EE 597: Wireless Networks

Department of Electrical Engineering
University of California

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Course Overview:

Wireless networks play an increasingly important role in the world of communications. This course provides an introduction to various current and next generation wireless networking technologies, and undertakes a detailed exploration of fundamental architectural and design principles used at all layers. Related protocols and their performance are studied using formal analytical tools and realistic simulations.

Prerequisites: EE 450 and EE 465

Recommended Preparation: EE 467, familiarity with Matlab and C programming.

Reason for Request:

This course fills a need in the networking curriculum in EE for a course that focuses on higher-layer protocol design and analysis for wireless networks. While we currently have related courses on wireless that focus on lower layer mechanisms (EE 535, Mobile Communications), network applications (EE 532, Wireless Internet and Pervasive Computing) as well as hands-on projects pertaining to implementing mobile and wireless applications (EE 579, Wireless and Mobile Networks Design and Laboratory), we currently lack a course that provides students a detailed introduction to the design and analysis of protocols for power control, medium access, routing, and congestion control that form the fundamental basis for a wide range of wireless data networks, from cellular networks, to mobile ad-hoc network, to sensor networks.

Intended Audience:

The primary intended audience for this course is graduate students in Electrical Engineering with an interest in wireless networks. These include MSEE, MSCENG, and MSEECN students, and Ph.D. students in Electrical Engineering.

Learning Objectives:

The specific objectives of the course are to help the students:

1. Understand the architecture and applications of current and next generation wireless networks: Cellular, WLANs, sensor networks, mobile ad-hoc networks and intermittently connected mobile networks.
2. Get a basic introduction to the key concepts and techniques underlying modern physical layer wireless and mobile communications: radio propagation modeling; performance of digital modulation schemes and coding techniques in fading environments; CDMA and OFDM; diversity and MIMO. (These topics are all explored in much greater detail in EE 535, the goal here is to provide a sufficient survey of this topics so that the higher layer protocols are well-grounded and motivated.)
3. Learn how to design and analyze various medium access and resource allocation techniques such as power control for fixed-rate and rate-adaptive systems, Aloha and CSMA-based randomized medium access, scheduling for TDMA/FDMA/CDMA-based wireless networks.
4. Learn how to design and analyze network layer routing protocols, along with key component mechanisms, such as link metric estimation and neighborhood table management for proactive and reactive routing protocols, opportunistic routing, backpressure routing, network coding, cooperative routing, routing with mobility and intermittent contacts.
5. Learn to design and analyze transport layer protocols, with an emphasis on congestion control, including TCP over wireless, congestion sharing mechanisms, explicit and precise rate control, utility optimization-based approaches, and backpressure-based utility optimization.
6. Learn how to evaluate MAC and network protocols using network simulation software tools such as NS-2 or Qualnet.

Required Texts:

There is no required textbook for the course. Students will be provided a set of course notes, currently under development. The following book is suggested as a reference:
Wireless Communications, Andrea Goldsmith, Cambridge University Press

Grading:

Grading will be based on the weighted average of scores on assignments, simulation projects, quizzes, and exams with the distribution as follows.
1. Assignments: there will be five assignments. These will together count for 25% of the grade.
2. Projects: There will also be 3 simulation projects. These will together count for 15% of the grade. These projects are to be worked on and submitted by pairs of students working together.
3. Midterm Exam: this exam will count for 30% of the grade.
4. Final Exam: this exam will count for 30% of the grade.

Grades will be based on absolute scores, not the relative distribution of scores (i.e., there will be no “curve”). A raw score of 90 or above is guaranteed an A. A raw score of 80 or above is guaranteed at least a B. A raw score of 70 or above is guaranteed at least a C.

Statement on Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. *Scampus,* the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/. Additional information on academic integrity standards for the Viterbi School of Engineering can be found online at http://viterbi.usc.edu/academics/integrity

Statement for Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

COURSE OUTLINE (by Week)

Week	**Topic**
1	Introduction to wireless network architectures: cellular networks, wireless local area networks, multi-hop networks
2	Radio propagation models, Narrowband digital modulation and Coding under wireless fading environments. *Assignment 1 on network architecture and phy-layer.*
3	Basics of CDMA and OFDM, Diversity and MIMO, Equalization. *Project 1 assigned: Simulation of coding and modulation on a single link.*
4	Power allocation for rate-adaptive parallel channels (Water-filling); power control for fixed-rate independent channels (Centralized linear solution; Foschini-Miljanic distributed algorithm)
5	Randomized medium access 1: Unslotted and Slotted Aloha. System throughput analysis and two-user saturation rate region analysis
6	Randomized medium access 2: CSMA. System throughput analysis and two-user rate region analysis for p-persistent CSMA. Bianchi's Markov chain analysis of throughput for the

	IEEE 802.11 CSMA protocol. Other window adaptation mechanisms. *Assignment 2 on power allocation/control and randomized medium access.*
7	Graph coloring and its application to channel allocation in (TDMA/FDMA/CDMA-based) wireless networks under the protocol model. **Mid-term Exam**
8	Integer Linear Programming formulation of channel allocation for both protocol and SINR interference models. Extensions to other objective functions such as non-homogeneous channel preferences, throughput maximization and fairness. Introduction to wireless network simulator (NS-2/QualNet). *Project 2 assigned (simulation of IEEE 802.11 MAC). Assignment 3 on Graph Coloring and ILP.*
9	Introduction to multi-hop wireless network routing. The AODV and OLSR protocols for mobile ad-hoc networks. Link estimation and neighbor management.
10	Geographic routing: greedy routing and different solutions for avoiding routing holes. Routing in intermittently connected mobile networks.
11	Theory and Practice of Dynamic Backpressure Routing. Theory: Lyapunov drift minimization yielding the centralized maximum weight independent set matching solution. Practice: the BCP protocol for sensor networks. *Assignment 4 on Wireless Routing.*
12	Opportunistic routing and Cooperative Routing: ExOR, Flash flooding, Barrage relay. *Project 3 assigned (Simulation of MANET routing protocol).*
13	TCP over wireless networks. Congestion sharing (IFRC, WCAP). Centralized and distributed explicit and precise rate control (RCRT, WRCP).
14	Optimization-based rate control with Lagrange duality and with queue backpressure. *Assignment 5 on Wireless Congestion Control.*
15	Wrap up and course review. Discussion of emerging industry standards such as 4G Cellular, IEEE 802.11p, and/or guest talk by visitor from industry/academia working on wireless networks.
Exam Week	**Final Exam**