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FRAUNHOFER INSTITUTE FOR
EXPERIMENTETAL SOFTWARE ENGINEERING IESE

The Middleware for Industrie 4.0

BaSys 4.0

The Challenge

Individuality is becoming ever more important in our society. This development is also reflected in purchasing behavior. And it is exactly what manufacturing companies have to respond to by offering a wide variety of products and variants. Reality shows, however, that today's production processes are very efficient, but not very changeable. This is why manufacturers are unable to respond promptly to individual orders. Changing the type of product may entail great effort and thus high costs. Potential customers who want small lot sizes to be produced are faced with high costs per unit – making the order unprofitable in the end.

The transition to Industrie 4.0 promises to remedy this situation. Increased changeability of the manufacturing processes shall enable fast and cost-effective realization of changes in product type. Economically feasible manufacturing even down to lot size 1 thus appears within reach and can increase competitiveness.

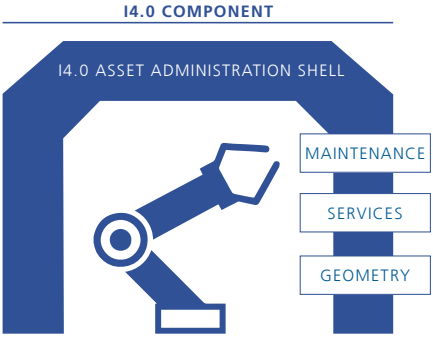
But how can companies make the transition to Industrie 4.0? This requires software that supports the changeable workflows in a manufacturing process. In addition, it must be capable of integrating heterogeneous machines by different manufacturers into one overall system.

Typical Issues

- How to implement changeable production?
- How to create and use digital twins?
- How to integrate devices from different manufacturers into a homogeneous communication system?
- How to establish open, highly networked automation systems that allow data to be accessed across several layers of the automation pyramid and even across company boundaries?
- How to enable the use of state-of-the-art infomation technology concepts such as Big Data in automation?
- How to accomplish the change of paradigm from embedded systems to cyber-physical systems?
- How to exploit data sources for predictive maintenance?

The Solution

In the BMBF-funded research project BaSys 4.0, Fraunhofer IESE is collaborating with 14 partners from the area of production technology to develop concepts and solutions for realizing digital twins as digital representatives for manufacturing. This creates a basic system for production plants that realizes efficent changeability of a manufacturing process as a central challenge of the fourth industrial revolution. The aim is to network and integrate existing technologies in such a way that Industrie 4.0 applications can be realized. To this end, the project team is developing a virtual middleware that allows the necessary services to be provided and linked with each other. In doing so, central concepts from Industrie 4.0 are being implemented, such as the digital twin in the form of the asset administration shell.



The asset administration shell and the asset as a central Industrie 4.0 component

The Benefits of BaSys 4.0

- Provision and implementation of central Industrie 4.0 concepts as an open-source project
- Change of the production possible within minutes, not months
- Enabler for lot size 1
- Easy creation of digital twins via defined interfaces
- Easy integration of both existing and new devices
- Access to process data from the office floor
- Ready-made reference components for fast commissioning
- Predictive maintenance

Application Examples

Connection between IT and manufacturing devices on the shop floor

How to monitor several devices from one place? How to create dashboards that combine data sources and show optimization potential?

Walking around the shop floor to check the status of machinery is inefficient and prevents operators from quickly getting a holistic overview of the entire manufacturing process.

BaSys 4.0 provides support in this regard by making data provision easy and thus opens up the following possibilities:

- Live streaming of manufacturing data
- Efficient process monitoring
- Holistic overview of the production

The BaSys 4.0 virtual automation bus (VAB) enables machine-to-machine communication across the layers of the automation pyramid; devices on the shop floor can interact directly with Enterprise Resource Planning (ERP) systems even if they use different protocols. Dashboards display focused process views and enable live monitoring of products and manufacturing processes.

End-to-end documentation of workpieces

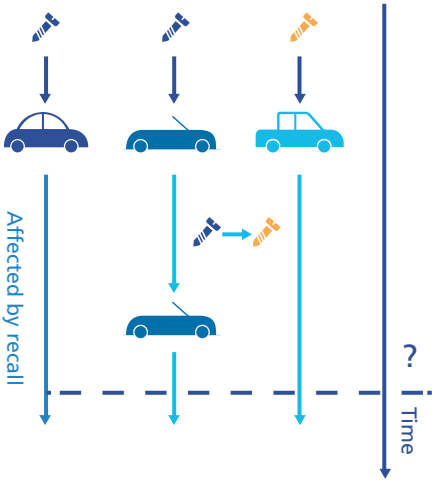
How to document the lifecycle of a workpiece? How to use this data effectively?

In today's manufacturing plants, huge amounts of data are generated that describe the flow of the entire process. Many OEMs today expect this data to be stored and packaged as part of a documentation obligation. This data can also be enriched with additional information over the course of the product lifecycle.

This results in the following benefits:

- Fault analysis: It is known for each workpiece which manufacturing step it has undergone when and how.
- Targeted recalls: If defects are discovered after delivery, precise knowledge is available of the products in which the workpieces in question were installed.
- Traceable product lifecycle: Companies can learn lessons for their future product generations.

BaSys 4.0 enables companies to collect and structure this valuable data. The virtual automation bus realizes the connection of devices. It enables capturing the process data, which can then be made available in a structured form via the asset administration shell, i.e., the digital twin of the workpiece. The documentation required by the OEMs can be satisfied by providing the asset administration shell of a workpiece along with its delivery.



Precise recall of products with BaSys 4.0 and improvement of future product generations

Enabler for Big Data Analytics

How to connect the manufacturing devices on the shop floor with data analytics on the office floor?

Every device in a factory generates a continuous stream of data. Data analyses can provide valuable insights into the manufacturing processes:

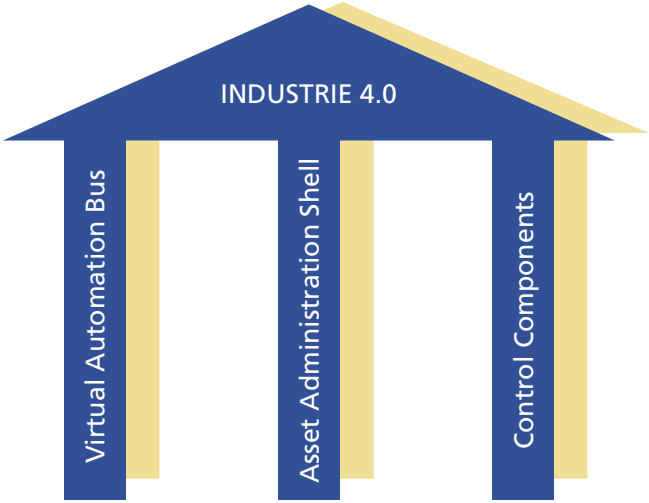
- Which variables have an impact on manufacturing costs and quality?
- How to predict manufacturing performance?
- Where is optimization potential hidden in the manufacturing processes?

Data analyses require a combination of data from various sources, i.e., from manufacturing devices, but also from IT servers. The ability of BaSys 4.0 to structure machine and manufacturing data in asset administration shells, to enrich both with semantic information, and to combine them with each other serves as an enabler for Big Data Analytics. The cloud to which the data shall be transferred can be freely chosen. This ensures that the data remains the property of the product and machine owners.

The Technology of BaSys 4.0

BaSys 4.0 realizes the following technologies implementing central pillars of Industrie 4.0 production architectures:

- The **virtual automation bus** enables corss-network and cross-protocol peer-to-peer communication between manufacturing machines (shop floor) and the IT.
- **Asset administration shells** are digital representatives of production assets, i.e., their digital twins. These assets may be physical or non-physical in nature. The asset administration shell of an asset contains sub-models providing, for example, its interface as well as status and live data.
- **Control components** realize uniform service interfaces for devices. They separate the implementation of production services from the production processes and make the production changeable. Control components also realize more abstract services, which abstract from the details of the implementation and are therefore easier to use. Control components are realized by means of runtime environments.



For each of these pillars, BaSys 4.0 offers open-source implementations that can be used off-the-shelf and enable fast transition to Industrie 4.0.

Our Services

We support you in your transition to Industrie 4.0 and help you implement corresponding solutions based on the use of BaSys 4.0. Fraunhofer IESE, as a competent partner with know-how in the area of Industrie 4.0 (for example in the creation of digital twins), can make a decisive contribution to the success of your project. We bring modern software architecture to manufacturing and demonstrate how easy it is to integrate this with existing automation and control systems. With our tool FERAL, we can simulate plant control systems for you before they are actually implemented. Support for this is provided by digital twins: They virtually map properties of your real plant and enable risk-free "What-if" analyses. Do you have any questions about BaSys 4.0? Then talk to us!

About BaSys 4.0

BaSys 4.0 is the Industrie 4.0 open-source middleware that has been funded by the German Federal Ministry of Education and Research (BMBF) since 2016. In the project BaSys 4.0, Fraunhofer IESE is collaborating with 14 partners from research and industry to realize central concepts and standards of the Platform Industrie 4.0.

www.basys40.de

Free Download of Eclipse BaSyx: www.eclipse.org/basyx

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Fraunhofer IESE

The Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern has been one of the world's leading research institutes in the area of software and systems engineering for more than 20 years. Its researchers have contributed their expertise in the areas of Processes, Architecture, Security, Safety, Requirements Engineering, and User Experience in more than 1,200 projects. The institute is working on innovative topics related to digital ecosystems, such as Industrie 4.0, Big Data, and Cyber-Security. It is a technology and innovation partner for the digital transformation in the areas of Autonomous & Cyber-Physical Systems and Digital Services, and its research focuses on the interaction between embedded systems and information systems in digital ecosystems.

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