# Embedded System Design and Modeling

**EE382N.23, Unique 16893, Fall 2015**

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**Lectures**: MW 3:00-4:30pm, RLM 5.114

**Instructor**: Andreas Gerstlauer <gerstl@ece.utexas.edu>
Office hours: M 4:30-5:30pm, W 2:00-3:00pm, POB 6.118

**Teaching Assistant**: Zhuoran Zhao <zhuoran@utexas.edu>
Office hours: TBD

**Class webpage**: http://www.ece.utexas.edu/~gerstl/ee382n_f15/

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## Background

Embedded computer systems are ubiquitous, integrated into many devices we interact with on a daily basis. With ever increasing application demands and advances in semiconductor technology, such systems are more than ever realized as application-specific, heterogeneous multi-processor systems-on-chip (MPSoCs). Exponentially growing complexities, tight constraints and rising chip design costs, however, have made traditional implementation approaches infeasible and instead demand novel, well-defined and formal methods for (parallel) programming and design of complete systems across hardware and software boundaries.

This course covers theory and practice of system-level design of embedded multi-processor and multi-core systems. Focusing on the necessary modeling foundations to enable design automation, the course will present state-of-the-art methods and techniques for specification, synthesis and performance modeling at the system level. In the labs, the SpecC and SystemC languages and the System-On-Chip Environment (SCE) will be used to specify, simulate, analyze, model and synthesize systems based on typical embedded application examples.

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## Catalog Description and Course Topics

Methods and techniques for formal specification, modeling, and electronic system-level (ESL) design of embedded systems:

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

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## Prerequisites

- Embedded & real-time system and software design
  (EE345M/EE380L.6 Real-time Operating Systems, or equivalent);
- Working knowledge of C/C++, algorithms and data structures
  (EE322C Data Structures, or equivalent);
- Digital hardware design and hardware description languages
  (EE360M 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 978-1-312-42740-2, 2015.
3. P. Marwedel, *Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems*, ISBN 978-94-007-0257-8, Springer, 2011.
4. A. Gerstlauer, R. Doemer, J. Peng, D. Gajski, *System Design: A Practical Guide with SpecC*, ISBN 0-7923-7387-1, Kluwer, 2001.
5. T. Groetker, S. Liao, G. Martin, S. Swan, *System Design with SystemC*, ISBN 1-4020-7072-1, Kluwer, 2002.

**Grading**

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|---|---|
| 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 26 | Introduction: embedded systems, design methodologies |
| **2** | Aug 31, Sep 2 | The SpecC system-level design language |
| **3** | Sep 7, 9 | Simulation and execution semantics, discrete event |
| **4** | Sep 14, 16 | System specification, Models of Computation (MoCs) |
| **5** | Sep 21, 23 | Process-based, KPN, dataflow MoCs |
| **6** | Sep 28, 30 | State-based, FSM, StateChart MoCs |
| **7** | Oct 5, 7 | System refinement, virtual platform prototyping |
| **8** | Oct 12, 14 | Performance modeling and estimation |
| **9** | Oct 19, 21 | Computation refinement, host-compiled OS & processor models |
| **10** | Oct 26, 28 | Communication refinement, transaction-level modeling |
| **11** | Nov 2, 4 | System synthesis, mapping, partitioning and scheduling |
| **12** | Nov 9, 11 | Design Space Exploration |
| **13** | Nov 16, 18 | System design tools, hardware/software synthesis |
| **14** | Nov 23, 25 | **Project presentations** |
| **15** | Nov 30, Dec 2 | Review, **Midterm** |

**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://www.utexas.edu/its/policies/emailnotify.html.

**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://ddce.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.

**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 http://www.utexas.edu/safety/preparedness/.