UNIVERSITY OF TWENTE.

4TU MASTER EMBEDDED SYSTEMS

Bert Molenkamp

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- What is an embedded system
- Examples of research topics
- Admission
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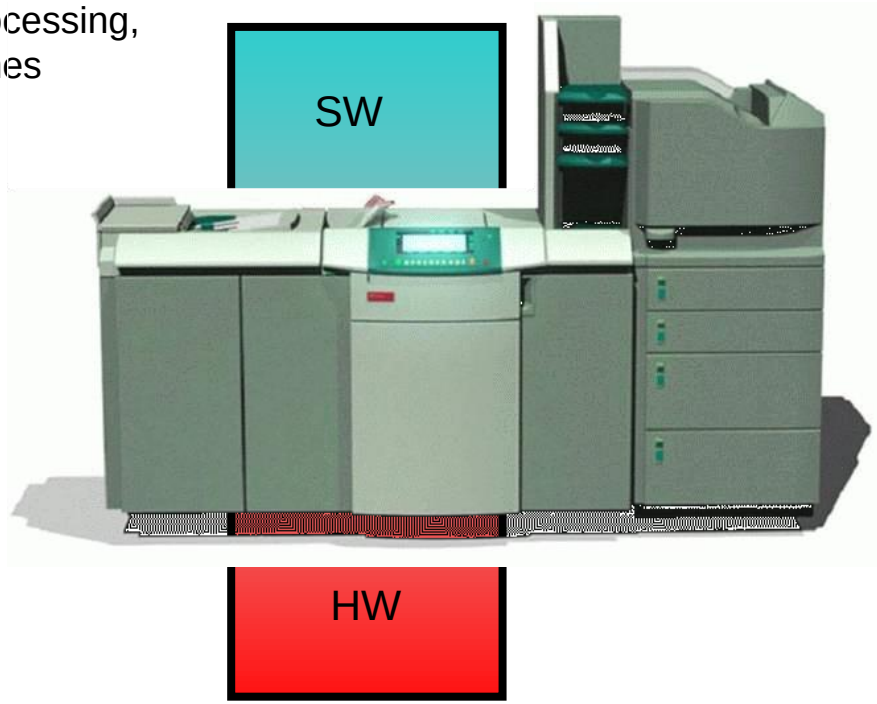
- Success rates

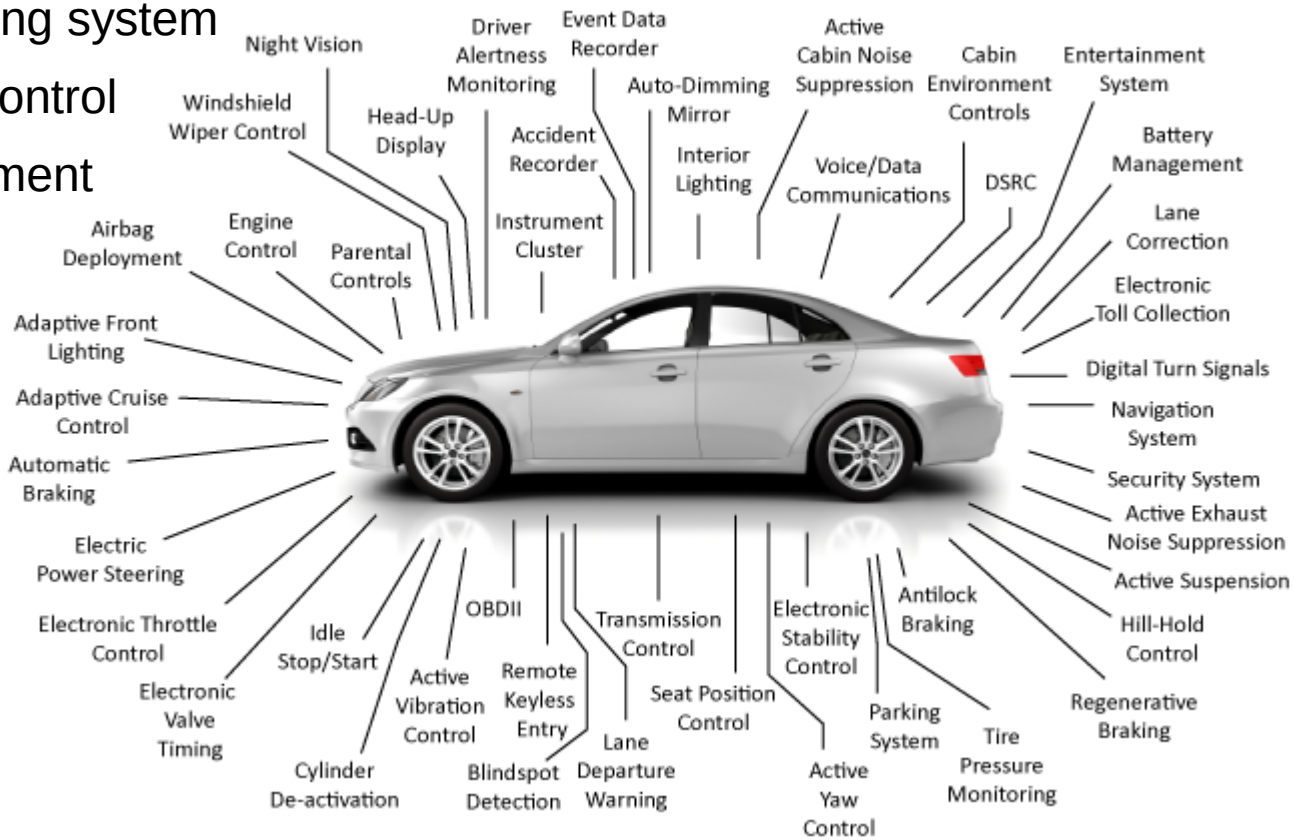
What is an Embedded System?

- Signal Processing in Hardware and / or Software for an application
- Application
  - mobile phone, audio / video processing, cars, robots, production machines
- Software
  - User interface
  - Data processing
  - Machine control
- Hardware
  - I/O
  - ASIC, DSP, FPGA
- Strong demands, e.g
  - Real time
  - Maintainability
  - Costs



A modern car contains many embedded systems

- Intelligent parking system
- ABS/Traction control
- Motor management
- Cruise control
- Navigation
- Airbag
- …



Source: http://www.chipsetc.com/computer-chips-inside-the-car.html

Suzanne Schulting, world champion short track 10 March 2019. European champion 26 January 2020)

- Sjinke Knegt and Suzanne Schulting prepared for the Olympic games (2018) using *Samsung SmartSuit*
- It calculates the distance from the hips to the ice
- 5 sensors and connected to the smartphone of coach

Schulting schreeuwt het uit nadat de wereldtitel binnen is. (Foto: ANP)

https://www.nu.nl/schaatsen/5782803/schulting-als-eerste-nederlandse-vrouw-ooit-wereldkampioen-shorttrack.html

https://en.letsgodigital.org/technology/samsung-smartsuit/

Examples of embedded systems research topics at the UT

- In the final project you will often contribute to ongoing research.
- An overview of the research groups is on:
  - https://www.utwente.nl/en/eemcs/research/
  - Groups that often have embedded systems oriented assignments are (alphabetically) CAES, DACS, DMB, FMT, ICD, PS, RAM
- On the next slides some examples

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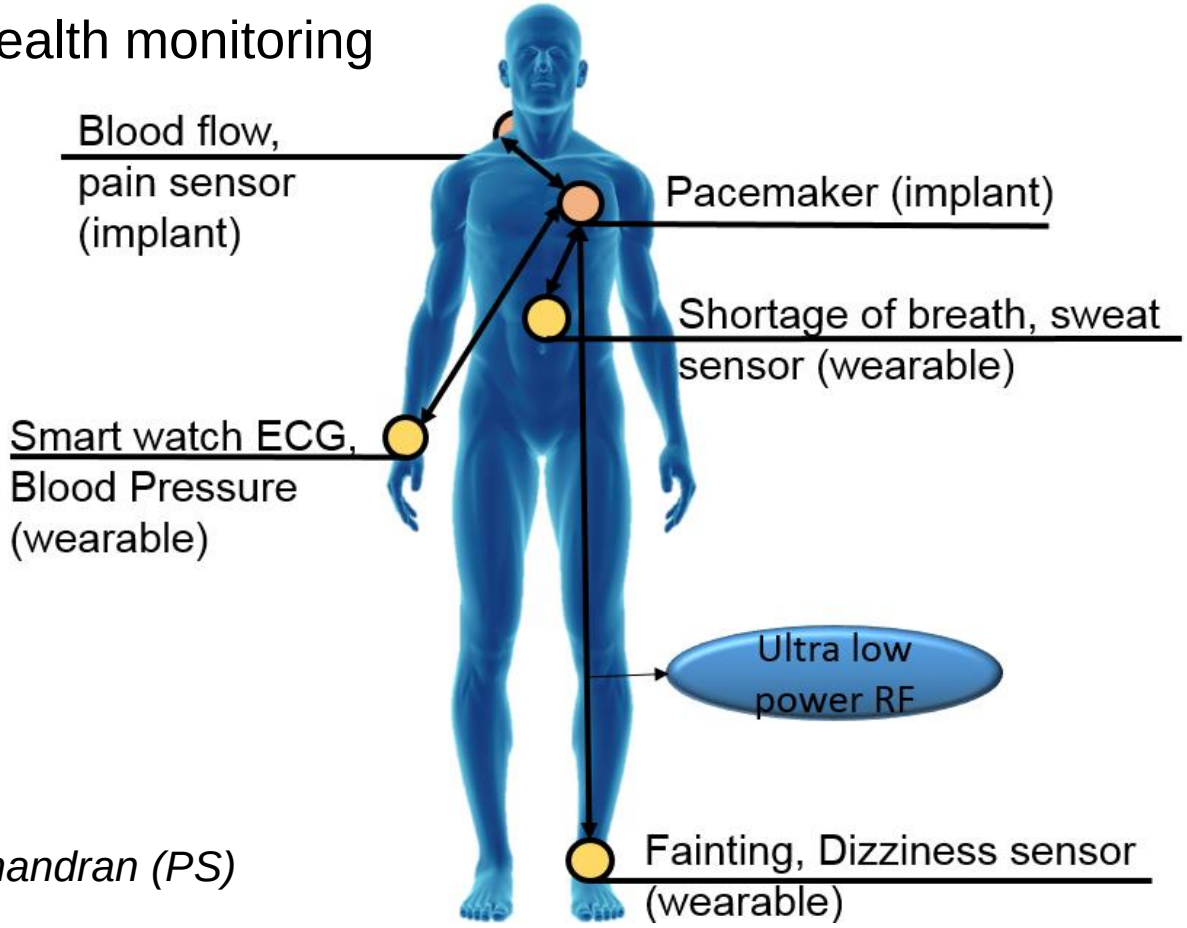
Pervasive Systems

- Bio-inspired wireless communication for medical implants
  Raja Karuppiah
- Long term health monitoring



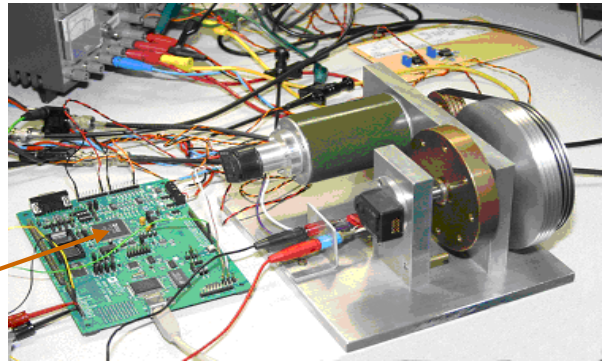
Source: Karuppiah Ramachandran (PS)

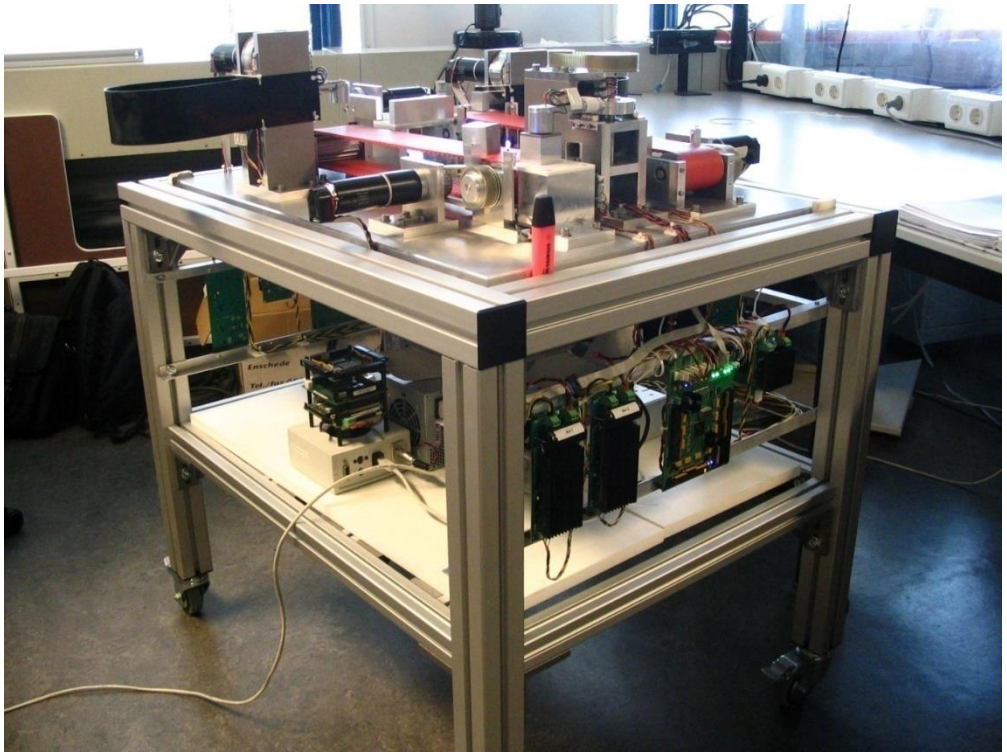
Production Cell Set-up

Robotics and Mechatronics

The Boderc project focused on distributed embedded real-time controllers of complex systems.

- Modelling
- Hardware
- Software

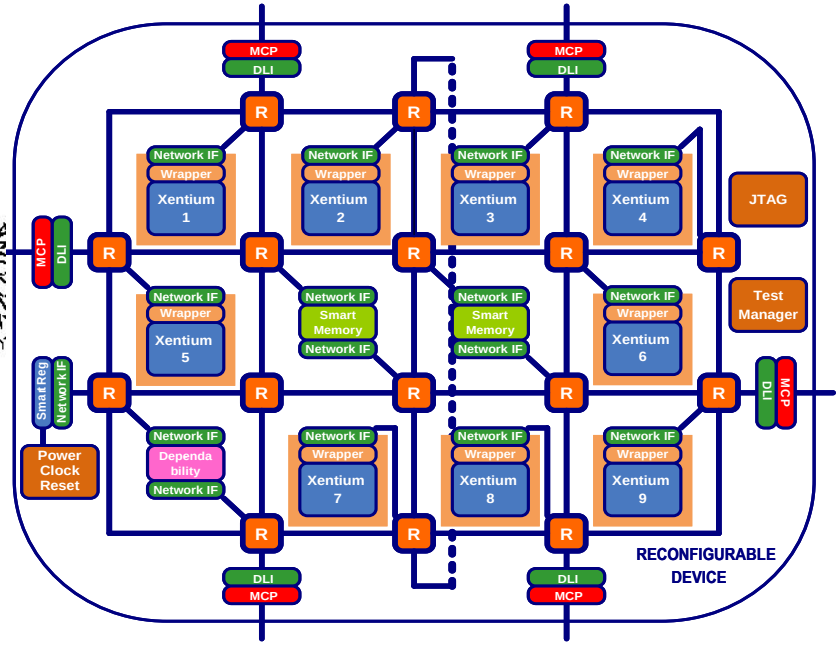




Boderc; Beyond the Ordinary: Design of Embedded Real-time Control

New generation of self-repairing multi-cores

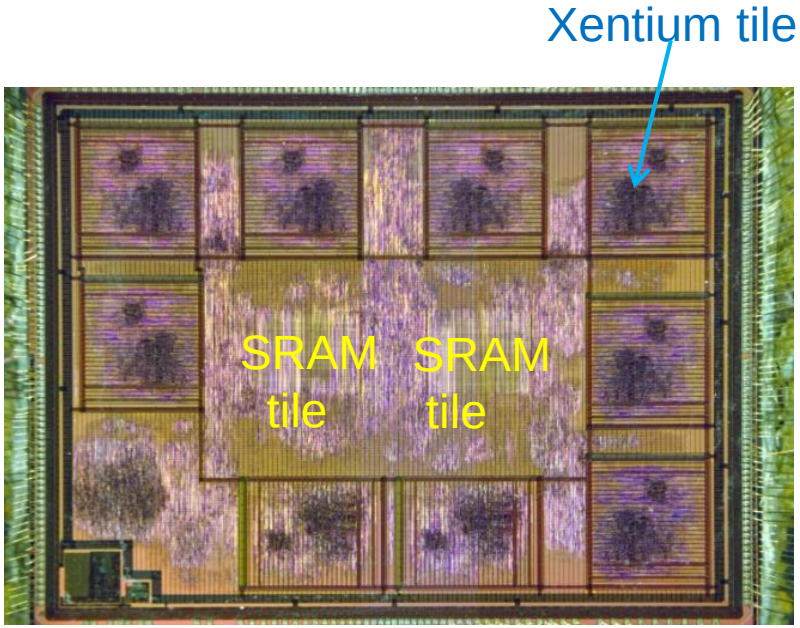
Chair Computer Architecture for Embedded Systems



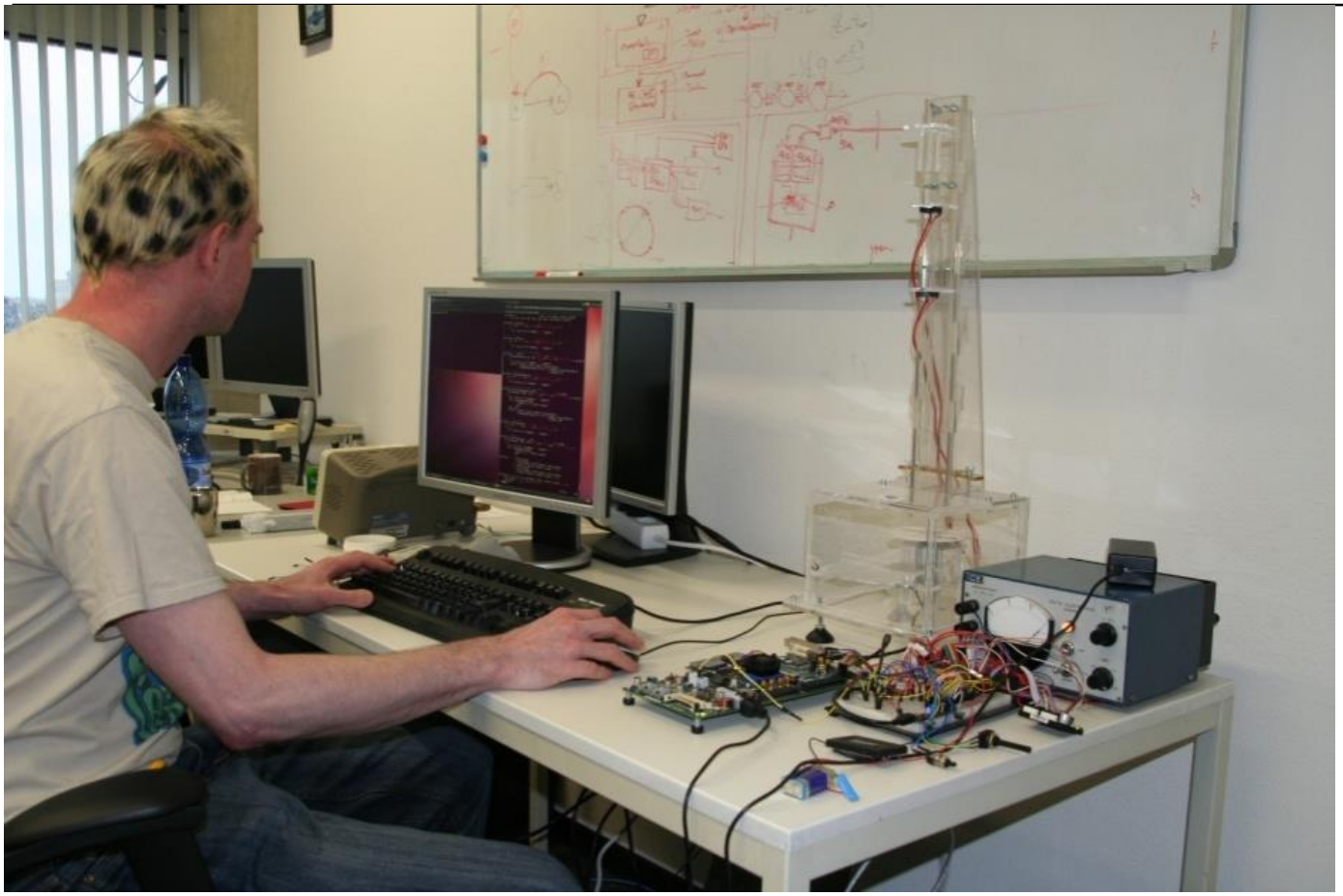
software for real-time repair!

CMOS chip design by CAES, Recore Systems, NXP, ATMEL

(> 1.2 M transistors)



Functional language used to control a setup



This resulted in a spin-off company QBayLogic: https://qbaylogic.nl/
More info on this topic: https://clash-lang.org/

Radio Systems (new research group); approximate computing

Source: IMPACT: IMPrecise adders for low-power Approximate Computing, Gupta et al.

- Do we always need a precise result?
- Many image processing applications use full adders.
  - Left image is the original
  - Middle image (DCT+IDCT) and truncation of the 8 lowest significant bits
  - Right image: Approximate full adders; accept incorrect results Power saving ~ 50%, area saving ~33% (compared to conventional FA's)
- https://en.wikipedia.org/wiki/Approximate_computing

Decentralized Energy Management in Smart Grids

Computer Architecture for Embedded Systems (CAES)

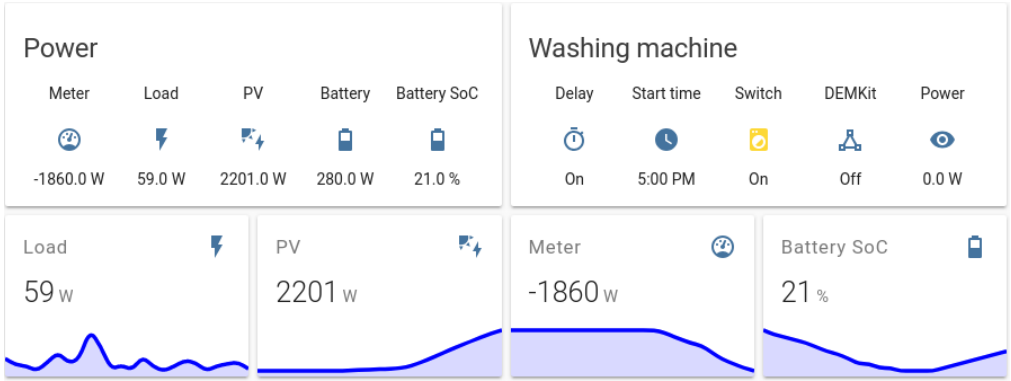
Control and optimize energy use in electricity grids with embedded systems

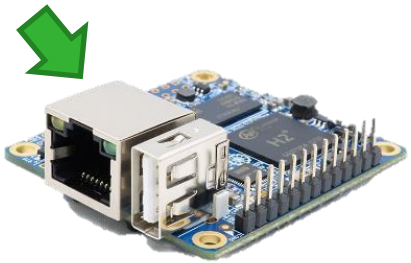
- Coordination among many (IoT) devices
- Increase share of renewable energy
- Reliable and resilient electricity grid

Simulation software

Challenges:

- Scalable and efficient algorithms to run on Embedded Systems!
- Robust control of real devices using models and predictions





Recently it was in the news that charging many electric cars at he same time can cause problems. This group already did such an experiment in 2015. Google: Lochem Utwente Pizza
https://www.utwente.nl/en/news/2015/4/43571/ut-researchers-test-power-network-with-pizza-ovens

VEHICULAR NETWORKING FOR COOPERATIVE AUTOMATED DRIVING

DESIGN AND ANALYSIS OF COMMUNICATION SYSTEMS (DACS)

Let vehicles and other traffic participants communicate to make road transport safer, more efficient, and more environmentally friendly.

- beaconing (sending your location, speed, acceleration, etc) 1 – 25 x per second
- send information from you sensors (camera's) to other vehicles
- (for automated vehicles) send you planned trajectory to others, and coordinate in case of conflicting trajectories

UT project on Cooperative Adaptive Cruise Control (ACC with wireless communication)

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UT/TUD/TU/e Bachelor EE and CS

You are unconditionally admitted with an UT, TUD and TU/e bachelor diploma in

- Electrical Engineering
- Computer Science

Bachelor Creative Technology

A bachelor Creative Technology is admitted with:

- Specialisation “Smart Technology” in bachelor programme
- Premaster programme of Embedded Systems in minor (with the course *instrumentation for embedded systems)*
  Note: the premaster programme in a couple of slides

Bachelor Advanced Technology

Students are admitted with 2 of the bachelor modules :

- Module 2.1 (CS) Computer Systems
- Module 3.2 (CS) Cyber Physical Systems
  or
  Module 2.3 (EE) Network Systems (with C++)

Premaster/minor programme HBO-Computer Science/Electrical Engineering: semester 1 (2020-2021)

- HBO premaster/minor coordinator
  - dr. Maarten Korsten
- Programme (semester 1)
  - Calculus A (5 EC)
  - Calculus B (4 EC)
  - Linear Algebra A (3 EC)
  - Linear systems (6 EC)
  - Algorithms, Datastructures and Complexity for embedded systems (4 EC)
  - Digital Logic and Computer Organization (3 EC)
  - Programming (HBO-Electrical Engineering) (5 EC)
  - Instrumentation for Embedded Systems (HBO-others) (5 EC)
- Admission decision after quartile 2 or quartile 3
  - After the last resit.
  - You must complete the premaster **within** one year!

More information on a course:
https://osiris.utwente.nl/student/OnderwijsCatalogusZoekCursus.do

Bachelor-before-Master / “Harde knip”

- Students will only be admitted to a Master's programme after they have completed a Bachelor's programme.
- A HBO bachelor is enrolled in a bachelor programme.
- The premaster programme is also available as HBO-minor programme (semester 1)
  - https://www.kiesopmaat.nl/
  - Check the deadline for enrollment in the minor
    - https://www.kiesopmaat.nl/modules/ut/EWI/137265/

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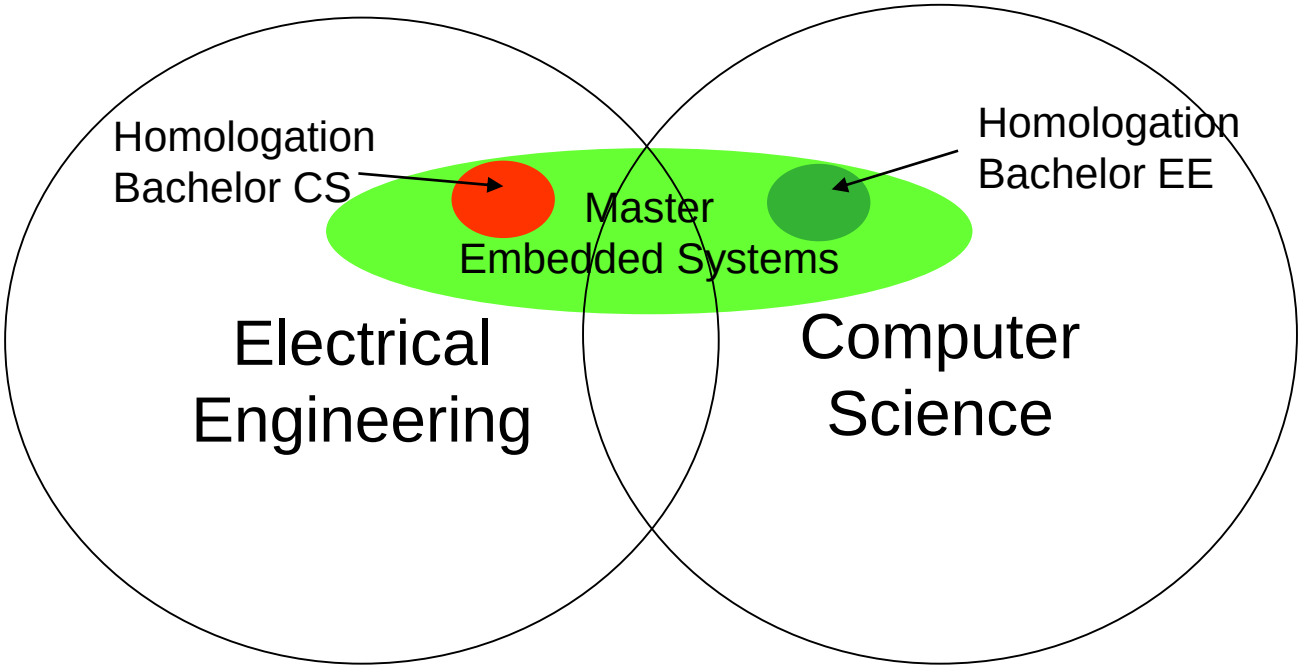
Positioning Master Embedded Systems



Embedded Systems uses subjects from electrical engineering (EE) and computer science (CS).
E.g. students with a bachelor CS will have an EE oriented homologation course.

Programme Embedded Systems

Premaster/minor HBO (not part of 120 EC master)	**30 EC**

Master	
Homologation (predefined for UT bachelor CS/EE, HBO bachelor, individual for others)	10 EC
Compulsory courses (same at TUD and TU/e)	25 EC
Internship (not for HBO bachelors)	20 EC
Elective courses (master EE, CS, Embedded Systems)	… EC
Final project preparation	10 EC
Final project	30 EC
	120 EC

Programme UT bachelor
Computer Science/Electrical Engineering

Homologation

UT Bachelor CS

- Instrumentation for ES
- Optional: self-study topics

Homologation

UT Bachelor EE

- Programming 2 (if module Network Systems is not part bachelor programme)
- Optional: self study topics

Compulsory courses (TUD, TU/e and UT)

- Embedded Computer Architectures 1
- Quantitative Evaluation of Embedded Systems
- Real-Time Systems 1
- System validation
- Embedded Systems Laboratory

Electives and final project

- The choice of the elective courses is important, e.g. for the research group where you want to do your final project!
- You can select electives from the master programmes Electrical Engineering, Computer Science and Embedded Systems
- In the final project you will often contribute to ongoing research
- Reports of the final projects are available:
  http://essay.utwente.nl/

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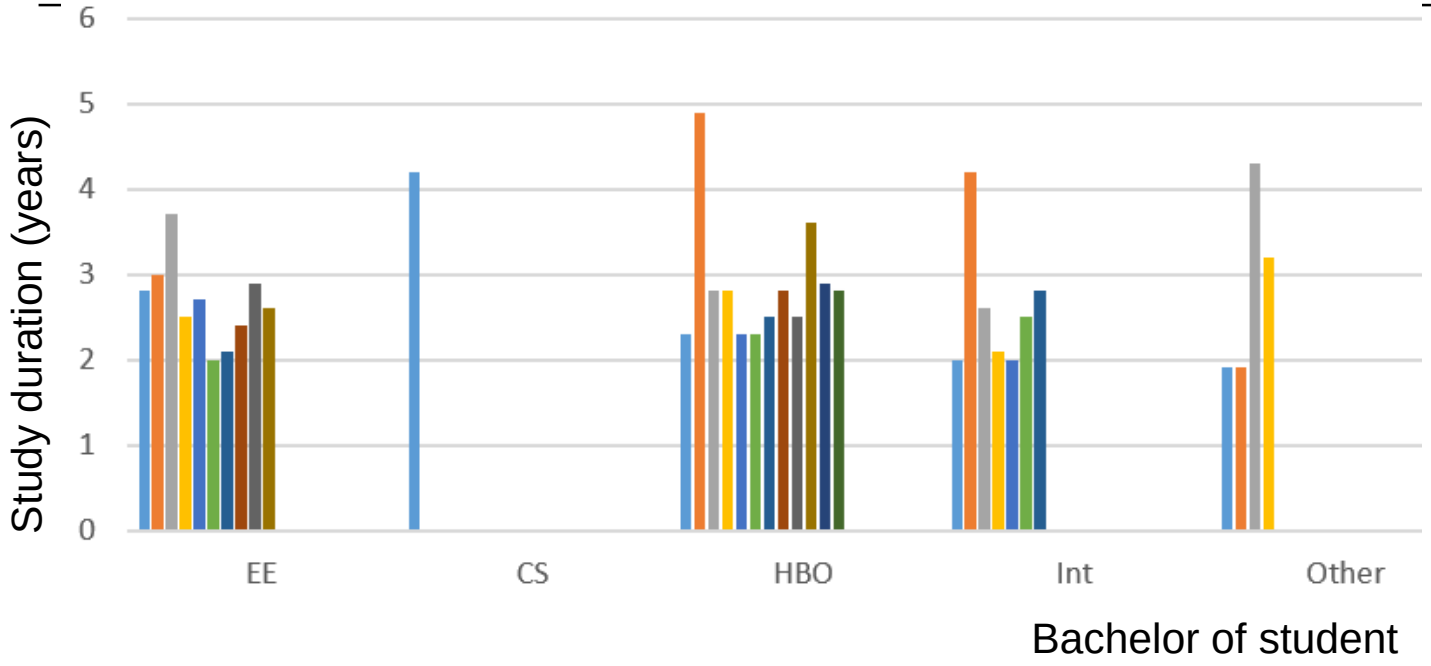
Study success of the premaster/minor

	Total premaster/minor	Pass percentage
2014-2015	11	64 %
2015-2016	21	73 %
2016-2017	15	71 %
2017-2018	11	64 %
2018-2019	24	63 %
2019-2020	13	38%-69% (resits yet to come)

Study success master programme



The study success of students that started the programme between 1 Sept 2013 until 31 August 2016

Int: International student
Other: e.g. Bachelor Creative Technology, Advanced Technology

Application fee

- All students (both EER and non-EER) with a non-Dutch higher education diploma must pay an application fee of €100 for this master programme

Career Opportunities

Students easily find a job.

Examples:

- Industry:
  - Philips, NXP, Thales, Nedap, …
- University
  - PhD-student

All information is in the online study guide

- www.utwente.nl/emsys