



Invited Talk at Enterprise Modeling Workshop (CAiSE 2016), June 2016, Ljubljana

## **CPS, IoT, Industry 4.0 & Co. :**

### **What are the implications for Enterprise Architecture Modeling?**

**Kurt Sandkuhl**  
**Rostock University, Germany**

[kurt.sandkuhl@uni-rostock.de](mailto:kurt.sandkuhl@uni-rostock.de)

---

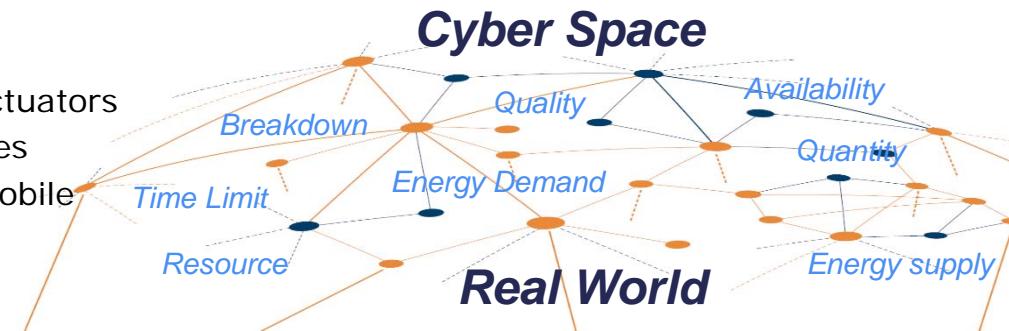
# Overview

- Motivation:  
Why discuss Internet-ofThings, Cyber-Physical Systems, Industry 4.0  
in the context of Enterprise (Architecture) Management?
- Implications for Enterprise (Architecture) Modeling – 3 Cases
  - IoT in Smart Garden (Husqvarna)
  - CPS in Logistics (DataChassi)
  - Digitization in Utility Industry (Stadtwerke Rostock)
- Conclusions

# Cyber-Physical Systems

## Technologies:

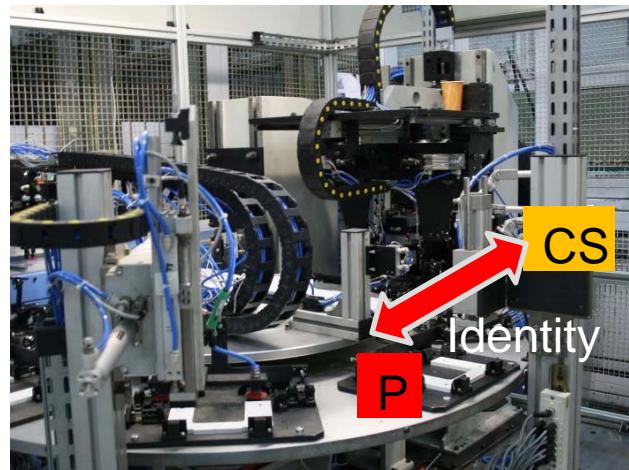
- Sensors & Actuators
- Cloud Services
- Wireless & Mobile Com.
- Self-X
- (Standards)



## Functions:

- Communicating & Negotiating
- Interpreting & Deciding
- Configuration & Adjusting
- Analyzing & Optimizing

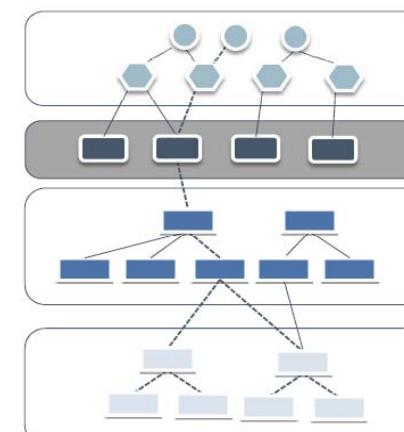
Physical World / Control Systems



CS  
Identity  
P

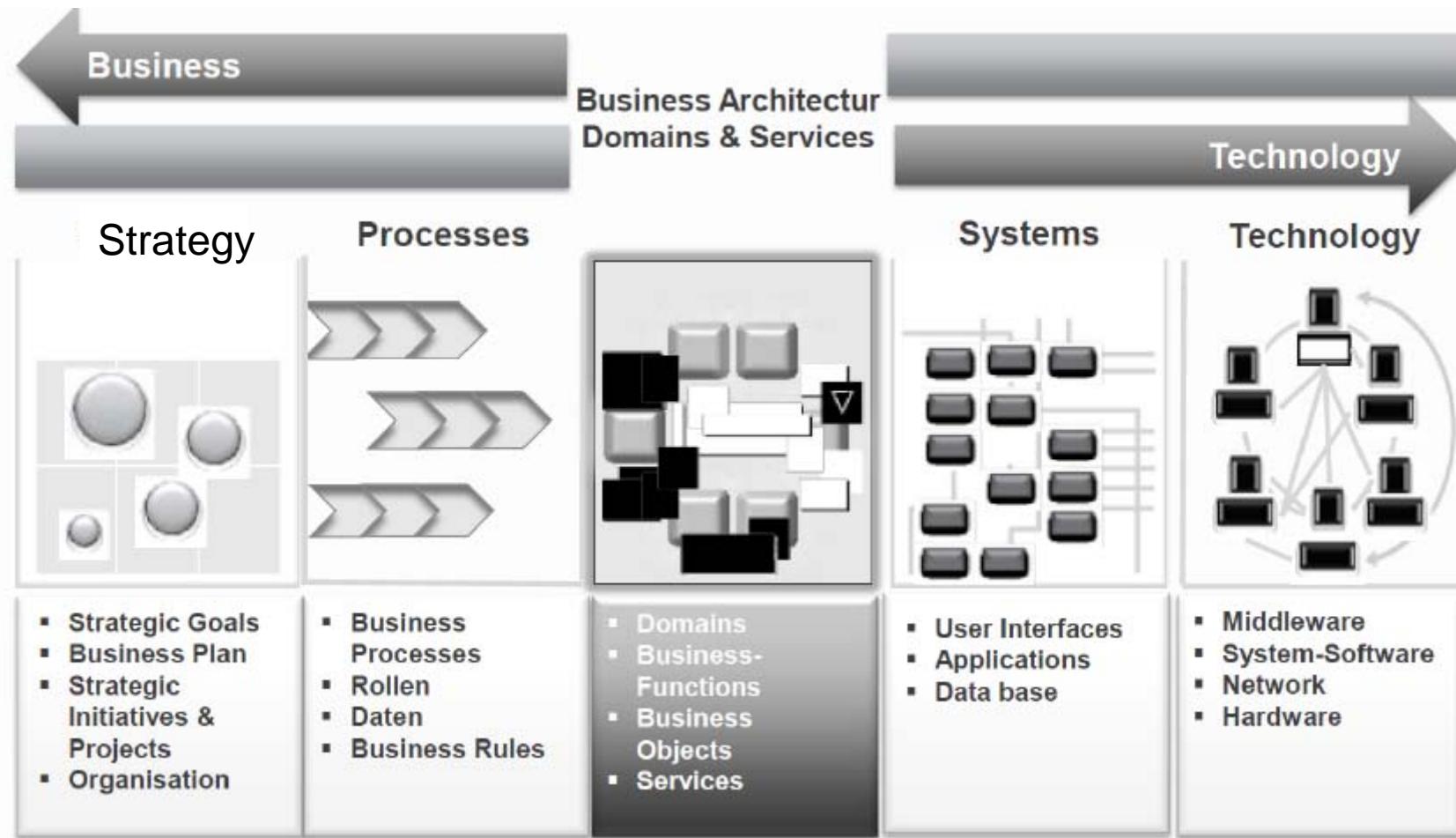
Manufacturing Order  
Realtime Update & Control

Manufacturing data



IT-World /  
Enterprise  
Computing

# Enterprise Architecture Management

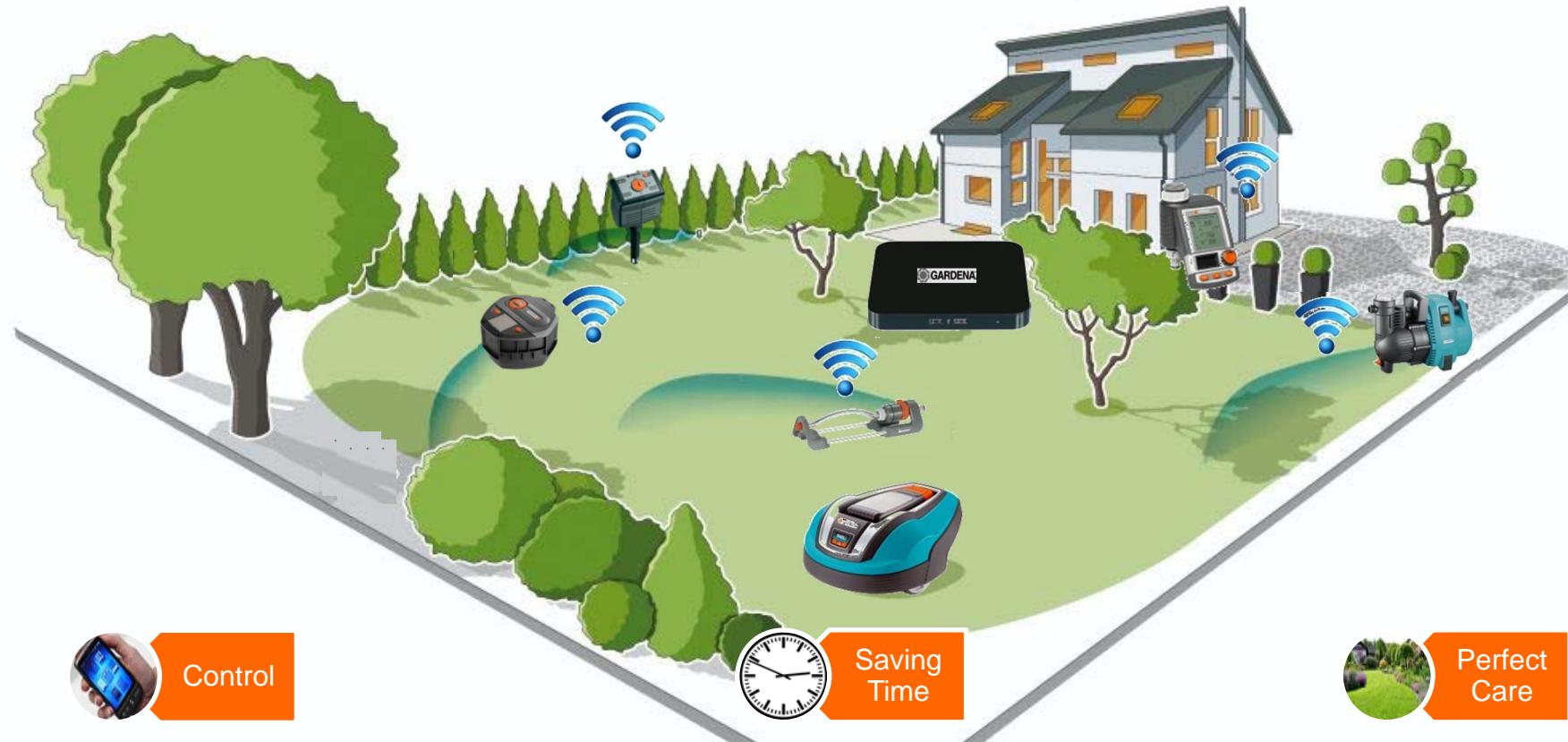


# Impact of IoT: The Husqvarna Case

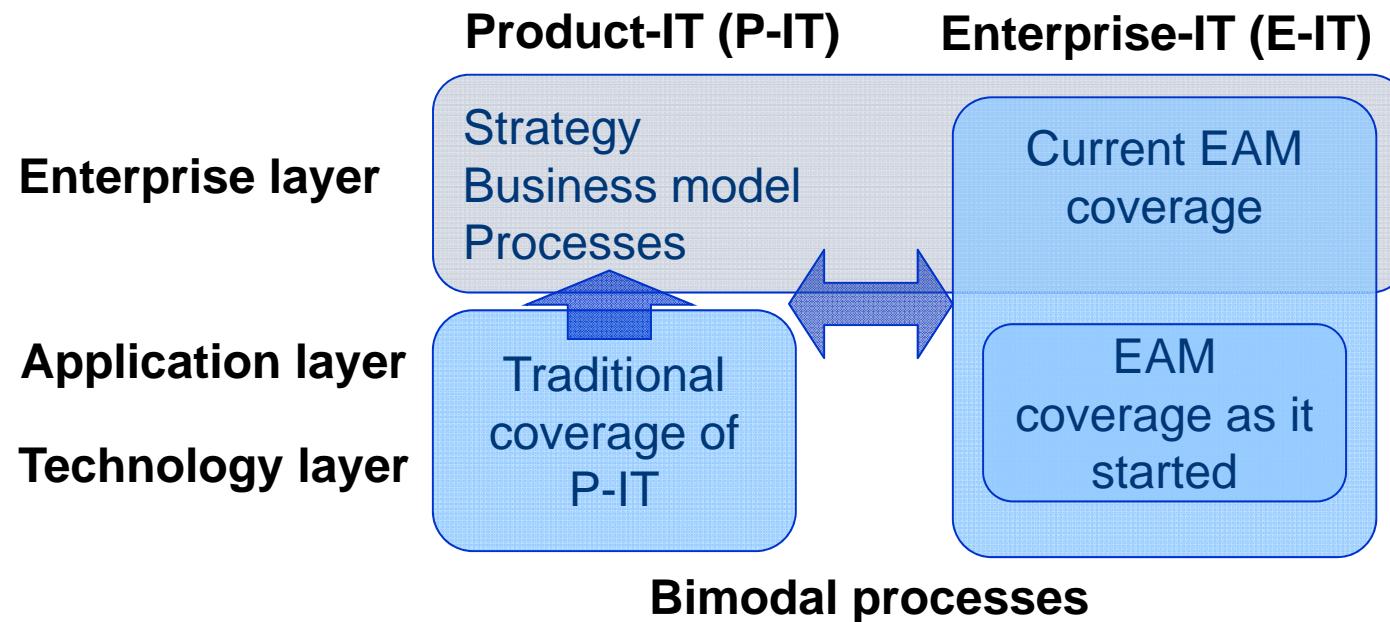
# Smart Garden System

**System structure...**

All products are connected to the hub and the user can simply interact with all devices thru apps.



# Product driven EAM



## Mode 2, requires:

- fast turnaround
- frequent update
- rapid path

## Mode 1, designed for:

- stability
- efficiency
- low cost
- traditional EAM



# Implications of IoT for Enterprise Architecture Modeling

- IoT is becoming part of product IT
- We have to integrate Product IT into Enterprise Architecture Models
  - The process, roles and principles for synchronizing Product-IT and Enterprise IT need to be redefined
- Different „paces“ in Product-IT and Enterprise-IT development will lead to different granularities and update cycles in enterprise models
- Highly dynamic situation in the field
  - What has to be part of the model, what should be excluded?
  - Potentially incomplete and quickly changing models

# Impact of CPS: The DataChassi Case

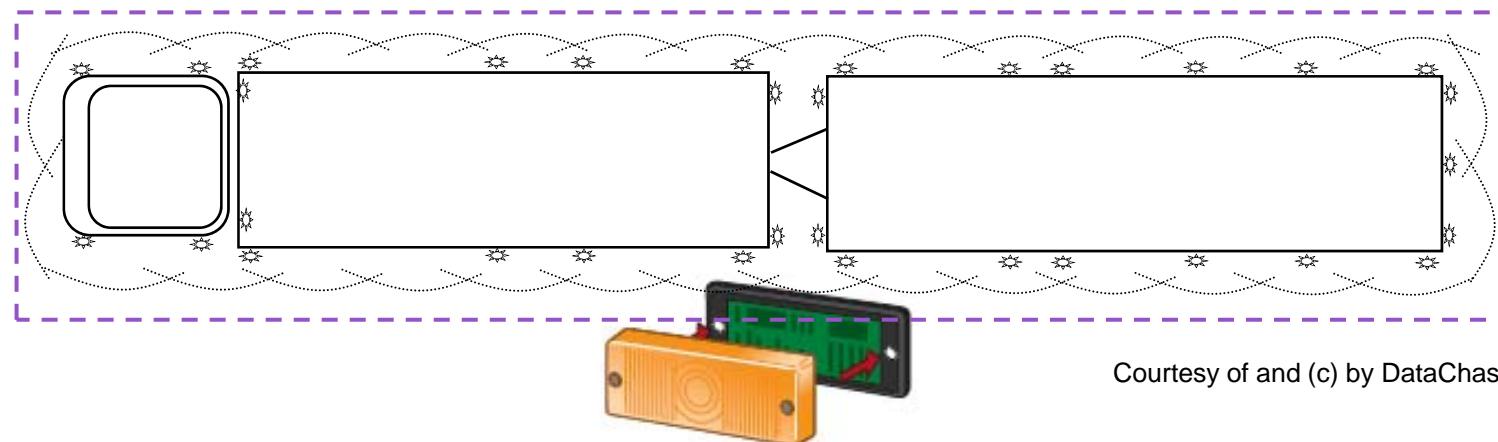
# Industrial Case from Transportation



Courtesy of and (c) by DataChassi AB, Sweden



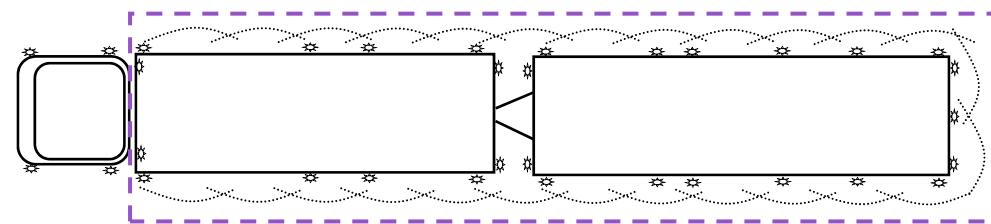
# "Electronic Fence"



Courtesy of and (c) by DataChassi AB, Sweden

Modified sidemarking lights allow for an "electronic fence" around lorry and trailer

... flexibility to exclude the cabin to prevent insiders ...



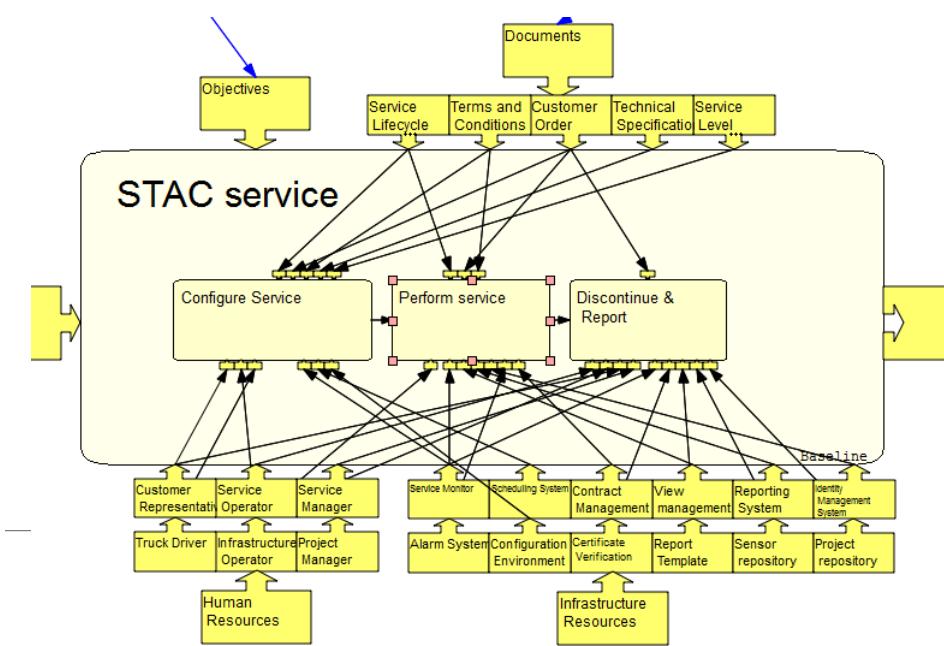
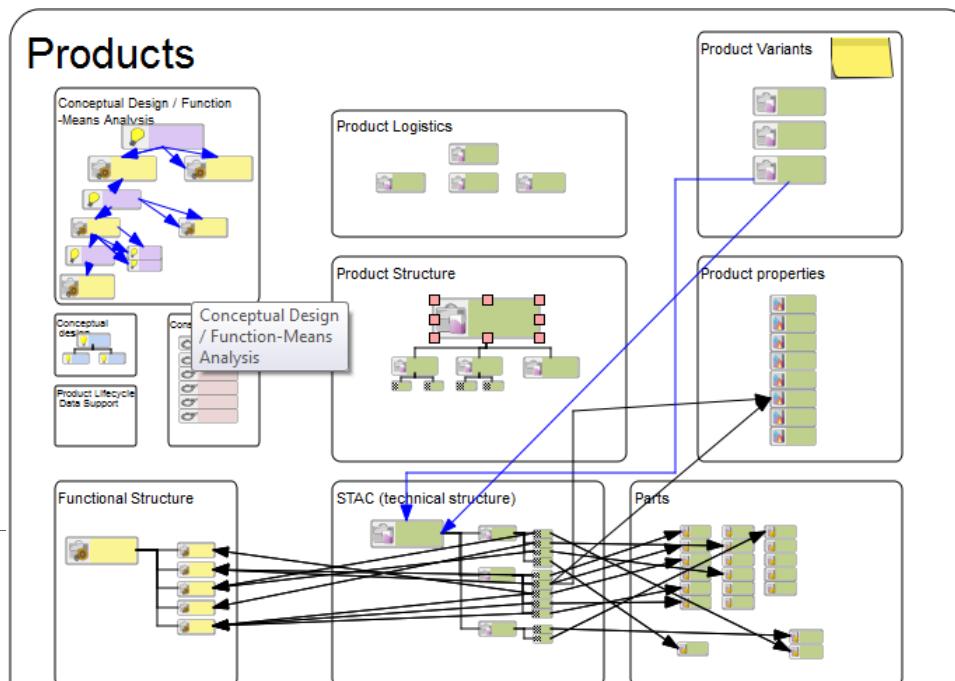
## CPS development process

- a. Business objectives Enterprise Modelling
- b. Business model Enterprise Modelling
- c. CPS integration into the enterprise Enterprise Modelling
- d. Specification of CPS
  - d.1 architecture of the technical solution
  - d.2 services for operating the CPS Enterprise Modelling
- e. Support of operations Enterprise Modelling
- f. Monitoring, maintenance
- g. CPS revision

# Example for use of Enterprise Modelling

## c. CPS integration into the enterprise

- Development of an enterprise model
  - Processes: product-in-use and back-office
  - Organisation: roles involved
  - Product: general service product structure
  - System: technology required

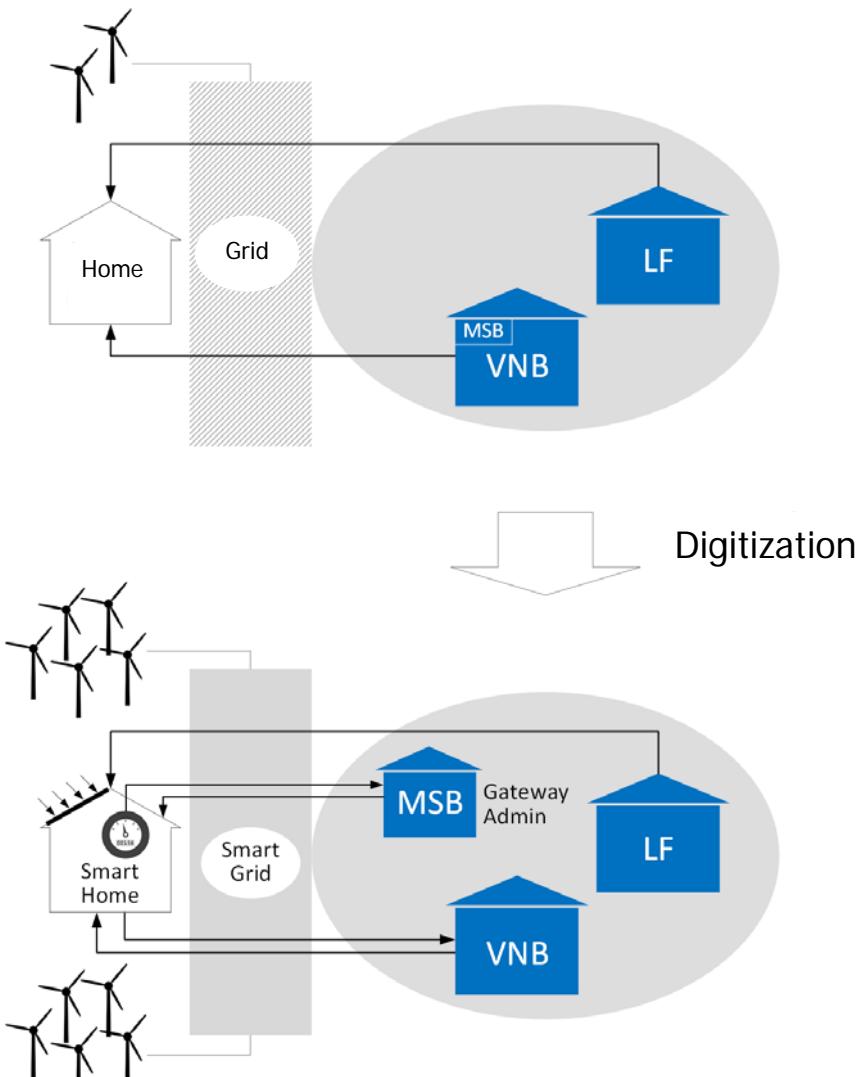


## Implications of CPS for Enterprise Modeling

- Enterprise Architecture is changed on several layers by CPS introduction
- Enterprise Models can serve as „glue“ between other model types
- Enterprise models as design time and runtime artefact?
- Business Model can be and should be captured in an enterprise model

# Impact of Digitization: The Utility Sector Case

# Developments in the Utility Sector

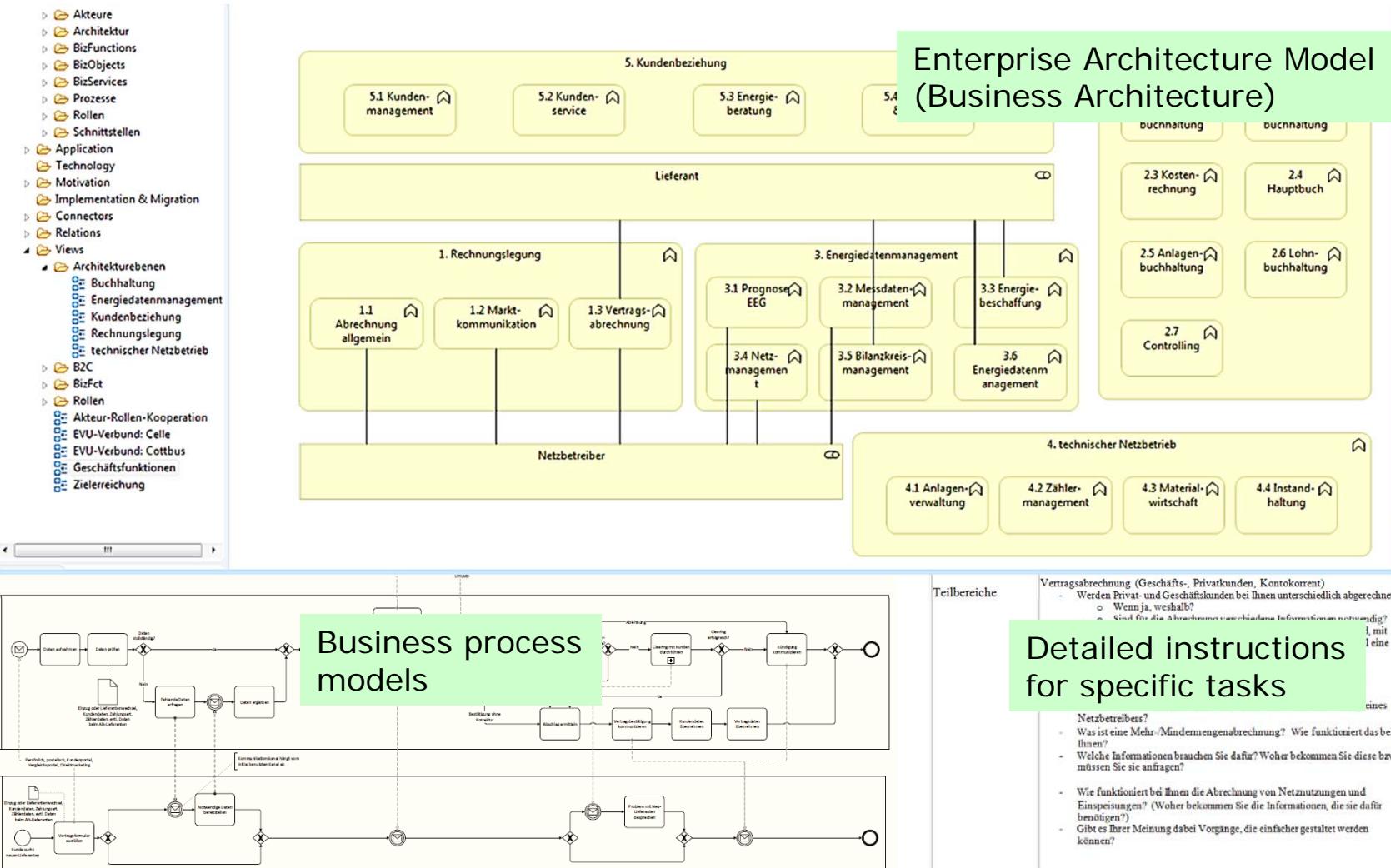


LF: Energi Supplier  
VNB: Grid Operator  
MSB: Metering Service Operator

Courtesy of and (c) by SIV.AG, Germany and ECLORA project

# Reference Architecture

## Business Architecture + Business Process Integration



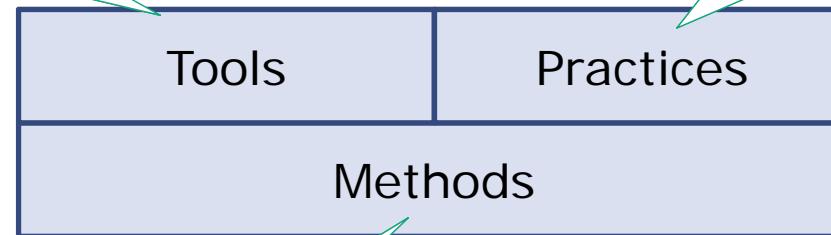
## Implications of Digitization for Enterprise Modeling

- Model the customer-side of services
- Integration of EAM and EM
  - Combine architecture view (higher abstraction level) with operational view (lower abstraction level)
  - Enterprise Model captures the value creation, Enterprise Architecture Model the context of this value creation

## Summary: Implications for Enterprise (Architecture) Modeling

- Design-time and runtime use of models
- Combine architecture view with operational view

- How to manage EA in bi-modal development processes?
- How to best model business models?



- CPS development methods
- Model customer-side of services
- Process, roles and principles for synchronizing Product-IT and Enterprise IT

Thank you for your attention!

Time for questions!