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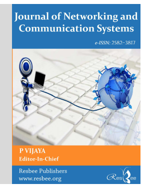


# Hybrid Seagull Optimization Algorithm and Thermal Exchange Optimization for optimal routing in VANET

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**Abstract:** Vehicle Ad-hoc Network (VANET), can setup scalable solutions, cost-efficient and therefore, it is applied in many applications like transportation fields with help of multi-hop wireless communications from vehicle-to-vehicle. On the other hand, due to the rapid change in regular and topology network disconnection, the development of multi-hop communication is considered as challenging task in VANET conditions. In conventional mobile ad-hoc routing protocols, this directs to routing failure or ineffectual. To solve the routing problem and also to obtain the multi-constrained Quality of Service (QoS) measures, many research works are performed in VANET. The main intention of this work is to present a cost model as the solution for the vehicle routing issue and the network quality measures are considered such as travel, congestion, collision, and QoS awareness cost. In complete routing cost, the QoS fuzzification factor is also considered. Moreover, the main aim of this paper is to concentrate on the routing cost model minimization and identifies the optimal route. Here, a new optimization algorithm called Hybrid Seagull Optimization Algorithm (SOA) and Thermal Exchange Optimization (TEO) is presented to recognize the optimal route. Finally, developed technique performance is evaluated against the existing techniques regarding the cost analysis as well as shows efficiency of the adopted model with minimized routing cost.

**Keywords:** Optimization Algorithm, Routing, Qos, VANET,

***Nomenclature***

| Abbreviations | Descriptions |
|---|---|
| **V2V** | Vehicle-to-Vehicle |
| **MANETs** | Mobile Ad-hoc Networks |
| **PBRP** | Partial Backwards Routing Protocol |
| **QoS** | Quality-of-Service |
| **RSU** | Road-Side-Unit |
| **V2I** | Vehicle-to-Infrastructure |
| **SOA** | Seagull Optimization Algorithm |
| **AP** | Access Point |
| **PGRP** | Predictive Geographic Rout Protocol |
| **ECDSA** | Elliptic Curve Digital Signature Algorithm |
| **TEO** | Thermal Exchange Optimization |
| **RSS** | Received Signal Strength |
| **TROPHY** | Trustworthy VANET Routing with group authentication keYs |

## 1. Introduction

An extensive exploit of automobiles is presented highly to the continuation of dangerous circumstances, and traffic saturation, which increases the probability of accidents. Hence, aforesaid issues inspired the improvement of applications that aid the vehicle conductor while making decisions and present the protection to all passengers. Therefore, a solution is addressed for an aforesaid problem that is to present the communication between the vehicles is the deploying of a VANET [1].

A VANET is an extremely mobile wireless ad hoc network modeled to attain numerous objectives associated with traffic management and driving security. This network is a self-organized network collected of the interlinked vehicles in that the vehicles can communicate with each other directly throughV2Vcommunications or with infrastructure such as the RSUviaV2I communication. Also, in such networks, a combined communication V2V and V2I is probable. Generally, VANET has their individual characteristics unlike the other classes of wireless ad hoc network, and also, it is not similar to neighboring class named MANETs. The maximum vehicular nodes mobility cause repeated topology alterations which reasons the complexity to exploit the topology-based routing protocols [3]. Numerous studies were done to identify the routing issues in VANETS namely geographic routing protocols [13] and [14].

Generally, with the introduction of VANET, for the traffic routing, there has been an important amount of works, and it is considered a challenging problem [12]. In a VANET routing service, one of the important challenging problems is to maintain the information updated as well as broadcast the alteration as rapidly as probable. Hence, the secure routing services efficiency can easily visualize and it is based upon the overhead related to the applied security models, as these inflict delays [11].

In VANET, to aid unicast communications, routing schemes amid vehicles are considered as an extended period. Additionally, it is very important to aid the connectivity of IP. Therefore, in order to secure the VANET routings, security schemes are very important. Nevertheless, it is not probable to use the conventional models namely handshake-based authentication protocols in the VANET routing model. Hence, few general security issues like secrecy, availability, and integrity do not have an extensively agreed solution [4].

Since the introduction of VANETs, there have been a noteworthy number of proposals for their traffic routing, and it is challenging in practice. In a VANET routing, the important challenging task service is to keep the information updated and propagate the changes as fast as possible. Hence, easily envision that the efficiency of secure routing service will naturally depend on the overhead related with the applied security mechanisms, since these impose delays.

The main contribution of this work is to reduce the cost model by exploiting network quality measures. Moreover, a novel optimization method calledSeagull Optimization Algorithm and Thermal Exchange Optimization (SOA-TEO) algorithm is proposed for efficiently reducing cost function. Subsequently, the proposed method performance is evaluated with the conventional models regarding the cost function.

## 2. Literature Review

In 2020, Ankita Srivastava et al [1] analyzed the challenges in VANET, and significantly evaluate the conventional solutions developed till now. Additionally, it presented a concise explanation of up-and-coming WAVE+LTE based technology besides with few feasible directions for further enhancements associated with the position-based routing protocols.

In 2019, Tawfiq Nebbou et al [2], proposed a new routing protocol named PBRP that comprises three combined schemes: partial forwarding approach, distribution of road traffic information, and backward recovery approach operational with the presented during and developed information concerning vehicular traffic that extensively aids the routing.

In 2018, Ramin Karimi and Saeed Shokrollahi [3], presented a PGRP which enhances connectivity to cope with the challenges in VANETS. Each vehicle gives weight to its neighbors in PGRP consistent with the direction and the angle of the vehicle. In each vehicle, PGRP can forecast the position during a hello packet on the basis of an acceleration of vehicles. On the basis of the vehicle position, PGRP forwards packets subsequent to the short interval.

In 2018, Pedro Cirne et al [4], examined the impact that occurred using ECDSA messages authentication of multi-hop routing control plane exploited in a real VANET. To keep precise, such a control plane exploits periodic environs updates, distributed routing paths, as well as ECDSA-based experimentation delays, which might force to abandon a lot of such updates.

In 2018, Pedro Cirne et al [5], developed TROPHY, protocols set to control the routing message authentication in a VANET in extremely demanding time circumstances able to protect the routing information distribution taking into consideration of the WAVE model. TROPHY messages are received by the authorized nodes recursively that allow them to refresh their cryptographic material as well as stay authentication keys updated over the network.

# 3. Route Selection Model

### 3.1 Network Model

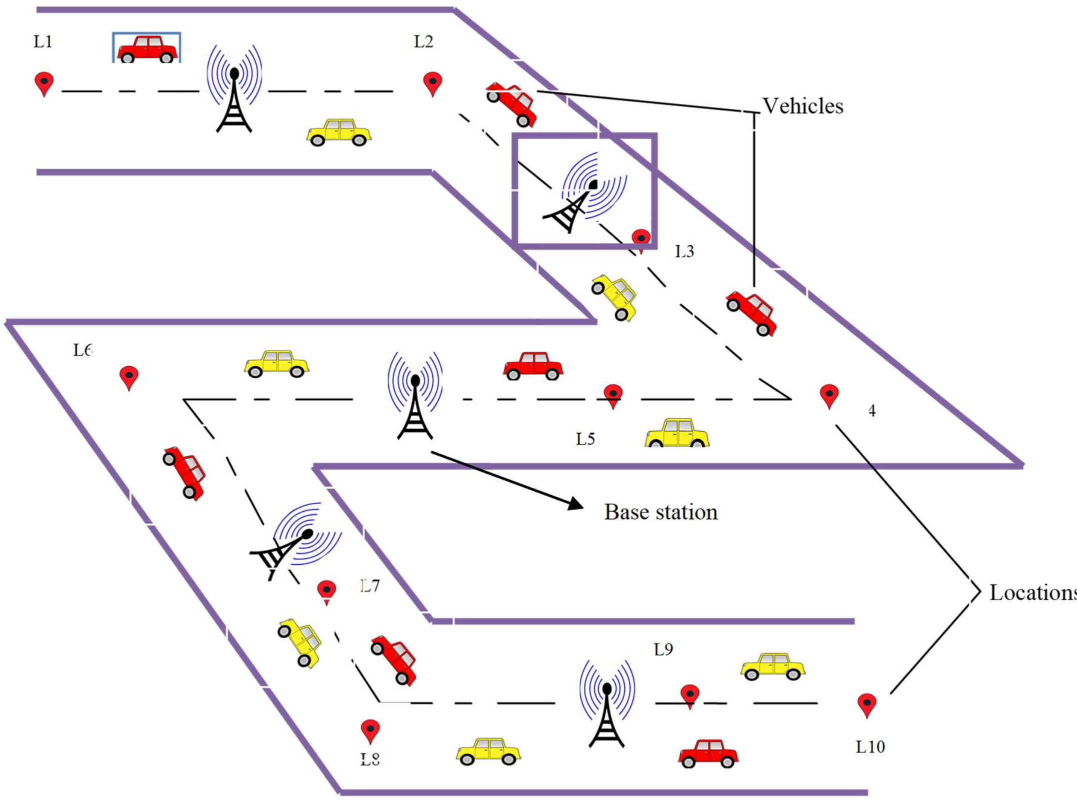


***Fig. 1*** *Network model of VANET*

The network model of VANET is exhibited in Fig 1. Here, the vehicles travel in diverse positions. The vehicle movement within the selected network, indicated as $Vh_n$ , whereas vehicle index is indicated as $n$ is carried out in diverse directions L1, L2, L3, L4, L5, L6, L7, L8 as well as L9. The vehicles travel in a constant speed in order to attain the desired positions. An accurate AP is exploited to complete each position with the same coverage area as well as it is exhibited as AP1, AP2, AP3, as well as AP4. Here, most vehicles travel from position 4 to 6. Suppose the route chosen is not optimal, subsequently, there happens a coverage issue. Therefore, to attain the utmost coverage there is a requirement in the optimal route selection. If a traffic hub does not exist there will be no collision. There is an ability to handle the number of vehicles for each AP. If the number of vehicles more in the particular is the congestion might be caused repeatedly. For instance, a general AP1 is shared by vehicles that travelled in position 1, 2, 4, and 5 as well as AP2 is shared between vehicles towards the direction 3 as well as 6. The vehicle that moved towards position 5 as well as 8, contributes to the instant AP3. The AP4, with coverage positions of 5, 6, 8, as well as 9,have appeared to possess a maximum congestion level. The improvement in QoS is done with the minimization of cost.

Let position in that the chosen vehicle is in motion is indicated as $Lt_k$ ; $k = 1,2,.....,Nu_{nodes}$ , where, , and $k^{th}$ location node is stated as $k$ and $Nu_{nodes}$ states the number of position/nodes. Let, $l^{th}$ vehicle as $Vh_l$ and is indicated as $Vh_l : l = 1,2,.....,Nu_{vehicle}$ , where, the number of vehicle in the network is stated as $Nu_{vehicles}$ . $AP_m$ indicates the AP used via the network and is stated as $AP_m : m = 1,2,.....,Nu_{AP}$ , whereas, the complete number of AP is shown as $Nu_{AP}$ .

Each AP possesses a separate coverage area in that vehicles are covered as well as network position falls. Here, the coverage area of each AP is indicated as $Cv_m$ and is belongs to $Cv_m \in Lt$ . Hence, $\|Cv_m\| \approx \frac{Nu_{nodes}}{Nu_{AP}}$ indicates the coverage area cardinality.

**State 1:** $Lt_k$ represents coverage of $AP_m$ , merely if $G( Lt_k , AP_m ) < Rd_e$ , whereas, $Rd_e$ represents coverage radius.

**Theorem 1:** The network diagonal length provides the coverage to complete nodes, which is stated as $\sqrt{2Lt_{net}^2}$ , where, $Lt_{net}$ denotes network dimension.

**Proof:** In a similar plane, consider the position of the complete node. Consequently, $P^{max} \approx Q^{max}$ , whereas, $P^{max} = \max(Lt_k(a))$ and $Q^{max} = \max(Lt_k(b))$ . Since $Lt_k$ is exhibited in the $a-b$ coordinate system, $a^{th}$ coordinate is stated as $Lt_k(a)$ and $b^{th}$ is stated as $Lt_k(b)$. The corner node determination is done by $(P^{max},0)$ and $(Q^{max},0)$ if the network nodes start from the origin.

Eq. (1) indicates Euclidian distance between2 points are considered as well as diagonal distance.

$$G^{diag} = \sqrt{(P^{max},0)^2 + (P^{max},0)^2} \quad (1)$$

$$G^{diag} = \sqrt{2(P^{max},0)^2} \quad (2)$$

Where, $P^{max}$ indicates the node length from the origin, $Lt_{net}$ and the Eq. (3) is stated as

$$G^{diag} = \sqrt{2Lt_{net}{}^2} \quad (3)$$

## 3.2 Cost Model

Presume the solution of routing issue as $Z_{i,j}$ , where $Z_{i,j}$ : $i = 1,2,.....,Nu_{paths}$ as well as $j = 1,2,.....,Nu_{nodes}$ , here $Z_{i,j} \in \{Lt\}$ , and $Nu_{paths} = Nu_{vehicles}$ . The solution of the routing cost $Z$ comprises the cost of QoS awareness, cost of collision, cost of travel, and cost of congestion cost and is stated as Eq. (4).

$$T(Z) = T_{travel} + T_{collision} + T_{congestion} + T_{QoS} \quad (4)$$

For travelling cost obtained from one position to other-regarding distance or time or fuel or all these integrations is indicated as cost of travel $T_{travel}$ . The distance matrix is the amalgamation of these, as well as the cost of travel, $T_{travel}$ is stated according to Eq. (5).

$$T_{travel} = \sum_{i=1}^{Nu_{paths}-1} \sum_{j=j+1}^{Nu_{nodes}-1} G(Z_{i,j-i}, Z_{i,j}) \quad (5)$$

By exploiting distance matrix, Euclidian distance amid node $C$ as well as $D$ is developed and is stated as $G(C,D)$ .

The collision probability between the vehicle is stated as collision cost $T_{collision}$ when moving between the direction and it is stated in below Pseudo code.

| Pseudo code: Purpose of collision cost | |
|---|---|
| Input | $Z_{i,j}$ // vehicles path |
| Output | $T_{collision}$ // cost of collision |
| | Set $T_{collision} = 0$ // Initialize cost of collision |
| | for each node till $Nu_{Nodes} - 1$ $\forall i$ |
| | Identify $Un_n$ // unique count of nodes available $\forall i$ |
| | Identify $N_{coll}$ // Count of coding vehicles |
| | $T_{collision} = Z_T \times Nu_{coll} + T_{collision}$ |
| | return $T_{collision}$ |

$Nu_{coll}$ indicates the number of the colliding vehicle as well as $Z_T$ indicates the penalty function is multiplied in the probability of collision, where; the number of vehicle fortitude is stated as $Nu_{coll}$ at $j^{th}$ immediate of position with single time immediate. On basis of a number of vehicles that is acted by AP at specified instantaneous, cost of congestion $T_{congestion}$ is obtained as well as stated in Eq. (6).

$$T_{congestion}(n) = \begin{cases} Cv_m^{over}(n); \text{if } Cv_m^{over} > 0 \\ 0; \text{otherwise} \end{cases} \quad (6)$$

$$Cv_m^{over}(n) = \sum_{\substack{i=1 \\ j\neq 1}}^{Nu_{paths}} CG_m(i,j) - Cv_m^{lim} \tag{7}$$

$$CG_m(i,j) = \begin{cases} 1; \text{if } Z_{i,j} \in Cv_m \\ 0; \text{otherwise} \end{cases} \tag{8}$$

Eq. (7) represents the congestion limit of $m^{th}$ AP which is indicated as $Cv_m^{lim}$.

The QoS awareness cost $T_{QoS}$ is determined by a fuzzy inference system by exploiting the QoS factors namely the AP congestion level and RSS.

### 3.3 QoS Factors Fuzzification

Fuzzy logic exploits non-numeric linguistic variables for factors such as RSS, congestion, Quality of Service cost, as well as Quality of Service. For each linguistic variable, a numerical value is allocated which indicates the fuzzy membership function. Table 1 summarizes fuzzy rules among the Quality of Service factors as well as cost included. Regarding congestion level of moderate, low, as well as high at the fair as well as good RSS, QoS cost is '0', high and high. Nevertheless, at poor RSS circumstances with low, moderate as well as high congestion levels, QoS cost is indicated as low, high as well as high correspondingly.

***Table 1.*** *Fuzzy Rules amid Cost and QoS Factors*

| No. | Congestion level | RSS | QoS cost |
|---|---|---|---|
| **1** | low | poor | low |
| **2** | moderate | poor | high |
| **3** | high | poor | high |
| **4** | low | fair | zero |
| **5** | moderate | fair | high |
| **6** | high | fair | high |
| **7** | low | good | zero |
| **8** | moderate | good | high |
| **9** | high | good | high |

## 4. Optimal Route Selection by the Optimization Algorithm

The most important contribution of this paper is to choose the optimal route, therefore a new optimization algorithm named the SOA-TEO method is chosen. This is due to the heuristic has an ability to discover an adequately better solution to an optimization issue, chiefly with imperfect information [8].In addition, optimization algorithm makes a small number of supposition to resolve the optimization issue, and therefore they might be exploited for a variety of issues [9] [10]. Moreover, the matrix represents the input solution to this approach, i.e. $\text{no of vehicles} \times \text{no of nodes}$.

### 4.1 Hybrid Optimization Algorithm

Technically, seagulls are called as the seagull family, are seabirds which cover the world. There are numerous types of seagulls, with diverse masses and lengths [6].

TEO is a novel optimization model on the basis of the Newton's law of cooling that makes the rate of heat loss of an object directly proportional to the temperature difference amid the object and its surroundings [7].

In this section, Hybrid SOA and TEO technique is explained. The SOA method possesses a better global search capability, when TEO method possesses strong local search capability. To enhance the local search capability of the SOA algorithm, this work develops hybrid optimization approaches. At first, for optimization one of the two techniques is arbitrarily chosen in the roulette manner.

From eq. (9) to (14), this algorithm arbitrarily chooses for the location update of this iteration, and creates employ of the benefits of the two equations to update the location, therefore strengthen the optimization capability. $P_s$ saves the optimal solution as well as updates the location of the search agents, $T_i^{env}$ indicates the preceding temperature of the object $c_1, c_2$ indicates the controlling variables, $L$ indicates the maximum iteration number.

$$P_s(x) = (D_S \times x' \times y' \times z') + P_{bp}(x) \tag{9}$$

$$T_i^{env} = (1 - (c_1 + c_2 \times (1 - t)) \times rand) \times T_i^{'env} \tag{10}$$

$$t = \frac{1}{L} \tag{11}$$

$$T_i^{new} = T_i^{'env} + \left(T_i^{old} - T_i^{'env}\right) \exp(-\beta t) \tag{12}$$

$$\beta = \frac{\cos t(object)}{\cos t(worst\ \ object)} \tag{13}$$

$$T_{i,j} = T_i^{'}, min + rand\left(T_{j,max} - T_{j,min}\right) \tag{14}$$

To avoid falling into the local optimization problem this algorithm will arbitrarily perform global and local search. This technique is named SOA-TEO [6] [7]. Then, this method will augment TEO techniques position update formulation subsequent to the position update formulation of SOA method. Subsequent to the SOA technique iteration, the TEO technique will improve its local optimization capability, as well as this the approach will augment Eq.14subsequent to Eq.9. This technique is named a proposed method.

At last, the formulation in the TEO method is enhanced to seagull attack formulation in SOA method to enhance the local search capability of the seagull method. Then the thermal exchange method is applied in TEO technique to improve the exploitation of seagulls. In Eq.12, $\beta$ transforms temperature somewhat among objects to obtain near to target object quickly. Therefore, $\beta$ is enhanced eq. (15) so that seagulls have the ability to improve move towards prey and it is stated in eq. (16).

$$A = f_c - (x \times (f_c / \max iteration)) \tag{15}$$

$$M_s = B \times (P_{bs}(x) - P_s(x)) \times \exp(-\beta t) \tag{16}$$

## 5. Result and Discussion

The experimentation of the developed method by exploiting the hybrid algorithm is stated in this section. Here, it was done in 5 chosen network areas. Here, the experimentation is performed by changing the instant and their vehicle numbers like 40 cities with 10 vehicles.

The obligatory result was attained by carried out the experimentation by 100 times. The performance analysis was performed regarding the cost function. Finally, the implemented model performance was subsequently analyzed with the conventional approaches like Firefly (FF), Whale Optimization Algorithm (WOA), Grey Wolf Optimization (GWO), and Particle Swarm Optimization (PSO) algorithms.

Fig. 2 indicates the adopted and existing models regarding QoS awareness cost analysis. The least QoS awareness cost is obtained by an adopted technique that is the main objective of this work. The analysis of the congestion cost for the adopted as well as existing technique is demonstrated in Fig. 3. Here, the proposed technique attained a minimal congestion cost than the conventional techniques. Fig 4 exhibits the analysis of the travel cost, here, the proposed method must pose the least collision cost as well as evidently shown in this analysis.

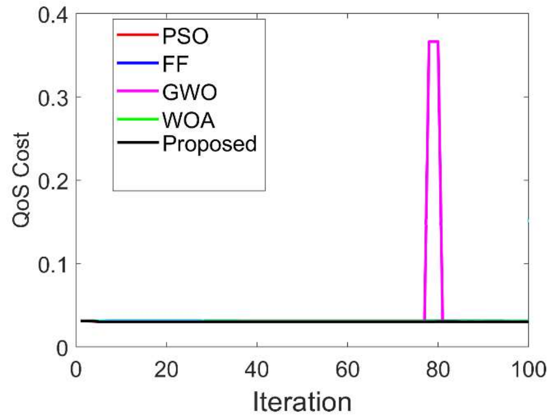


***Fig. 2***_Analysis of developed model with respect to QoS cost_

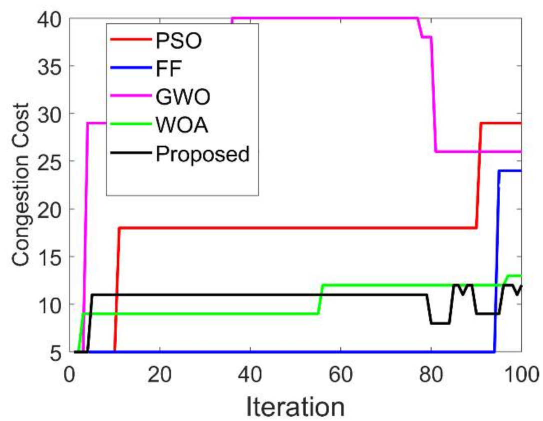


***Fig. 3***_Analysis of developed model with respect to congestion cost_

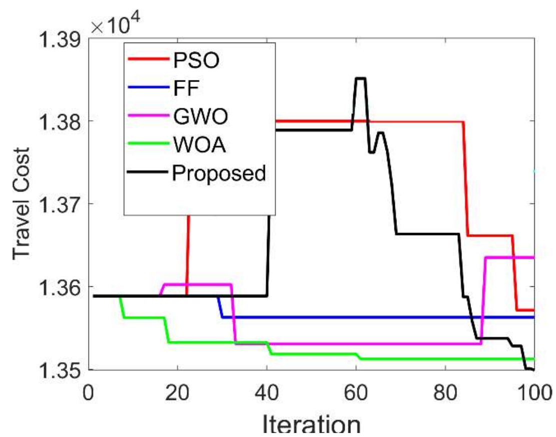


***Fig. 4***_Analysis of developed model with respect to Travel cost_

# 6. Conclusion

The attraction towards VANET has engrossed enormous investigation, to upgrade road safety and entertainment for the traveler, by imparting real time information between vehicles over the past few decades,. In order to attain this, network layer has obtained important attention. Therefore, in this research, to solve the routing issue for the vehicle in the VANET was described. Here, a novel Seagull Optimization Algorithm and Thermal Exchange Optimization (SOA-TEO) algorithm optimization technique was proposed in order to resolve the vehicle routing issue. The main intention of the developed technique is to identify an optimal route with minimum congestion, collision as well as QoS. While comparing with the existing technique, the developed technique travel cost was attained higher outcomes. In order to attain the reduction of collision cost the analysis of the developed technique with the existing models. Finally, the outcomes were exhibited that the developed technique was better than the PSO and FF, respectively.

# References


[1] Ankita SrivastavaArun PrakashRajeev Tripathi,"Location based routing protocols in VANET: Issues and existing solutions", Vehicular Communications, 15 January 2020.

[2] Tawfiq NebbouMohamed LehsainiHacène Fouchal,"Partial backwards routing protocol for VANETs", Vehicular Communications, 3 June 2019

[3] Ramin KarimiSaeed Shokrollahi,"PGRP: Predictive geographic routing protocol for VANETs",Computer Networks, 22 May 2018.

[4] Pedro CirneAndré ZúqueteMiguel L,"The impact of ECDSA in a VANET routing service: Insights from real data traces",Ad Hoc Networks, 28 August 2018.

[5] Pedro CirneAndré ZúqueteSusana Sargento,"TROPHY: Trustworthy VANET routing with group authentication keys", Ad Hoc Networks, 20 December 2017.

[6] Gaurav DhimanKrishna Kant SinghKorhan Cengiz,"MOSOA: A new multi-objective seagull optimization algorithm", Expert Systems with Applications, 9 November 2020.

[7] A. KavehA. Dadras,"A novel meta-heuristic optimization algorithm: Thermal exchange optimization", Advances in Engineering Software, 18 April 2017.

[8] Marini, F., Walczak, B.: ‘Particle swarm optimization (PSO). A tutorial’, Chemometrics and Intelligent Laboratory Systems, vol.149,pp. 153-165, 2015.

[9] Tang, Y., Cheng, N., Wu, W., Wang, M., Dai, Y. and Shen, X. ‘Delay-minimization routing for heterogeneous VANETs with machine learning based mobility prediction. IEEE Transactions on Vehicular Technology, vol. 68, no. 4, pp. 3967-3979, 2019.

[10] Gandomi, A.H., Yang, X.-S., Talatahari, S., Alavi, A.H..: ‘Firefly algorithm with chaos’, Communications in Nonlinear Science and Numerical Simulation, vol.18, no. 1), pp.89-98, 2013.

[11] Deepak Rewadkar and Dharmpal Doye,"Traffic-Aware Routing in Urban VANET using PSO Model",Journal of Networking and Communication Systems, vol. 2, no. 1, April 2019.

[12] Mukund B. Wagh and Dr. Gomathi N,"Improved GWO-CS Algorithm-Based Optimal Routing Strategy in VANET",Journal of Networking and Communication Systems, vol. 2, no. 1, January 2019.

[13] Dr.Sivaram Rajeyyagari,"Automatic Speaker Diarization using Deep LSTM in Audio Lecturing of e-Khool Platform", Journal of Networking and Communication Systems, vol 3, no 4, October 2020.

[14] Amol V Dhumane,"Examining User Experience of eLearning Systems using EKhool Learners", Journal of Networking and Communication Systems, vol 3, no 4, October 2020.