Department of Electrical and Computer Engineering
University of Massachusetts Amherst

ECE 697LP: Design Principles for Low Power Embedded Systems

Catalog Data

This course provides an overview of the core design principles used in the holistic design of low power embedded computing systems. The topics for the course will include wireless and ambient energy harvesting, alternative energy storage technologies, low power radio design, efficient sensor data processing, and low power AI accelerators. The course will include a survey of papers from recent top-tier conferences and journals. Students will have the opportunity to design a low power embedded system for IoT, mobile health, or other HCI application and empirically evaluate its performance. (3 credits)

Prerequisites
None

Credits
3

Instructors
Jeremy Gummeson, 211C Knowles Engineering Building, jgummeso@umass.edu

Course Meeting Times
Lectures: T TH, 4:00 PM - 5:15 PM, LGRT 206

Textbook
None

Course Goals
Students completing this course will be able to:

1. Understand recent research literature in embedded IoT and mobile health systems
2. Be able to code, measure, and evaluate embedded systems for low power and energy harvesting embedded systems
3. Understand hardware design principles for low power embedded systems including duty cycling, clock and voltage gating, AI accelerators, and other novel circuits that reduce CPU load

Course Topics (approximately 1 week for each topic)

1. **Applications:** Overview of applications that benefit from low power (Distributed IoT and mobile health)
2. **Low power hardware system design:** Look at hardware design techniques that allow embedded systems to operate at low power
3. **Low Power Wireless Radios / Protocols:** Introduction to low power networking including 802.15.4, Bluetooth Low Energy and LoraWAN.
4. **Backscatter / Battery Free Systems:** An overview of backscatter systems including ambient backscatter, RFID, and NFC.

5. **Energy Harvesting Systems:** Overview of different energy harvesting sources including wireless power transfer, the human body, and ambient environmental sources
6. **Energy Neutral System Design:** Overview of techniques used that allow embedded systems to persist indefinitely from harvesting sources.
7. **Intermittent Computing:** Core topics of intermittent computing including energy buffer sizing, software checkpointing, and intermittent clocks.
8. **Energy Aware Software and OS Design:** A look at software techniques that can be used to make user applications energy aware.
9. **Novel Hardware Systems:** Examples of systems that exploit synergies between harvesting and sensing.
10. **Device-Free Sensing:** A look at device free sensing including low power radars, RF sensing, and microphones**.**
11. **Edge Computing:** Overview of edge computing and architectures that leverage computational resources at the network edge.
12. **Energy-Efficient AI:** Overview of new circuit design primitives that can be used to accelerate artificial intelligence operations at much lower power than conventional adders and multipliers.

Grading Policy
Class Participation (10%)
Paper summaries (20%)
Programming assignments (20%)
Small research project (50%)

Prepared by: Jeremy Gummeson February 3, 2020