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Medium Access Control (MAC) Protocol for Resource Allocation in Cognitive radio Networks – A Survey

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Abstract— Cognitive radio network (CRN) is the wide and most popular emerging technology for a smart wireless communication environment rapidly in the recent years. Cognitive radio (CR) is an intelligent technology which provides eminent solution to the problem of spectrum scarcity and to allow the competent distribution of the available radio spectrum without affecting any destructive interference to the primary user (PU) in wireless networks. The utility of the spectrum sensing is to recognizing the offered and organizing through other users for spectrum access, increasing the channel utility, sinking collision rates, and growing detecting overhead are the primary aspects in cognitive radio medium access control protocols. The smart usage of radio spectrum widely depends on precise sensing of spectrum, mobility of spectrum and spectrum decisions. Therefore, the CR technology can considerably provide a smart solution to solve the spectrum scarcity problem by exploiting idle radio spectrum by licensed users. Though, several technical problems still essential to be solved for the suitable functioning of CRNs. The MAC protocols for CRNs should provide a comprehensive description of common control channels (CCC), sensing of spectrum, and harmful interference to PUs, the spectrum availability in distinction rates, the infrastructure support, required time management, and the quantity of radio transceivers. In this paper we studied the distinction MAC technology used for channel allocation and presented the literature survey on MAC protocols with their different usages and also highlight and explore some essential research issues and challenges that might drive further research in this field.

Keywords—CR, MAC, CCC, DSA

I. INTRODUCTION

In the recent years, the wireless communication system is an emerging novel technology; due to its rapid development of spectrum application it meets a spectrum scarcity problem. The CR is a novel technology which provides a smart solution to spectrum scarcity problem [1]. Obviously CRN consists of primary network (PN) and secondary network (SN). The PN consists of PUs (licensed users) and primary base station (PBS). The SN contains SUs (unlicensed users or cognitive users) and secondary base station (SBS) [2]. The SUs are permit to use idle channels opportunistically to avoid any interference or collision with the PUs. The CR plays an important role that to control and coordinate the communication over the channels. The SUs continuously monitors the communication and detects the available idle channels. In the heterogeneous CRN MAC protocol provides a well coordination among SUs. This is a very difficult task; the MAC layer plays an essential role that is how the SUs regulate when and which channels they can use to transmit or receive SU packets without affecting communication among the PUs. The multiple channels used in CRN have hidden terminal problem with PU and this problem can able to solve by MAC protocol [3]. The most of researchers used CCC in CR-MAC to discover the path among the SUs by sending the signals in CRN and continue the communication process of SUs without any interference. The CCC has congestion attacks by malicious users. In this paper we present a comprehensive study of MAC protocol and different implementation techniques are used to improve the effective channel allocation in heterogeneous CRN.

A MAC protocol doesn't have any central entity in distributed cognitive radio network (DCRN), like base station. Due to this reason DCRN-MAC protocol subdivided into MAC protocols based on time division multiple access technique (TDMA-MAC) and contention technique based MAC (C-MAC) protocols. In DCRN, there is no any local organizer, TDMA-MAC have no sufficient effective system so that it can required C-MAC protocols [23]. The CCC techniques also have important problems due to vulnerability caused by movement of PUs in the network. Some MAC protocols offered with the technique of CCC and without CCC technique. Only dedicated CCC can promise worldwide

time synchronization [24]. Certain MAC protocols operate with channel hopping (CH) technique which is based on CCC. When we can offered MAC protocols used single transceiver in multiple CRN it has meet the multichannel hidden terminal and it might be miss control signal when they should busy. When we proposed hardware constrained MAC protocol with single transceiver MAC, and it suffers with the problem of spectrum wastage [24].

The proactive spectrum handoff system has proposed for resource allocation in CRN [25]. They proposed fair MAC (FMAC) protocol that to ensure fair and efficient coefficient of CRN. The FMAC protocol is designed for centralized CRN and it couldn't provide any details on monitoring of PUs presence during the data transmission [26].

Numerous MAC protocols have already been proposed for CRN, then research indications are doesn't efficiently in a dynamic environment. In this paper, we have present research challenges prevalent in current MAC designs and future research direction.

In the rest of section, brief description of MAC layer in section II, the related work in section III, the comprehensive study in section IV and conclusion in section V.

II. MAC LAYER

In CRN SUs wants to communication with each other, they can exchange control information and spectrum information by CCC. This CCC must be recognized and accessible to all CR nodes for succeeding transmission to take place. The SU can access the available white space with the help of MAC protocol through CCC without interfering with the PUs. The primary goal of MAC protocol is that providing an efficient communication in terms of channel sensing and to determine its occupancy and sharing the available spectrum channels among the SUs in CRN without any interference to PUs [16]. The MAC protocol includes the functions of CR such as channel sensing, spectrum sharing, resource allocation and spectrum mobility.

In the recent years, the MAC protocol includes the principles of opportunistic spectrum access (OSA) system which is significantly growing the spectrum utilization. In CRN, the SUs include the functionality that to search and utilize dynamically the available idle spectrum of PUs with distinct factors like time and frequency. The efficient OSA-MAC protocol should include the functions like spectrum sensing, spectrum allocation, spectrum access, spectrum sharing, and spectrum mobility [17] (figure 1).

A. Spectrum Sensing

Its primary function is to find available idle channels and avoid interference with the PUs. The spectrum sensing technology used to improve the spectrum utilization effectively [18].

B. Spectrum Sharing

In CRNs, the spectrum sharing process should be take place between PUs and SUs can be defined as the real time management of the spectrum that permits SUs to access a spectrum of PUs with little or no interference to the PUs [18]

C. Spectrum Mobility

Spectrum mobility allows the CR user to modify its operating frequency. CR networks are trying to use the spectrum dynamically allowing radio terminals to functioning in the best existing frequency band, to keep transparent communication necessity during the transition to an improved frequency [18].

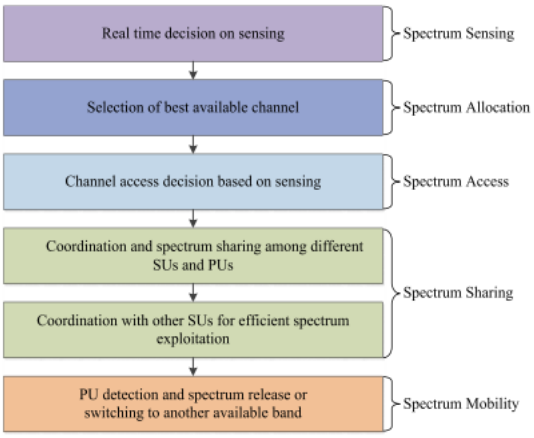

Figure 1. OSA MAC Protocol functionality [7]

III. RELATED WORK

In [19] the authors should have been considered underlay CRN for reducing the interface temperature at SBS, so that they should offered opportunistic p-persistent sense multiple access structures for CRN which could be transmits the data to the SUs and also they should improve quality of service (QoS) for communication between SUs and PUs, so that they offered another technique like an adaptive interference-level control algorithm, which controls the interference level at PUs in PN. The proposed algorithm achieved near optimal throughput at SN while they are backward-compatible to the conventional p-persistent CSMA scheme.

In [20] they should improve efficient spectrum assignment (SA) at SU based on multi-channel selection scheme. During this communication SUs are utilize multiple channel at same time to improve throughput. In this condition SUs used more idle channels and other SUs are left with no idle channels therefore the blocking probability will be increased and fairness will be decreased. So that they offered fair multichannel assignment system (FMCA) for scattered CRN. Further they should introduced new MAC structure for sensing and accessing the channels. The proposed FMCA

structures achieved good tradeoff between fairness and throughput.

In [2], usually SUs exchange the control information through common control channel (CCC), the most of MAC protocol designed with existing CCC and further they assumed that CCC was available for all SUs, thus the primary disadvantage of using static CCC is it is susceptible to PUs activities since the channel should be used by PUs at any time. So that they offered dynamic control channel assignment MAC protocol called DYN-MAC which supports to minimize the collision and it can be tolerate the activities of PUs.

In CRN, the CR technology empowers the SU to utilize the unused licensed spectrum of PU. The MAC protocol plays an important role in utilization of spectrum, interference management of PUs and coordination of SUs. Thus they offered a new MAC protocol and the transceiver is attached with the sensor which improves the spectrum sensing accuracy and prevents the PUs from interference. The proposed system improved the throughput in presence of sensing error [3].

The design of an efficient MAC protocol is serious for proper functioning of a scattered CRN and better utilization of the unused idle channels when PUs are idle. Thus, they should designed a contention based distributed medium access control (MAC) protocol for the secondary users' channel access. The suggested MAC protocol agrees collision-free access to the presented data channels and effectively utilized by SUs. Under optimal conditions, the offered scheme permits the SN utilize all available channels [8].

The cognitive radio ad hoc networks (CRAHNs) have recently proposed in CR technology for effective utilization of the idle channels by SUs when the PUs is idle. The design of MAC protocol has a vital problem is that addresses the decentralized control and local observation for spectrum management. Therefore, they offered propose a cognitive MAC protocol with mobility support (CM-MAC) based on carrier sense multiple access/collision avoidance (CSMA/CA) technique. The offered protocol should respond to the locality state of CR nodes. The proposed protocol achieved outperforms the throughput in the given network [10].

In [21] quiet protocol (QP) scheduling technology is used to identify transmission opportunities for 802.11 SN. The QP-CSMA-CA is a 802.11 based CRN MAC protocol which can be used to utilize the idle channel by SU based on QP-DIFS scheduling system that achieved significant performance of the entire networks.

They have proposed opportunistic Spectrum access With backup Channel (SWITCH) which is specially designed for multichannel access in the network and this protocol is used unlicensed channel as backup channel to adapt with sudden presence of the PUs in data communication channel [27].

IV. COMPERHENSIVE STUDY

Table 1. Comprehensive Study

Years of Publication	Algorithm Used	Results
2014[1]	They offered a time slotted spectrum sharing protocol named Channel Usage and Collision Based MAC protocol (CUCBMAC).	Achieved significant improvement of entire networks
2014[2]	They offered MAC protocol for CRN with dynamic control channel assignment (DYN-MAC)	This method control channels are dynamically assigned to SUs based on channel availability
2012[3]	They offered a new MAC protocol for dynamic resource allocation.	It avoids collision between SU and PU and also among SUs. Improved throughput of the given network
2011[4]	They offered a MAC protocol for CRN. Parameters: • Spectrum-sensing performance • Normalization of throughput	They achieved significant performance gain.
2010[5]	They offered cognitive radio multichannel medium access control protocol based on TDMA for channel allocation to SU.	ECR-MAC successfully exploits multiple channels to improve network throughput and the end-to-end delay.
2014[6]	They offered a semi-distributed cooperative spectrum sensing (SDCSS) and channel access framework for multi-channel cognitive radio networks (CRNs)	Achieved significant network performance gain, throughput performance
2015 [7]	They offered multi-constrained QoS aware MAC protocol for cluster based CRSNs.	Achieved better performance than existing MAC protocol for CRSN
2014 [8]	They offered a contention based distributed medium access control (MAC) protocol for the secondary users' channel access.	Achieved outperformance of the given network
2013 [9]	They offered Distributed Consensus Algorithm to address the problem of distributed CCC Allocation for cognitive radio ad hoc networks	Achieved significant improvement of network capacity and efficiency of spectrum.
2014 [10]	They offered cognitive MAC protocol with mobility support (CM-MAC) based on carrier sense multiple access/collision avoidance (CSMA/CA)	Achieved outstrips performance of the network throughput.

	technique for channel allocation.	
2016 [11]	They offered a novel cross-layer mobility-aware medium access control (MAC) protocol for CRSN. And also offered efficient spectrum-aware cluster formation and maintenance.	Achieved significant network performance like packet delivery ratio, energy consumption, and delay
2015 [12]	They offered common control channel based MAC protocol to avoid hidden terminal drop. And also offered an Interference-aware hybrid CCC cognitive MAC protocol with directional RTS/CTS and data transmission. Adaptive power control algorithm also offered	Achieved the greater throughput gain and reduced the cognitive control overhead.
2018 [13]	They offered a novel frame structure of request to send and clear to send approach which includes of cognitive radio ad hoc network. And also offered fairness based MAC protocol.	Achieved better performance of both terms like time and fairness
2018 [14]	They offered a hybrid technology like the integration of rendezvous and medium access control protocol called as novel cognitive radio rendezvous protocol	Achieved better performance of the given network based on throughput, delay and packet dropping.
2018 [14]	They offered a hybrid technology like the integration of rendezvous and medium access control protocol called as novel cognitive radio rendezvous protocol	Achieved better performance of the given network based on throughput, delay and packet dropping.
2018 [15]	They offered a self-organizing CR-MAC protocol for allocating available channels to the SUs	They achieved 99% of effective channel allocation of SU in less than 5% of idle slots from PN

V. CONCLUSION

The primary objective of this literature survey is to provide the different technoloy of CR-MAC protocol. Most of protocols are offered for dynamic CRN which doesn't cover main issuess of dynamic spectrum allocation in CRN. some proposals of research can be suggested in the framework of MAC protocol entity. In future more research is required for precise channel sensing system. In CRN, the spectrum sensing is critical problem due to hardware restrictions of CR users. So that we need to design some efficient and robust alternatives like CCC design. The MAC protocol design mainly focusing on energy improvement system is introduces in new challenge of the efficient MAC protocol design. The QoS system of SUs in wireless communication system is not possible without the significant support from the MAC protocol. Consequently we required further research of QoS for SUs in the context of dynamic spectrum availability.

The network coordination, reconfiguration and network reliabilty are the another main problem in CRN. In recent years, the majority of the researchers are focused on improving the throughput in entire CRN. Now, we can addressed some necessary design required for distributed CR-MAC protocol design. Like time synchronization and network coordination for SUs are need to improve without dedicated CCC. We can improve the probability of detection of PU presences during data communication in CRN. We trust that further modifications is required to improve the efficient MAC protocol. We have identified some modification is required to improve the design of the MAC protocol for effective utilization of the idle channel by SUs.

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