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Broadcasting in VANET: State of the Art

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***Abstract** – Vehicular ad-hoc network (VANET) is in the offing as the most promising technology to resolve all kinds of traffic problems such as those related to traffic congestion, road mishaps, and address upbringing issue such as those pertaining to noxious emissions. In VANET, relevant information should be disseminated with a minimum bandwidth usage thus requiring an efficient and dependable multi-hop data broadcast protocol. Broadcasting play an important role in VANET to distribution of information from vehicle to all neighboring vehicle for some specific purpose. It reduces collision, contention, redundant messages and hidden node problem. It also improves the message reliability. Due to limited range of radio communication in VANET, all the vehicles may not be able to receive the broadcast data in a single hop. So multi-hop communication is needed. This article investigates and compares the various multihop broadcasting protocols*

***Keywords:** VANET, broadcasting protocols*

I. INTRODUCTION

Traffic problems have been increasing alarmingly, and most of it is of recurring type such as congestion, accidents, environment related etc. This has led to a lot of research in the area of Intelligent transport systems (ITS) which aims to build a safe and an effective traffic environment using reliable real-time traffic information. Vehicular ad-hoc network (VANET), a part of ITS, is proving valuable for providing reliable real-time traffic information. VANET, being a subset of MANET, is essentially deployed for exchange of information from one vehicle to another vehicle (V2V), from a vehicle to an infrastructure (V2I) and from a vehicle to broadband (V2B). It consists of many nodes (vehicles) and stationary road side info- station that communicate with each other. The elements of VANET are always in a state of dynamic self-configuration. Vehicles or Mobile Stations are supposed to be moving randomly and thus have a dynamic topology. The VANET network can either be autonomous or can be connected to some other WAN such as the Internet. The information obtained from the moving nodes (vehicles) can be used to infer their future trajectory which in turn can lead to the build-up of the traffic data.

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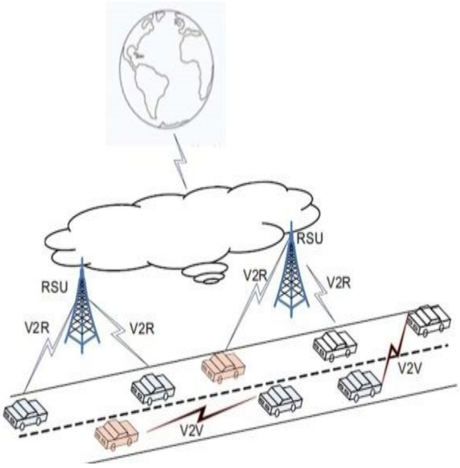

Figure 1. VANET Architecture

Four different types of communications can be specified based on packet source and packet destination. They are.

In-vehicle communication are communications entirely exchanged within the vehicle itself. These communications generally take place between the various electronic devices in the vehicle i.e. between the individual electronic modules. Sensing systems oversee the motorist condition, whether weary or asleep.

Vehicle-to-vehicle (V2V) are communications (wireless transmission) that take place between vehicles. Road information can be shared in real time. This exchange of information in real time can help to prevent accidents and traffic jams.

Vehicle-to-road infrastructure (V2I) communications takes place between vehicles and existing roadside infrastructure. Some examples of V2I communication includes real-time updates on traffic and weather from the infrastructure to the driver.

Vehicle-to-broadband (V2B) communications takes place between vehicles and broadband cloud structures using the cellular mobile network. The advantages of V2B are manifold such as remote traffic information, infotainment, etc. V2B communications are helpful for live assistance of drivers, tracking or vehicles, etc.

In VANET, relevant information should be disseminated with a minimum bandwidth usage to obviate the risk of mishap, avert precarious situations and extenuate such issues. VANET provide a variety of interesting applications from safety to comfort. Many of these applications rely on broadcasting. Broadcasting play an important role in VANET to dissemination of information from vehicle to all neighboring vehicle in the network for some specific purpose. In broadcasting there is no signal destination vehicle compare to the traditional vehicle to vehicle or vehicle to infrastructure communication. Instead the information is broadcasted from one signal source to all vehicles inside a certain geographic region.

Handling a myriad of alerts for the same event is a tricky situation inherent with broadcasting and needs to addressed adequately. The threshold for the extent of message dissemination must be established carefully taking into account factors such as journeying nodes, network density, radio idiosyncrasies, etc. Due to limited range of radio communication in VANET, all the vehicles may not be able to receive the broadcast data in a single hop. So multi-hop communication is needed.

This paper attempts to describe and evaluate the different broadcasting protocols used in VANET. This may benefit the forthcoming developments in VANET.

II.BROADCASTING IN VANET

The type of Broadcast Technology used greatly affects the Network performance. In the beginning, the most straightforward approach for implementing broadcasting were all based on the 'flooding methods,' a technique which was successfully deployed by the then telecommunications industry. By these methods, a node will communicate information to another node, which in turn would communicate the same information to another node and so on until every node in the network had access to that information. These methods worked well for small networks. For bigger network, these methods result in dispensable messages and much collisions. 'Simple flooding' sometimes also referred as 'blind flooding,' is plagued with the 'storm' phenomenon associated with broadcasting, whereby a large number of redundant messages are exchanged. A variety of techniques exists to resolve the 'storm,' the prominent being the Urban Multi-Volume Broadcast protocol (IEEE 802.11) which authorizes the outlying nodes to accept and transmit data for the purpose of reducing the 'storm' and notify others on the real transmitters and themselves. The protocol also utilizes ACKs (acknowledgement data) as an assurance of message delivery.

The IEEE-802.11protocols are an optional RTS/CTS handshake followed by an acknowledgement to delivers a unicast packet. Broadcast messages cannot use the RTS/CTS exchange because it would flood the network. For Examples, if all the receivers transmit a CTS in response to a RTS then many collisions can occur at the same time. If RTS/CTS mechanism is not used, then hidden terminal problem will occur. So the best way is multi hop broadcast using relaying. In the next section, broadcasting based MAC protocols are presented and then a comparative analysis on the protocols are designed.

III.EXISTING BRODCASTING SCHEMES

VANET broadcast protocol should be designed for dense traffic condition, sparse traffic condition and regular traffic condition on city and highway scenario. Survey of related literature reveals that lots of broadcasting protocols for VANET has been proposed but still a full-fledged protocol is not designed which can be useful in all the traffic condition.

Impairment of radio signals increases with the spacing between nodes and broadcasting schemes need to account for this, specifically in low density networks. There are obstacles like buildings in urban areas that frequently block signal transmission.

Message dissemination using broadcasting is divided into two categories- single hop and multi-hop schemes. Mostly dissemination schemes are multihop. Multi hop schemes are again classified into two categories- restrictive schemes and promiscuous schemes (Sanguesa et al, 2016). Restrictive scheme is used to address the problems of broadcast storms. Promiscuous scheme considers the VANET's characteristics such has fragmentation and frequent partition. So the techniques such as Store-and Forward is used to disseminate information. Figure 2 shows the taxonomy of broadcast protocols.

According to the characteristics of the protocol and the techniques used for establishing if a node is allowed to retransmit messages, the multi-hop schemes can be categorized as those based on: a) beacon, b) topology, c) distance, d) flooding, e) probabilistic, and f) store and forward techniques. Figure 3 shows the types of multi-hop broadcast protocols.

Beacon Based Scheme Beacons are periodic messages generated by vehicles about their position, speed etc. This information is used toimprove the knowledge about the surrounding area. ATB, CDS, RTAD, DV-CAST, and NSF.

Topology Based Schemes

In VANET, the communications between the vehicle are many topology aware broadcast techniques which utilizes topology data to boost message dissemination process. Examples of such protocols are: eSBR, CLBP, eMDR, NJL, NJL, DV-CAST, RTAD, and JSF.

Distance based Scheme greatly affected by the rapidly changing topology. There are

The methodology requires that the information is rebroadcasted depending on the distance between sender and receiver vehicles. Schemes like TLO, SBS, eSBR, eMDR, and FDPD are distance based schemes.

Counter Based Scheme

This technique is an improvement over flooding. Here the number of receiving nodes are reduced by means of a counter and a threshold value.

Probabilistic scheme

These methods are based on probability theory. In accordance with the settings of the transmitting nodes, appropriate probabilistic distributions are worked out to establish the probability of transmitting the message. FDPD, SBS, APAL, p-persistence approaches, LISCast, CPB and EEAPD are under this category.

Store and Forward Scheme

In this scheme, a vehicle car stores the message and waits to rebroadcast until a given criterion is fulfilled. A vehicle usually waits to rebroadcast the message until a new neighbor is found. Schemes like DV-CAST, UV-CAST, SCB, NSF, and JSF, fall under the store/forward approach.

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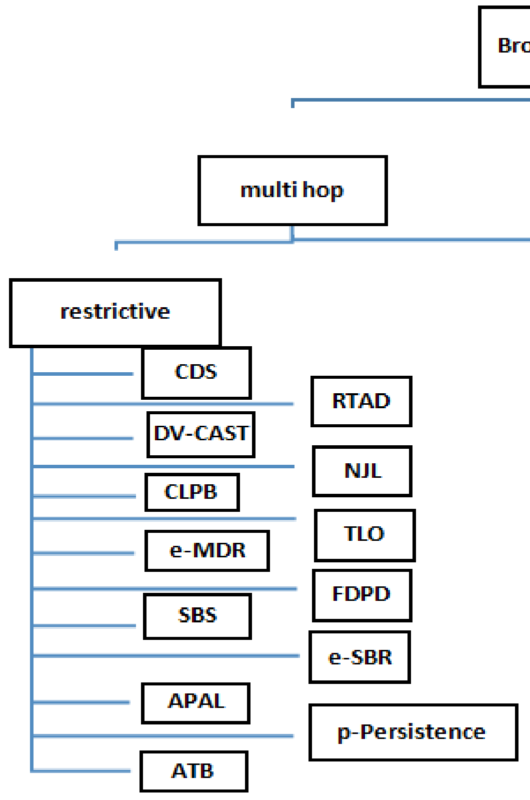

FIGURE 2 TAXONOMY OF BROADCAST PROTOCOLS

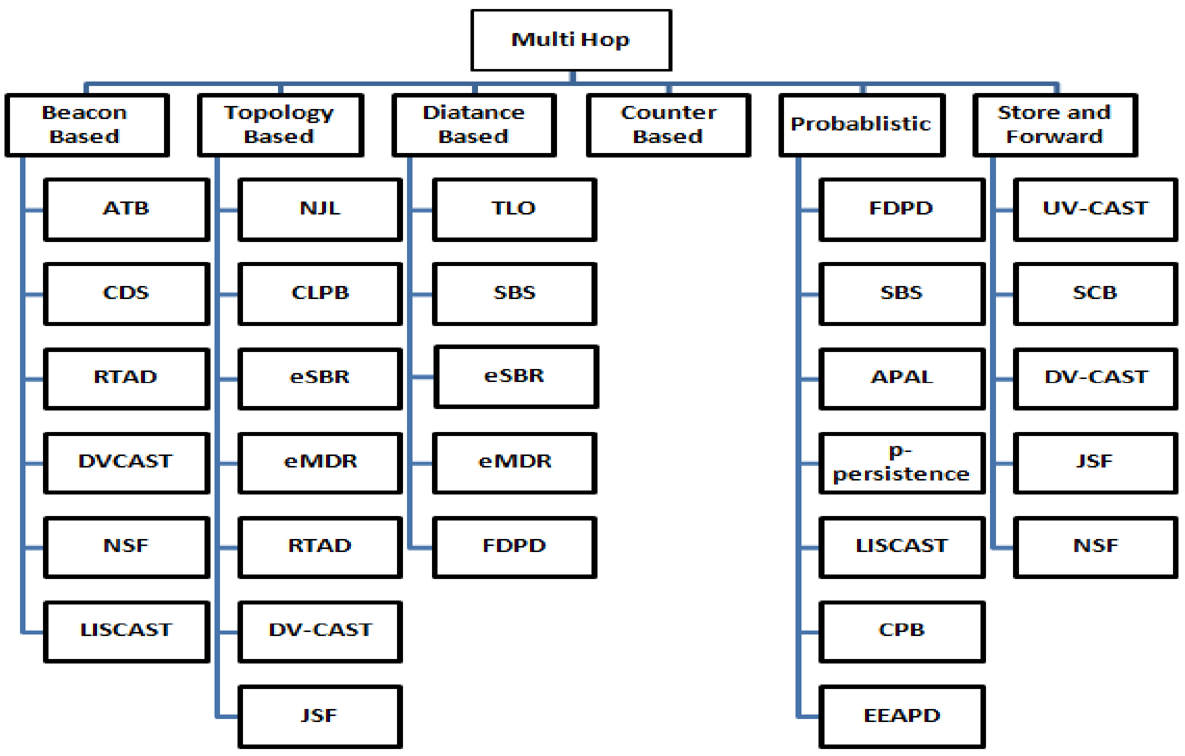

FIGURE 3 TAXONOMY OF MULTI HOP BROADCAST PROTOCOLS

Authors of [8] has already presented a comparative study of broadcast protocols proposed till 2016. This paper present the comparative study of the protocols proposed after 2016 till date. There are five such protocols which is discussed in this section.

LISCast[4] stands for local topology information sensing technology-based on broadcast protocol. It aims to resolve the 'storm' phenomenon while attaining a faster response. These protocols capitalize on probabilistic forwarding schemes to restrict superfluity. According to the beacon, LISCast utilizes a beacon for raw data collection from neighboring nodes (their numbers and spread), from which it seeks outs *characteristic information* such as maximal forwarding distance, effective candidate number, and overall traffic density. LISCast operates in conjuction with a roadside unit and producing a bit of redundant data but does not always work the best in the sparse networks, because the characteristic information provided by BSM (Basic Safety Message) is not so precise. LISCast can readily adapt to a dynamic topology by optimizing the parameters of delay, redundancy, and broadcast efficiency while achieving a high level of transmission reliability. It can also maximize the coverage of each hop, realizing the rapid dissemination of emergency messages. LISCast is best suited for high density networks as it reduces end-to-end delay. Further, it surpasses other protocols on performance parameters such as forwarding adequacy and redundancy.

Effective and Efficient Adaptive Probability Data Dissemination (EEAPD)

EEAPD is a probability-based protocol blended with a delay methodology founded on the measure of number of track sections and linear separation from the source node. EEAPD is formulated to work best in high density networks with the intention of maximizing productivity while at the same time minimizing the network bandwidth. Like the LISCast, EEAPD aims to resolve the 'storm' phenomenon while attaining a faster response. Most significantly, EEADP estimates the waiting time period based on the measure of linear separation from node. EADP takes into account the number of track sections (slots), message directionality, and node density. Moreover, it can probabilistically resolve a pertinent node to make a re-broadcast message with the least delay period. EADP considers the suitability of nodes which can re-broadcast an emergency packets based on the number of track sections. EADP is a versatile probability-based protocol very well suited for safety-based applications which in-turn requires superior degree of efficiency and effectiveness. Such applications are primarily concerned with ensuring passenger's safety. The two principal characteristics of EADP are: a) beaconless; i.e. irrespective of the network density, there is no periodic exchange of safety messages, and b) it is best suited for safety-based applications; its performance has been positively ascertained in a pragmatic environment [5].

AddP – Adaptive Data Dissemination Protocol – offers highly efficient and credible data dissemination. In AddP, the beacon frequency is actively adapted not only to reduce the number of beacons but also the number of transmitted messages. This is accomplished with the help of beacon congestion control algorithm adapted for high density networks. AddP implements a node selection scheme, for the purpose of rebroadcasting, premised on network density and separation from neighboring elements. AddP is both reliable and efficient (low overheads). The two principal characteristics of AddP are: a) to propogate message alerts to most of the participating nodes with reduced latency, and b) to resolve the 'storm' phenomenon while attaining a faster response with fewer disconnection, and the issue of the hidden nodes [1].

Cluster-based medium access control (CB-MAC) The CB-MAC protocol was developed for all types of communications (safety or non-safety data), the difference being that safety transmission must occur quickly with recommended delays not exceeding 100ms [4-6]. Further, the CB-MAC is aimed towards improving the credibility of communications together with a higher throughput and lower latency.

The protocol describes the mechanism for cluster configuration. The methods for egress or ingress of nodes from a cluster is also specified. The process of merging of different cluster is also set out. Moreover, the format for the conventional control packets have been revised and fresh control packets has been created to enable cluster-based communications. Safety messages cannot employ the RTS/CTS scheme (IEEE 802.11) because it is ineffective in broadcast mode. However, the RTS/CTS scheme is used for non-safety communications in order to alleviate the issues of hidden nodes. The Markov chain model forms the basis of the CB-MAC protocol which circumvents the hidden node problem by through RTS/CTS and simultaneously achieves maximum resource utilization [2].

SEAD (Simple and Efficient Adaptive Data Dissemination protocol) The protocol was developed to cope with the 'storm' phenomenon associated with broadcasts in a scalable vehicular network. The protocol is well suited for all types of applications (safety or ordinary data) and provides a resilient message transmission scheme. The scheme can further be used to configure the protocol to realize a desired performance (by way of packet delivery ratio, etc.) in accordance with the application's stipulations. SEAD imparts very small end-to-end period for communications while maintaining a superior packet transmission with insignificant packet drops and thus does not significantly loads the network. SEAD was conceived to be compliant with all classes of applications and can be easily tailored for a specific application through a native 'alpha' parameter. SEAD achieves a high level of efficacy for transmission of safety messages as substantiated through simulators. SEAD has excelled S1PD in enhancing the packet delivery ratio (PDR) with a very small end-to-end period and is low on bandwidth expenditure[7].

IV. COMPARATIVE ANALYSIS

A summary report is tabulated below (Table 1) which compares the various protocols discussed in this paper in terms of standard network parameters namely; reliability, efficiency, supported application class, scheme type, mode of transmission, and the objective of the protocol. A meticulous review of these protocols will aid in identifying their benefits and drawbacks and will thus prompt for refinement in existing protocols and/or formulation of entirely new ones.

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TABLE 1: COMPARATIVE ANALYSIS OF BROADCASTING PROTOCOLS

Protocols	Aim	Proposed in(year)	Reliability	Performance	Scenario	Application Type	Beacon Based	Minimize Broadcast Storm Problem	Communication mode
SEAD	It handles the 'storm' efficiently by limiting unreasonable broadcasts and ensures high packet delivery and reduces end-to-end time period	2016	high	high	Urban and highway	Safety and non-Safety	No	Yes	V2V and V2I
CB-MAC	It improve communication quality with higher throughput and lower delay	2019	high	high	highway	Safety andnon-safety	-		V2V
LISCAST	can redress for dynamic topology by optimizing the parameters of delay, redundancy, and broadcast efficiency	2019	average	average	highway	safety	Yes	Yes	V2X
EADDP	works best in high density networks; maximizes productivity while minimizing the network bandwidth	2018	high	high	Urban	safety	No	Yes	V2V
ADDP	limits unreasonable broadcasts and reduces network transmission delays	2017	high	high	Urban and highway	safety	Yes	Yes	V2V and V2I

PROS AND CONS OF PROTOCOLS

Protocols	**Pros**	**Cons**
LISCAST	Operates in tandem with a roadside unit; extra information generated in the process	It does not always work the best in sparse networks.
EADDP	It accounts for number of track sections and linear separation from the source node to determine those nodes who can participate in re-broadcasting of contingency information	This protocols needs to be revised for a scattered network since there is frequently a vehicle connectivity problem and the use of mathematical models to address the EEAPD parameterization.
ADDP	network programming is used to limit the amount retransmissions	Privacy and security requirements are critical issues that need to be ensured in VANETs
CB-MAC	CB-MAC attains high throughput and remains below the recommended time-limit of 100ms for safety messages.	circumvents the hidden node problem through RTS/CTS and simultaneously achieves peak resource utilization
CPB	The clustering algorithms can reduce the redundancy and control over the communication nodes without the central control	it is difficult to conduct a large-scale autonomous driving experiment, there are limitations in not verifying efficiency when various kinds of fading are applied on actual roads.
SEAD	compliant with all classes of applications and can be easily tailored for a specific application through a native 'alpha' parameter	sparse networks and the investigation of the connectivity problem between communicating vehicles.

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Amongst all the standard waiting methodology protocols utilizing the probabilistic approach, LISCast remains the best suited for high density networks as it reduces end-to-end delay. Further, it surpasses other protocols on performance parameters such as forwarding adequacy and redundancy. A downside of LISCast is that it may not perform satisfactorily in scantly populated networks primarily because the BSMs intelligence is not definitive [4]. The simulation study presented in [5] shows that EEAPD is comparatively superior to both SEAD and AddP as it has a very small end-to-end time period with enhanced packet delivery ratio irrespective of the network density. This is because there is no periodic exchange of safety messages. More significantly, EEADP can be viably implemented under pragmatic scenario such as V2V architecture within an established number of track sections.
Most of the proposed protocol till date are efficiently used in highway scenarios. Some of them can be used in urban areas also. But still protocols are not tested for semi urban area. They are not efficiently working in sparse traffic condition where vehicular connectivity problem frequently occurs.

Under probability-based broadcasting methodologies, every node in the system has a chance to participate in communications based on some specific odds assigned to them. Hence, all the nodes have a certain chance to participate in the broadcast operation. This is what makes the probability-based mechanisms more resilient to breaches and failures. Unlike the deterministic techniques, the probabilistic approach remains largely immune to journeying nodes. It is precisely for these reasons that most of the newer broadcasting techniques are using probabilistic approach.

V. CONCLUSIONS

In most of the VANET applications, multi hop broadcasting is required. Uncontrolled or blind retransmission in a multi-hop communication causes congestion and delays in a network. Various researchers have proposed various multihop broadcasting protocols for VANET. This paper presents the need of broadcasting, taxonomy of broadcasting protocols and a comparative study of multi hop broadcasting protocol. We have compared the all multihop broadcasting protocols proposed in last four years.

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