POWER ALLOCATION STRATEGY FOR COGNITIVE RADIO NETWORKS: A SURVEY

Ramyah.S.B, Srithar.A, Vidhya.B
PG Student, Department of ECE
School of Communication and Computer Sciences,
Kongu Engineering College, India.

ABSTRACT
Power allocation is a vital issue in Cognitive Radio Networks (CRNs), since it needs to maintain the Quality of Service (QoS) for Secondary Users (SUs), while sustaining the interference power to Primary User (PU) below the Interference Temperature (IT) threshold. In this paper, a survey of power allocation methodologies for cognitive radio is reviewed. Various traits of power allocation problem are studied from a cognitive radio perception and multi-level power allocation concept is introduced. Challenges associated with power allocation and empowering power allocation methods are reviewed.

KEYWORDS: *Cognitive radio, power allocation, opportunistic spectrum access, underlay, sensing based spectrum sharing*

I. INTRODUCTION

With the development of wireless devices and technology, new frequency bands are being used in the radio spectrum. Due to increase in the wireless device count, the radio spectrum is becoming gradually congested. Also, the extension in the new wireless devices with the development in technology has promised more and more frequency band to be utilized. This may result in the high level of intrusion among the frequency bands which are being operated adjacent to each other. Again, it depends on the time and place of use. However, if drift continues in the future, all the remaining frequency bands will be utilized and the devices need to face heavy interference thus restricting the performance. This may lead to deciding of the upper limit to the wireless device count.

Measurements and statistics show that a broad range of the spectrum is not being used all the time, depending on the geographical region, whereas the other ranges are used heavily. Thus, the radio spectrum is being underutilized depending on the place and time of the day. This results in the inefficient use of the spectrum. Generally, the frequency bands which are licensed operate at fixed time and remaining time they are free. These free or unused bands of the spectrum cannot be used by conventional wireless systems because these are licensed and can be used only by the respected owners of that band. So, to use those bands which are unused by the licensed user during certain time, we need a device which can automatically change the operating parameters whenever it senses the unused band.

Cognitive radios offer the promise of being a disruptive technology innovation that will enable the future wireless world [1]. Cognitive radios are entirely programmable wireless devices that can intellect their atmosphere and dynamically adjust their transmission waveform, channel access manner, spectrum usage, and networking protocols as needed for noble network and application performance. We antedate that cognitive radio expertise will soon emerge from early stage laboratory trials and vertical applications to become a general-purpose programmable radio that will serve as a universal platform for wireless system development, much like microprocessors have served a similar role for calculation. One of the most important elements of the cognitive radio concept is the ability to measure, sense, acquire, and be aware of the factors related to the radio channel features, availability of spectrum and power, radio's functional atmosphere, user requirements and requests, obtainable networks and nodes, local policies and other operating limitations. In cognitive radio networks, primary users can be declared as the users who have higher precedence or legacy rights on the usage of an exact segment of the band. On the other hand, secondary users, which have lower precedence, exploit this band in such a way that they do not cause intrusion to primary users. Therefore, secondary user essential to have cognitive radio abilities, such as sensing the spectrum consistently to check whether it is being used by a primary user and to alter the radio parameters to exploit the unused part of the spectrum

The Spectrum sensing and power allocations are two key Functionalities of a CR system, which involves discerning the spectrum usage and salvaging the primary band under given interference constraints. The earliest spectrum access approach is the opportunistic spectrum access where secondary user (SU) can only access the primary band when it is detected to be idle. The second approach is the underlay where SU is allowed to transmit beneath the primary user (PU) signal, while sensing is not needed as long as the quality of service (QoS) of PU is protected. The recent approach, sensing-based spectrum sharing, performs spectrum sensing to control the status of PU and then accesses the primary band with a high transmit power if PU is claimed to be absent, or with a low power otherwise. These three slants adopt either constant or binary power allocation at SU which is too 'hard' and limits the performance of SU. Various Spectrum access approaches of Cognitive Radio is discussed in section II, Performance analysis of these approaches along with the proposed method is discussed in section III and Conclusion of this paper is discussed in section IV.

II. VARIOUS SPECTRUM ACCESS APPROACHES

2.1 Opportunistic Spectrum Access

The basic idea is this: a device first senses the spectrum it wishes to use and characterizes the occurrence, if any, of primary user [2]. Based on that evidence, and regulatory policies, the device identifies communication opportunities ("holes") in frequency, time, or even code – and transmits using those opportunities in a manner that limits the interference perceived by primary users.

Opportunistic spectrum access (OSA) is also referred to as dynamic spectrum access, and is often included as part of the larger concept of cognitive radios. [2]While conceptually simple, the realization of opportunistic spectrum access is challenging. Several problems must be solved: sensing over a wide frequency band; identifying the presence of primary users and determining the nature of opportunities; coordinating the use of these opportunities with other nodes; and most importantly, the definition and application of interference-limiting policies, and adherence to these policies while utilizing the opportunities [6]. Fortunately, recent technological advances in a number of areas can be brought to bear on this problem. First, the emergence of Software Defined Radios has enabled the RF-level programmability and spectrum agility essential to opportunistic spectrum access. Second, wideband sensing technologies have come a long way due to faster digital signal processors and tunable filters. Third, the use of waveforms that can be adapted to fit a specified spectral profile – e.g., waveforms that can occupy non-contiguous frequencies – is beginning to be better understood [7, 8].

2.2 Underlay

The Underlay (UL) mode refers to a technique in which the SU can only share the spectrum, as long as its signal remains below the acceptable interference limit of the PU [3]. This threshold is the peak or average power that can be tolerated by the PU receiver. This constraint is useful when the signal variation at the PU receiver is quasi-static, such as Television unit. Even though, when signal variations from the PU transmitter to the PU receiver are random, outage probability is a better measure. Outage at the PU receiver happens when the Signal Interference plus Noise Ratio (SINR) falls below a certain threshold (different from the interference threshold). The spectrum sharing restriction in this scenario is based on the long term outage or short term outages acceptable to the PU network. The SU transmit power is a significant factor which determines its coexistence in an underlay mode. Due to the severe transmit power constraint, the coverage range of the secondary network in an underlay mode is very restricted.

Generally, the calculation of SU transmit power requires the knowledge of PU receiver location and the channel gains between the SU transmitter-PU receiver and PU transmitter- PU receiver. Since the SU operates independently of the PU network, these parameters are often unknown to the SU transmitter and must be estimated. This comes at a cost of increased signaling overhead. In recent years, it has been visualized that the potential of the CR underlay paradigm can be applied for interference management by the PU itself, such as femtocells. The possibility of a CR empowered femtocell (FC) has also been considered as a viable solution to increase spectrum availability for cellular operators. In short, a FC enables the reuse of macrocell (coverage area of primary base station) frequencies in a cellular network over a small range with the primary aim of improving indoor coverage. The FC consists of a low power femtocell base station which is connected to a backbone network by DSL or cable internet. In the case of multiple FCs, the interference problem becomes two tier i.e., macrocell to FC (cross-tier) and FC to FC (inner-tier). By introducing additional information through a sensing phase (similar to a CR), two-tier interference can be avoided in FC deployments.

2.3 Sensing Based Spectrum Sharing

In Sensing-Based Spectrum Sharing(SBSS) model consists of two stages: In the first stage, the secondary user (SU) listens to the spectrum allocated to the primary user (PU) to notice the state of the PU and in the second stage, the SU adjusts its transit power based on the sensing outcomes[4,5]. If the PU is absent, the SU allots the transmit power based on their own benefit. Even though, if the PU is present, the interference power limit is forced to guard the PU.
Under this new model, the evaluation of the ergodic capacity of the SU is formulated as an optimization problem over the transmit power and the sensing time. Due to the difficulty, two simplified forms, which are mentioned to as the perfect detecting case and the imperfect detecting case, are studied. For the perfect detecting case, the Lagrange dual decomposition is applied to develop the optimal power allocation policy to achieve the ergodic capacity. For the imperfect detecting case, an iterative algorithm is established to obtain the optimal sensing time and the matching power allocation strategy. Finally, numerical results are obtainable to confirm the proposed studies. It is shown that the SU can attain a significant capacity gain for the proposed model, compared with that of the opportunistic spectrum access or the conventional spectrum sharing model.

2.4 Multiple Level Power Allocation

In Multiple-level power allocation strategy for SU, the power level used at SU varies based on its receiving energy during the sensing period [9]. It can be easily known that the conventional constant or binary power allocations are special cases of this strategy.
The whole strategy is composed of two stages:

- Sensing stage, where the receiving energy is gathered and the transmit power of SU is decided;
- Transmission stage, where SU sends its own data with the consistent power level. Under the limitations of the average transmit power at SU and the typical interference temperature to PU, the sensing duration, energy threshold, and power levels are optimized to maximize the average achievable rate at SU.

III. PERFORMANCE ANALYSIS

PARAMETER	OSA	UL	SBSS	MULTIPLE LEVEL
Power Allocation(dB)	16	11	10	20
Average Achievable Rate(bit/sec/Hz)	1.5	1.3	1.57	1.65

IV. CONCLUSIONS

In this term paper, various issues in power allocation for cognitive radio and available techniques to handle those issues have been described. While traditional methods like opportunistic spectrum access, underlay and sensing based spectrum sharing were touched upon, special emphasis was given to multilevel power allocation method, was described in detail, each having their different strengths and weaknesses.

REFERENCES

[1]. Simon Haykin, (2005) "Cognitive Radio: Brain-Empowered Wireless Communications", IEEE-Journal on,vol 23,pp.201-202.F

[2]. S Stotas, A Nallanathan, (2012) "On the throughput and spectrum sensing enhancement of opportunistic spectrum access cognitive radio networks". IEEE Trans. Wirel. Commun. 11, 97–107

[3]. XW Gong, SA Vorobyov, C Tellambura, (2011) "Optimal bandwidth and power allocation for sum ergodic capacity under fading channels in cognitive radio networks". IEEE Trans. Signal Process. 59, 1814–1826

[4]. RF Fan, J Hai, Q Guo, Z Zhang, (2011) "Joint optimal cooperative sensing and resource allocation in multichannel cognitive radio networks". IEEE Trans. Veh. Technol. 60, 722–729

[5]. X Kang, YC Liang, HK Garg, L Zhang, (2009) "Sensing-based spectrum sharing in cognitive radio networks". IEEE Trans. Veh. Technol. 58, 4649–4654

[6]. J Ma, GD Zhao, Y Li, (2008) "Soft combination and detection for cooperative spectrum sensing in cognitive radio networks". IEEE Trans. Wireless Commun. 7, 4502–4507

[7]. GR Ding, QH Wu, YD Yao, JL Wang, YY Chen, (2013) "Kernel-based learning for statistical signal processing in cognitive radio networks theoretical foundations, example applications, and future directions". IEEE Signal Process. Mag. 30, 126–136

[8]. GR Ding, QH Wu, F Song, JL Wang, (2013) "Spectrum sensing in opportunity-heterogeneous cognitive sensor networks: how to cooperate?" IEEE Sensors J. 13, 4247–4255

[9]. Zhong Chen, Feifei Gao, Zhenwei Zhang, James C. F. Li, and Ming Lei, (2014)"Multiple-Level Power Allocation Strategy for Secondary Users in Cognitive Radio Networks" EURASIP Journal on Advances in Signal Processing 2014 2014:51.

BIOGRAPHY

RAMYAH.S.B is currently pursuing her Post Graduation in Embedded Systems at Kongu Engineering College, Erode. She received her undergraduate degree in Electronics and Communication Engineering at Sona College of Technology, Salem. Her area of interests include Embedded Programming and wireless networks especially in cognitive radio networks.

SRITHAR.A is currently pursuing his Post Graduation in Communication Systems at Kongu Engineering College, Erode. She received her undergraduate degree in Electronics and Communication Engineering at Sasurie Engineering College, Tripur. His area of interests include Reconfigurable antenna and wave propagation and Cognitive radio. He published a number of papers in three preferred journals and in five international conferences.

VIDHYA.B is currently pursuing her Post Graduation in Communication Systems at Kongu Engineering College, Erode. She received her undergraduate degree in Electronics and Communication Engineering at Sri Krishna College of Technology, Coimbatore. Her area of interests include wireless networks especially in cognitive radio networks and RF system design.