A Robust QoS based Clustering Protocol for Avoiding Link Failure and Maintaining Communication in Vehicular Adhoc-Networks

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Abstract-- ***The Vehicular Ad hoc Network (VANET) is a type of MANET that is distinguished by its extraordinary mobility. Therefore, it is a huge challenge to maintain the stability in these networks. These mobility-based routing methods neglect the Quality of Service demands, because this protocol performance depends on vehicle speed, driving environment, whereas the QoS baśsed algorithms neglect the conditions of high speed mobility. Truly, the increased movement of vehicles would reduce the network lifespan and result in connection outages owing to the clusters getting disconnected often. The primary contribution made by this research study is to propose a robust QoS-based Optimized Link State Routing (QoS-OLSR), which depends on Enhanced Particle Swarm Optimization () and preserve the stability of communications and avoid link outages when fulfilling the Quality of Service demands. This work proposes VANET QoS-OLSR, a novel cluster-based protocol for VANET. This protocol takes mobility constraints and Quality of Service requirements into account. It does this by (1) taking high mobility parameters into account when computing QoS, (2) using Enhanced Particle Swarm Optimization () to select Multi Points Relays (MPRs), and (3) using an MPR recovery method that can select an alternate and keep the network connected in the event of a link outage. that the network can remain stable, end-to-end latency can be reduced, packet delivery ratio can be increased, and communications complexity can be kept to a minimum with this suggested framework.***

Index Terms- QoS-based Optimized Link State Routing (QoS-OLSR), QoS, Enhanced Particle Swarm Optimization (), Points Relay (MPRs).

I. INTRODUCTION

An essential component of a future-generation transportation system for EPSO is the Intelligent Transportation System (ITS), which consists of all forms of communications between vehicles [1]. ITS is effective in providing riders with a number of conveniences, such as emergency alerts, safety applications, and assist EPSO for drivers. A self-organized version of Mobile Ad Hoc Networks (MANETs) is called VANET [2]. VANETs are made up of cars with On-Board Units that can communicate with each other and/or stationary road infrastructure units positioned next to roads. Because VANETs differ from MANETs in a number of ways, including greater node mobility, assumed and limited movement formats, rapid topology changes, and frequent battery charging, energy dissipation is not a major issue for VANETs[3]. However, because of their high speeds, vehicles frequently alter the topology of VANETs, which causes instability in the V2V link.

Therefore, the means of developing a V2V routing method to implement effectiv and robust transfer of information forms one among the hot research topics of VANETs. In comparison to the active routing method, the passive routing method provides a path between source node (node in short) and the destination node (node in S D short) when this is needed, reducing network problems[4]. Clustering routing, in the form of a passive routing method, can be useful in boosting routing efficacy for various reasons: 1) Nodes in the same cluster have the same velocities and positions, which can improve cluster connection stability, reduce the chance of link breakage, and boost the packet delivery ratio (PDR) [5]. 2) The cluster head can obtain the best route between nodes, decreasing compute and S D transmission delays, particularly in the cluster. 3) CH can assemble the data obtain from the common nodes present in its cluster, and then send it, and in accordance decrease the exchange of data, conserve energy of the nodes possess. 4) clustering topology can be adaptive to the nodes that are attaching and detaching and hence is apt for big-scale VANETs. However, the ordinary clustering routing is bogged down by disadvEPSOages [6]. For instance, the time taken for routing optimization is considerably higher (especially between various clusters), procedure of finding a route cannot take multiple constraint factors into consideration.

In the meantime, when clustering nodes, QoS-based clustering algorithms take into account QoS metrics such as energy, bandwidth, and end-to-end delay. However, the high speed mobility metrics are disregarded, making them useless for use with VANET [7]. A proactive routing system designed to work with MANETs is called Optimized Link State Routing (OLSR). Its fundamental idea is to split the network into clusters by choosing a cluster head for each group of nearby nodes. These cluster leaders then choose a group of nodes referred to as MultiPoints Relay. The role of MPR nodes is to reduce the amount of overhead caused by flooded messages by minimizing the number of replicated transmissions occurring in the same area [8]. When choosing MPR nodes and cluster heads, QoS-OLSR, an enhanced version of OLSR, takes into account each node's remaining energy as well as its current bandwidth. This allows MANET lifespan extension. Nevertheless, when calculating QoS parameters, this protocol does not account for node movement [9]. As a result, nodes with higher energy, bandwidth, and movement may be chosen as cluster heads, causing the link to repeatedly disconnect. Similarly, the MPRs chosen with this protocol do not satisfy the routing and mobility requirements of packet delivery ratio and end-to-end delay. Moreover, since some nodes may provide fictitious QoS values in order to be chosen as MPRs, the QoS-OLSR MPR selection process is susceptible to manipulation [10–11]. Furthermore, QoS-OLSR is not involved in enhancing any MPR recovery algorithm that can select quick substitutes and keep the network connected in the event that a link fails.

A novel cluster-based VANET protocol called VANET QoS-OLSR is presented in order to address the aforementioned issues. Protocol expands on QoS-OLSR, emphasizing the need for a balance between QoS requirements and the mobility criterion. It also addresses the shortcomings of QoS-OLSR, which impact network stability. First, a clustering technique based on Quality of Service is presented. The algorithm consists of choosing MPRs based on mobility and QoS criteria as well as cluster heads. In order to ensure reliability, bandwidth is taken into account; connectivity is taken into account to increase the area that cluster heads and MPRs can cover; and velocity and distance metrics are taken into consideration to maintain network stability. These features along with the maximum QoS value locally determine the cluster-head. After being elected, it is in charge of choosing the group of MPR nodes that connect clusters and broadcast messages. In order to reduce end-to-end time and increase packet delivery ratio while utilizing a path that guarantees quality of service and mobility, this work is completed using a method derived from Enhanced PArticle Swarm Optimization ().

The research work's remaining sections are organized as follows: in Section 2, evaluate a few of the VANET's currently available clustering-based routing protocols. The suggested technique is explained in section 3. In Section 4, the findings and their discussion are examined. Section 5 discusses the conclusion and future work.

II. LITERATURE REVIEW

This section outlines the various routing and clustering algorithms that have been enhanced to handle mobile devices and VANETs. Additionally, the key clustering algorithms that were developed for VANETs are shown. Both the routing algorithms and the significant QoS-specific clustering algorithms dedicated to MANETs are covered.

A unique QoS-specific clustering algorithm was created by Wahab et al. [12] with the goal of striking a balance between the maximum speed mobility criterion and QoS requirements. The goal is to satisfy QoS requirements by establishing stable clusters and maintaining stability through communications and link failures. This is accomplished in three ways: (1) using EPSO Colony Optimization to select MPRs; (2) considering high mobility measures during QoS computation; and (3) using MPR recovery method, which can choose the alternates and keep the network connection intact in the event of a link outage. Performance analysis and experimental results show that the proposed model can reduce communications complexity, improve packet delivery ratio, keep the network stable, and lower end-to-end delay.

An ideal route was created by Cloudin et al. [13] and is dependent on the vehicle's position and speed. The EPSO colony optimization (Bio-influenced) processes use these metrics to determine the best course of action. The suggested method uses independent clustering processes in addition to keeping only the buffer at the cluster head to lessen resource depletion. Finally, the data delivery ratio, delay, transmission cost, and throughput of the proposed SI-performance DYMO approach are compared with that of AODV.

Rajeswari et al [14] proposed a novel combined mechanism for a secure routing scheme which constitutes two novel algorithms known as Trust based Next Forwarding Node Selection method and Fuzzy Based Stable and Secure Routing method, which uses the trust based node selection process to yield effective performance with respect to routing. The primary achievement made by this suggested node selection process is that this approach utilizes the trust values to pull out the intruder nodes from the routing procedure so that the security can be improved. Therefore, this suggested stable and secured routing method carries out trustworthy routing by choosing just the reliable nodes with increased residual energy and link stability. One more achievement made by this research work is about developing a Fuzzy Inference System that helps dealing with unpredictability in the choice of trustworthy nodes and to find the stable routes by carrying out qualitative tests on trust values and link characteristics. In contrast to other secure routing algorithms, the simulation and testing conducted in this research work showed that the suggested secured routing algorithm can improve network performance with respect to enhanced packet delivery ratio, decreased delay, and lower false positive rate.

Vatambeti et al [15] presented an innovative EBDC technique in this technical work, which helps in the prediction of the link outages and improves the lifespan of nodes. In this, proposed EBDC technique is used for clustering and route preservation in MANET so that it establishes nodes applying star topology. At first, proposed mechanism elects CH and sends message over link established. Later, EBDC model detects the link outage, and it generates a fresh reference layer to get the failed layer replaced. Therefore, the proposed EBDC model exhibits improved network lifespan and limited energy usage. In addition, the implementation of this model is done with the help of NS- 2, measures such as accuracy, energy dissipation, PDR, network lifespan, E2E, throughput are computed. Additionally, the comparison between the results achieved with the proposed approach and the existing techniques are performed to show the usefulness of the proposed approach.

Luo et al [16] presented a novel routing protocol for VANET which depends on the former results, known as CBR (Cluster Based Routing). Rather than other routing protocols, this novel one exhibits an apparently improved average routing complexity and less average E2E delay jitter as number of vehicles increase. The real-time traffic applications need considerably stable data transmission delay time, reduced average end to end delay jitter as total vehicles increase so that real-time application requirements.

Abuashour et al [17] introduced a three algorithms, which include CBLTR, IDVR, CORA. The CBLTR protocol considers to improve xroute stability and mean throughput in the cases of bidirectional segment. CHs are elected on depending on maximum lifespan among all the vehicles, which are positioned within every cluster. IDVR protocol works towards improving route stability and mean throughput, to limit E2E delay in grid topology. selected intersection CH gets a bunch of candidate SCSR near to necessary destination from software specified network. IDVR protocol chooses optimum route on the basis of its present place, destination end, maximum of the minimum average throughput of SCSR. At last, objective of the CORA method is to limit control overhead messages passing through clusters by designing a novel scheme for calculating the optimum count of control overhead messages transferring among CMs and CH. Here, SUMO traffic generator simulations are used where MATLAB software helps in evaluation of the performance of the proposed protocols.

Lin et al [18] designed a moving-zone based framework wherein the vehicles coordinate with each other to establish dynamic moving zones such that data propagation is facilitated. Anew technique, which uses the moving object modeling and indexing approaches derived from principle of big moving object datasets to design VANET routing protocol is proposed. It is confirmed from the outcomes of elaborate simulation studies on actual road maps show the efficiency of this technique in comparison with clustering and non-clustering based routing protocols.

Two soft computing algorithms were presented by Aravindhan et al. [19] for effective routing in VANETs. First, a hybrid clustering approach that combines context- and geography-oriented clustering mechanisms is presented. Hybrid clustering reduces network traffic and control overhead. Second, for inter-clustering routing that lowers E2E delay and raises PDR, destination-oriented routing protocol is introduced. Instead of using the recommended technique's effectiveness, analysis is conducted using currently available cluster-based techniques. The results demonstrate that the proposed method performs better than the current methods.

Alowish et al [20] developed a cluster based routing (CBR) protocol, anticipated to be attained with VANETs. VANET consists of randomly travelling vehicles communicating for a particular objective. The routing process in VANET protocol is necessary to send the required data packets to vehicles within a brief time span. Traditionally, routing methods such as AODV, GPSR, DSDV and DSR routing is used in several ad-hoc networks. As per the evaluation results acquired through computer simulations carried out using OMNeT++, CBR routing protocol performs better than AODV, GPSR, and DSR protocols in view of PDR and messaging overheads.

Khan et al [21] introduced a novel TCRP aimed at cluster establishment & VH selection employing modified K-Means & Floyd-Warshall method. Presuming truncated normal distribution, confidence interval of vehicles velocities is specified. modified K-means splits vehicles to 3 clusters well with in confidence range of their velocities. Floyd-Warshall method computes shortest distance for every pair of vehicles of VANETs. vehicle with the least average distance to remaining vehicles &has the lowest variability in velocity is chosen to act as VH. It is revealed from the experiments and simulation outcomes that suggested TCRP improves consistency of cluster shape and prevent reselecting the VH in the subsequent stages, thereby making a highly stable sets of vehicles.

Hossen et al [22] introduced novel an innovative ONCH to increase VANET's QoS. In suggested approach, RSUs of VANET is split to various tiny bunches known as clusters. For each cluster, RSU functions as the gateway node and the connection between every gateway node and the WiMAX base station will occur via optical fiber. The performance achieved with the proposed ONCH approach is analyzed using numerical simulations. It is shown through results of simulation that ONCH approach of VANET yields improved energy efficiency compared to traditional WNCH approach of VANET.

The node is selected as CH and has the highest probability of being selected as MPR based on the above discussion of the available QoS-based clustering methods, such as QOLSR or QoS-OLSR, for the selection of heads and MPRs. Because protocol performance is dependent on vehicle speed and the driving environment, these mobility-based routing methods ignore QoS constraints, while QoS-based algorithms ignore high speed mobility limitations. Additionally, because of the increased node movement within the current network region, there is a general link failure when using these networks. Thus, this study, This work proposes VANET QoS-OLSR, a novel cluster-based protocol that takes Quality of Service requirements and mobility criteria into account.

III. PROPOSED METHODOLOGY

This technical work primarily contributes to the proposal of a robust QoS-based Optimized Link State Routing (QoS-OLSR) that relies on Enhanced Particle Swarm Optimization() to maintain stable communications and prevent link outages while meeting QoS requirements. This work proposes VANET QoS-OLSR, a novel cluster-based protocol for VANET. This protocol takes into account QoS requirements and mobility restrictions, and it does so by:

(1) Taking into account the high mobility metrics during the the QoScomputation,
(2) Employing Enhanced Particle Swarm Optimization () for selecting Multi Points Relay (MPRs), and

(3) Employing (MPR) recovery algorithm that has the capability of choosing the alternates and maintain the connectivity in the network if any link outages occur.

The figure.1.illustrate the overall procedure of the proposed methodology.

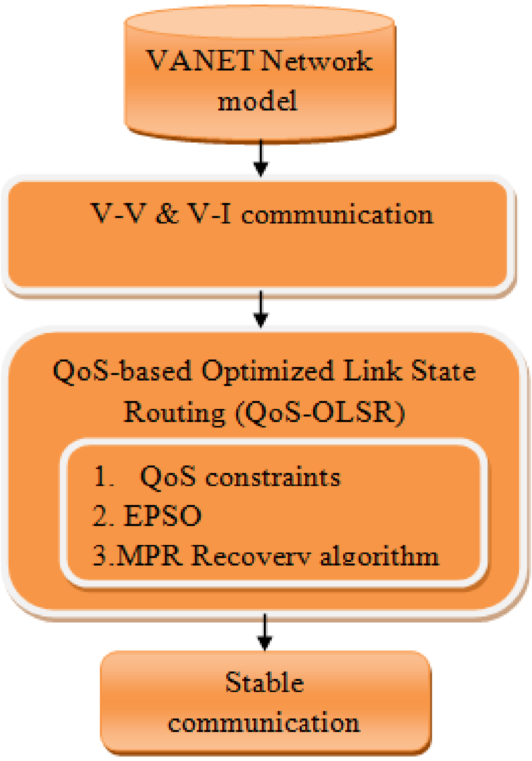

Fig.1 The overall procedure of the proposed methodology

3.1. VANET QoS-OLSR protocol

This section explains the introduction of the VANET QoS-OLSR protocol, which aims to maintain a stable vehicular network. Three of its components—cheating prevention, MPR recovery, and QoS-based clustering—are described here. The VANET's QoS-based clustering framework is presented. CH election and MPRs selection methods are the two methods on which the clustering framework is based. The protocol can be summed up as follows. The CH election method selects a set of optimal CHs in the first step. Second, using a cheat-proof method, up-voted CHs select a set of ideal MPR nodes in charge of message transmission and cluster connectivity. Finally, by selecting backup MPRs, the MPR recovery algorithm combats link failures.

3.1.1. Quality of Service metric models

Various Quality of Service (QoS) models have been put forth in an effort to increase QoS and stability. Every node in a MANET chooses its cluster head based on a number of factors, including residual energy and relative bandwidth. Here, the VANET topology incorporates other metrics, such as the vehicle's mobility indicated by residual distance and velocity, to be used in addition to bandwidth and connectivity. As a result, five different QoS frameworks that are based on various fusions of QoS parameters are proposed. While connectivity is used to improve coverage provided by CHs and MPRs, bandwidth is considered to ensure reliability, and velocity and distance metrics are considered to maintain network stability.

3.1.2. Competence of adding mobility metrics

The topic of QoS in MANets has been the subject of numerous works. The connection duration, PDR, E2E delay, and jitter are some of the significant suggested parameters in these works. However, these methods do not take vehicular topology into account. Therefore, it is recommended to include residual distance and velocity as two additional metrics related to VANET topology. Relative distance serves two purposes: Vehicles should be grouped into clusters with convergent residual distance in step (1). Heads and MPRs should be chosen with a significant amount of space to move around. In a similar vein, the velocity metric has two objectives: (1) assign cars to clusters with convergent velocity scales, and (2) guarantee that heads and MPRs are elected at a significant speed. The former goal aims to increase the clusters' lifespan, while the latter restricts the number of link outages. In order to produce a stable and reliable VANet, it is therefore necessary to incorporate these VANET-specific metrics with the other essential EPSO network-oriented parameters, such as bandwidth and connectivity.

3.1.3. The CH election method

This models the CH election method, which allows for network classification into clusters and the election of a set of optimal CHs. The method works as follows. The HELLO messages (Fig. 2) are broadcast by nodes with their QoS values at a two-hop distance. Next, each node casts a vote designating its neighbor as the local maximum based on the QoS metric value. If a node's local QoS value is maximum, it can also cast a vote for itself. The nodes broadcast their votes locally by using their unique HELLO messages, also referred to as Election messages. Following the election process, the chosen node transmits an Ack message (Fig. 3) containing its public key to indicate that it is willing to serve as the CH. Additionally, the message is sent over a two-hop distance. Subsequently, the selected CHs serve as MPR nodes for their constituents. They must thus send TC messages containing their electors. The procedure outlined in Algorithm 1 for CH election.

Algorithm 1. CH Election Process

```
Algorithm 1. CH Election Process
 procedure CLUSTER HEAD ELECTION
     for every node $i \in N$ do
         transmit HELLO message having QoS (i) 2-hop away
         Assume $k \in N_2(i) \cup \{i\}$
         $QoS(k) := \max \{QoS(j) | j \in N_2(i) \cup \{i\}$
         vote for k via Election messages
         MPR$Set(i) := \{k\}$
     end for
     for every elected head $k \in N$ do
         transmit Ack message 2-hop away
     end for
 end procedure
```

```
Algorithm 2. Cluster Head Election Process

 procedure CLUSTER HEAD ELECTION
     for each node $i \in N$ do
         broadcast HELLO message containing QoS (i) 2-hop away
         Let$k \in N_2(i) \cup \{i\}$
         $QoS(k) := \max \{QoS(j) | j \in N_2(i) \cup \{i\}$
         vote for k through the Election messages
         MPR$Set(i) := \{k\}$
     end for
     for each elected head $k \in N$ do
         broadcast an Ack message 2-hop away
     end for
 end procedure
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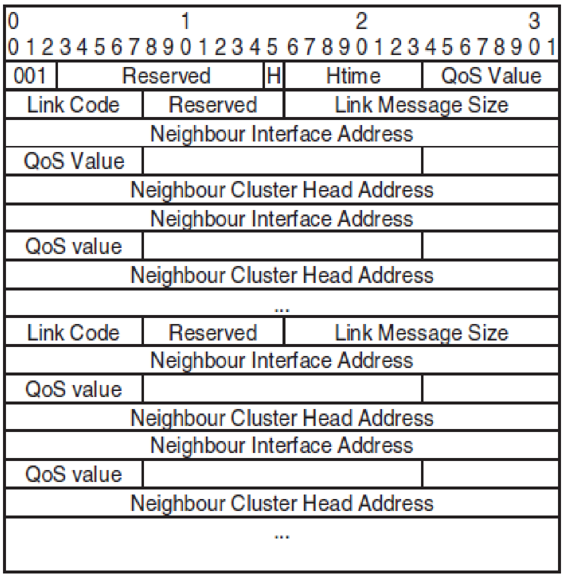


Fig. 2. HELLO message format: The nodes broadcast QoS values and use this message to obtain their 2-hop and 1-hop distant neighbors.

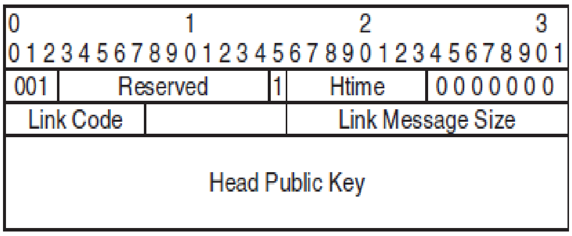


Fig. 3. The cluster head uses the Ack message format to accept serving its voters and to spread its public key, which is used to thwart fraud.

It is noted that the standard HELLO message only needs minor modifications. In the first, a flag known as the H flag is added to indicate that a node has been designated to function as the CH. The link code needs to be updated with a new neighbor type next. The neighbor selected to serve as CH is indicated by the H NEIGH flag. Nodes use election messages for the format of these messages to show which neighbors have voted for which node.

3.1.4. Enhanced Particle Swarm Optimization ()

This study uses a swarm intelligence algorithm to optimize cluster-to-cluster communications in the context of the cluster-oriented QoS-OLSR protocol. To do this, a small group of EPSO agents known as

EPSO-HELLO are in charge of gathering data on each link and making the best decision possible in this regard.

Several particles are combined into a swarm that moves through search space in order to find the optimal solution using particle swarm optimization (PSO) [23]. All particles are thought of as spots in a D-dimensional space that modify their "flight" according to their past experiences as well as those of other particles. The particles travel in D-dimensional space at a set speed in search of the best solution.

Particle's velocity i expressed as $V_i = (v_{i1}, v_{i2}, \dots, v_{iD})$, Particle I's location is provided by $(x, x_{i2}, \dots, x_{iD})$,, the best location of particle i is specified as$p_g = (p_{g1}, p_{g2}, \dots, p_{gD})$, it is also known as p_{best}.

The position of all particles at their global optimum is given by $p_g = (p_{g1}, p_{g2}, \dots, p_{gD})$, It's also known as g_{best}. In order to calculate fitness value, each particle in the group has a fitness function. Expressions (1) and (2) provide the velocity update expression of dimension d for the Traditional PSO:

$$v_{id} = w \times v_{id} + c_1 \times rand() \times (p_{id} - x_{id}) + c_2 \times Rand() \times (p_{gd} - x_{id}) \quad (1)$$

$$(X_{id} = x_{id} + v_{id}) \quad (2)$$

The PSO parameters are as follows: the random functions with values between [0,1] are represented by the functions rand() and Rand(), the population quantity (Q), the weight of inertia (w), the acceleration constants C1 and C2, the maximum velocity (vmax), and the maximum number of iterations (Gmax). Typically, the constant 2 is assigned to the values of C1 and C2.

In order to overcome the limitations of traditional optimization algorithms in solving multi-parameter, strong coupling, and nonlinear engineering optimization problems, the EPSO maintains population diversity and enhances information exchange between populations throughout the optimization process. Improved convergence and the propensity to quickly drift into local optimization are these disadvantages. The notion of parameter selection for performance is determined, and the parameters utilized in the imported "local-global information sharing" term are assessed. In order to demonstrate the global search performance of the EPSO, the performances of the conventional optimization algorithms and the EPSO are subsequently verified using various sets of conventional functions.

This technical work aims to introduce an EPSO variant that tries to enhance the PSO algorithm's performance in obtaining optimal solutions while preserving its simplicity and quick convergence. In order to increase the algorithm's capacity for both exploring new areas of the search space that may have better solutions and utilizing intermediate solutions, this mutation factor relies on introducing a straightforward but effective novel function into the iterative search process. Based on parameter configurations, an advanced variant of PSO serves as the foundation for the proposed form.

- *Mutation factor*

PSO particles will accumulate to a point where searching for the global best is no longer necessary because text feature vector dimensions in text classification are typically very large. Therefore, in order to guarantee optimal convergence, mutation factor K is added to PSO. We get the velocity formula from expression (1):

$$v_{id} = K[v_{id} + c_1 \times rand() \times (p_{id} - x_{id}) + c_2 \times Rand() \times (p_{gd} - x_{id})] \quad (3)$$

Algorithm 5.1 in this work utilized the formula introduced to compute the mutation factor K. Value c1and c2used 2.05which is similar values used in Clerc's experiment. In this, 4 decimal places of K are reserved for the tests. Expression (5.3) yields the velocity formula specified:

$$v_{id} = 0.7298 \times [v_{id} + 2.05 \times rand() \times (p_{id} - x_{id}) + 2.05 \times Rand() \times (p_{gd} - x_{id})$$

(4)

During the iterations in the primitive stage, a PSO particle has to perform the detection in an extensive level to decide the possible position of the best solution. In the subsequent iterations, it must be developed locally within a smaller range to decide best point. Therefore, K must use a bigger value in previos stages and use a lesser value subsequently. At the same time, K must tend to reduce gradually to the minimum in an extended span of latersteps. There is consistency between this type of modification and the con-cave function.

The mutation factor must choose a convex function at the beginning of iterations so that particles can obtain the optimal solution on a large scale, preventing early convergence. A concave function that allows the mutation factor to gradually decrease to the minimum for local development must be chosen for the following phases. In this case, algorithm convergence is guaranteed. In accordance with this idea, expression (5) provides the functional mutation factor that was created using the cosine function:

$$K = \frac{\cos((\pi/G_{max})\times T)+2.5}{4} \quad (5)$$

wherein T refers to total iterations. Assign G_{max}= 40, A fluctuating curve with value K appears. K's initial curve is convex, but it eventually becomes concave. The value K is replaced in expression (1), and later expression (1) is modified into expression (6). Expression (6) is explained as follows:

$$v_{id} = \left(\frac{\cos((\pi\times T/G_{max}))\times 2.5}{4}\right)\times[v_{id} + 2\times rand()\times(p_{id} - x_{id}) + 2\times Rand()\times(p_{gd} - x_{id})]$$

(6)

The nodes maintain the probabilistic routing tables having chances of selecting a neighbor to be consecutive hop taken for any destination. The EPSO agents update these tables regularly depending on quality of links. quality of links is specified, with respect to QoS and E2E delay.

3.2. MPR nodes selection method

Following election, CHs are in charge of selecting a set of ideal MPR nodes. The node group is in charge of creating a connected network and connecting the clusters. The MPRs selection method assumes that the EPSO-HELLO message contains a flag indicating the node's QoS value (Fig. 4). The MPR selection process works as intended. Consider the scenario where two CHs wEPSO select a set of MPR nodes to communicate with each other. Initially, EPSO-HELLO message type 0 is assigned by source CH to indicate that the messages are forwarded to destination CH. Subsequently, it spreads "m" messages to its 2-hop distant nodes (where "m" is the number of 1-hop distant neighbors connecting the destination head). Upon receiving this EPSO message, each intermediate node calculates its QoS parameter value and inserts it into the appropriate message field. In a similar vein, the EPSOs record each node that is visited in the "Nodes Visited Stack" field of the EPSO-HELLO message (Fig. 4) so that the route can be reversed at a later time. Before an EPSO-HELLO message reaches the intended cluster-head, it is broadcast over a 2-hop distance.

Following its arrival, this CH sets the type of EPSO-HELLO messages to 1, indicating that they should be sent backwards to the source. The QoS values of the intermediate nodes are later obtained by the CH, which adds them for the nodes that establish a single direct path. The E2E delay for each path is then calculated using the number of hops present in the "Nodes Visited Stack." Afterwards, the "route time" field is updated appropriately. The end-to-end delay is deducted from the total of the QoS values for each individual path in order to calculate the pheromone value for each path. Because of this, every path that leads to the cluster-head node's pheromone values are included in it. The values are updated in the "pheromone value" field (Fig. 4) as a result. In a similar manner, each node's pheromone value is calculated. This corresponds to the node's QoS value.

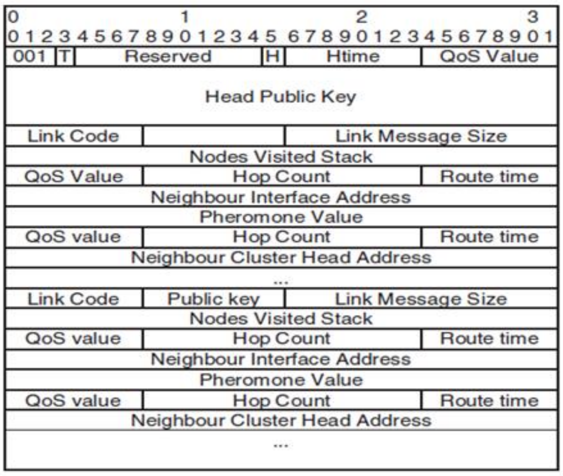
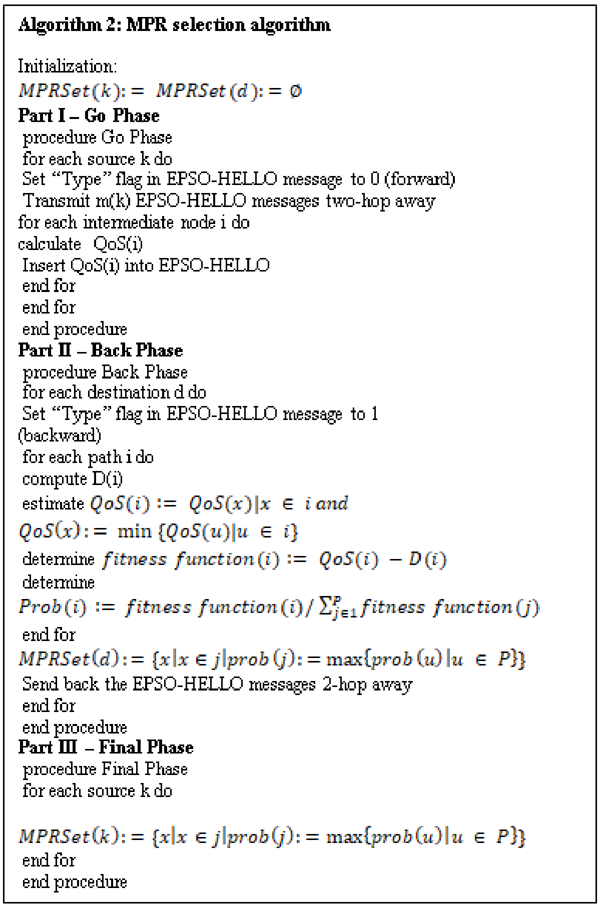


Fig. 4. EPSO HELLO message format: This message is used to collect data regarding the paths taken during the MPR selection process.

This CH then calculates the probability of a pheromone for each and every path. Afterwards, it selects the nodes in the path that have the highest pheromone probability and determines that they are the MPRs within the parameters of its cluster. Afterwards, it uses the chosen optimal path to send back the EPSO-HELLO messages over a two-hop distance until it reaches the source head. Once more receiving the messages, this new cluster-head selects the nodes within its cluster's optimum path as the MPRs. Thus, these two CHs are able to communicate with each other through the selected MPR nodes. It is noted that 2-hop distant nodes can be used to approach 3-hop distant CHs. Algorithm 2 examines the algorithm for choosing MPRs.



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Algorithm 2: MPR selection algorithm

Initialization:
$MPRSet(k) := MPRSet(d) := \emptyset$
Part I – Go Phase
 procedure Go Phase
 for each source k do
 Set "Type" flag in EPSO-HELLO message to 0 (forward)
 Transmit m(k) EPSO-HELLO messages two-hop away
for each intermediate node i do
calculate  QoS(i)
 Insert QoS(i) into EPSO-HELLO
 end for
 end for
 end procedure
Part II – Back Phase
 procedure Back Phase
 for each destination d do
 Set "Type" flag in EPSO-HELLO message to 1
(backward)
 for each path i do
 compute D(i)
 estimate $QoS(i) := QoS(x) | x \in i \ and$
$QoS(x) := \min \{QoS(u) | u \in i\}$
 determine $fitness\ function(i) := QoS(i) - D(i)$
 determine
$Prob(i) := fitness\ function(i) / \sum_{j\in 1}^{P} fitness\ function(j)$
 end for
$MPRSet(d) := \{x | x \in j | prob(j) := \max\{prob(u) | u \in P\}\}$
 Send back the EPSO-HELLO messages 2-hop away
 end for
 end procedure
Part III – Final Phase
 procedure Final Phase
 for each source k do

$MPRSet(k) := \{x | x \in j | prob(j) := \max\{prob(u) | u \in P\}\}$
 end for
 end procedure
```

3.3. MPR recuperation technique

Link breakages are a huge concern for a vehicular network's stability. Fig. 5. shows an example of a link outage where node 8 acting as MPR among Cluster 1 and Cluster 2 makes a decision to detach from its present cluster and attach to Cluster 3. Therefore, connection among Cluster 1 and Cluster 2 is damaged and there will be no communication between them until another set of MPRs is chosen. Link outages happen owing various reasons like: mobility, interference, and congestion.

- Mobility: VANET is defined by an improved mobility due to improved vehicle speed. This results in repetitive disconnections and outages in the link.
- Congestion: extremely loaded networks may create congestions in VANets, which would later create outages in the link.
- Interference: The interference happens generally because of packets collisions.

This could be an intentional or unintentional collision. In both cases, the interference would cause the link to fail. To ensure network stability and reduce overhead due to duplicate elections, an MPR recovery method is presented that can handle link breakdowns and maintain network connectivity.

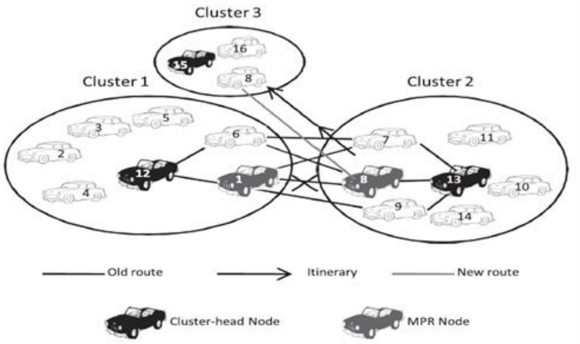

Fig. 5. Link failure scenario: Node 8, which is serving as the MPR between Clusters 1 and 2, decides to join Cluster 3 instead of staying with its current cluster.

The method does not depend on lower-level services to detect connection failures. When a certain MPR fails to send an anticipated TC message, the link is said to be down. The procedure functions as anticipated. Upon receiving the EPSO-HELLO message, the cluster-head arranges the "Nodes Visited Stack" in descending order of pheromone values. When a CH does not receive a TC message from a particular MPR, it removes the node from the stack in order to deactivate the link. This suggests that a link failure was brought on by the MPR. Subsequently, it selects the MPR as the first stack element. Due to ranking, this node shows the highest pheromone value and forms the path for the same destination that the EPSO-HELLO message has visited. Until the stack is empty, this process is repeated. The cluster-head starts the MPRs selection algorithm again to select a new set of MPRs after the stack has been cleared. Thus, the overhead is minimized by providing a simple method that can handle link failures and keep the network connected without necessitating frequent re-elections. Algorithm 3 provides the MPR recovery algorithm.

```
Algorithm 3: MPR selection algorithm

Procedure MPR Recovery
        for each cluster-head k do
        sort the "nodes visited stack" s
        if $(TCmsg\ Not\ Rcvd\ Time(n) > Time\ Allowed\ for\ TC())$ then
        s:=s-{n}
        $MPRset(k) := i / i \in s(1)$
        if (isEmpty(s))then
        MPR selection algorithm()
        end if
        end if
end for
end procedure
```

IV. RESULTS AND DISCUSSION

This section presents an experimental analysis and study of the suggested QoS-OLSR protocol. This section contains a thorough analysis of the findings. The simulation is run using 50 and 100 nodes for evaluation, and the experiment is run in NS-2. The network throughput, energy, and delay metrics are used in the analysis. To increase the lifespan of the network, the network energy, which represents the remaining energy in the nodes after the transmission is finished, must be as high as possible. The total data rate that is transmitted over the network in a given amount of time is known as the network throughput, and the time it takes for the data to be transmitted is known as the delay. The most effective method produces the highest energy throughput, but with less delay.

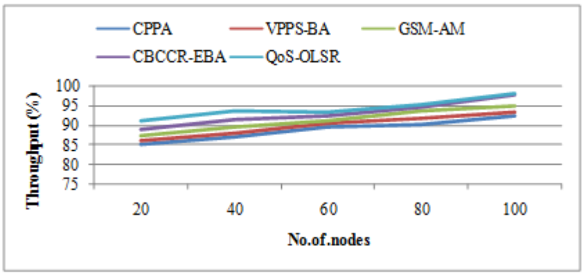

Fig.6. Comparison of Throughput between the proposed QOS-OLSR and available techniques

Fig.6. illustrates the throughput of the proposed QOS-OLSR which is much higher compared to the available techniques. The proposed QOS-OLSR yields improved throughput. It is shown that the proposed technique yields an increased throughput in comparison with the available routing protocol techniques.

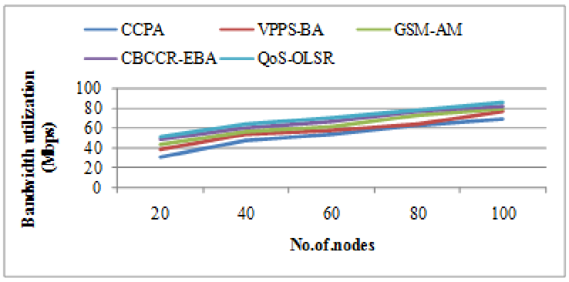

Fig.7. Comparison of bandwidth utilization between the proposed QOS-OLSR and existing methods

Fig.7. depicts the Consumed Energy of the proposed QOS-OLSR offers the best performance compared to the available techniques. The proposed QOS-OLSR consume reduced energy. It can be confirmed that the proposed technique consumes reduced energy in comparison with the available routing protocols.

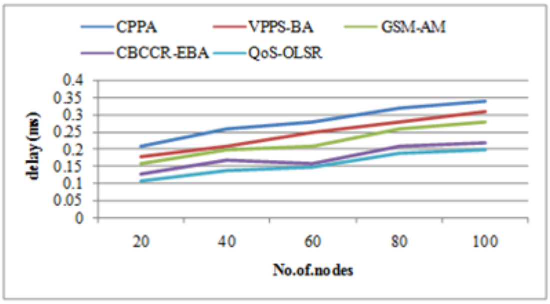

Fig.8. Comparison of delay between the proposed QOS-OLSR and existing methods

Fig.8. illustrates the delay comparison analysis between the proposed QOS-OLSR that yields superior performance compared to the available techniques. There is reduced delay in the proposed QOS-OLSR. It is proven that the proposed technique achieves reduced delay in comparison with the available routing protocols.

CONCLUSION

In this technological effort, the QoS-OLSR protocol is introduced with the objective of satisfying QoS requirements and preserving the stability of the vehicular network. The protocol consists of two parts: (1) MPR recovery algorithm; and (2) QoS-based clustering using Enhanced Particle Swarm Optimization. Cluster stability is ensured by adding the velocity and distance, which indicate fundamental mobility characteristics, to the QoS function. Subsequently, the protocol chooses CHs based on the maximum QoS value that is applicable locally. CHs then select a set of ideal MPRs that satisfy both mobility and routing criteria using an Enhanced Particle Swarm Optimization algorithm. To make sure that the election process is trustworthy and legitimate, fraud prevention measures are taken. Lastly, a method for choosing alternative MPRs and preserving network connectivity in the case of link failures is explained for the MPR recovery mechanism. The results of the simulation and performance analysis demonstrate that this protocol can both raise the packet delivery ratio and lengthen the network's lifespan. Additionally, this protocol finds an extension for VANET applications as a trust-sensitive clustering-based routing protocol.

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