

# QoE Aware Video Streaming and Optimal Relay for Emergency Message Dissemination in Graph Based VANET

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## To cite this article:

Aduomer Girmay Gebray, Dong Wang. QoE Aware Video Streaming and Optimal Relay for Emergency Message Dissemination in Graph Based VANET. *Advances in Applied Sciences*. Vol. 7, No. 1, 2022, pp. 1-14. doi: 10.11648/j.aas.20220701.11

**Received:** January 12, 2022; **Accepted:** January 28, 2022; **Published:** February 16, 2022

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**Abstract:** Vehicular Ad hoc Network (VANET) is a dynamic network environment that supports the transmission of any type of data that varies with size and delay constraints. VANET also enables to aid safety message forwarding in case of emergency by means of data dissemination. The major problematic issues in routing and data dissemination are delay and broadcast storm. With the advancements in VANET technology not only normal traffic data transmission but also video streaming is transmitted while the delay constraint has to be very less for video streaming. This article addresses these two problems by designing a graph aware network management for emergency message dissemination by selecting an optimal relay using multi-objective shuffled shepherd optimization algorithm that computes degree, goodness, waiting time, transmission range and link utility. Graph is constructed with the link stability, signal strength, distance and speed between vehicles. The selected relay vehicle from the graph is responsible to disseminate the safety message, which reduces the broadcast storm. The use of reinforcement learning is able to select the most suitable low delay neighbors for video streaming. In routing, the normal traffic data transmission is performed which is tolerable to delay, so Type-2 fuzzy logic is used with dynamic belief entropy that defines routes with the computation of quality of forwarding, bandwidth, distance and hop counts. This proposed work is implemented on OMNeT++ simulator and the results show better performances than the existing work in terms of packet delivery ratio, end-to-end delay, duplicate packets, throughput, and frame loss.

**Keywords:** Emergency Dissemination, Graph Network, Video Streaming Relay, Selection, Traffic Routing

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## 1. Introduction

Vehicular Ad hoc Network (VANET) is a sub-category of Mobile Ad hoc network (MANET) that allows transmission in high speed vehicles with the IEEE 802.11p standard. VANET is composed of vehicles with on-board units (OBUs) and road side units (RSUs). The data transmission between vehicles is performed by selecting a route between the source and destination vehicle [1-3]. The route is chosen on different aspects that uses geographical location, link stability, delay and so on [4, 5]. The vehicles moving on the road lane are grouped, which the prediction of route easier. The process of routing in VANET is critical due to the dynamic topology of the network. The routing is involved differently with real time and non-real-time applications. Also, routing is performed using artificial intelligence,

machine learning, meta-heuristics and reinforcement learning algorithms.

Among all, meta-heuristics, i.e. nature-inspired algorithms, are efficient in selecting routes for data transmission. The route is selected by using the computation of any particular parameter. From the available routes, an optimal route is selected with the support of using an optimization algorithm [6, 7]. The optimization algorithm is able to solve the problem of route selection with the specified objective. Also, the use of multi objective is becoming a promising solution to select a route from source to destination. Especially, in video streaming using routing, the Quality of Service (QoS) and Quality of Experience (QoE) plays a vital role. The common challenges that exist in

routing methods are:

Routing between source to destination in dynamic topology leads to frequent selection of intermediate hops, since the vehicles move at high speeds, and their direction changes.

The more the time taken for selecting a route tends to increase, the larger the end-to-end delays. Moreover, the delay requirement for each data type is not the same [8, 9].

Use of single constraint based objective development fails to select a good route, because it may consider only vehicle or link based metric.

VANET is aiding with safety message dissemination i.e. to spread an accident or other emergency message to make the vehicle aware about the situation that happened in the road lane [10-12]. The safety message includes vehicle crash, violation of traffic signal, assistance for lane changing, hurdle on the road lane, congestion and so on. The dissemination is broadcasted to one-hop or multi-hop vehicles in the network. However, this process is challenging because of the problem of broadcast storm. In this, there is a possibility for more than one vehicle broadcasting the same information, which leads to critical issues of collision and message replication. Hereby, to broadcast data dissemination is a significant process handled in VANET environment [13].

Emergency message dissemination is also performed by a cluster based network, relay selection that is operated using fuzzy logic, optimization and other algorithms too [14-18]. The dissemination of messages always contains emergency data and hence it is required to be forwarded in short time within the deadline. Hereby, the routing and dissemination plays a vital role in VANET.

### 1.1. Motivation

Routing in VANET is performed by using an optimization algorithm that involves the use of single objective and multi objective for selecting a route between vehicles. In contrast of this, the multi-objective is able to consider more than one constraint in routing [19]. An artificial bee colony (ABC) algorithm is proposed with fuzzy logic to compute the parameters and discovers the best route from it. The key factors that are taken for route selection are direction, distance and speed. Even though this route selection is better, it is used to transfer any type of data from the source to destination vehicle. That is to say, in case of video, this routing will certainly require time. Especially for video streaming multipath routing is performed using genetic algorithm (GA). Initially all the available paths are discovered and then using GA an optimal path is selected for video transmission. Here, the distance is the only key metric that is taken into account for optimal route that is determined from the operator's selection, crossover and mutation. From these routing methods, the main goal/objective is to develop individual methods to route video data and other traffic data.

According to [21], in data dissemination best forwarders are selected based on the partitioned network.

Also the coverage range of the vehicle is smaller than RSU and hence it is not tedious for the vehicle to perform portioning. In focus of data dissemination, the QoS is significant [22]. Generally, QoS is important in VANET while transmitting any data that can be emergent or non-emergent data. When it comes to video streaming the Quality of experience (QoE) is more significant since the quality of the video is the main key to evaluate the proposed VANET dissemination method. Hence it is required to consider QoS in video streaming.

In VANET, a route is selected in common for transmitting any data from one vehicle to another. The main motivations identified from VANET environment are:

Routing protocol using a procedure without knowing the type of data is not efficient, since the requirement of delay for video streaming is very low and it can be higher for other type of data transmission. Hence from this, separate methods are to be proposed for performing transmission of data and dissemination of emergency data. In VANET both the type of data is present and hence use of same method is not suitable for all type of data.

Data dissemination demands for the mitigation of broadcast storm problem which happens when the emergency message is sent by many numbers of forwarders. In simple it creates replications and degrades the channel characteristics for other transmission.

### 1.2. Contribution

The major contribution of this proposed research paper is depicted below:

Dynamic topology in VANET is managed by the construction of a graph in accordance to the link stability, signal strength, distance and moving speed. Based on these metrics, the graph in RSU is updated accordingly.

The broadcast storm in dissemination is minimized from the selection of relay by dividing the graph into sub-graphs and then multi-objective Shuffled Shepherd Optimization algorithm (MO-SSOA) using degree, goodness, waiting time, transmission range and link utility.

Routing of normal data is performed using Type-2 fuzzy logic with dynamic belief entropy, since the characteristics are dynamic. The type-2 fuzzy takes decision from quality of forwarding, bandwidth, distance and hop counts.

Video streaming by means of a route also depends on the graph structure; the neighboring selection is executed with the computation of primary and secondary mean opinion score. The decision making of the neighbor selection is performed using deep Q-learning algorithm that is able to learn the environment.

Based on these contributions, the proposed VANET environment is designed and the results are evaluated. The proposed system mainly focuses on routing of normal data traffic, video streaming and dissemination of emergency data.

### 1.3. Paper Organization

This paper is organized according to the following

sections: section II details the existing research works on VANET routing and dissemination with the major limitation, section III depicts the key problem identified in this research, section IV elaborates the proposed research solution for routing and dissemination, section V evaluates the proposed system with significant parameters and section VI concludes proposed research and extends future directions.

## 2. Related Work

In this section, the two main processes in VANET as routing and emergency message dissemination are detailed. Each work is executed in accordance to an algorithm that enables to select suitable route or forwarder. Hereby the key demits in each work is also illustrated.

### 2.1. VANET Research on Routing

Routing was performed using cluster-based VANET oriented evolving graph (CVoEG); here the link reliability is an important metric that was computed for cluster head (CH) and member selection [23]. A vehicle with higher Eigen-centrality score was computed for the selection of a cluster head. After construction of graph, the optimal numbers of clusters were determined and then CH is chosen. In routing, the route was discovered from Dijkstra algorithm by exchanging route request messages. Since, the network is dynamic cluster merging and splitting was performed. The problem here is that, the Dijkstra algorithm performs blind search and so the prediction of a route is not optimal. For optimal selection of route and decision making algorithm i.e. Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) that selects next-hop using attractor estimation [24]. A unicast routing protocol with attractor selecting (URAS) was proposed. A candidate set of vehicles was constructed from TOPSIS, and then an attribute matrix was computed from distance, congestion degree and relative speed. Further the next hop was selected for data delivery. The TOPSIS algorithm is supposed to be uncertain in calculating the weight values.

An adaptive weighted clustering protocol for clustering and enhanced whale optimization algorithm (EWOA) for head selection and then it performs routing by computing speed and position of the vehicles [25]. The routing of data packet between the vehicles based on the speed and position was not sufficient since, the link between vehicles will not be stronger in that time. An improved genetic algorithm-based route optimization technique (IGAROT) was proposed that considers significant parameters as received signal strength (RSS), transmit power, frequency and also path loss [26]. All these metrics are routing metrics computed by IGAROT; this work optimizes the route with the k-means clustering algorithm. Here the use of k-means algorithm requires proper selection of k-value and also the operators in genetic algorithm takes longer time to compute and hence the proposed IGAROT requires sufficient time for route selection and so a delay-aware routing is not

developed.

The authors M. Saravanan, P. Ganeshkumar have proposed deep reinforcement learning method for the purpose of selecting a route for transmission [27]. In this work two phases were followed they are route establishment and optimal route selection. At first the available routes were established based on the distance, density and position. Then the optimal route was selected by deploying deep reinforcement learning that learns the environment. The use of reinforcement learning is efficient but still, the parameters are completely vehicle characteristics based which also requires link based metrics. A maximum routing hop count selection algorithm called (MRHSA) was proposed in VANET [28]. In this algorithm, as per the vehicle density, the hops in the routes were adjusted adaptively. The node connectivity and packet delivery ratio was estimated, and then a reduction rate was estimated from the computed ratio. By this computation, the hops in the route were adjusted. According to M. Saravanan and P. Ganeshkumar only the hop count is taken in account, while the lesser hop count route also has poor link metric or moving speed and others [27].

On the other hand the routing was also performed for video streaming from source to destination. The authors of [29] paper have proposed video streaming using link efficiency and quality of experience aware routing protocol (LEQRV). In this work, an enhanced greedy forwarding based approach was used which identifies a stable route. Here the Mean Opinion Score (MOS), position, direction, link quality, link lifetime, density and buffer-free level were computed and then vehicle was selected. If vehicle not present in neighbour table, then distance was estimated from the Q-table which was maintained on the reinforcement learning algorithm [29]. After selection of a vehicle, the video packet was sent to the destination. Therefore, an Interference-aware Multipath Video Streaming (I-MVS) was proposed that predicts video quality with respect to the packet error rate [30]. This proposed multipath video streaming takes in account of node disjoint, link, signal power and bandwidth. For the purpose of eliminating the interference, it computes angle and link quality. Here the next forwarding vehicle was chosen only when it satisfies all the requirements. Hence, it requires a vehicle that needs to be true as expected, in case there is not vehicle with all these requirements, and then it waits for such vehicle.

### 2.2. VANET Research on Message Dissemination

Data dissemination by the design of time barrier mechanism that minimizes the message overhead and also reduces broadcast storm problem [31]. In this work, clusters were constructed and then the head vehicles are responsible to broadcast the emergency message. In this VANET, any vehicle has the potentiality to become CH, there was not specific constraint that was required to select particular vehicle as head. Each vehicle on receiving the message will check whether it was critical or non-critical, if

critical it was immediately disseminated. Hereby, the CHs were responsible to disseminate the message but it was not selected to be optimal and so the message dissemination was not effective. An adaptive intersection selection mechanism with ant colony optimization algorithm (AISM) for route discovery discussed [32]. In this work, the QoS metrics were considered for path selection. At first, the intersection of the source vehicle is determined and then zone of relevance and then route was identified to forward packets. For routing, carry and forward mechanism was used in this paper.

An intelligent forwarding protocol and a multi-hop broadcast protocol that aims to minimize collision [33], the sender vehicle computes SNR and the distance using Euclidean distance formula. Then the size of contention window was determined with these values. The vehicle waits until the waiting time reaches zero and then it rebroadcasts the safety message. In this work, the initial safety message broadcast was performed by the initiator without any selection of relay. Even though delay is reduced, there occurring excess of duplicate packets in this work. Fuzzy logic system for broadcasting in vehicular networks [34], in this work the fuzzy system was operated in two levels; the parameters that were taken in account are delay, packet delivery ratio, reachability and overhead. Here the two levels deals with upward and downward. Each fuzzy was deployed with a set of 9 rules based on the parameters that are taken in account. However multiple parameters are used for broadcasting, these metrics will depend only on the past transmission, but as per the vehicle's current speed those parameters will change.

QoS-aware broadcasting scheme that selects relaying vehicle nodes to mitigate broadcast storm [35]. In this work, fuzzy interference system was used for relay selection which makes decision by estimating the coverage kinetic degree (neighboring density), signal power and kinetic distance to mean. Based on these three constraints the relaying quality rank was determined from fuzzy IF-THEN, and then it is sorted in descending order. This work increases delay in disseminating emergency message, since it computes three parameters and then it is processed into fuzzy rules for selection. Also if the parameters are not able to satisfy in 27 rules, then that vehicle will not be selected as relay. The multiple relay vehicle to broadcast is selected as per the fuzzy rules, but if the multiple relay vehicles are too closer with good properties, then they will be selected for broadcast that increases duplicate messages and also the event message will not be spread to all the vehicles.

### 3. Problem Statement

For the selection of a next relay vehicle, a mean opinion score (MOS) was estimated based on the QoS factors such as packet loss rate, delay, and jitter as indicated in [36]. Along with this MOS the other factors as position, direction, speed and link expiration time was also taken in

account. A best next relay vehicle was selected by validating MOS in the neighboring table of the vehicle. The source vehicle computes QoE using delay, jitter, and packet loss and then it sends beacon message. The key problem stated in video streaming based on routing work is here below:

MOS based routing is not optimal since, it takes decision based on the information of the previous data transmission of the vehicle. The vehicle at previous transmission may have higher delay, jitter and packet loss which can be due to the signal properties (SNR, interference) or load in the vehicle buffer. Hence, preference of MOS with previous transmission information will miss to select best vehicle for video streaming.

The QoE is evaluated before performing transmission by the same parameters that are taken for MOS measurement. The quality of video streaming depends on the route and a failure in relay selection results with poor QoE. The QoE and Beacon contains similar information and hence it takes time to select next relay.

According to a geographic routing protocol in [37], the link utility was estimated from the residual bandwidth and link quality. This link utility was computed for two hop neighbors. The link quality was given as per the loss rate that was expressed using the expected transmission count. In this work carry and forward process was followed. The problems in normal data routing are stated as:

In this work, only two-hop neighbor's link utility is computed, but not all the source vehicle can transfer its data to destination within two hops. As per the distance and density of the vehicles, the number of hops will vary.

The use of carry and forward procedure takes longer waiting time, until the corresponding vehicle arrives into the coverage.

However, bandwidth plays an important role in the selection of relay which is not predicted accurately. And also it is not the only significant metric that exists between vehicles.

An epidemic algorithm called EPIC algorithm for message dissemination with respect to the time constraint [38] was proposed. The received message takes any one of the states as susceptible, infected and recovered. At first a vehicle receives message which was at susceptible state, which waits for a particular time and then after time expiration it moves into infected state. The decision to relay a message was done based on the detection of the transmission range of the message disseminated vehicle. The problems in emergency message dissemination are:

In this work, all the vehicles will relay the packet only after the waiting time expires, but the dissemination of emergency message (event) needs to be done in short time.

However, the transmission range of the vehicle is measured for making relay decision, within the waiting time vehicle could move and hence the message will be received again (duplicate message) from different vehicle.

The main problems stated in normal routing, video streaming and traffic data dissemination are concentrated and solved in this proposed research.

## 4. Proposed VANET Routing and Data Dissemination

The proposed VANET architecture composes of dynamic vehicles and static RSUs. The deployed vehicles move in both directions i.e. towards right and left. In contrast, the RSUs have larger coverage range than the vehicles and it is designed with two modules as network module and video streaming module.

**Definition 1 (Network Module):** The network module defines the management of graph that is constructed by the moving vehicles. Based on graph, relay selection is handled.

**Definition 2 (Video Streaming Module):** The video streaming module builds for the selection of route for video streaming from the constructed graphs.

Apart from these two modules in the proposed VANET model, the normal data routing is also performed by the vehicles with the selection of route by themselves using significant constraints. Our proposed VANET architecture

describes about vehicles, RSUs, source and destination of vehicles, how traffic information is routing as well as the movement direction of the vehicles. Hereunder, figure 1 depicts the proposed VANET architecture design with its details.

Among the four parameters in graph construction, the  $S_s$  depends on the distance between vehicles and the existence of signals between them. Based on this estimation, the graph is constructed dynamic as per the vehicle movements. From the graph optimal relay is selected after dividing the graphs into sub-graphs for minimizing broadcast storm problem. A graph in RSU is divided based on the communication range of the vehicle and then each sub-graph is selected with optimal relay using MO-SSOA algorithm. The benefits of dividing the graph into sub-graph are the ability to select an optimal disseminated at short time, since comparatively the competition in the whole graph will be lesser than in sub-graph. Also the problem of broadcast storm is recovered.

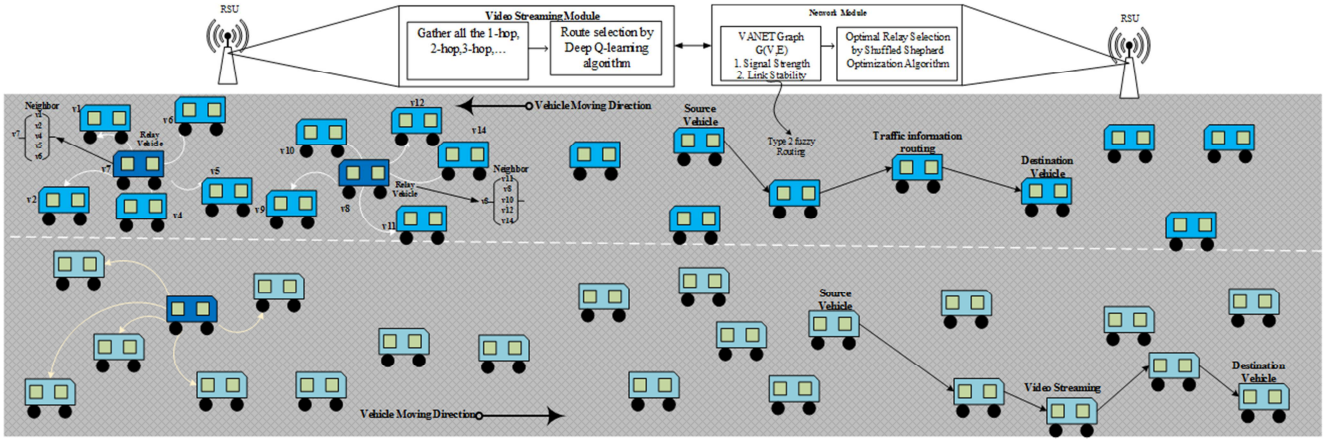


Figure 1. Proposed VANET Architecture.

### 4.1. VANET Graph Model

The RSU plays a vital role in VANET which constructs and maintains graph by taking in account of the vehicles. For graph construction, the key constraints between vehicles are measured they are link stability ( $L_s$ ), signal strength ( $S_s$ ), distance ( $D$ ) and moving speed ( $M_p$ ). This graph is dynamic in the RSU; it is updated from the monitored status of the vehicles that are present in its coverage. When an emergency event occur, the graph is split into sub-graphs that does not

ignore any vehicle idle, this is done to disseminate emergency message without eliminating any vehicle.

A graph is constructed from the nodes vertices and edges as  $G = (v, e)$ , that denotes  $v$  is the vertices,  $e$  is the edges. The edges are the vehicles and the vertices are the links between vehicles. Hereby, the vertices are in link by  $(L_s, S_s, D, M_p)$  estimated for each vehicle with the other. The mathematical formulation of each parameter between two vehicles  $v_i$  and  $v_j$  are given as:

$$L_{S(v_i, v_j)} = \frac{C_r}{D(v_i, v_j)} \quad (1)$$

### 4.2. VANET Message Dissemination

In VANET data dissemination refers to the process of spreading data or information over distributed wireless networks. From the networking point of view, it requires broadcast capabilities at the link layer, allowing a frame to be transmitted to all the vehicles in the radio scope. It also supposes implementation of network and transport mechanisms to disseminate the message in the whole

network. This dissemination uses one of the two available communication modes. The message will be disseminated in a multi-hop fashion when the vehicle-to-vehicle (V2V) communication is enabled and will be broadcasted by all the Road Side Units (RSU) when infrastructure-to-vehicle (V2I-I2V) communications are used instead. There is a hybrid version of data dissemination, which is RSUs broadcast the messages and, as they do not cover the whole

network, some vehicles are selected to forward the message in order to complete the dissemination.

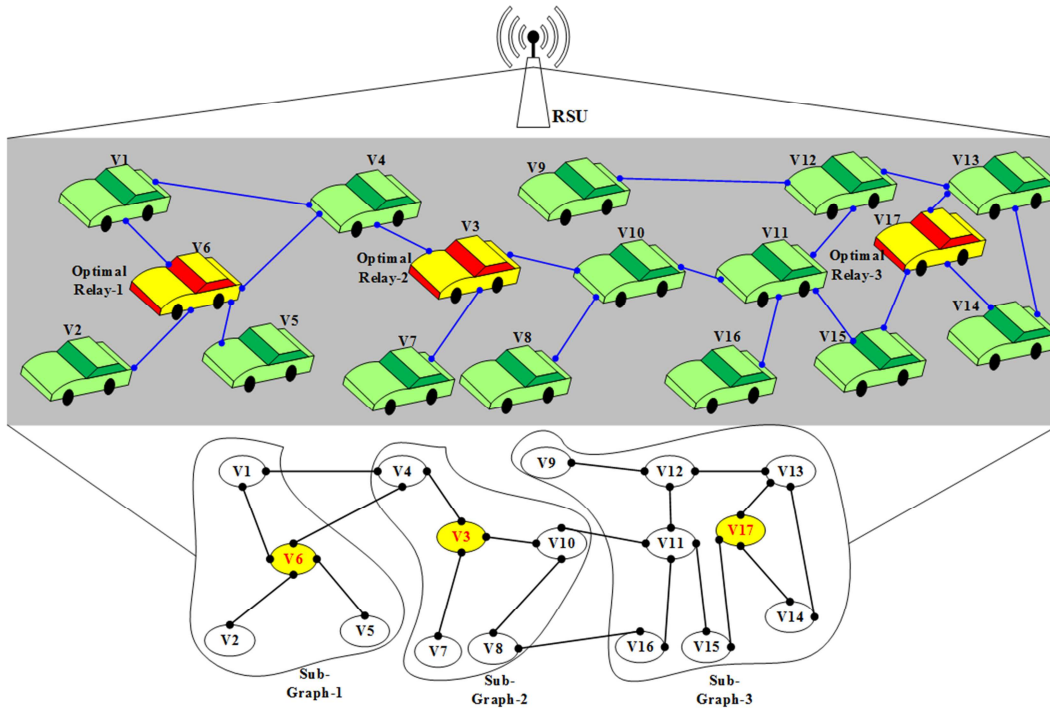


Figure 2. Divided Sub-graphs.

The figure 2 depicts an instance of graph that is managed by RSU in the network. In MO-SSOA, the fitness is estimated from degree, goodness, waiting time, transmission range and link utility. This optimization initializes all the vehicles in the graph that are in the coverage of particular RSU. The multi-objectives  $FIT$  are given as,

$$FIT = \max(d, G_n, W_t, T_r, L_u) \quad (2)$$

From the objective function the metrics are defined as below,

$$D(v_i, v_j) = \begin{cases} 1 - \frac{1 + \min D(v_i, v_j)}{1 + \max D(v_i, v_j)}, & \min D(v_i, v_j) \geq 0 \\ 1 - \frac{1 + \min D(v_i, v_j) + |\min D(v_i, v_j)|}{1 + \max D(v_i, v_j) + |\min D(v_i, v_j)|}, & \min D(v_i, v_j) < 0 \end{cases} \quad (3)$$

- (i) Degree ( $d$ ): It defines the number of vehicles that are connected with the one-hop neighboring vehicles. It is denoted as integers i.e. the number of vehicles.
- (ii) Goodness ( $G_n$ ): This denotes the summation of number of successful packet transmitted  $S_{pd}$  and dropped packet  $P_{pd}$  from the history of transmission. Hereby, the goodness is given as,

$$G_n = \sum_{x=0}^N (S_{pd} + P_{pd}) \quad (4)$$

$N$  denotes the total number of transmissions that are performed in the vehicle throughout in the network.

- (iii) Waiting time ( $W_t$ ): The waiting time denotes a time that the vehicle could wait for arrival of packets if the waiting time is too low, and then such node is not suitable for video streaming.
- (iv) Transmission range ( $T_r$ ): It defines the range of transmission within which the data from one vehicle is transmitted to other.
- (v) Link utility ( $L_u$ ): This metric defines the strength of the link between vehicles and it is computed from

residual bandwidth  $Rs_{bw}$  and quality of the link  $L_Q$ . This metric is expressed as,

$$L_u = \frac{Rs_{bw}}{L_Q} \quad (5)$$

where,

$$L_Q = ETX_{hop^1} + ETX_{hop^2} \quad (6)$$

Hereby, the quality of link is estimated from expected transmission count of 1-hop and 2-hop neighbors link that is  $hop^1$  and  $hop^2$  respectively.

On estimation of all the above parameters, the MO-SSOA is applied as per the below procedure:

Step 1: Initialize the number of vehicles as a set of elements i.e. generated as,

$$EL = Lb + (Ub - Lb) \times rand(nEL, nV) \quad (7)$$

Let  $EL$  be the elements i.e. vehicles in a sub-graph,  $Ub$  and  $Lb$  are the upper band and lower band,  $n$  denotes the



number of vehicles,  $V$  denotes design variables.

Step 2: Compute the objective function  $FIT$  and penalized objective function as  $PFIT$ . Then if the maximum iteration is not reached i.e.  $I < I_{max}$  it arranges the computed  $PFIT$ .

Step 3: Further step size is estimated and then the new elements are generated as  $newEL$ .

Step 4: And then the  $newEL$  is replaced with the previous  $EL$ .

Step 5: Best element is updated and the procedure is terminated.

As per the above procedure, the optimal relay is selected from the sub-graphs and it performs message dissemination only to the vehicles that are present in that sub-graph, hence the problem of broadcast storm is solved by the sub-graph based optimal relay selection.

#### 4.2.1. Video Streaming in VANET

The vehicles in VANET environment is able to perform routing for delay sensitive data transmission i.e. for video streaming. The routing for video streaming is performed at RSU using Deep Q-learning algorithm that is able to learn the environment. This algorithm takes in account of the primary MOS considers delay ( $d_t$ ), packet loss ( $P_{ls}$ ) and link quality ( $L_Q$ ) and the secondary MOS takes in account of signal to noise ratio (SNR), load ( $L_d$ ) and link lifetime ( $L_L$ ). Let the primary and secondary MOS be represented as  $P_{MOS}$  and  $S_{MOS}$  that is given as,

$$P_{MOS} = (d_t, P_{ls}, L_Q) \quad (8)$$

$$S_{MOS} = (snr, L_d, L_L) \quad (9)$$

where,

$$d_t = \frac{NB}{TR} \quad (10)$$

$$snr = 10 \log_{10} \left( \frac{Sg}{No} \right) \quad (11)$$

$$L_L = \frac{\sum_1^d \left( \frac{\Delta t}{t_{TB} - t_{TB-1}} \right)}{d} \quad (12)$$

The terms  $NB$  stands for number of bits to be transmitted,  $TR$  is the transmission rate,  $Sg$  is the signal,  $No$  is the noise,  $TB$  is the beacon interval. The  $MOS$  values are estimated in Deep Q-learning which is a combination of deep learning with Q-learning algorithm. The value of  $MOS$  is given as states in the deep Q-learning based on which the actions for routing is carried out. The steps in this method begin with the initialization of a state and action. Hereby, the nodes in the neural network store the past experience in the decision making. The loss function is determined as mean square error from the Q-value and target Q-value. Hence the update of Q-value is expressed as,

$$Q(S_t, A_t) \leftarrow Q(S_t, A_t) + \alpha \left[ R_{t+1} + \gamma \max_a Q(S_{t+1}, a) - Q(S_t, A_t) \right] \quad (13)$$

Let  $R_{t+1}$  be the reward that is 1 on each time step based on the decision. The agent in Q-learning learns the defined policy that is  $\pi(A_t|S_t)$  which is responsible in increasing

the reward values. Then  $\gamma$  is the learning rate,  $S_t$  and  $A_t$  is the state and action respectively. For making action, an epsilon-greedy policy is applied in deep Q-learning.

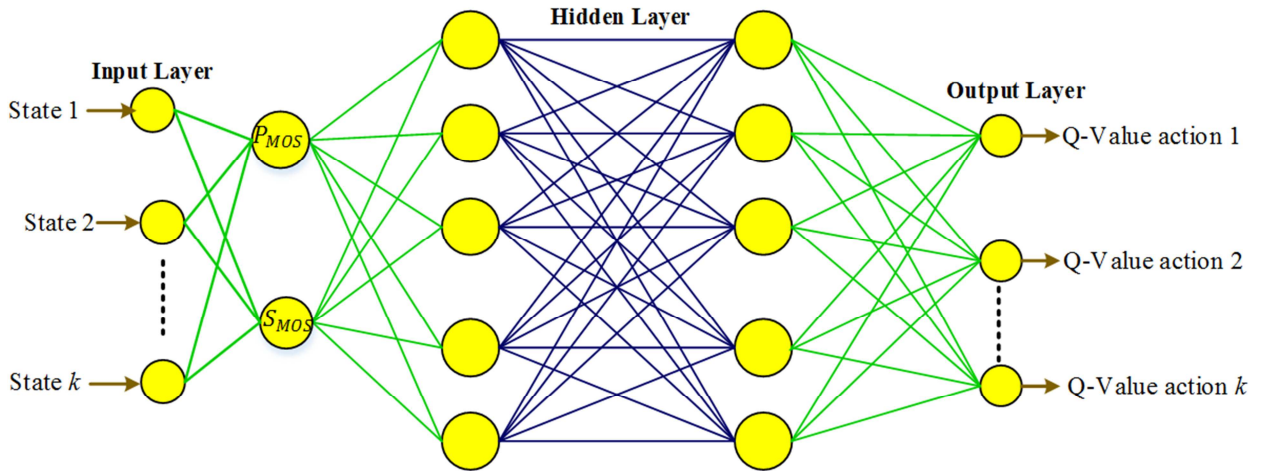


Figure 3. Deep Q-learning.

The proposed route selection for video streaming is performed with deep Q-learning as shown in figure 3. Here it represents  $k$  number of states as  $\{state1, state2, \dots, statek\}$  and it obtains actions as  $\{action1, action2, \dots, actionk\}$  from the  $P_{MOS}$  and  $S_{MOS}$  respectively.

#### 4.2.2. Normal Data Routing in VANET

The vehicles in VANET environment is able to perform routing for non-delay sensitive data transmission which is

normal traffic information. The routing of normal traffic data, type-2 fuzzy method is applied. In type-2 fuzzy, the membership functions are created and they are executed at the time of route selection when the vehicle has traffic information. This traffic routing is performed by the source vehicle by using the information present in the neighboring table. The defined membership functions include four main input parameters that are quality of forwarding (QoF), bandwidth, and distance and hop counts. Here the parameter

bandwidth cannot be static since it also shows impact when the signal characteristics is poor during bad weather conditions. Due to this, the proposed system using type-2 fuzzy is employed with belief entropy for dynamic threshold value. Let the QoF be expressed as follows,

$$QoF = t_{ct} + VA_{pt} \quad (14)$$

where,

$$VA_{pt} = \frac{TP}{TR} \quad (15)$$

The  $t_{ct}$  denotes transmission cost,  $VA_{pt}$  is the ability of the vehicle to transmit the data,  $TP$  denotes the number of transmitted packets. Here, the constraint  $VA_{pt}$  differs based on the buffer of the vehicle, since the vehicle may be already in a route to perform transmission and hence it will be carrying many packets in the buffer which is already present for transmission. This is important in the selection of route and so it is also taken as a constraint in QoF. The computed parameters bandwidth in the link ( $B$ ),  $QoF$ ,  $D$  and hop counts ( $HC$ ) in the route. Based on these constraints the membership degree is created with fuzzy set. Let the fuzzy set in type-2 fuzzy set,  $E: X \rightarrow \mathcal{F}\{[0,1]\}$  here  $\mathcal{F}\{[0,1]\}$  defines the normal fuzzy set. According to the procedure, the input parameters as  $\{B, QoF, D, HC\}$  into the fuzzifier first convert the input into fuzzy set which is able to be processed in the interference engine as rules.

After conversion, the fuzzy set matches in the interference engine and it returns with the mapped output sets. This process is handled by type-1 fuzzy set and then in the interval type-2 fuzzy set it is processed by reducing the type-1 results and then the results of route is obtained from the defuzzifier. The threshold prediction by belief function  $BF$  is defined as,

$$BF = \sum_{Y \in A} m(A) \quad (16)$$

The metric  $m(A)$  denotes the focal element that is required to be given in the threshold. This is also to be as mass function in the entropy as per the employed dynamic threshold, route for forwarding the information from the source to destination. The blocks in type-2 fuzzy are fuzzifier, interference, type-reducer and defuzzifier. In this the rules are deployed into the interference engine and the crisp output is attained from the defuzzifier. Hereby the computed dynamic threshold is also fed into the interference engine which is responsible for the fuzzy output set in the system. Therefore the use of dynamic threshold enables to select a suitable for the data transmission from source and destination.

This proposed VANET is able to select different routes for traffic information forwarding and video streaming which is the main reason to improve the network performance and also the management of graph by the RSUs helps in improving the data dissemination when there occurrence of emergency situation in the network. Hence this proposed system is able to aid data transmission for both safety and non-safety appliances in the network. Further the result of this system is evaluated with important parameters hereunder on the following section.

## 5. Experimental Evaluation

On this section we present the evaluation of our proposed system with respect to previous research works. In this work, on sub-section we discuss the details with simulation environment and the other expands the comparison with previous VANET work.

### 5.1. Simulation Setup

This proposed VANET environment is created using network simulator OMNeT++ integrated with SUMO-0.19.0 which is a real-mobility model to show VANET. OMNeT++ is termed as Objective Modular Network Testbed in C++ which is most suitable for VANET. This OMNeT++ environment is installed in Windows 7 operating system. The OMNeT++ version 4.6 is subjected to have best graphical user interface and hence it shows a real vehicular network with the support of all the characteristics of a vehicle on road lane. A two-way road lane is designed in which the vehicles move in both the directions on the road and perform data transmission.

Table 1. System Requirements.

Parameters	Configuration
Operating System	Windows 7 (Ultimate -x86)]
Processor	Pentium IV
RAM	2 GB
System type	32-bit
Processor speed	Minimum 2.5 GHz

Table 2. Simulation Parameters.

Parameters	Specifications
Area	2500×2500m
Number of Vehicles	100
Number of RSUs	2
RSU transmission range	500m
Vehicle transmission range	100m
IEEE Standard	802.11p
Number of car crash	1
Car crash	30 s
Bit rate	18 Mbps
Data time interval	5 s
Header length	256 bit
Mobility type	TraCI
Speed of the vehicle	50m/s
Simulation time	500 s

The table 1 and table 2 illustrates with the significant parameters that are taken in account of the proposed VANET implementation. Hereby, the parameters are not limited to these, since we also include all the other default specification that required in a network. For better visualization, SUMO is downloaded which has a built-in support on OMNeT++. To use this, we include Veins module framework and then executed SUMO for urban and highway vehicular network construction. Based on this specification, the routing and message dissemination are performed using the proposed algorithm and the parameters that are involved in the network. Figure 4 illustrates the VANET system architecture constructed from the above configured specifications or the network design.



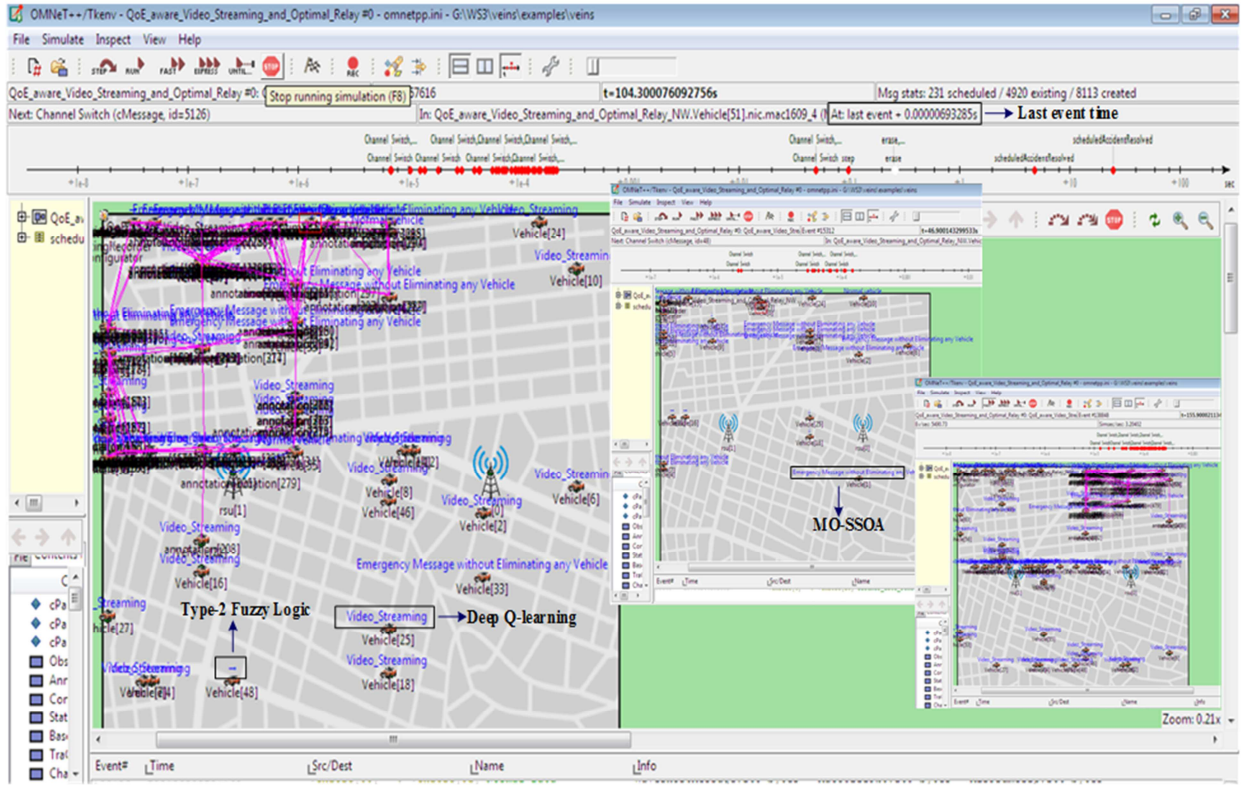


Figure 4. OMNeT++ Environment.

Table 3. Existing VANET Environment.

Reference	Process	Demerit
[35]	QoS based broadcasting using fuzzy logic	High delay in emergency message dissemination Selection of poor multi-point relay
[36]	QoE based video streaming	Not able to prefer optimal forwarder due to missing of important parameters in MOS computation
[37]	Geographic routing using link utility	Computation only for two hops is not efficient, since the destination could be present beyond two-hops. Longer waiting time, due to carry and forward.
[38]	Epidemic and Timer-Based Message Dissemination	Expiration of the waiting time is high and also it prolongs the time to disseminate. Selection of more than one relay within same transmission range increases the number of duplicate message.

## 5.2. Comparative Analysis

The previous research work in VANET focuses on the processing of routing and message dissemination. However, each work is subjected to certain limitations that are depicted in table 3. In concentration of the previous works, an efficient proposed solution is defined for the process of routing and message dissemination.

In this section, the proposed VANET is compared with previous work of [36] that evaluates MOS and selects optimal forwarder for video streaming. For comparison, this paper computes throughput, packet delivery ratio (PDR), end-to-end delay, duplicate packets and frame loss. In comparison, the proposed system shows the efficiency of the developed routing and message dissemination on VANET environment.

### 5.2.1. Estimation of Network Parameters

Throughput and PDR plays a vital role in measuring the

performance of the network in transmission of data. Throughput defines the data packets that are transferred from one point of source to the other destination in the bits per second. On the other hand, PDR is the ratio of packet counts that are delivered to the destination from the total number of packets.

The performance of throughput and PDR is illustrated in figure 5 and figure 6 respectively. Throughput and PDR is evaluated in terms of the packet transmission that is handled between the pair of source and destination. These two parameters are evaluated with respect to increase in the number of vehicles in the network. These two parameters are computed from the following equation,

$$TP = \frac{N_{PS}}{TT} \quad (17)$$

$$PDR = \frac{N_{DL}}{N_{PS}} \quad (18)$$

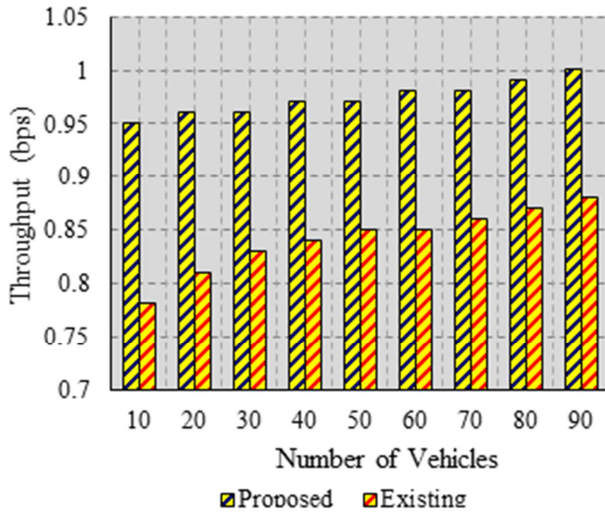


Figure 5. Comparison of throughput.

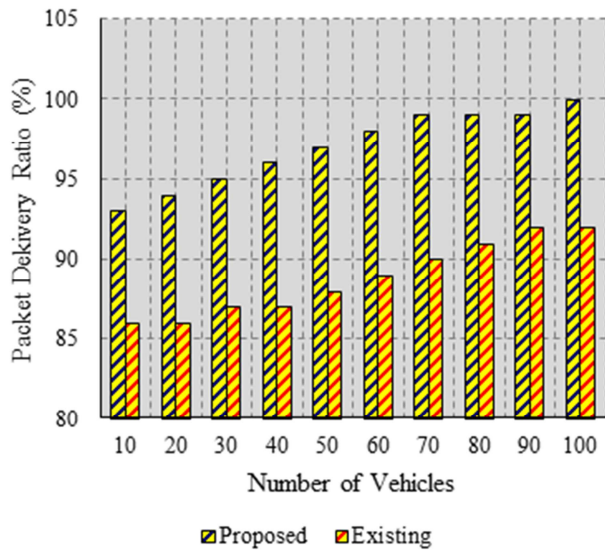


Figure 6. Comparison of PDR.

The  $TP$  throughput,  $N_{PS}$  is the number of packet sent,  $TT$  is time taken and  $N_{DL}$  is the number of data packets delivered.

Based on the above equation (17) and equation (18), the parameters are evaluated by varying the number of vehicles in the network. Hereby, the data transmission in VANET allows routing any type of data using deep Q-learning and type-2 fuzzy, where it is able to learn the environment to select a route. Initially, the RSU maintains a graph of vehicles from which it is easier in selecting the best route. Due to this, the data transmission is assured to be stronger and hence it reflects on throughput and PDR. In contrast, the existing work, estimates different parameters to choose a route based on MOS and other vehicle characteristics. In those works, it requires to search for a route by broadcasting request and responses in the network. Also the selection of route is based on vehicle or link features in the network.

In an average, the proposed work reaches 0.976 bps and 0.846 bps of throughput for existing work. Similarly, the PDR is 97% and 88.8% attained for the proposed and existing work

respectively. From this evaluation, the improvement of proposed VANET is highlighted here below.

Table 4. Comparison of throughput.

Number of Vehicles	Throughput (bps)				
	[35]	[36]	[37]	[38]	Proposed
20	0.902	0.935	0.913	0.927	0.95
40	0.914	0.948	0.924	0.932	0.968
60	0.928	0.957	0.937	0.945	0.978
80	0.937	0.968	0.941	0.959	0.986
100	0.947	0.976	0.955	0.968	0.992

Table 5. Comparison of PDR.

Number of Vehicles	PDR (%)				
	[35]	[36]	[37]	[38]	Proposed
20	79	87	81	83	93
40	82	89	83	85	95
60	84	90	85	86	96
80	87	91	88	88	97
100	88	92	89	89	99

Tables 4 and 5 demonstrates the performance of throughput and PDR with respect to the number of vehicles. As we discussed before, the existing works have been subjected to some critical issues in routing the packets. Hereby from this comparison, the proposed work shows better results than the existing. The increase in throughput and PDR for smaller number of vehicles will certainly improve these parameters even if the number of vehicles goes beyond this.

The improvement in throughput and PDR also impacts on the performance of other parameters of network. As a result of evaluation of these parameters, the throughput increase is about 13% and the PDR increase is of 10% than the existing works and hence this work is suitable even if the number of vehicles in the network increases.

### 5.2.2. End-to-End Delay

This metric is one of the QoS metric that is required to have low End-to-End delay in routing and so the proposed system is justified to be better than the existing works. The delay in transmission can be minimized by the following ways as:

Optimal selection of route by taking in account of the most important parameters that are involved.

Perform immediate transmission without any additional time for verifying the presence of vehicle in the proximity.

As per the above two note this proposed work reduces end-to-end delay by means of presenting an optimal route selection with the consideration of multiple parameters.

The end-to-end delay is defined as the excess time taken for the data transmission while transferring the data from source to the destination. Hereby, the end-to-end delay  $D_{E-E}$  is mathematically evaluated as follows:

$$D_{E-E} = (de_P + de_Q + de_T + de_G) \quad (19)$$

Here the  $de_P, de_Q, de_T, de_G$  represents processing delay, queuing delay, transmission delay and propagation delay respectively. Based on figure 7, the evaluation of delay is depicted with the existing work. Hereby, the proposed VANET system shows lesser delay than the existing system.



The selection of route based on the managed graph, results with efficient data transmission. In an average of end-to-end delay, the proposed system is 0.58s and existing is 1.064s which is higher than the proposed system. The existing system uses multiple parameters and optimization methods, but still the VANET is dynamic and hence the topology changes time to time and hence the graph management in proposed work also supports in route selection. Due to this, the end-to-end delay minimizes in proposed work.

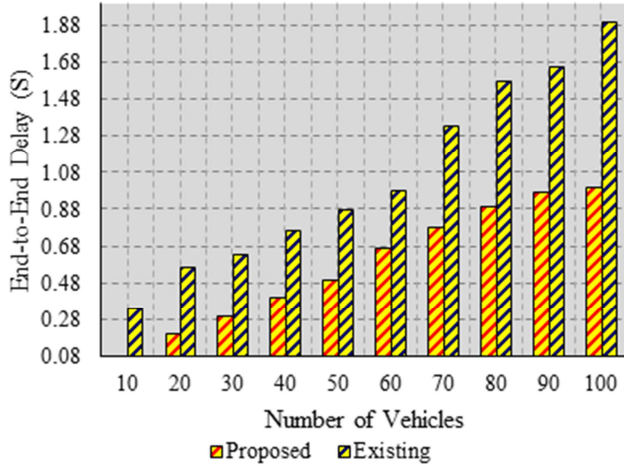


Figure 7. Comparison on End-to-End delay.

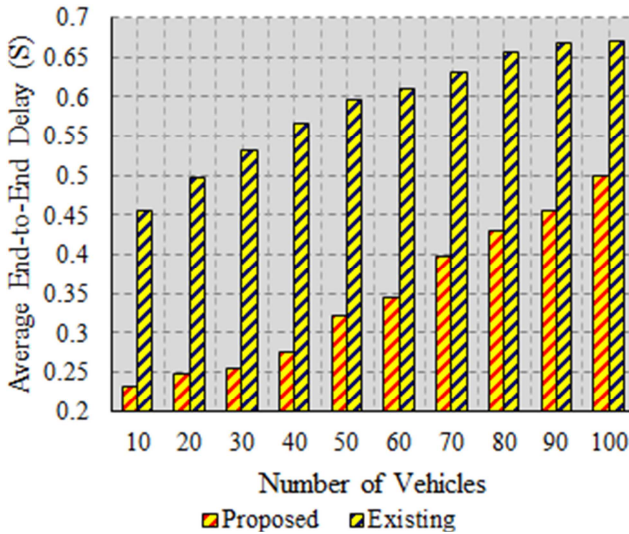


Figure 8. Comparison of Average End-to-End Delay.

Figure 8 depicts the performance of average end-to-end delay in the network in which the existing has higher delay than the proposed.

### 5.2.3. Measurement of Duplicate Packets

The duplicate packets are one of key problem in a network, since the increase in number of duplicate packets leads to degrade the network performance. In case of disseminating the emergency messages it causes duplicate packets due to the poor selection of relay or forwarder. That is, if more than one vehicle disseminates the same information within the same communication range, which creates excessive duplicate packets.

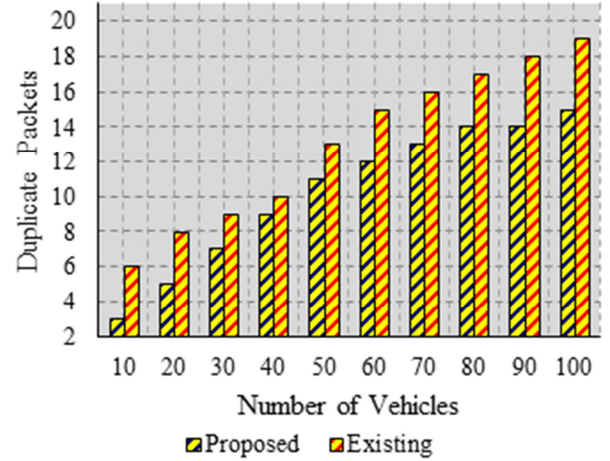


Figure 9. Comparison of Duplicate Packets.

In figure 9, the graphical plot for the duplicate packets is demonstrated in a comparison of proposed and existing VANET dissemination. A good data dissemination method will result with lesser duplicate packets in a vehicle. The proposed work develops data dissemination using deep Q-learning that selects a relay to disseminate the emergency data to the vehicles that are present in the transmission range. In this proposed work, a graph is maintained and it is divided into sub-graphs for selecting a relay. The sub-graph is divided based on the transmission range and also only one relay is supposed to disseminate the packet to the vehicles that are in that sub-graph.

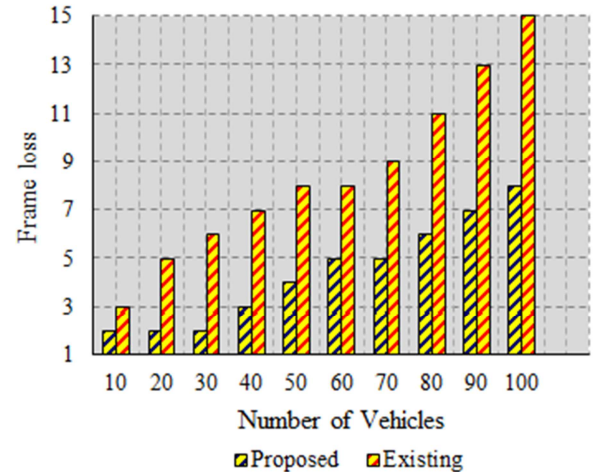


Figure 10. Comparison on Frame loss.

The shirked graph based relay selection for dissemination leads to improve the counts of duplicate packets. While the previous works selects a relay based on parameters and then it performs dissemination without the limitation of packets, and hence it increases the duplicate packet counts in the existing work.

### 5.2.4. Frame Loss

Frame loss defines the number of lost frames during video streaming from one vehicle to another. A poor selection of route for video streaming is the main reason that impacts on

the loss of frames when the intermediate vehicle moves away from the route.

The figure 10 illustrates the performance evaluation of frame loss for proposed and existing work. As a result, the increase in number of vehicle also increases the frame loss but still, the frame loss in proposed work is lesser than the existing work. This is due to the performance of the proposed video streaming route selection with reinforcement learning algorithm. The benefit of this algorithm is that it is able to learn the environmental parameters and hence the decision making is more optimal. On behalf of this video streaming, the frame loss is very low than existing and also in proposed the route for video streaming is also selected from the graph which is able to aid even at higher number of vehicles. As per the performance, the gradual increase in the frame loss results with the ability to operate better even if the vehicle density increases.

On the whole, the proposed VANET architecture with different methods for routing, video streaming and message dissemination show improvement in all the important network parameters.

### 5.3. Highlights of Proposed VANET Architecture

The key highlights of this proposed VANET system is illustrated from the identified main challenging issues in the area of VANET for performing the processes of routing and message dissemination.

The frequent changing topology of VANET is not easier to perform routing and data dissemination for safety messages. The management of topology of the VANET certainly requires a structure based method to view current connectivity of the vehicles, so that it will not increase the delay. If not, the delay constraint in routing and data dissemination will be high on Vehicular ad hoc networks.

In VANET the routing is performed using geographical, optimization and other algorithms. But the route selection based on the type of the packets was not established. Since all type of transmission is possible in VANET, a video streaming requires short delay while the normal transmission is tolerable to some amount of time delay. Also it can be pre-defined, that wither only video streaming will take place or the normal traffic data.

The main problem in dissemination is broadcast storm that increases multiple copies of messages received more than once. To solve this, relay vehicle was selection which is able to mitigate these issues. Either the relay will be appointed with longer waiting time or it will select nearer to each other. Even though multiple metrics were used for relay selection, it needs to cover the entire vehicle with the event message.

Above all, the proposed system solves these issues with intelligent solutions for routing of normal traffic and video streaming. On the other message dissemination is also performed with efficient selection of optimal relay from the network. The significant ideas that are concentrated in this proposed research are as follows:

Network topology in VANET is tedious to manage; here graphical structure is constructed by each RSU to manage the

vehicles that are present within its coverage. The constructed graph impacts on the effectiveness in the process of data transmission between vehicles.

Routing of video streaming packets as well as normal traffic information packets are presented in this work. In order to perform a delay aware routing of video streaming packets, two MOS values are computed and processed in deep Q-learning for the selection of route.

Normal traffic data routing between vehicles is done using type-2 fuzzy that operates on dynamic threshold computed from belief entropy. The threshold is dynamic, since the movement of vehicles changes from time to time.

Emergency message dissemination is highly delay sensitive which needs faster travelling of the safety information. So optimal relay vehicles are selected using SSOA algorithm on each split sub-graphs.

Based on the above specifications, this proposed system assures to process well in routing and data dissemination which is evaluated with different performance measures. Hence, this works stands for novelty and also it is able to work better even if the number of vehicles in the network increases in massive as in real-world environment.

## 6. Conclusion

In this article, VANET architecture is proposed for performing traffic routing, video streaming and emergency message dissemination. All the three processes play a vital role in VANET and so they are employed with individual methods, since these process take place simultaneously in a network. The VANET with vehicles composes of fast moving vehicles on the road lane, due to this the topology changes frequently. By this way, it becomes challenging to perform routing and other processes. In order to manage the topology, a graph is constructed in RSU based on the connectivity of the vehicles. From this graphs the route for video streaming is selected and also relay is selected for message dissemination. The graph is split into sub-graphs to mitigate the problem of broadcast storm and relay is chosen from each sub-graph using MO-SSOA based on the degree, goodness, waiting time, transmission range and link utility. Along with this, the RSU is only responsible for message dissemination and video streaming route selection. For video streaming the neighboring hops are preferred based on the computation of primary and secondary MOS, then the route decision is taken using deep-Q-learning algorithm. Beyond these two processes, the normal traffic routing is handled by the vehicle itself with the support of type-2 fuzzy that adapts with dynamic threshold from belief entropy. The parameters that are computed for normal traffic routing are QoF, bandwidth, distance and hop counts. At last the results of our proposed VANET architecture is evaluated in a testing environment using OMNeT++ tool with the deployment of all the methods for three processes. From the obtained results, our proposed work gives better performances than the existing with respect to throughput, PDR, delay, duplicate packet counts and frame loss counts.

In future this proposed work is planned to move in-depth into video streaming with the provisioning of priority for the video frames and used multipath routing protocol. Also in future, the secure selection of trusted vehicles as relay vehicle will be incorporated.

## Acknowledgements

This research work was supported in part by the National Natural Science Foundation of China under Grant 61772184, and Grant 61272061, 61732017, in part by the Key R & D Project of Hunan Province of China under Grant 2018GK2014, in part by the Open Fund of State Key Laboratory of Geo-Information Engineering under Grant SKLGIE2018-M-4-3, in part by the Scientific Research Project of the Department of the Natural Resources of Hunan Province under Grant 201910, and in part by the Hunan Provincial Innovation Foundation for Postgraduate under Grant CX20190308.

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