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A New Cluster-Based Efficient Broadcast Algorithm for Alert Message Dissemination in VANETs

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ABSTRACT: Data broadcasting is a major operation in VANET networks. So data dissemination management has a great impact on network performance. These networks are studied in two cases: infrastructure-based and infrastructure less networks. Infrastructure-based networks due to the high cost have no more use. The main challenge of networks without infrastructure is dissemination of alert messages. Many methods have been proposed for these networks. The method's simple, p-persistence and EDB have been provided for management of alert messages dissemination. The method's simple and p-persistence have low success rates and faced with the problem of excessive collisions. EDB method has a better performance than the other methods listed. This method is based on the idea that farthest nodes from the origin node disseminate messages. The problem with this approach is that primarily presented for urban roads. Second, once the node may already have received a message again maybe selected as relay nodes that did not need. Third, its delay is too much. So the idea of data broadcast storm management is presented in this paper that works based on the distributed clustering. This new approach performs better in contrast to previously mentioned methods like as EDB in the collision rate, the success rate and delay. Simulation and analyze of tests show the proposed ideas performance.

Key words: Alert message dissemination, Clustering, Ad-hoc networks, VANET, GPS.

INTRODUCTION

Many people due to unexpected events and accidents in road networks lose their lives or are injured. And traffic accidents are caused by wasting time and fuel. If information about traffic conditions of roads such as crashes, timely and dynamically, placed at the disposal of vehicles, safety and efficiency of the transport system can improved in terms of time, distance and fuel consumption. Many innovations in the field of safety and comfort, has already been made current vehicles to a very different car than what be earlier. Now a new technology that is characterized by low-cost wireless communication and peer to peer collaborative systems is developed that is changing the future generations of vehicles (Sutariya and Pradhan, 2010).

VANETs are ad-hoc vehicle networks between vehicles equipped with communication facilities. These vehicles are such as network nodes so each node is as a data source and destination for receiving data and also act as a network router. VANET is an efficient tool to improve road safety through warning message in the spread between vehicles, against potential obstacles in the road (Sutariya and Pradhan, 2010).

So the data emissions in VANET play an important role in the security and non-security applications (Tomar et al.,2010). In the mentioned applications, vehicles equipped with communication facilities are capable of acting in the frequency band 5/9 GHz through dedicated short range communication (DSRC) based in communication device. The short-range communication based proprietary applications are in the field of public security and traffic management, are included warning message and warning to approaching emergency vehicles (Sutariya and Pradhan, 2010). Ad-hoc networks of vehicles divided in two main areas:

Security applications (e.g., collision warning and the warning of work area) and non-security applications (for example, application about traffic conditions and application that are associated with comfort). For example, if a vehicle has an accident in highway, emergency information will soon be broadcast to vehicles that may be compromised due to this accident to notify the apparatus.

The second area is related to traffic and transportation and using VANET networks improves traffic system performance (Tomar et al.,2010).

Information about the traffic can be immediately received so that the drivers going to the crowded area can get the information and they will have enough time to choose an alternative route. Traffic signs can be equipped with communications equipment for more precise control and can be applied to road traffic. In the field of no security applications, the user can easily find some suitable restaurants using services location through the VANET. Also advertisements as well as benefits can be shown to travelers. For example, sales at chain stores, place for parking in garages, hotel room availability and its price and the food menu in the restaurants. Despite the wide applications of VANET, especially in security applications, it may be time dependent. Therefore, information should be sent quickly to other vehicles. In the dissemination of information in VANET, the different scenarios or different patterns of communication must be considered. Nodes movement, extremely high density of network, changing topology in urban routes to rural traffic and information needs to change the speed of moving vehicles, has made VANETs laborious and onerous networks. We review the issue of data dissemination in VANET, in which vehicle network includes a large number of data sources and users of data; each vehicle is also source and user of data. Various types of applications included, such as traffic management and location awareness. The aim of data dissemination is to satisfy all users of network resources in order to maximize the used data. Every vehicle that participates in the VANET periodically produces reports on traffic conditions (Tomar et al.,2010). Data dissemination between vehicles is dependent on the type of network architecture. If there be a network infrastructure in the roads, there are two methods for data dissemination:

1. Push-based
2. Pull-based

In the push-based method, data disseminated to all nodes. But in the pull-based method data transmission is based on request and response. In the absence of infrastructure there are two approaches for discuss:

1. Overflow
2. Relay

In the overflow approach there will created more traffic. So the main challenge that we face is to avoid the broadcast storm problem. In the relay approach we face with two other challenges:

1. Selection of the relay points.
2. Reliability ensure when selected nodes participate in data retransmission (Sutariya and Pradhan, 2010).

This paper has presented the idea of reducing the broadcast storm using Clustering of vehicles in the road. Our new approach is very efficient because uses a limited number of vehicles. These vehicles selected from a limited area of named cluster and the next cluster head selected from this area. In this new approach only the new cluster head is responsible to rebroadcast alarm messages. The rest of the paper is organized as follows: Related works are reviewed in Section 2. Using clustering algorithm for reducing broadcast storms will be described in Section 3. In Section 4 the analysis of experiments with the existing node is presented. Finally, in Section 5 we summarize and express discussions.

Related Works

Flooding is one of the approaches that can be used for data dissemination in a pure vehicular ad hoc network which does not have any infrastructure support for communication. Because of the shared wireless medium, blindly flooding the data packets leads to frequent contention and collisions among neighboring nodes (Rezaei, 2009). This problem is sometimes referred as broadcast storm problem. This problem also exists in the MANET environments which less number of nodes are involved. However, high density and fast movement of vehicles add to its severity in the vehicular networking context (Suriyapaibonwattana et al., 2009). This section presents the proposed broadcast storm mitigation techniques reviewed in the literature which focuses on this issue.

Simple broadcast

Simple broadcast is the simplest protocol that used for warning messages broadcast in VANET networks. When there is an accident, safety alert application will send alarm messages to all vehicles approaching towards accident site. When a vehicle that is in the transmission range of broadcasting vehicle receives a broadcast message for the first time, it retransmits the message (Bae, 2011). The vehicle then ignores all subsequent broadcast messages (with same ID) it receives from other vehicles rebroadcast the same message. Simple broadcast method has two main problems. First, there are many redundant rebroadcast messages because of flooding. Thus, there will be a media contention between vehicles (Suriyapaibonwattana and Pomavalai, 2008). Each vehicle will severely contend with one another for access to medium. As show in Figure 1, when accident is occur B, C, D, E and F, which are in transmission range of broadcasting vehicle, receive alert message and rebroadcast it. Second, it will then give rise to broadcast storm, and collision will occur, which lead to retransmission and further collision.

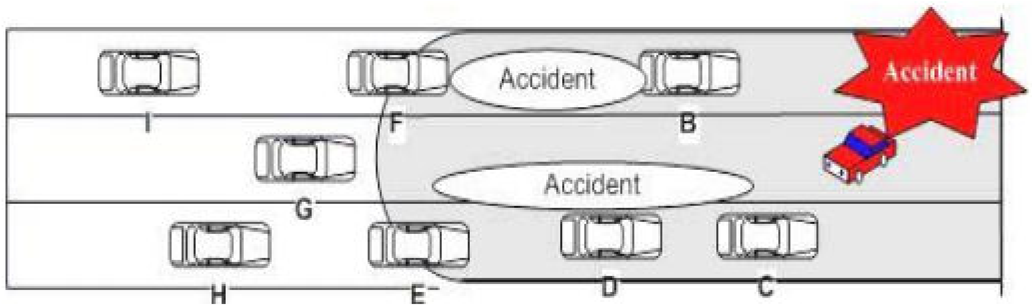

Figure 1. An accident and the vehicles on the road (Bae, 2011)

P-persistence Algorithm

P-persistence approach tries to reduce the broadcast storm problem. It uses a stochastic selection method to decide the vehicles that will rebroadcast the alert message. When a vehicle in the road receives a broadcast message for the first time, it will rebroadcast the alert message with a random probability p. This approach helps to reduce number of re-broadcasting vehicles and also broadcast storm problem. However this will cause the loss of alert message. For example, if all vehicles B, C, D, E and F decide not to rebroadcast the message, no car behind them will receive the alert message.

When node j received a packet from node i, checks the packet ID and rebroadcasts with probability P if it receives the packet for the first time; otherwise, it discards the packet. Denoting the relative distance between nodes i and j by D_{ij} and the average transmission range by R, the forwarding probability P_{ij}, can be calculated on a per packet basis using the following simple expression (Bae, 2011):

$$P_{ij} = \frac{D_{ij}}{R} \quad (1)$$

Efficient directional broadcast algorithm (EDB)

(Li et al., 2007) presented a new broadcast protocol called Efficient Directional Broadcast (EDB) for VANET. When a vehicle broadcasts on the road, only the furthest away receiver is responsible to forward the message. This new forwarding vehicle rebroadcast the alarm message just in the opposite direction where the message packet arrives. Because of rapidly changing topology of VANET, EDB makes receiver-based decisions to forward the message with the help of the GPS information. The receiver only needs to forward the message in the opposite direction where the message arrives. After a vehicle receives a message successfully, it waits for a time before taking a decision whether to forward the packet or not. During this waiting time, the vehicle listens to other relay of the same message. The waiting time can be calculated by the following formula (Bae, 2011):

$$\mathrm{WaitingTime} = \left(1 - \frac{\mathrm{D}}{\mathrm{R}}\right) \times \mathrm{maxWT} \quad (2)$$

In the formula 2, D is the distance from the transmitter vehicle. This distance can achieved using location information of the transmitter that can be placed in the message; also R is the transmission range. maxWT is an adjustable parameter which can be adjusted according to the vehicle density (Bae, 2011).

Another disadvantage of this method is that the vehicle just broadcast messages to the vehicles that are contrary to the received packet. So that makes it the propagation speed in order to achieve the goal to fall down.

PROPOSED METHOD

Weaknesses of previous methods

In this paper a new algorithm provided to broadcast messages. It has been suggested to cover the weaknesses of previous methods. The weaknesses of previous methods are as follow:

In the simple broadcast method, always there is a lot of duplicate messages phenomenon which leads to the collision and will cause broadcast storms .

P-persistence algorithm also helps to reduce the broadcast storm but not completely solves the broadcast problem and it only reduces the probability and chance of broadcast storm occurrence.

In the EDB Algorithm we also face the problem of delay but this problem is not acceptable for real-time applications. So in a VANET network sending and receiving messages quickly is much more desirable and acceptable in these networks.

Our proposed method has high efficiency and in contrast to previous methods has high propagation speed and its rate of propagated messages is less. This approach prevents occurrence of broadcast storm in VANET networks.

The algorithm of proposed method

Our proposed method (Cluster-Based Efficient Broadcast) that has high efficiency and do better in contrast to previous methods in propagation speed and propagated messages rate and finally it can prevent the occurrence of broadcast storm. The main idea in the proposed method in this paper is using three parameters: rebroadcast possibility (P_{ij}), Vehicle speed (V) and receiving order of messages by nodes (MSG_No). In the proposed algorithm all vehicles are equipped with GPS receiver and are aware of their position. Also the road is considered as bilateral and the algorithm will runs on roads are unilateral. When an accident occurs, the accidental vehicle broadcasts a message in its broadcast area which includes a vehicle ID and also the situation where the accident occurred. This scenario is shown in Figure 2:

Massage (Vehicle ID, Location)

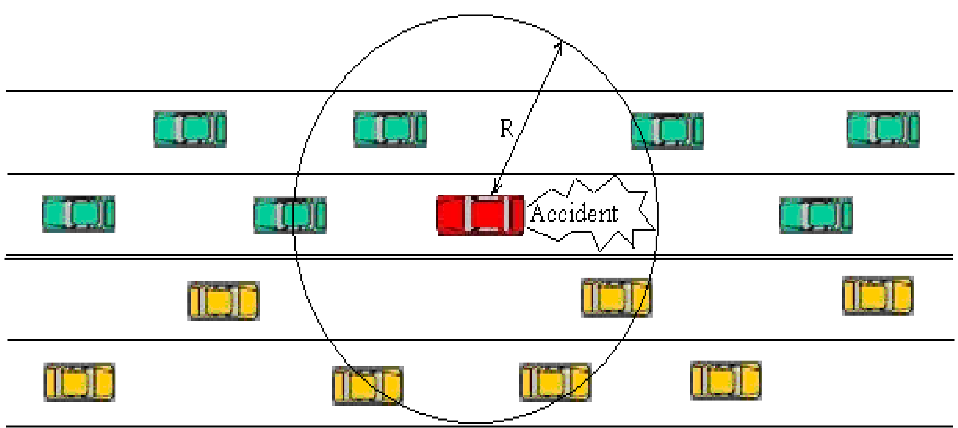

Figure 2. Message broadcast in the transmission range of crashed vehicle

The proposed algorithm is composed of two phases: Setup Phase and Steady-state phase. These two phases are described in more detail:

Setup Phase

Each accidental vehicle, create a cluster with the radius to its radio range. Accidental vehicle is considered as the base station. Warning message sent by the base station to all nodes in the created cluster. Nodes within the cluster that have received this message send a response message to the base station. The response message is containing speed, the identifier and the moving direction of vehicle. Base station divides vehicles into two categories based on moving direction. And for each category choose a vehicle as cluster head based on their speed. Each vehicle that was faster, selected as cluster head. Flowchart of this phase of the algorithm is shown in Figure 3.

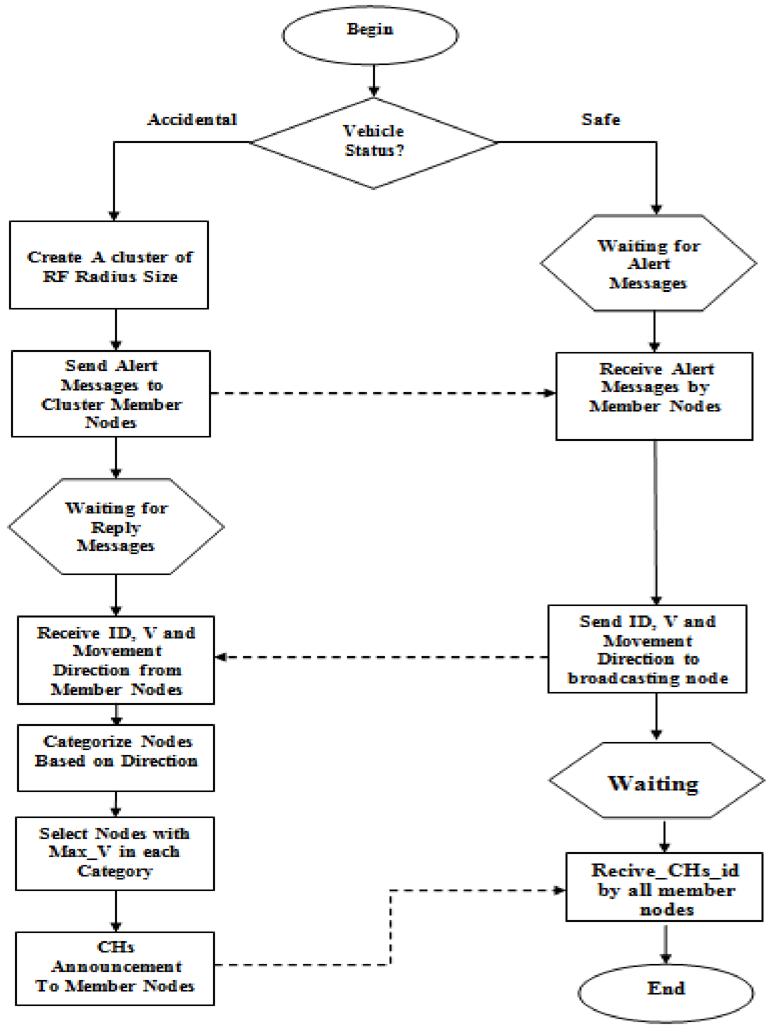

Figure 3. Flowchart of Setup Phase

Steady-state phase

After determining cluster heads in the setup phase, they began to rebroadcast warning message. To speed up message rebroadcast operations, the new cluster heads are determined. This phase consists of several stages and at each step a new cluster head selected which is described in Figure 4. Rebroadcast order number by current cluster head continues until the next cluster head is set. So in each period, number of message rebroadcast by the current cluster head may be variable. In this phase, cluster head selection is performed as distributed and this selection is done according to the following rules:

Node that is farther than the current cluster head with a higher probability of being selected as the next cluster head and this possibility calculated by $P_{i,j}$ and $P_{i,j} = D_{i,j} / R$ (line 8 in Figure 4).

The node that its moving speed is more quickly, more likely to be selected as the next cluster head.
The node that its received warning message is less with a higher probability is selected as the next cluster head.

Steady-state phase pseudo-code is shown in Figure 4.

```
1 Function_ClusterHead() {
2    Broadcast Alert_MSG;
3    Receive ACK_MSGs(ID,V,Loc,Dir_Veh,MSG_No) From cluster nodes;
4       For (j=1;j<=Cluster_Size;j++)
5          If  Dir_Veh_j=Dir_Veh_i
6             Cluster_Members  ←  Veh_j;
7    For (j=1;j<=Size(Cluster_Mems);j++){
8        Calc P_i,j=D_i,j/R;
9        Result_j ← P_i,j * V_j * 1/MSG_No_j; }
10   Create Table_Veh_i;
11   Return Max {Result_j}
12   Next_CH ← Veh_j;}
```

Figure 4. Pseudo-code of steady-state phase

In this phase after the current cluster head node broadcast the warning message (Line 2 in Figure 4), receives a response message that contains the node identifier (ID), node velocity (V), node location (Loc), movement direction of node (Dir_Veh) and order of broadcast message that is received (Line 3 in Figure 4). Nodes those are moving in the direction of cluster head, puts into Cluster_Mems group (lines 4 and 5 and 6 in Figure 4). For each member of this group, a criterion will calculate as Result (line 7 in Figure 4). In result criterion calculation three factors are involved. These three factors are:
Distance from the relay node
Nodes speed
Order of receiving a warning message (Line 9 in Figure 4).

The first two factors have a direct relationship with the Result criterion but the third factor has an inverse relationship. After obtaining the above information, the current cluster head node form a table named as Table_Veh$_i$ (Line 10 in Figure 4). An example of this table is shown in Table 1.

Finally the current cluster head using information of this table, decides to choice the next cluster head between nodes in the Cluster_Mems (Lines 11 and 12 in Figure 4).

Table 1. Table_Veh$_i$ table

Result	MSG_No.	$P_{i,j}$	Loc	V	Cluster_Mems
45	2	1.0	(x_1,y_1)	90	Veh$_1$
48	1	0.4	(x_2,y_2)	120	Veh$_2$
56	1	0.8	(x_3,y_3)	70	Veh$_3$
...	...	...	...	...	...

In this table, the second vehicle speed is higher than others, but due to the proximity to the current cluster head it is not selected as the next cluster head. The first car is also very fast and farther than current cluster head in contrast to other cars, but because of receiving warning message for the second time, it is not selected as the cluster head. Based on the above table, Veh3 will be selected as the next cluster head because it has the maximum Result.

Simulation and performance evaluation
Simulation Environment

Simulation is done on the Linux ubunto11 operating system using network simulator NS3. Assessment has been conducted in a real environment. Over 10km of roads considered and the number of vehicles is variable. Radio transmission range of 300 meters is considered. Interval between the broadcasts was 3 seconds and the road has four lanes. Vehicles speed is between 55 to 130 kilometers per hour. Experiment has been done with simple broadcast, P-persistent, EDB and our proposed method protocols.

Simulation Results

One of the evaluation criteria of broadcast algorithms in the VANET networks is the warning packet collision rates. Figure 5 shows the number of warning message collisions occurring in the simulation environment. Simulation results in Figure 5 show the lowest collision rate for the proposed method compared with other methods. Because in the proposed method only the node is allowed to relay messages that selected as cluster head. This low rate of collision is caused by a large decrease in broadcast storm in the CBE-Cast (proposed method algorithm).

Another important criterion to evaluate the optimization of broadcast algorithms in the VANET networks is the success rate of warning messages delivery. In proposed algorithm due to low rate of messages relay that resulting in lower rates of collision, success rate is always full. In Figure 6 the success rates of various methods and our proposed method are compared.

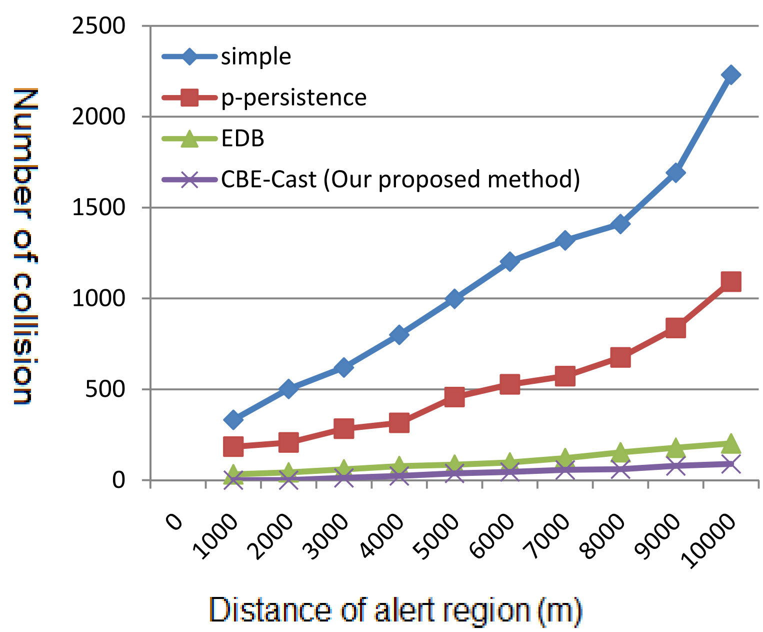

Figure 5. Comparison of warning message broadcast collision rate

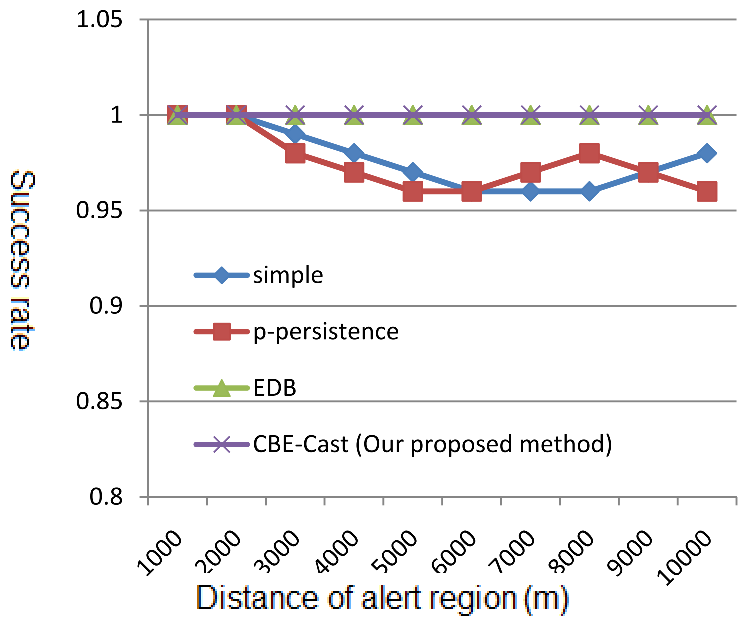

Figure 6. Comparison of success rate in warning message delivery

Delay time of messages dissemination, has an important role in the performance of VANET networks. Therefore, the proposed algorithm has less latency than EDB algorithm. This improvement in the sparse networks is too much. So this experiment is done in two scenarios: high node density and low node density. Figure 7 shows the propagation delay in a network with high node density and Figure 8 shows the propagation delay in a sparse network. Delay in dense networks is less than sparse networks. That is due to that the number of vehicles in dense networks is greater than sparse networks. In the sparse networks the number of vehicles is less. So alarm messages reach to destination by a delay and this delay will be high.

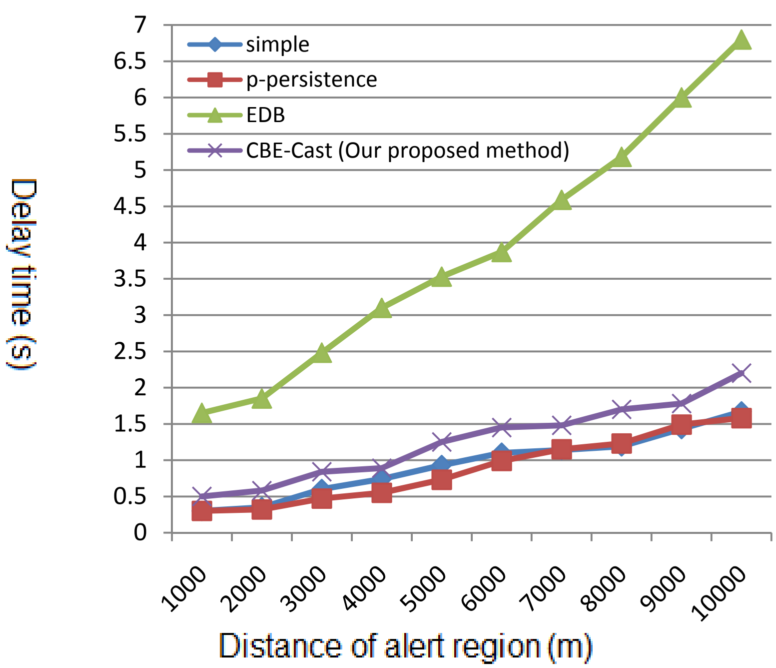

Figure 7. Delay time in a dense network

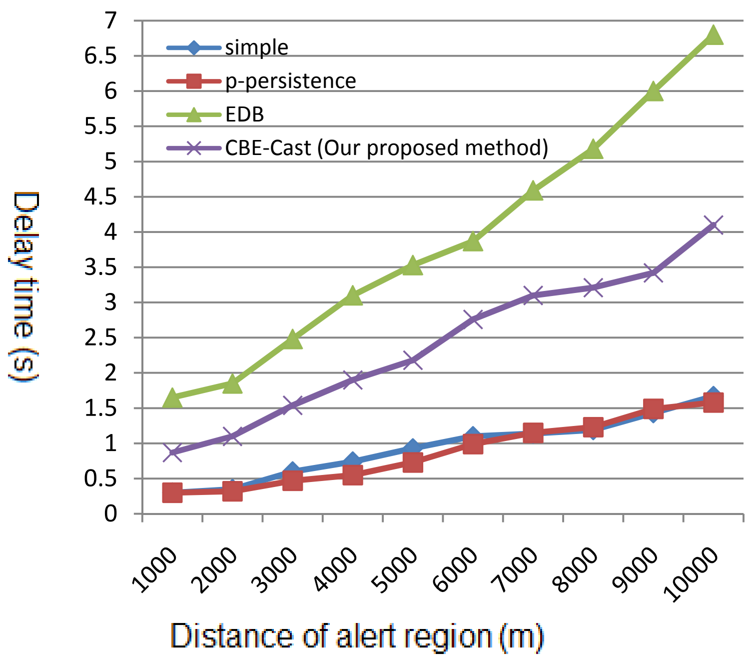

Figure 8. Delay time in a spars network

Table 2 shows the improvement rate of proposed algorithm in a numeric expression. These rates include the number of collisions, success rate and delay time.

Table 2. Improvement rate of our proposed method algorithm in comparison with other algorithms

Algorithms	Collision rate reduction	Success rate increase	Latency
EDB	-61.79%	0%	-67.55%
P-PERSISTANCE	-92.23%	+2.5%	+43.81%
SIMPLE	-96.39%	+2.3%	+34.07 %

CONCLUSION

Since most applications in the VANET networks unlike point to point transmission use broadcast transmission, routing protocols must solve broadcast storm problem and prevent unnecessary loss of safety-related message in message propagation. In our proposed method algorithm, when a vehicle received a warning message, responses to the sender with an ACK message. If its movement direction be the same with broadcasting node, based on the next cluster head selection algorithm, it will participate in optimal cluster head selection algorithm to be the next cluster head. Simulation results show that our proposed algorithm is optimal in contrast to other algorithms from the perspective of collision rate, success rate and packet delay. Since for every application the algorithm must provide an optimal performance, therefore our future work includes the study of a new warning message broadcast algorithm that studies the road shape and condition, to offer a better performance compared with previous ones.

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