UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

DOTTORATO DI RICERCA / PHD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

Course announcement

Title: Industrial Embedded Systems Design with the ARM Architecture

Lecturer: prof. Mario Barbareschi

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Short CV: Mario Barbareschi is a Tenured Assistant Professor of Computer Systems the Department of Electrical Engineering and Information Technologies of the University of Naples Federico II. He received the Ph.D. in Computer and Automation Engineering in 2015 from the University of Naples Federico II. His research interests include Hardware Security and Trust, Approximate Computing, emerging technologies, and embedded systems. He participates in international projects, collaborating with academic institutions and several industrial partners. He has authored more than 80 peer-reviewed papers published in leading journals and international conferences.

Credits: 4

Overview:

The course offers attendees the opportunity to delve into the intricacies of ARM-based microcontroller utilization, a cornerstone in modern embedded system design. Through its comprehensive program, the course aims to equip participants with a robust understanding of pipeline stages of Cortex-M core, the Embedded Application Binary Interface (EABI) principles, alongside fundamental concepts in C-Assembly optimization. Furthermore, students will engage in a practical exploration of designing an embedded operating system, serving as a compelling case study to reinforce theoretical foundations. Participants in the course will receive embedded boards featuring processors based on the ARM Cortex M3 architecture.

The relevance of this course extends beyond theoretical comprehension, offering practical insights essential for developing cutting-edge embedded systems tailored for Internet of Things (IoT) and edge applications. In an era marked by the proliferation of battery-powered, resource-constrained devices, adeptness in ARM-based microcontroller utilization becomes indispensable.

Moreover, with a focus on safety-critical systems, students will be introduced with open challenges and will gain valuable insights into ensuring the reliability and robustness of their embedded solutions, vital for mission-critical applications.

The final assessment for the course will be structured around a self-assigned project, providing students with the opportunity to explore topics close to their own research activities and aptitudes, as well as their own curiosity. Moreover, in association with the fourth lecture, students will be challenged with a homework assignment.

Lectures will be held in the Aula Seminari, I floor, DIETI, building 3/A, Via Claudio 21, 80125 Naples.

Schedule

Lecture	Date	Time	Topics
1	3/6, 11:00-12:00	1h	Introduction to Industrial Embedded System
2	7/6, 9:30-11:30	2h	Embedded System Design: Architectures and Technologies
3	10/6, 11:00-14:00	3h	ARM Architecture: EABI and GNU GCC Compiler
4	12/6, 9:30-12:30	3h	Essentials for an Embedded Operating System
5	13/6, 9:30-12:30	3h	C code optimization on ARM Cortex
6	14/6, 9:30-12:30	3h	Safety-Critical Applications based on Cortex M architecture
7	26/6, 9:30-11:30	2h	Assessment test

Content details

Lesson 1 – Introduction: participants will be introduced to the course, the assessment method, the main topics covered in the lectures, and the software environments for developing embedded projects on the board. Q&A

Lesson 2 – Embedded System Design: Architectures and Technologies: Embedded Systems and enabling technologies; memory, processing units, and peripherals in embedded architectures. Programming Languages for Embedded Systems: C/C++, Assembly. Basics of C programming language tailored for embedded systems. High-Level Languages and Development Tools: model-based design. Future Trends and Emerging Technologies: Internet of Things (IoT), edge computing, and Artificial Intelligence in embedded systems. Q&A.

Lesson 3 – ARM Architecture: EABI and GNU GCC Compiler: The ARM architecture basics: the Advanced RISC Machine philosophy. Thumb and extensions. The Cortex M core: internal architecture, Embedded Application Binary Interface. Interrupt service routine and Nested Vector Interrupt Controller. Q&A. Hands on: Thumb Instruction Set encode and GNU-GCC ARM cross compiler. Example of embedded software compilation and on-board execution.

Lesson 4 – Essentials for an Embedded Operating System: Operating system: goals and requirements. Implementing the context switch and task loading. Introduction to task scheduler approaches. Inter process communication mechanisms. Security and dependability hints; energy optimizations.

Lesson 5 – C code optimization on ARM Cortex: register pressure. C Functions: global functions, local functions and inline functions. Compiler driven optimization: hot and cold functions. Const and pure functions. Calling optimization: head and tail calls, function crossing. Branch optimization: likely and unlikely conditions. Q&A

Lesson 6 – Safety-Critical Applications based on Cortex-M architecture: safety-critical system requirements. Architectures for safety-critical application: redundancy and self-testing. Cortex-M safety-related functionalities. Hands on Memory Protection Unit. Q&A

Assessment: the final lesson is dedicated to the assessment. Attendees will present their own work by means of discussion of about 10 minutes.

Participants are requested to join by May, 31st 2024, the following MS Teams group: https://teams.microsoft.com/l/team/19%3APtuDja8o6qLQ3-hHISLx-8NtODemHEVy0_jp0L9axNo1%40thread.tacv2/conversations?groupId=9060aa30-275f-4d47-834f-e0d41b286e03&tenantId=2fcfe26a-bb62-46b0-b1e3-28f9da0c45fd

Once accepted in the Teams group, students must fill the following .xlsx file with their own information (i.e., Student name and surname, e-mail, name of the PhD course, PhD cycle): https://communitystudentiunina.sharepoint.com/:x:/r/sites/IndustrialEmbeddedSystemsbasedontheARMArchitecture/_layouts/15/Doc2.aspx?action=editNew&sourcedoc=%7B9a569cf1-14dd-4bef-af37-1380d7117643%7D&wdOrigin=TEAMS-MAGLEV.teamsSdk_ns.rwc&wdExp=TEAMS-TREATMENT&wdhostclicktime=1710774467492&web=1

The course is conducted on-site. However, students pursuing their PhD period abroad (for research purposes) have the option to request remote attendance for classes via MS Teams.

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