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Broadcast Protocol for V2V and V2RSU in VANET

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Abstract: This system combines algorithmssuitable for locations with and without road side units. It is the integration of the vehicle to vehicle(V2V) and vehicle to road side unit(V2R) communication. The V2V algorithm uses the signal messages to acquire the information of the neighbors, broadcast the messages and acquire acknowledgements. Connected dominating set (CDS) is calculated and CDS nodes use a shorter waiting period before possible retransmission. At time-out vehicle retransmits if there is at least one neighbor in need of the message. The road side units (RSU) have a high range of communication. Thus V2R algorithm disseminates data faster. RSU is also used to reduce the redundant retransmissions. The integration of V2V and V2R communication is beneficial due to the fact that V2R provides better service sparse networks and long distance communication, whereas V2V enables direct communication for small to medium distances/areas and at locations where roadside access points are not available.

Keywords: Broadcasting, CDS, data dissemination, NES, RSU, vehicular ad-hoc networks.

I. INTRODUCTION

Vehicular Ad hoc NETworks (VANETs) is collection of vehicles capable with wireless communication. Broadcasting is the task of sending a message from a source node to all other nodes in the network which is frequently referred to as data dissemination. Road Side Unit (RSU) is wireless LAN access point and can provide communications with infrastructure. It can have higher range of communication up to 1000m. But the installation of RSU is very expensive.

For successful vehicular communication service we need reliable and efficient broadcasting. Most of the services like safety applications to traffic management and infotainment [10] rely on the delivery of broadcast messages to the vehicles. But along with this it is also required to deliver the message with less number of transmissions and in shorter time.

Combining V2V and V2R communication will exploit the advantages of both modes of communication in VANET.

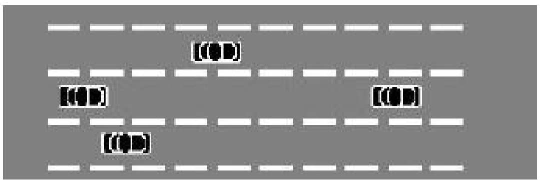

Fig: 1. Vehicles without infrastructure

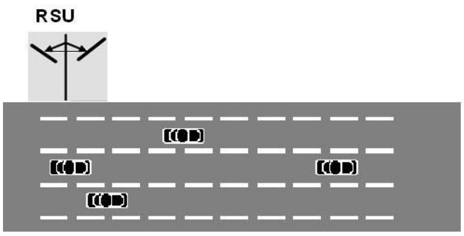

Fig: 2. Vehicles with infrastructure

II. LITERATURE SURVEY

There exist numerous proposed broadcasting protocols for wireless ad hoc networks. Several surveys describe many of them. Here, we only refer to those techniques and protocols that are directly related to our approach.

A. CDS-NES Based Broadcasting

Today efficient broadcast protocol for ad hoc networks is required. Probably, CDS is commonly used[4][5]. In CDS-based broadcasting, only those nodes belonging to the CDS are needed to retransmit the broadcast message, and of course it will reach the whole network. Since, there exist less number of nodes in the CDS, the redundant broadcasts will also be less.

In NES the vehicle to which message is sent are assumed to have received and thus are removed from the not received list. Also, the vehicle from whom the message is received, that vehicles' neighbors are assumed to have received the message and thus are removed from this nodes not received list. This assumption reduces the number of vehicles from the not received list thus reducing the number of retransmissions. If all the neighbors are assumed to have received the broadcast message, then there is no retransmission.

Wu et al. described several lightweight backbone construction schemes. We will use a modified definition from [4] and [5] of the basic concept in [6]. It is based on two concepts: CDS and NES.

In [1], they combine CDS and NES along with acknowledgements for the received messages to the sender called ABSM protocol. But the acknowledgements itself lead to lot of transmissions, thus acquiring most of the traffic. ABSM is very efficient data dissemination protocol without the infrastructure. But, acknowledgements may increase reliability but not enough to be used in the Time critical applications. So, when using this protocol for less time critical applications, the acknowledgements can be eliminated and the best of ABSM can be achieved.

Here we combine CDS and NES along with the road side units to achieve the best of three. We try to design a protocol suitable for non-time critical applications with or without the Infrastructure. We try to achieve the best use of the RSU wherever available.

B. VANET-Specific Broadcasting

We limit our review to protocols designed primarily for non-safety applications (and therefore not emphasizing minimal delay as the main objective).

In our paper we are interested only in distributed algorithms. V2V is local, and based on applying the CDS and NES concepts on the currently available neighborhood information. The protocol assures the reception of the message sent using the acknowledgements [1]. A message is acknowledged during its complete lifetime. At expiry, it is removed from the vehicle's buffer and no more acknowledgments are issued further. Given that broadcast messages are acknowledged, it is assumed that they can be identified uniquely.

C. Integration with the road side unit

The RSU can have higher range of communication of about 1000m [7]. Using this property of the RSU the communication becomes faster which reduces the redundant retransmissions. But the installation of the RSU is very expensive because of which the infrastructure independent communication protocols are very popular. But the combination of the V2V and V2R uses the advantages of both modes of communication which leads to enhanced performance with respect to the reduction in number of transmissions and faster communication.

Our research has important features such as reliability (reaching all nodes in the absence of message collisions), significant rebroadcast savings and is localized and without parameter. The vehicles here can communicate with and without the RSU. It gets the best of both V2V and V2R communication.

III.PROGRAMMERS DESIGN

We propose a VANET communication which is a combination of V2V and V2R mode of communication. The integration of V2V and V2R communication is beneficial due to the fact that V2R provides better service sparse networks and long distance communication, whereas V2V enables direct communication for small to medium distances/areas and at locations where roadside access points are not available.

Communication Modes: We define 2 basic types of communication:

1. V2V (Vehicle to Vehicle): The vehicles communicate with each other.
2. V2R (Vehicle to Road Side Unit): The vehicles communicate with the road side unit.

A. V2V Communication:

Here we focus on the problem of broadcasting in VANETs without infrastructure support. Regardless of criticality, the infrastructure for support of data dissemination is currently sparse, and therefore a protocol not relying on it is required.

Our primary goal is to achieve high reliability while minimizing the total number of retransmissions. In some safety applications, the delivery latency is critical. However, achieving the best of reliability, retransmissions and latency is a very challenging task. We have to trade-off between the three. So here we concentrate on the non-safety applications like marketing, publicity, information gathering. At the same time, vehicle still may not delay retransmission for too long as the reliability would otherwise suffer.

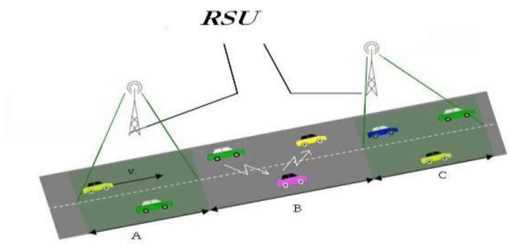

Fig: 3. Combination of V2V and V2R

Here is the V2V protocol, a fully distributed adaptive algorithm suitable for VANETs without infrastructure. V2V automatically adjusts its behavior without keeping track of the degree of mobility sensed by the vehicle. In V2V, we combine two different techniques, CDS and neighbor elimination scheme NES [4], [5] but have removed the acknowledgements to get the data moving faster. Moreover, we are targeting the non-safety applications so the acknowledgements can be avoided.

B. V2R Communication:

The switching of the mode, between V2R and V2V, can have a strong impact on the quality of the communication, e.g. in terms of packet delay, bandwidth consumption, and packet loss. This fact, together with the need to achieve a good scalability, suggests adopting a criterion based on the optimal path.

In figure 3, we depict how broadcasting can be optimal if RSU is introduced in the V2V communication. When the vehicles are in the range of the RSU, it will get all the messages that vehicles in the vicinity have. The RSU will consolidate these messages and send them to all the vehicles which are in its range. For vehicles in section B to communicate, when communicating via V2V every node has to calculate the CDS and NES. While for V2R in section A and C, single broadcast by the RSU serves the purpose.

C. *Algorithms*

1) Algorithm 1: V2V Protocol Details

When the broadcast message is received by vehicle 'A', it includes sender and all its neighbors in the received list 'R', assuming all of them will receive the message. The remaining neighbor-vehicles of 'A' are put in the not received list 'N'. Simultaneously the vehicles calculate the CDS and mark themselves as CDS or non-CDS nodes. All vehicles have a retransmission time off 'ret_off'.

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Since the CDS nodes are highly connected to vehicles they should retransmit first. So the value of 'ret_off' for CDS will be less than 'ret_off' for the non_CDS nodes. So, the CDS nodes retransmit before the non-CDS nodes. However, this does not mean an increased number of collisions, since V2V runs at the network layer but these messages still have to contend to access the medium at the link layer (IEEE 802.11p).

The value of 'ret_off' will be reset whenever the 'N' list changes, due to NES. Also, whenever a new neighbor is detected the 'ret_off' is reset.
If list 'N' becomes empty before 'ret_off' expires, 'ret_off' is cancelled. If the 'ret_off' times out, then the message is retransmitted and the vehicles in list 'N' are transmitted to the list 'R'.

2) Algorithm 2: CDS(Connected Dominating Set)
Every vehicle 'v' initially marks itself as 'T'. Then every vehicle 'v' exchanges its neighbor set N(v) with all its neighbors. If a vehicle has two unconnected neighbors, then it marks itself as 'C'. All the nodes marked as 'C' broadcast their status of being 'C' node to their neighbor. Further these nodes are reduced using rule 1 and 2.
Rule 1: Consider two vertices 'a' and 'b' in G. If N[a] is subset of N[b] in G and id(b) is less than id(a), change the marker of b to 'T' if node b is marked, i.e., G is changed to G - v.

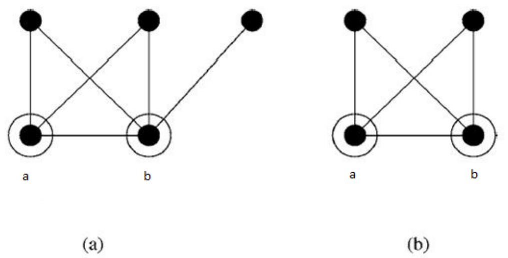

Fig.: 4. Rule 1

Rule 2: Assume 'a' and 'c' are two marked neighbors of marked vertex 'b' in G. If N(b) subset of N(a) union N(c) in G and id(b) = min {id(b), id(a), id(c)}, then change the marker of b to 'N'.

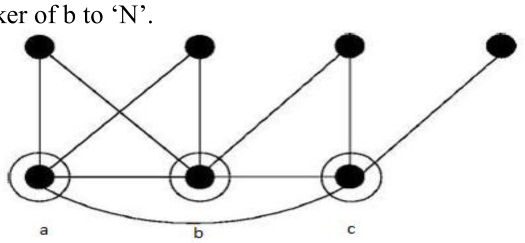

Fig.: 5. Rule 2

3) Algorithm 3: V2R Protocol Details:
The RSU will continuously broadcast Hello messages. The vehicles that enter in the range of this RSU when find RSU as its neighbor, they send to it all the messages that they have along with their neighbor list. The RSU consolidates all such messages and broadcast them. Since the RSU has higher reachability its retransmission time off will be less than the CDS, so as to avoid the redundant retransmissions by the CDS.

IV. EVALUATION SETUP

We have performed different tests to assess the performance of the Protocol with and without the Road Side Unit (RSU). We have concentrated mainly on the highway scenario with a single stretch of road. To simulate the network we have built our own simulator. It takes the vehicle names, their initial position, speed, range of communication and the message they have as input. By using the basic formula distance = speed * time, we have updated the position of the vehicles at equal intervals, thus simulated the network. The vehicles communicate to each other over the TCPIP Socket. Each vehicle will create its own socket. Thus the message collision was handled by the network layer. The RSU will also be treated as a vehicle with speed as zero. RSU will have a higher value for range of communication.
Table 1 summarizes the main simulation parameters.

Table 1: Parameters for Simulation

Range of RSU	1000m
Range of vehicle	250m
Retransmission time-off for non-CDS vehicle	20 sec
Retransmission time-off for CDS vehicle	15 sec
Retransmission time-off for RSU	9 sec
Hello message interval	25 sec

Retransmission time-off for RSU < CDS node < non-CDC node. This is in-order to achieve the best of the CDS and the RSU.

We focus on the number of transmissions and retransmissions of the vehicles with and without the RSU. We also evaluate on the basis of the reachability in the same time period with different number of RSU spread across the road. We also evaluate on the basis of number of transmissions and retransmission for different density of vehicles on the road.

V. RESULTS

In [1], it has been experimentally proved ABSM which is the base for V2V performs very well as compared to PBSM-1p and PBSM-2t in terms of reliability and number of transmissions.

We have simulated the network with the RSU and without the RSU and compared the two on the basis of number of transmissions and retransmissions. We also compare the number of transmissions/retransmissions of CDS nodes with and without the RSU. We have further evaluated the performance of the network as the number of the RSU increases.

A. With RSU vs Without RSU

We evaluated the protocol with different number of vehicles once without RSU and once with RSU. In case of with RSU we used only a single RSU. Fig:6 shows the performance of the protocol with and without RSU. As it can be seen, the number of transmissions and retransmissions decrease with the presence of the RSU, since the RSU has higher broadcast power and thus can

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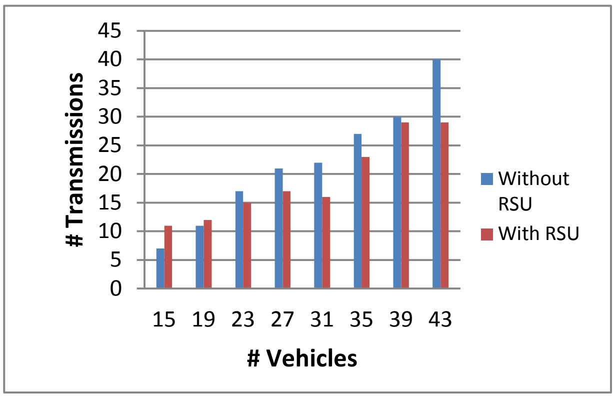
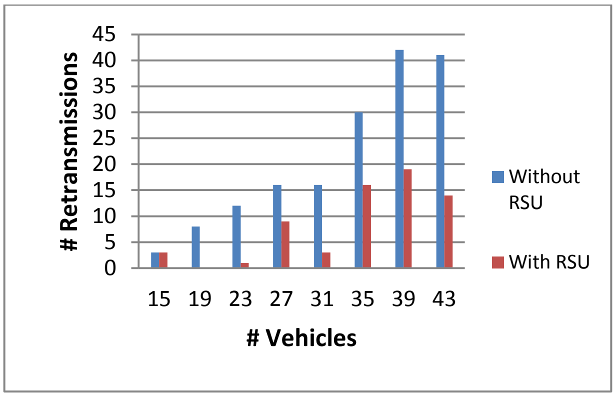
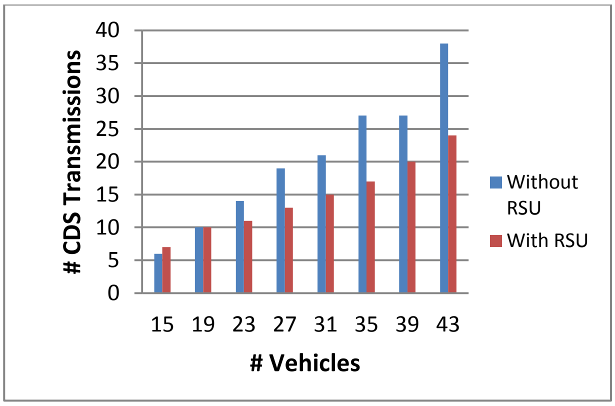
reach more number of vehicles, thus reducing the redundant transmissions and retransmissions. It's also very relevant that the number of CDS transmissions and retransmissions have also reduced since their retransmission time-off is less than that of the RSU.



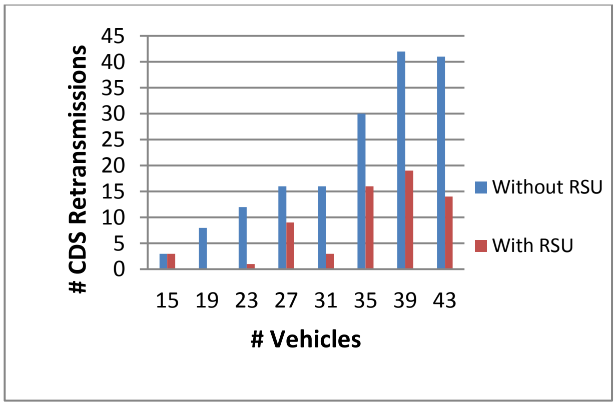
a.Transmissions with and without RSU



b. Re-transmissions with and without RSU



c.Transmissions with and without RSU



d. Re-transmissions with and without RSU

Fig: 6 Performance with and without RSU

B. Effect of number of RSU

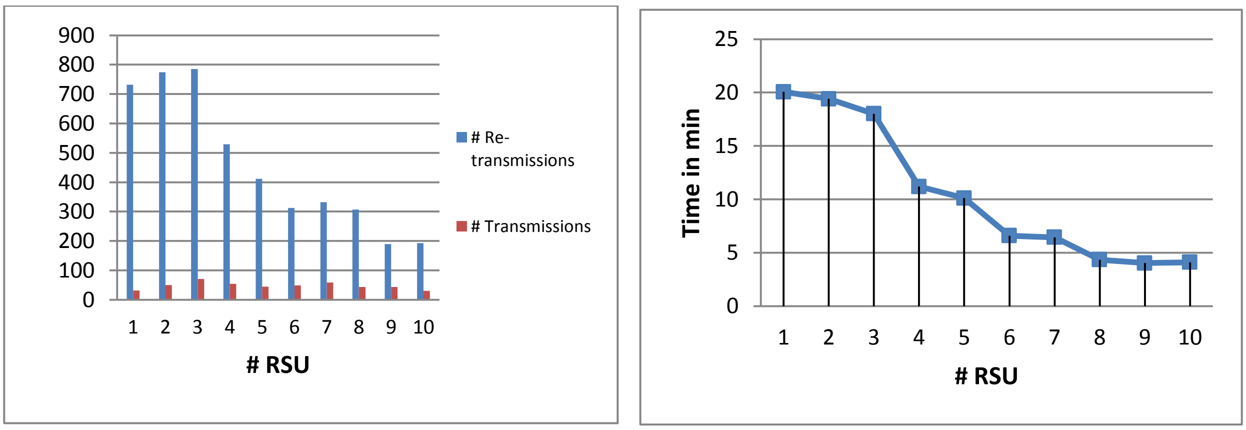


Fig:7 Effect of number of RSU on transmissions and re-transmissions

Further we evaluated the effect of the number of RSU on the total number of transmissions and re-transmissions. Fig:7 show that as the number of RSU increase the total number of transmissions and retransmissions decrease. This is turn is relevant with the fact that the higher range of RSU to broadcast reduces the transmissions and retransmissions of the CDS and non-CDS nodes.

As the number of RSU increase, most of the data dissemination happens through the RSU, reducing the burden of the vehicles to transmit. Many a times even the calculation of CDS is also not required, since all the neighbor vehicles of the vehicles will already have been covered by the RSU.

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Fig: 8shows the impact of the number of RSU on the total time taken to disseminate the data to all the vehicles. As the number of RSU increase, the network becomes more connected and the speed of data dissemination increase thus the time for data to reach all the vehicles decrease.

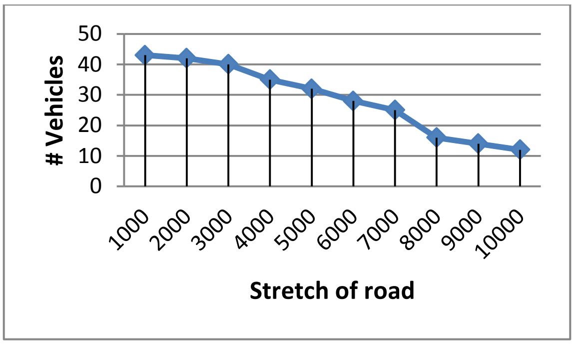

Fig:8 Effect of density on the number of vehicles receiving message in 45 secs

C. Effect of Density of Vehicles

We also, evaluated the effect of the density of vehicles on different length of stretch of road. This evaluation set up had 43 vehicles distributed over different length of stretch of road, with a single RSU. Here we calculated the number of vehicles that receive the data for the same interval of time i.e. 45 secs. Fig:8 shows that as the density of vehicles decrease i.e. the distribution of the vehicles become sparser, number of vehicles that receive the message in the same interval of time also decreases. This is due to the fact that as the density of vehicles increase the network becomes more connected and also more number of vehicle come in the range of the RSU.

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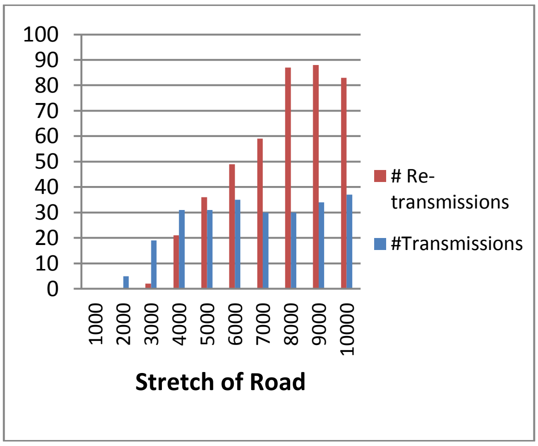

Fig:9 Effect of density of vehicles on the number of transmissions and retransmissions

We also evaluated the effect of density of vehicles on the number of transmissions and retransmissions of vehicles. Fig 9 shows that as the density of vehicles decreases the number of retransmissions increase. This is again due to the connectivity of the vehicles. As the density decreases the vehicles become more disconnected. Moreover, the number of vehicle in the vicinity of the RSU also decreases. All of this adds to more number of retransmissions.

The number of transmissions though is maintained. These transmissions are mainly the basic transmissions by the vehicles which are the source of the message, the RSU since it will be transmitting after the RSU reset time out and the first transmissions by the CDS nodes. Also, note that they are very few as compared to the retransmissions.

Also, it can be seen that there are no transmissions of retransmissions when the vehicles are highly dense on the stretch of road of lenth 1000m. This is due to the fact, that all the vehicles present there are also reachable by the RSU. So they receive message in a single transmission of the RSU.

In all the cases effect of Road Side Unit (RSU) is very evident. Also the effectiveness and better performance of the V2V (combination of CDS, NES) have already been proven in [1] and [4][5]. From the result it can be strongly said that even a single RSU can impact highly the performance of the data dissemination in VANET. Also, that the combination of the V2V and V2R will get the best out of the RSU's capability to disseminate at a larger range and also reduce the number of transmissions and retransmissions by using CDS and NES.

VI. CONCLUSION

The number of irrelevant redundant transmissions is reduced in the VANET system for non-critical applications by combining the advantages of the V2V and V2R communication where applying the concept of connected dominating set and the neighbor elimination scheme for the V2V communication. The transmissions for the acknowledgement are also reduced by the assumption that the vehicles that have been sent the message have also received the message. Further V2R reduces the redundant transmissions by using the transmission range capacity of the road side unit. Using RSU also makes the communication faster and reduces the overhead on the vehicles by avoiding the calculations of CDS and NES.

We plan to continue working on testing the protocol over the suburban scenarios using the more realistic Network simulators. We would also look at making the protocol suitable for time critical safety applications.

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