Study of Broadcasting Protocols in Vehicular Ad-Hoc networks

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Abstract—*Vehicular Ad-Hoc network (VANET) is an approaching technology which aids in communication between the vehicles on the road. The chief purpose of VANET is to improvise public safety and vehicular traffic flow. Out of all the routing protocols in VANETS, broadcast routing protocol is used most frequently for sharing weather and emergency, traffic and road conditions amongst the vehicles. A source vehicle broadcasts safety messages to other vehicles in VANET enabling smooth and safe driving. Broadcasting in VANET is developing as one of the most demanding areas of research. This paper focuses on broadcast protocol and their type used in vehicular Ad-Hoc networks and finally provides a tabular comparison of these protocols.*

Keywords—*VANET, routing protocol, broadcasting, flooding.*

I. INTRODUCTION

The world is progressing at a very fast speed in almost all aspects of life. This is evident from the recent advancements in hardware, software and communication technologies that have enabled the design and implementation of various types of networks utilized in different environments. One such upcoming technology that has received great significance in the automobile industry to provide broad range of safety and non-safety applications like weather conditions, traffic updates, enhanced navigation, location based services such as finding the closest fuel station, restaurants, toll plazas etc. for the comfort and lack of difficulty of passenger is Vehicular Ad-Hoc Networks (VANET). Being ad-hoc in nature, VANET uses the principle of vehicular communication using access points like Global system for mobile (GSM), Wireless fidelity (WIFI), and Universal mobile telecommunication system (UMTS). It is reliable, autonomous and a self-organizing network that makes it a special type of Mobile Ad-Hoc Network (MANET). MANETS are communication links between two or more mobile nodes which maybe single hop or multi hop communication. On comparison of VANETS with MANETS, VANETS comprise of following special features like:

- Mobility models
- Localization functionality
- Infinite energy supply
- Dynamic topology

VANETS provide a distinguished approach for Intelligent Transport Technology (ITS). Nodes in VANETS act as servers or clients for sending or receiving information that is they are transceivers. VANETS are very helpful on highways and urban environments. There are basically three types of communication that take place in VANETS. They are:

1. Vehicle to Vehicle Communication (V2V)
2. Vehicle to Infrastructure Communication (V2I)
3. Infrastructure to Infrastructure (I2I)

Fig 1: Communication in VANETS [8]

Broadcast communications are widely used for sending road traffic reports, information to improve drivers or passengers comfort, sending emergency messages etc. Typically, a broadcast operation is used when a node detects or produces significant information that has to be shared with all other nodes. The broadcasted message has to reach every node and hence, the source of the broadcast sends message to all its neighbors regardless of the identity of the receivers. In absence of any collision or interference, each adjacent node receives the message within the transmitter's communication range. [2][8]

The requirements for VANET application enhances various considerations of broadcast protocols.These protocols should fulfill the following summarized requirements:

- Effectiveness: The broadcast message should be received by all the vehicles in the destination region, is guaranteed by the broadcast protocol.
- Efficiency: The broadcast protocol has to eliminate message redundancy to remove the broadcast storm problem.
- Scalability: To assure the correct operation of safety applications the broadcast protocol has to consider both dense and sparse networks.
- Dissemination Delay: The broadcast protocol has to instantaneously propagate safety messages without any lag.
- Delay-Tolerant Dissemination: When the network is disconnected the broadcast protocol has to transiently store the propagated messages and the protocol has to forward them later when new vehicles are associated to the network.
- Robustness: The broadcast protocol has to compromise with packet loss with the aim of running meticulously in significant safety applications.

II. DIFFERENT ESTABLISHMENTS FOR BROADCASTING IN VANETS:

The three different regimes for broadcasting in VANETS are:

1) Dense traffic regime

2) Sparse traffic regime

3) Regular traffic regime.

The broadcasting protocol has to be able to deal with all the three regimes. The review of these establishments is explained below:

1) ***Dense traffic regime:*** This regime causes the broadcast storm problem. The solution for resolving this issue are:

a) Investigate the seriousness of broadcast storm in VANET with the help of a four-lane highway scenario.

b) Offer three light-weight broadcast techniques namely:

- weighted p-persistence
- slotted 1-persistence
- slotted p-persistence

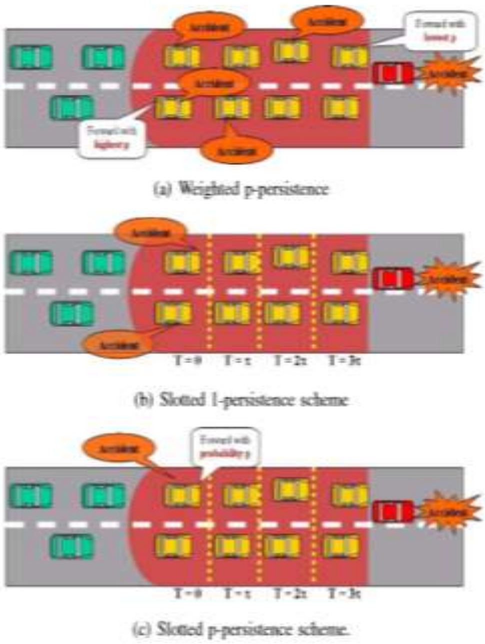

Fig 2: Broadcast Suppression Techniques [5]

The fundamental broadcasting techniques use either a 1-persistence rule or a p-persistence rule. In spite of excessive overload, most of the protocols use Brute Force-1 persistence flooding rule where all nodes rebroadcast the packets with a probability of 1 because of high packet penetration rate and less complexity. [5] Figure 2 shows the obtained results with the three schemes outlined. They can provide 100% reach ability in a well- connected network. The proposed schemes depend on the GPS information and do not require prior idea about network topology.

The slotted p-persistence scheme can considerably minimize the packet loss ratio at an expense of small increment in total delay and decrease the penetration rate. The broadcast technique follows a p-persistence rule.

2) ***Sparse traffic regime:*** The case where there is less number of vehicles on the road is the other kind of extreme situation. At certain point of time when the target node is out of the transmission range of the source, the traffic is so low that multi-hop relaying from the source to vehicle coming from behind is not possible.[5]

3) ***Regular traffic regime:*** in regular traffic regime some vehicles may have many neighbors while some may have very few neighbors, i.e. not every vehicle will have the same local topology. In this scenario some vehicles will have to employ broadcast suppression algorithm while some will have to retain-carry forward the message in order to conserve the network connectivity. [5]

III.BROADCAST ROUTING PROTOCOLS

Broadcast has many important functions in VANETS such as sharing and fast trafficking of packets, emergency and weather, road conditions among vehicles and delivering advertisements and announcements but the main functions of BCRPV (Broadcast Control-Based Routing Protocol for Internet Access in VANETS) are as follows: [15]

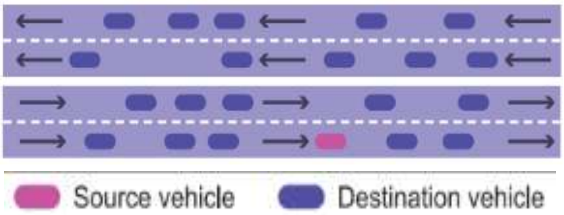

Fig. 3: Broadcasting protocol in VANETS [11].

1) It acts as an accessory to the fixed infrastructure by providing alternative opportunistic access to the Internet using mobile gateways.

2) Considerably it generates less overhead when determining routes between mobile getaways and vehicles by choosing the most appropriate nodes while selecting the forwarders during the route discovery process.

3) The stability of wireless links is reduced by taking into consideration to minimize route failures created because of frequent handoffs.

In broadcasting multi hops are used. It sends packets to all the nodes in the network, using flooding ensuring the delivery of packet. The bandwidth is wasted and nodes received, duplicates [11]. Some of the requirements for broadcasting are high accuracy, great reliability and speed by means of short latency in multi-hop and single-hop communication. The various broadcasting methods are:

A) Simple Broadcasting:

In this method, the source will send a distinct packet to each destination. The drawbacks of this method are a lot of bandwidth is wasted and the source has to have a complete list of all destinations.

B) Flooding:

Flooding is another method used for broadcasting. On receiving the message for the first time, a vehicle must re-broadcast it. This procedure must be repeated by all the vehicles receiving a message for the first time, until all the vehicles receive the message in a desired area. Its drawbacks are it has a point to point routing algorithm and it consumes a lot of bandwidth generating too many packets. [1][2]

C) Multi destination routing:

In this algorithm each packet will contain a list of destinations or a bit map which indicates a desired destination. When such a packet arrives at a router, the router first checks all the destinations then it decides the set of output lines that will be required based on destination address. The router then generates a new copy of the received packet for each output lying to be used. It includes a list of only those destinations that are to use the line in each packet going out on that line. This will save the bandwidth to a great extent and generation of too many packets from the sending end will be avoided.

A. Topology based broadcasting

A packet is broadcasted from the source node to all its neighbors and in turn the packets are rebroadcasted from the neighbors once. This processcontinues until all the packets have been received by the network nodes. [6] These protocols use network topology information such as link connectivity and node density to perform packet forwarding. Few of the topology based broadcasting schemes are specified below.

1) **Distributed vehicular broadcast protocol (DV-CAST):** It relies on local topology information provided by one hop neighbors for handling broadcast messages in VANETS. When there is a network disconnection it is robust against very sparse traffic conditions. In such cases until a vehicle is connected to other vehicles the message will be carried forward. In vehicular Ad-Hoc networks DV-CAST sends regular hello messages in order to broadcast the information. To check if the packet is applicable or not, a flag variable is used. Various courses

of action are taken by DV-CAST to check the state of the vehicle that it is operating in. [12]

- Routing Parameters of DV-CAST: Local topology information and region of interest are the most important parameters of DV-CAST protocol. Each vehicle uses a flag variable to check whether the package is redundant. The destination flag (DFlG) determines whether it is intended recipient of the message that is moving in the same direction as source. The other two parameters are Message Direction Connectivity (MDC) and Opposite Direction Connectivity (ODC). MDC determines whether the last vehicle is in group/cluster. ODC determines whether it is connected whether it is connected to at least one vehicle in opposite direction.

2) Density-aware reliable broadcasting (DECA): It is a reliable and efficient broadcast protocol for data dissemination. It does not require position knowledge of nodes and for broadcasting messages. It selects the node with highest density information. It uses store and forward technique and employs number of neighbors (local density information) to make decision on forwarding. It provides a very high data dissemination speed and avoids waiting timeout. The source node selects a neighbor with highest density or highest number of 1-hop neighbor nodes to rebroadcast the information. This neighbor is accountable for rebroadcasting the message immediately without waiting time. Before the timeout if all the nodes do not recognize the rebroadcasted message, it broadcasts the message again. By this process, number of nodes that receive the message in one transmission can be increased. This is because nodes on the real traffic always form groups. The identifiers of the received broadcast messages are included in periodic beacons so a node can easily discover its neighbor which has not received the messages and rebroadcast those messages for that particular neighbor. One of the advantages of DECA is that it is more suitable and flexibility fit into any environment and that it does not require GPS.

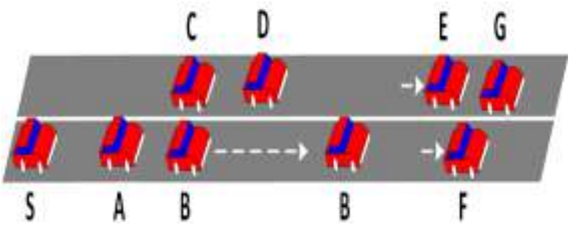

Fig. 4: Density-aware reliable broadcasting (DECA) [9]

Let us consider the above Fig.4. Let S be the source broadcasting messages. Hence it is the broadcasting source. S is able to identify its neighbors A, B, C & D by beaconing. A beacon contains identifiers and local density of the broadcasted messages. The function of the identifiers of the received messages is to check if the nodes contain the information missed by the neighboring nodes or if the neighboring nodes miss the information they have. Assuming D to be the node having the highest local density. So S in that case selects D to be the next broadcasting node by filling in the identifier of D and broadcasting it. A, B, C & D receive the broadcast message by this transmission. D, which is the next broadcasting node selects a neighbor from its neighbor list having the highest local density. The neighbor's identifier is filled and the message is broadcasted immediately. This occurs till the message expires. Messages received by A, B &C are not selected hence buffering takes place and a waiting timeout is randomly set. If D does not rebroadcast the message A, B & C will do it. Assuming in the current scenario that B has shorter waiting time as compared to A & C timeout of B will expire first and hence B will rebroadcast the message with the chosen node. A & C realize that rebroadcasting is taking place so they cover their area and therefore their waiting timeout is cancelled not causing retransmission. The performance assessment consists of the following two metrics: [14]

- Reliability: It is measured as percentage of number of nodes.
- Overhead:It is a measure of the bandwidth consumption after the message retransmission.

Consider Fig.1 again as a recurring connectivity scenario. D is the selected node and considering that at that period E, F & G are out of D's transmission range and are not its neighbors. D's transmission is possible with the help of A, B or C but they would not retransmit as they have already received the message. As time passes B overtakes C & D and thereby becomes closer to E, F & G. With the help of periodic beacons B knows that E, F & G have missed have missed the message so it retransmits it. The selected node field will be left blank when rebroadcasting occurs due to new neighbors missing the message. This results to E, F & G randomly setting waiting timeout. The only node that retransmits the message with its own selected node is the one which has the shortest timeout. Among E, F & G the one who has better information about this area as compared to B will make the decision of next rebroadcast. [9] DECA also reduces redundant retransmission of data by using the density information available only in the nearby nodes.

B. *Location based broadcasting:* These broadcasting protocols spread information or messages to a particular geographic region. In these protocols the vehicles estimate the extra coverage area based on their location [3]. The location of every node is added in the header of the message which is utilized by the receiving node to calculate the additional coverage area [12]. If the coverage area is less than threshold, message is not rebroadcasted by the vehicle. Some of thelocation based broadcasting schemes are specified below:

1) ***Urban Multi-hop broadcast (UMB):*** It is designed to overcome hidden node packet collision and interference problem during message distribution and to address the reliability, hidden node and broadcast storm in multi-hop broadcast. The road sections inside the transmission range are divided into segments by UMB and it chooses the furthest non-empty segment for forwarding and acknowledging the packet without any prior topology information. At higher packet loads and vehicle traffic densities, the UMB protocol performs with better efficiency and much success. Ad-hoc multi-hoc broadcast (AMB) is an ad-hoc extension of UMB protocol. Repeaters are not essential (in AMB). Whenever there is an intersection in the message distribution path, new direction of broadcast are performed by the vehicle closest to the intersection to all the road segments through a fully ad-hoc algorithm.

2) ***Location Division Multiple Access (LDMA):*** It uses GPS with tightly coupled time synchronization to temporal slot schedules and spatial cell resolutions in the regional map through an out-of-band control channel. In an active cell, a vehicle is allowed to broadcast a message by scheduling spatial cells like pipelining communication. The cells adjacent to the active cell are inactive and the vehicles in them are in receiving node. The active cell is at a different spatial location in the next time slot. Hence, this reduces the number of collisions due to concurrent transmissions. Adaptive LDMA (A-LDMA) is an enhancement protocol of LDMA. Its function is to provide isolation of beacon traffic from the broadcast storm to obtain more consistent reliability of safety messaging than the LDMA.[3]

C. *Table based Broadcasting:* These broadcasting protocols, each vehicle maintains an up-to-date list of neighbor vehicle and their routing information that is updated periodically through periodic beacon messages. [3] In these protocols latency period for real-time applications is low and no route discovery is needed.These Some of the table based broadcasting schemes are specified below:

1) ***Track Detection (TRADE):*** This is also GPS based broadcasting protocol. Its categorization consists of neighbors into different road groups: same road behind, same road ahead, different road. Then it selects the farthest vehicle from each group as the relay vehicle.

2) ***Vector based Tracing Detection (V-*Trade):** This is a GPS based message broadcasting protocol. V-Trade classifies the neighbors into different forwarding groups depending on their movement, information and position. For each group, a small subdivision of vehicles is selected to rebroadcast the message. It improves the bandwidth utilization but some routing overheads are experienced from selecting the relay vehicle in every hop because of lesser number of nodes utilized for multi-hopping, the bandwidth is used significantly.

D. *Cluster based Broadcasting:* Inthese broadcasting protocols, each vehicle is a part of one or more clusters, and only such cluster head vehicles can broadcast the messages or information. The cluster heads make sure that the message is delivered to their cluster vehicles. Gateway vehicles are responsible for spreading of messages among the clusters. [4][12] In these protocols, the overhead routing is average, packet delivery ratio is high and the packet delay is substantially low. Some of the cluster based broadcast routing protocols are specified below:

1) ***Selective Reliable Broadcast (SRB):*** To efficiently rebroadcast messages, a cluster head is selected within a cluster. The two vehicles belong to the same cluster if the distance between the nearby vehicles is lesser than the threshold; else they belong to a different cluster. The furthest vehicle is elected by the source vehicle inside each vehicle as the cluster head, when multiple clusters are detected. On highways, it works efficiently.

2) ***Cluster Based Efficient Broadcast (CBE-B):***It consists of two phases, a steady state phase and a step-up phase. By using speed and direction of vehicle movement, the step-up phase creates two front clusters and two rare clusters. The faster vehicle is selected as

the cluster head in the front cluster. The lower vehicle is selected as the cluster head in the rare cluster.[3] Steady state phase selects new cluster heads based on the following rules: a) the vehicle that is farthest from the cluster head is selected as the next cluster head. b) The slowest vehicle is selected as the next cluster head. c) The vehicle that moves at fastest speed is selected as the front cluster head. d) The vehicle receiving fewer messages is selected as the next cluster head. This reduces the delay rate. This protocol is designed for unilateral streets.

allocated to the transceivers in the individual hops to avoid collision in broadcasting.[3]

3) ***Optimal ODAM-based Broadcast (ODAM-C):*** This protocol improves the packet delivery rate by the two mechanisms based on the forwarding features listed as follows: a) the first distance based mechanism considers the angles between receiving nodes, forwarding nodes and source nodes and hereby reducing the possibility of packet loss. b) The second mechanism ensures packet success delivery ratio by increasing the redundancy of forwarding nodes. [3]

Protocol	Category	Relay Selection Criteria	Aim
DV-CAST	Topology based	Local Connectivity	Reduces number of forwarders, handle different traffic densities
DECA		Highest Density Vehicles	Adds up reliability and reduce overhead
UMB	Location based	Furthest Vehicle	Reduces rebroadcast storm, address hidden node problem
LDMA		Nearest Vehicle	Reduces end-to-end delay
TRADE	Table based	Furthest Vehicle	Increase bandwidth utilization and reachability
V-TRADE		Furthest Vehicle	Increase bandwidth utilization, reduce redundant message retransmission
SRB	Cluster based	Furthest Vehicle	Reduces rebroadcast storm, detects cluster automatically
CBE-B		Furthest Vehicle	Increase broadcast speed and propagation rate
MHVB	Distance Based	Furthest Vehicle	Increases coverage area, handle different traffic situations
CTR		Furthest Vehicle	Reduces number of forwarders
ODAM-C		Furthest Vehicle	Enhances packet delivery ratio

Table 1: Comparison of Broadcasting Protocols in VANETS [3]

E. ***Distance based Broadcasting:*** These broadcasting protocols use relative distance to select the vehicles to rebroadcast messages [3]. The signal strength of a neighbor vehicle is determined by each vehicle which is equipped with a GPS device. Some of the distance based broadcasting schemes are specified below:

1) ***Multi-hop Vehicular Broadcast (MHVB):*** This is a flooding algorithm which uses the velocity and position of the vehicles and the angle of transmission sector. The procedure is executed in two steps: by introducing the new dynamic algorithm and changing the backfire region. The right forwarding vehicle (backfire) is identified by the backfire algorithm depending upon its relative position from the sender by changing the angle of the sector. The delay time of each vehicle is inversely proportional to the distance from the sender vehicle set by the dynamic scheduling algorithm.[3]

2) ***Cut- Through Rebroadcasting (CTR):*** Inside the transmission range, the highest priority is given to the furthest vehicle from the source vehicle to minimize the forwarding hops. In CTR, every vehicle consists of at least two transceivers and different channels are

CONCLUSION

Routing is a very important element in VANET communication. Broadcasting is a significant communication technique to disseminate safety messages in VANET and as most of the messages transmitted are broadcast messages, it is an important research area. The broadcast protocols are classified as follows: topology based, location based, table based, cluster based, distance based. Road structuring, driving environment, mobility model, vehicular density etc. are the parameters responsible for performance of broadcasting protocols. These are some of important features controlling the performance of the protocols. It is found that the broadcast based routing does not require digital map requirement, virtual infrastructure environment, it sends packets in less time and it has realistic work flow. One of the major drawbacks of broadcasting protocols is that network overhead is high. This study provides a general clarity about the parameters one should consider while designing a new broadcast protocol.

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