OMG Event “Model Based Engineering, Automation and IoT in Smart Manufacturing”

AutomationML - Industrie 4.0 Candidate Standard for Asset Model Engineering and Plug & Work

Dr. Kym Watson (Fraunhofer IOSB)

Burlingame, December 6, 2017
Engagement of Fraunhofer IOSB in the Industrial Internet

CAEX (IEC 62424) as umbrella format

CIRP, contribution to STC-O

Contribution to UMCM working group

Head of thematic group „IT in der GPP“
FA Digitale Fabrik
FA 5.15 „Agentensysteme“
FA 5.23 „XML in der Automation“
FA 6.12 „Durchgängiges Engineering von Leitsystemen“
FA 7.21 „Industrie 4.0“
FA 140 „MES“
FA 146 „MES-AG 2 Energiemanagement mit MES“
VDI-GPL - Fachbereich A5 „Modellierung und Simulation“

NA 060-30-05-04 (committee mechanical engineering, NAM)

OPC UA is international standard
IEC 62541

Member of Industrie 4.0 working groups of VDI and the Platform I4.0

Model factories in Karlsruhe and Lemgo

IOSB is one of the awarded locations of Industrie 4.0 in Baden-Württemberg

IIC Testbed with KETI (South Korea);
Testbed + Smart factory working groups

Working group 9 of SC 65E AutomationML

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Industrie 4.0 and IIC  (Quelle: Plattform Industrie 4.0)
IIC Industrial Internet Reference Architecture (IIRA)

Figure 3-4: Industrial Internet Architecture Viewpoints

Source: IIC, http://www.iiconsortium.org/IIRA.htm
Reference architecture model Industrie 4.0 (RAMI 4.0)

Source: Plattform Industrie 4.0 and ZVEI

Source: BMWi, Structure of the Administration Shell
Application Example

Smart Factory Web Testbed

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Smart Factory Web: Goals

- Flexible adaptation of production capabilities and sharing of resources/assets in a web of Smart Factories to improve order fulfillment
- Provide the technical basis for new business models with flexible assignment of production resources across factory locations
- Factory-to-factory interoperability with the industrial standards OPC UA and AutomationML
- Enable cross-site usage scenarios with secure Plug & Work functions and data analytics
Usage Scenario and View: Order driven, flexible adaption of production value chain

**Factory A**
- Check the status of other factories
- Find an available Factory B
- Place an order via the SFW portal

**Factory B**
- Check its production status
- Adapt production assets of Factory B by secure Plug & Work techniques *(replace AS 2 and 3&4 with AS 2’ and AS 3’)*
- Factory B starts to produce products

**Smart Factory Web Portal**

**Factory B Production line**

* AS: Assets (e.g. robots, machines....)

* Conveyer System

**Factory A**

**Factory B**

I need more production lines since my factory is running at full capacity with customer orders
Towards a Marketplace for Manufacturing

- search for capabilities and assets
- matchmaking and mediation
- registration of capabilities and assets
- secure plug & work of assets → adaptable production

Customer requests:

- new business models
- manufacturing as a service
- immediate visibility on a global market

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Today’s problem for IIoT: semantic interoperability

Cloud storage & analytics
Visualization
Monitoring & Control

Image sources (left to right): MOC Danner, KUKA, MAG, Schunk
Standards applied in Smart Factory Web: Integration of AutomationML and OPC UA

- Generation of OPC UA server from AutomationML
- Exchange of AutomationML models via OPC UA

Benefit: simplified creation of information models in AutomationML and OPC UA

Communication including security

- IEC 62541
- Companion Specification “OPC Unified Architecture for AutomationML”
- DIN SPEC 16592

Semantic description of assets
Integration of AutomationML and OPC UA for Plug&Work

Image Source:
OPC Day Europe, Mathias Damm, 2013
Relation to RAMI4.0

Reference architecture model Industrie 4.0 (RAMI 4.0)

Source: Plattform Industrie 4.0 and ZVEI

Source: BMWi, Structure of the Administration Shell
Relation to I4.0 Component

Offline
- Planning
- Structure, topology
- Connections
- Static view

AutomationML

Online
- Actual values
- Processes
- Dynamic view

OPC UA

Source: BMWi, Structure of the Administration Shell
Relation to IIC Connectivity Framework

Figure 2-2: The focus of this document is on connectivity layers above the network layer, namely the connectivity transport and the connectivity framework layers.

Source: IIC Connectivity Framework
AutomationML: an IEC Standard

- Open, vendor independent, XML-based data format for storage and exchange of plant engineering information
- Goal: Interconnect engineering tools of different disciplines in a heterogeneous tool landscape
CAEX Element

- Concrete instances, real or logical elements
- Arbitrarily scalable: company, site, plant, cell, machine, sensor, screw, ...
- Level of detail depending on engineering phase
External Interfaces of CAEX Elements

- Interface to interlink objects
- Interface to other documents
- Connections between interfaces

Collada
PLCopen
XML
RoleClass of CAEX Elements

- Semantic definition of objects
- Object oriented modeling
- In Smart Factory Web: Capability description of assets based on an ontology
Capability description of assets

Describing HOW (process view) and / or WHAT (product view)

Each Entity has labels in different languages
Example Asset: Manual Assembly Table with M2-Assist

**CAPABILITIES**

**Manual Visual Inspection**

<table>
<thead>
<tr>
<th>Material</th>
<th>Processing Speed</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td><strong>Material</strong></td>
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<tr>
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</tr>
<tr>
<td>MaxValue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value</td>
<td><em>metal parts</em></td>
<td></td>
</tr>
<tr>
<td>Unit of Measure</td>
<td></td>
<td></td>
</tr>
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</table>

**Water Pump Assembly**

<table>
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<tr>
<th>Processing Speed</th>
<th>Product</th>
<th>Size</th>
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</thead>
<tbody>
<tr>
<td>Name</td>
<td><strong>Product</strong></td>
<td></td>
</tr>
<tr>
<td>minValue</td>
<td></td>
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</tr>
<tr>
<td>MaxValue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value</td>
<td><em>Water Pump</em></td>
<td></td>
</tr>
<tr>
<td>Unit of Measure</td>
<td><strong>Product Identifier</strong></td>
<td></td>
</tr>
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</table>

**Screwing**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rotation-speed</th>
<th>Size</th>
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<tbody>
<tr>
<td>Torque</td>
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</table>

<table>
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<th>Depth</th>
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<tbody>
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<tr>
<td>MaxValue</td>
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</tr>
<tr>
<td>Value</td>
<td></td>
</tr>
<tr>
<td>Unit of Measure</td>
<td><em>Millimeter</em></td>
</tr>
</tbody>
</table>
Phased Approach Overview

Phase 1: Geospatial Mapping and Factory Information
- Factory A
- Factory B
- Factory N

Registration via SFW portal

Sub-Scenario 1.1 & 1.2: Registering and Discovering Smart Factories

Sub-Scenario 1.4: Adapting Factory Production

Phase 2: Plug & Work

Adapting Production with Plug & Work (OPC-UA, AutomationML)

Order Request

Phase 3: Data & Service Integration

Pre-Integration Test Simulation

Sharing software assets “Software Plug & Work”

Phase 4: Collaboration

Sub-scenario 1.6: Collaborative Engineering

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Call for Collaboration: http://www.smartfactoryweb.de

Statement of General Interest
• want to be informed progress in the Smart Factory Web testbed

Statement of Training Request
• interested in training events (workshops, webinars, ...)
• requests information on customized training

Statement of Investment
• want to actively contribute in at least one of the participating smart factories
• like to provide HW/SW components to be integrated
• interested in providing financial and engineering support

Statement of Smart Factory Integration
• want to offer a further smart factory to be registered or integrated into the Smart Factory Web
• terms and conditions to be negotiated on a case by case basis
References


- Fraunhofer IOSB. *Web site on Plug & Work* https://www.iofb.fraunhofer.de/servlet/is/51300/

- AutomationML https://www.automationml.org

- OPC Foundation https://opcfoundation.org

- Industrial Internet Consortium. *IIC Connectivity Framework* https://www.iiconsortium.org/IICF.htm

- Fraunhofer IOSB. *Web site on AutomationML* https://www.iofb.fraunhofer.de/servlet/is/32460/

- Fraunhofer IOSB. *Web site on OPC UA* https://www.iofb.fraunhofer.de/servlet/is/32483/
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