Computer Architecture for Embedded Systems (CAES)

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Our main interests

What's in a name?

• CAES read as *kaas*



• Mission statement (WiP):

CAES provides methods and tools for **designing**, **building**, **and deploying efficient computer systems**. Our research lies at the **intersection between CS and EE**.

This large scope allows us to tackle real problems with a broad and systemic view, allowing for the design and development of new technologies, architectures, design automation tools, algorithms, methodologies, and system models.

We serve applications at different scales, from **scientific computing** and **simulations** to **distributed digital services** and **embedded (real-time) workloads**.

	Problem	
	Algorithm	
(Program/Language	
	System Software	
	SW/HW Interface	
	Micro-architecture	
	Logic	
	Devices	
	Electrons	



















Who we are?

- 11 staff members (~6.75 FTE, CS+EE)
- 15+ PhD students
- 10+ MSc students (EMSYS, EE, CS, BIT ...)
- Lots of BSc students (EE, TCS, ...)

What do we do?

- We target applied systems research on:
 - Distributed / Embedded / Safety-Critical / Cyber-Physical / Data Processing

• We research:

- System design and optimization
- Special-purpose/domain-specific computer architectures
- Embedded AI, edge computing
- Energy management in distribution grids
- Emerging computing and storage technologies

Who do we work with?

• Within UT

- Centre for Cybersecurity Research
- Center for Brain-Inspired Nano Systems (BRAINS)
- The energy group := CAES + MOR + PE
- The EDGE center := PS + DACS + CAES
- Embedded AI Lab := DMB + CAES
- All faculties
- National Collaboration
 - UvA, TU/e, TU Delft, VU, ULeiden
 - TNO
 - SURF
 - NLR, ESA-ESTEC

International Collaboration:

- CERN (CH)
- Politecnico di Milano (IT)
- University of Rome Tor Vergata (IT)
- National Tsing-Hua University (TW)
- TU Dortmund, TU Dresden (DE)
- FORTH, University of Crete (GR)
- University of Klagenfurt (AT)



Example #1: IMAGINE

CMOS-compatible, energy-efficient framework for sensing and computing at the edge.

- CMOS-compatible: scalable
- Energy-efficient: sustainable
- Edge: on device, without 'cloud'

DNPU: new type of "transistor" for AI



Example #1: IMAGINE





Example #2: MEGAMIND

Measuring, Gathering, Mining and Integrating Data for Self-management in the Edge of the Electricity System

"Research Program comprises a significant step in the second digitization wave in the energy distribution grid by developing a new way in which value-chain partners in local electricity systems (the electricity grid edge) interact with each other and with value-chain actors in the higher-level electricity system. We envision a highly self-managed system that automatically and dynamically steers electrical energy flows taking into account the technical boundaries of the network and while the energy transition unfolds."

- <u>https://megamind.energy/</u>



Example #3: TRISTAN

- Project Objective:
 - Develops next-generation industrial hardware and expand European RISC-V ecosystem
- What do we do?
 - Design of checkers to detect security and safety issues inside a RISC-V processor
 - Radiation experiments for reliability and sidechannel analysis for security
 - Design and implementation of a demonstrator together with Technolution







Example #4: Graph Massivizer



- Project Objective:
 - Develops a high-performance, scalable, and sustainable platform for large-scale graph processing
- UT in charge of performance engineering and co-design:
 - Model & benchmark performance and energy footprint for a given workload and system.
 - Provide performance and footprint bounds for various(/all?) mappings.
 - Use DSE to select ideal system configuration
 - Enable code generation.
 - Facilitates at-scale prediction and deployment.



Takeaway

- We do **computing systems** research
 - Heterogeneous, multi-scale, distributed, ...
- We rely on architecture foundations
 - HW/SW co-design, system integration
- We target non-functional properties
 - Performance, efficiency, reliability, cost, security
- We like systematic approaches
 - Methods and tools, model-based analysis and engineering
- We are happy to collaborate!