Efficient use of Bidirectional Communication to Increase Communication Capabilities in Distributed VANET

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Abstract

Intelligent transportation system (ITS) is the need for today’s luxurious life where the traffic is unavoidable part of our life. Vehicular Ad hoc Network (VANET) is a wireless network that is formed on the fly between collections of cars connected by wireless links. In ITS the different cars flying there information to share with each other. VANET has gain a lot of attention in smoothly and safe driving. One of the most promising areas where VANET can be proved to be very useful is Traffic Management. In this paper we examine the problem of sharing information on one directional lane in sparse situation and proposed the information sharing using bidirectional communication, to find the sophisticated route in traffic jams in faster way. For this, we simulate the message sharing on one directional lane in sparse situation by increasing the gap between vehicles and show the problem associated with it. In result we simulate the bidirectional communication and show the efficient use of opposite direction vehicle to circulate information in traffic jams to find the traffic free sophisticated root.

1. Introduction

VANET is an enhancement in ad-hoc wireless network toward the application of vehicular system. In VANET different types of vehicles communicate with each other to share the speed, location and different parameters. The size of information shared and message to be sent at distance is varying according to the density of vehicles.

In today’s life traffic congestions are unavoidable part. Drivers waste their most of time in traffic congestion. Intelligent transportation systems are accepted to avoid road accidents, to find nearest road segment, and traffic free movement of vehicles.

According to the recent report [1], in India the lane capacity is low - most national highways are two lanes or less. A quarter of all India's highways are congested. Many roads are of poor quality and road maintenance remains under-funded - only around one-third of maintenance needs are met. This leads to the deterioration of roads and high transport costs for users. In Mumbai, Delhi and other metropolitan centres, roads are often severely congested during the rush hours. The dramatic growth in vehicle ownership during the past decade - has reduced rush hour speeds especially in the central areas of major cities.

2. Problem description

In this paper we introduce the new framework for vehicle to vehicle (distributed) communication in which we restraint DSRC – enabled vehicles to communicate with each other. Our framework is not only to provide smoother driving in traffic congestion but also to increase communication capability between vehicles. It helps to locate traffic congestion even in the sparse density of vehicles on one directional lane. The vehicle from opposite direction lane can also be used to carry information when vehicles on one direction lane fail to report the congestion due to insufficient range of communication. The situation is not always same of all vehicles remains in range with each other, some time it may possible that front vehicle cannot deliver the front traffic situation information due to the large gap between each other to behind vehicles shown in Fig 1. In this case the opposite direction vehicle can carry the information about front situation of opposite direction lane and deliver it to the other sided behind vehicle. In this way other sided vehicle can take the decision to change the path and accept new
segment to reach smoothly to the destination as shown in Fig 2.

The rest of the paper is structured as follows: We are using the NS3 to simulate our research. First, we simulate the one way communication between different vehicles on one directional lane in sparse situation to show how the sparse densities can break the communication range.

Fig 1: Problem arises in sparse situation

Second, we introduce the opposite direction vehicle to increase the communication capabilities. Then we show how the improved cost based aggregation helps to send maximum information through wireless channel. Finally, we present the simulation result for, bidirectional communication to catch the traffic congestion situation in front of vehicle using opposite direction lane vehicle in sparse situation. Here, we show the comparison of delay time required for one way and bidirectional communication.

Fig 2: Bidirectional communication in distributed VANET

3. Related work

The research in Inter-Vehicle-Communication has emerged in the past couple of years; mainly because it is a good experimental platform for Mobile Ad Hoc Networks (MANETs), and has a great market potential [2].

Several major automobile manufactures and universities have begun to investigate in this field; GM research centre in CMU [3], BMW Research Labs [4] and Ford Research Labs [5], Rice University [6][7], and Harvard University [8] are a few to name. CarNet [9] project focuses on how the radio nodes in the vehicles get IP connectivity with the help of Grid [10]. In [11], a wireless traffic light system is presented. At the intersection, a static control unit periodically broadcasts the current light status, location of intersection, and a reference point, using which the vehicles approaching the intersection can check their relative position and make a decision accordingly. They also designed collision warning system [5] in which peer-to-peer beacon message exchange is used.

Architecture of the vehicular communication is described in [12]. It integrates inter-vehicle communication (IVC) with Vehicle-Roadside Communication (VRC), where both moving vehicles and base stations can be peers in the system. The peers are organized into Peer Spaces for message exchange, in which flooding is the main method of delivery. Authors in [7] examine the feasibility of short range communication between fast moving vehicles using Bluetooth, and a mobile test-bed RUSH has been established in [6], composed of the fixed base station and mobile nodes on shuttle buses.

4. System design

In this section we present the implemented prototypes.

A. Data representation

Each vehicle broadcast the message with following attributes:

- **Broadcasting Time:** Each vehicle broadcast the message in specific interval of time of 2sec.
- **Vehicle Identification No.:** Each vehicle is assigned with unique identification number.
- **Position:** The estimated position of vehicle is shown.
- **Speed:** Current speed of the vehicle. Estimate the position of vehicle if no message is received from that vehicle about its information.
- **Message:** The current situation of the road. Traffic jam, road blocking message.
- **Lane:** Lane no. on which the vehicle is moving.
- **Dir:** Direction shows the positive and negative direction way.

All vehicles moving on both the direction and in communication range of each other shares the message. The Fig.3 shows the simulation of vehicles in our research.
B. Communication

Communication channel we are using is, IEEE 802.11b. A MAC layer protocol (IEEE 802.11b protocol) limits the size of the payload that is sent on the network channel to a maximum size (which is 2312 bytes for 802.11b). In distributed framework, the number of records in a node’s validated dataset can be large, making it impossible to fit all of them in one broadcast message.

Fig 3: Simulation of vehicles

C. Data Aggregation

In order to deliver as much information about vehicles as possible, data aggregation techniques should be applied to the records. The distributed VANET only stores information about the vehicles in front of the current vehicle, and ignores the ones behind it.

According to the way the aggregated fields are calculated, the aggregated records should have close values to their position, speed, direction and broadcast time fields to reduce the error resulting from the aggregation. If two records have close position values, they are expected to have close broadcast time values.

At the same time, if the difference between the speeds of two vehicles that are close to each other are big, their distance will grow in a short time as well. Keeping in mind that the broadcast period is in the order of seconds, we can ignore the speed difference among the aggregated records, because the record will be updated with the new up-to-date position information as soon as new broadcast messages are heard. As a conclusion, the records are selected for aggregation based of their relative distances and direction only. To achieve this in an efficient manner, records are kept sorted on the estimated relative distance and direction of the current vehicle to the corresponding vehicles.

Whenever a node receives a record containing information about some vehicles, it first checks the information in that record against the dataset records it has. If the record contains information about some vehicles which the node already knows, it performs the following:

If the broadcast time of the records is greater than the broadcast time of the stored record, it means the new record is fresher, and therefore the node removes the corresponding vehicle ID from its stored record, otherwise, the new record contains older information, and hence the node removes the corresponding vehicle ID from the received record.

In distributed VANET, vehicles apply the aggregation procedure on the records in the dataset each broadcast period to prepare the broadcast packet. The effect of each vehicle either replacing its current records with the aggregated version, or maintaining the original records in its dataset, on the quality of the information gained by other vehicles on the road, is almost identical; the only difference being the imposed overhead in the next broadcast period. We therefore decided to replace the dataset records with the new aggregated version during each broadcast period in order to reduce the overall aggregation overhead [13]. We use the cost based aggregation algorithm with some improvements. So we called it improved cost based aggregation algorithm. The improved cost based algorithm is given below.

5. Improved Cost-based Aggregation

Cost-based algorithm assigns a cost for aggregating each pair of records, and whenever it needs to aggregate two records, the two that correspond to the same direction & minimum cost are chosen. Assume two records storing aggregated information about s1 and s2 vehicles, with a relative distance of d1 and d2, respectively. The cost of aggregating the two records is calculated as follow [14]:

\[ \text{Cost} = \frac{|d_1-d_a| \times s_1 + |d_2-d_a| \times s_2}{d_a} \]

In this paper we are using improved cost based aggregation for bidirectional communication as follows:

Table 1: Sample records used to illustrate improved cost-based aggregation algorithms

<table>
<thead>
<tr>
<th>ID</th>
<th>Relative Distance</th>
<th>Speed</th>
<th>Broadcast Time</th>
<th>Lane No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>30</td>
<td>9.80</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>65</td>
<td>25</td>
<td>9.75</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>35</td>
<td>9.00</td>
<td>3</td>
</tr>
</tbody>
</table>
Assume the road is 2x2, and as the communication is between lanes 1, 2, 3, 4 we need to aggregate the data of all vehicles on all lanes. Lane 1, 2 have east bound and lane 3, 4 have west bound. So, little modification in cost based aggregation is that, we have to aggregate the information on the basis of lanes i.e. direction. In table 1 the sample data need to aggregate is given.

Table 2: Records sent out by the improved cost-based algorithm

<table>
<thead>
<tr>
<th>ID(s)</th>
<th>Relative distance</th>
<th>Speed</th>
<th>Broadcast Time</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2</td>
<td>52.5</td>
<td>27.5</td>
<td>9.75</td>
<td>1,2</td>
</tr>
<tr>
<td>4, 6</td>
<td>210</td>
<td>17.5</td>
<td>6.75</td>
<td>2,1</td>
</tr>
<tr>
<td>3, 5</td>
<td>185</td>
<td>32.5</td>
<td>6.90</td>
<td>3,4</td>
</tr>
</tbody>
</table>

As an example refer table 1, assume vehicle with ID = 0 intends to use this algorithm having $a_1 = a_2 = 0.5$, $p_1 = p_2 = 0.5$ and cost-threshold= 0.9. During the first iteration (a1) it first aggregates records 1 and 2 (cost = 0.50,) which are on same direction then 4 and 6 (cost = 0.66,) and finally 3 and 5 (cost = 0.70.) In the second phase (a2,) the minimum cost is 1.05, which is greater than the cost threshold, therefore the algorithm terminates. Table 2 lists the records that are sent out by vehicle 0 and the corresponding fields. In this case, vehicle 0 cannot fit record 7 in its message [13].

6. Simulation & results

We run simulation model for 200 ms to show the problem arises in the sparse situation due to the one way communication. We take the average gap between the vehicles as 1000 m and the average speed of vehicles as 27m/s. The broadcasting time of each record is 2ms.

A. Improved aggregation algorithm result:

We are simulating the scenario for 200ms where we can see number of vehicles are 92. Sharing information of 92 vehicles on single channel is not possible as the payload of IEEE 802.11 is 2312 bytes. The result of non-aggregating records is shown in Fig 4.

We can see, non aggregation of information generates large no of message (send/receive). For vehicle id 2 it is 1821, for vehicle id 3 it is 315 and for vehicle id 5 it is 81 and so on.

We compare this result with, aggregation of information result. Fig 5 shows the resulted graph for aggregation of information.

We can also see after aggregating the information i.e. the no of messages send and receive are minimizes. For vehicle id 2 it is 239, for vehicle id 3 it is 27 and for vehicle id 5 it is 35.
Here No of vehicles shows the vehicles generated during simulation for different lane and direction. Received Msg shows total no. of messages received during simulation, by all vehicles. Send Msg shows total no. of messages send during simulation, by all vehicles.

Table 3: Comparison of Delay Time for one way and Bidirectional communication

<table>
<thead>
<tr>
<th>Lane</th>
<th>Direction</th>
<th>No. Of Vehicles</th>
<th>Received Msg</th>
<th>Send Msg</th>
<th>Delay Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
<td>65</td>
<td>1777</td>
<td>15822</td>
<td>46.2336</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>42</td>
<td>1538</td>
<td>11861</td>
<td>147.05</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>60</td>
<td>1423</td>
<td>14592</td>
<td>527.949</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>35</td>
<td>1595</td>
<td>13019</td>
<td>1136.15</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>44</td>
<td>549</td>
<td>8728</td>
<td>485.329</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>20</td>
<td>624</td>
<td>12145</td>
<td>997.837</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>26</td>
<td>114</td>
<td>4539</td>
<td>891.184</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>11</td>
<td>114</td>
<td>3607</td>
<td>399.96</td>
</tr>
</tbody>
</table>

Delay Time shows the time required to send information and acknowledge by all vehicles during simulation. We can see during simulation of 5 lane highway in one direction the delay time required is 147.05 ms, for 4 lane highway it is 1136.15 ms, for 3 lane highway it is 997.837 ms and for 2 lane highway it is 399.96 ms. During simulation of 5 lane bidirectional highway the delay time required is 46.2336 ms, for 4 lane highway it is 527.949 ms, for 3 lane highway it is 485.329 ms and for 2 lane highway it is 891.184 ms. so comparing all delay time we can see delay time required for bidirectional communication is less as compared to one way communication.

7. Conclusion

We simulated the one way communication scenario for 200 ms for sparse situation and shows the problem arises due to the large gap between vehicles. Due to the large gap, behind vehicles do not receive the information about road block and faced the problem of traffic jams. To avoid this problem we used the bidirectional communication for information sharing. We simulated the bidirectional scenario for 200 ms & perform the aggregation to utilize the 802.11 channel and compare the delay time of one way & bidirectional communication.
communication. The improved cost based aggregation aggregates the information to send maximum number of information on both direction through communication channel. Comparing delay time shows that bidirectional communication works better than one way communication in sparse situation. The delay time of bidirectional communication is almost half of single way communication. So getting traffic jam information in sparse situation also, helps driver to take decision of changing segment (lane) to reach to destination.

8. References

[12] I. Chisalita, and N. Shahmehri, “A peer-to-peer approach to vehicular communication for the support of traffic safety applications,” in 5thIEEE Conference on Intelligent Transportation

About the Authors:

Mr. Amit R. Welekar is currently pursuing the M.E. in Wireless Communication & Computing from G.H. Raisoni College of Engineering Nagpur.

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