

Spectrum Sensing with Energy Detection in Cognitive Radio Networks

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Abstract - Cognitive radio could be a low-price communication system which might opt for the on the market frequencies and waveforms mechanically on the boundaries of voiding interrupting the authorized users. The spectrum sensing is that the key modify technology in psychological feature radio networks. It ready to fill area within the wireless spectrum and might dramatically increase spectral potency. The author use matlab to breed the received signals from the psychological feature radio networks associated an energy observe or to detect whether or not the spectrum is being employed. The report additionally parallels the onpaper worth and therefore the simulated result so describes the connection between the signal to noise quantitative relation and therefore the detections. At last, the method, energy detection and simulation and results mentioned that is taken into account because the pointers for the longer term work.

1. INTRODUCTION

1.1 Background

Today with the technology and therefore the science developing the spectrum was nearly totally occupied. But there area until still sizable amount of multiple allocations required producing enough capability for the numerous wireless services for money and non-financial application, like defense, traffic, and scientific exploration.



Fig-1: Spectrum allocations in the US [1]

Figure (1) shows the spectrum allocations within the US. every color stands for a service kind which is allotted to the special band within the US. Several of the first allocations such as TV (TV), FM (FM) radio, international positioning systems (GPS), Wi-Fi, Bluetooth, etc. area unit identical. 2.4 GHz and 5 GHz bands area unit usually used for wireless laptop networking, these bands, and a few others area unit referred to as the economic, scientific, medical (ISM) bands.

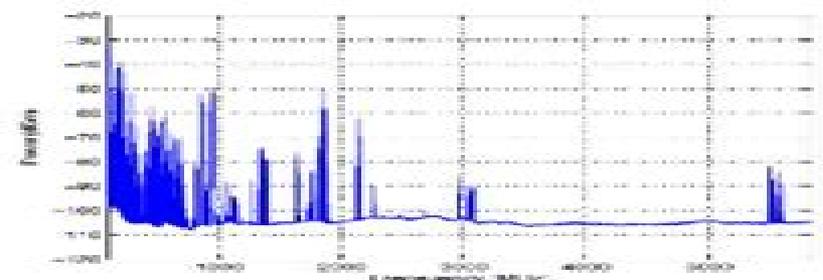


Fig-2: Received power vs. frequency in Singapore [2]

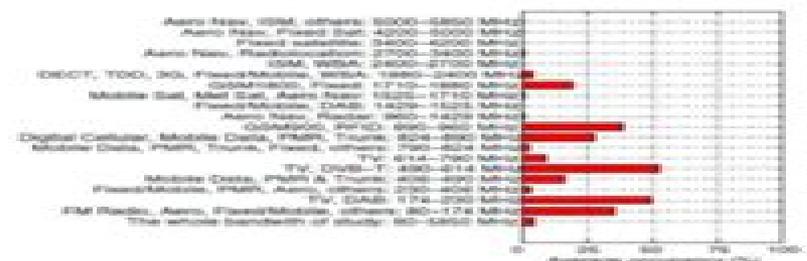


Fig-3: Band by band average spectrum occupancy in Singapore [2]

Meanwhile, in Singapore, low frequency spectrum bands area unit used -crowdedly however high frequency spectrum bands area unit used partly. Figure(2) and Figure (3) show the occupancy of spectrum bands in Singapore, we are able

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Energy Detection for Spectrum Sensing in Cognitive Radio Saman Atapattu,Chintha Tellambura,Hai Jiang,2014-02-15 This Springer Brief focuses on the current state of the art research on spectrum sensing by using energy detection a low complexity and low cost technique It includes a comprehensive summary of recent research fundamental theories possible architectures useful performance measurements of energy detection and applications of energy detection Concise practical chapters explore conventional energy detectors alternative forms of energy detectors performance measurements diversity techniques and cooperative networks The careful analysis enables reader to identify the most efficient techniques for improving energy detection performance Energy Detection for Spectrum Sensing in Cognitive Radio is a valuable tool for researchers and practitioners interested in spectrum sensing and cognitive radio networks Advanced level students studying wireless communication will also benefit from this brief

'Advances in Networks, Security and Communications, Vol. 1 Sergey Yurish,2018-01-17 The 1st volume of new Advances in Networks Security and Communications Reviews Book Series contains 15 chapters submitted by 42 contributors from 13 countries The book is divided into 3 parts Networks Security and Communication The book provides focused coverage of these 3 main technologies Chapters are written by experts in the field and address the immediate and long term challenges in the authors respective areas of expertise Coverage includes wireless sensor network routing improvement connectivity recovery augmentation and routing in wireless Ad Hoc networks advanced modeling and simulation approach for the sensor networks management security aspects for mobile agent and cloud computing various communication aspects and others This book ensures that readers will stay at the cutting edge of the field and get the right and effective start point and road map for the further researches and developments

Energy Detection Based Spectrum Sensing in Cognitive Radio Pranav Patel,2015-06-25 The rapid usage of wireless communications in personal commercial and governmental capacities efficient spectrum utilization has become a prime topic of interest Most of the licensed bands suffer from under utilization and less spectral occupancy of spectrum Cognitive radio technology promising solution to the problem of low spectral occupancy and inefficient utilization of the licensed radio spectrum A prime constituent of the cognitive radio technology is spectrum sensing Energy detection ED is one of the popular spectrum sensing technique for cognitive radio In this work I Proposed RTL 2832U SDR stick is suitable for energy detection based spectrum sensing method In this experiment we capture the real time signal coming from the BTS over the different city in rural urban area using an RTL 2832U SDR stick to decide the frequency band available or not The GNU Radio software allows for the implementation of Energy detection spectrum sensing technique using the RTL SDR

Harvest of research outcomes to confirm achievement of the millennium development goals Simeon O. Jekayinfa,2017-09-15 In 2000 the leaders of member states of the United Nations adopted the Millennium Declaration which set out a series of clear commitments goals and targets to achieve Human Development These ambitious goals were subsequently refined into eight

Millennium Development Goals MDGs designed to provide a framework for accountability donor coordination and resource mobilization The MDGs are Eradicate extreme poverty and hunger achieve universal primary education promote gender equality and empower women reduce child mortality improve maternal health combat HIV AIDS malaria and other diseases ensure environmental sustainability and develop a global partnership for development The first seven of these Goals are concerned with outcomes identifying the progress towards certain standards of human well being and decent living which should be achieved globally and nationally by 2015 The eighth Goal is concerned with relationships identifying various aspects of a global partnership for development which must be forged to support the realization of these poverty reduction human development and environmental sustainability standards The MDGs provide opportunities to start working from real life development problems Addressing these problems requires multidisciplinary approaches that combine the natural sciences the life sciences and technical approaches with social science approaches The challenge is to integrate social economic political and institutional concerns into research strategy To be able to achieve this there is a need to establish a linking pin between research policy and practice in Nigeria The aim of such a linking pin would be to synthesize research outcomes on specific MDGrelated topics and to translate these into implications for policy and decision making through easily accessible gathering where individual stakeholders can air their views The articles contained in this book address research outcomes from stakeholders Sociologists Economists Agronomists Agricultural Engineers Civil Engineers Environmental Scientists and Engineers Geographers Geologists Microbiologists Medical Practitioners Policy Makers Educationists etc to confirm achievement of Millennium Development Goals in Nigeria and other neighboring countries

Improving the Energy Efficiency of Mobile Networks Josip Lorincz, Zvonimir Klarin, 2025-09-09 This book provides an analysis of the problem of high energy consumption of mobile networks and describes methods for improving the energy efficiency of mobile networks It explores new technologies and strategies that will enable mobile networks to operate with less energy and become more sustainable while not compromising service quality Improving the Energy Efficiency of Mobile Networks Strategies for 5G and 6G Technologies is designed to help readers understand how to optimize energy consumption in mobile networks It explores technical solutions for reducing the energy consumption with a focus on innovative solutions such as network energy consumption optimization using artificial intelligence AI in the management of network resources energy harvesting EH software defined networking renewable energy sources and implementation of advanced techniques and protocols for improving the energy efficiency of mobile networks The book analyzes how the integration of different advanced technologies network function virtualization and non orthogonal multiple access techniques along with the implementation of AI renewable energy sources and EH can contribute to the optimizing energy use of mobile networks without compromising network performance It offers an overview of concrete solutions with an insight into future directions of development which makes it particularly relevant at a time when industry is increasingly moving toward

sustainability and the implementation of green technologies This book is ideal for researchers industry professionals and scholars who want to gain a deeper understanding of the excessive mobile network energy consumption and contribute to the development of energy efficient and sustainable mobile networks

Digital Transformation Technology Dalia A. Magdi, Yehia K. Helmy, Mohamed Mamdouh, Amit Joshi, 2021-08-23 This book is a collection of best selected research papers presented at the Second World Conference on Internet of Things Applications Future ITAF 2020 organized by Global Knowledge Research Foundation during 16-17 December 2020 It includes innovative works from researchers leading innovators business executives and industry professionals to examine the latest advances and applications for commercial and industrial end users across sectors within the emerging Internet of things ecosphere It shares state of the art as well as emerging topics related to Internet of things such as big data research emerging services and analytics Internet of things IoT fundamentals electronic computation and analysis big data for multi discipline services security privacy and trust IoT technologies and open and cloud technologies

Innovations in Smart Cities Applications Edition 3 Mohamed Ben Ahmed, Anouar Abdelhakim Boudhir, Domingos Santos, Mohamed El Aroussi, İsmail Rakıp Karas, 2020-02-04 This book highlights original research and recent advances in various fields related to smart cities and their applications It gathers papers presented at the Fourth International Conference on Smart City Applications SCA19 held on October 2-4 2019 in Casablanca Morocco Bringing together contributions by prominent researchers from around the globe the book offers an invaluable instructional and research tool for courses on computer science electrical engineering and urban sciences It is also an excellent reference guide for professionals researchers and academics in the field of smart cities This book covers topics including Smart Citizenship Smart Education Digital Business and Smart Governance Smart Health Care New Generation of Networks and Systems for Smart Cities Smart Grids and Electrical Engineering Smart Mobility Smart Security Sustainable Building Sustainable Environment

Heterogeneous Cellular Networks Xiaoli Chu, David Lopez-Perez, Yang Yang, Fredrik Gunnarsson, 2013-05-23 This detailed up to date introduction to heterogeneous cellular networking introduces its characteristic features the technology underpinning it and the issues surrounding its use Comprehensive and in depth coverage of core topics catalogue the most advanced innovative technologies used in designing and deploying heterogeneous cellular networks including system level simulation and evaluation self organisation range expansion cooperative relaying network MIMO network coding and cognitive radio Practical design considerations and engineering tradeoffs are also discussed in detail including handover management energy efficiency and interference management techniques A range of real world case studies provided by industrial partners illustrate the latest trends in heterogeneous cellular networks development Written by leading figures from industry and academia this is an invaluable resource for all researchers and practitioners working in the field of mobile communications

Proceedings, 2006 **Energy Based Spectrum Sensing for Enabling Dynamic Spectrum Access in Cognitive Radios** Samson Sequeira, 2011 Spectrum scarcity is increasingly

becoming an obstacle for the implementation of new wireless technologies. On the contrary, recent studies have discovered considerable underutilization of the allocated spectrum by the licensed users. This suggests that the solution to the problem is a transition from static spectrum allocation policies to dynamic spectrum access methodologies. This can be accomplished through the use of Cognitive Radio technology. Cognitive Radio is considered as an intelligent radio which is capable of altering its transmission or reception parameters in accordance to the radio environment and the network state to use the available spectrum optimally. Significant research efforts have furthered Cognitive Radios since the idea was first conceived by Joseph Mitola in 1998. Cognitive Radio technology allows for the licensed spectrum of the primary users to be used on an opportunistic basis by unlicensed secondary users. A vital requirement of such an opportunistic scheme is that the licensed primary users be protected from detrimental interference from the secondary users while at the same time optimizing the performance for the secondary users. Thus, the reliable detection of primary users offers better secondary system throughput via increased spectral efficiency in addition to safeguarding the primary system. Spectrum sensing is a technique used to detect the presence of primary users in the licensed spectrum. It is the estimation of the instantaneous occupancy of the frequency spectrum and is a key enabling factor for Cognitive Radios. Various techniques exist for performing spectrum sensing. In addition to primary user detection, spectrum sensing can also be employed for secondary detection and co-existence interference analysis in multi-radio environments, etc. In this thesis, we study adaptive spectrum sensing based on energy detection with a purpose of demonstrating Dynamic Spectrum Access. The major focus has been to evaluate algorithms that can allow for estimation of noise in the presence of the signal, which is essential for energy detection based schemes. We also present the system-level implementation and evaluation of a Dynamic Spectrum Access setup developed using the USRP2 GNU Radio platform on the ORBIT Wireless Testbed at WINLAB as part of the WINLAB NEC Collaborative Cognitive Radio Project.

[Spectrum Sensing for Cognitive Radio](#) Kamal M. Captain, Manjunath V. Joshi, 2021-12-30. This comprehensive reference text discusses concepts of cognitive radio and the advances in the field of spectrum sensing. This text discusses the concept of cognitive radio for next-generation wireless communication and a very critical aspect of cognitive radio that is spectrum sensing in detail. It covers important topics including narrowband spectrum sensing, wideband spectrum sensing, cooperative spectrum sensing system, and channel models, detection algorithms, approximation of decision statistics, and theoretical analysis of detection algorithms in detail. Separate chapters are dedicated to discussing the analysis and use of detection algorithms for narrowband spectrum sensing, wideband spectrum sensing, and cooperative wideband spectrum sensing. Aimed at graduate students and academic researchers in the fields of electrical engineering and electronics and communication engineering, this text discusses concepts of cognitive radio and research in spectrum sensing. It presents mathematical analysis of algorithms considering practical environment, explains novel wideband spectrum sensing algorithms with detailed analysis, provides mathematical derivations to help readers, discusses basic spectrum sensing

algorithms from narrowband spectrum sensing to the more advanced wideband spectrum sensing

Analysis of Energy Detection in Cognitive Radio Networks Saman U. B. Atapattu, 2013 Cognitive radio is one of the most promising technologies to address the spectrum scarcity problem Cognitive radio requires spectrum sensing which is used by unlicensed users to opportunistically access the licensed spectrum Spectrum sensing using energy detection offers low cost and low complexity In this thesis a comprehensive performance analysis of energy detection based spectrum sensing is developed Detection performance over composite fading and shadowing channels is first investigated using the K and K_G channel models To further facilitate analysis of energy detection over different wireless channels a unified channel model based on a mixture gamma distribution is developed The unified model can accurately represent most existing channel models A single value performance metric the area under the receiver operating characteristic curve is proposed to measure the overall detection capability and is investigated over various wireless fading channels The energy detection based cooperative spectrum sensing is also studied which can largely improve the detection performance Since spectrum sensing is required to identify activities of licensed users at a very low signal to noise ratio SNR performance of energy detection with low SNR is also analyzed in this thesis

Implementation of Energy Detector for Cognitive Radio Zahir A. Hussein Alsulaimawi, 2013 Cognitive radio is a technology that provides a promising new way to improve the efficiency of the use of the electromagnetic spectrum that available Spectrum sensing helps in the detection of spectrum holes unused channels of the band and instantly move into vacant channels while avoiding occupied ones A brief overview of the energy detection based spectrum sensing for cognitive radio technology is introduced An energy detector with baseband sampling for cognitive radio is presented with mathematical analyses for an additive white Gaussian noise AWGN channel Practical implementation issues on Texas Instruments TMS320C6713 floating point DSP board are presented A new multiple antenna technique based energy detector is proposed As well as several algorithms for generating white noise are implemented

Spectrum Sensing Techniques and Applications Marcelo Sampaio de Alencar, Fabricio Braga Soares de Carvalho, Waslon Terlizzie Araújo Lopes, Carlos Danilo Miranda Regis, 2018-11-09 Spectrum sensing deals with several subjects that range from statistical and probability theory to radio propagation and signal processing with cognitive radio playing an important role to the evolution and dissemination of new applications in the area The objective of this book is to connect the basic statistical formulation the fundamental concepts from signal detection and spectrum sensing cognitive radio and dynamic spectrum access leading to an interesting robust and illustrative content with recent practical applications of cognitive radio and spectrum sensing

Performance Analysis of Energy Detector Over Different Generalised Wireless Channels Based Spectrum Sensing in Cognitive Radio Hussien Al-Hmood, 2015 *Performance of Cooperative Spectrum Sensing in Cognitive Radio Networks* Chilakala Sudhamani, 2020-10-08 Doctoral Thesis Dissertation from the year 2020 in the subject Engineering Communication Technology grade A language English abstract Cooperative

spectrum sensing technique is used to maximize the utilization of unused licensed spectrum As the cooperation among the secondary users increases the detection performance increases which increases the average channel throughput and energy efficiency but it depends on the number of cooperative secondary users fusion rules channel conditions and detection threshold In this thesis average channel throughput energy consumption and energy efficiency are estimated for variable number of secondary users and detection thresholds using hard fusion rules i e AND OR and MAJORITY fusion rules From the results it has been observed that the performance of AND fusion rule is better at low detection thresholds and for less number of secondary users The performance of OR fusion rule is better at high detection thresholds and for large number of secondary users The performance of MAJORITY fusion rule follows the performance of AND fusion rule at low detection thresholds and it follows the performance of OR fusion rule at high detection thresholds However as the number of cooperative secondary users increases the energy required for spectrum sensing and reporting sensing results to the fusion center increases which increases the energy consumption and reduces the energy efficiency Therefore energy efficiency can be improved by maximizing the average channel throughput or by minimizing the energy consumption To minimize the energy consumption in cooperative spectrum sensing optimization technique has been proposed in this thesis and it is used for further improvement of energy efficiency With this optimization technique optimal number of cooperative secondary users are derived by maximizing the energy efficiency using AND and OR fusion rules but not with MAJORITY fusion rule Because it is very difficult to estimate the optimal number of cooperative secondary users using MAJORITY fusion rule so optimization of final decision threshold was proposed in the existing methods to maximize the energy efficiency using MAJORITY fusion rule Therefore AND and OR fusion rules are used in this work to optimize the number of cooperative secondary users

Adaptive Spectrum Sensing for Cognitive Radio Networks Arash Vakili,2011 Spectrum sensing is an important functionality of cognitive radio as a means to detect the presence or absence of the primary user PU in a certain spectrum band Energy detection is a widely used spectrum sensing technique based on the assumption that the PU is either present or absent during the whole sensing period However this assumption is not realistic in a dynamic environment where the PU could appear or disappear at any time The performance of the conventional energy detector ED actually deteriorates in the scenario where the PU activity status changes during the sensing period Therefore it is crucial to design a detector which can adapt to such an environment and reliably detect a change in the PU activity Several sequential change detection techniques already exist in the literature however change detection in a fixed sensing duration has not been given enough attention In this dissertation three adaptive EDs are proposed to improve the

Wideband Spectrum Sensing for Cognitive Radios in the Presence of Correlation Between Subband Occupancy Khalid Shamsuddin Hossain,2010

Adaptive Weighting of Multi-taper Spectrum Sensing in Cognitive Radio Networks ,2020-03-18 Master s Thesis from the year 2019 in the subject Mathematics Applied Mathematics grade Master Degree language English abstract This thesis

discusses the performance enhancement of multi taper spectrum sensing as a powerful technique for cognitive radio networks. In multi taper spectrum sensing regular detection of unused spectrum holes is performed to make cognitive radio networks aware of users activities. As a result more effective spectrum management is expected and unlicensed users could use unused spectrum holes. In this thesis an analytical study was proposed in which reliable simple and computationally efficient mathematical expressions for the mean and variance of the probability density function PDF of the multitaper spectrum sensing techniques were derived. The proposed analytical study was evaluated by intensive simulations using MATLAB. The presence of Additive White Gaussian Noise is assumed. Many important aspects of spectrum sensing in cognitive radio networks are included such as receiver operating characteristics detection rate versus signal to noise ratio SNR and the minimum required sample points for a specific performance. All simulations were performed to include most factors affecting the efficiency of the proposed sensing methodology such as number of tapers K number of sample points N and the probability of false alarm P_f . A comparison with energy detection method was done. All simulation results and comparisons confirm that the proposed model is reliable and robust under all factors considered in the simulation.

Cognitive Radio Omar Hamad Altrad, 2013. Efficient utilization of the spectrum has become a fundamental requirement in modern wireless networks due mainly to spectrum scarcity and the ever increasing demand for higher data rate applications and internet services. A particularly interesting proposal to meet this requirement is the cognitive radio CR system which can adapt its transmission parameters according to the environment. CRs as will be shown in later chapters are very efficient in maximizing spectrum utilization due to their inherent spectrum sensing capability. The purpose of this dissertation is to investigate and analyze two main components of CR. First is the sensing or exploring component which is the core of a CR device as it is the first stage to discover spectrum holes SHs in a spectrum band. For this component a new algorithm to compute the detection probability in the case of odd degrees of freedom and a closed form expression for the detection probability in Nakagami m fading channels are presented both for a local spectrum sensing scenario. For a cooperative scenario the errors of CRs decisions which are caused by erroneous feedback channels are analyzed. In addition the optimal number of CRs that are required to mitigate against such errors is derived. The second component is the access or exploiting component i.e. how a CR device can exploit SHs efficiently. To study the second component the interactions between the primary users PUs and secondary users SUs are modeled as a continuous time Markov chain CTMC. Based on the CTMC model the effect of two inevitable sensing errors misdetection and false alarm on the blocked call probability the dropped call probability and system utilization is investigated for two access schemes. In the first scheme the PUs are considered to access the system using a standard access policy. In the second scheme the PUs use non standard access policies. In both schemes the overall primary and secondary system utilization is analyzed and compared under both perfect and imperfect sensing. The simulation results obtained concur with the analytical ones and it is determined that spectrum

utilization can be improved by choosing a suitable non standard access policy

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