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Editorial

Dear readers,

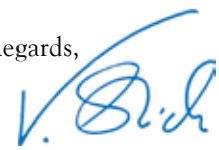
Germany is one of the most competitive industrial locations in the world. This is due in no small part to the country's specialisation in the research, development and manufacture of innovative production technologies and its ability to control complex industrial processes. With strong mechanical and plant engineering work, a wealth of globally recognised IT competence and expertise in the field of automation technology and embedded systems, Germany is predestined to unlock the potential of a new form of industrialisation.

Against this background, no other future-oriented project is enjoying more attention in the specialist community at present than Industry 4.0. The vision of the "fourth industrial revolution" is based on "smart factories" that can implement a highly networked, intelligent production world and follow the paradigm of a decentralised and augmented organisation. At the core of Industry 4.0, with the concept of "collaborative productivity", is a new dimension to the performance of value creation activities that can multiply current productivity many times over. The production systems of the future with powerful ERP systems, must therefore be able to exchange relevant information across companies in real time, simulate alternative strategies in the form of "what if" scenarios and thus optimise the way in which they work, largely independently. In the near future, availability requests will have to continue to evolve in the direction of a "capable to execute" approach. This involves not only an availability check, but also an automatic transfer of all necessary changes to the production system. Furthermore, using standardised interfaces, future ERP systems will allow integrated planning and comprehensive engineering across the entire value chain, thus fundamentally extending current Multi-Site functions in the sense of an intercompany collaboration.

The journey toward the vision of Industry 4.0 will require a huge amount of work in terms of research and development and is an evolutionary process that will progress at different speeds in the different industries and industrial companies. Together with our partner PSI AG, we are working on ensuring that the future-oriented project Industry 4.0 does not remain just a theory, but quickly finds its way into your everyday work.

Dear readers, I hope you enjoy reading this white paper and find valuable food for thought for your smart factory.

Regards,



Prof. Dr.-Ing. Volker Stich
Managing Director FIR e. V. at RWTH Aachen

Smart production is the future

PSI AG software solutions support the structural change to Industry 4.0

Many advanced methods, structures and paradigms have been developed in the last decade, with hundreds of billions of investments in the Internet economy. Many of the concepts are so familiar today that it is hard to remember what came before and the revolutionary force with which these concepts have conquered the world in a very short space of time: hypertext markup language, releases, universal resource locator, crowd, content, cloud, browser.

In the industrialised nation of Germany, as part of the Industry 4.0 program, industrial associations, research institutes, innovative software providers and the federal government are working on transferring these paradigms to the physical production of goods in order to identify new potential for increasing efficiency and for differentiation.

In their activities, these bodies are using the technology of the mobile Internet itself, both in terms of hardware (mobile chipsets) and software. The result is a self-organizing, highly flexible production system in which product design, components, manufacturing cells and logistics systems are networked with each other and equipped with decentralised intelligence. By 2025, this will be nothing less than the fourth industrial revolution and will break down, regroup or even completely replace many achievements of the previous industrial revolutions, such as mechanisation, engines and the production line.

Communicating manufacturing cells

One example of this change is the replacement of the production line with manufacturing cells. The machines in a manufacturing cell will log on to the cloud with a description of their own capabilities (processing modes, precision, availability) via hypertext markup languages. Workpieces will become smart objects thanks to the attachment of a grain-sized microprocessor equipped with its own energy-harvesting capability, own sensors, wireless communication and satellite navigation. A processing plan will be stored in this microprocessor by the product design team or by independent production schedulers, allowing it to make its way independently from manufacturing cell to manufacturing cell and from manufacturer to manufacturer like an network packet by requesting means of transport.

Independent product designers and releases

The product designer has the intellectual ownership of the product and bears responsibility for the design and for entrepreneurial risks. The product designer may not have any connection to the company that is responsible for the performance of production and transport services. Exceptions to this rule can be highly specific value creations that feature a new level of quality and are decisive

in terms of differentiation. Usually, however, production and transport service providers will grant everyone access to the manufacturing cells without prior notice and only with electronic billing – just as anyone can offer their product worldwide via YouTube or in the App Store and use the associated reproduction and transport capacities.

The products are developed further in the course of releases. Every end product produced may differ slightly (minor release) or structurally (major release) from previous products. Highly individual products, customized products and mass-produced products differ only in the price of the individual design service costs. Old and new releases are produced at the same time.

Entrepreneurial capital for the opportunities and risks of product design, production planning, manufacturing cells and transport facilities will be used, as it is today, by creative businesses – but also by corporations and in even greater detail and more directly by crowds.

On the internet, this is all difficult to imagine any other way, but when it comes to physical production it sounds very much like a dream for the future. Arranging plant annual shutdowns for the conversion of a production line for a new vehicle model will one day become something as obsolete as the record shops, cathode ray tube televisions and wired telephones that originated from the same era. The flexibility, efficiency and differentiation of the new value creation chain of the fourth industrial revolution excel over conventional forms of production by double-figure percentages, and will win the day.

Integrated software solutions and future-oriented product strategy

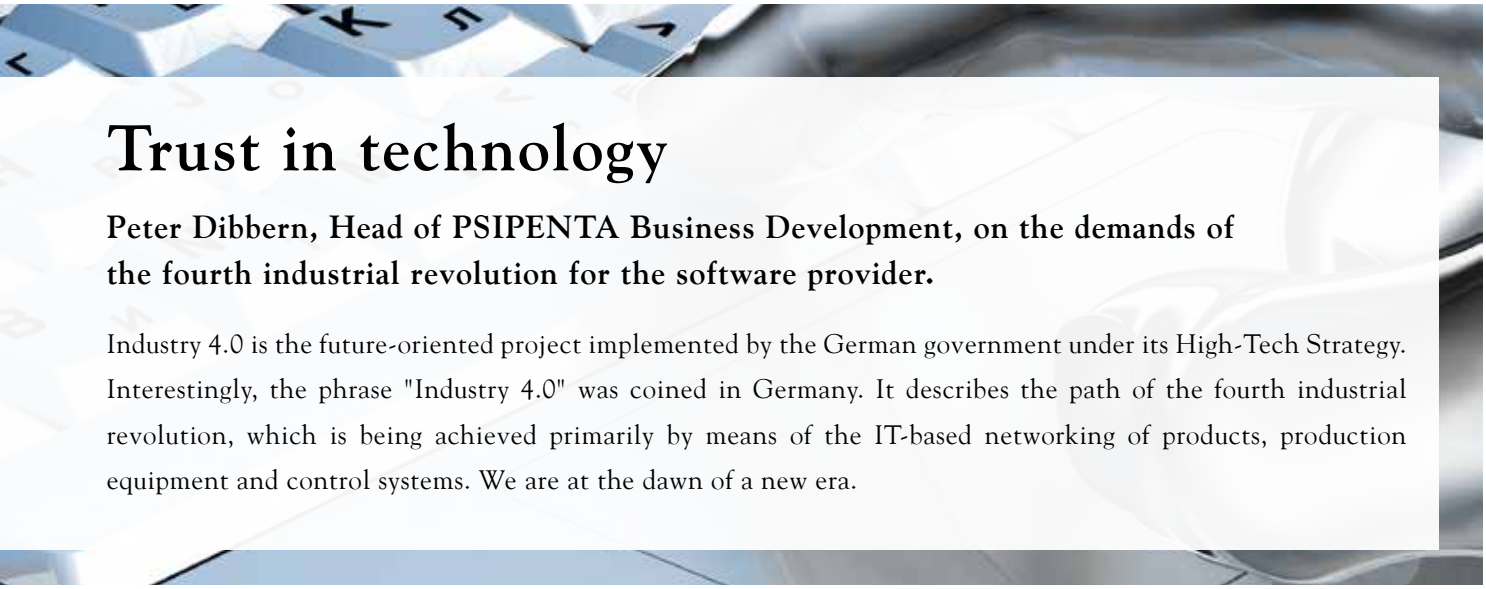
It is a concrete vision that all associations, businesses, researchers and suppliers can use as the basis for their work. The challenge now is to find the right steps at the right time to cope with all the necessary transitional stages.

As one of the most experienced software companies in Germany, PSI has a wealth of expertise and products built up over many years that cover the entire production and logistics process as well as all levels of resource planning systems for planning and optimisation through to production control. With our extensive solution portfolio and the industry expertise that has grown in the last 45 years, we have already begun at an early stage to prepare our products for the requirements of the future-oriented project Industry 4.0. In close collaboration with leading partners from the fields of science, research and industry, we are involved in implementing the vision in production and logistics in multiple research projects. The results are tested practically in pilot projects and are incorporated in the further development of our software products, making them available to all PSI customers.

PSI implements the software products in Java, the leading programming language, in the open development environment Eclipse. With hundreds of thousands of engineering hours, the group has built its own platform in this environment in order to deliver high availability in industry and real-time performance. With the rollout of this platform in all PSI business areas, we are also creating a basis that guarantees our customers a high degree of flexibility and security for the future. The new PSI*penta* product version 9 (see p. 18) is an example of the successful implementation of this strategy.

The combination of customer proximity, ground-breaking research projects and important industry standards as part of our group platform is a significant part of our product strategy. This ensures that our solutions take into account current and future trends and actively support the structural change to Industry 4.0.

Dr. Harald Schrimpf
Chairman
PSI AG



Trust in technology

Peter Dibbern, Head of PSIPENTA Business Development, on the demands of the fourth industrial revolution for the software provider.

Industry 4.0 is the future-oriented project implemented by the German government under its High-Tech Strategy. Interestingly, the phrase "Industry 4.0" was coined in Germany. It describes the path of the fourth industrial revolution, which is being achieved primarily by means of the IT-based networking of products, production equipment and control systems. We are at the dawn of a new era.

What potential does Industry 4.0 offer? What are the objectives in concrete terms?

First and foremost, Industry 4.0 is about safeguarding Germany as a business location. These new approaches offer great opportunities not only for our key industries in particular – mechanical engineering and the automotive industry – but also for the domestic IT industry. The progressive individualization of products is increasing the complexity in production processes. This complexity will have to be overcome in the future. The challenge is achieving one-off production at the cost of series production. A strong real economy therefore both benefits and drives IT – with the combination of the two bringing an additional competitive advantage for Germany!

But what are the current stumbling blocks?

An "industrial revolution" always describes an era and not a specific date. The cycles are becoming shorter, but ultimately what this revolution involves is ground-breaking and long-term projects in the capital goods industry. The dimensions of a corporate strategy compliant with Industry 4.0 include not only classic IT solutions, but also and in particular automation and production technology, as well as all control systems along the value creation chain. The interaction in the current production process must be fundamentally re-assessed, with the standardisation of interfaces, protocols and physical transmission paths playing a key role in this. For medium-sized businesses, it is sensible to develop an implementation strategy involving small steps to avoid being completely overwhelmed by the size of the project.

What relevance does Industry 4.0 have in principle for the MES market?

Industry 4.0 is clearly relevant for MES, as these systems are dedicated directly to the production process at workshop level. Today, many workers already benefit from a high degree of integration in manufacturing, a high detection rate and a multitude of sensors that, for example, are controlled in real time using a central production control system. Here we are talking about horizontal integration and integrated data management. As far as intelligent factory systems are concerned, the challenge now is to further intensify communication with the machines so that energy consumption and load distribution data, are included in the calculations in addition to classic machine data. Modern systems essentially record production data automatically; manual processes are gradually being replaced with automated control systems. The "Internet of Services" will most definitely play an important role in defining future MES solutions.

To what extent are medium-sized users aware of the topic?

Cooperation and networking are already practised today and are supported by modern ERP systems or communication platforms. This applies to both company-wide

communication and the integration into cross-company production networks. In the factory, intelligent algorithms for optimising sequences according to a wide range of criteria help users to implement production schedules. Inventory management and forecasting techniques reduce waste in everyday business. From a technical perspective, a lot of things are already possible today but, for the most part, are only partly implemented. In high-income countries in particular the pressure being placed on production is growing. It is clear to everyone that the only way to achieve long-term success is for companies to be able to align their production flexibly and respond quickly to changes in the product range or the range demanded. However, there is still a long way to go.

What technological and organisational requirements does Industry 4.0 involve in principle for both providers and users?

As a software provider, we have to be more open, and set new or comply to industry standards. The level of data exchange and, in particular, the data volume are increasing dramatically. The number of system users is also increasing, all of which require new functions and profiles. Users must in turn think across departments and across companies and promote a cooperative way of working. Trust in technology, whether in production technology or IT, is essential for the implementation of Industry 4.0 projects; the primary focus here is not on rationalisation but rather on delivering speed and greater output while using the same level of resources. Anyone who does not pursue this path will find themselves unable to continue manufacturing in Europe in the long term.

How much time and effort does converting a production plant or a production planning system to "4.0" involve?

No medium-sized business will be able to support such a project with a "big bang" start from a financial or capacity perspective. However, many businesses are in a good position to take small steps towards an integrated industry. A modern ERP infrastructure and integration into shopping pages and marketplaces are already a reality in a lot of cases.

How can end-to-end integration of the MES in the sense of "4.0" be guaranteed in business and production processes?

The boundaries of systems today are becoming increasingly blurred. As a provider of ERP and MES systems, PSIPENTA pursues a highly integrated approach and, in the Aachen research project WInD, worked on the standardisation of interfaces for real-time production systems. However, generally speaking we can say that systems are increasingly moving away from a simple classification according to their purpose or task, and are covering the various aspects of business and production control more and more comprehensively. The use of standards is crucial, because intelligent factory systems place the highest demands on the capability of the system components to integrate and communicate.

What role does "mobility" play in this situation?

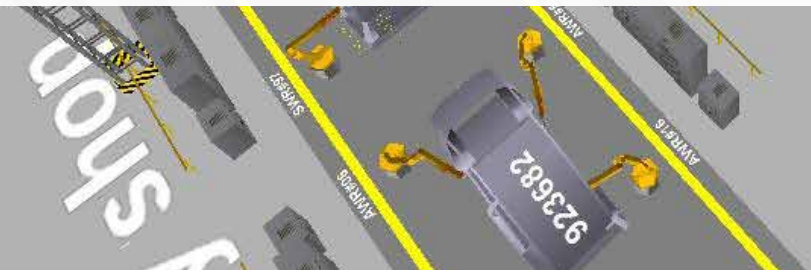
The retrieval of information from ongoing production processes will become increasingly mobile. This involves, control of the production technology by "smart products" that log on to the machine independently and send the information required for processing. Intelligent sensors and actuators record production data or intervene directly with the processes. Interventions or corrections by people can then also be supported by mobile systems independent of location.

Peter Dibbern
Head of Business Development
PSIPENTA Software Systems GmbH

The PSI solution architecture for production systems of the future

On the way to the smart factory

Requirements for software systems can be derived from the basic ideas of the smart factory. These are based on technology stacks widely used in the industry, ensuring the future viability of the solutions. With the Java-based solution architecture, PSI AG offers a powerful platform that, with a modern user interface and numerous productivity enhancements, provides the customer with the optimum technological basis for future production processes.



The implementation recommendations for the future-oriented project Industry 4.0 made by the research alliance make it clear that this is, importantly, an integration project for the industry as a whole.

The core element is the "smart factory", which consists of cyber-physical systems (CPS). The smart factory is thus a cyber-physical production system (CPPS). The smart factory is integrated into the entire flexible infrastructure and has interfaces to smart mobility, smart logistics, smart grids and smart services. The production systems will be adaptable and use adaptive logistics concepts. The production of the future is economical, urban, "human" and conserves resources.

Human-centric applications and interaction concepts

The new requirements in the context of Industry 4.0 need innovative assistance systems and multimodal user interfaces with the production process, the machines and systems, as well as the participating software systems. The smart factory therefore requires human-centric applications and interaction concepts. The need for information is based on the role of the person in the process, this person's tasks, the tools used, the available sources of information and the overall organisation of the factory of the future.

The information needs of employees depend on a wide range of influencing factors. For this purpose, role-based application concepts in conjunction with tailored and flexible interaction interfaces are required. In addition, work is becoming increasingly mobile. Mobile application scenarios together with location-based services help users to fulfil their tasks in the smart factory.

Safety and security

The high-level networking between machines and systems and the software systems that control them requires safe and stable communication channels (safety and security) based on standards. The use of the Internet of Things and Services requires secure connections and the reliable authentication of operators, machines and software systems when interacting with each other.

Horizontal and vertical integration

The vertical integration of the systems involved, from engineering

to automation technology, requires standardised interfaces and technology for networking. The flexible design of the interfaces requires simple and stable tools to ensure the efficient networking of all components. Only in this way can the high-resolution production control systems be coupled – right down to the machine control system. The horizontal integration within value creation networks requires open and stable interfaces between the partners of the higher level production system.

The underlying technological basis for such software systems has the required properties for the implementation of the Industry 4.0 concepts, such as real-time capability, sophisticated communication and software safety and security, flexible design options for interaction with the process and the software, support for context-adaptive methods or automated workflows and notification mechanisms.

On the way to the smart factory

The PSI platform is built 100% on Java™. In the first instance, this ensures support for different platforms (Windows, Linux, HP/UX, AIX etc.) and an integrated means of handling internationalisation. In the context of the requirements of Industry 4.0, however, other aspects come into focus. The special modular capabilities of Java and an OSGi-based core system allow the dynamic compilation of generic modules at runtime. This enables the composition of requirement-oriented systems that implement self-organizing logistics in an adaptive manner. The co-modelling of real and virtual production, which is the aim of Industry 4.0, thus includes the software modules as integral system components.

Multiple layers

The PSI platform supports multi-layer client/server architectures. The main motivation behind this is to separate the business processes and production structures from aspects of the presentation logic. The multimodal interaction required for the interaction with a cyber-physical production system is hardly conceivable without the separation of these layers. But separation alone is not sufficient. The different modes of interaction must be specifically addressed. Here, in addition to the conventional user interfaces, technologies such as "multi-touch" and "motion detection" are used on the PSI platform and are represented by stand-alone modules.

GUI – graphical user interface

The user interface of the PSI platform (GUI) allows the interaction interface to be adapted on an individual basis. In addition to role-based versions, the user can edit personalised views of the data worlds and save them in profiles. This includes not only the relational data and comprehensive functions such as presentation in tables (sorting, filtering, grouping), but also many graphic design possibilities (schematic 2D diagrams as well as realistic 3D visualisation) that make it easy to use the task context of the employee to provide proactive support functions. As an example, location-based views can represent the immediate physical environment and thus integrate augmented reality technologies into the user interface.

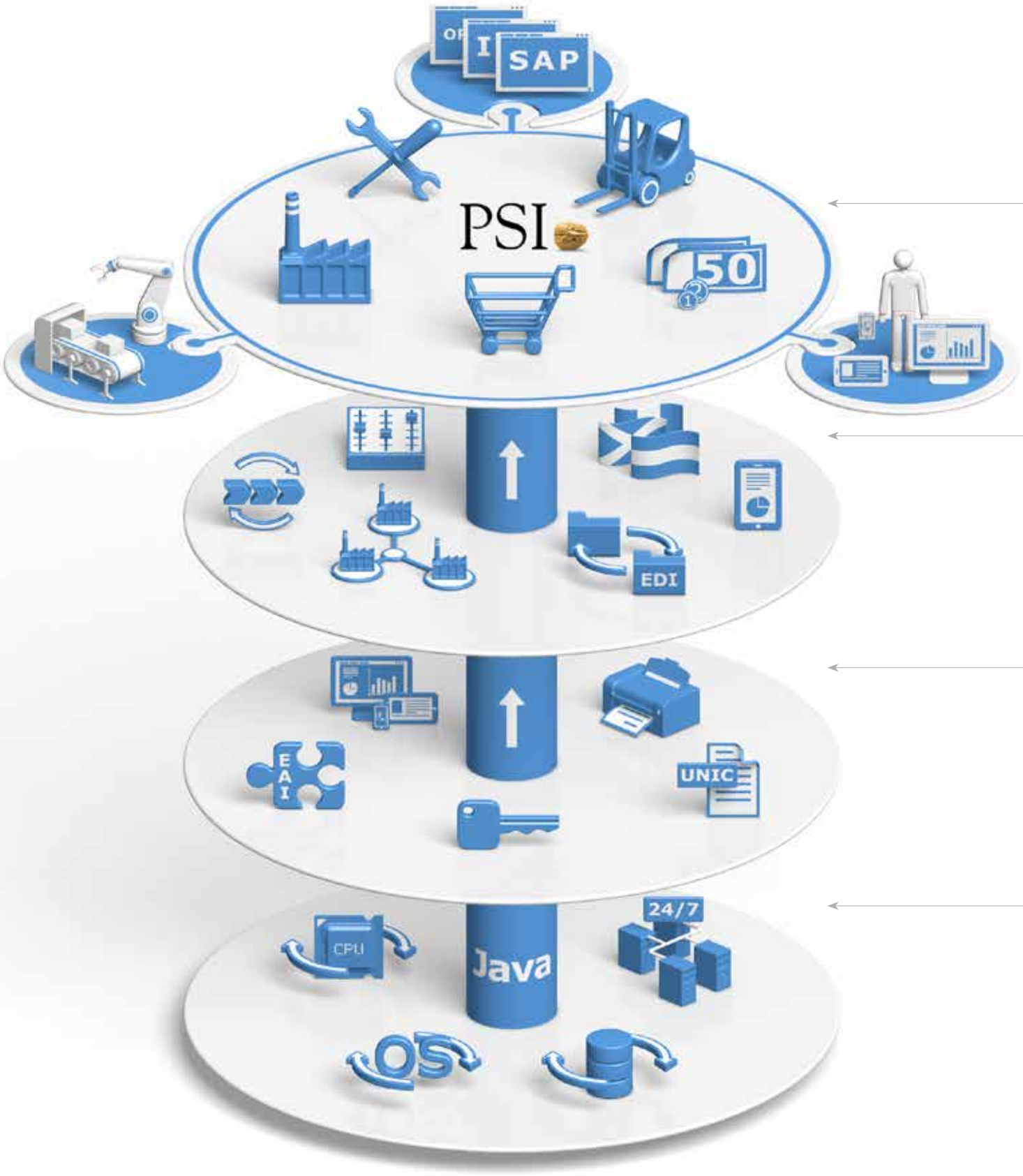
Role-based authorisation

From a system perspective, support for context-adaptive working methods requires the application of role-based authorisation, which the PSI platform provides consistently. Not only the elements of the user interface but also the underlying service structures on other system levels are fully controlled by the "AUTH" module.

The protection of critical infrastructure is also ensured. In addition, with the CPCT (Code Protection) module, the PSI platform supports various mechanisms for ensuring that digital process expertise is protected and protecting against manipulation and sabotage.

Standardisation

Model-based methods are particularly important in the PSI platform. The structure of the applied models is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The technology behind the PSI software

The highly available, scalable PSI platform based on state-of-the-art Java technology is the common, powerful basis for all PSI products.

Industry solution

The standard software is enhanced with industry-specific or customer-specific functional areas if necessary. These include interfaces to individual financial systems or project-specific connections to the machinery via SCADA systems. Typical industry enhancements to the standard software can be complete stand-alone modules or can expand the scope of the existing application (functions and data).

Application

The application layer provides ready-to-use and useful functions for solving operational tasks. The new developments are in the form of Java applications based on the PSI framework. Functional areas offered include materials management, production control and logistics. In close cooperation with research institutions and customers, the application is continuously being developed further in accordance with market requirements.

Framework

The PSI framework contains a large number of basic interfaces and tools that enable the infrastructure to be used efficiently and enable the fast and cost-effective development of applications. The entire architecture, in particular the layered model and the communication, is based on the fundamental principles of Java EE (Enterprise Edition) and thus provides the framework for scalable, reliable and secure software solutions.

Infrastructure

The infrastructure layer provides all components and services required for the operation of application software. Key elements include the operating system (client and server), databases and networks. A prerequisite for the PSI applications is a Java Virtual Machine (JVM) or a suitable application server. If necessary, the infrastructure can be designed for high availability.

not specified by the platform and can be adapted to the needs of the application. Various modelling aspects in the context of Industry 4.0 are not yet universally standardised. With the progressive standardisation of the reference architecture, the PSI platform structures based on meta-modelling can be adapted to a specific architecture at any time.

The PSI platform already supports automation technology modelling such as factory models in the context of preconceived product-specific domain models. With the workflow module, controlled by process models, the programmed sequence logic can be made more controllable via structures that can be adapted at runtime.

A further aspect is the ability of software systems to monitor and control value creation networks. This includes not least the integration of actuator and sensor signals. The "PSI*integration*" module helps to transmit these signals in real time. System interfaces across all levels and company boundaries can also be implemented via stable asynchronous data exchange. The digital vertical and horizontal consistency of the data and information flows allows transparent control over the entire production network.

Dr. Michael Bartmann
Management Central Development
PSI AG

Research projects supporting the fourth industrial revolution

Comprehensive software expertise for securing the future

Strong partnerships with leading research institutes and the top industrial associations in Germany ensure our software solutions remain practical and are always ready to meet future challenges. Manufacturing companies in a high-income economy such as Germany or other European Union countries set themselves apart in the global market with flexibility and a high level of automation. To ensure this competitive edge can be sustained in the future, PSI carries out research with excellence clusters in the German engineering sector and top universities. This includes five projects rated as important pioneers of the fourth industrial revolution.

EUMONIS – software and system platform for energy and environmental monitoring systems

Over the entire plant life cycle, the EUMONIS project addresses the operation and maintenance of renewable energy plants, such as wind, solar or bio-energy plants. To do this, integrated software systems must be created in the areas of energy park operations planning and service management, facilitating the communication between all elements involved in the life cycle of these plants via a central platform. As part of EUMONIS, PSIPENTA is therefore researching the development of monitoring and control systems (MDC, SCADA) to support advanced business models of component suppliers, plant manufacturers, energy park operators, network operators and external service providers. Particular areas that we are focusing on are the collection of plant and operating data, the early identification of operational problems and the identification of preventive maintenance. The efficient planning of the elimination of faults must take into account criterias such as weather forecasts, failure compensation, plant yield, energy efficiency and route optimisation. The implementation in the context of service management software components must consider current standards in this environment.

ProSense – high-resolution production control based on cybernetic support systems and intelligent sensors

The aim of this research project is to develop a high-resolution, adaptive production control system based on cybernetic support systems and intelligent sensors. The control systems must be designed in such a way as to ensure, by means of high-resolution data, that they provide optimal support for individuals, the decision-makers, in production control. At the detail planning level, the focus is on the development of versatile, adaptive detail planning of manufacturing and production control. The integration of mass data will enhance innovative, intelligent sensors from the production process with existing technologies and products. A standardisation of the technical interfaces to the sensor technology will also be pursued. In addition to the technical interfaces of the sensors in the detail planning modules, the intelligent processing of this mass data using new analysis and processing algorithms and the integration of these algorithms into existing software systems such as PSI*penta*/Adaptive is also a significant task that PSIPENTA Software Systems GmbH is undertaking as part of this project.

WInD – versatile production systems through integrated IT structures and decentralised production planning and control

The dynamics and variety of products in mechanical engineering and plant engineering is growing, increasing the diversity of processes in order control. This diversity of the planning and control processes requires a huge degree of coordination with respect to the organisation and the information systems. The overall goal of the project is to design a versatile production system for the mechanical engineering and plant engineering sector. In particular, the project aims to significantly increase coordination in production networks.

One objective is to design process-oriented standard interfaces between the relevant IT systems (PLM-ERP, ERP-MES) to enable vertical and horizontal integration of the IT infrastructure. A further objective is to design a modular planning and control logic and to identify thresholds for situational changes to planning and control methods in ERP systems. Overall, the results of the research project mean a significant improvement to the planning basis in the mechanical engineering and plant engineering sector.

PSIPENTA is involved in this research project as an IT partner, bringing with it an extensive range of expertise relating to ERP and MES. In the summer of 2013, the project was successfully completed by all consortium partners.

KPI-controlled optimisation of production planning and control of small series (KOPC) by means of fuzzy logic

Small-series manufacturing requires a radical new approach for lean production planning. The project, funded by the German Federal Ministry for Economic Affairs and Energy, favours decentralized, highly flexible material flow units realised by cyber-physical systems. The practical relevance of the results achieved in the project will be illustrated using demonstrators. F/L/S Fuzzy Logik Systeme GmbH is involved in the following focus areas:

- Development of a new planning methodology for production planning for small series
- Development of an operating concept for decentralised electric vehicle small-series manufacturing
- Development of a control concept for CPS for car manufacturing and material supply
- Support in the development of a monitoring and assistance system for the early detection of faults
- Support in the development of a simulation system for production control

Smart Logistic Grids – adaptive, multimodal logistics networks through integrated logistics planning and control

The aim of the research project is to develop a system that enables better action alternatives across a logistics network, thus increasing the efficiency of the overall system. The project will develop methods and systems for considering, developing and optimising global logistics networks as a whole. The following priorities will be addressed: development of an integrated model of adaptive supply chains to expand classic approaches to strategic, tactical and operational logistics planning and control, as well as the development of a supply chain operations room and the global supply chain event cloud. The consortium partners involved in the research project, led by PSI Logistics GmbH, are FIR at RWTH Aachen University, the Logistics Division at TU Berlin, Hellmann Worldwide Logistics GmbH & Co. KG, TOP Mehrwert Logistik GmbH and ZITEC Industrietechnik GmbH.

The Industry 4.0 ecosystem: People, machines and software

Industry 4.0 as a future concept for society as a whole

The fourth industrial revolution – Industry 4.0 – is the consequence of the changed production conditions in Germany and Europe. One key objective is assuring the competitiveness of German and European industry in international competition in the supply chains. It is no longer only individual companies or company groups that are in competition for the favour of the global customer. The performance of these production networks is decisive for the success or failure in global markets.

Customer wishes that are becoming increasingly individual lead to a very wide range of variants, with production more frequently of a batch size of just one. This has far-reaching effects on company processes that can only be managed if manufacturing processes are integrated not only horizontally but above all vertically — up to the level of automation. To manage this high variant diversity economically, companies have to be extremely agile. This can only be achieved by creating smaller units and through cooperation, including joint value creation, between different companies.

Megatrends in business

Globalisation of demand goes hand in hand with the globalisation of production. "Local content" plays an increasingly greater role in conquering foreign markets. Managing the resulting requirements for production control and company management requires an efficient networking of all locations and value creation partners. The networking of various companies and the necessity of communication between the many different software systems available today is just one of the significant challenges. In addition to the technical issues, intercultural collaboration between the people involved in the processes must be considered.

The demographic change demands new concepts in the design of the production environment. The ageing

company with a simultaneously declining labour force potential requires, in addition to an increasing level of automation in production, modified interaction concepts with the production process. The interaction will be aligned with the user to a significantly greater extent and must consider the given work context. This also means that, from the large quantity of information to be expected, the information relevant to the specific situation must be filtered out and presented. In addition to tools, new interaction concepts also require people with the appropriate training.

The change in values is making people focus on new or different aspects when planning their lives. Social and economic sustainability is more important now than ever before.

Smart factories

Production systems are shaped by cyber-physical systems (CPS).

One of the main properties of this CPS is the advanced networking of the production systems using Internet standards. It is not only the machines that are communicating with each other — the work pieces are communicating more and more with the production technology. To do this, resources and workpieces have an identity in the Internet of Things. The decentrally organised production units have an unprecedented level of agility. The interaction between workpieces and production technology in smart factories allows flexible and application-based reconfiguration of production systems. The resources and capabilities of these production systems are visible and available in the Internet of Things ("Production as a service").

A key factor for the success of the smart factory concept is the integrative development of products and production systems. First and foremost, this means that the interdisciplinary collaboration, from the product development process to the development of the corresponding production technology, must be raised to a new level within the company.

Agile production systems require equally agile software systems for the planning, simulation and control of manufacturing processes (Internet of Services). Today's centralist concepts will be replaced with smart, high-resolution decentralised systems as a result of the gradual development of CPS.

Big data

High-resolution production control systems use huge amounts of data from sophisticated sensors to assess the actual situation. The data and information gained must be prepared taking into account the given context and are used to control the current production parameters in a targeted manner. It is no longer merely an issue of establishing a reporting system and assessing a situation "post mortem". The data collected (big data) controls the process and aids the elimination of faults in real time.

Society 4.0

Industry 4.0 must be understood as a future concept for society as a whole, "Society 4.0" so to speak, in which people, perhaps more than ever, are at the forefront. The profiles of certain job descriptions are certain to change or be completely reformed. The increasing diversity of products with short delivery cycles and simultaneously decreasing numbers of specialist personnel available can present an additional challenge for many companies. It is also important not to forget that the urban production of the future is moving closer to where people live. This will require different logistics concepts for production supply and disposal.

People are not being disregarded, quite the opposite in fact. Their requirements must be taken into account to a much greater extent in corporate planning in the future. The Industry 4.0 eco system consists not only of smart factories and intelligent products with a memory that control production. It is a question of allowing people to perform high-quality and creative work and giving them the opportunity to achieve a work/life balance – with just as much flexibility as the production systems of the future that will be controlled by people.

Find out more!
The implementation recommendations for the future-oriented project Industry 4.0
German Federal Ministry of Education and Research (BMBF)

ERP/MES integration in the age of Industry 4.0

Industry 4.0 as an integration project – integrating value creation chains horizontally and processes and systems vertically up to automation level

The fragmentation of manufacturing systems will increase. This does not necessarily mean that the factory of the future will be smaller. Production systems will be controlled in more detail. From the point of view of production planning and control, the advantage of smaller units is a greater degree of flexibility and easier local optimisation of production. The integration of systems and standardised automatic communication are essential for such units to work in an overarching network.

One characteristic of the smart factory is the ability to reconfigure the production system. This results in the properties and parameters of the participating manufacturing systems being modified. Manufacturing execution (i.e. production control) must take this into account. To do this, this new production control system requires a constantly updated overview of the production system to be influenced. This means not only the local systems but also all other elements involved in the process. The resources available throughout the entire supply chain must be visible and completely transparent in terms of availability.

Production control with up-to-date information

To achieve production control that is as realistic as possible requires constantly up-to-date information regarding the actual situation in production with respect to the existing resources, the current properties of these resources and the order situation today and in the future. This can be achieved by means of a deep integration of the planning world (ERP) with the implementation layer (MES). Efficient control loops between planning and production help manufacturing companies to achieve even the most ambitious of objectives. On the basis of simulations, the scenarios that best match the objectives are implemented by the MES components.
Information regarding the current state of production must be available at any time and must be reliable. There are standardised key performance indicators (KPI) for this purpose. Unlike today, based on the KPIs, the planning and implementation systems intervene in the production process in the case of deviations and correct faults or propose measures for eliminating the deviations. The subsequent, "post mortem" analysis is replaced by a continuous evaluation of the production KPIs. In order to do this, the physical production system and the automation technology must be deeply integrated with the IT.

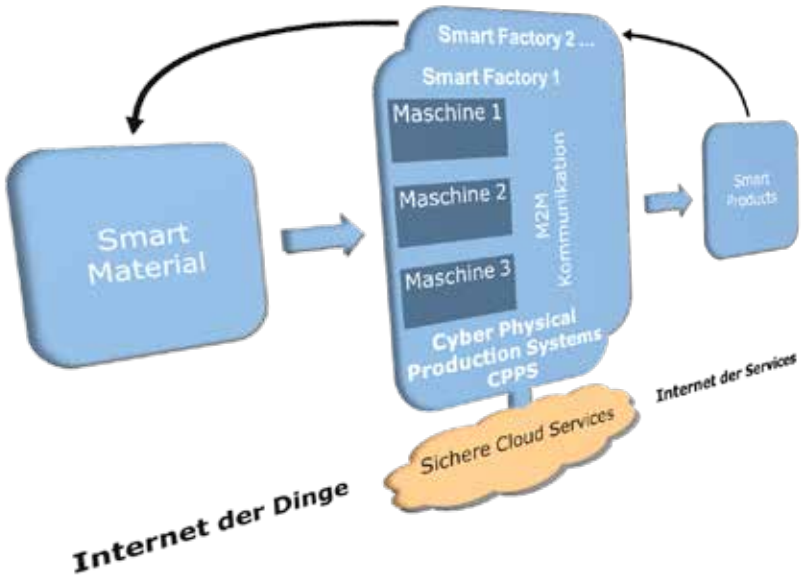
Integration of ERP and MES

The challenge is integrating the processes at the interface between company level (ERP) and plant management level (MES) while working with increasingly detailed manufacturing and planning units. While ERP systems tend to control administrating logistics and business processes at a higher level across the company, MES systems are very closely connected to the production line and are used to continuously optimise production and to record information and technical parameters of the

manufacturing process. This data can be very diverse: time and quantity reports, quality data, status of machines and systems, faults and their causes. This information thus reflects the status of the production system, which in turn influences the production planning in ERP systems.

We expect that the boundaries between ERP and MES systems will become increasingly blurred in the context of Industry 4.0. The company level is becoming more and more integrated in the plant management level. The fulfilment of typical tasks of MES systems is being taken over by the ERP systems, and the classic planning tasks performed by ERP systems are moving to MES detail planning in part.

While in the case of pure reporting systems the entire planning sovereignty remains in the ERP system, MES systems can also take over sub-areas of detail planning. Finite capacity scheduling solutions with the option of planning in situations with limited capacities help with the implementation of potentially less detailed specifications from ERP systems.



A highly flexible production system

MES systems make it possible for production processes to be controlled on a very detailed level. In conjunction with ERP systems and depending on the functionality provided by the individual system components, there are various opportunities for integration. In general, a coordinated integration tailored to the requirements of the respective application is advantageous. The strengths of today's already highly developed planning systems (e.g. APS) will be supported effectively by corresponding MES components. Having up-to-date information about the production process available significantly improves the accuracy of the planning process and aids the elimination of pervasive faults. In addition, MES systems with equally sophisticated detail planning components can support the execution of plans from higher level ERP systems that plan in less detailed time intervals. This allows both production and economic objectives to be achieved.

In addition to the creation of appropriate production technology for the smart factory, one of the most important next steps is the development of integration concepts along the supply chain. A reference architecture is required for the "smart object" construct in a smart factory in a future smart supply chain supplemented by smart services. This reference architecture then ensures a uniform understanding of the processesand standardised interaction of all elements involved in the process. The objective of all activities is to achieve a highly flexible, low-hierarchy and, above all, efficient production system.

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Meeting future requirements

PSI*penta*/ERP version 9 confirms modern trends in business software

PSI*penta*/ERP and the supplementary components are the first choice when it comes to dynamic production processes, high levels of system integration capability and flexible production control together with the highest possible level of stability and availability. It is therefore only logical to align the solution portfolio with future requirements and take coming trends in business software into account. These requirements are not fundamentally new, but against the background of the forthcoming change in the industry they have added significance.

One of the most important future-oriented projects in Germany relates to the issues surrounding the structural change of German and European industry summarised under the term "Industry 4.0". PSIPENTA is involved in a large number of projects in this area, some of which are flagship projects (see page 12). These projects address the main tasks involved in the fourth industrial revolution. Participation in the research secures the future viability and practicality of the solutions by means of active work in the community. This combination of characteristics guarantees market-ready and pioneering applications. PSI*penta*/ERP version 9 and the following releases will take into account the new requirements for modern business software in particular.

User interface

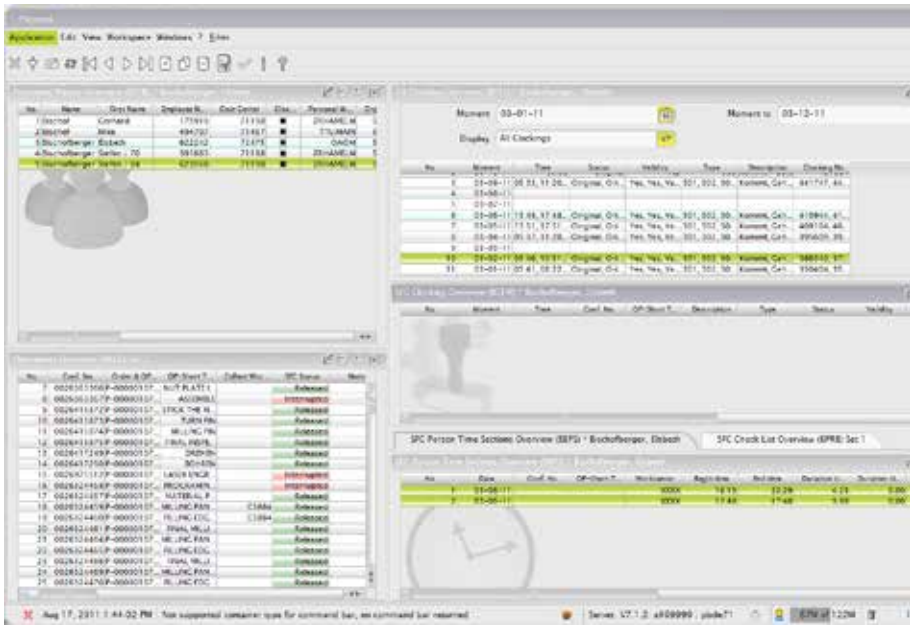
The majority of projects relating to Industry 4.0 consider the user interface and interaction. In addition to ISO 9241, the requirements in terms of usability can be defined using the terms self-descriptiveness, task suitability, promotion of learning and customisability. This is precisely where the new PSI*penta*/ERP user interface comes in.
The interface is extensive and easy to customise, making it easy to present the role of the user or the user's current working context or the task clearly according to the information. The contexts of the data can be visualised simultaneously through synchronised views, as configured by the user. The aim is to simplify the handling of the (necessary and existing) complex functionality and to enable task-based or process-oriented operation of the system.

MES integration

Making production systems more flexible increases the requirements for production planning and control drastically. The planning processes will be even more complex in the future. Mastering the processes from rough-cut planning (projects) to the creation of optimal sequences in production (finite capacity scheduling and sequencing) requires a deep integration of the supporting IT systems. The status of the production system must be known at all times. The shop-floor and machine data collection module (PSI*penta*/SFDC, MDC) provides up-to-date information in this regard.

Adaptive production control

The objective of adaptive production control to synchronise the production system (controlled system) with the sales and procurement markets (disturbance variables). The key elements of adaptive production control are the specific influencing of scheduling and production planning to minimise the (required) stock levels and the gradual transition to the pull principle. The issue is primarily to avoid waste and improve efficiency. In the Industry 4.0 environment, adaptive production control is about the self-optimisation of detail planning in volatile markets and with atomised demand.



Mobility

The extension of business processes into the online world is rapidly gaining in importance. With the existence of highly efficient mobile end devices and the corresponding technology platforms, as well as the increasing mobility of employees, the demand for mobile solutions is growing. The "Range Extender" from PSI*penta*/ERP & MES provides support for mobile business processes. The existing application for mobile data collection for materials management and production is constantly being expanded to include new processes. The focus of the further development is the service processes. This involves mobile applications for service management in the area of incident recording and processing and feedback from service activities, as well as the recording of personnel working hours for field employees. The platform for the applications needs to be independent of the devices used.

Integration capability

The integration of internal and cross-company value creation chains is already extremely important today. Cross-company cooperation is promoted in many different ways. In this context, PSIPENTA offers industry-based solutions that support the mapping of the automotive value creation chain with EDI (Electronic Data Interchange) solutions that are in compliance with standards. Participation in the bodies responsible (e.g. VDA – the German Automobile Industry Association) ensures that the EDI connection is constantly up-to-date. The automation of communication – for mechanical and plant engineering in particular – can be achieved through the use of the myOpen Factory platform. The support of other processes, in particular on the sales side, will further enhance the solution offered. The technological transition to Web services will take place at the same time.

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