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RESEARCH ARTICLE

Cluster-Based Protocol for Prioritized Message Communication in VANET

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ABSTRACT VANET can support a wide range of time-sensitive applications. The communication and computational overheads for these computations are minimal, and there are numerous requirements that must be met. Because of the mobility of vehicles, some traditional MANET routing protocols may not be suitable for the VANET. Aside from its usual use in urban environments, various applications on VANETs have emerged in recent years for rescue, military, communication, security systems. VANETs are entirely wirelessly connected via nodes, which typically have dynamic topologies. When it comes to road safety applications for VANETs, alert communication must be done in a quick manner so that the vehicles receive warning messages without any delay. Based on clustering approach, a protocol is proposed in this paper to communicate emergency messages in less time. The proposed protocol allows storage of non-urgent information temporarily, so that emergency messages are communicated quickly.

INDEX TERMS Cluster-head, cluster-member, data dissemination, prioritization, VANET.

I. INTRODUCTION

Due to economic and population growth, there has been a rapid increase in the number of vehicles in recent years. This has naturally increased road accidents, driver exhaustion, and the deterioration of roads and support infrastructure. According to a World Health Organization (WHO) healthcare report, road accidents are the leading cause of death among people aged 15 to 29 years old, with 1.3 million people killed in accidents worldwide each year. This rapid increase in traffic accidents can be managed by utilizing cutting-edge technology such as VANET to communicate emergency messages. Vehicles in the Vehicular Adhoc Network (VANET) self-regulate and communicate as nodes without the intervention of a central authority. The vehicle's topology varies quickly, making the routes unpredictable. The efficiency of a routing protocol is determined by both internal characteristics such as node mobility and external factors such as path topology and signal blocking barriers. This necessitates a highly adaptable strategy to deal with emergency situations by selecting the appropriate routing and forwarding plan [1]. Vehicle-to-vehicle data transfer is one of the most difficulties in VANET architecture since it necessitates the development of a complicated routing protocol.

In VANETs, clusters represent a collection of vehicles called as cluster member (CM) where each cluster has only one cluster head (CH). As shown in Figure 1, cluster topology can be divided into two types: one-hop clusters and multi-hop clusters [2]. One-hop clusters are typically built based on the communication range of the CH. CHs group together with their one-hop neighbors to form clusters [3]. The most important aspect of a clustering algorithm is selecting a dependable leader and it is mostly chosen at the starting of clustering process [4]. As observed, multi-hop clusters usually provide higher cluster stability than single-hop clusters. But multi-hop clustering process and maintenance is more complex.

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In multi-hop clustering, CHs can have indirect communication with CMs and CMs can have communication with their own CHs indirectly through other CMs [5]. In a highly dynamic VANETs, balanced message communication can happen via cluster-based communication. In this process, a leader i.e., CH is chosen for each cluster to handle in and out cluster traffic [6]. The VANET can be built on any wireless networking technology. Wireless Local Area Network (WLAN), cellular technologies, and Long-Term Evolution (LTE) can all be used for VANETs [7].

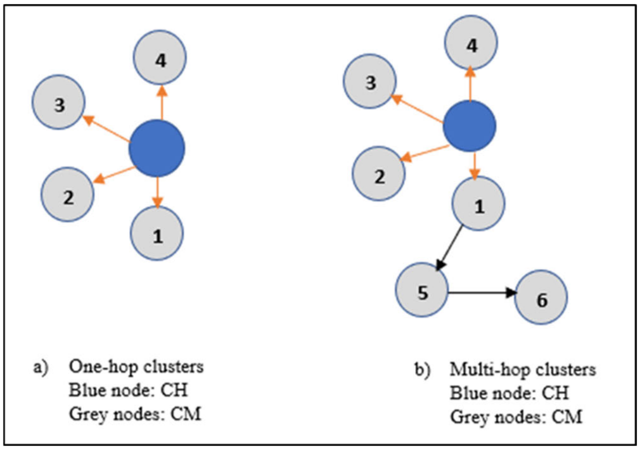


FIGURE 1. Types of cluster topology.

Even though VANETs provide dependable communication services due to its infrastructure-based nature, but because of the increased mobility of cars, these networks feature low connection times. For example, two cars going in the same direction and starting from the same point can only maintain a solid link for 25 seconds [8]. Position-based routing protocols, broadcast-based routing protocols, cluster-based routing protocols, and multicast/geocast routing protocols are four categories in VANET system topology that have important differences, particularly in the idea of transferring data and information between nodes [1], [9]. Proposal of an efficient protocol for data transfer between nodes is of special significance and is probably worth further investigation.

II. LITERATURE SURVEY

The authors in [3] classified VANET clustering into three types of strategies: strategies based on intelligence, mobility, and multi-hop topology. The authors mentioned that performance metrics, simulation scenarios differ significantly between different clustering algorithms. However, without a classification and detailed algorithm comparison, this survey is considered incomplete.

In another survey [10], the authors provided classification of VANET clustering based on various key metrics. This work is much completer and more meaningful than the previous survey, but, the comparison of metrics between different protocols and algorithms couldn't convince the research community.

The authors in [11] meticulously summarized the procedure of the clustering approach considering formation of cluster, selection of cluster head, cluster maintenance etc. Even though the paper provided with a good report of analysis as well as comparisons; the authors failed to examine the context and simulation environment of the algortithms. The authors of [12] presented a hybrid of fog computing and Software-Defined Networks (SDN) to create a strong architecture capable of overcoming problems posed by technological advancement and the rapid increase in the number of smart vehicles.

From decades, numerous VANET applications have been investigated and clustering algorithms have been developed but most of them given less attention towards increasing cluster stability [13]. Due to demand of various applications and limited wireless communication range, multi-hop clustering process (e.g., K-hop [2], Hierarchical Clustering Algorithm [3] etc.) was widely accepted. Meanwhile, the advancement of cellular technologies such as Universal Mobile Telecommunications System (UMTS) and Long-Term Evolution (LTE) has increased the use of clustering algorithms in vehicular networks.

The following algorithms that were specifically designed for VANETs, are chosen as the most popular algorithms: cooperative interest-aware clustering [14], affinity propagation [15], supervisory protocol [16], k-hop clustering [2], TDMA-based VANET [17], position and distance-based clustering approach [18], Cluster-based medium access control protocol [19], and Path-based clustering [20].

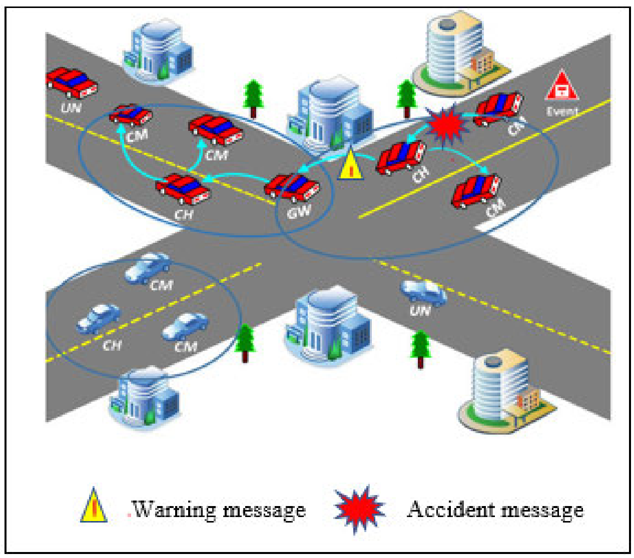


FIGURE 2. Emergency message communication.

In this paper, a cluster-based architecture design is proposed in which different clustering metrics such as relative velocity, vehicle relative position, and link lifetime are considered and their impact on cluster performance is evaluated.

III. METHODOLOGY

In the proposed methodology, it is assumed that each vehicle is equipped with a GPS device to share their position, motion speed, moving direction in periodic Cooperative Awareness Messages (CAM). The GPS device is capable of determining the vehicle's current geo-location, motion direction as well as velocity. All the vehicles are connected via wireless communication in an Ad-hoc manner while moving along roads [21]. This cluster-based protocol mainly aims to send alert messages within the specified area. As shown in Figure 2 [22], the accident vehicle will immediately broadcast an alert message once the accident happens. Vehicles exchange information with their immediate neighbors via beacon messages. Vehicle-ID, cluster-ID, present state, axis position, velocity motion direction are all included in the beacon message. In the Figure 2, gateway is represented by GW. It serves as a relay node, connecting two clusters to extend information coverage without the need for road-side units [22].

A. CLUSTERED ARCHITECTURE

Each vehicle in the proposed clustered architecture can be in either of these transition states [22]:

Unregistered Cluster Node (UCN): It is a node's initial state. A node in this state is not registered to any cluster.

Cluster Head (CH): Coordinator node of other members of the cluster. There is only one cluster head for each of the clusters.

Cluster Member (CM): Registered nodes of a cluster and coordinated by the cluster head.

Cluster Member Nominee (CMN): The node which has sent a join request message to a cluster but yet to receive a join confirmation notification.

Clustering occurs in three layers in this architecture: Stable-node Sampling, Cluster head Selection based on Timers and Choosing a backup cluster head.

1) STABLE-NODE SAMPLING

Each unregistered node is denoted as UCN. The process starts a timer called T_{acc} to determine their single hop surrounding area, which is known as Candidate Adjacency Set (CAS). To eliminate unnecessary communication, the adjacent node sampling method selects a set of balanced adjacent nodes from CAS, denoted as the Balanced Adjacency Set (BAS). Algorithm 1 describes the stable-node sampling procedure and Figure 3 depicts workflow of the same. Here, T_{acc} is Timer during which vehicles exchange and accumulate Beacons.

Every BASi(j) in adjacent list entry contains the following information:

(xi, yi): Position (vehicle Vi)

LinkLifeij: Lifetime of Vi's and Vj's Link

ΔSpeedij: comparative speed of Vi and Vj

ΔDistij: comparative distance of Vi and Vj

If a UCN vehicle cannot find a balanced adjacent node during the Tacc, it will transit to CMN and will not participate in the timer-based selection process of cluster head.

Algorithm 1 Stable-Node Sampling

```
1. while (T_acc > 0) do
  2. if Node UCNi accumulates beacon from UCNj, then
    3. if (Direction (Vi) == Direction (Vj)) &&
       if (ΔSpeed_ij ≤ ΔSpeed_th), then
       4. Calculate LinkLife_ij
       5. if (UCNj ∈ BASi), then
           6. update BASi(j)
       7. else
         8. add the entry BASi(j) to BASi
         9. Increment adjacency set by 1
       10. end if
    11. end if
  12. end if
13. end while
```

2) CLUSTER HEAD SELECTION

In the proposed cluster head selection process, each vehicle can set its own $Backoff_{timer}$. It waits for $CH_{announce-msg}$ (an announcement message by the cluster head) to be broadcast. The vehicles that broadcast $CH_{announce-msg}$ messages to their adjacent nodes at first, will be considered as the first CHs. A $CH_{announce-msg}$ must contain information such as message type, vehicle ID, vehicle's axis location, list and count of balanced adjacent nodes.

There are two approaches for selecting the CH. The first method is metric-based, whereas the second is random-based. The following three metrics are considered in the metric-based method:

1. $\overline{LinkLife_i}$ (average link lifetime between Vi and its balanced neighbors)
2. $\overline{\Delta Dist_i}$ (average relative distance)
3. $\overline{\Delta Speed_i}$ (average relative speed)

The term link lifetime refers to the period of time that two vehicles remain connected while driving in the same direction. The calculation is defined by Eq. (1).

$$LinkLife_{ij} = \frac{-\Delta Speed_{ij} * \Delta Dist_{ij} + \left|\Delta Speed_{ij}\right| * Comm_{range}}{\left(\Delta Speed_{ij}\right)^2} \quad (1)$$

Here, LinkLifeij = Link Lifetime (vehicle Vi and Vj)

ΔSpeedij = Relative speed (vehicle Vi and Vj)

ΔDistij = Relative distance (vehicle Vi and Vj)

During the Tacc time period, vehicle Vi calculates LinkLifeij, ΔSpeedij and ΔDistij for each received beacon message from vehicle Vj, where Vj is a subset of the Balanced Adjacency Set (BASi). The metrics ΔSpeedij and ΔDistij is calculated using Eq. (2) and Eq. (3)

$$\Delta Speedij = velo_i - velo_j \quad (2)$$

$$\Delta Distij = xi - xj \quad (3)$$

The positions of Vi and Vj are denoted by xi and xj, respectively. Speed of Vi and Vj are denoted by $velo_i$ and velo$_j$ respectively. When Tacc expires, Vi computes the metrics: average link lifetime, average relative distance, and average relative speed using Eq. (4), (5), and (6).

$$\overline{LinkLife}_i = \sum\nolimits_{V_j \in BASi} LinkLife_{ij} \Big/ N_i \tag{4}$$

$$\overline{\Delta Dist}_i = \sum\nolimits_{V_j \in BASi} \left|\Delta Dist_{ij}\right| \Big/ N_i \tag{5}$$

$$\overline{\Delta Speed}_i = \sum\nolimits_{V_j \in BASi} \left|\Delta Speed_{ij}\right| \Big/ N_i \tag{6}$$

Here, Ni = Number of balanced adjacent nodes of Vi. The Backofftimer is calculated using Eq. (7).

$$Backoff_{timer\_i} = Timer_{min} + (Timer_{max} - Timer_{min}) * M_i + \phi \tag{7}$$

where M_i is calculated using Eq. (8)

$Timer_{min}$ and $Timer_{max}$ are set to 0s and 2s, respectively. $LinkLife_{max}$ can be given the same time as the simulation time, $\Delta Dist_{max}$ is the same as the communication range, and $\Delta Speed_{max}$ is set to the same value as $\Delta Speed_{th}$ and ϕ follows a uniform distribution from 0 to 0.1. $\Delta Speed_{th}$ denotes the speed difference threshold between two vehicles.

$$M_i = \begin{cases} 1 - \overline{LinkLife}_i / \Delta LinkLife_{max} \\ \overline{\Delta Dist}_i / \Delta Dist_{max} \\ \overline{\Delta Speed}_i / \Delta Speed_{max} \end{cases} \tag{8}$$

In random based method when T_{acc} expires, each vehicle selects a random Backoff$_{timer}$ according to Eq. (9), where $Timer_i$ follows a uniform distribution from 0 to $Timer_{max}$ and ϕ follows a uniform distribution from 0 to 0.1.

$$Backoff_{timer\_i} = Timer_i + \phi_i \tag{9}$$

If vehicle-i receives a *CHannounce-msg* during $Backoff_{timer\_i}$, it abandons the Cluster head competition process, cancels $Backoff_{timer\_i}$, and changes its state from UCN to CMN; otherwise, when $Backoff_{timer\_i}$ expires, vehicle i changes its state from UCN to CH and broadcasts a CHannounce-msg to notify its vicinities of this state transition. Algorithm 2 describes the cluster head selection procedure and Figure 4 depicts workflow of the same.

Here, Mi = Metric, Backoff$_{timer}$ = Distributed backoff timer, CH$_{announce-msg}$ = CH Announcement message.

Once a UCNj receives a CHannounce-msg from CHi, it immediately transits to CMNj and sends a join request message to the CHi. When CHi receives the join request message from CMNj, it first checks the count of already existing CMs in the cluster and based on following steps decides acceptance or rejection within Timer$_{acknowledgement}$. Algorithm 3 describes the cluster head selection procedure and Figure 5 depicts workflow of the same.

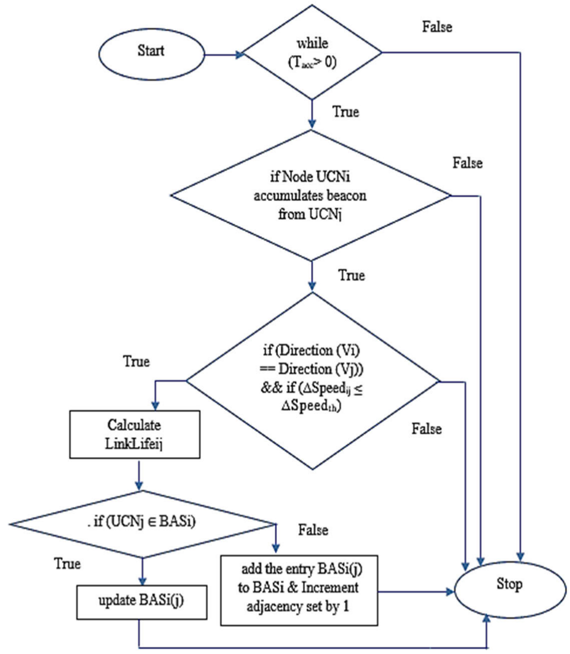


FIGURE 3. **Workflow of stable-node sampling.**

Algorithm 2 Cluster Head Selection

1. when (T$_{acc}$ = = 0)
2. UCNi calculates metric Mi
3. UCNi calculates Backoff$_{timer_i}$ and starts it
4. set T_Backoff$_{timer}$ ← 1
5. while (Backoff$_{timer_i}$ > 0), do
   6. if UCNi receives announcement from the cluster head j, then
      7. set T_Backofftimer ← 0
      8. set UCNi → CMNi
      9. perform cluster formation
   10. end if
11. end while
12. if (T_Backofftimer = = 1), then
      13. set UCNi → Chi
      14. CHi broadcasts CHannounce-msg
15. end if

3) CHOOSING A BACKUP CLUSTER HEAD

Steps performed by CH:

1. if (CM$_{exist-count}$ < Cluster$_{capacity}$), then
   2. add CMNj to CM$_{list}$ and return Msg$_{acknowledgement}$
3. else
   4. ignore join request.

Steps performed by CMN:

1. if CMNj receives Msg$_{acknowledgement}$, when (Timer$_{acknowledgement}$ > 0), then
   2. CMNj transits to CM node
3. else
   CMNj sends join request message to another CH.

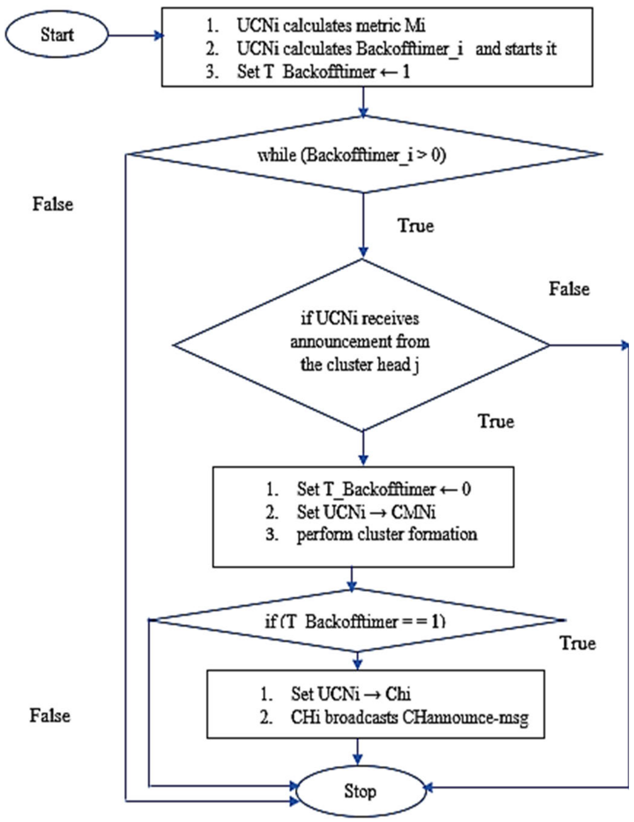


FIGURE 4. Workflow of cluster head selection.

Algorithm 3 Choosing a Backup Cluster Head

1. Vi examines Backup-$_{\text{CHLi}}$
2. if (Backup-$_{\text{CHLi}}$ == Ø), then
   3. if (Vi == CMN), then
      4. CMNi restarts Timer$_{\text{backup-CH}}$
   5. else
      6. if (Vi == CM), then
         7. set CMi → CHi
      8. end if
   9. end if
10. else
   11. if sizeof ((Backup-$_{\text{CHL}}$) ≥ 1), then
      12. Choose the CH with highest priority
      13. Send join request message and start the acknowledgement timer
   14. end if
15. end if

Every CMN node, such as CMN_i, that has not been clustered will set a timer- $Timer_{Backup-CH}$, during which CMN_i may receive beacon messages from CHs. For each detected CH_j, CMN_i only selects the qualified CHs and records their link lifespan $LinkLife_{ij}$ and relative speed $\Delta Speed_{ij}$ in its Backup CH List Backup-$_{\text{CHLi}}$. The qualified CHs should move in the same direction as CMN_i and $\Delta Speed_{ij} \leq \Delta Speed_{th}$.

Here, $CM_{exist-count}$ = Count of already existing CMs, $Cluster_{capacity}$ = Cluster capacity, CM_{list} = Cluster member list, $Timer_{acknowledgement}$ = Acknowledgement timer, $Msg_{acknowledgement}$ = Acknowledgement message. Backup-$_{\text{CHL}}$ = Backup cluster head list.

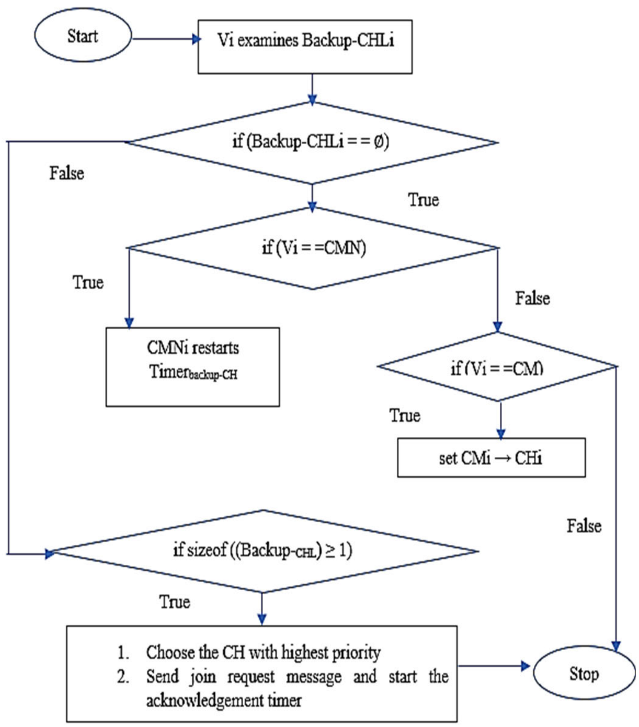


FIGURE 5. Workflow of choosing a backup cluster head.

Every unclustered CMNi can fix a time for receiving the beacon messages from the CHj. Any CMNi can select only qualified CHj. It will record the LinkLifeij and ΔSpeedij in its Backup CH List. The qualified CH should move in the same direction as CCMi in this case, and the relative speed between vehicle Vi and Vj should be less than or equal to the predetermined threshold V_{th}.

Backup cluster heads are ordered in the backup cluster head list by priority. Backup cluster heads with longer link lifetimes are given higher priority. If all of the link lifetimes in the backup cluster head list are equal, the backup cluster head with the lowest v will be prioritized. Vehicles select the backup cluster head with the highest priority.

B. PRIORITIZED MESSAGE COMMUNICATION

1) STEPS FOR PRIORITIZED MESSAGE COMMUNICATION

(i) The moment any CH receives an alert message from a vehicle that encountered an accident, or any other kind of vehicles, it performs following steps:

Steps performed by CH:

1. if ($Alert\text{-}Msg_{current}$! = $Alert\text{-}Msg_{prev}$), then
   2. broadcast the $Alert\text{-}Msg_{current}$ to CMs and reserve in the internal storage for short duration.

TABLE 1. Vehicle configuration.

Type of Vehicle	Max speed of Vehicle	Acceleration of Vehicle	Deceleration of Vehicle
1	45 m/sec	3.9 m/sec^2	8.5 m/sec^2
2	35 m/sec	3.9 m/sec^2	8.5 m/sec^2
3	30 m/sec	3.0 m/sec^2	7.5 m/sec^2
4	20 m/sec	2.5 m/sec^2	6.5 m/sec^2

3. else
    4. if ((Alert-Msg$_{current}$ == Alert-Msg$_{prev)}$ &&! (relayed)), then
        5. broadcast the Alert-Msg$_{current}$ to CMs.
    6. end if
7. end if

In the proposed cluster-based protocol, once a CH receives an alert message and finds that Alert-Msg$_{current}$ and Alert-Msg$_{prev}$ both are not same, it reserves the message in the internal storage for short duration. During this short period of storage time, the CH will broadcast the alert message repeatedly at uniform intervals. Through this process, the moving CH can send alert message to more vehicles on a low-density road.

(ii) The moment any CM receives an alert message from an accident encountered vehicle, or from a relay-node, it performs following steps:

(a) Steps performed by CM (CM receives an alert message from an accident encountered vehicle):

1. if (Alert-Msg$_{current!}$ = Alert-Msg$_{prev)}$, then
    2. deliver the Alert-Msg$_{current}$ to the CH.
3. else
    4. if ((Alert-Msg$_{current}$ == Alert-Msg$_{prev)}$ &&! (delivered)), then
        5. deliver the Alert-Msg$_{current}$ to the CH.
    6. end if
7. end if

(b) Steps performed by CM (CM receives an alert message from a relay-node):

Check if the Alert-Msg$_{current}$ is delivered by own CH. If not, forward the Alert-Msg$_{current\ to}$ own CH.

IV. RESULT DISCUSSION

Table 1 shows the vehicle configuration and Table 2 shows simulation environment. The clustering process begins only when all the vehicles enter the road at start time. Vehicles form cluster head to cluster member connections in accordance with the clustering scheme. All connections between cluster head to cluster member are automatically disconnected after the end time.

TABLE 2. Simulation environment.

Parameter	Values of Parameter
Simulation Package	SUMO
Simulation run time	300 sec
Start time	300 sec
End time	600 sec
Accident time	350 sec
Road length	20 km
Vehicle count	100
Beacon Interval	1.0 s
Beacon size	60 bytes
Traffic flow rate	500 vehicles/hour
Propagation model	Two ray ground
Frequency	5.8GHz/10MHz
Antenna	Omni Antenna
MAC protocol	IEEE 802.11p
Iteration count	10

The proposed Cluster-based Protocol for Prioritized Message Communication (CBP-PMC) is tested against the VMaSC-LTE [23] clustering scheme. Figure 6 depicts comparison result of average of packet delivery ratio as the communication range of the vehicle increases. During simulation, the communication range is considered from 200m to 350m. Based on this varying range of communication, performance is measured. From the simulation result it can be observed that with an increase in communication range, there is a considerable increase in the packet delivery ratio. For communication range of 350m, CBP-PMC achieved 0.68 packet delivery ratio whereas for VMaSC-LTE it was only 0.38. Another drastic difference was observed for communication range of 550m where CBP-PMC achieved 0.91 packet delivery ratio but VMaSC-LTE could achieve only 0.65. Hence it can be claimed that for packet delivery ratio, the proposed CBP-PMC outperformed VMaSC-LTE.

Figure 7 shows average delay of packet transmission when communication range is increasing. With an increase in the communication range, packet delivery delay decreases slightly. The alert message is received by all of the vehicles in less time. For communication range of 450m, CBP-PMC achieved 9s packet delivery delay whereas for VMaSC-LTE it was 25s. When communication range was increased to 500m, CBP-PMC could achieve packet delivery delay of 4s but VMaSC-LTE it was 13s which is more compared to the

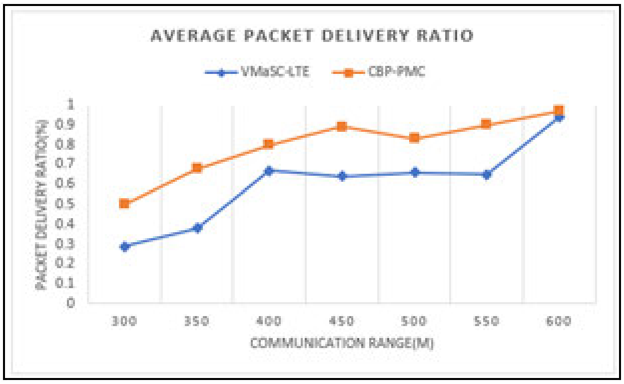


FIGURE 6. Comparison of average packet delivery ratio.

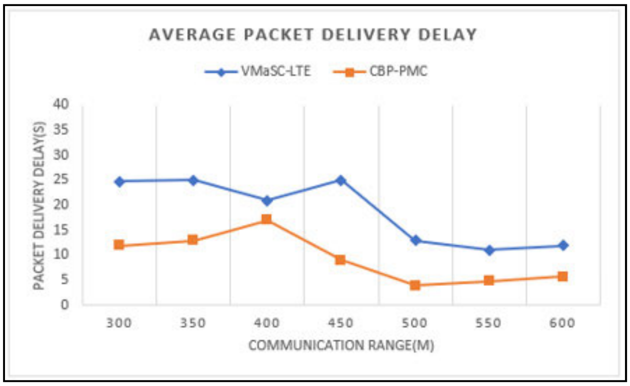
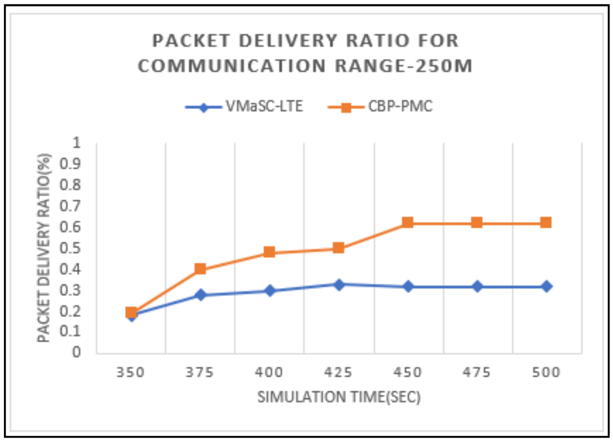
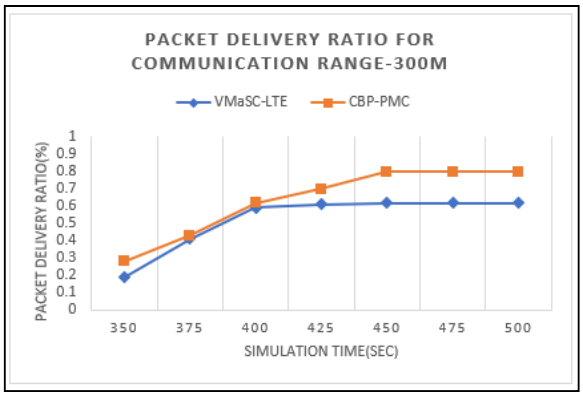


FIGURE 7. Comparison of average packet delivery delay.

proposed CBP-PMC protocol. Therefore, in terms of average packet delivery delay also, the proposed CBP-PMC outperforms the VMaSC-LTE message transmission algorithm. It is possible because of the proposed CBP-PMC's backup cluster head selection scheme. The backup cluster head selection scheme allows all disjoint cluster members to be connected back in less time. It will also allow alert messages to be successfully delivered with less packet loss. The packet delivery ratio for a communication range of 250m and 300m is depicted in Figure 8. In the beginning, the packet delivery ratio can be observed as increasing with an increase in the simulation run time, but the ratio gets stabilized after a short period of time. In the result graph as shown in Figure 8(a) for communication range of 250m, it can be observed that when simulation time is 375s, packet delivery ratio for CBP-PMC is 0.40 and for VMaSC-LTE it is 0.28. Once the simulation time is increased to 425s, packet delivery ratio also increased to 0.51 for CBP-PMC and 0.33 for VMaSC-LTE. But from the simulation time 450s till 500s the packet delivery ratio is stabilized to 0.62 for CBP-PMC and 0.32 for VMaSC-LTE. Similar scenario can be observed in Figure 8(b) for communication range of 300m. For simulation time of 375s, packet delivery ratio for CBP-PMC is 0.43 and for VMaSC-LTE it is 0.41. When simulation time is increased to 425s, packet delivery ratio gets increased to 0.70 for CBP-PMC and 0.61 for VMaSC-LTE. From the simulation time 450s till 500s the packet delivery ratio is stabilized to 0.80 for CBP-PMC and 0.62 for VMaSC-LTE. As packet delivery ratio is stabilized after a short period of time, the accident vehicle no longer broadcasts the alert message. It interprets that the alert messages arrive faster to the target vehicles. From the result graphs it can be observed that the proposed CBP-PMC protocol provides better performance w.r.t packet delivery ratio in comparison to the VMaSC-LTE message transmission algorithm.



(a)



(b)

FIGURE 8. Packet delivery ratio for communication range-(a) 250m (b) 300m.

V. CONCLUSION AND FUTURE WORK

VMaSC is one of the most recent and widely used clustering techniques, with extensive simulation parameter choices. The paper proposes a Cluster-based Protocol for Prioritized Message Communication and compares its performance to the VMaSC-LTE message transmission algorithm [23]. Vehicle clusters are used as a backbone structure for information transmission, data aggregation, packet delivery, and so on. An unexpected vehicle separation may result in the loss of an emergency message. Our goal in the proposed CBP-PMC protocol is to ensure that the detached vehicles can successfully join another existing cluster as quickly as possible.

The backup cluster head selection approach in the proposed CBP-PMC protocol enables all disjoint cluster members to be reconnected in less time. The vehicle's state possibly can change from UCN to CH or CMN. As a result, in the proposed protocol, each vehicle undergoes at least one state change during the simulation. While using the stable node sampling technique, the vehicle only considers stable adjacent nodes by satisfying the criteria ΔSpeedij ≤ ΔSpeedth. The result graphs show that the proposed CBP-PMC performs better than VMaSC-LTE in terms of both packet delivery ratio and packet delivery delay.

In future, clusters can be configured to handle simultaneous distribution of multiple types of messages that can be handled by cluster head vehicles using content caching and information aggregation use cases. The cluster size optimization can also be considered in the future deployment of this proposed protocol. Vehicles can precompute list of optimal cluster size based on various road conditions, application requirements, packet delivery size, and so on. Finally, based on location condition the CH can decide which cluster size is most suitable.

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DATA AVAILABILITY STATEMENT

The dataset used for the findings is included in the manuscript.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest exists.

AUTHOR CONTRIBUTION

Sanchari Saha and V. Vinoth Kumar conceived of the presented idea. Sanchari Saha and V. Vinoth Kumar designed the model and the computational framework and analysed the data. V. R. Niveditha developed the theory and performed the computations. K. Gunasekaran and Krishnamoorthy Venkatesan verified the analytical methods. Velmurugan Athiyoor Kannan and Krishnamoorthy Venkatesan worked out almost all of the technical details, and performed the numerical calculations for the suggested experiment. Velmurugan Athiyoor Kannan encouraged V. Vinoth Kumar to investigate [a specific aspect] and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

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