1st Conference on Production Systems and Logistics

Blockchain-based Services in the Machinery and Plant Engineering Industry

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Abstract

A large number of product-accompanying services in the machinery and plant engineering industry is based on the cross-company exchange of data and information. By providing services, additional sales potential on the manufacturer side as well as far-reaching product and process advantages for appliers can be reached. However, the necessary cross-company exchange of information is nowadays limited due to a lack of trust in the interacting partner and the applicable existing technologies, which results in significant losses in the terms of business potential. The uncovering of this potential now seems to be made possible by the use of the Blockchain technology. Through the key factors security, immutability, transparency and decentralisation, it serves as an enabler for cross-company communication and product-accompanying services. The technological implementation of a Blockchain can take on a broad spectrum of attributes, which can lead to decisive restrictions for the execution of services. This justifies the necessity for a qualified and context-related assessment of service-types-individual specifications and the resulting requirements on the system. Within the scope of this paper, different types of product-accompanying services are identified and analysed regarding their requirements for a Blockchain-based machinery and plant connection. This can serve as a basis for a qualified and goal-oriented configuration of the Blockchain.

Keywords

Blockchain; Digital services; Blockchain-based Services, Machinery and Plant Engineering Industry

1. Introduction

The most efficient use of resources and capacities in production is a fundamental prerequisite for the competitiveness of companies. The machinery and plant engineering industry is under constant pressure to offer their internationally distributed customers reliable products. Increasing competition in the machinery and plant engineering market leads to declining margins, which can be achieved by simply selling the physical product.[1] The solution for creating business potential are product-accompanying services that generate additional value for the applier based on data generated during the user cycle. For the realization of services, data and information necessarily flow from the machinery or plant operating company to the service providing company. Due to concerns about the misuse of this information, many operators block the corresponding monitoring and remote access to their machinery and plants. [2,3] Blockchain technology combines approaches from academic disciplines such as cryptography, network and database management, and can create technology-based control and trust and thereby function as an enabler for service realization [4,5]. However, the implementation or design of such a Blockchain-based system offers a complex and difficult to obtain prerequisite analysis due to the versatile technical freedom of design such as the structure of data storage, the proof mechanism, access rights or the ability of carrying out smart contracts. The design

of the Blockchain implementation is decisive for its possible success and must be defined in a qualified manner. [6]

These widely differing technical configurational opportunities require a qualified and detailed requirements analysis of the intended service implementation. Within the scope of this publication, different types of data-based services are identified and described with regard to their requirements of a Blockchain-based machinery and plant connection.

2. Identification of data-based services

Based on the classification of assets used in the literature, data-based services can be sorted in the field of intangible goods (see Figure 1). In the context of the machinery and plant industry, data-based services are product-accompanying value creators, which can be offered based on data and information, which are generated during the user cycle of the machinery or plant. [7]

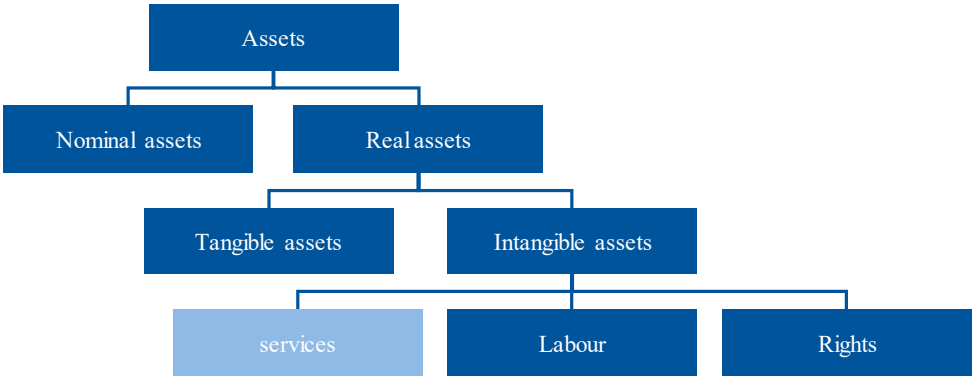

Figure 1: Classification of assets [8]

All services which are considered within this paper, require production and process data as a base for service execution. Depending on the offering portfolio of the machinery and plant manufacturing company, data-based services can be executed in a one-to-one relationship between the manufacturer and the applier, but as well with third parties as service providing companies.

The following chapter 2.1 describes the characteristics with an impact on the design of the Blockchain-based machinery and plant connection, for the differentiation of data-based services. In the chapter 2.2, different types are diverted.

2.1 Criteria for differentiating data-based services

In the following chapter, the characteristics and specifications for the differentiation of the service requirements are worked out. For the given research purpose, the high number of potential characteristics for the design of a Blockchain-based machinery and plant connection are reduced to those service characteristics, which are actually affecting technical properties. This restriction reduces the number of characteristics for differentiation to a total of five features in the context of Blockchain and three in terms of machinery and plant connection.

2.1.1 Characteristics of data-based services with an impact on the Blockchain

Transmission content – The kind of data necessary for executing service is a decisive factor for the implementation and can vary from simply event related notification to extensive control data sets. In the case of services with an extensive data analysis, large amounts of data are necessary for meaningful data analyses [9]. Nevertheless, since machines are generating several gigabytes of data per day, not all data can be shared in a network [10]. Due to this fact, only the data or information should be transferred, to keep the

necessary network traffic low. The unification for separating different quantity requirements is realized in event-related notification, protocols and data records up to extensive control data sets. Whereby a remote control of a machine requires full data records, for certain application only a data transmission in the event of an exceeded tolerance is sufficient.

Access rights (Reading right, writing right, identity assignability) – The specification of the service in terms of access rights require characteristics for the differentiation regarding reading rights, writing rights and the identity assignability. Last one describes the possibility, whether the identity of the stakeholder is publicly visible or anonymized/pseudonomized. The properties of the right to read and write are each subdivided into an approval or approval-free authorization right. This characteristic describes whether a third party may access the transaction and its content without prior clearance.

Latency tolerance – The latency tolerance describes the temporal offset of the information transfer from the time of creation to the arriving at the responding instance. The specifications vary from uncritical to real time. This characteristic is highly dependent on the degree of interaction which is required by the service. The implication of this characteristic is far-reaching for the design of the Blockchain, as the latency depends heavily on the respective consensus algorithm.

Plausibility check with context data – A technical opportunity which can be applied in dependence of the Blockchain realization, is the application of context data related plausibility checks. This characteristic is not a requirement originating from the data-based services, but might support services in their qualitative execution. Due to the historical immutable saving of information in the Blockchain, the service can relate to own historical data as well as external information. The benefit of using contextual data for avoiding wrong decision bases, can be specified into value adding and not value adding.

Smart Contracts – Another technical opportunity which is made available by the Blockchain are smart contracts. A smart contract is a software code, which represents a business logic and initiates automatically predefined actions between interacting parties. [11] Smart contracts are web-based computer protocols that map contracts and handle them automatically. Since the reason for service initiation as well as the scope are directly protocolled in the Blockchain, the application got useful aspects for numerous services. The specification of smart contracts are value adding or not value adding.

2.1.2 Characteristics of data-based services with an impact on machinery and plant connection

Direction of communication – For most data-based services, the communication direction from machine to network is sufficient, since the output of the service is physically disconnected. In this case, the data and information from the machinery or plant are applied as a decision base. Nevertheless for single services, a remote access is mandatory, which require access to actuators and corresponding control technology for by the service provider. [12,13]

Measurement principle – The measurement principle describes the information gathering during the user cycle, which can be specified into event-discrete, time-discrete or continuous. A continuous measurement process is created by an analogue signal, whereas a time-discrete measurement process measures values at regular time intervals. An event-discrete measurement only generates values when a certain event occurs, such as the exceeding of a threshold. [14] The measurement principle, which is related to the required kind of data of the service, restricts the range of possibilities in service execution.

Type of data – When designing a machinery and plant connection, it should be determined which data is required for the service and transmitted into the Blockchain. The possible data to be generated during the user cycle of the machinery or plant are process data (technical data as pressure, temperature or flow rate), machine data (Set-up times, production and downtimes, interruptions), order data (number of units or production times) or personnel data (hours worked and absences). [15]

2.2 Types of data-based services

The evaluation of system requirements regarding of specific use-cases, four types of data-based services are derived. Based on the differentiation characteristics of data-based services described above in combination with the concrete examples identified by secondary literature, the following types of data-based services are defined. These service types are used to derive requirements for the system design of the Blockchain and the machinery and plant connection. The described characteristics are found in the morphological boxes to describe the differentiations.

2.2.1 Type 1 – Event-discrete services

The first Type of services are the "event-discrete services", which describe services that only require a single information notification for initiation and are executed in an exclusively bilateral relation. Based on a predefined event-discrete trigger, as for example reaching a threshold, a specific mileage or operating hours, process or machine information gets transferred to the service executing party. Examples for this type of services are reactive maintenance, preventive maintenance and object self-service. Reactive maintenance provides the service of the machinery or plant after its failure, whereas for preventive maintenance, operating data is used for precautionary service offers [16,17]. Object self-service describes needs-based operating material provision. The scope and details of the service which gets executed, must be predefined in a service level agreement.

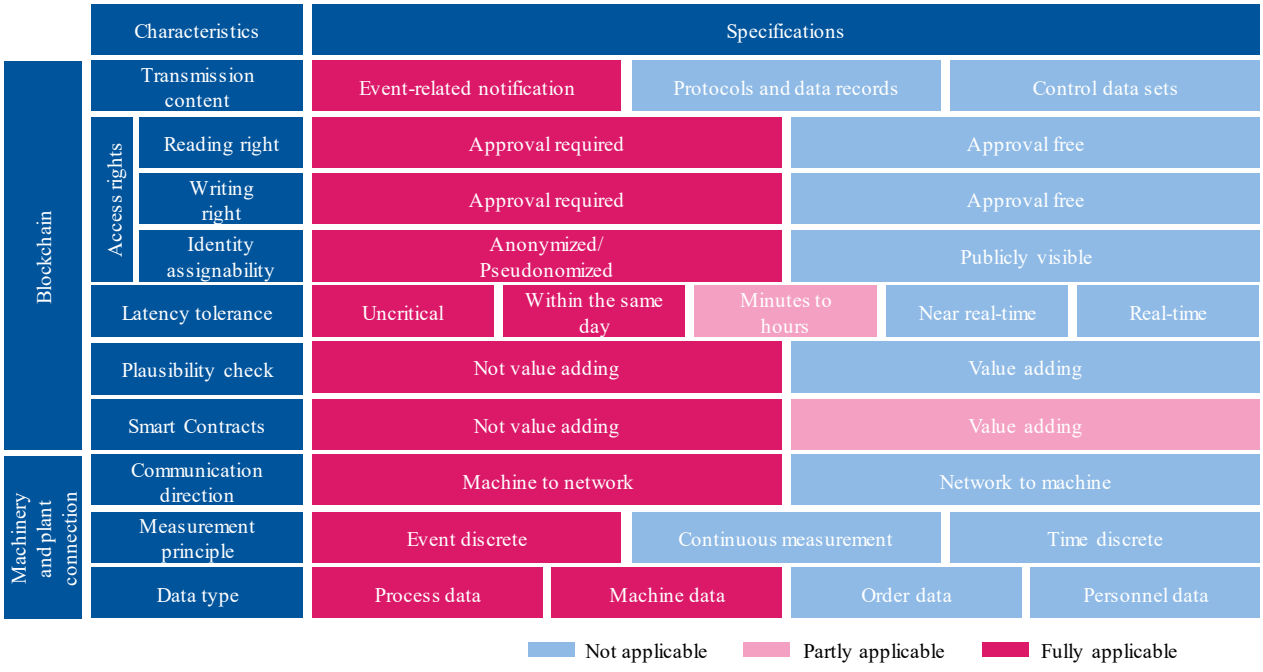

Figure 2: Characteristics of event-discrete-bilateral services

Due to the predefined service conditions, the unilateral information exchange is exclusively visible for the two parties. The access rights are approved in advance and pseudonyms ensure the secure information access. The latency tolerance of these services is tendentially uncritical, since these services are reactive and the service content is not time critical on real-time or near-real-time level. Since only an information notification is transferred, the data quantity is not sufficient for a plausibility check with external data. Even if the scope of services is predefined, the use of smart contracts may bring added value under certain circumstances.

2.2.2 Type 2 – Operating-data-based services

In comparison to the first type of services, the "operating-data-based services" found on the exchange of more detailed and extensive data as protocols and data records. The broader data can be used for analytical

purposes, where background information is required. Examples for services of this type are predictive maintenance, remote monitoring, data-based component and machine optimization as well as data-based production optimization. The access rights are similar to those from the first type of services, since the services require as well predefined agreements, which follow in a bilateral exclusively data and information exchange. The latency tolerance is still not in the real-time or near-real-time range, but the data transfer should take place within minutes to hours or within one day.

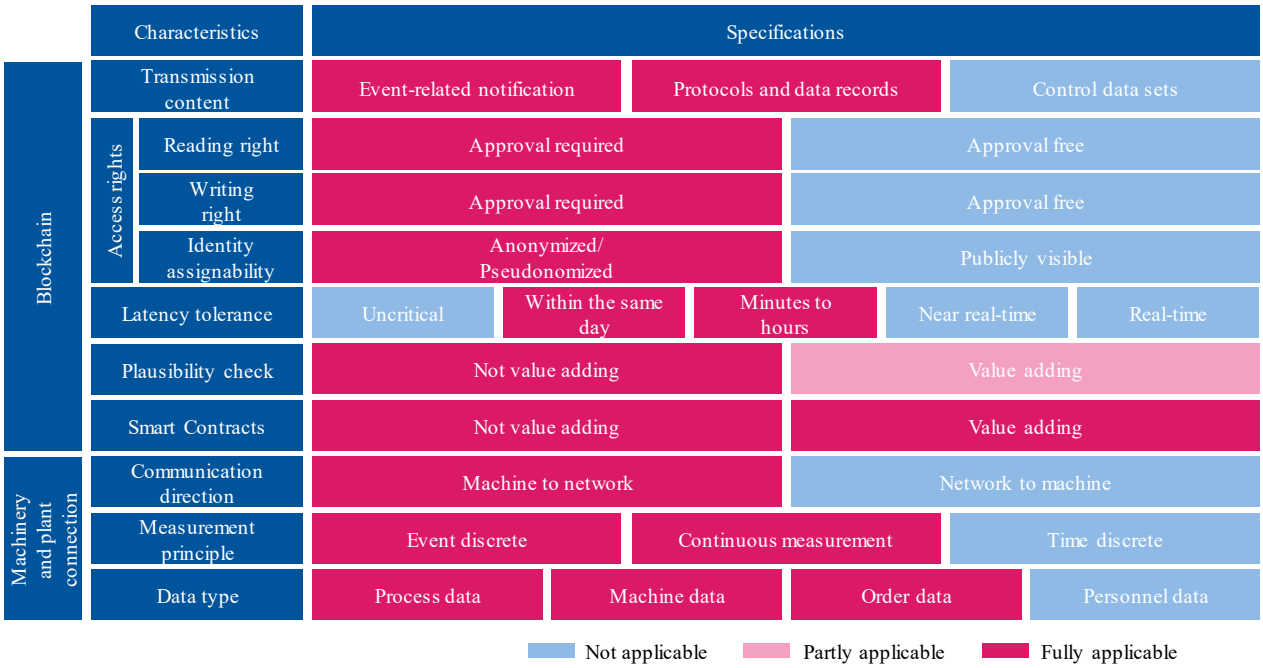

Figure 3: Characteristics of operating data-based bilateral services

For some data based services of this type as those with an optimizing purpose, the context based plausibility check can be applied beneficially, for taking external data as additional data bases. Since the scope and effects of these services are far-reaching, the use of Smart Contracts may also be effective, if automated actions are to be carried out. The communication direction is furthermore unilateral from the machine to the network, since the service content is independent from the operation of the machinery or plant. For some services, event discrete measurement principles are no longer sufficient, as continuous information and detailed historical process-data is necessary. Furthermore, a broader type of data is required to generate the intended value.

2.2.3 Type 3 – Bidirectional services

The third type of services are bidirectional services. These services are characterised by the direct remote access to the machinery or plant by the service provider, for generating added value from remote. Examples for services of this type are remote control and software activation. Remote control describes the functionality to take over the complete control sovereignty for e.g. maintenance work or machinery or plant adjustments. The service of software activation describes the functionality to activate software features and programs, as special manufacturing programs, even after the machinery or plant had been handed over.

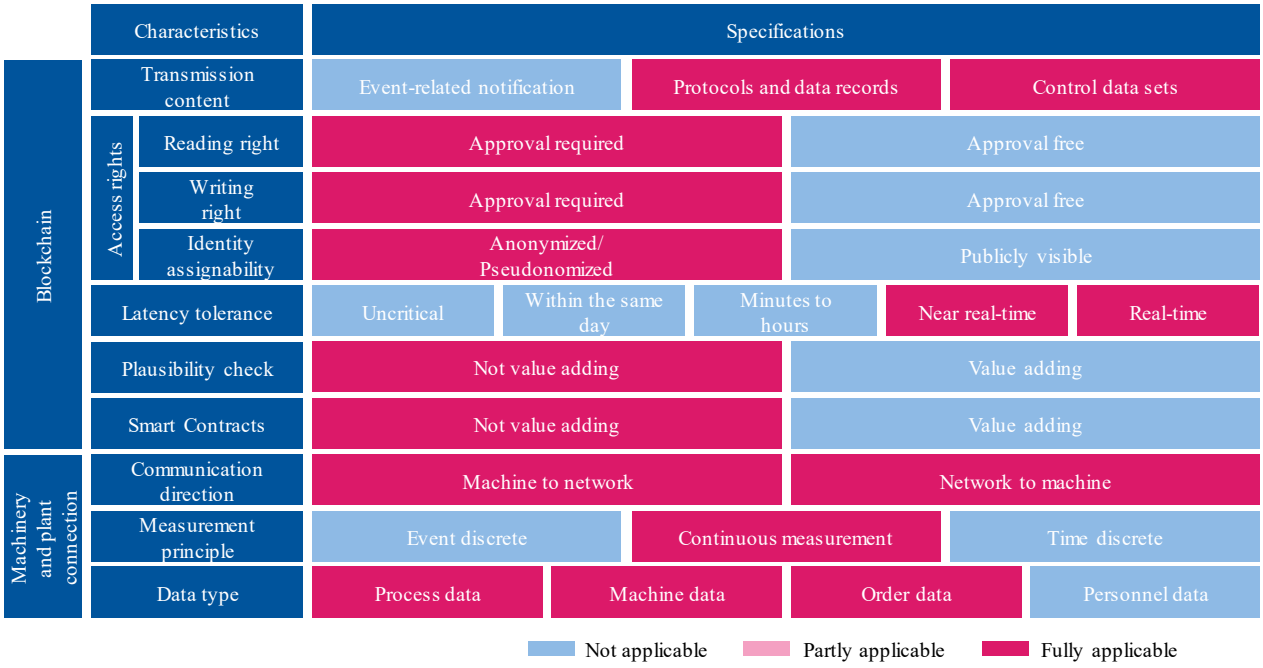

Figure 4: Characteristics of bidirectional services

Based on this functionality, more detailed data in the form of control data sets must be transferred to the value creating company. These services require near real-time to real-time data interchange with a very low latency tolerance and a continuous measurement of process and machine data. The communication direction is bidirectional with exclusive access and control rights. Smart contracts and plausibility checks are not value adding, since those services take place immediately.

2.2.4 Type 4 – Operating data marketplace

The fourth type of service is the operational data marketplace, which is a special case that differentiates fundamentally from the previous types. In this case, the interacting companies are not necessarily known in advance. The concept provides that companies offer their process or machine data unilateral on a marketplace, where third parties can buy them for data analysis without a direct interconnection to the providing company.

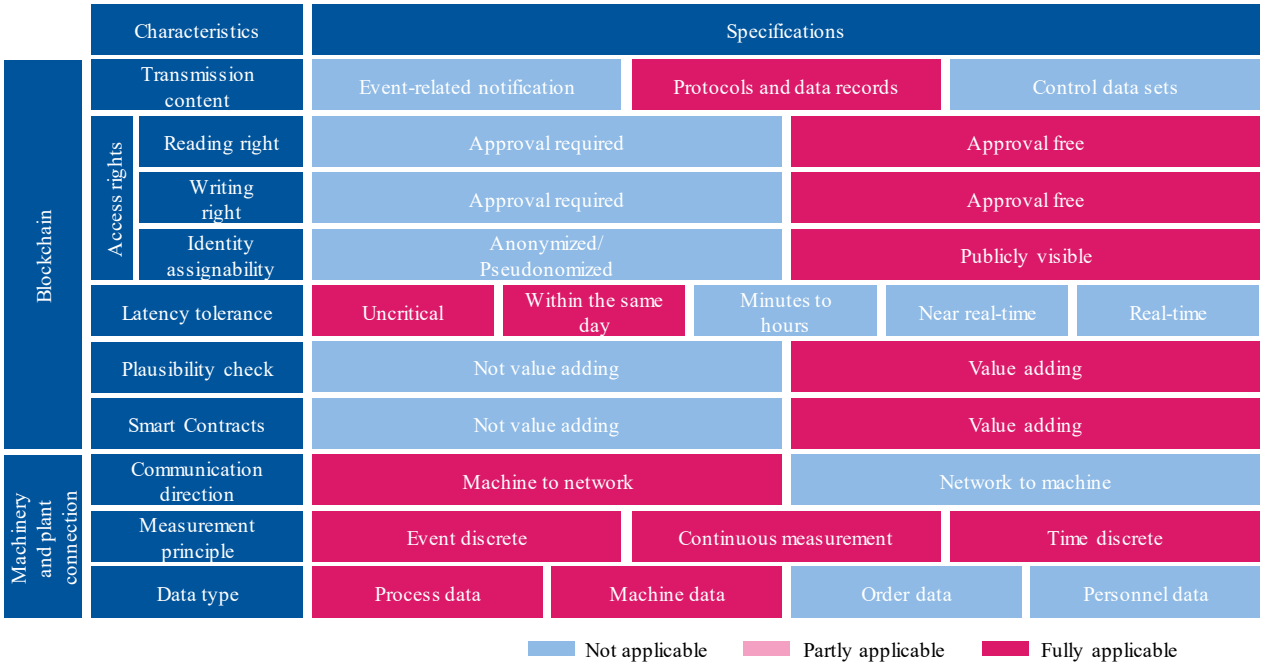

Figure 5: Characteristics of operational data market place

The required data is relevant in form of protocols and data records. Since the information and data must be accessible to every interested party, the rights must differ to those of the other services. The reading and writing right must be approval free and the identity behind the information must be shown publicly. The latency tolerance of the marketplace is rather uncritical. Plausibility checks with contextual information can validate the quality and content and raise the market value. The usage of smart contracts enable automated billing in case of access to the shared data.

3. Conclusion and Summary

Against the background of the growing digitalization and networking of machinery and plants, data-based services will play an increasingly important role for companies in the future. For the implementation of data-based services, a wide variety of prerequisites and requirements for a qualified design of the Blockchain-based machinery and plant infrastructure have to be met. In the present paper, a typology of data-based services regarding their technical requirements is carried out. The varying requirements between the different types of services show, that the technical realization needs a precise and qualified analysis of the service properties. Only by a detailed preliminary work and a Use-case specific consideration of the requirements, the fulfilment of the necessary specifications for an efficient system design is realizable. The elaborated analysis is now to be further concretized with regard to the effects on the actual design of the Blockchain-based machinery and plant connection.

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Biography

Themo Voswinckel, M.Sc. (*1992) is Project Manager and PhD-Candidate at the Institute for Industrial Management (FIR) at RWTH Aachen University. He works in the department of production management and is member of the task force ‘Blockchain for industrial applications’. In the context of his work, he is managing projects in the context of digitalized production and process management in research, consortia and consulting projects.

Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Günther Schuh (*1958) is the director of the Institute for Industrial Management (FIR) at RWTH Aachen University, holds the Chair for Production Systems at the WZL and is a member of the board of directors of the Fraunhofer Institute for Production Technology IPT in Aachen. He is the founder of Schuh & Co. Group as well as founder and CEO of e.GO Mobile AG in Aachen. Professor Schuh is a member of several supervisory boards and boards of directors.

Prof. Dr.-Ing. Volker Stich (*1954) is head of the Institute for Industrial Management (FIR) at the RWTH Aachen University since 1997. Prof. Dr.-Ing. Volker Stich worked for 10 years for the St. Gobain-Automotive Group and lead the management of European plant logistics. His research focuses on operations management, logistics and business applications systems.

Dr.-Ing Jan Reschke (*1984), studied industrial engineering at the RWTH Aachen University. Since 2012 he has been working as a research assistant at the RWTH Aachen and since 2015 as head of the production management department at the FIR. He is also head of the Enterprise Resource Planning Center.