ECE 697PS: Principles of Embedded and Cyber-Physical Systems

Instructor

C. Mani Krishna

krishna@ecs.umass.edu

Office

KEB 309K

Office Hours

Tues/Thurs: 10-11

Course Overview

Embedded and cyber-physical systems are an increasingly important part of computing. This course covers topics in scheduling algorithms, communication protocols, energy and thermal issues, dependability and fault-tolerance, all as pertain to the integration of the computer in the feedback loop of a controlled plant.

This course is complementary to ECE 622, *Embedded Systems – Design, Modeling and Verification*. There is very little overlap between these two courses and graduate students interested in embedded systems can choose to take either or both of them.

Required Text

Giorgio Buttazzo, *Hard Real-Time Computing Systems* (3rd ed), Springer 2011.

Course Materials

Other course material will be posted on the Moodle page. A small part of the material will be drawn from Krishna and Shin, *Real-Time Systems*, McGraw-Hill, which is on reserve at the library.

Tentative Course Content

1. Introduction to cyber-physical applications.
    - Bahedi and Gill (see course moodle page).
    - Buttazzo, Chapter 11.
2. Integrating the cyber and physical sides of a CPS
    - Bradley and Atkins, 2012 (see course moodle page) [Sections I, II, VI.]
3. Clock signals
    - Phase locked loops to deliver multiple frequencies using dividers.
    - Fault-tolerant design of phase-locked clocks. (Krishna and Shin, 1997.)
4. Basics of scheduling (including performance measures)
    - Buttazzo, Chapter 2
    - Krishna and Shin, 1987 (see course moodle page).
5. Aperiodic scheduling algorithms

        - Buttazzo, Chapter 3
6. Periodic scheduling algorithms.
        - Buttazzo, Chapter 4.
7. Resource access protocols (priority ceiling and inheritance).
        - Buttazzo, Chapter 7.
8. Fixed-priority servers.
        - Buttazzo, Chapter 5.
9. Dynamic priority servers
        - Buttazzo, Chapter 6.
10. Energy Issues
    - Batteries
        - Rakhmatov and Vrudhula (see course moodle page).
        - Shin, et al. (see course moodle page).
    - Supercapacitors
        - Chai and Zhang, 2015 (see course moodle page).
    - Dynamic voltage and frequency scaling
        - Pillai and Shin, 2001(see course moodle page).
11. Thermal Issues.
        - Krishna and Koren, 2017 (see course moodle page).
12. Mixed criticality scheduling.
        - Burns and Davis, 2017 (see course moodle page).
13. Real-time kernel.
        - Buttazzo, Chapter 10.
14. Controller Area Network protocol.
        - Avatefipour and Malik, 2018 (see course moodle page).
15. Dependability and fault-tolerance (if time permits).

Grading Policy

All tests and the final will be closed-book, closed notes with no calculators or other electronic devices allowed.

Test 1	25%
Test 2	25%
Final Exam	35%
Homework	15%