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RBCAST: An Efficient Data Dissemination Technique to Reduce Broadcast Storm Problem In Vehicular AD-HOC Network

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Abstract

Vehicular Ad-hoc Network (VANET) is an outgrowth of Mobile Ad-hoc Network (MANET). Vehicles in VANET are considered as nodes with wireless links. It enables communication among vehicles and Road Side Units (RSUs). In VANETs, many vehicles tries to send warning messages. So every vehicle within the transmission range will receive the broadcast message and rebroadcasts these messages to other vehicles. This makes the vehicles receive the traffic warning message repeatedly. Hence, redundancy, contention, and packet collisions occur due to simultaneous forwarding (usually known as the Broadcast storm problem). In this paper, RBCAST is proposed to address the broadcast storm problem in VANET. It reduces the number of retransmissions and more number of vehicles is alerted about emergency situation. In order to deliver the packets successfully and to reduce the broadcast storm problem, nodes must relay the packets with the help of the intermediate nodes.

Keywords: *Broadcast storm, Redundancy, Relay, Road Side Unit, Vehicular Ad-hoc Network.*

I. INTRODUCTION

The smart city concept began in the early 1990's with the rising of new technologies of mobiles and wireless networks. Advances in wireless communication introduced many new possibilities for Intelligent Transportation Systems (ITS). Many new vehicles come equipped with Global Positioning System (GPS) receivers and navigation systems. In the near future, the number of vehicles equipped with computation technologies and wireless network interface will increase dramatically. In order to improve road safety conditions by taking the advantage of the development of Autonomous systems, VANET was introduced which is equipped with sensors and radio access technologies. VANET are a special class of MANET where nodes are self-organized and self-managed in a distributed way. The networks consist of vehicle and infrastructure that communicate with each other. Wireless technologies like Dedicated Short Range Communication (DSRC) and IEEE 802.11p Wireless Access for Vehicular Environment (WAVE) enables peer to peer mobile communication among vehicles. In recent years, much research efforts have been put into VANET, such as routing, data dissemination, security, etc. Among these research areas, the data dissemination mechanism has gained more attention as it determines whether users acquire on-demand services timely. Data dissemination in VANET is used as a way to disseminate messages (i.e., emergency accident, traffic information services, and advertisement) among a group of vehicles. Avoiding accidents and traffic jams are two main benefits of VANET. In VANET, the vehicles communicate with each other in 3 different ways. They are as follows:

1.1 Vehicle to Vehicle (V2V) Communication

In some situations, within a short range a vehicle needs to communicate to its neighbour vehicle. In such case, communication is done with the help of V2V.

1.2 Vehicle to Infrastructure (V2I or I2V) Communication

V2I communication enables Safety as well as infotainment applications through Multi-hop communication.

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1.3 Hybrid Communication

At some point, a vehicle needs to communicate to the neighbor vehicle as well as to the infrastructure. In that case, communication in VANET can be done by combining both V2V and V2I forming hybrid communication. Figure 1 represents the different types of Communication in VANET.

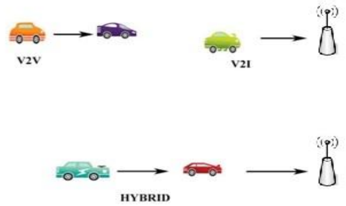

Figure 1. Types of Communication in VANET

In short, all the types of communication in VANET collectively is represented as V2X communication where 'X' represents vehicle, infrastructure or any other wireless devices. The key term in VANET is to transmit messages to the intended destination with minimum delay and maximum throughput.

In VANET, vehicles move in a predictable manner. Using the GPS which is embedded in the On Board Unit(OBU), geographical locations of the vehicles are tracked. GPS is composed of 24 satellites which orbits around the earth at a height of 20,200 km. Each satellite circles the earth and makes two complete rotations every day[1,2]. The GPS receiver uses Time of Arrival (ToA) technique to calculate the distance between the vehicles.

The use of Broadcast technique is a good strategy to disseminate data because the vehicles do not know an address and a route to the target [3][4]. Using the broadcast technique the forwarding of message is poorly prepared, with more number of duplicate messages and multiple retransmissions [5]. This problem is generally referred to as Broadcast storm problem. It is necessary that the intermediate vehicles forward the messages with some constraints. The rest of the paper is organized as follows: In Section 2, related works on data dissemination protocols are investigated. The broadcasting technique for Emergency Message (EM) RBCAST is proposed in Section 3 and Section 4 shows the Results and Discussions of RBCAST. Finally, the conclusion is specified in Section 5.

II. RELATED WORKS

The Flooding is a fundamental mechanism to implement data dissemination in VANET. But flooding mechanism results in significant communication overhead due to redundant broadcasting. This causes Broadcast storm problem. A common solution to reduce the Broadcast storm problem is by suppressing the number of redundant packets. This is typically solved by selecting a specific vehicle to relay the packets rather than to rebroadcast it. Priscilla et al.,[6] proposed the Connected Dominating Set(CDS) method to broadcast the message in VANET. By reducing the total number of forwarders, the number of retransmissions is reduced. The major drawback in CDS method is that, redundancy is not reduced when there is simultaneous transmissions. Korkmaz et al.,[7] explained the Urban Multi-hop Broadcast (UMB) protocol to solve the reliability in Multi-hop broadcasting and the broadcast storm problem. The relay vehicle tries to select a far relay vehicle in the intended direction on a linear road through Request To Broadcast (RTB) packet and Clear To Broadcast (CTB) packet. In order to disseminate the message in all directions, a repeater vehicle is employed at the intersection to rebroadcast the message. T.Seng et al.,[8] investigated the Counter-based and Distance based scheme to mitigate broadcast storm problem. The Counter based scheme uses a threshold 'C', and a counter 'c' to keep track of the number of times the broadcast message is received. Whenever $c \geq C$, rebroadcast is terminated. In the Distance-based scheme , the authors use the relative distance'd' between vehicles to decide whether to rebroadcast or not. It states that when the distance'd' between two vehicles is short, the Additional Coverage (AC) of the new rebroadcast is lower. So rebroadcasting the warning message is not recommended. If 'd' is larger, the additional coverage will be larger. In VANET, routing is an important challenge for reliable messaging between V2V and V2I. VANET deals with different types of routing protocols like Geographical / Position Based Routing for effective communication in Vehicular Environment. One such protocol is Greedy Perimeter Stateless Routing (GPSR). It is used to transmit message to the farthest nodes by finding Relay Node positions through GPS.

GPSR utilizes the positions of routers and a packet's destination to make packet- forwarding decisions [9]. GPSR algorithm uses a greedy algorithm to establish the route. The source node chooses a node that is nearest to the destination from its neighbors as its next hop. Xu et al.,[10] developed a Delay based Broadcasting technique called DAYcast. It allows the effective neighbors of the source vehicle to broadcast the received packet and selects the forwarder the based on the position of one hop neighbors. Imen et al.,[11] proposed a simple and efficient beaconless strategy for safety applications. Each vehicle dynamically defines a probability of rebroadcast to mitigate the broadcast problem. Manoel et al., [12] designed a probabilistic technique for the broadcast storm problem using a game theory called the volunteers dilemma. Yang et al.,[13] proposed a data dissemination technique for both broadcasting and on demand scenarios. Nearest neighbor prediction algorithm with self feedback is used for emergency message broadcasting. Although the above mentioned data dissemination mechanisms can reduce some network overheads, they do not have an appropriate solution for emergency and personal interested information. This urges to a data dissemination technique which depends upon emergency broadcasting message. Calduwel Newton et al., [14] proposed Shortest Path Genetic Algorithm (SPGA) is proposed to perform efficient routing and the detection of Denial of Service (DoS) through immune mechanism. Nismon Rio et al., [15] developed a technique to identify the optimum path in MANETs. In which, nodes were calculated mathematically to count the neighboring nodes and delay of each link to find the optimum path.

III. RBCAST: A PROPOSED TECHNIQUE

Consider the dissemination of messages along a linear highway. The RSU periodically broadcasts messages to vehicles located in its vicinity. In order to deliver the data to many vehicles in a cost-effective way and without installing additional infrastructure, vehicles on the highway can be elected as Relay Node to support message propagation. If nodes were elected to forward the received packets, in a manner that is not properly coordinated, a substantial number of packets may be discarded, leading to low packet delivery ratio and low throughput. In this section, a broadcast based RBCAST technique is proposed to reduce the broadcast storm problem in urban scenarios. To simplify the analysis without the loss of generality, consider the forwarding of messages at one side. The advantage of RBCAST is that it abandons the arbitrary method used in the traditional VANETs that might cause a broadcast storm. The arbitrary method causes not only network congestion and subsequent loss of data but also wastes network resource.Despite some improvements in all the other protocols and UMB protocol that introduce a probabilistic resilient multicast scheme to avoid broadcast storm, broadcasting messages were repeated periodically to ensure the message coverage rate in the network. In Broadcast based data dissemination scheme, safety messages are transmitted every T_w seconds.T_w is the time interval between safety warning messages. In RBCAST mechanism, 'V' indicates vehicles, 'm' indicates the message sent or received by vehicle.In a flooding based broadcast, when a vehicle V starts the broadcast of a message it sends 'm' to all its neighbors. It is then rebroadcasted to other neighbors within the range. Assume a road as shown in Figure 2 with lane block after 4km.

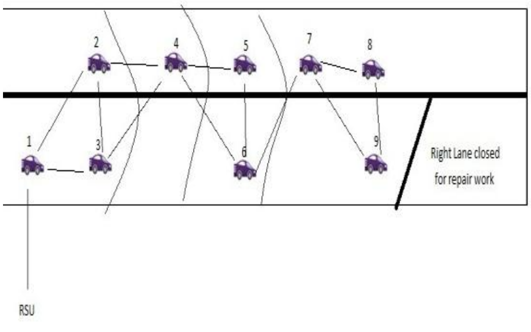

Figure 2. Flooding Based Data Dissemination

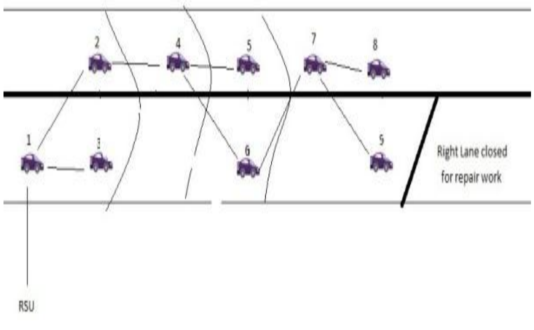

Figure 3. RBCAST Data dissemination

In Figure 2,The RSU first informs the vehicle 1. It then broadcasts to its neighbor vehicles. The neighbor vehicle in turn rebroadcast to other vehicles within its range. As it clearly shows that there are a pretty number of redundant transmissions which leads to broadcast storm problem.Figure 3 shows the broadcast based on RBCAST technique which is highly reliable upon the source node. After receiving a safety message from the RSU, node 1 broadcasts it to neighbor vehicles 2 and 3 by invoking the procedure for RBCAST. Consider vehicle 2 moves faster than vehicle 3. In this case, vehicle 2 is elected as a relay node and the flag is set as 'T' (means 2 is selected to rebroadcast the packets to its neighbors). At the receiving end, vehicle 2 verifies its flag has 'T' (True) or 'F' (False). It rebroadcasts if and only the selected vehicle's flag is set to 'T'. Thus, the redundant broadcast is eliminated.

Following are the number of steps involved in RBCAST:

1. Initially for disseminating data, the nodes (vehicles) send 'hello' message to the nodes. Upon receiving the reply from the neighboring nodes within the broadcast region ,source node checks the 'msg id' is same or not.
2. If the 'msgid' is same, it drops by not broadcasting the current 'msgid'.
3. If it's not same, it compares the speed of the neighboring vehicle.
4. It chooses the vehicle which is approximately more in speed and assigns flag 'T'.
5. Broadcast the packet to all the nodes after updating the flag
6. When a vehicle receives the packet it verifies the flag tag. If it has 'T' it rebroadcast the packet to the neighbor node within the range by repeating steps 1-5.

Finding distance using location information

The Procedure for proposed RBCAST:

```
procedure computedist (lt1 , ln1 , lt2 , ln2 )
{
        R←6378.137 ; //Radius of earth in KM
        dLt←( lt2 - lt1) ×3.14  / 180;
        dLn←( ln2 - ln1) × 3.14 / 180;
        b←sin(dLt/2)×sin(dLt/2)+cos(lt1×/180)×cos(lt2×/180)×sin(dLn/2)×sin(dLn /2);
        c←2×tan2(sqrt(b) ,sqrt(1-b));
        d←R×c;
        return d×1000; //it returns distance in meters
}
```

```
Let     Nj←Total Number of Vehicles within range
        Vi← Vehicle i
        lai←Latitude of Vehicle i
        loi←Longitude of Vehicle i
        laj←Latitude of Vehicle j
        loj←Longitude of Vehicle j
        Dij←Distance between vehicle Vi and Vj
        Ri←RSU
        Sj←Speed of Vj
        where 'i' represents relay node,
              'j' represents receiver Vehicle
```

```
Initialization:- Vi receives a packet P from Ri
If Vi receives P first then
        Extract Nj, lai, loi,Ti, laj, loj, Tj;
        Dij←computedist(lai, loi, laj, loj);
            Sj←Dij / Tij;
                If Sj max of speed in Nj then
                        set flag 'T';
                Else
                        set flag 'F';
                        Broadcast 'P' again;
                        return;
                End if
Else
            delete P;
            return;
End if
```

By using the latitude and longitude position of vehicles, the distance between any two vehicles on the road is calculated. Let, lt1,ln1,lt2,ln2 refer geographical latitude and longitude of two vehicles. The difference between two latitude positions and longitude positions is stated as dLt and dLn. Let 'c' represents the spherical angular distance or central angle which is calculated from the law of cosines. The distance is calculated by multiplying radius with central angle. In order to get distance in meters, 1000 is multiplied with the 'd'. The following procedure represents the calculation of distance between any two nodes.

Table 1 show the Values after the RBCAST Data Dissemination Procedure is executed. Total Distance between two vehicles is calculated based on the computedist procedure. Total time of the vehicle travelled during a specific period is shown. Using the distance and time, the average speed of the vehicle is listed. Vehicle with maximum speed within the range is marked as ‘T’.

Table 1. RBCAST Data dissemination

Vehicle No.	**Distances between vehicles**	**Total distance**	**Total Time**	**Speed**	**Flag**
V1	V1-V2	15.76964739	2	7.884824	T
	V1-V3	0.889581683	3	0.296527	F
V2	V2-V4	24.44212519	4	6.110531	T
V4	V4-V5	16.14147245	3	5.380491	F
	V4-V6	23.97380797	4	5.993452	T
V6	V6-V7	1.046589491	1	1.046589	T

IV.RESULTS AND DISCUSSIONS

Figure 3 clearly shows that the number of re-transmission in the proposed technique is reduced. Table 2 shows the number of retransmissions in the existing Broadcast based Data dissemination method.

Table 2. Comparison of Retransmission in Flooding Technique and RBCAST Technique

Vehicle number	Retransmissions in Flooding based method	Total No of Retransmissions in Flooding	Retransmissions in RBCAST method	Total No of Retransmissions in RBCAST
1	RSU-1	1	RSU-1	1
2	1-2 3-2	2	1-2	1
3	1-3 2-3	2	1-3	1
4	2-4 3-4	2	2-4	1
5	4-5 6-5	2	4-5	1
6	5-6 4-6	2	4-6	1

Figure 4. Graph for number of retransmissions in the Flooding Technique and the RBCAST Technique

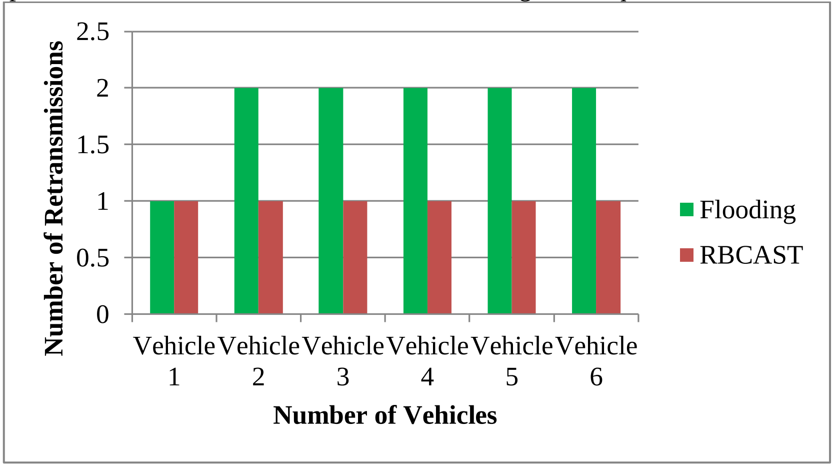

Figure 4 shows that the number of retransmission is decreased when compared to the proposed technique with the Flooding technique.

V. CONCLUSION

It is very important to achieve an efficient dissemination of messages in VANET, so as to warn the drivers about the critical conditions. However broadcasting of warning messages leads to increase channel contention and packet collision due to simultaneous message transmission known as the broadcast storm problem. In this paper RBCAST method is proposed to reduce the broadcast storm problem which improves the performance of the warning message dissemination.

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