EEL4515 - Advanced Communication Systems

Three Credits, Two hours and fifty minutes, Engineering Topic.

Instructor: Dr. Ahmed S. Ibrahim.

Textbook: D. Tse and P. Viswanath "Fundamentals of Wireless Communications," Cambridge, 2005, available online at: https://web.stanford.edu/~dntse/wireless_book.html

Goldsmith, "Wireless Communications," Cambridge University Press, 2005.

Specific Course Information:

Our life is surrounded by so many advanced wireless communication devices (e.g. phones, laptops, printers, watches). Therefore, there is a crucial need to understand the fundamentals of wireless communication, and this is the main objective of this course. For instance, we need to understand how transmitters and receivers communicate together over wireless fading channels. Furthermore, in wireless systems, multiple users attempt to simultaneously access the same physical medium in order to communicate. If not correctly designed, such multiple-access problem will result in huge interference and unreliable detection. Hence in this course, we will investigate the multiuser communication problem as well. For example, we will study various multiple access techniques such as CDMA and OFDMA, and how each one combats the interference. From theoretical (information theory, signal processing) perspectives, we will consider the capacity of MIMO multiuser channels. Moreover, from a practical perspective, we will study various advanced communication systems (e.g., 2G/3G/4G cellular systems, Wi-Fi, Personal Area Networks). Performance metrics of multimedia applications will be discussed. The taught concepts will be validated further via computer simulations.

Specific Goals for the Course

a. Specific outcomes of instruction

Upon successful completion of this course, the student will:

1.Course introduction, wireless Channels, flat/frequency-selective fading, Fast/slow fading
2.Detection and time diversity
3.Frequency and spatial diversity
4.Cellular Systems: GSM, Flash OFDM Introduction to Capacity of wireless channels
5.Capacity of Wireless Channels: noise-only fading, diversity
6.Opportunistic Single-user Communication; uplink AWGN multi-user capacity
7.Current research areas and project description
8.Multi-user capacity: uplink/downlink AWGN and fading channels, SIC, Superposition coding, opportunistic multi-user Communication, multiuser diversity, dumb antennas
9.Single-user MIMO channel: Capacity, SVD, MIMO channel physical modeling, angular/spatial domains, diversity and DoF gains, Fading.
10.MIMO Multiplexing architectures: V-BLAST, D.o.F/ power gains, decorrelator, matched filter, MMSE-SIC
11.Multi-user MIMO: SDMA, uplink, downlink, uplink-downlink reciprocity.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.

In this course the student will have to show

(a) an ability to apply knowledge of mathematics, science, and engineering (X)

(b) an ability to design and conduct experiments (simulations), as well as to analyze, interpret data (X)

(c) an ability to design a system, component, or process to meet desired needs (X)
(d) an ability to function in multi-disciplinary teams (N/A)
(e) an ability to identify, formulate, and solve engineering problems (homework) (X)
(f) an understanding of professional and ethical responsibility (N/A)
(g) an ability to communicate effectively (through project reports) (N/A)
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context (N/A)
(i) a recognition of the need, and an ability to engage in life-long learning (N/A)
(j) a knowledge of contemporary issues (X)
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (X)
(l) a knowledge of probability and statistics (X)

Brief list of the topics to be covered

1.Fundamentals of wireless channels (input/output model of wireless channel, time/frequency coherence)
2.Signal detection in wireless systems including time and space diversity techniques
3.Various multiple access techniques such as TDMA, CDMA and OFDMA, and how each one combats inter-user interference.
4.Information-theoretic channel capacity covering both single-antenna (SISO) and multiple-antenna (MIMO) systems
5.Multiuser capacity and opportunistic communication (Uplink/Downlink AWGN and fading channels, Multiuser diversity)
6.Multiuser MIMO communication (MU-MIMO Uplink/Downlink)
7.Practical communication systems (e.g., LTE and Wi-Fi), with emphasis on multimedia applications
7.Using Matlab in simulating wireless systems

GRADING(EEL4515):

Course Requirements	Weight
Homework	25%
Quizzes	25%
Mid-term exam	25%
Project	10%
Final Exam	15%
Overall Grade	100%

Conversion of Numerical Grade to Letter Grade

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