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Comparison of the MAC Protocols in Vehicular Ad-Hoc Network

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ABSTRACT: The number of vehicles have increased on road recently has increased the possibilities of potential threats and road accidents. The deployment of the vehicles with the communicating on board unit has become a necessity so that the vehicles may communicate with each other and prevent the potential threats up to a certain level. VANETs (Vehicular AD-HOC Networks) are the most important and one of major popularity gaining sector in AD-HOC networks because it has the significant potential to enable vast applications associated with safety, efficiency and many more application of traffic. In these networks MAC (Medium Access Control) protocols are responsible for coordinating the access from the active nodes. In this paper we introduced the basic protocols used in VANETs to provide the overview by giving brief description based on their principles and underlying features. Also various advantages and disadvantages of the protocols are focused in this paper.

KEYWORDS: ITS, VANET, IEEE 802.11p, ALOHA, WAVE, DSRC.

I.INTRODUCTION

An Ad-Hocnetwork is defined as a collection of nodes dynamically forming a network without any existing infrastructure or centralized administration which the usual telecommunication system or the mobile communication system has. One special type of mobile ad hoc networks is the network among moving vehicles, which is known as vehicular ad hoc network (VANET).To develop the safety, security and the efficiency of the on road moving vehicles an intelligent transport system (ITS) has been developed. One of the important component of the ITS is VANET (vehicular ad hoc network) which includes inter-vehicular communication (IVC) including both vehicle to vehicle communication (V2V) and vehicle to roadside communication (V2R). Each vehicle consists of a device called on board unit (OBU) which can communicate with other vehicles and the roadside infrastructures (RSUs) located at the side of the roads.

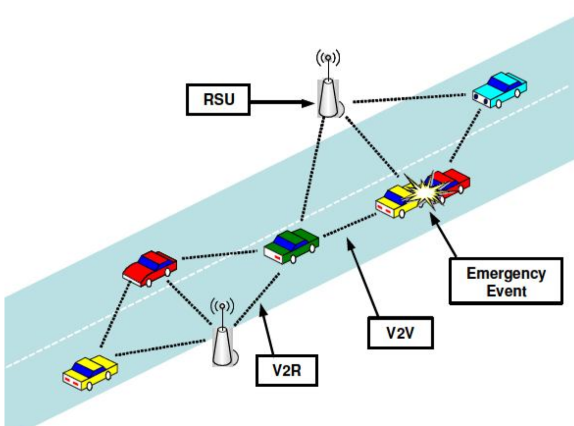

Fig 1: Example of a VANET [14].

MAC PROTOCOL:

The aim of the media access control protocol is to arbitrate the access to the shared medium. The MAC protocol restricts the nodes within the transmission range of each other from transmitting at the same time. If no precaution is taken then collisions would take place which will lead to loss of packets. Therefore the MAC protocol must be fair to all the nodes; it has to be efficient, collision free and reliable.

In VANETs the major problems which the MAC protocol has to resolve are:

i. Transmission collision
ii. Hidden terminal problem
iii. Exposed terminal problem

II. RELATED WORK

1. IEEE 802.11p

DSRC refers to dedicated short range communication which is medium ranged wireless communication channel specially designed for vehicles to communicate.
IEEE 802.11b protocol which may have been implemented as wireless communication standard between V2V but since the nodes in the VANETs are mobile there are numerous challenges such as speed of the vehicle, traffic pattern, mobility that questions the efficiency of the standard. To overcome these challenges IEEE 802.11b was updated to IEEE 802.11p that works on data link and physical layer which can be used for reliable communication between vehicles moving at high speeds. IEEE 802.11p standard uses channels of 10MHz bandwidth in the 5.9GHz band (5.850-5.925 GHz). This is half the bandwidth, or double the transmission time for a specific data symbol, as used in 802.11a.
Furthermore to address the challenges a new model emerged called wireless access for vehicular environment (WAVE). [11] In WAVE protocol, at the physical layer IEEE 802.11p standards are used. The Wave protocol works on the rest of the OSI layers. Standards of the IEEE 802.11b and IEEE 802.11p are tabulated below:

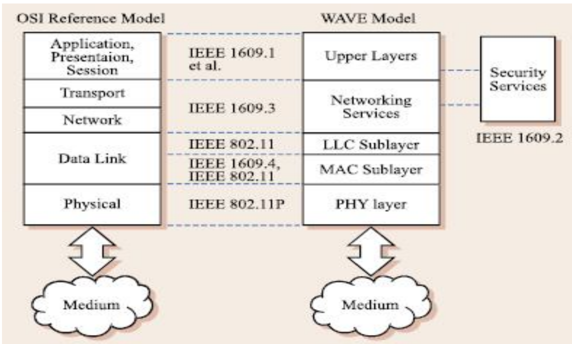

Fig 2: WAVE Model and OSI reference model [11].

2. THE ADHOC-MAC PROTOCOL

ADHOC-MAC operates on a time division structure, where slots are grouped into virtual frames (VF) of length N. All the active nodes are allowed to transmit a packet in frame periodically, frame synchronization and slot is provided by the first terminal that turns on. For well functionality, in ADHOC MAC basic channel is assigned to all the active nodes corresponding to the slot in the virtual frame. This is seen in RR-ALOHA protocol, which is described in the following section.
RR-ALOHA refers to the Reliable R-ALOHA which is a distributed MAC layer architecture. The architecture implements a reliable single hop broadcast channel among all the nearby terminals. RR-ALOHA extends the R-

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ALOHA protocol to safely operate in an environment that suffers from the hidden-terminal problem, and is also able to provide reserved channels of variable and width according to terminals needs. [15]
The operation of RR-ALOHA in almost similar as R-ALOHA where contention is used to get access the available slot in the frame and when a node wins the contention the same slot is reserved for the following frames and no other terminal is allowed to access the channel for that slot unless the current slot releases the slot. The transmitted packet contains frame information (FI) besides the payload which includes status information of a specific slot at a time. The frame information received is used to update the status of the of the following N slots. A slot is identified as reserved (RES) if coded as BUSY in at least one FI. Otherwise it is decoded as available (AV).
In the beginning, all the slots are AV, and the terminals start transmitting according to the protocol described unless and until all of them have acquired their own basic channel (BC). The basic channel is automatically released as the active terminal goes beyond the coverage area or turns off its transmission. [15]
To show the appropriate operation of RR-ALOHA, refer to the fig. shown below in which terminals are shown in the cluster A, B, C and D. The terminals of each cluster enjoy full connectivity within the cluster but cannot communicate with each other as they are not in range of each other so there are no problems of interference. The cluster overlap is a typical application considered i.e. terminals belonging to joint subset of AB, BC and CD has full connectivity with both adjacent clusters. There may be a problem of hidden terminal but it is overcome as in the each active nodes provide FI regarding all the clusters it belong to. The FIs prevents the terminals in A to interfere with terminal B and so on. All the terminals of A and B transmit in their own slot on the same frame, Frame 1 in figure 3. Again the terminals of BC can see the transmissions in terminals B and C but not of A, terminals in C do not receive the transmissions from set AB and slots are therefore free to be reused by A, yielding frame 2 in figure 3. Frame 3 represents a possible frame used by terminals [15].

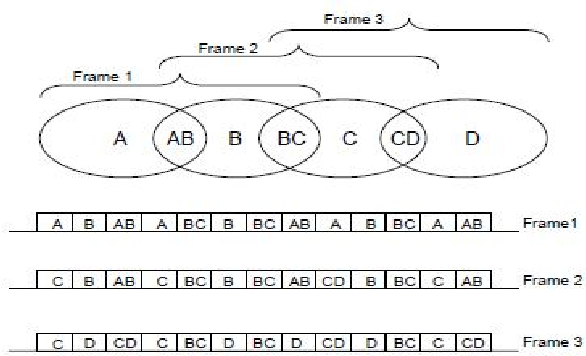

Fig 3: Example of how transmissions in frames become organized. [15]

3. DIRECTIONAL ANTENNA

MAC protocols have some major issues among which reliability and efficiency find their places on the top. Both of these issue have led to the rejection of some major protocols that were proposed, as either they had a large number of collisions, or were not efficient enough to accommodate large number of users. One way to cope with these issues is to use directional antennas.
Directional antennas are the ones used to direct or restrict a signal to a particular area/region. This can help by reducing the collisions that might happen because of the hidden and exposed terminal issues. Also it increases the efficiency by allowing more number of users to get into the network. As you can see in the figure 4 once a node begins its transmission it blocks only the area that needs to wait, other areas can at that moment send data and hence the problem of exposed terminal sways away.

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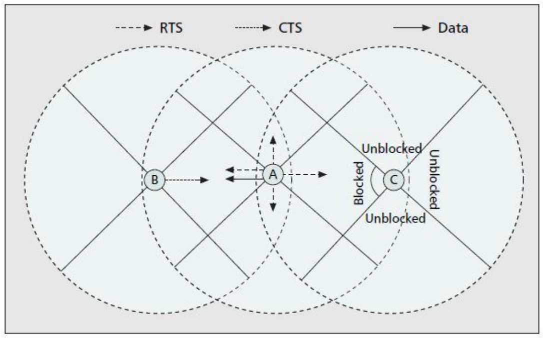

Fig:4 MAC protocol with Unidirectional RTS/CTS. [14]

4. Improved MAC using TDMA / FDMA / CDMA

When it comes to improving MAC protocols, we can put into use a variety of techniques, techniques that can reduce the probability of collisions, increase the capacity etc. We have come across a variety of multiple accesses like CDMA, FDMA and TDMA. I we put forth all these techniques in a contemplative manner; we can achieve our goal of bettering the MAC protocols.

Taking an instance where we inculcate the TDMA technique into one of our MAC protocols for deciding the allocation procedure. If the allocation cycles are run according to TDMA, and also, some time slots are restricted for the use of some high priority slots, we can achieve a state of discipline and balance in our system. Using TDMA can also help us in having different time slots for different functions on the MAC layer. One of the major disadvantages of TDMA can be the importance of synchronization in its functioning. If there happens to be even the slightest of anomaly in synchronization, our whole system could fall to ground.

Using FDMA can also help, as then we will not be much considered about our nodes getting collided at the time of contention or even transmission. This will increase the reliability. But if that was to be the case, we all would have started using FDMA from the time of its inception. But that is something we refrain from. When we use FDMA, our demand for bandwidth increases with the number of different frequencies required. Now that is one of the reason as to why we cannot use FDMA in all our applications.

Finally when we talk about CDMA, we at least get an upper hand in terms of bandwidth efficiency and maybe we can maintain a loose grip when it comes to synchronization. CDMA is a boon to communication field, using this technology we can deploy a large number of devices that too without the issue of increase in costs. We can use it to overcome hidden terminal problems in many scenarios and also if we use the concept of cell reuse (using CDMA as a cell), we can increase the capacity of our system as well, that will lead to a further increase in our bandwidth efficiency.

III. SIMULATION AND RESULT

Table 1: PHY layer values of IEEE 802.11b and IEEE 802.11p

Parameters	IEEE 802.11b	IEEE 802.11p
Channel BW	20 MHz	10 MHz
Data rate	1-11Mbps	3-27 Mbps
Slot time	20 µs	16 µs
SIFS time	10 µs	32 µs

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Table: 2 Comparison between various MAC protocols for VANETs

Protocol	Advantages	Disadvantages
802.11p	1. Does not adopt TDMA, so less costly than RR-ALOHA or D-MAC. 2. Applied on physical and MAC layer in order to cope with rapidly changing communication environment. 3. Enables relatively reliable communication using cheap hardware and software. 4. Simple, fair and ease of use main features.	1. It cannot overcome the hidden terminal problem. 2. Since it is a DSRC protocol, it can be only applied to short distances.
Directional MAC	1. Utilizes the Directional Transmission capability which improves the bandwidth efficiency up to an extent. 2. It is used to increase the spatial reuse of wireless channel.	1. Problem of Deafness 2. Due to high gain, interference takes place. 3. Virtual carrier sensing is imperfect. 4. Mobility also affects, a) Reachability in higher range. b) Reachability in different sector. c) d- Condition of total unreachability.
Ad-Hoc MAC	1. Reliable layer two connectivity information on all the stations of the network. 2. Contention-less access to a reliable single-hop broadcast service. 3. Efficient multi-hop broadcast service. 4. Provision of different QOS according to application needs.	1. Frequent periodical transmissions are needed in broadcast signalling channel. 2. For VANETs, broadcast channel set-up delay is of few hundred s of ms. 3. Overheads required for the transmissions are more in number.

IV.CONCLUSION

We can see from the comparison above that all the MAC protocols we took into consideration have some inherent issues when it comes to their implementation part in VANET. For instance we can see that 802.11p has an advantage of cheap implementation, and also, we must not forget the ease of use that it brings about. But this protocol fails as soon as we think about the hidden terminal problem and its limitation to short distances. Just by looking at other protocols we can tell that there are some or the other advantages that are coming in a package with some issues and limitations. Thus, we can conclude that all these MAC protocols are reasonably good, but can only be applied in a limited number

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of scenarios. We would need to optimize them a bit to use them at different places, but still their usability is highly restricted to their specified domains in which they can work without their inherent limitations.

REFERENCES

[1] Bijan Paul, Md. Ibrahim and Md. Abu NaserBikas. "VANET Routing Protocols: Pros and Cons". International Journal of Computer Applications (0975 – 8887) Volume 20– No.3, April 2011

[2] Prof. Vaishali D. Khairnar and Dr. S. N. Pradhan. "Comparative Study of Simulation for Vehicular Ad-hoc Network". International Journal of Computer Applications (0975 – 8887) Volume 4– No.10, August 2010.

[3] Mrs. Vaishali D. Khairnar and Dr. KetanKotecha. "Simulation-Based Performance Evaluation of Routing Protocols in Vehicular Ad-hoc Network". International Journal of Scientific and Research Publications, Volume 3, Issue 10, October 2013

[4] Avanti Chimote, CharanHebri, KuppurajGunasekaran, Sandeep N L and SaravananSathanandaManidas. "Collision Avoidance in Vehicular Networks".

[5] Hassan Aboubakr Omar, WeihuaZhuang and Li Li." VeMAC: A TDMA-based MAC Protocol for Reliable Broadcast in VANETs". 2011 IEEE INFOCOM Workshop.

[6] Hamid Menouar and FethiFilali, Eurecom ; MassimilianoLenardi, and Hitachi, Europe, A survey and qualitative analysis of MAC protocols for vehicular ad hoc networks, Inter-Vehicular Communications, IEEE Wireless Communications,October 2006.

[7] Young-BaeKo, Jong-Mu Choi, and Nitin H. Vaidya, MAC protocols using directional antennas in IEEE 802.11 based ad hoc networks, Wireless Communications and Mobile Computing, Wiley Interscience.

[8] Zhuochuan Huang ,Chien-Chung Shen, ChavalitSrisathapornphat, and ChaipornJaikaeo, Department of Computer and Information Sciences, University of Delaware, Newark, DE.

[9] C. Siva Ram Murthy." Ad Hoc Wireless Networks: Architectures and Protocols'.

[10] AlexandruOprea. "MAC Protocols for VANETs". February 2010 , Ad Hoc Networks Seminar.

[11] Chan-Ki Park, Min-Woo Ryu, and Kuk-Hyun Cho, "Survey of MAC Protocols for Vehicular Ad Hoc Networks",4, August 2012,Smart Computing Review

[12] F. Borgonovo, A. Capone, M. Cesana and L. Fratta, "ADHOC MAC: a new, flexible and reliable MAC architecture for ad-hoc networks", Med-Hoc-Net 2009, Baia Chia, Italy

[13] Tim Weil,"Securing Wireless Access in Vehicular Environments (WAVE)", New Orleans. 1 December 2008,IEEE GLOBECOM Design and Developers Forum.

[14] Yi Qian, Kejie Lu and Nader Moayeri, "A Secure VANET MAC Protocol for DSRC Application".

[15] F. Borgonovo, A. Capone, M. Cesana RR-ALOHA, "a Reliable R-ALOHA broadcast channelfor ad-hoc inter-vehicle communication networks".