2EL6120 – Intelligent Wireless Access & Experimentation

Instructors: Georgios Ropokis
Department: CAMPUS DE RENNES
Language of instruction: ANGLAIS
Campus: CAMPUS DE RENNES
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Engineering Sciences
Advanced level : Yes

Description

The scope of the course is to present the essential knowledge necessary to understand the characteristics of wireless communications systems and standards. To this end, the course focuses on some of the several aspects of communications systems including:

1. transmission technologies used in current and future standards, including 4G and 5G
2. Multiple Access technologies used in current and future standards (starting from 2G and moving to 5G and beyond 5G),
3. the basics and characteristics of telecommunications hardware including the architecture of computing equipment used in communication and the behavior of RF chains,
4. architectures of mobile processors
5. the process of experimentation and prototyping for wireless communications systems.

The course covers all the technical essentials for students that are interested in understanding the fundamentals of wireless communications and its applications, and can serve as a first step for those interested in taking further studies in wireless communications engineering. Moreover, as the course exposes students to several aspects of wireless communications engineering, it serves as an excellent opportunity for those of them interested in pursuing a career in project/team management in the broad area of Communications Engineering. The course will help students familiarising with the most significant aspects of Wireless engineering including wireless communications standards and their characteristics, wireless hardware and prototyping. The presentation of the material will follow a standard oriented approach such as to cover students interested both in the fundamentals of Wireless Communications as well as students mostly interested in a more applied approach to Wireless Communications.

Quarter number
SG8

Prerequisites (in terms of CS courses)

- Notions of probabilities
- Digital Signal Processing (Fourier Transform, Spectral Analysis)
- Basic programming skills

These presrequisites correspond to signal processing (1CC4000),modelisation (1CC3000) and programming (1CC1000) courses.

Syllabus

Part 1: Fundamentals of Wireless transmission

- Physical modelling of wireless channel
- Detection in a fading channel
- Digital Single Carrier and Multicarrier modulation
- Diversity techniques

Part 2: Multiple Access Schemes and Standards : (Multiple Access Schemes for 2G, 3G, 4G, 5G and Beyond 5G networks).

- TDMA, FDMA, CDMA, SDMA
- FDD, TDD, half duplex and full duplex
- Interference management
- Applications in GSM/UMTS/4G/5G network standards
- Other wirless access standards: WLAN, WPAN and LPWAN
- IoT standards and connected objects

Part 3: Computing architectures for wireless communications

- Adaptable wireless communications architecture: the Software-Defined Radio (SDR)
- Analog/Digital front-ends and ADC/DAC data converters
- Embedded computing architectures: from mobile ARM processors to DSPs, FPGAs and GPUs
- Embedded computing platforms for wireless communications

Part 4: Hardware implementation fon wireless systems using GNU Radio and USRP platforms

- Tutorial on GNU Radio
- Implementation of a simple FM receiver
- Implementing a file transfer application on GNU Radio and USRP with QPSK based modulation and demodulation

Class components (lecture, labs, etc.)

Course layout, course organization (CM, TD, EL / TP sequencing) in hours:
Fundamentals of Wireless Communications Lectures: 4.5h
Multiple Access Schemes and Standards Lectures: 6h
Practical work on Fundamentals of Wireless Communications and Multiple Access Schemes: 3h
Computing Architectures for Wireless Communications CM: 9h
GNU Radio tutorial CM: 1.5h
Experimentation/Practical work using GNU Radio and USRPs : 9h
Exam: 2h
Total (HPE): 35h

Grading

Final (written or oral) exam and evaluation of practical/laboratory work

Course support, bibliography

- Handout provided to students
- Tse, D., & Viswanath, P., “Fundamentals of Wireless Communication”. Cambridge: Cambridge University Press, 2005.
- Holma H., & Toskala A., “LTE for UMTS: OFDMA and SC-FDMA Based Radio Access”, Wiley Publishing, 2009.
- Vaezi M., Ding Z., & Poor H. V., “Multiple Access Techniques for 5G Wireless Networks and Beyond”, Springer 2018.
- Yannick Bouguen, Eric Hardouin, François-Xavier Wolff, “LTE et les réseaux 4G”, Eyrolles, 2012
- A. Elnashar, M. A. El-saidny, M. Sherif, K. Abdulla, “Design, deployment and performance of 4G networks”, Wiley-Blackwell 2014,
- Fattah Hossam, “5G LTE narrowband Internet of Things (NB-IoT)”, CRC Press in 2019.
- A. Pacaud, “Électronique radiofréquence”, Ellipses, 2000,B. Razavi
- “RF microelectronics, communication electronics”, Prentice Hall, 1997
- P.L.D. Abrie, “Design of RF and microwave amplifiers and oscillators”, Artech House, 1999,
- S.C. Cripps, “RF power amplifiers for wireless communications”, Artech House, 2006,
- Gernot Hueber, Robert Bogdan Staszewski “Multi-Mode/Multi-Band RF Transceivers for Wireless Communications: Advanced Techniques, Architectures, and Trends” , John Wiley & Sons, Inc, 2010

- Peter B. Kenington, ” RF and Baseband Techniques for Software Defined Radio ", Artech House, 2005.
- Collins, T.F.; Getz, R.; Pu, D.; Wyglinski, A.M. Software-Defined Radio for Engineers; Artech House: Norwood, MA, USA, 2018.

Resources

- Teaching staff (nales of professors delivering lectures): Haïfa Farès, Amor Nafkha, Georgios Ropokis, Ruben Salvador
- Size of TD (by default 35 students): 20
- Software tools and number of required licences: MATLAB and GNU radio for practical and personal work
- Practice rooms (deparment and capacity):

Learning outcomes covered on the course

At the end of the course, the students should be able to:

- understand the basics of digital transmission and multiple access schemes used in existing standards
- understand how a complete wireless communications RF chain works (Radio, Analog and Digital domains)
- become familiar with several different digital processing platforms available for building wireless communications systems and their impact on system requirements (cost, performance, lifetime, energy efficiency etc)
- understand the terminology, structure and characteristics of modern wireless and mobile communications standards
- experiment on building a real wireless communication system

Description of the skills acquired at the end of the course

The course addresses the folowing skills

- C1.2 skill "Develop and use appropriate models, choosing the correct modelling scale and simplifying assumptions when addressing a problem"
- Tutorals and practical work address:
    - The C1.4 skill "Design, detail and corroborate a whole or part of a complex system"
    - Core Skills "C3.1-Be proactive and involved" and "C8.1-Work collaboratively in a team"