Wireless Networking Systems
CS 5966, CS 6966, ECE 5960, ECE 6960

Fall 2025
Administrative Details and Syllabus
(***Subject to change***)

August 8, 2025

Course Information

Description. This is a combined CS/ECE and combined undergraduate/graduate level course on Wireless Networking Systems. The course will provide a cross-disciplinary perspective on the design of state-of-the-art wireless networking systems. Topics range from the physical analog multipath radio propagation channel, to the antenna, to digital modulation and data rate, to multi-user multiplexing, to the higher networking layers. 5G cellular networking protocols will be studied in depth. Spectrum sharing systems such as CBRS and RDZ will be introduced. Topics will be covered both via lecture and via experimentation on the Platform for Open Wireless Data-driven Experimental Research (POWDER), a large-scale software-defined radio testbed on the University of Utah campus. Students will work in interdisciplinary teams to set up, configure, execute, and modify wireless networking experiments.

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

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

Prerequisites. Full Major status in Electrical Engineering or Computer Science OR Computer Engineering OR Software Development.

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. Mondays and Wednesdays, 03:00-04:20 PM MT in WEB L114.

Instructors.

- Dr. Neal Patwari, neal.patwari@utah.edu, Professor, Kahlert School of Computing, Professor, Department of Electrical and Computer Engineering, Office hours: request a meeting via email.
- Dr. Jacobus (Kobus) Van der Merwe, kobus@cs.utah.edu, Jay Lepreau Professor, Kahlert School of Computing, Office hours: request a meeting via email.

Course Materials

Textbook. We will use online material, including:

- Private 5G: A Systems Approach - Larry Peterson, Oguz Sunay and Bruce Davie
  - `https://5g.systemsapproach.org`
- Other online material and/or material provided by instructors.

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

Website. The course Canvas website is at:

- `https://utah.instructure.com/courses/1172174`.

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%), Exams (25%), Course Project (25%) 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. (Final assigned grade will be rounded up for the purpose of assigning a letter grade.)

Class attendance. Class attendance 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.

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 a variety of open source mobile and wireless stacks and tools. Several lab assignments will require coding in Python, typically on a Jupyter notebook. (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 instructors.)

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

Course Project. There will be a course project in which students will be required to *extend* one of the lab/homework assignments and present the results in class. The Course Project will be evaluated through a combination of a report and an in-class presentation.

Getting Help

Instructor office hours. Office hours for both instructors 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 requiring accommodations. 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 sessions planned for each. (*Subject to change.*)

- *Getting Started* (2 sessions)
  - Course overview, administrative details.
  - Overview of the POWDER platform.
  - POWDER experimental workflow.
- *Mobile and wireless networking* (14 sessions)
  - 5G architecture
  - RF channel, antennas, path loss, signal-to-noise ratio (SNR)
  - Digital modulation, multipath effects and mitigation
  - Radio access network
  - Core mobile network
- *Advanced wireless topics* (10 lectures)
  - Open Radio Access Network (O-RAN)
  - O-RAN plus machine learning (ML)
  - Spectrum sharing and management
  - Ultra-Reliable Low Latency Communication (URLLC)
  - 6G

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

- Real world spectrum monitoring using software-defined-radios (SDRs) in the POWDER platform.
- SDR-based measurement of radio channels.
- Software transmitter and receiver design and algorithms, for narrowband and wideband signals.
- Exploring 5G mobile network architecture, protocols and functions in the POWDER testbed, using open source mobile networking stacks (e.g., srsRAN, openAirInterface 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.)
- Using O-RAN interfaces to realize ML-driven RAN control.
- Exploring spectrum management with open source spectrum management tools.