Reference Architecture Model Industry 4.0 (RAMI4.0) and International Collaboration

Viite Arkkitehtuuri Malli Teollisuus 4.0 (RAMI 4.0) ja kansainvälinen yhteistyö

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Bosch Rexroth AG
Industry 4.0 and international collaboration

Agenda

- RAMI 4.0 and I4.0 Component
- International Comparison
- Product Criteria Industry 4.0
Reference Architecture Model Industry 4.0 (RAMI4.0)

The solution space with coordinate system for Industry 4.0
Reference Architecture Model Industry 4.0 (RAMI4.0)

Industry 4.0 Communication

The Old World: Industry 3.0

- Hardware-based structure
- Functions are bound to hardware
- Hierarchy-based communication
- Product is isolated
Industry 4.0 Communication

The New World: Industrie 4.0

• Flexible systems and machines
• Functions are distributed throughout the network
• Participants interact across hierarchy levels
• Communication among all participants
• Product is part of the network
Who Is Responsible for Interpreting?
The Administration Shell:

- ... is the interface connecting I4.0 to the things
- ... stores all data and information about the asset
- ... serves as network’s standardized com interface
- ... can integrate passive things into I4.0 networks
- ... could be used for migration of existing equipment
Reference Architecture Model Industry 4.0 (RAMI4.0)

The Industry 4.0 Component

Each product needs its Administration Shell to be integrated into the Industry 4.0 network.

RAMI4.0

- Business
- Functional
- Information
- Communication
- Integration
- Asset

I4.0 Communication

The connection is made via the I4.0 communication.

Administration Shell

The Administration Shell is the digital content.

Asset, e.g. Machine

The Thing is the real content.
Reference Architecture Model Industry 4.0 (RAMI4.0)

I4.0 components inside RAMI4.0

Quelle: Prof. Epple, openAAS
Reference Architecture Model Industry 4.0 (RAMI4.0)

Important topics for Industry 4.0

I4.0 Component

RAMI4.0

Technology topics I4.0

Worldwide standards for the main technology topics are needed

* Refers to individual components such as Sensors, actuators, controllers, software, ...
Reference Architecture Model Industry 4.0 (RAMI4.0)

Communication Layer as ISO/OSI Model

OSI Layers

7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical

In discussion
Mainly Filetransfer
HTTP(s) ?

In discussion
AMQP ?, oneM2M ?

Connected World
Enterprise
Work Center
Station
Control Device
Field Device
Product

Development Type
Maintenance Usage
Production Instance
Maintenance Usage

Example: I4.0 Component – Electrical Drives Converter

- Project Planning
- Service Info
- Load characteristic
- ...

- Energy Optimization
- Startup Feature
- Condition Monitoring
- ...

Reference Architecture Model Industry 4.0 (RAMI4.0)
Reference Architecture Model Industry 4.0 (RAMI4.0)

Example I4.0 Component: Hydraulic Cylinder

- **Sensor-Monitor**
- **Connectivity**
- **Data Sheet**

Hydraulic Cylinder, w/o Electronics

**Admin Shell**
- e.g. Server
- **I4.0 Business**
- **I4.0 Functions**
- **I4.0 Data Files**
- **I4.0 Information**

**Admin Shell**
- e.g. IoT-Gateway
- **I4.0 Business**
- **I4.0 Functions**
- **I4.0 Data Files**
- **I4.0 Information**

**Communication**
- Smartphone
- QR-Code
- I/O Link

**Asset**

**Digital**

**Real**

OPC-UA
Industry 4.0 and international collaboration

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Industry 4.0 - International Collaboration

The Internet of Things and Services

- Smart Grid
- Smart Home
- Smart Building
- Smart Factory
- Smart Mobility
- Health-care
- Smartphone
- Smart Meter
- Smart Factory
- Industry 4.0
- Plattform I4.0
- Smart Devices

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IIRA - Vertical Connectivity

Source: IIC „Connectivity Framework“
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Comparison RAMI 4.0 – IIRA: First common Definition

- Transmission based on TCP/UDP/IP today, later TSN or 5G possible
- OPC-UA based communication protocol

**IIC Testbed – TSN with OPC-UA**

Additional companies promoting OPC UA over TSN:

- ABB
- GE
- Parker
- SEW Eurodrive

Life Cycle Phase: Production and Service
Functional Hierarchy: from Product to Work Center Level
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系统层级：
协同
企业
车间
控制
设备
资源要素

系统集成
互联互通
信息融合
新兴业态
智能功能

设计 生产 物流 销售 服务

生命周期

来源：Bosch Rexroth AG
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IEC TC65/ ISO TC184 Joint Working Group 21
Smart Manufacturing Reference Model(s)

- Co-Convenor: Prof. Fumihiko Kimura (ISO)
- Co-Convenor: Mr. Martin Hankel (IEC)
- Editor: Ms. Yan LU (NIST)
- Kickoff July 2017

80 Members from 16 countries
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Referencemodel Architecture – Overview of international suggestions for IEC/ISO JWG21 „Smart Manufacturing Reference Model(s)“

CN: Intelligent Manufacturing

FR: Reference model for the smart manufacturing standards landscape

JP: Unified Reference Model – Map and Methodology

GE: IEC/PAS Reference Architecture Model Industry 4.0 (RAMI4.0)

JP: Industrial value chain reference architecture (IVRA)

Industry 4.0 and international collaboration

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Industry 4.0 - Criteria for Industry 4.0 Products

Criteria for Industry 4.0 Products - Motivation and Benefits

General
- Guidance, what is Industrie 4.0 AND what is not.
- Not every product is Industrie 4.0.
- Positioning for the market.

Customers
- Future proof cross-company set of terms.
- Manufacturer independent definition.

Manufacturer
- Guidance, what should be called Industrie 4.0.
- Properties as a guidance for the product development.

Implementing Entity
- Manufacturer independent.
- Knowledge of the current state of Industrie 4.0 standardization.
- The current state of Industrie 4.0 standardization is fed into the product implementation via the product criteria.

Important Prerequisite
- Self-audit, no certification.
- A company-own Industrie 4.0 label can be linked to the product criteria.
- Company decision of the placement (inside the catalogue, on the product, in the advertisement, etc.)
- Free of charge and available for everyone

First manufacturer-independent orientation for customers and manufacturers
## Industry 4.0 - Criteria for Industry 4.0 Products

### 2017 Properties / Criteria for I4.0 Products

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Requirements</th>
<th>L</th>
<th>C</th>
<th>Product properties 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identification</td>
<td>Cross-manufacturer identification with unique identifier (ID) attached to the product, electronically readable. Identification in: 1) Development 2) Goods transport (logistics), production 3) Sales, service, marketing 4) Network</td>
<td>T</td>
<td>M</td>
<td>For 1) material number(^7) (electronic) in accordance with ISO 29502-5(^8) or URI</td>
</tr>
<tr>
<td>2. Industrie 4.0 communication</td>
<td>Transfer of product data and data files for interpretation or simulation, for example product data in standardised form. The product can be addressed via the network, supplies and accepts data. Plug &amp; Product via Industrie 4.0 compliant services</td>
<td>T</td>
<td>M</td>
<td>For 2) serial number or unique ID 3) manufacturer + serial number or unique ID 4) electronically readable, physical products via 2D code or RFID 5) participant identification via IP network</td>
</tr>
<tr>
<td>3. Industrie 4.0 semantics</td>
<td>Standardised data with manufacturer-independent unique identification in the form of characteristics with a syntax, e.g.: 1) Commercial data 2) Catalogue data 3) Technical data: mechanics, electronics, functionality, location, performance 4) Dynamic data 5) Data regarding the lifecycle of the product instance</td>
<td>T</td>
<td>M</td>
<td>Manufacturer makes data that is relevant for the customer available accessible online with the aid of identification, e.g.: PDF via MTPG</td>
</tr>
<tr>
<td>4. Virtual description</td>
<td>Virtual representation in Industrie 4.0 compliant semantics Virtual representation across the entire lifecycle. Characteristic attributes of the actual component, information regarding relationships between the attributes, production and production process relevant relationships between Industrie 4.0 components, formal description of relevant functions of the actual component and its processes</td>
<td>T</td>
<td>M</td>
<td>Catalogue data can be accessed online</td>
</tr>
<tr>
<td>5. Industrie 4.0 services and commons</td>
<td>Definition still open (service system) General interface for loadable services and messages regarding statuses Essential basic services that an Industrie 4.0 product must support and provide</td>
<td>T</td>
<td>O</td>
<td>Catalogue data and data regarding the lifecycle of the product instance can be accessed online</td>
</tr>
<tr>
<td>6. Standard functions</td>
<td>Basic standardised functions that run on various products regardless of manufacturer and provide the same data in the same functions. These serve as the foundation for the functionality, on which all manufacturers can build their own enhancements.</td>
<td>T</td>
<td>N</td>
<td>Relevant information for customers can be accessed digitally based on the type identification (product description, catalogue, image, technical features, data sheets, security properties, etc.)</td>
</tr>
<tr>
<td>7. Security</td>
<td>Minimum requirements to guarantee the security functionality.</td>
<td>T</td>
<td>M</td>
<td>Digital contact to service and information for product support incl. spare part information possible from in the field</td>
</tr>
</tbody>
</table>

### Link:
https://www.zvei.org/pressemedien/publikationen/welche-kriterien-muessen-industrie-40-produkte-erfuellen/
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Summary

Support OPC-UA as the communication standard

New international working group IEC/ISO JWG21

Standardized properties for Industry 4.0

Product criteria Industry 4.0

Thank you for your attention
Rexroth booth Hall 6 F50

Important Papers:

- Discussion paper: Interaction Model for Industry 4.0 Components
- Discussion paper : Network-based Communication for I4.0: Proposal for an Administration Shell

ZVEI:  https://www.zvei.org/de/themen/industrie-40/
- Whitepaper: Examples for the Admin Shell- Basic
- Guideline: What Criteria do Industrie 4.0 Products need to fulfil?