

Towards Sustainable Software Engineering

Mikkel Baun Kjærgaard

Professor, Vice-Head of Research, Head of Software Educations

Sustainability vs. Software Engineering

Software engineering is concerned with developing and maintaining software systems that behave reliably and efficiently, are affordable to develop and maintain, and satisfy all the requirements that customers have defined for them. [ACM]

Provide functionality for the customers that provide value but also address quality attributes:

- Sustainable Resource Use
- Energy Efficiency
- ...

Energy Efficiency



BATTERY



CPU

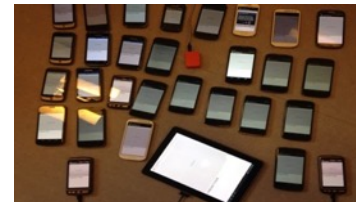


MEMORY



STORAGE

Sustainable Resource Use



SDU Software Units

Our goal is to develop and disseminate effective and efficient methods and technologies to support high quality and rapid software development of innovative and complex systems.

Locations:



SDU Odense



SDU Sønderborg



Laboratories:

Data & Intelligence Lab

Software-driven Machines Lab

Cyber-Safe Lab

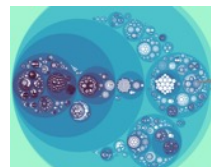
Coding and Software Engineering Lab

Computer Human Interaction and Innovation Lab

Distributed Edge and Cloud Computing Lab

Trustworthy Systems Lab

Modeling and Simulation Lab



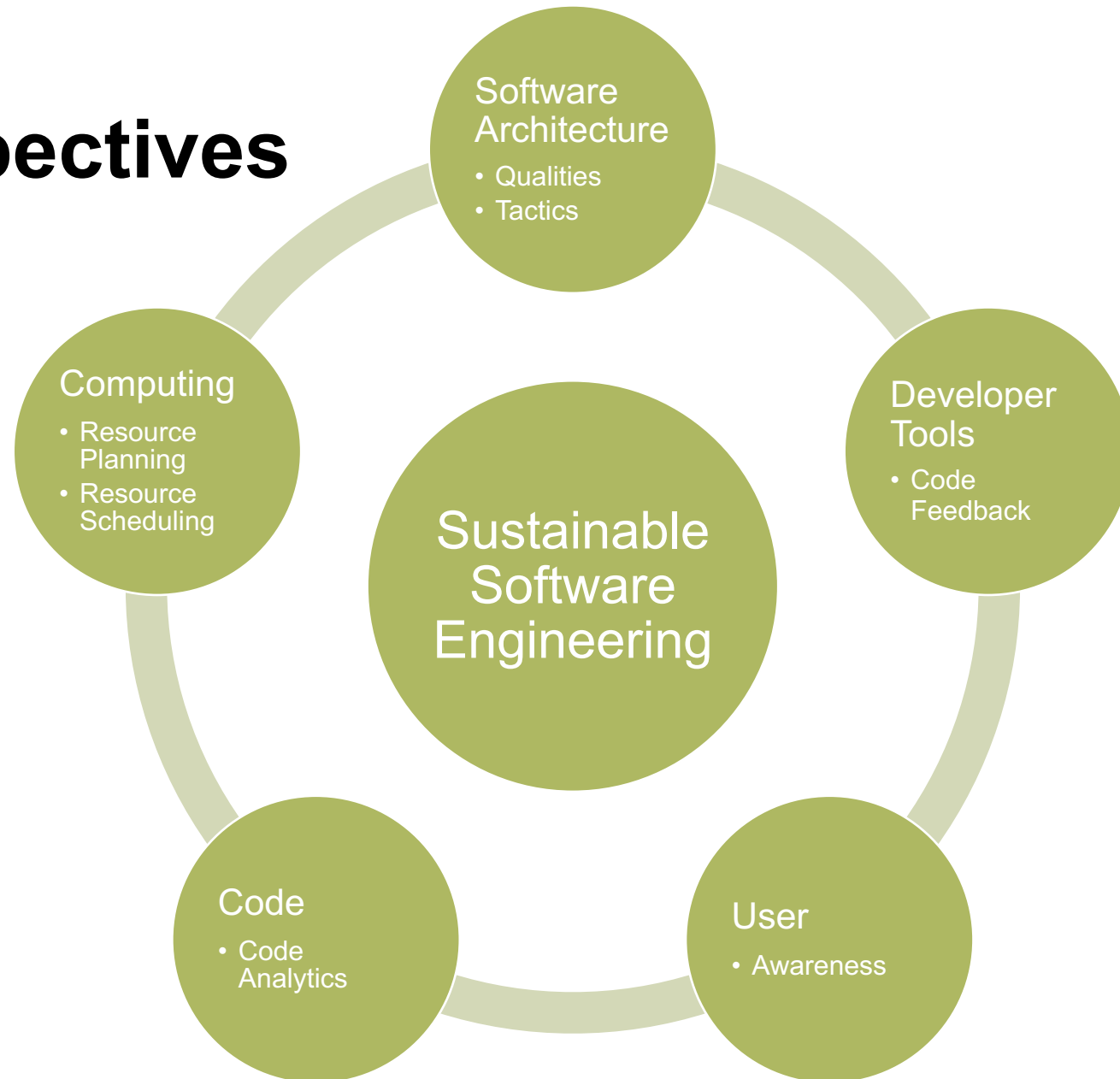
Project Example:



Low-Code Programming of Spatial Contexts for Logistic Tasks in Mobile Robotics

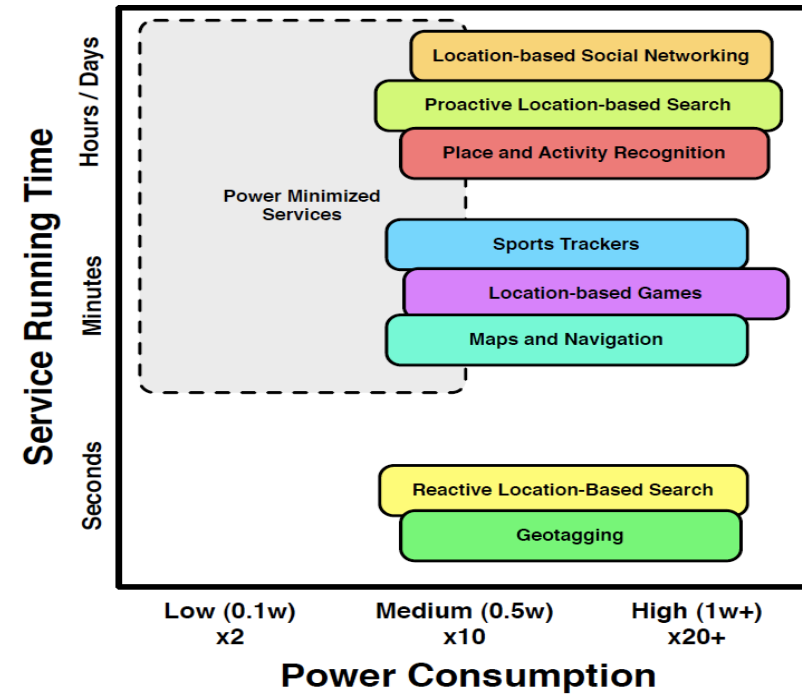
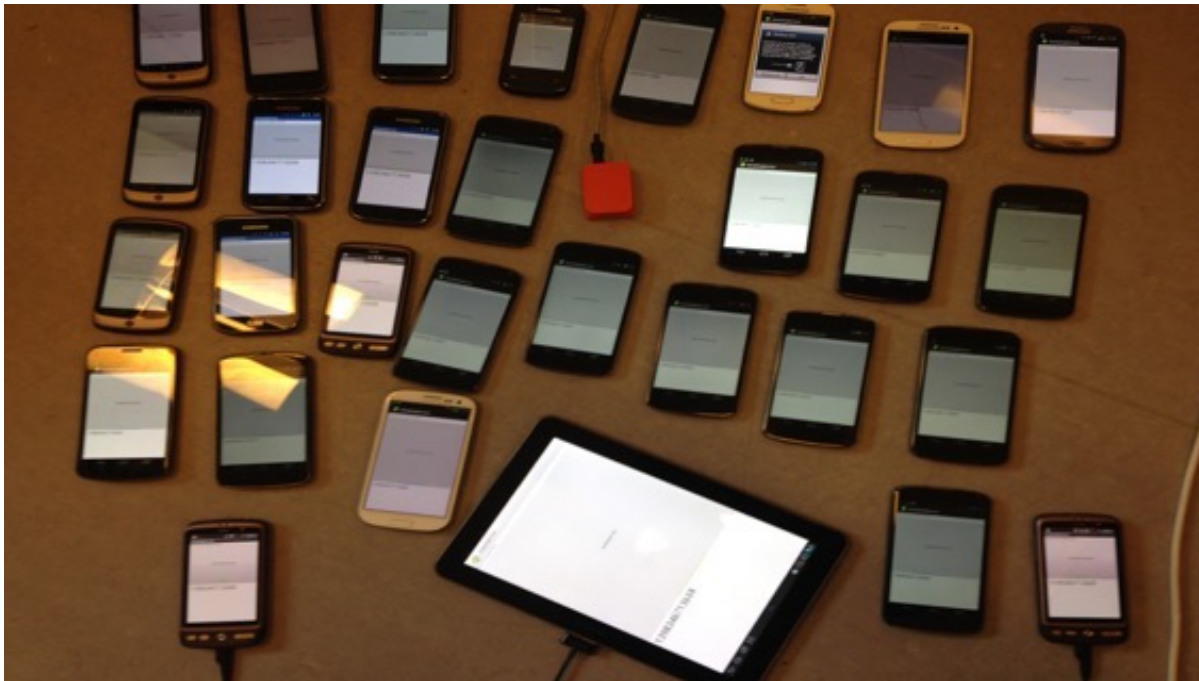
Logistics tasks in low-volume production represent an important opportunity for automatization via mobile robots. However, for successful application easy programming solutions are needed that address the variability of the spatial context in full 3D. The project partners SDU and RUC aim to provide an adaptive and re-configurable low-code programming approach to this problem and demonstrate the approach with the mobile platform of Enabled Robotics.

Many Perspectives



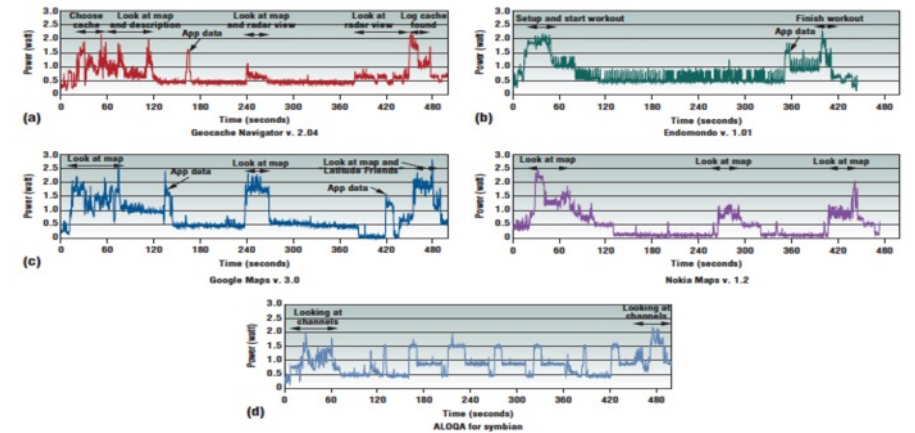
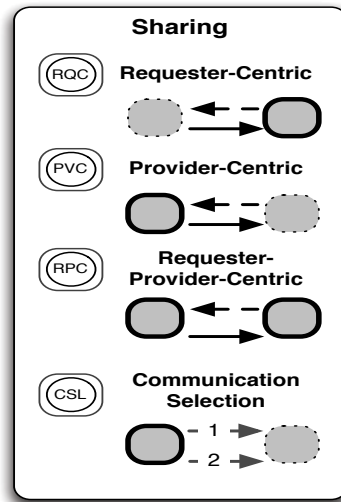
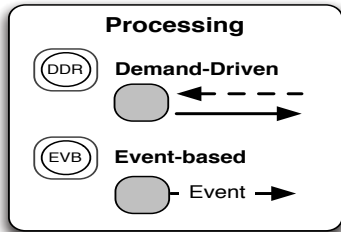
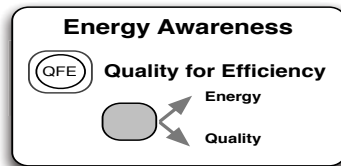
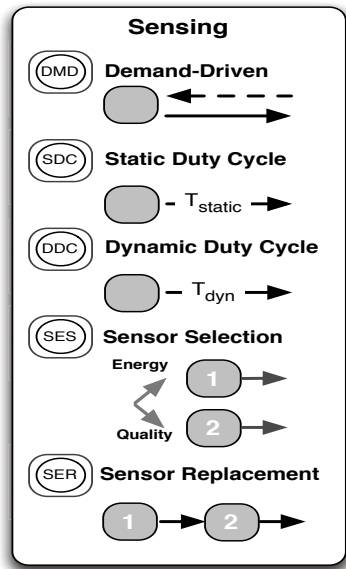
Software Architecture (2008-2015)

→ **Energy Efficiency:** the 'amount' of energy required to provide and/or deliver a (mobile) service at a given quality of service (QoS)



Mikkel Baun Kjærgaard, Minimizing the Power Consumption of Location-Based Services on Mobile Phones, IEEE Pervasive Computing Magazine

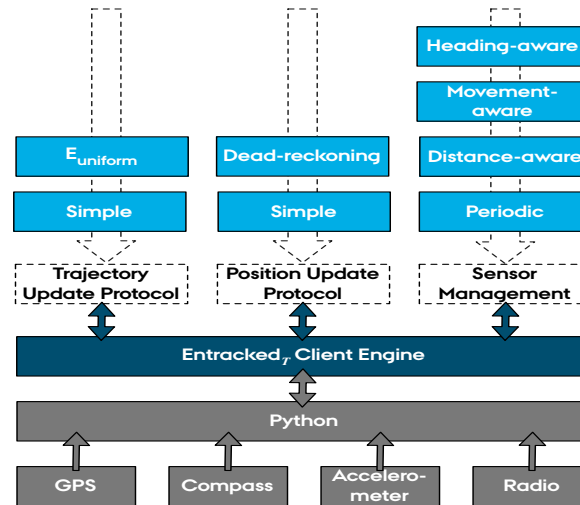
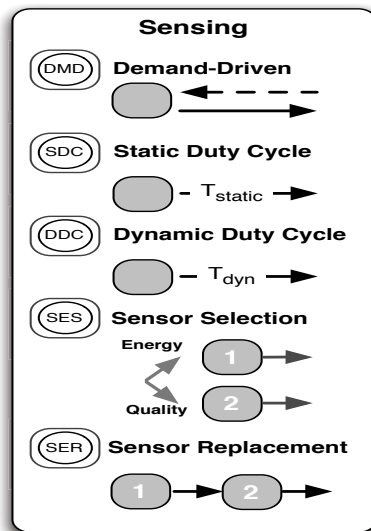
Energy Efficiency Tactics



Kjærsgaard, M. B., & Kuhmann, M. (2015). On Architectural Qualities and Tactics for Mobile Sensing. In Proceedings of the 11th International ACM SIGSOFT Conference on Quality of Software Architectures (pp. 63-72). ACM.

Energy Efficiency Tactics for Sensing

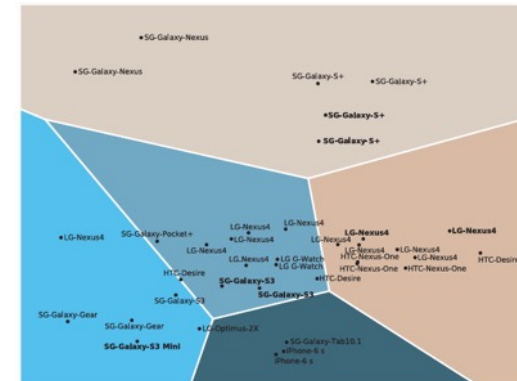
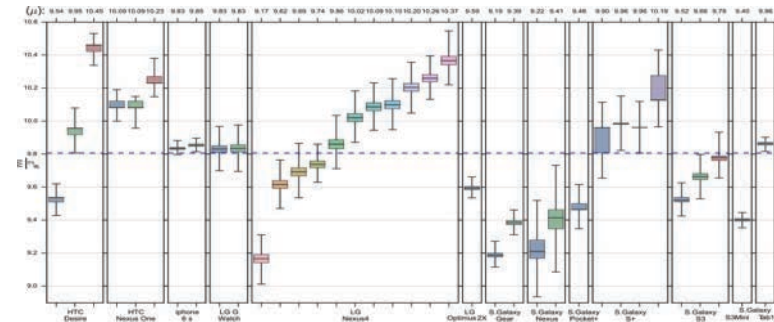
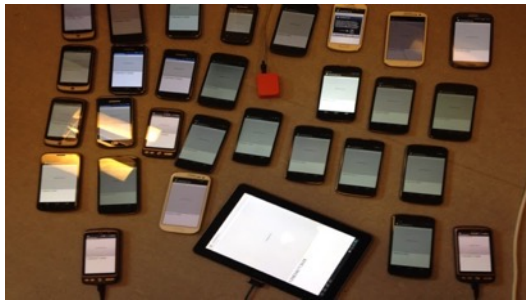
Implementation Methods and Technologies



Energy Efficient Position Tracking (ACM MobiSys 2009)
 Energy Efficient Trajectory Tracking (ACM MobiSys 2011)
 Resource Adaptive Tracking (IEEE Trans. on Mobile Computing 2015)



Resource Adaptability – Prolonged life-time of devices



Allan Stisen, Henrik Blunck, Sourav Bhattacharya, Thor Siiger Prentow, Mikkel Baun Kjærgaard, Anind Dey, Tobias Sonne, Mads Møller Jensen: Smart Devices are Different: Assessing and Mitigating Mobile Sensing Heterogeneities for Activity Recognition. ACM SenSys 2015: 127-140

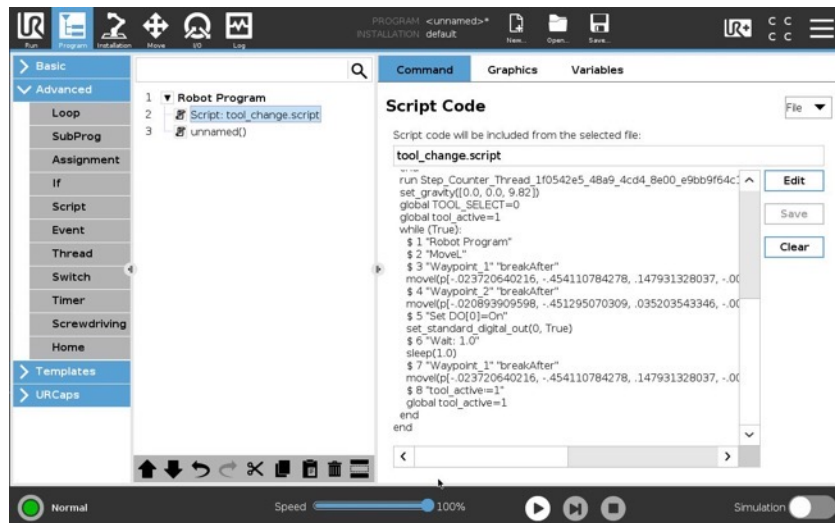
NOKIA Bell Labs
Carnegie Mellon University

Developer Tooling and Training (2019-)



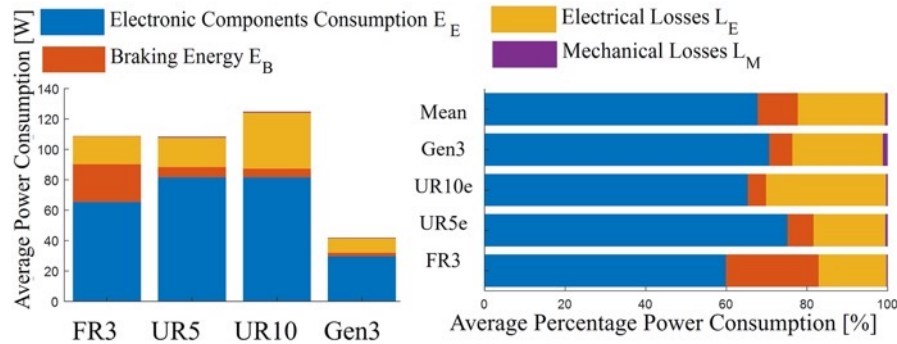
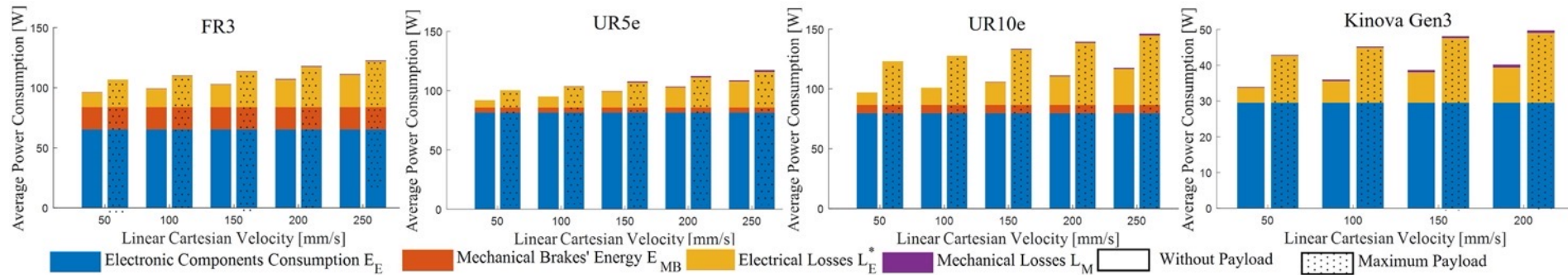
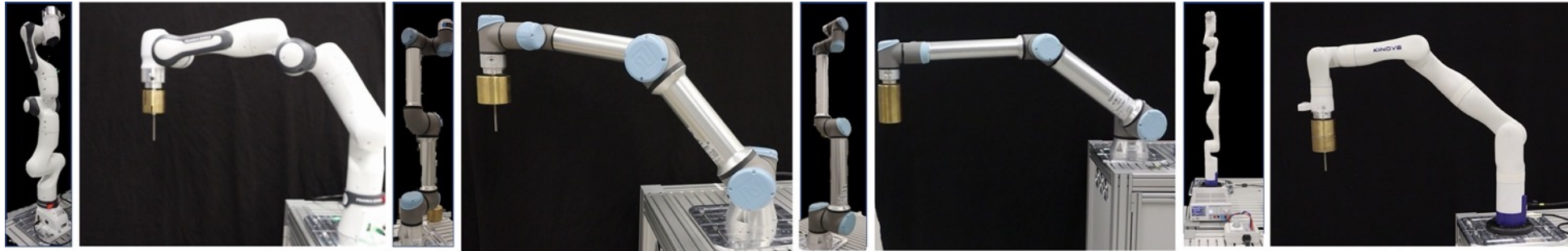
CoSE Lab: The Coding and Software Engineering Lab

Lab facilities shared by Center for Industrial Software (CIS) and SDU Software Engineering



Software is increasingly the core fundament for the value creation of products and services. However, there is a major lack of professional software developers. Therefore, we need to support the already working

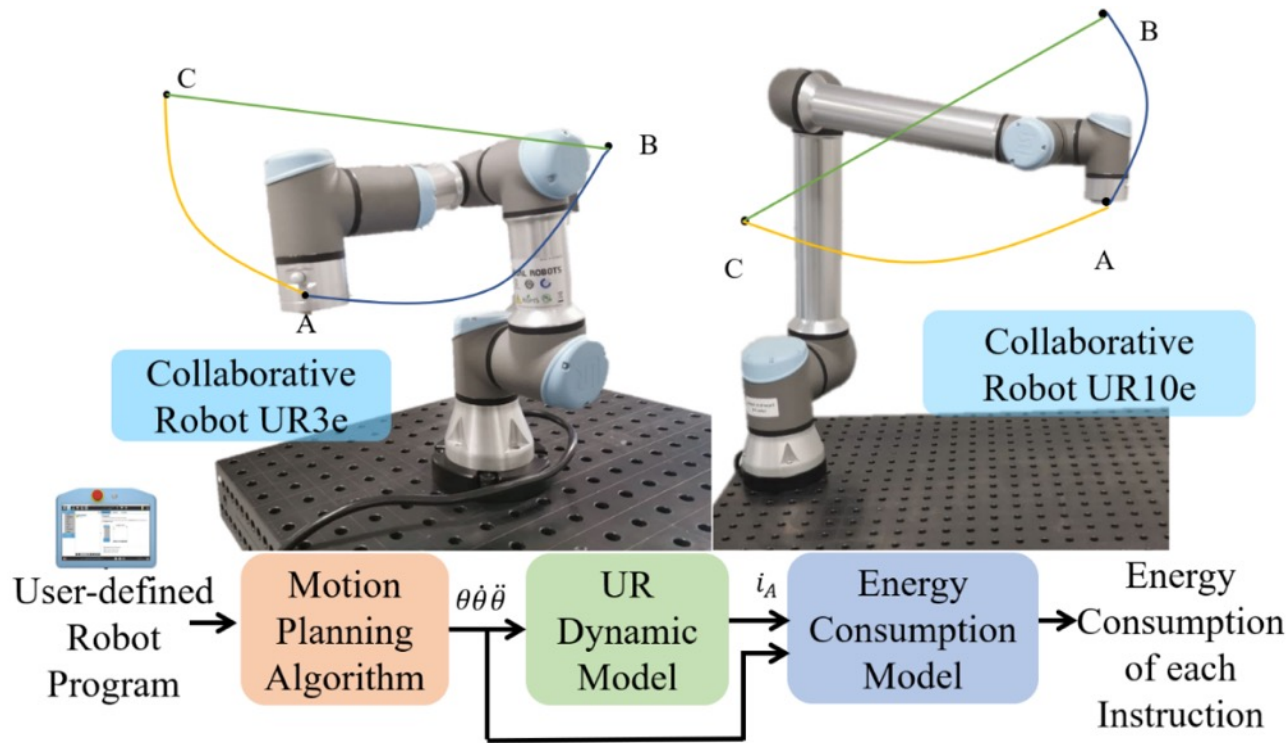
- Home SDU Software Engineering
- Research areas



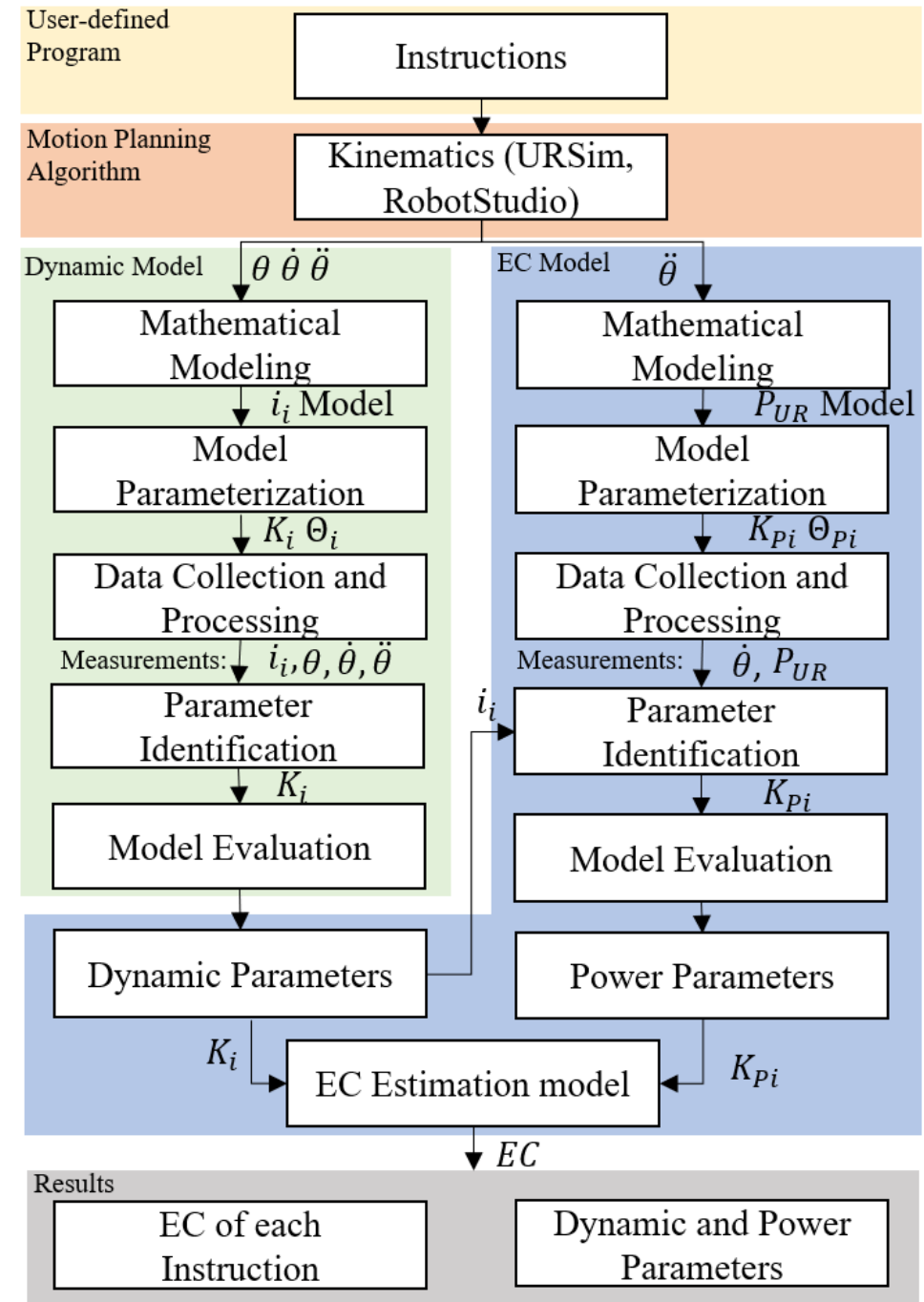
Heredia, J., Kirschner, R. J., Schlette, C., Abdolshah, S., Haddadin, S., & Kjærgaard, M. B. (2023). Labelling Lightweight Robot Energy Consumption: A Mechatronics-Based Benchmarking Metric Set. In 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (pp. 1789-1796). IEEE.

Model of the Energy Consumption for Collaborative Robot

A hybrid model based on a data-driven and process-driven methodology.

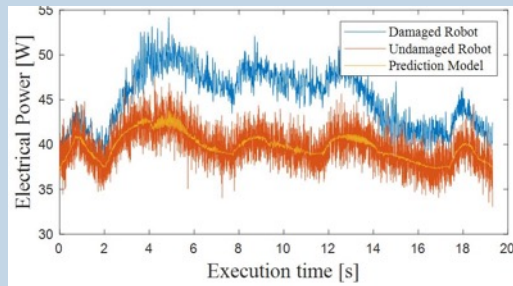


Data-Driven Energy Estimation of Individual Instructions in User-Defined Robot Programs for Collaborative Robots, Heredia, J., Schlette, C. & Kjaergaard, M. B., Oct 2021, In: IEEE Robotics and Automation Letters. 6, 4, p. 6836-6843



Applications of Energy Prediction Models

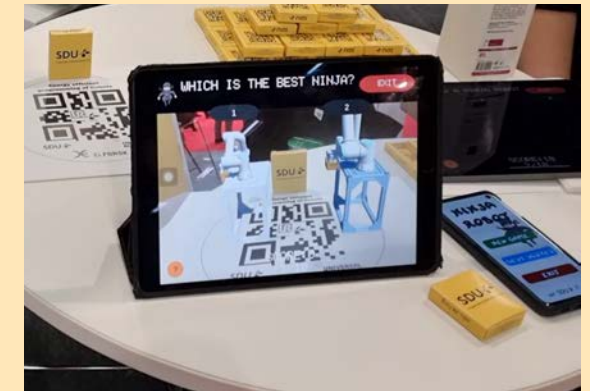
Robot Troubleshooting



Robot Commissioning



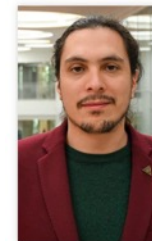
Training and Energy Optimization



Juan Esteban Heredia Mena

Assistant Professor
SDU Software Engineering

jehm@mmmi.sdu.dk
+4565507606



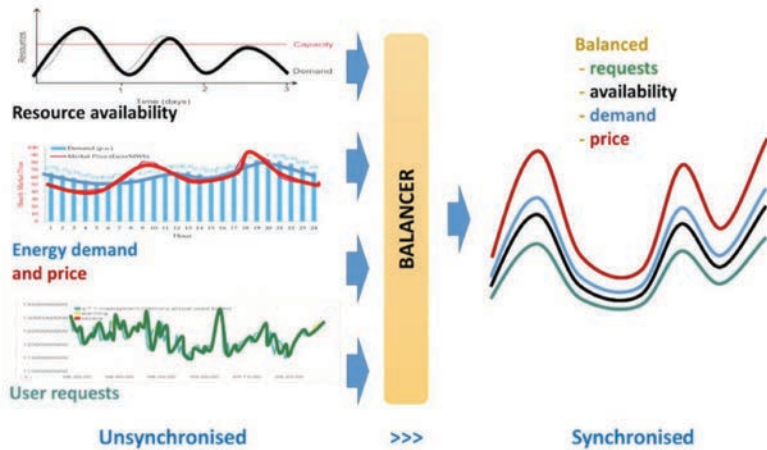
Miguel Enrique Campusano Araya

Associate Professor
SDU Software Engineering

mica@mmmi.sdu.dk
+4565508558

Efficient Computing

- Resource availability, energy, requests



- Process at the edge?
- Process on the cloud?
- Establish a computing continuum?

DECO Lab - Distributed Edge and Cloud Computing

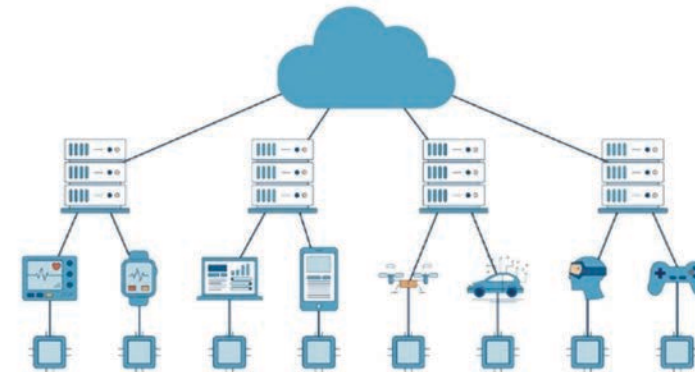
Lab facilities shared by Center for Industrial Software (CIS) and SDU Software Engineering



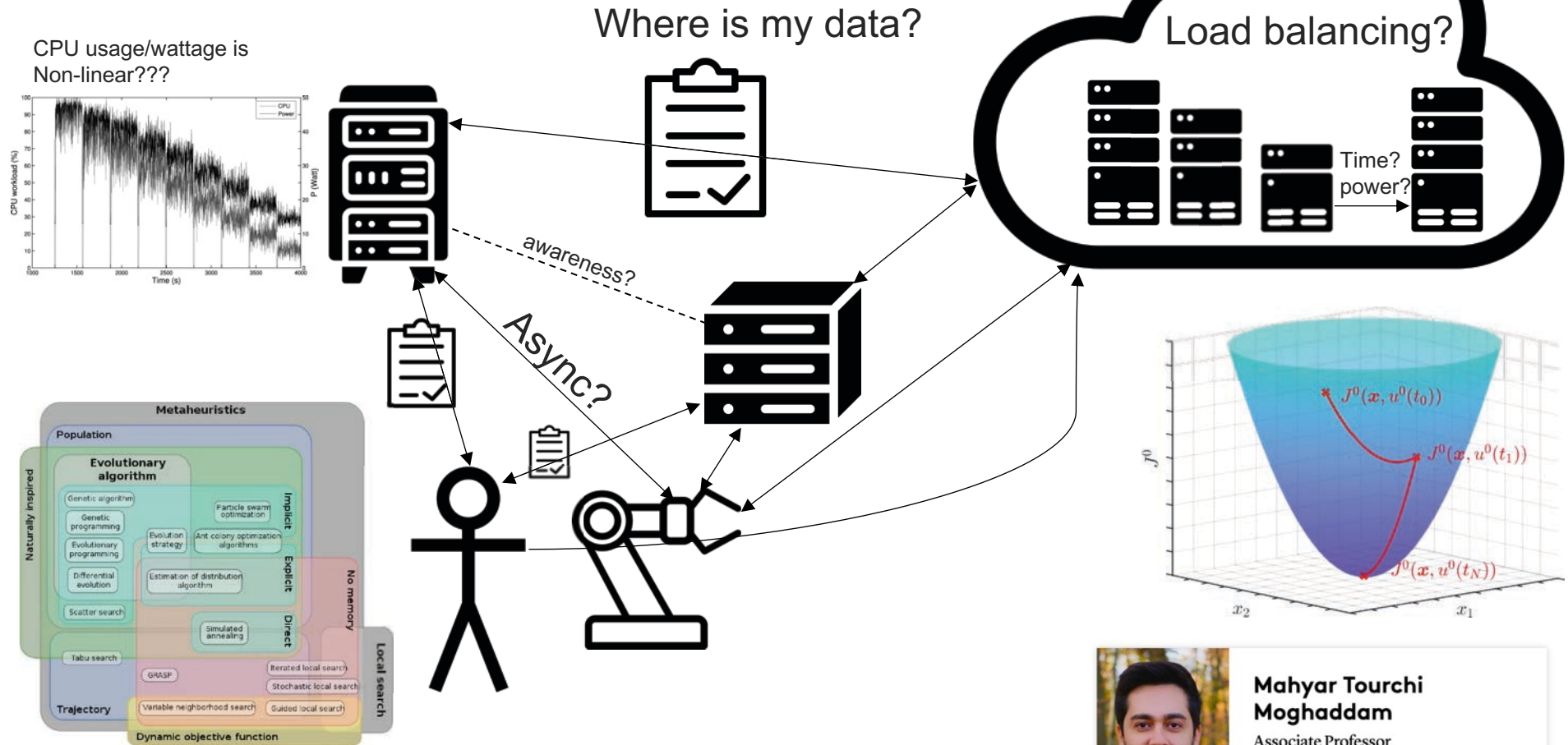
Advancing the knowledge in software engineering for distributed systems, spanning from cloud-edge-IoT computing to hybrid systems, DECO Lab will reinforce European research, development, education, and innovation efforts in the computing continuum. For the first three years horizon (2024, 2025, 2026), the lab will focus on:

Overview of facilities

- Home Facilities
- DECO Lab
- Computer Human Interaction &



Challenges

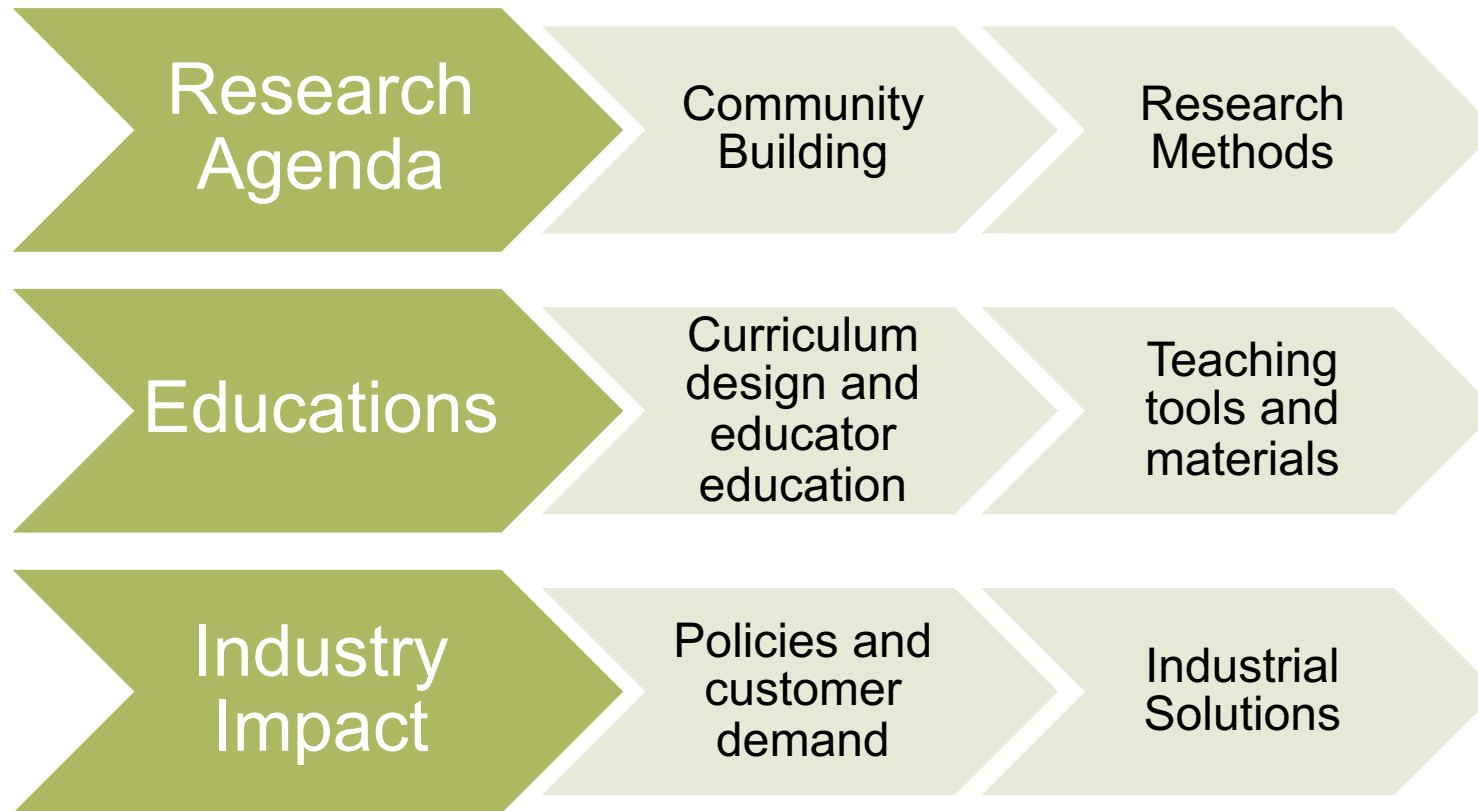


Energy Efficient Cloud Architecture Solutions: A Real Case
 Moghaddam, M. T., Osmanovic, A. & Enroth, M., 2023, Proceedings of the IEEE/ACM
 16th International Conference on Utility and Cloud Computing. ACM



Mahyar Tourchi Moghaddam
 Associate Professor
 SDU Software Engineering
 mtmo@mmmi.sdu.dk
 +4565507296

The Road to Creating Impact



Thank you for your attention

Read more here:

<https://www.sdu.dk/en/forskning/sdusoftwareengineering>

<https://www.sdu.dk/en/forskning/cis>

Contact info: Mikkel Baun Kjærgaard,
mbkj@mmmi.sdu.dk

Thanks to all the people who contributed to the work presented