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An Alert Message Propagation Scheme Considering Various Densities in VANET

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Abstract: Vehicular Ad Hoc Networks (VANETs) have the potential to increase the safety, efficiency and convenience of transportation systems. Therefore, VANETs present many unique networking research challenges and the design of an effective routing protocol for VANETs is very crucial. Traditional position based approaches try to forward data with best-known neighbour finding that is typically the neighbour closest to the next junction in a greedy forwarding way. The aim of this study is to design an Opportunistic Position Based (OPB) approach which is based on forwarding data packets using the optimal path without using any location service. Also this schema, instead of flooding a message to all reachable vehicles, immediately will maintain the message for duration of time. Therefore, it can substantially reduce hop count. Moreover, without using the traditional flooding scheme in Ad-hoc and mobile network, we can guarantee the delivery of the message to all reachable vehicles for a period of time in sparse and dense traffic scenarios. Lastly, OPB compares with three other techniques under realistic scenarios and the effects of changing vehicles density are analyzed.

Key words: Vehicular Ad-Hoc Network, routing protocols, position-based routing, warning message, vehicle safety

INTRODUCTION

Vehicular communications have been considered to make safe journey and to transmit information application during the travel. Every automobile manufacturer that support VANET in their vehicles has different stages of integrating communication devices. Also, environment of roads and streets with intersections in city are main and important scenarios for VANET. Data dissemination in highways and streets has many distinctive characteristics, for example, signal reception is more difficult due to the radio obstacles such as buildings and interference of noisy radio waves (Guoqing *et al*., 2008). Moreover, vehicles always move quickly by road patterns and network density always changes depending on the time and area. Therefore, more attention must be paid to environment and network characteristics when researchers decide to design every routing protocol.

The majority of VANET applications have focused on road vehicles and safety, avoiding intersection collision, automatically escort and mobile internet between vehicles (Willke *et al*., 2009). Furthermore, the emerging wireless technologies significantly reduce the delay in propagating emergence warnings. For example, if one vehicle can send a warning message to other vehicles, other vehicles approach can receive this message with little delay and they can avoid the accident. Therefore, major goal for emergency warning dissemination is to achieve low latency in delivering emergency warning.

In VANETs, safety applications are usually provided by means of vehicular multi hop broadcasting in order to support reliable and fast alert message dissemination to all surrounding vehicles within a certain dangerous region. However, these approaches may cause broadcast storm problem, which can lead to serious contention in transmission between adjacent nodes. Generally, the most of research design routing protocols are good for one application and detrimental to another.

The main focus of this study is to propose an approach for two-way highway and reducing the number of retransmission for decreasing latency as far as possible. The core mechanism of the proposed scheme is that all vehicles will maintain the alert messages for duration of time, instead of flooding a message immediately.

Since, the network topology and the communication conditions depend on several factors in the roads, such as type of the road, daytime, weather, traffic density and even the driver himself, the routing of data packets through the VANET is very challenging. Hence, the network topology in VANET changes frequently and the used routing protocol has to adapt itself continuously.

Nowadays, protocols with pure Ad-hoc architectures have been studied by many researchers. However,

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position based routing protocols have some advantages for proposed systems (Mauve *et al.*, 2001). It does not require routing tables or store routes. Instead of position based routing, protocols use position information about neighbouring and destination nodes to determine next-hop forwarding to destination. Due to position based routing, protocols are based only on local knowledge like GPS information and they are considered more scalable and robust against topological changes.

For as much as we need to propagate the warning message in this approach, we have to investigate some routing protocols that are suitable for these situations. Some researchers have proposed several type of position based routing protocol for data dissemination in VANET (Mauve *et al.*, 2001; Andziulis *et al.*, 2013). The multicast or broadcast-based packet forwarding is more applicable for some vehicle safety applications such as sharing traffic, emergency among vehicles rather than another approach like unicast protocols. The wireless multi-hop transmission and carry-and-forward techniques are two ways for message propagation from source to destination. In the wireless multi-hop forwarding, the intermediate vehicles should relay data as soon as possible from source to destination. However in the carry-and-forward technique, source vehicle carries data as long as possible to reduce the number of data packets. The delay-time delivery cost by carry-and-forward technique is normally longer than wireless multi-hop transmission technique.

The Naïve Broadcast (NB) schema applies for Cooperative Collision Avoidance application. This mechanism forwards the alert messages after detecting an emergency event. The detecting vehicle starts sending wireless collision warning messages periodically at regular intervals (Zeadally *et al.*, 2012). Executing the Naïve Broadcast ensure that all vehicles within the road will receive a warning message and will decelerate to avoid collisions with vehicles ahead. However, this technique has the large number of messages flooded over the network, especially in a high traffic density scenario. Also this method will increase the bandwidth request because each node has to broadcast the message after receiving it almost at the same time. Therefore, these methods will bring contentions and collisions, broadcast storms and high bandwidth consumption (Wisitpongphan *et al.*, 2007). Some researchers proposed several ideas to reduce these problems and modified simple broadcast to weighted p-persistence (Wisitpongphan *et al.*, 2007) and slotted persistence (Tonguz *et al.*, 2007) etc. These schemes propose some methods to optimize performance and reduce broadcast storms. In these methods, a received message is not transmitted immediately and its rebroadcast is delayed for a given time. This time can calculate randomly or compute according to some network conditions (Chennikara-Varghese *et al.*, 2006).

The nodes in the Probabilistic Broadcast (PB) schema (Ni *et al.*, 1999) only rebroadcast the message with a predetermined probability. In dense traffic scenario, multiple nodes share similar transmission coverage. Thus, some nodes do not rebroadcast the messages randomly and network transmits the message without harming delivery effectiveness. However, in sparse traffic scenario, there is much less rebroadcast of the message. Therefore, nodes would not receive the entire broadcast message with the mechanism unless the probability parameter is high.

Briesemeister and Hommel (2000) purposed Role-Based Multicast (RBM) that achieved maximum reachability in a sparse traffic by using the carry-and-forward mechanism. In this case, each node starts broadcasting the alert message only when it has a neighbor in its communication range. However, RBM must keep a list of all its neighbors and the maintenance will generate additional overhead. Also, it has considered passing information only through vehicles traveling in the same direction.

In an emergency message propagation, protocol divides the highway into virtual cells (Durresi *et al.*, 2005). These cells move as the vehicles move. Briesemeister *et al.* (2000) developed a contention based strategy to disseminate a message among vehicles in road traffic. The number of multi-hopping depend to threshold number of hops and does not depend on the lane direction of the vehicle. A formal model of data dissemination in VANETs is also proposed by Nadeem *et al.* (2006) and the results show how opposite vehicles can be exploited as carriers to disseminate information to the vehicles approach. However, these above studies do not allow for information to be maintained in an area for a specific time.

The Clustering method is adapted from two similar cluster based routing protocols (Basu *et al.*, 2001; Little and Agarwal, 2005). Usually, cluster Based approaches create the clusters and select some nodes as cluster-head. The cluster-heads have the responsibility of propagating information in the network. Therefore, other nodes must not broadcast the messages received from cluster-head and the number of nodes to broadcast messages would be reduced to number of cluster-heads. Moreover, choosing the right cluster-head is another aspect in cluster based routing protocols. The mobile nodes exchange information with each other to find the ones that could play the role of cluster-head longer than the rest (Basu *et al*., 2001). The reason is that in maintaining cluster-heads, periodic exchanging information is needed which increases the overall network traffic and delay.

The above schemes have several advantages. For example, they can effectively mitigate broadcast storm problem and MAC layer collisions. However, one problem associated with these schemes is that they are highly sensitive to the chosen threshold and may perform very poorly in some scenarios.

DESCRIPTION OF OPPORTUNISTIC POSITION BASED APPROACH

The proposed algorithm OPB, Opportunistic Position Based approach is adapted with broadcast method based on various nodes densities in the linear vehicular Ad hoc network. The main idea of the proposed system is as follows: (1) While detecting an emergency event, the vehicle prepares the alert message and try to find suitable neighbor for massage propagation, (2) When receiving the emergency message, each node monitor its neighbors to select next-hop forwarders, (3) After detecting the best neighbor, the only vehicle selected as forwarder rebroadcasts the message to restrain the redundant transmission between vehicles.

It is assumed that vehicles are equipped with Global Positioning System (GPS) and wireless devices such as Wi-Fi. The data are attributed with parameters such as time-based Time to Live (TTL) parameter and movement direction, etc. For achieving scalability in high mobility networks, this approach does not require fixed infrastructures and adjusts its radio spectrum based on node densities in the network.

The proposed system will initially focus on information propagation along two directed pathway. The dissemination of information to other pathways can be extended from this scheme using map-based information. The data propagation protocol includes the following components attribute-based data, position based formation and maintenance. In this system, the attribute of data is specified. Under this scheme, recipients can route or discard data according to the rules of the application. Moreover, communication between vehicles is supposed to be omnidirectional on the two way highway. In this system, the alert message will broadcast by only one vehicle which has detected the problem and the vehicle that have chosen as the best neighbour acts as relays.

As a realistic situation, the alert message relaying within 6 km highway distance so that each direction (from East to West and vice versa) is composed of three lanes. Also, the proposed system has evaluated in two scenarios; sparse and dense traffic scenarios.

PROPAGATION STRATEGIES

The Opportunistic Position Based approach (OPB), as one kind of position based approaches, is based on forwarding data packets using the optimal path without using any location service. This schema will also maintain the message when it does not have any reachable neighbour instead of flooding a message periodically. However, the most problem occurs when the gap between the vehicles increase in the sparse traffic, because in this location, nodes forwarding packets might not be able to find a next hop to reach the destination. In order to overcome fragmentation, the proposed system uses vehicles in the opposite direction as relays.

In fact, the emergency message should be delivered quickly to the rear drivers because vehicles travel at a high speed and drivers do not have enough time to react to the vehicle in front. The proposed approach adapts several methods for reducing the number of retransmission for decreasing latency. Three strategies for dense and sparse traffic environment are described so that source node has to find the best neighbour as relays.

The first condition of highway traffic occurs where vehicle has several neighbours in its communication range. When an accident occurs in front of the vehicle, an alert message will be created immediately. First the vehicle broadcast the message to its neighbours then it has to decide which neighbour can relay the message faster than other neighbours. Also, which vehicle can use the alert message usefully rather than other neighbours.

The second condition occurs where vehicle should choose sender from opposite direction because it does not have any neighbour in its communication range in the same direction. It is obvious that the farthest vehicle in its communication range is the best candidate for relaying the message rather than near vehicles in the opposite direction. Therefore, the source node sends message to the farthest vehicle in opposite direction. In this time, if the farthest node has any neighbour in the main direction (where the accident is happened), definitely it should send this message to it. However, if this vehicle does not have any neighbour in the main direction, it should relay the message to farthest vehicle in the same direction. For example, as is shown in Fig. 1, vehicle A detects an

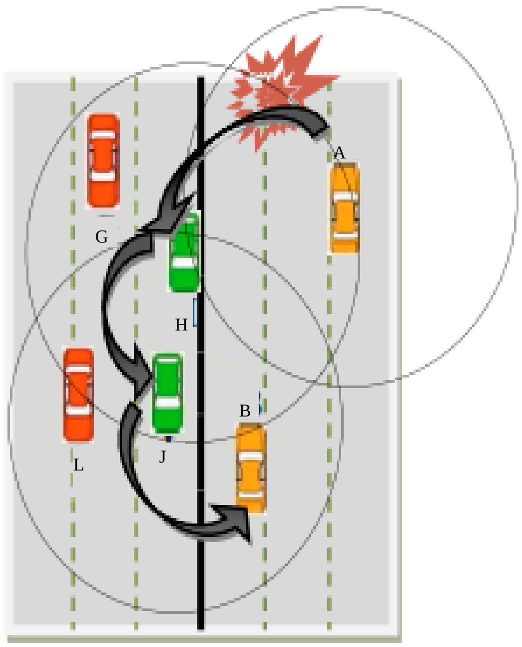

Fig. 1: Passing the message from opposite direction to main direction in dense traffic environment

accident in the road and propagates the alert message immediately. Since this node does not have any neighbour in the same direction, it forces to choose vehicle H as a relay in opposite direction.

But vehicle H also have no any neighbour in the main direction, so it selects vehicle J which is the farthest neighbour as appropriate candidate for relaying competition. This method will be continued until vehicles in the opposite direction find a neighbour in the main direction or the lifetime of message is expired.

Moreover, OPB approach can support the sparse traffic environment as well. Unlike previous studies that retransmit the message periodically, each vehicle, which is designated by OPB, maintains the message until detect a suitable neighbour as relay. Therefore, it can substantially reduce the number of broadcast. The most problems in the sparse traffic occur when the gap between the vehicles increase because in this situation, the selected node as forwarder might not be able to find a next hop to reach the best neighbour as relay. Therefore, the data will be loosed due to creating fragmentation in low-density environments.

Figure 2 indicates the pseudo code of OPB approach. This figure describes the message transmission when a new alert message is received in the main and opposite directions. It determines a vehicle that will be selected as relays for data propagation.

```
Initialize Node_ direction;
For any message do
Check source node and relay node direction;
If source node direction == relaying direction Then
If the direction of arrival message == Back Then
Ignore the message;
Else
If there is any car in the same direction Then
Select the furthest node as a relay;
Else if there is any car in the opposite direction
Select the node which goes out of radio range
                      faster as a relay;
Else do
                      Keep the message;
        Until
                  Find any neighbour for relaying or
                  the message be expired;
        End do
End if
End if
Else source node direction!=relaying direction
Then
If the directions of arrival message==Front Then
Ignore the message;
Else
If there is any car in the opposite direction Then
      Select the nearest node as a relay;
Else if there is any car in the same direction
Select the node which goes out of radio range
      faster as a relay;
Else do
      Keep the message;
Until
Find any neighbour for relaying or message be
      expired;
End do
      End If
End if
End if
End for
```

Fig. 2: Pseudo code of OPB approach

RESULTS AND DISCUSSION

Some of the comparison findings, as observed during simulation by position based method that is adapted with broadcast method based on various nodes densities in the linear vehicular Ad-hoc network, are described here. The NS2-based simulation evaluates the performance of OPB approach with other existing broadcast and cluster-based scheme (i.e., NB, PB and clustering method) by measuring the broadcast overhead and end-to-end delay under various conditions. For achieving this target, it is assumed that end-to-end delay is defined as the time duration between when the alert

Table 1: Simulation parameters

Parameters	Values
MAC type	IEEE 802_11
Radio-propagation model	Two ray ground
Channel type	Wireless channel
Network interface type	Wireless phy
Antenna model	Omni antenna
Transmission range	250 m
Network topology size	6000×70 m
Vehicle speed (Minimum)	70 km h^{-1}
Vehicle speed (Maximum)	120 km h^{-1}
No. of nodes in sparse traffic	30-100
No. of nodes in dense traffic	100-50

message creates in the road and when a corresponding alert message is delivered to all the vehicles would be informed about this information. Certainly, lower time delay shows that the method has higher speed in propagation and is more reliable in VANET environment. Moreover, the routing overhead can be measured by the number of alert message exchanged that occur during the period of simulation. The relevant parameters for proposed approach are summarized in Table 1.

These techniques were compared with OPB using NS2 simulation environment with various number of vehicles from 30-500 on the two ways highway.

Comparison results in dense traffic: When a traffic density is above a certain value, one of the most serious problems is retransmission the message by several consecutive vehicles. This problem is usually referred to as broadcast storm problem. Figure 3 plots the broadcast overhead for four approaches in dense traffic scenarios. It is obvious that NB outperforms the OPB, PB and Clustering method. These results are apparent since the OPB, PB and Clustering method have the lower number of retransmission. Hence, the broadcast overhead should be less for emergency messages.

The number of transferred messages in Clustering method is even more than PB method. This is true for both sparse and dense traffic scenarios. The reason is that the number of exchanged messages to manage the clustering is quite high. In this simulation, vehicles enter to the area randomly. Thus, the cost of creating and managing cluster is much higher than the time they come in groups.

As shown in Fig. 3, OPB performs best than other schemes, this is because OPB finds the suitable neighbour as relay before rebroadcasting the alert message immediately. Also, after running of vehicles, the OPB ignore the message if it comes from behind with respect to the direction of movement.

As shown in the Fig. 4, latency of PB is more than NB in the first of graph. The reason is that when the number of vehicle is low, the PB cannot support the delivery message to all vehicles behind the source node and there

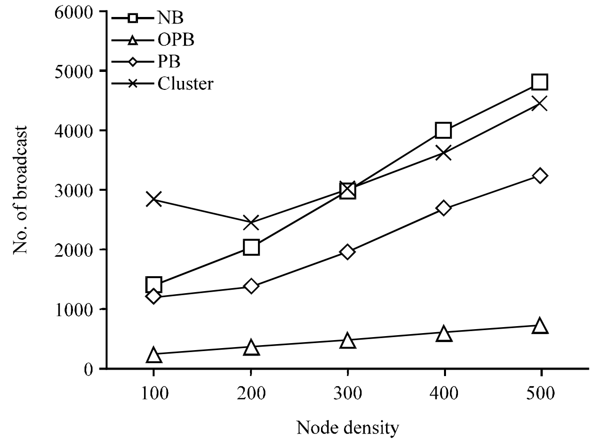

Fig. 3: Broadcast overhead under different number of vehicles in dense traffic scenario

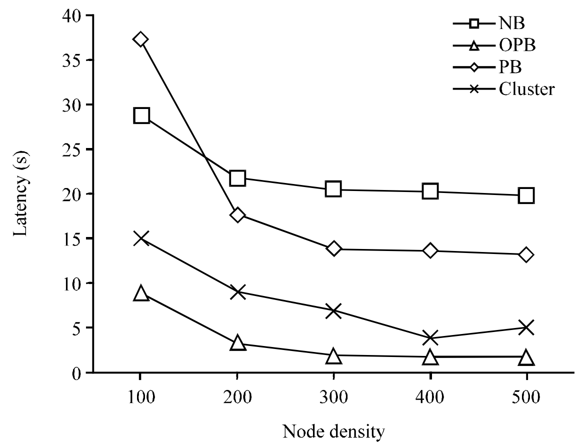

Fig. 4: End-to-end delay under different number of vehicles in dense traffic scenario

is almost no benefit in using the probabilistic broadcast in first stage of the scheme (Wisitpongphan *et al*., 2007). Therefore, latency will be increased in this situation. As shown in the result, the delay values are not variable in OPB and Clustering methods.

In both methods, by increasing the number of vehicles, the delay is decreased. The reason is that when there are not enough vehicles in the road, vehicles have to carry the message instead of propagating the message to the other neighbors. By increasing the number of vehicles, there is more chance for them to find a proper neighbor to relay the message to adjacent vehicles.

Comparison results in sparse traffic: The other scenario is the case where there are not many vehicles on the road. At certain times of the day, usually between midnight and 4 am in the morning, the traffic density might be very low.

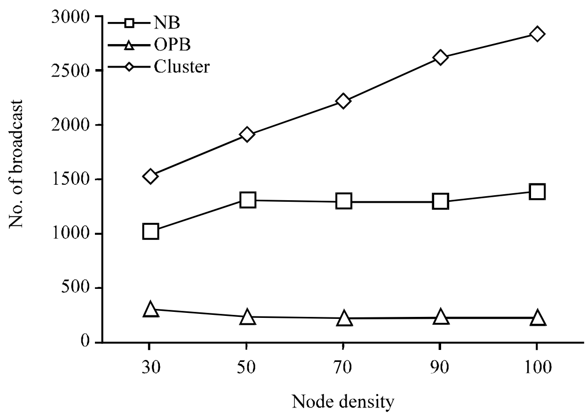

Fig. 5: Broadcast overhead under different number of vehicles in sparse traffic scenario

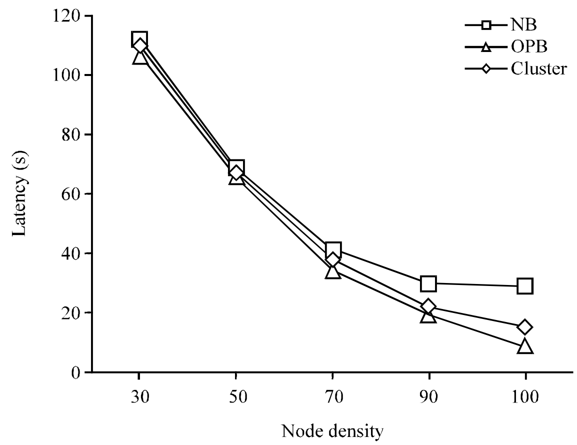

Fig. 6: End-to-end delay under different number of vehicles in sparse traffic scenario

In this case, there is no vehicle within the transmission range of the source and it creates gap between vehicles that are traveling in the road. Therefore, vehicles are not able to communicate after creating fragmentation in this situation and data will be loosed.

The comparison of OPB with NB and Clustering method in sparse traffic scenarios is discussed here. In this step, the PB approach has not compared with other because when the number of vehicles is low, vehicles won't receive the entire broadcast message with this mechanism.

Figure 5 plots the routing overhead that occurred during the simulation for different approaches. As shown, the performance of OPB is better than NB and Clustering schemes. The main reason for decreasing the routing overhead is that every vehicle, after running the OPB, selects the forward location in the farthest region and propagates the message if it comes from the front. From these results, we can conclude that the OPB approach can efficiently suppress transmission redundancy by using a small number of predetermined forwarders.

As shown in Fig. 5, Clustering method performs worse than the other scheme, because this method can not manage the cluster creating in sparse traffic and can not avoid the redundant rebroadcast messages as well. As expected, NB scheme also not use any of suppression to reduce the number of routing overhead because the NB schema messages are propagating within transmission range of the sender in order to prevent message die out and guarantee the reliable delivery to all reachable vehicles.

Figure 6 illustrates the end-to-end delay for OPB, NB and Clustering method. In sparse traffic scenarios, NB and Clustering method suffer relatively higher end-to-end delay compared to OPB. As shown in Fig. 6, the OPB model has better result than other. It is logical that when the number of vehicles in the road increase, end-to-end delay will be decreased. Moreover, the last delivery time of OPB is only 8.88 sec while this time for Clustering method and NB is 15 and 28.76 sec, which means drivers can save more time for emergency reaction by OPB, especially when the number of vehicles has increased.

CONCLUSION

In this study, Opportunistic Position Based approach is proposed for propagation of the alert message in the highway. The results observed the performance of the OPB approach with respect to the various parameters. Also, it used the vehicles travelling in opposite direction as preferred relays to overcome fragmentation and reduce the redundant transmission between vehicles. In addition, OPB approach can guarantee the delivery of the message to all reachable vehicles for a period of time in sparse and dense traffics. Lastly, OPB compared with three techniques under realistic scenarios and the effects of changing vehicles density were analyzed. The results showed that Opportunistic Position Based approach has low overhead and latency rather then Naïve Broadcast, Probabilistic Broadcast and Clustering method. Therefore, it is more suitable for VANET's use because it suppressed transmission redundancy and it can propagate the alert message sooner than other techniques.

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