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Manufacturing service bus: an implementation

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Abstract

We present the concept and implementation of a Manufacturing Service Bus (MSB, an application and adaptation of the service bus principle of the general IT domain to meet the more specific communication and integration requirements of manufacturing industry scenarios. The Manufacturing Service Bus is the communication middleware component of the Virtual Fort Knox (VFK), a federative cloud platform for manufacturing companies. Key requirement of VFK is the security of the component which is realized through security by design including encryption, authentication and authorization. The flexibility of the system is reached by providing numerous interfaces to existing communication protocols and the expandability with additional interfaces to upcoming communication protocols.

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Keywords: Integration; Service-oriented architecture; Industrie 4.0; Manufacturing service bus

1. Motivation

During the operational phase of a production plant all information regarding the (quality) condition of the manufacturing equipment as well as its performance monitoring is distributed throughout many information systems and interfaces. These information systems can be allocated to different layers or levels of a production company respectively: Manufacturing Execution Systems (MES) for manufacturing process control and systems for management tasks like enterprise resource planning (ERP), warehouse management (WMS) or product lifecycle management (PLM) and others depending on the area of application and the planning horizon [1, 2]. Large companies usually utilize a much larger number of complex IT-supported tools for the optimization of their products and processes than small and medium sized enterprises (SMEs). Such behavior has direct implications on the availability of digital information, which can be used to optimize the planning of processes and additional measures. Especially SMEs often face challenges in making this data and information available, which leads to substantial waste of potential [3, 2]. One of the main reasons for this is a lack in integration of the big number of diverse IT-Systems, digital tools and equipment. Another cause for this is the use of „historically grown" complex monolithic systems, which are nowadays often used in manufacturing. These systems are either very limited in their functionality or far too complex but only a subset of their functionality is actually used based on the specific requirements of the respective company which is utilizing them.

Because of this the trend is towards the use of applications, which are based on modern service-oriented architectures (SOA). One the benefits of this architectural approach is that applications can be provided on premise by the companies themselves, as well as a service based remote solution over the internet in the form of a Software-as-a-Service (SaaS) applications from the cloud. This architectural paradigm builds the premise that a system's components are separated into self-contained services. These services can be flexibly connected and orchestrated while they are communicating through their well-defined interfaces which can be loosely coupled and used to exchange messages with each other [24]. Next to the virtualization aspects SOA and web services therefore can be seen as the fundamental building blocks of cloud computing.

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One closely related and very important topic is the so called Internet of Things (IoT). This term has generally two meanings: The IoT-paradigm and the IoT-Network. The first meaning encapsulates the vision of the merging of the digital and physical world into an indiscernible unit. The second meaning refers to the to a global Network, which is an physical extension of the internet as it's known to us and which encompasses new types of smart respectively intelligent devices [4]. These smart devices, often called smart objects, are capable to identify themselves and offer some sort of self-description. Moreover they have profound sensory and actuatorial capabilities [5]. The various fields of application of Machine-to-Machine (M2M) applications are experiencing a strong growth which is expected to accelerate over the next few years. The reason for this is not only the utilization of IoT in consumer electronics, health care, smart homes and buildings, smart cities, but especially the „smartification" of production equipment in large industries like the automotive industry [6].

To enable companies to harness the potentials regarding increased flexibility of the IT-systems landscape and consistent availability of data, which have been mentioned in the previous section, a communications platform is required, which encompasses all the listed developments and provides a common technological basis. A platform like this should enable fast, inexpensive and low-risk provision of secure, agile and customer-specific IT-solutions by means of highly automated integration functionality. Independent service vendors (ISVs) have to be put in a position to create novel services and business models in the area of production IT, both in regards to functionality and accounting models. For this the platform has to support ISVs in all phases of a service life cycle with business process development, consulting, frameworks and basic functionality in the form of base services. This will lead to ISVs being able to provide more and more specialized microservices, which fulfill specific tasks. Customers and end users can pick and choose the best fitting services respectively functionality and combine them flexibly with each other, to combine them into the optimal solution for their requirements. This solution can then be provided from the platform inexpensively, fast and without any major risk, because it can be based on a flexible subscription or pay per use model. An approach like this vastly reduces the cost for implementation, integration and operating of such IT solutions. New software functionality for end customers can be provided quicker and at lower cost [7]. The usual high investment cost can be transformed into variable cost which is directly dependent on the actual demand and consumption of the service. Moreover customers need to be able to integrate their production equipment with the platform to provide the data from their systems to the data-driven services of the platform to generate information and value from them. Integration is still one of the biggest challenge for production IT because of the lack of interoperability. To provide a possible solution for this challenge a problem solving approach for interoperability and interface compatibility between such a platform and shop floor systems and equipment is needed.

2. State of the art

Software systems, whose main purpose it is to integrate other software systems and components with each other, are generally referred to as middleware, sometimes also integration middleware [8]. These systems often offer services for communication, integration application execution, monitoring and operation. The main intent of middleware is it to make development of applications easier by offering common abstractions which add an abstraction layer to hide the heterogeneity of the available interfaces [9].

Normally middleware can be classified by its domain or area of application, which is cloud integration, business process integration, application integration and data integration. Cloud integration middleware is used to integrate cloud services, cloud applications and mobile applications, cloud infrastructures and other cloud resources [10]. Middleware for integration of business processes aims at the integration of applications of customers, providers and business partners, which offer various interfaces but need to be used in common business processes and exchange data and information between each other [11]. Application middleware is often used to integrate the on-premise software solutions in companies as they are nowadays still broadly used with each other, or, as the trend has been showing for some time now, with applications in private or public cloud infrastructures [12]. Data integration middleware mainly integrates a number of data sources and sinks, which in enterprises can be databases or information systems [13]. As examples for applications classic database systems, Distributed Computing Environments (DCE) and Remote Procedure Call Systems (RPC), an industry standard which has been widely established since the 90s [14], can be named. The use of so called Enterprise Service Bus Systems (ESB) in companies mainly serves the integration of distributed systems in the application environment of a company [15].

The arrival of Internet of Things technologies in production as part of Industrie 4.0 [16] has opened up new possibilities, but also has led to new challenges. Newer machines have been equipped with communication technology, which allows them to provide data and information comparably easy and transfer it via standardized protocols like OPC UA. Older machines and legacy systems rarely have the ability to either directly communicate or make their data available. Often the integration of production equipment isn't a matter of feasibility, but a question of practicability and profitability. The point of an actual non existing Industrie 4.0 standard (the fourth stage of industrialization) suggests that the complexity of the integration with the increasing number of smart objects continues or increases. Another challenge is the increasing complexity of managing the increasing number of networked smart objects. Here the concept of a Manufacturing Service Bus (MSB) can offer a solution.