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A Refined Data Dissemination Technique to reduce Broadcast Storm Problem in Vehicular Ad-hoc Networks

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ABSTRACT

Recently a lot of attentions in the research is attracted by Vehicular Ad-hoc Networks (VANETs). In order to increase the road safety and comfort in driving, information dissemination acts as a tool among vehicles. The techniques used in Mobile Ad-hoc Networks (MANETs) for disseminating data are no longer helpful in VANETs. Although many data dissemination techniques were proposed, unique characteristics of VANETs bring out many research challenges. In this paper, a refined data dissemination technique is proposed to reduce Broadcast storm Problem based on the information shared by the neighbour nodes. Depending upon the number of neighbour nodes, packets are relayed. This leads to suppression of transmissions to give a better performance with low latency.

Keywords: Data Dissemination, Neighbour node, Relay, Transmission, VANETs.

1. INTRODUCTION

VANET is an autonomous system composed by a group of vehicles equipped with transceivers and Global Positioning System (GPS). Communications in VANETs are helpful for the drivers to react for an emergency situation as early as possible. Not only the driver and the passengers react for the situations, but they can make use of the Infotainment services such as searching for nearest Automated Teller Machines (ATM)s, chatting, accessing email, etc. The main goal of VANETs is to safeguard and to provide comfortable journey for the passengers [1]. VANETs are designed basically to transmit Emergency Warning Message (EWM) among vehicles. To avoid traffic accidents, Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication is needed. Some of the applications in VANET require EWM to be delivered with high reliability and low latency constraints. Due to high mobility, it has a dynamic topology. With this stream of research, Highway safety has gained more attractions such as Pre accidental and post Accidental warning, Safe turning at the junctions, Information about the traffic light, etc.

Each vehicle in VANETs acts as a router for transmitting the information, due to limited transmission range. For transmitting the EWM from source to destination (also called as Data Dissemination), Broadcasting is used. Broadcasting techniques used in Mobile Networks and VANETs are generally classified as

- Flooding based algorithms
- Probability based algorithms
- Neighbour knowledge based algorithms
- Position based algorithms

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Flooding is the basic approach among common Broadcasting mechanisms. The shared wireless medium blindly broadcasts packets leading to contention and collision. When broadcasting to the neighbour nodes, the effect of transmission to the neighbour node leads to number of duplicate packets. This is referred as the Broadcast storm problem [2].

In order to suppress the broadcast storm problem, broadcast technique follows the probability based methods, namely, 1-persistence, p-persistence and weighted p-persistence rule [3, 4]. Although many mechanisms have been proposed to reduce the broadcast storm, they are not effective for all range of node density and packet loads in VANETs [5,6]. Therefore Multi-hop broadcast in VANETs faces many challenges.

For enhancing the Multi-hop broadcast reception rates, many works depend on relay transmissions strategies. Some work states about the probability based methods and temporal ordered transmissions [7]. It is found that the rebroadcast suppression methods fails in medium and dense scenarios and must be complemented with other mechanisms.

The rest of this paper is organized as follows. Section 2 presents the related works. Section 3 explains the proposed technique Refined ReBroadCAST (RRBCAST). The Results and findings are provided in Section 4. Finally, Section 5 concludes this paper.

2. RELATED WORKS

Due to the characteristics of decentralization and high mobility in VANET, it is a challenging task to deliver EWM to all the vehicles with a required level of throughput. To minimize the issues caused when sending the packets by Unicast method, many researchers have started using the broadcasting methods.

Deng et al., [8] developed a reliable and efficient highway broadcast model based on gain prediction. They used the parameters such as Relative speed, inter-vehicle distance and coverage difference of neighbouring vehicle is converted into predictive gain. Neighbour node with the minimum gain is chosen as the next hop on every direction of the road. Gokulakrishnan et al., [9] proposed a Road Accident Prevention (RAP) technique in VANETs. RAP initiates a prevention scheme by constructing activities like Prediction Report (PR), generating Emergency Warning Message (EWM) based on abnormal PR, forming a Vehicular Backbone Network structure and disseminating the EWN to high risk factored vehicles.

Celimuge et al., [10] proposed a path diversity mechanism for high reliability and low delay Multi hop protocols. It is a sender oriented broadcast protocol which chooses one auxiliary node for each relay node. Both nodes rebroadcast the received packet but only the relay node selects the next auxiliary and relay node. The auxiliary node rebroadcast only once.

Ihn et al., [11] in order to disseminate safety message in VANETs, proposed an early warning intelligence broadcasting mechanism called EW-ICAST. It uses the Time to Collision (TTC) which is the basis for early warning system. And also it uses basis of fuzzy logic. When an emergency situation occurs, the vehicle creates a TTC. If TTC is less than the threshold TTC, the broadcasts safety message. If the average speeds of the vehicle is more it uses Hybrid Intelligent broadcast (HI-CAST). Otherwise it uses Intelligent broadcast mechanism (I-CAST).

Tina et al., [12] proposed a technique based on neighbour vehicle distance and speed. One hop neighbour vehicle with maximum speed is chosen as the relay node for the next hop. Celimuge et al., [13] developed a protocol which provides light weight and reliable solution for data dissemination in VANETs. This protocol creates a dynamic vehicle backbone using vehicle movement and link quality based on fuzzy logic algorithm. Koosha et al., [14] proposed a combined architecture of V2V, DTN communication and V2I communication. It adopts the idea of store and carry forward communication model.

3. RRBCAST : A PROPOSED TECHNIQUE

The advantage of RRBCAST is that it does not use the traditional method applied in VANETs which causes the Broadcast storm problem. The traditional method wastes the network resource. Despite many improvements in the mechanisms developed for broadcasting the emergency messages, still research on finding an efficient method is under progress. The proposed RRBCAST reduces the number of rebroadcasting and guarantees that all the vehicles receive the EWM.

Assume all the vehicles are moving on a linear highway. When a data is received by the source node it checks the neighbour nodes within the range by exchanging the hello messages. Sender chooses a neighbour node within the broadcast range. It is assumed that each node knows its neighbour list. Using this information, sender chooses the vehicle which has at least two neighbour nodes at its 1 hop. If so, then it sets the flag as true for that vehicle and broadcast the data. All the neighbour nodes upon receiving the data checks whether it is chosen as the relay vehicle or not. If it is selected as a relay node, then it acts as the sender and the process is repeated. The RRBCAST technique is explained as follows with the assumptions, methodology, flow diagram and pseudo code.

3.1. Assumptions

This paper consists of the following assumptions:

- Each vehicle knows its current position using the Global Positioning System (GPS). This information is exchanged periodically among the neighbours using beacons. The beacon message adheres the standard WAVE Service Advertisement (WSA) format where WAVE means Wireless Access in Vehicular Environment. The information is as shown in Table 1.

Table 1
Beacon message format

Bits	1-16	17-32	33-48	49-64	65-80
Fields	Vehicle Id	Vehicle Position	Speed	Timestamp	Neighbour Vehicles

- All the vehicles have the knowledge of its neighbouring vehicles (E.g., current position, speed, one hop neighbours position and its neighbour hops) by exchanging the Beacons.

3.2. Methodology

Following are the number of steps involved in RRBCAST.

1. Extract the broadcast radius R, for Source node 'S'. Then traverse the neighbour set X of S. For each node in X, if the distance is less than R and the direction of the nodes in X is same then choose X as the neighbour.
2. For each node in X extract the one hop neighbours and name it as H_x.
3. Node that is within the transmission range R and $N_n \geq 2$ is chosen as the Relay node.

   Where - $N_n = |H_x|$ Total number of nodes in neighbour set.
4. Source node Broadcasts the EWM to one hop neighbours using the format as shown in Table 2.

Table 2
Emergency Message format

Bits	8 16	24 32	40 48	56 64
Broadcast header	Type	Priority	Sender ID	Hop Count
	Relay Vehicle 1	Original MAC Address	Relay Vehicle 3	Relay Vehicle 4
Emergency Payload	MinDist	Relay Vehicle 2	Emergency Message ID	Sender Longitude
	Sender Latitude	DissDirec	Emergency Warning Message	

The complete Emergency format contains 320 bits and particular field represents:

- **Priority**: this field is used by WAVE MAC Layer which assigns packet to the corresponding traffic class.
- **Sender ID**: Identifies the originating vehicle number.
- **Hop Count**: represents the number of hops from the originating node to the node currently processing the broadcast.
- **Relay vehicle's**: specify a flag to inform whether it is a relay vehicle or not.
- **Min distance**: this field specifies the minimal broadcast distance from the originating position.
- **Diss Direc**: specifies which dissemination direction the vehicle is heading.
- **Emergency Message ID**: ID of the Emergency message
- **Sender Latitude and Longitude**: Position of the originating node.

3.3. Flow diagram

Figure 1 describes the flow diagram of RRBCAST.

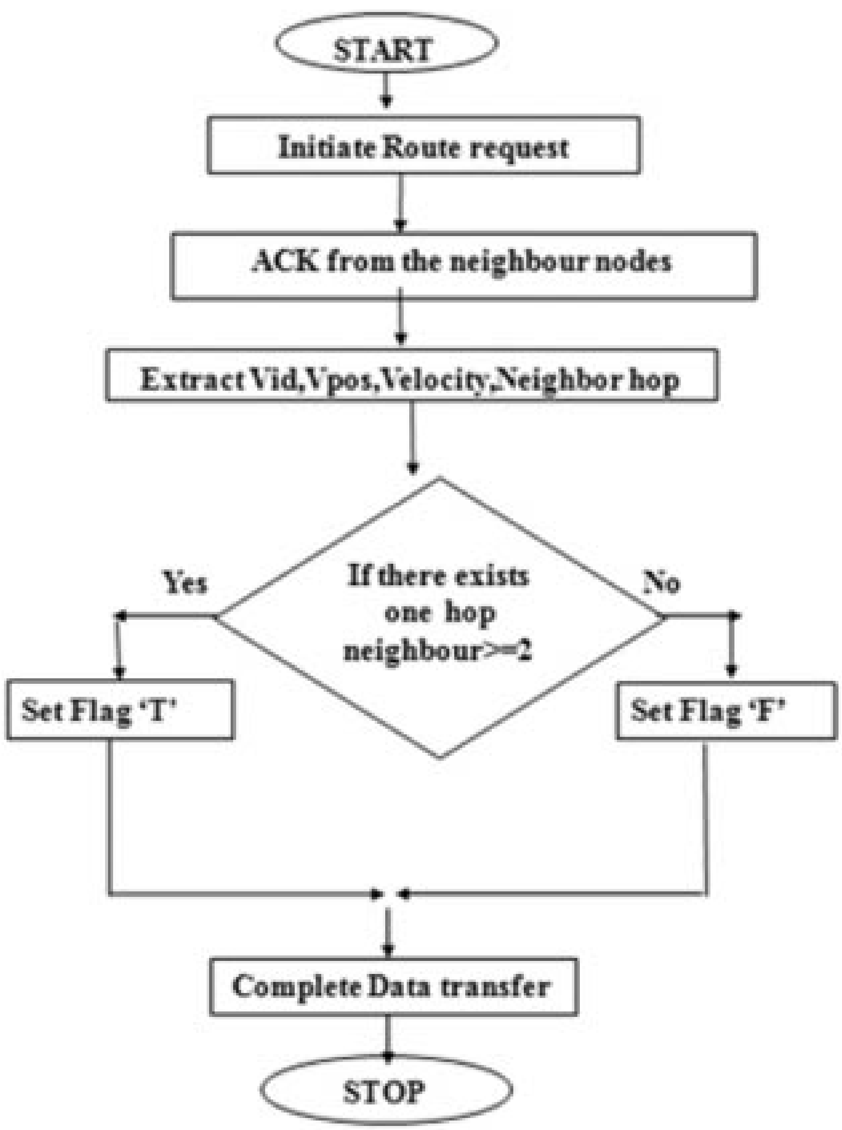

Figure 1: Flow diagram of RRBCAST

3.4. Pseudo Code of RRBCAST

Notations:

R←Transmission range

EWM←Emergency warning message

V_{id}←Vehicle id

V_{pos}←Position of the vehicle

E_{id}←EWM unique id

V_h←Set of neighbour nodes

V_{relay}←Relay Vehicle with flag 'T' or 'F'

T←True

F←False

RRBCAST

Procedure Sender_Oriented()

Start

Sender Vehicle,V_S sends the message "Hello"

Receive Response from neighbours.

1. Read V_{id},V_{pos},V_h
2. Check V_{pos} is within the range R
3. ***For*** each Vi_d in V_h

If V_{id} has atleast two neighbour node at its one hop ***Then***

Rebroadcast EWM with E_{id}

Set V_{relay}='T'

Else

Rebroadcast EWM with E_{id}

Set V_{relay}='F'

End if

Go to: Receiver_Oriented();

End for

End

Procedure Receiver_Oriented()

Start

If received E_{id} already exists ***Then***

Discard E_{id} and EWM

Else

If V_{relay}=T ***Then***

Call Sender_Oriented();

Else

Don't forward E_{id} and EWM;

End if

End if

End

4. RESULTS AND FINDINGS

Assume a scenario as represented in Figure 2. It shows the data dissemination using flooding based technique. In Existing flooding based technique, each sender vehicle chooses more than one relay node (i.e., one relay and more than one auxiliary node) thus forming redundant transmissions.

4.1. Case 1

Figure 3 shows the data dissemination under RRBCAST scenario. Initially, the data is broadcasted from node 1 to 2 and 3. Node 3 has two neighbour nodes at its one hop. But node 2 has no neighbour node at its one hop. In this situation node 3 is selected as a relay node which rebroadcasts further.

Table 3 shows the comparison of Flooding based transmission and RRBCAST. It is clearly found that in Flooding based transmission, the total number of Broadcast is 13 whereas in RRBCAST the total number of transmission is 9. Thus the number of transmission is reduced comparatively.

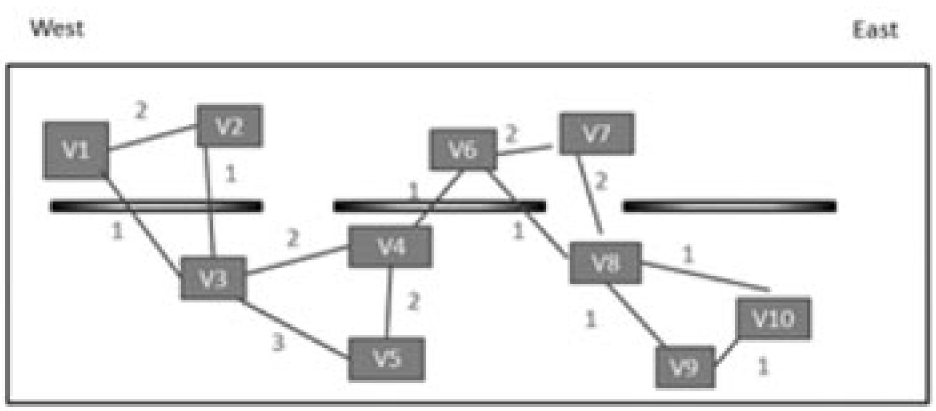

Figure 2: Existing Flooding based method

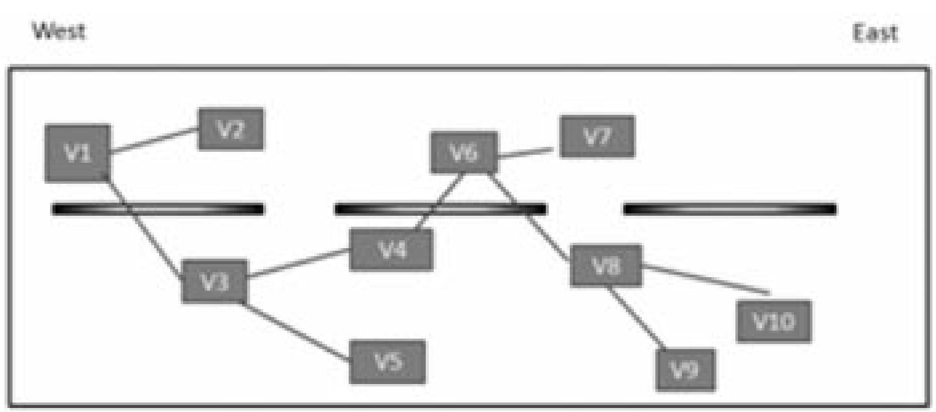

Figure 3: Proposed technique RRBCAST

Table 3
Comparison of Flooding based Transmission and RRBCAST

Vehicle ID	*Transmission in Flooding based*	*Total Transmission in Flooding based*	*Transmission in RRBCAST*	*Total Transmission in RRBCAST*
1	1→2, 3	2	1→2, 3	2
2	2→3	1	2→0	0
3	3→4, 5	2	3→4, 5	2
4	4→6	1	4→6	1
5	5→4	1	5→0	0
6	6→7, 8	2	6→7, 8	2
7	7→8	1	7→0	0
8	8→9, 10	2	8→9, 10	2
9	9→10	1	9→0	0
10	10→>0	0	10→0	0
Total in Flooding based and RRBCAST	13		9	

Figure 4 shows the Graphical Representation for number of Transmission in the Flooding based Technique and RRBCAST Technique. It is clearly found that the number of transmission under RRBCAST is reduced for vehicle 2, 5, 7 and 9. Thus the Broadcast Storm problem is also reduced.

4.2. Case 2

Figure 5 represents the Flooding based transmission when there are equal neighbour nodes at its one hop.

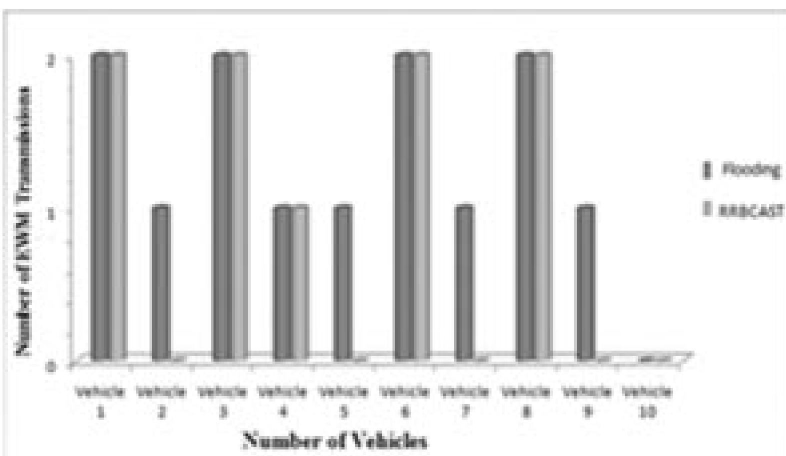

Figure 4. Number of Transmissions in the Flooding based Technique and RRBCAST

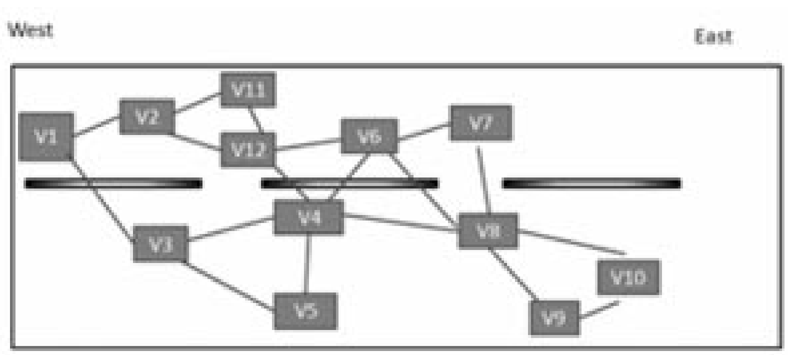

Figure 5.Flooding based Transmission when there are equal nodes at its one hop

Figure 6 shows the data dissemination in RRBCAST, when there is an equal neighbour node at one hop. In this case sender verifies the response time for the hello message shared by the neighbour node. Node which responded quickly (less response time) is selected as the relay node.

Table 4 shows the response time of each node. Vehicle 2 and 3 has equal neighbour nodes. Sender checks the response time of 2 and 3. Comparatively node 3 responds quickly than node 2. So vehicle 1 chooses 3 as the relay node.

Table 5 shows the comparison of Flooding based transmission and RRBCAST when there is an equal neighbour node at its one hop. It is found that in Flooding based transmission, the total number of Broadcast transmission is

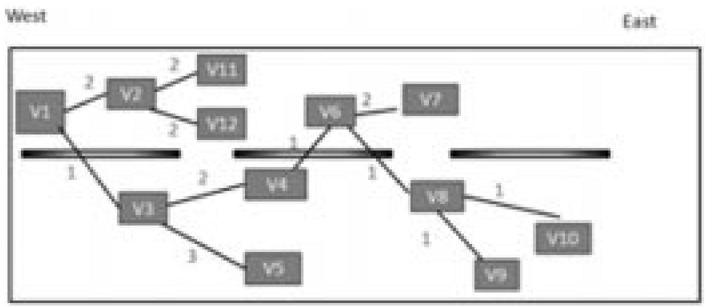

Figure 6: RRBCAST: Data Dissemination with equal neighbour hops

Table 4
Response time of vehicles

Vehicle No.	*Delay in Milli- seconds (ms)*
2	2
3	1
4	2
5	3
6	1
7	2
8	1
9	1
10	1
11	2
12	2

Table 5
Comparison of Flooding based Transmission and RRBCAST when there is an equal neighbour node at its one hop

Vehicle ID	*Transmission in Flooding based*	*Total Transmission in Flooding based*	*Transmission in RRBCAST*	*Total Transmission in RRBCAST*
1	1→2,3	2	1→2, 3	2
2	2—>11, 12	2	2→11, 12	2
3	3→4,5	2	3→4, 5	2
4	4→6, 8	2	4→6	1
5	5→4	1	5→0	0
6	6→7, 8	2	6→7, 8	2
7	7→8	1	7→0	0
8	8→9, 10	2	8→9, 10	2
9	9→10	1	9→0	0
10	10→0	0	10→0	0
11	11→12	1	11→0	0
12	12→4, 6	2	12→0	0
Total in Flooding based and RRBCAST		18		11

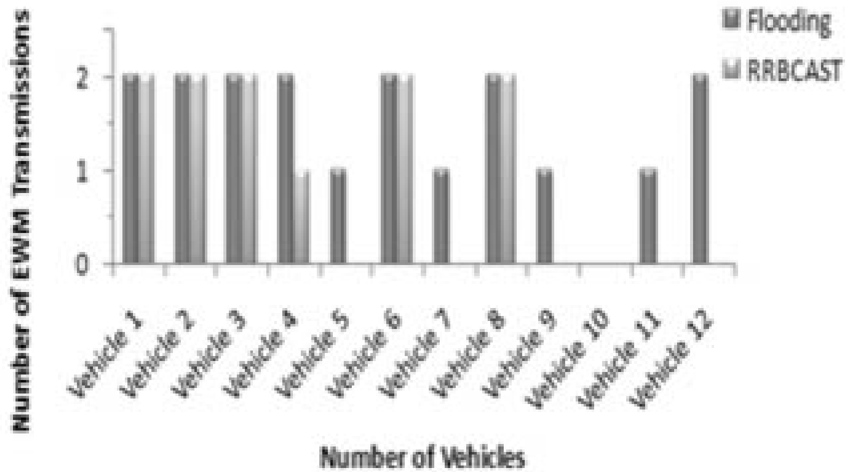

Figure 7: Number of Transmission in the Flooding based Technique and RRBCAST when there is equal number of neighbour node at its one hop

18 whereas in RRBCAST the total number of transmission is 11. Thus the number of transmission is reduced comparatively.

Figure 7 shows the Graphical Representation for number of Transmission in the Flooding based Technique and RRBCAST Technique. The number of transmission under RRBCAST is reduced for vehicle 4,5,7,9,11 and 12. Even though the number of vehicles gets increased, the Broadcast Storm problem is also reduced.

5. CONCLUSION

It is necessary to implement Data Dissemination under cases where safety is needed. But due to simultaneous transmission by different vehicles, the receiving vehicle gets same data repeatedly. This forms the Broadcast storm problem. RRBCAST technique is proposed to handle the problem and results a better performance with low latency.

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