Preface

White spaces refers to licensed frequencies that are unoccupied in a specific local area. The bands with the most significant white space are the VHF and UHF bands historically assigned to analog television broadcasting services and now also being used for Digital TV broadcasting. The migration to Digital TV (DTV) frees up a significant amount spectrum due to a much higher level of spectral efficiency in DTV transmissions. This freed up spectrum is known as the digital dividend and blocks in the 700 and 800 MHz bands have been or will be auctioned off for new 4G licensed services.

White spaces, on the other hand, opportunistically makes use of unused licensed spectrum in specific geographic locations. Legislation will either mandate licensed or unlicensed operation of white space devices operating as secondary users in unused frequency bands licensed to primary broadcast users. The current key application for white spaces is broadband and M2M communication. The FCC in the USA approved the unlicensed use of white space in 2008 and since this ruling a number of countries including Canada, UK, Malawi, Kenya, India and South Africa are running trial networks to decide if the technology provides a significant advantage for new markets such as rural broadband and wide-area M2M communication.

Many wireless standards are emerging for White space communications, these include IEEE 802.22, 802.11af, ECMA-392, and Weightless. Each have their own niche application areas. IEEE 802.22 is focused on providing long range connectivity in rural areas with a range of 30 km (even 100 km has been promised). 80211af and ECMA-3392 are focused on the wireless LAN market, providing improved range and penetration in urban environments. However, long range outdoor applications may also be possible with high gain antennas and some small adjustments to the MAC protocol to deal with longer round-trip times.

The white space standards stand apart from other wireless standards in that they require cognitive radios built on software defined radio platforms and spectrum databases to avoid interference with primary users. Since the introduction of white space standards, there are a number of key research areas being studied. These range from debates around the best propagation models for geo-location spectrum databases (US and Europe) to co-existence strategies for secondary users and channel allocation algorithms. This monograph will detail some of the major developments leading towards the implementation of white space radios and cover some of the key research areas in the field. In editing this monograph, the main focus has been on adding contributions which address implementation issues. We expect this book to act as a critical source of information for researchers and engineers involved in designing and installing white space-based systems. This book will also serve as a good introduction to researchers who are starting work in areas related to white space communication. And lastly, we believe this book will also help policy makers to grasp some of the key issues in this field. A field that has the potential to extend the reach of wireless communication to populations without Internet access—especially those in rural areas.

The layout of this monograph is as follows:

We start with chapters that review the current White space engineering developments and platforms that are available for building White space solutions.

Chapter 1, titled Engineering Review of IEEE 802.22 Standards on Cognitive Radio by Hiremath et al., reviews IEEE 802.22, the white space communication standard developed for long-range rural communication. This chapter expounds the standard and summarises the major technical specifications as proposed by the standard.

Chapter 2, titled A Review of Hardware Platforms for White-space Communication by Hazarika et al., describes the availble set of hardware platforms, which can be used for white-space communication research and prototyping.

In the second set of chapters we present field measurements done in white space bands in Southern Africa and India. These chapters will provide insights into the amount of white space available in rural and urban areas of these two countries.

Chapter 3, titled A Study on White and Gray Spaces in India, by Naidu et al., analyses spectrum measurements run in few a states in India in the bands corresponding to TV white spaces and GSM gray spaces.

Chapter 4, titled The Television White Space Opportunity in Southern Africa: From Field Measurements to Quantifying White Spaces by Lysko et al., presents spectrum scans in the TV white space bands in rural and urban areas of South African using a mobile setup and long term measurements done during the TV white space trial in Cape Town.

In the next set of chapters, we present two works in the broad area of spectrum sensing and spectrum database management related to white space bands. There are two methods to avoid interference to primary users. The first is to use dynamic spectrum sensing and this is described in Chap. 5. The second is through the use of a geo-location database and this is described in Chap. 6.

Chapter 5, titled Spectrum Sensing for Cognitive Radio Networks by Srinu et al., describes the spectrum sensing algorithms which have been prescribed for white space detection for cognitive networks in general and for white space communication in particular.

Chapter 6, titled Geo-location White Space Spectrum Databases: Review of Models and Design of a Dynamic Spectrum Access Coexistence Planner and

Manager by Mfupe et al., describes models and methods used to design a geo-location white space spectrum database (GL-WSDB) in the US and Europe. The chapter also describes a GL-WSDB developed by the CSIR in South Africa and compares its performance to field measurements and other results from other commercial GL-WSDBs.

Creating white space device solutions requires software defined radio hardware that is capable of carrying out computationally complex operations for spectrum sensing and OFDM communication used by white space protocols. In the next set of chapters, solutions for some of the implementation issues in white-space communication have been expounded. These discuss a hardware design capable of running a white space protocol as well as some channel characterization and equalization in white spaces.

Chapter 7, titled White RHINO—A New SDR Platform for Whitespace Communication by Hazarika et al., describes the development of a new software defined radio board fine-tuned to cater for the strict requirements set by the white-space communication standards.

Chapter 8, titled Challenges and Solution for TV White Space Channel Estimation and Equalisation by Bhatia, lists some of the established algorithms for channel equalisation for white space communication systems. Channel equalisation is a major challenge in all communication systems. OFDM mitigates the issue of fading in the channel to some extent but it is not a full proof solution.

In the last set of chapters, we focus on the use of white spaces for rural communication. Due to the long-range nature of rural connectivity, we focus on channel characterization and allocation for multiple long-range links. We also examine the interesting question of the value of white space spectrum for rural operators.

Chapter 9, titled VillageLink: A Channel Allocation Technique for Wide-Area White Space Networks by Pejovic et al., describes the challenges in selecting optimal channels in white space networks. The chapter then discusses VillageLink, an extension to 802.22 to allocate channels to base stations in a distributed manner using a Gibbs sampling-based method.

The last chapter, titled A Non-Cooperative TV White Space Broadband Market Model for Rural Entrepreneurs by Nleya et al., discusses the challenges of producing an optimal pricing scheme for leasing spectrum from primary users. It proposes a game-theory based solution to the problem of several primary users competing with each other to sell spectrum to secondary users that use QoS measures of delay and throughout to regulate price.

In conclusion, we wish to thank all the contributors for their thorough and practical set of chapters—crucial to the current worldwide debate on the use of white spaces. We also wish to thank Springer for their timely and professional service in editing the book.

Amit Kumar Mishra
David Lloyd Johnson

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