Course guide
230369 - CR - Cognitive Radio and Spectrum Sharing: a Key Technology of 5G Networks

Last modified: 09/11/2022

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: **Academic year:** 2022 **ECTS Credits:** 2.5
Languages: English

LECTURER

Coordinating lecturer:

Others:

PRIOR SKILLS

Basic knowledge about radiocommunications.

REQUIREMENTS

none

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.
CE2. Ability to develop radio-communication systems: antennas design, equipment and subsystems, channel modeling, link dimensioning and planning.
CE9. Ability to deal with the convergence, interoperability and design of heterogeneous networks with local, access and core networks, as well as with service integration (telephony, data, television and interactive services).

Transversal:
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

TEACHING METHODOLOGY

- Lectures
- Individual work
- Final Exam

LEARNING OBJECTIVES OF THE SUBJECT

Most wireless systems today work in frequency bands that are intended for the exclusive use of licensed users (licensed bands). On the other hand, new technological improvements have resulted in a great development of personal wireless technologies, and as a result of this, scarcity of free spectrum to assign to new systems. This problem is exacerbated by the introduction of 5G systems that are expected to be used, among others, in industrial environments (Industry 4.0), support for the Internet of Things (IoT), or private mobile communications networks.
One solution to this problem of free spectrum lack is that these new users, in addition to using unlicensed bands, also use licensed spectrum bands, as long as they can ensure that the level of interference perceived by the holders of these spectrum licenses will be minimal. This new concept of managing the radio spectrum is called Cognitive Radio.

The aim of this seminar is:
• Understand the concept of Cognitive Radio and to know its applications and limitations in the context of new 5G systems.
• Know and understand the concept of dynamic spectrum management.
• Know the use of LTE and 5G technologies in unlicensed bands, and which are the interference limiting techniques used and their limitations.
• Know and understand the concept of TV White Spaces and its applications.

STUDY LOAD

Type	Hours	Percentage
Self study	42,5	68.00
Hours large group	20,0	32.00

Total learning time: 62.5 h

CONTENTS

COGNITIVE RADIO AND SPECTRUM SHARED TECHNIQUES: A KEY TECHNOLOGY FOR 5G NETWORKS

Description:
Topic 1.- Introduction to Cognitive Radio
1.1 Reasons for the deployment of Cognitive Radio
1.2 Cognitive Radio Concept
1.2.1 Cognitive Cycle: Spectrum Awareness; Spectrum Selection; Spectrum Sharing; Spectrum mobility
1.3 Structure of a Cognitive Transceiver.

Topic 2.- Use of artificial intelligence techniques in spectrum management
2.1. Spectrum management techniques: Planning, authorisation, monitoring and spectrum sharing.
2.2. Review of artificial intelligence techniques applied to spectrum management
2.3. Application of artificial intelligence techniques to spectrum management
2.3.1. Monitoring of the spectrum based on Deep Learning techniques: Cooperative sensing
2.3.2. Spectrum Sharing: Optimization of the use of the spectrum in heterogeneous networks.
2.3.3. Spectrum Planning: Traffic Analysis and Spectrum demand forecast.

Topic 3.- Unlicensed Systems in 5G context
3.1. Motivation and use cases: Private mobile communication networks (applications in Industry 4.0)
3.2 Benefits and Challenges of LTE in Unlicensed Spectrum
3.3 LTE in unlicensed spectrum: LTE-Unlicensed (LTE-U); Licensed assisted access (LAA) and MulteFire
3.4 5G unlicensed Spectrum Allocation: Regulatory Requirements
3.5 5G-NR in unlicensed spectrum:
3.5.1 Technologies: Licensed assisted access NR-U (LAA NR-U) and Stand-alone NR-U.

Topic 4.- Dynamic Access Technologies and Shared Spectrum Use
4.1 Introduction
4.2 Licensed Shared Access (LSA)
4.2.1 Concept: LSA rolls and responsibilities
4.2.2 LSA architecture for Cellular Systems: LSA functional blocks and interactions
4.2.3 European position with respect to LSA: ETSI framework on LSA
4.2.4 LSA in 3GPP: Functional split between LSA Controller and OAM
4.3 Spectrum Access System(SAS)
4.3.1 Concept: Rolls and responsibilities
4.3.2 SAS architecture: Functional blocks

Topic 5.- TV-White Spaces
5.1 Digital Dividend & TV-White Spaces concept
5.2 Regulatory Aspects
5.3 Characteristics of the CR devices for TV-WS
5.4 Standards: IEEE 802.22 and IEEE 802.11af

Related competencies :
CE2. Ability to develop radio-communication systems: antennas design, equipment and subsystems, channel modeling, link dimensioning and planning.
CE1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Full-or-part-time: 62h 30m
Theory classes: 20h
Self study : 42h 30m

GRADING SYSTEM

Continuous assessment 50% of the final mark
Final exam 50% of final mark.

BIBLIOGRAPHY

Basic:
- Venkataraman, H.; Muntean, G.-M. Cognitive radio and its application for next generation cellular and wireless networks [on line]. Dordrecht: Springer, 2012 [Consultation: 02/04/2020]. Available on: http://dx.doi.org/10.1007/978-94-007-1827-2. ISBN 9789400718265.
- Papadias, C.P.; Ratnarajah, T.; Slock, D.T.M. Spectrum sharing : the next frontier in wireless networks. 2020. Hoboken, NJ: Wiley, 2020. ISBN 9781119551492.

RESOURCES

Audiovisual material:
- Transparències del seminari. Seminari slides

Other resources:
- Papers and presentation published in IEEE, ITU, ETSI and other standardization bodies
- Papers published in magazines, conferences and other research bodies.