VICCI

Visual and Interactive Cyber-Physical Systems Control and Integration

EICS2012 – MODIQUITIOUS2012

Towards a flexible control center for cyber-physical systems

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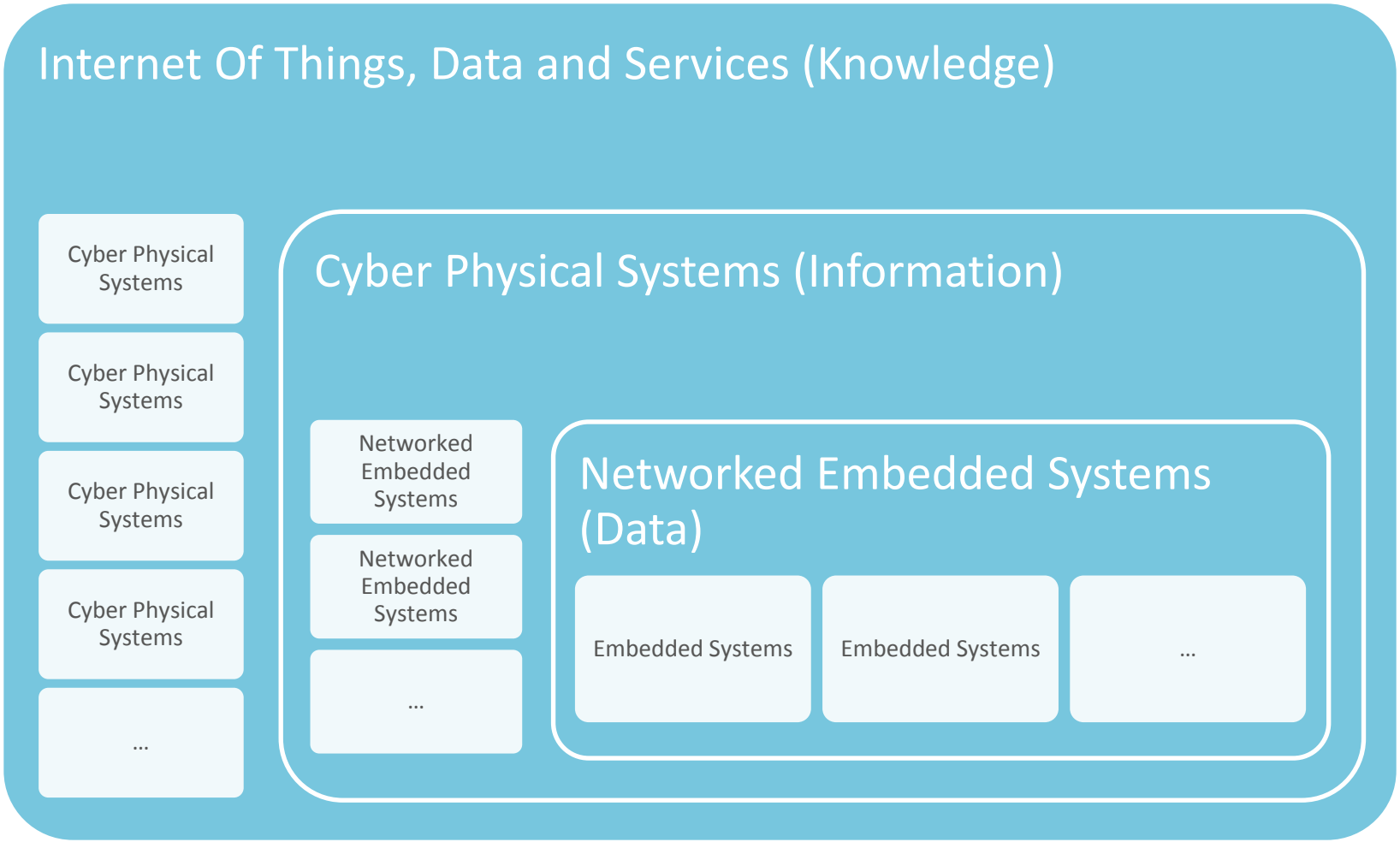
Agenda

- Ubiquitous and Cyber-Physical Systems vs.
- VICCI Project
  - Motivation
  - Goals
  - Global Scenario
- Towards a flexible control center for cyber-physical systems
  - State-Of-The-Art
  - Concept
  - Scenarios
- Conclusion and further work

Ubiquitous and Cyber Physical Systems

- *1991: “In the 21st century the technology revolution will move into the everyday, the small and the invisible.” [12]*
- *2007: “Vision become reality, thanks to wireless networks, mobile computing and agents” [4]*
- *2008: “Cyber Physical Systems are integrations of computation and physical processes” [Edward A. Lee]*

Cyber-Physical Systems (based on ACATECH2012)



[http://www.acatech.de/typo3temp/pics/fa00a30040.jpg]

Smart Enviroments and Cyber-Physical Systems

- Classification based on Sou [9]
  - Individual Smart Space (ISS): e.g. Static SmartHome environments
  - Open Smart Spaces (OSS): e.g. Open SmartHome with seamless intgretation of existing devices; use of Internet Services is also possible
  - Smart Communitys (SC): e.g. Social Interconnection of OSS

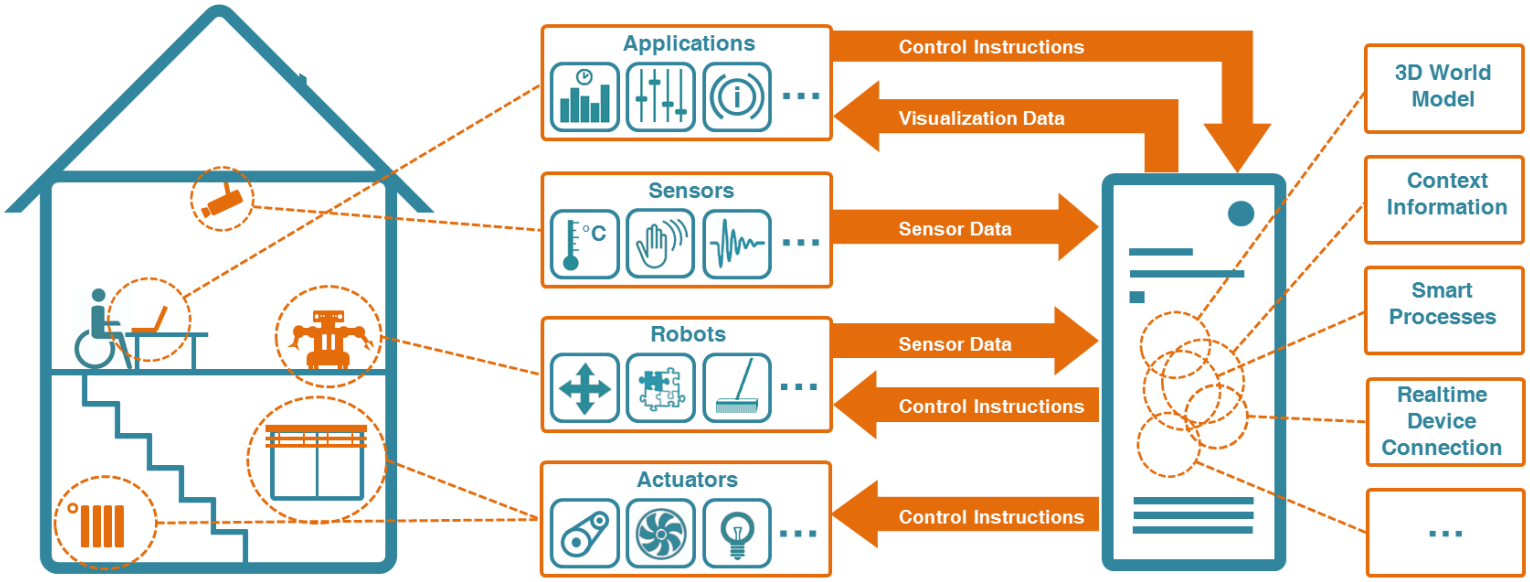
VICCI – Visual and Interactive Cyber-Physical Systems Control and Integration

VICCI Project – Motivation

- Area of application for cyber-physical systems shows an increasing interest, like AAL with robots, intelligent work offices, smart traffic infrastructures or smart grids

- Composition, development and optimizing of this networked ubiquitous systems, consisting of PCs, sensors and actuators, is a complex process [8]

VICCI Project – Global Scenario



VICCI Project – Main Goals

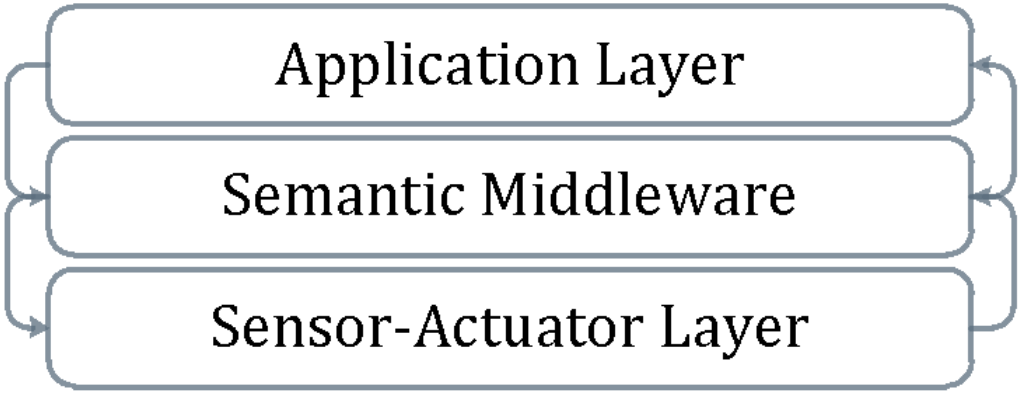
- Dynamic assisting of the user in cyber-physical systems
- Help to visualize and control of as much as possible user groups
- Knowledge-assisted interconnection for seamless integration of heterogeneous CPS-elements, like sensors, actuators and existing devices
- Methods for quality assurance, like reliability, real time behavior and efficiency

Towards a flexible control center for cyber-physical systems

Flexible control center for cyber-physical systems

- Control center is an adaptive, ubiquitous dashboard to offer personalized and intuitive visualizations/interaction abilities [2]
- Controlled by different devices, like smartphones, tablets and PCs, and their corresponding interaction concepts

  - *Concept for adaptive controlling with devices (Apps)*
  - **Concept for a middleware combining all together**



State-Of-The-Art – Requirements

- Requirements for middleware-based context-aware applications [5]
  - **Coordination of all resources**
  - *Interoperability with all participating devices*
  - **Mobility of the user**
  - **Autonomous behavior of the system**
  - *Auto-Discovery of services and devices*

State-Of-The-Art – PERSONA

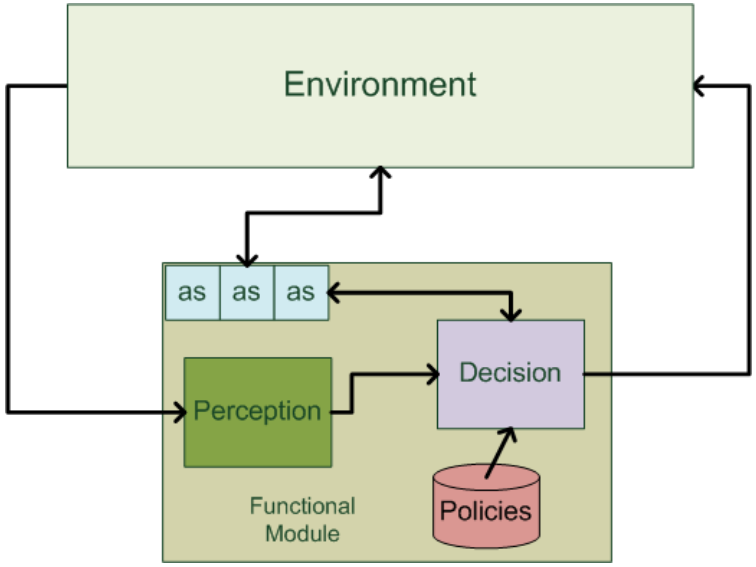
- PERSONA [1]
  - Middleware-based context-aware system
  - Self-organizing infrastructure with point-to-point connection (after registration)
  - Components register on communication bus, middleware provides channels

PERceptive Spaces prOmoting iNdependent Aging

[http://img7.custompublish.com/getfile.php/549442.357.abbcxqrvwf/logo_persona.png]

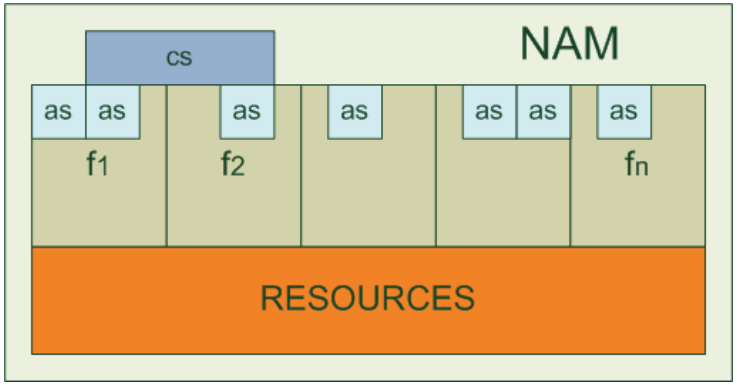
State-Of-The-Art – NAM

- NAM – Networked Autonomic Machines [7]
  - Middleware-based context-aware system
  - Designed for autonomic wearables
  - Fully decentralized P2P Network



State-Of-The-Art – NAM

- Nodes are described by
  - Set of physical resources
  - Set of functional modules
    - Provided Services
    - Consumed Services
    - Consumed Context Events
    - Provided Context Events



- Services are described according to the IOPE pattern from OWL-S [6]

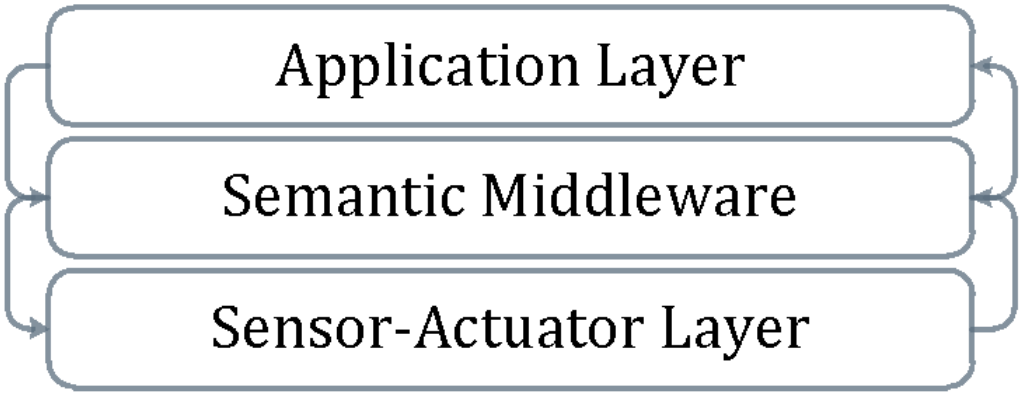
State-Of-The-Art – Drawbacks

- Main drawback is the lack of flexibility with later added devices or distributed instances of applications
- PERSONA defines communication channels in time of registration
- NAM can handle late-added devices, but cannot update provided channels

	PERSONA	NAM
Coordination	(X)	(X)
Interoperability	(?)	X (NAM4J – Java)
Mobility of the user	-	-
Autonomous behaviour of the system	X	X
Auto-Discovery of services and devices	X	(X)

Concept – Architecture

- Seamless integration backend
  - UI is done over Apps
  - All participated elements (applications, sensors and actuators) register them at the Semantic Middleware (SeMiWa)



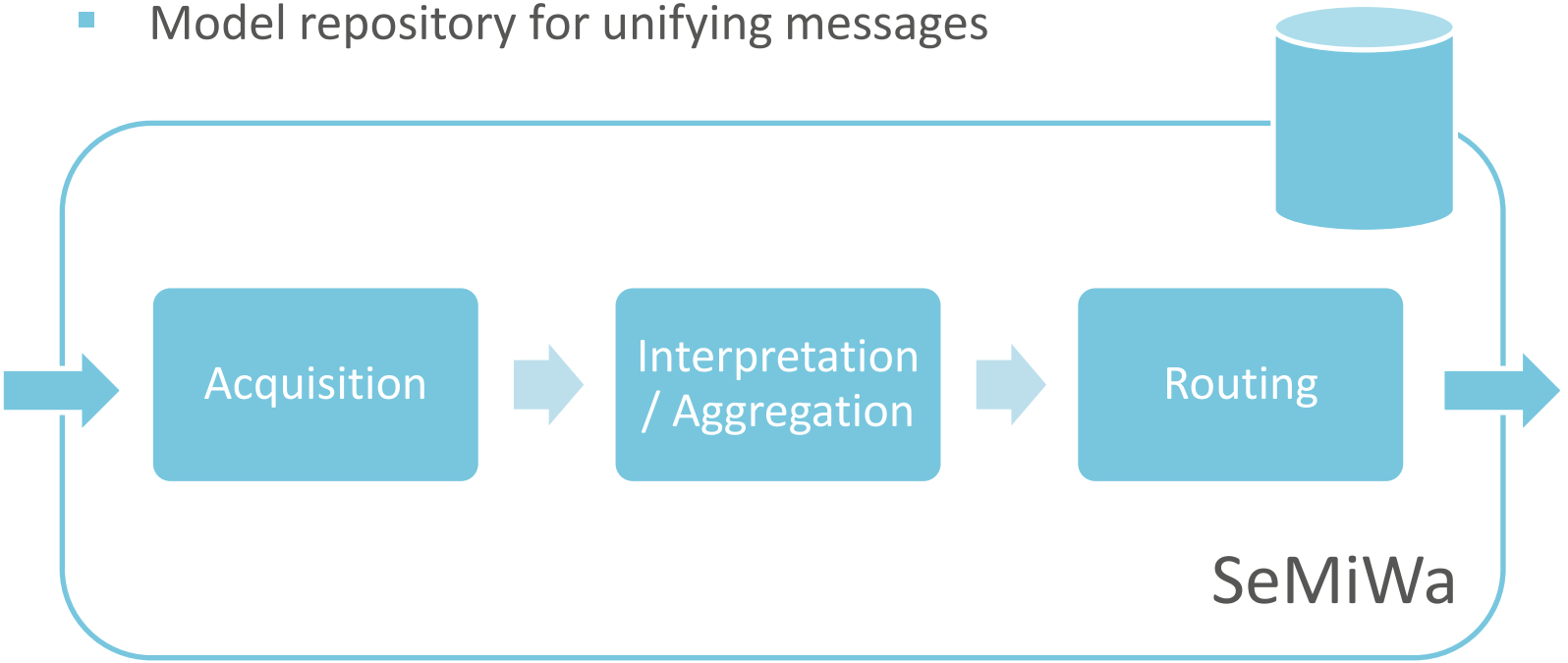
Concept – Application Layer

- Execution Layer, respectively Runtime Layer
- Distributed over multiple devices like smartphones, tablets or PCs
- Abstract Layer, cause the heterogeneous devices

- Apps have to provide
  - Interface for data transmission (bidirectional)
  - Dynamic description of Input / Output (IO) data in semantic way, e.g. “get temperature *X* from *Y*” or “open windows *Z* in *W*”
    - Parameterized during runtime, e.g. X={all, < 18°C, …}; Y={all, living room,… }
  - Precondition and Effect (PE), e.g. “windows *Z* in *W* are opened”, deemed to used for error checking

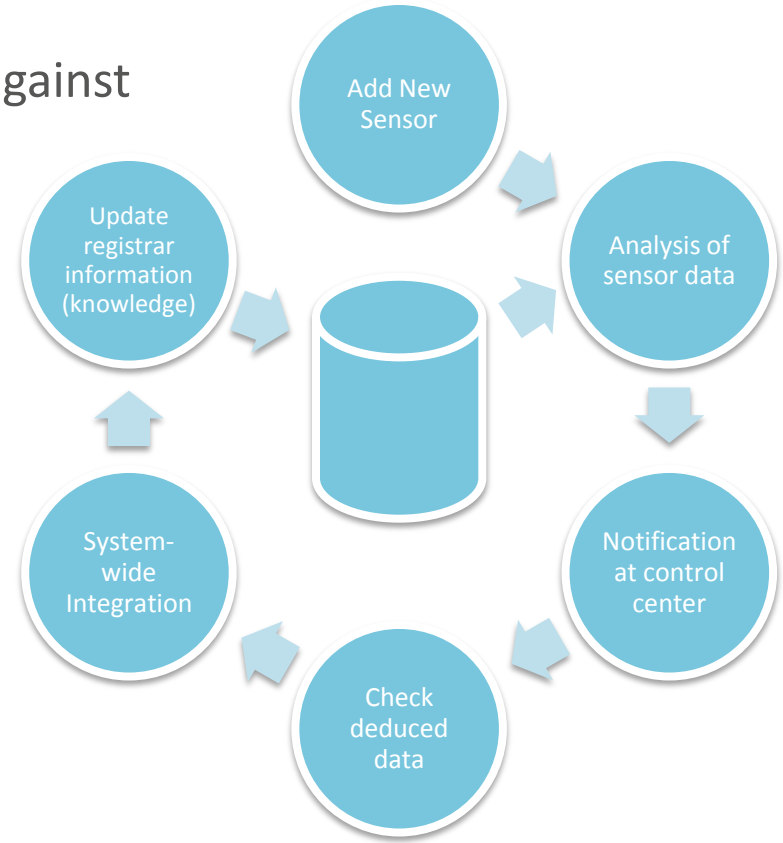
Concept – SeMiWa

- Semantic Middleware
  - Knowledge Base with all lifecycle information about applications, sensors and actuators (Registrar)
  - Model repository for unifying messages



Concept – SeMiWa

- Registration of a sensor/actuator
  - Acquisition: Provide a network interface between the layers to transmit data **to** SeMiWa
  - Interpretation: Unify plain data against sensor model, annotate the provided channel
  - Routing: Provide a network interface interface between the layers to transmit data **from** SeMiWa



Concept – SeMiWa

- Routing of data to or from applications
  - Acquisition: Provide a network interface between the layers to transmit data **to** SeMiWa
  - Aggregation: Decompose semantic annotated instructions, aggregation of sensors/actuators (situation)
  - Routing: Provide a network interface interface between the layers to transmit data **from** SeMiWa, routes data according to decomposed IOPE

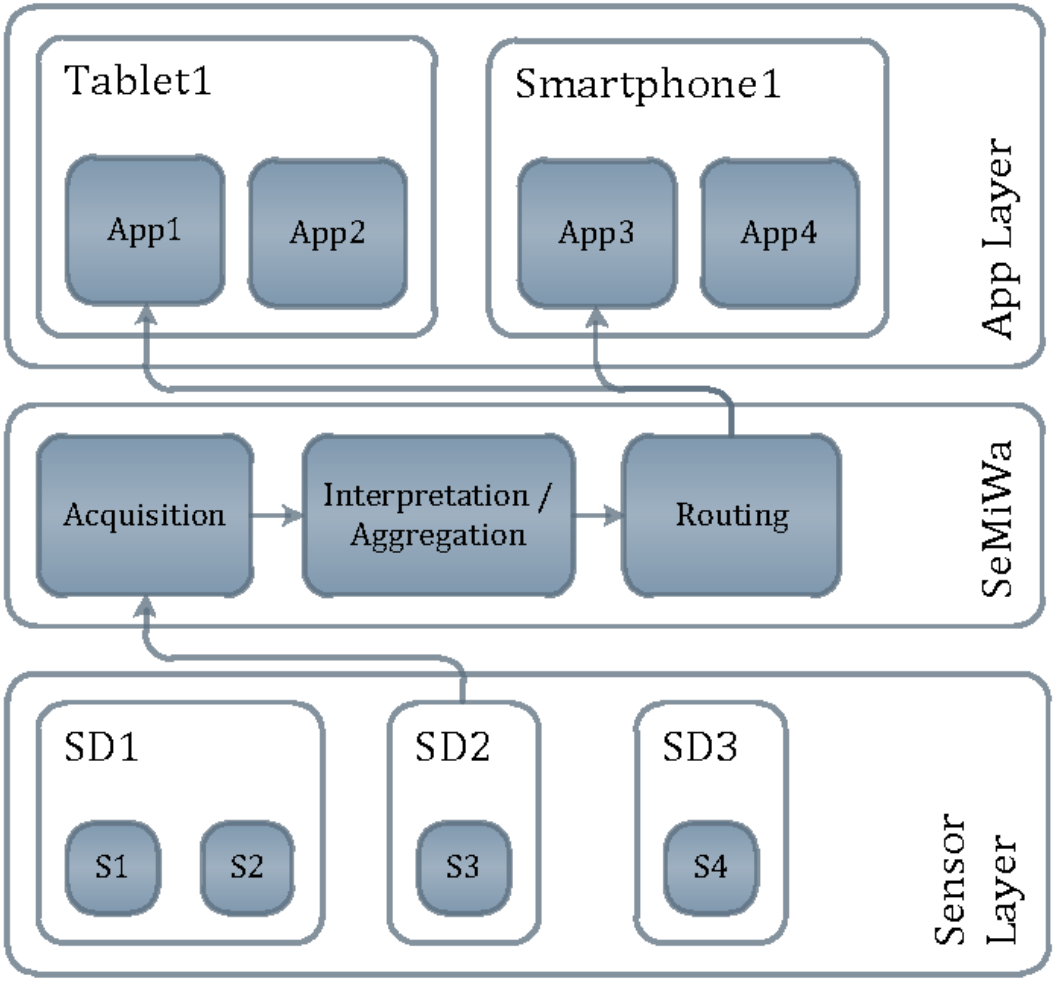
Concept – Sensor/Actuator Layer

- Distributed over multiple devices like microcontroller, robots or PCs
- Abstract Layer, cause the heterogeneous devices

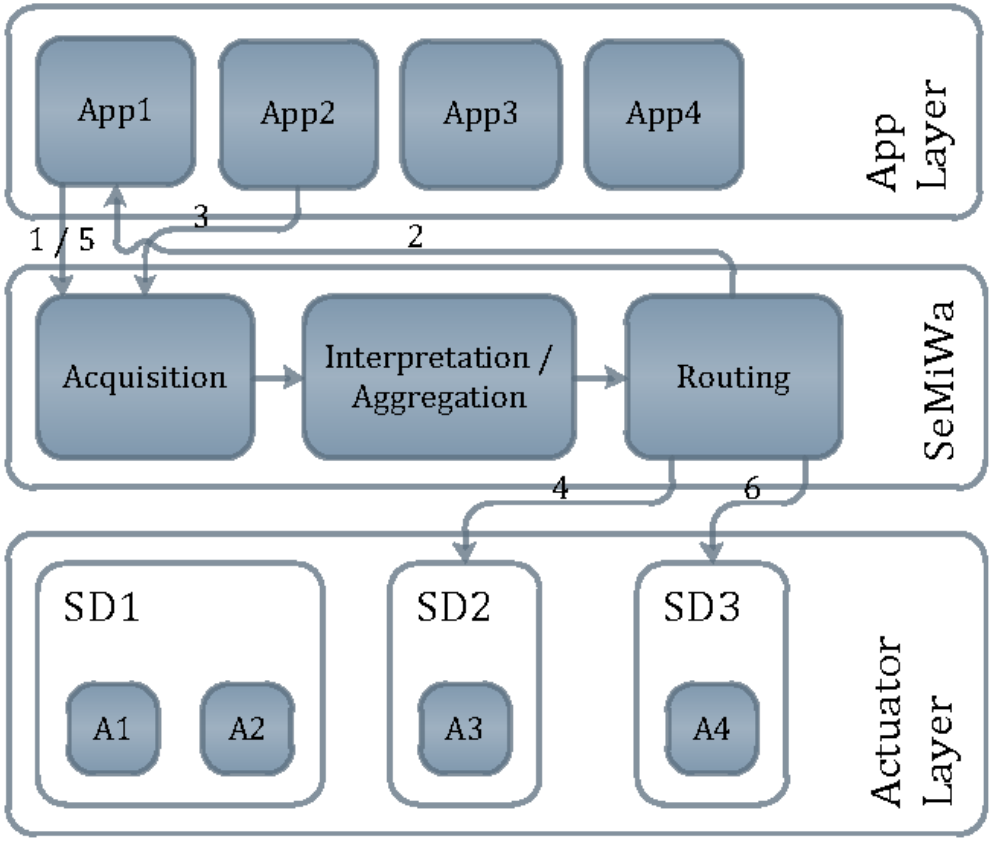
- Elements has to provide the “Semantic Driver”
  - Network interface for data transmission
  - Semantic description of the sent data (sensor)
  - Semantic description of possible control instructions (actuator)
  - *Reconfiguration during runtime*

Scenarios

- Data flow from sensors to applications



Scenarios



- Control flow from applications to actuators
  - 1) Open all windows in living room
  - 2) Heatings in living room are turned on
  - 3) Turn of heatings in living room
  - 4) *Real instruction* (Turn off…)
  - 5) Open all windows in living room
  - 6) *Real instruction* (Open windows…)

Conclusion and further work

Conclusion

- Need of adaptive user interface spread over devices, based on model description

- SeMiWa
  - Flexible data routing according to semantic model descriptions
  - Seamless integration of new components
  - Error checking with pre- and postcondition
  - Potential knowledge-tracking of made decisions

Further Work

- Creating Models
  - Sensor models and aggregation rules
  - Application models (IOPE)
- Dashboard concept for real-time and user-centered data visualization
- Reuse of technologies
  - NAM approach for decentralized P2P [7] vs. OSGi for life-cycle management [10]
  - Soprano for real-time processing and deduction on semantic models
  - UPnP connector for in-house communication and XMPP for WAN [10, 3]

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