



HAEC

Gerhard P. Fettweis – Coordinator
W. Lehner, W. Nagel, C. Baier, D. Plettemeier

29.05.2015

Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing

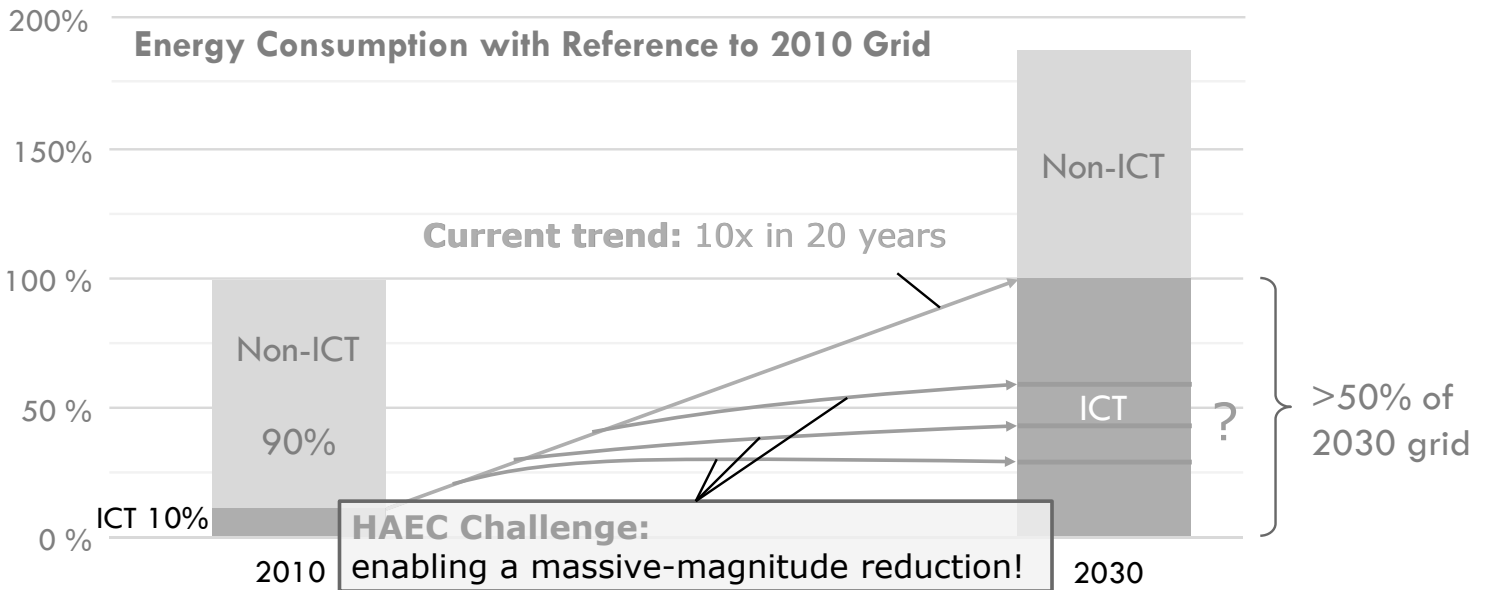


3

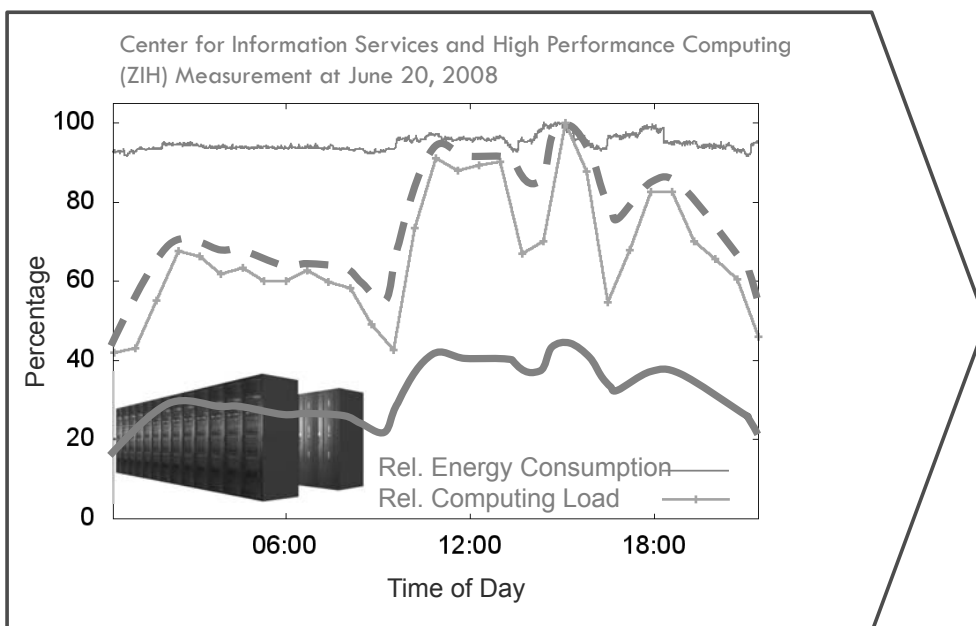
Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing

The Research Idea of HAEC: Highly Adaptive Energy-Efficient Computing

Motivation



Energy Proportionality/Efficiency



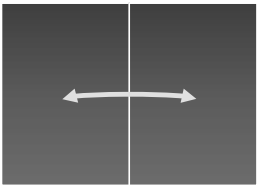
Goal:
Minimizing Energy
by
Multi-Layer
SW/HW
Adaptivity

The Communication Bottleneck of Parallel Computing

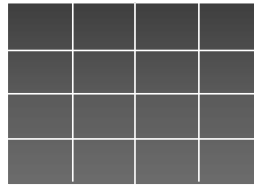


5

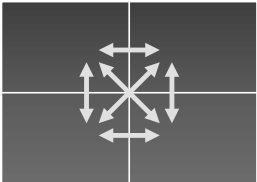
Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing



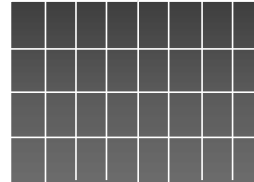
Parallelism = 2
Comm. Links = 1



P = 16
C = 120



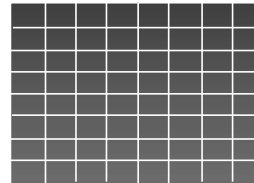
P = 4
C = 6



P = 32
C = 496



P = 8
C = 28



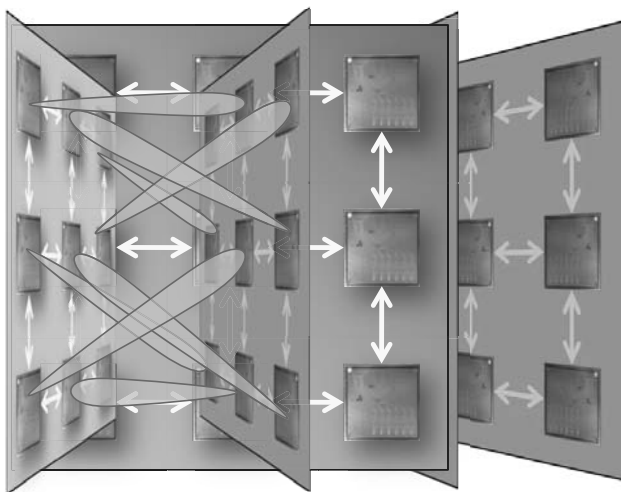
P = 64
C = 2016

Highly Adaptive Energy-Efficient Computing High-Rate Inter-Chip Communications



6

Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing



Optical Interconnect

- adaptive analog/digital circuits for e/o transceiver
- embedded polymer waveguide
- packaging technologies (e.g. 3D stacking of Si/III-V hybrids)
- 90° coupling of laser

Radio Interconnect

- on-interposer/on-package
- antenna arrays
- analog/digital beam steering and interference minimization
- 100Gb/s
- 25 GHz channel @ 200GHz carrier
- 3D routing & flow management



Today's energy optimizations

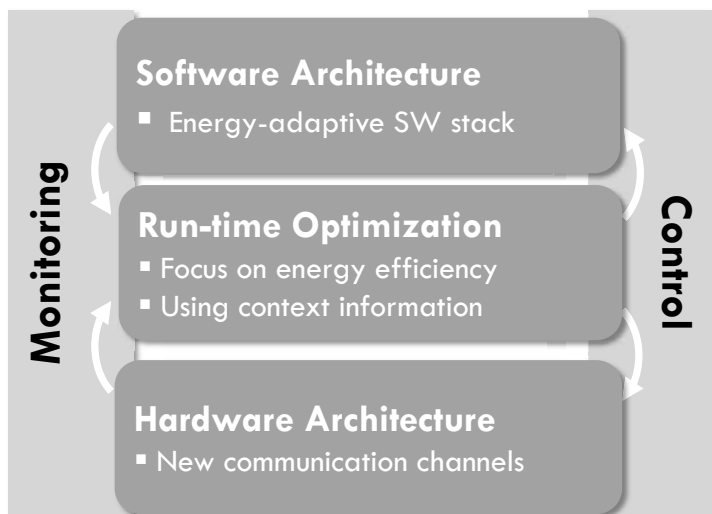
- Are considered on a **component level**
- Mostly in **isolation**
- Unaware of applications and **contexts**



Goal of project group B

- Address **energy-efficiency at all system levels** in an integrated holistic manner
- Ranging from the OS to software components to virtual machines

HAEC B – Closed Energy-Control Loop



Energy-Optimization Control Loop

- Measurement
- Analysis & verification
- Strategic regulation
- Adaptation

Energy-Adaptive Software Architecture

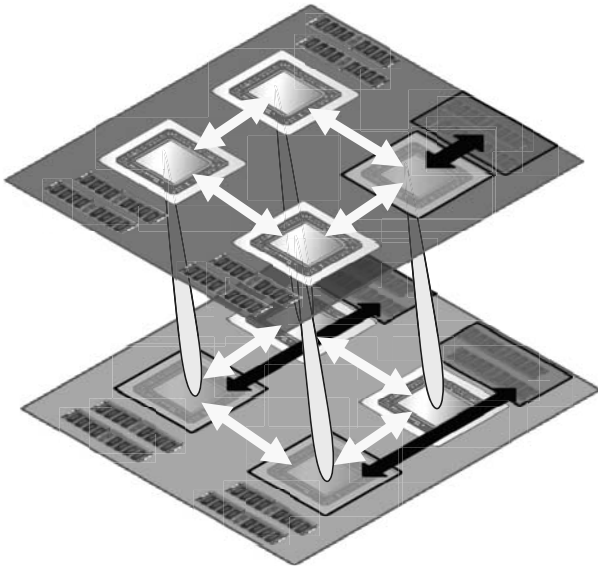
- Global QoS optimization with “Energy-Utility Functions”
- Cross-layer adaptation: application - system - hardware

Example of Adaptivity by Software



9

Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing



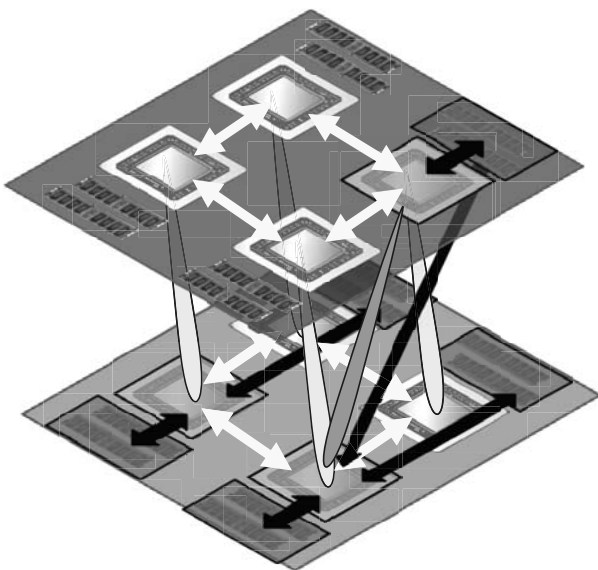
- Three in-memory database services
 - All are using a scan to access their data
- Under-utilized cores and interconnects

Example of Adaptivity by Software



10

Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing



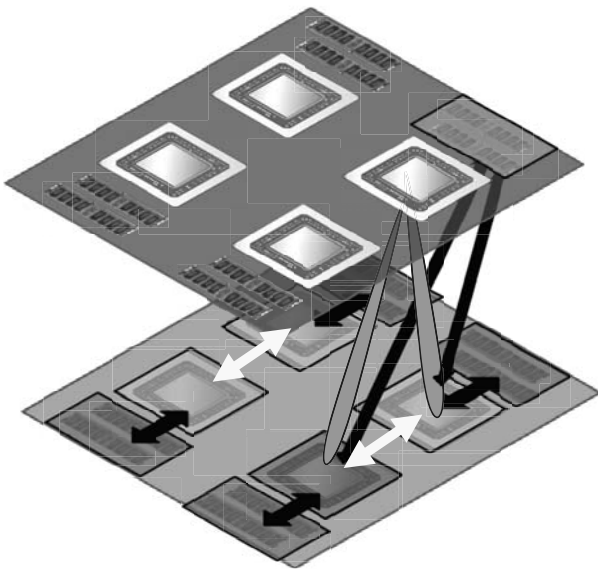
How to optimize?

- 1) Exchange software implementations (dbscan → index scan)
- 2) Migrate database service
- 3) Migrate memory
- 4) Turn off unnecessary interconnects

Hardware and software adaptations

Necessary for optimal energy-efficiency/proportionality

Example of Adaptivity

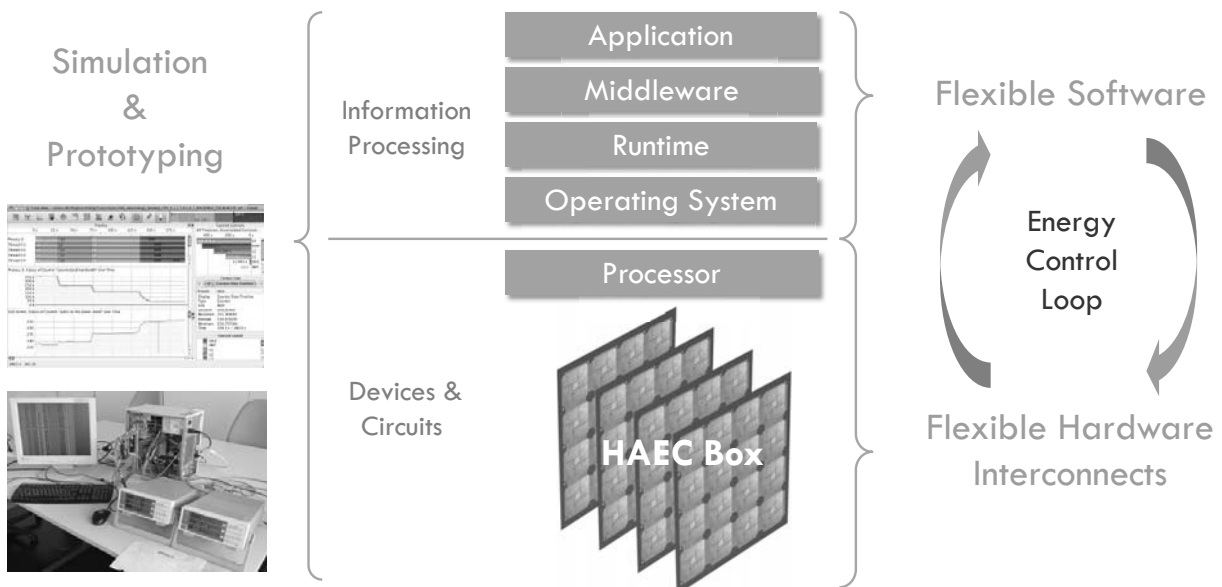


How to gain (more/less) utility from (more/less) energy ?

- 1) Partition memory and activate additional sockets and interconnects
- 2) Add more computing power and activate necessary interconnects

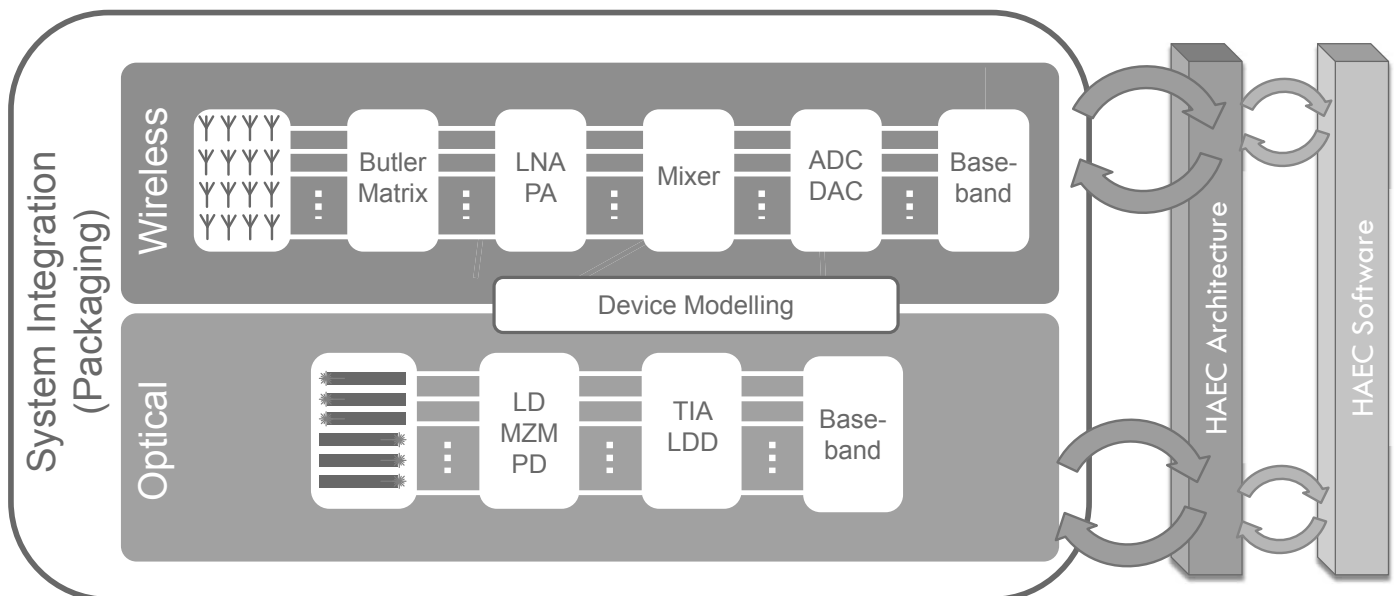
Trade Energy for Utility/Capacity

Highly Adaptive Energy-Efficient Computing



Highlights of Phase I (2011-2015)

HAEC A

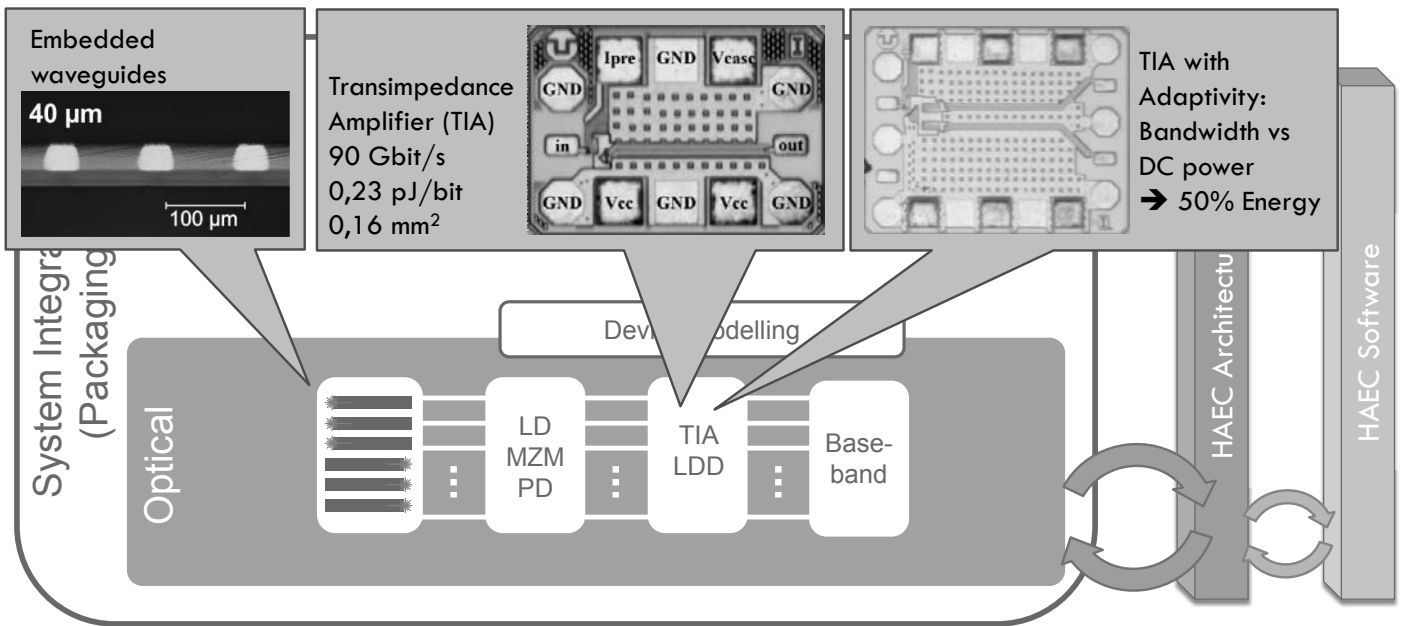


Selected HAEC A Highlights



21

Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing

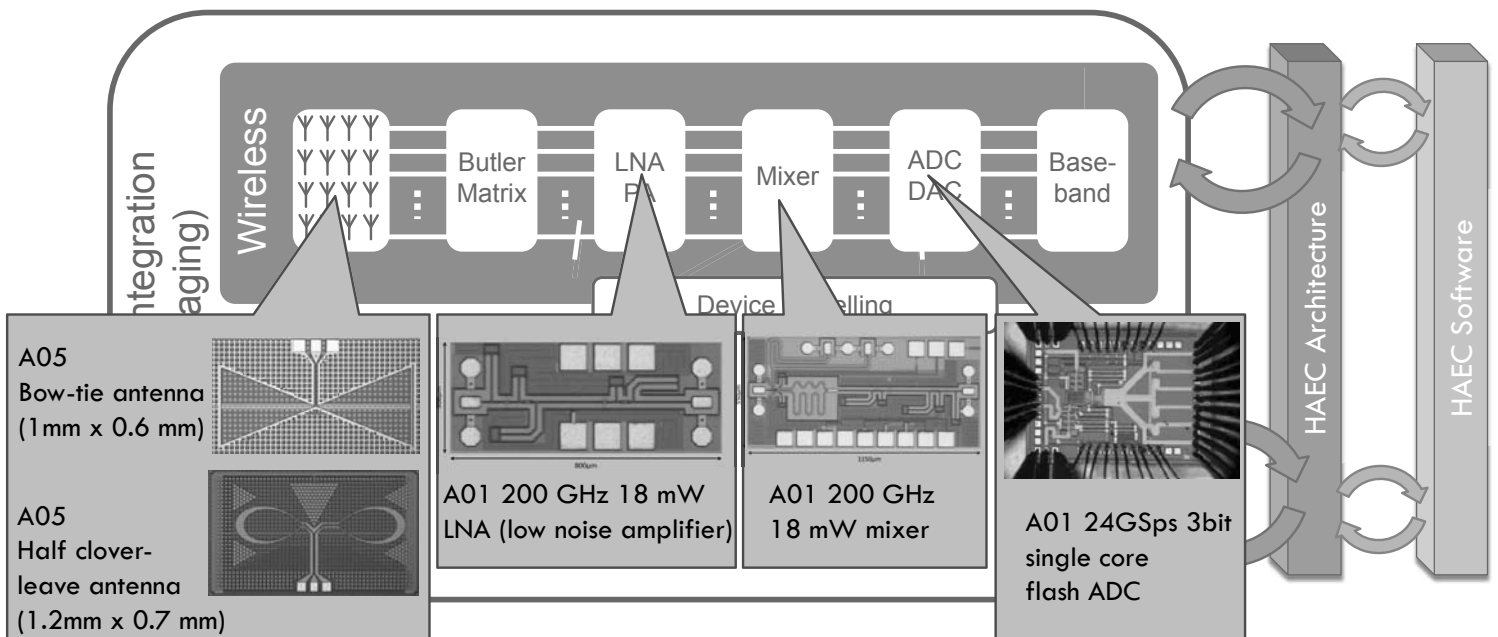


Selected HAEC A Highlights



22

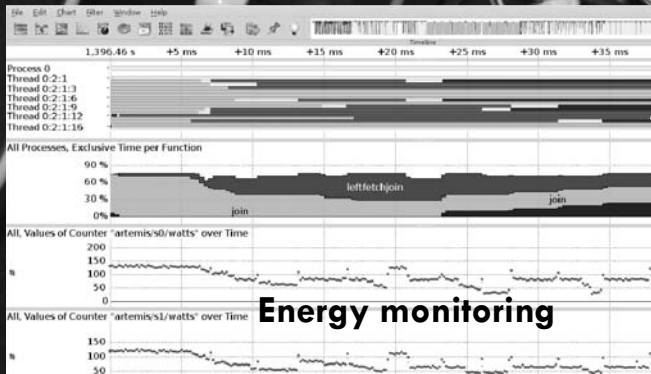
Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing



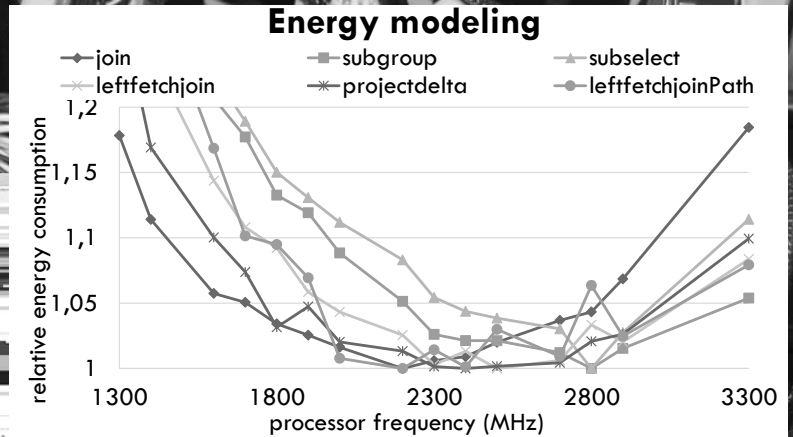
Selected HAEC A Highlights: Artemis



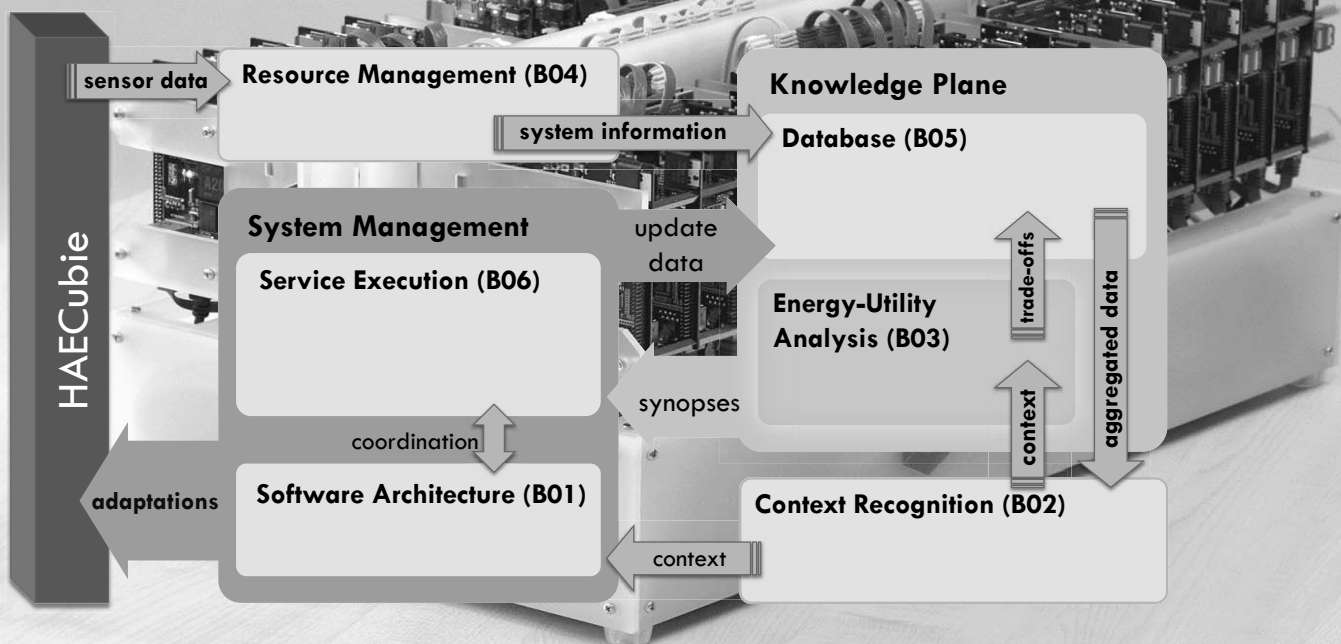
Shunt-based instrumentation for energy measurements in a state-of-the-art server



Energy monitoring



Selected HAEC B Highlights: HAECubie



The Outlook: The HAEC Box in 2030+

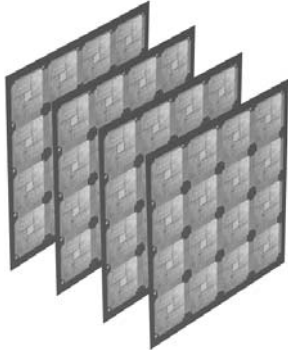


30

Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing

Assume 64K processors per chip
160x chips stacked in 3D

double-sided 4x4 chip-stacks on board
4x boards in a box



in 10x10x10 cm³ (1 liter)

1.6K processor + 16K memory chips

→ 10⁸ processors!

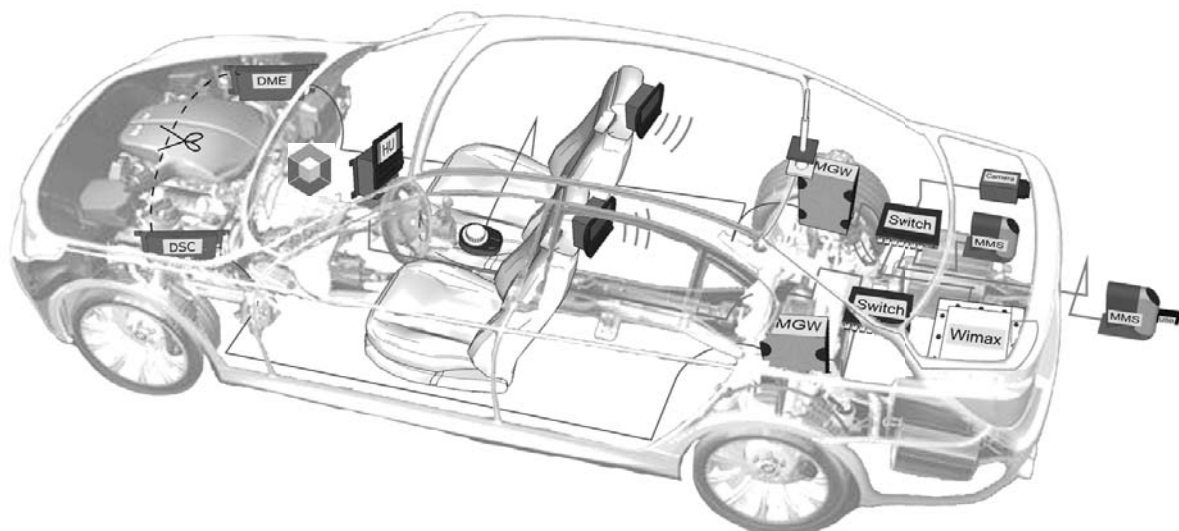
→ 10⁴x performance of today!

HAEC Box Embedded Everywhere



31

Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing



High-Level Highlights / Conclusions



32

Collaborative Research Center 912: HAEC – Highly Adaptive Energy-Efficient Computing

- Adaptivity → Energy proportionality
- Energy efficiency

- Revolutionary approach to computing hardware/software
- Impact onto more than computing applications
- Chance for scalability of the box and the software approach

- Chance for transfer



Thank You

www.tu-dresden.de/sfb912



