

IBCAST: An Intelligent Broadcasting Technique for Efficient Bandwidth Utilization in Vehicular Ad-hoc Networks

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Abstract

Objectives: To propose a new Data Dissemination Technique that intelligently works for finding the Best forwarding node. By using this forwarding Technique, the effective utilization of Bandwidth is achieved. **Methods/Analysis:** The Link Expiration Time and the Distance Rate is calculated between two vehicles within a Transmission Range. Node having the minimum Link Expiration Time is chosen as the next forwarder. **Findings:** Number of Redundant Transmission is reduced and the Bandwidth is efficiently utilized in Vehicular Ad hoc NETWORKS (VANETs). **Conclusion/Application:** This paper proposes an Intelligent Broadcasting Technique which involves selecting best Forwarder node. Thus it reduces the number of redundant transmission and utilizes the Bandwidth efficiently.

Keywords: Data Dissemination, Link Expiration Time, Relay, VANET, V2V

1. Introduction

The word Ad-hoc evolved from the language Latin which means “for this purpose only”. A VANET is a type of Mobile Ad-hoc Network (MANET)¹ that is used to provide communications between nearby vehicles, between vehicles and fixed infrastructure on the roadside. Without following any fixed infrastructure or centralized administration, a set of vehicles can move freely and relay packets. This is referred as VANET. Each vehicle in the network has an On Board Unit (OBU) and is called as node.

In order to increase Road safety and awareness to the drivers, many Application plays a vital role in transmitting the alert message to the neighbour vehicles. There are two types of applications commonly used by the VANET 1. Safety 2. Infotainment^{2,3}. Safety Application aims to minimize accidents by informing alert to all nodes in the range. Infotainment application provides driver with information, advertisements and entertainment during the journey

In order to communicate between Vehicle to Vehicle and Vehicle to Road side Unit, the Federal Communication Commission (FCC) allocated a frequency spectrum in 1999. The FCC then established the Dedicated Short Range Communications (DSRC) service in 2003⁴⁻⁶. In VANET Vehicles can communicate with one another with the help of Dedicated Short Range Communication (DSRC). DSRC uses the 5.850-5.925GHz frequency band for safety and private related applications.

In VANET vehicles communicate with the help of DSRC. Neighbouring vehicles that are within a transmission range directly communicate over a wireless links. VANET supports vehicles that are equipped with computing device, short range wireless interface and Global Positioning System (GPS) receiver. This paper proposes an Intelligent Broadcast Technique.

The rest of this paper is organized as follows. Section II presents the related works. Section III explains the proposed technique An Intelligent BroadCAST (IBCAST) Technique. The Results and findings are provided in Section IV. Finally, Section V concludes the paper.

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2. Related Works

Recently Different kinds of Techniques were proposed to address the Data Dissemination Techniques in VANET. For Safety Message Dissemination Some techniques were specifically designed.

Due to excessive amount of redundant transmissions with limited Bandwidth resources, many of these techniques are facing the Broadcast storm problem. In order to find solution to this problem, many researchers have proposed various Techniques.

In⁷ compared the different data collection schemes based on communication overhead, latency and Packet delivery ratio. In⁸ proposed a method to address the problem of detecting and correcting attack in VANET to enhance the safety of the nodes. it is shared with the immediate neighbours to improve the broadcasting rate. In⁹ designed a technique to find an efficient path for reliable routing of data packets using stable links¹⁰ discussed about the existing Broadcasting techniques with their advantages and disadvantage both in sparse and dense network.

In¹¹ proposed hop by hop multicast routing scheme based on link stability from source to receivers. The path is constructed by route request and route reply packets with the help of cache and database maintained at every node. By minimizing the impact of receiver departures, this technique supports unicast clouds, allowing incremental deployment to have a stable tree structure,

In¹² used Minimum Calculated Desired Time (MCDT) for Intelligent Data Dissemination in VANETs. First the link stability is computed. Then a peak stable zone is constructed which is used to estimate the virtual connectivity of the nodes. For recovering the lost link using minimum angle method a method is proposed.

In¹³ designed a technique to raise the life span of the direction and to lessen the need for route maintenance. An algorithm titled “Enhancing Link Stability of Multicast Routing Protocol (ELSMRP) in Wireless Mesh Networks” is proposed. This method modifies the route detection method to discover the most secure route against route failure and movement of mobility node.

In¹⁴ intended to employ hybrid approach for establishing a link between two neighbouring nodes in “Adjustable Parameter Based Information Dissemination Model (APIM) for VANET”. Hybrid approach behaves differently within and outside zone. In¹⁵ proposed a Simple and Efficient Adaptive Data dissemination

Protocol (SEAD) which combines delay and probability based dissemination techniques. It reduces excessive broadcasts.

In¹⁶ proposed a Reliable Coverage Area (RCA) based LET routing metric which helps in selecting reliable and stable links. In¹⁷ discussed about the different kinds of Routing protocols in Mobile Ad-hoc Networks. Due to mobility of nodes, the node has to find another route for transferring the data. For this reason route must be discovered where there is no link breakage before all the packets reach the destination.

In¹⁸ proposed a protocol called Border node based Most Forward Progress within Radius Routing (BMFR) Protocol where only the nodes present inside the Border of the senders transmission range are selected as the next trip nodes for further packet transmission. Poisson distribution method is used to develop a mathematical model to estimate the path duration in VANETs.

In¹⁹ designed next hop vehicle selection algorithm based on multi metric for geo casting in VANETs. To increase efficiency and performance knowledge of the link lifetime is needed. With the help of velocity and density or degree link life time is estimated based on the empirical study.

3. IBCAST: A Proposed Technique

This paper introduces a new Technique IBCAST in order to find the best next forwarder that intelligently transmits the Data packets to a number of receivers. It combines the mobility and the neighbour information. Based upon this, it finds Link Expiration Time. A source vehicle sends the Hello message to its neighbour vehicles. Upon receiving the acknowledgement, source vehicle finds whether the individual neighbour vehicle is within the coverage area. This is done with the help of calculating the Distance rate.

3.1 Distance Rate

Upon reception of Hello message from one vehicle ‘i’ (Source vehicle or previous relay), a vehicle ‘j’ computes a Distance Rate (DR_{ij}) which is defined in Equation 1.

$$DR_{ij} = \frac{d_{ij}}{R} = \frac{\sqrt{(X_i - X_j)^2 + (Y_i - Y_j)^2}}{R} \quad (1)$$

3.2 Link Expiration Time

The Link Expiration Time (LET) is the estimated time that two nodes maintain association between them in the VANET. Each vehicle in the VANET can predict a LET using the position and mobility information provided by GPS, For this, it is assumed that vehicles are equipped with GPS devices. Therefore, by using the known position, speed and direction of two neighbour nodes, the time that the association can be maintained between these two nodes can be predicted. The objective of this metric is to select a most stable link between two vehicles. Consider two vehicles ‘i’ and ‘j’ which is identified by coordinates (X_i, Y_i) and (X_j, Y_j) and move in directions θ_i, θ_j ($0 \leq \theta_i$ and $\theta_j < 2\pi$) with speed Vel_i and Vel_j at an instant, respectively, and R be the wireless transmission range of nodes. Using Equation 2 the LET can be estimated.

$$LET_{ij} = \frac{(ab - cd) + \sqrt{(a^2 + c^2)R^2 - (ad - bc)^2}}{a^2 + c^2} \tag{2}$$

Where

$$a = V_i \cos\theta_i - V_j \cos\theta_j$$

$$b = X_i - X_j$$

$$c = V_i \sin\theta_i - V_j \sin\theta_j$$

$$d = Y_i - Y_j$$

$i, j =$ Any Two Vehicles

$Vel_i =$ Speed of Vehicle ‘i’

$Vel_j =$ Speed of Vehicle ‘j’

R = Transmission Range of nodes

In the above statements ‘a’ represents the relative velocity of the receiver node with the sender node along X axis. ‘b’ represents distance of the sender and receiver along X axis, ‘c’ represents relative velocity of the receiver node with the sender node along Y axis, and ‘d’ represents distance of the sender and receiver along Y axis.

Following are the steps involved in disseminating data through IBCAST and the Flow Diagram is shown in Figure 1.

1. Initially source vehicle sends Hello messages to the neighbour vehicle.
2. Upon receiving the Hello message, neighbour vehicle sends the information like co-ordinates, Velocity and Direction.
3. Sender then checks whether each neighbour vehicle is within the transmission range by calculating the Distance rate.
4. If the vehicle is within the Transmission range, source vehicle Broadcasts the safety message called

Emergency Warning Message (EWM).

5. Source vehicle then finds whether LET is more than LET_Threshold.
6. If it’s true, then it finds the minimum of LET and selects that vehicle as relay node for further broadcast.

3.3 Flow Diagram

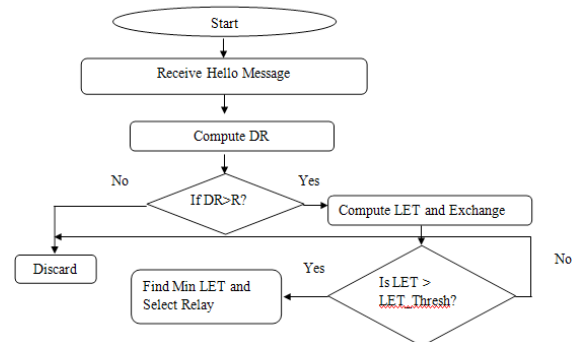


Figure 1. Flow Diagram of IBCAST.

3.4 Pseudo code

Notations

- R ← Transmission range
- EWM ← Emergency Warning Message
- V_{id} ← Vehicle id
- E_{id} ← EWM unique id
- V_{relay} ← Relay Vehicle with flag ‘T’ or ‘F’
- T ← True
- F ← False
- Vel_i ← Velocity of vehicle i
- Vel_j ← Velocity of vehicle j
- la_i ← Latitude of Vehicle i
- lo_i ← Longitude of Vehicle i
- la_j ← Latitude of Vehicle j
- lo_j ← Longitude of Vehicle j
- DR ← Distance Rate
- LET ← Link Expiration Time
- D_{ij} ← Distance between vehicle V_i and V_j
where ‘i’ represents source vehicle,
‘j’ represents receiver Vehicle

IBCAST Procedure

Start

When a vehicle receives HELLO Message it computes

DR

If (Vehicle i is within Transmission Range) Then compute LET and exchange it with neighbours.

upon receiving LET from neighbours, update in LET

list table.

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If (LET > LET-Threshold) Then
    find Minimum(LET) and select
Relay node
else
    discard the message
End If
    
```

```

Else
Discard the message.
End if
End
    
```

4. Results and Discussions

Assume a Highway scenario as shown in Figure 2. Each vehicle is travelling from west to East. Consider there is a safety message (e.g., Avoid using cell phone while driving) to be disseminated from the source vehicle to all the vehicles travelling on the same highway. IBCAST is used to disseminate safety message in an efficient way than the SEAD based transmissions.

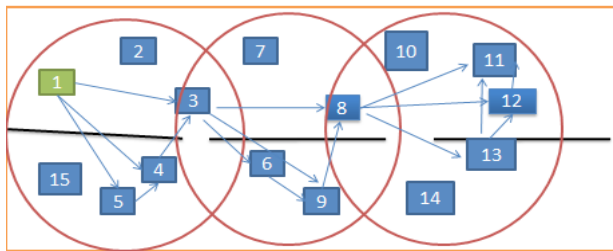


Figure 2. SEAD Data Dissemination.

From Figure 2, it is observed that in a SEAD based data dissemination, redundant transmissions occur. Consider the data dissemination in Figure 3. Based on the minimum value of LET, vehicle which reaches out of the transmission range quickly is elected as a relay vehicle. Vehicles represented in Red color are Relay vehicles chosen and Green color vehicle is the source vehicle.

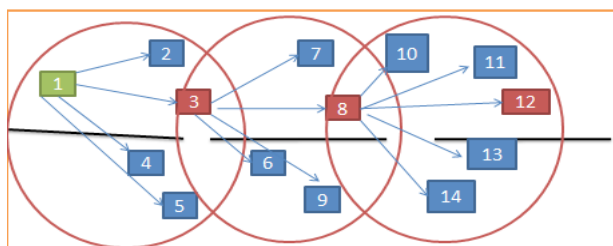


Figure 3. IBCAST Data Dissemination.

Table 1 represents the information of a vehicle gathered from the Beacon message exchanged. For e.g., Latitude of Vehicle id ‘1’ is the X_1 and Longitude of Vehicle id ‘1’ is Y_1 . Speed is represented as V_{el1} and Direction is represented as θ_1 . By using this vehicle information distance rate and the LET is calculated with the help of equation 1 and 2 for all the vehicles.

Table 1. Vehicle Information

Vehicle id	Latitude	Longitude	Speed	Direction
1	10.815042	78.67733	50	60
2	10.815051	78.677347	60	60
3	10.81504	78.677353	70	60
4	10.81506	78.67739	55	60
5	10.815043	78.677418	53	60
6	10.815081	78.677463	65	60
7	10.815061	78.677483	67	60
8	10.815098	78.677509	45	60
9	10.81508	78.677537	74	60
10	10.815112	78.677567	40	60
11	10.815094	78.677587	50	60
12	10.815124	78.677619	65	60
13	10.81511	78.677647	63	60
14	10.81514	78.677674	54	60

Applying Equation 2 with the values specified in Table 1, the calculated LET is specified in Table 2. Vehicle 1 communicates with Vehicle 2,3,4,5. After calculating the LET, Vehicle 3 has the minimum LET value. So it is chosen as the next Forwarding node. Similarly Vehicle 3 calculates the LET of Vehicle 6,7,8,9. Vehicle 8 has minimum LET and it is selected as the next Forwarding node. This process continues until all the vehicles receive the safety message.

Table 2. LET for Vehicle Links

Vehicle Link	LET
1---2	9
1---3	4
1---4	17
1---5	28
3---6	17
3---7	29
3---8	4
3---9	22
8---10	17
8---11	17
8---12	4
8---13	5
8---14	10

Table 3 represents the number of times the safety message is received in the Existing SEAD based Data dissemination and in IBCAST.

Table 3. Comparison of Number of Transmissions in SEAD and IBCAST

Vehicle id	Number of times Safety message Received	
	SEAD	IBCAST
1	1	1
2	0	1
3	2(1,4)	1
4	2(1,5)	1
5	1	1
6	1	1
7	0	1
8	2(3,9)	1
9	2(3,6)	1
10	0	1
11	3(8,12,13)	1
12	2(8,13)	1
13	1	1
14	0	1
15	0	0

The graphical representation of Table 3 is shown in Figure 4. It is clearly found that the number of redundant transmissions is reduced in IBCAST when compared to SEAD.

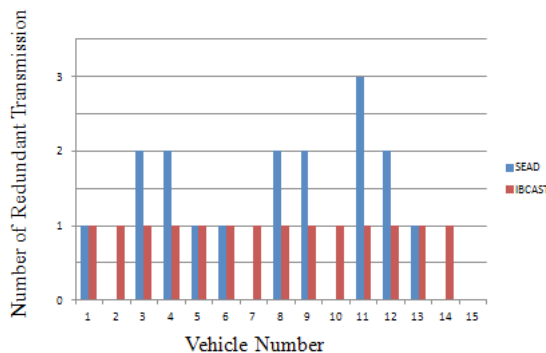


Figure 4. Number of Redundant Transmission in SEAD and IBCAST.

On the basis of Simulation results presented in Figure

5, it is noticed that the Bandwidth utilization decreases with SEAD and IBCAST. This shows the impact of forwarding node selection on reducing the number of redundant transmission thus saves bandwidth efficiently.

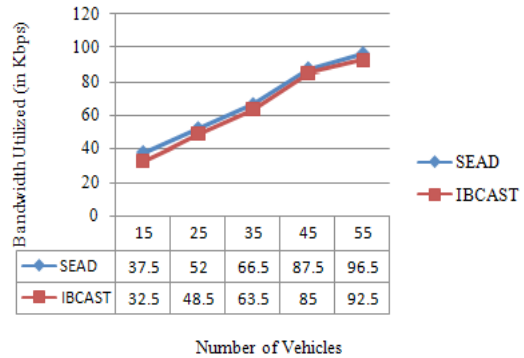


Figure 5. Bandwidth Utilization in SEAD and IBCAST.

5. Conclusion

In this paper, a new Data dissemination technique is proposed which chooses the best forwarder for relaying data packet using LET and Distance Rate. By combining both LET and Distance rate, the data dissemination to the next transmission range is achieved without redundant transmission. It is observed that the bandwidth is efficiently utilized in IBCAST when compared to SEAD.

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