International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 5 Issue 2, February-2016

Short Comings of Wireless Technology and its Potential Solutions

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ABSTRACT

This paper discusses the development of wireless communication for providing the solution for overcrowded but underutilized frequency spectrum. Cognitive Radio (CR) technology can overcome the existing challenges in today's wireless technology, therefore helps to specify an effective solution to the in-efficient networks utilization. RECR-MAC (Reliable and Energy efficient Cognitive Radio multi-channel) protocol is proposed, based on Back Data Channel and Data Channel selection criteria. Several objectives are proposed that includes the development of RECR-MAC protocol framework for CRAHNs. Cognitive Radio Networks CRNs) operation is described, that includes various key operations between the primary users and the secondary users. They include spectrum management, spectrum sensing, spectrum sharing and mobility along with applications of CR technology.

Keywords: cognitive radio, channel sensing, primary users, adhoc.

1. INTRODUCTION

As the secondary user does not own the channel, the most vital and salient feature of cognitive radio Ad-Hoc network CRAHN is that it provides successful transmission of information between SUs (secondary users), while it occupies the channel when the primary user is not active. This paper discuss about the background of CRN, their issues and the solutions for successful data transmission in cognitive radio network.

The FCC (Federal Communication Commission) and several other organizations in [1] [2] have noticed that around 30 percent of licensed spectrum is utilized, due to which the spectrum can become scarce any time, especially in crowded areas. The spectrum utilization in rural areas is less than 6%. Therefore dynamical allocation of spectrum was proposed in [3]. This technique aims to improve RF band spectrum utilization. In the cognitive scheme, the secondary user is given the opportunity to access the underutilized spectrum band when the primary user is not active.

Thus the cognitive radio CR technology has open new doors in several wireless areas like defense, satellite communication, public safety, next generation technologies and health monitoring as stated in [4][5][6]. In cognitive radio networks, the secondary user can do the scanning and identification of the wireless spectrum band. On the basis of results obtained the secondary user's receiver is tuned dynamically to that vacant identified channel and then the transmitter starts without having interference with primary user starts the communication known as incumbent or licensed user.

2. ARCHITECTURE

Cognitive radio has two types the primary and the secondary networks. Primary network constitute primary users PUs, which can access the network any time in their licensed bands of mobile, TV and microwave for communication. The secondary band comprises of SUs. They can access the licensed band of spectrum without causing the interference with the primary users PUs. Cognitive radio network is further divided in to infrastructure based or infrastructure less networks. In order to manage operation amongst the nodes, the infrastructure based cognitive radio network contains access point in WLAN (Wireless Local Area Network) or base station in mobile network as the central entity. While, the infrastructure less also known as de-centralized ad-hoc networks contains no central entity fir providing the communication between CR nodes.

Therefore for communication amongst the secondary users, additional resources are required which creates overheads. As compared to the infrastructure based, the communication less communication for accessing the spectrum is more challenging. The architecture of CRN suggests the need of multiple entities to manage the idle channels [7]. In infrastructure less networks, the cognitive radio nodes are required to sense manage and assign resources themselves, whereas spectrum owner is responsible for all these tasks in infrastructure based network. In this paper the infrastructure less cognitive radio networks are considered, whereby the sensing of unused space, assigning and management of communication is done amongst the secondary users.

3. CHALLENGES AND ISSUES:

Before implementing the technology of cognitive radio, there are several issues and challenges associated with this scheme that must be resolved. The major challenges and problems are related to the regulatory authorities like office of communication (Of Com) in UK, FCC in USA and other vendors/server provides for the licensed spectrum bands sharing. However if secondary users use the unlicensed bands like ISM (Industrial Scientific and Medical) bands, then there is no need of this technology as the currently used wireless applications can use this band any time without restrictions.

There are some physical layer issues, i.e. hardware compliance, which includes antenna transmission power rate and its capability. Other issues include connectivity, bit error rate, signal to noise ratio, modulation scheme used, fading statistics, battery life and computational power. CR applications spectrum sensing is also a challenging task, as it requires high range and resolution, along with advanced signal processing with high sampling rate for analog to digital conversion.

Other issues discussed in [8] are related to network layer that includes the routing protocols requirements, for the identification of primary users position such that those routes can be avoided for the secondary users. The network layers enables to maintain the end to end routing path for the cognitive radio traffic along with the distribution of the traffic over multiple paths depending upon the bandwidth availability and channel conditions.

The issues related to medium access control constraints includes frame error rate, data rate, security, inefficient utilization of wireless spectrum and random data channels selections as stated in [9][10]. Another challenge due to inconsistent primary user activity is selection of random data channel selection in CRAHNs. Therefore it is difficult to maintain communication between the secondary users successful. The data channel may not be available for equal time internal all the time.

Thus the random channel selection decreases the successful communication probability PSC, amongst the secondary users due to frequent return of the primary user and interference, thereby results in large energy consumption. This issue becomes more severe during the voice and disaster information as proposed in [11] [12] [13] [14] [15] [16] e.g. messages and text for secondary user real time traffic. The entire process of channel sensing, selection and communication over data and control channel may need to restart when the primary users returns frequently, which directly impacts on the energy efficiency and throughput and additional time is consumed.

Energy efficiency, especially in wireless networks is also a challenging issue. As the battery life is limited and it is difficult to recharge all the time, especially in ad-hoc networks. There it has no availability of central entity as discussed in [17] [18]. The demand of efficient energy utilization increases in CRAHNs. Due to the exchange of data and control frames, and if the primary user returns the retransmission has to be made which results in large amount of energy utilization. Network security is also an important task required by network administrator to protect from the hackers and attackers. Due to its adaptive nature enhanced security features are necessary. If the hacker pretending to be secondary user enters the network, he can destroy the network user data as no authentication is required. [19].

4. PROPOSED SOLUTION

On the basis of discussion made above, in this paper the strategy of channel selection, introduction of backup data channel (if primary user returns) and the successful data communication are the important features of CRAHNS MAC layer.

Therefore for solving the above stated issues, new CR-MAC protocol needed to be design to increase the wireless network efficiency and increase the possibility of reliable data selection possibility. With this proposed scheme there should be no interference amongst the secondary users and based on channel selection strategy decease the back data channel utilization. It is also necessary to improve the restart process frequency over the data and control channels for the secondary users when the primary user returns during communication. This issue is resolved by proposing the back data channel techniques. The selected data channels DCH are backup if the primary user returns.

Figure1. Proposed Solution Components

A. Spectrum Sensing Techniques Classification

In Cognitive radio networks, the spectrum sensing technique plays important role due to its sensing capabilities and awareness of the surrounding environment. Secondary user utilizes unused spectrum through sensing and recording primary and second users. The activities of primary and secondary users are detected by energy detection, matched filter and cyclostationary detection feature. Therefore, the tradeoff exists between complexity and accuracy while selecting the technique of sensing spectrum for cognitive radio networks CRNS.

B. Spectrum Sharing without Interference

The primary users have the top priority of utilizing the channel as they are the primary users. Therefore the first consideration should be the selection of secondary user spectrum, without overlap or interference with the primary users. To overcome the interference and overlapping issues between the primary and secondary users, the RECR-MAC protocol frame work is proposed, which allows the secondary user to have the communication over the DCH, without causing interference with the primary users.

C. Exchanging Control Information

The primary task in infrastructure based or less CRN includes the exchange of control information over CCH- Control Channel. The centralized system i.e base station controls the secondary user activity over the control channel in the infrastructure based networks. While, the central entity is absent in the infrastructure less networks to manage the exchange of control information. The control information is exchanged by the secondary user over the CCH. It provides the information regarding frame size including data, communication duration, primary user activity and the DCH to be used. This challenge is overcome by proposed RECR-MAC protocol, which is capable of managing the control information over CCH successfully. It also provides the information regarding subsequent data communication to the secondary user.

D. Control Information Overheads

The overheads in the control information, such as control frames length and number of handshakes greatly impact the successful or unsuccessful exchange over control channel. Therefore control overheads reduction is a complex and vital task in CRAHNs. The RECR-MAC protocol optimizes the control frames to overcome this issue. ACL (Available channel list) and acknowledgement of ACL is introduced which reduces the control frame size and number of handshakes. It removes the unnecessary fields to increase the transmission opportunity, bandwidth consumption and severe delays to other cognitive nodes that are contending for the medium thus increasing the post-transmission time and reducing the pre transmission time for data communication.

E. Criteria for Data Channel Selection

Another vital step is the selection of reliable data channel amongst the secondary users for successful data communications. It plays an important role in robustness of data communication. The chances of selecting reliability for secondary user become less, on random channel selection by secondary user, which interns can make unsuccessful communication of data between the secondary users. So there is a need to define the selection criteria for reliable channel to make successful communication amongst the secondary users.

F. Selection of Backup Data Channel(s)

Another challenge in CRN is that, if the primary user returns or due to negative acknowledgment the channel degrades, the communication should still continue over the data channel. Therefore additional time is required to exchange the control information and data channel selection. Addition energy is consumed in the restart process for data frames which also includes delay in the networks; hence the overall throughput of CRAHN is reduced. To overcome this problem backup data channel technique has been introduced, it will keep the communication intact even if the primary user returns on the data channel.

5. PROTOCOL DESCRIPTION

The successful transmission of information between the secondary users is the most significant and vital characteristic of CRAHN, as the secondary user does not own the channel instead it uses the channel when the primary user is not utilizing the channel. It is also necessary during the transmission to maintain the link between different secondary users if a primary user returns to the licensed channel for data exchange. In this part, the RECR (Reliable and Energy efficient Cognitive Radio multi-channel) MAC protocol is presented, based and BDC and DCH selection criteria. In terms of communication time, reliability of DCH selection criteria, throughput and energy utilization of CRAHN and the RECR-MAC protocol is considered to be an energy efficient protocol.

Multiple factors contribute to the selection criteria of the reliable data channels. Initially, based on the maximum free time, the reliable channels are selected on the DCH, after that they are ranked depending on the negative or positive acknowledgements along with the history of DCHs. If during the second, third and next iterations, more than two DCHs have same ranking values, and then based on maximum free time the DCHs are selected. RDCH1 and RDCH2 are given the highest priority followed by the priority of RDCH 3, 4 and so on. The RECR-MAC protocol also protects against the overlapping and interferences between the primary and secondary users over DCH, by considering the channel selection criteria and providing within robust and effective communication with in the CRAHN.

From the knowledge of literature review, the efficient and reliable energy efficient protocol and framework is yet to be developed in which RDCs are selected based on selection criteria and simultaneously uses the BDC. The major contribution of this paper proposed is to increase the reliability of the secondary user, reducing the energy consumption, communication time and delays due to control channel overhead's reduction while doing retransmissions and thus increasing the throughput of the overall network.

A. Aim and Objectives

This paper focuses on design and development of new reliable energy efficient cognitive radio multichannel MAC protocol for ADHOC networks. The objectives that are taken in to consideration include the development of RECR-MAC protocol framework for CRAHNs. After that the Design of channel selection strategy for reliable data channel selection based on channel ranking and its past history is required. The ranking criteria depend on number of positive or negative acknowledgements. The positive acknowledgements represent no retransmissions, while retransmissions are required for negative acknowledgements. In order to continue the communication process even if the primary user returns over the data channel, BDC is introduced. Evaluation and comparison of analytical results of the RECR-MAC protocol from those of returning by other CR-MAC Protocols and finally RECR-MAC protocol simulation development and comparing the analytical and simulated results. It will Increase the reliability of the secondary user, reducing the energy consumption, communication time and delays due to control channel overhead's reduction while doing retransmissions and thus increasing the throughput of the overall network.

6. IMPORTANCE AND APPLICATIONS OF COGNITIVE RADIO

The author in [20] discusses the 5G cognitive radio access in the 4G LTE currently used cellular network. It may be used to study the concepts of cognitive radio in various scenarios including the migration from 4G to 5G systems, communication between different devices, machine type communication and load balancing. The author also suggested that OFDM based LTE and GFDM can coexist. The GFDM was preferred over the OFDM for next generation Cognitive Radio wave form; furthermore it helps in accessing the frequency holes in LTE [20].

The author in [21] proposes the delay assisted scheme, for optimized TV white space-TVWS, and maximum conservation of energy in 5G mobile networking architecture for cognitive radio. The energy consumption is minimized by use of radio spectrum broker, which amongst several 5G base stations. Monitors the network recourses management processes to improve the QOS- Quality of Service. The author's proposed scheme compares the secondary nodes and radio access points delays. The life time span of wireless nodes were taken in to consideration along with the energy consumption and delay sensitive exchange processes for the recourses allocated [21].

Several access technologies have occupied the licensed frequency spectrum; therefore the small cells deployment would need complex planning algorithm. The author has provided a possible solution of small cell and reconfigurable radio technology, also introducing the tentative network architecture for 5G. He further suggested that communication interference can be eliminated and throughput is enhanced by implementing two planning approaches, genetic and graph based [22].

The networking technology of the cognitive radio has been employed rapidly in communication and other infrastructures of networking for smart grids, due to the unique feature of adaptive and dynamic spectrum allocation capabilities of cognitive radio. The major issue results when the primary user returns to the channel the secondary user of cognitive radio has to leave the occupied channel, while the returning of primary user may occur in random manner. This interruption could result in delays along with packet losses, which in returns affects the control and monitoring feature of smart grids for its stability. The author in [23] has proposed the power system model for automatic generation control of the smart grid, where the cognitive radio network is modeled as on off switch.

Smart grid has applications of remote system monitoring as discussed above, automatic metering and fault diagnosing of the equipment. The demand of cognitive behavior was needed, because many smart grids require customized network and communication solutions. Moreover, large amount of data needed to be sent over existing wireless standards with limited frequency band and intensive amount of interference has to be overcome because of crowded radio frequency spectrum. Therefore the author in [24] suggests the use of cognitive radio technology, with versatile features to satisfy the transmission requirements over wireless channels by assigning the unoccupied spaces in the frequency spectrum to the secondary user. Furthermore, he proposed the multimedia communication solution for smart grid communication using cognitive radio networking.

The author further investigated the issues in channel selection by separating the traffic in to different classes to guarantee the requirement of QOE for each node, to ensure that the network is utilized at full capacity. The design of secondary user's channel allocation for multimedia and power scheduling was discussed, along with the optimization of the transmission aspects. The work suggested by the author is useful for the improvements and advancements in the network wireless technologies for the smart grid and also for the growing demands of homes, solar panels, building and the monitoring of wind turbines.

The author in this paper [25] has designed the energy efficient reliable MAC protocol for cognitive sensor networks. He proposed a receiver based MAC protocol CRB-MAC for cognitive sensor networks CSNs. According to [26] the cognitive radio instead of just having the feature of DSS- Dynamic spectrum sharing it should be capable of self-reconfiguring and self-managing itself depending on the Radio frequency environment, using the reconfigurable antenna while learning continuously from the past experience. He proposed such cognitive radios name as Radio bots.

The active antenna system practical performance evaluation is presented in [27] on the basis of several testes performed in harsh environments, with HSPA (High Speed Packet Access network). The author suggested the flexible beam forming technique as a solution to varying usage characteristics of users on the basis of changing situations of the user in the network. As a result the throughput of the system can be considerably increased using the AAS technique. Since the altering radio network demands continuous system optimization, therefor AAS requires intelligent control which can be accomplished by SON (Self organizing Networks) feature of cognitive radio. Moreover, sectors are added on the basis of capacity requirement through cognitive engines, which could be turned off if the demand of capacity decreases,

CONCLUSION:

The dynamical allocation of spectrum was proposed because of unused frequency spectrum. This technique aims to improve RF band spectrum utilization. In the cognitive scheme, the secondary user is given the opportunity to access the underutilized spectrum band when the primary user is not active. Thus the cognitive radio CR technology has open new doors in several wireless areas. In this paper the strategy of channel selection, introduction of backup data channel (if primary user returns) and the successful data communication for CRAHNS MAC layer are discussed. Move over several objectives are proposed that includes the development of RECR-MAC protocol framework for CRAHNs. The design of channel selection strategy for reliable data channel selection, based on channel ranking and its past history. The ranking criteria depend on number of positive or negative acknowledgements. BDC is introduced to cater the return of the primary user. RECR-MAC protocol simulation development and comparing the analytical and simulated results are suggested which will increase the reliability of the secondary user, reducing the energy consumption, communication time and delays due to control channel overhead's reduction while doing retransmissions and thus increasing the throughput of the overall network.

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