A comparative study of Broadcasting Protocols in VANET

A.Noble Mary Juliet[1], Vijayakumar.S[2], Joan Pavithra.R[2], Kaleeswari.P[2]

[1]. Assistant Professor, Dept of Computer Science and Engineering

[2]P.G Scholars, Dept of Computer Science and Engineering

N.P.R College of Engineering and Technology, Natham, Tamil Nadu, India

ABSTRACT:

Vehicular Ad-hoc Network (VANET) represents a challenging class of mobile ad-hoc networks that enables vehicles to intelligently communicate with each other and with roadside infrastructure. Reliable and efficient broadcasting in vehicular ad hoc networks is one of the keys to success for services and applications on intelligent transportation system. Many protocols have been introduced but none of them has been evaluated in realistic scenario. In this research, we discuss the reliable broadcasting protocols such as Distance Based Routing (DBR), Street cast and Acknowledgement-Based Broadcasting Protocols (ABBP) on VANET. Then, we evaluate performance of these protocols by simulation. From simulation result, we found a performance and problem in each protocol, which can lead to broadcast storm problem and inefficient operation.

Keywords: *DBR, ABBP, Streetcast, VANET.*

I. I.INTRODUCTION

Work on the ad hoc network begins from 1970s when network were originally called packet radio networks. Inter-vehicle communications (IVC) and Roadside-to-Vehicle communication (RVC) are becoming one of the most popular research topics in wireless communications. Capability of VANET has to provide safety and traffic management: vehicles can notify other vehicles of hazardous road conditions, traffic jamming, or rapid stops [5].

VANET is formed by vehicles with wireless equipment for communication. It allows vehicles to communicate directly to each other without infrastructure deployment.

VANET is one of the special forms of mobile ad hoc networks (MANET), which gains interest from many researchers. But VANETs are different from MANETs in several ways. First, vehicles are in large volume, and network topology changes rapidly. Second, the mobility of vehicles is constrained by roads with limitations on driving speed. Although vehicles can move in high speed, their directions and speeds are predictable. Third, vehicles usually do not have tight energy budget. Instead, bandwidth issues are more critical than energy ones in VANETs [5] [7].

VANET brings up the communication solution instead of relying on infrastructure to be ready. So most of applications in Intelligent Transportation System [2] can exchange information directly with less delay. To achieve this, communication protocols must cope with the mobility of vehicles and the dynamics of wireless signals.

Broadcasting is the task of sending a message from a source node to all other nodes in the network. The two major challenges of broadcast are to ensure the reliability of messages while disseminating message over the intended regions and keeping the delay time within the requirements of the application. The design of reliable and efficient broadcast protocols is a key enabler for successful deployment of vehicular communication services. To design a reliable and efficient broadcast protocols. One should take the following metrics into considerations. The first metric is reliability; that is, a broadcast message should deliver to as many vehicles as possible. Second metric is overhead; that is, delivery of the broadcast message to all vehicles should generate as few redundant messages as possible. The last metric is speed of the data; that is, a broadcast message should be delivered to all vehicles as fast as possible. Although a broadcast message can reach all vehicles, it can be meaningless if it arrives too late. This metric is very critical for emergency services.

In VANET, several reliable broadcasting protocols have been proposed such as DBR, ABBR and STREETCAST. The details of each protocol will be discussed in further. In this paper, we compare these reliable broadcasting protocols on VANET. We then evaluate the reliable broadcasting protocols in terms of reliability, overhead and speed of data by simulation. Our simulation results show problems on each protocol [6].

This paper is organized as follows. In Section II, details of the DBR protocol is described. In Section III, details of ABBP are described. In Section IV, details of STREETCAST protocol is described. In Section V, simulation and performance evaluation are shown. Section VI has a conclusion portion [1] [6].

II. DBR PROTOCOL

In DBR, every vehicle computes the inter vehicular distance between itself and its neighboring vehicles based on the propagation delay. This distance is calculated by using the following formula.

$$D = S * T \qquad (1)$$

Where D represents the inter vehicular distance, S represents the velocity and T is the propagation delay. From equation 1 that the D is directly proportional to S of the vehicle and T. Fig 1 depicts the procedure involved in determining the inter vehicular distance based on equation 1. The n1 and n2 represent two vehicles moving on road with velocity v1 and v2 respectively [3]. The vehicle n1 broadcasts position and speed information at time T0 and the vehicle n2 receives this information at time T1. Based on the information received, the vehicle n2 computes the intervehicular distance with respect to propagation delay using equation 4. The d2 represents the distance between the current positions of vehicle n1 at time T0. It is determined by equation 2. Similarly d1 as shown in equation 3 represents the distance covered by the vehicle n1 in time (T1-T0).

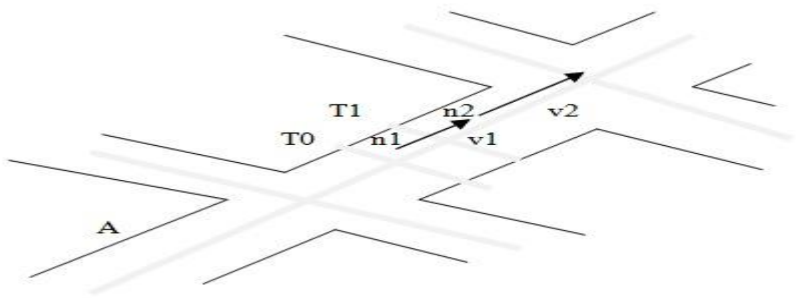

Fig 1. Calculation of intervehicular distance.

Vehicle identification number
Source X-coordinates
Source Y-coordinates
Destination X-coordinates
Destination Y-coordinates
Speed of the neighboring vehicle
Intervehicle distance

Table I: Routing Table

$$d2= v2 * (T1-T0) \qquad (2)$$
$$d1=v1 * (T1-T0) \qquad (3)$$
$$inter\_vehicular\_distance=d2-d1 \qquad (4)$$

In this approach every vehicle makes use of digital map. We suppose that digital map provides entire detail of the road network such as coordinates of intersection. All the vehicles determine its initial position using GPS technology or from users and identifies its location in the digital map. Table I represents routing table maintained by all the vehicles. The vehicles keep track of velocity and direction information. Whenever there is a change in these parameters, the vehicle will broadcast a hello message. The neighboring node which receives the hello message will updates its routing table accordingly and recomputed intervehicular distance analogous to change in velocity and also updates the vehicle ID,velocity,position information and coordinates of destination in the routing table. The size of the table depends on the traffic congestion of the road. When there is huge traffic congestion, maintaining all the vehicle information will increase the computational load. So the delay of updating and searching while forwarding the data is minimized with the help of varying table size... Then DBR forwards the data packet using both location information and vehicle ID present in the routing table.

Packet sequence number
Destination vehicle id
Next hop
Previous hop
Number hops

Table II: Data Forwarding Table

In ordered to forward the data packet, a vehicle selects the next hop based on the direction if the location of destination is known. Table II represents data forwarding table maintained by every vehicle. Before forwarding any data packet the parameters of data forwarding table associated with the data packet are stored in the table. The vehicle searches for necessary information in data forwarding table to select the next hop whenever a data packet is received [3].

III. STREETCAST PROTOCOL

This protocol comprises of three components: *relay-node selection, MRTS handshaking,* and *adaptive beacon control.* It uses two units such as Roadside Unit (RSU) and OnBoard Units (OBUs). RSU can pick up relay nodes from its one-hop neighbors and disseminate packets over specified road segments. The selected OBRs upon receiving messages disseminate packets in their forward direction. The selected OBUs will reply ACKs to ensure reliability [2].

A. Selection of Relay Nodes

In order to reduce redundancy, we apply the Multi-Point Relay (MPR) broadcast strategy to reduce the number of relay nodes. Every OBU and RSU maintains the neighbor table. Each node in VANETs periodically broadcasts a "hello" beacon, which includes the node's Dislocation and timestamp. When a node receives a "hello" beacon, it checks the digital street map and updates the neighbor information to its neighbor list. A neighbor is deleted from the table if no beacons are received from it for a period of time. Then the node with the optimal distance is picked from each neighbor list as a relay node.

B. Multicast Request to Send

We use MRTS to protect from collision. With MRTS mechanism, senders can send packets to multiple receivers simultaneously without worrying about collision and hidden-terminal problems. A sender transmits an MRTS and waits for CTSs from receiver. Nodes receiving MRTS frame set their NAVs (Network Allocation Vector) if they are not the relay nodes. Only relay nodes reply CTSs to the source following the order specified in the MRTS frame. Fig 2 illustrates the MRTS frame format [2].

2	2	6	6	6	6	6	6
FC	Duration	Src	Ra1	Ra2	Ra3	Ra4	FCS

FC: Frame Control
Duration: NAV Duration
Src: Source Address
Ra1, Ra2, Ra3, Ra4: Receiver Address
FCS: Frame Check Sequence

Fig 2. MRTS Frame Format

If transmission may fail due to loss of CTSs or ACKs. According to the number of received ACKs, a source can decide whether the transmission is successful or not, and re-initiate the MRTS procedure. If no CTS are received, then the source will directly re-initiate the MRTS procedure.

C. Adaptive Beacon Control

In urban areas, there could be thousands of vehicles moving across intersections in short period of time. If each vehicle keeps sending beacons, it will cause many collisions and failures. So, this protocol uses a beacon control mechanism to adjust beacon generation rate. The main function of beacons in this approach is to find the farthest neighbor in each direction for greedy forwarding. It is not necessary to let all nodes send beacons. There should be a proper number of nodes sending beacons.

IV. ABBP PROTOCOL

It is an adaptive broadcast protocol that is suitable for a wide range of mobility conditions. The main problem that a broadcast protocol must face is its adaptability to the very different vehicular arrangements in real scenarios. It should achieve high coverage of the network at the expense of as few transmissions as possible, regardless on whether the network is extremely dense or highly disconnected[1].

ABBP is localized. Vehicles are assumed to be equipped with Global Positioning System (GPS) receivers. Periodic beacon messages are exchanged to update the vehicles' local topology knowledge. The position of the sender is included within the beacons, which suffices to calculate a CDS (Connected Dominating Set) backbone after each beacon message round. The source node transmits the message. Upon receiving the message for the first time, each vehicle initializes two lists: list R containing all nodes believed to have received the message, and list N containing those neighbors in need of the message. Then each receiving node sets a time-out waiting period. If a node is not in the CDS, then it selects longer time-out than the nodes from the DCS, so that the latter reacts first. For each further message copy received, and its own message sent, every node updates R, N and the time-out. At the end of the time-out period, it transmits if N is nonempty. Both ways, the message is buffered until it expires. For each beacon message received, N and R are updated according to the presence or absence of acknowledgement. Nodes that are no longer one-hop neighbors are eliminated from these lists. Regardless of previous decisions, all nodes that so far received the broadcast message check whether N becomes nonempty. If so, they start a fresh time-out. In addition, acknowledgements of received broadcast messages are piggybacked to periodic beacons. Nodes that was included in R because they were believed to have the message, but did not actually get it, are later removed from R and inserted into N. This algorithm is executed for each different message. Therefore, the beacon size increases linearly with the number of simultaneous broadcasting tasks [1].

V. PERFORMANCE EVALUATION

For the purpose of performance evaluation detailed performance simulations are performed for three main VANET broadcasting protocols [7] i.e. DBR, ABBP and STREETCAST.

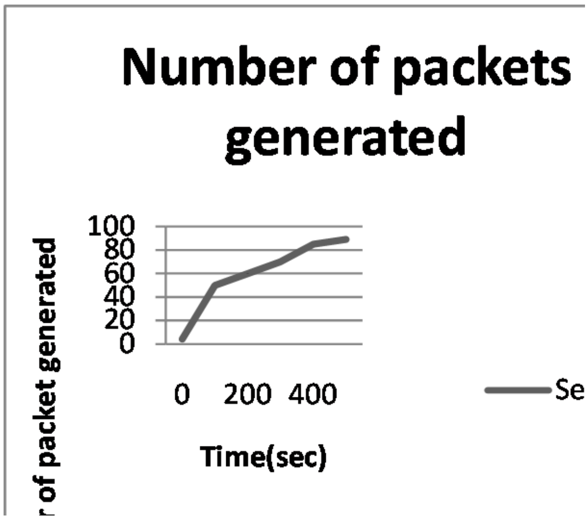

Fig. 3. Hello packets generated in unit time (DBR)

DBR is simulated using Network Simulator2 (NS2) and road map is generated using SUMO & MOVE. The simulation was carried out for duration of 500 seconds over an area of 1000sq. meters, with the varying traffic density of 100vehicles to 600vehicles. As indicated in Fig. 3 the number of hello messages generated directly depends on the number of vehicles and frequency of change in their velocity. Therefore, when compared to the traditional approach, it facilitates in reducing the number of hello messages involving periodic broadcast. And in this approach, the changes in the velocity of the vehicle do not affect the hop count because this approach selects the forwarding vehicle based on stability of velocity of the vehicle. The inter vehicular distance increases with increasing speed. In DBR, the next hop is selected from both routing table and forward data table depending on the vehicle speed and inter vehicular distance, so that the connectivity with the next hop is maintained for a longest duration [1].

In order to evaluate the performance of the Street cast, we use the GloMoSim 2.03 simulator, which is an event driven simulator. In Street cast approach, all nodes (OBUs, RSUs) have the same transmission and collision range with r=80m.

PARAMETRES	DBR	ABBP	STREET CAST
Transmission Range	250m	250m	80m
Vehicle Speed	100m/sec	50-80km/hr	30 – 50km/hr
Simulation Time	500s	120s (after steady state)	100s
Beacon Signal	Whenever change in velocity and direction parameter beacon signal is broadcasted	After source will send the message	Periodically broadcast the beacon signal
Preferred node selection	Based on the inter_vehicular distance.	Nodes within the CDS	Nodes with the optimal distance
Beaconing interval	Not periodically send	Periodically send	Periodically send
Information in a beacon message	Position of the vehicle, speed of the vehicle and destination coordinates.	Position of the sender, acknowledgement	Node's ID, location and timestamp
No of vehicles	100-600/ km	-	30cars/100m

Fig 4 Comparison chart of the protocols

Two nodes can directly communicate with each other if the distance between them is less than the transmission radius r=80m. The average traffic flow evaluated from the statistic data is about 30cars/100meters. All cars are deployed in the map based on the Poisson distribution with random speed between 30km/hr~50km/hr and turn into different direction at intersections with equal probability. Each RSU periodically broadcasts packets to the specific coverage area. Street cast has a higher delivery ratio than other protocols. Because the MRTS protects wireless communications and selects relay nodes to reduce the redundancy and provide reliability. However, the delivery ratio becomes lower as the increasing of the packet generation rate.

ABBP is simulated using Network Simulator2 (NS2). The simulation was carried out for duration of 120 seconds. The broadcast message contains 500bytes of payload. In order to create highway and suburban scenarios, as well as to generate the mobility traces of the vehicles, we have employed the SUMO microscopic road traffic simulation package. This allows us to simulate common vehicular situations such as overtakes and stops at intersections. This leads to intermittent connectivity and uneven distribution of vehicles. In each scenario, we defined several routes which are followed by the vehicles. In order to get a wide range of network connectivity, we have varied the traffic injection rate per route from 1/75 to 1/5 vehicles per second. The higher the traffic injection, the higher the network density. Maximum speed allowed in this approach is 50 and 80km/hr. ABBP is more efficient approach. In any case, ABBP behaves very well when compared to the other approaches.it provides high reliability for broadcasting in highways because it is based upon the DS-NES forwarding framework, which is meant to cover the whole network. The lowest reliability offered by this scheme is the 94.1 percent of the vehicles that could have received the message. Furthermore, the number of broadcast messages issued by ABBP is almost constant with respect to the simulated traffic flow rate. This indicates the suitability if ABBP as a scalable solution for broadcasting in highways and urban roads. It takes the advantage of the piggybacked acknowledgements to reduce the protocol redundancy. Fig.2 describes the advantage of each protocol.

Advantage of DBR Protocols:
• **It locates the neighboring in digital map using the velocity information even though an error occurs in position information obtained by GPS.** • **Avoids periodic broadcast of hello message.** • **Deals with challenges of both rural and urban road environment.**

Advantage of ABBP Protocol:
• **It is very robust and reliable protocol that extremely reduces the number of transmission needed to complete the broadcasting task.** • **This algorithm is delay tolerant in nature; it does favor low delivery latencies.**

Advantage of STREETCAST Protocol:
• **It has higher delivery ratio.**

Fig. 5 Advantage of each protocol

VI. CONCLUSION

In this paper the characteristics of the Vehicular Ad-Hoc Networks were discussed and explained how it is differ from the Mobile Ad-Hoc Networks. Then characteristics of broadcasting protocols used in VANET such as DBR, ABBP and STREETCAST were discussed and their working procedure was explained. In the performance evaluation section, performance of each protocol was discussed and advantage of each protocol was explained. However, there are many challenges to be faced in the broadcasting protocols of VANETs. A central challenge is the development of the dynamic broadcasting protocol that can efficiently perform the communication between vehicles even though they change their speed, direction frequently. Also, in order to analyze and improve the existing or new VANET broadcasting protocols, it is desirable to examine other metrics such as power consumption, fault tolerance, jitter ect.in various traffic models [6].

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