ESD Electronic Systems Design
Synthesis Verification Testing Power Communication

Progettazione di Sistemi Embedded
embbedded systems design

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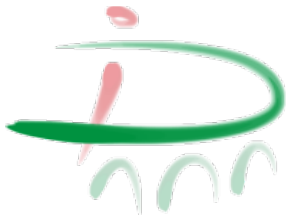


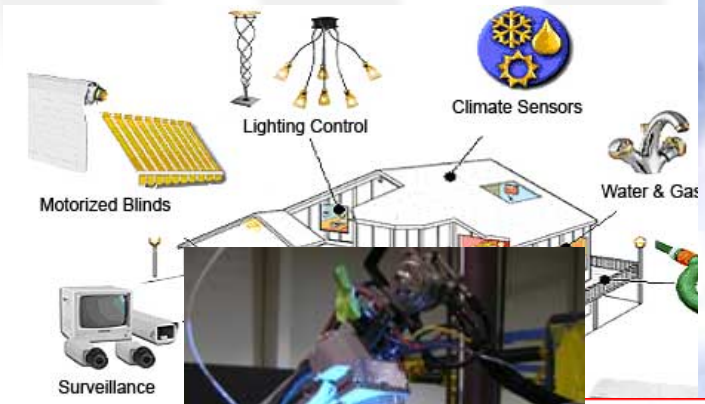
EDALab
Networked Embedded Systems

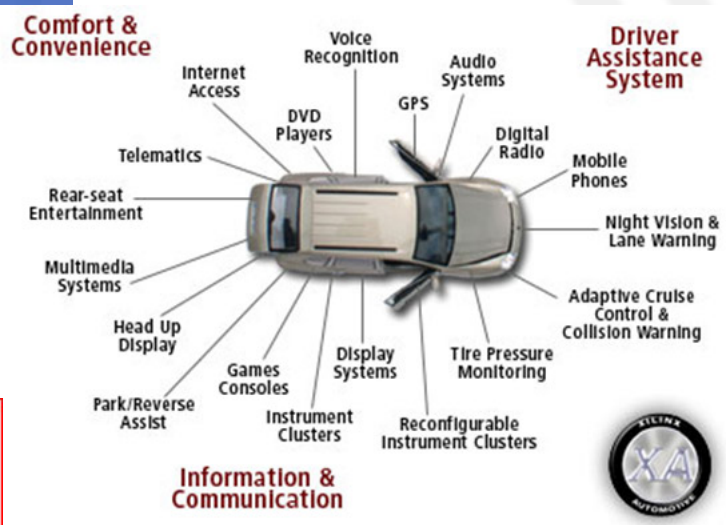
Laurea Magistrale in Ingegneria e Scienze Informatiche
Embedded Systems Design Course

Goals

- Techniques for the automatic design of embedded systems:
  - starting from their specification throughout:
    - validation / verification
    - automatic synthesis
    - testing
- This lecture is focused on:
  - most important design languages
  - most evolved tools for their manipulation

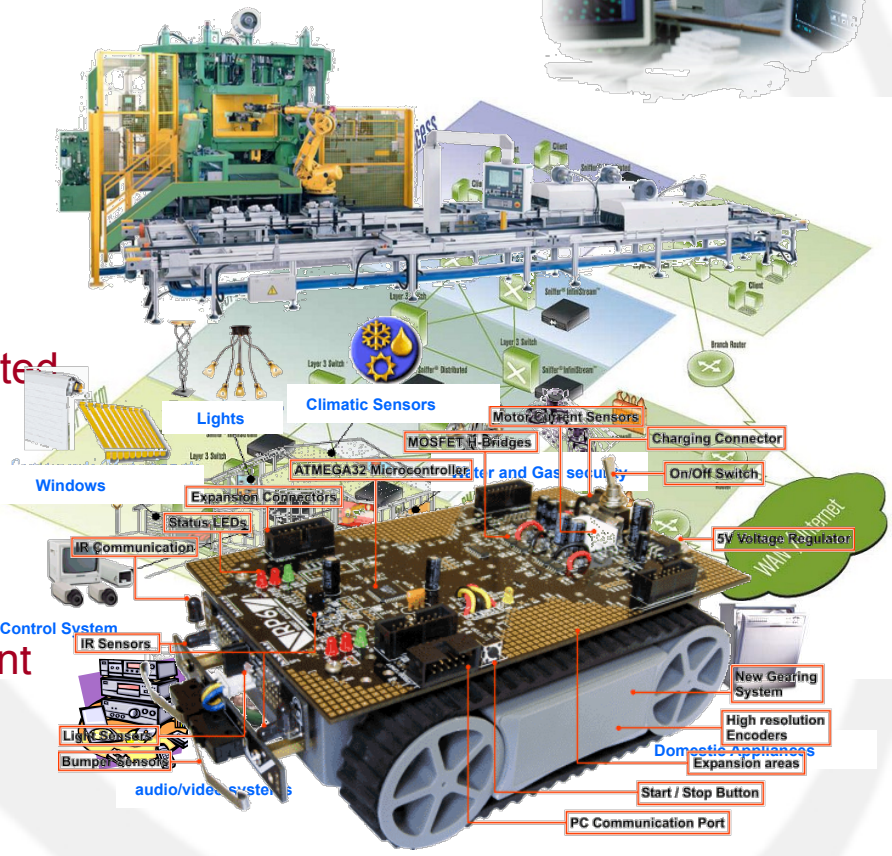
Embedded Systems: Where?





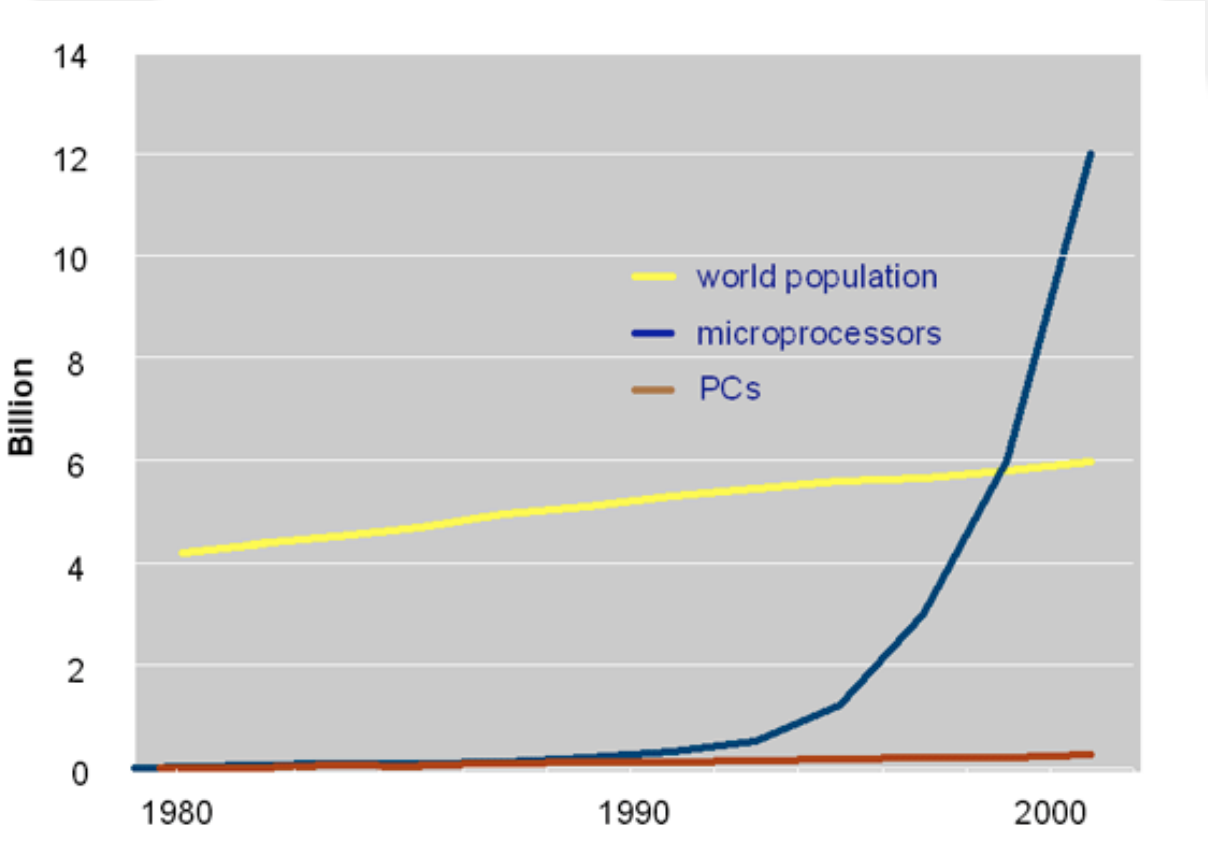
ES: Historical perspective

- 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 cooperating through the network
- To embedded systems (’00-):
  - Distributed systems integrated in non computing objects and in the environment
- To cyber-physical systems (’10-):
  - embedded systems integrated with physical processes

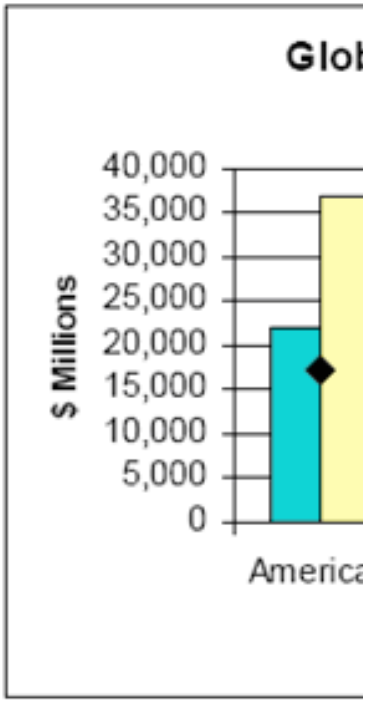


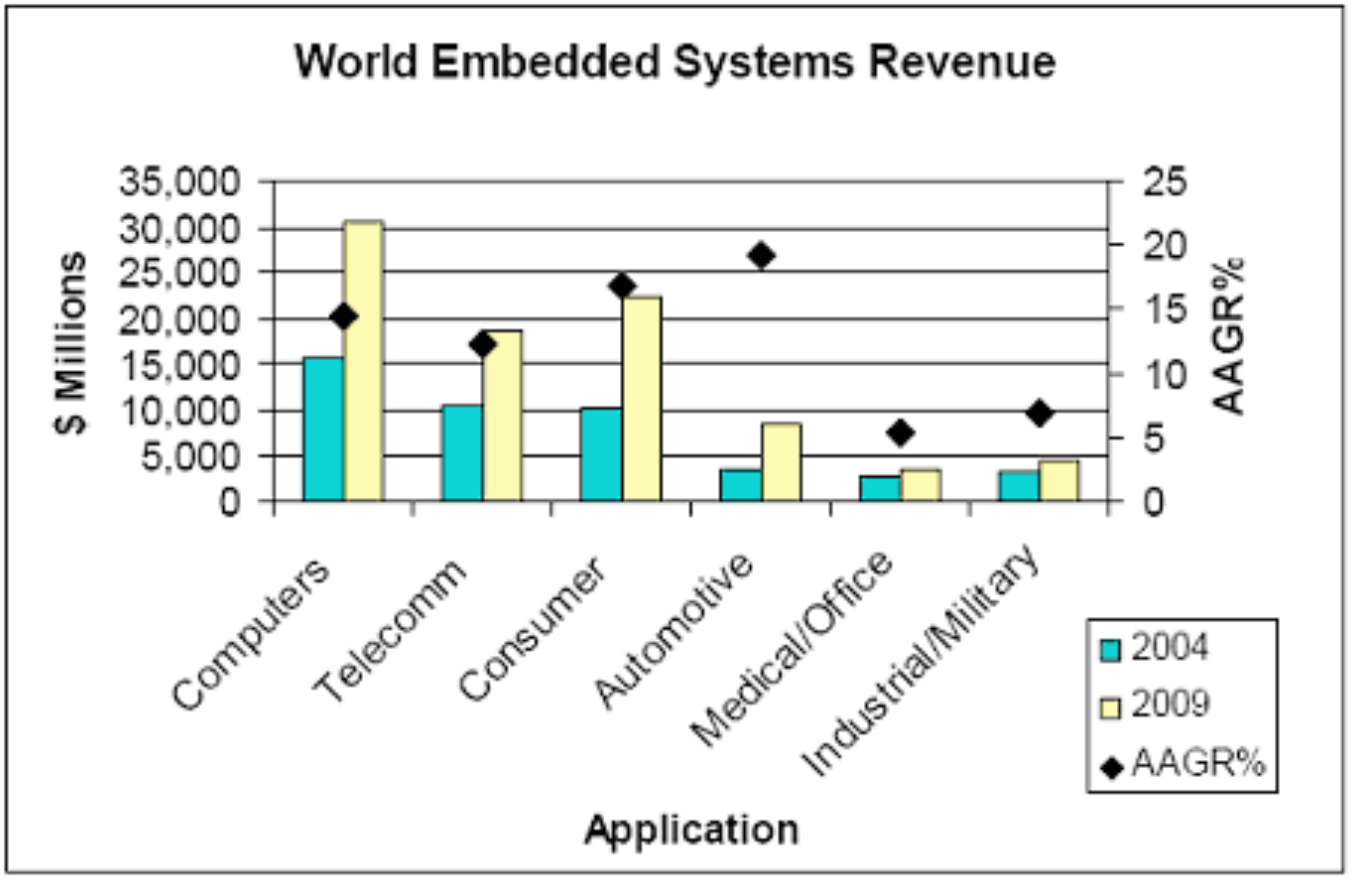
ES: History

- First comp
  Systems:
  - not show
    to the pa
    compute
- The Apollo
  the world's
  - small siz
    devoted
- Mass prod
  - 1961 witl
- No stop…



ES Market

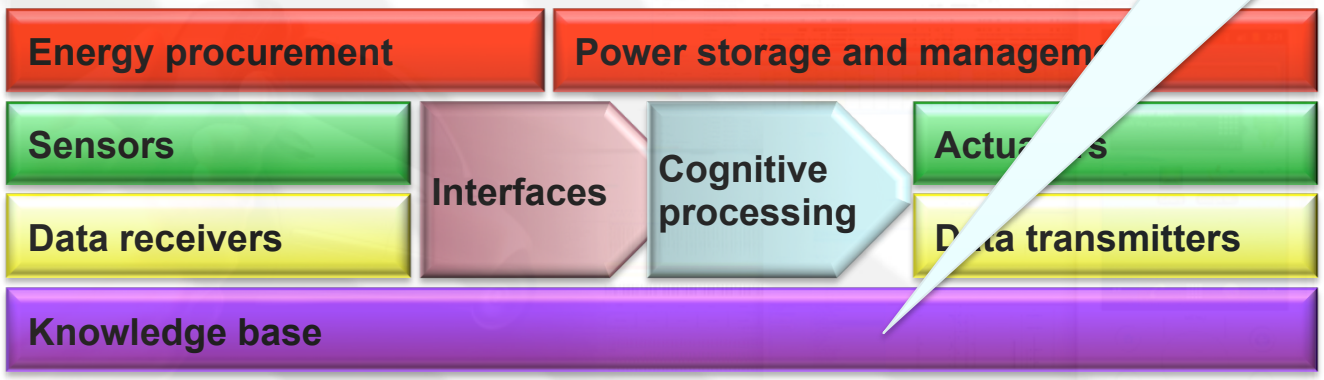




Embedded software			
Embedded IC			
Embedded boards			
Total Revenues	45,873	88,144	14.0

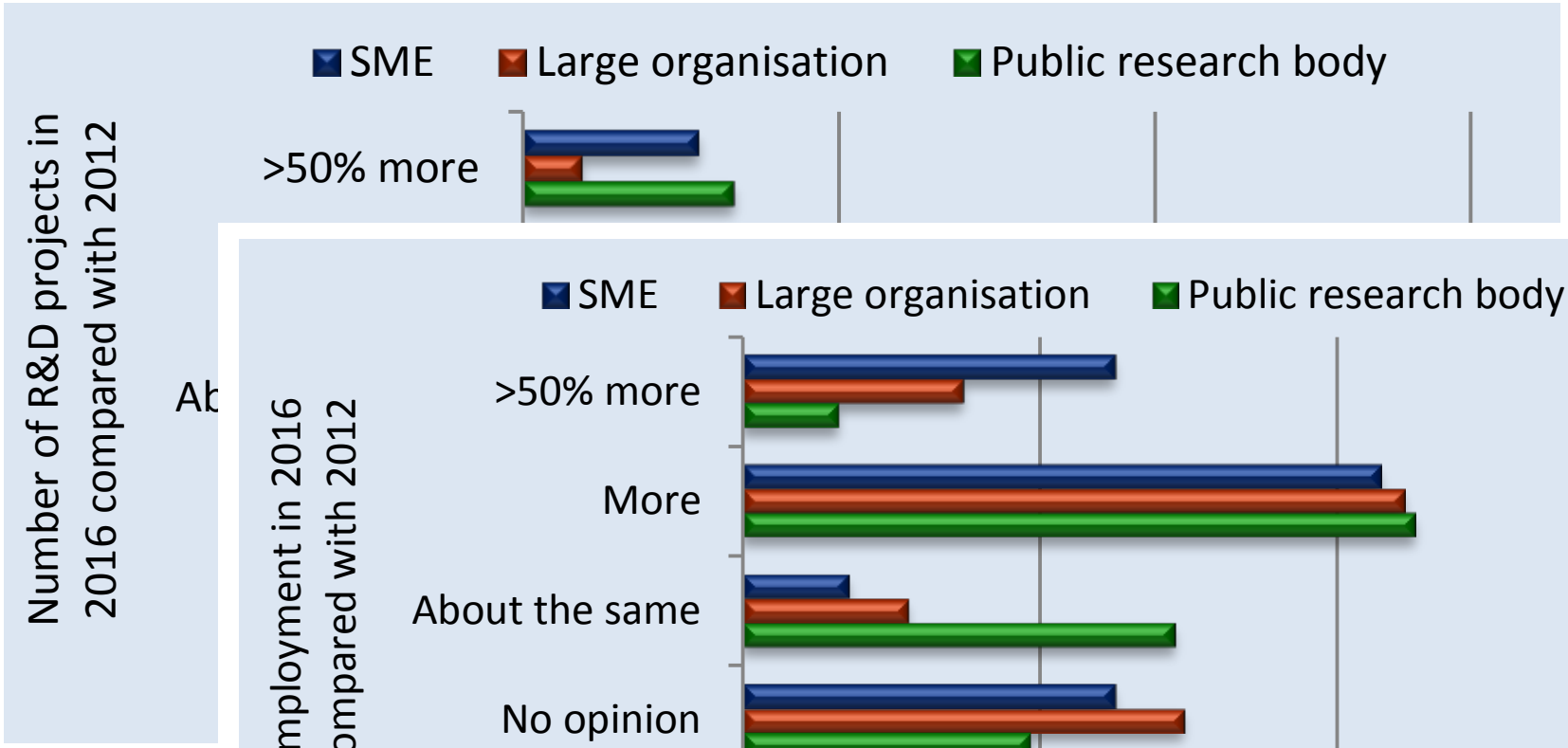
From ES to Smart Systems

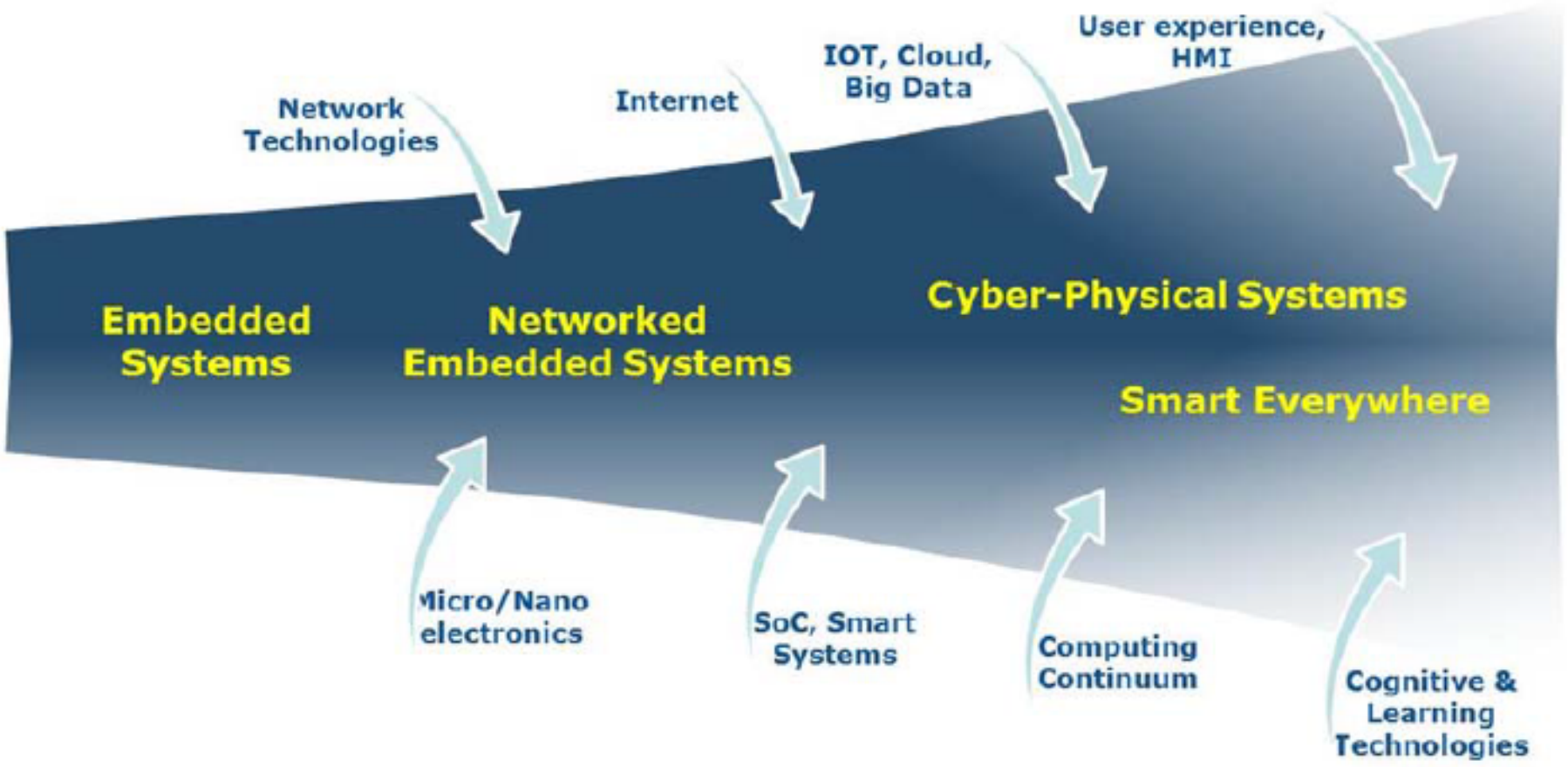
- Miniaturized self-sufficient device that
  - Incorporates **functions** of sensing, actuation, and control
  - To describe and analyze a situation, an
    decisions based on the available data
  - In a **predictive** or adaptive manner (sm
  - Energy-**autonomous** and ubiquitously



Knowledge base separates smart systems from systems which, although they may be automated, remain purely reactive

Grow in smart system R&D




Network Technologies
Internet
IOT, Cloud, Big Data
User experience, HMI
Embedded Systems
Networked Embedded Systems
Cyber-Physical Systems
Smart Everywhere
Micro/Nano electronics
SoC, Smart Systems
Computing Continuum
Cognitive & Learning Technologies

How Relevenat (I)

How Relevant (II)

- & progetti europei completati e attivi:
  - Angel, Vertigo, Coconut, C4C, Complex, SMAC, Contrex
- 2 progetti europei in FP6
  - ANGEL (mobile gateway for sensors network)
  - VERTIGO (HW formal verification)
- 5 progetti europei in FP7
  - COCONUT (embedded systems design and verification)
    - best evaluation of the overall embedded systems track
  - C4C (control for coordination of distributed systems)
  - COMPLEX (platform-based design space exploration)
  - SMAC (smart systems design)
  - CONTREX (mixed-criticality systems)

ES: 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

ES: 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

ES: 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

Course Structure

- 34 lectures:
  - 32 theory hours
    - 22 lectures
  - 24 practical hours
    - 12 lectures
- People:
  - Franco Fummi (theory)
  - Michele Lora (laboratory class)
  - … for practical elaborations

Modalità di Esame (I)

- Teoria + lab. + opzioni:
  - teoria
    - scritto con votazione /30
  - relazione laboratorio
    - +3 punti max
  - on demand
    - elaborato 0 +∞
    - (orale) +3 -∞
- Regole generali:
  - elaborato dura 1 anno accademico
  - consegna in date stabilite

Modalità di Esame (II)

- Alternative:
  - Elaborato personale
    - stage aziendale
    - tesi
  - Teoria
    - no way :-)
- Design&Reuse:
    - tesi
    - stage pre-tesi

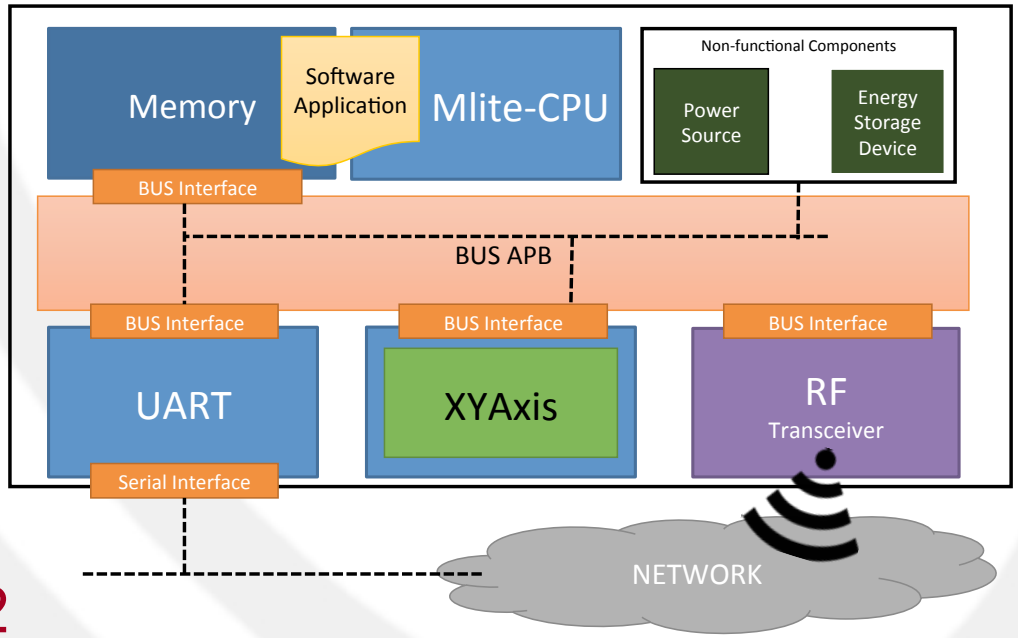
COMPUTER SCIENCE PARK

Pre/post Condizioni

- Precedenze Indispensabili:
  - Architettura degli Elaboratori
  - Programmazione
  - Linguaggi ...
  - Sistemi (Metodi di specifica)
- Fondamentale per
  - Curriculum sistemi embedded (magistrale in Ingegneria)
    - Sistemi operativi avanzati, Architetture avanzate, Software per Sistemi Embedded, Sistemi Embedded Multimediali, Sistemi Embedded di Rete…

A Challenging Benchmark

- Smart devices:
  - The Open Source Test Case (SMAC project)
- Laboratorio Ciberfisico:
  - Secondo piano CV2



Detailed Program

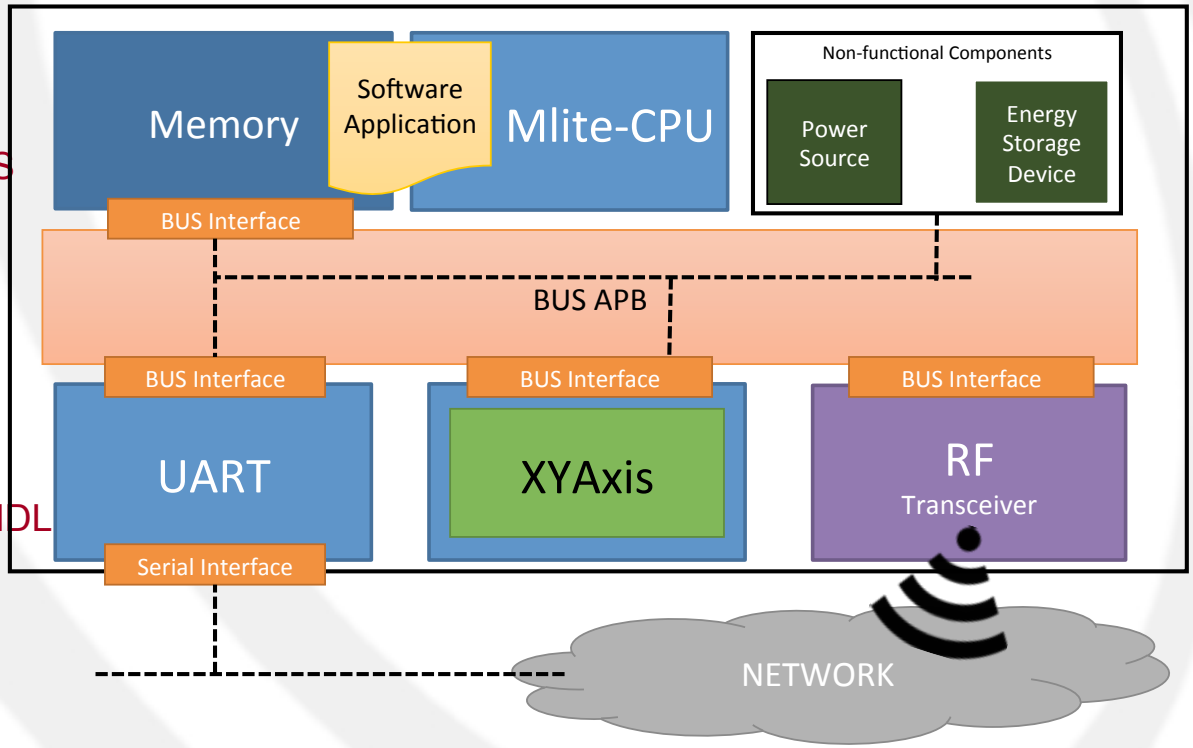
week	data	day	lecture	lab.	topic
1	2-Oct	Fri.	3		Course introduction; Embedded systems modeling
2	7-Oct	Wed.	2		Embedded systems modeling II; SystemC-based design
2	9-Oct	Fri.	3		SystemC-based design II; SystemC-based design III
3	14-Oct	Wed.		2	SystemC modeling at RTL
3	16-Oct	Fri.	3		Platform-based design; Transactional-based design; TLM 2.0 standard
4	21-Oct	Wed.		2	SystemC compilation/execution/debugging
4	23-Oct	Fri.	3		TLM 2.0 standard II; SystemC/AMS support
5	28-Oct	Wed.		2	SystemC timing evolution
5	30-Oct	Fri.			An embedded architecture for cars managing
6	4-Nov	Wed.		2	SystemC modeling at TLM
6	6-Nov	Fri.	3		High-level synthesis (HLS): scheduling; High-level synthesis: allocation
7	11-Nov	Wed.		2	SystemC/AMS
7	13-Nov	Fri.	3		Software embedded synthesis; Model-based design (MBD) of embedded software; HMI design
8	18-Nov	Wed.		2	SystemC/AMS and IP-Xact
8	20-Nov	Fri.			**intermediate exam**
9	25-Nov	Wed.		2	Mixed RTL/TLM/AMS SystemC
9	27-Nov	Fri.			Cyber-physical systems: models of computations
10	2-Dec	Wed.		2	Platform, testbench and device driver (OSTC)
10	4-Dec	Fri.	3		VHDL introduction; VHDL syntax
11	9-Dec	Wed.		2	Embedded software design
11	11-Dec	Fri.	3		VHDL modeling; VHDL timing simulation
12	16-Dec	Wed.		2	VHDL modeling at RTL
12	18-Dec	Fri.	2		VHDL timing simulation II; VHDL synthesis
13	8-Jan	Fri.			GPGPU: design problems and opportunities
14	13-Jan	Wed.		2	VHDL timing simulation
14	15-Jan	Fri.	2		Networked embedded systems (NES); Middleware for embedded systems
15	20-Jan	Wed.		2	Automatic synthesis from RTL and TLM
15	22-Jan	Fri.	2		Introduction to embedded systems verification; Introduction to embedded systems testing
16	27-Jan	Wed.			NO
16	29-Jan	Fri.			**final exam**
	hours	56	**32**	**24**	
	credits	6,0	**4,0**	**2,0**	

Topics (theory)

- Specification:
  - Embedded systems modeling
  - SystemC-based design
  - TLM design introduction
  - TLM 2.0 standard
  - VHDL modeling
  - VHDL syntax
  - Networked ES (NES)
  - Smart systems
- HW synthesis:
  - Introduction to TLM design
  - High-level synthesis
  - Automatic VHDL synthesis
- SW synthesis:
  - Embedded software generation
  - Automatic device driver generation
  - Middleware for embedded systems
  - Model-based design
  - HMI deisgn
- Verification & testing:
  - Introduction to verification
  - Introduction to testing
  - VHDL timing simulation
  - RTL-TLM mixed simulation
  - Embedded software verification

Topics (lab.)

- Specification:
  - Compiling / executing /debugging SystemC
  - Modeling SystemC TLM
  - Modeling SystemC RTL
  - Timing evolution in SystemC
  - Analog modeling in SystemC/AMS
  - Platforms and IP-Xact
  - Mixed modeling RTL/TLM/AMS
  - Timing modeling in VHDL
- Hardware synthesis:
  - Automatic synthesis from TLM
  - VHDL modeling at RT
  - Automatic synthesis from RTL VHDL
- Software synthesis:
  - Testbench and device driver
  - Model based design: radCASE
  - Embedded software design



Teaching supports (I)

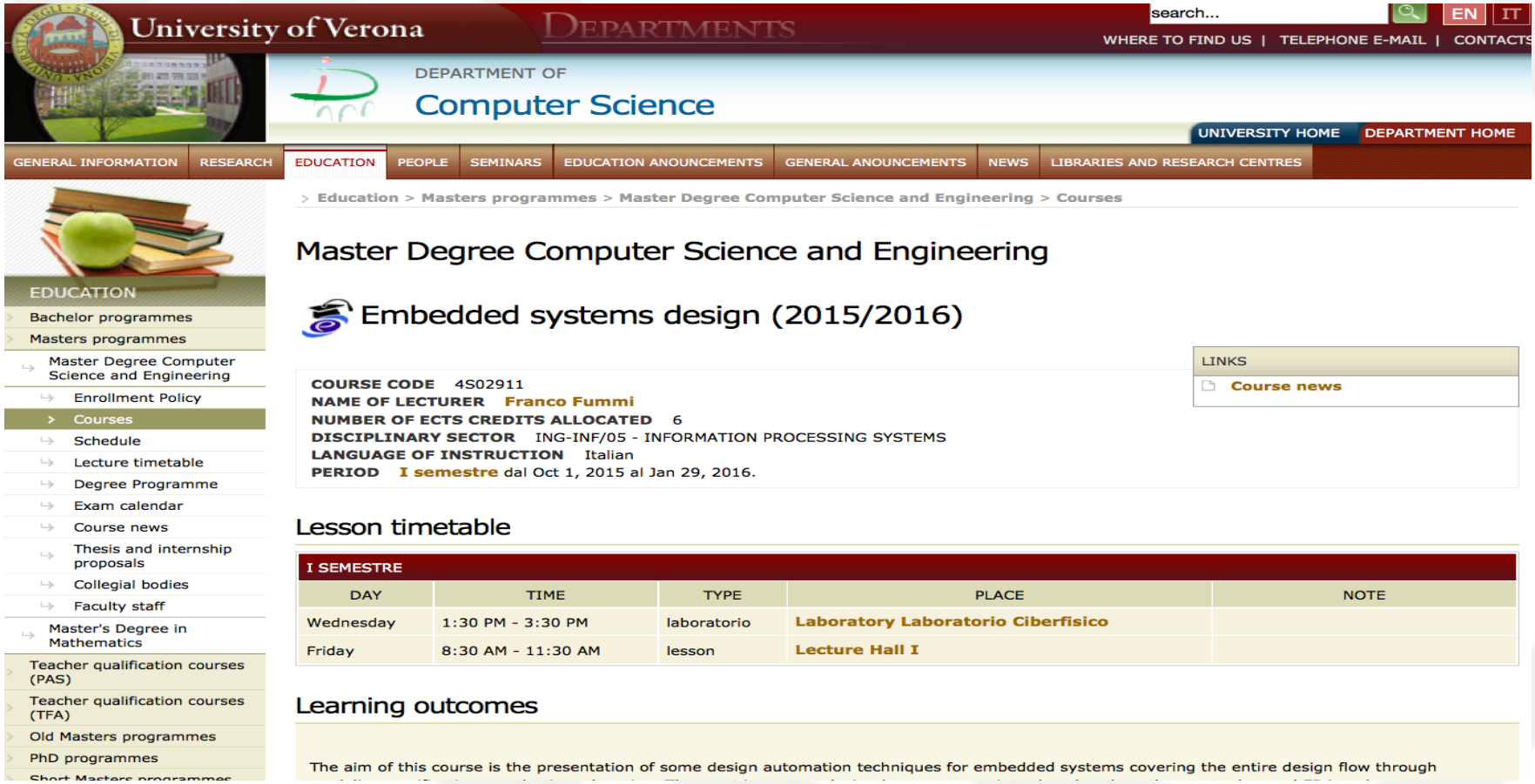
- Course web page
  - Detailed program
  - Complete program
- E-learning web page
  - Slides
  - Laboratory instructions
  - Questions/answers
- Seminars
  - Indications during the course

Teaching supports (II)

- Theory slides:
  - 0.CourseIntroduction
  - 1.EmbeddedSystemsModeling
  - 2.SystemCBasedDesignFlow
  - 3.PlatformBasedDesign
  - 4.TLMBasedDesign
  - 5. SystemC/AMS
  - 6.HighLevelSynthesis
  - 7.EmbeddedSoftware
  - 8.ModelBasedDesign
- Theory slides:
  - 9.VHDLDesignIntroduction
  - 10.VHDLSyntax
  - 11.VHDLSpecification
  - 12.VHDLSimulation
  - 13.VHDLSynthesis
  - 14.NESDesign
  - 15.SmartSystems
  - 16.VerificationAndTesting

More information

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



For the stronger ...

7994

Tuesday
8:30 – 10:30

In the
corridors...
running

franco.fummi@univr.it

For the strongest…

7048

Monday
10.00 – 11.00

On the e-learning

michele.lora@univr.it