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A DSRC BASED SMARTVANET ARCHITECTURE

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Abstract- Vehicular Ad Hoc Network (VANET), which is based on Dedicated Short Range Communication (DSRC) provides an opportunity to enable communication-based cooperative safety systems in order to diminish road ills and improve traffic efficiency. VANET provides a wide range of profitable and documentary applications. VANET exposes unique characteristics that create new challenges. This paper talks about the DSRC technology and its defects in order to achieve reliable content distribution. To optimize the performance of the vehicular networks, a novel network architecture using the cross-layer paradigm is presented. The architecture is called Smart Vehicular Ad-hoc Network (SmartVANET) architecture. The SmartVANET architecture can support safety, traffic management and commercial applications. The SmartVANET architecture abides by the DSRC channel plan. The architecture divides road into segments and assigns a service channel to each segment. The SmartVANET combines a segment based clustering technique with a hybrid Medium Access Control (MAC) mechanism (known as the SmartMAC protocol). Using cross-layer integration, SmartVANET also provides a solution for broadcast storm problems and offers scalability. The paper presents the SmartVANET architecture and states its advantages.
Keywords- Cross-layer design, DSRC, Road safety, VANET

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Introduction

Decline of road accidents and traffic congestion are two serious challenges in today's society. Existing active safety systems have improved safety of the occupants. However, the state-of-the-art expensive active safety systems provide limited range and view. Therefore governments and automotive industry are working towards communication based cost effective safety systems. Vehicular Ad-Hoc Network (VANET) provides a unique opportunity to establish communication-based helpful safety systems. VANET comprises two modes of communication: Vehicle-to- Vehicle (V2V) communication and Vehicle-to-Infrastructure (V2I) communication. Dedicated Short Range Communication (DSRC) technology is envisioned as a key enabler technology for VANET. DSRC technology is based on a cost effective local area network technology .VANET opens doors for a surplus of mobile applications. Such proposed applications are mainly categorized into safety, transport efficiency and information/entertainment applications [5].VANET exhibits unique features and such unique features present challenges at different layers of the communication protocol stack. Channel conditions, node density, and dynamic topology changes create challenges in VANET. Speed of vehicles and communication scenarios (buildings, trees etc.) directly force the indicator quality and Bit Error Rate (BER) performance. High node density (due to an accident or traffic jam) deteriorates the performance of the contention based non-deterministic DSRC medium access control (MAC) layer by inducing network congestion and high rate of collisions. Proposed cross-layer design based SmartVANET architecture combines the DSRC channel plan, a location based deterministic channel access mechanism and a cluster-based routing concept. SmartVANET employs a clusterbased message dissemination technique to achieve reliable message broadcasting in highly dynamic VANETs. SmartVANET integrates

MAC and routing layers. The architecture divides the road into small segments and allocates one service channel to each segment.

Dedicated short range communications (DSRC)
It is a promising wireless technology which operates in the 5.9 GHz range with 75 MHz of spectrum . It is a wireless protocol standard which is designed to support vehicle-to-vehicle and vehicle to infrastructure communication. Its primary purpose is to support critical safety applications which will reduce the number of accidents on the road and as a result will reduce the number of lives lost and its secondary purpose is to improve traffic flow, although aside from these twoprivate services will also be permitted. DSRC will have six service channels and one control channel .The control channel will be used for the transmission and reception of “safety of life” messages and also service advertisements and the service channels will be used for other non-safety-critical messages.

DSRC Protocol Overview
Dedicated Short-Range Communications Protocol is a multi-channel wireless protocol, still under development , that is based on the IEEE 802.11a Physical Layer and the IEEE 802.11 MAC Layer . It operates over a 75 MHz licensed spectrum in the 5.9 GHz band allocated by the FCC for the support of low latency vehicle-to-vehicle and vehicle-to-infrastructure communications. The motivation behind the development of DSRC is based mainly on the need for a more tightly controlled spectrum for maximized reliability. But even with a licensed band , some issues arise , such as fair access to all applications , including priority scheduling of traffic between different application classes (safety over non -safety).Unlike 802.11 , multi-channel coordination is a fundamental capability of DSRC.DSRC is similar to 802.11a , but there are still some major differences.[2]

i. Operating Frequency Band- DSRC operates in a 75 MHz spectrum in a 5.9 GHz dedicated band , but IEEE 802.11a operates only on the unlicensed portions of the 5 GHz band.
ii. Application Environment- DSRC is supposed to work in an outdoor high-speed environment as opposed to 802.11a which is designed for indoor WLAN. This brings new problems for wireless channel propagation considering the multi-path delay and Doppler effects caused by high speed.
iii. MAC Layer- The DSRC band is divided into 7 channels , one control channel to support safety applications and 6 service channels to support non-safety applications. Prioritizing safety messages over non-safety ones is one of the DSRC MAC layer capabilities , this being related to multi-channel coordination. Aside from this , the MAC layer follows the original 802.11 MAC.
iv. Physical Layer- The bandwidth of each DSRC channel is 10 MHz , as opposed to 20 MHz channel in 802.11a [2].

SmartVANET: A cross layered architecture
DSRC based VANETs present unique research challenges. Multi-hop communication with limited capital calls for coordination amongst nodes. Clustering of nodes is a very well-known concept. SmartVANET architecture employs cross-layer amalgamation between network and MAC layers. A CHV is selected based on a cluster-head election algorithm. This CHV provides deterministic medium access to all Cluster- Member Vehicles (CMVs) in that respective cluster. as bandwidth task is done centrally,so that any CMV can transfer the information even in dense traffic scenarios. Fig. 1 shows the working of the SmartVANET architecture and DSRC spectrum. Event 1 (E1) refers to an incident and broadcast of the message on segment specific SCH (CH 174 in this case). During this event CHV and all CMVs of segment A receive this broadcast. Event 2 (E2) shows that only CHV of segment A unicast this information to the CHV of the adjacent segment during CCH period. According to event 3 (E3) CHV of the segment B determines the importance of the message and decides to re-broadcast it in segment B during its beacon period using SCH 182. CHV of the segment B further relays this message to CHV of the segment C using CCH during Event 4. CHV of the segment C does the same job as CHV of the segment B based on the importance of the message. Furthermore, when any CMV wants to exchange nonsafety commercial application related packets, it can acquire required bandwidth by registering its demand with CHV.

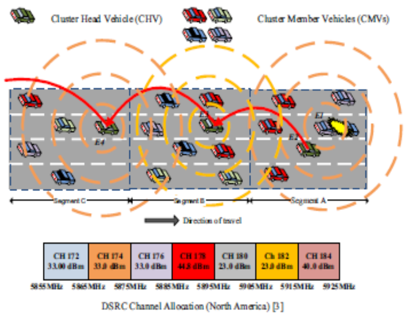

Fig. 1- (SmartVANET working scenario and DSRC channel plan.)

Assumptions and Channel Allocation
As shown in Fig.2, as a starting point, we have used two non-adjacent service channels. We have assigned CH 174 to one segment and CH 182 to an adjacent segment. Again these channels are not adjacent to CH 178, so we avoid channel interference issues. In future, we plan to use all the available SCHs from the DSRC spectrum and assign them carefully to the segments.

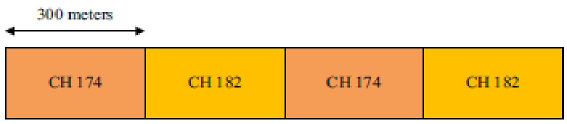

Fig. 2- (Road is divided into 300meters long segments and a specific service channel is allocated to each segment.)

The assumption is that all the vehicles are fitted with DSRC radio and navigation system (GPS/Galileo).. We also assume that vehicles are synchronized on the basis of slots and the navigation systems work with adequate precision (so that cars know when they are within a particular segment and when not). In this paper, we only consider linear road segments with multiple lanes without any junctions[10].

Cluster-Head Election Algorithm
The cluster-head election algorithm is unique, as algorithm uses location information to elect a cluster-head. Vehicles entering into

the segment first listen for the CHV beacon to detect the presence of a cluster-head. If no CHV beacon is received for a threshold time (Tthr), recently entered vehicles set a random timer. A vehicle whose timer expires first, announces itself as a CHV in SCH. As this vehicle just arrived into the segment, it can serve as a CHV for a longer period. Furthermore, in case of roads with multiple lanes, it is possible for more than one vehicle to enter the segment at the same time. The CHV maintains a table of CMVs. Furthermore, it also collects the information regarding the CHVs in adjacent segments using CCH. This way CHVs play the role of an administrative entity. The one more responsibility of CHV is that when a particular CHV is about to leave the segment, it elects a new CHV. From the CMVs table it selects the last arrived CMV as a new CHV for the segment. CHV assembles this information into its beacon message. All present CMVs receive this beacon message and change their respective CHV entries to the newly selected CHV. This is shown in the Fig. 3.After this, the newly selected CHV takes charge and starts its duty as a CHV. In this way, the latest arriving CMV becomes the CHV so it is likely to be in the segment longest to serve as a CHV.

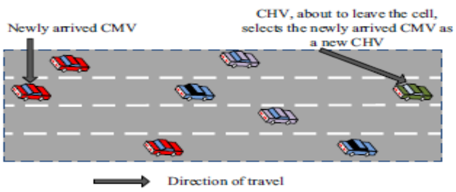

Fig. 3- (CHV selects the new CHV from its table.)

On the event when CHV meets with an accident and becomes unavailable as a cluster-head, new CHV election process starts. All CMVs expect beacon from CHV in the beginning of the SCH period. Absence of CHV beacon for Tthr indicates unavailability of the CHV. Newly arrived vehicles based on their location sets the timer and begin the countdown process to become CHV. And it also creates the tables regarding CMV

Advantages of SmartVANET architecture

The SmartVANET architecture has potential to solve issues related with DSRC based VANET. The advantages are as follows-

I. SmartVANET architecture uses physical layer adaptive equalization technique to address channel impairments.
II. SmartVANET uses non-adjacent SCHs in adjacent segments. Thus, it avoids co-channel and adjacent channel intrusion.
III. SmartVANET is DSRC compliant and efficiently utilizes the DSRC spectrum. It also supports multichannel operation proposed in IEEE 1609.4 standard.

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Conclusion

SmartVANET architecture can solve broadcast storm issues and provide scalability. Its performance will be evaluated for safety and non-safety applications. The performance of cluster-election algorithm and the SmartMAC protocol will be evaluated under different traffic conditions and different channel scenarios.

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