COURSE DESCRIPTION CARD - SYLLABUS

Course name

Radiowe systemy i sieci programowalne - Programmable radio systems and networks

Course

Field of study
Teleinformatics

Year/Semester
1/2

Area of study (specialization)

Profile of study
general academic

Level of study
second-cycle studies

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
30

Other (e.g. online)

Tutorials
0

Projects/seminars
0/0

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

dr hab. inż. Adrian Kliks, prof. PP
Faculty of Computing and Telecommunications, Institute of Radiocommunications, email: adrian.kliks@put.poznan.pl, phone: +48 61 665 3813

Responsible for the course/lecturer:

Prerequisites

Student:

- has knowledge of the construction and architecture of programmable digital circuits and the possibility of their practical use
- has advanced knowledge of modern wireless access systems and techniques used in them
- can communicate freely in English, also use professional vocabulary, can understand the use of professional literature in English
- can choose the appropriate numerical methods and simulation methods for solving typical tasks related to the analysis, design, and optimization of ICT systems
- to a limited extent, can act as a leader of a group of associates, can lead a small team

Course objective

Understanding the principle of operation and basic problems of programmable radio systems, software-defined radio networks and methods of dynamic management and control of them, and implementation of the programmable radio system.

Course-related learning outcomes

Knowledge

Student:
- he has advanced knowledge in the field of construction and architecture of programmable radio systems and the possibility of their practical use.
- has advanced knowledge of software defined radio networks and their optimization.
- has extended knowledge of wireless networks optimized for energy and spectral efficiency

Skills

Student:
- has advanced knowledge in the construction and architecture of programmable radio systems and the possibility of their practical use
- has advanced knowledge of software-defined radio networks and their optimization
- has extended knowledge of wireless networks optimized for energy and spectral efficiency

Social competences

Student:
- understands the impact of own work on the results of the team and the need to comply with the rules of working in a team in the case of multi-person system software development
- is aware of the social role of the designer of devices affecting the energy consumption of these devices and the natural environment

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The condition for passing the content of the lectures is a positive assessment of the colloquium - a test with problem and descriptive questions. The condition for passing the laboratory exercises is solving the design problem concerning the programmable radio system and the implementation of

individual components of the laboratory tasks. Students' activity during classes will also be taken into account for the final assessment, especially in the context of promoting active participation.

A grading scale was adopted: very good (A) - 5.0; good plus (B) - 4.5; good (C) - 4.0; sufficient plus (D) - 3.5; satisfactory (E) - 3.0; insufficient (F) - 2.0

Programme content

The content of the lecture:
1. The problem of wrong use of statically allocated frequency resources in the context of contemporary and future wireless communication
2. Idea of Software Defined Radio (SDR)
3. Traditional and ideal hardware architecture of the SDR transceiver, taking into account the requirements and limitations resulting from the currently available hardware and software solutions
4. Software management on the SDR platform
5. The idea of cognitive radio (CR), features of CR
6. Problems of detection and dynamic use of unused radio resources
7. The problem of the frequency spectrum sharing
8. Development of CR technology (hardware and programming platforms, standards, implementations)
9. Development of CR towards the use of contextual information and artificial intelligence
10. Software Defined Networks (SDN), virtualization of network functions
11. Management and control of the SDN network
12. Development of radio technology and programmable networks towards energy efficiency

Lab:
1. Getting to know the hardware architecture of the SDR transceiver
2. Programming of SDR systems within the selected software and hardware platform - implementation of a few sample applications
3. Cloud implementation of a spectrum management system and / or cognitive radio

Lecture:

1. The problem of wrong use of statically allocated frequency resources in the context of contemporary and future wireless communication
2. The idea of Software Defined Radio (SDR), in particular definitions, the need to use SDR technology, the desired features of transceiver devices, main technical goals
3. Traditional and ideal hardware architecture of the SDR transceiver, taking into account the requirements and limitations resulting from the currently available hardware and software solutions. In particular, taking into account the requirements and solutions for the radio frequency (RF) stage and antennas in transceiver systems, the problem of analog-to-digital conversion and digital implementation of intermediate frequency (IF) modulation in SDR, the presentation of the basic hardware components of digital signal processing (hardware)
3. Software management on the SDR platform, in particular a description of the ideal software architecture, forward compatibility concept, and the possibility of downloading software updates
4. The idea of cognitive radio (CR), CR features taking into account the requirements and expectations for such systems and the limitations resulting from currently available technological solutions

5. Problems of detection and dynamic use of free radio resources, in particular, the presentation of selected techniques, the so-called sensing, and RV methods
6. The problem of sharing the frequency spectrum, including the overlay, underlay, and interweave concepts
7. Development of CR technology (hardware and programming platforms, standards, implementations), in particular, presentation of activities implemented under FCC, IEEE, ETSI, or ECC, presentation of LSA and CBRS platforms
8. Development of CR towards the use of contextual information and artificial intelligence, especially taking into account intelligence algorithms on the edge
12. Software Defined Networks (SDN), virtualization of network functions
13. Introduction to the issues of management and control of the SDN network
14. Development of radio technology and programmable networks towards energy efficiency

Lab:
1. Hardware architecture of the SDR transceiver
2. Programming SDR chips within the selected software and hardware platform (e.g., GNU Radio, USRB, BladeRF)
3. Cloud implementation of a spectrum management system and/or cognitive radio

Teaching methods

The lecture will be conducted in the form of both lectures and conversations with elements of the discussion. Laboratories assume work in groups in order to perform selected component tasks and, if possible, allow them to gain experience in working in the SCRUM (or similar) methodology

Bibliography

Basic

1. H. Bogucka, Technologie radia kognitywnego, Wydawnictwo naukowe PWN, Warszawa 2013
2. Paul Goransson, Chuck Black, Software Defined Networks: A Comprehensive Approach, Elsevier, Jun 5, 2014 - Computers.
3. Benzekki Kamal et al., “Software-defined networking (SDN): a survey.”, Security and Communication Networks 9, no. 18 (2016): 5803-5833.
4. K. Cichoń, A. Kliks and H. Bogucka, "Energy-Efficient Cooperative Spectrum Sensing: A Survey," in *IEEE Communications Surveys & Tutorials*, vol. 18, no. 3, pp. 1861-1886, thirdquarter 2016. doi: 10.1109/COMST.2016.2553178
5. J. Perez-Romero *et al.*, "On the use of radio environment maps for interference management in heterogeneous networks," in *IEEE Communications Magazine*, vol. 53, no. 8, pp. 184-191, August 2015. doi: 10.1109/MCOM.2015.7180526
6. M. Wasilewska *et al.*, "Artificial Intelligence for Radio Communication Context-Awareness," in *IEEE Access*, vol. 9, pp. 144820-144856, 2021. doi: 10.1109/ACCESS.2021.3119524

Additional

O. Holland, H. Bogucka, A. Medeisis, (eds.) “Opportunistic Spectrum Sharing and White Space Access: The Practical Reality”, John Wiley & Sons, April 2015, ISBN: 978-1-118-89374-6

Breakdown of average student's workload

	Hours	ECTS
Total workload	86	3.0
Classes requiring direct contact with the teacher	45	2.0
Student's own work (preparation for tests, preparation for laboratory classes, literature studies)	41	1.0