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AND ARTURAS MEDEISIS

*OPPORTUNISTIC  
SPECTRUM SHARING  
and  
WHITE SPACE ACCESS*

*THE PRACTICAL REALITY*



WILEY

# Opportunistic Spectrum Sharing And White Space Access The Practical Reality

**Gervais Mendy, Samuel Ouya, Ibra  
Dioum, Ousmane Thiaré**



## **Opportunistic Spectrum Sharing And White Space Access The Practical Reality:**

**Opportunistic Spectrum Sharing and White Space Access** Oliver Holland, Hanna Bogucka, Arturas Medeisis, 2015-06-15 Details the paradigms of opportunistic spectrum sharing and white space access as effective means to satisfy increasing demand for high speed wireless communication and for novel wireless communication applications This book addresses opportunistic spectrum sharing and white space access being particularly mindful of practical considerations and solutions In Part I spectrum sharing implementation issues are considered in terms of hardware platforms and software architectures for realization of flexible and spectrally agile transceivers Part II addresses practical mechanisms supporting spectrum sharing including spectrum sensing for opportunistic spectrum access machine learning and decision making capabilities aggregation of spectrum opportunities and spectrally agile radio waveforms Part III presents the ongoing work on policy and regulation for efficient and reliable spectrum sharing including major recent steps forward in TV White Space TVWS regulation and associated geolocation database approaches policy management aspects and novel licensing schemes supporting spectrum sharing In Part IV business and economic aspects of spectrum sharing are considered including spectrum value modeling discussion of issues around disruptive innovation that are pertinent to opportunistic spectrum sharing and white space access and business benefits assessment of the novel spectrum sharing regulatory proposal Licensed Shared Access Part V discusses deployments of opportunistic spectrum sharing and white space access solutions in practice including work on TVWS system implementations standardization activities and development and testing of systems according to the standards Discusses aspects of pioneering standards such as the IEEE 802.22 Wi-Fi standard the IEEE 802.11af White-Fi standard the IEEE Dynamic Spectrum Access Networks Standards Committee standards and the ETSI Reconfiguration Radio Systems standards Investigates regulatory and regulatory linked solutions assisting opportunistic spectrum sharing and white space access including geo location database approaches and licensing enhancements Covers the pricing and value of spectrum the economic effects and potentials of such technologies and provides detailed business assessments of some particularly innovative regulatory proposals The flexible and efficient use of radio frequencies is necessary to cater for the increasing data traffic demand worldwide This book addresses this necessity through its extensive coverage of opportunistic spectrum sharing and white space access solutions Opportunistic Spectrum Sharing and White Space Access The Practical Reality is a great resource for telecommunication engineers researchers and students

**Opportunistic Spectrum Sharing and White Space Access** Oliver Holland, Hanna Bogucka, Arturas Medeisis, 2015-05-04 Details the paradigms of opportunistic spectrum sharing and white space access as effective means to satisfy increasing demand for high speed wireless communication and for novel wireless communication applications This book addresses opportunistic spectrum sharing and white space access being particularly mindful of practical considerations and solutions In Part I spectrum sharing implementation issues are considered in terms of hardware platforms and software architectures for

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*Internet of Things, Smart Spaces, and Next Generation Networks and Systems* Yevgeni Koucheryavy, Sergey Balandin, Sergey Andreev, 2022-03-15 This book constitutes the joint refereed proceedings of the 21st International Conference on Next Generation Teletraffic and Wired/Wireless Advanced Networks and Systems NEW2AN 2021 and the 14th Conference on Internet of Things and Smart Spaces ruSMART 2021 The conference was held virtually due to the COVID-19 pandemic The 41 revised full papers presented were carefully reviewed and selected from 118 submissions **Spectrum Sharing in Wireless Networks** John D. Matyjas, Sunil Kumar, Fei Hu, 2016-11-17 Spectrum Sharing in Wireless Networks Fairness Efficiency and Security provides a broad overview of wireless network spectrum sharing in seven distinct sections The first section examines the big picture and basic principles explaining the concepts of spectrum sharing hardware software function requirements for efficient sharing and future trends of sharing strategies The second section contains more than 10 chapters that discuss differing approaches to efficient spectrum sharing The authors introduce a new coexistence and sharing scheme for multi-hop networks describe the space-time sharing concept introduce LTE-U and examine sharing in

broadcast and unicast environments They then talk about different cooperation strategies to achieve mutual benefits for primary users PU and secondary users SU discuss protocols in a spectrum sharing context and provide different game theory models between PUs and SUs The third section explains how to model the interactions of PUs and SUs using an efficient calculation method to determine spectrum availability Additionally this section explains how to use scheduling models to achieve efficient SU traffic delivery The subject of the fourth section is MIMO oriented design It focuses on how directional antennas and MIMO antennas greatly enhance wireless network performance The authors include a few chapters on capacity rate calculations as well as beamforming issues under MIMO antennas Power control is covered in the fifth section which also describes the interference aware power allocation schemes among cognitive radio users and the power control schemes in cognitive radios The sixth section provides a comprehensive look at security issues including different types of spectrum sharing attacks and threats as well as corresponding countermeasure schemes The seventh and final section covers issues pertaining to military applications and examines how the military task protects its data flows when sharing the spectrum with civilian applications

**e-Infrastructure and e-Services for Developing Countries** Gervais Mendy, Samuel Ouya, Ibra Dioum, Ousmane Thiaré, 2019-03-21 This book constitutes the thoroughly refereed proceedings of the 10th EAI International Conference on e Infrastructure and e Services for Developing Countries AFRICOMM 2018 held in Dakar Senegal in November 2018 The 28 full papers were carefully selected from 49 submissions The accepted papers provide a wide range of research topics including e health environment cloud VPN and overlays networks services e Learning agriculture IoT social media mobile communication and security

*Advanced Multicarrier Technologies for Future Radio Communication* Hanna Bogucka, Adrian Kliks, Pawel Kryszkiewicz, 2017-08-14 A practical review of state of the art non contiguous multicarrier technologies that are revolutionizing how data is transmitted received and processed This book addresses the advantages and the limitations of modern multicarrier technologies and how to meet the challenges they pose using non contiguous multicarrier technologies and novel algorithms that enhance spectral efficiency interference robustness and reception performance It explores techniques using non contiguous subcarriers which allow for flexible spectrum aggregation while achieving high spectral efficiency and flexible transmission and reception at lower OSI layers These include non contiguous orthogonal frequency division multiplexing NC OFDM its enhanced version non contiguous filter bank based multicarrier NC FBMC and generalized multicarrier Following an overview of current multicarrier technologies for radio communication the authors examine particular properties of these technologies that allow for more efficient usage within key directions of 5G They examine the principles of NC OFDM and discuss efficient transmitter and receiver design They present the principles of FBMC modulation and discuss key challenges for FBMC communications while comparing performance results with traditional OFDM They move on from there to a fascinating discussion of GMC modulation within which they clearly demonstrate how that technology encompasses all of the advantages of previously discussed techniques as well as all

imaginable multi and single carrier waveforms Addresses the problems and limitations of current multicarrier technologies OFDM Describes innovative techniques using non contiguous multicarrier waveforms as well as filter band based and generalized multicarrier waveforms Provides a thorough review of the practical limitations and solutions for evolving and breakthrough 5G communication technologies Explores the future outlook for non contiguous multicarrier technologies as regards their greater industrial realization hardware practicality and other challenges Advanced Multicarrier Technologies for Future Radio Communication 5G and Beyond is an indispensable working resource for telecommunication engineers researchers and academics as well as graduate and post graduate students of telecommunications At the same time it provides a fascinating look at the shape of things to come for telecommunication industry executives telecom operators regulators policy makers and economists

Sensing Techniques for Next Generation Cognitive Radio Networks Bagwari, Ashish, Bagwari, Jyotshana, Tomar, Geetam Singh, 2018-08-30 The inadequate use of wireless spectrum resources has recently motivated researchers and practitioners to look for new ways to improve resource efficiency As a result new cognitive radio technologies have been proposed as an effective solution Sensing Techniques for Next Generation Cognitive Radio Networks is a pivotal reference source that provides vital research on the application of spectrum sensing techniques While highlighting topics such as radio identification compressive sensing and wavelet transform this publication explores the standards and the methods of cognitive radio network architecture This book is ideally designed for IT and network engineers practitioners and researchers seeking current research on radio scene analysis for cognitive radios and networks

Internet of Things in Smart Sewer and Drainage Systems Abdul Salam, 2023-12-14 This multidisciplinary book provides insights into the applications of the Internet of Things IoT to combined sewer overflows CSO and stormwater management SWM systems It explores technical challenges and presents recent results to improve sewer and drainage system management using wireless underground communications and sensing in IoT The book addresses both existing sensing network technologies and those currently in development in three major areas of CSO combined sewer overflow management subsurface sensing and antennas in the layered medium It explores new applications of IoT in sewer systems to improve public health foster economic growth and enhance environmental quality and responsibility for the community Internet of Things in Smart Sewer and Drainage Systems Theory and Applications will be a valuable reference for graduate students and academic researchers as well as a hands on guide for wastewater technicians sanitary engineers environmental specialists and related industry practitioners

Strategic Innovations and Interdisciplinary Perspectives in Telecommunications and Networking Meghanathan, Natarajan, 2019-02-22 The lack of clear communication especially internationally plagues the modern world in a variety of fields Researchers and practitioners within the modern networking and communication industries strive to discover new and innovative ways for humans to better contact one another Strategic Innovations and Interdisciplinary Perspectives in Telecommunications and Networking provides emerging research exploring the theoretical

and practical aspects of network management and security as well as applications within computer science mobile and wireless computing and multimedia technology Featuring coverage on a broad range of topics such as coding theory mobile devices and contextual advertising this book is ideal for students researchers social media marketers brand managers networking professionals and engineers seeking current research on cross disciplinary applications of electrical engineering computer science and information technology

**Internet of Things and Sensors Networks in 5G Wireless Communications** Lei Zhang,Guodong Zhao,Muhammad Ali Imran ,2020-01-24 The Internet of Things IoT has attracted much attention from society industry and academia as a promising technology that can enhance day to day activities and the creation of new business models products and services and serve as a broad source of research topics and ideas A future digital society is envisioned composed of numerous wireless connected sensors and devices Driven by huge demand the massive IoT mIoT or massive machine type communication mMTC has been identified as one of the three main communication scenarios for 5G In addition to connectivity computing and storage and data management are also long standing issues for low cost devices and sensors The book is a collection of outstanding technical research and industrial papers covering new research results with a wide range of features within the 5G and beyond framework It provides a range of discussions of the major research challenges and achievements within this topic

**Software Engineering Application in Systems Design** Radek Silhavy,Petr Silhavy,Zdenka Prokopova,2023-01-01 This book presents the latest research on software engineering application in informatics The fields of software engineering informatics computer science and artificial intelligence are critical for study in the intelligent systems issue space This is the first part of the refereed proceedings of the 6th Computational Methods in Systems and Software 2022 CoMeSySo 2022 The CoMeSySo 2022 conference which is being hosted online is breaking down barriers CoMeSySo 2021 aims to provide a worldwide venue for debate of the most recent high quality research findings

**Applications in Electronics Pervading Industry, Environment and Society** Alessandro De Gloria,2018-07-12 This book provides a thorough overview of cutting edge research on electronics applications relevant to industry the environment and society at large It covers a broad spectrum of application domains from automotive to space and from health to security while devoting special attention to the use of embedded devices and sensors for imaging communication and control The book is based on the 2017 ApplePies Conference held in Rome Italy in September 2017 which brought together researchers and stakeholders to consider the most significant current trends in the field of applied electronics and to debate visions for the future Areas addressed by the conference included information communication technology biotechnology and biomedical imaging space secure clean and efficient energy the environment and smart green and integrated transport As electronics technology continues to develop apace constantly meeting previously unthinkable targets further attention needs to be directed toward the electronics applications and the development of systems that facilitate human activities This book written by industrial and academic professionals represents

a valuable contribution in this endeavor      Reconfigurable Intelligent Surface-Empowered 6G Hongliang Zhang,Boya Di,Lingyang Song,Zhu Han,2021-05-29 This book presents novel RIS Based Smart Radio techniques targeting at achieving high quality channel links in cellular communications via design and optimization of the RIS construction Unlike traditional antenna arrays three unique characteristics of the RIS will be revealed in this book First the built in programmable configuration of the RIS enables analog beamforming inherently without extra hardware or signal processing Second the incident signals can be controlled to partly reflect and partly transmit through the RIS simultaneously adding more flexibility to signal transmission Third the RIS has no digital processing capability to actively send signals nor any radio frequency RF components As such it is necessary to develop novel channel estimation and communication protocols design joint digital and RIS based analog beamforming schemes and perform interference control via mixed reflection and transmission This book also investigates how to integrate the RIS to legacy communication systems RIS techniques are further investigated in this book benefited from its ability to actively shape the propagation environment to achieve two types of wireless applications i e RF sensing and localization The influence of the sensing objectives on the wireless signal propagation can be potentially recognized by the receivers which are then utilized to identify the objectives in RF sensing Unlike traditional sensing techniques RIS aided sensing can actively customize the wireless channels and generate a favorable massive number of independent paths interacting with the sensing objectives It is desirable to design RIS based sensing algorithms and optimize RIS configurations For the second application i e RIS aided localization an RIS is deployed between the access point AP and users The AP can then analyze reflected signals from users via different RIS configurations to obtain accurate locations of users However this is a challenging task due to the dynamic user topology as well as the mutual influence between multiple users and the RIS Therefore the operations of the RIS the AP and multiple users need to be carefully coordinated A new RIS based localization protocol for device cooperation and an RIS configuration optimization algorithm are also required This book targets researchers and graduate level students focusing on communications and networks Signal processing engineers computer and information scientists applied mathematicians and statisticians who work in RIS research and development will also find this book useful      Spectrum Sharing for Wireless Communications ChunSheng Xin,Min Song,2015-02-26 This SpringerBrief presents intelligent spectrum sharing technologies for future wireless communication systems It explains the widely used opportunistic spectrum access and TV white space sharing which has been approved by the FCC Four new technologies to significantly increase the efficiency of spectrum sharing are also introduced The four technologies presented are Dynamic Spectrum Co Access Incentivized Cooperative Spectrum Sharing On Demand Spectrum Sharing and Licensed Shared Spectrum Access These technologies shed light on future wireless communication systems and pave the way for innovative spectrum sharing with increased spectrum utilization Increased utilization will allow networks to meet the demand for radio spectrum and promote the growth of wireless industry and national economy Spectrum Sharing is a



valuable resource for researchers and professionals working in wireless communications Advanced level students in electrical engineering and computer science will also find this content helpful as a study guide

*Dynamic Sharing of Wireless Spectrum* Haibo Zhou,Quan Yu,Xuemin (Sherman) Shen,Shaohua Wu,Qinyu Zhang,2016-09-02 This book focuses on the current research on the dynamic spectrum sharing for efficient spectrum resource utilization which covers the overlay spectrum sharing underlay spectrum sharing and database assisted spectrum sharing related research issues Followed by a comprehensive review and in depth discussion of the current state of the art research literature and industry standardization this book first presents a novel overlay spectrum sharing framework for dynamic utilization of available cellular frequency bands formulates the dynamic spectrum sharing problem as a dynamic resource demand supply matching problem and accordingly develops a distributed fast spectrum sharing algorithm to solve the resource matching problem A self awareness power control approach for multi hop routing selection is proposed which can establish an effective and practical routing selection optimization in secondary access networks and minimize the interference to primary users Finally this book offers dynamic secondary access scheme for database assisted spectrum sharing networks which is targeted to support the prosperous wireless multimedia networking applications by leveraging the TV white spaces of geolocation databases while satisfying QoS guarantees of secondary users The overlay spectrum sharing underlay spectrum sharing and database assisted white spaces spectrum sharing research results that are presented in this book provide useful insights for the design of next generation wireless access networks This book motivates a new line of thinking for efficient spectrum resource utilization and performance enhancements of future wireless access applications

Dynamic Spectrum Sharing by Opportunistic Spectrum Access with Spectrum Aggregation Haeyoung Lee,2015

*Wireless Coexistence for Spectrum Sharing* Hossein-Ali Safavi-Naeini,2016 Much of the spectrum licensed for usage by the regulatory authorities remains idle or heavily underutilized By allowing opportunistic access to these dormant resources spectrum sharing promises to dramatically boost the supply of spectrum that is available for high bandwidth wireless communications This shared access arrangement will lead to the expected coexistence of multiple wireless systems within the same frequency band giving rise to the study undertaken in this dissertation Our work begins by considering TV Whitespaces TVWS which were the first major instance of spectrum sharing to be considered We look at adapting the 802.11 WLAN standard for operation in TVWS bands by incorporating sensing into the Wi-Fi MAC layer We use this study to explore the potential of Software Defined Radio systems and the role they play in spectrum sharing systems while identifying the challenges and pitfalls inherent in such implementations Our focus then shifts to spectrum sharing in radar bands First we aim to shrink the exclusion regions as defined by the NTIA by inheriting from the techniques developed for TVWS The key outcome of this work is to provide an analytic framework for the selection of Wi-Fi parameters that can deliver the desired radar protection performance This framework supports the aim of maximum spectrum utilization by reducing the areas which are deprived of shared access to

radar spectrum The last major result in this dissertation is a detailed study into the impact of radars on communication systems We present what is to our knowledge the first detailed look at the physical layer obstacles that hinder network throughput for devices deployed in radar bands Looking at the two major broadband standards IEEE 802.11 WLAN and 3GPP LTE we identify vulnerabilities that would render networks inoperable in close proximity to radars before providing effective solutions to recover the desired performance The line of investigation in this thesis furnishes some of the solutions that are necessary for the future success of spectrum sharing systems

Opportunistic Wireless Spectrum Access Rahman Doost-Mohammady, 2014 The limited availability of usable wireless spectrum and the ever increasing demands of high bandwidth data transfer raise concerns on whether current spectrum access regimes can match future communication requirements Moreover most desirable frequency ranges with good channel characteristics are already licensed and purchasing new licenses for small operators is often prohibitively expensive This thesis proposes methods for achieving efficient spectrum access through devising protocols for identifying and sharing unused spectrum analyzing the theoretical bounds of these protocols and implementing these solutions in practical medical and vehicular environments A significant portion of the thesis is focused on opportunistic spectrum access within licensed frequency bands where cognitive radios transmit on frequencies without interfering with the primary users in them First a cooperative sensing method based on reinforcement learning technique is designed to efficiently detect spectrum opportunities After identifying portions of the available spectrum a channel allocation technique is devised for the cognitive radios with quality of service provisioning The supporting analytical framework is constructed using Markov process and ensures that radios opportunistically using the licensed spectrum meet their latency and throughput requirements The analytical framework is tested through traces collected in the wireless medical telemetry service WMTS band and reliability enhancements in possible hospital application areas are quantified A mobile architecture composed of vehicular networks is also investigated where spectrum databases that provide the spectrum availability information are included in the network design Apart from reuse of the licensed spectrum this thesis investigates full duplex channel access scheme for improving throughput Full duplex enables simultaneous transmission and reception on the same channel for a single radio which promises doubling of the throughput An analytical framework for the performance of CSMA/CA based channel access for full duplex enabled network of nodes is formulated The closed form expressions for the average throughput and packet collision probability in such a network is analytically derived and verified through comprehensive simulations

Opportunistic Spectrum Sharing System S. S. Kawade, 2014 **Towards Practical Dynamic Spectrum Sharing** Lei Yang, 2011 Static spectrum allocation policies of the past have led to an artificial spectrum scarcity problem The ideal solution is dynamic spectrum sharing where wireless devices dynamically access spectrum matching their demands and share spectrum with peers to minimize interference

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