COMMUNICATION ENGINEERING AND ELECTRONIC TECHNOLOGIES

(Lecce - Università degli Studi)

Teaching WIRELESS SYSTEMS

GenCod A006429

Owner professor ANGELO COLUCCIA

Teaching in italian WIRELESS SYSTEMS

Teaching WIRELESS SYSTEMS

SSD code ING-INF/03

Reference course COMMUNICATION ENGINEERING AND ELECTRONIC

Course type Laurea Magistrale

Credits 9.0

Teaching hours Ore-Attivita-frontale: 81.0

For enrolled in 2021/2022

Taught in 2022/2023

Course year 2

Language INGLESE

Curriculum PERCORSO COMUNE

Location Lecce

Semester Secondo-Semestre

Exam type Orale

Assessment Voto-Finale

Course timetable https://easyroom.unisalento.it/Orario

BRIEF COURSE DESCRIPTION	The course provides an overview of modern communication principles and techniques, and how they are composed into "systems". The focus is on multiuser wireless systems, in particular mobile cellular networks from 2G (GSM) to 4G (LTE) and 5G, satellite and localization systems.
REQUIREMENTS	Communications, Networks, Statistical Signal Processing.

COURSE AIMS

Knowledge and understanding. Students must have a solid background with a broad spectrum of basic knowledge of digital communications and systems:

- Describe the characteristics of advanced digital communication techniques and discuss the principles of modern system design;
- Understand the different types of diversity that can be exploited to improve the performance of a communication system;
- Illustrate data-aided and non-data-aided synchronization techniques for timing recovery in baseband and passband;
- Describe how surveillance and (geo)localization can be performed via radio signals, and illustrate satellite-based navigation system.

Applying knowledge and understanding. After the course the student should be able to:

- Work with analytical models and solve optimization, detection, and estimation problems related to the course topics;
- Describe the peculiar aspects and main challenges of (mobile) multiuser systems, and how advanced digital communication techniques can be adopted to efficiently cope with them;
- Discuss the evolution of cellular networks from a system perspective, state-of-the-art technologies and security, and the ongoing trends;
- Understand the differences among several techniques addressing the same problem and recognize the main trade-offs.
- Recognize and understand the tendencies and innovations in the ICT field, with awareness of related privacy, security, and ethical issues.

Making judgements. Students are guided to learn critically what is taught during classes, comparing different approaches to address modern telecommunication needs, and to have a clear view of the big picture.

Communication. It is essential that students are able to communicate with a varied and composite audience, not culturally homogeneous, in a clear, logical and effective way, using the methodological tools acquired, their scientific knowledge, and the specialty vocabulary. The course promotes the development of the following skills: ability to highlight and expose in precise terms the characteristics or a variety of telecommunication systems, identifying their salient features without getting lost into protocol/standard details; ability to describe and analyze the different options available for a given application scenario or use case, and illustrate the main trade-offs.

Learning skills. Students must acquire the critical ability to discuss, with originality and autonomy, the most important aspects in the design of telecommunication systems and, in general, cultural issues linked to related areas within the ICT domain. They should be able to develop and apply the knowledge learned in the continuation of their studies and in the broader perspective of cultural and professional self-improvement of lifelong learning. Therefore, students are explicitly asked to refer to and compare different sources and textbooks, also by autonomously selecting authoritative materials from the vast amount of information available (libraries, online repositories, and the Web at large), summarizing them for an effective study.

TEACHING METHODOLOGY	**Teaching Methods.** The course aims at enabling students to understand and be able to solve design issues in telecommunications systems, keeping an unified view and being able to navigate the complexity of modern scenarios. This will be done using the following teaching method. Every system will be introduced in terms of motivations, technical peculiarities, and application scope. The presentation of each topic will be linked to the background studied in previous courses, and continuously connected to the preceding and subsequent topics within the present course. The discussion will be organized into four parts: 1. Description of the main characteristics of the system. 2. Comparison with previous technology addressing the same communication needs, and analysis of the additional requirements. 3. Derivation of selected algorithms and optmization/detection/estimation techniques relevant to the addressed system. 4. Analysis of the implications in terms of user experience, applications to contemporary/future contexts, and security. The course consists of frontal lessons with slides and blackboard, together with class exercises and labs using MATLAB and software-defined radio equipment. There will be theoretical lessons, qualitative discussion on system aspects, and examples about how knowledge is put into practice in real systems. A part of the lessons will be also devoted to illustrate related ongoing research directions in the field.
ASSESSMENT TYPE	Written and/or oral. The final (typically written) exam consists of five open questions aimed at verifying to what extent the student 1) has gained knowledge and understanding of the selected topics of the course, 2) is able to discuss complex aspects in a synthetic way, and 3) has gained adequate degree of maturity in linking concepts within a system view. Small exercises may be included in the questions so that the student can demonstrate his/her ability to 1) correctly adopt formal techniques for solving well-defined problems, and 2) integrate different concepts and tools.
OTHER USEFUL INFORMATION	**Office Hours** By appointment; contact the instructor by email or at the end of class meetings.

FULL SYLLABUS

Advanced digital communication techniques and modern systems (hours: 24 + 2 lab/seminar)
Recapitulation of fundamental principles of digital communications; diversity, combining techniques and MIMO systems; multiuser systems: multiplexing, multiple access, optimality and fairness in resource allocation, link adaptation functions (power control, Adaptive Modulation and Coding, tradeoffs), error recovery (ARQ, FEC and Hybrid-ARQ); overview on spread-spectrum and multi-carrier systems (CDMA, OFDM), multiuser detection.

Telecommunication networks and mobile cellular systems (hours: 27 + 8 lab/seminar)
Historical development of data and voice networks, PSTN; general principles of cellular networks. The GSM system: architecture, burst structure, overview on signaling and mobility procedure. Evolution towards GPRS/EDGE. 3G: UMTS overview and evolution towards HSPA. 4G technologies and next generation systems: LTE, main ideas towards 5G (cooperation, smart antennas, cognitive radio). The 5G ecosystem and its main innovations (mmWave, massive MIMO, fronthaul-backhaul, virtualisation). Introduction to Network Security and intrusion detection (scanning, attacks, DDoS).

Satellite systems (hours: 4 + 2 lab/seminar)
Overview on satellite and deep space communications systems. High-throughput (broadband) satellite communications.

Localization and positioning systems(hours: 12 + 4 lab/seminar)
Introduction to surveillance through radio signals. Recapitulation of synchronisation techniques and relationship with ranging and position estimation. Overview on radar systems. (Geo)localization and satellite-based positioning systems. GPS: principles, signal structure, augmentation, modernization. Current trends and topics in localization.

REFERENCE TEXT BOOKS

Textbooks (other specific references are provided during the course)

A. Goldsmith: "Wireless Communications", Cambridge University Press, 2005
J.G. Proakis: "Digital Communications" (4th ed.), McGraw Hill, 2000
T.S. Rappaport: "Wireless Communications: principles and practice" (2nd ed.), Prentice Hall, 2002
S. Sesia, I. Toufik, M. Baker: "LTE: The UMTS Long Term Evolution - from theory to practice", Wiley, 2009
U. Mengali, A.N. D'Andrea: "Synchronization techniques for digital receivers", Springer, 2007
J. Bao-Yen Tsui: "Fundamentals of Global Positioning System Receivers: A Software Approach", Wiley, 2000