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Prediction Based Bandwidth Selection using Cognitive Radio Network: Survey and Discussions

Saurav Kumar mishra[1], Prof. Jitendra Mishra[2]

[1]M. Tech Scholar, Department of EC, PCST, Bhopal (India)

[2]Head & Professor, Department of EC, PCST, Bhopal (India)

ABSTRACT
The emergence of Internet of Things and other applications of wireless communication has resulted in increase of air interference among various wireless devices. In upcoming time we will be connecting more and more devices wirelessly. In addition to an increase in number of devices, many devices also demand higher bandwidth. With the ever-increasing need for spectral resources, it becomes necessary for a secondary user (SU) to smartly and efficiently access the resources of idle channel primary radio systems without creating harmful interference to the licensed users, which is possible through Cognitive Radio (CR) technology. the unlicensed user systems can adopt Opportunistic Spectrum Access (OSA) techniques to fulfill spectrum needs of their customers. CRNs consist of two kinds of consumers, the Primary Users (PU), who are the licensed consumers, and the Secondary Users (SU), who are the unlicensed ones. In this paper we present the literature review for the improvement of radio frequency for the unlicensed user or secondary user to utilize the spectrum or frequency in an efficient manner.

Keywords:- Wireless sensor network, Cognitive radio, Neural network, Primary user, Secondary user.

INRODUCTION
The Severe scarcity of spectrum resource inspires the development of new spectrum management techniques. Cognitive radio networks (CRNs), in which secondary users (SUs) are able to sense and access the spectrum white spaces by using dynamic spectrum access (DSA) technology, has become a promising approach to improve SU's spectrum efficiency [1]. For example, seven dedicated channels used in vehicular networks based on IEEE 802.11p standard could easily get congested if the vehicle density is high. In this case, DSA technology can help avoid congestion by allowing vehicles to sense and access underutilized licensed frequency bands, On the other hand, full-duplex (FD) operation, which allows devices to transmit and receive over the same frequency band at the same time, has also emerged as a solution to alleviate the spectrum scarcity problem. FD operation brings new transmission mechanisms to CRNs. SUs are allowed to sense the channel while transmitting data. They can also sense the channel and then transmit-and-receive data at the same time. These mechanisms are called transmission-and-sensing (TS), and transmission-and-reception (TR), respectively. In TS mode, the collision probability is low because of the continuous sensing operation. SU's throughput is also lower than that of TR mode since it cannot transmit and receive at the same time. In TR mode, SU can gain higher throughput due to the simultaneous transmission-and-reception. However, the SU cannot be aware of primary user's (PU's) return during its transmission-and-reception, which causes higher collision probability than that of TS mode. These two modes give rise to a trade-off between higher SU's throughput and lower collision probability.

A direction for accomplishing spectrum better utilization is to equip the framework with cognitive radio capabilities. CR is considered as a smart radio which sense spectrum channel availability and adjust its operating parameters to communicate effectively with other user by avoiding interference. direction for accomplishing spectrum better utilization is to equip the framework with cognitive radio capabilities. CR is considered as a smart radio which sense spectrum channel availability and adjust its operating parameters to communicate effectively with other user by avoiding interference [3]. As represented by authors in [3] in below figure that sensing and analysis provides the means for RF awareness, such as the presence/absence of the licensed users, their transmit powers and the channel conditions. Decision making and learning exploit the RF awareness for choosing actions that maximize the CR's utility, such as the data rate. These include choosing the operation frequency, transmit power, modulation, coding, etc., which are carried out in the adaptation step. Each secondary/unlicensed user (SU) can detect and access the spectrum when the spectrum is unoccupied by primary/licensed users (PUs). At the point when a PU solicitations to get to its own range, the SUs utilizing a similar range astutely ought to change to other vacant spectra to ensure the transmission of the PU and proceed with their own particular information conveyance. Decision making and learning exploit the RF awareness for choosing actions that maximize the CR's utility, such as the data rate. These include choosing the operation frequency; transmit power, modulation, coding, etc., which are carried out in the adaptation step. Each secondary/unlicensed user (SU) can detect and access the spectrum when the spectrum is unoccupied by primary/licensed users (PUs). At the point when PU solicitations to get to its own range, the SUs utilizing a similar range astutely ought to change to other vacant spectra to ensure the transmission of the PU and proceed with their own particular information conveyance [3]. According to Communication regularity bodies it has been found that a large amount of licensed Spectrum band is not utilized fully, for this unused spectrum to be utilized completely, we use the Cognitive Radio Technology. Cognitive radio is a widely used promising solution of Spectrum Scarcity. The concept of Cognitive radio was first proposed by Joseph Mitola in 1999 as a solution to optimize the unused licensed Spectrum. Cognitive radio system has the ability to sense the unused spectrum by adjusting their parameters in its environment [7].

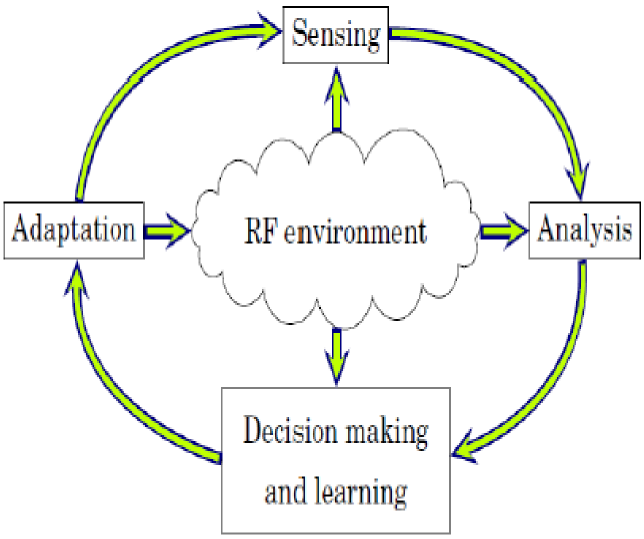

Fig 1: Cognitive cycle of cognitive radio [3].

To mitigate problem of interference to Licensed (Primary) user, Cognitive users require some techniques. There are several techniques for Spectrum Sensing from which some techniques are able to sense the full band of Cellular Network. While due to hardware limitations secondary users only sense one part of the spectrum in a slot. On the additional side sensing energy can be conserved by avoiding the used portion of the spectrum. To make the secondary users efficient to manage the spectrum, spectrum prediction is used. The secondary users can predict the spectrum which is based on the sensing history and sense only if a spectrum slot is predicted to be an idle in the next time slot, so secondary user can save the energy by spectrum sensing. By Spectrum Prediction, predicted spectrum slots can be used by the secondary users without causing any interference and QoS will be increased.

Spectrum sensing is an important component of CR systems because it reveals the presence or absence of PUs. Numerous mechanisms have been suggested in literature like Energy Detections (ED), cyclostationary detections or matched filter detections. In all of the mentioned conventional mechanism, when PUs are operating, SUs are not permitted to transmit their own information. To put it accurately, in OSA, SUs are permitted to transmit information solely when spectrum sensing blocks have determined that PUs are not currently operating. The innate restriction ensures that CR networks are in line with PU data forwarding frames as well as to detect PU activities at the starting point of all PU data frames. If spectrum sensing reveals that PUs are not present, SUs then can send their information across the remaining data frames [9].

Machine learning (ML) proves to be a powerful tool for a CR system opening up versatile DSA applications viz. spectrum sensing, spectrum occupancy modeling, spectrum prediction, traffic pattern prediction, spectrum scheduling etc., The primary advantage of ML over other statistical models is that it does not require a priori knowledge of the distributions under consideration. In the context of CR, ML techniques are generally used for signal classification, feature extraction, spectrum prediction etc. For CR, mainly artificial neural networks (ANN) and Support Vector Machines (SVM) have been investigated in case of supervised ML. But application specific work in reference to DSA and channel allocation based on learning has not been explored in sufficient detail in the existing literature. Moreover, most of the mentioned papers are restricted to one possible traffic model only [5].

II MEDIUM ACCESS CONTROL LAYER

Medium access control (MAC) layer is responsible for the control and coordination of communication over wireless channels, several cognitive radio functions like channel sensing, spectrum sharing, resource allocation and spectrum mobility need to be included in the design of MAC protocol for CRN. In the rapidly changing radio environment, the CRN MAC protocol shall make number of decisions in real time. This makes the design of CRN very challenging compared to conventional MAC protocols, that work under the current static spectrum policies. In recent decades, the concept of opportunistic spectrum access (OSA) has emerged to significantly increase spectrum utilization. Efficient sensing and dynamic spectrum
access are the key challenges of an OSA MAC protocol. For this, the SUs should have the ability of dynamically search and utilize opportunities in the licensed spectrum along in different dimensions like time, frequency or even code. Thus an OSA MAC should integrate both sensing and channel access functionalities. In essence, spectrum sensing, allocation and access, spectrum sharing and spectrum mobility, are the key elements for efficient OSA MAC protocol design.

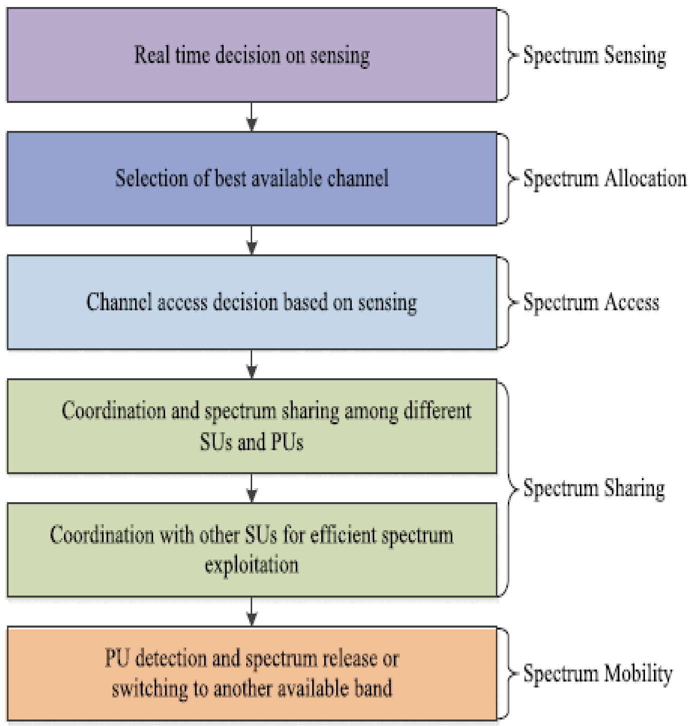

Fig. 2: OSA MAC protocol functionalities [4].

III RELATED WORK

[1] In this paper author propose a neural network (NN) predictor for multi-slot prediction and an adaptive mode selection scheme, with the goal of improving secondary users (SUs) throughput while alleviating collision to primary user (PU) in full duplex (FD) cognitive networks. Conventionally, FD SU can either operate in a transmission-and-reception (TR) mode to improve its throughput, or a transmission-and-sensing (TS) mode to avoid collision to PU. The difference between TR and TS modes in goal gives rise to a trade-off between higher SUs throughput and lower collision probability, which can be optimized by allowing SU to switch between these two modes. Accordingly, they design an NN predictor to predict PUs future activity which is considered as the basis of switching. In such a context, they analyze the prediction performance in terms of prediction error probability.

[2] In this paper they propose a model-driven framework with a joint off-line and on-line way, which is able to achieve fast and optimal network selection through an alliance of machine learning and game theory. Further, we implement a distributed algorithm at the user side based on the proposed framework, which can reduce the number of frequent switching, increase the possibility of gainful switching, and provide the individual service. The simulation results confirm the performance of the algorithm in accelerating convergence rate, boosting user experience, and improving resource utilization.

[3] In this paper they used neural network to propose this decision of resource allocation more accurately by providing bandwidth, power, antenna gain, azimuth, angle of elevation and location as a supplements factors to increase the predicting accuracy of Available channel frequencies for secondary user in particular bands. The comparative analysis is done between artificial neural network techniques to determine the maximum decision accuracy in order to design a suitable neural network structure and the system to make fast prediction for available channels. The dataset is divided in to cellular 850 MHZ and Advanced wireless service 1900/2100 MHZ bands. In both bands, Feed Forward networks performs better as compared to Elman and Radial basis network for predicting the best available channel to accommodate the secondary user.

[4] In this work article author focus on the opportunistic spectrum access (OSA) functionality of the CR network MAC layer by which the secondary users (SUs) access licensed spectrum in space and time with no harmful interference to primary users (PUs), without prior information on spectral usage. To achieve this, the unlicensed users should have the ability to adaptively and dynamically seek and exploit opportunities in licensed spectrum in time, polarization and frequency domains. There have been several OSA MAC schemes proposed for CR networks. This article presents a detailed review of such state-of-the art schemes. First the differences between the conventional MAC protocols and OSA based MAC protocols are discussed.

[5] In this work, the importance of machine learning spectrum prediction is highlighted in the context of CR for efficient DSA. In contrast to the existing method of statistical prediction, the use and applicability of supervised learning based prediction in various traffic scenarios have been studied in this paper. Prediction accuracy is investigated for three machine learning techniques, artificial neural network based Multilayer Perceptron (MLP), Support Vector Machines (SVM) with Linear Kernel and SVM with Gaussian Kernel, among which, the best one is chosen for prediction based opportunistic spectrum access. The results highlight the analysis of the learning techniques with respect to the traffic intensity.

[6] The analysis of spatial opportunities to reuse frequencies by secondary users (SU) in a Cognitive Radio (CR) network is the main objective of this work. Methods/Statistical Analysis: Here lineal and no-lineal models are developed and evaluated to forecast the received

power of different channels base on measurements performed in Bogota Colombia for the global system for mobile communication (GSM) bands. Seasonal autoregressive integrated moving average (SARIMA), generalized autoregressive conditional heteroskedastic (GARCH), Markov, empirical mode decomposition support vector regression (EMD-SVR) and wavelet neural models were utilized for the forecasting of the channel occupancy.

[7] In this paper, they have developed a dataset utilization of different frequencies by spectrum sensing. This data is used as an input to machine learning algorithm in order to predict white spaces and transmission levels at which secondary users can transmit without creating any interference with primary users. For creation of the database they have performed spectrum sensing on different frequency bands. After analysing the data, we found out spectrum holes (white spaces, where primary user isn't transmitting) and transmission levels of primary user so that secondary user can transmit without creating interference. From this dataset, they trained our machine learning algorithm to accurately predict spectrum holes and transmission levels for secondary users. Using machine learning we were able to predict accurately within a fraction of time.

[8] In this paper, they propose a new prediction based Spectrum management strategy to tackle this challenge. Both spectrum prediction and users' mobility prediction are fully considered in the proposed strategy. Combining the prediction information and cooperative sensing, a CR base station can obtain the sensing information for future location of each secondary user, so as to prearrange high-quality channels for secondary users ahead of time. In addition they propose a new channel selection scheme when multiple channels are available simultaneously. Besides traditional decision factors, the new channel selection algorithm takes the channel's future availability obtained from spectrum prediction into account. By properly integrating the spectrum prediction, user mobility prediction, and channel selection, the new spectrum management strategy is capable of allocating the spectrum resource more efficiently.

[9] In this paper, a spectrum predictor based on Neural Networks model Multi-Layer Perceptron and Back Propagation that do not need prior information regarding traffic features of licensed customers is designed. Binary Shuffled Frog Leaping Algorithm is proposed for structure optimization, the binary structure is suggested to show the memes with the purpose of developing a sub-collection with lesser dimensions than that of the original collection where detecting sensitivity and accuracy would be scalable with that of the primary status. Spectrum Predictor's performance is examined through exhaustive experiments.

[10] In this paper a comprehensive survey has been conducted on various ANN techniques, its comparison with other machine learning techniques and discussion on various learning models to increase the decision making ability of cognitive radio's cognitive engine. ANN uses supervised learning and this paper compares it with other supervised learning techniques (like SVM) and also unsupervised learning techniques and statistical models. The paper provides detailed knowledge about what factors influence the use of ANN in cognitive engines and under certain conditions which ANN technique is most suitable.

[11] In this paper they presented the basic functionalities of Cognitive radio network and discussed different prediction techniques and their applications. Various prediction techniques have been studied over the time to predict the spectrum state to reduce the sensing time and improve the efficiency. However there are certain limitations of each technique. HMM provides accurate prediction and can be used widely but it can mostly be applied on statistical models. Neural network based model on the other hand eliminates the needs for parameter and threshold settings that are required in HMM. Both neural networks and HMM are characterized by high convergence time and complexity.

IV PROBLEM STATEMENT

Ever increasing service demand poses two major challenges in the next generation wireless communication paradigm. One is the spectrum scarcity and the other is the demand of high data rates, upto few Gbps. Cognitive radio network (CRN) has distinctive characteristics from a traditional wireless network where it intelligently recognizes the status of the radio environment and adjusts its functional parameters accordingly. Most critical part of CRN is allowing CR users to share the licensed spectrum with PUs without degrading their performance. This imposes new challenges and open research issues. Medium access control (MAC) layer is responsible for the control and coordination of communication over wireless channels. According to the channel usage strategy, MAC schemes can be classified into single channel or multi-channel MAC protocol. Simpler architecture of single channel based protocol makes it attractive; however, network throughput is low due to lower data transmission rate. In addition, the well known hidden terminal problem, shadowing, multipath fading and receiver noise/interference uncertainty issues may cause severe impact on network performance in single channel scenario. On the contrary, multi-channel MAC protocol performs better than single channel protocol in several aspects such as 1) increased network throughput due to multiple simultaneous data transmissions, 2) reduced interference among SU nodes and, 3) reduced number of SU nodes affected by sudden PU activity.

V CONCLUSION AND FUTURE SCOPE

Radio spectrum is the most valuable resource to implement wireless communications. With ever growing new applications in wireless communications, the traditional static spectrum allocation scheme reveals its inherent limitation. On one hand, the limited amount of available radio spectrum can no longer meet new demands, which leads to the issue of spectrum scarcity. On the other hand, according to the study of Federal Communications Commission, the utilization of allocated spectrum is relatively low, from 15% to 85%. In this paper we present the comparative review study for the cognitive radio and quality of services in wireless communication, here we found some problems related to spectrum sensing and analysis, in future we develop a techniques based on some classification techniques and improve the results of quality of services.

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Saurav Kumar Mishra received his Bachelor`s degree in Electronics & comunication engineering, UTD-UIT-BU, Bhopal, M.P., in 2013. Currently he is pursuing Master of Technology Degree in Electronics & Comunication (Digital communication) from PCST, (RGPV), Bhopal, Madhya Pradesh India. His research area include wireless communication.

Mr. **Jitendra Mishra** he is Associate Professor and Head of the Department of Electronics and communication in PCST, Bhopal (RGPV). 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 11 years of teaching experience and publish 50+ papers in International journals, conferences etc. His areas of Interests are Antenna & Wave Propagation, Digital Signal Processing, Wireless Communication, Image Processing etc.