ECE 592-78 (also CSC 591-78)
LTE and 5G Communications

Instructor(s): Ismail Guvenc

Objective or Description: The course provides an introduction to the theoretical fundamentals and practical/experimental aspects of Long Term Evolution (LTE) and 5G technologies. A basic understanding of digital communication systems and radio access networks are required. Six main areas will be studied: 1) User and control plane protocols, 2) physical layer for downlink, 3) physical layer for uplink, 4) practical deployment aspects, 5) LTE-Advanced, and 6) 5G communications. Some of the fundamental concepts that will be covered in the context of LTE/5G systems include OFDMA/SC-FDMA, synchronization, channel estimation, link adaptation, MIMO, scheduling, and millimeter wave systems.

Prerequisites: Although not required, the students are advised to have the prior knowledge gained from ECE 570 or ECE 582 before taking this course. They are also expected to use Matlab extensively throughout the course, including the LTE System Toolbox and Communications System Toolbox.

Textbook: While the slides will mostly be self-sufficient, we will be using the following book for the course.

Stefania Sesia (Editor), Issam Toufik (Editor), Matthew Baker (Editor), "LTE, The UMTS Long Term Evolution: From Theory to Practice", Wiley, 2nd Edition, Sept. 2011, ISBN-10: 0470660252 | ISBN-13: 978-0470660256.

Topics: The course is organized into 17 course modules that cover the following concepts.

1. Introduction and Background on LTE
2. Network Architecture and Protocols: Network architecture; control plane protocols; user plane protocols.
3. Physical Layer for Downlink: OFDMA technology overview and downlink PHY design; synchronization and cell search; reference signals and channel estimation; downlink physical data and control channels; link adaptation and channel coding; multiple antenna techniques; multi-user scheduling and interference coordination; broadcast operation.
4. Physical Layer for Uplink: Uplink PHY design; uplink reference signals; uplink physical channel structure; uplink capacity and coverage; random access channel for uplink; uplink transmission procedures.
5. Practical Deployment Aspects: User equipment positioning; radio propagation environment; radio frequency aspects; radio resource management; paired and unpaired spectrum; picocells, femtocells, and home eNodeBs; self optimizing networks; LTE system performance.
6. LTE Advanced: Introduction to LTE-Advanced, carrier aggregation, multiple antenna techniques for LTE-Advanced, relaying, additional features of LTE Release-10.
7. 5G Communications: mmWave communications, massive MIMO, machine type communications (MTC), device-to-device communications (D2D, ProSe), vehicle-to-vehicle communications (V2X), tactile Internet

Grading:

Grading Policy:

- Homeworks: 30%
- Project: 35%

- Final (comprehensive, take home): 35%
- Piazza participation (extra credit): 2%

(1) Homeworks involve standard textbook questions, Matlab programming exercises, and weekly multiple choice questions to refresh the material that are covered in the slides.
(2) There will be a semester-long course project which can be (depending on the interests of the students): a survey on a given topic related to LTE/5G; studying a recent journal paper related to 5G technology and replicating/extending the findings in the paper; or an experimental project involving LTE/5G measurements (e.g. using USRPs or 5G mmWave devices that will be provided).
(3) There will also be two mandatory small projects (5% total) involving the use of software defined radios such as RTL-SDR to capture signals from neighboring LTE base stations and decode their broadcast channel.

Grading Scale:

- A+: Above 100, 95 <= A <= 100, 90<= A- < 95
- 85 <= B+ < 90, 80 <= B < 85, 75 <= B- < 80
- 70 <= C+ < 75, 65 <= C < 70, 60 <= C- < 65
- 55 <= D+ < 60, 50 <= D < 55, 45 <= D- < 50
- F: Below 50

Cross-listing in other departments:

Course is cross-listed with the Computer Science Department, under the course number CSC 591 - 78.

For more details, students can check the 2017 Fall offering of the course from the following website: https://sites.google.com/site/ece792fall2017/home

The main differences from the 2017 Fall offering will be: 1) Further techical material will be included related to 5G technologies, and 2) two mandatory SDR based mini-projects will be introduced for hands on experimentation with SDRs and LTE.

The course is recommended for:

1. MS students to improve their competitiveness in the wireless job market by adding fundamental LTE and 5G skills into their CV (check e.g.: https://www.indeed.com/jobs?q=LTE&l= for jobs related to LTE technology and https://www.indeed.com/jobs?q=5G&l= for jobs related to 5G technology);
2. PhD students who would like to conduct fundamental research on 5G technology and beyond;
3. Part time students from industry who would like to learn details of LTE and 5G technologies.