Wireless Protocols for the Internet of Things
CS397/CS497

Syllabus - Winter 2021

Instructor
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Overview
The Internet of Things promises a world of computers woven into our physical world. A common need for these devices is low-power, wireless communication. The goal of this course is to introduce students to a variety of wireless networks that target low-power, machine-to-machine communication as is common in the Internet of Things. While we introduce the physical layer and have a goal of getting data to the internet at large, the focus of this course is on the wireless protocols themselves. How are packets structured, and why? How are they designed to enable low-power communication? How do they deal with contention and reliability? What makes them more or less suitable for different applications? We will explore local-area protocols such as Bluetooth Low Energy, Thread (and other 802.15.4 protocols), low-power, wide-area networks (LPWANs) such as LoRaWAN and Sigfox, and other related topics such as backscatter and localization. The class will include lectures on these topics. practical hands-on lab sessions interacting with networks, and a final project culminating in a presentation and short paper.

Location and Time
Lectures: 1:00-1:50 PM Central, Monday/Wednesday/Friday
All lectures will be held in zoom and recorded.

The strength of this class will be in discussion, however, so plan on attending every lecture and being willing to speak up, even over zoom. Mondays and Wednesdays will be primarily “lecture”, with course content and discussion. Fridays will be primarily “lab” and “project” focused, with small, guided projects and time for discussion and meetings about final projects.

Prerequisites
No formal requirements. The course also expects students to have a background in C programming. The course will also rely on some knowledge of embedded programming and computer networks, which could be satisfied through CE346, CS340, or other means. For example, knowledge of C, experience with Arduino (or another microcontroller), and interest in networks should be sufficient to participate in the course.

Course Materials

There is no course textbook. We'll be interacting with plenty of specifications and a few research papers. But they are all freely available online. However, there are hardware materials necessary for labs and projects, strictly less than $100 including shipping. The instructor will reach out to students with more details, and students with financial concerns will be subsidized.

Grades

35% - Lab projects

- 5% - Embedded programming
- 10% - BLE advertisements
- 10% - BLE connections
- 10% - Thread

65% - Final project

- 10% - Proposal
- 5% - Updates
- 10% - Presentation
- 10% - Paper
- 30% - Project quality

This class isn't graded on a curve, and you should note that there are no exams. Instead, course participation is expected (rather than graded), and you'll be graded predominantly on your final project.

Lab Projects

These provide guided, hands-on experience with networks. Labs are done individually, will be started on Fridays in class, and will have about a week to complete. These are subject to change in case there are problems getting them working.

- Embedded programming: get a build environment set up and perform the embedded versions of "Hello World".

- BLE advertisements: get BLE advertisements working, transmitting and receiving, and use smartphones and wireshark to introspect them.

- BLE connections: get BLE connections working, with a service and characteristics, and use smartphones or other embedded devices to connect to them.

- Thread: get a Thread network with traditional IP working, including a transmitter and a gateway, and use wireshark to introspect it.

These projects will include a one-page submission demonstrating that you got the lab working and commenting on the results.

Final Project
These are open-ended and can focus on any topic related to the class. They can be performed individually, or preferably in groups. The labs should help give you some basis for a project, but you are not required to do something with BLE or Thread. Projects can be in simulation or on real hardware.

Example ideas:

- Discrete event simulation of a wireless network
- Analysis of transmissions in a wireless network from a throughput or energy perspective
- Implementation and evaluation of a modified network

Project proposals will be due about 1/3rd of the way into class. They will include a short writeup of the project plan and a discussion with the instructor about the project.

Updates will be given once or twice between proposal and submission, detailing completed work, unexpected challenges, and revisions to the project goals.

An in-class presentation will be given for each project. The presentation will be 10-15 minutes plus time for questions and should include a demo if appropriate. These will take place the last week of class.

A research-style paper describing the project is due at the end of the quarter. These will be up to six pages and include related work, design, implementation, and evaluation of your project.

The final projects themselves are also graded based on quality and difficulty. The instructor's understanding of these projects will come primarily through the presentation and paper. The proposal and updates will be used to guide students so that they can anticipate how their project will be judged.

Accessibility
Any student requesting accommodations related to a disability or other condition is required to register with ANU (accessiblenu@northwestern.edu; 847-467-5530) and provide professors with an accommodation notification from AccessibleNU, preferably within the first two weeks of class. All information will remain confidential.

Should you need them, additional campus resources are available, including, but not limited to:

- Accessible NU www.northwestern.edu/accessiblenu/
- CAPS www.northwestern.edu/counseling/index.html
- Student Enrichment Services www.northwestern.edu/enrichment/

I believe in providing reasonable accommodations that allow for full access to learning for all. Please contact me if there is anything that I should be aware of that might have an impact on your participation in this course (documented disability, language challenges, absences for religious observations, etc.).

Diversity and Inclusion
I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability—and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class.

This course will also include a mix of undergraduates and graduate students with differing backgrounds in embedded systems and networks. Do not feel discouraged by this. Each student will bring a different aspect of their knowledge to discussions, and we'll all be contributing towards increasing each other's understanding of wireless networks and the Internet of Things.

Recording
Portions of this class will be recorded by the instructor for educational purposes. These recordings will be shared only with students enrolled in the course and will be deleted at the end of the quarter. Your instructor will communicate how you can access the recordings.

Schedule (tentative)
This is the first time this course is being offered. So this schedule is definitely subject to change. If there is a topic you wish was covered in the class, but isn't included, please let the instructor know!

Week	**Monday**	**Wednesday**	**Friday**
Jan 11-15	Introduction	*slack*	MAC Protocols +Recorded Lab Embedded
Jan 18-22	*MLK Day*	BLE Advertisements	Lab Advertisements
Jan 25-29	BLE connections	Bluetooth Classic	Lab Connect
Feb 1-5	802.15.4	Thread	Lab Thread
Feb 8-12	Zigbee/Advanced	WiFi	*slack*
Feb 15-19	WiFi 2	LPWANs	Updates
Feb 22-26	Cellular	Cellular 2	*slack*
Mar 1-5	Localization	Backscatter	Updates
Mar 8-12	Wrapup + Extra	Presentations	Presentations 2