Future scenario for 2025: Tim Baumeister is the production manager of a large industrial enterprise. His organization uses the entire production equipment until it is 100% depreciated, or even longer. Tim’s company does not buy any new machinery unless he presents a convincing business case. His boss is particularly skeptical about new IT-based features; they have to ensure that lead times, manufacturing costs or product quality are improved considerably.

Tim Baumeister still remembers those long-past years when a complete hall had to be cleared for a new product because, in most cases, new equipment had to be installed for a new product generation, and it took up to the last minute to manage the go-live. At that time, the manual configuration of the entire equipment and its components gave him many a headache, particularly as some interfaces had to be developed spontaneously to get the system going. It even happened that one of the operators renamed the control variables at short notice or added new values. In those cases, there was no point using Excel. Instead, handwritten notes were passed on to the system integrators or IT providers. The team, of course, was extremely stressed until late at night.

Error-prone paper-based work

In those days, the descriptions of machinery and its components were, at best, available as pdf files. Some of the machine manufacturers printed them out and sent the hardcopy to the construction site, together with the machine and the delivery note. Subsequently, each and every operator, whether from the machine manufacturer, the system integrator or an IT service provider, had to find the relevant data and transfer it manually to their own engineering tool, which was both painstaking and time-consuming. No wonder that many a typing error occurred, which was not discovered until the system was taken into operation.

False economies

It once happened that a smart purchasing manager tried to reorder some spare parts from a low-cost supplier rather than from the original provider. At the end of the day, this resulted in a relatively long standstill of the production line because the parts and the machinery were not compatible.

Communicating in a universal language

The fact that, today, older investments can easily be reused and combined with new equipment goes back to one of Tim’s innovative ideas. Some years ago, it occurred to him that machines and field devices could describe themselves - in a universal language that leaves no doubts about the features and capabilities, the
components and the significance of each and every value of a machine. This unambiguous information is then available to everybody involved in the factory processes! For machine manufacturers, this means that the start-up procedure of new equipment is accelerated considerably, running far more smoothly. Start-up engineers have to spend markedly less time on the construction site, and it is less strenuous. In addition, every spare part has an electronic certificate of authenticity today, which is why failures owing to seemingly cheaper parts cannot happen any more.

Self-configuring systems

Tim’s organization also uses the “awareness” of the equipment about its states and its manufacturing capacities for shopfloor related IT systems. New equipment or equipment components also include this kind of self-description. Using a universal interface, they transmit their description to the connected IT systems, which then configure themselves. The “change manager” of the interface also notifies the IT systems when existing installations are modified to account for new products. When Tim was a young engineer, he had to configure the controls himself and manually enter the configuration files exported from the controls into the higher-level monitoring system.

Basic ideas of plug and work

In Industrie 4.0, intelligent plant components, machinery and equipment and IT systems are connected with each other. Every component of the factory is aware of the relevant ‘partners’ and their characteristics. As a matter of fact, there are various heterogeneous software systems on every level of the factory today, most of which have proprietary interfaces, which have to be adjusted or re-programmed manually to account for every change. They are thus cost-intensive and error-prone.

Changes in software may

› result from embedded software in field devices connected via the field bus, e.g. in sensors, actuators, drives, valves, etc.
› affect the controlling software of machinery and equipment, e.g. programmable logic controllers (PLCs) or be associated with the information technology above the level of the immediate equipment controls (manufacturing execution systems - MES).

Our efforts are aimed at ensuring PLUG and WORK compliance in the shopfloor-related software components, consistently across the various levels of the manufacturing hierarchy. In this process, we use open standards currently being used in industry. Even today, we are able to export configuration data from devices and equipment, convert it to a standardized format, and thus provide all the relevant information for the automated configuration of monitoring and control systems and their visualization. The automated engineering of control systems even includes the generation of process control images with all the relevant connectivity information. To this end, we use CAEX (Computer Aided Engineering Exchange) and/or AutomationML and OPC UA. A ‘companion standard’ of the two organizations (OPC Foundation and AutomationML e.V.) describes how an AutomationML model can be converted into the information model of an OPC UA server.

Currently, these technologies are being enhanced in cooperation with industrial partners. The SecurePLUGandWORK (www.secureplugandwork.de) project focuses on ensuring that only authorized participants (components, machines and IT systems) can connect with the production system and that the communication of the capabilities is encrypted to prevent spying.

Semantic solution components

Originally designed as an exchange format for engineering data, AutomationML™ was enhanced by the partners of the AutomationML Association from science and industry. It is now a powerful description format and has been standardized internationally (IEC 62714). AutomationML is an open standard, which means that it is immediately available to any organization free of charge. We use AutomationML for the self-description of devices, machinery and equipment and of controls and network components, broken down into products, processes and resources. This includes the geometry and kinematics of the objects in a factory, their logic and behavior as well as logical and physical interfaces. A higher-level AutomationML model integrates the individual models. It visualizes the interaction between factory, lines, equipment, topology and the integration in the plant network.

Communication solutions components

OPC Unified Architecture (OPC UA) presents a modern and powerful communication standard, which is becoming more and more widespread in the manufacturing industry around the globe. Standardized as IEC 62541, it provides interconnected information models and enables event-driven communication between servers and clients of industrial information technology. OPC UA includes future-oriented IT security mechanisms, ensuring that your data can be shared between multiple sites. Models created for planning purposes, e.g. AutomationML, can be converted into an OPC UA information model on the basis of the joint “companion specification” of the AutomationML Association and the OPC Foundation.
The fact that OPC UA is scalable down to the chip level and thus applicable in embedded systems has been proved at our Centrum Industrial IT (CIIT), where the TPS-1 tiger chip has been developed. The Internet of Things thus appears to be within reach.

**Implementation in embedded systems**

Basically, Industrie 4.0 requires modular, distributed systems in the automation industry. This leads to smart products, processes and resources. This kind of intelligence is realized by means of highly integrated, embedded systems capable of communicating with each other in networks. The objective is to distribute the information to all levels of a production system or an automated technical system in a reliable way and in the necessary quality. This results in intelligent technical systems. Embedded systems, consisting of hardware and software components designed to perform technical tasks, have an enormous significance. Highly compact and yet powerful embedded systems are indispensable to fulfill the requirements of features such as plug and work. To achieve complete and automated plug and work even at the field level, we use intelligent embedded systems forming the memory of components and machines. Depending on the place of deployment and required functionality, the solutions vary in size and shape. Sample implementations include the TPS-1 PROFINET chip having a chip surface of 15x15 mm, FPGA/ASIC-based special solutions and even our Beagle-Bone based SecurePLUGandWORK adapter. The embedded systems developed by Fraunhofer IOSB-INA can be used in a wide variety of ways. They do not only serve as enablers of plug and work features, they also endow machines with their own intelligence, which in turn results in additional features such as self-diagnosis, self-optimization or lifecycle monitoring. In view of the considerable requirements with regard to reliability, while the resources of field devices are often limited, we always consider hardware and software as a whole.

**Benefits and potentials for savings**

If Industrie 4.0 actually looks like the aforementioned future scenario for 2025, there will be new tasks and challenges for independent IT service providers, forming the interface between software suppliers and plant operators. They will spend far more time on maintenance, configuration and parameterization than on programming. This trend has already become apparent and has been confirmed by recent studies.

Using our experience and our solution components, you will be able to design an Industrie 4.0 PLUG and WORK solution customized to your organization and its specific practical needs. As a system integrator, you will be able to offer your customers a comprehensive interoperability framework consisting of our components, your own software elements and third-party solutions. The success of the factory of the future will depend on how quickly your software systems can be reconfigured and adjusted to new scenarios, among other things. For this very purpose, we offer suitable solution components, which have been proven in practice. PLUG and WORK allows manufacturers of machinery and equipment to realize specific and verifiable savings in time and start-up costs because the characteristics stored on the components can be imported into monitoring and control directly rather than being copied from a data medium or transferred manually. Plant operators using our solution components significantly reduce the time and costs of the initial start-up and every modification of their SCADA and shopfloor-related IT systems as the configuration data from the controls are directly available as OPC UA data points, in a structured and comprehensible way. Also take advantage of our AutomationML and OPC UA training opportunities. Proven training modules for various target groups and industries will facilitate your first steps with PLUG and WORK and thus interoperability, which is indispensable for the factory of the future.

In cooperation with the Institute of Industrial IT (inIT) of the OWL University of Applied Sciences we use our smart factories in Karlsruhe and Lemgo to study, test and demonstrate future information and communication technology (ICT) solutions in the field of automation. This means that we have a distributed Industrie 4.0 production system in place to test Industrie 4.0 technologies. In this environment, we develop and test PLUG and WORK technologies for manufacturers of machinery and equipment, system integrators and IT suppliers.

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