

AutomationML, OPC UA, and the Asset Administration Shell of Industrie 4.0 Components

MOTIVATION

The 'Industrie 4.0 component' and its services, as well as the corresponding administration shell including component manager and manifest (see definitions for details) must be 'somehow' realized (see also [Basys], [I40realize]). The obvious way is to apply already existing standards of the automation domain. The diversity of exactly these standards is an existing challenge especially of small and medium-sized enterprises which should definitively be simplified. Harmonization of multiple existing standards instead of creating new ones for Industrie 4.0 is the logical consequence. Thus, standards which are open for such a harmonization are preferred.

SOLUTION FOR INTEROPERABILITY

Pure OPC UA communication is not enough to realize Industrie 4.0 components and their interfaces and services. A meta model which explicitly defines the data content to exchange is necessary. OPC UA provides a framework for the description of such meta models as basis for the companion specifications, but does not define the content of the meta model. AutomationML is one example for such a companion specification (focusing on engineering of automation systems), but it can be combined with other companion specifications to integrate knowledge and semantics of multiple domains. Thus, one possible solution for the I4.0 component and its asset administration shell is a technology combination of OPC UA (IEC 62541) and AutomationML (IEC 62714) which is depicted in Figure 1.

AutomationML describes which data and information is exchanged while OPC UA determines how the exchange of data and information takes place. Thus, AutomationML can be classed as standard on information layer of the RAMI 4.0 [RAMI4.0], while OPC UA can be classed as standard on communication (and information) layer of the RAMI4.0 (see Figure 1). The combination of both standards is described in the OPC UA Companion Specification „AutomationML for OPC UA“ [AMLUA]. It describes rules how to transform AutomationML models into OPC UA information models. The DIN SPEC 16592 [DINSPEC] bases on this companion specification. It details and extends the existing transformation rules. Furthermore it describes possible use cases for the combination of AutomationML and OPC UA and shows how to integrate further standards, e.g. CANopen and STEP.

AutomationML is explicitly open for the integration of other existing XML standards/models. Especially for assembled components and intelligent production systems [ZVEI] this fact can be very useful. An example of an Industrie 4.0 component which includes other Industrie 4.0 components and their descriptions is illustrated in Figure 2 by machine tool and its components.



<AutomationML/>
The Glue for Seamless
Automation Engineering

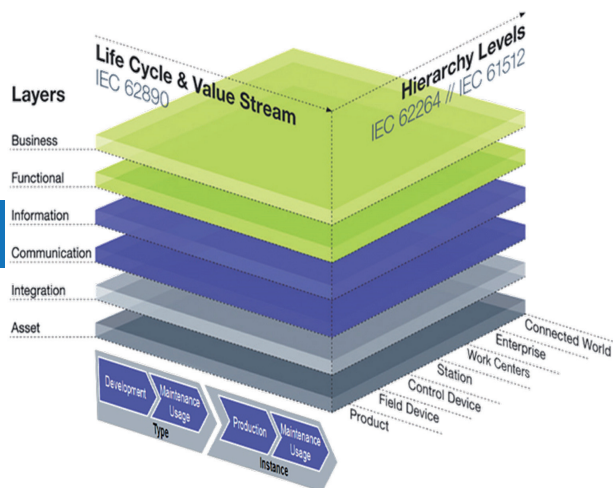


Figure 1: AutomationML and OPC UA in RAMI 4.0

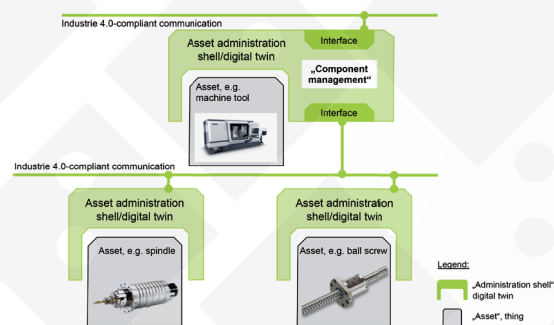


Figure 2: Machine tool and its components

OPC UA deals with access and information management, e.g. with aggregating servers and underlying OPC UA or other communication servers for data access. Within the administration shell, OPC UA is able to realize all accessible services of the component manager by means of basic services of OPC UA or specific OPC UA methods (see [I40service] and Figure 3).

AutomationML can describe the content and is able to decompose data and to reference internal and external sub models (see Figure 3). Examples for the external link to other information models are ISA95, eCl@ss properties, or PDF files. AutomationML references these external and internal models based on a plugin pattern. There are defined interfaces as references to link in numerous extensions without knowing their exact content and rules. In this context, the AutomationML e.V. and its community provides an application recommendation for automation project configuration [AMLAPLC]. Currently its members define the modelling of automation components based on a template that covers various typical aspects of a component as part of bigger systems. This information is an example of a sub model requested for the administration shell for Industrie 4.0 components. Currently, it is still open whether to use AutomationML for the realization of the manifest of the administration shell for an Industrie 4.0 component or the virtual representation of the assets in detail (see Figure 3).

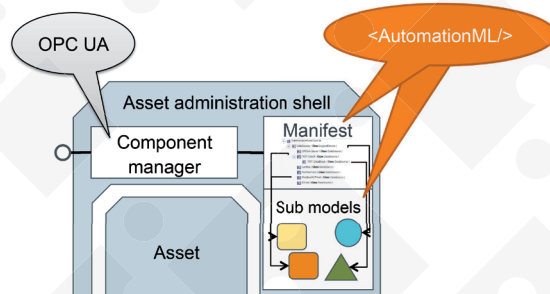


Figure 3: Localization of OPC UA and AutomationML in the Industrie 4.0 component administration shell.

The advantage of using AutomationML is to continue working during runtime with the models coming from the engineering process and its tools. Thus, AutomationML closes the loop between engineering and runtime keeping the information pool up-to-date. A future online re-engineering is simplified. System integrators dealing with components to be assembled and integrated to intelligent manufacturing lines are more comfortable with generic AutomationML models in their engineering tool suite than with proprietary/user-specific OPC UA information models. They would have to adapt these during runtime for each customer. For example, version and configuration management are much easier to realize based on a meta data format such as AutomationML.

In conclusion, the combination of AutomationML and OPC UA is capable of fulfilling the requirements of the asset administration shell, its component management and the Industrie 4.0-compliant communication!

Definitions

According to I40Terms an Industrie 4.0 component is “a globally uniquely identifiable participant with communication capability consisting of administration shell and asset within an I4.0 system which there offers services with defined QoS (quality of service) characteristics” [I40Terms].

The administration shell is a “virtual digital and active representation of an I4.0 component in the I4.0 system” and “contains the manifest and the component manager” [I40Terms].

The manifest is an “externally accessible defined set of meta-information, which provides information about the functional and non-functional properties of the I4.0 component” [I40Terms]; the component manager is an “organizer of self-management and of access to the resources of the I4.0 component, for example, I4.0 component, item, technical functionality, virtual representation” [I40Terms].

The definition of the RAMI 4.0 states about I4.0 components that “an important part of the virtual representation is the ‘manifest’ ... which can be regarded as a directory of the individual data contents of the virtual representation. It therefore contains what is termed meta-information. Furthermore it contains obligatory data on the I4.0 component, used among other purposes for connection with the object by providing for the corresponding identification” [RAMI4.0].

Literature

- [I40Terms] Industrie 4.0 Begriffe/Terms. VDI status report Industrie 4.0, https://www.vdi.de/fileadmin/vdi_de/redakteur_dateien/gma_dateien/7153_PUB_GMA_-_Industrie_4.0_Begriffe-Terms_-_VDI-Statusreport_Internet.pdf. April 2017.
- [AMLUA] Companion Specification “AutomationML for OPC UA”, <https://opcfoundation.org/developer-tools/specifications-unified-architecture/opc-unified-architecture-for-automationml/>, February 2016
- [DINSPEC] DIN SPEC 16592 “Combining AML and OPC Unified Architecture”, <https://www.beuth.de/de/technische-regel/din-spec-16592/265597431>, December 2016.
- [I40realize] Arndt Lüder, Miriam Schleipen, Nicole Schmidt, Julius Pfommer, Robert Henßen: One step towards an Industry 4.0 component. 13th Conference on Automation Science and Engineering (CASE 2017), Xi’an, China, August 20-23, 2017.
- [Basys] Drath, Rainer; Malakuti, Somayeh; Grüner, Sten; Grothoff, Julian Alexander; Wagner, Constantin August; Epple, Ulrich; Hoffmeister, Michael; Zimmermann, Patrick: Die Rolle der Industrie 4.0 „Verwaltungsschale“ und des „digitalen Zwilling“ im Lebenszyklus einer Anlage. In: VDI/VDE-Gesellschaft Meß- und Automatisierungstechnik -GMA-, Düsseldorf: Automation 2017. Technology networks processes : 18. Leitkongress der Mess- und Automatisierungstechnik; Kongresshaus Baden-Baden, 27. und 28. Juni 2017. Düsseldorf: VDI-Verlag, 2017 (VDI-Berichte 2293), ISBN: 978-3-18-092293-5
- [RAMI4.0] DIN SPEC 91345, Referenzarchitekturmodell Industrie 4.0 (RAMI4.0), <https://www.beuth.de/de/technische-regel/din-spec-91345/250940128>, April 2016.
- [I40service] Industrie 4.0 Service Architecture - Basic concepts for interoperability. VDI status report Industrie 4.0. <https://www.vdi.de/index.php?id=58664&pubid=48>, November 2016.
- [ZVEI] Beziehungen zwischen I4.0-Komponenten – Verbundkomponenten und intelligente Produktion Fortentwicklung des Referenzmodells für die Industrie 4.0-Komponente, SG Modelle und Standards, ZVEI, 2017.
- [AMLAPC] AutomationML e.V.: Application Recommendation « Automation Project Configuration », https://www.automationml.org/o.red/uploads/dateien/1494835012-AR_001E_Automation_Project_Configuration_V1.0.0.zip.