EE249 F07

EMBEDDED SYSTEM DESIGN: MODELS, VALIDATION AND SYNTHESIS

Location: TuTh 11-12:30P, Tu 5-6P, Th 4-6PM,
521 Cory Hall

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Units: 4 **CCN:** 25782, 25785

Embedded systems are electronics systems that sense physical quantities, elaborate the data and respond to the environment by sending commands to actuators. These computing systems are everywhere: in our homes, automobiles, and work place. Their complexity increases steadily: a top-of-the-line car electrical system may include more than 80 processors that control its power train (engine and transmission) as well as its stability (suspension and chassis), interior functionality (air conditioning, displays), stability, communication (cellular) and entertainment; the comfort and security of a modern building requires the installation of thousands of sensors reporting measurements to central computers that run sophisticated control algorithms for energy-use optimization and safety functions. New methods are needed to allow designing reliable and secure distributed systems quickly, inexpensively and, most importantly, with no errors to avoid recalls and expensive retrofits. We argue that a novel system theory is needed that at the same time is computational and physical, bringing together the traditional computer science abstraction, where the physical world has been carefully and artfully hidden, and classical system theory that deals with the physical foundations of engineering where quantities such as time, power and geometric dimensions play a fundamental role in the models upon which this theory is based. ***The basis of this theory cannot be but a set of novel abstractions that partially expose the physical reality to the higher levels and methods to manipulate the abstractions and link them in a coherent whole.***

This class presents approaches to the new system science based on theories, methods and tools that were in part developed at the Berkeley Center for Hybrid and Embedded Software Systems (CHESS) and the Giga-scale System Research Center (GSRC) where heterogeneity, concurrency, multiple levels of abstraction play an important role and where a set of correct-by-construction refinement techniques are introduced as a way of reducing substantially design time and errors. Real-life applications including car electronics and building automation are used to illustrate system-level design methodologies and tools.

CLASS ORGANIZATION	
Part 1: Introduction	Design complexity, Example of embedded systems, traditional design flow, Platform-Based Design
Part 2: Functional modeling, analysis and simulation	Introduction to models of computation. Finite State Machines and Co-Design Finite State Machines, Kahn Process Networks, Data Flow, Petri Nets, Hybrid Systems. Unified frameworks: the Tagged Signal Model, Agent Algebra
Part 3: Architecture and performance abstraction	Definition of architecture, examples. Distributed architecture, coordination, communication. Real time operating systems, scheduling of computation and communication.
Part 4: Mapping	Definition of mapping and synthesis. Software synthesis, quasi static scheduling. Behavioral synthesis. Communication Synthesis and communication-based design
Part 5: Verification	Validation vs Simulation. Verification of hybrid system. Interface automata and assume guarantee reasoning.
Part 6: Applications	*Automotive*: car architecture, communication standards (CAN, FlexRay, AUTOSAR), scheduling and timing analysis *Building automation*: Communication (BanNet, LonWorks, ZigBee). Applications to monitoring and security

The course is graded on assignments and on a final project (We expect a number of projects will be eventually published in Conference Proceedings). The Tuesday afternoon sessions are devoted to the presentation of important papers in the literature. The quality of class presentation on the papers is expected to be part of the grade. The student will gain experience on actual system designs through graded laboratories (Thursday afternoon sessions) dealing with realistic design examples and case studies. During lab sessions, students will use and analyze various design academic and industrial tools. There are no pre-requisite for this course but some exposure to the basics of real-time embedded system and an inclination to formal reasoning is welcome. At the end of the course the student will have an understanding of the system-level design issues in the areas of specification, validation and system implementation.

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