ECE 8448-001 Embedded Systems Architecture

Spring 2018

Instructor: Dr. Xiaofang "Maggie" Wang (xwang@villanova.edu)
Office: Tolentine 431; Tel: (610) 519-3830

Office Hours: Thursday, 2:00 p.m. - 4:30 p.m. or by appointment.

Course Web: http://www.ece.villanova.edu/~wang/courses/ECE8448/ECE8448.htm

The web pages are constantly being updated. You are required and assumed to check them regularly for updates and announcements.

Textbook: No required book. I will be integrating materials from many sources.

References:

1. *An Embedded Software Primer*, by David Simon, Addison-Wesley Professional.

2. *ARM System Developer's Guide: Designing and Optimizing System Software*, by Andrew Sloss et al., Morgan Kaufmann, 2004

3. **Intel Cyclone V ARM SoC & DE1-SoC development kit** Literature.

4. More references are available through the course **References** web page

Required Background: Fundamentals of Computer Engineering, computer/processor architecture, assembly and C/C++ programming.

Course Objectives

After finishing the course, students will

- Understand the special requirements that are imposed upon embedded systems
- Understand the key features of embedded processors, particularly ARM processors
- Have the knowledge of special features of programming with embedded processors
- Understand how microprocessors, memory, peripheral components and buses interact in an embedded system
- Understand how architectural and implementation decisions influence performance and power dissipation
- Write more efficient code for embedded systems

- Understand the role of the compiler in the embedded system design process
- Understand the properties of real-time operating systems, including real-time scheduling policies
- Have improved engineering system design and implementation techniques
- Be able to design and implement an embedded system around an embedded processor using an FPGA development board

Course Overview

Embedded computing systems are special-purpose, dedicated systems in which the processing unit is completely encapsulated in a larger system it controls. They are ubiquitous in many aspects of our everyday life: wireline and wireless computer networks, automobiles, airplanes, appliances, industrial control systems, wearable computer systems, etc. Embedded systems often have specific requirements and are characterized by extraordinary diversity and fast pace of development. The core of most embedded systems is a single- or multi-core processor. Power has also become a top-priority specification in the last few years.

This course is an introduction to hardware and software aspects of processor-based embedded systems. Students will learn both the fundamentals of embedded system design and practical design methodology and tools. Please check the following table for the topics covered in the lectures. In addition to hands-on homework assignments, students will work on a comprehensive hardware/software codesign project to learn how to solve practical real-world problems. Hands-on homework assignments and the project will be implemented using the **Altera DE1-SoC development kit**, which features a SoC FPGA that integrates the latest dual-core ARM Cortex-A9 embedded cores with programmable logic for ultimate design flexibility.

Grading Policy

- Homework Assignments (20% penalty per school day for late submissions) -- 30%
- Exam -- 30%
- Course Project -- 40% (design and implementation + demonstration/presentation + final report)
    - Check the link http://www.ece.villanova.edu/~wang/courses/ECE8448/handouts/project.html for a complete description, schedule, and related documents.

Notes:

- Homework assignments will be posted on the course schedule web page. Each homework assignment is due at the beginning of next class meeting unless otherwise announced. Late submissions will be accepted with a 20% penalty of the points per late day.
- Please post your questions and problems on the course discussion forum. You are highly encouraged to participate in discussions.
- The exam is closed book and closed notes. One letter-size sheet of notes may be used for the exam. The sheet must be one-sided and in your handwriting.
- If you miss a class meeting, you are responsible for all the material covered in the class. If you are unable to take the exam on the scheduled date, you must contact me before the exam.

Academic Integrity

As Villanova students you recognize that integrity is central to the University's mission. As engineers, our code of conduct requires us to place honor and integrity at the forefront of everything we do. As engineering students, it is expected that you will adopt these values and instill them into your work habits. You are encouraged to consult the Academic Integrity Policy and Code at the beginning of each semester (https://www1.villanova.edu/villanova/provost/resources/student/policies/integrity.html).

Academic Accommodations for Students with Disabilities

It is the policy of Villanova to make reasonable academic accommodations for qualified individuals with disabilities. If you are a person with a disability (non-physical) please register with the Learning Support Office by contacting learning.support.services@villanova.edu or 610-519-5176 as soon as possible. Registration is needed to receive accommodations.

The Office of Disability Services collaborates with students, faculty, staff, and community members to create diverse learning environments that are usable, equitable, inclusive and sustainable. The ODS provides Villanova University students with physical disabilities the necessary support to successfully complete their education and participate in activities available to all students. If you have a diagnosed disability and plan to utilize academic accommodations, please contact Gregory Hannah, advisor to students with disabilities at ods@villanova.edu.

Planned Lectures Topics

(Please check the course schedule web page for detailed information)

Meeting	Topics
1	Course overview; Introduction to embedded system design
2	Embedded processor architecture: ARM
3	Project kickoff; Build and implement an ARM HPS system with Linux on the DE1-SoC board
4	Developing software for embedded systems
5	Communicating with I/O devices
6	More about embedded software
7	Firmware and Operating systems for embedded systems
	Break, no class
8	Real-time scheduling policies
9	Semaphores and ISRs
10	Connectivity: Embedded buses and networks
11	Memory technology and memory design
12	Introduction to parallel and distributed embedded systems
	Break, no class
13	Design for low power/energy
14	Project-related and students-proposed topics
15	Project presentation/demonstration; Final Exam