An Ensembled Optimization Algorithm for Secured and Energy Efficient Low Latency MANET with Intrusion Detection

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Received: August 09, 2022; Accepted: October 02, 2022; Published: November 30, 2022

Abstract

The property of dynamic infrastructure that adjusts the network automatically and allows for faster deployment has made Mobile ad hoc networks (MANETs) extremely fitting for locations that don't have support for radio communication due to disasters or other crises. Since the topology is dynamic, security is one of the major concerns in MANET which will be exposed for various attacks like eavesdropping, routing based attacks and modification of executables. Though MANET is vulnerable to these attacks, another major issue to be addressed is the attacks based on intrusion. The proposed model uses an Ensemble optimization algorithm that addresses the security issues in MANET by the effective usage of the Cluster Head and the intrusion detection is done by using fuzzy clustering and fuzzy Naïve Bayes models. The algorithms considered here are, Chimp Optimisation technique and Grasshopper Optimization methodology. Chimp Optimization technique selects cluster head that selects the optimized route for the dynamic performance of MANET. The optimal routes are chosen related to few parameters are conformity, power, certainty, and bandwidth. Grasshopper Optimization Algorithm is used to reduce the defects to obtain better global optimization ability. The implementation of the above techniques are measured by different assaults like flooding, blackhole, and selective packet drop and Ensembled optimization is found to perform well than the individual algorithms.

Keywords: MANET, Chimp Optimization, Grasshopper Optimization, Naïve Bayes, Intrusion Detection.

1 Introduction

A network with a collection of multiple nodes which can communicate among themselves without the need for any centralized controller is known as an ad hoc network. Those ad hoc network with the properties that allow them to organize themselves in a dynamic manner without the need of a fixed network topology are called as Mobile ad hoc networks (MANET) [1]. Since the Remote sensor network

Journal of Internet Services and Information Security (JISIS), volume: 12, number: 4 (November), pp. 156-163
DOI: *10.58346/JISIS.2022.I4.011*

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are outfitted with various advantages like reliability, scalable dynamic architecture for example, observing in army installations, checking the development of individuals and their health [2].

The huge development in Internet of Things has enabled different gadgets to be associated together and communicate among themselves without the need of human intervention. Through IoT, the devices in a dynamic network are able to exchange data among themselves in a faster way with a very limited infrastructure [3].

Since the topology of MANET is dynamic, there is a need for a design that is, both energy conservative and trustable in terms of communication. One issue associated with this is the exchange of energy information between various layers present in the node rather than sharing among the nodes [4]. In general, the MANET's will choose a dynamic wireless server to be the controller that aids in communication of data. Attacks such as worm hole and malware attacks in MANET's are often a thing to be addressed in real time scenarios [5].

One major concern about the MANET is the limited energy in the nodes that are present in the network and it is expected to have an energy effective directing calculation to delay the organization lifetime close by keeping them from different assaults that are possible without reducing the performance of the network [6].

If the data exchange process requires more energy from a node, the process is shifted to another node by the optimized rerouting algorithm thereby improving the lifetime of the network [7]. The important considerations of ensemble model as per the following:

- The Chimp Optimization Algorithm (COA) is used for choosing the best possible routing path in MANET to make it more energy efficient. It allows a rerouting mechanism that shifts the data exchange from a relatively low power node to a node with more power thereby reducing the latency in the network.
- To improve the security of the MANET and prevent it from intruders, grass hopper optimization algorithm is used to trim down the defects and allows to obtain a globally acceptable optimization value for exchanging of data.

The remainder of the paper is coordinated by giving a study in section II. Section III explains the proposed ensemble model and outputs are correlated with previous technique against various factors in section IV. The paper is concluded with the future enhancements that can be applied to the proposed algorithm.

2 Related Work

The data in MANET are exchanged through a wireless medium which enables them to be attacked by intruders during the transmission. COA is used to decide an optimal route for selecting the data exchange path and thereby enhancing the network lifetime by the efficient usage of energy in nodes. A COA based Energy Aware Secure Routing Protocol that provides an optimal route for data exchange was discussed by **P. Manjula et al., (2019).** This protocol is used to provide a function that is compared based on various parameters like trust, energy level and delay [8].

Particle Swarm Optimization based Selection (PSOBS) was used by **Tabibi S et al., (2019)** for the selection of optimal route for data exchange by choosing the rendezvous points. The PSOBS model was efficient in identifying the optimal route for efficient utilization of resources based on the weight computation methodology done for every node based on the data exchange.

The PSOBS was compared against various methodologies with parameters such as efficiency, energy level and number of hops [9]. Energy knowing confident on safe routing methodology described by author **Selvi M et al., (2019)** that uses the trust scores at every node and identifies the faulty nodes efficiently in WSN based on a decision tree algorithm with spatio-temporal constraints to identify the best optimal route for data exchange [10].

X. Guo et al. (2021), proposed an enhanced framework for identification of adjacent or nearer nodes in MANET. This model does not consider the issues with one directional connection and the impact of it on the network efficiency. The proposed model also makes use of an approach to regulate the structure to use a controller for MANET [11]. ***S. S. Jadhav et al., (2014)*** simulated the MANET with dynamic routing protocol approach for data management in disaster networks that provides a better efficiency than the traditional approaches when compared against performance, endwise delay in exchange of packets [12].

Ghaffari Ali (2015) represented a key traffic check method utilized on WSNs and grouped them as traffic signal, asset control, line helped and need mindful conventions [13].

Preeti Kaur et al., (2022) extended the COA to address the energy constraint issues with Dimension Learning based Hunting search mechanism. The above search mechanism needs to diversify and enhance the trade-off between exploitation and exploration [14].

A detailed survey [16] starting from the traditional Grasshopper Optimization Algorithm (GOA) and its various modifications for generalized binary and other multi output classes of application are discussed by **Laith Abualigah et al., (2020).** Various algorithms are evaluated for metrics and their applications are discussed in detail.

Hicham Deghbouch et al., (2021) addressed the deployment problem in WSN using a fusion technique by joining the Bees technique and GOA called as BAGOA technique shows the highlight of GOA to build the utilization of BA [16]. The ensemble technique was compared with other existing mechanisms considering the factors such as overlapping area, average distance moved and energy level.

Anand Tanwar et al., (2020) devised a mechanism by applying fractional calculus in GOA called as Fractional-GOA to reduce the energy utilization per node for efficient sleep or awake schedule for all the nodes [17]. The proposed methodology uses 2 forms such as initialization and activation form to control sleep/wake modes of the nodes in the network for monitoring and data exchange. The factors considered for the evaluation of this algorithm are efficiency and maximum energy utilized by the nodes.

3 Proposed Ensembled Optimization Algorithm

The proposed model is a two-step process that combines both the COA and GOA models to generate a new ensembled optimization algorithm. The COA is used to create the cluster with the cluster head and choose the best route for data exchange minimizing the energy usage while the GOA is focussed on improving the security of the MANET against various attacks over them.

COA is a bio-inspired swarm optimization algorithm based on the behaviour of Chimp that jumps between the branches based on their confidence over the strength of the branch. If the chimp jumps over a weak branch, it will fall down. To keep track of the stronger branches, the chimp has to jump among the branches frequently. Since this is done dynamically, no one can predict the next jump of chimp. Based on these factors, the following chimp behaviours are identified:

- Attacking Chimp
- Blocking Chimp
- Chasing Chimp
- Driving Chimp

$$X_1(t+1) = X_{attack}(t) - k\ 1.d_{attacker} \quad (1)$$

$$X_2(t+1) = X_{Barrier}(t) - k\ 2.d_{Barrier} \quad (2)$$

$$X_3(t+1) = X_{Chaser}(t) - k\ 3.d_{Chaser} \quad (3)$$

$$X_4(t+1) = X_{Driver}(t) - k\ 4.d_{Driver} \quad (4)$$

$$X_{Chimp}(t+1) = \frac{X1 + X2 + X3 + X4}{4} \quad (5)$$

The behaviour of chimp is expressed mathematically as per the assumption that the initial clarification given by rider, hacker, trapper and hindrances are better than the information about the position of target. The initial clarifications are safeguarded to calculate the upcoming novel solution, whereas the remaining associated made to modernize the position in accordance with the good search agent in case of exploration.

In GOA algorithm is based on the behaviour of the Grasshopper that eat anything and every plant that come along their path which are still a nightmare for the farmers as they make a huge damage for them. The longevity is comprised of 2 phases viz., elemental and legal age. The congestion in the larval stage is limited to minimal number of steps as there are no wings where as in the adulthood stage, they swarm to a larger distance using their wings in air [18]. The GOA is a modern nature-inspired algorithm based on their behaviour and the movement is represented using the following formula:

$$X_n = S_n + G_n + W_n \quad (6)$$

Where X_n denotes the position of nth grasshopper, S_n denotes the interaction, G_n denotes the gravity and W_n denotes the wind.

$$S_n = \sum_{\substack{k=1 \\ k \neq n}}^{N} s(d_{nk})\, \widehat{d_{nk}} \quad (7)$$

Where d_{nk} denotes the distance between two grasshoppers.

$$G_n = g\widehat{c_g} \quad (8)$$

$$W_n = u\widehat{w_g} \quad (9)$$

Where g and u are constants and the w_g and c_g are unit vectors with respect to centre of earth for wind and gravity. The pseudo code of the proposed ensembled algorithm combining COA and GOA is given below.

Pseudo code for Cluster head Selection based on COA:

Input: The sensor node set S, Count of Cluster Heads (C), Crowd Size (N) and No. of Hierarchy (H)

Initializations:

$M = \{m_1, m_2, \ldots., m_N\}$

$M_i = \{x_{i,1}, x_{i,2}, \ldots., x_{i,N}\}$ and $X_{ij} = (x_{ij}, y_{ij})$

for iteration 2 to H_{max} **do**

Calculate x_1, x_2, x_3 and x_4

for w = 1: nodes **do**

for i = 1 to N Calculate d_{ij} for all $s \in S$

end for

Find min(d_{ij}) and make it cluster head for the current generation

Update x_1, x_2, x_3 and x_4 using equations (1) to (4)

End for

Update x_{n+1} using equation (5)

Modify the neighbourhood radius

Choose best ChoA

Update the crowd

Return the best choA

Pseudo code for defect identification using GOA:

Randomly initialize the position of grasshoppers

Initialize c_{max} and c_{min}

while $t \leq maxiter$

Assess the fitness population

Sort them based on fitness

Update the value of C

Select **n** solutions with highest fitness for adjacent search

Select **ne** foragers for each **nt** elite sites among the best sites

Select **nb** foragers for remaining sites

Randomly calculate new solutions for adjacent foragers

Calculate the distance between them

Update the position

Calculate the feasibility of the current solution

Select the fittest solution among the current ones

Allocate the remaining ones for new solutions

Form new population

Store the best solution achieved

Increment t by 1

End

The above said algorithms are combined to form the ensembled algorithm used in the proposed system. The first step is the cluster head selection using COA followed by defect identification by GOA.

4 Implementation Outputs

The results of novel ensembled algorithm for MANET was done in Matlab 2017a software. The performance of the ensemble techniques are contrasted against individual evaluation of COA and GOA. It is referred that ensemble methodology is efficient than the previous ones in order of efficiency, packet loss, lifetime of the network. The algorithms taken for comparison are COA, GOA and Improved Chimp Optimization Algorithm (I-COA). The results obtained are discussed below.

Fig.1 shows the exact match of throughput of the ensemble technique than the previous methodologies. The evaluation of the novel methodology in order to network lifetime and packet loss are displayed in Fig. 2 and Fig. 3.

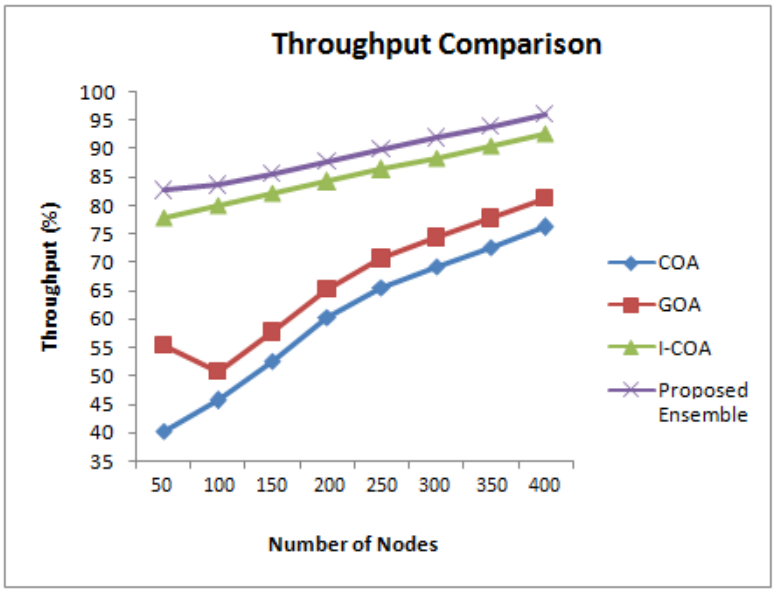

Figure 1: Throughput Match

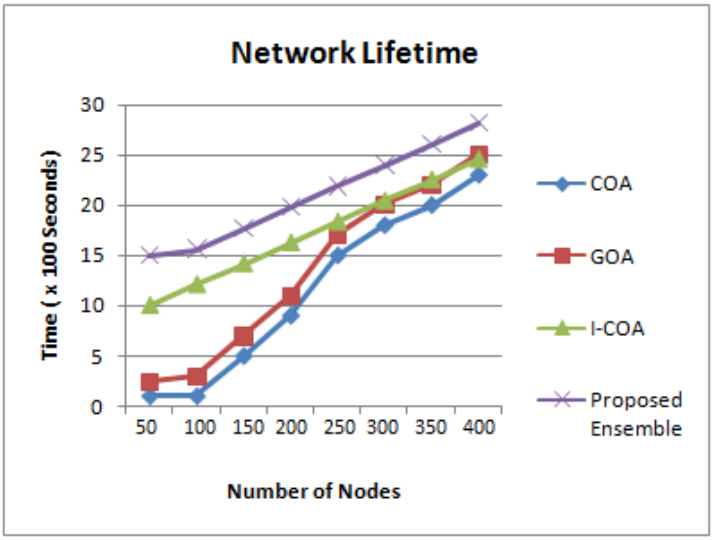

Figure 2: Network Lifetime Comparison

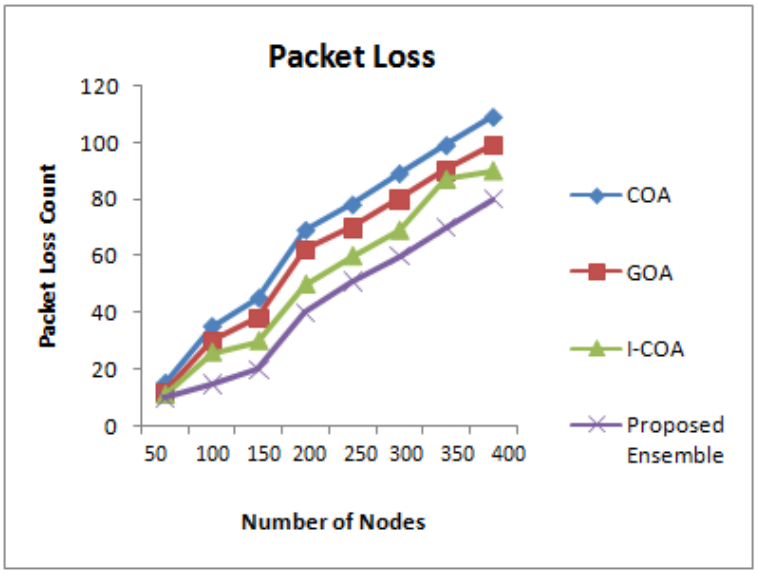

Figure 3: Packet Loss Comparison

5 Conclusion and Future Work

The proposed methodology uses an ensembled algorithm formed using COA and GOA and is implemented in Matlab 2017a. The results obtained are compared against various existing algorithms used for optimization in MANET. The results reveal that the proposed algorithm outperforms the existing algorithms in all factors. As a future work, the same ensembled algorithm can be used to evaluate the network performance in MANETs.

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