CS 4961/6961: Special Topics (Mobile and Wireless Networking)

Administrative Details and Syllabus
Spring 2024
(***Subject to change***)

December 29, 2023

Course Information

Description. This is a combined undergraduate/graduate level course on Mobile and Wireless Networking with a systems emphasis. The course will cover basic principles of wireless communication and focus on understanding and applying those principles in practical systems. The primary goal of the course is for students to obtain an in-depth understanding of all aspects of mobile and wireless networking through a combination of hands-on exploration and "textbook" learning. The course is suitable for both undergraduate and graduate students who have completed the prerequisites. The course will briefly review basic networking concepts before focusing on a variety of mobile and wireless topics, including: 5G/NextG networks, radio-access-networks, spectrum usage, digital communication basics and advanced wireless applications (wireless sensing, spectrum sharing, Internet-of-Things (IoT), augmented & virtual reality (AR/VR)).

Objectives. The course have the following learning objectives for students:

1. To understand basic networking concepts.
2. To understand the architecture and functions of a modern mobile network.
3. To be able to build, configure, instantiate and use open source mobile networking stacks.
4. To be able to use open source tools to explore the functions of mobile and wireless networks.

Prerequisites. Full Major status in Computer Science or Computer Engineering and "B" or better in CS 4480 (or equivalent computer networking course).

Additional requirements. Students are expected to be comfortable working in the Unix/Linux operating system environment, and be able to program in a structured high-level programming language, such as Python.

Meetings. Tuesday and Thursdays, 2:00-3:20 PM in WEB 1230.

Instructor. Prof. Kobus Van der Merwe. *Email:* kobus@cs.utah.edu. *Office:* MEB 3490D.

Course Materials

Textbook. We will use online material, including:

- Computer Networks: A Systems Approach - Larry Peterson and Bruce Davie
  - `https://book.systemsapproach.org/`
- Private 5G: A Systems Approach - Larry Peterson, Oguz Sunay and Bruce Davie
  - `https://5g.systemsapproach.org`
- Peer-reviewed papers and technology white papers

POWDER testbed. Most lab-assignments/hands-on exploration will use the POWDER mobile and wireless platform. (`https://www.powderwireless.net`)

Website. The course public website is at:

- `https://users.cs.utah.edu/~kobus/teaching/cs4961_6961_2024.html`

and in Canvas at:

- `https://utah.instructure.com/courses/928024`.

We will use Canvas as the primary course information repository, including lecture schedule, assignments, links to course material etc.

Lecture notes and supplementary material. The instructor will make use of supplementary materials, including slides and other materials. Material used during lectures will be posted in Canvas following the lecture. However, such documents may not completely represent the material covered in the class.

Student Evaluation

Grading. Grading for the course will be based on: Lab/Homework Assignments (40%), Quizzes (20%), Exams (30%) and Course Participation (in class and on Canvas) (10%). (***This breakdown is subject to change.***)

Scale for assigning letter grades. 100-93 → A, 92-90 → A-, 89-87 → B+, 86-83 → B, 82-80 → B-, 79-75 → C+, 74-70 → C, 69-65 → C-, 64-60 → D+, 59-55 → D, 54-50 → D-, 49-0 → E.

Class attendance. This is an in-person class and attending class is *required.*

Appeals. *Students who wish to appeal a grade must do so within one week of receiving the grade.*

Submitting assignments. Homework Assignments will be submitted through Canvas.

Late submissions. No late submissions will be allowed.

Reading assignments. You will get reading assignments for most classes. You are expected to do the reading assignments to enable us to discuss the material in class.

Quizzes. There will be weekly (brief in class) quizzes based on reading assignments.

Lab/Homework assignments. Most lab assignments will involve hands-on exploration of concepts and technologies covered in the course. Most of the assignments will make use of the POWDER mobile and wireless platform (`https://www.powderwireless.net`), which students will be able to access via their laptops/desktop computers. (Lab assignments will involve both in-class and at-home work.) Lab assignments will include the use of open source mobile and wireless stacks and tools. Additional homework assignments might be assigned. (Students will receive a grade for each assignment. For each assignment this grade may be based on a detailed or cursory evaluation, at the discretion of the instructor.)

Exams. There will be three midterm exams, but **no** final exam. All exams will be closed-book. Midterms will be given in class during regular class time. (Dates TBD.)

Getting Help

Instructor office hours. Instructor will have regular weekly office hours. (Which will be posted in Canvas.) Additional office hours are available by appointment. (Please send email to the instructor to schedule a meeting.)

Communication. For questions outside of class, students are encouraged to use email or the Canvas discussions function. If your question is of a general nature, i.e., something that your fellow students might benefit from knowing, or might be able to answer for you, please make use of the Canvas discussions function. Otherwise, please feel free to send email to the instructor.

The instructor will also use Canvas to send urgent messages to the class (e.g., corrections to assignments or changes in due dates etc).

Course Guidelines

Behavior in class. Students are expected to maintain professional behavior in class according to the University of Utah *Student Rights and Responsibilities* policy, which is available here:

`http://www.regulations.utah.edu/academics/6-400.html`

Students should read the Policy carefully and know what their responsibilities are. According to Faculty Rules and Regulations, it is the faculty responsibility to enforce responsible classroom behavior, beginning with verbal warnings and progressing to dismissal from class and a failing grade. Students have the right to appeal such action to the Student Behavior Committee.

Working together. Students are encouraged to discuss assignments with fellow classmates, however, each student is responsible for completing his/her own assignment. *Cheating is:* sharing code or other electronic files either by copying, retyping, looking at, or supplying a copy of a file. *Cheating is not:* discussing concepts, answering questions about concepts or clarifying ambiguities, helping someone understand how to use the computer systems or basic tools (e.g., using the POWDER platform), or helping with high-level design issues or general debugging.

Except when explicitly designated otherwise, each assignment is to be done individually. For all assignments, the solution submitted by each student will be checked against the solutions of other students for anomalies. If an anomaly is found that cannot be explained satisfactorily, the students involved will fail the course.

Academic Misconduct and Use of Generative AI. It is expected that students will adhere to generally accepted standards of academic honesty, including but not limited to refraining from cheating, plagiarizing, misrepresenting one's work, and/or inappropriately collaborating. This includes the use of generative AI tools without citation, documentation, or authorization. Students will also be expected to adhere to the prescribed professional and ethical standards of the profession/discipline for which the student is preparing. Any student who engages in academic dishonesty or who violates the professional and ethical standards for the profession/discipline for which the student is preparing, may be subject to academic sanctions as per the University of Utah *Student Academic Performance, Academic Conduct, and Professional and Ethical Conduct* policy:

`https://regulations.utah.edu/academics/6-410.php`

Students are also required to adhere to the School of Computing academic misconduct policy:
`https://www.cs.utah.edu/undergraduate/current-students/policy-statement-on-academic-misconduct/`

Note. *Any student found cheating will fail the entire course.*

College of Engineering guidelines. Information on withdrawing from courses, appealing grades, and more, see the College of Engineering Academic Affairs website:
`https://www.price.utah.edu/students/academic-affairs`
and the College of Engineering Semester guidelines:
`https://www.price.utah.edu/students/current/semester-guidelines`

Students with disabilities. The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in class, please follow instructions from the Center for Disability and Access website:
`https://disability.utah.edu`
As needed, the center will work with you and the instructor to make arrangements for accommodations.

Syllabus

Below are the key topics we plan to cover in this course and the approximate number of lectures planned for each. (*Subject to change.*)

- *Getting Started* (1 lecture)
  - Course overview, administrative details.
- *Review of basic networking concepts* (4 lectures)
  - Application and transport layers
  - Network layer
  - Link layer
  - Wireless links
  - Access networks
- *Mobile and wireless networking* (14 lectures)
  - 5G architecture
  - Radio access network
  - Core mobile network
  - Radio transmission
  - 6G/NextG
- *Advanced wireless applications* (10 lectures)
  - V2X
  - Wireless sensing
  - IoT
  - AR/VR

Hands-on explorations are expected to include the following. (*Subject to change.*)

- Exploring 802.11 (WiFi) wireless local area networking functionality using open source tools (e.g., Wireshark.)
- Exploring 5G mobile network architecture, protocols and functions in the POWDER testbed, using open source mobile networking stacks (e.g., srsRAN, openAirInterface, Aether etc.)
- Exploring software-define radio-access-network (SD-RAN) functionality in the POWDER testbed, using open source SD-RAN stacks (e.g., NexRAN, FlexRAN, ONF SD-RAN etc.)
- Exploring the interplay between "endpoint stacks" (application and transport layer protocols) and mobile/wireless networks using the POWDER testbed and Linux-based endpoints.
- Exploring basic wireless communication functions using the POWDER testbed open source tools (e.g., GnuRadio, UHD etc.)