A Survey on Broadcasting Protocols in VANETs

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Abstract: Vehicular Ad-Hoc Networks [VANET] is one of the fastest emerging technologies for research as there are many issues and challenges to be addressed by the researchers before the technology becomes commercialized. The challenges in VANET are, designing suitable routing protocols appropriate to the traffic model, providing security of the data and emergency messages, avoiding the collision of messages, avoiding flooding of messages, etc. The progress of research in the field of VANET promises to deliver a robust, safety, efficient and intelligent transportation in the future. This paper gives the review of various Rebroadcasting policies in VANETs. The reason for analyzing the broadcasting protocols is that, in most of the emergency situations, there is less time to make a handshake with other nodes in the networks, as the emergency message is to be delivered fast and efficient. Therefore broadcast based routing protocol plays a major role in almost all the safety applications. A detailed understanding of the existing protocol is needed before contributing new protocol for the upcoming research field.

Keywords: VANET, Broadcasting, Intelligent Transportation.

I. INTRODUCTION

VANET is a special type of Mobile Ad-Hoc Networks [MANET] which is a self organized wireless communication network. Because of high mobility of vehicles and orderly fashion of node movement in a defined path [road structure], the protocols that are suitable for MANET is of no use in VANET without modification. In VANET, the vehicles are equipped with On-Board Units [OBUs] which is used for the communication and it act as the mobile node. The Roadside Units [RUs] are equipped with communication devices and it acts as the static node. The Roadside infrastructure is interconnected to the centralized server located at the transport regulation authority. The moving vehicles will form an ad-hoc network among the static as well as the mobile nodes. The RUs can be used as a gateway for the internet. The two types of communications in VANETs are Vehicle-to-Vehicle [V2V] communication and Vehicle-to-Infrastructure [V2I] communication. In V2V communication, the broadcasting protocols are the frequently used method. The vehicular communication is done with the help of Dedicated Short Range Communication [DSRC] standard [IEEE 802.11p] that operates in 5.9GHz band that offers the communication in the range up to 1000m.

1.1 WAVE (IEEE 802.11p)

The IEEE 802.11 standard defines medium access control (MAC) and physical layer (PHY) specifications for the wireless connectivity of fixed, portable, or moving stations within a local area network. It defines a single set of MAC procedures to support packet delivery services and several physical signaling techniques.

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Wireless Access in Vehicular Environments (WAVE) has got its own amendment (802.11p). The WAVE system Architecture is a set of standards that describes the communication stack of vehicular nodes and the physical airlink between them (Fig. 2). Any RSU may have two interfaces, one for the wireless WAVE stack and the other for external interfaces like wireline Ethernet that may be used to enable connectivity to the Internet. Similarly, each OBU may have two interfaces, one for the wireless WAVE stack and the other for sensor-connections and human interaction.

WAVE standard consists of five complementary parts,

- 802.11p "Wireless Access in Vehicular Environments (WAVE)" [16], which is an amendment to the well-known IEEE 802.11 Wireless LAN Standard and covers the physical layer of the system.
- 1609.1 "Resource Manager" [17] that covers optional recommendations for the application layer.
- 1609.2 "Security Services for Applications and Management Messages" [18] that covers security, secure message formatting, processing, and exchange.
- 1609.3 "Networking Services" [19] that covers the WAVE communication stack.
- 1609.4 "Multi-Channel Operation" [20] that covers the arrangement of multiple channels and how they should be used.

1.2 WAVE Short Message Protocol (WSMP)

The WAVE Short Message Protocol (WSMP) is a new protocol designed especially for an optimized operation in WAVE environments. If any node prefers not to join a WBSS (for example, a transmitter has a short data to broadcast) it will have to use only WSMP over the CCH. WSMP is used for direct transmission of short messages without joining WBSS. Messages of this protocol are designed to consume minimal channel capacity. Hence, it is the only protocol allowed over the CCH (and may be used on any SCH as well). The suggested frame format of a WAVE Short Message (WSM) is shown in Fig. 2-9 (lengths are in octets of bits).

The 'WSM Version' is used version of WSMP (currently, its value is zero). The 'Security Type' indicates the security processing of the WSM Data i.e. the transmitter application can sign or encrypt the message with an indication in security field. The 'Channel Number' is used to identify the radio channel used for the WSM. The 'Data Rate' indicates the data rate used for the WSM. The 'Tx Power Level' indicates the transmit power used for the WSM. The 'Provider Service Identifier' identifies the application that originated the WSM (each application will have a unique number).

The ‘WSM Length’ indicates the length in octets of the following WSM Data field (limited to 1400 in its default value). The ‘WSM Data’ contains the application data being transferred.

II. CLASSIFICATION OF ROUTING PROTOCOLS

There are five classifications of routing protocols depending upon the applications where they fit suitably. They are: Topology based, Position based, Cluster based, Geocast based, and Broadcast based routing protocols. Among this classification, this paper addresses the issues in broadcast based routing protocols. The oldest form of the broadcast protocol in the vehicle is the brake light and the left/right turn indicator lights. With the help of VANET these signaling lights are replaced by the communication devices, so that these signaling messages will be delivered to other vehicles as audio or image. Thus the driver will get the warning message promptly and drive the vehicle safely. The reason for analyzing broadcasting protocols is that, in most of the emergency situations, there is less time to make a handshake with other nodes in the networks, as the emergency message is to be delivered fast and efficient. Therefore broadcast based routing protocol plays a major role in almost all the safety applications.

The most general applications that require broadcast based routing protocol are sending traffic information, weather information, emergency information, road condition information, advertisements and announcements. Broadcasting is needed to disseminate the information to the vehicles beyond the transmission range using multi-hop transmission. The packets are flooded in the network to ensure the success rate of packet delivery.

Any broadcasting protocol should be reliable, fast and robust. They will use both single-hop and multi-hop communication to reach the most dangerous vehicles on the road. The major challenges in the broadcast based routing protocol are the high possibility of collision in the messages, and the hidden node problem. In VANETs collision happens between the vehicles as well as between the messages.

Almost all the broadcasting protocols deliver the messages to vehicles within the communication range and relay the messages to all the vehicles in the network. The broadcasting protocols can be classified into two types based on the applications related to direct neighbors and applications related to the entire network:

1. Reliable Protocols – Collision avoidance
2. Dissemination Protocols – Traffic Management

The Reliable Protocols are further classified into three types:

1. Rebroadcasting Protocols
2. Selective Acknowledgement Protocols
3. Changing transmission parameters

The dissemination Protocols are further classified into two types:

1. Flooding Protocols
2. Single Relay protocols

The safety related applications in VANET demand time-critical and reliable broadcasting protocol. The reliable routing protocol can deliver the emergency message from the source vehicle to all the vehicles in the

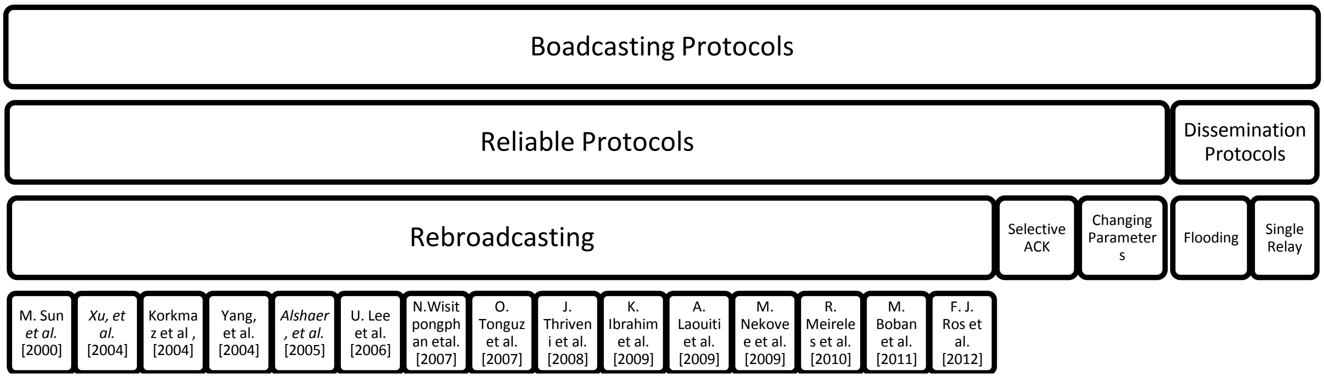

Figure 1. Classification broadcasting protocols

entire network with low latency time. The performance of the reliable routing protocol is measured based on the success rate of the message delivery, and time taken for latency in a single broadcast phase. The success rate of the message delivery can be increased by three methods:

1. Rebroadcasting the message
2. Selective Acknowledgement
3. Changing transmission parameters

Retransmitting the same broadcasted message is called as the rebroadcasting policy. Here the challenge is that how the rebroadcasting is to be done and how many times the rebroadcasting should happen.

III. LITERATURE SURVEY

Sun, et al. [2000] uses the parallel lane highway model to demonstrate the broadcasting. Here the vehicle will broadcast the message along with the information about the furthest neighbor in the same direction of the vehicle movement. They propose another method where the receiver will decide the furthest node and select the back-off time based on the inter-vehicle distance from the previous forwarding vehicle. But both the methods do not address the reliability issue.

Xu, et al. [2004] was the first author to introduce the rebroadcasting as a method to increase the reliability in broadcasting protocol in VANET. Here the broadcasted message is rebroadcasted in each time-slot for a fixed number of times. They proposed many rebroadcasting mechanisms of which Asynchronous Fixed Repetition with Carrier Sensing [AFR-CS] Protocol perform better with high success rate and AFR-CS requires less overhead and does not require global synchronization. The author did not solve the hidden node problem, and the AFR-CS protocol requires the same number of repetitions neglecting the effect of network condition and traffic volume.

Korkmaz et al. [2004] proposed the Urban Multihop Broadcast [UMB] protocol to solve the hidden node problem and introduced the rebroadcasting mechanism. Here the RTB/CTB is transmitted with only one of the recipients among its neighbors. Because of the small size of the VANET safety message, it occupies the channel only for a short period of time. Also because of the distributive nature of the vehicles in VANET, hidden terminal node is present outside the transmission range of the receiver which results in poor handshaking. The success rate is directly dependent on the rebroadcaster and also it does not guarantee high reliability.

Yang, et al. [2004] proposed the Vehicular Collision Warning Communication protocol [VCWC]. Here higher success rate is achieved by rebroadcasting the messages but with less number of retransmission. A single communication range is used for slowing down as prescribed by the DSRC consortium [10-Sec traveling time with a minimum of 110 meters and a maximum of 300 meters]. If the following vehicles react aggressively, they will be considered abnormal and send new warning messages on their own.

Alshaer, et al. [2005] proposed an optimized rebroadcasting algorithm which uses the probability of rebroadcasting the emergency warning messages from the density information available in the list of two-hop neighbors. Here the density information is obtained from the beacon messages exchanged between the neighbors with help of AODV protocol. The position information about each vehicle is obtained from GPS. Here the number of rebroadcasting vehicles is reduced with the help of distance between the neighbor and abnormal vehicle [400m] which is used for making the decision of rebroadcasting. This algorithm suffers from packet redundancy, channel contention and collision.

Lee, et al. [2006] proposed various Geocasting algorithms which use the one-hop neighbors to broadcast the massages followed by n-hop neighbors rebroadcasting by maintaining a hop counter. Also they use the probability of rebroadcasting by obtaining the one-hop neighbors with the help of k proxy vehicles. These proxy vehicles periodically advertise their one-hop neighbors. These algorithms do not address the issue of reliability.

Fasolo, et al. [2006] proposed to segment the transmission range into multiple geographical sectors based on the distance and use the multihop forwarding mechanism. Here the emergency messages are delivered in the opposite direction of the driving. The vehicles obtained their position from the GPS. Each vehicle broadcast beacon message to its neighbors every 100ms. Nodes present in each segment will select a random backoff value for the contention window. Here the vehicles present in the furthest window can transmit first. Because of the random nature of the window, there is a possibility that two vehicles in the same window will select the same backoff values and thus collision becomes common. Even if the segment size is reduced, many time slot collision nodes may present in adjacent lanes.

Wisitpongphan, et al. [2007] proposed many redundant broadcasting methods to solve the broadcast storm problem. Here the probability of weighted and slotted time is used to optimize the number of rebroadcastings, but the reliability and success rate dependent on the number of rebroadcasters. When a vehicle receives a message it will wait for a back-off time to check it will get the same message again. If not then it will rebroadcast the message with a probability depending on the distance between that vehicle and the forwarder, otherwise it will discard the message. They also proposed slotted 1-persistence method where they use maximum number of time slots. Here the slotted time is used for rebroadcasting with a predetermined probability if that particular vehicle does not receive any duplicate messages within the time slot.

Tonguz, et al. [2007] proposed the Distributed Vehicular Broadcast [DV-CAST] protocol which uses the clustering of vehicles in driving direction based on the one-hop neighbors and also the behavior of vehicles is considered. The message is rebroadcasted by the sparsely connected vehicles [connected with a minimum of one vehicle in opposite direction] in the forward direction. The message is discarded if it travels in the same direction of the source. The protocol is not suitable for all the highway scenarios [like intersections] and there is no guarantee of delivery of messages to all the vehicles in the transmission area.

Thriveni, et al. [2008] proposed a new method to solve the broadcast storm problem by reducing the number of rebroadcasters thereby reducing the channel occupancy time of the message. Here the method is applicable for the MANET and does not consider the effect of high node mobility.

Ibrahim, et al. [2009] proposed the probabilistic inter-vehicle geocast [p-IVG] protocol. Here the vehicle will wait for certain time depending on the distance between the sender and the receiver vehicles. If the selected random probability number is less than the reciprocal of the traffic density, then the rebroadcasting will happen till the timer expires; otherwise the message gets dropped.

Laouiti, et al. [2009] addressed the presence of transmission holes by presenting a Reliable Opportunistic Broadcast in VANETs [ROB-VAN] algorithm. Here the algorithm is claimed as the most reliable to transfer the safety messages. Here each node is responsible for the high reliability of the messages within the transmission range. Each node sends the list of neighbors by appending it with the beacon messages. Once the node receives the safety message, it checks for reliability for all other nodes in the transmission range. If it finds any node which is not present in the neighbor list, this is identified as a hole and the message is broadcasted to that node. Here the overhead is that the beaconing message will occupy the channel, and it also includes all the one-hop neighbors which also cause the channel contention.

Nekovee, et al. [2009] proposed a probabilistic algorithm which uses the back-off time depending on the urgency of the message.

They used both front and back next-hop counters and decide the rebroadcasting decision is taken on its own. Here the protocol uses one direction of traffic only.

Meireles, et al. [2011] conducted many experiments and identified that the mobile obstacles present in the transmission range within the line of sight causes the loss in signal strength and the portion of the broadcast region being uncovered. Here the transmission holes in the broadcast region are studied and it shows that even a single obstacle will cause an RSS drop of over 20dB with the inter-vehicle distance as 10m and in non line of sight condition the success rate of communication is about 90%.

Ros, et al. [20012] proposed the Acknowledgement-based Broadcast Protocol [ABSM] which uses the Connected Dominating Set [CDS] and Neighbor Elimination Scheme [NES]. If the vehicle receives a broadcast message, it will wait for the rebroadcasting by the neighbor within the range. The nodes that lie within the CDS will select low waiting time and participate in the rebroadcasting. Here periodically beacon messages are transmitted between the neighbors. The identifier present in each beacon message will act as an acknowledgement of the recently broadcasted message thereby eliminating the neighbor. Therefore the node can decide whether or not to rebroadcast the message on its own. Because of the broadcast acknowledgement, the protocol is robust to broadcasting failures. Hence the protocol is reliable but it can be used only for non-safety applications as the recovery phase takes longer time [because of beaconing cycle] and the size of the acknowledgement list in the beacon can be reduced.

IV. CONCLUSION

Various broadcasting protocols have been developed that works in IEEE 802.11p which is suitable for the VANETs. This paper gives the review of various rebroadcasting policies in VANETs. Every rebroadcasting policy has its own advantages and disadvantages. Almost all the broadcasting protocols are suitable for V2V communication and suitable for urban traffic conditions. Any broadcasting protocol should address the hidden node problem and the broadcast storm problem. We hope that this concise work will help in better understanding of broadcasting protocols in VANETs and pave their way to develop a new protocol which handles the hidden node problem, broadcast storm problem, other traffic considerations into a new broadcasting protocol that works for both rural and urban traffic conditions.

REFERENCES

1. M. Sun, W. Feng, T. Lai, K. Yamada, H. Okada, and K. Fujimura, “GPS-Based Message Broadcast for Adaptive Inter-Vehicle Communications,” Proc. 52nd IEEE Vehicular Technology Conf. [VTC ’00], vol. 6, pp. 2685-2692, 2000.
2. Q. Xu, T. Mak, J. Ko, and R. Sengupta, "Vehicle-to-vehicle safety messaging in DSRC," In Proc. of the 1st ACM Int. Workshop on Vehicular Ad Hoc Networks VANET'04, NY, USA, pp.19-28, 2004.
3. G. Korkmaz, E. Ekici, F. Özgüner, and U. Özgüner, “Urban multi-hop broadcast protocol for inter-vehicle communication systems,” in Proceedings of the 1st ACM International Workshop on Vehicular Ad hoc Networks, VANET ’04, [New York, NY, USA], pp. 76–85, ACM, 2004.
4. X. Yang, L. Liu, N.H. Vaidya, and F. Zhao, "A vehicle-to-vehicle communication protocol for cooperative collision warning," In Proc. of the 1st Int. Conf. on Networking and Services MOBIQUITOUS’04, pp.114-123, 2004.
5. H. Alshaer and E. Horlait, “An optimized adaptive broadcast scheme for inter-vehicle communication,” In Proc. of the 61st Int. IEEE Vehicular Technology Conf. VTC’05, vol.5, pp. 2840–2844, 2005.
6. U. Lee, J. Lee, J. Park, E. Amir, and M. Gerla, “FleaNet: A Virtual Market Place on Vehicular Networks,” Proc. Third Ann. Int’l Conf. Mobile and Ubiquitous Systems: Networking and Services, pp. 1-8, July 2006.
7. E. Fasolo, A. Zanella, and M. Zorzi, “An effective broadcast scheme for alert message propagation in vehicular ad hoc networks,” in IEEE International Conference on Communications, vol. 9, pp. 3960 –3965, June 2006.
8. M. Li, W. Lou, and K. Zeng, “Oppcast: Opportunistic broadcast of warning messages in vanets with unreliable links,” in IEEE 6th International Conference on Mobile Adhoc and Sensor Systems, pp. 534 –543, Oct. 2009.
9. N.Wisitpongphan, O. Tonguz, J. Parikh, P. Mudalige, F. Bai, and V. Sadekar, “Broadcast storm mitigation techniques in vehicular ad hoc networks,” IEEE Wireless Communications, vol. 14, pp. 84 –94, Dec. 2007.
10. O. Tonguz, N. Wisitpongphan, F. Bai, P. Mudalige, and V. Sadekar, “Broadcasting in VANET,” Proc. Mobile Networking for Vehicular Environments, pp. 7-12, May 2007.
11. J. Thriveni, B. Ashwini, A. Latha, K. Sandhyashree, G. Prakash, A. Alice, K. Venugopal, and L. Patnaik, “Dual covered broadcast with negative acknowledgements for enhanced reliability in mobile ad hoc networks,” in IEEE Region 10 Conference [TENCON], pp. 1 –6, Nov. 2008.
12. K. Ibrahim, M. Weigle, and M. Abuelela, “p-ivg: Probabilistic inter-vehicle geocast for dense vehicular networks,” in 69th IEEE Vehicular Technology Conference [VTC], pp. 1 –5, Apr. 2009.
13. A. Laouiti, P. Muhlethaler, and Y. Toor, “Reliable opportunistic broadcast in vanets [rob-van],” in 9th International Conference on Intelligent Transport Systems Telecommunications,[ITST], pp. 382 –387, Oct. 2009.
14. M. Nekovee, “Epidemic Algorithms for Reliable and Efficient Information Dissemination in Vehicular Ad Hoc Networks,” IET Intelligent Transportation Systems, vol. 3, no. 2, pp. 104-110, 2009.
15. R. Meireles, M. Boban, P. Steenkiste, O. Tonguz, and J. Barros, “Experimental study on the impact of vehicular obstructions in vanets,” in IEEE Vehicular Networking Conference [VNC], pp. 338 –345, Dec. 2010.
16. M. Boban, T. Vinhoza, M. Ferreira, J. Barros, and O. Tonguz, “Impact of vehicles as obstacles in vehicular ad hoc networks,” IEEE Journal on Selected Areas in Communications, vol. 29, pp. 15 –28, January 2011.
17. F. J. Ros, P. M. Ruiz, and I. Stojmenovic, “Acknowledgment-based broadcast protocol for reliable and efficient data dissemination in vehicular ad hoc networks,” IEEE Transactions on Mobile Computing, vol. 11, pp. 33 –46, Jan. 2012.
18. IEEE P802.11p, “Amendment 6: wireless access in vehicular environments (WAVE),” October 2010.
19. IEEE P1609.1, “Trial-use standard for wireless access in vehicular environments (WAVE) - resource manager,” Draft D17, July 2006.
20. IEEE P1609.2, “Trial-use standard for wireless access in vehicular environments (WAVE) - security services for applications and management messages,” Draft D7, April 2006.
21. IEEE P1609.3, “Trial-use standard for wireless access in vehicular environments (WAVE) - networking services,” Draft D22, January 2007.
22. IEEE P1609.4, “Trial-use standard for wireless access in vehicular environments (WAVE) - multi-channel operation,” Draft D08, July 2006.