ECE 8448 Embedded Systems Architecture

Spring 2021

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

Lectures: Wednesdays, 12 p.m. – 2:30 p.m., live on ZOOM. Lecture videos available by the end of the day.

Office Hours: Tuesdays, 1:00 p.m. - 3:00 p.m. on ZOOM (6105193830) or by appointment.

Course Web: Blackboard: https://elearning.villanova.edu
We will be using the Blackboard (Bb) to organize class materials. The folders on the class content homepage will be constantly updated with lecture slides and videos, assignments, readings, references, etc. You are required and assumed to check the Bb homepage regularly.

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** & **DE10-Standard development kit** Literature.

4. More references are available through the course **References** folder.

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

Course Overview

Embedded 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, customization, tight constrains, and fast pace of development. The core of most embedded systems is single- or multi-core processors. Power has also become a first-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 the fundamentals of embedded system design and exercise practical design methodology and tools. Please check the following table for the topics covered in the lectures. Hands-on assignments will be implemented using the **Altera DE10-Standard development kit**, which features a SoC FPGA that integrates a dual-core ARM Cortex-A9 processor with programmable logic for ultimate design flexibility.

Course Objectives

After finishing the course, students will

- Understand the special requirements that are imposed upon embedded systems
- Understand the key instruction set architecture (ISA) features of embedded processors, particularly ARM processors
- Understand how architectural and implementation decisions influence performance and power dissipation
- Have the knowledge of special features of programming embedded processors
- Write more efficient code for embedded systems
- Understand how microprocessors, memory, peripheral components and buses interact in an embedded system
- 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
- Have hands-on experience with industrial standard development software and hardware.
- Understand key state-of-art issues for embedded systems

Grading Policy

- Homework Lab Assignments -- 60%
- Final Exam -- 20%
- Course Project -- 20%
    - Detailed description and requirements will be posted in the Assignments folder

Notes:

- Homework assignments will be posted in the Bb course Assignments folder. Late submissions will be accepted with a 10% loss of the points per late day, unless approved by the instructor.
- If you are unable to take the exam on the scheduled date, you must contact me before the exam.

Tentative Schedule of Topics

Date	Topics
01/27	Course overview; Introduction to Embedded Systems
02/03	Embedded Processor Architecture: ARM TutorialA: Using ARM processor on DE10-Standard with Intel Monitor Program
02/10	Hardware Platforms of Embedded Systems TutorialC-1: My first HPS-FPGA (hardware); TutorialC-2: My first HPS-FPGA (software)
02/17	Software Architectures for Embedded Systems
02/24	Communicating with (Controlling) I/O Devices
03/03	More about Embedded Software
03/10	Connectivity: Embedded Networks
03/17	Tutorial B: Using Linux and EDS on DE10-Standard
03/24	RTOS1: Firmware & OS for Embedded Systems
03/31	RTOS2: Real-Time Scheduling Policies
04/07	RTOS3: Semaphores and ISRs Tutorial: IRQ with Linux on DE10-Standard Board
04/14	Memory Technology; Processor Power Management TutorialD: Using HPS+FPGA+Linux
04/21	Project presentations
04/28	Project presentations
05/05	**Final exam**

About Self-Guided Learning

Learning how to look for appropriate technical documentation, read and understand them efficiently in a focused manner is one of the essential engineering skills, and one of the objectives of the course. Due to the hands-on nature of this course without a textbook, you are expected to learn from appropriate documentation, mostly through vendor's website or google,

when you have questions or problems with the assignments and project. In addition to the lectures, additional readings/references will be posted on the course web as needed.

Attendance and Participation

You are expected to attend class meetings or watch class videos. You are responsible for all the material covered in class including handouts and class notes. In-class students should inform the instructor if they plan to be late or absent from class. In all cases, students should be prepared to provide documentation to petition for *excused* absences to the appropriate Associate Dean. The form for requesting an *excused* absence can be found here (http://www1.villanova.edu/villanova/engineering/resources/policies/forms/studentAbsence.html). Absence from class does not release the student from work assigned. Students who miss an in-class obligation (exam, presentation, etc.) due to an excused absence will not be penalized - the instructor may offer a make-up test, arrange an alternative time for a presentation, exempt a student from the assignment, or provide another arrangement.

Inclusive Classroom

I consider our classroom to be a place where everyone is treated with respect; and, I welcome individuals of all ages, backgrounds, beliefs, ethnicities, gender, gender identities and expressions, sexual orientation, and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class.

Adherence to the Student Code of Conduct and the CARITAS Commitment

Students are expected to act in a professional and respectful manner to their fellow students, faculty, and staff. Students should become acquainted with and understand the responsibilities set forth in the Student Handbook, especially those in the sections on Policy and Regulations. Adherence to University regulations is expected and required for successful completion of the program of studies. Enforcement within the classroom of policies regarding classroom behavior is the responsibility of the faculty member. All other discipline problems are to be referred to the Dean of Students.

Students, faculty, and staff are expected to comply with the CARITAS Commitment. Students should wear masks, practice social distancing and good hygiene, wipe down their work area upon arrival and departure, and request an excused absence if they are not feeling well.

Academic Integrity

The College of Engineering is committed to creating an environment of academic integrity and ethical decision-making that we hope is reflected in the actions of our students and graduates. As Villanova students, integrity is central to the University 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 begin to adopt these values and instill them into your work habits. Students violating the academic integrity policy will receive a zero on that assignment or exam and the violation will be reported to the Associate Dean for Academic Affairs.
The University's academic integrity policy can be found here:
https://www1.villanova.edu/villanova/provost/resources/student/policies/integrity.html.
The College of Engineering has adopted the following exam guidelines:

- Students must arrive before the start of the exam. Under exceptional circumstances a student may need to arrive late, but he/she can enter the exam no later than 5 minutes after the start of the exam.
- All cell phones must be turned off and stored away until the student exits the exam room.
- The official Villanova class attendance policy must be followed when requesting excuses for absences or lateness to an exam.
- Each student must write and sign the following statement, "*I have neither given nor received any unauthorized assistance in the completion of this exam.*"

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 please contact me after class or during office hours to make arrangements.
If you have a non-physical disability you need to register with the Learning Support Office by contacting 610-519-5176 or at learning.support.services@villanova.edu 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 and register with Gregory Hannah, advisor to students with disabilities @ 610-519-3209 or visit the office on the second floor of the Connelly Center.

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