A collaborated genetic with lion optimization algorithms for improving the quality of forwarding in a vehicular ad-hoc network

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ABSTRACT

Vehicular ad-hoc network (VANET) is dynamic and it works on various noteworthy applications in intelligent transportation systems (ITS). In general, routing overhead is more in the VANETs due to their properties. Hence, need to handle this issue to improve the performance of the VANETs. Also due to its dynamic nature collision occurs. Up till now, we have had immense complexity in developing the multi-constrained network with high quality of forwarding (QoF). To solve the difficulties especially to control the congestion this paper introduces an enhanced genetic algorithm-based lion optimization for QoF-based routing protocol (EGA-LOQRP) in the VANET network. Lion optimization routing protocol (LORP) is an optimization-based routing protocol that can able to control the network with a huge number of vehicles. An enhanced genetic algorithm (EGA) is employed here to find the best possible path for data transmission which leads to meeting the QoF. This will result in low packet loss, delay, and energy consumption of the network. The exhaustive simulation tests demonstrate that the EGA-LOQRP routing protocol improves performance effectively in the face of congestion and QoS assaults compared to the previous routing protocols like Ad hoc on-demand distance vector (AODV), ant colony optimization-AODV (ACO-AODV) and traffic aware segment-AODV (TAS-AODV).

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1. INTRODUCTION

In recent years, vehicular ad-hoc networks (VANETs) becomes a new category of mobile ad-hoc networks and it covers a major part of intelligent transportation systems (ITS). Due to the highly volatile network topologies in the real world, massive human, ecological and financial loss happens. Currently, we are in the need of an imperative application to guarantee road safety [1]. To achieve an effective and consistent vehicle transmission a novel routing protocol creation is essential [2]. Due to the highly dynamic networks, the traditional routing protocols do not apply to them. Routing overhead is generally high and Path loss probability increases in the VANET network [3], [4]. Thus, it is significant to develop an optimal reliable path for transmission in multiple routes [5], [6]. Currently, passive routing protocols like Ad hoc on-demand distance (AODV), dynamic source routing (DSR), and the destination-sequenced distance vector (DSDV), do not apply to vehicle-to-vehicle communication [7], [8]. To solve the routing problems in VANET, an enhanced genetic algorithm (EGA) and lion optimization routing protocol (LORP) are suggested. LORP routing protocol and genetic algorithm (GA) are enhanced and then combined to develop a better routing prototype to find the best routing path. This combination is done because the general GA or lion algorithm (LA) is not suitable to handle the routing model. The major system parameters which are considered for routing are energy, throughput, and latency. Secondly, cross-over mutation of both GA and LA is combined to develop a better-improved model for path selection.

Routing protocols play an important role to provide effective communication in the VANET network. So, its classification is a complicated task. In Figure 1 the comparison of all the routing protocols of VANET communication is shown [9], [10].

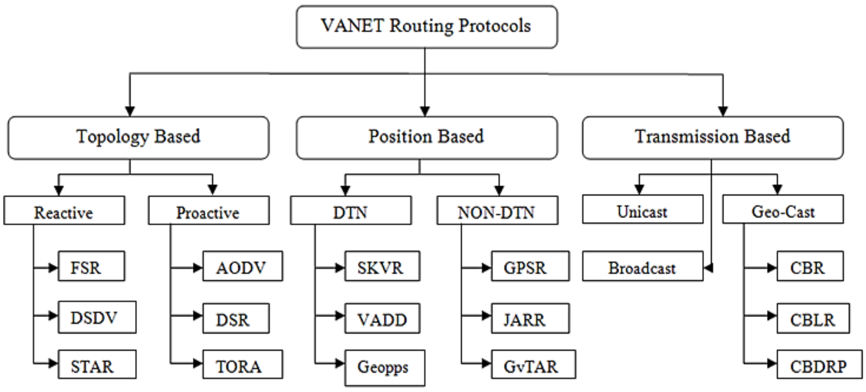

Figure 1. Routing protocol classification

A few other important routing protocols are traffic aware segment-based routing (TASR) protocol, particle swarm optimization (PSO), GA, differential evolution, and optimization to control the congestion in the network [11]–[13]. Jindal *et al*. [14] suggested a protocol that uses the best path selection for reducing the extreme congestion in the VANET network called improved hybrid ant particle optimization (IHAPO) algorithm-based routing protocol. Sree *et al*. [15], create a design called the ant colony-based temporarily ordered (ACbTO) algorithm which concentrates on optimal path selection based on priority. To solve traffic issues traffic management unit (TMU) is used as a control unit mainly to collect the data from the vehicle, transmission of data, path selection as well as cluster formation. Gao *et al*. [16], developed a data routing decision scheme based on the Manhattan mobility model to perform multi-hop communication in VANET.

Mohaisen *et al*. [17], is proposed a unified routing protocol for a hybrid network of VANET-WSN to improve network lifetime. A novel clustering model has been introduced for VANETs by Goswami *et al*. [18], GA and ant colony optimization (ACO) were combined in this environment to reinforce the network lifetime as well as the reliability. Jindal *et al*. [19] proposed a preemptive hybrid ant particle optimization (HAPO-P) algorithm to reduce congestion in the network. Wang *et al*. [20] develop a hybrid ITS to reduce traffic congestion with the combination of VANETs and cellular systems. In all these studies, the impact of the optimal path, as well as the best path selection for VANET communication, was not clear. For that reason, in our work, the optimal and best path selection is done using an EGA and LORP mainly to do congestion control and reduce energy consumption in the network.

2. MATERIALS AND METHODS

2.1. System model

In the system model, the movement of vehicles and their directions are explained. Here 50 vehicles are used for analysis where the exact locations (EL) and the access points (AP) are included [21]. The vehicle's speed remained constant in some areas and in other locations the mobility is high. So, an optimal path selection for the system becomes a primary requirement to improve the overall quality of forwarding (QoF). Five numbers of APs are fixed to cover the vehicles of the entire coverage area. Due to mobility, there is a chance of congestion in a particular location when the number of vehicles increases over the limit. For this reason, a novel routing protocol enhanced genetic algorithm-based lion optimization for QoF-based routing protocol (EGA-LOQRP) is initiated. The vehicle's communication is monitored by the AP. Each vehicle consists of its onboard unit (OBU) which mainly works for transfer; receiving as well as forwarding the information to another vehicle or an AP [22]. Favorably, an intellectual routing protocol takes the responsibility to enhance the quality of the VANET network. In earlier studies, the network structure has a few issues like problems in vehicle direction finding [21], environmental constraints, complex road conditions, intermittent connectivity among the vehicles [22], and pathfinding issues in routing [23]. A few other parameters which are considered here to improve the overall performance are energy efficiency, accuracy, and network utility. Some of the earlier works which are employed in this study are traffic aware protocol for ITS [24], improvement of AODV routing protocol for VANET [25], and trunk line-based geographic routing (TLBGR) protocol [11].

2.2. Enhanced genetic algorithm and operation

2.2.1. EGA basics

In general genetic algorithm (GA) algorithm is one among the meta-heuristic algorithm utilizing high position as well as it is mainly used to simulate chromosome evolution behavior of selection, crossover, and mutation to obtain the best resolution for particular issues. Intending to provide betterment in the crossover and mutation process we use a dynamic adapting strategy in GA to dynamically control the crossover and mutation process. And we call this updated GA an EGA. The workflow of EGA is represented in Figure 2, and the working process is illustrated in detail in the Algorithm 1.

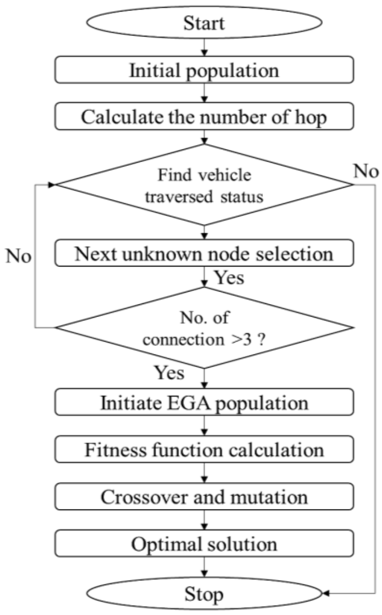

Figure 2. EGA algorithm

Algorithm 1. Workflow of EGA

```
Begin
   Step1 Initialization of EGA to solve the optimization problem. Primarily it consists of
         a string of bits that have similar elements with it.
   Step2 The work continues with a randomly generated population that spreads everywhere to
         provide n number of solutions as possible.
   Step3 The inclusion process with the next generation is done using these copied strings,
         the fitness of the individuals is responsible for the selection standards.
   Step4 In the area of the chromosome, two of the chromosomes get the crossover and
         produce two of the new chromosomes in the random condition.
   Step5 Staggering amounts of various string values are generated using the selection as
         well as a crossover.
   Step6 The end process contains the evolution cycle counts and predefined fitness values.
End
```

2.2.2. EGA operation

EGA is one of the global optimization algorithms applied to find the optimal path among the available paths as so to improve the QoF. The major steps behind the process of EGA are coding scheme, population initialization, path selection, crossover, and mutation. The path-finding process of EGA is explained in a step-by-step manner.

Coding scheme: The path taken between the sender and the receiver is similar to an individual the chromosome deposition is termed as the route's serial number sequence of intersections and it is a direct encoding process. Mainly to avoid route circulation which is caused due to the variable length of chromosomes this coding method is used and always this circulation must be lesser than the number of intersections.

Population Initialization: The initial population is considered from EGA paths according to its size.

Path Selection: The detailed pros and cons of the individuals are measured based on fitness function in EGA. Selecting the path with the highest fitness value is our target. To achieve this individual section with the highest fitness value is essential. For that reason, the expression for the fitness function is shown in (1),

$$F_f = Xp_c + \frac{Y}{AD_{n^{th}}} \tag{1}$$

where p_c– Probability for connections, $AD_{n^{th}}$-Average delay of n^{th} individuals, X and Y are the weight parameters and here $(X, Y) \epsilon (0,1)$. Previous to chromosome crossing, the worst ones are removed by the best individuals as well as based on the fitness function that becomes offspring individuals, the individual selection from the remaining population is done by a roulette wheel process, according to the greater probability of the individuals with maximum fitness value is selected.

Crossover: Crossover operation is termed as that it is the exchange of paths between two individuals. As described in Figure 3 the RP1 and RP2 are the parents routing paths. This crossing process is selected randomly among the crossing sited with the condition both are in the parent's sites. Once all the nodes get exchanged in the crossing sites two new offspring are generated which are 〖RP〗 _1^′ and 〖RP〗 _2^′.

Mutation: Finally, the mutation is technically used in the randomly chosen RP. Followed by that the node n_i is chosen randomly from RP to proceed with the mutation operation and that is called the mutation node it is explained in Figure 4 elaborately. Among the neighbors of mutated node n_i the node n_j is selected. From the sender node, two new routes (nr1 and nr2) are selected which are the sender to the hop node and the hop node to the receiver. In case any duplication occurred in nr1, then the nr2 selection process is automatically canceled and the operation gets stopped. If not, these paths are get connected to create a fresh mutated chromosome RP'. All these above processes are repeated until it reaches the maximum number of iterations or the best path RP' is chosen.

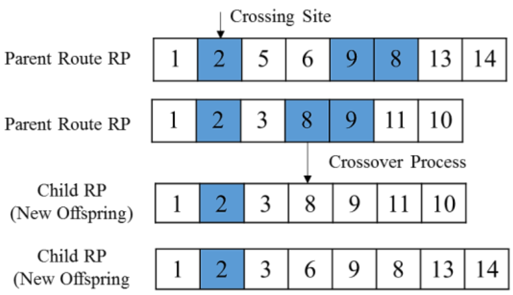

Figure 3. Sample for crossover technique

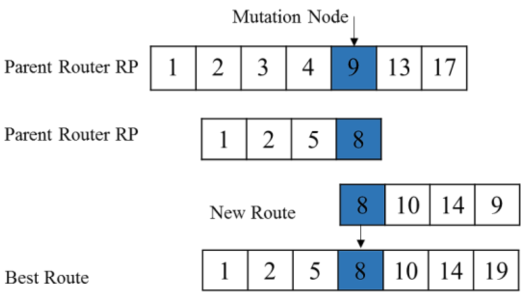

Figure 4. Sample for mutation technique

2.3. EGA-LOQRP protocol

The purpose of finding the best possible routing path using EGA with our routing protocol is the core idea of our work. Consumption of energy can be increased because of its random structure which results in reduced efficiency. So our EGA-LOQRP protocol is effective enough to handle this situation in the networks. We initiated two trial methods called LOQRP maximization and LOQRP minimization. The overall flow diagram of the EGA-LOQRP protocol is described in Figure 5.

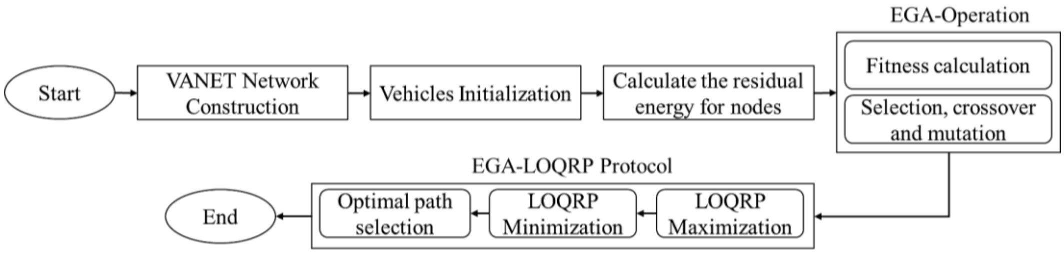

Figure 5. Flow diagram of EGA-LOQRP

2.3.1. LOQRP maximization and LOQRP minimization

In this section, the process of LOQRP maximization and LOQRP minimization is performed mainly to improve the efficiency of the VANETs by enhancing the routing protocol. The major parameters which are involved in the process of LOQRP maximization and LOQRP minimization are power factor, message success rate, throughput, latency, and optimal path.

a. LOQRP maximization

Primarily the power factor varied from (0,1). If the power factor of the node is zero then the node will be maintained a sleep condition and the uppermost power factor is 1. The middle levels are nodes given in Table 1.

The path stability of the node primarily depends on its power factor that is the node with nil power will result in network collusion and packet loss. And the power factor of the node is defined as the summation of the consumed power and the aggregated power and it is mathematically expressed in (2).

$$P_e = P_c + P_a \quad (2)$$

Here P_e indicate the electronic power of the network, P_c indicate power consumed from the allocated power factor and P_a indicate data aggregation power. To measure the present power factor of the node i after the communication is mathematically expressed in (3) and it is the subtraction of the node's initial power and the electronic power.

$$\mathrm{P_r} = \mathrm{P_n} - \mathrm{P_e} \quad (3)$$

Here P_r represents the remaining power of the node at the end of the transmission, P_n represents the initial power of the node. Then the power factor of each node at the end of the process of the entire data transmission is mathematically expressed in the (4) which is measured using the terms such as final part values and the total number of nodes present in the optimal path between the source and the destination.

$$\mathrm{P} = \frac{\mathrm{P_1, P_2, \ldots\ldots P_r}}{\mathrm{N}} \quad (4)$$

Where N indicates the nodes count in the particular optimal path. In the final part the value of P lies in between (0 to 1) then, according to Table 2, the power allocated will be done. Similarly, the next parameter is message success rate calculation. The input and output rate of the message is variable at the initial condition. At a certain instant of time, the node will forward every message, at that moment that mode is accepted as a high-confidence node in the network. In certain cases, the output rate of the message is lesser than half the rate of input which represents the node is not trustworthy. Then automatically the node is considered a sleep node. Table 2 shows information about the message success rate.

Table 1. Power factor allocation

Power Factor Allocation	Node Representation
0	Sleep Node
0.0-0.2	Node with below Quarter power factor
0.2-0.4	Node with the above Quarter power factor
0.4-0.6	Node with above half and midst power factor
0.6-0.8	Node with above three-fourths energy
0.8-1.0	Half active node

Table 2. Power factor allocation

Power Factor Allocation	Node Representation
0	M_{out}=0
0.0-0.2	M_{out}=$M_{in}/5$
0.2-0.4	M_{out}=$M_{in}/2.5$
0.4-0.6	M_{out}=$M_{in}/1.66$
0.6-0.8	M_{out}=$M_{in}/1.25$
0.8-1.0	M_{out}=1

Where M_{out} indicates the output packets and min indicates the input packets. All the nodes in the network are allocated with values based on its computational model. According to Table 2, the message success rate of the node ranges from 0 to 1. To receive the highest network reliability the path which consists of more nodes with a high message success rate will be provided priority and that can be formulated as,

$$\mathrm{MSR} = \frac{\text{output message}}{\text{input message}} \tag{5}$$

finally, network throughput is taken into account and it is represented as the queue length of the node. The throughput of the network is defined as the calculation of the amount of data transmitted between the source and the destination for the entire transmission. The calculation of the throughput of the node is done according to the number of messages in the queue, and then it is expressed in the (6),

$$\mathrm{TH} = \frac{\mathrm{MQ}}{\text{number of nodes}} \tag{6}$$

$$N = \frac{(TH-ol)*(Nu-Nl)}{om-ol} \tag{7}$$

where MQ indicated the number of a message which is present in the queue and the normalization value can be calculated using the network throughput. It is represented in (7). Here, ol and om denoted the least and most values ranging from 0 to 3, Nu and Nl denote the upper and lower limit of normalization values ranging from 0 to 1. By using the expression (4)-(6) the LOQRP maximization value is calculated and it is expressed as,

$$RP_{max} = \sum_{i=1}^{N} \frac{P+MSR+TH}{3} \tag{8}$$

b. LOQRP minimization

The parameters which are used for the minimization process are latency and optimal path. The term latency is defined as that during the process of communication between the sources and the destination the calculation of delay occurrence is called the latency. Now the latency is the delay time taken in each path and it is expressed as,

$$L = L_1, L_2, \dots L_{n-1} \tag{9}$$

here, n indicates the node count of the particular path. As a continuation, the optimal path calculation is done. It is measured by the use of the weight of the path which is the number of intermediate nodes present in the path among the sender as well as the receiver. The calculation of optimal path finding is given in (10).

$$OP = hop\ count\ in\ the\ path \tag{10}$$

Finally,

$$\text{LOQRP Minimization} = \min \mathrm{L}, \mathrm{OP}\ \big||\mathrm{L}\ \&\ \mathrm{OP}|\big| \tag{11}$$

2.3.2. Optimal path selection

The final best fitness value of the EGA-LOQRP protocol is mathematically expressed in the (12), and it is obtained using the routing protocol maximization process where it is the combination of the parameters such as power factor, message success rate, and the network throughput. By the use of these parameters, the optimal path selection is performed in VANETs.

$$\mathrm{F_{best}} = \sum_{i=1}^{N} \frac{\mathrm{RP_{max_1}, RP_{max_2}, \dots\dots\ RP_{max_N}}}{\mathrm{N}} \tag{12}$$

The final best fitness value is calculated using the (12) and that is represented as the optimal path for our protocol EGA-LOQRP. The good quality of our work is that we select the best possible path rather than selecting the shortest path. Why because in some cases the shortest path may contain collision where the path strength is not accessed clearly. That leads to link breakage and increases the delay time at the time of data transfer. So, it is very prudent to choose the path which is logically examined.

3. RESULTS AND DISCUSSION

This section is illustrating the performance of this work as well as the states of the art of protocols that were analyzed with the help of several simulation topographies. To do a comparison, we selected two states of art protocols named AODV, ACO-AODV [25], and TAS-AODV [11]. Those parameters taken for performance evaluation are discussed. Network Lifetime-The lifetime of the network is termed as that of the round count of the nodes till all those nodes reach the fully exhaust stage of the energy values.

Network Energy Consumption: The amount of energy that got reduced from the initial energy until the end of the transmission is termed the energy consumption calculation. Network Throughput: It is defined as the total data bytes effectively transmitted to the destination per instant of time. And it is mathematically expressed as,

$$Throughput\ (kbps) = \frac{Total\ bytes\ transmitted\ in\ the\ network*8}{Time\ (\delta)} \tag{13}$$

Packet delivery ratio (PDR): The packet delivery ratio of the network is termed as that it is the percentage of packets that are accurately transmitted to the destination over the total number of packets that are generated and transmitted from the sender. It is expressed mathematically in the (14),

$$\text{PDR} = \frac{\text{Packets received accurately}}{\text{Transmitted Packets}} \times 100 \tag{14}$$

Packet loss ratio (PLR): The packet loss ratio of the network is termed as that it is the percentage of lost packets at the time of communication for every packet broadcasted and it is very essential to reduce the loss ratio to achieve effective communication in VANETs. The mathematical expression for the calculation of packet loss ratio is given as,

$$\text{PLR} = \frac{\text{Transmitted Packet} - \text{Received Packets}}{\text{Transmitted Packets}} \times 100 \tag{15}$$

End-to-End delay (EED): It is defined as the total delay time taken to transfer the information from the source to the destination. To achieve stable communication in VANETs, it is very essential to reduce the end-to-end delay during communication. So, the values of EED are calculated using the expression given in the (16),

$$\text{EED} = \frac{\text{Packet Delivery Time}}{\text{Number of packets delivered}} \tag{16}$$

Network overhead (NO): Network Overhead is calculated as the ratio among the extra routing packets as well as the received packets of the nodes. It is otherwise defined as the calculation of the total amount of forwarded packets produced during the process of communication between the source and the destination. So the values of EED are calculated as,

$$\text{NO} = \frac{\text{Overhead messages of the network}}{\text{packets transmitted overall}} \tag{17}$$

3.1. Simulation setup

For analysis, network simulation 2 with version (NS-2.34) is used. Generally, NS2 is an open-source event-driven simulator for front-end script creation TCL language is used. Then after the execution, two output files are generated is a trace file and a network animator (NAM) file. Here trace file is used for performance analysis [24]. The simulation parameter setup is described as shown in Table 3.

Table 3. Simulation parameter setting

Parameter	Value
Simulator	NS-2.34
Simulation time	100ms
Area	1000*1000 m2
Transmission rage	300m
No. of vehicle	100
Propagation model	Two-ray propagation model
Antenna	Omni-direction Antenna
Traffic type	CBR
Traffic rate	0.01 to 0.50 sec
Packet size	512 bytes
Agent type	TCP
Initial power	100 J
Idle power	0.1 J
Queue type	Drop-Tail

3.2. Performance evaluation

The performance analysis of the proposed model is tested in terms of network lifetime, network energy consumption, throughput, packet delivery ratio, loss ratio, end-to-end delay, and network overhead. The results calculated from our proposed model are compared with the start-of-art approaches namely ACO-AODV and TAS-AODV. Figure 6 shows the graph plot for the parameter of network lifetime with no vehicles and nodes. From this test analysis, the lifetime achieved by the proposed work is 89.90 % whereas the existing works are 74.91% and 77.57% respectively. Our proposed work achieved a better network lifetime.

This simulation observed that the consumption of energy of EGA-LOQRP is minimum to the comparison protocols and the details are shown in Figure 7. From the figure, it is shown that the energy consumption of the proposed EGA-LOQPR is 17.99% whereas the earlier methods such as ACO-AODV and TAS-AODV are 41.84% and 35.22% which is around 17% to 25% higher than the EGA-LOQPR respectively.

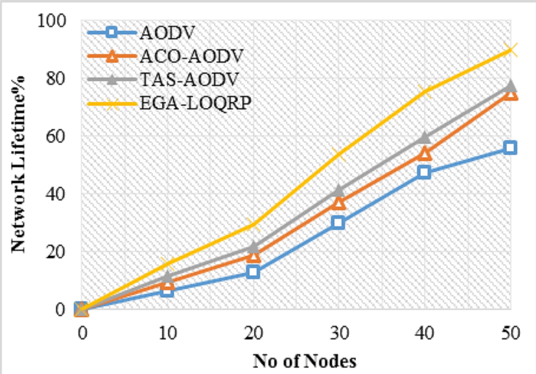

Figure 6. Lifetime calculation Vs nodes

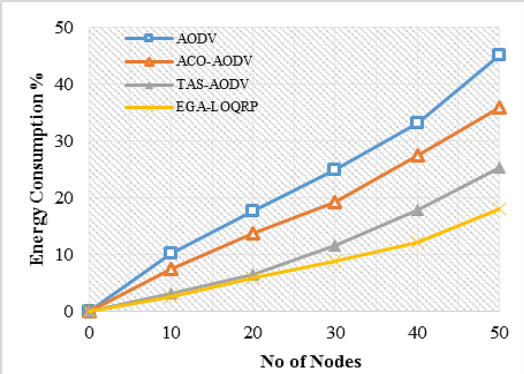

Figure 7. Consumption graph Vs nodes

Figure 8 shows the comparative results of throughput Vs number of nodes. Here the throughput value of the proposed work is higher than the earlier works. The analysis and comparison of the PDR of the proposed approach are shown in Figure 9. EGA-LOQPR achieves a reasonable packet delivery ratio of around 93% which is comparatively higher than the earlier approaches where the PDR of ACO-AODV is 75.12% and TAS-AODV is 85.98%.

Figure 9 shows the packet delivery ratio of the methods such as ACO-AODV, TAS-AODV, and proposed EGA-LOQPR. From the figure, it is understood that the EGA-LOQPR higher packet delivery ratio when compared with the earlier methods. The packet delivery ratio achieved by the proposed EGA-LOQPR is 93.55% and the earlier works such as ACO-AODV and TAS-AODV are 60.12% and 85.98% respectively.

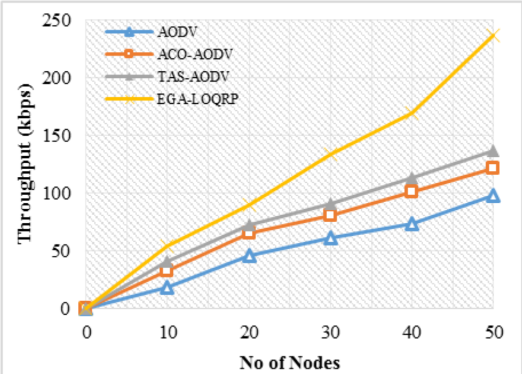

Figure 8. Throughput Vs nodes

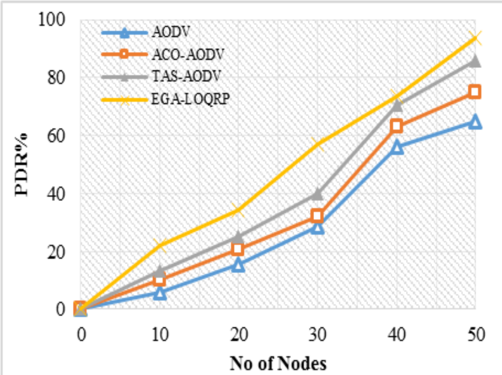

Figure 9. PDR comparison Vs nodes

Figure 10 show the packet loss ratio of the three considered routing protocols with proposed work in term of the number of nodes. From the figure, it is understood that the packet loss achieved by the proposed

EGA-LOQPR is lower than the earlier works where the loss produced by the EGA-LOQPR is 45 packets, and the loss produced by the earlier works like ACO-AODV and TAS-AODV are 144 packets and 134 packets.

Figure 11 depicts the end-to-end delay calculation of the proposed work. From the graph, it proved that the proposed routing protocol generates low delay by choosing the best possible path. The delay proposed by the proposed EGA-LOQPR is 155ms whereas the earlier ACO-AODV and TAS-AODV are 257ms and 195ms respectively.

The comparison results of network transmission overhead are illustrated in Figure 12 for the different routing protocols. It is essential to produce lower routing overhead to achieve higher performance. The proposed EGA-LOQPR proposed routing overhead up to 1723 packets whereas for the earlier works such as ACO-AODV and TAS-AODV it is 4979 packets and 2587 packets respectively.

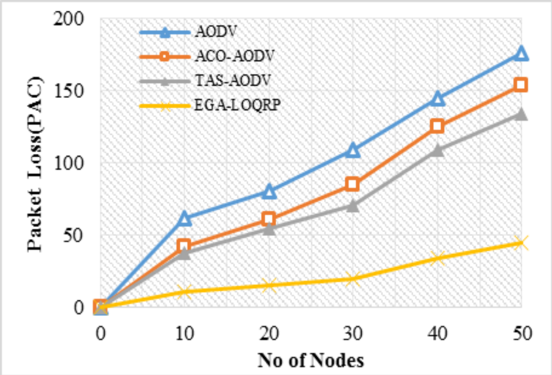

Figure 10. Packet loss calculation Vs node

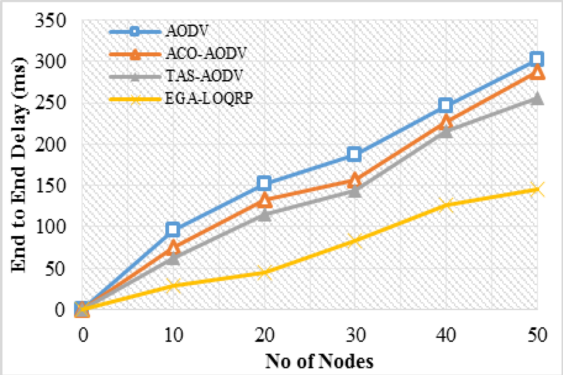

Figure 11. E2E delay Vs nodes

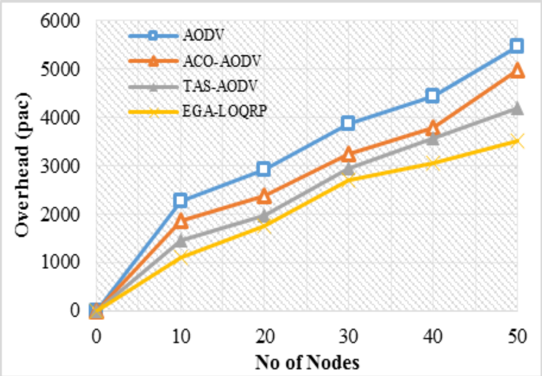

Figure 12. Overhead calculation Vs nodes

4. CONCLUSION

The VANET is dynamic in nature and can be used for a variety of applications in the ITS. There have been several previous research projects aimed at developing a better routing protocol for VANETs. Routing overhead is generally higher in VANETs due to their characteristics. Hence, the new routing protocol is proposed in this research for VANETs which is more effective and optimal. The performance is achieved by selecting the best possible path by incorporating the power factor, packet delivery ratio, delay, and network throughput in LOQRP maximization and minimization. These parameters play a major part in finding the best possible path for the process of packet forwarding. This path is selected by an adaptive genetic algorithm-based LOQRP routing protocol. The results are analyzed and it is compared with the existing protocols as well as the proposed EGA-LOQRP protocol outperforms those protocols. For future research, the extension of this work is to provide security solutions for routing protocols.

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