Tutorial proposal

Engineering and state-based control of Cyber Physical Production Systems

1. Presenters:

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2. Brief description:

The process industry has to deal with challenges as a shorter time-to-market, shorter product lifecycles, highly volatile markets and additional requirements, e.g. regarding lot size one. One possible solution to handle these challenges in industrial production is to equip and organize the production plant with cyber physical systems (CPS). CPS are known as the integration of computation in physical processes. The application of CPS in an industrial environment is referred to as a cyber physical production system (CPPS). To understand how the application of CPPS can fulfil the mentioned requirements, an introduction to CPPS in different domains is given within the tutorial. Additionally to CPPS, service-oriented architectures and Microservice architecture approaches are presented. A possible implementation of a CPPS in the process industry is the modular process plant. These plants consist of intelligent modules that are equipped with their own controller. Each module itself is a CPS and offers encapsulated process functions as services to the superior control system. Each service is controlled by means of a state model, which is referred to as state-based control. By introducing the services as a new layer in the automation architecture, the design of the services has to consider different aspects such as the service granularity, service type, mandatory and optional service states, service parameters and assurance of safe states. All aspects will be presented and discussed in detail.

The division of the intelligence of the system into the services in the modules and the service-orchestration in a superior control system results in a divided engineering process: the module engineering carried out by the module vendor and the integration engineering carried out by the plant operator. During the module engineering, the module vendor encapsulates process functions as services. The engineering tool of the module vendor should export a Module Type Package (MTP) as a model of the module which contains all needed information for the start of the integration engineering by the plant owner, such as information regarding the communication, the human-machine interface (HMI), and the services. To integrate modules of different vendors, the MTP should follow a vendor-

independent standard which is currently under development. The standardization of the MTP is an ongoing process in which the speakers of this tutorial participate actively. In the tutorial, the MTP will be presented in detail, and new concepts regarding the HMI and the applicability of the MTP will be demonstrated in a simulation environment, based on Matlab Simulink Stateflow and a platform independent web application. Additionally, practical aspects for the module engineering and the configuration of a modular process plant will be shown by ABB, one of the leading process automation companies in the world. Thus, the audience will be guided through a step-by-step procedure for the module and the integration engineering including the automatic generation of the MTP. The tutorial will be concluded with the presentation of the first results of the implementation of the concept in real life industrial modular process plant at BAYER, one of the largest life science companies worldwide. An outlook of the use of the concepts will be given, especially the use of MTP for migration projects at ABB.

3. Outline:

The tutorial will start with an introduction to the actual trends and challenges from an industrial perspective by Dr. Knohl. Prof. Fay will present CPPS in different domains and their requirements from a technical point of view. Mr. Bloch will explain service oriented and Microservice architectures as solutions for the upcoming trends and challenges. Furthermore, Mr. Bloch will present the general setup of modular process plants and a guideline for module vendors how to design services in this context. In the guideline, the aspects regarding granularity, service type, mandatory and optional service states, service parameters and assurance of safe states will be presented in detail, and an example will be provided. For the industrial practice, the MTP will be introduced and the main aspects will be discussed for a better understanding of the concept of vendor independence. Mrs. Menschner will link the MTP aspect of the HMI to new visualization concepts for modular plants. These concepts will include the design of HMIs for different devices and will present several examples for better understanding. Additionally, a guideline will be presented to design HMIs and generate the corresponding MTP.

After the concepts have been introduced, Mr. Hensel will present an example case implementation in the simulation environment of Technische Universität Dresden and Helmut-Schmidt-University. The example case is provided by Namur (User Association of Automation Technology in Process Industries, www.namur.net). The example case shows the concepts of state-based control, new visualizations and orchestration of services. The presentation will be held as a live demo.

To present the applicability of the concepts in an industrial context, Mr. Funderburg will show a live demo of the module and integration engineering of modular process plants.

The tutorial will conclude by the presentation of an implementation of a modular process plant at BAYER by Dr. Knohl. The setup of the plant and the design of the services as well as the first lessons learned will be presented. At the end of the tutorial, an open discussion round with all speakers is planned.

4. Publications:

Bloch, H., Fay, A. and Hoernicke, M. (2016). Analysis of service-oriented architecture approaches suitable for modular process automation. In 21th IEEE Conference on Emerging Technologies and Factory Automation (ETFA). Berlin, Germany. September 6-9, 2016.

Hahn, A.; Hensel, S.; Hoernicke, M.; Urbas, L. (2016): Concept for the Detection of Virtual Functional Modules in existing plant topologies. IEEE Conference on Industrial Informatics (INDIN). Futuroscope-Poitiers, 18-21 July 2016.

Bloch, H., Hoernicke, M., Hensel, S., Hahn, A., Fay, A., Urbas, L., Knohl, T. and Bernshausen, J. (2017). A Microservice-Based Architecture Approach for the Automation of Modular Process Plants. In: 22nd IEEE International Conference on Emerging Technology and Factory Automation (ETFA). Limassol, Cyprus, 13-15 September 2017.

Bloch, H., Hensel, S., Hoernicke, M., Hahn, A., Fay, A., Urbas, L., Wassilew, S., Knohl, T., Bernshausen, J. and Haller, A. (2017). Model-based Engineering of CPPS in the process industries. IEEE International Conference on Industrial Informatics (INDIN). Emden, Germany, 24-26 July 2017.

Bloch, H.; Hensel, S., Menschner (née Hahn), A., Grebner, T., Hoernicke, M., Fay, A., Urbas, L., Knohl, T., Bernshausen, J. (2018): Orchestration of services in modular process plants. 44th Annual Conference of the IEEE Industrial Electronics Society, Washington D.C., USA. October 21-23. Paper submitted

5. Presenter's biography:

Alexander Fay (M'02-SM'07) was born in Germany in 1970. He received the Diploma (with honours) and the Ph.D. (with honours) in electrical engineering from the Technical University of Braunschweig, Germany, in 1995 and 1999, respectively. He had worked five years at the ABB Corporate Research laboratories in Heidelberg and Ladenburg before he was appointed Full Professor at the Institute of Automation Technology at the Helmut-Schmidt-University in Hamburg, Germany, in 2004. His main research interests are models and methods for the engineering of large automated systems, especially in the process and manufacturing industries, in buildings, energy distribution, and transportation systems. Professor Fay served as a member of the AdCom of the IEEE Industrial Electronics Society and was General Chair and Program Committee Co-Chair of the IEEE Int. Conf. on Emerging Technologies and Factory Automation in 2008 and 2015, respectively. Between 2011 and 2017, he served as an Associate Editor of the IEEE Transactions on Industrial Informatics. In 2018, he is Program Committee Co-Chair of the 14th IEEE Int. Conf. on Automation Science and Engineering (CASE).

Torsten Knohl was born in Marl, Germany, in 1968. He received the diploma in electrical engineering from the Ruhr-University Bochum, Germany, in 1995. From 1995, he worked as research fellow at the chair Elektrische Steuerung und Regelung, Ruhr-University Bochum,

Germany. He received a Dr-Ing. in 2001 in electrical engineering from Ruhr-University Bochum, Germany, with thesis “Anwendung künstlicher neuronaler Netzte zur nichtlinearen adaptiven Regelung” (Artificial neural networks for nonlinear adaptive control). Since 2001, he works in the engineering department of Bayer AG. He was responsible for the automation and electrical engineering in large-scale capital investments in Germany, China, Singapore and Brazil. In his current role as Senior Project Manager, he develops the strategy for the digitalization of production and R&D in the Bayer AG. He is member of Namur WA1 “Project Planning and Construction”, member of IEC TC65WG-12 “P&I diagrams, P&ID tools and PCE-CAE tools” Co-Chair of DKE-K941 “Engineering”, and Chair of IEC TC65/SC65EWG3 “Commissioning".

David Funderburg was born in USA in 1974. He received the Bachelor of Science Diploma in chemical engineering from Case Western Reserve University, Cleveland, Ohio, USA in 1997. He had worked three years at the Elsag Bailey prior to ABB acquiring Elsag Bailey in 2000 and has since worked at ABB. He has served various roles with ABB including technology management, product development, sales support, marketing, project management, and project engineering. His current role is the Global Technology Manager of Product Group Chemicals and Refining within ABB’s Industrial Automation Oil, Gas, Chemicals Division. As a Technology Manager, David’s primary responsibilities include developing the technology in line with chemical and refining client requirements, providing technology support of client engagements, and providing technical consulting to project execution groups implementing projects within ABB. David specializes in process control and batch control implementation within the chemical industry. David works heavily with ABB’s corporate research centers globally on implementing their research results into industrial products such as Modular Process Automation. He is also a TÜV Functional Safety Certified Engineer.

Henry Bloch was born in Hamburg, Germany in 1988. He received the B.Sc. and M.Sc. degrees in industrial engineering and management from a joint study programme of University Hamburg, University of Applied Science Hamburg and Helmut-Schmidt-University Hamburg in 2012 and 2015. Since 2015, he is a research associate at the Institute of Automation Technology at Helmut-Schmidt-University Hamburg. His area of research is modular process automation. He is an active member of the joint standardization working groups of Namur and ZVEI as well as the VDI/VDE GMA FA 5.16 which defines the VDI/VDE/Namur standard 2658 “Automation engineering of modular systems in the process industry”. In 2018, he is member of the Program Committee of the 23rd IEEE Int. Conf. on Emerging Technologies and Factory Automation (ETFA).

Anna Menschner (née Hahn) was born in Taschkent, Usbekistan, in 1987. She received the Diploma in Electrical Engineering from the Technische Universität Dresden, Germany, in 2014. Since 2014, she is a doctoral researcher at the Chair of Process Control Systems and Process Systems Engineering Group. Her area of research is Re-Modularization of process plants. She is an active member of several task forces of the Namur which defines the VDI/VDE/Namur standard 2658 “Automation engineering of modular systems in the process industry”.

Stephan Hensel was born in Räckelwitz, Germany, in 1990. He received the Diploma in Information Systems Engineering from the Technische Universität Dresden, Germany, in 2014. Since 2015, he is a doctoral researcher at the Chair of Process Control Systems and Process Systems Engineering Group. His area of research is the evolution of information models. He is an active member of the joint standardization working groups of Namur and ZVEI as well as the VDI/VDE GMA FA 5.16 which defines the VDI/VDE/Namur standard 2658 “Automation engineering of modular systems in the process industry”.