally, this paper concentrated in the improving the lifetime of the network. Through fuzzy interface system, clustering and energy efficiency is estimated based on the fuzzy set theory for input and output. This paper suggests choosing the network's most energy-efficient and trustworthy node as the CH. The cluster head voting procedure continues based on trust mark and behavior analysis. PSO is an optimization approach inspired by flocking bird behavior. It searches an N-dimensional search space for the best answer. Each swarm particle has two values: its current position and its velocity. Particle movement is calculated using these values, and then added to the previous position. The particle has memory and can recall its optimal place. The PSO found the global best value by monitoring each particle's best value and location.

The BAT Algorithm is one of the optimizations and arithmetic intelligence algorithms. This program is based on a theory inspired by microbat echolocation behavior. To find the swarm's frequency, speed, and position, the method uses the provided dimension of the search space. The location represents the issue's solution vector. During the repeated search process, the best options are saved. The HPSO and BAT concepts are applied to identify the best route between the source and destination. Figure 1 shows the proposed FLPSO-BAT method architecture.

A) CLUSTER HEAD ELECTION PROCESS

The set-up and steady state stages of the CH selection process are the two key phases [21]. The cluster formation process takes into consideration of two parameters such as density and residual energy of the nodes. The clustering will occur in iterations, as in the traditional Leach method. The clustering idea comprises two phases: an energy-efficient and cluster head election based on security procedure and the cluster is formulated. According to this plan [22–24], the most power-efficient and safest network node will be elected as CH. Because of this, the CH election process proceeds on the basis of the evaluated trust mark and behavior analysis.

1) TRUST MARK CALCULATION

This section defines the nodes trust value calculations by evaluating the trust stage1 and trust stage2 .by using these two stages we can find the final trustworthiness of the nodes. The total number of packets received acknowledgment from destination node compared to total number of packets sent from source node in trust stage 1.

$$\text{Trust}_{\text{stage 1}} = \frac{\text{The number of packets that have received acknowledgements}}{\text{The number of packets sent}} \times 100 \quad (1)$$

Equation 2 is used to calculate the second trust stage based on the rejected packets.

$$\text{Trust}_{\text{stage 2}} = 100 - \left(\left(\frac{\text{The number of packets rejected by the nodes}}{\text{Total number of packets rejected by the network}}\right)\right) * 100 \quad (2)$$

Finally, equation 3 is used to determine the overall trustworthiness of each node.

$$\text{Total trustworthiness} = \frac{\text{Trust stage1}}{\text{Trust stage 2}} \quad (3)$$

2) DETECTING AND REMOVING MALICIOUS NODES FROM THE NETWORK

Equation 4 is used to calculate the Trust $_{\text{Threshold}}$ based on the total trust mark's mean value.

$$\text{Trust}_{\text{Threshold}} = \sum_{i=1}^{n} \frac{\text{Overall\_Trust\_Level}}{n} \quad (4)$$

Equation 5 is used to determine the Selection_Mark for routing nodes in the process.

$$\text{Selection\_Mark} = \frac{(\text{W1Xoverall\_Trust\_Level} + \text{W2XREL})}{(\text{W1} + \text{W2})} \quad (5)$$

Where, residual energy of the nodes is defined as REL.

level w1+w2=1

If the node's measured choice level is less than or equal to the Trust$_{\text{Threshold}}$, the node is either considers malicious or normal nodes. Otherwise, the node is considered as the trustable node for estimation of the CH in the function if the node's measured choice level is greater than the Trust$_{\text{Threshold}}$.

B) FORMATION OF CLUSTERS USING A FUZZY-BASED PROCESS

This section discusses the method of forming fuzzy clusters

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based on fuzziness [25]. After the FIS has been applied, the nodes involved in the identification for discover and connect with the most appropriate CH by evaluating the member based on election of CH. Cluster density and the energy level of the CH are two characteristics that will be used by the member nodes in this work to choose which CH is most suited for their needs. Figure 2 depicts a system diagram of the Fuzzy based clustering work, which is comprised of the following components:

1) FINDING A CH DEGREE

A cluster load or cluster density is defined as the member node number in a cluster. Therefore, cluster density is one of the most crucial metrics for balancing workloads inside a cluster. The equation (6) is used to calculate the CH degree.

$$\text{CH degree} = \frac{\text{Number of nodes in the clusters}}{\text{total number of nodes in the network}} \quad (6)$$

2) ENERGY MODEL

The energy model that we employed in our investigate is similar to [5] and is described in (7) and (8). The electronic energy, free space energy, and multipath energy are denoted by the symbols Eelec, εfs, and εmp, respectively. The following is the amount of transmission energy necessary to send a l-bit message across a distance d:

$$E_T(l,d) = \begin{cases} lE_{\text{elec}} + l\varepsilon_{\text{fs}}\, d^2 \text{ ford } < d_0 \\ lE_{\text{elec}} + l\varepsilon_{mp} d^4 \text{ ford } \geq d_0 \end{cases}$$
(7)

The needed reception energy for a l-bit message is provided in Equation (8).

$$E_R(l) = lE_{\text{elec}} \quad (8)$$

3) FUZZY MEMBERSHIP FUNCTIONS

In fuzzy membership function based on the triangular and trapezoidal membership functions from [26-27] that are employed in the FIS to display input parameters are provided in Equations (9) and (10) respectively.

$$\mu_{A1}(x) = \begin{cases} \frac{0}{x-a1} & x \leq a1 \\ \frac{b-a1}{b_1-a_1} & a1 \leq x \leq b1 \\ \frac{c1-x}{c1-b_1} & b1 \leq x \leq c1 \\ 0 & c1 \leq x \end{cases} \quad (9)$$

$$\boldsymbol{\mu_{A1}(x)} = \begin{cases} \mathbf{0}, \boldsymbol{x \leq a2} \\ \frac{\boldsymbol{d2-x}}{\boldsymbol{d2-c2}}, \boldsymbol{c2 \leq x \leq d2} \\ \mathbf{1}, \boldsymbol{b2 \leq x \leq c2} \\ \frac{\boldsymbol{d2-x}}{\boldsymbol{d2-c2}}, \boldsymbol{c2 \leq x \leq d2} \\ \mathbf{0}, \boldsymbol{d2 \leq x} \end{cases} \quad (10)$$

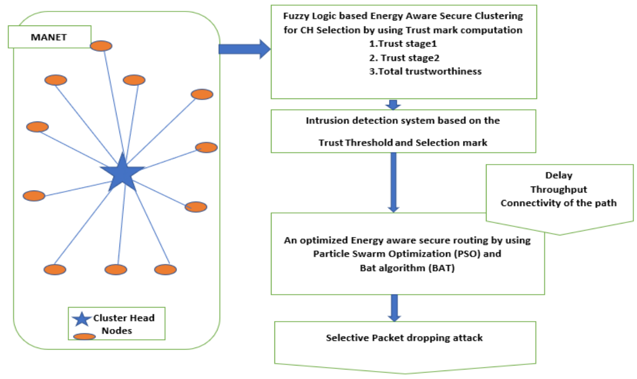

FIGURE 1. The proposed FLPSO-BAT method architecture

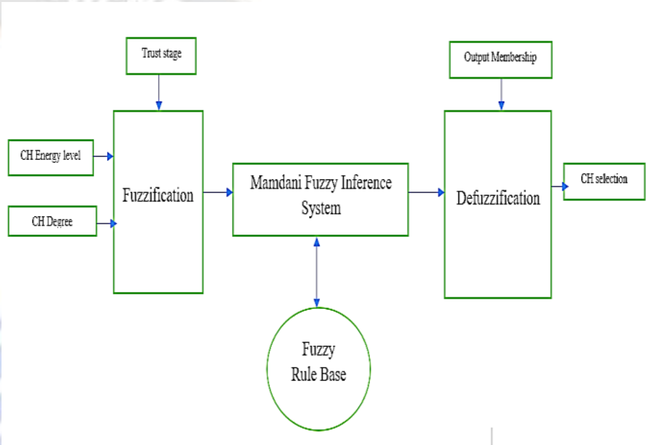

FIGURE 2. Fuzzy-based clustering architecture

4) FUZZY RULES

The Mamdani Fuzzy inference system is used in this work. In general terms, Mamdani FIS is more extensively used, mostly because it produces acceptable results with a very basic structure and the rule base is straightforward and interpretable, which contributes to its widespread usage. It is necessary to employ two input variables, each of which has three levels. The fuzzy input variables are described in detail in Table 2.

TABLE 2. Different parameters and stages

Parameters	Stages
CH energy level	Low medium and high
CH degree	low, medium and high
Trust stage	Low medium and high

As a result, fuzzy if-then rules are used to calculate the potential member selection values for a total of 3^2 =9.

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There are nine degrees of output variable for the member CH selection, including very weak, weak, medium, high medium,

strong, and very strong. In order to describe the steps of CH selection, triangular and trapezoidal functions are utilized. Table 3 contains a list of the fuzzy if-then rules that are employed in our system.

TABLE 3. The Fuzzy "if-then" rules

Fuzzy Set Rules
Case 1: if (CH low energy level of the nodes) and (CH higher degree) and (low trust stage) then (CH selection is weak)
Case 2: if (CH high energy level) and (CH lower degree) and (high trust stage) then (CH selection is denoted as strong)
Case 3: if (high CH energy level) and (medium CH degree) and (High trust stage) then (CH selection is medium)

This work makes use of the model developed for the Mamdani inference system. In addition, equation describes the Center of Area (COA) method (11).

$$\text{COA} = \frac{\int \mu_A(x) \cdot x dx}{\int \mu_A(x) dx} \tag{11}$$

C) HYBRID PSO AND BAT

1) THE PSO ALGORITHM

PSO is a population randomness-based optimization technique [28]. Kennedy and Eberhart initially introduced PSO, beginning with a collection of random solutions (particles). The value of the cost function measured at the particle's position is optimized. Each particle develops in the search space numerous times, trying to find a better solution

$$vk(j+1) = wvk(j) + s1n1[\text{ P bestk } - xk(j)] + s2n2[\text{ Gbest } - xkj] \tag{12}$$

$$xk(j+1) = xk(j) + vk(j+1) \tag{13}$$

In equation (12), (x) represented the position of the particles and velocity (v) and (k) and iteration is denoted as (j). The stable acceleration value is presented as s1, s2 those equal to2. Independent random range is denoted as n1 and n2 between (0,1) and the Pbest solution of the particle in the network is represented as Gbest based in the swarm position. In those equations, the particle placement is evaluated based on the best cost involved in provision of best solution.

2) BAT

The Bat approach solves optimization challenges by replicating bat behavior, which relies on microbat echolocation to update position and velocity [29]. The location of each bat is updated based on the sound wave's velocity and hertz number. Bats symbolize the problem parameters in network optimization. Every iteration will measure the location and velocity of every bat in the swarm based on prior velocity, frequency, and global data. To update velocity and location, the BAT method employs the following equations:

$$F[j] = F[min] + (F[max] - F[min])\beta \tag{14}$$

$$Vt[j] = Vt - 1[j] + (Xt[j] - X[g])F[j] \tag{15}$$

$$Xt + 1[j] = Xt[j] + Vt + 1[j] \tag{16}$$

Where F (j), F (min), and F (max) are the hertz of the microbat's sound wave at time t.β is a randomly generated vector with values ranging from 0 to 1. For each bat, X (g) represents the current global best solution. After all of the iterations, the swarm's global best solution X (g) is computed.

D) THE HYBRID PSO-BAT ALGORITHM

A hybrid PSO-BAT routing method flow diagram is shown in figure 3 and table 4 represents the algorithmic steps.

IV SIMULATION RESULTS

A) SIMULATION AND PERFORMANCE PARAMETERS

The proposed optimized Energy aware secure clustering protocol's performance is assessed using the ns2 simulator. The suggested Fuzzy logic-based particle swarm optimization -Bat (FLPSO-BAT) is compared to the FUZZY cat slap single-player algorithm (C-SSA) [11] and efficient routing for MANET using optimized hierarchical routing algorithm (EA-OHRA) [7] in terms of performance. Table 3 lists the simulation parameters required to create FLPSO-BAT. In this simulation, we are using 100 nodes and a simulation duration of 40 ms. The study's parameters include delay, energy, throughput, and detection rate, and the suggested protocol is compared to all current processes based on competency metrics with and without selective packet dropping attack.

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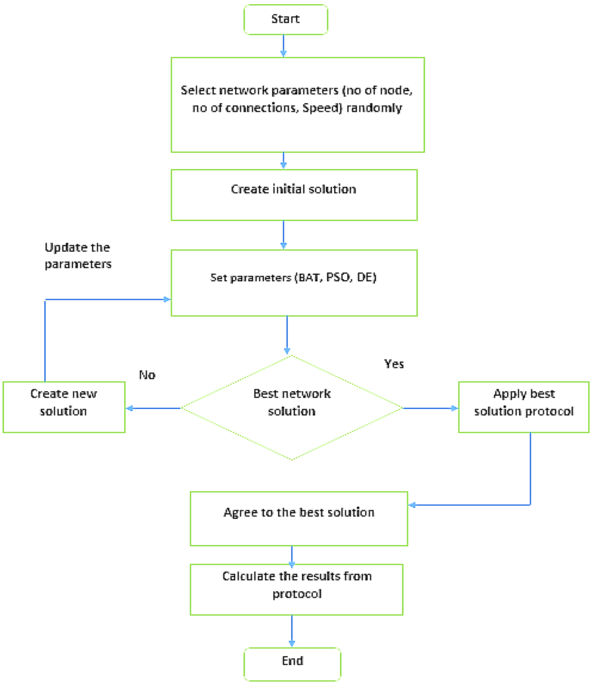

FIGURE 3. Hybrid PSO-BAT flow diagram

TABLE.4. Proposed hybrid PSO-BAT algorithm

Step 1	Sequentially provide the number of nodes, connections, and speed
Step 2	Give the results of the scenarios to the algorithm as a dataset
Step 3	Compare the dataset to the network parameters created at random
Step 4	Collect evaluation data (throughput, energy consumption, delay).
Step 5	Using equations (12) and (13) in PSO and equations (15) and (16) in BAT, calculate the current particle's or bat agent's location and velocity
Step 6	The operation should be finished after all of the updates have been done
Step 7	If no optimum solution is found after step 2, go on to the next agent and repeat steps 3–6 to optimize

Figure 4 depicts the delay analysis. From the figure 3, delay of the method is EA-OHRA is 0.004, FUZZY C-SSA is 0.003 and FLPSO-BAT is 0.0019 msec. When compared to the previous works, Fuzzy C-SSA and EA-OHRA, the suggested work has a shorter lead-time. This is due to the fact that the proposed method is superior to Fuzzy C-SSA and EA-OHRA at minimizing the transmission delay brought on by malicious nodes. The proposed scheme is based the consideration of energy and trust value of node may operate as a cluster leader, and data is transferred across these selected CH. As a result, in FLPSO-BAT, the delay caused by malicious nodes has decreased.

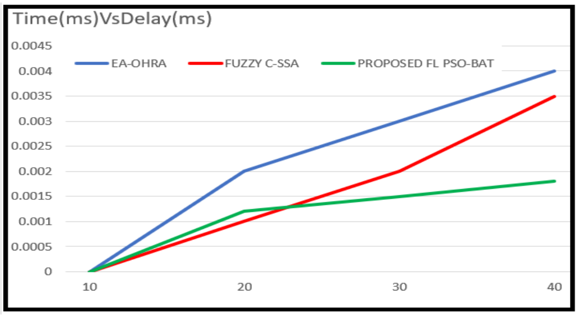

FIGURE 4. Delay of the proposed FLPSO-BAT

Figure 5 shows the energy consumption analysis of the proposed work FLPSO-BAT with the existing works of FUZZY C-SSA and EA-OHRA. In the suggested work, one of the most important factors in cluster leader selection is energy level. Also, the proposed technique is more effective than previous efforts at finding and eliminating malicious nodes in a network.

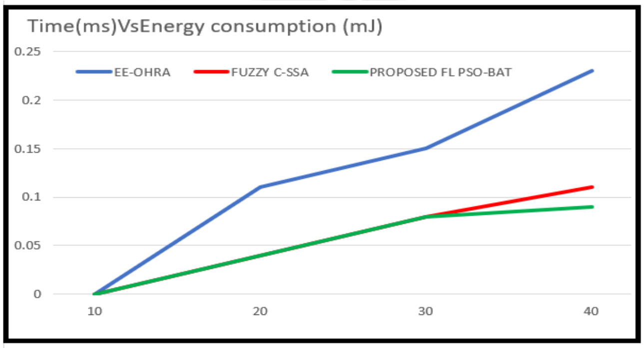

FIGURE 5. Energy consumption of the proposed FLPSO-BAT

According to Figure 5, the method's energy consumption is 0.22 for EA-OHRA, 0.11 for FUZZY C-SSA, and 0.09mJ for FLPSO-BAT. The proposed FLPSO-BAT saves power since the energy formerly expended by malicious nodes is now preserved. The proposed FUZZY C-SSA and EA-OHRA were compared and contrasted in Figure 6. From the figure 6, detection rate of the method is EA-OHRA is 75%, FUZZY C-SSA is 90% and FLPSO-BAT is 90.5%. The analysis of the nodes with each other are used to assess the trust mark of the nodes in the proposed work in terms of energy. As a result, FLPSO-BAT detects a higher number of malicious nodes.

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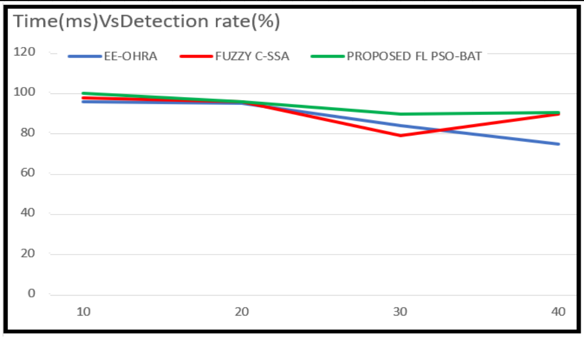


FIGURE 6. Detection rate of the proposed FLPSO-BAT

Figure 7 shows the Throughput analysis comparatively with the proposed work with FUZZY C-SSA and EA-OHRA. From the Figure 6, throughput of the method is EA-OHRA is 0.45 bps, FUZZY C-SSA is 0.74bps and FLPSO-BAT is 0.76 bps. According to the results, the FLPSO-BAT outperforms the Fuzzy C-SSA and EA-OHRA. This is so because most of the work to be done occurs during the cluster-forming phase. Parameters include the total amount of CH energy and the intensity of CH. In addition, the cluster head degree determines whether or not the new member node will be admitted to the CH. The proposed work has a longer network lifetime than both Fuzzy C-SSA and EA-OHRA.

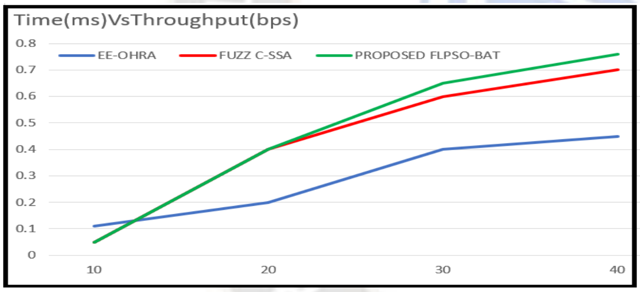
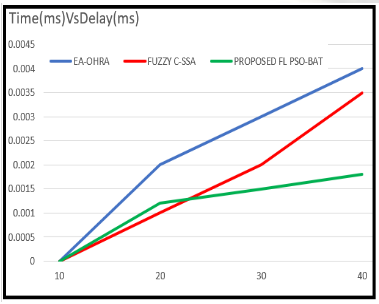


FIGURE 7. Throughput of the proposed FLPSO-BAT

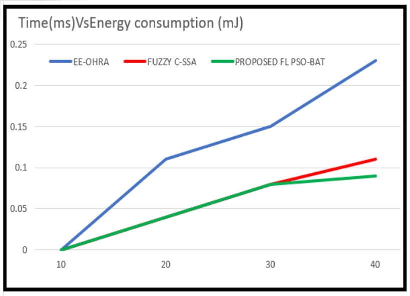
B) RELATIVE ANALYSIS OF THE SELECTIVE FORWARDING ASSAULTS

The following data is a relative assessment of the approach. Figure 8(a) depicts the estimated relative delay. EA-OHRA has a delay of 0.007, FUZZY C-SSA has a delay of 0.006, and the proposed FLPSO-BAT has a delay of 0.003 msec with a period of 40 seconds. Figure 8(b) shows the energy consumption. The EA-OHRA energy consumption is 0.23, Fuzzy C-SSA is 0.10, the suggested FLPSO-BAT is 0.09 mJ, and it takes 40 seconds to complete. Figure 8(c) displays the detection rate. The detection rate is 74 percent for EA-OHRA, 89 percent for FUZZY C-SSA, and 90 percent for FLPSO-BAT. Figure 8(d) shows the contrast with the Throughput. Throughput of the method is EA-OHRA is 0.70 bps, FUZZY C-SSA is 0.76 bps and proposed FLPSO-BAT is 0.78 bps. According to the simulated results, the performance of the proposed method shows good results in the case of the selective packet dropping attack.

Compared to the existing methods of Fuzzy Clustering with hybrid algorithm, the cat slap single-player algorithm (C-SSA), Efficient routing for MANET using optimized hierarchical routing algorithm (EA-OHRA) the proposed Fuzzy logic-based particle swarm optimization - Bat (FLPSO-BAT) method provides better performance because here we use Fuzzy Logic based Energy Aware Secure Clustering technique for clustering and cluster head selection. The two major steps of the CH selection process are set-up and steady state. Cluster formation is influenced by two variables: cluster density and residual energy. Clustering will be done in rounds, as in the old Leach method. The clustering concept is divided into two stages: an energy efficient and clustering for the leader election technique, and a fuzzy cluster construction procedure. In this proposed endeavor, the most energy and trust value of the node in the network will be voted as CH. As a result, the CH election process continues, based on the assessed trust mark and behavior analysis.



(a)



(b)

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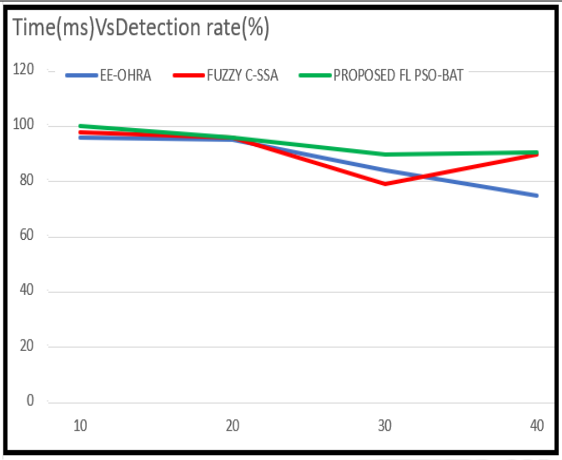
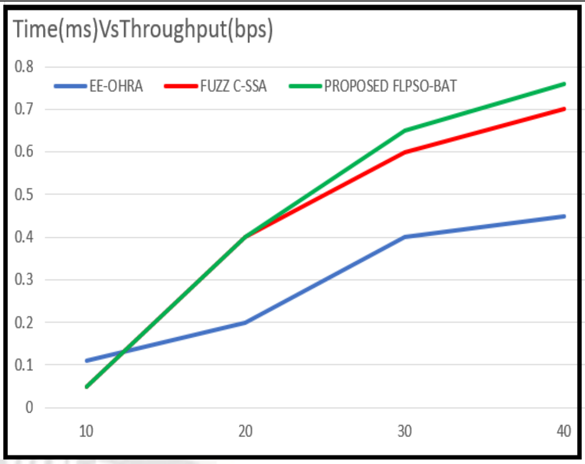


(c)



(d)

FIGURE 8. (a) Proposed FLPSO-BAT delay (b) Proposed FLPSO-BAT Energy consumption (c) Proposed FLPSO-BAT Detection rate (d) Proposed FLPSO-BAT Throughput

From simulated, and the suggested protocol delay without attack is 0.0019msec and with selective packet dropping attack is 0. 003msec.In terms energy consumption the suggested protocol provide is 0.09mJ of energy consumption without attack and with selective packet dropping attack. In the case of detection rate the suggested protocol provide 90.5% without attack and with selective packet dropping attack the detection rate is 90%. The performance parameter throughput for the suggested protocol is 0.74bps at without attack and with selective packet, dropping attack the throughput is 0. 78bps.From the overall results the performance of the proposed method shows good results with and without attacks.

V CONCLUSION

The main goal of this paper is to provide an energy-aware safe clustering technique for MANET. To solve the security concerns created by malicious nodes and select a trustworthy node as CH, we propose a trust-based security architecture. As a result, a trust and energy, Fuzzy Logic based Energy Aware Secure Clustering, is suggested for the successful selection of trust value of the nodes in CH. In MANET, BAT and PSO are used to solve the problem of finding the best solution. The PSO technique is inspired because it imitates the sociological behavior of a flock of birds by starting with random population solutions. The BAT is a metaheuristic algorithm inspired by microbat echolocation behavior. The proposed enhanced energy-aware secure clustering protocol is compared to both existing methods with and without a selective packet-dropping attack, looking at how each performs in terms of key performance parameters. According to the simulation results, the suggested FLPSO-BAT technique has a minimum delay of 0.0019 milliseconds, energy consumption value is 0.09millijoules, detection rate value of 90.5% and throughput is computed as 0.76 bits/sec for selective dropping. Based on the results of the performance comparison, the authors conclude that the suggested FLPSO-BAT is an improvement over the status quo.

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