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A Study On Reduction Of Radio Traffic Jam In Wireless Communications Using Cognitive Radio

Ms. Y. Smruthi
Asst. Prof, Dept of ECE, ACE Engineering College, Hyderabad, TS

Dr. P. Sumithabhashini
Professor, Dept of ECE, ACE Engineering College, Hyderabad, TS

Abstract: A cognitive radio (CR) is a radio that can change its transmission parameters based on the perceived availability of the spectrum bands in its operating environment. CRs support dynamic spectrum access and can facilitate a secondary unlicensed user to efficiently utilize the available underutilized spectrum allocated to the primary licensed users. A cognitive radio network (CRN) is composed of both the secondary users with CR-enabled radios and the primary users whose radios need not be CR-enabled. In this paper, we are able to provide an exhaustive analysis of the issues and the state-of-the-art literature solutions available with regards to the CRNs. We discuss the various techniques/mechanisms/protocols that have been proposed for CRNs. This paper serves as a good comprehensive review and analysis of all the critical aspects for CRNs, and would lay a strong foundation for someone to further develop onto any particular aspect of CR's in greater depth.

Index Terms: Cognitive radio, spectrum sensing, dynamic spectrum access, multi-dimensional spectrum sensing, cooperative sensing.

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I. INTRODUCTION

Wireless technology is proliferating rapidly, and the vision of pervasive wireless computing and communications offers the promise of many societal and individual benefits. While consumer devices such as cell phones, PDAs and laptops receive a lot of attention, the impact of wireless technology is much broader, e.g., through sensor networks for safety applications and home automation, smart grid control, medical wearable and embedded wireless devices, and entertainment systems. This explosion of wireless applications creates an ever-increasing demand for more radio spectrum. However, most easily usable spectrum bands have been allocated, although many studies have shown that these bands are significantly underutilized. These considerations have motivated the search for breakthrough radio technologies that can scale to meet future demands both in terms of spectrum efficiency and application performance.

The rest of the paper is organized as follows: Section II presents cognitive radio and its functions, Section III explains spectrum sensing methodologies to detect PUs presents Section IV describes spectrum management Section V presents spectrum sharing Section VI Spectrum mobility Section VII Conclusion

II. COGNITIVE RADIO

Cognitive radio (CR) is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, and instantly move into vacant channels while avoiding occupied ones. This optimizes the use of available radio-frequency (RF) spectrum while minimizing interference to other users. CR is a hybrid technology involving software defined radio (SDR) as applied to spread spectrum communications. Possible functions of cognitive radio include the ability of a transceiver to determine its geographic location, identify and authorize its user, encrypt or decrypt signals, sense neighboring wireless devices in operation, and adjust output power and modulation characteristics.

There are two main types of cognitive radio, full cognitive radio and spectrum-sensing cognitive radio. Full cognitive radio takes into account all parameters that a wireless node or network can be aware of. Spectrum-sensing cognitive radio is used to detect channels in the radio frequency spectrum. One of the most important components of the cognitive radio concept is the ability to measure, sense, learn, and be aware of the parameters related to the radio channel characteristics, availability of spectrum and power, radio's operating environment, user requirements and applications, available networks (infrastructures) and nodes, local policies and other operating restrictions. In cognitive radio terminology, primary users can be defined as the users who have higher priority or legacy rights on the usage of a specific part of the spectrum. On the other hand, secondary users, which have lower priority, exploit this spectrum in such a way that they do not cause interference to primary users. Therefore, secondary users need to have cognitive radio capabilities, such as sensing the spectrum reliably to check whether it is being used by a primary user and to change the radio parameters to exploit the unused part of the spectrum.

Cognitive radio has four major functions. They are Spectrum Sensing ,Spectrum management, Spectrum Sharing and Spectrum Mobility.

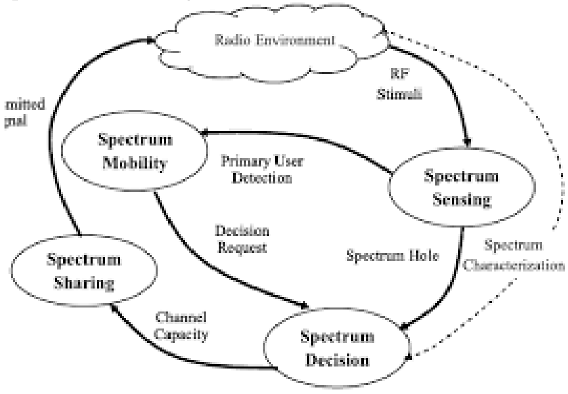

Figure 1: Cognitive Radio System

Spectrum Sensing is to identify the presence of licensed users and unused frequency bands i.e., white spaces in those licensed bands. Spectrum Management is to identify how long the secondary users can use those white spaces. Spectrum Sharing is to share the white spaces (spectrum hole) fairly among the secondary users. Spectrum Mobility is to maintain unbroken communication during the transition to better spectrum. Since most of the spectrum is already assigned, the most important challenge is to share the licensed spectrum without interfering with the transmission of other licensed users as illustrated inFig.2. The cognitive radio enables the usage of temporally unused spectrum, which is referred to as spectrum hole or whitespace.

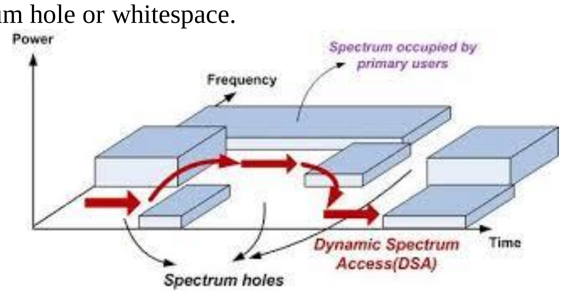

Figure 2: Spectrum hole concept

III. SPECTRUM SENSING

The key objective behind spectrum sensing and detection is to see how reliably one could detect the radio users given a particular scenario with an acceptable payoff or trade-off. In other words, the main objective is to maximize the probability of detection without losing much on the probability of false alarm while minimizing the complexity and time to sense/detect the radio. In this section, we present various methods and techniques to detect the radio users in the environment which is shown in fig 3.

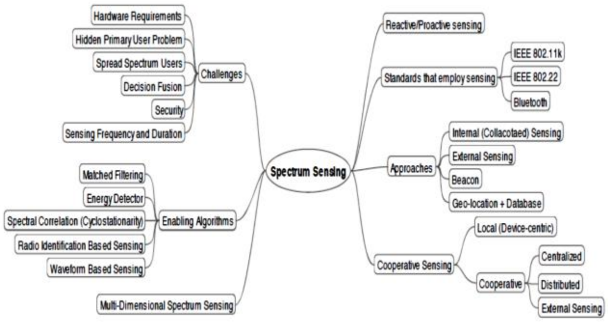

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Figure 3: Issues related to spectrum sensing

IV. SPECTRUM MANAGAING

SA belongs to a class of modern spectrum management techniques that are often vaguely defined To clear the ambiguity in terminology let us briefly introduce our classification in Fig. 4. Spectrum Management Static Dynamic Spectrum Commons Exclusive Hierarchical Overlay Underlay - Dynamic Frequency Selection - Dynamic Frequency Sharing - Spectum Auctioning - Spectrum Leasing - Negotiated Spectrum Access ISM, UNII Access OSA UWB Figure 4. Modern spectrum management: Classification with the application examples

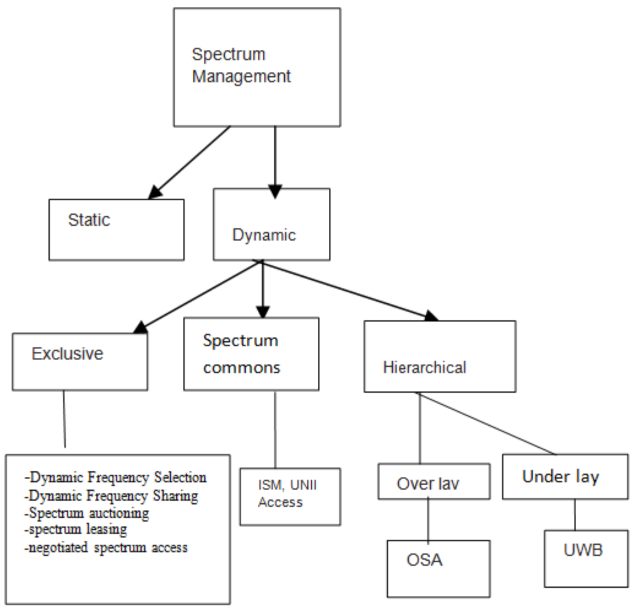

Figure 4: Modern Spectrum Management

V. SPECTRUM SHARING

Spectrum sharing is the simultaneous usage of a specific radio frequency band in a specific geographical area by a number of independent entities, leveraged through mechanisms other than traditional multiple- and random-access techniques

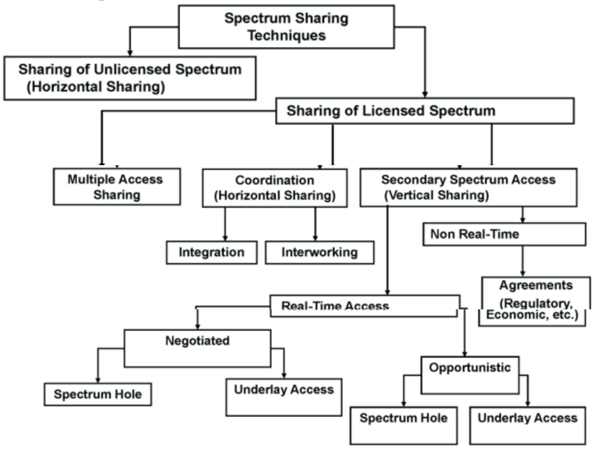

Figure 5: Spectrum Sharing Techniques

VI. SPECTRUM MOBILITY

Spectrum mobility enables the secondary users to switch to idle channels. Spectrum mobility occurs when the primary user occurs in the band occupied by secondary user. Since these secondary users has no control over the resource availability, thus secondary system must be designed to sense leftover spectrum as quickly as possible and switch to next idle slice of spectrum as soon as the primary user appears. The most important and challenging issues in spectrum mobility is the coexistence of secondary users with primary ones, to avoid interference to primary users without any negotiation with primary network and attain a seamless communication. In order to address the problem of interference, interference management is done at both transmitter and receiver. At receiver, interference limit or interference temperature is calculated on the basis of location, fading, modulation, coding and accordingly the power of transmitter are restricted. On the other hand, at transmitter, by using sensing procedures, first of all it classifies the status of channel and then determine when, where and with how much power is used for transmission. Power control in cognitive radio mitigates unnecessary interference. Further discussion of interference management is omitted here to reduce the complexity, as spectrum handoff is the area of discussion.

DESIGN ISSUES IN SPECTRUM MOBILITY

This section briefly discusses design issues in spectrum mobility. PU DETECTION Sensing speed and accuracy in spectrum sensing are two important factors for efficient spectrum mobility. In fact, there is a trade-off between the two. Fast sensing speed would lead to less accurate sensing output. In addition, recent spectrum sensing techniques are also prone to imperfect sensing results due to radio propagation effects, such as channel fading or shadowing. To increase sensing speed and accuracy, CR nodes can select other idle CR nodes as partners to perform cooperative spectrum sensing instead of local sensing. In [6], a cross-layer protocol called ESCAPE (Embedded Spectrally Agile Radio Protocol for Evacuation) using cooperative spectrum sensing in CRAHNs was suggested. Specifically, CR nodes are divided into evacuation groups and each group shares the same CDMA spreading code. If PU arrival is detected, warning messages are spread periodically to the entire group.

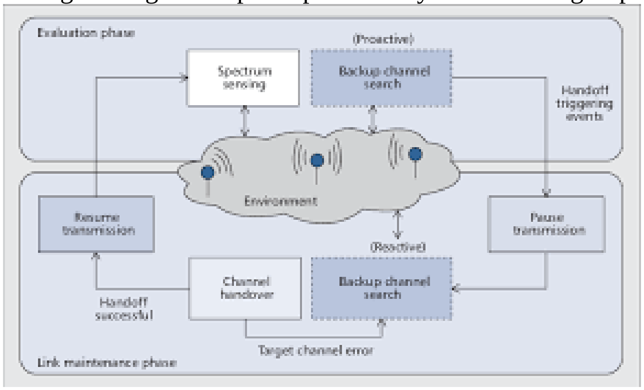

Figure 6: Spectrum handoff process

HANDOFF DECISION

Generally SUs use spectrum overlay technique where radio signals are transmitted with a power above PU noise level. In contrast, SUs with underlay technique transmit radio signals with a power below PU noise level so that both SU and PU can use the same licensed band at the same time. Nevertheless, if the aggregate interference to the PU exceeds a certain threshold, SU should leave the licensed band. Therefore, spectrum handoff decision is an important issue even in CRNs with spectrum underlay technique. Fuzzy logic based spectrum handoff algorithm in multihop underlay CRAHNs is proposed. Using fuzzy logic controller, SU will first adjust the transmitting power of the radio signal. If power adjustment is unlikely to lower the aggregate interference, then SU should do spectrum handoff.

TARGET CHANNEL SELECTION

Finding a suitable target channel over which a SU can continue data transmission session is the most pressing issue in CR research related to spectrum mobility. In fact, target channel selection for spectrum handoff is a non-trivial task, because it depends on many factors, such as channel capacity, channel availability at the time of handoff, and probability of channel being available in the future. Poor target channel selection can cause multiple spectrum handoffs in a single data transmission session that degrades overall performance. The most common approach to this issue is using backup channel list (BCL). SU anticipates spectrum handoff by listing potential target channels into BCL and maintaining it periodically between communicating peers. IEEE 802.22 Wireless Regional Area Network (WRAN) Standard adopts this approach [8]. Another approach is predicting target channel availability. Using prediction, partial spectrum sensing rather than conventional full sensing can be performed to reduce sensing delay during spectrum handoff [9]. Also, instead of relying only on sensing result, SU can get accurate target channel selection based on historical spectrum statistics. In [10], a proactive channel access algorithm using both spectrum sensing results and spectrum statistics to determine a handoff target channel is suggested. Assuming that PU arrival pattern is not statistically random (because it depends on human behavior) PU traffic can be modeled so that SU can estimate both channel availability and the length of time that channels will be available. As a result, intelligent target channel selection can be performed.

VII. CONCLUSION

This paper provides an up-to-date summary of cognitive radio research. The concept of cognitive radio is a promising technique to efficiently use the frequency spectrum. The introduction of cognition into telecommunication in the form of cognitive radios with the emphasis on learning opens up the more general notation of cognitive dynamic systems that can also be applied to other disciplines. In the future the principles of cognitive radio will be extended to cover other resources available in the network, leading to the emergence of a more generic type of approach, namely cognitive networks. The future systems will be intelligent in terms of spectrum utilization but the legacy systems cannot be changed. Therefore, the introduction of cognitive radio capabilities in the future wireless networks should have no impact on the existing networks. There is a constant need for radio regulation, especially as the operation environment is changing toward cognition.

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