ESE 566: Hardware/Software Co-Design of Embedded Systems
Fall 2016

Instructor: Dr. Alex Doboli.
Credits: 3 credits
Schedule: TBD.

Description: The course presents state-of-the-art concepts and techniques for design of embedded systems consisting of analog, hardware and software components. Discussed topics include system modeling and specification, architectures for embedded mixed-signal systems, performance evaluation, and system optimization. The course follows the top-down design paradigm based on IP cores. Course requirements include three reports on system specification and various co-design tasks.

Goal: Upon completion of the course, students will possess knowledge about state-of-the-art methodologies and techniques for hardware/software co-design of embedded systems. They will be able to (1) develop system-level specifications using high-level languages, (2) model system performance, and (3) implement algorithms for co-design.

Text Book and other Teaching Material:

1. A. Doboli, E. Currie, "Introduction to Mixed-Signal Embedded Design", Springer, 2010.

Other Material:

2. G. De Micheli, R. Ernst, W. Wolf, "Readings in Hardware/Software Co-Design", *Morgan Kaufman*, 2002.
3. Other published papers will be provided in class.

Prerequisites: ESE 545 (Computer Architectures), ESE 554 (Computational Models), and ESE 333 (Real-Time Operating Systems) or equivalent. Upon request, the instructor might wave the prerequisites.

Covered Topics:

1) **Introduction to Co-Design**:
   a. Problem description, goals of co-design, co-design steps, existing co-design approaches, and present challenges.
2) **System Modeling and Specification**:
   a. Models of computation (Signal flow graphs, Data flow model, Task graphs, Finite State Machines, hierarchical models).
3) **Architectures for Embedded Systems**:
   a. Single processor – coprocessor architecture, mixed-signal architectures, multiprocessor architectures, reconfigurable architectures, Systems on Chip.
   b. Report 1 on embedded mixed-signal architectures.
4) **Performance Modeling**:
   a. System-level performance modeling vs. low-level performance modeling.
   b. Modeling of system latency, energy consumption etc for hardware and software.
   c. Modeling of analog and mixed-signal systems.
   d. Estimation of memory requirements.

5) **System-Level Synthesis and Trade-off Analysis**:
   a. Design of customized digital and analog blocks.
   b. Hardware/software partitioning. Task binding.
   c. IP core integration and communication synthesis: Hardware and software interface synthesis.
   d. Hardware IP core synthesis: High-level synthesis: behavioral specification of hardware, module set allocation, resource binding, operation scheduling, controller design.
   e. *Reports 2 and 3 on various embedded design tasks*.

Other Course Material:

1) Other relevant papers will be provided in class.

Grading:

$$\text{Final grade} = 0.25\ \text{Report}_1 + 0.25\ \text{Report}_2 + 0.25\ \text{Midterm} + 0.25\ \text{Final}$$

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