

USCSchool Name

Course ID and Title: 5G Wireless Systems

Units: 3

Term—Day—Time: Spring 2016

Day/Time: TBD

IMPORTANT:

The general formula for contact hours is as follows:

Courses must meet for a minimum of one 50 minute session per unit per week over a semester.

(Please refer to the *Contact Hours Reference*, located at usc.edu/curriculum/resources.)

Location: TBD

Instructor: Andreas F. Molisch

Office: EEB 530

Office Hours: (General guideline: 1 weekly office hour for each 4 unit class taught. Office hours are not to be calculated in “contact hours.”)

Contact Info: phone: ext 04670

Email: molisch@usc.edu

Teaching Assistant: N/A

Office: Physical or virtual address

Office Hours:

Contact Info: Email, phone number (office, cell), Skype, etc.

IT Help: N/A

Hours of Service:

Contact Info: Email, phone number (office, cell), Skype, etc.

Course Description

The course will provide an overview of research for fifth-generation (5G) wireless communications systems. 5G systems are currently developed by industry (with support from academia) for deployment starting in 2020, and international standards are being developed. The goal is to provide a system that will achieve ten times the peak data rate of 4G systems (i.e., 10 GBit/s) and hundred times the throughput of those systems.

Key components are (i) use of mm-wave spectrum, (ii) massive MIMO systems (i.e., base stations with hundreds of antenna elements), (iii) heterogeneous networks, and (iv) device-to-device communications. The course will both deal with the scientific basis of those technologies, and discuss practical implementation and developments in the standardization bodies.

Learning Objectives

Students are expected to learn the cutting-edge technologies that are main topic for industrial research departments and standardization groups in industry (as well as many academic research groups). The course builds on a number of courses in the communications framework (e.g., EE535 Mobile Communications, EE564 Digital Communications), but also hardware courses (in particular mm-wave technology) and wireless networking.

Prerequisite(s): EE 535

Co-Requisite (s):

Concurrent Enrollment:

Recommended Preparation:

Course Notes

Grading Type: standard letter grade

Course material: printed (paper) lecture notes (to be developed over the next months)

Technological Proficiency and Hardware/Software Required

N/A

Required Readings and Supplementary Materials

Supplementary material: various research papers, will be part of handouts to students

Description and Assessment of Assignments

What kind of work is to be done and how should it be completed, i.e. how the learning outcome will be assessed. Include any assessment and grading rubrics to be used.

Grading Breakdown

How will students be graded overall, including the assignments detailed above. Participation should be no more than 15%, unless justified for a higher amount. All must total 100%.

Assignment	Points	% of Grade
Homework 1	100	8
Homeowork 2	100	8
Homework 3	100	8
Homework 4	100	8
Midterms	100	28
Final project	100	40
TOTAL	600	100

Assignment Submission Policy

Assignments to be submitted in writing, 2 weeks after assignment, during class

Additional Policies

Students are expected to attend class, but no penalty will be invoked for missing class (though material must be learned from notes etc. for homework and exams).

Course Schedule: A Weekly Breakdown

Provide a detailed course calendar that provides a thorough list of deliverables—readings, assignments, examinations, etc., broken down on at least a weekly basis. The format may vary, but the content must include:

- Subject matter (topic) or activity
- Required preparatory reading, or other assignments (i.e., viewing videos) for each class session, including page numbers.
- Assignments or deliverables.

IMPORTANT:

In addition to in-class contact hours, all courses must also meet a minimum standard for out-of-class time, which accounts for time students spend on homework, readings, writing, and other academic activities. **For each unit of in-class contact time, the university expects two hours of out of class student work per week over a semester.**

(Please refer to the *Contact Hours Reference*, located at usc.edu/curriculum/resources.)

	Topics/Daily Activities	Readings and Homework	Deliverable/ Due Dates
Week 1 Dates	MASSIVE MIMO (weeks 1-4) * Motivation for systems with large number of antennas * Pilot contamination	Handouts	
Week 2	Hybrid	Handouts	

Dates	(analogue+digital) transceiver structures		
Week 3 Dates	Multi-user capacity in massive systems	Handouts	
Week 4 Dates	Testbeds and alternative implementations	Handouts	HOMEWORK 1
Week 5 Dates	MM-WAVE SYSTEMS (weeks 5-8) mm-wave propagation channels	Handouts	
Week 6 Dates	* Beamforming approaches * Channel sparsity and impact on beamforming design	Handouts	
Week 7 Dates	* On-chip antennas and array design * Hybrid transceivers for mm-wave	Handouts	
Week 8 Dates	* Mm-wave for backhaul links MIDTERMS	Handouts	HOMEWORK 2
Week 9 Dates	HETEROGENEOUS NETWORKS (weeks 9-11) Basics of random geometry	Handouts	
Week 10 Dates	* Capacity of single-layer systems in random geometry * Motivation for hetnets	Handouts	
Week 11 Dates	* Capacity of hetnets in random geometry * hetnets with multiple antennas at the BS	Handouts	HOMEWORK 3
Week 12 Dates	DEVICE-TO-DEVICE COMMUNICATIONS (WEEKS 12-15)	Handouts	

	Motivation for D2D, and differences to ad-hoc networks Neighbor discovery and channel estimation		
Week 13 Dates	Resource allocation in mixed cellular/D2D structures	Handouts	HOMEWORK 4
Week 14 Dates	D2D in combination with caching	Handouts	
Week 15 Dates	FINAL PROJECT	Handouts	
FINAL Date			Date: For the date and time of the final for this class, consult the USC <i>Schedule of Classes</i> at www.usc.edu/soc .

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards* <https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions>. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct>.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* <http://equity.usc.edu> or to the *Department of Public Safety* <http://adminopsnet.usc.edu/department/department-public-safety>. This is important for the safety of the whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* <http://www.usc.edu/student-affairs/cwm/> provides 24/7 confidential support, and the sexual assault resource center webpage <http://sarc.usc.edu> describes reporting options and other resources.

Support Systems

A number of USC’s schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* <http://dornsife.usc.edu/ali>, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicssupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an

officially declared emergency makes travel to campus infeasible, *USC Emergency Information* <http://emergency.usc.edu> will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.