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Potentials of the Asset Administration Shell of Industrie 4.0 for Service-Oriented Business Models

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Abstracts

The ongoing integration of information and network technologies into the production process leads to cyber-physical system (CPS), specifically designed for industrial purposes. CPS provide a bi-directional information flow between products, machines and top-floor systems, thus enabling the instant adaptation of each process to external and internal conditions. Thereby they offer a high potential to obtain flexible manufacturing systems for custom tailored products at the efficiency level of mass production. Furthermore the functionality and adaptability of future production systems can be considerably improved, thus accommodating service-oriented business concepts. These additional services often include remote accessibility of CPS for monitoring, diagnosis and control over existing networks. With those services the machine-availability can be significantly increased. Further services include data analytics, Internet market places and additional options to meet the customer demands.
For the realization of a consistent information flow, the interoperability between the different components has to be guaranteed. Therefore one important goal of current CPS-related research is to develop new standards and platforms for the network communication. To overcome this problem, the German high-tech strategy Industrie 4.0 aims at creating binding standards for the interfaces of all components. A major step towards the standardization was made by defining an administrative shell for each component, which is a framework for the middleware between the existing machines and external networks. This contribution offers an insight into the current developments of Industrie 4.0, focusing on the standardization of CPS, communication technologies and business models.

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Keywords: Industrie 4.0; cyber-physical systems; services; automation

1. Introduction

For many enterprises the globalization of the markets increases the competition while simultaneously offering great opportunities by raising the amount of potential customers. Furthermore the influence of new technical and social developments on a global market are distinctly higher, thus have to be considered in the product creation process. Low reaction times may cost profits or even make an entire product line obsolete. In the past years these developments have led to significantly reduced product life-cycles especially for consumer products. Consequently the whole product creation process had to be accelerated by reducing the development time and the time-to-volume [1, 2]. To persist on the market, it is necessary to meet increasing customer demands, which result in reduced lot sizes. This leads to a vast variation of each product line, thereby making it difficult to maintain a high level of automation with common technologies. Future production systems have to be significantly flexible and dynamically respond to continuously changing orders while assuring a high time-to-volume [1]. This adaptation process has to be fully automated to maintain considerable efficiency levels. Therefore it is necessary not only to include the specifications of each order, but the status of all production components and even external information such as transportation systems into the decision-making process [3].

Those features can be achieved with the integration of advanced information and communication technologies into the production process, which allow for capabilities highly exceeding current embedded systems. The integration of

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computers into physical processes are leading to cyber-physical systems (CPS) [1]. More available network technologies and sinking prices for the hardware are massively supplying the extensive usage of CPS for industrial purposes. The main feature of CPS is their ability to identify, evaluate and process complex information and use the results to adapt its operation to the current situation [4]. These capabilities combined with the ability to communicate with other CPS lead to a huge potential for self-optimizing and self-managing production systems. In particular they are interconnected and thus can use all available information provided by the surrounding components. The interoperability makes CPS ideal to meet the requirements for future production systems.

2. Cyber-Physical Systems

Every CPS has to provide a minimum amount of information to identify itself, thereby gaining a digital representation (DR). But it can be more beneficial to include all available information of the physical system into the DR, thus being able to accumulate a digital twin of the component.

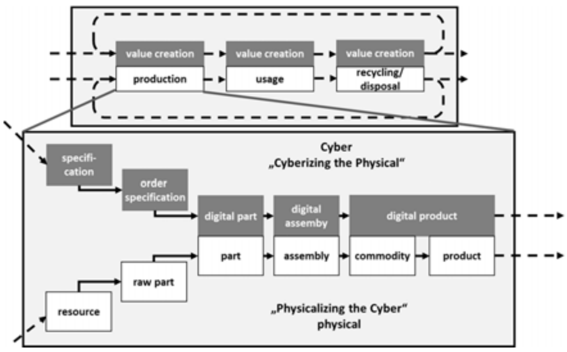

Fig. 1. The digital twin contains data of every step in the product life-cycle [4].

This data can contain information about the different steps of the product life-cycle. Information from the development process can be used to understand the design of the CPS, while information about the production step can be relevant for future optimization or quality management. Additional information can be gathered from the product usage step. Depending on the use case, the physical system either carries the entire information or can reference it on external systems. In combination with network technologies the huge potential of CPS in the production process becomes apparent. CPS can communicate with each other, determine their status, purpose, operation history and functionality. This information can be used to adapt and control subsequent processes.

2.1. Communication Requirements

The main challenge for a CPS-based production system is the immense variety of vendor-specific designs, interfaces and standards, thereby making interconnectivity very difficult. Therefore, a key requirement is to enable interoperability between components, which were previously acting as isolated systems [1]. Both the horizontal and the vertical integration of CPS into the production process have to be far more flexible than current standards allow for [5]. An effortless configuration of the network participants is important to enable a decentralized structure of the production systems. The authentication and integration process of additional CPS into the network system has to be automated. Therefore it is essential to use highly standardized network technologies and a common syntax. While there are numerous industrial interface standards, the communication between CPS should be service-oriented and use common http-based paradigms such as SOAP or REST [6, 7]. This is particularly important for the vertical communication, for instance between shop-floor machines and servers on the management level. These two paradigms entail several characteristics, which have to be considered for the implementation:

- By using SOAP or Rest, it is not necessary to define the metadata for the usage of the functionality. WSDL and WADL are standardized formats describing the necessary parameters to invoke functions and are designed for automated processes.
- The http-protocol is designed for server-client systems. The client has to initiate the communication while the server responds. For industrial components it has to be determined, which CPS are clients, server or both.
- Most routers by default are forwarding http-request from the internal to the external network. Thereby, if an internal CPS initiates requests, a configuration of the network is not necessary.
- Most of the Internet Communication is based on http. Thereby the communication between CPS and existing servers can be realized with little effort.
- Mobile devices such as smartphones and notebooks can be used to access the CPS solely via web-browser, thus no additional or vendor-specific software is needed.
- Every http request and response has to be particularly programmed and defined, thus each manufacturer of a CPS can determine specific interfaces for the communication.

The main disadvantage of a http-based communication is a high overload, which can be a challenge for CPS with low resources and time-critical functions. If necessary, CPS can be designed with additional interfaces for virtual private networks (VPN) or secure shell (SSH), which might provide more performance for specific use cases.

2.2. Security Requirements

The interoperability between different systems has a huge potential for new products and business models, but the application of connected devices can increase security risks. Considering the differences between common computer systems and industrial CPS, the relevance of security threats becomes more apparent. First the operation requirements for industrial components are very high. Small disturbances of the process can lead to significant failures. Therefore the error tolerance is low. Furthermore, the computation power of some CPS might be very low, which can lead to denial-of-service attacks and obstruct security software. In addition, the life-cycle