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An Adaptive Relay Selection Scheme for Enhancing Network Stability in VANETs

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ABSTRACT Vehicular ad hoc networks (VANETs) are a special type of wireless ad hoc network that requires highly scalable routing strategies to establishing reliable end-to-end communication. Because of the high dynamic of VANETs, the mobility of vehicle nodes increases the control traffic overhead. Accordingly, establishing reliable end-to-end communication paths depends entirely on the routing mechanism and the type of nodes mobility information. In this paper, we propose a new improvement to the mechanism of the Optimized Link State Routing Protocol(OLSR) protocol, named Cluster-based Adept Cooperative Algorithm (CACA), where each vehicle estimate a reliable low-overhead path using the cluster-based QoS algorithm. The CACA algorithm is introduced to improve the ability of the MPR scheme for maintaining long-lived routes. Moreover, the network scalability is enhanced by adaptively selecting most sustainable paths based on a signal strength beacon and the mobility degree of a node, which reduces significantly minimizes the size of control messages overhead as well the routing tables recalculation process. Simulation experiments using the network simulator are presented to demonstrate the effectiveness of our solution. The results show that the proposed algorithm can improve network performance effectively relative to other algorithms.

INDEX TERMS Quality of service, VANETs, cooperative MPR scheme, routing, cluster-based, OLSR protocol.

I. INTRODUCTION

VANET is a promising technology developed to provide proven solutions for Intelligent Transport Systems (ITS) [1]. Vehicles in VANET can dynamically act as mobile nodes or a router and exchange information with a low-cost compared with existing network infrastructure, which expected to support cooperative driving among vehicles and safety applications in fifth-generation (5G) system [2]. VANET are inheritors the most characteristics of Mobile Ad-hoc Networks (MANETs) in which act as communication mobile nodes and relays [3], [4]. Generally, most of the developed vehicular communication technologies are based on ad hoc network which provides real-time traffic information via vehicular-to-vehicular (V2V) Vehicle-to-Infrastructure (V2I), and Device-to-Device (D2D) communications [5], [6]. In fact, the aim of Dedicated Short Range Communications(DSRC) [7], and multi-hop routing protocols [8] is developed to provide an efficient communication mechanism during the vehicles communicate with each other. However, the routing packet in such kind of networks is a challenging task due to the frequent change in the network topology. Most MANET routing protocols can not guarantee the network topology during the routing process. Increasing processing overhead on vehicles due to the size of control messages used for making routing decisions is significant for network designers, the highly dynamic scenario may cause wrong routes selection which leads to shorten the network lifetime and cause link failures [9], [10].

Clustering is one of the most attractive solutions proposed to solve the issue of scalability, it considers a trade-off between constraints of high mobility movement and QoS requirements to enhance the stability of network [11], [12]. OLSR-RFC [13] is one well-known proactive routing protocol using a Multipoint Relays (MPRs) [14] scheme as a key functionality to limit the number of relays node by minimizing the duplicate transmissions within the same zone. The beaconing of control messages is the basic idea used

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in OLSR to elect a cluster-head for each group of neighbor nodes. However, in a high dynamic scenario such as VANET, this protocol does not consider the constraints of nodes mobility which leads to recurrent disconnections, network overhead and significantly reduces network lifetime [15]–[17]. The additional control overhead leads to a collision in the network and thus wasting network resources [18]–[21]. To overcome this problem, several studies focused on Quality of Service (QoS) constraints as a key feature to enhance the ability of routing protocols for reducing the impact of the highly dynamic environment of VANET [22]–[24] and [25]. Utilizing network resources information is also should be considered to serve VANET application requirements [20], [26]. Instead of choosing the neighbor which has a higher link reachability degree, adapting the ability of native clustering of MPR selection scheme to keep the network connection and select quick alternatives routes in case of link failures is a fundamental task.

This paper proposes a new Cluster-based Adept Cooperative Algorithm (CACA) for VANET. This algorithm considers the most effective parameters to solve a trade-off between mobility constraints and QoS requirements, it attempts to enhance the scalability of routing by electing cluster-heads and selecting MPRs with concerning a bout the mobility constraints and QoS requirements. Based on distance parameters and values of signal strength metrics, the proposed algorithm estimates effectively the quality of the link between each pair of nodes. The relay vehicles are selected according to the maximum value of QoS, which computed to ensure the stability, reliability, and durability of routes. To improve the multi-hop packet delivery ratio over the network with acceptable End-to-End delay, the heuristic limitations of MPR selection scheme is solved by focusing on the distance from the source, link quality, and the coverage range of cluster-heads. Finally, the effectiveness of the adaptive scheme is verified by the simulation. The simulation results show that our algorithm reduces the number of topology control packets overhead as well as End-to-End delay.

The remainder of this paper is organized as follows. Section 2 presents related work. Section 3 discusses our proposed routing scheme CACA. The extensive simulation evaluated the performance of the CACA-OLSR which is presented in Section 4. Finally, the conclusion is given in Section 5.

II. RELATED WORKS

Generally, the multi-hop and relay selection approaches were typically introduced to cope with in MANETs network. However, the existing methods that enable communication in MANETs cannot be directly applied in VANETs due to the specific characteristics of a highly dynamic network. The packet delivery ratio, network overhead, and End-to-End delay are the major challenges. For solving the routing problem in VANETs, clustering is one of the solutions to solve the issue of QoS and scalability, it is proposed to the effective utilization of network resources.

n [13], the authors propose Multipoint Relay (MPR) for OLSR to enhance the scalability of routing by reduced the control topology overhead. Based on the principle of a heuristic selection mechanism, the basic idea of MPR operations lays when electing a cluster-head that divides each group of neighbor nodes into clusters. Upon received control messages, each node periodically constructs and maintains the set of its neighbor's based on link reachability metric in one-hop and two-hops set. These heads then select a set of specialized relay nodes called MPR. This mechanism reduces the overhead of controlling messages within the same zone by minimizing duplicate transmissions. This method suffers from instability selection when facing a high mobility environment.

In order to solve the problem of minimizing the number of native clusters of MPR set, authors in [19] reducing locally the number of relay nodes only when all two-hop neighbor nodes are covered. The performance of this technique is noticeable only in dense networks. It also leads to a waste of resources due to wrong selection. Accordantly, authors in [20] developed a new routing scheme based on link reachability and necessity of selecting called Necessity First Algorithm (NFA) to solve the problem of relay selection, it improves the MPR selection scheme to a certain extent which introduced a good performance. The computation of the MPR set may take a long time and increases overhead significantly. Consequently, the New Cooperative Algorithm (NCA) in [21] was proposed to reduce topology control overhead by reducing the number of MPR relay nodes. This method has locally minimized the number of head cluster, it considers the degree of cooperation and link reachability degree. It splits the nodes based on a master/slave role to obtain the minimal set. However, the COOP, NFA and NCA algorithms were designed for MANET, they introduced a moderate performance in VANETs.

In [27] the authors assigned weights to individual links in order to choose the optimal MPRs. The average delay and bandwidth metrics considered to choose the optimal MPRs. The QoS allows OLSR to obtain a better performance, especially in terms of reduced topology control overhead compared to the best effort OLSR. However, this protocol was designed for MANET. The authors in [28] enhanced routing decision based on QoS constraints, they proposed Link Defined OLSR (OLSR-LD) that considers the quality of link when select MPR set. Simulation results showed outperform the results of the ordinary one, however, this metric is not effective in reducing link failure in VANET as well as guaranteeing successfully packets retransmission. In [29] introduced a method for reducing the network overhead. They enhanced the scalability of routing by taking into account; the link stability, link quality, and node mobility level when enhancing relay selecting mechanism. The discovered rousts taking the advantages of the most important information exchanged between nodes. The network performance was enhanced, specifically in terms of packet delivery ratio.

However, the QoS metric was neglected when selection relays vehicles.

The facility of sensing the signaling techniques was introduced in [30] to a selected group of nodes as the suitable member nodes using GSA-PSO optimization. This technique applied to the MPR-OLSR as a method to reduce Control Topology overhead and utilize efficiently the available bandwidth. This technique has enhanced the performance of routing in terms of delay, packet drops, channel utilization, packet delivery ratio, and throughput. However, the effect of vehicle mobility was not considered in their studies. in [31], a Cluster Head Electing in Advance Mechanism (CHEAM) was developed for crossroads in VANETs. The capability of the cluster metric was enhanced by taking into account transmission power loss and mobility in order to determine and maintenance which node is suitable for a cluster head. The communication quality was enhanced which ensured a stable cluster with low overhead, especially when reducing the number of isolated vehicles.

In [9] authors proposed Quality of Service Optimized Link State Routing (QoS-OLSR) to maintain network stability during communication. They considered QoS requirements and mobility constraints to avoid link failure. This method maintains network stability as well as reducing end-to-end delay and the communications overhead. However, the routing complexity to maintain the alternative route is not considered in the result. The authors in [32] introduced a clustering scheme, chain-branch-leaf (CBL), that builds a virtual backbone in VANET. They optimized the size of packet flooding by limiting the packet retransmission according to a predefined strategy. A realistic traffic road configurations generated by SUMO evaluated both MPR and CBL over several scenarios. The CBL can perform based on the position and velocity information without referring to the conjunction that may happen at the cluster-head that is connected to ordinary members. However, The control overhead associated with the proactive approach is the main drawback, especially in VANET scenarios.

As a summary, several clustering approaches were proposed to solve the scalability of the OLSR protocol in order to reducing routing overhead in a dynamic network. Our proposal aims of our proposal is to use a clustering approach to elects optimal MPR concerning the quality of the path. The objective of our work is to reducing the number of cluster heads to guarantee the lowest network overhead as well as the highest packet delivery ratio.

III. OLSR AND MPR

OLSR Link State routing protocol is developed especially for MANETs. It is an optimization of classical pure link-state protocols developed to meet the requirements of mobile wireless. The link-state information is generated only by the nodes elected by a Multipoint Relay (MPR) scheme as a promising solution to reduces the size of the control packet. To perform this task, every node applies a basic cluster-head to elect a group of neighbor nodes called MPR set. Each source node periodically broadcasts a HELLO-Interval and control messages to minimizing the duplicate transmissions within the same zone, it divides the network into clusters to calculate the optimal MPR set as described in Figure 1. Therefore, OLSR provides shortest routes to all destinations if an MPR scheme declares symmetric links for their relays selectors set. A routing table keeps updated to maintains routes with a small set of forwarding neighbor nodes.

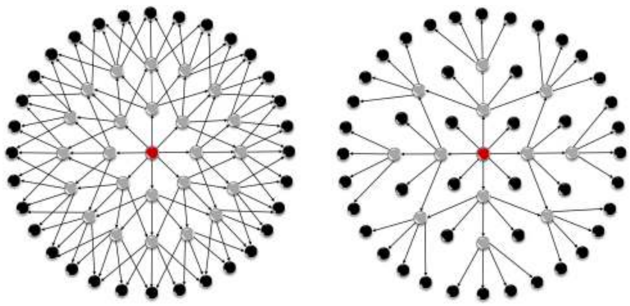

FIGURE 1. Optimized flooding in OLSR.

When a node receives a HELLO-Interval message from its own one-hop neighbor's nodes, it initiates to estimate the quality of the link based on link-state information. This information should contain simple mobility information via one-hop and two-hop neighbors. To calculate the MPR set, nodes have to gathered mobility link quality information from HELLO messages. Also, the willingness degree of each node should be taken into consideration. This mechanism is done only if the link to this neighbor is symmetric, and this neighbor covers the maximum number of two-hop neighbors with a high degree of links reachability. The two-hop nodes that are covered by a candidate MPR will not be considered in the next selection iteration of the algorithm. This process is repeated by the MPR nodes until all the two-hop neighbors are covered to locally minimize the number of MPR. This mechanism used to select the lowest number of MPR as well as the route with the optimal link quality.

OLSR functionality adapts well to the continuous topology changes besides its simple operation, it defined based on ad hoc network architectures to provide a very competitive delay in dynamic networks. Because of OLSR features, this protocol can be integrated easily into VANETs systems [33]. However, the vehicle's speed and road obstacles challenges have a great impact on the efficiency of OLSR routing operation resulting in frequent link disconnect and high control messages overhead require to correctly maintain routes. The vehicles (nodes) cannot quickly determine the next hops for data transmissions due to their specific type of neighbors location knowledge. These factors limiting the quality of mobility information and route selection mechanism to ensure the reliable delivery of messages. This work aims reduce the unnecessary broadcast overhead problem by solving the route selection mechanism.

IV. PROPOSED VANET CLUSTER-BASED OLSR PROTOCOL

In this section, the proposed Cluster-based Adept Cooperative Algorithm (CACA) algorithm for urban VANET is presented. This algorithm enhances the scalability of OLSR by utilizing bandwidth, connectivity, velocity and distance metrics. These factors are defined to enhance the capability of OLSR functionality to improve the end-to-end delay and increase the packet delivery ratio in VANETs.

A. SELECTION CRITERIA

OLSR considers the basic clusters concept which uses reachability with willingness degree of the node for MPR to improve the scalability. This technique does not consider the deployed environment for VANET scenarios. The process of forming clusters without creates routes between clusters. This is because of OLSR control messages operates used to find clusters neighbors. Similarly, the proposal algorithm MPR clusters used these messages to MPR clusters and distributed to all other clusters via the HELLO messages only. Therefore, we describe our proposed route selection algorithm, namely, Cluster-based Adept Cooperative Algorithm (CACA). We propose an efficient route selection algorithm based on a cluster approach to achieve a high delivery ratio, short delay, and small overhead. To achieve these goals, a new heuristic selection algorithm to improve the scalability of the OLSR protocol in VANET is proposed. The basic principle of the MPR selection mechanism is adapted to creates routes between clusters in which a cluster-head divides each group of neighbor nodes into clusters.

To enable OLSR nodes to form and maintain clusters, a HELLO message with path quality value is periodically sent by cluster heads to declare their leadership. The degree of link reachability and the capabilities of the node to retransmit the data packet successfully are taken into account. So, OLSR nodes need to periodically exchange messages to declare their leadership between the cluster heads and their branches. The quality of path parameters such as bandwidth, connectivity, velocity, and distance are considered in calculating the quality of the path. The bandwidth is consideration to guarantees reliability, the connectivity factor is taken into account to guarantees higher coverage area, velocity and distance are considered to guarantee the stability of routes.

Our proposal presents a new clustering approach based on a quality of path metric that combines some factors without adding any changes to standard control messages in the fields or size. The quality of the path metric is incorporating in an MPR scheme to enhance the selection of cluster heads and MPRs. The cluster head elects the candidate MPR nodes. For this, each node periodically broadcasts its HELLO messages, containing the list of its neighbours and their link status. Upon received HELLO messages, each node instates to checked all links status in both directions to be considered valid. The election of cluster heads will focus on the density of one-hop and two-hop neighbour nodes. The optimal communication link distances between a cluster head and the members are guarantee. This is achieved with the adapted selection mechanism to utilizes the important key factors, such as, appropriate communication distance, vehicle speed, link quality, and mobility of nodes in the route computation. These factors give the highest priority to the nodes that are far enough from the source but not close to the source border. The probability that the nodes will stay within the cluster head communication range for a long time is increased. Thus, the proposed selection scheme preemptively removes the possibility of link breakage and causes the route to converge to a more efficient route. Hence, it maintained an optimal route easily in which guarantees optimal communication links between a cluster head and the members.

B. THE PROCESS OF CLUSTER HEAD SELECTION

In [19], [20], and [21], the shortest path algorithm of OLSR routing protocol attempts to reduce the number of MPR as well as the size of control messages problem. These heuristic do not always provide the optimum solution, they disregard alternate available routes having the same link reachability and hop path length. In many cases, those routes may be better in terms of packet delivery ratio, end to end delay and network overhead. One of our objectives is to giving priority to the optimal path by maximizes the number of one-hop neighbours selected.

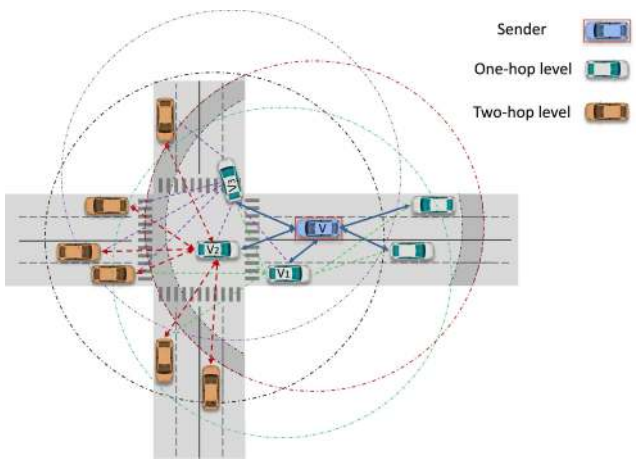

FIGURE 2. Optimized flooding in OLSR.

Let v be a source node in the network and $v2$ a two hop vehicle node. The link between $(v, v2)$ is assigned these values; $rang_{v,v2}$ is range between v and $v2$, while $weight_{v,v2}$ is the cooperative weight of both v and $v2$ Figure 2. $Bw_{v,v2}$ is the bandwidth available between v and $v2$. $QoP(v)$ is the quality of path for v while $N(v)$ is a representation to the source node neighbours. When there is a link between $(v, v2)$ but with a low path quality in $v2$, our proposed algorithm is build to avoid the link connection with $v2$ Figure 3.

$weight_{v,v2}$ is simply the ratio between the MPR of $v2$ over the total MPR of both $(v, v2)$. This ratio is then multiplied with the value of distance $rang$ between v and $v2$ over

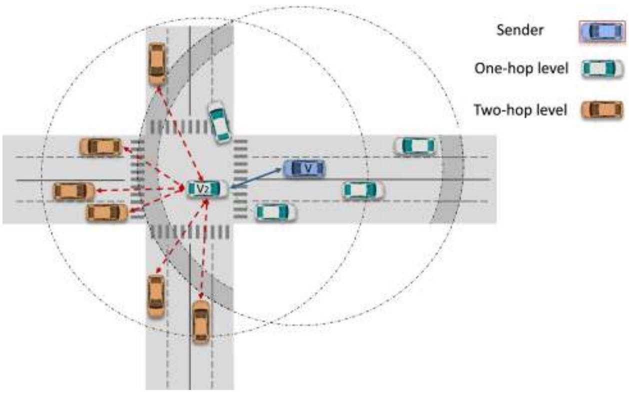

FIGURE 3. Optimized flooding in OLSR.

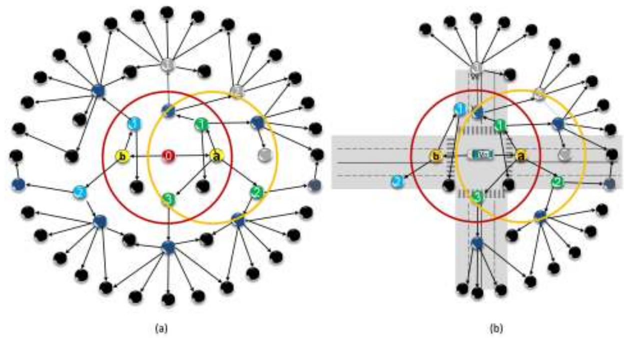

FIGURE 4. The mechanism of CACA algorithm.

Algorithm 1 CACA-MPR

Step 1: Start with an empty multi-point relay set MPR
Step 2: Calculate $V_1(v)$, $V_2(vj)$, and QoP_{v,v_j} of all the vehicles in $V_1(v)$.
Step 3: While there is vehicle in $V_1(v)$ who are the only vehicle providing reachability to some vehicles in $V_2(vj)$ with higher quality of path QoP_{v,v_j}.
Step 3a: Select that node of MPR.
Step 3b: delete that node of $V_1(v)$.
Step 3c: delete all vehicles in covered intersection $V_1(v)$ and $V_2(vj)$ from $V_1(v)$.
Step 3d: If there isn't any vehicles in $V_2(vj)$ then over.

Mobility Factor MF as described in the following equation:

$$weight_{v,v2} = \frac{MPR_{v2}}{MPR_v + MPR_{v2}} \times \frac{rang}{MF}, \quad (1)$$

Using Hello Interval messages, the source node will determine $weight_{v,v2}$ through the distance between two vehicles represented by Equation 2 proposed by [34].

$$rang_{ij} = \frac{\lambda\phi}{4\pi} - \frac{\lambda N}{2}, \quad (2)$$

where λ is a carrier wavelength. N is an unknown integer and ϕ is a round-trip phase measurement determined from signals transmitted at a single carrier frequency.

A Higher mobility indicates a higher velocity. In our work, the vehicles with lower velocity are more qualified to be a MPR node to rebroadcast the message. Equation 3 describes the average mobility factor based on the velocity of own vehicle v. This equation prioritizes next hop calculation.

$$MF_{v,v2} = \frac{V_r - V_{min}}{V_{max} - V_{min}}, \quad (3)$$

where V_{max} and V_{min} indicate the maximum and minimum velocity of the vehicle, respectively. V_r denotes the current velocity of the receiver vehicle.

Finally, the quality of path is determined by the bandwidth multiplied with the $weight_{v,v2}$. This is because the $weight_{v,v2}$ will be a low value in the event of high mobility factor which will result in a lower value of $QoP_{v,v2}$ as in Equation 4. However, if the denominator value MF is low, this means that $weight_{v,v2}$ generated from Equation 1 is high resulting in a higher $QoP_{v,v2}$.

$$QoP_{v,v2} = Bw_{v,v2} \times weight_{v,v2}. \quad (4)$$

Fundamentally, vehicle node ($v2$) with a higher number of MPR links are prioritised to become an MPR of v by the new procedure of MPR selection heuristic. Accordingly, quality of path $QoP_{v,v2}$ select vehicle node $v2$ with the highest MPR links, while maintaining a low number of MPR in v.

The source vehicle's MPR set is selected based on QoP_{ij} parameter in our algorithm; The algorithm selects vehicle nodes in $V_2(v2)$ with the highest QoP_{ij} without repetition. These vehicle nodes will be added to MPR set. The mechanism of our algorithm is sketched in Figure 4.

In the first step is having an empty MPR set in Algorithm 1. Step 2: source vehicle v lists all neighbor nodes within its coverage area $V_1(v)$. Every node will calculate its path quality $QoP_{v,v2}$ within $V_2(v)$ (a in Figure 1). In step 3: source vehicle v then selects the nodes with the highest $QoP_{v,v2}$ from $V_1(v)$ as long as there are vehicles $V_1(v)$. Step 3a: vehicle node $v2$ will be added to the MPR following the selection of the highest quality of the path. In step 3b: once a vehicle node is added to MPR, it will be deleted from $V_1(v)$ to avoid same-node repeated selection in the next iteration. Step 3c: ensures the elimination of all candidate nodes within the coverage intersection area of both $V_1(v)$ and $V_2(v)$ because $v2$ already has a better path quality than all vehicle nodes within the intersection area. Step 3d: the iteration will continue until there are no vehicles in $V_1(v)$.

In our algorithm, before a node is listed as an MPR, it is important to know the Quality of Path $QoP_{v,v2}$ that node provides for each one hop neighbor without repetition. However, QoP is not a parameter readily provided by OLSR Hello messages. Hence, we utilized the reserved field of HELLO messages to avoid introducing any additional overhead on the network.

Fig.6(a) shows the standard HELLO message format in OLSR with a description of RFC3626. Fig.6(b) shows how the reserved field is utilized to get path quality in one hop.

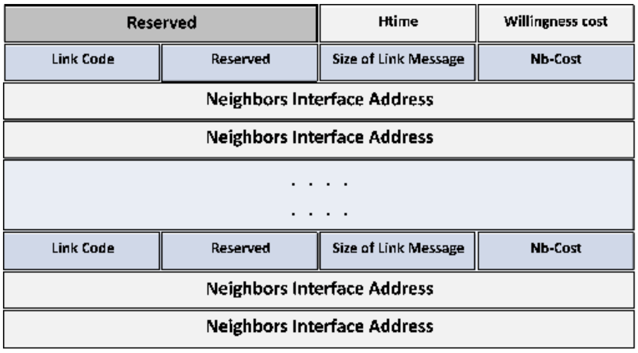

FIGURE 5. The stander hallow massage stricture in OLSR protocol.

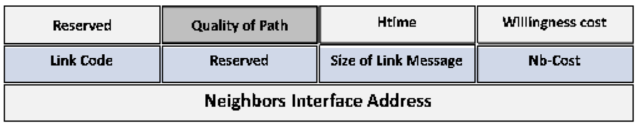

FIGURE 6. The modification hallow massage in OLSR protocol.

Figure 5 shows the standard HELLO message format in OLSR with a description of RFC3626. Figure 6 shows how the reserved field is utilized to get path quality in one hop.

V. PERFORMANCE EVALUATION

The CACA presented in this chapter mainly aims to solve routing overhead problem of the trade-off between mobility constraints and QoS requirements in VANETs. Simulation Environment have been carried out to investigate and evaluate the proposed algorithm in UM-OLSR. To this aim, NS2 simulation were used to compare and evaluate the performance of the discussed algorithm, also a performance comparison of both TC and overhead to highlight the effectiveness of our new algorithm. We evaluated the performance of the CACA with the following routing protocols as the baseline; UM-OLSR [35], COOP [19], NCA-MPR [21], NFA [20] and QOLSR [27]. Those protocols are all extensions of original OLSR protocol, and they are strongly depend on the link reachability and their configuration parameters. For that reason, the same configuration parameters were used to guarantee that they behave exactly as defined in the RFCs. We use the following performance criteria in the comparison: Packet Delivery Ratio, Overhead, Average End-to-End Delay, and Average Number of MPR.

VI. SIMULATION SET-UP

In this section, we present the performance evaluation of different proposed relay selection algorithms. The Network Simulator NS [36], version 2.34 tool was selected to run 10 urban network scenarios and to validate the impact performance parameters on relay selection metrics. The experiments have been carried out by evaluating our algorithm compared with these of UM-OLSR [35], COOP [19], NCA-MPR [21], NFA [20] and QOLSR [27]. So, we define realistic urban scenarios using the free tool Simulation of

TABLE 1. Simulation parameters.

Parameters	Value
Ad hoc network area	1400 m × 1200 m
Simulation time	300 second
Application type	CBR
Transport protocol	UDP
Packets size	512 bytes
Number of mobile vehicles	100
Pause time	20s
Speed of vehicle	2.7 - 30 m/s
MAC protocol	IEEE 802.11
Propagation model	Two-ray ground
Transmission range	250 m
queue size	50

Urban Mobility (SUMO) [37] to generate a Manhattan Grid mobility models within the space of 1400 m × 1200 m. The traffic Simulation (SUMO) is used to create the most common information such as road direction, edges, conditions, traffic signs and lights, and vehicle speeds, etc. Moreover, the traces file for mobility which defines wireless vehicular network is generated using sumo, where the 100 nodes distributed randomly and follow the behavior of vehicles in a road. The vehicles are moving randomly in different directions with a constant speed of 15 m/s. The vehicles exchange data packets generated by traffic generator that can create a constant bit rate (CBR) with a 512 bytes data packet size.

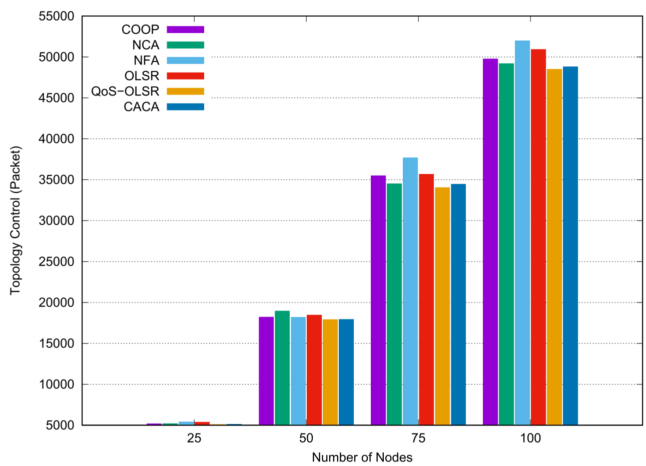

FIGURE 7. Number of TC messages.

VII. RESULTS AND DISCUSSION

Figure 7 represent the number of TC packets generated by the CACA algorithm compared to the number of TC messages generated by native clustering of COOP, NCA, NFA, QoS-OLSR and standard OLSR. According to the number of vehicles at each density, the results show that the number of TC messages of our CACA algorithm based on clustering and QoS constraints is less than other algorithms. This result reflects the efficiency of nodes coherence to establish routes with minimum overhead. It shows the accuracy degree of each relay vehicle selected to retransmit control packs. As the number of vehicles increase, the number of control topology packets increases significantly for all algorithms. The mobility and road obstacles have a great impact on the performance of NFA, NCA, COOP, OLSR, and QoS-OLSR which suffer from the retransmission of TC packets, especially in low vehicle density.

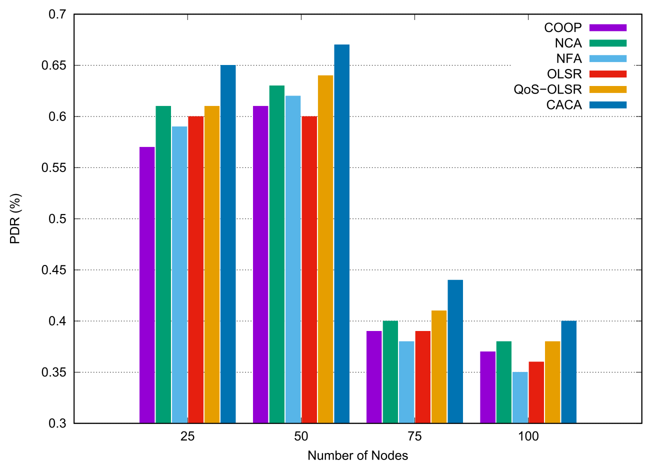

FIGURE 8. Level of packet delivery ratio.

Figure 8 shows better packet delivery ratio of the CACA algorithm based on the quality of path metric when compared to the standard OLSR, NFA, NCA, COOP, OLSR and QoS-OLSR protocols. This is because of the weighted link qualities metric in our algorithm which used to select the set of MPR with; less mobility, low collision probability, and wide bandwidth route compared to the native clustering of cooperative algorithms. This leads to select the best vehicle located in its trust communication rang as its cluster head while MPRs are used link quality metric to further connect cluster heads to improve the network connectivity and maximizes the network performance, especially in high vehicle density scenario. In particular, this result explains the efficiency of NFA, NCA, COOP, OLSR, and QoS-OLSR clustering operations, which are not significant to improve the packet delivery ratio.

Figure 9 present the average end-to-end delay values for paths in the network. The delay of each algorithm increases when the density of vehicles increases. The delay of the proposed algorithm is lower than NCA, NFA, COOP, OLSR and QoS-OLSR algorithms in all scenarios. This is because of the consequent of the lower hop count of the proposed protocol. However, the percentage of improvement, 20 on average, makes the proposed algorithm offers the lowest average delay compared to NCA, NFA, COOP, OLSR and QoS-OLSR algorithms in all scenarios. This result explains the coherence factor of the CACA algorithm which reduces the number of MPR sets significantly. It reflects the quality of the selection of the native clustering approach in standard OLSR witch shows the highest end-to-end delay. The selection mechanism selects MPR set randomly without considering the mobility level and link reachability factors in their selection mechanism.

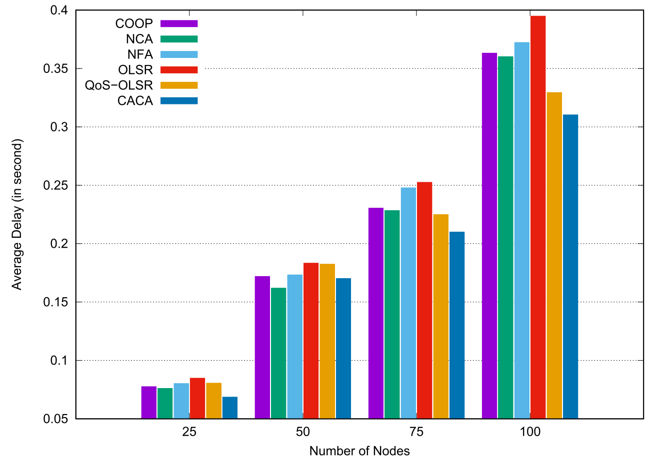

FIGURE 9. Average end-to-end delay.

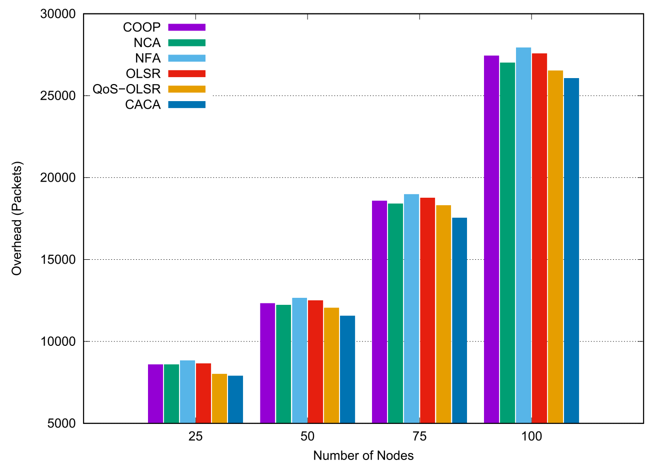

FIGURE 10. Overhead level.

Figure 10 present the overhead values generated by each algorithm according to the vehicle level density. The proposed CACA based on the cluster, QoS and bandwidth factors reduced the overhead problem at all vehicle density levels. this algorithm outperforms OLSR, QoS-OLSR, NCA, NFA and COOP algorithms which incurred the lowest network overhead. This is because NCA, NFA, COOP, and OLSR need to send more control messages to maintain routes than CACA and QoS-OLSR algorithms. The weighted quality of path metrics reduces link failure as well as collision probability by limiting the number of messages sent. This makes a big difference to the performance of the CACA algorithm from the cooperative algorithms.

Figures 11 presents the average number of MPR vehicles as a function in each algorithm. The lowest number of MPR vehicles is achieved by the proposed CACA algorithm, especially when the network is dense enough to achieve more accurate routing tables. This result confirms the fact that CACA flood fewer TC messages compared to the

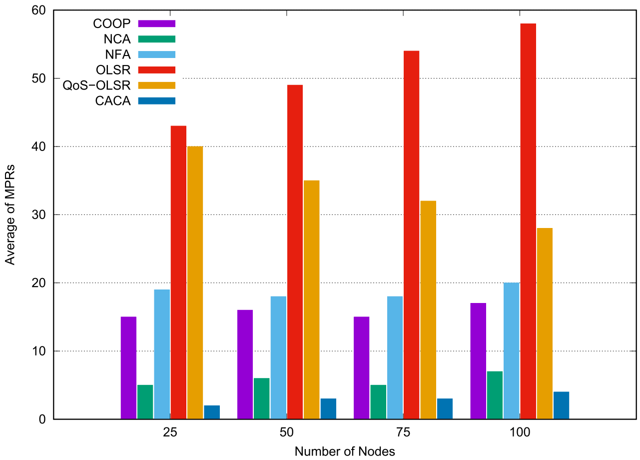

FIGURE 11. **Average number of MPR vehicles.**

standard OLSR, QoS-OLSR, NCA, NFA and COOP algorithms. The quality of the path metric increases the weight of relay vehicles that guarantee reliable links with high bandwidth. In addition, NCA consumes more MPR than CACA due to route re-establishment. This is because of link failure and collisions. While OLSR shows the worst result which faces the link failure frequently and TC message collisions.

In summary, the proposed forwarding algorithm outperforms in terms of packet delivery ratio, the average number of MPR, overhead, and end to end delay while providing comparable results in topology control messages. This is due to the consideration of QoS in the selection of cluster heads which enhance the connectivity between clusters and MPR sets. The size of control messages overhead can be reduced significantly by guarantee the quality of links as well as the minimum size of the MPR set. On the other hand, the native clustering selection mechanism of standard MPR may not be enough to list the qualities of the path generated. However, it presents a high level of path availability, especially in high node density.

VIII. CONCLUSION

This paper presented a cluster-based Adept Cooperative Algorithm for urban VANET, namely CACA. This protocol has been introduced to increase network performance by enhancing the flooding broadcast traffic. The scalability of routing is improved based on the Quality of Path (QoP) metric which used to solve the trade-off routing overhead problem between mobility constraints and QoS requirements in VANETs. The main objective behind this metric is to collect the important and effective information about neighbors during the route discovery phase and use it to select the next forwarding node after checking whether this forwarding is stale meeting the QoS requirement or not. The clustering and QoP metric helps in decreasing vehicles acting as cluster-heads which leads to decreasing the retransmission traffic of TC messages. The simulation results have confirmed the effectiveness of our proposed algorithm, especially in terms of packet delivery and delay. As future works, we plan to improve our work to support other parameters to adapt our mechanism to integrate it into other routing protocols.

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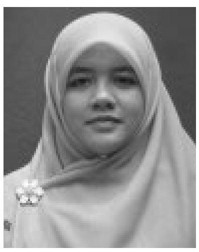

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