Master Programmes Computer Engineering and Embedded Systems

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Note

- Although they will officially still exist as separate programmes for one more year, starting from Sep. 2022, the master programmes Computer Engineering and Embedded Systems will share the same curriculum.

- It is expected that, starting Sep. 2023, both programs will officially merge into one master named Computer and Embedded Systems Engineering.

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Outline

- What is Computer Engineering and Embedded Systems?
- CE&ES versus other MSc. programmes
- Curriculum MSc. CE&ES
- CE&ES research groups
- Thesis projects
- Entry requirements
- Some statistics

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Computer Engineering
Putting software and hardware together to make computers

Hardware
Computer Arch., Logic design, Heterogeneous architectures, Quantum computing etc.
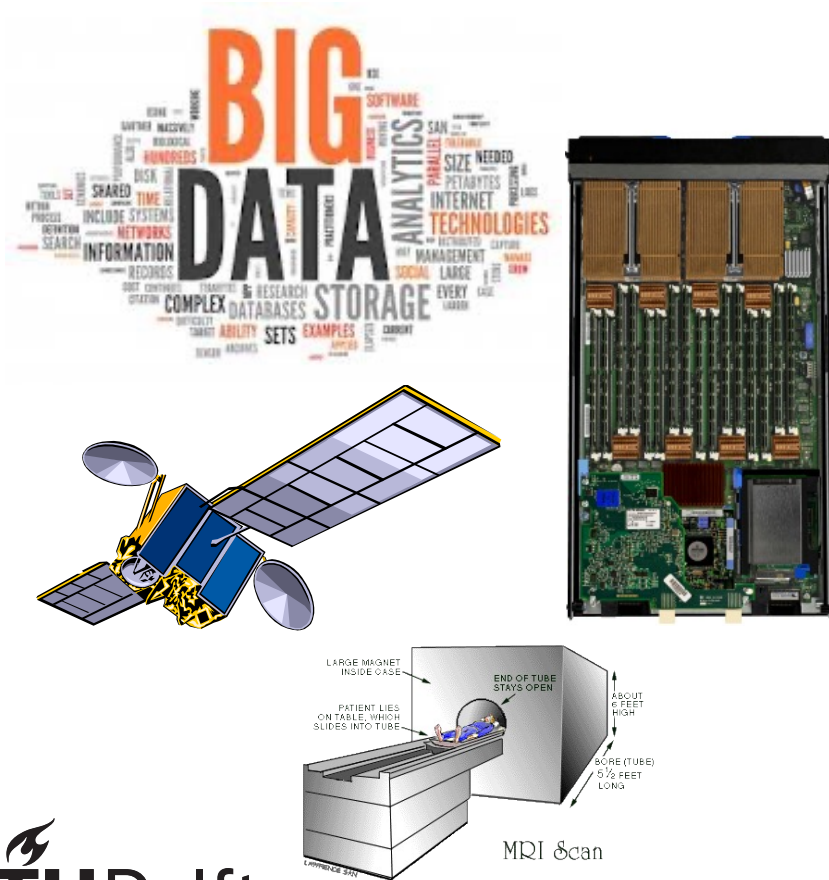
Software
Compilers, Operating Systems

Design tools & Methodologies
Design tools, Logic synthesis, HW/SW partitioning

Communication Networks
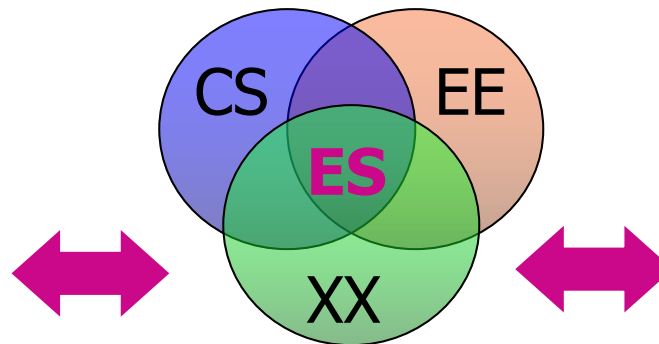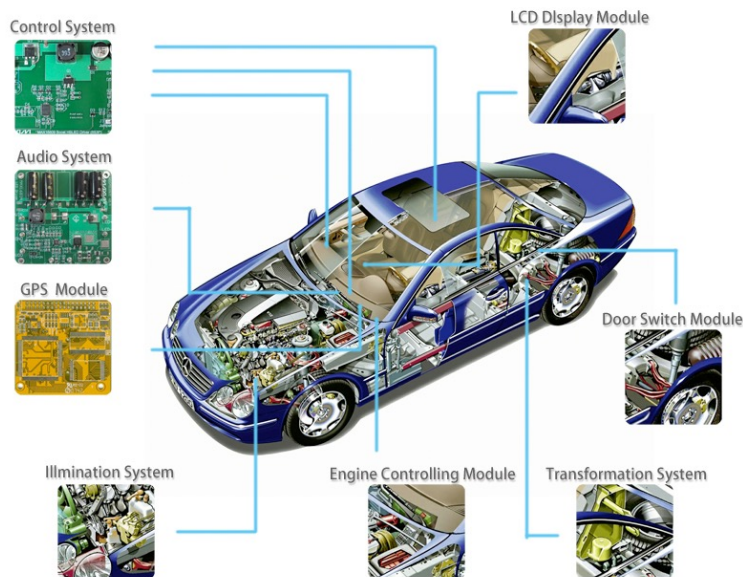Network Arch., QoS, Mobile Networks, etc.

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Embedded Systems
Computer systems, embedded in other systems to determine their functionality

E.g. systems to control:
- car functionalities
- the automatic pilot of an aircraft
- a robot

- a smartphone
- a pacemaker
- IoT

Control System

LCD DIsplay Module

Audio System

GPS Module

Door Switch Module

Illmination System

Engine Controlling Module

Transformation System

CS

EE

ES

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Keywords: dependability, multi-disciplinarity, embedded software, system of systems

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MSc. CESE versus other programmes

Electrical Engineering

Computer Science

hardware

software

Computer Engineering
& Embedded Systems
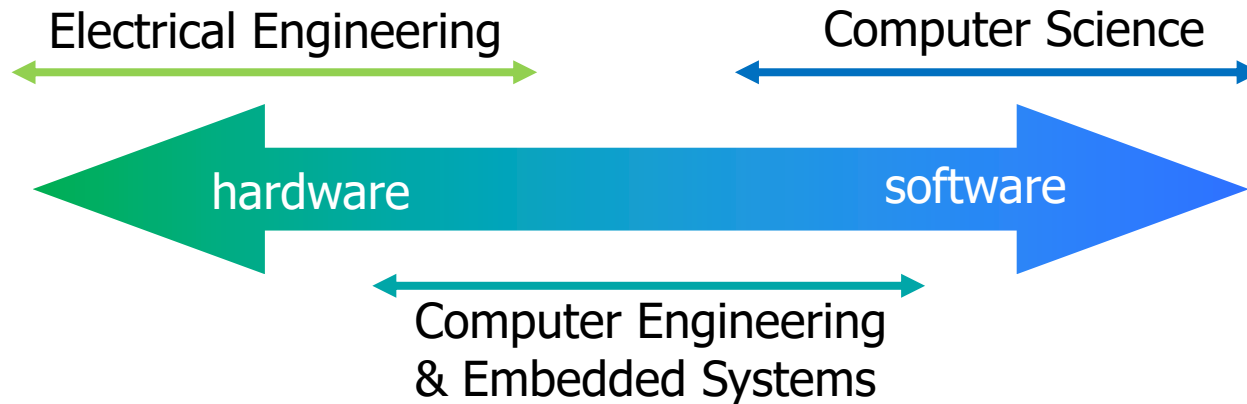
As an CE/ES student:

- you will learn about hardware and software, and their integration

- you will learn how to use hardware and software to control other systems

- you can specialize on many different CS, EE and Systems & Control topics

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Curriculum

First Year (60 EC)			
1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Advanced Computing Systems (5 EC)	Software Systems (5 EC)	Specialization (5 EC)	Effective & Responsible Engineering (5EC)
Systems Engineering (5 EC)	Real-time Systems (5 EC)	Embedded Systems Lab (5 EC)	Specialization (5 EC)
Software Fundamentals (5 EC) or Hardware Fundamentals (5 EC)	Specialization (5 EC)	Computer Arithmetic (5 EC)	Processor Design Project (5 EC)

Second Year (60 EC)			
1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Project, internship, or set of elective courses (e.g. quantum, AI, sustainability, entrepreneurship)	Thesis project (45 EC)		

Duration: 2 years (2 x 60 EC = 120 EC)

Programme

Common core	
System Engineering	5 EC
Effective & Responsible Engineering	5 EC
Software Fundamentals/Hardware Fundamentals (homologation)	5 EC
Advanced Computing Systems	5 EC
Software Systems	5 EC

At least 1 integration set should be chosen:

Integration set 1	
Real-Time Systems	5 EC
Embedded Systems Lab	5 EC

Integration set 2	
Computer Arithmetic	5 EC
Processor Design Project	5 EC

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Specialisation Courses

From one specialization profile, at least 15 EC on specialization courses should be chosen:

- ## Software

  Systems Security, Compiler Construction A, Compiler Construction B, Evolutionary Algorithms, Algorithms for Intelligent Decision-Making, Machine Learning 1, Machine Learning 2, Deep Learning, Seminar: Decentralised Systems, Artificial Intelligence Techniques, Smart Phone Sensing, Software Architecture, Real-Time Software Development, System Validation, and/or Distributed Systems.

- ## Networking

  High-Performance Data Networking, Networking, Measuring and Simulating the Internet, Fundamentals of Wireless Communications, Ad-hoc Networks, Wireless IoT and Local Area Networks, Mobile Networks, Network Security, Performance Analysis of Complex Systems, and/or Networks Advanced Practical IoT and Seminar.

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Specialisation Courses (cont.)

- **Computer Architecture**

  Electronics for Quantum Computing, Digital IC Design, Digital IC Design II, Hardware Architectures for Artificial Intelligence Hardware Dependability,, Methods and Algorithms for System Design, Modern Computer Architectures, Supercomputing for Big Data, VLSI Systems on Chip, High Speed Digital Design for Embedded Systems, Reconfigurable Computing Design, Compilation technology focussed on backend design, Quantum Hardware 1 - Theoretical Concepts, and/or Quantum Hardware 2 - Experimental State-of-the-Art.

- **Control Systems**

  Control System Design, Control theory, Filtering & Identification, Control Systems Lab, Knowledge Based Control Systems, Optimisation for Systems and Control, Non-linear Systems Theory, Modelling and Control of Hybrid Systems, Control Engineering, Networked and Distributed Control Systems, Dynamic Programming and Stochastic Control, Model Predictive Control, and/or Fault Diagnosis and Fault Tolerance Control.

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Other electives

The remaining 15 EC (or 25 EC if only one integration set is chosen) can be filled with e.g.

- Joint Interdisciplinary Project

- Internship

- More specialization courses

- Other CS, EE and System and Control courses

- A few non-technical courses (language, business)

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Research groups for thesis projects

| Group	Department
Algorithms	ST
Circuits and Systems	ME
Computer Engineering	Q&CE
Cyber Security	IS
Distributed Systems	ST
Electronic Instrumentation	ME
Embedded and Networked Systems	ST
Interactive Intelligence	IS
Multimedia Computing	IS
Network Architectures and Services	Q&CE
Quantum Circuits Architecture & Technology	Q&CE
Software Engineering	ST
Cognitive Robotics	(Faculty 3ME)
Delft Centre for Systems and Control	(Faculty 3ME)

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Some Research Topics

- Heterogeneous multi-core systems
  - Which parts of the application will use which hardware resources ?
  - Run-time reconfiguration

- Hardware security

- In-memory computing

- Quantum computing
  - New logic building blocks and architectures are required to build Quantum computers.
  - Intel invested US$50 Million in TU Delft and TNO

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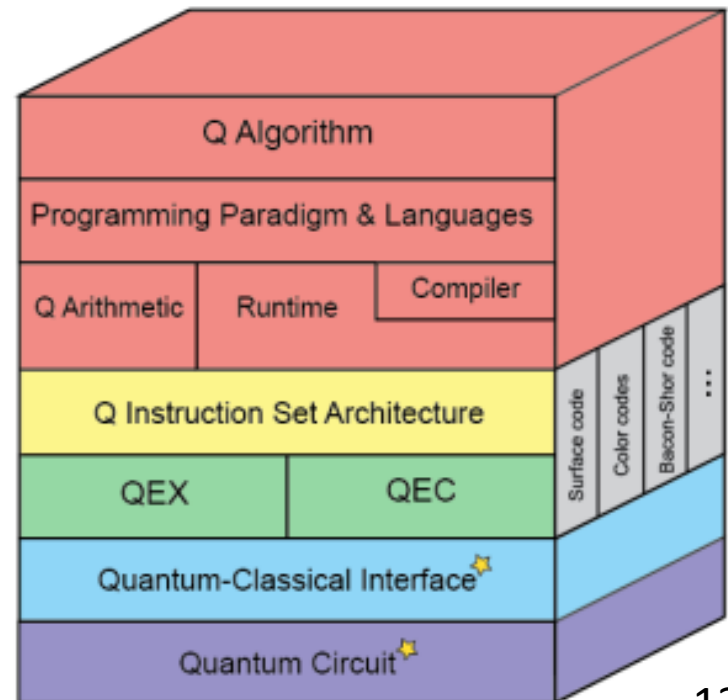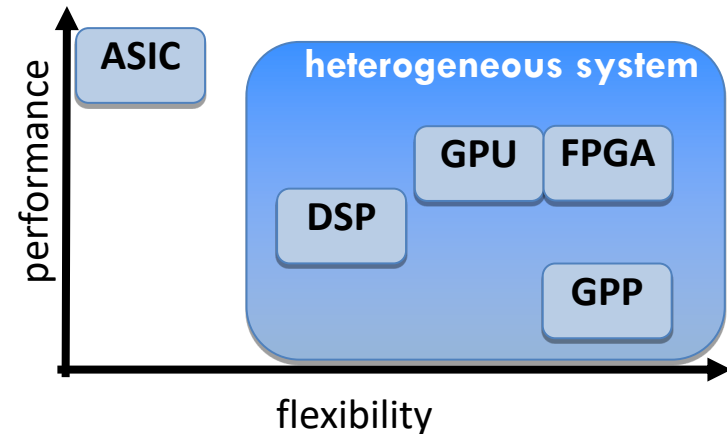
Some Research Topics (cont.)

- Wireless sensor networks
  - self-configuration
  - node localization
  - low-bitrate communication
  - ad-hoc routing
  - in-network data processing
  - time synchronization

- Cyber physical systems
  - medical monitoring
  - mobile-phone sensing
  - robotics

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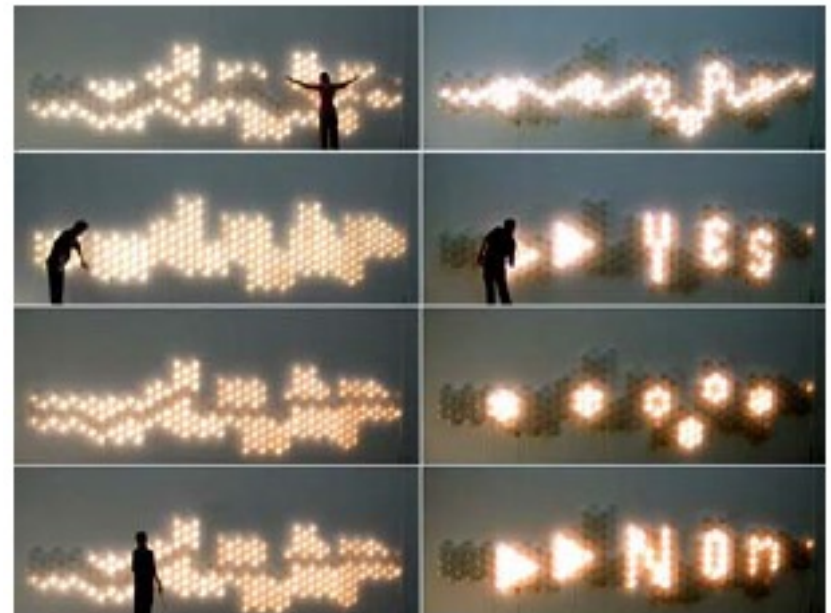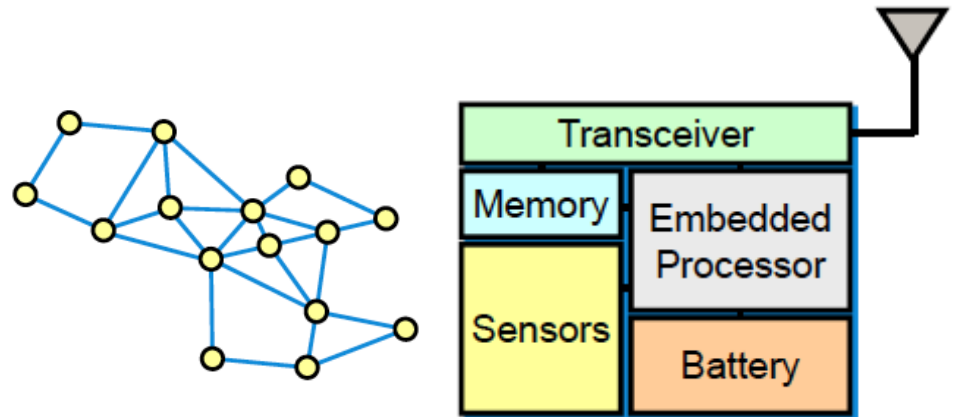
Some Thesis Projects

- Design for Testability for Secure ICs
- Interconnect Test for 3D Stacked Memories
- Porting Linux to the ρ-VEX reconfigurable VLIW softcore
- GPU-Based Simulation of Brain Neuron Models
- Libswift-PPSPP Information Centric Router: SHA1 Accelerator
- Fault-Tolerant On-Board Computer Software for the Delfi-n3Xt Nanosatellite
- Acceleration of Cancer Diagnosis Algorithms on Super Computing FPGA Platforms
- Acceleration of Big Data Algorithms for Behavioral Experiments
- A Quantum Emulation Platform

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Some Thesis Projects (cont.)

- Fault diagnosis of advanced wafer scanners (ASML)
- Hardware Components for Real-Time Stereo Matching: Acceleration of 3D HD TV with FPGAs (IMEC)
- A Cow-Feeding Robot (Lely)
- Profiling of Algorithms for a Biomedical-Implant Architecture
- Control of Suction Distributions on Boundary Layer Suction Systems for Automotive Wind Tunnels (Actiflow B.V.)
- Memory and Power Efficient Architecture for Embedded Microcontrollers
- How to optimize a RFID UHF System for Mass Sports Timing
- Handshake Recognition Applied to Wireless Data Exchange in Smartbands (Shake-On YES!Delft)
- Localization with Wireless Power

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Entry Requirements

B.Sc. in EE → M.Sc. in Computer Engineering and Embedded Systems

B.Sc. in CS → M.Sc. in Computer Engineering and Embedded Systems

B.Sc. in Engin. (Minor CE&ES) → M.Sc. in Computer Engineering and Embedded Systems

B.Sc. in Engin. → Pre-master CE&ES → M.Sc. in Computer Engineering and Embedded Systems

HBO EE → English + Math Test → Bridging Program CE&ES (including mathematics) → M.Sc. in Computer Engineering and Embedded Systems

HBO TI → English + Math Test → Bridging Program CE&ES (including mathematics) → M.Sc. in Computer Engineering and Embedded Systems

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New students per year

	MSc. CE + ES			
	total	NL	Int EU	Non EU
2013/2014	55	33	7	15
2014/2015	80	53	10	17
2015/2016	78	22	12	44
2016/2017	77	31	13	32
2017/2018	95	41	16	38
2018/2019	95	37	28	30
2019/2020	77	51	5	21
2020/2021	90	46	6	28
2021/2022	88	49	10	29

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Who is employing our students?

- Philips
- NXP
- ASML
- ARM
- Alten
- Fox-IT
- Vanderlande
- Rijkswaterstaat
- ABB
- TU Delft

- Technolution
- Erasmus MC
- Intel
- Qualcomm
- NVIDIA
- Synopsys
- WhatsApp
- TomTom
- CERN
- Thales

- Robot Care Systems
- Lely Industries
- Ned. Octrooibureau
- ISIS Space
- Deloitte
- MyOmega Systems
- Imagination Techn.
- Bosch
- BMW
- ....

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Thank you!

See also
https://www.tudelft.nl/en/education/programmes/masters

and https://www.tudelft.nl/en/eemcs/the-faculty/departments/quantum-computer-engineering/sections/computer-engineering/staff/arjan-van-genderen

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