E-MAC: Efficient Medium Access Control Protocol for Vehicular Ad-Hoc Network

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ABSTRACT

VANET poses some extreme challenges including dropping out of connections as the moving vehicle moves out of the coverage range, joining of new nodes moving at high speeds, dynamic change in topology and connectivity, time variability of signal strength, throughput and time delay. One of the most challenging issues facing vehicular networks lies in the design of efficient resource management schemes, due to the mobile nature of nodes, delay constraints for safety applications and interference. The main application of VANET in ITS lies in the exchange of safety messages between nodes. Moreover, as the wireless access in vehicular environment (WAVE) moves closer to reality, management of these networks is of increasing concern for ITS designers and other stakeholder groups. As such, management of resources plays a significant role in VANET and ITS. For resource management in VANET, a medium access control protocol is used, which makes sure that limited resources are distributed efficiently. In this work, an efficient Multichannel Cognitive MAC (MCM) is developed, which assesses the quality of channel prior to transmission. MCM employs dynamic channel allocation and negotiation algorithms to achieve a significant improvement in channel utilization, system reliability, and delay constraints while simultaneously addressing Quality of Service.

Keyword: - *Vehicular Ad Hoc Network , Multichannel Cognitive MAC Protocol, Channel Utilization, Waiting Time Interval, Delay, Jitter, and Frame Error Rate*

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1. INTRODUCTION

Vehicular Ad-Hoc Network with the use of Multichannel Cognitive Medium Access Control Protocol. A Vehicular Ad-Hoc Network or VANET is a sub form of Mobile Ad-Hoc Network or MANET that provides communication between vehicles and between vehicles and road-side base stations. The main application of VANET is the exchange of safety messages between nodes. In VANET, a Medium Access Control protocol is used, which makes sure that limited resources are distributed efficiently. Vehicular ad-hoc network (VANET) is a network of moving vehicles where participating vehicles or infrastructures create a network that facilitates vehicle to vehicle and infrastructure communications. Due to the nature of communication, VANET offers some extreme challenges, and some of these challenges include: dropping out of connections as the moving vehicle moves out of the coverage range, joining of new nodes moving at high speeds, dynamic change in topology and connectivity, time variability of signal strength, throughput and time delay.

The IEEE 1609.4 draft standard for VANET defines the sync interval which constitutes of control channel interval (CCH interval) and service channel interval (SCH interval). The IEEE 1609.4 standard defines the time division scheme for WAVE radios to alternatively switch between CCH and SCH during a sync interval to support different applications concurrently. Start of a sync interval is synchronized with the coordinated Universal Time (UTC) second and multiples of 100 ms thereafter. A sync interval with a default length of 100ms is equally divided into 50 ms CCH and 50 ms SCH interval. According to the WAVE, a Wave Basic Service Set (WBSS) consists of one provider and one or more WBSS users. As described in the IEEE 1609.4, in VANET has to switch to CCH every

50ms to listen to safety messages and for network management processes. Therefore, SCH is not utilized during the CCH interval which is 50% of every sync interval. This causes underutilization of available resources, which ultimately results in more waiting time, more jitter and increased frame error rates for the transmission of safety messages.

Multichannel Cognitive MAC (MCM) is developed, which assesses the quality of channel prior to transmission. The main purpose of the proposed multichannel cognitive MAC (MCM) protocol is to improve channel utilization and transmission reliability of safety related data. According to the concept of the cognitive radio, primary providers (PPs) are mapped as nodes with safety related data (e.g., emergency vehicles such as police cars, ambulance, fire trucks) and secondary providers (SPs) and secondary users (SUs) are mapped as commercial and general automobiles, whereas primary users(PUs) can be any node in the system.

.2. LITERATURE SURVEY

Paper presented by Niravkumar Shah, Daryoush Habibi and Iftekhar Ahmad [1] that medium access control (MAC) protocol for WAVE system to improve the channel utilization (CU) and reliability of safety messages. The proposed protocol has been developed based on the concept of cognitive radio and it outperforms the existing channel access mechanism by a significant margin in terms of channel utilization, jitter and robust delivery of safety data. Simulation results confirm that the proposed cognitive MAC protocol increases the CU up to 70% compared to the IEEE 1609.4 standard, and improves reliability for the safety related data transmission.

Paper presented by Qi Chen, Daniel Jiang, Luca Delgrossi [2] that while IEEE 1609.4 is currently being updated and revised, this paper is intended to contribute to the technical discussions, and to bring attention to the most relevant and critical issues. This paper also contains results from software simulations conducted to study vehicle safety communications under stressful but realistic conditions. These results confirm concerns for the currently proposed scheme and provide a motivation for updating and revising the standard.

Paper presented by Liljana Gavrilovska, Daniel Denkovski, Valentin Rakovic, and Marko Angjelichinoski [3] that C-MAC proposals is a complex task due to many C-MAC related aspects. Paper introduces and develops generic, modular and easily extensible layout for classification and systematization of C-MAC protocols referred as C-MAC cycle. Each C-MAC protocol can be easily fragmented, mapped and visualized using the C-MAC cycle, regardless of the operational scenario and settings. The survey offers extensive overview on the state-of-the-art advances in C-MAC protocol engineering by reviewing existing and up-to date technical solutions, identifies their basic characteristics and maps them into the C-MAC cycle. The survey also highlights the role of regulative and standardization activities on C-MAC cycle.

Paper presented by Duc Ngoc Minh Dang_, Hanh Ngoc Dangy, Cuong The Do_ and Choong Seon Hong [4] that Vehicular Enhanced Multi-channel MAC protocol (VEMMAC) for Vehicular Ad hoc Networks (VANETs). The VEMMAC adopts the IEEE 1609.4 with alternating sequences of the Control Channel (CCH) interval and the Service Channel (SCH) interval. Different from the IEEE 1609.4, the VEMMAC allows nodes to transmit non-safety messages during CCH interval and broadcast safety messages twice with each in the CCH and SCH interval. Our proposal can utilize the channel resources more efficiently than the IEEE 1609.4. The simulation results show that the proposed VEMMAC protocol achieves higher throughput for service data and is more reliable for safety messages broadcast than other protocols.

Paper presented by S. M. Kamruzzaman [5] that Author's proposed protocol enables secondary users (SUs) to utilize multiple channels by switching channels dynamically, thus increasing network throughput. In proposed protocol, each SU is equipped with only one spectrum agile transceiver, but solves the multichannel hidden terminal problem using temporal synchronization. The proposed cognitive radio MAC (CR-MAC) protocol allows SUs to identify and use the unused frequency spectrum in a way that constrains the level of interference to the primary users (PUs). Our scheme improves network throughput significantly, especially when the network is highly congested. The simulation results show that author's proposed CR-MAC protocol successfully exploits multiple channels and significantly improves network performance by using the licensed spectrum band opportunistically and protects PUs from interference, even in hidden terminal situations.

Paper presented by Luis Fernando Pedraza, Ingrid Patricia Paez, Felipe Forero a [6] that author presents a comparative analysis between the mechanisms of media access control IEEE 802.11 and MMAC-CR (Multichannel MAC protocol for Cognitive Radio) in MANETs (Mobile Ad Hoc Networks). The IEEE 802.11 standard allows the use of multiple channels available at the physical layer, but its MAC protocol is designed for a single channel. However, a MAC protocol of a single channel does not work well in a multichannel environment due to the hidden terminal problem. The simulation results show how the MMAC-CR protocol allows a better use of spectral opportunities thereby increasing the throughput of the MANET network.

3. MCM (Multichannel Cognitive MAC) protocol

In the MCM protocol, all the nodes are required to perform wide-band spectrum sensing [1] to utilize the cognitive radio Figure 6. The operation of the proposed MCM protocol concept which is presented in the flow chart as summarized in Fig 1. Each node senses the spectrum across all six SCHs using its radio trans-receivers and update the spectrum condition at the beginning of each CCH interval. Once all the nodes go through the sensing phase, they establish their own Channel Status Tables (CST) which have the information about all six SCHs.

The CST indicates whether the channel is available during the desired intervals. As mentioned above, each provider needs to go through a channel contention and negotiation process during the CCH interval. A provider advertises its WSA frame during CCH interval for channel access and negotiation process. The SCH that the provider targets to switch to, is decided based on its own CST. Once all interested users acknowledge the WSA frame with a WSAR frame, the handshake process is finished and the provider is ready to send it’s data in the next SCH interval.

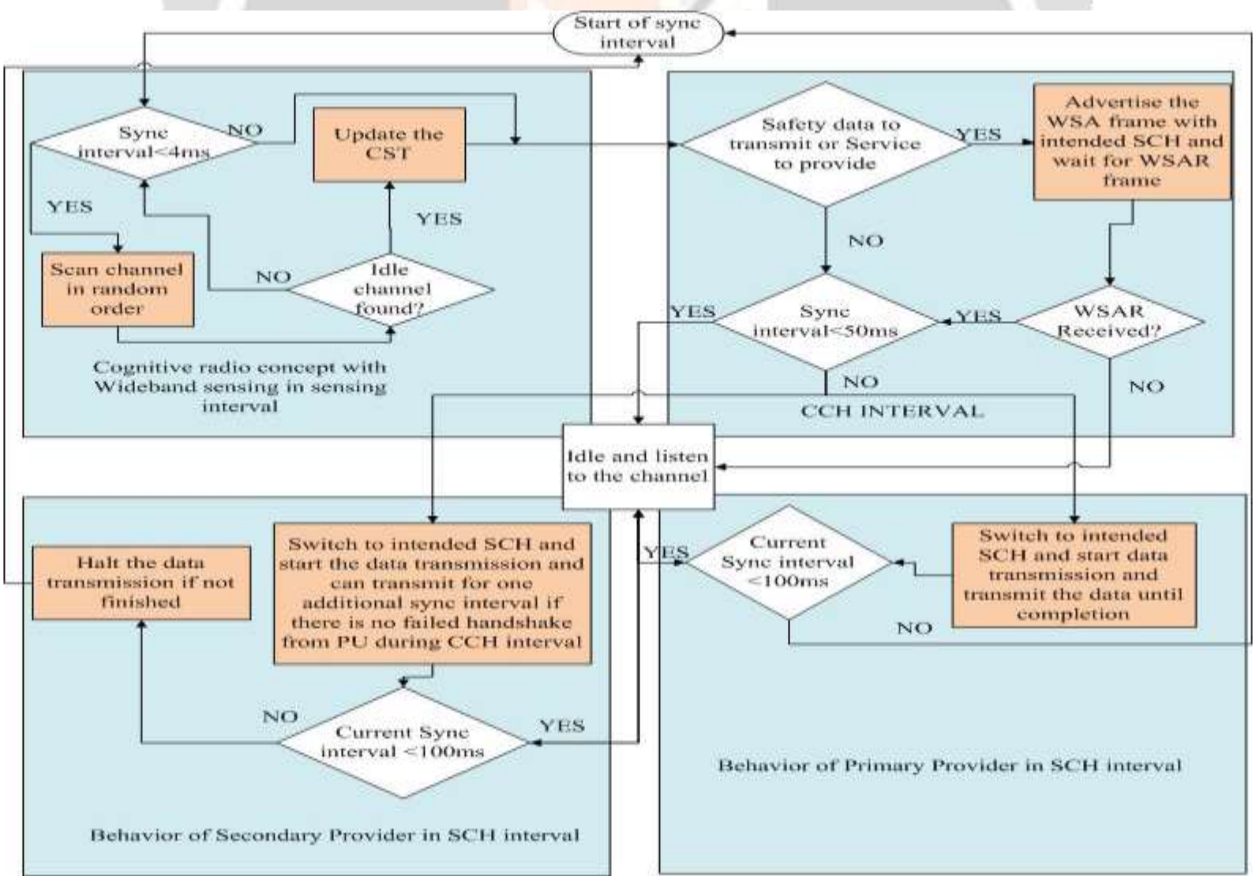

Fig 1 : System flow diagram for the proposed MCM protocol. [1]

4. PROPOSED WORK

1. Start of sync interval.

2. Check whether guard interval < 4ms.

3. if guard interval < 4ms,

   Then scan channel in sequence order,

   Else it will transmit safety data.

4. Now after scanning channel in sequence order it will check whether Idle channel found or not.

5. If Idle channel found,

   Then update CST,

   Else it check whether guard interval < 4ms or not. (Step 2)

6. After update CST then safety data is transmit.

7. It checks whether safety data is transmitting or not,

   If transmit then advertise WSA frame and wait for WSAR frame.

   Else channel will be Idle and again start sync interval and this way the cycle is continue.

8. If it receive response frame then it checks sync interval < 100ms or not.

   Else channel will be Idle and again start sync interval and this way the cycle is continue.

9. If sync interval < 100ms then switch to intend SCH and transmit data until completion.

   Else it again start sync interval and this way the cycle is continue.

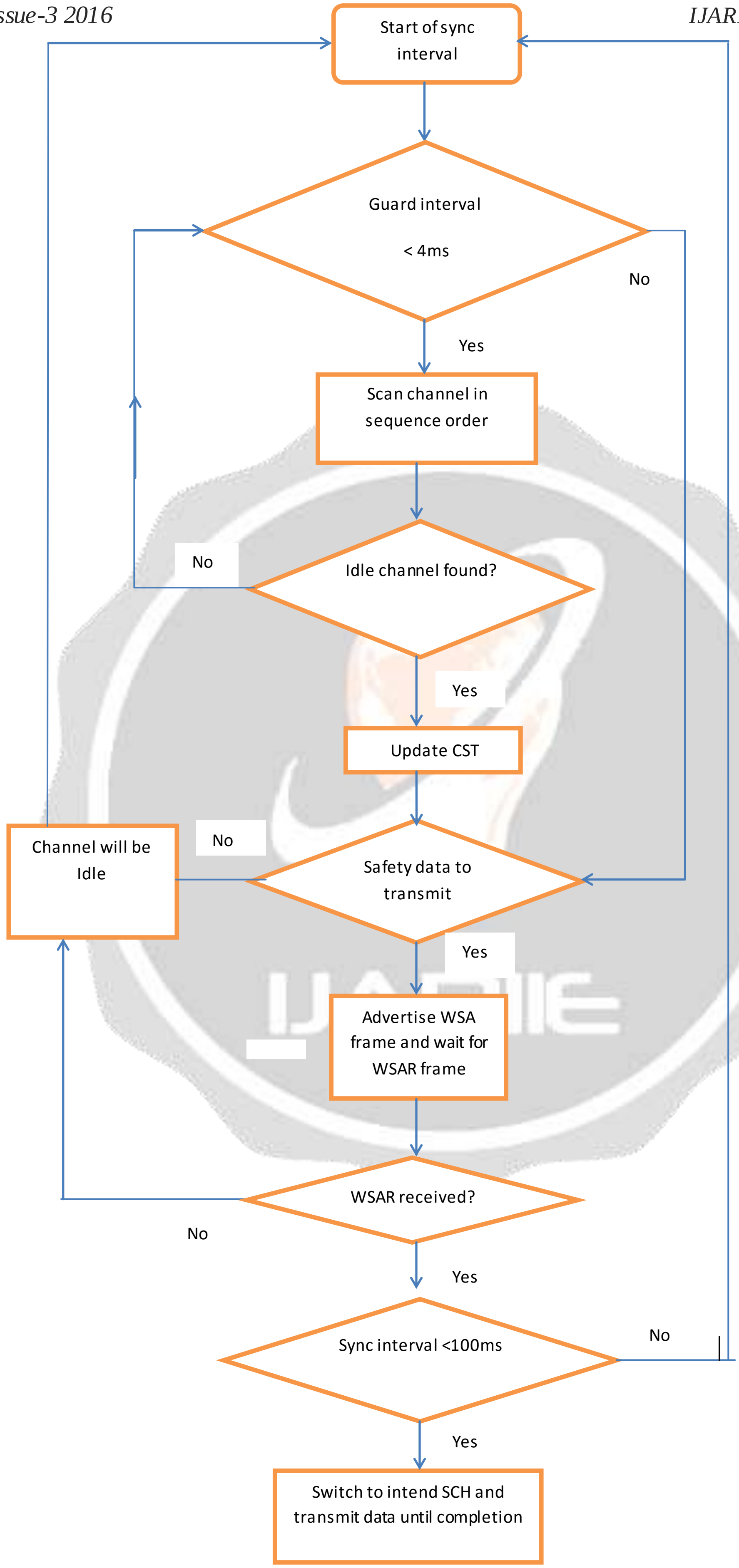
Start of sync interval
Guard interval
< 4ms
No
Yes
Scan channel in sequence order
No
Idle channel found?
Yes
Update CST
Channel will be Idle
No
Safety data to transmit
Yes
Advertise WSA frame and wait for WSAR frame
WSAR received?
No
Yes
Sync interval <100ms
No
Yes
Switch to intend SCH and transmit data until completion

Fig 2: Flow of Work

4. CONCLUSIONS

In this paper, a new multichannel cognitive MAC protocol is introduced, followed by modified of EDCA and safety message acknowledgment for improving the performance of MAC protocol. Modify Enhanced Distributed Channel Access protocol to improve the reliability for safety application, which will have capabilities to prioritize traffic to ensure QoS. Develop a simulation model for IEEE 1609.4, which is close to real model to simulate close to real scenario for VANET. The proposed protocol together with the enhancement mechanism were both evaluated with ns-2 and simulations showed improvement for the MAC in-terms of Channel utilization, waiting time interval, delay, jitter, and frame error rate.

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