Requirements for an AI-enabled Industry 4.0 Platform - Integrating Industrial and Scientific Views

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Content

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He conducts research in the areas of software product lines, model-based engineering, performance monitoring, and performance analysis. In particular, he is interested in the integration of these areas to create adaptive software systems. In IIP-Ecosphere he leads the think tank "Platforms" as well as the AI Accelerator. He studied computer science at the University of Würzburg, where he received his PhD on the automatic layout of UML diagrams.

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His research interests focus on domain knowledge elicitation and modeling for explanatory and context-sensitive AI applications. He studied at the University of Hildesheim and received his PhD in Computer Science from the University of West London. During his PhD, he investigated and developed methods for knowledge elicitation and knowledge modeling for explanatory and context-sensitive AI applications.

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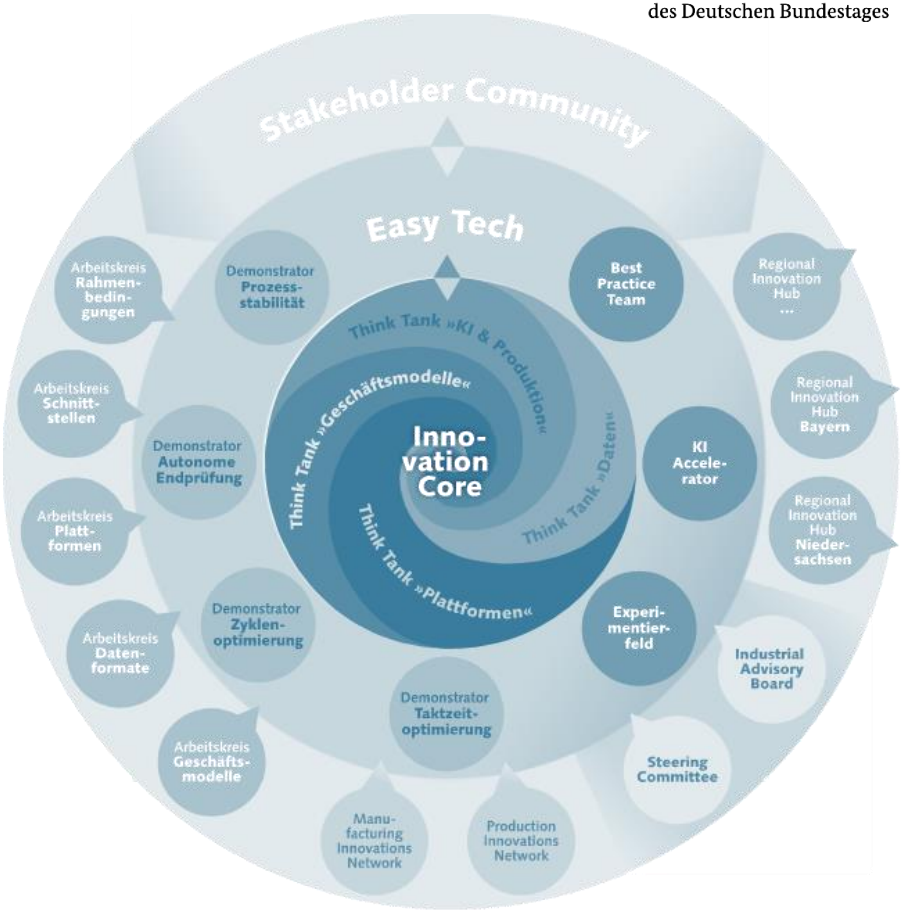


Aim:

- Concepts and solutions for ‘easy-to-use’ AI in Industry 4.0
- Bring AI close to production resources, e.g., to industrial edge devices
- Demonstrate the results in a prototypical IIoT platform.
- Creation of an ecosystem, include external parties, transfer to industry

https://www.iip-ecosphere.de/

Research Goals

Core questions:

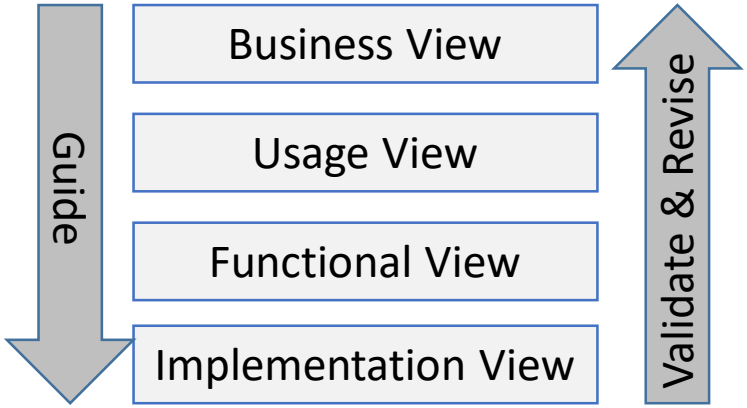
- Which demands shall drive the development of such a platform?
- How can a feasible set of requirements can be determined balancing scientific and industrial interests?

Results:

- Pragmatic requirements elicitation approach for Industry 4.0 platforms
- Two interlinked perspectives:
  - A **usage view** with 67 activities / scenarios
  - A **functional view** with 141 top-level and 179 detailing sub-requirements
- Experiences on elicitation and comparison of the views
- More than 35% of the requirements are realized
- Some identified concepts are taken up in standardization

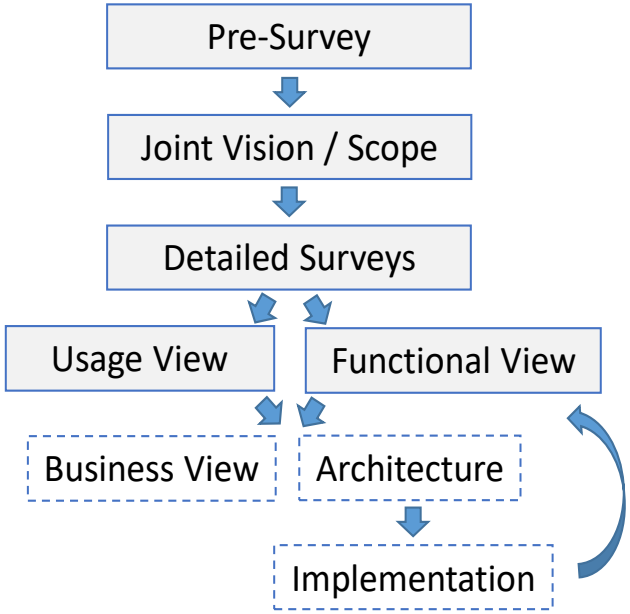
Approach (1)

- **Goal:** Research-integrated requirements collection based on relevant standards/approaches for Industry 4.0 and IIoT.
- Based on the Industrial Internet Reference Architecture (IIRA)



Approach (2)

1. **Start with an open-minded pre-survey**, e.g., surveys on IIoT platforms *
2. **Create a joint vision:** Identify further (research-) relevant topics.
3. **Stabilize the vision by detailed surveys**, i.e., assure the gaps through focused surveys *
4. **Create an usage and a functional view**:
   - Use joint vision as scope
   - Elicit the requirements in two complementing views.
   - Compare views and assess differences.



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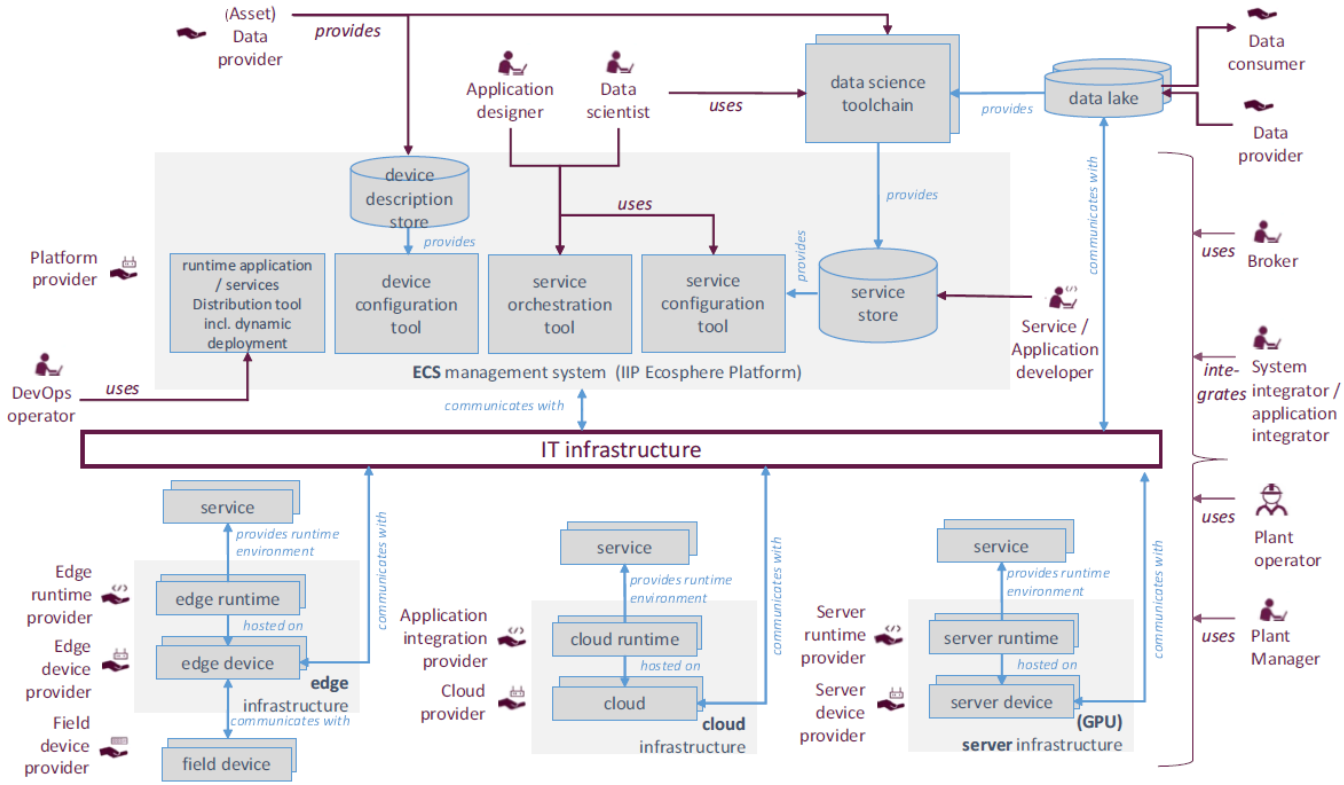
Usage View (1)

- Based on LNI 4.0 Edge Configuration View
- Elicited by workshops and iterative discussions
- Extended System under Consideration:



Usage View (2)

- Some results:
  - Field-level is out of scope
  - Pre-deployment/testing
  - Self-description of entity via Asset Administration Shells
  - Data science to be considered orthogonal, not to be part of platform
- Summary:

Element	This paper	LNI 4.0
Entities	18	5
Roles	19	7
Scenarios	43 (Edge) + 27 (AI)	27 (Edge)

- **Entities** (18)
- **Roles** (19)
  - *Edge device provider*
  - *Data scientist*
- **Activities for ECS management** (7)
  - Adding Entities (4)
  - Removing Entities (4)
  - Provision of Entities (8)
  - Provision of service and application template (4)
  - Service configuration and orchestration (6)
  - Setting up operational configurations (9)
  - Activities for (distributed) applications (8)
    - *Simulating the integration*
    - *Simulating the deployment*
    - *Visualizing the results*
- **Activities for AI services and processes** (5)
  - Activities for data exploration (5)
  - Activities for model training and evaluation (10)
    - *Training of AI models*
    - *Provision of intermediary model results*
    - *Continuous application of a model on new data*
    - *Re-calibration of model parameters*
  - Use of AI applications/services (2)
  - Analysis/Prediction of performance and accuracy (5)
    - *Provision of metrics for an application/service*
    - *Analysis of metadata to detect deviation/model drift*
  - Using AI services/applications manually, offline (2)

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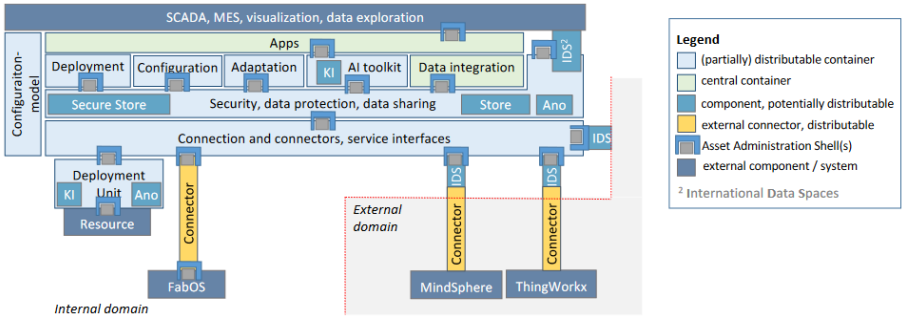
Functional View

- Second team
- Sources: Document analysis, interviews, workshops, focused questionnaire
- Documentation based on template sentences
- Summary: 141 top-level requirements, 179 sub-requirements, initial architecture



- **General Requirements** (12, 15)
- **Connectors and Connections** (10, 20)
- **Heterogeneous, dynamic Deployment** (15, 24)
  - *R24. Resource properties/functions must be described as AAS.*
  - *R26. Platform must support on-premise deployment.*
- **Security** (7, 6)
- **Data Protection** (24, 8)
- **Central Storage Services** (10, 21)
- **Data Sharing** (4, 8)
- **Data Integration** (10, 0)
- **Configurability** (9, 9)
  - *R94. Platform must support automatic configuration validation.*
  - *R96. Configuration must include optional/alternative components/services.*
- **Optimized / Adaptive Deployment** (8, 9)
- **AI (Service) Toolkit** (10, 27)
  - *R110. The AI toolkit must define interfaces for AI components in industrial production.*
  - *R111. The AI toolkit must be extensible.*
- **Adaptive Service Selection** (7, 6)
- **Virtualization** (4, 0)
- **Application Support** (11, 26)

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Comparison of the views

- Overlap of the views: > 60%
- Some topics untouched here, e.g.,
  - pre-deployment
  - AI development integration
- Usage view scenario steps helpful here, e.g.,
  - Management of IoT applications
  - Device management (on/offboarding)
  - Details of (service) monitoring

Experiences

- **Templates** (activities and phrases): Good guidance for participants.
- **Usage view workshops** allowed for more creativity, e.g., discussions on system interactions or known limitations.
- **Functional view workshops** were more technical, e.g., on developing applications for the platform.
- Different **background** in the workshops: More technical in the functional view workshops.
- Research-integrated requirements **do not come for free**, e.g., “Why do we need this?” for self-adaptation capabilities

Integrating Industrial and Scientific Views

- Integrated approach
  - Proved successful for the IIP-Ecosphere platform.
  - Helped complementing requirements.
  - Helped the partners to clarify their views, e.g. terminology.
- First companies in IIP-Ecosphere started taking up (a variant) of our approach.
- Concepts and ideas were fed back to LNI 4.0 and do influence the work on a revised Edge configuration approach there.

Conclusions

The core questions of our research were:

1. Which demands shall drive the development of the IIP-Ecosphere platform?
   - Scientific techniques as basis (SoTA, gaps, industrial surveys)
   - Systematic approach to requirements (based on industrial standards)
   - Defend the scientific needs
2. How can a feasible set of requirements be determined balancing scientific and industrial interests?
   - Joint vision and elicitation (for industrial voices)
   - Joint summarization and prioritization
   - **Multiple views** can help complementing each other

Moreover:

- Creating multiple views also increases the effort (2 views, > 2 * effort).
- Platform is in realization based on the requirements.
- Results are about to influence standardization efforts.