

ESD

Embedded & IoT Systems Design (EISD)

EDALAB

UNIVERSITÀ di VERONA
Dipartimento di INFORMATICA

Franco Fummi

1 October '20

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ESD

Goals

- Methodologies and tools for modelling and design of CPPSs and IIoT:
 - hw/sw modelling
 - hw/sw design
 - IoT sensor-edge-cloud infrastructure
 - CPPS modeling, simulation, integration

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Embedded & IoT Systems: Where?

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ES: Historical perspective

- From computer ('60-'80):
 - General purpose systems for solution of general problems
- To digital control systems ('80-'90):
 - Systems dedicated to control and automation
- To distributed systems ('90-'00):
 - General purpose systems and/or dedicated systems operating through the network
- To embedded systems ('00-):
 - Distributed systems integrated in the environment
- To cyber-physical systems ('10-):
 - Embedded systems integrated with physical systems
- To IoT systems ('20-):
 - Smart everywhere

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Not everything is IoT (or IIoT)

- No** Air conditioner activated by smartphone is IoT?
- No** Vibration sensors reporting to a PLC is IIoT?
- Yes** Air conditioner communication to a service provider for automatically regulating turn on/off according to power consumption from other appliances?

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How Relevant (I)

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How Relevant (I)

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How Relevant: The Four Industrial Revolutions

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ES/IoT: How to design?

- We cannot design embedded systems like general purpose systems
 - Different design constraints, different goals
 - Embedded design is about the system, not about the computer
- E.g.
 - In general purpose computing, design often focuses on building the fastest CPU
 - In embedded systems the CPU simply exists as a way to implement control algorithms communicating with sensors and actuators

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ES/IoT: Design constraints

- Size and weight
 - Hand-held electronics
 - Weight costs money in transportation
 - Human body cannot eat desktops
- Power
 - Buttery power instead of AC
- Harsh environment
 - Power fluctuation, RF interferences, heat, vibration, water, ...
- Safety critical and real time operations
- Low costs

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ES/IoT: Designer knowledge

- HW architecture alternatives
 - for a correct HW/SW trade-off
- SW design skills
 - lots of languages continuously extending
- HW/SW interaction mechanisms
 - O.S., MW, HdS for efficient SW development
- Network infrastructure
 - all ES are now networked embedded systems
- Computation effort estimation
 - theory is important when used in practice
- Join 3C: computation, control & communication

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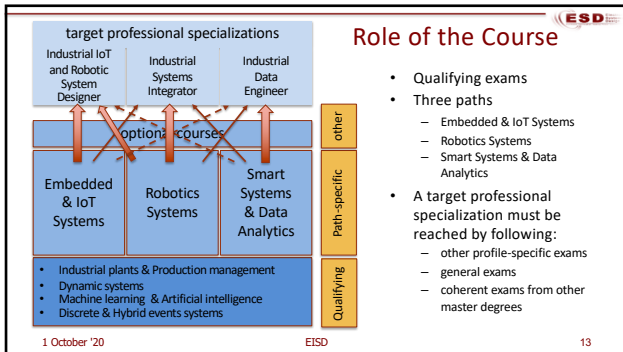
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Course Structure

- 35 lectures:
 - 30 theory hours
 - 20 lectures
 - 22 practical hours
 - 11 lectures
 - 6 seminar hours
 - 4 lectures
- People:
 - Franco Fummi (theory)
 - Stefano Spellini (lab. classes)
 - Alessia Bozzini / Marco panato (lab. classes)
 - for practical elaborations
 - Industrial support

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Assessment methods and criteria (I)

- To pass the exam, the students must show:
 - they have understood the principles of embedded and IoT system architectures
 - they are able to model and simulate a complex embedded and IoT system
 - they are able to design, verify and test a complex digital device
 - they are able to develop embedded software interacting with network and operating system
 - they are able to apply the acquired knowledge to solve application scenarios in the context of Industry 4.0

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Assessment methods (II)

- Theory + lab. + options:
 - theory
 - written exam 18-30
 - laboratory report
 - max +3 points
 - on demand
 - extra practical work 0 +∞
 - (oral exam) +3 -∞
- General rules:
 - laboratory report cannot be more than 1-year long
 - reports must be provided at fixed times

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Assessment methods (III)

- Alternatives:
 - Personal practical work
 - company stage
 - thesis
 - Theory
 - no way :-)
- Design&Reuse:
 - thesis implementation
 - pre-thesis stage
 - cross-exam practical work

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Benchmark and Labs.

- Virtual platforms:
 - Smart devices:
 - the Open Source Test Case 6502
 - RISC Core:
 - Risc-V
- Laboratories:
 - Cyber-Physical
 - NES/Parco
 - ESD
 - Industrial Computer Engineering (ICE)

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ICE – Course Contribution

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Simulation with Real Data

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ICE lab: IoT Data Viewer

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Data Collection Architecture

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2021 News

Handbook of Hardware/Software Codesign
 Semiformal Assertion Based Verification of Hardware/Software Systems in a ModelDriven Design Framework
 Pravadelli, G., Quaglia, D., Vigna, S., Fummi, F.

Completely Updated set of slides

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Topics (theory)

- Embedded and IoT Systems Modeling:**
 - Course introduction
 - Embedded systems modeling
 - SysML for systems modeling
- System Level Description Languages**
 - SystemC-based design
 - SystemC TLM
- Hardware Description Languages:**
 - HDL introduction
 - VHDL syntax
 - verilog syntax
 - HDL timing simulation
- Register Transfer Level Synthesis:**
 - RTL synthesis: VHDL
 - RTL synthesis: Verilog
- High-Level Synthesis:**
 - High-level synthesis (HLS) introduction
 - High-level synthesis scheduling
 - High-level synthesis allocation
 - High-level synthesis application
- Platforms and Virtual Platforms:**
 - Virtual platform modeling: IP-Xact
 - Virtual platform design and FMI
 - SystemVerilog introduction
 - SystemVerilog main characteristics
 - SystemC & Verilog AMS
- Embedded Software:**
 - Embedded software modeling
 - Model based design of embedded software
 - Embedded AI software modeling
- Industry 4.0 – CPPSs:**
 - Industry 4.0: software hierarchy
 - Industry 4.0: digital twin
 - IoT and Industrial IoT
 - IoT and Cloud
- Seminars:**
 - UVM for Digital Systems (Ogheri)
 - Plant simulation (ICE)
 - Edge/Cloud embedded architecture (Kratech)
 - Control Industrial Software (ASEM)

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Topics (lab.)

- SystemC compilation/execution/debugging
- SystemC modeling at TLM
- VHDL modeling
- verilog modeling and simulation
- Pynq Platform: FPGA synthesis
- Pynq Platform: C/C++ High-level synthesis
- SystemC/AMS - verilog AMS
- Virtual platform: 6502
- SysML CPPS modeling and design
- Model-based design: Matlab/Simulink/FMI
- Embedded AI application design
- Control Sw Generation

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Detailed Program

week	date	day	lecture	lab.	topic
1	2-Oct	Fri.	2		Course introduction: Embedded systems modeling I
1	5-Oct	Mon.	1		Embedded systems modeling II
1	5-Oct	Mon.	2		SystemC for systems modeling: SystemC-based design I
2	8-Oct	Fri.	2		SystemC-based design II: SystemC TLM I
2	12-Oct	Mon.	1		SystemC TLM II
2	12-Oct	Mon.	2		HDL introduction: VHDL syntax
3	16-Oct	Fri.			HO
3	16-Oct	Mon.	1		verilog syntax I
3	16-Oct	Mon.	2		SystemC compilation: newcos/compiler/bugging
4	23-Oct	Fri.	2		verilog syntax II: HDL timing simulation
4	26-Oct	Mon.	1		RTL synthesis: VHDL
4	26-Oct	Mon.	2		SystemC modeling: all TLM
5	30-Oct	Fri.	2		RTL synthesis: verilog: High-level synthesis (HLS) introduction
5	2-Nov	Mon.	1		High-level synthesis scheduling & allocation
5	2-Nov	Mon.	2		VHDL modeling
6	6-Nov	Fri.	2		High-level synthesis application: Virtual platform modeling: IP-Xact
6	9-Nov	Mon.	1		Virtual platform design: IP-Xact
6	9-Nov	Mon.	2		verilog modeling and simulation
7	13-Nov	Fri.			Intermediate exam
7	13-Nov	Mon.	1		SystemVerilog introduction
7	16-Nov	Mon.	2		FPGA Platform: FPGA synthesis
8	20-Nov	Fri.	2		SystemVerilog: main characteristics: SystemC & Verilog/AMS
8	23-Nov	Mon.	1		Embedded software modeling
8	23-Nov	Mon.	2		FPGA Platform: SoC+ High-level synthesis
9	27-Nov	Fri.			Seminar: UVM for Digital Systems
9	30-Nov	Mon.	1		Method-based design of embedded software
9	30-Nov	Mon.	2		SystemC/AMS - verilog AMS

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- ### Teaching supports (I)
- Course web page
 - Detailed program
 - Complete program
 - E-learning web page
 - Slides
 - Laboratory instructions
 - Questions/answers
 - Book
 - Published
 - Seminars
 - Indications during the course
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More information

<http://www.di.univr.it/~fummi>

Embedded & IoT Systems Design (2020/2021)

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For the stronger ...

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For the strongest...

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