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OPC UA & Industrie 4.0 - enabling technology with high diversity and variability

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Abstract

Industrie 4.0 demands flexibility, adaptability, transparency and many more requirements which have to be fulfilled by Industrie 4.0 components or systems in order to achieve horizontal and vertical interoperability as well as interoperability over the lifecycle.
The present paper describes different scenarios and deployed use cases, which are all based on the OPC Unified Architecture (OPC UA), to state the role of OPC UA as enabling technology for flexible, adaptive, and transparent production.
Nevertheless, the scenarios, based on different methods, architectural approaches, hardware and software, are located in different application domains, and cover different parts of the OPC UA standard series. The application domains include quality defect tracking, monitoring and control, and code analysis.

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Keywords: OPC UA; data; information; semantics; flexibility; adaptability; transparency

1. Introduction

Industrie 4.0 demands flexibility, adaptability, transparency and many more requirements which have to be fulfilled by Industrie 4.0 components or systems (see also [1]). The implementation strategy (Umsetzungsstrategie, April 2015) of the German Initiative Industrie 4.0 names several existing and usable approaches or technologies for individual aspects which are candidates for Industrie 4.0 standards. Due to the complexity of Industrie 4.0, there is no single standard (series), but the need to integrate and combine different standards from different domains which cover different aspects. OPC UA [2] was named as a good prospect for the communication aspect. The variability and flexibility of OPC UA ranges from simple process data acquisition to complex monitoring, control, and analysis. It covers security aspects and provides the ability to represent and cover semantics by its information model. Additionally, OPC UA is explicitly open for the integration and combination with other standards based on so called companion specifications. The number of collaborations between the OPC Foundation and other organizations grows, which focus on creating various companion specifications. These companion specifications range from general device descriptions (OPC UA for devices) and analyzer device models (ADI) over plant descriptions in AutomationML (AML for OPC UA) to the implementation of IEC PLCOpen programming models in OPC UA servers (OPC UA for IEC 61131-3).

The VDI (German Association of Engineers) GMA Committee 7.21 'Industrie 4.0' sub group 'terms' defines basic terms and definition for Industrie 4.0 under the lead of the Fraunhofer IOSB (see [3]). According to this definition, a CPPS (cyber-physical production system) is a CPS (cyber-physical system) which is used in the production. CPS is defined as system which connects real (physical) objects and processes with information processing (virtual) objects and processes via information networks which are open, partially global, and at any time connected. Optionally a CPS uses local or distant services, possesses man-machine interfaces and supports the dynamical adaption of the system during

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runtime. To meet the defined requirements, the CPS must come with self-x properties. The components of the system therefore:

- must be able to communicate via networks and be aware of their communication partners (self-organization, context awareness),
- must possess a self-description (self-explaining) and protect this information in an adequate way (self-protection),
- must be able to configure and optimize themselves based on their available information (self-configuration, self-optimization, self-healing)

To this end semantic technologies are needed to realize building blocks for reaching this goal, which contribute to the specification of a Reference Model for Industry 4.0 System Architectures [4]. The Reference Architecture Model Industrie 4.0 (RAMI4.0, [5]) was published in 2015 and describes a possible general reference architecture for Industrie 4.0 components and Industrie 4.0 systems which can consist of CPS.

2. OPC UA in Cyber-Physical Production Systems (CPPS)

Even though OPC UA is mostly used in higher automation levels for the purpose of monitoring and control, it also increases device connectivity via standard communication in lower automation levels [6]. Therefore, OPC UA was named as candidate for communication aspects in RAMI4.0. The OPC-UA approach abstracts data from the network technology and software application, and offers a generic communication interface. It can be seen as one of the key technology for a transparent data representation/ transmission between heterogeneous system components [7].

But OPC UA does not only deal with simple data access, but also with a wide range of other aspects e.g. security, reliability, access control, alarming, or historical data. This contribution shows some possible building blocks which can be realized by means of OPC UA and which are listed in the following:

- **Separation of information model and data base structure:** hiding hierarchical data base structures behind object-oriented, full-meshed information models in OPC UA to be independent of the fixed structure of the data base.
- **Minimal OPC UA client functionality:** implementing base OPC UA client functionality for applications to hide OPC UA from developers
- **Graphical information model definition:** developing OPC UA servers together with end users (or a system integrator) based on graphical representation of OPC UA models (see [8])
- **Common info view:** data acquisition by means of OPC UA (e.g. with additional Raspberry Pi) e.g. for a management view which is accessible from different sources e.g. web interfaces, and which runs in parallel to the real-time communication
- **Aggregating OPC UA server functionality:** OPC UA server which integrates and combines different underlying servers and their information (see [9])
- **AutomationML or other description model as base/data source:** usage of external descriptions as base/data source for information models in OPC UA or for the automatic generation of process visualization with OPC UA connection to the production process (see [10, 11, 12])

To relate those building blocks to RAMI4.0, they can be assigned to the interoperability layers/dimension which are represented on the vertical axis. The listed building blocks of this contribution focus on integration, communication and mainly information layer in RAMI4.0 [5], see Fig. 1.

Today, the common information view is the most frequently used application of OPC UA in the industrial context which can be seen as 'door-opener' or starting point for future applications. This is why this building block is also present in all of the scenarios described in the following.

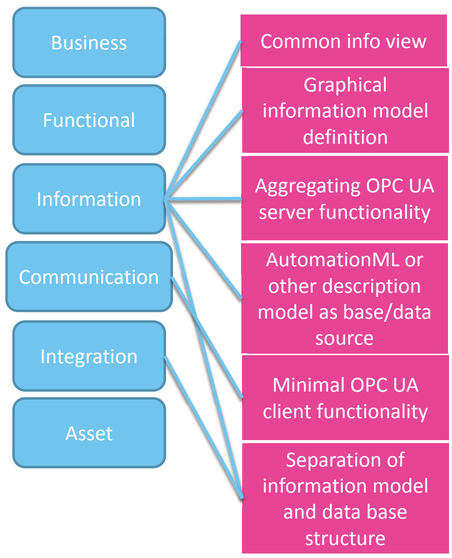

Fig. 1. Relation of OPC UA building blocks (on the right) to interoperability layers of RAMI4.0 [5] (on the left).

3. Application scenarios of OPC UA

Four different application scenarios will be described, which were designed for and realized with OPC UA and which make use of the listed building blocks. Other applications can be found e.g. in [13].