	UE-COM1: Multi-user communications	Semester 1
Contributes to	MICAS	

Coordinators:	Philippe CIBLAT, Telecom Paris Michèle WIGGER, Telecom Paris	
Volume:	30h	**3 ects**
Hours:	Lectures: 19.5h, Exercises: 4.5h, Labs: 3h	
Assessment:	2 Assignments and 1 Final Exam	
Language:	English	

Objectives:
The course considers networks with multiple interfering users. In particular, it discusses techniques for interference mitigation (successive decoding, decoding of non-intended data) and interference avoidance (orthogonal access techniques) and advanced techniques, such as non-orthogonal access, network coding, and resource allocation. Finally, the course also discusses fundamental limits (capacity) of multiuser networks.

Outcomes:
On completion of the course students should be able to:
- Know the standard orthogonal and non-orthogonal multiple access techniques and the most common multi-user receivers
- Characterize and solve resource allocation problems
- Understand some of the most important capacity results for multiple-user networks

Prerequisite
- Introduction to Convex Optimization
- Introduction to Information Theory
- Introduction to Communication Theory

Syllabus
- Practical multi-user communication techniques
  - Orthogonal multiple access techniques: Time sharing, TDMA, FDMA, OFDMA, CDMA
  - Non-orthogonal multiple access techniques: NOMA
  - Multi-user decoding techniques: successive interference cancellation (SIC) and parallel interference cancellation (PIC)
- Capacities of networks
  - Capacities of Gaussian multi-access channels (MAC) and broadcast channels (BC), MAC-BC Duality
  - Cutset upper-bound on the capacity of general networks, Max-flow min-cut theorem
  - Linear network coding, Capacity of deterministic multicast networks
- Resource allocation techniques
  - Waterfilling
  - SNR target
  - Interference function and application to Base Transceiver Subsystem (BTS) allocation
  - Non convex case leading to convex one: Geometric Programing, Fractional Programing
  - Monotonic programing
  - Non-convex case: successive convex approximation, block-coordinate descent
  - Biconvex programing
  - Relaxation approach (assignment example, second-order cone programing)
  - Lab on resource allocation (Yates' algorithm)

Bibliography:

- D. Tse and P. Viswanath, "Fundamentals of wireless communication", 2005.
- A. Goldsmith, "Wireless Communications", 2005.
- M. Schubert and H. Boche, "Interference Calculus: A General Framework for Interference Management and Network Utility Optimization", 2012.
- S. Stanczak, M. Wiczanowski, and H. Boche, "Fundamentals of Resource Allocation in Wireless Networks: Theory and Algorithms", 2008.
- T. Cover and J. Thomas, "Elements of Information Theory", 2012
- A. El Gamal and Y.-H. Kim, "Network Information Theory", 2011.