Trends that Shape the Future of Automation Engineering

On Cyber-physical Systems, Smart Components and other Innovations

Institute of Industrial Automation Technology and Software Engineering (IAS)

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03. April 2014

Institute of Industrial Automation and Software Engineering (IAS); Faculty of Computer Science, Electrical Engineering and Information Technology of Stuttgart University

Research and Teaching of the Institute is focused on software systems for automation engineering and is based on our background in information technology, software and electronics.

We are researching towards applications of automated manufacturing, automotive and consumers products.

Resume

- Education in the area of mechatronics
  - Studies of Electronic Engineering and Control Engineering at University of applied science (Saarbrücken), Ruhr University (Bochum) and University of Westminster (London)
  - Doctorate, RWTH (Aachen) in Mechanical Engineering
- Daimler
  - Member of the exchange group research and technology
  - Digital Factory Powertrain and Head of Function CAx Process Chain Production
  - Head of Department Engineering Services, Bangalore (India)
- Siemens Automation & Drives /Motion Control
  - Head of Department, direct Report to Head of Business Unit

10 years

- University Professor
  - Chair of Manufacturing Automation, University of Siegen
  - Institute of industrial Automation Technology and Software Engineering, University of Stuttgart

5 years

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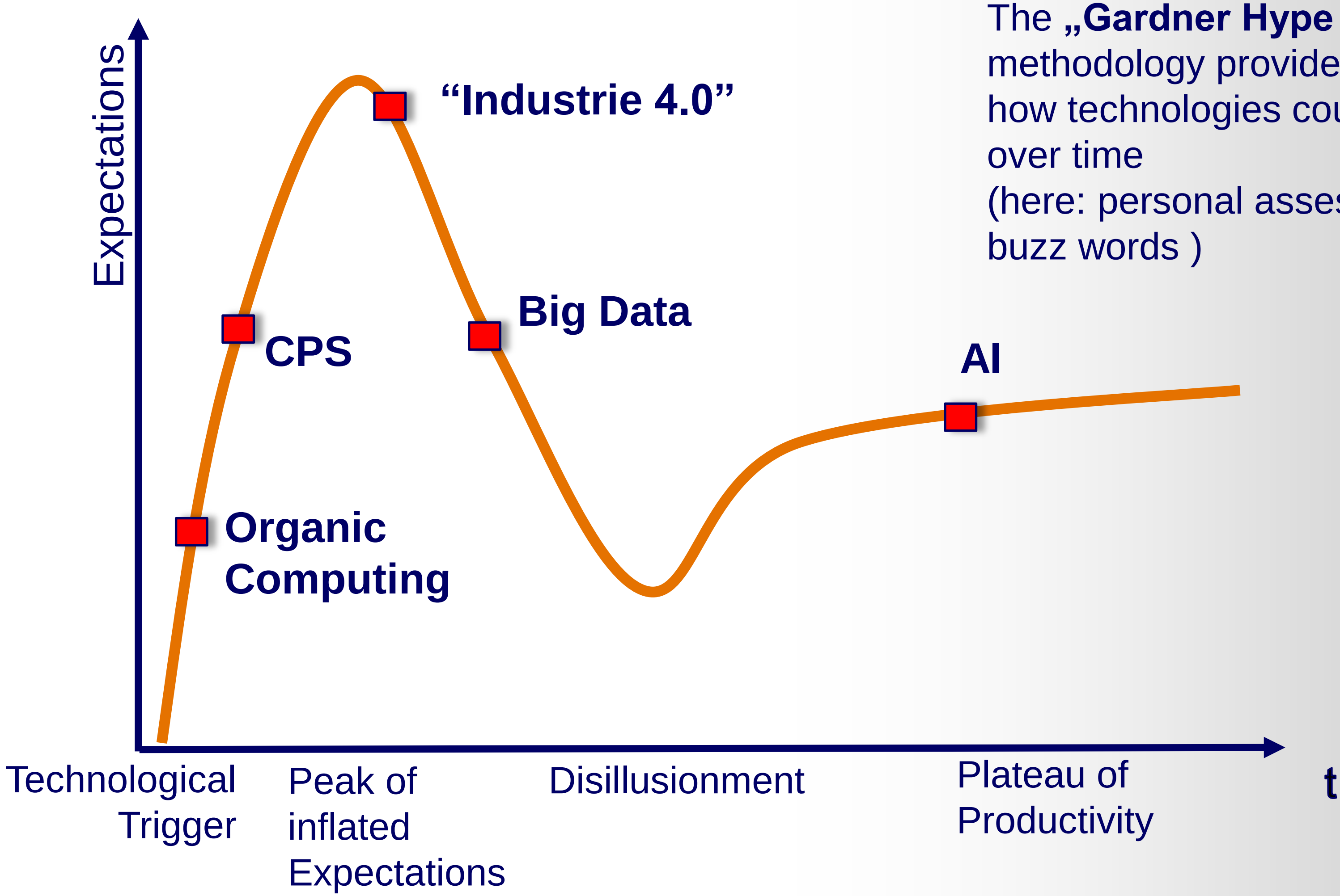
Which Technologies are promising changes towards Disruptive Innovation?



The **„Gardner Hype Cycle"** methodology provides a view on how technologies could evolve over time
(here: personal assessment of buzz words)

Prime Example for Disruptive Innovation

Success story of the Apple-iPhone:
on how Apple revolutionized the business model based on technology

Business Model: creation of an ecosystem for Apps and downloads such as music, games and navigation

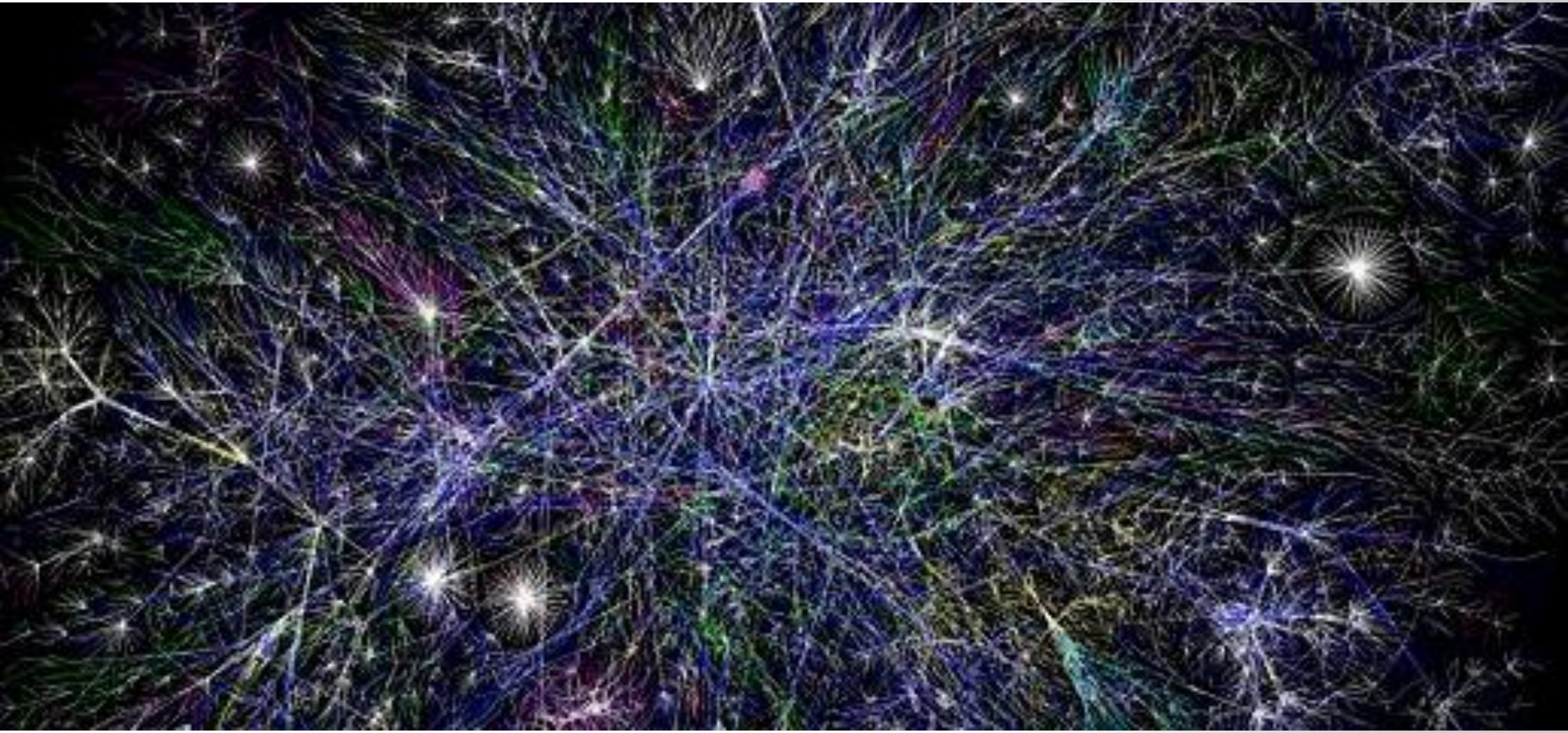
Redefinition of the utility value of a phone – meets requirements which were unavailable to users before

Technology: new chips, data centers and software (e.g. Apps)

Useful and elaborated– sophisticated functionality activates the genius of developers

Source of picture: Apple

Vision:
Smart Units / Nodes in the Internet of things and services are automating the world



Source of Picture: Wikimedia Commons

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Vocabulary and Concepts

"Ubiquitous Computing"

1991

The Computer For the 21st Century

"Cyber-Physical Systems"

2006

NSF Workshop

2010

acatech

Common Definition)*

A cyber-physical system (CPS) is a system of collaborating computational elements controlling physical entities

)* Wikipedia En, 23.03.14

Mark Weiser ✝

XEROX PARC

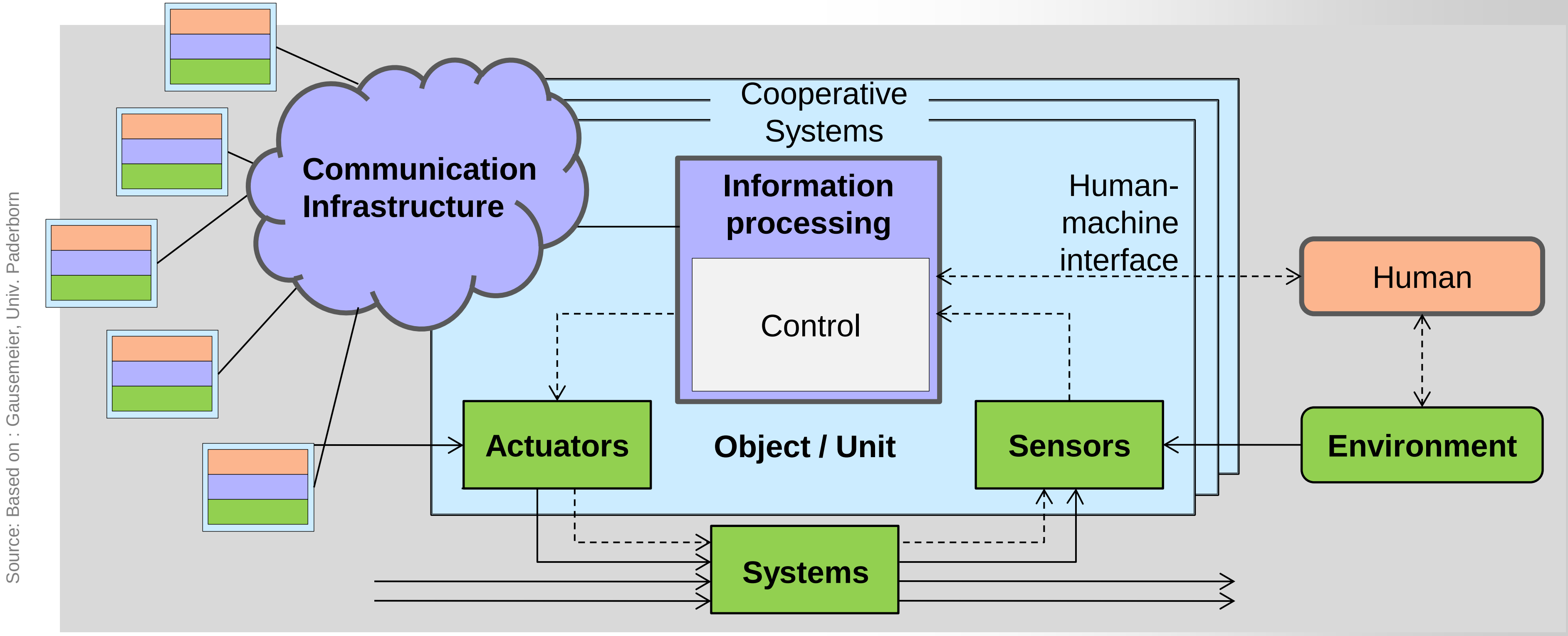
Weiser: "Next comes ubiquitous computing … when technology recedes into the background of our lives"; "… it won't be done until everything is on the Web …"

Cyber-Physical Systems
└── Systems of Systems
└── Embedded Systems

Source of picture: Internet

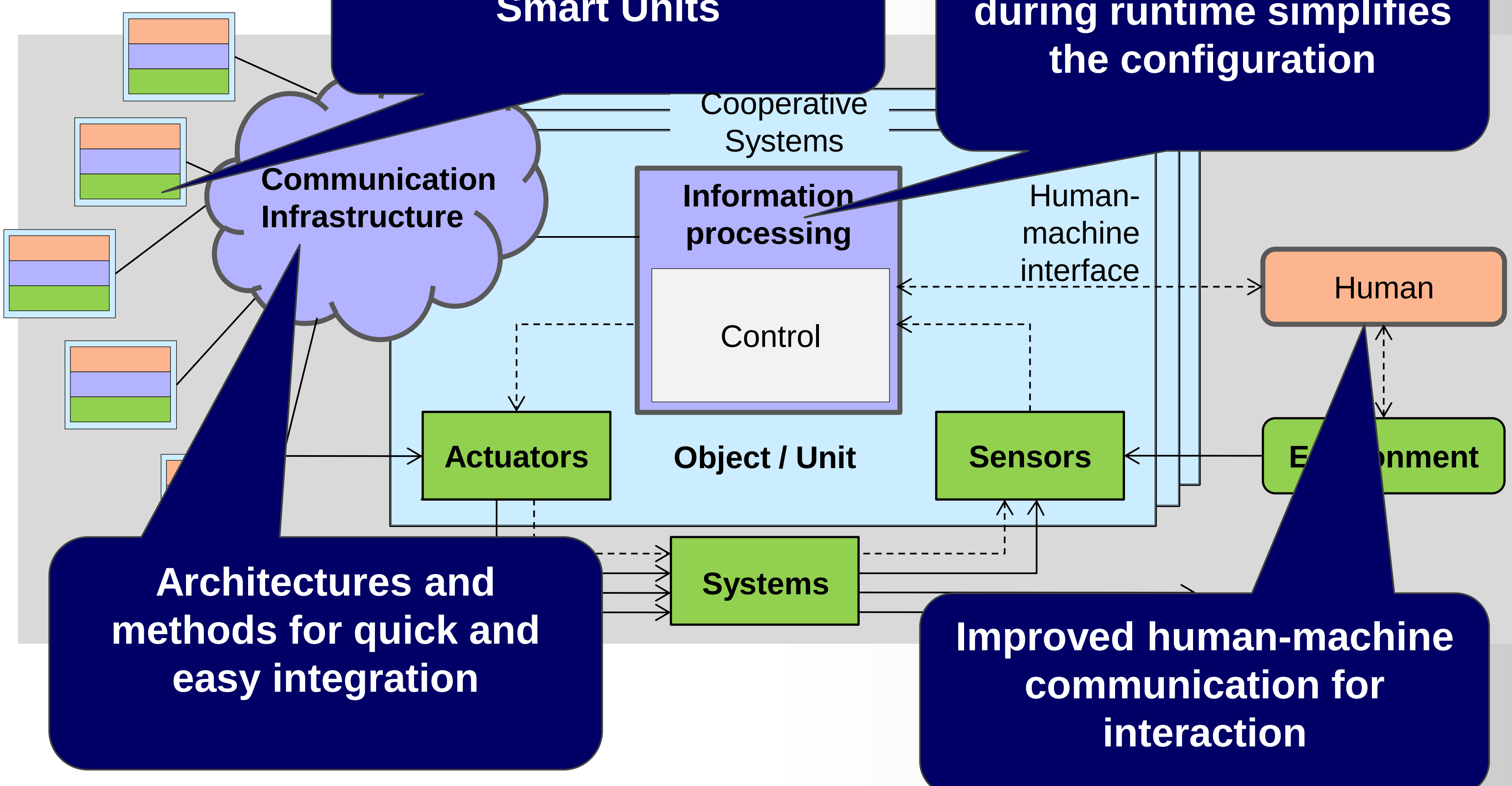
Cyber-physical Systems

Smart, networked Systems as a game-changer: New ways of cooperation among distributed and intelligent units as well as with human



Cyber-physical Systems

Smart, networked Systems as a game-changer: New ways of cooperation among distributed and intelligent units as well as with human



Source: Based on : Gausemeier, Univ. Paderborn

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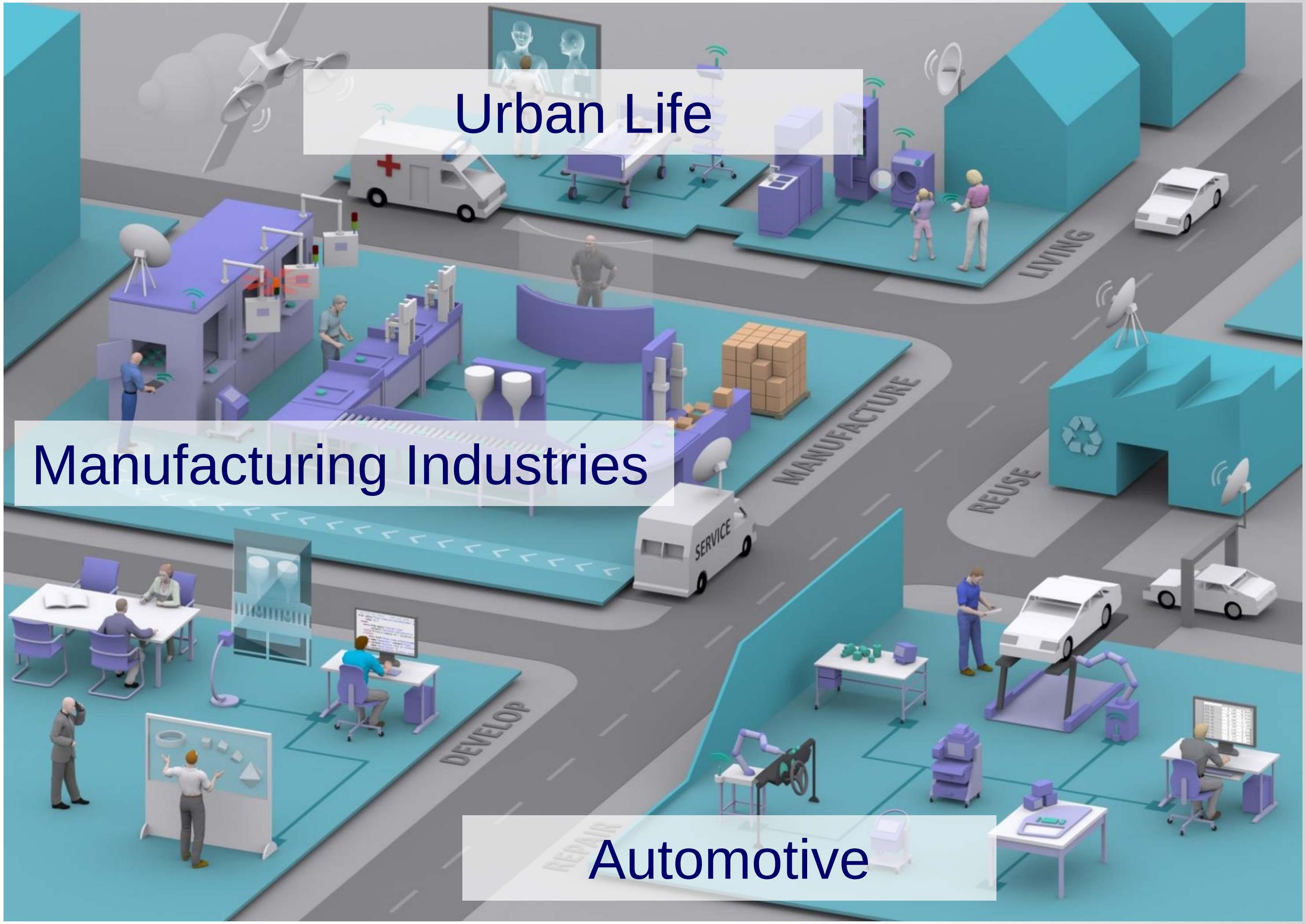
Research in Automation Technology revolves around the application domains

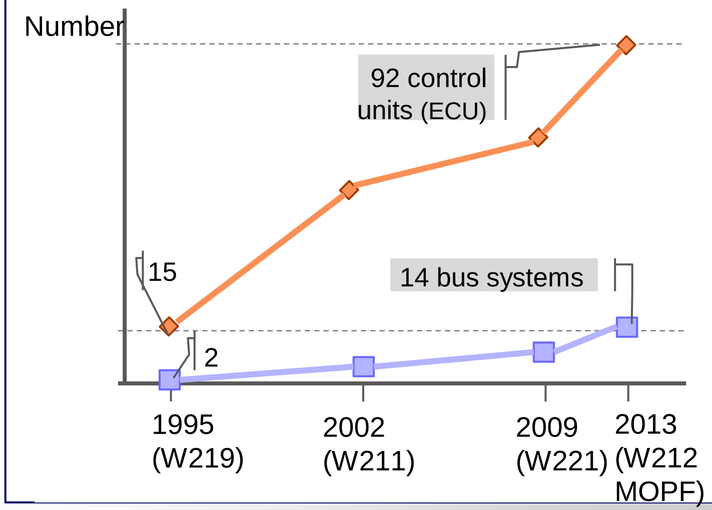


Networking Technology of the Car changes the process of Development

- The number of ECU (Electronic control units) and bus systems is increasing
- Complexity of Electric / Electronics and software increases due to driver assistant systems and connected cars

- Process improvement and quality management in development (AUTOSAR Standard)
- Model-based development and simulation (SiL, HiL)

Example Daimler (E class)



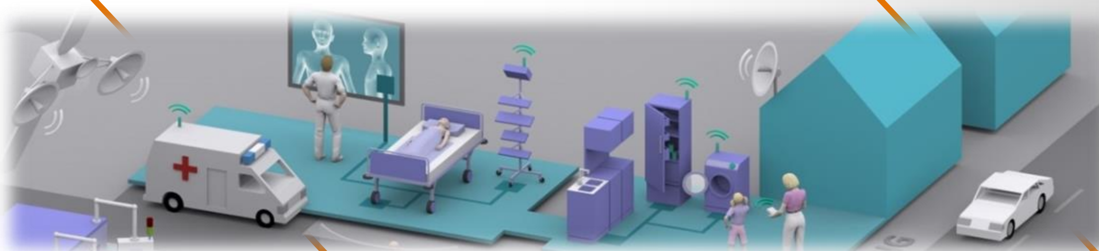
Source of pictures: Daimler AG

Urban Life is being automated

Award-winning research for automated consumer products

RFID automates a drug cabinet

Coffee from the internet



Multi-modal HMI of a ticket vending machine

App based diagnosis of household appliances

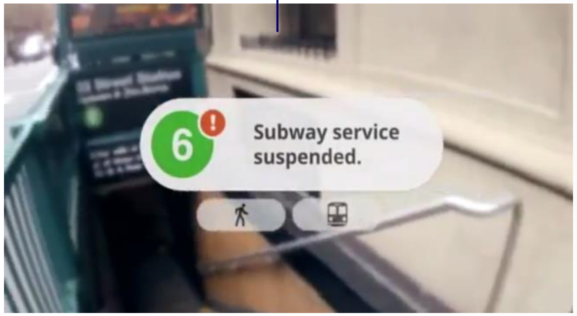
“The New Digital Age – Transforming Nations, Businesses and our Lives“)*

Vision of Google: omnipresence of Cyberspace and physical world in the sense of a hybrid reality.

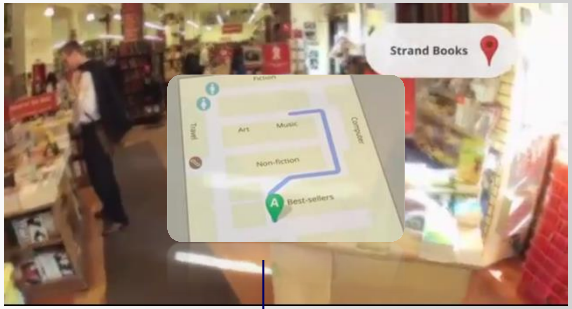
Google Project Glasses

Human machine interface

Location- dependent information



Navigation



Paradigm change:
Merging information from the internet, mobile communication und the physical world

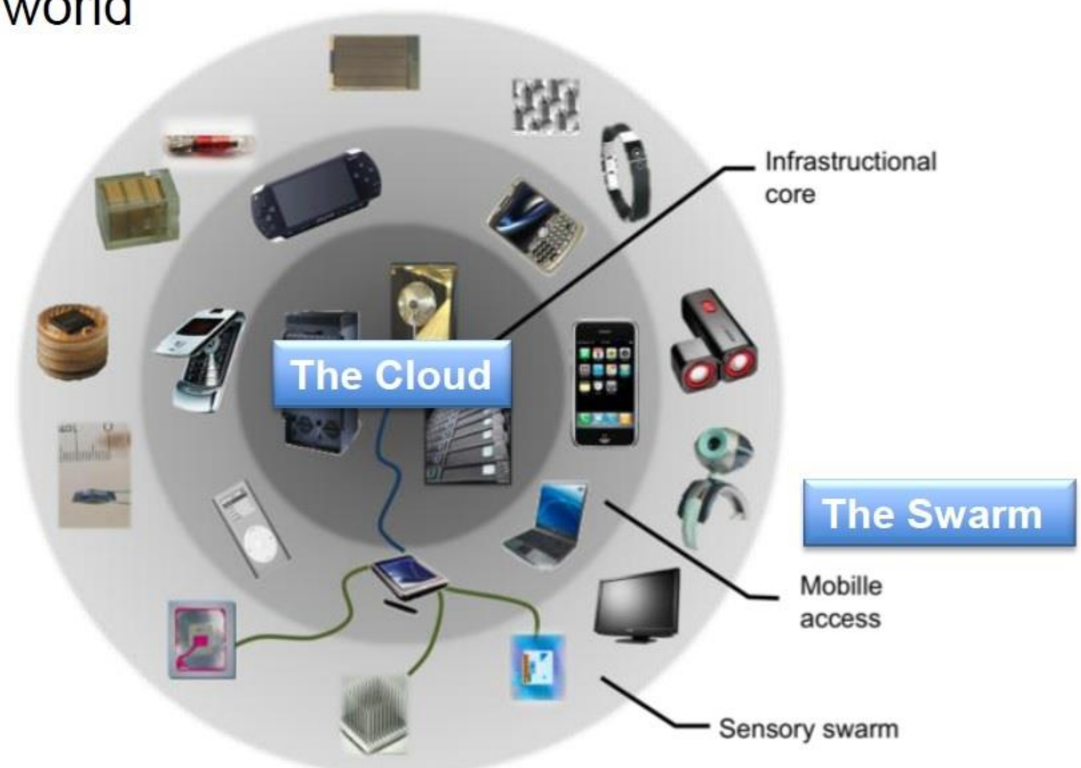
)* see book of same name: **Eric Schmidt (Goggle Executive Officer) and Jarred Cohen (Head Think tank Google Ideas)**;

Source of pictures: Google, http://www.youtube.com/watch?v=JSnB06um5r4

SWARM Lab
UC BERKELEY

THE SWARM AT THE EDGE OF THE CLOUD

Emerging information-technology platform that fundamentally changes the ways we interact with and live in information-rich world



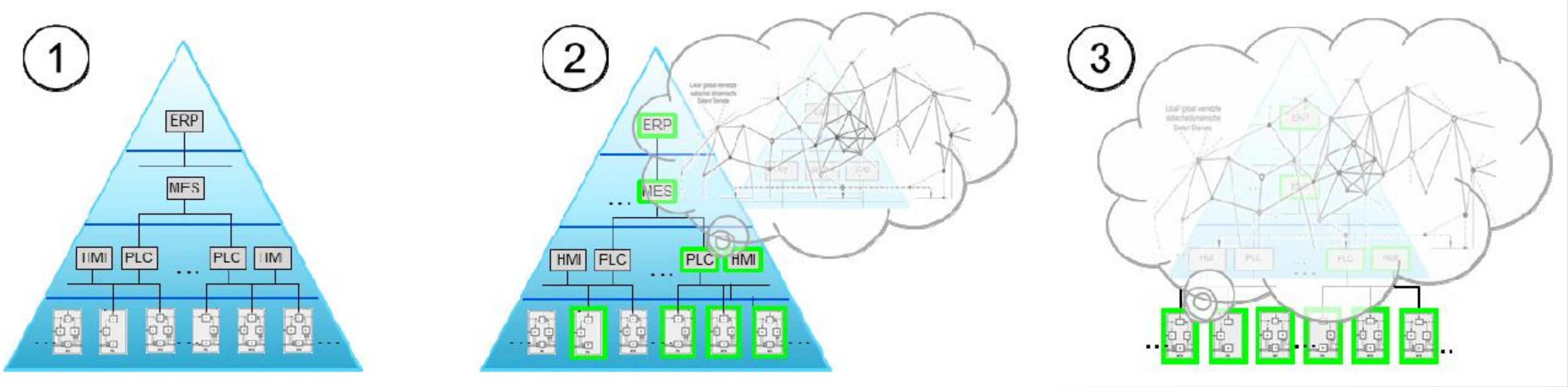
[J. Rabaey, ASPDAC'08]

Swarm operating system
New operating system as mediating layer between apps, resources and the cloud?

Source of pictures: Swarm Lab, UC Berkeley

(Partial) Decentralization of the Architecture

- The level structure in automation (so called automation pyramid) is dissolving
- Decentralized services are self-organizing and any hierarchy becomes blurred
- Real-time Systems remain however for some time on the bottom field level in the close future



Source: VDI, Hypotheses and fields of action: Opportunities form the perspective of automation technology, April 2013

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"Industrie 4.0"

Integration, Internet of things and services as well as Standards in the field of Big Data, Security and the business areas)[1]

Source: VDI

)[1] Result of a meeting at the VDI Düsseldorf on10. Juli 13: Participants: Prof. ten Hompel, Fraunhofer IML; Klaus Bauer, Trumpf; Dr. Dagmar Dirzus, VDI Wissensforum; Dr. Ralf Ackermann in SAP Research Center; Prof. Dr. Dieter Wegener, Siemens AG, Dieter Westerkamp, VDI; Prof. Dr. Michael Weyrich, Universität Stuttgart; Christoph Winterhalter, ABB AG; Dr. Heyjo Jacobi,VDI

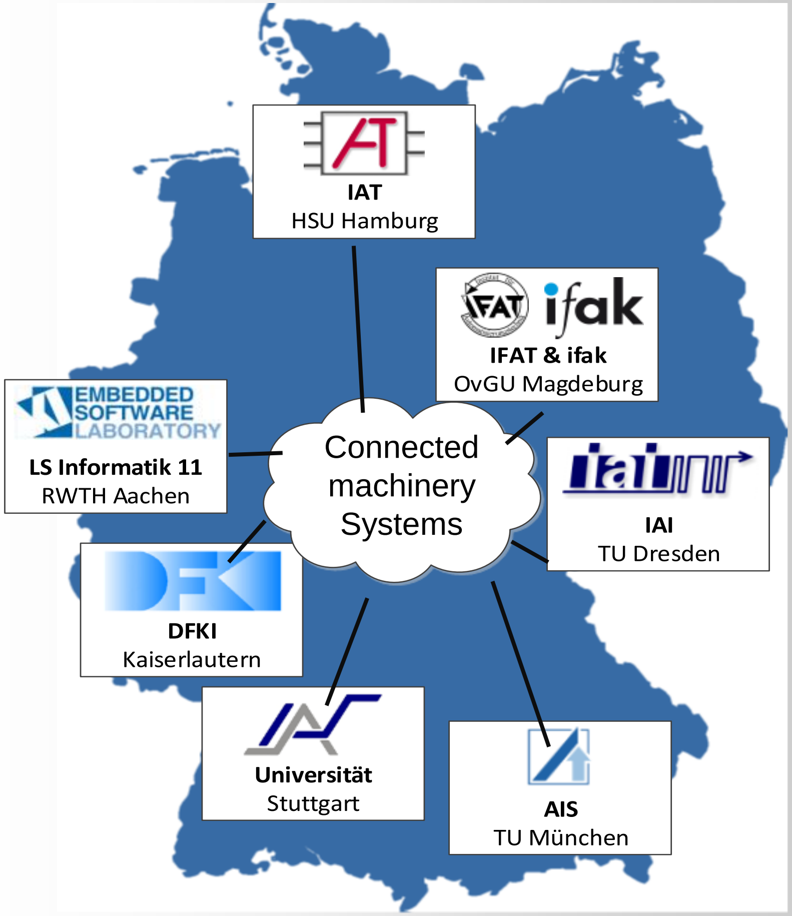
Case Study: “Industrie 4.0” Demonstrator

Cooperation between university institutes of the Automation Community

Application Scenario “My Yogurt“

- ***Individual Product Configuration:***
  Customers can order various amounts of yogurt of different flavors via the internet. The yogurt is produced by different machinery all around Germany.

- ***Diagnosis of the distributed machinery:***
  In the event of failure of similar units, an inquiry can be launched to obtain information on how the incident was resolved at another system. This approach can also be deployed for preventive maintenance.



Scource: [Christian Diedrich, OvGU]

Case Study: Research Aspects

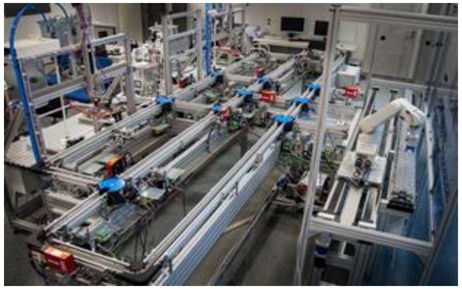
Requirements

- Configuration of products with interactive resource allocation
- Diagnosis to improve reliability
- Reliable and easy to use by operators
- Flexible and re-configurable in the sense of interoperability, adaptively and ad hoc cooperation

Technology

- Scheduling, Modelling of Processes
- Apps for human machine communication
- Service-oriented Architecture
- Network Management - Web Based Enterprise Management
- Cloud-Services for validation of embedded systems

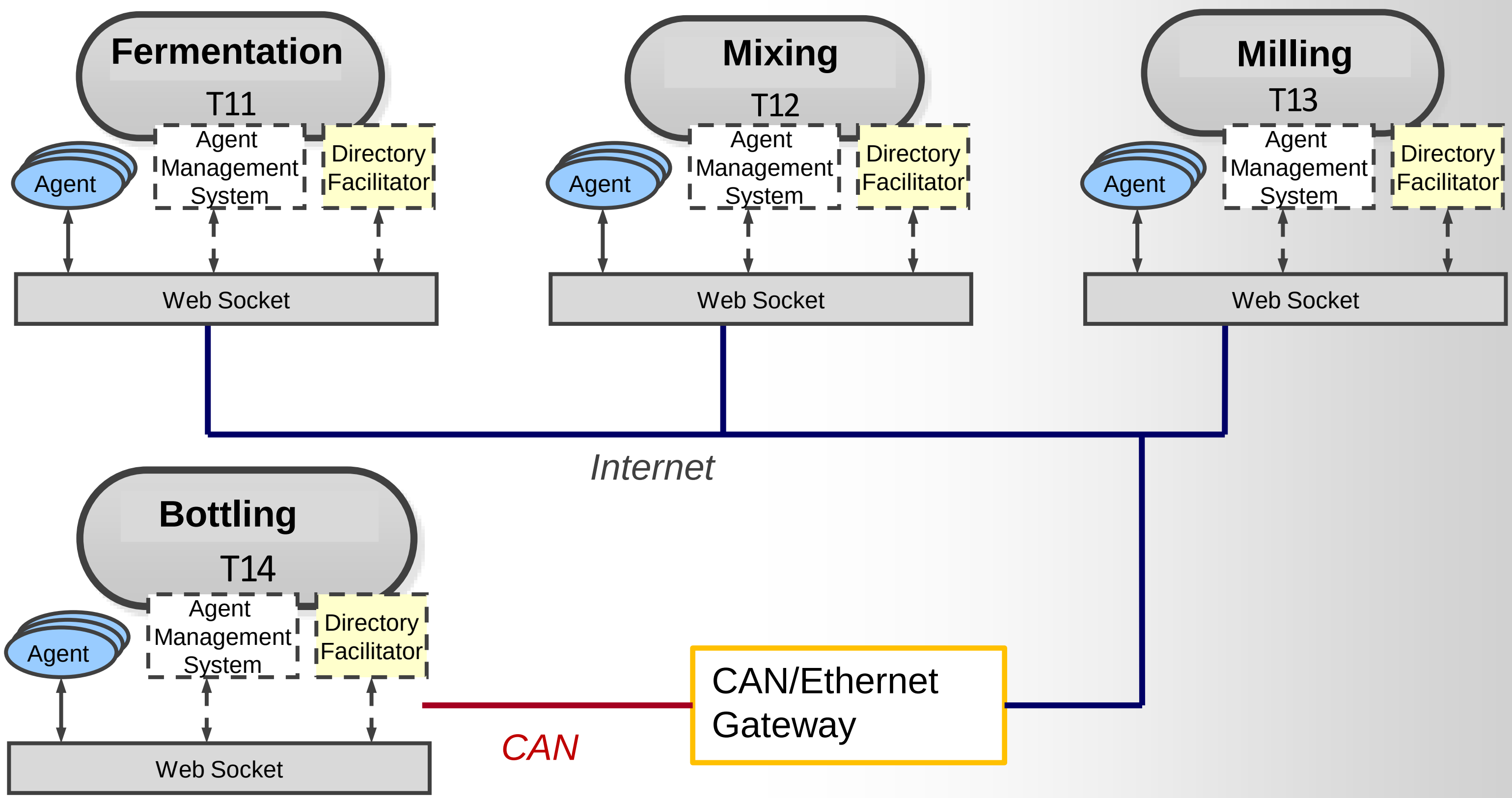
Scource: [Christian Diedrich, OvGU]





Automation Architecture based on Agents

- Agents are autonomous entities
- Agents achieve goals and may learn
- Agents interact with the environment and other agents

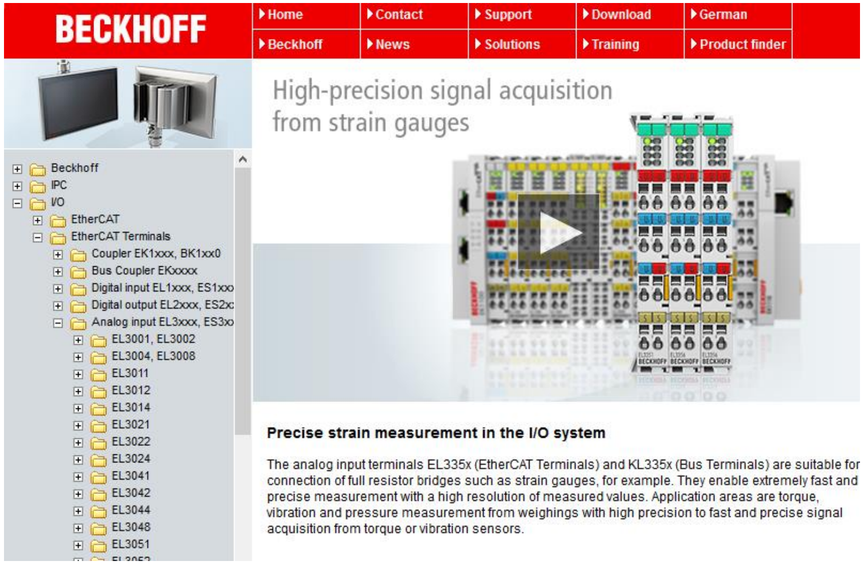


Examples for Smart Units

"Smart Units" are dedicated towards special application thereby fulfilling a particular customer value

Intelligent Bus Terminal facilitates signal processing and control

„Intelligent Bin" requests for a refill on its own



Source: Beckhoff

Source: Fraunhofer IML, Prof. Dr. Michael ten Hompel

iBin is counting the parts using an integrated camera. The system interacts with the cloud for part logistics

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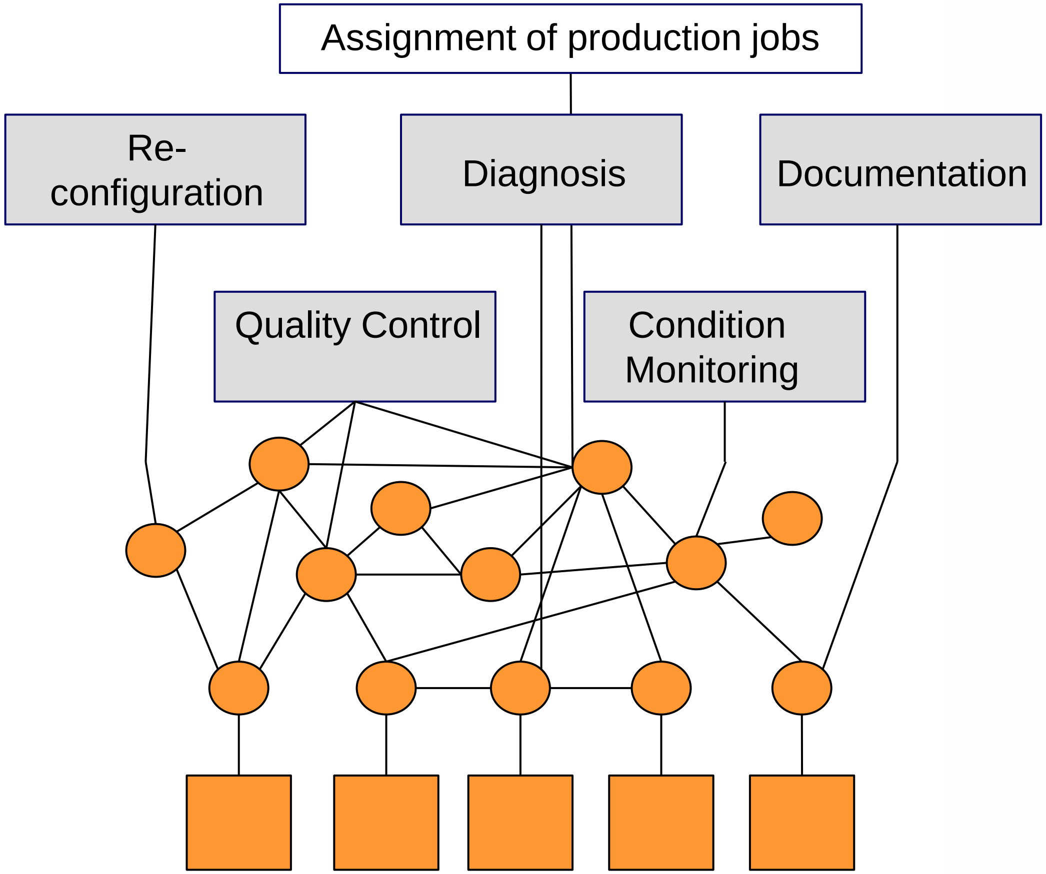
Decentralization of Architecture

- Hierarchies are fading and borders become blur
- Decentralized services are partially self-organised by agents



Services for human machine Communication (Apps)

Coordination layer:
Agents with directory of services and data processing

Field Level (Real time level):
Process Control, Sensors, Actuators etc.

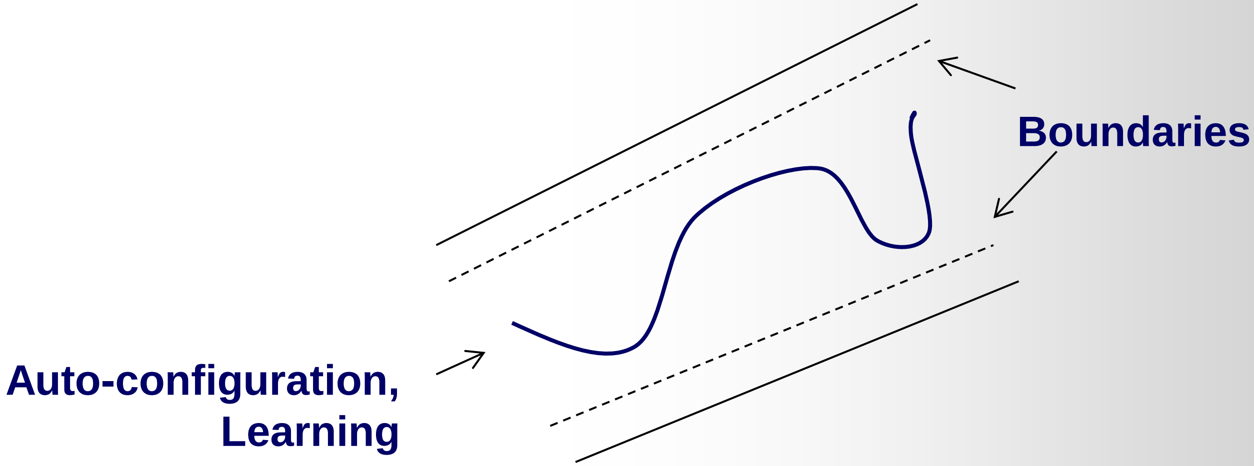
„Moving Design to Runtime“

Smart engineering through learning and self configuration

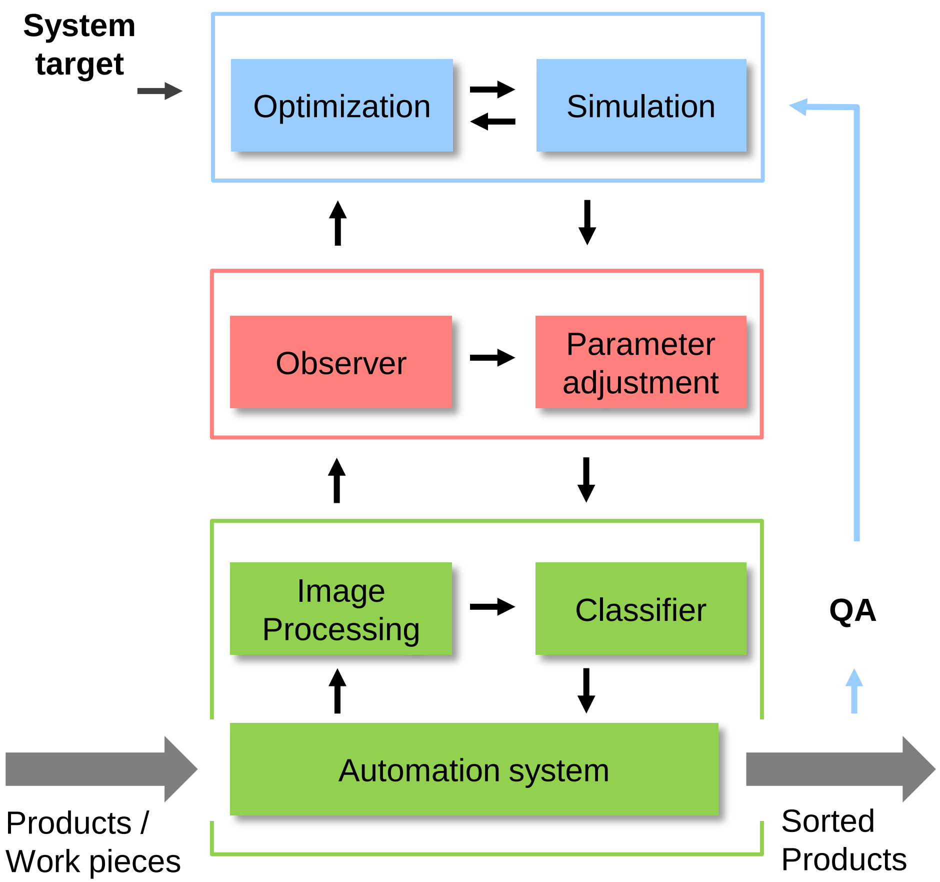
Method: Configuration of automation systems through an agent-based Configuration of preconceived Components.
=> Flexible and Re-configurable

Challenge of learning from the perspective of the engineer

- Keep system compliant with changing requirements



Learning Architecture
(Example of industrial image processing)



Layer 3

Optimization
- Simulation-based optimization upon models (closed loop control)

Layer 2

Adaption layer
- Observation for parameter adjustment (open loop control)

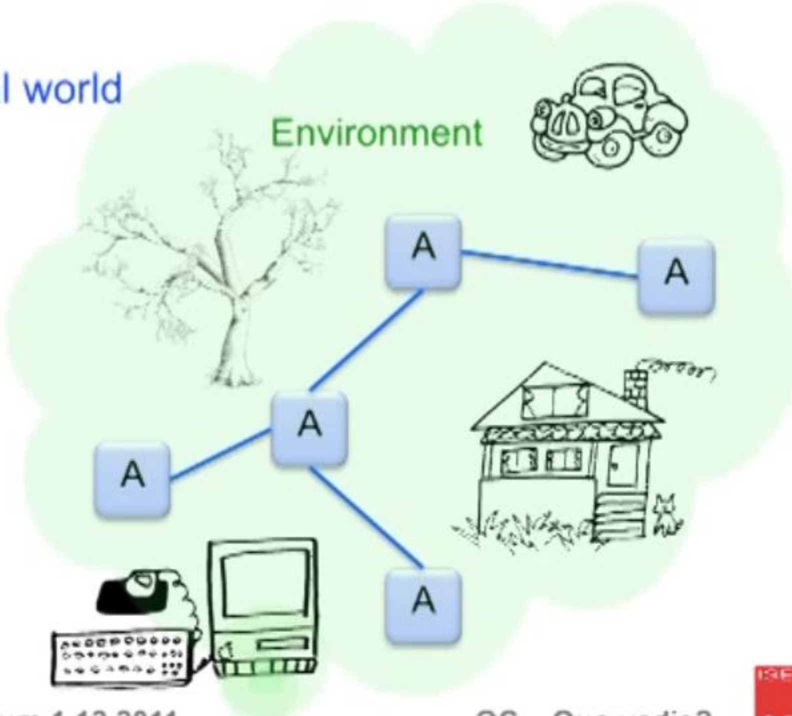
Layer 1

Execution layer
- Image processing with classifier
- Product recognition
- Camera-guided robot

Citation of the DFG SPP: Organics Computing

5 Lessons learnt

1. OC means: Move design time decisions to runtime!
2. „Self" is nothing magic, it has to be done.
3. Principle of non-critical complexity
4. No decentralization at any cost!
5. OC is about agents situated in a real world
   - Cognitive agents
   - Social agents



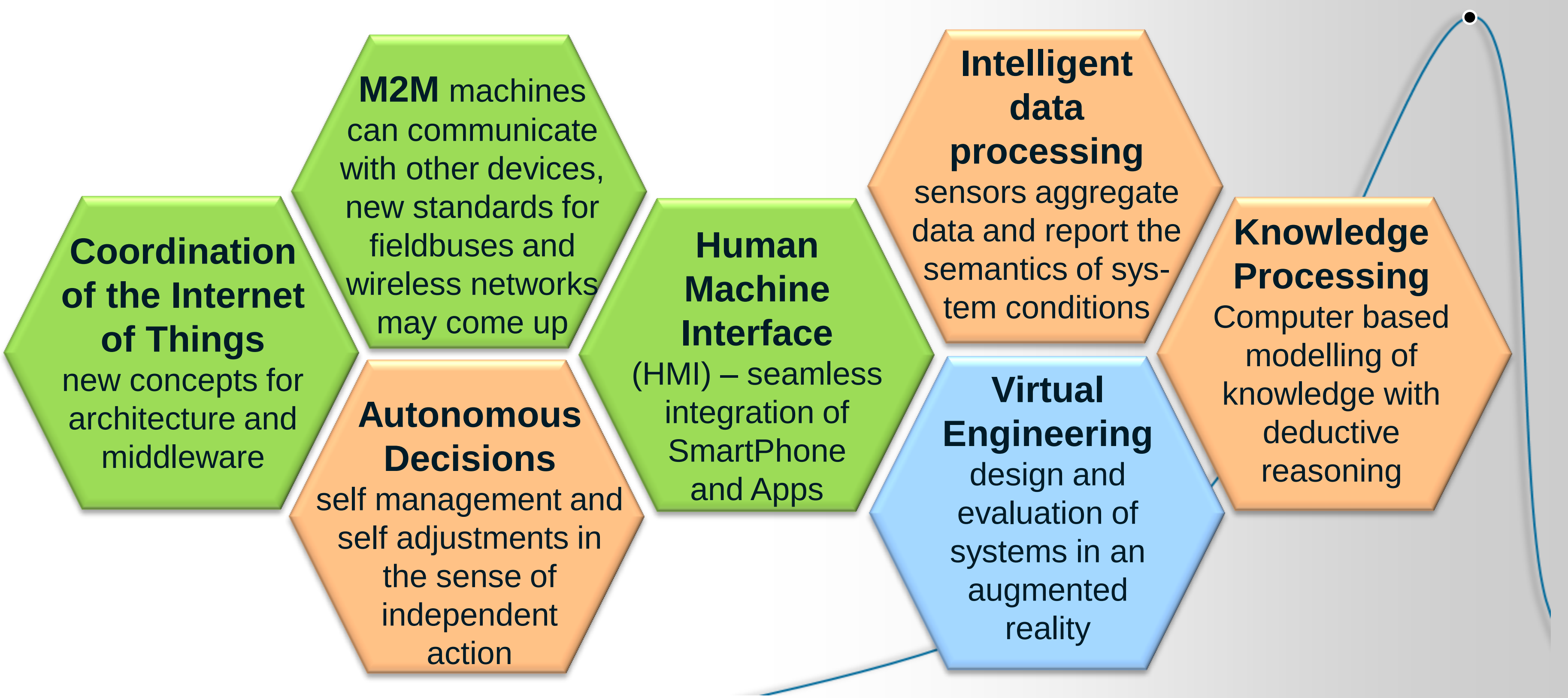
© C. Müller-Schloer 2011

22 HNI-Forum 1.12.2011 OC – Quo vadis?

Quelle: Prof. Christian Müller-Schloer, Leibniz Univ. Hannover, Vortrag „Organic-Computing – Quo vadis?“; http://www.youtube.com/watch?v=ebHgJc4sTKY

Seamless integration of Automation Technology

Information technology has reached a stage from which disruptive changes of existing paradigms can be expected



Key Factors

Demonstration of new Technologies
Which technology provide better products or improves the process?

Examples for Value Proposition
Which new value is created based on which technology?

Architecture of Value Creation
What is the best configuration to deliver?