Embedded System Design and Modeling

EE382N.23, Unique 16725, Fall 2019

Lectures: TTh 12:30-2:00pm, ECJ 1.316

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Background

Embedded computer systems are ubiquitous and deeply integrated into many devices we interact with on a daily basis. They often have to provide strict correctness and real-time guarantees while operating under stringent performance, energy or other resource constraints. Associated challenges demand formal and automated methods for programming and design of such systems. The basis for any formal and automated design process are, however, first and foremost well-defined models that allow predicting system behavior before it is built or deployed.

This course covers theory and practice of system-level design of embedded systems. With an emphasis on the formal modeling foundations and design automation solutions, the course will present methods and techniques for specification, synthesis and performance modeling at the system level. State-of-the-art design languages and design automation tools will be introduced and used in the labs to specify, simulate, analyze, model and synthesize systems based on typical embedded application examples. Specifically, the labs will involve taking a deep learning based visual object recognition application and mapping it onto a cluster of edge devices representing a smart camera network in an Internet-of-Things (IoT) setting.

Catalog Description and Course Topics

Formal methods and design automation techniques for specification, modeling, synthesis, and electronic system-level (ESL) design of embedded systems:

- Models of Computation (MoCs), concurrency and time: finite state machines (FSMs), process networks, dataflow;
- System-level design languages (SLDLs): discrete event and synchronous reactive simulation semantics;
- System refinement and modeling, virtual platform prototyping and system simulation: processor and OS modeling, transaction-level modeling (TLM) for communication;
- System-level synthesis: algorithms for partitioning, scheduling, design space exploration, and embedded hardware and software synthesis;
- System-level design tools, examples and case studies.

Prerequisites

- Fundamentals of embedded & real-time systems and software
  (EE445M/EE380L.6 Real-time Operating Systems, or equivalent);
- Working knowledge of C/C++, algorithms and data structures
  (EE422C Software Design and Implementation, or equivalent);
- Fundamentals of digital hardware design and hardware description languages
  (EE460M Digital System Design using VHDL, or equivalent).

Textbooks

Recommended

1. D. D. Gajski, S. Abdi, A. Gerstlauer, G. Schirner, *Embedded System Design: Modeling, Synthesis, Verification*, ISBN 978-1-4419-0503-1, Springer, 2009.

Optional

2. E. A. Lee, S. A. Seshia, *Introduction to Embedded Systems: A Cyber-Physical Systems Approach*, Second Edition, ISBN 978-0-262-53381-2, MIT Press, 2017.
3. P. Marwedel, *Embedded System Design: Embedded Systems, Foundations of Cyber-Physical Systems, and the Internet of Things*, Third Edition, ISBN 978-3-319-56045-8, Springer, 2018.
4. A. Gerstlauer, R. Doemer, J. Peng, D. Gajski, *System Design: A Practical Guide with SpecC*, ISBN 978-0-7923-7387-1, Springer, 2001.
5. T. Groetker, S. Liao, G. Martin, S. Swan, *System Design with SystemC*, ISBN 978-1-4020-7072-1, Springer, 2002.

Grading and Academic Dishonesty Policies

Homeworks:	20%
Labs:	20%
Midterm:	20%
Project:	40%

Late submissions will not be accepted. Oral discussion of homework problems is encouraged but make sure to submit your own individual and independent solution. Labs and final projects can be done in teams. Collaboration on projects is encouraged. Copying of any part of a solution without explicit reference to its source is plagiarism and considered cheating.

Outline and Schedule (Tentative)

Week	Dates	Topic
1	Aug 29	Introduction: embedded systems, system-level design
2	Sep 3, 5	System-level design methodologies
3	Sep 10, 12	System specification, Models of Computation (MoCs)
4	Sep 17, 19	Process-based, process network & dataflow MoCs
5	Sep 24, 26	State-based, hierarchical & concurrent state machine MoCs
6	Oct 1, 3	System-level design languages
7	Oct 8, 10	System refinement and implementation modeling
8	Oct 15, 17	Task, OS and processor modeling
9	Oct 22, 24	Communication and transaction-level modeling
10	Oct 29, 31	System synthesis, mapping and decision making
11	Nov 5, 7	Partitioning, scheduling, design space exploration
12	Nov 12, 14	Review, **Midterm**
13	Nov 19, 21	Network-level and IoT design
14	Nov 26	System Design Tools, *Thanksgiving holiday*
15	Dec 3, 5	**Project presentations**

Electronic Mail Notification Policy

In this course e-mail will be used as a means of communication with students. You will be responsible for checking your e-mail regularly for class work and announcements. The complete text of the University electronic mail notification policy and instructions for updating your e-mail address are available at http://cio.utexas.edu/policies/university-electronic-mail-student-notification-policy.

Use of Canvas and Class Web Site

This course uses the class web page and Canvas to distribute course materials, to communicate and collaborate online, to submit assignments and to post solutions and grades. You will be responsible for checking the class web page and the Canvas course site regularly for class work and announcements. As with all computer systems, there are occasional scheduled downtimes as well as unanticipated disruptions. Notification of disruptions will be posted on the Canvas login page. Scheduled downtimes are *not* an excuse for late work. However, if there is an unscheduled downtime for a significant period of time, I will make an adjustment if it occurs close to the due date.

Students with Disabilities

The University of Texas at Austin provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact the Services for Students with Disabilities (SSD) at 471-6259, http://diversity.utexas.edu/disability.

Religious Holidays

Religious holy days sometimes conflict with class and examination schedules. If you miss an examination, work assignment, or other project due to the observance of a religious holy day you will be given an opportunity to complete the work missed within a reasonable time after the absence. It is the policy of The University of Texas at Austin that you must notify each of your instructors at least fourteen days prior to the classes scheduled on dates you will be absent to observe a religious holy day.

Counseling and Mental Health

Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful. If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. The Counseling and Mental Health Center (CMHC) provides counseling, psychiatric, consultation, and prevention services that facilitate students' academic and life goals and enhance their personal growth and well-being: http://cmhc.utexas.edu/.

Classroom Evacuation and Emergency Preparedness

All occupants of university buildings are required to evacuate a building when a fire alarm and/ or an official announcement is made indicating a potentially dangerous situation within the building. Familiarize yourself with all exit doors of each classroom and building you may occupy. Remember that the nearest exit door may not be the one you used when entering the building. If you require assistance in evacuation, inform your instructor in writing during the first week of class. For evacuation in your classroom or building:

1. Follow the instructions of faculty and teaching staff.
2. Exit in an orderly fashion and assemble outside.
3. Do not re-enter a building unless given instructions by emergency personnel.

Emergency evacuation route information and emergency procedures can be found at http://www.utexas.edu/emergency and https://preparedness.utexas.edu.