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# Destination-aware context-based routing protocol with hybrid soft computing cluster algorithm for VANET

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**Abstract**
Due to the rapid topology change, frequent link failure, high vehicle mobility and hard delay constraints, the vehicular ad hoc network (VANET) became a hot research topic in this smart era. VANET has vast application areas including road congestion notification, parking, traffic management, smart transportation, road-side business advertisements. In all these applications, the messages should reach the target location within certain time limits. So, there must be efficient soft computing-enabled routing in VANET which meets these delay constraints. Two soft computing algorithms were proposed in this paper: First, a hybrid clustering algorithm is proposed which combines the geographic- and context-based clustering approaches. The hybrid clustering reduces the control overhead and traffic in the network. Second, the destination-aware routing protocol is proposed for inter-clustering routing which improves the overall packet delivery ratio and reduces the end-to-end delay. The performance of the proposed approach is compared with the well-known cluster-based approaches. The result shows that the proposed approach outperforms the existing approaches.

**Keywords** Vehicular ad hoc network · Clustering · Context-aware clustering · Destination-aware routing · Geographic-based routing · VANET · MANET

## 1 Introduction

The smart transportation system is an important application of VANET which includes all types of communications between vehicles. It provides many facilities to the passengers, such as safety applications, assistant to the drivers, emergency warning. In VANET, vehicles are equipped with an on-board units (OBUs) that can communicate with each other (V2V communications), and/or with stationary road infrastructure units (V2I) that are installed along the roads (Tal and Muntean 2012). VANETs have several characteristics that make them different from MANETs, such as high node mobility, predictable and restricted mobility patterns, rapid network topology change and frequent battery charging, so energy consumption is not a big issue in VANET (Tayal and Triphathi 2012). VANET adapts different types of routing protocols, such as proactive (Spaho et al. 2012), reactive (Ding et al. 2011), hybrid- (Wu et al. 2013; Chai et al. 2013) and geographic-based routing protocols (Liu et al. 2008; Luo and Zhou 2011). The proactive and reactive routing protocols are classified under the topology-based routing protocol category, which aims to discover the route between the source and destination before starting the data transmission.

The hybrid routing protocol combines the features of both proactive and reactive routing protocols. The nodes in the hybrid network are grouped together in a particular area called clusters. Hybrid routing protocols, sometimes called cluster-based routing (CBR) protocols, are designed to improve the network scalability by allowing the nodes within the clusters to communicate through a preselected cluster heads (CHs) using a proactive routing protocol. However, in the case of communication between clusters, a reactive routing protocol is triggered. In geographic-based routing protocols, the data are transmitted directly from the

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source to the destination without initiating any route discovery process.

The primary focus of this work is to develop routing protocol which improves the overall packet delivery ratio and reduces the end-to-end delay in VANET through the destination-aware context-based routing protocol and hybrid clustering. Firstly, a hybrid clustering algorithm is proposed which combines the static and context of the VANET nodes to form the clustering. The static clustering divides the area into segments, and the context-based clustering takes the following parameters into consideration while forming the clusters: location of vehicle, direction of vehicle, velocity of vehicle, point of interest of vehicle and destination of vehicle. By this context-based clustering, every cluster has some interests like interest in parking information, accident notifications, congestion information. When a CH receives a message, it checks whether the vehicles inside the cluster are interested in the message or not. If the vehicles inside the cluster are interested, then CH will forward the message to the cluster members. Otherwise, the message will be forwarded to the next CH without propagating the message inside the cluster (Paridel et al. 2012). This will reduce the irrelevant information propagation in the network.

Secondly, a destination-based routing protocol is proposed for these hybrid-based clusters in VANET for efficient inter-cluster communication. In hybrid-based clustering, we use destinations of vehicles in cluster formation due to which every cluster has some destination which is determined from the destinations of the vehicles within the cluster. When a cluster head needs to forward the message, it must select the optimal cluster heads in its neighborhood to carry the message. A cluster head selects the optimal neighbor cluster heads based on two parameters: direction of neighbor cluster heads and destination of neighbor cluster heads.

The remaining part of this paper is organized as follows: Sect. 1 develops the introduction. Section 2 provides a literature review of the research area. The hybrid clustering model is explained in Sect. 3. The destination-aware routing protocol is introduced in Sect. 4. Numerical results and conclusions are finally given in Sects. 5 and 6, respectively.

## 2 Literature review

Generally, cluster-based routing (CBR) protocol is a hybrid routing protocol that divides the large network into small areas called clusters. The communication within the cluster is taken place by the intra-cluster routing protocol, and the communication between clusters is performed via preselected nodes called cluster heads (CHs). The CHs are responsible for coordinating the members of the cluster and communicating between clusters using inter-cluster routing protocol (Luo et al. 2010). By clustering, only the CH requires to find the destination route. Therefore, the routing overhead is proportional to the number of clusters and not the number of nodes. The objectives of using clusters are to minimize the control overhead and increase the scalability of the network.

Cluster-based directional routing protocol (DBR) was proposed in Song et al. (2010), where a source node forwards the message to the neighbor cluster head whose moving direction is similar to transmission direction of a message. Transmission direction of the message is computed by a node using its position coordinates and target location of the message. Jerbi et al. (2009) proposed an improved greedy traffic-aware routing protocol (GyTAR), which is an intersection-based geographic routing protocol. It uses clusters concept between adjacent intersections to forward the data packet, and it also considers the distance to cluster center to select the cluster head. Vehicle density and load-aware (VDLA) routing protocol for VANETs was proposed in Zhao et al. (2012) which selects a series of intersections to construct the route to the destination. The selection is based on the real-time vehicle density, the traffic load of the corresponding road segment and the distance to the destination.

In Anandakumar and Umamaheswari (2017), cluster-based algorithm for connectivity maintenance in VANET (AODV-CV) was proposed, in which the CH is elected based on the closest actual velocity to the average velocity of all nodes located inside the cluster zone. The proposed protocol outperforms AODV in terms of throughput by increasing the velocity. New CBR protocol called CBVANET was proposed in Louazani et al. (2014). This model focused on the development of clustering framework for communication among the VANET vehicles. This model decreased the latency in VANET by reducing the cluster creation time, CH election time and cluster switching time. The vehicle with minimum velocity was chosen as the CH. The proposed protocol outperformed other protocols in terms of the creation time and switching time.

Ramakrishnan et al. (2011) proposed a new clustering algorithm that takes into consideration the vehicle position and speed for selecting the CH. The proposed algorithm is intended to increase the clusters stability by reducing the number of CH changes, which yields the reduction of the control overhead produced from frequently re-election process, but the authors does not consider the impact of the control messages in terms of its size and its updating time period.

Lo et al. (2013) proposed a lane-based clustering algorithm to improve the network stability by reducing the CH

election times. The proposed algorithm elects the CH based on the traffic flow of vehicles in the cluster. Mohammad and Michele (2010) enhanced a new parameter to improve the CH election. This parameter is the speed difference. By using this parameter, the cluster becomes categorized based on different speeds.

Arulmurugan et al. (2017) proposed a cluster-based routing algorithm which considers the destination of the node and the context for cluster head selection and inter-cluster routing. But the authors does not include the when the cluster head change the role. It is like a dynamic clustering which increases the clustering overhead.

A novel cluster-based lifetime routing (CBLTR) protocol was proposed in Rawashdeh and Mahmud (2012). The objectives of this protocol are to increase the route stability and average throughput in a segment topology, reduce end-to-end delay in a grid topology scenario and reduce the control overhead messages in the clusters.

## 3 Hybrid clustering

Grid- or segment-based clustering algorithms reduce the control overhead, but the existing grid-based clustering algorithms do not consider the point of interest of the vehicle. Some vehicles are interested in parking information, some vehicles are interested in nearby restaurant information, and some vehicles are only interested in accident and congestion information, etc. It is necessary to transmit only the required to the requesting vehicles, which also reduces the network traffic. The grid-based solutions suffered congestion or packet loss and high delay during peak traffic. The dynamic clustering algorithm manages these traffic by increasing the required number of clusters heads, but the number of control messages transmitted is very high. So, this work combines the segment-based approach with the dynamic (context-based) approach.

First the road is divided into segments, and each segment has multiple clusters. Each vehicle must be assigned to one cluster at each unit of time based on its location and with a unique. Figure 1 presents a segment with two clusters; it also shows the cluster edges between the clusters. The cluster head selection process is context based, and the CH is elected based on the following parameters: location, direction, velocity, destination, point of interest and the calculated metrics called remaining lifetime (RT).

At any unit of time, if a vehicle enters any cluster zone (enters the cluster edge lines between the clusters), then it becomes a member of this cluster and must send CH_REQ message to the CH of the cluster. Each cluster has the threshold point (TP), and when a CH reaches the TP, it initiates the process of new cluster head selection. After cluster head selection, the handover process is initiated.

In context-based clustering, vehicles are grouped to form clusters based on six parameters as follows:

**Location** Location of the vehicle is considered as the important parameter, and it can be determined using a location-aware device known as global positioning system (GPS). This GPS device supplies information to on-board unit (OBU), which determines its current location.

**Direction** The direction of a vehicle is determined by calculating the difference between last two locations collected by a GPS device.

**Velocity** The velocity of a vehicle is determined by OBU. For vehicles to be in the same cluster, the velocity difference should be minimum.

**Destination** There can be two choices to determine the destination of a vehicle—one is final destination (FD) which is determined by GPS, and other is relative destination (RD) which is determined with respect to some reference point.

**Point-of-Interest list** Every vehicle has some interests. Some vehicles are interested in parking information, some vehicles are interested in nearby restaurant information, and some vehicles are only interested in accident and congestion information, etc. To represent the interests of a vehicle, a vector is used. Every vehicle "$k$" maintains a vector of interests in the form of:

$$\mathrm{PK}_I = (\mathrm{PK}_1\mathrm{PK}_2\mathrm{PK}_3 \ldots \mathrm{PK}_n) \quad (1)$$

Here, $\mathrm{PK}_I$ is a value (expressed as a fraction or percentage) which indicates how much the user is interested in topic "$I$." For example, [1, 0, 1] may indicate that a vehicle is interested in parking and congestion information but has no interest in accident information. For vehicles to be in the same cluster, the point of interests of vehicles should be similar.

**Residual Lifetime** It represents the time duration for which the nodes are available in the cluster. The threshold point on each segment is fixed; based on the distance between current location and threshold point and velocity the residual lifetime of the node.

Based on above parameters, the clusters are formed and each cluster has one representative known as cluster head (CH). The CH will maintain the interests of a vehicle. When a CH receives some message, it first checks whether the vehicles inside the cluster are interested in the message or not. If the vehicles inside the cluster are interested, then CH will forward the message to all the members of the cluster. Otherwise, the message will be forwarded to the next cluster head without propagating the message inside the cluster. This will reduce the irrelevant network transmissions within the cluster.

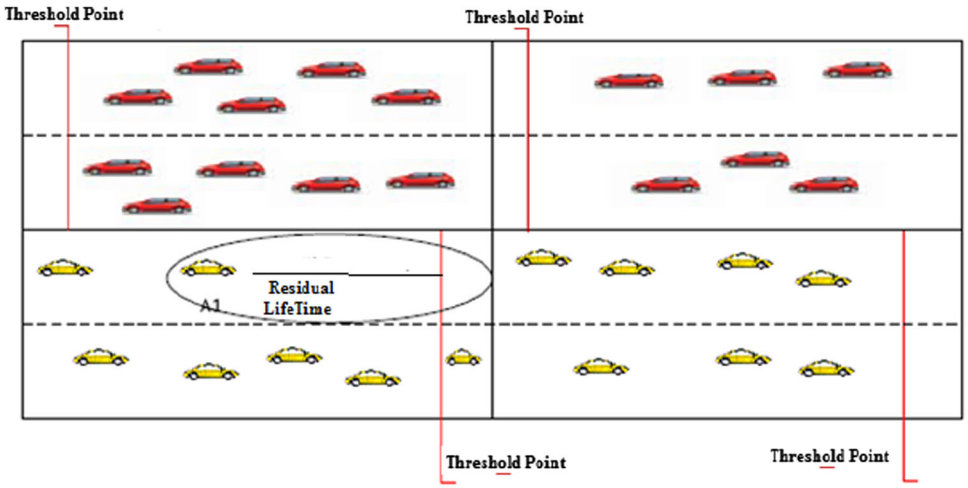



**Fig. 1** Segment-based clustering (static clustering)

### 3.1 Cluster head selection

For optimal cluster head selection, a geographic- and weight-based cluster head selection algorithm is proposed in which every node computes a weight based on certain parameters and the node with maximum weight will be elected as the cluster head. The cluster head selection is the time-bound process (Smys and Bala 2012). The total time taken to complete the cluster head selection is $T$. This is divided into five sub-time lines ($T1$–$T5$).

Cluster head selection involves the following steps:

(1) Each vehicle obtains its clustering parameters: location, direction, velocity, destination and point of interest and residual lifetime in the segment from its on-board unit (Sethi and Chand 2017). The time taken to complete the cluster parameter is $T1$.

(2) Each vehicle identifies its neighboring vehicles whose point of interest is similar, after identifying its neighboring vehicles; each vehicle sends/receives its clustering parameters to/from its neighbors.

(3) When a vehicle gets the clustering parameters from each of its neighbor, it maintains a list for each neighbor (NL). The time taken to complete the neighbor collection is $T2$. A list consists of neighbor vehicle's ID, its location, its velocity, its destination, its point of interest and point-of-interest compatibility (IC).

$$\mathrm{NL} = (N1, N2, \ldots Nn) \tag{2}$$

Point-of-interest compatibility (PC) is computed using cosine similarity formula. For example, PC between vehicle "$X$" and vehicle "$Y$" is calculated by using Eq. (3):

$$PC_{xy} = \frac{\sum_k^n px_k py_k}{\sqrt{\sum_{k=1}^n px_k^2 \sum_{k=1}^n py_k^2}} \tag{3}$$

(4) Next, the average distance (AD) between vehicle "$k$" and each of its neighbor "$j$" is calculated using Eq. (5).

$$AD_k = \frac{\sum_1^j \sqrt{(x_j - x_k)^2 + (y_j - y_k)^2}}{N} \tag{4}$$

Here $(x_k, y_k)$ $(y_j, y_j)$ represents position coordinates of vehicles "$k$" and "$j$", respectively, and "$N$" is the number of neighbors. The time taken to complete this calculation is $T3$.

(5) Residual lifetime (RLT) of the segment is calculated using the distance from the current location of the vehicle to the directional edge of the segment and the vehicle velocity. It is calculated as

$$\mathrm{RLT}_k = \frac{\sqrt{(x_k - x_e)^2 - (y_k - y_k)^2}}{V_k} \tag{5}$$

where RLT($k$) is residual lifetime of vehicle $k$. Distance between vehicle $k$ and directional edge of the segment is taken as numerator, and $V_k$ is velocity of vehicle $k$. Time taken to complete the calculation of RLT is $T4$. $T5$ is fixed and it is same for all vehicles.

(6) Each node calculates the random waiting time "$T_\mathrm{w}$" as

$$T_\mathrm{w}(si) = \frac{\mathrm{RLT}(k)}{\mathrm{TLT}} \times \frac{1}{\alpha|\mathrm{NL}(k)|} \times T5 \times R \tag{6}$$

where TLT is threshold lifetime which is the average lifetime of the current segment, calculated based on the segment length, time and the traffic pattern. $\alpha$ denotes the number of times the node "$k$" acts as a CH previously. |NL ($k$)| is the number of neighbors for the node "$k$". $R$ is a random number between 0.1 and 0.2. Each node may have different waiting time. The node waits for the random waiting time "$T_\mathrm{w}$" and calculates the CHSV. If any CH advertisement is

received with in this "$T_w$", the node does not calculate the CHSV. It just accepts that node as a CH.

(7) Each node calculates the cluster head selection value (CHSV) after waiting for the random waiting time "$T_w$". Immediately after calculating CHSV, the node sends the CH advertisement message. Each node has different waiting time because of $R$. The CHSV is calculated using (7)

$$\mathrm{CHSV}_k = \frac{\mathrm{APC}_k}{\mathrm{AD}_k \mathrm{AV}_k} \times \mathrm{RLT}_k \tag{7}$$

In order to increase CHE value of a vehicle, these parameters $\mathrm{AD}_k$ and $\mathrm{AV}_k$ should be minimum. Here the point of inertest is taken as main parameter. So if the direction of vehicle is in opposite direction of CH, then the sub-cluster head is selected in opposite direction.

Figures 2 and 3 show the process of hybrid clustering where the clusters were divided into sub-clusters based on the point of interest.

## 4 Destination-aware context-based routing

The destination-aware context-based routing (DACR) protocol is divided into two sub-protocols.

1. Intra-segment routing protocol ($\mathrm{DACR}_{\mathrm{intra}}$)
2. Inter-segment routing protocol ($\mathrm{DACR}_{\mathrm{inter}}$)

### 4.1 Intra-segment protocol

$\mathrm{DACR}_{\mathrm{intra}}$ aims to propagate the packets within the segment through the selected CHs. Each CH builds its routing table and stores in it the adjacent CH Identification (CHID) and its associated locations. In order to keep track of the neighbor CH and route information, each CH maintains the routing table. Table 1 shows the contents of the CH routing table, which contains the CHID, its location, its RLT and expiry time. The expiry time is used to keep updating the routing table contents. When the local CH receives a packet, it searches in its routing table for the candidate CHs

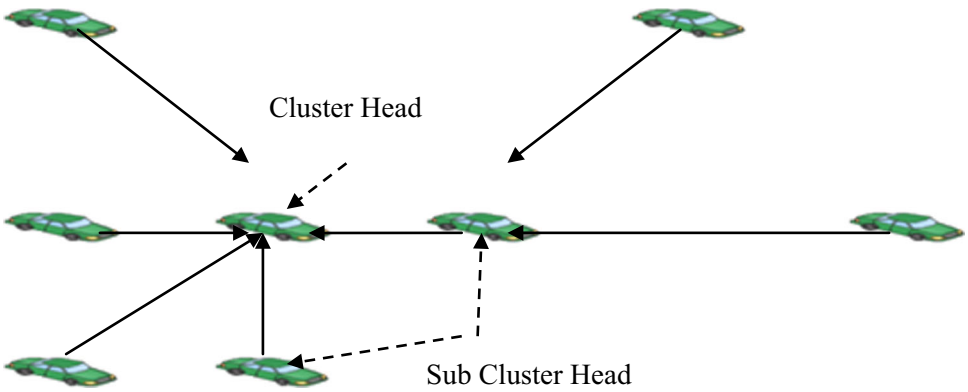



**Fig. 2** Sub-cluster formation

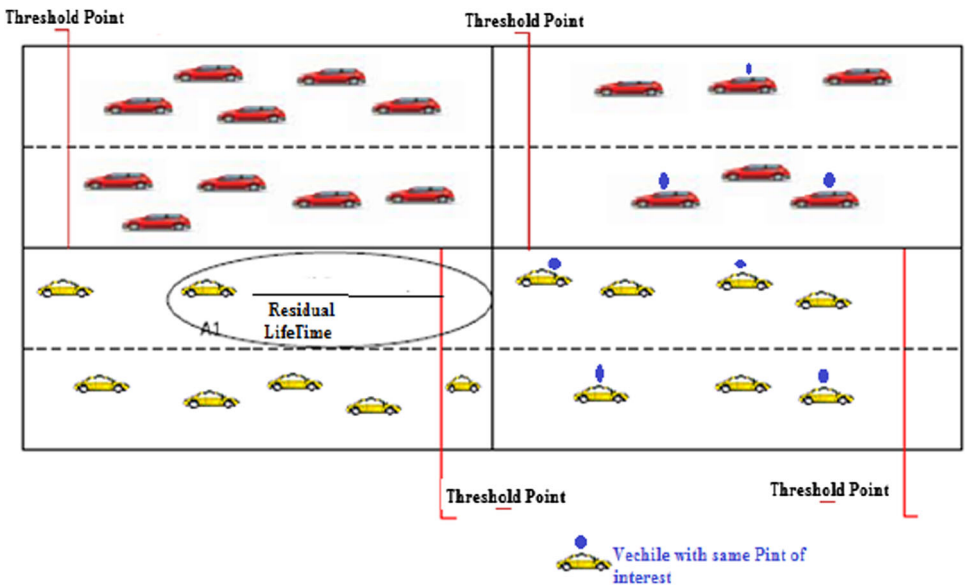



**Fig. 3** Hybrid clustering

**Table 1** Format of the routing table

| Routing table | | | |
|---|---|---|---|
| CHID | Location | RLT | Expiry time |

that are located close to the destination regardless of the CH's direction, and then it forwards the packet to the next CH that has the maximum RLT. If two candidate CHs with equal LT are available for forwarding the packets, then the CH in the same direction of the local CH is selected.

If there are no relaying CHs to the destination, then as a recovery process the local CH follows a store-and-forward process; it stores the packet in a specific buffer and keeps moving till it finds another relaying CH.

Algorithm 1 shows a pseudocode of the $DACR_{intra}$ protocol that presents the steps of propagating the packets within the segment. At any time of the simulation, if the vehicle receives a packet, it first checks its CH routing table and then selects the CHs that are closest to the destination in another table, called the candidate CH table. The CH with maximum RLT of the candidate CH table is selected as the next forwarder vehicle. In case RLT values are equal, then the one closest to the destination is selected regardless of its direction. Finally, if the CH routing table is empty, then the current CH follows a store-and-forward process.

The following are the steps of our proposed destination-based routing protocol:

(1) When a source node "*s*" wants to send a message to the destination node "*d*", the node "*s*" first forwards the message containing target location TL ($x_{tl}$, $y_{tl}$) *x y* to its cluster head "*k.*"

(2) Then, the direction of transmission DT ***is*** calculated. Direction of packet transmission is said to be similar to the direction of cluster head "h" if their cosine similarity (CSM) is greater than 0. The similarity between DT and the velocity Vector ($V_h$) is computed using Eq. (8).

$$\text{CSM} = \frac{\text{DT}.V_h}{|\text{DT}||V_h|} \tag{8}$$

where DT is the direction of transmission, which is the distance between the node and the target location. Every cluster head "h" has a velocity vector which can be represented as

$$V_h = v_h\hat{i} + v_h\hat{j} \tag{9}$$

Also, every cluster head "h" has some destination which is represented as ($x_{dest}$, $y_{dest}$). The distance between the target location and the destination of cluster head is also taken for selecting the forward node.

**Soft Algorithm 1** $DACR_{intr}$ Protocol
1: **for each packet received by CH do**
2: **if** *Packet received by CH at time* D *t* **then**
3: *Check routing table of the CH*
4: **if** *Routing table NOT empty* **then**
5: *Store the closest CHs to destination in Candidate CH table*
6: **if** *Candidate CHtable has* 2 *or more CH* with *same maximum RLT* **then**
8: *Next CH* = *CHth at closest to the destination*
9: **else**
10: *NextCH = CH with maximum RLT*
11: **end if**
12: **else**
13: *Store and Forword*
14: **end if**
15: **end if**
16: **end for**

### 4.2 Inter-segment protocol

$DACR_{inter}$ aims to propagate the packets among the segment through the selected CHs.

(3) In order to select the next forwarding cluster head node (Abuashour and Michel 2017), a cluster head "h" uses the destinations and directions of its neighbor cluster heads. First, it calculates the direction of transmission of a message DT. Then, it calculates CSM using

Eq. (8) for each neighbor cluster head node "h" having velocity $V_h$. Then, it calculates the distance between the target location and destination $\Delta D_h$ for each neighbor cluster head node "h".

(4) After calculating CSM and $\Delta D_h$ for each neighbor cluster head node "h", a cluster head node "$k$" calculates the following metric Fs (forwarding selector) for each neighbor luster head node "h":

$$\mathrm{FS} = \frac{\mathrm{CSM}}{\Delta Dh} \times \mathrm{RLT} \tag{10}$$

(5) The neighbor cluster head in other segment whose FS value is maximum is selected as the next forwarding cluster head node.

(6) Again, the next forwarding cluster head node checks whether the target location TL is inside the cluster or not. If it finds the TL inside the cluster, it forwards the message to TL. Otherwise, it again selects the next forwarding cluster head node by using FS, and the process is repeated.

### 4.3 DACR protocol

(1) When a source node "S" gets a message, it forwards the message to its cluster head.

(2) The cluster head first checks whether the target location is within the cluster or not.

   a. If yes, it forwards the message to the target location.
   b. Otherwise, it checks whether the target location is within the segment
      i. if yes, $\mathrm{DACR}_{\mathrm{intra}}$ protocol is used for forwarding the packets, where it selects the next forwarding CH node from its routing table.
      ii. Otherwise, $\mathrm{DACR}_{\mathrm{inter}}$ protocol is used, where it selects the next forwarding CH node based on the FS metric in other segment. The next forwarding CH node again checks the availability of target location within its cluster. If it does not find the target location, it again selects the next forwarding CH node, and the process is repeated until the message reaches its target location.

## 5 Performance analysis

To test the performance of our proposed clustering and routing protocol, two types of simulators are used—traffic simulator which simulates the mobility of vehicles across the streets and network simulator which simulates the network among the vehicles. SUMO (Simulation of Urban Mobility) (Harikumar and Raj 2014) is the most popular traffic simulator used in VANET. There are many features of SUMO which make it a very useful traffic simulator such as multi-lane streets with lane changing, different vehicle types, representing networks with many streets, coupling with network simulators (ns2), etc. For network simulation, ns2 is used. The output of SUMO is a mobility trace which acts as an input to the network simulator ns2.

To evaluate the proposed protocol, a 1000-m-long and 20-m-wide bidirectional segment is implemented; the segment is further divided into clusters. Initially, 100 vehicles are distributed on the segment using uniform distribution, and each vehicle is assigned constant velocity randomly selected from predefined velocity ranges as follows: 10–30 km/h, 30–50 km/h and 50–70 km/h. The performance of the proposed algorithm is presented as simulation results, and it is compared with CBLTR, AODV-CV, CBR and DBR protocols, in terms of average cluster head duration, average number of cluster head changes, packet delivery ratio, packet transmission delay and ratio of the control messages (Table 2).

In simulation, the factors like loss average cluster head duration, average number of cluster head changes, packet delivery ratio, packet transmission delay and ration of the control messages in our proposed approach are compared with the existing scheme.

Figure 4 shows the average duration of the cluster head in seconds based on different speed of the vehicle. As the speed of the vehicle increases, the cluster head frequently changes, i.e., the CH crosses its static boundary very frequently. The average duration of a mode as CH will be decreases.

Figure 5 shows the effect of speed in cluster head selection process, i.e., average number of CH re-election processes. As the speed of the vehicle increases, the cluster head also changes.

In Fig. 6, the delivery ratio is calculated over different speeds of vehicles in destination-based routing, cluster-based routing and broadcast scheme. It is found that

**Table 2** Simulation parameters

| Simulation parameters | Value |
|---|---|
| Simulation time | 1000 s |
| Number of segments | 75 |
| Number of vehicles | 100–500 |
| Communication range | 250 units |
| Vehicle speed ranges | (10–60) kmph |
| Packet size | 1024 |
| MAC | 802.11 p |

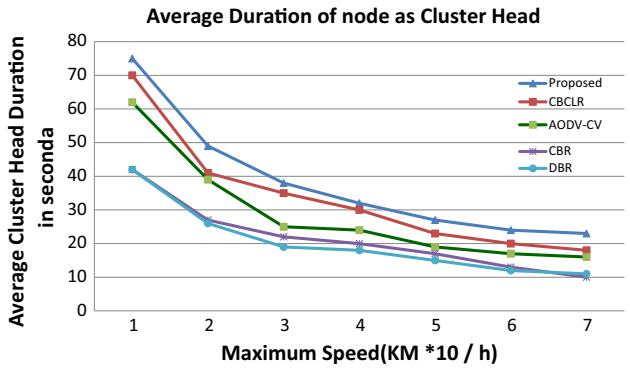



**Fig. 4** Average cluster head versus speed

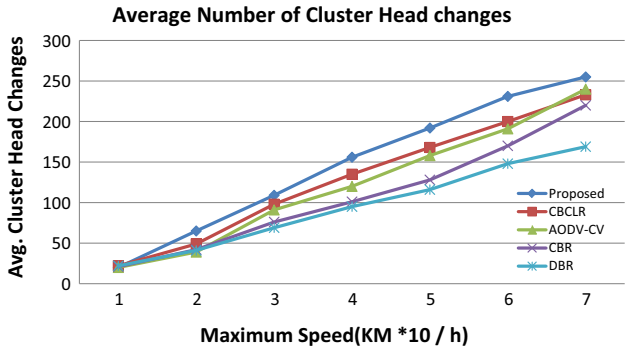



**Fig. 5** Average number of cluster head changes versus speed

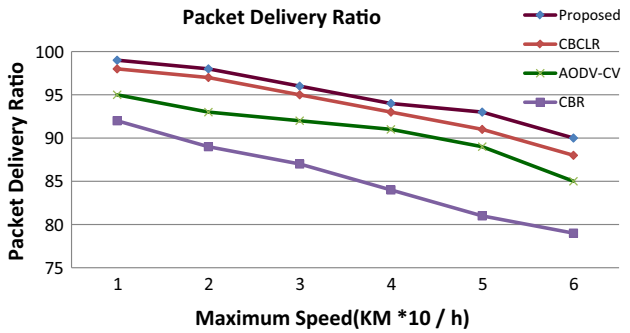



**Fig. 6** Packet delivery ratio

delivery ratio decreases as the speed of vehicles increases. The delivery ratio is checked with three set of speeds—100 m/s, 200 m/s and 500 m/s.

In Fig. 7, delay in delivery of packets is calculated over speed of vehicles 10 km/h and 60 km/h. It is found that the delay increases as the speed of vehicles increases. This is due to the fact that the link between the nodes changes as the speed of vehicles increases. From the figure, it is noted that the delay is very less in lower speed and higher speed as compared to other algorithms.

The important parameter in evaluating any routing algorithm is the percentage of control messages used for

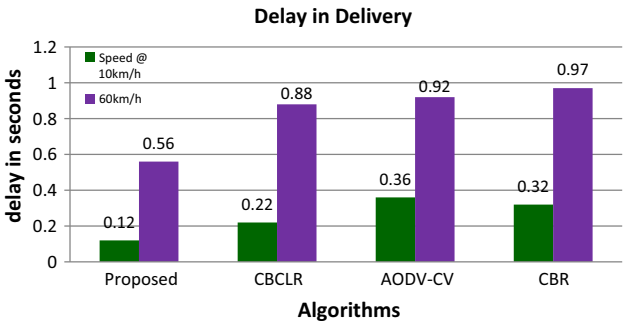



**Fig. 7** Delay in packet delivery versus speed

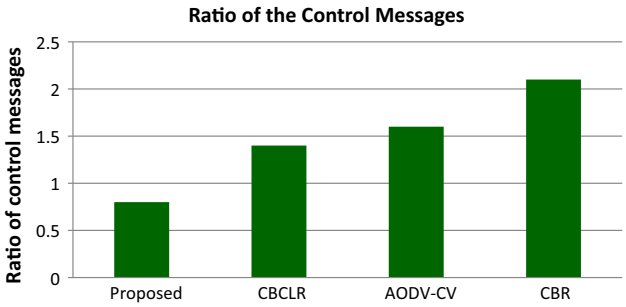



**Fig. 8** Ratio of the control messages

route establishment and route maintenance. Less number of control messages will reduce the network traffic which will increase the packer delivery ratio. Figure 8 shows the ratio of control message over the data message. The proposed protocol is the hybrid protocol which is specially designed to reduce the control message.

## 6 Conclusion

A novel framework for clustering and data transmission is proposed in the paper which includes two algorithms: First, a hybrid clustering algorithm is proposed. Hybrid clustering combines the geographic- and context-based clustering approaches, which is designed to reduce the control overhead and traffic in the network. Second, the destination-aware routing protocol is proposed for inter-clustering routing which improves the overall packet delivery ratio and reduces the end-to-end delay. Many cluster-based routing techniques like CBR, AODV-CV make use of current location of a node and its neighbor nodes in order to determine the next forwarding node. This may not be the optimal next forwarding node selection as the node may be currently closer or at small angle with the target location, but it may change its direction and move away from the target location in future. So, we must take the direction of movement of a node as well as destination of a node in order to select the next forwarding node. This will increase

the delivery ratio and reduce the overall delay to route the message from source node to destination node.

## Compliance with ethical standards

**Conflict of interest** K. Aravindhan and C. Suresh Gnana Dhas declare that they have no conflict of interest.

**Research involving human participants and/or animals** This article does not contain any studies with human participants performed by any of the authors.

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