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Routing Topologies and Architecture in Cognitive Radio Vehicular Adhoc Networks

Priya Bakshi, Prabhat Thakur and Payal Patial

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Priya Bakshi[1], Prabhat Thakur[2], Payal Patial[1]

[1]Department of Electronics and Communication Engineering,
Chandigarh University, Mohali, Punjab, India
[2]Department of Electrical and Electronics Engineering Sciences,
University of Johannesburg, Auckland Park Kingsway Campus, University of Johannesburg-2006, S Africa

Abstract –With the advancement in the wireless communication, there has been an immense growth in the number of vehicles on the road.The unpredictable nature of vehicular adhoc network (VANET) due random increase and decrease of the nodes/users (vehicle) on the roads is a challenging issue. Moreover, the increase in the number of nodes creates the problem of spectrum scarcity due to shortage of licensed spectrum for vehicular servives. In order to solve the issue of spectrum scarcity, the cognitive radio network (CRN) has been developed which exploites the unlicensed spectrum for communication without affecting the licensed communication that is using interference avoidance. The CRNs are more vulnerable to the security and the privacy of the networks because the transmission parameters required for communication avoids the interference with the licensed and unlicensed users. Moreover, the safety message among the vehicles ensures the safety of the vehicles in the cognitive radio vehicular ad-hoc network (CR-VANET) and also manages the sharing of the licensed/ primary and the unlicensed /secondary users in the network. The routing and network topologies is a challenging issue due to mobility of vehicles. Therefore, in this review paper, we present the applications and various routing topologies for CR-VANET.

Keywords: Cognitive Radio, Radio Spectrum, Routing Topologies, Vehicular Adhoc Networks, V-to-V Communication

1. Introduction

Increase in number of vehicles on the road has conveyed main emphasis on enhancing safety of vehicles. With this demand, we are observing arise in expansion of the novel presentations and facilities for VANET situations. The most common instances are:

(i) Safety of Roads
(ii) Collision Avoidance
(iii) Traffic Management

(iv) Vehicle – to- Vehicle communication(V2V) [1].

For VANET, all the vehicles/nodes need to communication with each other (V2V)) and other roadside units (vehicle-to-infrastructure (V2I)). The radio spectrum is the compulsory resource for communication and the allocated spectrum bands for VANET by the Federal Communications Commission (FCC) and European Telecommunications Standards Institute (ETSI) are 75 MHz and 30 MHz of spectrum in 5.9 GHz band[2, 3]. However, in future with increase in vehicles, these allocated bands will be insufficient for communication, therefore, we need some plateforms which can fulfill this demand of spectrum bands. The Cognitive Radio Network is an emerging solution to overcome the problem of spectrum shortage. The main idea of CRN is to share similar bandwidth with secondary/unlicensed users (SUs) without causing any interference to primary/licensed users (PUs). Cognitive Radio equipment detects the available channel and allow SUs to occupy the bandwidth. The CR includes spectrum knowledge representation which vigorously changes routing topology protocol in order to satisfy requirement for more proficiency[4].
The use of CR in the VANET can improve the issue of spectrum shortage. Therefore, CR-VANET is a emerging technology that can support VANET applications. Vehicular ad hoc networks defined as unstructured Ad-Hoc Network shifting on the road. The vehicle can communicate with each other or with road side infrastructure to increase the safety of roads. The main challenges for Cognitive Radio Network (CRN) deal between nodes in VANET in high-mobile network under dynamic channel situations. In addition to this, the un-predictable behavior of VANET, data security, node mobility and priority assignment are the main challenges [4].There are some challenges in developing CR-VANET. The open problems in CRN development network like CC(Control Channel), JSS(Joint Spectrum Sensing), CIA(Cognitive Implementation Architecture).

2. Overview of Cognitive Radio and its Architecture

Spectrum users are categorized as licensed users, and unlicensed users or cognitive radio. Licensed users legally operate in a specific frequency band while cognitive users are not granted with any specific frequency to transmit and receive the data. Cognitive Radio provides the spectrum to unlicensed users for communication purpose [5-7]. Cognitive radio network users identify the spectrum holes, these holes are defined as a provisionally non utilized spectrum that can accessed by CU's. If a spectrum band is available, then Cognitive Radio(CR) fully utilizes the channel, although primary users are there.

The major applications of Cognitive Radio are:-

i) White Space and regulation[8]
ii) Smart Grids [9].
iii) Wireless Sensor Network (WSN)
iv)Public Security and Medicinal Network
v) Internet-of-Things
vi)Vehicular Networks[10]

Cognitive Radio in VANET is one of the major submissions of CR. Each vehicle in a geographical area can interconnect with each other straightly via some communication infrastructure.
The VANET architecture of cognitive radio vehicles based with On Board Units (OBU'S) and infrastructure services.The network architecture for cognitive radio are as follows :-
i)Incomplete Infrastructure Support [10].
ii)Complete Structure Provision [10].

The architecture is defined as without infrastructure support or non-centric construction. The detecting could be communal among the network. Organization support non appearance minimizes the geographical attention of communication performed in Fig 1. The repeaters and routers are connected through main highway with fixed infrastructure support and low complexity. The range of data is fixed by minimum infrastructure, thus data are conveyed only to the vehicle in the range of services installed above in Fig 2.

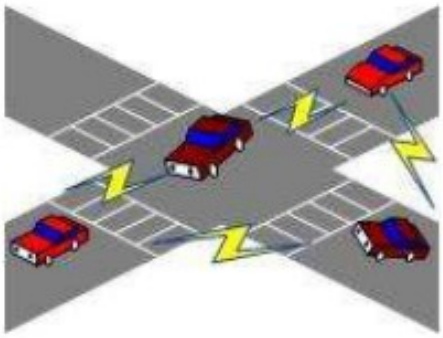

Fig 1. Cognitive Radio for Vehicular Ad hoc Networks (CRV) Architecture (Non-centric) [10]

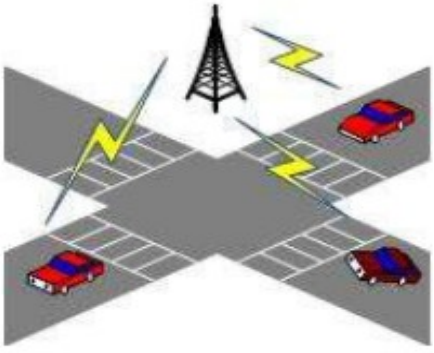

Fig 2. Limited structure cognitive radio Architecture [10]

3. Cognitive Radio Vehicular Adhoc Network

Currently, all auto-makers are capitalizing to stretch infotainment explanations and new substitutions to passengers and car drivers. Geographies and facilities tend to overload the obtainable range in auto-motive background. In cars, high suffering of the internet is determined in high traffic roads. Cognitive radio can be introduced to vehicle communication.

Cognitive Radio enhances the throughput, and also CR VANET'S enables more users to function in high user friendly scenarios. Transceiver with re-configurable software defined radio (SDR) equipments are being included to vehicles. The operating parameters can be dramatically changed via software, which reduces data flexibility and operations dissimilar bands [10]. So hardware limitations are optimized in the development of novel equipments. The spectrum sensing (SS) is fundamental in Cognitive radio networks as well as in CR-VANET. SS means to detect the presence of License Users or secondary users in a specific frequency band more correctly; this reduces the practice of spectrum holes resourcefully.

Spectrum Sensing (SS) methods are categorized as:-

(i) Per-vehicle sensing.
(ii) Spectrum Database(DB) methods.
(iii) Co-operation.

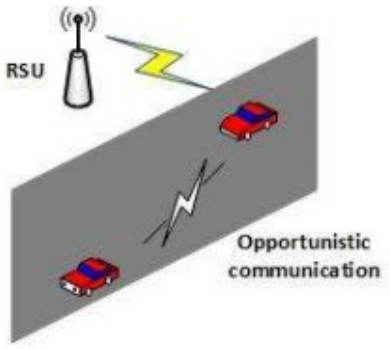

Fig 3.Adaptable Communication in VANET [10]

In per vehicle sensing, each car achieves the range sensing independently and separately from the others. SS is performed with traditional Spectrum Sensing strategies as Energy Detection (ED), Matched Filter Detection (MFD), Cyclostationary Detection(CD) and others [11]. However, despite the fact that individual car can achieve its own sensing with no record of any infrastructure support, the accuracy of the sensing decreases in situations of obstructions in Fig 3 [11].

4. Literature Review

Uddin, SM Nadim., et al., (2016) [12] proposed the cognitive radio (CR) enabled vehicular ad hoc networks mainly for the multi-agent relied Traffic Management System (TMS). Due to the continuous interest of researchers in the concepts of CR, the demand of CR based vehicular adhoc networks was flourishing. It played out a major role in the communication of sensor nodes with high efficiency and reliability. In VANET, the sensor nodes are the moving vehicles that continuously changed the topology of the network. In the present research work, a cognitive radio based network was proposed mainly for the vehicles that used the multi-agent. A skeleton was introduced mainly for the learning purposes and for the decision making. The present technique had two basic phases. The first one was the dynamic and the second was the semi-dynamic. The dynamic was the communication of vehicle to vehicle without accessing any other device for the data exchange, whereas the same dynamic was the data communication of vehicle with Road Side Units (RSU). The communication was taking place by accessing a wireless link with the use of cognitive radio. Subsequently, a cluster formation approach was utilized to acquire the more accuracy in the data transmission. The experiment was proven better in terms of the throughput, consumption of energy, delay considered while data packets were sent and the overhead of the network. **Elgaml, Nada., et al., (2017) [13]** recommended the low delay and high throughput CR-VANET. Because of the advancement of the technology, the wireless sensor networks were utilized for various purposes in most of the applications and CR-VANET was one of them. It exploited CR for the access of unused channels by vehicles under the radio region. Therefore, CR VANET was not just passed through the common challenges of cognitive ratio mainly the spectrum sensing. But it also faced some difficult issues related to the mobility of the sensor nodes in the network. The current research was described the low delay and high throughput CR region method for the better working criteria of CR-VANETS that had the tendency to manage with the general stands of VANET as IEEE802.11p. The experiment depicted that the current technique was easily declined the time consumption and the throughput was flourishing. **Ahmed, et al., (2016) [14]** described the co-operative spectrum sensing, particularly for the CR-VANET with the detailed description and the research challenges of CR. These days, VANETs are being more interested in the field of intelligent traffic management and it enhanced in several ways to serve the people with better performance while data is transmitted from one node to the other. In VANET the sensor nodes are the moving vehicles. It was supportive to various kinds of applications, mainly for the safety purposes, traffic efficiency and even for the entertainment requirements. It makes the driving more comfortable with a lot of facilities. The cognitive radio simply increased the bandwidth mainly for the communication of moving vehicles. The main purpose of using Co-operative Spectrum Sensing (CSS) was to exploit the temporary and spatial diversity to search out quickly the primary users of the data. The current research introduced the detailed description of the CSS approach mainly for the CR-VANETs. The major advantages of the technique were discussed in the literature review section. The other objective of the research was to clarify the common research challenges and future direction of the current research approach. **JalilPiran, et al., (2015) [15]** proposed the fuzzy based sensor fusion approach mainly for the CR-VANET. Generally, in the field of wireless sensor networks (WSN). The sensor fusion was introduced to integrate it with the gathered data via sensors basically to give access for the unified interpretation. The biggest characteris-

tic of the sensor fusion was the high level data in the statistical and in the definitive ways. It was difficult to acquire by using a single sensor. The current research initialized a dynamic sensor fusion method which was fully dependent upon the fuzzy theory. For the present approach, for input sensor readings and a final output was considered. The sensor nodes in CR-VANET were concatenated with the diverse sensors. Along with this, the crash severity was utilized as the consequent variable. The procedure and the fusion were obtained via using the fuzzy logic criteria. The results obtained from the present research approach was introduced the applicable system mainly to decline the causality rate of the vehicles. **Eze, Joy, et al., (2017) [16]** give the explanation about CR technology which was utilized with VANET. The present status, issues and research trends were described in detail. The vehicular networks and the cognitive radio networks both were being a fascinating advancement of the technology. The applications of cognitive radio were utilized for the intelligent vehicles and to sort out the common issues occurred because of the scarce spectrum. Current research gave the description of cognitive radio advancements which set a goal to enhance the efficiency in the vehicle communication. The description given in the research was introduced the dynamic technique and the major issues that were linked to the cognitive radio. Additionally, the research work also identified the different issues which were faced by the design and the creation of cognitive radio vehicular ad hoc networks. Table 1 defined that the the basic comparison of TCR, VANET and CR-VANET, respectively.

Table 1. Comparison Of TCR (Traditional Cognitive Radio), VANET And CRV [17,18]

	TCR	**VANET**	**CRV**
Range	~30 killometer	Few Km	Few Km
Mobility Characteristics	Stationary	High mobility can, exceeds 100 km per hour	High mobility can exceed 100 km per hour.
Topology	Centralized	V2I, V2V and V2P	Both integration path
Performance	Throughput Delay	Transmission Delay and capacity	Transmission capacity and delay

5. CR-VANET for Topology and Routing Protocols

CR-VANET has the characteristics of high mobility and rapid dynamic topology and data reliability for road safety. Designing appropriate Media Access Control(MAC) protocol for CR-VANET is a main task. According to the review paper[4], there is still no domination structure of the CR-VANET protocol.

Moreover, in order to provide a normal view of Cognitive Radio Vehicular Adhoc Network (CRVANET) MAC-LAYER, we summarize some essential articles[19]-[22]

and present a preliminary structure of the CR-VANET protocol (MAC). The Slot Design of CR-VANET Network system is shown in the Fig 4.

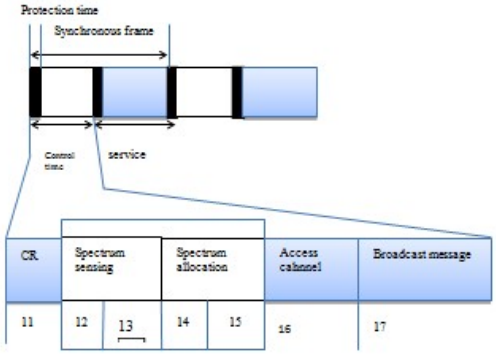

Fig 4. Slot Design of CR-VANET [23]

Routing in CR-V faces unique challenges when compared with Mobile adhoc networks (MANETs). In VANETs, the routing topologies are expected to accept the vehicle mobility of the node and the state of the channel. In CR-V allotted route shall be more rapidly changed according to the event of license users and frequency in the spectrum pool [24]. In most of these topologies routing methods, the route is designed during the route-discovery and it can be modified when messages are missed or novel PU activity is detected. Algorithms suffer from performance degradation, when the spectrum state or spectrum availability ,vehicle node positions modify speedily than the rate of route-updates. Various routing methods for VANETs have been implemented in [25]. Moreover, most of them are focused on short range communication in ad-hoc networks to aid Intelligent transport system (ITS) in urban areas. The distance between binary vehicle nodes is much smaller than broadcast Range. Furthermore, none of them measured the adaptable range access unlicensed Industrial-Scientific-Medical (ISM) band to obtain more capacity. At current, the research on routing schemes for CR-VANET is really rare.

A. Prediction based Cognitive Topology Control (PCTC) Routing

It is a distributive prediction based technology control method over the cognitive capability of routing CR-V. It is a middleware like cross layer module residing. It utilize cognitive connection data availability forecast, which is conscious of distortion to primary users and predicts the available duration connections. Based on connection predicts, it considers the dynamic modification of the topology and builds enhancing effective methods, which is objective in reducing routing frequency and enhancing End to End (E2E) delay network performance like as throughput and delay.

B. Spectrum aware beacon less geographical routing(SABE)

The main objective of Spectrum aware beacon is that the routing rules as-well-as the resource allocation policy is made by receivers on a per-packet and hop basis, so that

the SABE protocol can be effective in spectrum dynamic. A CRV broadcasts advancing request packet, and adds its data available resources and location.

C. Cognitive Multicasting uses Orthogonal frequency division multiplexing (OFDM)

It is a cognitive multi-cast routing protocol inspired by on demand multi-cast routing protocol. Its attempt to provide adequate throughput performance by choosing and using idle ISM channels. After searching the channels, vehicle nodes collaborate to form a multi-cast tree using and adhoc demand distance vector. [25]

Table 2: Comparison Between Dissimilar Routing Protocol [26]

Methods	Advantages	Disadvantages
PCTC	Most effective and reliable topology than other, low re-routing frequencies and delay	Requires local link knowledge consequence in huge message overhead.
SABE	Overhead for choosing delay vehicle nodes is substainally reduced	Robustness of proposed algorithm shall be enhanced
Co-Cast	Channel over-lap in frequency	Overhead for communication might be a problem.

6. Conclusion and Future Scope

In this paper, CR-VANET was described and the work done in this area were categorized and few key attainments were studied. CR is a developing Wireless Announcement Topology (WAT) that can spread the vehicle announcement networks characteristics. CR motivates the development and growth in Vehicle–to-Vehicle,Vehicle-to-Infrastructure and Vehicle-to-Peer communications. Though, there are still structural problems to combine the cognitive radio vehicles. The main problems and challenges in cognitive radio vehicles have been studied. Various high-lighted issues SS, MPs of observation, interference, end to end delay and security system are the main concepts in CR-VANET. The future scope will improve the lack of data adaptive approach and optimization of the recent CR-VANET varities.

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