CEBE | Centre for Integrated Electronic Systems and Biomedical Engineering

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CEBE IAB Meeting 19.05.2015

Cyberphysical System Design

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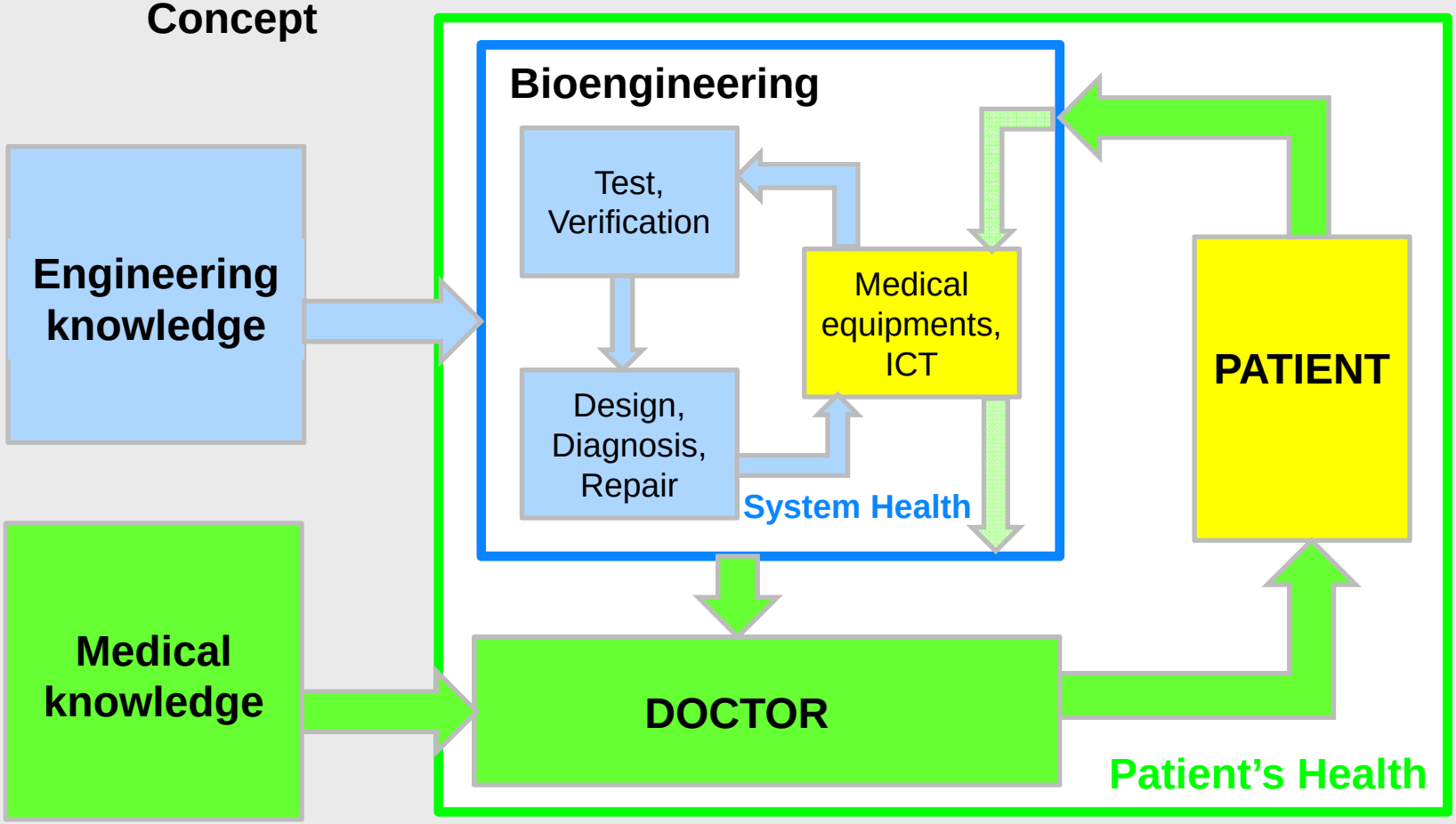
Tallinn University of Technology
Department of Computer Engineering

Outline

- ✓ Research Goals
- ✓ Dependable Embedded Many-Core Architectures
- ✓ Design Platform for Biomedical Applications
- ✓ „Blackbox“-Project: Scalable Bioimpedance Measurement

Risk Managment for Health² - RM4Health²

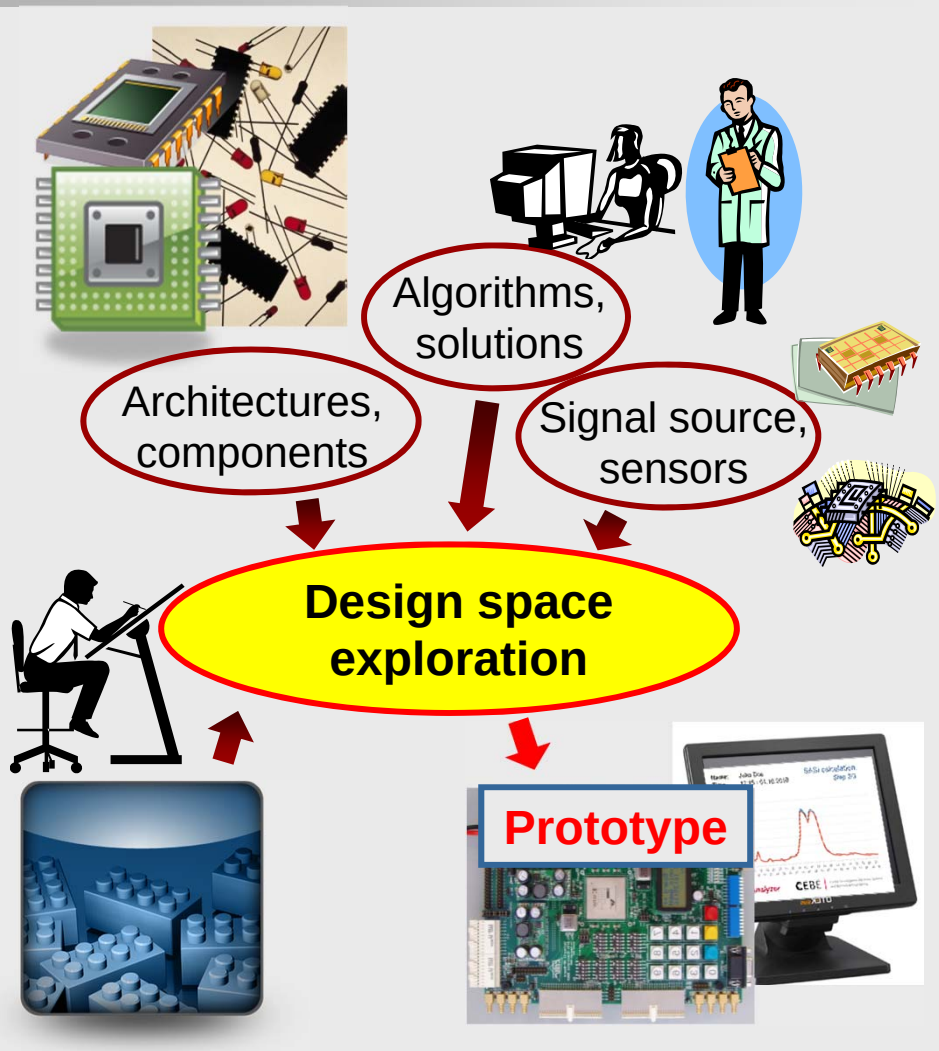
Nested Health² Management Concept



CEBE Design Cooperation Goals:

Goals: Contributions of Embedded System Design Research:

- Provision of methods, components and services for system health monitoring and fault tolerance (intellectual property)
- Fast Concept Evaluation and Feasibility analysis for new project ideas
- Provision of research environment and infrastructure for system prototyping



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CEBE Competences and Projects Flow

Competence fields:

Design and test of embedded systems

1 – Verification and diagnosis
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Electronics and signal processing

4 – Signals and signal processing
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Biomedical engineering

6 – Brain studies
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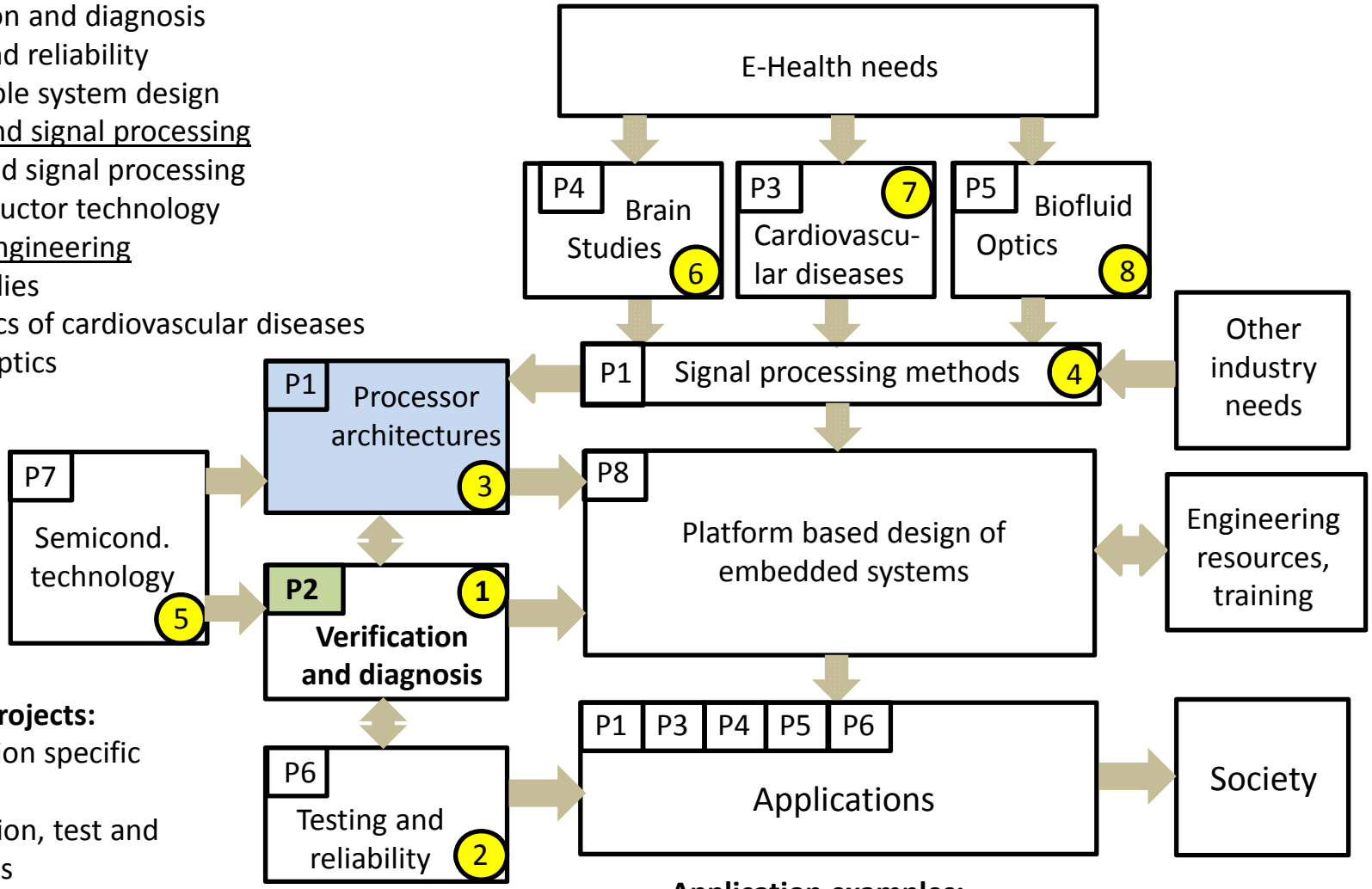

Coperation projects:

P1 – Application specific processors
P2 – Verification, test and fault diagnosis
P3 – Cardiovascular diagnostics
P4 – Evaluation of mental disorders using EAG analyzer
P5 – Reliable monitoring of dialysis
P6 – Embedded instrumentation platform for board testing
P7 – Semiconductor devices
P8 – Embedded system design platform

Application examples:

P1 – QUADRA^{R}, Pacemakers
P3 – Smart optical cardiovascular sensor
P4 – EEG analyzer
P5 – Diasens, Optofluid Dialysis Sensor
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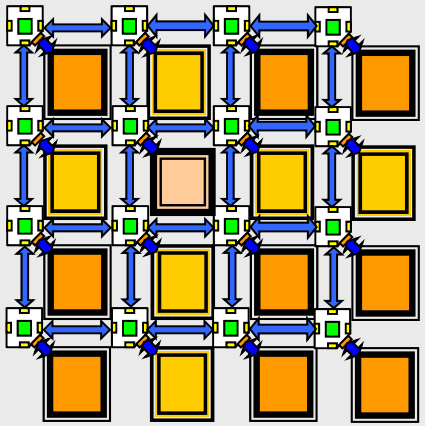
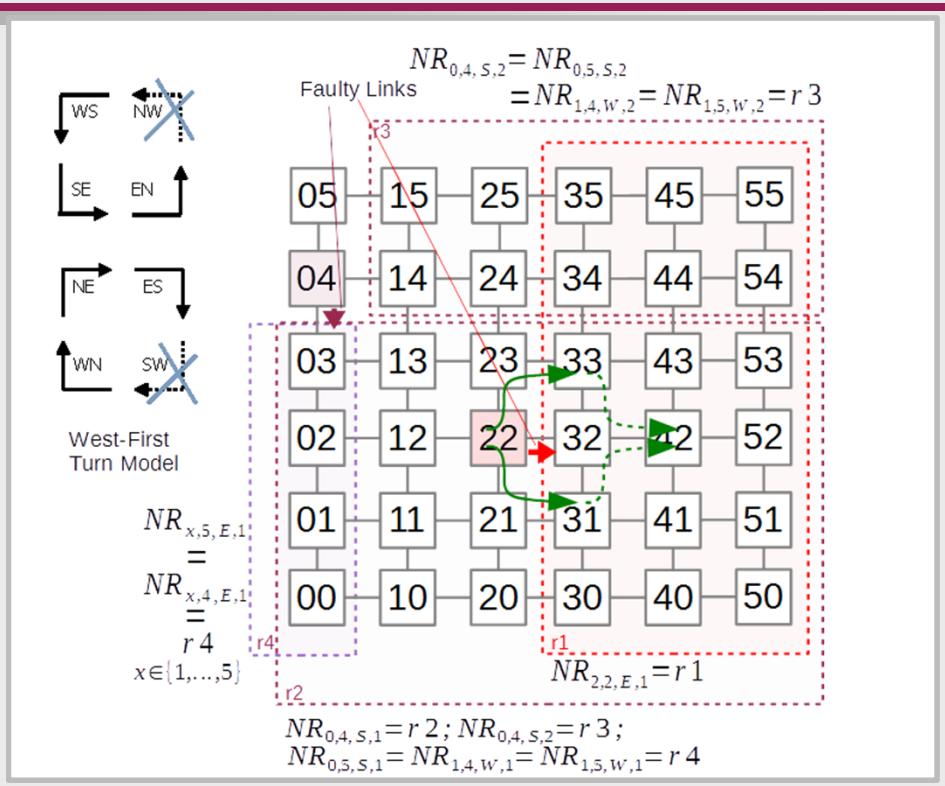
Dependable NoC Architecture

Research results:

- ✓ Adaptive 3D Routing
- ✓ Fault-tolerance concept for any amount of defect routing segments in the NoC





1. Hollstein, Thomas; Payandeh Azad, Siavoosh; Kogge, Thilo; Ying, Haoyuan; Hofmann, Klaus (2015). NoCDepend: A flexible and scalable DependabilityTechnique for 3D Networks-on-Chip. IEEE International Symposium on Design and Diagnostics of Electronic Circuits and Systems 2015.
2. Ying, Haoyuan; Hofmann, Klaus; Hollstein, Thomas (2014). Dynamic quadrant partitioning adaptive routing algorithm for irregular reduced vertical link density topology 3-Dimensional Network-on-Chips. 2014 International Conference on High Performance Computing & Simulation (HPCS). , 516 - 522.
3. Haoyuan Ying, Ashok Jaiswal, Thomas Hollstein, Klaus Hofmann (2013). Deadlock-free generic routing algorithms for 3-dimensional Networks-on-Chip with reduced vertical link density topologies. Journal of Systems Architecture, 59(7), 528 - 542.

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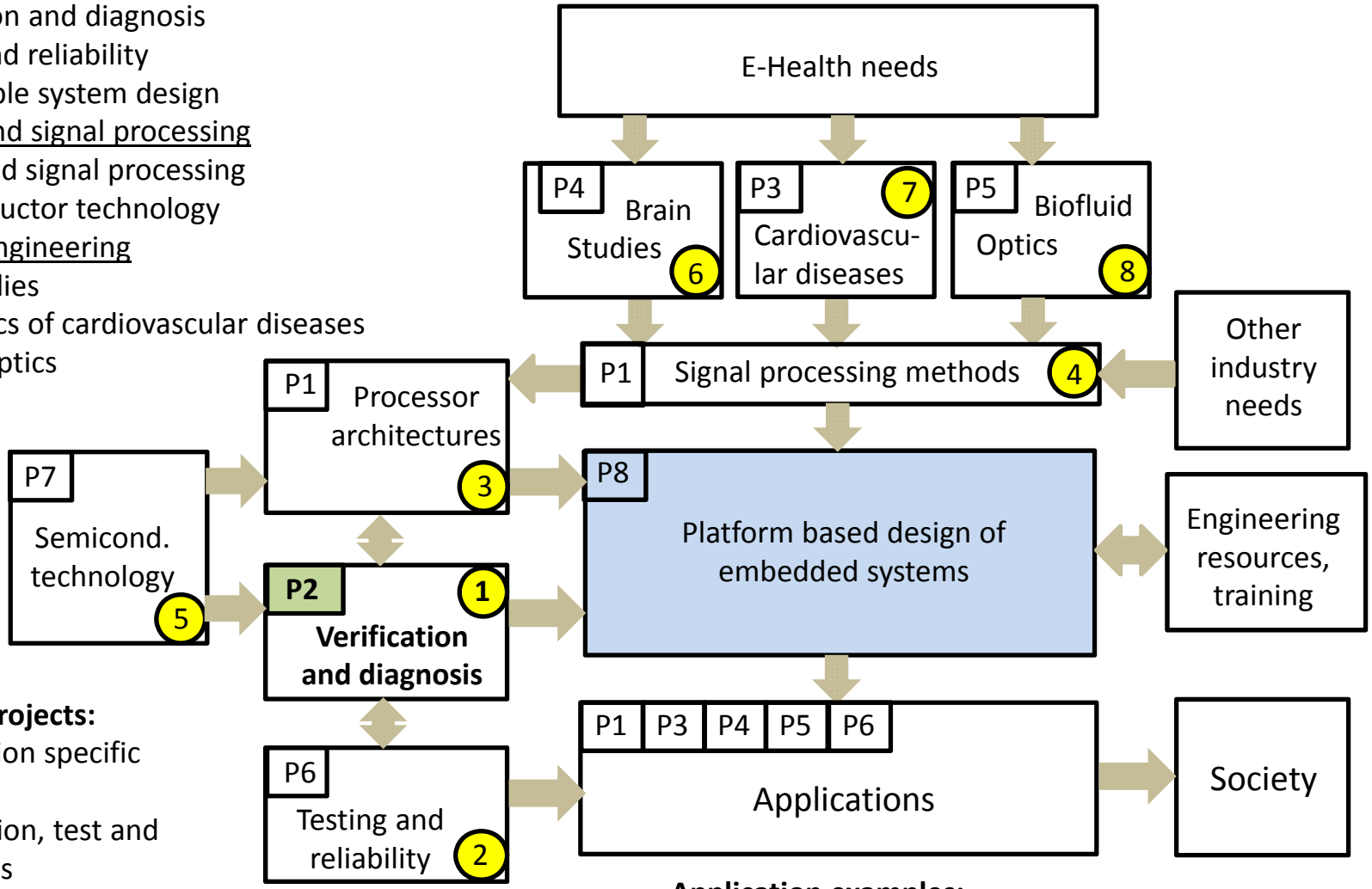

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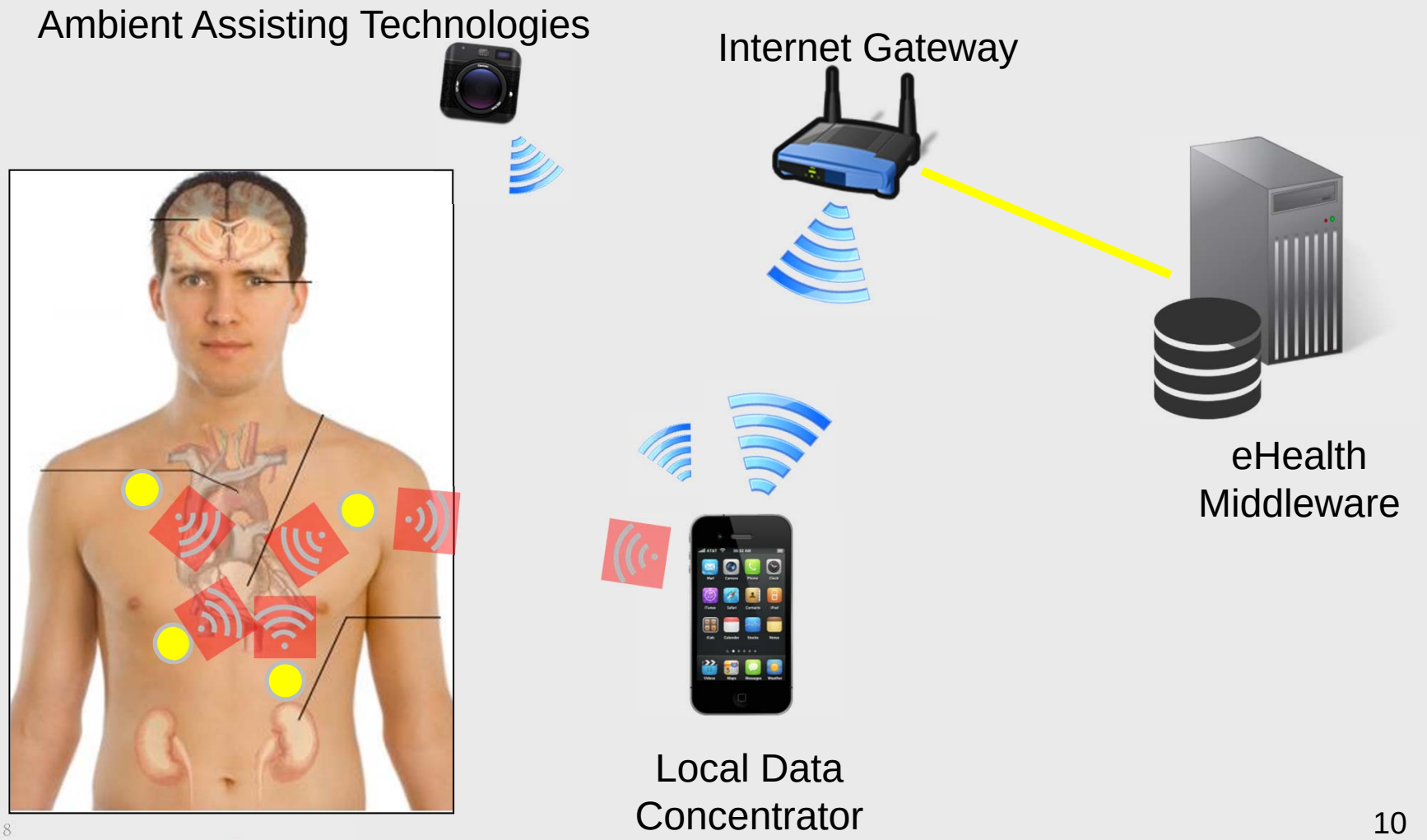
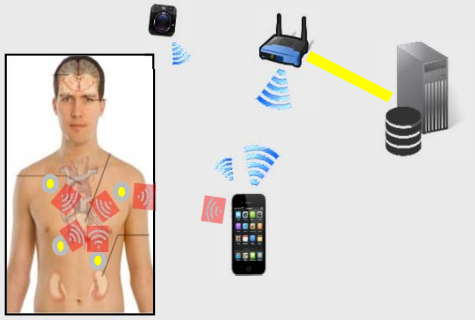
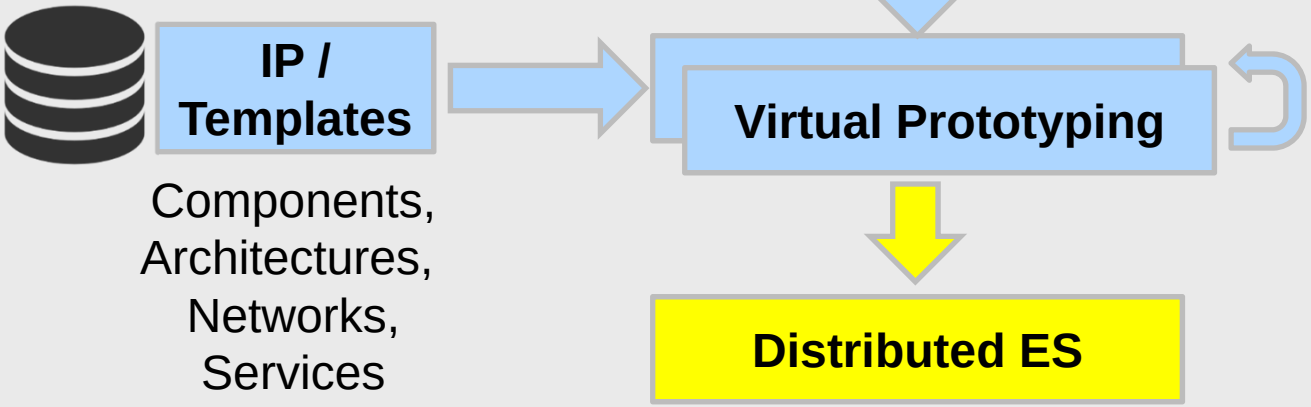
Generic Distributed Emb. Sys. Arch.



Design Method: IP-based +Virtual Prototyping



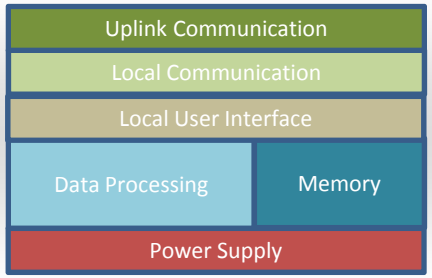


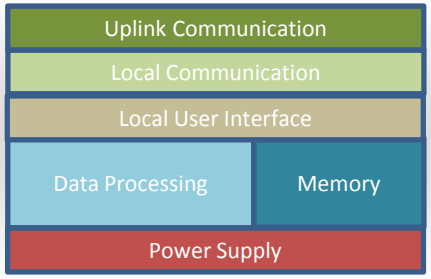
Generic Platform Architecture

Medical Services

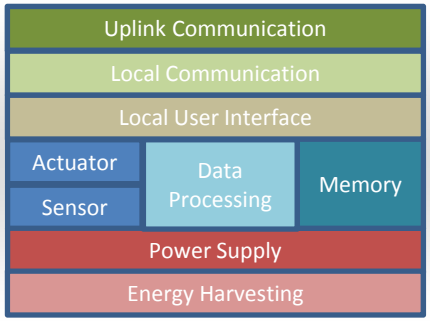
Data Services

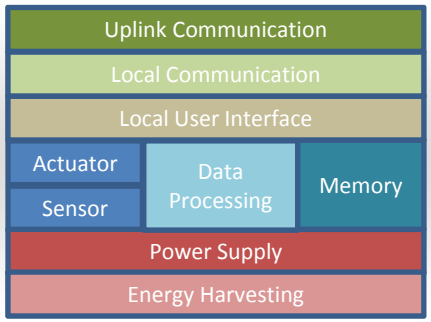
Smart In-house infrastructure





Smart Personal Environment.





Generic Platform Architecture

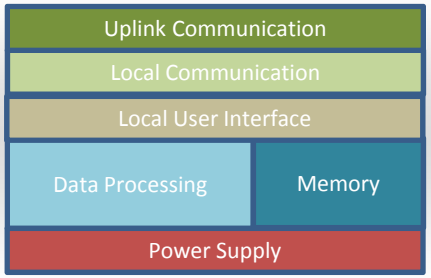
Medical Services

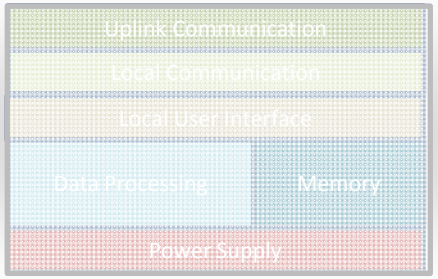
Data Services

Structure Instantiation for Bioimpedance Application

Smart In-house infrastructure

LAN





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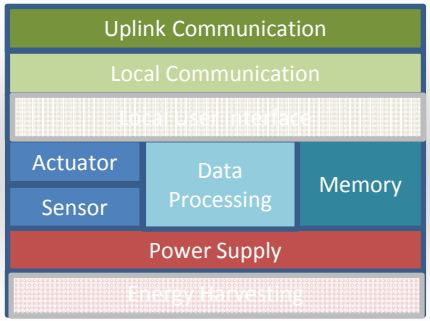

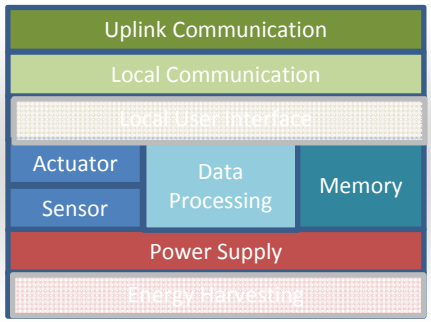

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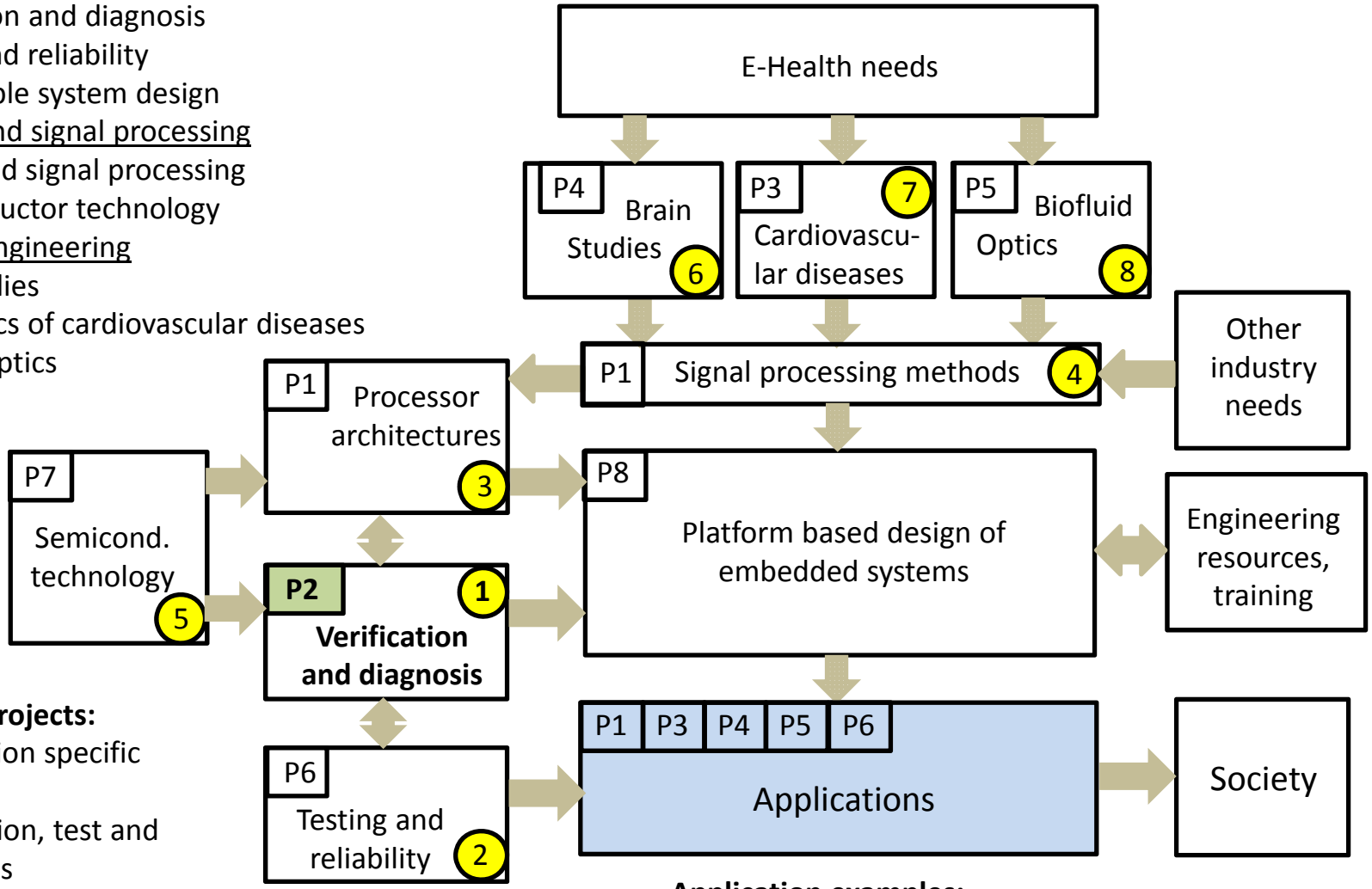

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The „Blackbox“ Project: Scalable Bioimpedance Measurement

Seebeck Institute

- Bioimpedance know-how
- DSP/signal proc. know-how
- First bioimpedance measurement implementations

Paul Annus
Yannick Le Moullec & team
Marko Reidla
Alar Kuusik (Eliko)
Raul Land

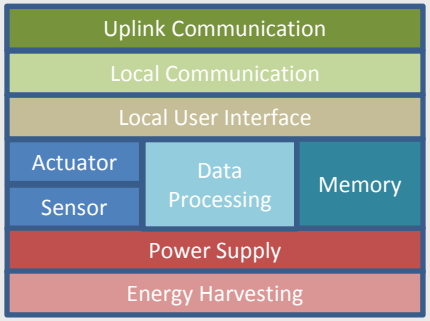
ATI:

- Platform concept
- Test and Dependability concepts and models
- Networking know-how

Thomas Hollstein
Uljana Reinsalu
Priit Ruberg
Karl Janson

Scalable and Networked Bioimpedance Measurement System „Blackbox Project“ (final CEBE demonstrator and flexible front-end for e-health applications)

The „Blackbox“ Architecture



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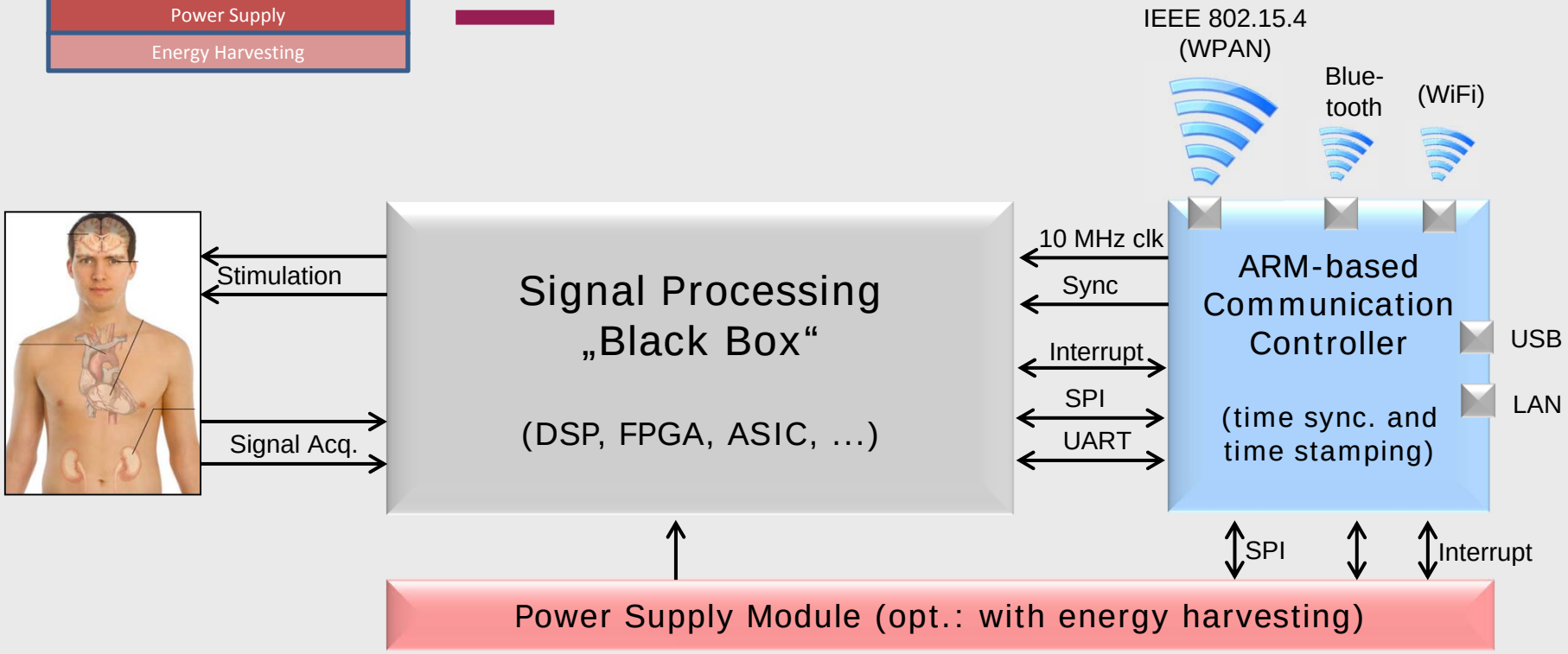
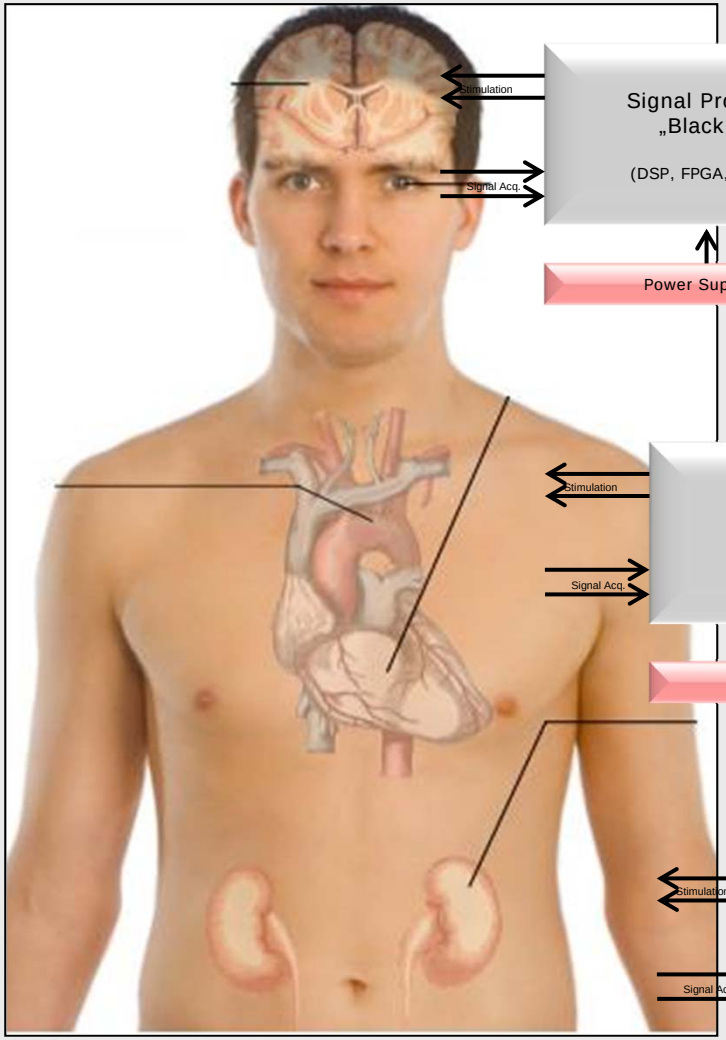


1) Le Moullec, Y.; Lecat, Y.; Annus, P.; Land, R.; Kuusik, A.; Reidla, M.; Hollstein, T.; Reinsalu, U.; Tammemäe, K.; Ruberg, P. (2014). A Modular 6LoWPAN-based Wireless Sensor Body Area Network for Health-Monitoring Applications. Asia-Pacific Signal and Information Processing Association Annual Summit and Conference 2014 (APSIPA ASC 2014). IEEE.

Scalable Usage Scenario



IEEE 802.15.4 (WPAN)

Blue-tooth

(WiFi)

Stimulation

Signal Acq.

Signal Processing „Black Box“

(DSP, FPGA, ASIC, ...)

10 MHz clk

Sync

SPI

UART

ARM-based Communication Controller

(time sync. and time stamping)

USB

LAN

SPI

Power Supply Module (opt.: with energy harvesting)

IEEE 802.15.4 (WPAN)

WPAN2(W)LAN Gateway

LAN

Concluding Remarks

Results:

- ✓ Methods for Design and Deployment of Fault-tolerant Many-Core Architectures
- ✓ Design Platform/Templates and IP-based concept
- ✓ „Blackbox“-Project: Joint Seebeck/ATI platform: scalable Bioimpedance Measurement >> final demonstrator in integration phase

Future Research based on Design Platform Concept:

- ✓ Future Research: Methods and Tools for Fast Virtual Prototyping

Thank you!