Analysis of Performance of Broadcasting Protocol in Vehicular Ad-hoc Network Environment

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Abstract

Wireless communications are becoming the dominant form of transferring information and the research field. In this paper, we deal with the most applicable forms of the Vehicular Ad -Hoc Networks (VANETs). VANET is the technology of building a robust Ad -Hoc network between mobile vehicles and each other. VANETs applications are unique characteristics and promising challenges. This paper presents a complete study of the broadcasting protocols in VANET environments. The novel reliable broadcasting protocol is designed for an optimum performance of public-safety related applications. It possesses minimum latency, minimum probability of collision in the acknowledgment messages and unique robustness at different speeds and traffic volumes.

Keywords: *VANET, Ad-hoc network.*

1. Introduction

Wireless technology i s expected to be adopted by both governments and manufacturers in the very near future. It directly affects car accidents and the sales of the largest markets. It is the technology of building a robust network between mobile vehicles that technology called VANETs. In this paper, we deal with the VANET introduction and a novel broadcasting protocol.

1.1 What is VANET

VANET is the technology of building a robust Ad-Hoc network between mobile vehicles and each other. There are 2 types of nodes in VANETs. One is mobile nodes as On Board Units (OBUs) and static nodes as Road Side Units (RSUs). An OBU resembles the mobile network module and a central processing unit for on -board sensors and warning devices. The RSUs can be mounted in centralized locations such as intersections, parking lots or gas stations. They can play a significant role in many applications such as a gate to the Internet.

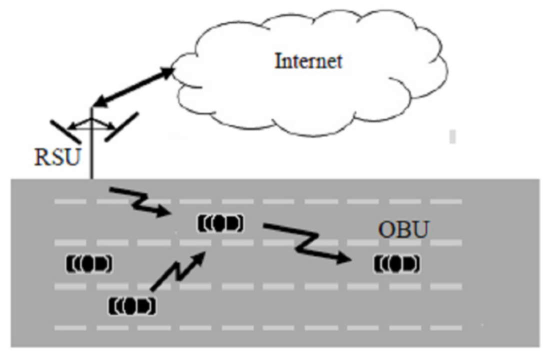

Figure 1. Node types in VANETs

1.2. Why VANET

Vehicle accidents are the primary cause of death. Today, 6.14 million vehicle crashes causing approximately 2.69 million injuries & 40,000 sufferers. Accordingly, vehicle manufacturers are competing in equipping their vehicles with devices that collect data from the interior and exterior of vehicles and deliver it to a central processing unit that can analyze this data to boost the road safety while increasing the on -board luxury. Global positioning systems (GPS), Event Data Record (EDR) resembling the Black-Box used in avionics, small range radars, night vision, light sensor s, rain sensors and navigation systems are well -known intelligent devices used in many newly produced vehicles, what is rather referred to as Computers-on-Wheels. Tele-Communication researchers have been recently working on a prominent step; if each vehicle has a device that can communicate with other vehicles; it can talk to each other and inform each other of any probable danger.

1.3. Why Ad-Hoc

Vehicular networks should make use of but not depend on the centralized infrastructure nodes. The elephantine size of paved roads and high mobility of nodes limit the usefulness of any static infrastructure node. Researchers recommend this network to be in the Ad-Hoc topology where RSUs act as regular nodes. VANET is a special case of the general MANET to provide communications among nearby vehicles and nearby fixed roadside equipments.

2. Why Broadcasting

In the high mobility of vehicles, the distribution of nodes within the network changes rapidly & unexpectedly. VANET operates in the absence of servers, force OBUs to organize network resources distributive. Broadcasting of messages in VANETs plays a crucial rule in every application and requires novel solutions that are different from any other form of Ad -Hoc networks. Broadcasting requirements are high reliability & high dissemination speed with minimum latency in single-hop as well as multi -hop communications. Problems associated with regular broadcasting algorithms are the high probability of collision in the broadcasted messages. In VANETs, there are 2 types of collisions, collisions of wireless messages in the network domain and the physical collisions of running vehicles.

2.1. Broadcasting Goals

Any broadcasting protocol should satisfy the goals of high reliability, Low latency, Low probability of collision, Hidden node problem, No prior control messaging, human factors & High robustness. These categories are, the first one is used with applications related to direct neighbors (collision avoidance) and the second is used same to the entire network (traffic management)

Table 1. Categories of broadcasting protocols

Broadcasting Protocols	Reliable Protocols	Rebroadcasting Protocols
		Selective ACK Protocols
		Changing Parameters Protocols
	Dissemination Protocols	Flooding Protocols
		Single Relay Protocols

In rebroadcast, the transmitter node retransmits the same message for many times. In selective ACK, the transmitter requires ACK from a small set of the neighbors, and changing parameters and it changes transmission parameters due to the expected state of the network. Published dissemination protocols use two methods.

These are,
1. Flooding- Each node is determine whether it will re-broadcast the message or not, and

2. Single relay- The transmitter is determining the next ho p node.

2.1.1. Reliable Protocols

VANETs opened a new research challenge of time -critical reliable broadcasting that intended to serve a bunch of public safety related applications. The reliable protocols deliver a message from a single source to every node in his transmission range with the highest possible reliability & minimum latency.

The metrics of reliable protocols are,

• Success rate: The number of nodes that have successfully received the broadcast, divided by, the number of nodes in the transmitter communication range and

• Latency: The total time required in a single broadcast phase.

2.1.2. Rebroadcasting

The first method of increasing broadcast reliability is by retransmitting the same message for many times. The effect of retransmission on increasing the reliability and developed six MAC protocols:

a) Asynchronous Fixed Repetition(AFR) where the message is repeated in each time -slot for a fixed number of times.
b) Asynchronous p-persistent Repetition (APR) where the transmitter node transmits the message in each time -slot with probability P, where P is a configurable parameter.
c) Synchronous Fixed Repetition(SFR) is the same as AFR except that all nodes in the network are synchronized to a global clock.
d) Synchronous p -persistent Repetition (SPR) is the same as APR except that all nodes in the network are synchronized to a global clock.
e) Asynchronous Fixed Repetition with Carrier Sensing (AFR -CS) is the same as AFR except sensing the channel before transmission.
f) Asynchronous p-persistent Repetition with Carrier Sensing (APR-CS) is the same as APR except sensing the channel before transmission.

Although both SFR and AFR -CS protocols gave the best success rate, the author suggests using the AFR -CS as it does not require a global synchronization and it uses the minimum overhead. Vehicular Collision Warning Communication protocol (VCWC) proposed two new concepts. The 1st one shows that the same degree of reliability can be achieved and the protocol saves some unnecessary transmissions. The 2^{nd} one of single communication range is sufficient for an easy slowing down. In case of the following vehicles react aggressively, they will be considered abnormal & send new warning messages by their own.

Selective Acknowledgment

There is no doubt about that, acknowledging is the ultimate method of reliable communication and it is widely implemented in unicast messages. However, in broadcasting, the destination node is unidentified. In this paper, how this acknowledging can be used in improving the reliability of the broadcast. The Broadcast Medium Window (BMW) protocol treats broadcasting as multiple unicast operations. For every message broadcast, the transmitter unicast it to every node of its neighborhood using the "RTS/CTS/DATA/ACK" scenario.

2.3. Changing Parameters

It minimizes the collision rate and hence increases broadcast reliability of a single communication range. In this protocol, each node should include its own MAC address and a sequence number within the status message. Hence, nodes can estimate the count of lost messages and change the contention window size accordingly. In case of low loss rate, as an indication of good network condition and small number of vehicles, the protocol attempts to decrease the contention window size and hence decrease latency. On the contrary, if the loss rate is high, the protocol increases the contention window size and limits collisions.

2.3.1. Dissemination Protocols

Broadcasting messages to the entire network in Ad-Hoc mode is not an easy job especially in case of highly mobile nodes. Building a routing table will consume a heavy messaging load and is useful for only a couple of seconds before every node changes its location. The problem statement for dissemination protocols is to design a protocol that can coordinate between network nodes to deliver the message to the largest number of nodes in the network within the shortest time duration. These metrics are:

a) Success rate: The number of nodes that have successfully received the broadcast divided by the total number of nodes in the network.
b) Redundancy: The total number of useless transmissions i.e. when all nodes within the broadcast range have already received the message.
c) Dissemination speed: Speed of the message along the propagation direction; i.e. do all broadcasting hops are allied with the direction of propagation, which is an indication of the cumulative time that a message will take to reach all nodes.

2.4. Flooding

Flooding protocols are highly distributive that it is based on the number of messages it has already overheard and the current locations of their sources. This broadcast storm problem happens when attempting to send the intended message to all nodes by forcing each node to rebroadcast the message (simple flooding). Simple flooding will result in a serious redundancy, and collision. These schemes are reduce the redundancy by inhibiting some nodes from rebroadcasting. These schemes are,

• Probabilistic Scheme: A node rebroadcasts the message with a probability p, $0 \le p \le 1$.

• Counter-Based Scheme: A node rebroadcasts the message only if it overheard message for $c < C$ times, where C is a constant (equals 3 or 4 as recommended by the author).

• Distance-Based Scheme: A node rebroadcasts the message only if its distance from the transmitter is $d > D$, where D is a constant.

• Location-Based Scheme : Each node compares its location with the transmitter location and calculates the additional coverage. A node rebroadcasts the message only if the additional coverage > A, where A is a constant.

• Cluster-Based scheme: The author suggests dividing the network into circular clusters each cluster has a small set of nodes acting as a gateway to the neighbor clusters. Finally, the author concludes that the location-based scheme resulted in the minimum redundancy. The Dynamic Delayed Broadcasting (DDB) protocol is just an updated version of the "Location - Based scheme", where nodes that receive the broadcast packet calculate the additional coverage that can be provided.

2.5. Single Relay

A single relay protocols as sequential ones, where the transmitter node handles the responsibility of the broadcast to another following node. The best node to handle such a job in dissemination protocols is the furthest one. The Minimum Connected Dominating Set (MCDS) is defined as the minimum set of connected nodes. In the MCDS-based broadcast protocols, the message is forwarded only by the nodes of the MCDS. This protocol achieves the largest progress along the propagation line, while guaranteeing the coverage of the entire network. The MCDS gives the theoretical optimum performance. However, this protocol needs extensive real - time information about the exact location of every node in the network, which is not practical in VANETs. In the Urban Multihop Broadcast Protocol (UMB), the transmitter sends an RTB message containing its geographical location and the intended direction of message propagation. The protocol divides the transmission area into adjacent and non -overlapping segments of equal lengths. The node located in the furthest nonempty segment reply the transmitter with a CTB message containing its identity and prepare itself to be the relay node for the incoming broadcast. The mechanism of electing the furthest node is: upon reception of an RTB message, each node transmits a channel-jamming signal (black -burst) of a length proportional to its current distance from the transmitter. Then, it checks the status of the wireless channel. If the channel is busy with another black -burst signal i.e. another node is still transmitting, the node exits the contention phase and listens to the incoming broadcast. In such situation, the transmitters resend the RTB again requiring division of the segment into sub -segments and start again the same procedure.

3. The Basic Algorithm

The Smart Broadcasting Protocol seeks the best performance as a dissemination protocol. It elects the furthest node to relay the broadcast it its followers. The election methodology is to divide the transmission range into a number of adjacent & non - overlapping segments. The node located in the furthest non-empty segment should reply with a CTB message containing its identity and prepare itself to be the relay node for the incoming broadcast. On receiving of an RTB message, every node should perform the following steps.

1. Find the segment number and choose a random backoff period within the contention window assigned to its segment.

2. On receiving of a valid CTB, exit the contention phase and on receiving of a colliding CTB messages, hold its countdown timer until the end of collision.

3. On the end of its countdown timer, send a CTB message.

In this algorithm, decisions of the receiving node depend solely on information from the RTB message and GPS device without using any prior information. The Smart Broadcasting Protocol assumes dividing the transmission area into ten segments. This protocol chooses the furthest node with a plain uniform distance –based segmentation algorithm.

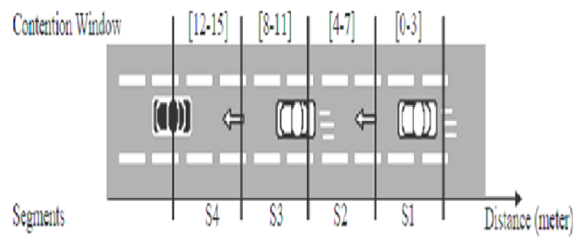

Fig:2 Arrangement of segments for the basic algorithm

Broadcasting beyond a single transmission range: As recommended by the DSRC, the communication range of the abnormal vehicle is 10 sec travel time. A vehicle beyond this range is expected to have a sufficient distance and time for an easy s lowing down. The proposed protocol considers that this range is very efficient for one abnormal vehicle. In casethat a following vehicle reacts aggressively, it will become abnormal and issue a new warning message itself.

Application Adaptive (Modes of Operation): VANET applications require message broadcasting. Each application has its unique flavor and requires a special treatment. The RTB message should contain a field for the Mode which will inform other vehicles of the category of the broadcasting application so that the following nodes arrange priority accordingly. Without loss of generality, we propose only four modes covering major applications.

3.1. Mode-0 Basic Broadcasting

This mode is omnidirectional with no intended vehicle nor acknowledgement. This mode is useful in VANET environment in case of the status message, whereas recommended by DSRC, every vehicle should broadcast its position, speed, direction of travel, & acceleration every 300Ms.

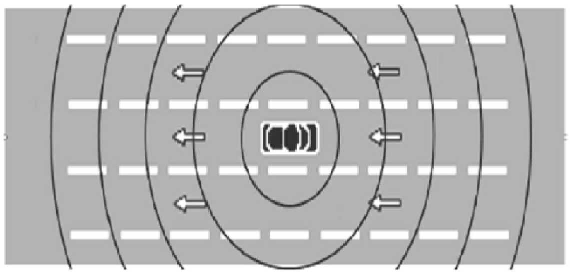

Figure 3. Mode 0 “Basic Broadcasting”

3.2. Mode-1 The Furthest Following Vehicle

This mode is suitable to be used with dissemination protocol for applications like “Traffic Information ”, and “Work Zone Warning”. With these applications, the broadcast is required to be delivered to the physically furthest node; that we recommend the regular uniform distance -based protocols to be used in this mode. Acknowledgment is recommended to be with a basic ACK packet.

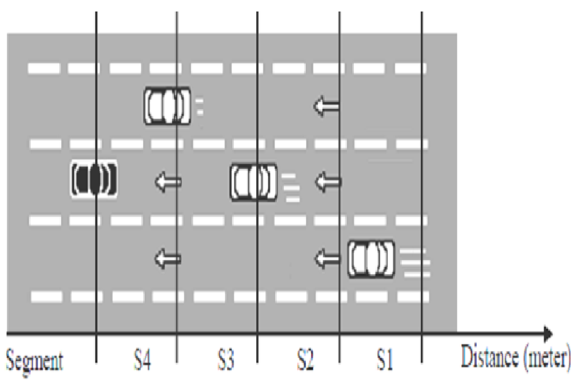

Figure 4. Priority arrangement of mode 1

3.3. Mode-2 Nearest-in-time Following Vehicle

This mode is suitable to be used with reliable protocols for all public -safety related applications like “Cooperative Collision Warning” and “Stop Light Assistant ”.

The headway-based protocol is the superior in this mode. Acknowledgment is recommended to be with the same message setting the ACK flag. This same message ACK is to compensate collisions at far range nodes due to hidden node problem.

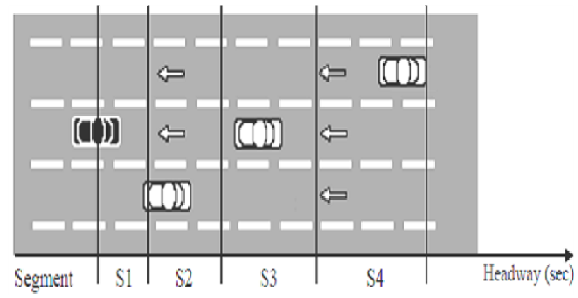

Figure 5. Priority arrangement of mode 2

3.4. Mode 3 - The Furthest Leading Vehicle

This mode is suitable f or emergency applications like “Approaching Emergency Vehicle” either it was an ambulance or a police car. In this case, the headway is identical to distance because the speed is constant. However, with headway -based protocols, we can implement a non -uniform segmentation based on headwaystudies. Acknowledgment is recommended to be with a basic ACK packet. Although these four modes cover major application categories, any other mode can be added according to the application requirements.

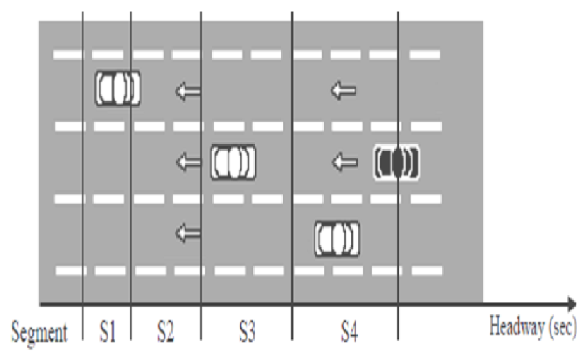

Figure 6. Priority arrangement of mode -3

4. Performance Metrics

The performance metrics used to validate the proposed protocol are, time required first attempt to broadcast to the complete of the broadcasting phase Collision Probability: The average probability of collision in the ACK messages in each segment of the transmission range.

5. Conclusion

In this paper, a novel broadcasting protocol in VANET environments with new features. These features are headway -based segmentation and to include effects of human behaviors in its design with the headway model, Non-uniform segmentation achieving a unique a minimum slope linearly increasing latency distribution and Unique robustness at different speeds and traffic volumes rooted to the headway robustness at different traffic volume variations. This paper also deals with Superior minimum latency for public safety applications, Application adaptability with special multi-mode operations and it offering a solution to applications like approaching emergency vehicle.

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