

Enabling Industry 4.0 with Eclipse BaSyx

Towards the Factory of the Future with Digital Twins and SOA

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I. TUTORIAL TOPIC

A. Tutorial Title

Enabling Industry 4.0 with Eclipse BaSyx: Architecting the Factory of the Future with Digital Twins and Service Oriented Architectures.

B. Summary

The fourth industrial revolution is mainly a software revolution. The end-to-end digitalization, and the flexibility of manufacturing and supply chains require revisiting concepts like Service Oriented Architectures (SOA) and Digital Twins, which are being considered the foundation of Industry 4.0, as well as developing new software and system architecture concepts.

In this tutorial, we intend to discuss Industry 4.0 current trends and challenges that require active research by the software and systems architecture community, as well as architecture drivers (i.e., business drivers, quality & key functional requirements, and technical, organizational, & legal constraints) and architecture decisions that we have compiled from (i) the literature and (ii) consultancy and research projects in the field. Additionally, we intend to discuss how these architecture drivers and decisions are addressed by Eclipse BaSyx¹, which is an open-source solution being actively developed in the context of the BaSys 4.0² series of projects that aims at supporting manufacturing companies and research institutions to architect Industry 4.0 solutions. Last, we also plan to run practical small sessions, where the tutorial participants can reason on architecture decisions and specific Industry 4.0 architecture scenarios, experiencing, then, the first steps to realize Industry 4.0 solutions.

C. Description of the Tutorial Goals / Relevance to ICSA

The tutorial aims at encouraging practitioners to architect Industry 4.0 solutions based on service orientation and digital twins. To this end, it will be provided guidelines, data, and examples from real industry cases. The architecture community will profit from tailored knowledge to architect industry 4.0 solutions, and also to properly communicate them to stakeholders with different educational and professional backgrounds, like mechanical and production engineers.

The tutorial covers the following important aspects of Industry 4.0:

- State-of-practice and migration to Industry 4.0;
- Architecture drivers and decisions of Industry 4.0;
- Applying the SOA paradigm to manufacturing;
- The role of the digital twin in Industry 4.0, and its implementation as Asset Administration Shell (AAS) and
- Standardization as enabler for Industry 4.0.

D. Intended Audience

The target audience includes both practitioners and researchers. We aim at having 15-30 participants (smaller numbers is also acceptable) from:

- different disciplines (e.g., software and system architecture, maintenance and evolution, mechanical engineering, electrical engineering, production engineering);
- industries sectors (e.g., system or service providers, service integrators, tool developers, service users, plant engineers, production, engineers, logistic managers) and

E. Key Take-Away Messages / Learnings

- State-of-practice and migration strategies to Industry 4.0;
- Key architecture drivers and decisions of Industry 4.0;
- How to tailor SOA and digital twins to enable Industry 4.0 and
- First steps to realize Industry 4.0 solutions with Eclipse BaSyx.

II. TUTORIAL IMPLEMENTATION

A. Tutorial Duration

We aim at a full day tutorial (half-day is also possible).

¹ <https://projects.eclipse.org/projects/technology/basyx>

² <http://www.basys40.de/>

B. Preliminary Schedule

The full day tutorial comprises four sessions à 90 minutes:

- Session 1: Introduction to Industry 4.0: History of the industrial revolutions, core concepts, state-of-practice, and core concepts;
- Session 2: Addressing key architecture drivers and decisions of Industry 4.0 with tailored SOA and Digital Twins;
- Session 3: Enabling Industry 4.0 with Eclipse BaSyx - AAS as standardized digital twin, control components, the virtual automation bus, and Docker container and
- Session 4: Realizing First Industry 4.0 solutions - Hands-On Examples starting with a small legacy system and extending it to an Industry 4.0 ready component.

C. Tutorial Conduction

The tutorial will include a mix of lecture, hands on exercises, facilitated discussion, and group activities.

D. Tutorial Requirements

We would require 3-4 whiteboards or paperboards (depending on the number of participants) and a spacious room for the group activities.

III. PRESENTERS' BACKGROUNDS

Dr. Thomas Kuhn is Head of the superordinate Embedded Systems division of the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern, Germany. He holds a PhD in Computer Science from Technische Universität Kaiserslautern, and has experiences with virtual engineering and virtual validation of software and system architectures with digital twins. Dr. Kuhn manages the BaSys 4 project series that aim at developing an open-source middleware for Industry 4.0 production systems together with 18 partners from Industry and Academia.

Frank Schnicke is project manager at the Fraunhofer Institute for Experimental Software Engineering IESE in the department Embedded Software Engineering and mainly involved in Industry 4.0 projects. Presently, he is working in the "BaSys 4.2" project funded by the German Federal Ministry of Education and Research (BMBF). His main contribution focuses on architectures that enable service-based production. Additionally, he coordinates the implementation of the Eclipse BaSyx reference implementation. His research focuses on Industry 4.0 software architectures that enable changeability in industrial plants.

Dr. Pablo Oliveira Antonino is Head of the Embedded Software Engineering department of the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern, Germany. He holds a PhD in Computer Science from Technische Universität Kaiserslautern, and has experience with the design, evaluation, and integration of dependable embedded systems from various domains, such as automotive, avionics, agricultural and construction machines, medical devices, and

smart industries. The Industry 4.0 middleware BaSyx is mainly developed by employees in the department managed by Dr. Antonino.

IV. TUTORIAL BACKGROUND

The tutorial has been held in different companies that are aiming at or already transitioning to strategies based on Industry 4.0 principles. Beyond these on-site customers tutorials, it has been held by 5 times as part of the dissemination activities of the BaSys 4.0 project, each time counting with 20 participants.

The tutorial is continually enhanced based on the experiences gathered in projects with customers and discussions with practitioners and researchers.