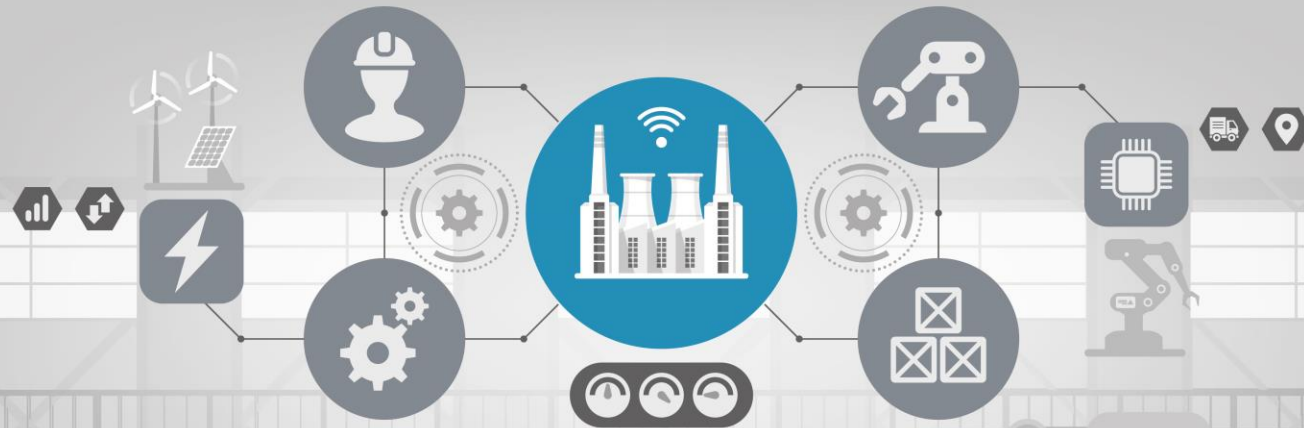




**IIP-Ecosphere**

Next Level Ecosphere for  
Intelligent Industrial Production



# Model-driven platforms for Industry 4.0 – the IIP-Ecosphere case

Gefördert durch:



Bundesministerium  
für Wirtschaft  
und Klimaschutz

Holger Eichelberger (Universität Hildesheim)  
SECPPS 1/23 – 2 June 2023 · Hildesheim



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# IIP-Ecosphere

- **Goal:** Ecosystem to ease the access to AI in production / factories
- **Funding:** BMWK (until September 2023)
- **A core activity:** Platform concepts for AI-enabled I4.0 / IIoT
- **Specific focus:** Model-driven I4.0 platforms and (performance) experience  
Agenda: Along the „usual“ SE phases + Evaluation



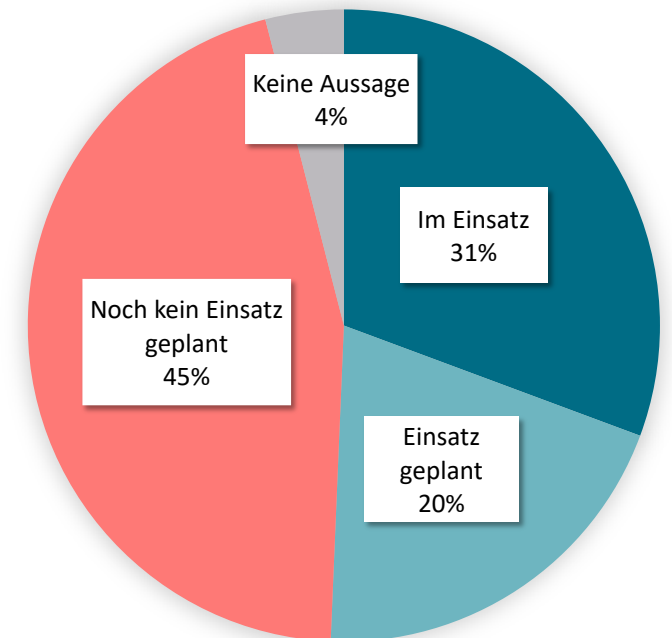


# Why yet another platform?

- There are many Industry 4.0 platforms ...
- The basic idea: A virtual platform
- Intensive vision discussion
  - Asset Administration Shells (AAS)
  - AI@Edge

Survey with 75 companies (DE)

Nutzung von Industrie 4.0 Plattformen

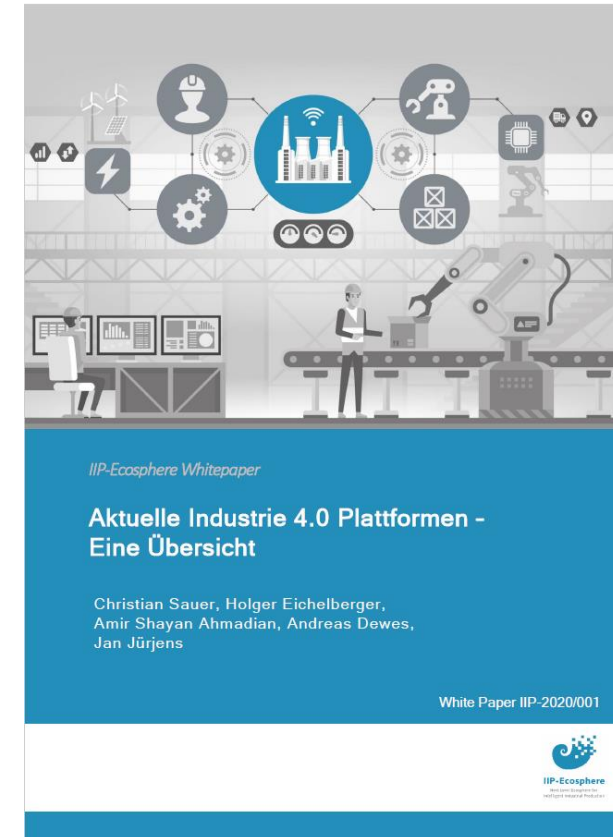


C. Niederée, H. Eichelberger, H.-D. Schmees, A. Broos, P. Schreiber, KI in der Produktion – Quo vadis? IIP-Ecosphere, 2021, <https://doi.org/10.5281/zenodo.6334521>



# Related platforms

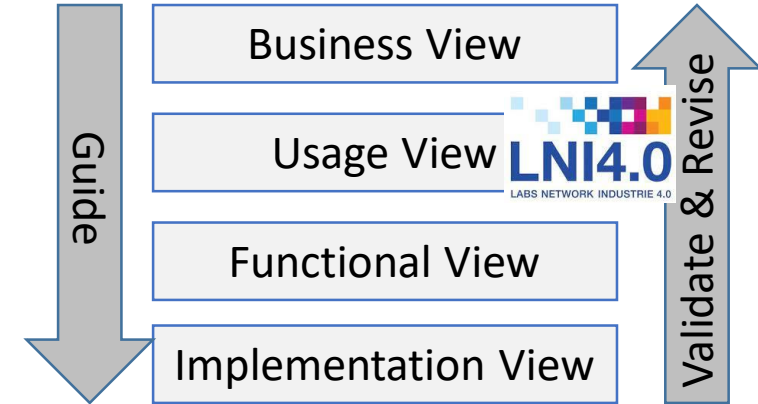
- 21 industrial IIoT platforms, 16 topics
  - Including AI, configurability, Edge usage, etc.
- Ongoing SLR (2014-2022)
  - ~40 relevant papers
  - 4 on model-based / driven approaches
- Challenges / Differences
  - Device heterogeneity (OT / IT)
  - Standards, e.g., AAS
  - Configurability, flexibility, openness
  - AI integration



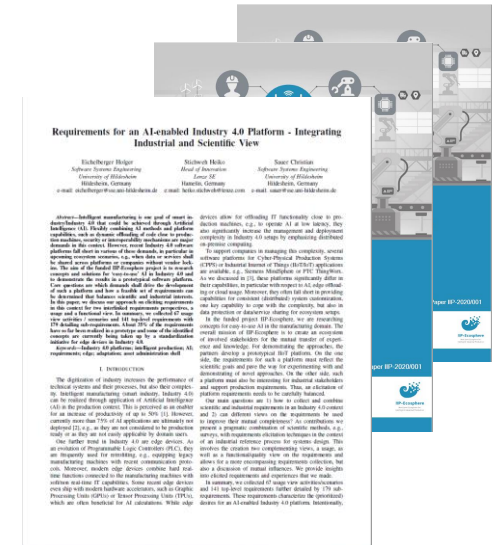


# Platform requirements

- Intensive requirements collection
  - Based on ideas of IIRA
  - 67 usage scenarios (service deployment, AI)
  - 141 (top-level) platform requirements
- > 60% overlap of both views
  - Limitation: Usage view for specific topics
  - Different ‘dynamics’ in the views
  - Don’t forget the scientific side



H. Eichelberger, C. Sauer, H. Stichweh, Platforms for an AI-enabled Industry 4.0 Platform, Integrating Industrial and Scientific View, SOFTENG'22

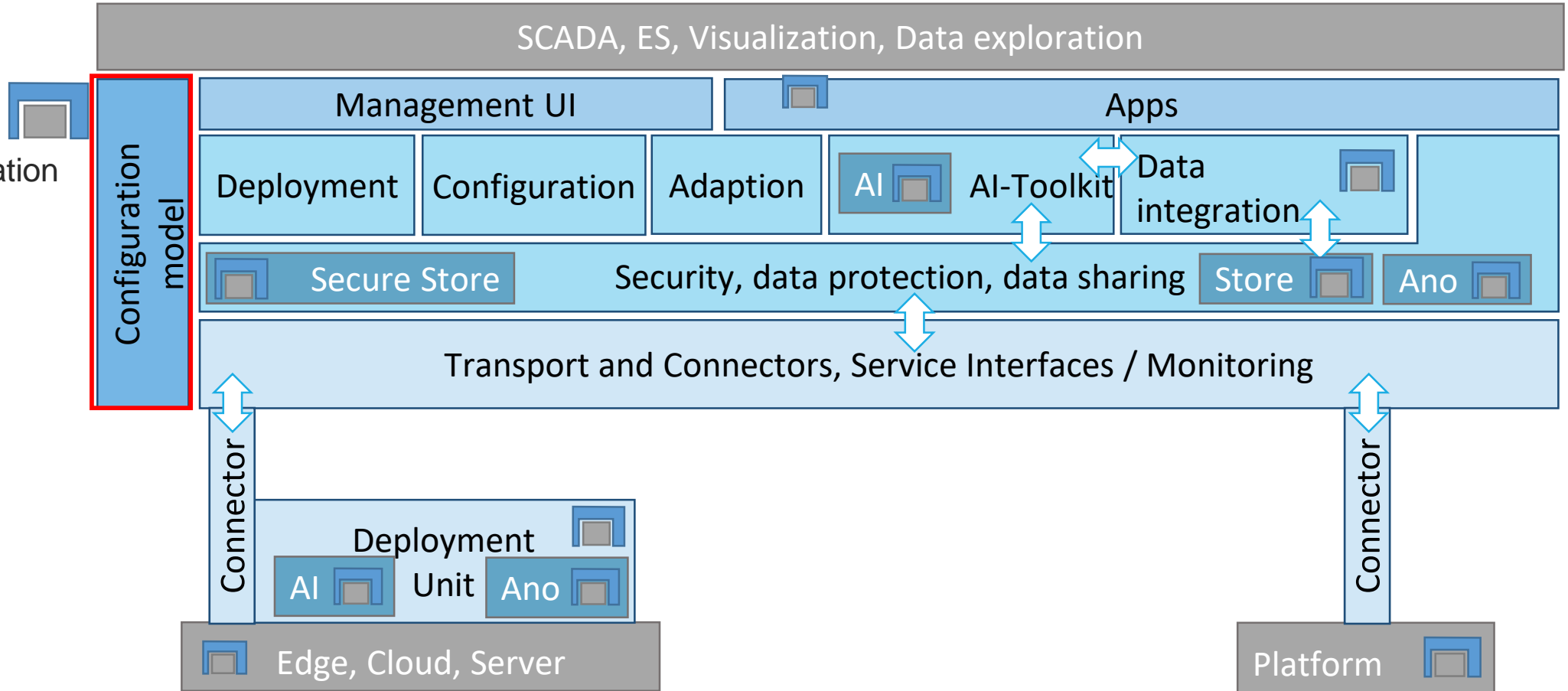




# Architecture

Asset Administration Shell

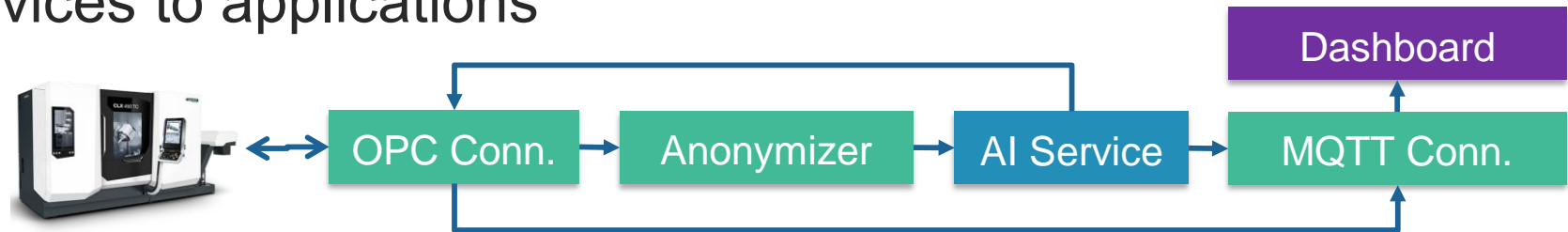
powered by  
 BaSyx





# Model-driven Configuration

- **Aim:** Flexibility, customizability, less programming (“low code”)
- Configuration from “devices to applications”

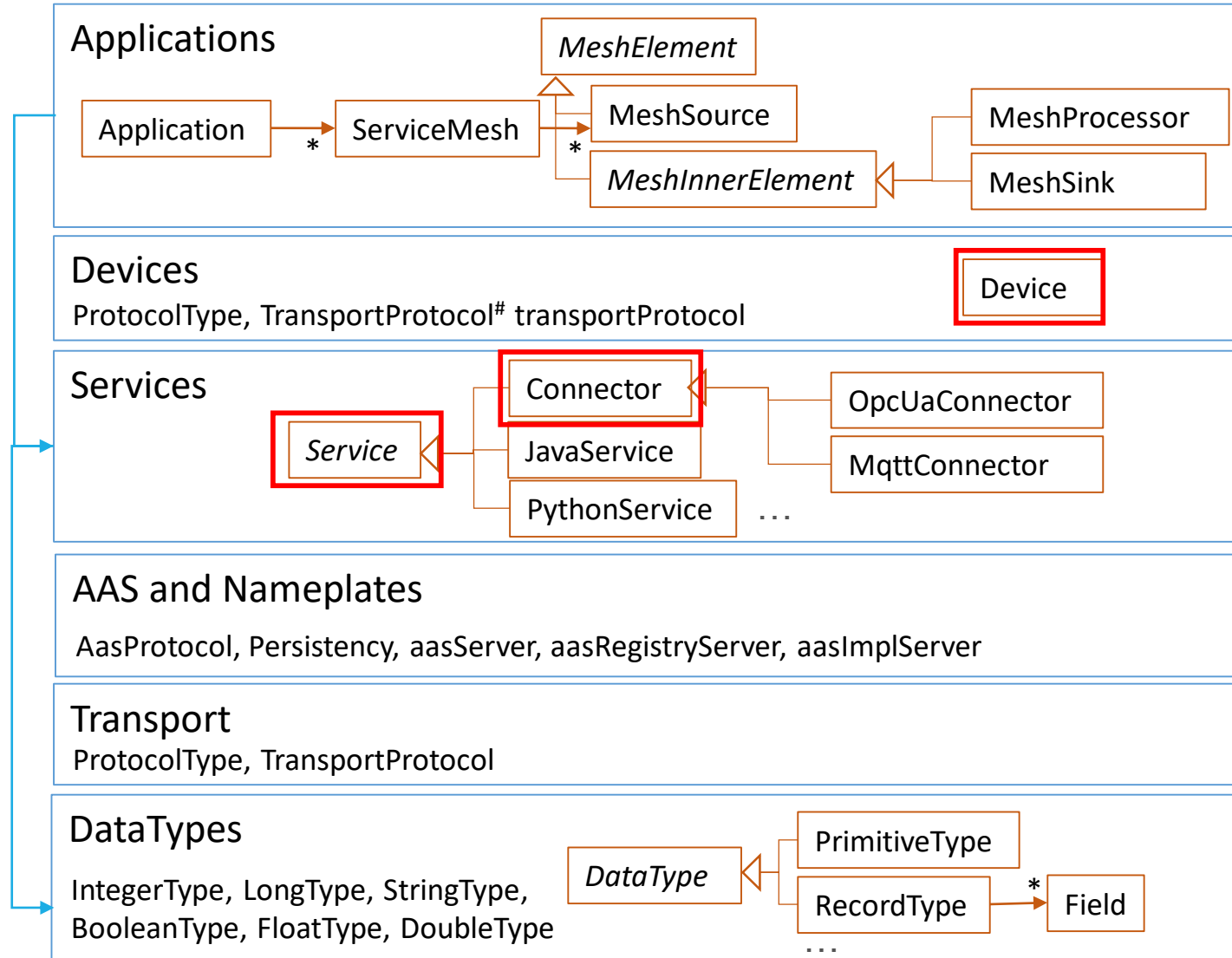


- Model validation
- Instantiation / Artifact-Generation
  - Platform components
  - Application interfaces
  - Customization of services, integration of applications
  - Creation of containers



# The „variability“ side

- Topological configuration with constraints
- IVML, similar possible with MOF
- Multi-layered
- Extensible
- Includes OPC UA







# Building an Application

- Configure the application
- Generate the interface / data types artifact
- Generate the application template (e.g., Eclipse project)
  - Production code templates (Java, Python)
  - Tests (Java, Python) and artifacts
  - Build process
- Generate the integrated application

Later problems do hurt exponentially.



# Generating containers

- Docker / Kubernetes does it all... or not?
- Requirements
  - AllApps, application-specific or service-specific
  - Device specific
  - (Python) dependencies and conflicts
- Building time:
  - Artifact generation for 2 applications: ~2.5 minutes
  - AllApps containers for 3 devices: 30 minutes



- Reuse layers / containers: -7 minutes
- Change / impact analysis: -7 minutes
- Resource / memory usage!



# Validation / Evaluation (1)

- Validation: Demonstrators



> 7 services  
> 60% generated artifacts

- Industry workshops

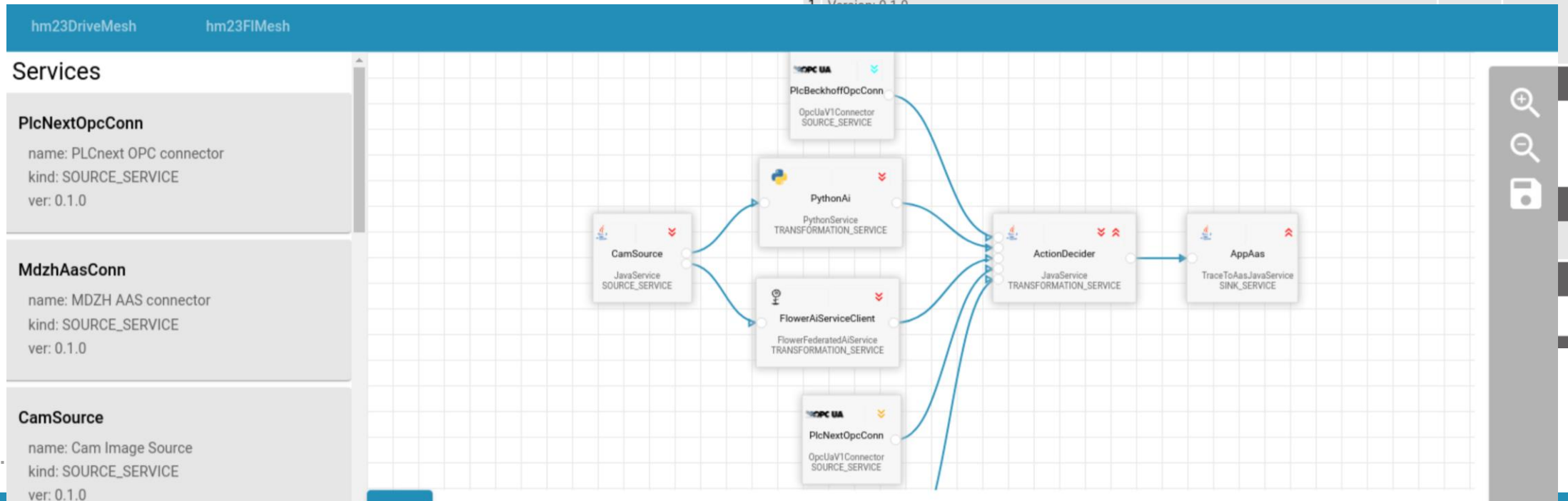
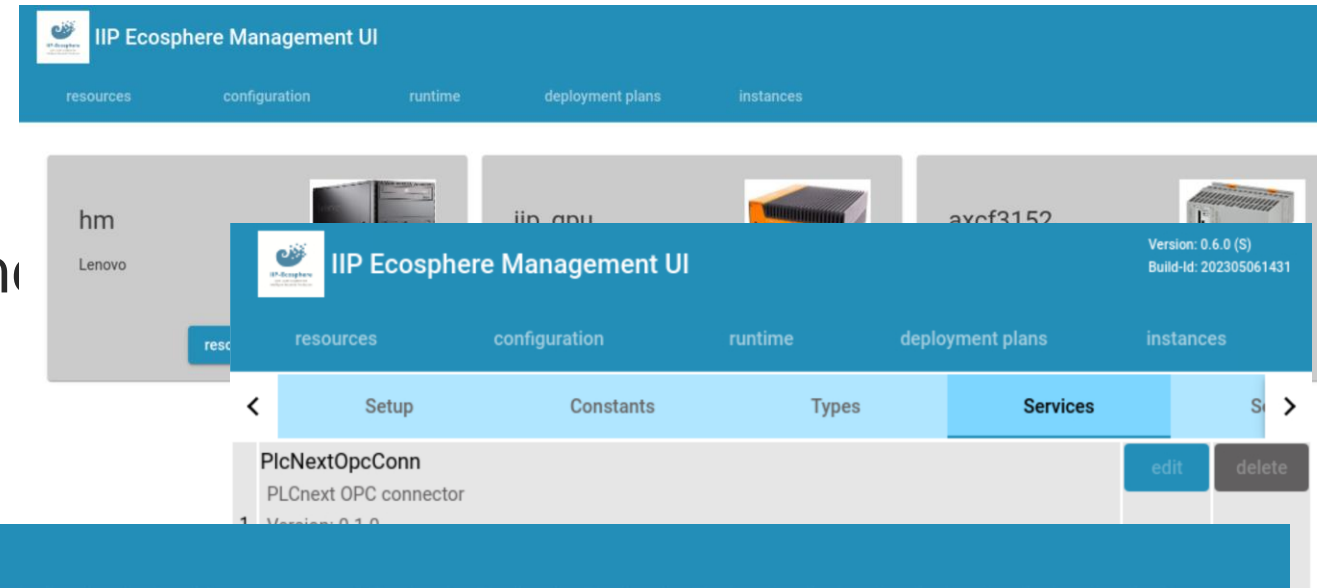
H. Eichelberger, G. Palmer, S. Reimer, T. T. Vu, Hieu Do, Sofiane Laridi, A. Weber, C. Niederée, T. Hildebrandt,  
Developing an AI-enabled IIoT platform - An early use case validation, SASI4 @ ECSA'22



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# MBSE, configuration and UI

- Industry: „You need an UI!“
- Literature: „You need a good frontend“
- Basis: Platform AAS
- Configuration AAS submodel

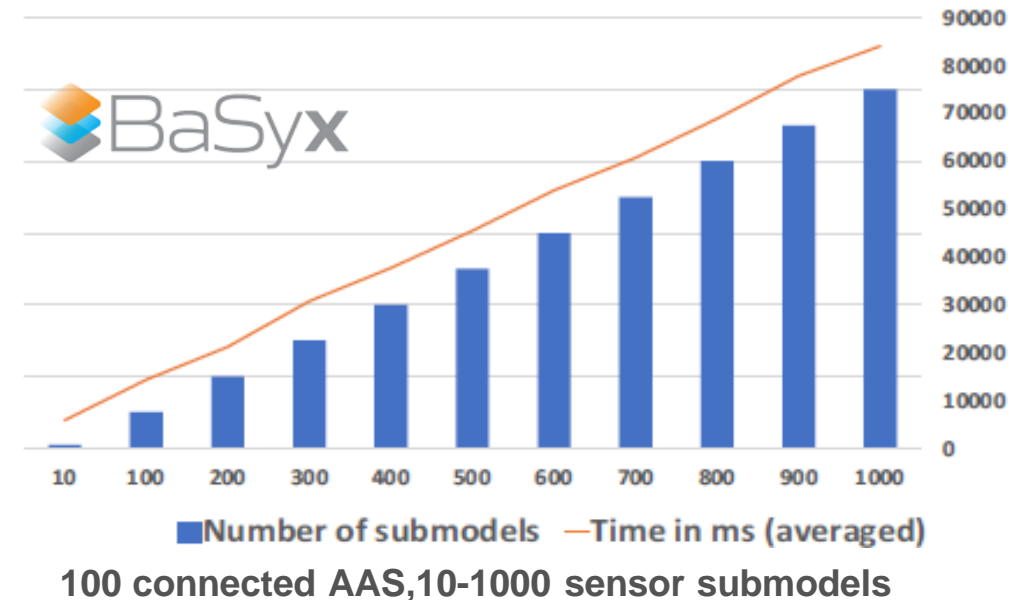




# Validation / Evaluation (2)



- AI@Edge
  - Works, but far away from „real-time“
- AAS and monitoring
  - Requires specific architecture patterns
- AAS and scalability
  - Surprisingly good up to 1000 AAS



- H. Eichelberger, G. Palmer, C. Niederée, Developing an AI-enabled Industry 4.0 platform - Performance experiences on deploying AI onto an industrial edge device, SSP'22
- M. G. Casado und H.Eichelberger, Industry 4.0 Resource Monitoring - Experiences With Micrometer and Asset Administration Shells, SSP'21
- C. Sauer, H. Eichelberger, Performance evaluation of BaSyx based Asset Administration Shells for Industry 4.0 Applications, SSP'22



# Summary and Outlook

- Model-driven Industry 4.0 platforms: IIP-Ecosphere
  - Meets the usual expectations
  - „Advanced“ topics ahead
- Industrial interest:
  - Asset Administration Shells
  - Integrated Configuration and Generation
- Validation / Evaluation
  - Public demonstrators: „Tag der Informatik“, ..., EMO'23
  - External contributions („dynamic demonstrators“)
  - In-factory evaluation with Phoenix Contact (in preparation)



**Maven**<sup>™</sup>





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# Contact



Dr. Holger Eichelberger



eichelberger@sse.uni-hildesheim.de



<https://www.iip-ecosphere.eu>



@de\_iipecosphere