CS 655: Wireless and Mobile Computing
Fall 2019

Time and location

Mondays, 4:30 pm - 7:10 pm
Innovation Hall 134

Instructor

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Course description

This course will cover state-of-the-art topics in wireless networking and mobile computing. The objective of the course is to introduce students to recent advances in mobile networking and sensing, with an emphasis on practical design aspects of mobile systems.

We will start with introductory topics in wireless networking and mobile sensing which will cover design of today's wireless networks such as 802.11n and 802.11ac, and smartphone/wearable sensing techniques including activity and context recognition. In the second part of the course, we will cover more advanced topics including next generation multi-gigabit wireless networks (5G) such as millimeter wave (802.11ad) and visible light communication, integrated sensing paradigms including localization and RF sensing, low power networking with a focus on RFID backscatter and Internet-of-Things (IoT) devices, and networking aspects of future mobile systems such as drones and autonomous cars.

A list of topics that will be covered in the course is provided below. Please note that this is a tentative list and is subject to change (including the order of topics) based on our progress. Instructor will provide required and optional reading material (lecture notes and research papers) for each class. Detailed schedule and course material will be posted on the course website.

1. **Wireless networking** **[5 weeks]**

   Primer on wireless communications and networking

   1.1. Physical layer
   - OFDM and 802.11 (WiFi) PHY
   - Multi-antenna systems and MIMO
   - Overview of 802.11n/ac PHY including beamforming

   1.2. MAC layer
   - CSMA/CA and WiFi MAC overview
   - Wide bandwidth channel access techniques (802.11n/ac)
   - Energy efficiency and rate control

   1.3. Network layer
   - Wireless routing protocols
   - Multi-hop wireless networks

   1.4. Transport layer
   - Reliable delivery over wireless networks

- TCP/UDP variants for unreliable wireless links

1.5. Applications and cross-layer design
- Communication between layers for wireless networks

2. Mobile and wearable sensing **[3 weeks]**

2.1. Overview of smartphone/wearable sensors
- Accelerometer, gyroscope, magnetometer etc.
- Smartphone orientation and heading detection

2.2. Activity recognition and healthcare
- Identifying human activities and context through sensors
- Health monitoring and fitness tracking

2.3. Wearables overview
- Wrist-worn wearables - gesture and remote interaction
- Sensor fusion in body-area networks

3. Multi-gigabit wireless networks **[2.5 weeks]**

Next generation (5G) wireless technologies
Upper Gigahertz and Terahertz wireless communications

3.1. Millimeter wave networking
- Directionality and beamforming
- Mobility and signal blockage
- IEEE 802.11ad (60 GHz WLAN) MAC and PHY overview

3.2. Visible light communication
- High-speed networking using LEDs
- IEEE 802.15.7 PHY and MAC overview

3.3. Sensing through visible light
- Visible light indoor localization and positioning

4. Indoor localization and RF sensing **[2 weeks]**

4.1. Smartphone localization
- WiFi fingerprinting - protocols and challenges
- Non-WiFi localization

4.2. Device-free sensing with radio frequency
- Mining wireless PHY channel state information
- Device-free localization and indoor human tracking
- Activity and gesture recognition through RF

5. Low-power networking **[2 weeks]**

5.1. Backscatter communication
- Radio Frequency Identification (RFID) technology overview
- Energy harvesting tags and applications

5.2. Internet-of-Things (IoT)
- IoT protocol overview - CoAP and MQTT
- IPv6 networking in low-power PANs (6LoWPAN)

6. Future mobile networks **[If time permits]**

6.1. Drone networking
- Multi-UAV networks, architectures and civilian applications
- Communication challenges and protocols for micro UAVs

6.2. Connected and autonomous cars

- Wireless technologies for Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) communications

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Required and reference textbooks

The course has no required textbook. The course is based on lecture notes and a list of research papers from recent conferences and journals, both of which will be provided by the instructor.

The following textbooks can serve as good references -

1. 802.11 Wireless Networks: The Definitive Guide, Book by Matthew Gast (available online through GMU library).
2. Wireless Communications: Principles and Practice, by Theodore S. Rappaport, Prentice Hall.
3. 802.11n: A Survival Guide, by Matthew Gast, O'Reilly Media.
4. 802.11ac: A Survival Guide, by Matthew Gast, O'Reilly Media.
5. Wireless Networking Complete, by Pei Zheng et al., Morgan Kaufmann.

Prerequisites

CS 555: Computer Communications and Networking

Course structure and grading

Reviews	15%
Programming assignments	25%
Class participation	10%
Class presentation	10%
Class project	40%

Reviews and presentation: Students will be provided with 1-2 research papers after every alternate class. You will be asked to read the papers and write a short review (2-3 paragraphs) explaining the important aspects (central idea, pros, cons) of the papers. A format of the review will be provided beforehand. The presentation will include one oral presentation per student. A list of topics/papers relevant to the course will be provided to choose from.

Programming assignments: The course will include 3-4 mini programming assignments. These assignments will be based on measurements and/or datasets of wireless networks and smartphone sensors. The students will be asked to analyze the datasets/measurements using simple tools and the programming language of their choice to complete the assignment. The assignments will help students in understanding practical aspects/issues in wireless and mobile computing, and also help them prepare for the final project.

Project: The project will design and implement a mobile sensing technique or a wireless networking protocol within the topics of the course described above. Instructor will provide many sample ideas (e.g. smartphone localization with WiFi, activity tracking with smartwatch, and many more), tutorials and other necessary resources. Necessary mobile devices such as smartphones can be provided for implementation. Experience with development on mobile platforms is *not* mandatory.

The project can be done individually or in teams of 2 students. The project topic and team size should be discussed and approved by the instructor. There will be three project deliverables - 1. Project proposal (5%) 2. Final project report (15%) and 3. Final project presentation/demo (20%). The final project report and presentation will be due at the end of the semester.

Policies
GMU Honor Code All students must adhere to the GMU Honor Code and the Computer Science Department's Honor Code Policies. Violation of the Honor Code will result in a failing grade.

Accommodations for Disabilities If you have a documented learning disability or other condition that may affect academic performance, you should: 1) make sure this documentation is on file with the Office for Disability Services (SUB I, Rm. 4205; 993-2474; http://ods.gmu.edu) to determine the accommodations you need; and 2) talk with me within the first week of the semester to discuss any accommodation needs.
