ISSN: 2581-3404 (Online)
International Journal of Innovative Research in Technology and Management, Vol-5, Issue-6, 2021.

Spectrum Sensing in Cognitive Radio Network Communications: Survey and Discussions

Mukesh Sakpal[1], Prof. Jitendra Kumar Mishra[2]

[1]M. Tech. Scholar, [2]Head & Professor

[1,2]Department of Electronics and Communication Engineering

[1,2]Faculty of Engineering and Technology, Bhopal

[1,2]Madhyanchal Professional University, Bhopal (M.P.)

Abstract:- The expected rapid development sought after higher information rates and further developed administrations in cell networks infer that the cell network design should be reconsidered. It implies that there is need for new strategies to expand the range use. Method dependent on broadening existent arrangements with CR usefulness joined with specially appointed organization strategies is needed to help the expected interest for higher throughputs. The main viewpoints are the need to grow precise and effective administration systems to administer the unique range access of CR. The CR territory has zeroed in among others on new answers for energy and phantom effectiveness in remote correspondence (green activity), range task for quick range access, directing and handover instruments, dynamic and expectation calculations to limit the effect of optional clients (SUs) on essential clients (PUs). In this paper discussed the different spectrum sensing techniques in cognitive radio network.

Keywords:- Cognitive Radio Network, Primary User, Secondary User, wireless Communication, Spectrum Sensing.

Introduction

The demand of more bandwidth and increase in cellular traffic causing a severe spectrum scarcity problem in radio frequency environment. Cognitive radio (CR) is a popular solution to overcome this by improving the overall spectrum utilization. One key property of CRs is the ability to learn from its surrounding which is done by spectrum sensing (SS). Many authors pointed that more often a case occurs when licensed users or primary users (PU) does not occupy the spectrum band. This creates a way for unlicensed devices, often called as secondary users (SU) to access the vacant spectrum band opportunistically. Here SUs will evaluate the presence or absence of licensed users, either individually or cooperatively [1]. Cognitive Radio Networks (CRNs) provides a promising solution to reliable and time-efficient spectrum utilization by mitigating the spectrum scarcity issues created by the requirement for wireless bandwidth growing significantly due to the explosive growth of wireless devices. It enables primary user (PU) networks to share their spectrum with the secondary users (SUs), on condition that that the SU's transmission does not affect the PU's performance adversely. Notwithstanding, CRNs have been found to be susceptible to external malicious threats, due to the broadcast nature of the PU-SU cooperation transmission techniques which may allow for a malicious eavesdropper to acquire the transmission

information of Pus [7]. The ability to sense accurately the presence of PU is of the absolute importance of CRNs. In situations where individual SU sensing is shadowed by severe multipath fading and shadowing effects, the SU may not reliably detect the PU signal and access the channel when there is a PU signal present leading to interference of the licensed PU. To overcome this hidden terminal problem and increase the spectrum sensing credibility, cooperative spectrum sensing (CSS). In CSS, each sensing result from multiple SU are sent and fused at a data fusion centre (FC).

Today wireless communication is widely used in our daily lives. We use wireless access technologies to watch TV and enjoy high-definition videos. However, wireless spectrum is limited and expensive, and most frequency bands need to be authorized before access. Furthermore, spectrum assignment policies are regulated by governmental agencies. On the other hand, according to a report of Federal Communications Commission (FCC), the utilization of licensed spectrum is quite low, i.e., 15% to 85% [2]. Hence, dynamic spectrum access (DSA) has been proposed to exploit wireless spectrum opportunistically to improve spectrum utilization and provide more opportunities for wireless access and wide-band communications [3]. DSA technique combined with cognitive radio (CR) facilitates the implementation of next generation networks, i.e., cognitive radio networks (CRNs) [4]. In CRNs, by opportunistically accessing unoccupied spectrum (also called “spectrum holes”), a CR device can transmit data whenever wireless bandwidth is available. CR engine is the core in CRNs. It can acquire the knowledge of available spectrum in a wireless environment and form a spectrum pool. The DSA technique aims to select optimal spectrum holes from a spectrum pool for communications. CR enables the secondary users (SUs) to perform a series of operations, such as spectrum sensing, spectrum management, spectrum sharing, and spectrum mobility. Spectrum sensing is the foundation of opportunistic spectrum access [9].

II. Cognitive Radio Characteristics

The dramatic increase of service quality and channel capacity in wireless networks is severely limited by the scarcity of energy and bandwidth, which are the two fundamental resources for communications. Therefore, researchers are currently focusing their attention on new communications and networking paradigms that can intelligently and efficiently utilize these scarce resources. Cognitive radio (CR) is one critical enabling technology for future communications and networking that can utilize the limited network resources in a more efficient and flexible way. It differs from traditional communication paradigms in that the radios/devices can adapt their operating parameters, such as transmission power, frequency, modulation type, etc., to the variations of the surrounding radio environment. Before CRs adjust their operating mode to environment variations, they must first gain necessary information from the radio environment. This kind of characteristics is referred to as cognitive capability , which enables CR devices to be aware of the transmitted waveform, radio frequency (RF) spectrum, communication network type/protocol, geographical information, locally available resources and services, user needs, security policy, and so on. After CR devices gather their needed information from the radio environment, they can dynamically change their transmission parameters according to the sensed environment variations and achieve optimal performance, which is referred to as re-configurability.

III. Related Work

Manish Kumar Giri, Saikat Majumder, “Extreme Learning Machine Based Cooperative Spectrum Sensing in Cognitive Radio Networks”, 7th International Conference on Signal Processing and Integrated Networks, IEEE, 2020, pp. 636-641, [1] In this paper, they consider the application of Extreme Learning Machine (ELM) with Neural Networks in cooperative spectrum sensing (CSS) for cognitive radio networks (CRN). Based on a statistical analysis of classical energy detector, the probability of detection and the false alarm has

been calculated, which depends solely on SNR and the number of samples values. The channel occupancy detection results obtained from the proposed approach are compared with established analytical techniques such as MRC and AND/OR rules and well-known Machine Learning (ML) techniques, including, Support Vector Machine (SVM) and K-Means. The Comparison matrices were receiver operating characteristic (ROC) curve and area under the curve (AUC). We obtain the computational performance of the aforementioned NNELM model during the training phase and calculated the channel detection probability. Ultimately, the results demonstrate that the NN-ELM technique presents a better trade-off between training time and detection performance.

J. Tlouyamma, M. Velempini, "Investigative analysis of channel selection algorithms in cooperative spectrum sensing in cognitive radio networks", South African Institute of Electrical Engineers, 2021, pp. 4-15, [2] The proliferation of wireless mobile devices has led to a number of challenges in mobile data communication. The world is experiencing an increasing usage of finite spectrum bands for social media and other data communication services. It is due to this high usage that the Federal Communications Commission (FCC) sought to open up some spectrum bands to be used opportunistically by secondary users (SUs). However, the coexistence of Primary Users (PUs) and SUs may cause interference which leads to wastage of spectrum resources. This study investigates the impact of interferences between PUs and SUs. To ensure higher detection of PU signal, a cooperative rule was used to decide which SU to share and make a final decision about the availability of the spectrum band. To maximize the throughput of SU, a maximum likelihood function was designed to reduce delays in searching for the next available channel for data transmission. To discover more transmission opportunities and ensuring that a good number of free channels are detected, a parallel sensing technique was employed. Matlab was used to simulate and generate the results in a distributed cognitive radio environment. The proposed extended generalized predictive channel selection algorithm (EXGPCSA) outperformed other schemes in literature in terms of throughput, service time and probability of detection.

A. Manasa, V. Srikanth, "Reinforcement Learning Approach to Reduce Latency for Spectrum Sensing in Cognitive Radio Wireless Networks", Turkish Journal of Physiotherapy and Rehabilitation, 2021, pp. 3044-3049, [3] The detection of available wireless channels will allow CR radio transceivers, discovering which communication channels are in use and which are not. The main goal of Cognitive Radio devices is to move into vacant channels while avoiding occupied ones. It passes the transmission of multiple signals into a single medium, optimizing the spectrum while minimizing interference with other users low latency routing algorithm based on dynamic programming in cognitive wireless mesh networks through modified Q-learning algorithm. This research aims to use an RL technique known as changed Q-Learning to provide a potential solution for allocating channels in a wireless network containing independent cognitive nodes. The proposed method demonstrates the results by spectrum sensing scheme achieves significant performance gain over various reference algorithms in scanning overhead and access delay for particular applications.

Dongfang Xu, Xianghao Yu, Robert Schober, "Resource Allocation for Intelligent Reflecting Surface-Assisted Cognitive Radio Networks", IEEE 2020. pp. 1-5, [4] In this paper, they investigate resource allocation algorithm design for intelligent reflecting surface (IRS)-assisted multiuser cognitive radio (CR) systems. In particular, an IRS is deployed to mitigate the interference caused by the secondary network to the primary users. The beamforming vectors at the base station (BS) and the phase shift matrix at the IRS are jointly optimized for maximization of the sum rate of the secondary system. The algorithm design is formulated as a non-convex optimization problem taking into account the maximum interference

tolerance of the primary users. To tackle the resulting non-convex optimization problem, they propose an alternating optimizationbased suboptimal algorithm exploiting semidefinite relaxation, the penalty method, and successive convex approximation. Their simulation results show that the system sum rate is dramatically improved by our proposed scheme compared to two baseline schemes. Moreover, our results also illustrate the benefits of deploying IRSs in CR networks.

Amjad Ali, Sikandar Tariq, Muddesar Iqbal, Li Feng, Imran Raza, Muhammad Hameed Siddiqi, Ali Kashif Bashir, "Adaptive Bitrate Video Transmission Over Cognitive Radio Networks Using Cross Layer Routing Approach", IEEE Transactions on Cognitive Communications and Networking, 2020, pp. 1-13, [5] Due to the recent developments in the wireless mesh and ad-hoc networks, multi-hop cognitive radio networks (MCRNs) have attained the significant attention towards providing the reliable multimedia communications. However, in reliable multimedia communications each multimedia application observed a very stringent quality-of-service (QoS) requirements. Moreover, in MCRNs, channel allocated to the multimedia secondary users (MSUs) can be re-occupied by the primary users (PUs) at any time which causes the end-to-end-path discontinuity that severely affect the performance of the MCRNs. Therefore, under the dynamic channel availability, selecting an end-to-end path that is not only stable but also fulfills the QoS requirements of the real time and multimedia (RM) applications is a challenging task and still an open research problem. Hence, in this paper, they propose a cross-layer routing scheme that supports adaptive bit-rate multimedia (ABM) transmissions over MCRNs. Moreover, our path selection is based on the QoSaware end-to-end path delay, and PU-activity aware end to end path stability metrices. Furthermore, to avoid the PU interference, continuity in transmission, efficient channel utilization, and supporting error resilience over time varying wireless channels our selected end-to-end path is periodically updated. Simulation study shows that the proposed scheme is more robust and suitable for supporting ABM over MCRNs.

Mohammad Amzad Hossain, Michael Schukat, Enda Barrett, "MU-MIMO Based Cognitive Radio in Internet of Vehicles (IoV) for Enhanced Spectrum Sensing Accuracy and Sum Rate", IEEE 2021, pp. 1-8, [6] Vehicular ad-hoc networks (VANETs) provide the basic infrastructure for intelligent transportation systems (ITS), as it allows vehicles to access the Internet and to communicate intra-vehicle, inter-vehicle and vehicle to the roadside base station. The Internet of Vehicles (IoV) is an evolution of VANETs following the IoT paradigm. Nowadays, the spectrum scarcity is a big issue for the IoV networks due to the increased demand for connecting more vehicles. The cognitive radio (CR) enabled IoV networks can address this issue. In this paper, they propose a multi-user multiple-input and multiple-output (MU-MIMO) antennas aided cluster based cooperative spectrum sensing (CBCSS) scheme for CR enabled IoV networks. In this proposed scheme, each CR embedded vehicles (CRV) sends sensing data to the cluster head (CH) which makes a cluster decision by using the soft data fusion rule like the equal gain combining (EGC) fusion rule and the maximal ratio combining (MRC) fusion rule; whereas the fusion centre (FC) makes a final global decision by using the K-out-of-N rule to identify the presence of the PU signal. Simulation results show that the proposed MU-MIMO antennas aided CB-CSS scheme achieves a better sensing gain, enhanced the sum rate and lower global error probability when compared to both the conventional single-input and single output (SISO) antenna based cooperative spectrum sensing (CSS) and non-cooperative spectrum sensing (NCSS) schemes.

Oluyomi Simpson, Yichuang Sun, "Robust Statistics Evidence Based Secure Cooperative Spectrum Sensing for Cognitive Radio Networks", IEEE 2020, pp. 1-7, [7] Cognitive radio networks (CRNs), an assemble of smart schemes intended for permitting secondary users (SUs) to

opportunistically access spectral bands vacant by primary user (PU), has been deliberated as a solution to improve spectrum utilization. Cooperative spectrum sensing (CSS) is a vital technology of CRN systems used to enhance the PU detection performance by exploiting SUs' spatial diversity, however CSS leads to spectrum sensing data falsification (SSDF), a new security threat in CR system. The SSDF by malicious users can lead to a decrease in CSS performance. In this work, they propose a CSS scheme in which the presence and absence hypotheses distribution of PU signal is estimated based on past sensing received energy data incorporating robust statistics, and the data fusion are performed according to an evidence based approach. Simulation results show that the proposed scheme can achieve a significant malicious user reduction due to the abnormality of the distribution of malicious users compared with that of other legitimate users. Furthermore, the performance of our data fusion scheme is improved by supplemented nodes' credibility weight.

Youheng Tan, Xiaojun Jing, "Cooperative Spectrum Sensing Based on Convolutional Neural Networks", Appl. Sci. 2021, pp. 1-13, [8] Cooperative spectrum sensing (CSS) is an important topic due to its capacity to solve the issue of the hidden terminal. However, the sensing performance of CSS is still poor, especially in low signal-to-noise ratio (SNR) situations. In this paper, convolutional neural networks (CNN) are considered to extract the features of the observed signal and, as a consequence, improve the sensing performance. More specifically, a novel two-dimensional dataset of the received signal is established and three classical CNN (LeNet, AlexNet and VGG-16)-based CSS schemes are trained and analyzed on the proposed dataset. In addition, sensing performance comparisons are made between the proposed CNN-based CSS schemes and the AND, OR, majority voting-based CSS schemes. The simulation results state that the sensing accuracy of the proposed schemes is greatly improved and the network depth helps with this.

Sara A. Attalla, Karim G. Seddik, Amr A. El-Sherif, Tamer ElBatt, "A Reinforcement Learning Approach to ARQ Feedback-based Multiple Access for Cognitive Radio Networks", IEEE 2021, pp. 1-6, [9] In this paper, they propose a reinforcement learning (RL) approach to design an access scheme for secondary users (SUs) in a cognitive radio (CR) network. In the proposed scheme, we introduce a deep Q-network to enable SUs to access the primary user (PU) channel based on their past experience and the history of the PU network's automatic repeat request (ARQ) feedback. In essence, SUs cooperate to avoid collisions with other SUs and, more importantly, with the PU network. Since SUs cannot observe the state of the PUs queues, they partially observe the system's state by listening to the PUs' ARQ packets. To model this system, a Partially Observable Markov Decision Process (POMDP) is adopted, and an RL deep Q-network is employed for the SUs to learn the best actions. A comparative study between the proposed scheme with baseline schemes from the literature is presented. They also compare the proposed scheme with the perfect sensing system (which constitutes an upper bound on the performance) and the system exploiting only the last ARQ feedback. Their results show that the proposed RL based access scheme yields comparable performance to the baseline ARQ based access schemes, yet, with minimal knowledge about the environment compared to the baseline which assumes perfect knowledge of key system parameters, e.g., PUs arrival rates.

IV. Problem Identification

Spectrum sensing is a prime step in cognitive radio based dynamic spectrum management to gain the understanding of the radio environment. Regardless its influence in past generations, the research of spectrum sensing has attracted considerable interest from the wireless communications society. Spectrum sensing is a system initially created for military applications, to supply secure communications by spreading the signal over a large frequency band. Despite the

fact that the fixed spectrum assignment outlook served well in the past, due to exceptional increasing in the number of users competing the spectrum has led to the deficiency of spectrum. Spectrum holes is a consequence of inefficient usage of spectrum. As a result, potential shift from fixed spectrum sensing to dynamic spectrum sensing is absolutely necessary to overcome the contemporary constraint. Dynamic Spectrum Sensing (DSS) is the crucial remedy for rational spectrum switching. The problem of wastage of spectrum has been widely studied in the literature. To avoid collision of channels which occur when two or more users strive to transmit simultaneously over a common channel, or when two users attempt to transmit simultaneous in a half-duplex communication channel.

V. Conclusion

A major point for studying and making progress in CR is the technique of DSA. In the early period of wireless communication, the target was to remove interference among users. To avoid interference, "Command and Control" [6] was used to give the license to all the operators. The license was the permission to use the specifics portion of the spectrum. In the early days of wireless communication, the term "Command and control", simply means that the spectrum was assigned by no special rules and the only task was to remove the issue of interference.

References:

[1] Manish Kumar Giri, Saikat Majumder, "Extreme Learning Machine Based Cooperative Spectrum Sensing in Cognitive Radio Networks", 7th International Conference on Signal Processing and Integrated Networks, IEEE, 2020, pp. 636-641.

[2] J. Tlouyamma, M. Velempini, "Investigative analysis of channel selection algorithms in cooperative spectrum sensing in cognitive radio networks", South African Institute of Electrical Engineers, 2021, pp. 4-15.

[3] A. Manasa, V. Srikanth, "Reinforcement Learning Approach to Reduce Latency for Spectrum Sensing in Cognitive Radio Wireless Networks", Turkish Journal of Physiotherapy and Rehabilitation, 2021, pp. 3044-3049.

[4] Dongfang Xu, Xianghao Yu, Robert Schober, "Resource Allocation for Intelligent Reflecting Surface-Assisted Cognitive Radio Networks", IEEE 2020. pp. 1-5.

[5] Amjad Ali, Sikandar Tariq, Muddesar Iqbal, Li Feng, Imran Raza, Muhammad Hameed Siddiqi, Ali Kashif Bashir, "Adaptive Bitrate Video Transmission Over Cognitive Radio Networks Using Cross Layer Routing Approach", IEEE Transactions on Cognitive Communications and Networking, 2020, pp. 1-13.

[6] Mohammad Amzad Hossain, Michael Schukat, Enda Barrett, "MU-MIMO Based Cognitive Radio in Internet of Vehicles (IoV) for Enhanced Spectrum Sensing Accuracy and Sum Rate", IEEE 2021, pp. 1-8.

[7] Oluyomi Simpson, Yichuang Sun, "Robust Statistics Evidence Based Secure Cooperative Spectrum Sensing for Cognitive Radio Networks", IEEE 2020, pp. 1-7.

[8] Youheng Tan, Xiaojun Jing, "Cooperative Spectrum Sensing Based on Convolutional Neural Networks", Appl. Sci. 2021, pp. 1-13.

[9] Sara A. Attalla, Karim G. Seddik, Amr A. El-Sherif, Tamer ElBatt, "A Reinforcement Learning Approach to ARQ Feedback-based Multiple Access for Cognitive Radio Networks", IEEE 2021, pp. 1-6.

[10] Shuai Liu, Jiayun Wu, Jing HE, "Dynamic Multichannel Sensing in Cognitive Radio: Hierarchical Reinforcement Learning", IEEE Access 2021, pp. 25473-25482.

[11] V. Balajia, Pranav Kabrab, P. V. P. K. Saieesh, C. Hota, G. Raghurama, "Cooperative Spectrum Sensing in Cognitive Radios using Perceptron Learning for IEEE 802.22 WRAN", Procedia Computer Science, Elsevier, 2015, pp. 14- 23.

[12] Shuangyi Zhang, Hua Tian, Xueqiang Chen, Zhiyong Du, Luying Huang, Yuping Gong, Yuhua Xu, "Design and implementation of reinforcement learning-based intelligent jamming system", IET Commun., 2020, pp. 3231-3238.

[13] Nisha Yadav, Suman Rathi, "A Comprehensive Study of Spectrum Sensing Techniques in Cognitive Radio", International Journal of Advances in Engineering & Technology, 2011, pp. 85-97.

[14] Akyildiz, I.F.; Lo, B.F.; Balakrishnan, R. Cooperative spectrum sensing in cognitive radio networks: A survey. Phys. Commun. 2011, 4, 40–62.

[15] Na,W.; Yoon, J.; Cho, S.; Griffith, D.W.; Golmie, N. Centralized Cooperative Directional Spectrum Sensing for Cognitive Radio Networks. IEEE Trans. Mob. Comput. 2017, 17, 1260–1274.

Mukesh Sakpal Mukesh Mahadeo Sakpal has done B.E. in Electronics from Hi Tech Engineering College, Pune (Maharashtra) in 2003. He is Pursuing M.Tech. in Digital Communication from School of Electronics and Communication Engineering, Under the Faculty of Engineering and Technology, Madhyanchal Professional University, Bhopal (M.P.).

Prof. **Jitendra Kumar Mishra** he is Associate Professor and Head of the Department of Electronics and Communication Engineering Faculty of Engineering and Technology, Madhyanchal Professional University, Bhopal (M.P.). His received Master of Technology and Bachelor's of engineering respectively in Digital communication from BUIT, Bhopal and from RGPV, Bhopal. He has more than 12 years of teaching experience and publish 60+ papers in International journals, conferences etc. His areas of Interests are Antenna & Wave Propagation, Digital Signal Processing, Wireless Communication, Image Processing etc.