EEP 5xx Wireless Networks for 4G/5G (Wtr 2019)

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Course Description

The course will serve as an introduction to *selected topics in 4G/5G oriented wireless communication networks* - the material is a mix of lectures on principles and design fundamentals complemented by network performance evaluation via simulation. With high-speed wireless data access fundamental to the growth of the Internet, students will be exposed to the 2 major broadband wireless network technology standard families: 802.11 WLANs and LTE/LTE-Advanced. The course project and some homework will require use of the open-source ns-3 network simulator (available at https://www.nsnam.org) via a set of experiments utilizing existing basic wireless, 802.11 and LTE protocol stack implementations in ns-3.

Course Objectives By the end of the course, the student will have demonstrated

• grasp of fundamental elements of wireless networks and IEEE 802.11 WLAN, 4G LTE and emerging 5G network networks
• ability to conduct network simulation experiments in ns-3 for network performance evaluation, produce and interpret statistical outputs
• ability to define and conduct a network simulation project and explore an aspect of network performance optimization.

Detailed Course Outline

I. Network Simulation [2 weeks]
 • (**week 1**) Introduction to ns-3: installation, basic usage, example programs, data output management, introduction to ns-3 LTE and Wi-Fi
• (**week 2**) Wireless experiments with ns-3: Scripting, wireless networking APIs, execution and debugging, collecting simulation data, principles of statistical simulation & data visualization
II. Wireless Channels: Models & Performance Evaluation [3 weeks]
 • (**week 3**) Basic wireless (narrowband) propagation, statistical models
• (**week 4**) Link & MAC level performance evaluation models
• (**week 5**) Wideband communications, MIMO
III. 802.11 WLANs & LTE Network Models [5 weeks]
 • (**week 6**) OFDM & OFDMA fundamentals: Block diagram of all the major transceiver (PHY) blocks + associated MAC processing; Network architecture
• (**week 7**) Multi-user techniques (DL and UL MU-MIMO, beamforming, DCF and EDCA)
• (**week 8**) System aspects: Mobility management, transport protocols over wireless (QUIC, TCP)
• (**week 9**) Coexistence: LTE and Wi-Fi coexistence, radar coexistence, white space networking, spatial reuse, interference mitigation

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- **(week 10)** 5G advanced topics: 5G modulation, cloud-RAN, millimeter wave, New Radio

Course Policy

Students are welcome to discuss assignments or project design/implementation with instructors, TA or fellow students. However all homework submitted must be individual, including your own ns-3 code/experiments. The Final project will be conducted by teams of 2 and will require: (i) an initial proposal (2 pg) for approval mid-way and (ii) a written report due finals week. Students are encouraged to define a project based on their interests in wireless communications with consultation/input of instructors.

Pre-requisites:

The 1st two are strongly desirable requirements (either formal courseware or equivalent experience).
- Programming Proficiency: C/ C++ programming and running Bash line commands. Ability to plot raw data files in some plotting framework (Excel, MATLAB, Python Matplotlib, etc.).
- Undergraduate Probability Digital/Wireless Communications
- Exposure to concepts of TCP/IP protocol stack & Internet architecture (e.g. UW EE 461 Intro to Computer Networks or equivalent)

TA: TBD

Assessment: The overall grade will be based on -
(i) 5 Homework assignments [60%] and (ii) Final Class Project [40%]

References:
The texts below are intended for background/in-depth information. The lectures and supplementary material will suffice as the primary source.

- T. Rappaport, "Wireless Communications," Prentice Hall, 2002 2nd. ed. (ch 4, 5: radio propagation)
- D. Tse and P. Viswanath, "Fundamentals of Wireless Communication," Cambridge Univ. Press, 2005 (ch. 3 - diversity, ch 6&7: multi user communications, MIMO)
- M. Gast, "802.11 Wireless Networks: The Definitive Guide," O'Reilly, 2002.
- J. Heiskala and J. Terry, "OFDM Wireless LANs: A Theoretical & Practical Guide," SAMS Publishing, 2002.
- A. Tanenbaum, "Computer Networks," Prentice Hall, 4th edition or later.
- E. Dahlmann, S. Parkvall & J. Skold "4G: LTE/LTE-A for Mobile Broadband," Acad. Press, 2013, 2nd ed.
- "ns-3 Tutorial": https://www.nsnam.org/docs/tutorial/ns-3-tutorial.pdf