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VDMA Guide - Interoperability in Industrie 4.0

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VDMA e.V.

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Table of contents

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1. Interoperability in Industrie 4.0

Introduction

The project "Interoperable Interfaces for Intelligent Production", funded by the German Federal Ministry of Economic Affairs and Climate Action (BMWK), aims at developing cross-industry OPC UA standards and making them known. The Forschungskuratorium Maschinenbau e.V. (FKM) is carrying out this project and is supported by the VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.).

In the course of the project, this catalog of relevant interoperability efforts (e.g., technologies, concepts, organizations) related to Industrie 4.0 as well as their network of relationships is being developed.

The complete catalog can be saved offline as PDF here.

Instruction

The catalog can be used in three ways

- in the top right-hand corner there is a full-text search mask.
- In the menu on the left, the descriptions of the individual interoperability approaches can be selected directly.
- For selected entries, the respective relationships are displayed as a network. The graphical representations can be found under #Entry points.

Entry points

The entry points make it possible to find an overview of a specific aspect. The following entry points are currently defined:

1. OPC UA
2. AAS
3. Organizations
4. Geographical Focus

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OPC UA

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AAS

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Organizations

In this view all organizations are listed. In some cases the relations between them are listed as well.

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Geographical Focus

The following view shows the geographical areas in which the individual concepts are driven.

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Methodology

To create this catalog, different interoperability efforts in Industrie 4.0 have been gathered by the Beirat Interoperabilität - Ökosystem I4.0 of the VDMA in the form of short profiles. The most important efforts have been selected by the Beirat Interoperabilität and categorized by the VDMA and ISW. Along with the categorization, the short descriptions of the individual catalog elements have been extended. After a further review by both the Beirat Interoperabilität and experts in the respective Industrie 4.0 efforts, the catalog elements are presented in the catalog you are reading now.

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Google Trends

The term is queried on Google Trends for the last 5 years. The regions in which the term is most frequently searched for are considered. The classification is made according to continents with the options Africa, Asia, Europe, North America and South America. If a more precise option than the query of a "general search term" is possible, this option is taken, e.g. if google trends offers a topic for the term.

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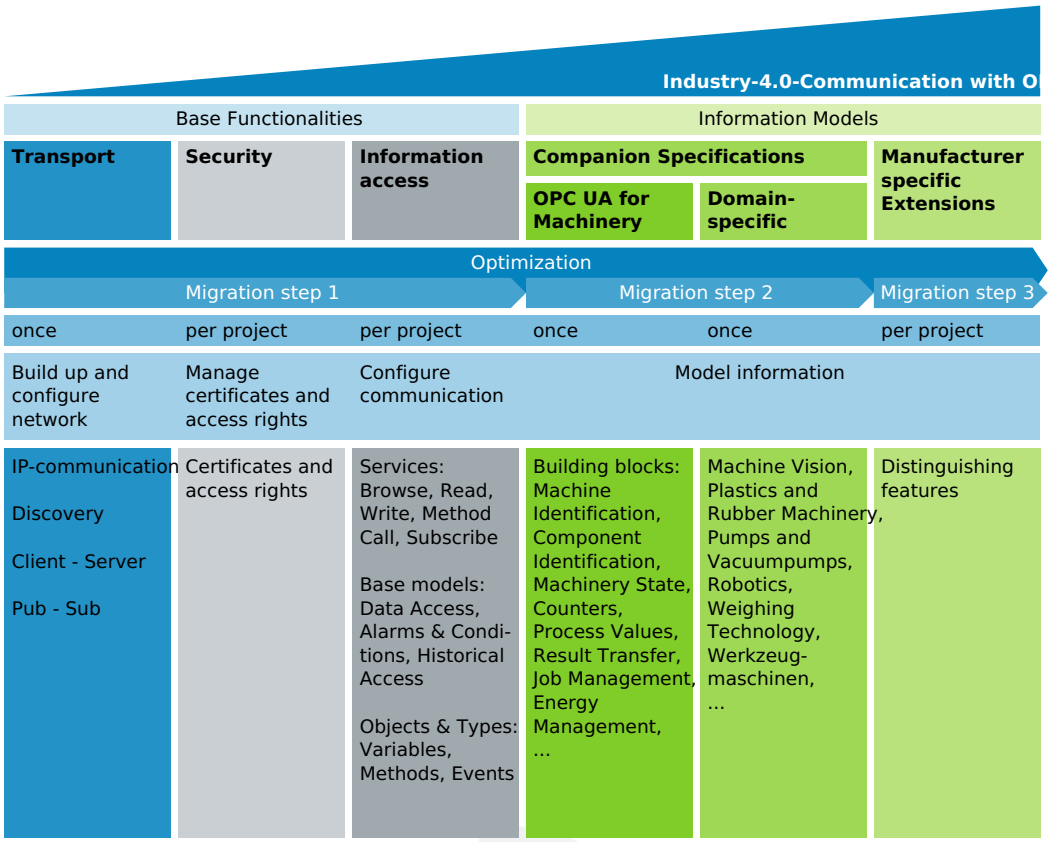
2. OPC UA

OPC UA

This section of the catalog holds information about various topics in the realm of Open Platform Communications Unified Architecture (OPC UA). Currently, the following entries are available:

- OPC UA (Open Platform Communications Unified Architecture)
- OPC Foundation
- OPC Foundation Harmonization Group
- OPC UA FLC Initiative and FX
- OPC UA Communication Layer
- OPC UA Information Layer

OPC UA in industrial communication



An brief overview of OPC UA is given in OPC UA (Open Platform Communications Unified Architecture). OPC UA is being developed and published by the OPC Foundation.

As shown in the figure, for Industrie 4.0 communication with OPC UA there are multiple migration steps to take, some of them have to be implemented only once, some have to be done per project.

The first major part of OPC UA is the ability to create a communication network for the transport of defined data: OPC UA Communication Layer.

The second major part of OPC UA is the ability to create and standardize semantic data in form of information models: OPC UA Information Layer

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OPC Foundation

Connections to other Concepts

- Defines OPC UA (Open Platform Communications Unified Architecture)
- Publishes OPC UA Companion Specifications
- Organizes working groups, such as OPC Foundation Harmonization Group, OPC UA FLC (Field Level Communications) or VDMA 40001 - OPC UA for Machinery

Short Description

- The OPC Foundation is an industry consortium that creates and maintains standards for the open connectivity of industrial automation devices and systems.
- It was formed in 1994 by five industrial automation vendors: Fisher-Rosemount, Rockwell Software, Opto 22 and Intellution.
- Aims to develop and expand the development of interoperability specifications

Facts and Figures

- 894 members (as of September 2022)
- 1996: first publication of the OPC standard
- 2006: first publication of OPC UA version 1.0
- Since 2006: focus on OPC UA Companion Specifications

Stakeholders

- List of members: https://opcfoundation.org/members

Use Cases

- Create and maintain OPC UA specifications
- Ensure compliance with OPC specifications via certification testing
- Collaboration with industry-leading standards organizations

Industry Sectors

- OPC UA (Open Platform Communications Unified Architecture) is a cross-sector communication standard

International Distribution

- Asia
- Europe
- North America

Google Trends

Sources

https://opcfoundation.org/

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OPC Foundation Harmonization Group

Connections to other Concepts

- Develops several OPC UA Companion Specifications, i.e. OPC 10000-110 - OPC UA for Asset Management Basics

Short Description

- This working group brings together members of various Companion Specification working groups and modelling experts to harmonize the way Companion Specifications are modeled
- The working group is responsible for the Companion Specification template and
- Forms sub-groups to define common modelling concepts that can be used universally.

Facts and Figures

- Operational since 2019

Stakeholders

- OPC Foundation
- OPC Foundation working groups and their leading organizations. i.E. VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.), VDW (Verband Deutscher Werkzeugmaschinenfabriken e.V.), NAMUR

Use Cases

Current sub-groups: - Application Hierarchies - Asset Management Basics - Base Relationship Between Components - Calibration Target Management - Information Model Best Practice - Relative Spatial Location - Scheduler - Stacklights - XML Data Type Mapping

Industry Sectors

- Cross-sector working group in the realm of OPC UA (Open Platform Communications Unified Architecture)

International Distribution

Google Trends

Sources

https://opcfoundation.org/about/working-groups/opcf-wg/ https://sites.google.com/opcfoundation.online/opc-harmonization/home

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OPC UA FLC (Field Level Communications)

Connections to other Concepts

- Is an initiative of the OPC Foundation
- Defines OPC UA FX (Field eXchange)

Short Description

- Definition of a basic model for automation components that is uniform for all controllers and field devices.
- Definition of system behavior and processes of common functionalities such as bootstrapping, connection establishment, etc.
- Harmonization and standardization of application profiles, e.g. I/O, motion control, functional safety, instrumentation
- Standardisation of OPC UA information models for field level devices in online and offline scenarios
- Integration of existing and future OPC UA Companion Models
- Support of Ethernet TSN for deterministic communication and IT/OT convergence
- Mapping of application profiles to underlying communication protocols and transmission physics, including Ethernet TSN and Ethernet APL (Advanced Physical Layer)
- Definition of facets, profiles and conformance units that can be tested to ensure cross-vendor interoperability

Facts and Figures

- Introduced in 2018
- Steering Committee consists of 27 members (as of 2022)

Stakeholders

- OPC Foundation
- Led by the FLC Steering Committee (members of the OPCF).
- (indirect beneficiaries) IEEE 802.1 TSN Task Group as future partners for a unified fieldbus solution (partly shared members with OPCF)

Use Cases

- Alternative to conventional fieldbuses
- M2M communication in real-time / controller-to-controller communication
- Vertical integration: from sensor and actuator to the cloud
- Data exchange (OPC UA Safety) (see Safety-related control)

Industry Sectors

- Manufacturing companies from the process industry and discrete manufacturing: from semiconductor manufacturers, to automotive, to aerospace.

International Distribution

Google Trend Analyse

Sources

https://opcfoundation.org/flc/

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OPC UA Communication Layer

OPC UA Communication Layer

This section of the catalog contains information about the Communication Layer of OPC UA.

Currently, the following entries are available:

- Client Server
- Pub Sub
- Security

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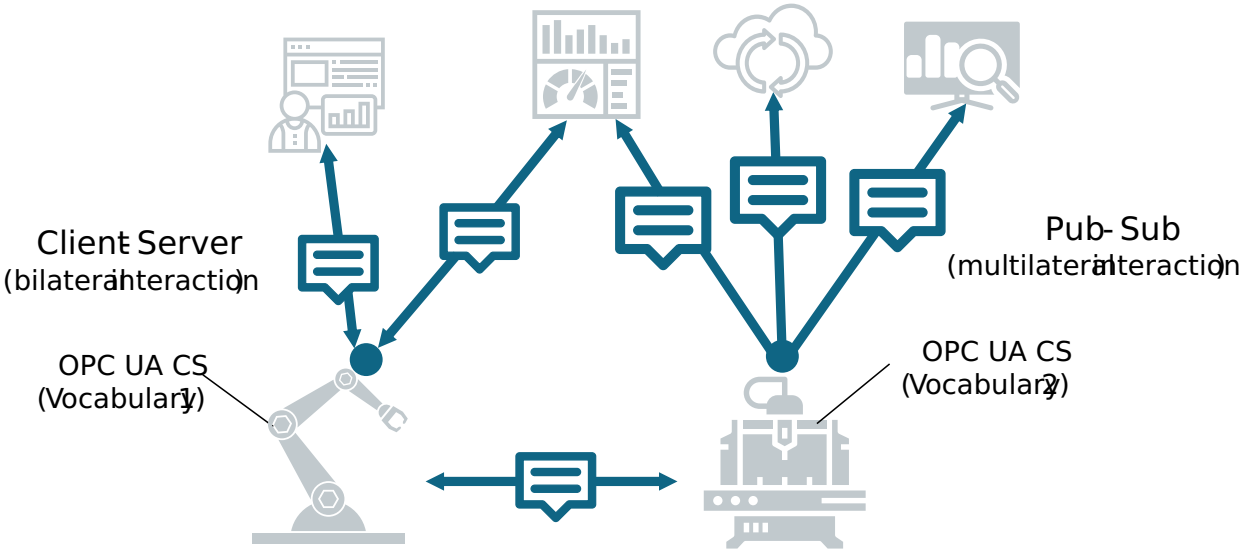
Connections to other Concepts

- Part of OPC UA (Open Platform Communications Unified Architecture)
- Defines OPC UA over TSN (Time-Sensitive Networking)

Short Description

- Describes how data is transferred using OPC UA Client-Server and/or Publish-Subscribe



- Mapping to protocols
- Mapping to encodings (e.g. JSON, HTML)
- Ensuring built-in Security
- OPC UA Applications can use both types of communication in parallel

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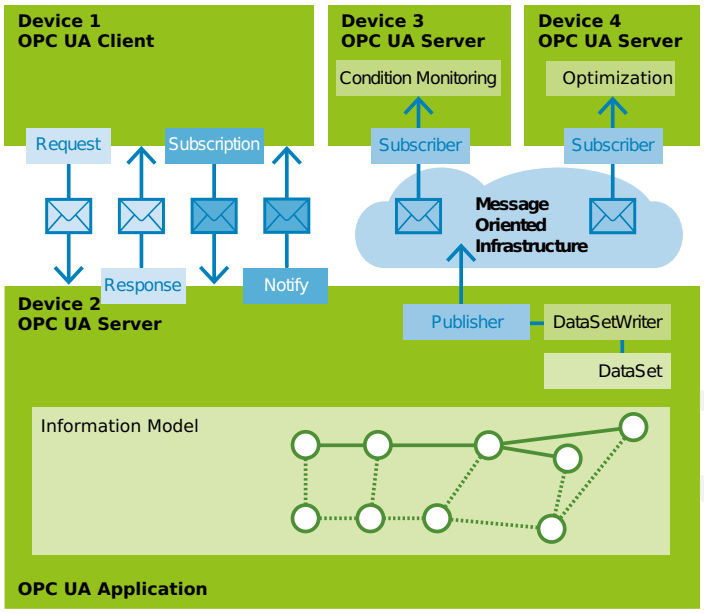
- 

Facts and Figures

Stakeholders

- OPC Foundation

Use Cases

- Technical aspect of data transport

Industry Sectors

- OPC UA (Open Platform Communications Unified Architecture) is a cross-sector communication standard

International Distribution

GOOGLE TRENDS

Sources

- OPC Foundation Specifications
- VDMA Publications on Interoperability

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OPC UA Client-Server

Connections to other Concepts

- Part of OPC_UA/OPC_UA_Communication_Layer/index

Short Description

- Describes how data is transferred using OPC UA in a bilateral interaction

Facts and Figures

- Supporting various protocols (e.g. TCP, HTTPS)
- Client accesses information from the Server via a permanently configured connection
- Distinguish between the patterns of Request -> Response (Analogy = Letter service with registered mail and advice of receipt) and Subscription -> Notify (Analogy = Registration to football live ticker with feedback on special events like goal via Push notification)

Stakeholders

- OPC Foundation

Use Cases

- Technical aspect of data transport

Industry Sectors

- OPC UA (Open Platform Communications Unified Architecture) is a cross-sector communication standard

International Distribution

GOOGLE TRENDS

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OPC UA Publisher-Subscriber

Connections to other Concepts

- Part of OPC_UA/OPC_UA_Communication_Layer/index

Short Description

- Describes how data is transferred using OPC UA in a multilateral interaction

Facts and Figures

- Supporting various protocols (e.g. UDP, MQTT)
- Publisher sends to unknown Subscribers without a fixed connection (Analogy = Setting a radio frequency)

Stakeholders

- OPC Foundation

Use Cases

- Technical aspect of data transport

Industry Sectors

- OPC UA (Open Platform Communications Unified Architecture) is a cross-sector communication standard

International Distribution

GOOGLE TRENDS

Sources

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OPC UA Security

Connections to other Concepts

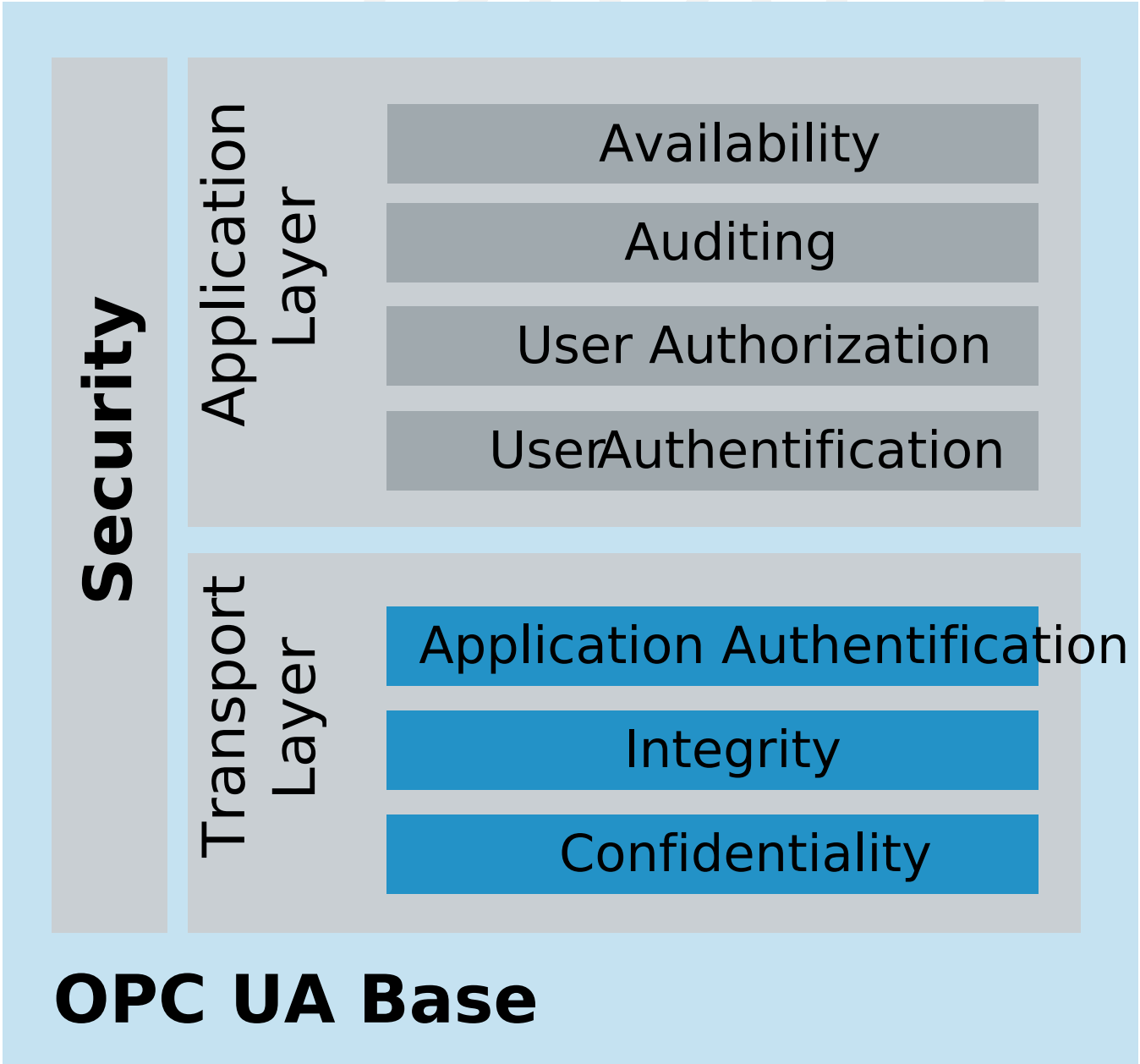
- Part of OPC_UA/OPC_UA_Communication_Layer/index

Short Description

- Describes how Security is a built-in aspect of OPC UA (Open Platform Communications Unified Architecture)

Facts and Figures

- Distinguish Security between Application Layer and Transport Layer
- Latest news and developments available at the OPC Foundation Website
-



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Stakeholders

- OPC Foundation

Use Cases

- Technical aspect of data transport

Industry Sectors

- OPC UA (Open Platform Communications Unified Architecture) is a cross-sector communication standard

International Distribution

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Sources

- Industrie 4.0 Interoperability through OPC UA with Companion Specficiations

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OPC UA Information Layer

OPC UA Information Layer

Connections to other Concepts

- Part of OPC UA (Open Platform Communications Unified Architecture)
- Implementation of OPC UA Companion Specifications from the VDMA and VDW done by umati

Short Description

In terms of information access, there is an overview of information models in OPC UA Information Models.

OPC UA Companion Specifications are information models that are not developed by the OPC Foundation but by experts in the domain of the model. These models are published and distributed via the OPC Foundation.

To ensure the information models follow similar principles and don't duplicate information, there is the [[OPC Foundation Harmonization Group]

VDMA 40001 - OPC UA for Machinery is a companion specification that can be used as a basis of more specific domain models. It contains building blocks that are useful across domains.

The following topics are special models within OPC UA, in the case of FX they span both the base functionalities and the information models: - OPC UA FX (Field eXchange) - OPC 10000-110 - OPC UA for Asset Management Basics

The OPC 30400-1+2 - OPC UA for Cloud Library is a repository of information models, especially when used in conjunction with cloud infrastructures.

Facts and Figures

Stakeholders

- OPC Foundation
- VDMA
- VDW
- ZVEI

Use Cases

- Technical aspect of data transport

Industry Sectors

- OPC UA (Open Platform Communications Unified Architecture) is a cross-sector communication standard

International Distribution

GOOGLE TRENDS

Sources

- OPC Foundation Specifications
- VDMA Publications on Interoperability

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OPC UA Information Models

Connections to other Concepts

- Part of OPC UA (Open Platform Communications Unified Architecture)

Short Description

- Graph with edges and nodes
- With the help of the information model, data can be provided with context
- Information models can be instantiated in an OPC UA server and then form the AddressSpace of the server

Facts and Figures

- currently 71 information models either published or in development as OPC UA Companion Specifications (as of April 2023)

Stakeholders

- OPC Foundation
- Any entity defining an OPC UA Information Model

Use Cases

- Represent information for use in OPC UA (Open Platform Communications Unified Architecture)

Industry Sectors

- OPC UA (Open Platform Communications Unified Architecture) is a cross-sector communication standard

International Distribution

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Sources

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OPC UA Companion Specifications

Connections to other Concepts

- Published by the OPC Foundation
- Describes OPC UA Information Models
- OPC 10000-110 - OPC UA for Asset Management Basics and VDMA 40001 - OPC UA for Machinery are Companion Specifications (CS) listed in this catalog
- OPC 30400-1+2 - OPC UA for Cloud Library provides an overview of Companion Specifications

Short Description

- New information models can be created based on the OPC UA data model and eventually derived from OPC UA basic information models
- Typically address a specific industry problem, like the communication of subsea equipment with monitoring systems in the oil and gas industry
- All OPC UA Companion Specifications for the Machinery and Equipment Manufacturing Industry from the VDMA can be downloaded at https://www.vdma.org/catalogs

Facts and Figures

- currently 71 CS either are published or in development (as of April 2023)

Stakeholders

- OPC Foundation
- Collaboration partners like VDMA and working group members
- List of OPC Foundation CS working groups: https://opcfoundation.org/about/working-groups/

Use Cases

- using OPC UA (Open Platform Communications Unified Architecture) in a specific context

Industry Sectors

- OPC UA (Open Platform Communications Unified Architecture) is a cross-sector communication standard
- individual CS often concern a specific industry sector

International Distribution

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Sources

- Overview of all OPC UA activities in the VDMA
- List of all OPC UA Companion Specifications
- Graphical representation of the dependencies

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OPC 10000-110 - OPC UA for Asset Management Basics

Connections to other Concepts

- is a OPC UA Companion Specifications
- defined by a working group of the OPC Foundation resp. OPC Foundation Harmonization Group
- uses OPC UA (Open Platform Communications Unified Architecture)

Short Description

- It takes into account various aspects of asset management.
- Applications do not have to use all or nothing of this specification, but can choose which concepts they want to support.

Facts and Figures

- Release 1.00.0 2022-01-13
- Currently there is a Release Candidate 1.01 with further Use Cases

Stakeholders

Use Cases

- Technical Specification: Skills / Capabilities
- Technical Specification: Requirements
- Location/Contextualisation: Functional Contextualisation
- Location/Contextualisation: Hierarchical Location
- Location/Contextualisation: Time/Local Time Location
- Location/Contextualisation: Digital Location
- Structure of Assets: Identifying the Structure of Assets
- Asset management

Industry Sectors

International Distribution

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Sources

- https://reference.opcfoundation.org/AMB/v101/docs/

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OPC 30400-1+2 - OPC UA for Cloud Library

Connections to other Concepts

- Part 1 defines the overall architecture and use cases
- Part 2 contains the API Definition
- Working group of the OPC Foundation and CESMII (Clean Energy Smart Manufacturing Innovation Institute)
- Database of OPC UA Information Models

Short Description

- A specification, a reference implementation and a publicly accessible instance for a database hosted on the Internet that contains OPC UA information models
- This database can be made publicly accessible via a RESTful interface
- User access control is integrated in the UA Cloud Library
- This cloud library can be made available to manufacturers who want to use industrial plants with standardised and with non-standardised information models for their SCADA or analysis systems

Facts and Figures

- Working group started in 2021

Stakeholders

- OPC Foundation
- CESMII (Clean Energy Smart Manufacturing Innovation Institute)

Use Cases

- Configuring the application behind the OPC UA client that retrieves the data from the machine
- Checking specification conformity for new machines
- Retrofitting OPC UA on existing machines
- Downloading a UA AddressSpace from the UA Cloud Library to an "empty" UA Server instance
- Technical support of existing AddressSpaces

Industry Sectors

- OPC UA (Open Platform Communications Unified Architecture) is a cross-sector communication standard

International Distribution

GOOGLE TRENDS

Sources

https://opcfoundation.org/markets-collaboration/cloudlib/

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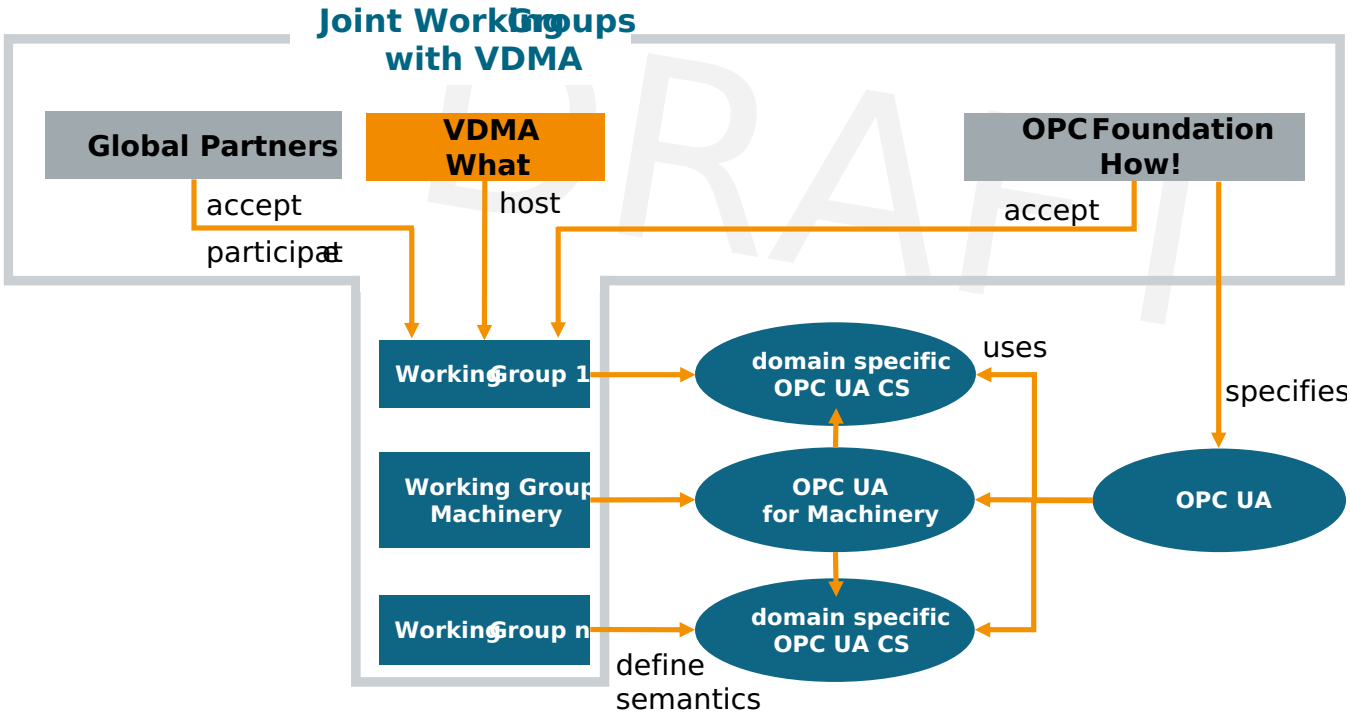
VDMA 40001 - OPC UA for Machinery

Connections to other Concepts

- Defines OPC UA Companion Specifications OPC 40001-1, 40001-2, 40001-3, 40001-101
- Collaboration with OPC Foundation Harmonization Group
- Driven by OPC Foundation, VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.) and VDW (Verband Deutscher Werkzeugmaschinenfabriken e.V.)
-



Short Description

- Through the central coordination in the VDMA, it turned out that some interface contents occur across industries.
- These contents are to be mapped in a basic specification for the entire factory and plant engineering sector.
- It serves as a basis for existing and emerging Companion Specifications.
- In order to enable an early and demand-oriented adaptation, the contents are developed and published in so-called building blocks.
- Each module represents one or more specific use case.
- The first implemented building blocks are intended for the identification of machines and components for the entire shop floor.
- Furthermore, the status of machines and components, for example, was described in order to provide the basis for calculating key figures.

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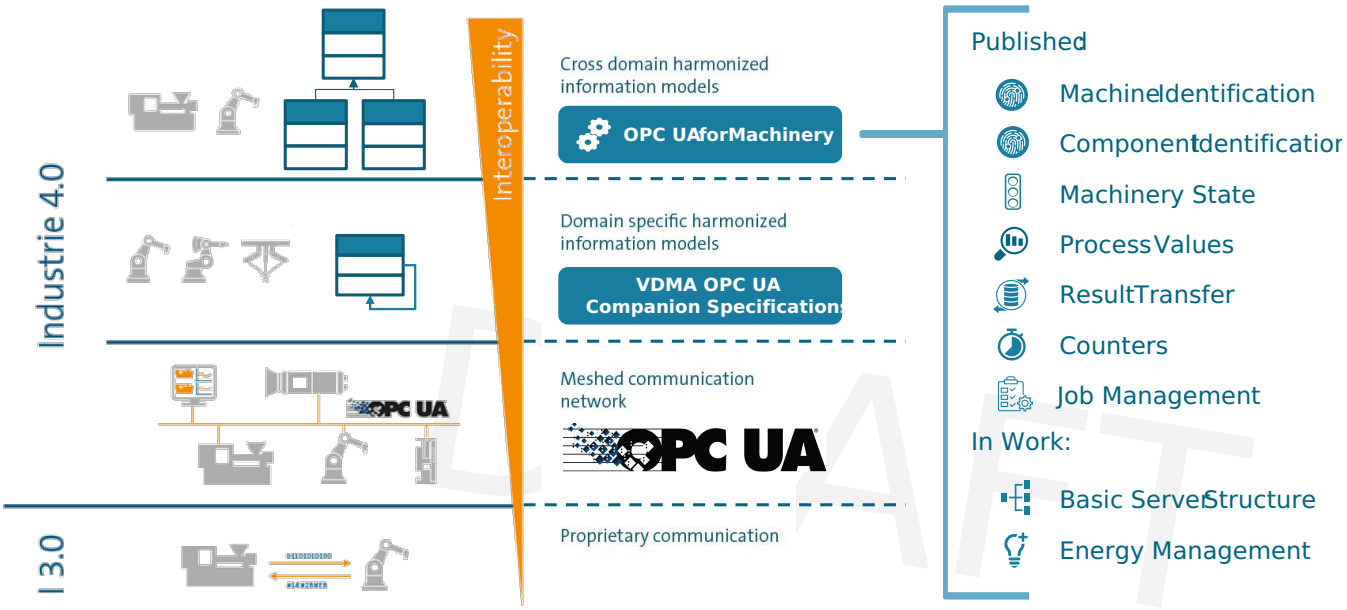

Facts and Figures

Stakeholders

- VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.)
- VDW (Verband Deutscher Werkzeugmaschinenfabriken e.V.)

Use Cases

- Asset management
- Production monitoring
- Production control

Industry Sectors

- Production Industry
- Machinery and Equipment Manufacturers
- Discrete Manufacturing
- Continous Manufacturing

International Distribution

GOOGLE TRENDS

Sources

https://www.vdma.org/viewer/-/v2article/render/855496

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OPC UA FX (Field eXchange)

Connections to other Concepts

- Part of OPC UA (Open Platform Communications Unified Architecture)
- Defined by OPC UA FLC (Field Level Communications) Initiative
- Uses AML (AutomationML) and TSN (Time-Sensitive Networking)

Short Description

- Extension of the OPC UA framework for the field level
- Covers requirements of the field level, especially deterministic and functionally safe communication
- Example Communication between controllers, communication between controllers and field devices
- Defines OPC UA Core Specifications (Parts 80-84)

Facts and Figures

- First release Nov. 2022

Stakeholders

- OPC Foundation
- OPC UA FLC (Field Level Communications) initiative

Use Cases

- Alternative to conventional fieldbuses
- M2M communication in real-time / controller-to-controller communication
- Vertical integration: from sensor and actuator to the cloud
- Data exchange (OPC UA Safety) (see Safety-related control)

Industry Sectors

- Manufacturing companies from the process industry and discrete manufacturing: from semiconductor manufacturers, to automotive, to aerospace.

International Distribution

GOOGLE TRENDS

Sources

https://opcconnect.opcfoundation.org/2021/06/opc-ua-fx-field-exchange-release-candidate-1-completed/

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3. AAS

AAS

This section of the catalog contains information about the Asset Administration Shell (AAS). Currently, the following entries are available:

- Asset Administration Shell
- AAS Metamodel
- AAS Application Programming Interface
- Katalog/AAS/AAS_Submodel_Templates_(SMT)_and_Submodels/index_and_Submodels/index.md)

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AAS Metamodel

Connections to other Concepts

- Part 1 of the Specifications of the Asset Administration Shell
- Is the basis for the development and definition of AAS Submodel Templates and Submodels_and_Submodels/AAS Submodel Templates and Submodels.md) and AAS Application Programming Interface

Short Description

- The AAS and the related specifications aim to enable meaningful exchange of information about Assets between partners in a value creation network
- The AAS Metamodel focuses on how information needs to be processed and structured
- The so-called Environments purpose is to list all Asset Administration Shell, AAS Submodel Templates and Submodels_and_Submodels/AAS Submodel Templates and Submodels.md) and ConceptDesciriptions - in other word, all identifiables within an ecosystem

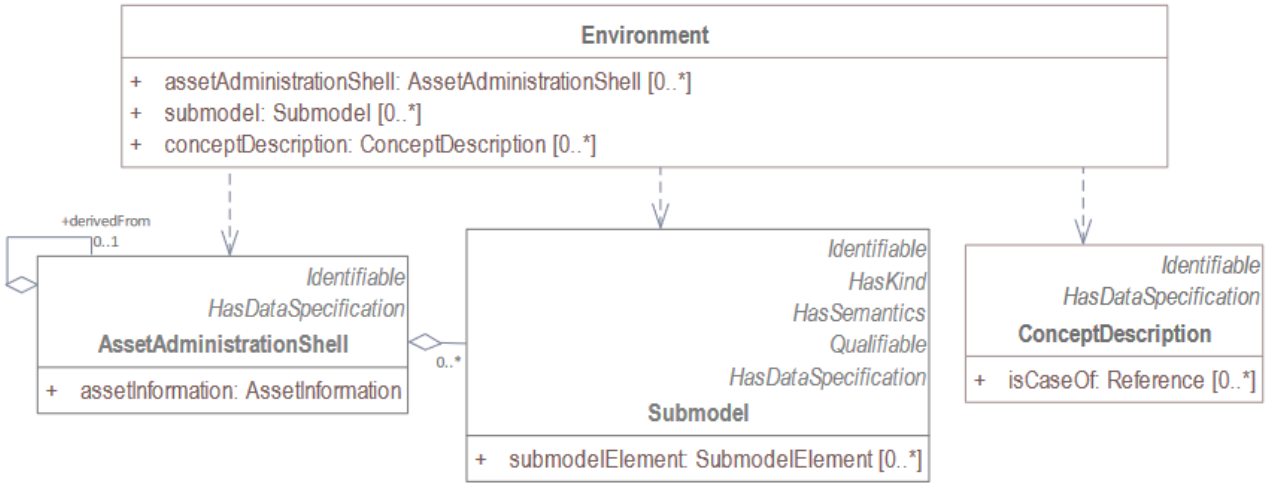

Figure 11 Metamodel of Environment

Facts and Figures

- Version 3.0 from April 2023

Stakeholder

- Plattform Industrie 4.0
- IDTA (Industrial Digital Twin Association e.V.)

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Use Cases

Industry Sectors

International distribution

Google Trends

Sources

Katalog/Data/Documents/IDTA-01001-3-0_SpecificationAssetAdministrationShell_Part1_Metamodel.pdf

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AAS Application Programming Interface

Connections to other Concepts

- Part 2 of the Specifications of the Asset Administration Shell
- Is the basis for the development of interfaces as well as APIs in selected technologies for the Asset Administration Shell and its AAS Submodel Templates and Submodels_and_Submodels/AAS Submodel Templates and Submodels.md)

Short Description

- The Industrie 4.0 Service Model basically distinguishes between associated concepts on several levels

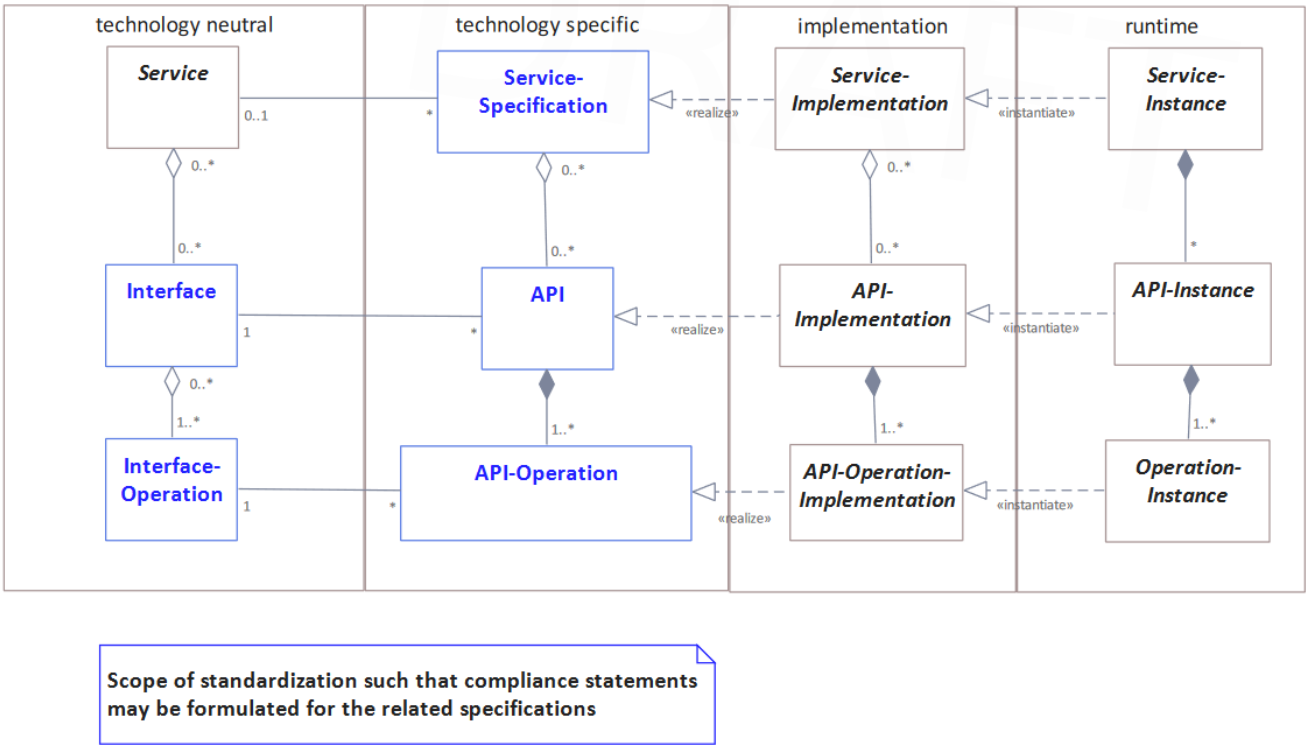

Figure 2 Services, Interfaces & APIs and Operations

- The operations of the interfaces follow a resource-oriented approach which is close to general REST principles but not as strict in every situation

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- There are Discovery, Registry, Repository, AAS and Submodel Interfaces and Service Specifications

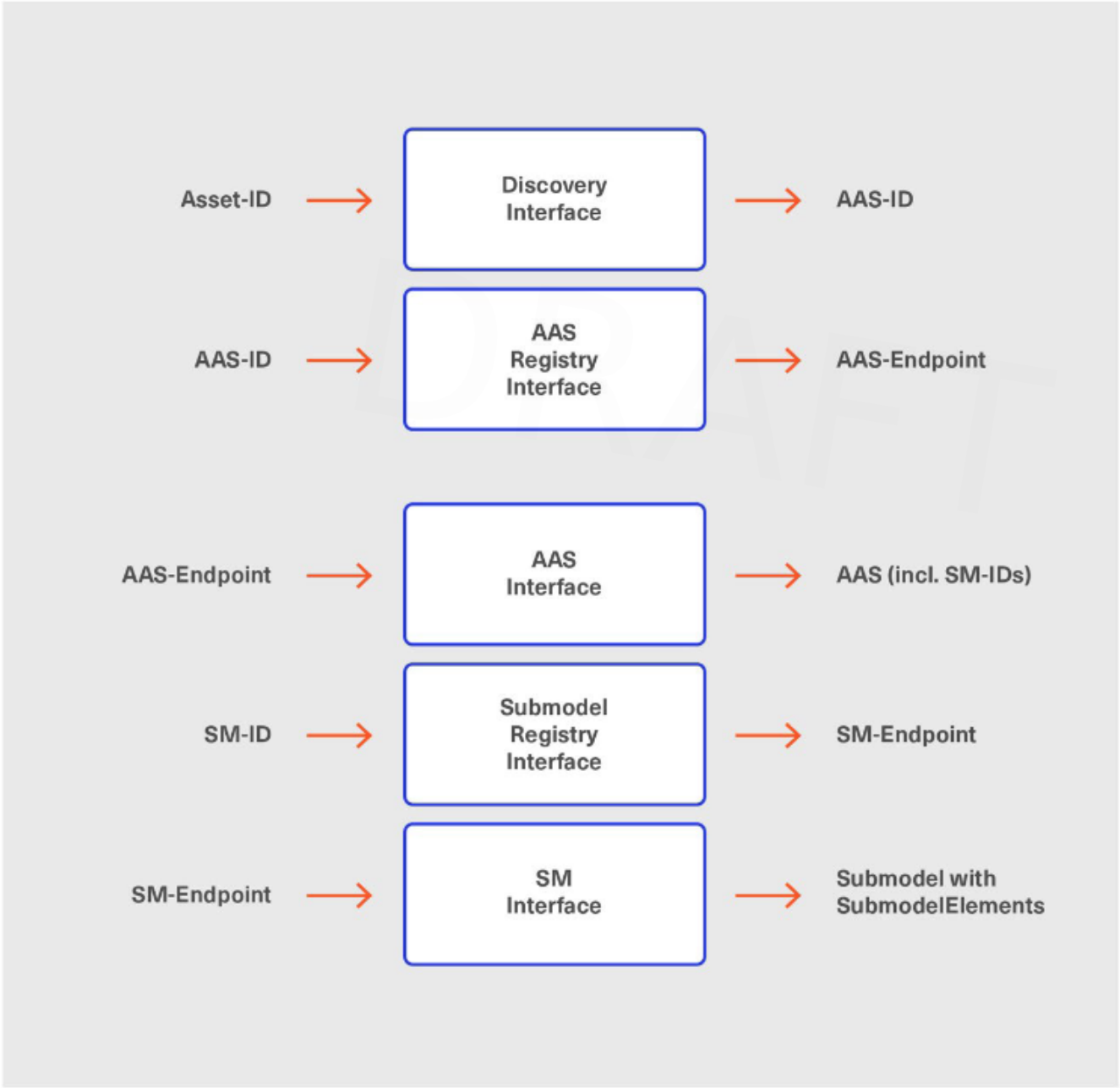

Figure 3 Retrieval of Asset-related Information by AAS and Submodels

Facts and Figures

- Version 3.0 from April 2023

Stakeholder

- Plattform Industrie 4.0
- IDTA (Industrial Digital Twin Association e.V.)

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Use Cases

Industry Sectors

International distribution

Google Trends

Sources

IDTA-01002-3-0_SpecificationAssetAdministrationShell_Part2_API.pdf

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AAS Submodel Templates (SMT) and Submodels

AAS Submodel Templates (SMT) and Submodels

This section of the catalog contains information about the Submodel Templates (SMT) and Submodels of the AAS.

Currently, the following entries are available:

- AAS Submodel Templates and Submodels
- Generic Frame for Technical Data for Industrial Equipment in Manufacturing (coming soon)
- Digital Nameplate for Industrial Equipment (coming soon)
- Nameplate for Software in Manufacturing
- Handover Documentation (coming soon)
- Hierarchical Structures enabling Bill of Materials (coming soon)
- AAS SMT OPC UA Server Datasheet

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AAS Submodel Templates and Submodels

Connections to other Concepts

- Part of the Asset Administration Shell
- Based on the AAS Metamodel
- IDTA (Industrial Digital Twin Association e.V.) defines and publishes Asset Administration Shell Submodel Templates
- There is a Submodel Template aiming to provide hierarchical structures applicable to industrial equipment in an interoperable manner.
- There is a Submodel Template for the inclusion of MTP (Module Type Package)
- There will be a Submodel Template for the information needed with regards to an OPC UA Server

Short Description

- The creation process of a Submodel Template consists of the proposal and the development
- The process of creation overview and the application form can be found here
- The development process of how to create a Submodel Templates distinguishes between following workflows
- Document driven workflow
- Model based workflow
- Semantic driven workflow
- Submodels can be standardized and thus become of kind = Template

Facts and Figures

- All published AAS Submodel Templates and Submodels can be found on GitHub https://github.com/admin-shell-io/submodel-templates/tree/main/published

Stakeholders

- IDTA (Industrial Digital Twin Association e.V.) hosts Submodel Working Groups which define and publishe AAS Submodel Templates and Submodels

Use Cases

Industry Sectors

International Distribution

GOOGLE TRENDS

Sources

I40-IDTA-WS-Process-How-to-write-a-SMT-FINAL-.pdf

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AAS Submodel OPC UA Server Datasheet

Connections to other Concepts

- Part of the Asset Administration Shell
- Instance of an Asset Administration Shell Submodel Template
- Content describes an OPC UA Server

Short Description

- The Asset Administration Shell Submodel Template describes the content of an OPC UA Server
- The provision of OPC UA Server implementation details via the AAS shall enable developers and users of OPC UA Client applications to prepare the later integration of the assets containing OPC UA Servers.
- This shall ease support and accelerate the engineering, integration and on-boarding of the product with OPC UA Server into the later environment.
-

Facts and Figures

- It is a Submodel Working Team in the context of the Joint Working Group (JWG) between the IDTA and OPC Foundation
- The specification has the IDTA Number 02009

Stakeholders

- IDTA (Industrial Digital Twin Association e.V.)
- OPC Foundation
- VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.)

Use Cases

- Interoperability of OPC UA (Open Platform Communications Unified Architecture) and Asset Administration Shell

Industry Sectors

International distribution

GOOGLE TRENDS

Source

https://industrialdigitaltwin.org/content-hub/teilmodelle

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4. Architectures

Architectures

This part of the catalog holds information about different models that define the architecture of specific parts of industrial communication.

Currently, the following entries are available:

- BIM (Building Information Modeling)
- GAIA-X RAM
- IDS-RAM (International Data Spaces Reference Architecture Model)
- IICF (Industrial Internet of Things Connectivity Framework)
- IIRA (Industrial Internet Reference Architecture)
- IMSA (Intelligent Manufacturing System Architecture)
- ISA-88 Batch control
- ISA-95
- ISO 23247 - Digital twin framework for manufacturing
- MESA B2MML (Manufacturing Enterprise Solutions Association Business to Manufacturing Markup Language)
- NOA (NAMUR Open Architecture)
- OMAC PackML (Organization for Machine Automation and Control Packaging Machine Language)
- RAMI 4.0 (Reference Architecture Model Industrie 4.0)

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BIM (Building Information Modeling)

Connections to other Concepts

- This can be used as part of/in conjunction with a Digital Twin of the building
- Interoperability with BACnet
- Definition by ISO in ISO 19650

Short Description

- Documentation in the building industry through virtual models (three dimensions in space, added information)
- Collaborative process in planning, design and construction of building projects
- Used as information storage and source during the building's lifecycle
- Within BIM, there are different standards (some open, some proprietary) with limited interoperability between each other

Facts and Figures

- First concept developed in 1970s by Charles M. Eastman
- ISO 19650 has been launched in January 2019
- Term "Building Information Model" first appeared in 1992 in a paper by G.A. van Nederveen and F.P. Tolman

Stakeholders

- Exchange format IFC (Industry Foundation Classes)
- Standardized by ISO (International Organization for Standardization)

Use Cases

- Increased transparency in building lifecycle, resulting in increased security in planning, scheduling and cost in construction
- Increased quality of project planning
- Decisions can be made sooner and with more quality information
- Tests and checks for the building based on project documentation, e.g. energy efficiency, construction scheduling, defect tracking
- Overview of data sources

Industry Sectors

- Architecture and construction industry especially for project planning, construction coordination and historic preservation (information management).

International Distribution

- Africa
- Asia
- Europe
- North America
- Oceania
- South America

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Google Trends

Sources

- Kensek, Karen (2014). Building Information Modeling, Routledge. ISBN 978-0-415-71774-8
- Forschungsinitiative ZukuftBAU. BIM-Leitfaden für Deutschland - Information und Ratgeber. https://www.bmvi.de/SharedDocs/DE/Anlage/DG/Digitales/bim-leitfaden-deu.html

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GAIA-X RAM

Connections to other Concepts

- Developed by GAIA-X AISBL
- Includes concepts of RAMI 4.0
- Can be used to gather data for the Digital Product Passport
- IDS can be used for data access
- Catena-X Automotive Network e.V. implements the GAIA-X RAM for the automotive industry
- Conformity to BSI (Bundesamt für Sicherheit in der Informationstechnik Federal Office for Information Security) rules

Short Description

- Gaia-X aims to create a federated open data infrastructure based on European values regarding data and cloud sovereignty i.e. to establish an ecosystem, whereby data is shared and made available in a trustworthy environment
- The GAIA-X-RAM (Reference Architecture Model) document describes the concepts required to build the GAIA-X data and infrastructure ecosystem
- It integrates the providers, consumers, and services required for this interaction
- These services include assurance of identities, implementation of trust mechanisms, and usage control over data exchange and compliance - without the need for individual agreements
- The GAIA-X RAM document describes both the static decomposition and the dynamic behavior of the GAIA-X core concepts and federation services

Facts and Figures

- Gaia-X started as an initiative by the former German Minister of Economic Affairs Peter Altmaier and his French counterpart Bruno Le Maire in 2019
- The name of the project bears reference to the Greek goddess "Gaia"
- Officially, the Association was founded by 22 companies and organisations in January 2021 and until today, over 350 members have joined Gaia-X out of which more than 40% are SMEs
- The mission of Gaia-X is to design and implement a data sharing architecture that consists of common standards for data sharing, best practices, tools, and governance mechanisms

Stakeholders

- The founding members of GAIA-X AISBL on the German side include Beckhoff Automation, BMW, Bosch, DE-CIX, Deutsche Telekom, German Edge Cloud, Deutsche Telekom, PlusServer, SAP, Siemens along with Fraunhofer Gesellschaft and the IDSA (International Data Spaces Association) and the European cloud provider association CISPE.
- On the French side, Amadeus, Atos, Docaposte, Électricité de France (EDF), Institut Mines-Télécom (IMT), Orange, Outscale, OVHcloud, Safran and Scaleway are among the French Founding Members
- California-based company Palantir, part of the military-industrial complex of the US was also a founding member.

Use Cases

- Provide small and medium-sized businesses common data-exchange mechanisms that adhere to the common needs of trust while building individual interfaces for data exchange and interoperability solutions
- Provide mechanisms to verify the actual level of interoperability of commercial leading Digital Platforms
- Development of framework that enables people to make informed decisions when exchanging data
- Reducing the barriers to cloud adoption

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Industry Sectors

- Cloud data services (storage & sharing)

International Distribution

- Asia
- Europe
- North America

Google Trends

Sources

- https://gaia-x.eu/wp-content/uploads/2022/06/Gaia-x-Architecture-Document-22.04-Release.pdf
- https://gaia-x.eu/
- https://www.bmwk.de/Redaktion/EN/Dossier/gaia-x.html
-

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IDS-RAM (International Data Spaces Reference Architecture Model)

Connections to other Concepts

- Defined by IDSA (International Data Spaces Association)
- Used in GAIA-X RAM for data exchange
- Connectors exist for e.g. OPC UA (Open Platform Communications Unified Architecture), MQTT (Message Queuing Telemetry Transport) or Asset Administration Shell

Short Description

- The IDS Reference Architecture Model (IDS-RAM) provides the conceptual foundation for data exchange between organizations
- IDS-RAM defines security standards, control and enforcement rules for data use, as well as mechanisms for data traceability and data provenance verification

Facts and Figures

- July 2019: IDS-RAM 3.0 was launched at the Hannover Messe trade fair.

Stakeholders

IDSA (International Data Spaces Association)

Use Cases

- Big data (information, fusion, mapping, aggregation, etc.)
- Artificial intelligence (alerting, monitoring, data quality, etc.)
- IIoT, blockchain technology
- Certification, security and governance (Data handling & trustworthiness)
- Security standards and roles and responsibilities for the data economy
- Control and enforcement rules for data use
- Rules and mechanisms for traceability of data and identification of data sources
- Provision of process data

Industry Sectors

- Goverment (Certification)
- Mobility (Data network, forecasting & optimization of resources)
- Manufacturing & logistics (Optimization of data sharing & energy consumption, increasing trustworthiness while sharing valuable & IP-relevant engineering data and transparency in supply chain)
- Construction (Optimal site selection)
- Energy (Increasing efficiency)
- Aircraft industry (Trusted exchange for quality assurance)

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International Distribution

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Sources

- https://internationaldataspaces.org/offers/reference-architecture/
- https://internationaldataspaces.org/wp-content/uploads/IDS-RAM-3.0-2019.pdf
- https://internationaldataspaces.org/wp-content/uploads/dlm_uploads/Use-Case-Bro_2021-1.pdf

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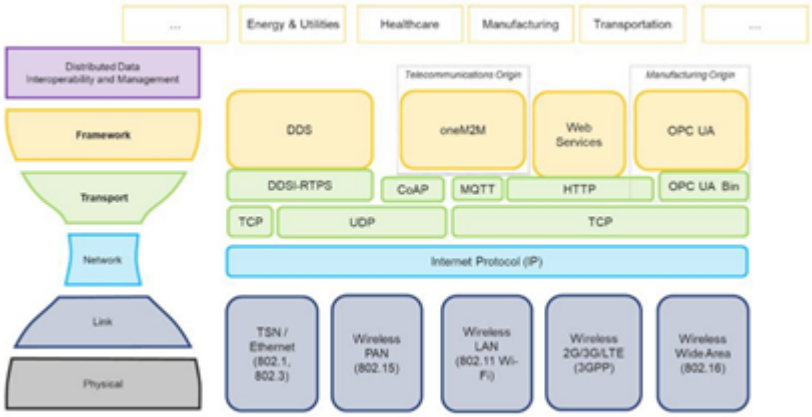
IICF (Industrial Internet of Things Connectivity Framework)

Connections to other Concepts

- Developed by IIC (Industry IoT Consortium)
- Extends IIRA (Industrial Internet Reference Architecture) in the realm of connectivity considerations

Short Description

- Reference Architecture for IIoT (Industrial Internet of Things) system
- The IICF architecture suggests that each IIoT system shall choose a “connectivity core standard” to which all communications bridge.
- Provides an assessment template to determine the suitability of connectivity standards to simplify the choice of connectivity core standard
- Simplifies interoperation between various subsystems, devices and applications in the IIoT system, and also simplifies integration with other IIoT systems, even if they use a different connectivity core standard.
- Defines an open connectivity reference architecture, and helps practitioners navigate their way to categorize, evaluate, and determine the suitability of a connectivity technology for the system at hand
- Provides a catalog of IIoT connectivity standards



Facts and Figures.

- 2015: First publication of IICF
- Based on the Open Systems Interconnect (OSI) Model and the Internet Protocol Suite, but has been designed to support the separation of the transport and framework layers

Stakeholders

- Stakeholder IIC (Industry IoT Consortium)

Use Cases.

- Data exchange and interoperability between components and subsystems
- Accelerating the development of new applications
- Connectivity architectures that can address the diversity of IIoT systems

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Industry Sectors

- Energy
- Healthcare
- Manufacturing
- Mining
- Retail
- Smart Cities
- Transportation

International Distribution

Google Trends

Sources

- https://www.iiconsortium.org/iicf/
- https://www.iiconsortium.org/wp-content/uploads/sites/2/2022/06/IIoT-Connectivity-Framework-2022-06-08.pdf

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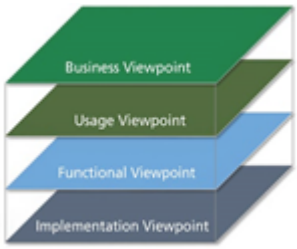
IIRA (Industrial Internet Reference Architecture)

Connections to other Concepts

- Developed by IIC (Industry IoT Consortium)
- Alignment with RAMI 4.0 (Reference Architecture Model Industrie 4.0)
- Alignment with IMSA (Intelligent Manufacturing System Architecture)

Short Description

- Based on the Industrial Internet Architecture Framework (IIAF)
- A reference architecture that serves the basic definition of Industrial Internet Systems (IIS). These systems are defined as end-to-end application systems for industrial tasks. They include technical components as well as interactions with users.
- IIRA describes the logical structure of overall systems and processes in the IIoT (Industrial Internet of Things) environment
- Focuses on the uniform definition of abstraction levels and semantic relationships
- It is defined for multiple vertical markets, not just manufacturing
- Consists of four viewpoints (Business, Usage, Functional and Implementation) that address the IIoT system concerns
- These viewpoints are the basis of the architecture and may be extended by defining additional views and viewpoints as needed to organize system concerns based on their specific system requirements.



Facts and Figures.

- 2015 first release
- Current version 1.10

Stakeholders

- IIC (Industry IoT Consortium)

Use Cases

- Central guidance for industry 4.0
- Defining IIoT system requirements

Industry Sectors

- Manufacturing
- Automation
- IIoT (Industrial Internet of Things)

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International Distribution

Google Trends

Sources

[1] JTG2_Whitepaper_final_20171205.pdf - https://www.iiconsortium.org/iira/ - https://www.iiconsortium.org/pdf/IIRA-v1.9.pdf - https://www.iiconsortium.org/wp-content/uploads/sites/2/2022/11/IIRA-v1.10.pdf

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IMSA (Intelligent Manufacturing System Architecture)

Connections to other Concepts

- Alignment with RAMI 4.0
- Follows MIC2025 (Made in China 2025) plan

Short Description

- Reference architecture model for digitalized production
- Enables various concepts in Industrie 4.0 to be systematically classified and further developed.
- All assets in the digital factory can be clearly mapped.

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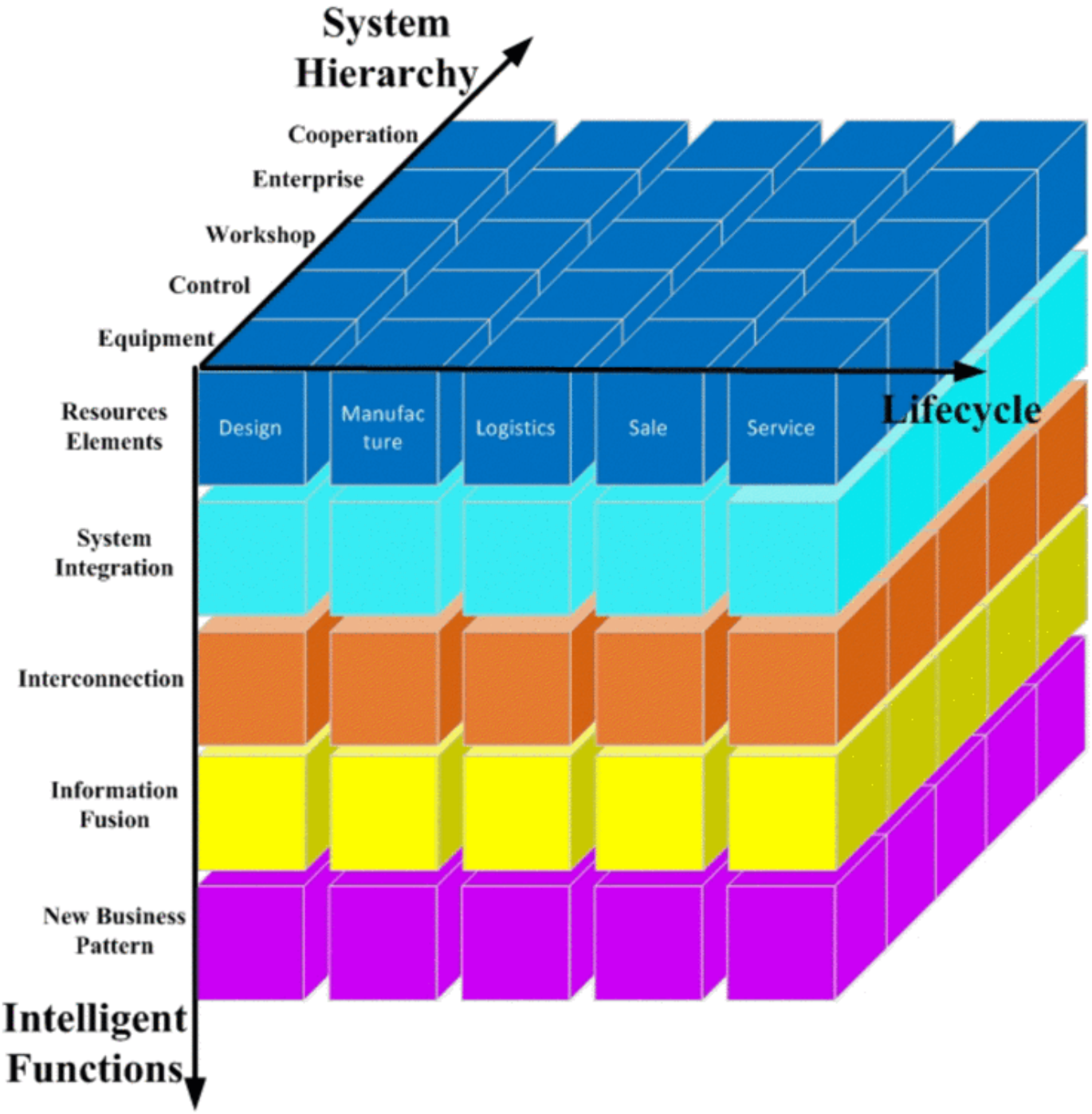

Image source: https://ieeexplore.ieee.org/mediastore_new/IEEE/content/media/8244402/8256062/8256234/8256234-fig-1-source-large.gif

The IMSA model covers three dimensions: "lifecycle", "system hierarchy" and "intelligent functions".

The "lifecycle" dimension refers to activities in value creation, starting from product prototypes and ending at product recycling and remanufacturing. This dimension is subdivided in the following elements (ordered from the beginning of the product lifecycle towards the end): - Design (research and development activities towards the product) - Manufacture (the product is created) - Logistics (the product is transported to its destination) - Sale (the product is transferred from the manufacturer's enterprise to a client) - Service (activities and results generated during the communication between service providers and clients, e.g. recycling)

The "system hierarchy" dimension represents the organizational structure of the enterprises related with the products. It is subdivided in: - Equipment (realization, perception and actuation with regards to control of the physical process) - Control (information processing, monitoring and control of the physical process) - Workshop (structuring of manufacturing and

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management in the factory/workshop) - Enterprise (structuring of effective enterprise management) - Cooperation (interconnection and sharing of internal and external information by the enterprise)

The dimension "intelligent functions" focuses on aspects in communication technology. They aim to achieve self-sensing, self-learning, self-decision, self-execution and self-adaptation. This dimension is subdivided in: - Resources Elements (digital process during the manufacturing process) - System Integration (integration of intelligent equipment within the production unit or line, the workshop, factory and/or manufacturing system) - Interconnection (connections between equipment and control systems through communication technologies) - Information Fusion (achieve collaborative information, e.g. with cloud computing, big data) - New Business Pattern (perform value chain integration between enterprises)

Facts and Figures

- First release Dec 30, 2015

Stakeholders

- Standardization Administration of the People's Republic of China
- China Electronics Standardization Institute

Use Cases

- Central guidance for intelligent manufacturing
- Seamless integration of the onsite data

Industry Sectors

- Manufacturing
- Automation
- Energy
- IIoT (Industrial Internet of Things)

International Distribution

Google Trends

Sources

- https://www.plattform-i40.de/IP/Redaktion/EN/Downloads/Publikation/hm-2018-manufacturing.html
- Wei, Sha, et al. "The essential elements of intelligent manufacturing system architecture." 2017 13th IEEE Conference on Automation Science and Engineering (CASE). IEEE, 2017.

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Industrial Data Spaces

Connections to other concepts

- Reference architecture model IDS-RAM is based on RAMI 4.0
- IDS-RAM (reference architecture model for international data rooms)
- GAIA-X RAM describes the concepts required to build the GAIA-X data and infrastructure ecosystem with the aim of creating a federated open data infrastructure
- OPC UA with Companion Specifications is a basis of sovereign digital ecosystems. This achieves interoperability through system and platform independence, standardized use of different types of communication and standardized content.
- AAS with SMT is a digital representation of an asset in the context of Industrie 4.0 and provides data about an asset (e.g. product life cycle data). In combination with the asset, it is referred to as an Industry 4.0 component and serves as an enabler for mapping an entire value chain.

Short description

- The Data Space Support Center (DSSC) defines that a data space is a distributed system defined by a governance framework. It enables secure and trustworthy data transactions between participants supporting trust and data sovereignty. It is implemented by one or more infrastructures and enables one or more use cases.
- Fraunhofer characterizes Industrial data spaces by the following key features
- data sovereignty - the data owner determines terms of use of their data and under which conditions transactions of their data may take place
- security of data transactions - Guarantee of data security across entire data supply chains via a protection level concept
- Decentralization and federal architecture - no central instance for data storage or governance tasks, but manifestation as the totality of all endpoints with Industrial Data Space Connectors
- Governance and common rules - Joint development of rights and obligations for data management, derived from user requirements
- Network of platforms and services - Connection between data provider (companies, machines, persons, data platforms or marketplaces) and data user
- Scaling and network effects - the more participants in the data space, the more attractive it is for data providers, users and data service providers (infrastructural character)
- According to Fraunhofer, there are designated roles in the Data Space and each participant can perform one or more roles and can delegate individual activities to third parties:
- Data provider: Owner of data sources that he can make available to other participants in the Industrial Data Space while maintaining his sovereignty over them.
- Data user: obtains data from other participants.
- Broker: Mediates data offers and data requirements between data providers and data users.
- AppStore operator: Software and data services developed by different participants can be made available in the app store.
- Certification body: ensures that the software components of the Industrial Data Space fulfill the jointly defined user requirements and comply with norms and standards.

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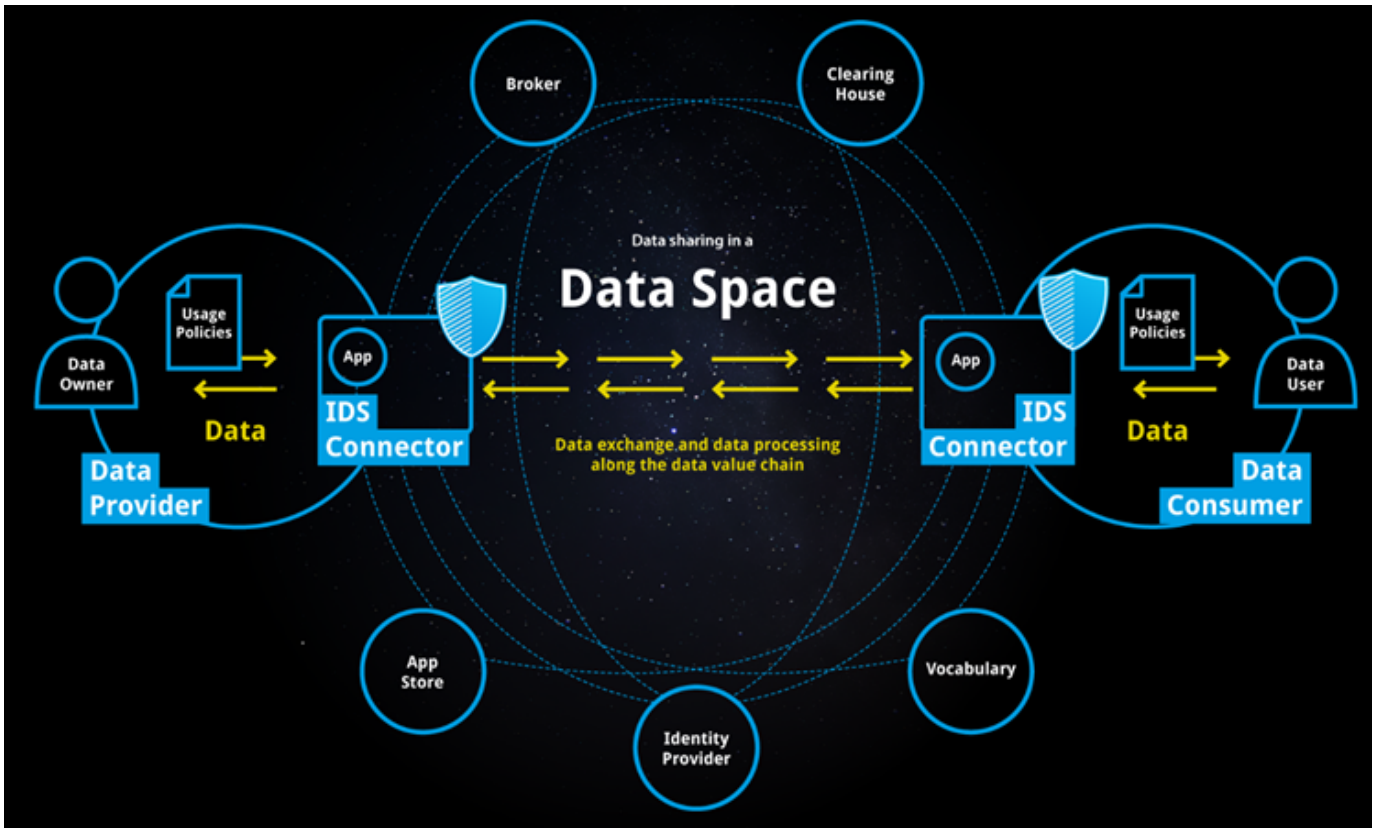

Figure 1 Overview of functionality of a Data Space (Source: https://internationaldataspaces.org/why/data-spaces/)

Facts and figures

- The Fraunhofer-Gesellschaft has produced a white paper on Industrial Data Spaces to provide an overview of their objectives and architecture and to present selected application scenarios and the Industrial Data Space e.V.
- Influence of European legislation as part of the European data strategy: Data Act, Data Governance Act, Digital Services Act, Cyber Resiliency Act and NIS-2
- Overview of the various European initiatives on digital sovereignty

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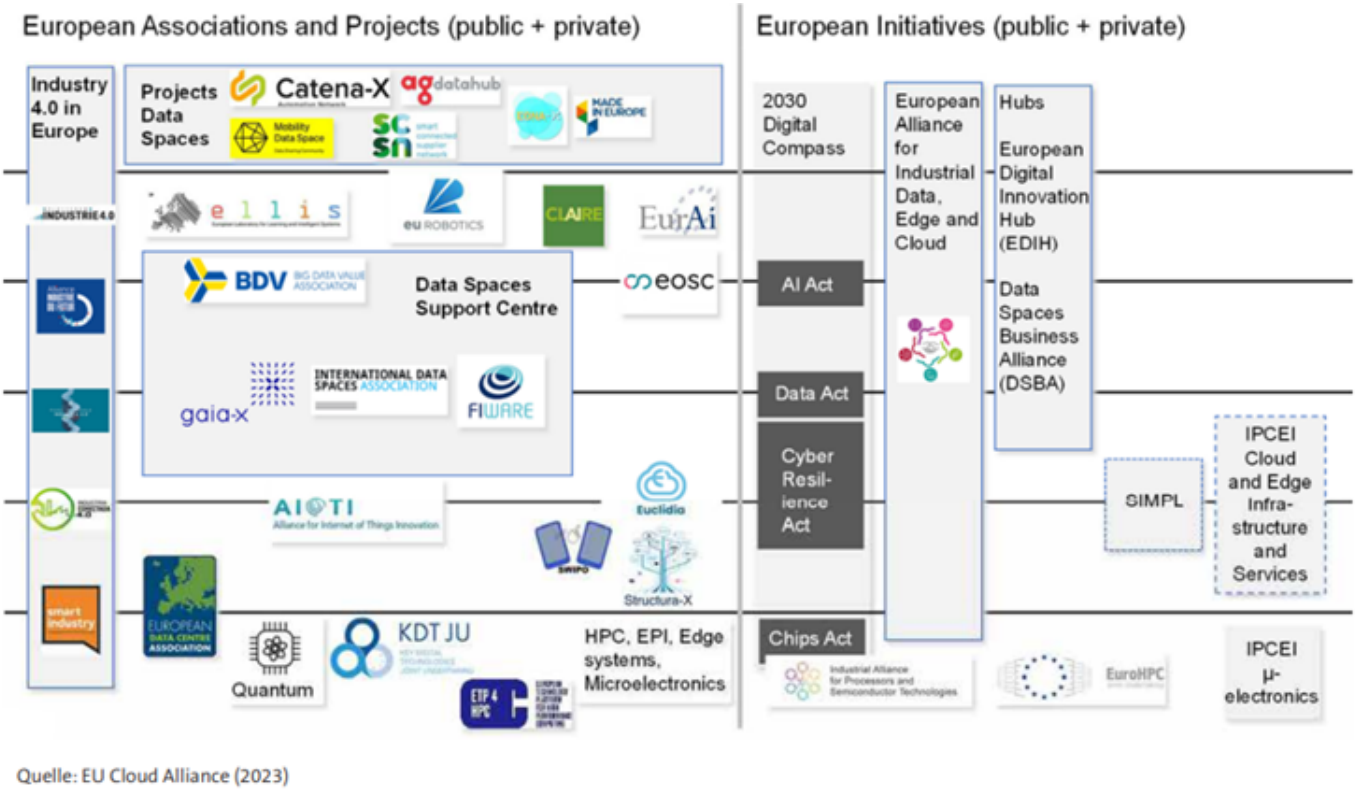

Quelle: EU Cloud Alliance (2023)

Figure 2 European initiatives on digital sovereignty (Source: d7ddb31f-7d90-1e9e-d6ae-ed05246dee63 (vdma.org))

Stakeholders

- VDMA (German Engineering Federation)
- Fraunhofer-Gesellschaft
- DSSC (Data Space Support Center)
- Industry 4.0 platform
- IDTA (Industrial Digital Twin Association)
- IDS (International Data Space e.V.)
- European Commission
- National ministries (EU)
- IDSA (International Data Spaces Association)
- GAIA-X AISBL
- Catena-X Automotive Network e.V.

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Use cases

- Industry-related data room initiatives
- Manufacturing-X (Plattform Industrie 4.0 - Manufacturing-X Initiative (plattform-i40.de))
- SM4RTENANCE (Home - SM4RTENANCE)
- Catena-X Automotive Network (Catena-X Automotive Network | Catena-X)
- Mobility Data Space (Mobility Data Space - Mobility Data Space - The Data Sharing Community (mobility-dataspace.eu))
- Silicon Economy (Homepage - Silicon Economy (silicon-economy.com))
- Smart Connected Supplier Network (SCSN) (Home (smart-connected.nl))
- FabOS (FabOS (fab-os.org))
- InterOpera (Homepage - InterOpera)
- EuProGigant (EuProGigant The lead project for GAIA-X in the production environment)
- SmartAgriHubs (Homepage | SmartAgriHubs)

Industry sectors

- Mechanical engineering
- Chemical and pharmaceutical industry
- Food industry
- Automotive industry
- Electrical industry
- Other industries

Sources

- Industrial Data Space - Digital sovereignty over data (White Paper) (fraunhofer.de)
- d7ddb31f-7d90-1e9e-d6ae-ed05246dee63 (vdma.org)
- Starter Kit for Data Space Designers | Version 1.0 | March 2023 - Starter Kit - Data Spaces Support Center (dssc.eu)
- 2. core concepts - Glossary - Data Spaces Support Center (dssc.eu)
- Data Spaces - International Data Spaces

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ISA-88 Batch control

Connections to other Concepts

- Published by ISA (International Society of Automation) as ANSI/ISA-88
- Published by IEC (International Electrotechnical Commission) as IEC 61512-1
- Example implementation in OPC UA Companion Specifications for PackML OPC 30050
- JSON and XML (BatchML) implementation available from MESA B2MML (Manufacturing Enterprise Solutions Association Business to Manufacturing Markup Language)

Short Description

- ISA-88 provides consistent standards and terminology for batch-oriented control
- Data structure to simplify programming, configuration tasks and communication between the various components of the system
- Defines an architecture based on hierarchical models:
- Process model
- Physical model
- Procedural control model
- Control activity model
- Recipes
- The picture shows an overwiew of the elements in the physical model, the procedural control model and the process model of ISA-88

Facts and Figures

- 1995: Published by the ISA (International Society of Automation)
- 1997: Published by the IEC (International Electrotechnical Commission) under the name "IEC 61512-1 Batch Control: Models and Terminology".

Stakeholders

- Published by ISA (International Society of Automation) and IEC (International Electrotechnical Commission)
- Technology Partners: Care Automation, Rockwell Automation, Siemens, Wonderware Benelux B.V., Schneider Electric

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- Associates: Actemium, ÅF Group, Apriso, Agidens, ICT Automatisering, Beenen Industriële Automatisering, KSE Process Technology, ProLeiT B.V., Raster, Simac Quadcore
- OMAC with OMAC PackML (Organization for Machine Automation and Control Packaging Machine Language), an implementation example of ISA-88

Use Cases

- Software design, equipment and processes in batch control

Industry Sectors

- Process Technology, such as chemical, pharmaceutical, and food and beverage manufacturing

International Distribution

Expert Review

- Originally North America
- Asia
- Europe
- Oceania

Google Trends

Quelle

- https://www.isa.org/
- https://www.mesa.org

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ISA-95

Connections to other Concepts

- Published by ISA (International Society of Automation) as ANSI/ISA-95
- Based on ISA-88 concepts
- Represented in OPC UA Companion Specifications OPC 10030 and OPC 10031-4
- JSON and XML implementation available from MESA B2MML (Manufacturing Enterprise Solutions Association Business to Manufacturing Markup Language)

Short Description

- ISA-95 is the international standard for the integration of business and control systems.
- ISA-95 consists of models and terminology that can be used to define what information needs to be exchanged between systems for sales, finance and logistics and systems for production, maintenance and quality
- This information is structured in UML models, which are the basis for the development of standard interfaces between ERP and MES systems

Facts and Figures

- 2000: published by ISA (International Society of Automation)

Stakeholders

- Published by ISA (International Society of Automation)
- Technology Partners: Care Automation, Rockwell Automation, Siemens, Wonderware Benelux B.V.
- Associates: Actemium, ÅF Group, Apriso, Agidens, ICT Automatisering, Beenen Industriële Automatisering, KSE Process Technology, ProLeiT B.V., Raster, Simac Quadcore

Use Cases

- Hierarchical models to define corporate structures
- Functional models to assign departments and systems to their functions
- Functional models to exchange information
- Unified definition of functions and information flows
- Object models and attributes to represent and exchange relationships between different types of information

Industry Sectors

- Discrete Manufacturing
- Discrete Manufacturing, Process Manufacturing, Batch Manufacturing

International Distribution

- Originally North America
- Asia
- Europe
- Oceania
- South America

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Google Trends

Sources

- https://www.isa.org/standards-and-publications/isa-standards/isa-standards-committees/isa95
- https://opcfoundation.org/markets-collaboration/isa-95/

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ISO 23247 - Digital twin framework for manufacturing

Connections to other Concepts

- Published by ISO (International Organization for Standardization) as ISO 23247
- Manages Digital Twin

Short Description

- The Digital twin framework for manufacturing consists of a number of protocols for generation and maintenance of digital twins
- The standard is structured in four layers:
- First layer: This layer describes the elements in the manufacturing area that need to be modeled
- Second layer: This layer collects all state changes of the monitored manufacturing elements and controls these manufacturing elements if changes are necessary
- Third layer: This layer models the digital twins. It reads the data gathered in the second layer and uses the information to update its models
- Fourth layer: Applications that use the digital twins, to make production more efficient (ERP, PLM)

Facts and Figures

- Published Oct. 2021 by ISO (International Organization for Standardization) as ISO 23247 (4 parts)

Stakeholders

- ISO (International Organization for Standardization) technical committee "Industrial data"

Use Cases

- Integration of automation systems
- Digital Twin in production
- Empower applications to develop better products more efficiently

Industry Sectors

- IoT (Internet of Things)

International Distribution

Google Trends

Sources

https://www.ap238.org/iso23247/

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MESA B2MML (Manufacturing Enterprise Solutions Association Business to Manufacturing Markup Language)

Connections to other Concepts

- Defines ISA-95 XML and JSON implementation

Short Description

- Defines an XML implementation of the data structures defined in ISA-95 for the integration of business and control systems.

Facts and Figures

- First released in 2002 as version 1.0, current version 7.0 released in 2020.
- Includes XML implementations of IEC 61512 (ISA-88) and ISO 22400 KPI specification

Stakeholders

- Published by MESA international (Manufacturing Enterprise Soloutions Association)
- Technology Partners: Rockwell Automation, Siemens, Aveva, Yokogawa

Use Cases

- Exchange of production schedules and production responses
- Exchange of work orders and work responses
- Exchange of production capability
- Exchange of recipes and batch records
- Exchange of KPIs

Industry Sectors

Discrete, Process, and Batch Manufacturing

International Distribution

Google Trends

Sources

- https://mesa.org/topics-resources/b2mml/
- https:/www.mesa.org

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NOA (NAMUR Open Architecture)

Connections to other Concepts

- Developed by NAMUR and ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)
- Based on OPC UA (Open Platform Communications Unified Architecture)
- Compatible with MTP (Module Type Package)

Short Description

- NOA offers a conceptual approach for an open structure in process automation
- Namur pyramid as an extension of the classic automation pyramid
- Expands automation structures for more flexible implementation of Industrie 4.0 for new and existing plants
- Focus of the standard:
- Supplement to existing process automation structures
- Based on existing standards
- Easy integration of it-components on all levels of the automation pyramid
- Lower the cost of information through open, scalable and integrative approaches
- Pose no risk to availability and security of the existing system
- Five building blocks
- "NOA Information Model" to define the syntax and semantics of the data transmitted
- "NOA Diode" for data transfer from production devices (core process control CPC) to monitoring and optimization (M+O) devices
- "NOA Verification of Request" for a controlled data transmission from M+O domain to CPC domain
- "NOA Aggregating Server" aggregates data sources for M+O applications
- "NOA M+O additional sensors" new sensors that are not part of process automation and can be used flexibly and at low cost

Facts and Figures

- First published in 2020

Stakeholders

- NAMUR
- ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)

Use Cases

- Monitoring of field devices, process analysis devices, electrotechnical equipment
- Plant or fleet management of mechanical equipment
- Access to additional data and the associated possibility for extended evaluations and process optimisation
- Production monitoring

Industry Sectors

Process Technology, such as chemical, pharmaceutical, and food and beverage manufacturing

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International Distribution

Google Trends

Sources

https://www.namur.net/de/fokusthemen/namur-open-architecture.html https://www.namur.net/fileadmin/media_www/fokusthemen/20200710_NAMUR_NOA_Overview_DE.pdf

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OMAC PackML (Organization for Machine Automation and Control Packaging Machine Language)

Connections to other Concepts

- Implementation of the ISA-88 Batch control procedure state model for equipment
- Adopted by ISA (International Society of Automation) as TR88.02
- Representation as OPC UA Companion Specifications in OPC 30050

Short Description

- ISA standard interface to converting and packaging equipment
- Data structure to simplify programming, configuration tasks and communication between the various components of the system

Facts and Figures

- Originally published in 1998, adopted by ISA (International Society of Automation) in 2008, updated in 2015 & 2022 (latest version)

Stakeholders

- Technology Partners: Mettler-Toledo, Domino, Corning, Emerson, Rockwell Automation, PMMI, Bosch Rexroth, Weihenstephan Group, Yaskawa, Beckhoff, Pepsico, Siemens, Mitsubishi Electric, Beckhoff, Nestlé

Use Cases

- Monitor and control production equipment
- Increase speed to production
- Ease line integration
- Improve reliability
- Standard defined machine states and operational flow
- Overall Equipment Effectiveness data
- Root Cause Analysis data
- Flexible recipe schemes and common SCADA or MES inputs

Industry Sectors

- Process Engineering
- Packaging
- Discrete assembly

International Distribution

- originally North America
- Asia
- Europe

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Google Trends

Sources

- https://www.isa.org/
- https://www.omac.org/packml

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RAMI 4.0 (Reference Architecture Model Industrie 4.0)

Connections to other Concepts

- Alignment with IMSA
- Part of Data Spaces in GAIA-X RAM
- Scope is Industrie 4.0
- Mentions OPC UA (Open Platform Communications Unified Architecture) as option for the communication layer
- AML (AutomationML) can be considered on the information layer
- Developed by Plattform Industrie 4.0 and ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)

Short Description

- Reference Architecture Model Industry 4.0
- Enables various concepts in Industrie 4.0 to be systematically classified and further developed.
- All assets in the digital factory can be clearly mapped.

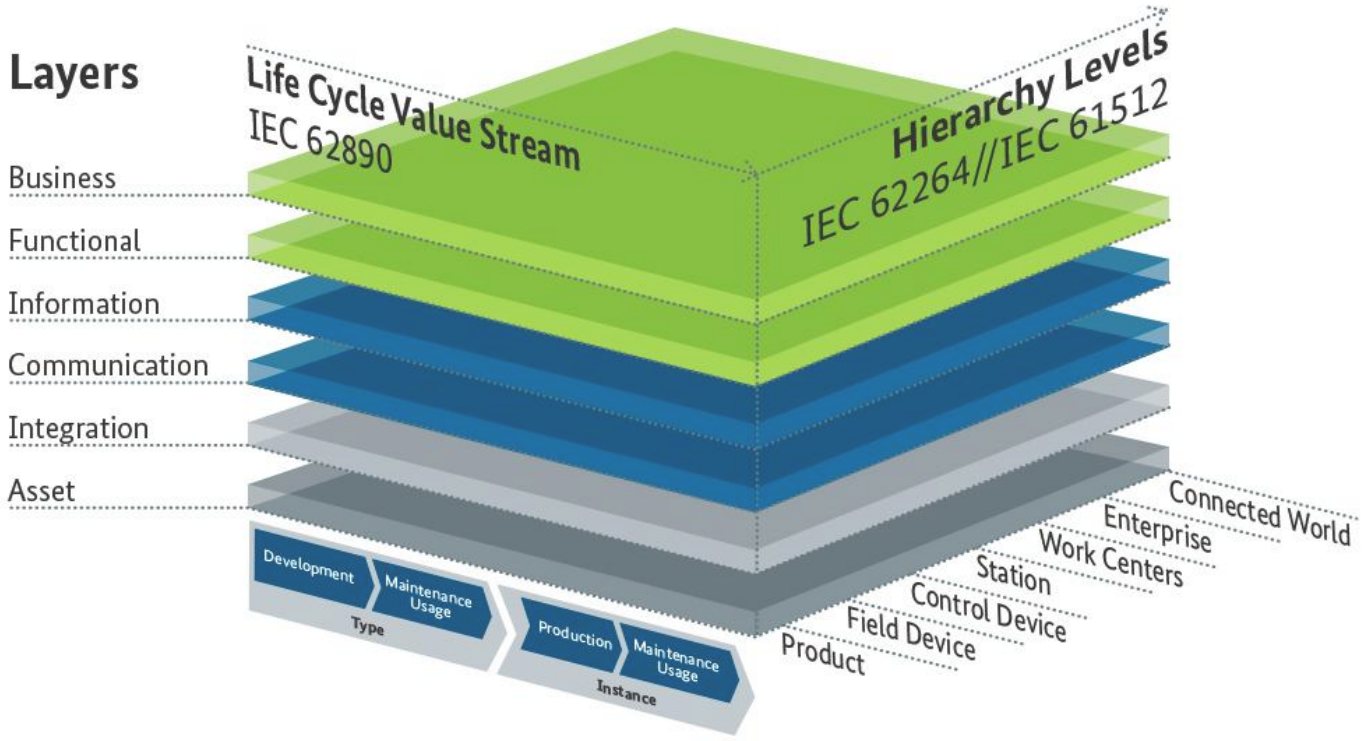

Image source: https://www.plattform-i40.de/IP/Redaktion/EN/Infographics/reference_architecture_model_40.html

The "Layers" axis represents different perspectives: - Business (Business models and business processes, orchestration, legal and regulatory framework) - Functional (description and integration of functions, run time environment for applications and technical functionality) - Information (Processing and handling of events) - Communication (standardisation, uniform data format) - Integration (information on assets, process control, event generation, interaction with humans) - Asset (represents reality)

The "Life Cycle & Value Stream" is split in two major categories: - Type (ideas in development phase, development and testing with first prototypes) - Instance (individual manufactured products)

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On the "Hierarchy Levels" axis, the location of functionalities and responsibilities within the factories/plants is represented. It contains: - Product - Field Device - Control Device - Station - Work Centers - Enterprise - Connected World

Facts and Figures

- Presentation 2015 (Hanover Fair)
- First release as DIN SPEC 91345 (Published 2016)

Stakeholders

Development: - ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie) (German Electrical and Electronic Manufacturers' Association) - Plattform Industrie 4.0

Use Cases

- Central guidance for industry 4.0

Industry Sectors

- Cross-sector architecture model

International Distribution

- Asia
- Europe

Google Trends

Sources

[1] JTG2_Whitepaper_final_20171205.pdf

https://www.dke.de/de/arbeitsfelder/industry/rami40 https://www.plattform-i40.de/IP/Redaktion/EN/Infographics/reference_architecture_model_40.html

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5. Concepts

Concepts

This part of the catalog contains different kinds of broader concepts within industrial communication. They are defining solutions and efforts, thus have a high impact in planning and development. Yet they are usually both broad and lack a precise description with universal validity. For this reason, the same term might be used for different aspects when encountered in different sources.

Currently, the following entries are available:

- Digital Product Passport
- Digital Twin
- I4.0 Component
- Industrie 4.0
- Manufacturing-X
- MIC2025 (Made in China 2025)

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Digital Product Passport

Connections to other Concepts

- Neutral in technology, possible representations among those listed in this catalog are AAS Submodel Templates and Submodels_and_Submodels/AAS Submodel Templates and Submodels.md), OPC UA Information Models
- Can be considered part of a Digital Twin

Short Description

- The digital product passport is a data set that originates from all phases of the product life cycle and can be used in all these phases
- The data summarizes the components, materials and chemical substances, as well as information about reparability, spare parts or proper disposal for a product
- The data can be used for different purposes, e.g. in design, production, use or disposal
- The overall aim is to achieve more transparency in materials and products

Facts and Figures

- An integral part of the political strategies of the European Union (EU)

Stakeholders

- European Union

Use Cases

- Structuring environmentally relevant data in a standardized, comparable format enables all actors in the value and supply chain to work together towards a circular economy
- The digital product passport is a basis for reliable consumer information and sustainable consumption decisions in stationary as well as online retailing

Industry Sectors

- Cross-sector data description

International Distribution

- Asia
- Europe
- North America

Google Trends

Sources

https://www.bmuv.de/digitalagenda/auf-einen-klick

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Digital Nameplate

Connections to other Concepts

- Uses Asset Administration Shell

Short Description

- The digital nameplate enables a user to obtain information about a product in a digital way. It is a human- and machine-readable identification
- A QR code or RFID chip is intended to be used as the data medium
- The Digital Nameplate includes all legally required information and labelling for the distribution, transport and safe use of the product in digital and standardized form
- The minimum requirements, such as the manufacturer and product name, are still present in plain text on the conventional type plate
- Conformity marks, such as the CE mark, will also remain visible
- The digital nameplate contains all information of physical nameplates and may add further data
- These include, for example:
- Manufacturer name and address
- Product name and type
- Serial or batch number
- Country of manufacture
- Year of manufacture
- References to relevant documents -

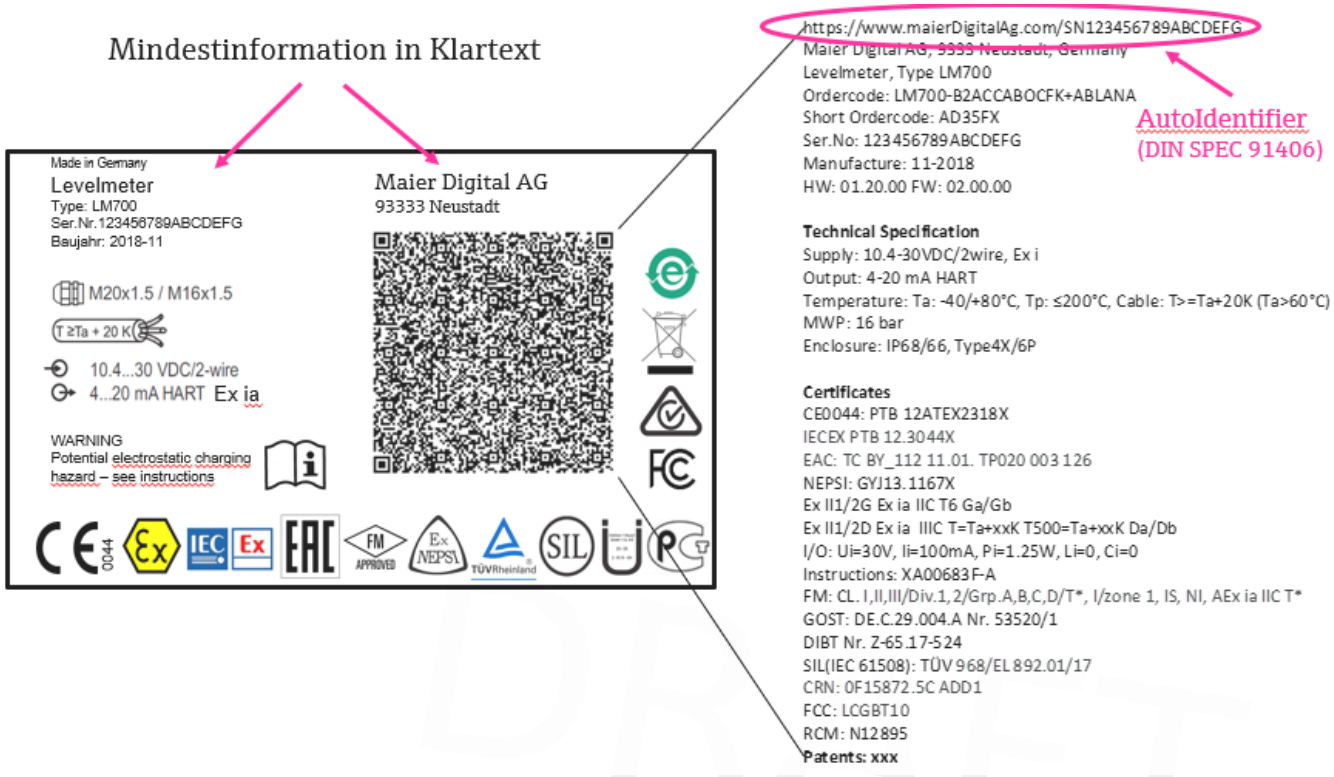

Image source: https://ex-magazine.r-stahl.com/article/detail/das-digitale-typenschild-im-zeitalter-von-industrie-40

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Facts and Figures

- Development since 2018
- DIN SPEC 91406, a standard for digital product identification that essentially corresponds to the digital type plate published at the end of 2019

Stakeholders

- Co-developed by ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)
- Co-developed by Helmut Schmidt University Hamburg (UniHamburg)
- Co-developed by Plattform Industrie 4.0

Use Cases

- Save time and money: Immediate access to the latest documents is made possible.
- No printing and logistics costs: A valid, manufacturer-independent standard according to DIN SPEC 91406.
- It helps to protect our woodland and to reduce CO2 emissions
- Independence of limitations in space (size of physical nameplate, dimensions/weight of printed documentation)
- Worldwide availability: Documents in the respective national language, as well as the local certificates (CE, CCC, ...) are made available.
- Easier updatability if new information is available
- Sustainability: It saves resources and makes paper documentation superfluous.
- Asset management

Industry Sectors

- Cross-sector data description

International Distribution

Google Trends

Sources

- https://www.plattform-i40.de/IP/Redaktion/DE/Kurzmeldungen/2020/2020-10-20-Digitales_Typenschild.html
- https://ex-magazine.r-stahl.com/article/detail/das-digitale-typenschild-im-zeitalter-von-industrie-40

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Digital Twin

Connections to other Concepts

- May contain a Digital Shadow
- Contains Digital Master
- There are various forms of representations, either singular or in conjunction, like Asset Administration Shell, Digital Product Passport and Digital Nameplate
- Can aggregate different other representations of the physical item, like BIM

Short Description

General

- To date, there is no consensus on what a digital twin is and what characteristics it should have. Many different definitions and characteristics have emerged.
- Nevertheless, the description of the digital twin has been developing steadily since 2003 and has decoupled itself from the NASA definition as a pure simulation of a system.
- Current definition: A digital twin is a digital representation of a product instance (real device, object, machine, service or intangible good) or an instance of a product-service system (a system consisting of product and associated service).
- A digital twin contains selected characteristics, states and behaviour of the product instance or system
- Allows simulation, control and improvement of the systems
- According to the different levels of integration, the digital twin can be divided into three subcategories: Digital Model (DM), Digital Shadow (DS) and Digital Twin (DT)
- Can be based on the Digital Master and linked to the Digital Shadow.

Digital Twin Theory:

- A digital twin is a digital representation of an instance
- A digital twin can be in multiple locations simultaneously
- A digital twin has multiple states
- In an interaction situation, the digital twin has a context-specific state
- The information model for digital twins is infinite, it is a real information model
- The real information model can be finitely approximated for a specific application scenario and thus becomes a rational information model
- The rational information model cannot be stored in one place
- The rational information model is never completely visible

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Facts and Figures

- 2002: The concept of the digital twin goes back to a presentation by Dr. Michael Grieves at the University of Michigan on the foundation of a Product Lifecycle Management (PLM) centre.
- The presentation was called "Conceptual Ideal for PLM" and contained various elements of the Digital Twin: real model, virtual model, the connection of the data flow from the real to the virtual model...
- 2010: A first definition of the term "Digital Twin" was published by the National Aeronautics and Space Administration (NASA):
- "integrated multiphysics, multilevel, probabilistic simulation of a vehicle or system that uses the best available physical models, sensor updates, fleet history, etc., to represent the life of its "flying twin". Following this definition, the Digital Twin is a highly detailed simulation model of spacecraft or aircraft that attempts to reproduce physical behaviour as accurately as possible in the virtual world."

Stakeholders

Use Cases

- Production monitoring, production optimisation, predictive maintenance, quality management, restructuring, plant planning and virtual commissioning, logistics planning Product monitoring, product development
- Diagnosis and prognosis of real product instance behaviour as well as safeguarding of new product generations
- Basis for the development of new business models

Industry Sectors

- Cross-sector concept

International Distribution

- Africa
- Asia
- Europe
- North America
- Oceania
- South America

Google Trends

Sources

- A. Deuter und F. Pething - "The Digital Twin Theory"
- https://ntrs.nasa.gov/api/citations/20120008178/downloads/20120008178.pdf

Digital Shadow

Connections to other Concepts

Short Description

- The digital shadow is the process data that machines generate during their operation when producing an instance.
- This is raw data, which is also referred to as a digital footprint.
- These include, for example, operating and status data, process data, layout data, scan data...

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- Is enriched with real data from the use of the real product

Facts and Figures

Stakeholders

Use cases

- On the one hand, data is the input for condition monitoring and on the other hand, it forms the basis for comprehensive insights that can be gained through data mining (pattern finding in the raw data)
- Allows conclusions to be drawn from the enriched data, as well as optimizations and changes to be tested and made

Industry Sectors

- Cross-Sector concept

International Distribution

- Asia
- Europe
- North America
- Oceania
- South America

Google Trends

Sources

https://www.industrie40.net/index.php/61-beitraege-d/224-digitaler-schatten

Digital Master

Connections to other Concepts

Short Description

- Enables organisations to collect and maintain system information and to make system information available to stakeholders at a given point in time.
- Represents a document-based approach in the development of complex products that enables modern organisations to exchange product data with downstream processes

Facts and Figures

Stakeholders

Use Cases

- Allows conclusions to be drawn from the enriched data, and optimisations and changes to be tested and implemented

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Industry Sectors

- Cross-Sector concept

International Distribution

- Africa
- Asia
- Europe
- North America
- Oceania
- South America

Google Trends

Sources

Biahmou et al. - "Digital Master as an Enabler for Industry 4.0"

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I4.0 Component

Connections to other Concepts

- Data is represented via Asset Administration Shell
- Based on RAMI 4.0 (Reference Architecture Model Industrie 4.0)

Short Description

- The I4.0 component is the unit of asset and digital image (Asset Administration Shell), both uniquely identified with URIs
- An I4.0 system can offer services to the I4.0 component via a standardized API

Facts and Figures

Stakeholders

- ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)
- Plattform Industrie 4.0
- IDTA (Industrial Digital Twin Association e.V.)
- SCI 4.0 (Standardization Council Industrie 4.0)

Use Cases

Industry Sectors

- Cross-sector concept

International Distribution

Google Trends

Sources

https://i40.iosb.fraunhofer.de/I4.0-Komponente

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Industrie 4.0

Connections to other Concepts

- GAIA-X RAM, IDS-RAM (International Data Spaces Reference Architecture Model), IIRA (Industrial Internet Reference Architecture) and IMSA (Intelligent Manufacturing System Architecture) provide architecture models for Industrie 4.0
- The Asset Administration Shell, BIM (Building Information Modeling), ISA-88 Batch control, ISA-95, OMAC PackML (Organization for Machine Automation and Control Packaging Machine Language) and many others describe possible individual parts within such a whole architecture
- Projects such as Manufacturing-X support the idea "Industrie 4.0" both from a research and an industry perspective
- All Organizations listed in this catalogue contribute to Industrie 4.0
- All technologies listed in this catalog are used in the context of Industrie 4.0

Short Description

- The intelligent internetworking of machinery and processes in industry
- Central technology: internet, worldwide connectivity across companies and geographical borders

Facts and Figures

Stakeholders

Use Cases

- Continuous acquisition and analysis of production data
- Predictive Maintenance - preventative maintenance tasks based on analyses of device data
- Introduction of smart products and services
- Increase in productivity, e.g. by means of data-backed process optimization
- Monitoring of production tasks and quality
- Usage of augmented reality in production, e.g. for training
- Resource-saving circular economy

Industry Sectors

- All sectors

International Distribution

- Africa
- Asia
- Europe
- North America
- South America

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Google Trends

Sources

https://www.plattform-i40.de/IP/Navigation/DE/Industrie40/WasIndustrie40/was-ist-industrie-40.html

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MIC2025 (Made in China 2025)

Connections to other Concepts

- IMSA (Intelligent Manufacturing System Architecture) can be considered an intermediate result

Short Description

- Made in China 2025 is a strategic plan of the Chinese government from May 2015.
- An initiative to comprehensively upgrade China's manufacturing sector, inspired by Germany's Industrie 4.0, among other things
- The domestic manufacturing sector is to be modernized and reach an advanced level by 2025. Beyond MIC 2025, further milestones are planned. The goal is to reach a medium-class level by 2035 and a world-class level by 2049, eventually catching up with leading industrialized nations
- The goal is to restructure the entire industry to make it more competitive internationally. The focus is primarily on quality and efficiency

Facts and Figures

- Founded in May 2015

Stakeholders

China

Use Cases

- Within the framework of MIC 2025, 10 key sectors have been defined in which major breakthroughs are to be achieved and dependencies on foreign countries are to be reduced:
- Machinery for agriculture
- Shipbuilding and marine technology
- Energy saving and electromobility
- New generation information and communication technologies
- High-end controlled machine tool systems and robotics technology
- Electricity equipment
- Aerospace equipment
- New materials
- Advanced equipment for rail transport
- Biomedicine and high-performance medical equipment

Industry Sectors

- Cross-sector strategic plan

International Distribution

- Asia
- Europe

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- North America
- Oceania
- South America

Google Trends

Sources

https://www.ifo.de/publikationen/2018/aufsatz-zeitschrift/made-china-2025-technologietransfer-und-investitionen

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Manufacturing-X

Connections to other Concepts

- GAIA-X
- Industrial Data Spaces
- OPC UA with Companion Specifications
- AAS with SMT_and_Submodels/AAS Submodel Templates and Submodels.md)

Short Description

- Manufacturing-X is an initiative to implement the Data Space principle in the domain of the manufacturing industry in order to put the entire equipment industry in a position to shape the future and maintain its competitiveness
- The challenge facing the supplier industry is the gradual shift of production of directly upstream functions to the software industry due to the effects of digitalization and the platform economy. This may result in the potential loss of direct access to the end customer market and thus also of importance.
- The solution offered by Manufacturing-X is the creation of a Data Space to enable every manufacturer of network-compatible machines and systems to share their own machine data multilaterally, without a central instance for storage
- As an alternative to the centralized platform economy, the Manufacturing-X Data Space allows its users to determine the rules for accessing and using shared data themselves and remain the sovereign of their company data, while at the same time benefiting from the network effects of data sharing

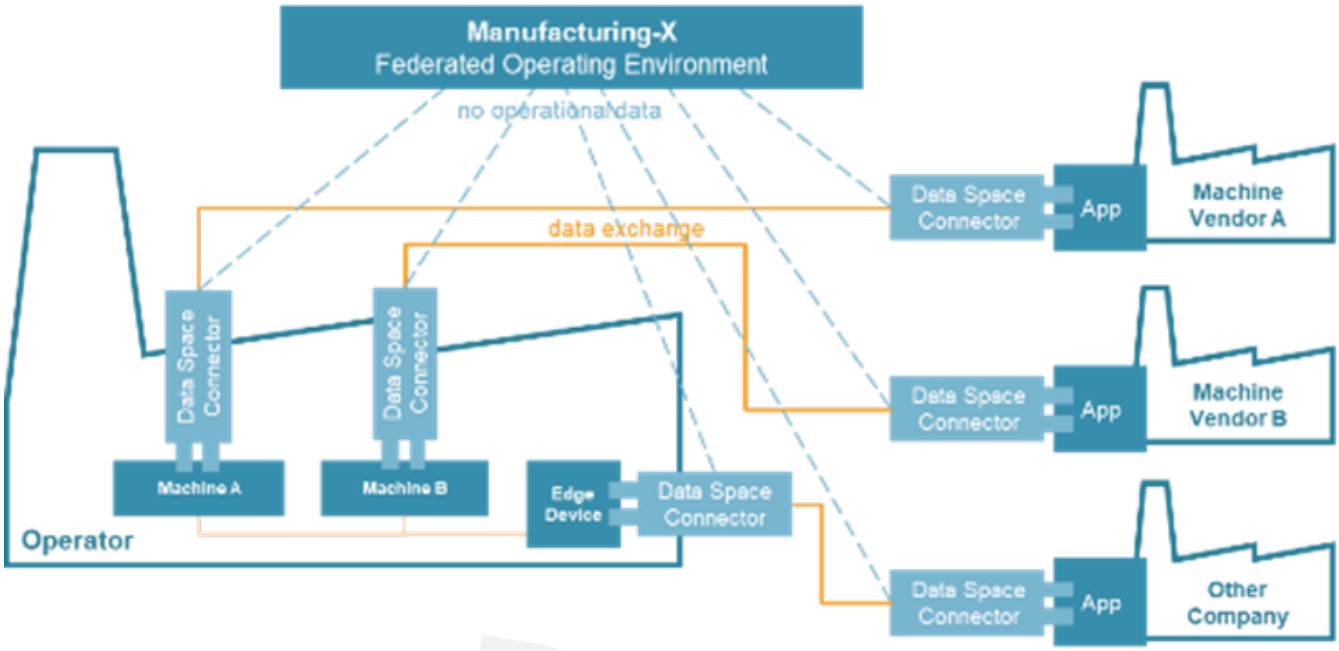

Figure 1 Overview of functionality of the Manufacturing-X Data Space (Source: VDMA)

Facts and Figures

- Announcement by the Federal Ministry for Economic Affairs and Climate Protection (BMWK) of the funding guideline "Digitization of vehicle manufacturers and suppliers and industrial supply chains" in the funding framework "Future investments vehicle manufacturers and suppliers" gives the starting signal for the "Manufacturing-X" funding programme
- The Fraunhofer-Gesellschaft conducted a preliminary study on the Manufacturing-X data room on behalf of the VDMA and ZVEI

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- Plattform Industrie 4.0 published a white paper on Manufacturing-X as an initiative for the digitalization of supply chains in industry
- VDMA published a white paper on Manufacturing-X about approaches to building and establishing a German and European data ecosystem for the manufacturing industry

Stakeholders

- Industry 4.0 platform
- VDMA
- ZVEI
- BMWK
- Fraunhofer

Use Cases

- Supply chain transparency
- Production and factory optimization
- Collaborative product innovation
- Energy and CO2 management
- Business models
- Capabilities

Industry Sectors

International Distribution

- Europe

Google Trends

Sources

- https://www.plattform-i40.de/IP/Redaktion/DE/Downloads/Publikation/Manufacturing-X.html
- d7ddb31f-7d90-1e9e-d6ae-ed05246dee63 (vdma.org)

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6. Organizations

Organizations

This part of the catalog holds information about organizations that are active in the realm of interoperability in Industrie 4.0.

Currently, the following entries are available:

- BSI (Bundesamt für Sicherheit in der Informationstechnik Federal Office for Information Security)
- Catena-X Automotive Network e.V.
- CESMII (Clean Energy Smart Manufacturing Innovation Institute)
- DTC (Digital Twin Consortium)
- ECLASS e. V.
- GAIA-X AISBL
- IDSA (International Data Spaces Association)
- IDTA (Industrial Digital Twin Association e.V.)
- IEC (International Electrotechnical Commission)
- IIC (Industry IoT Consortium)
- ISA (International Society of Automation)
- ISO (International Organization for Standardization)
- LNI 4.0 (Labs Network Industrie 4.0)
- NAMUR
- OI4.0 (Open Industry 4.0 Alliance)
- PI (PROFIBUS & PROFINET International)
- Plattform Industrie 4.0
- prostep ivip Association
- SCI 4.0 (Standardization Council Industrie 4.0)
- umati (universal machine technology interface)
- VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.)
- VDW (Verband Deutscher Werkzeugmaschinenfabriken e.V.)
- ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)

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BSI (Bundesamt für Sicherheit in der Informationstechnik / Federal Office for Information Security)

Connections to other Concepts

Short Description

- The Federal Office for Information Security is a German higher federal authority in the division of the Federal Ministry of the Interior, Building and Community
- Responsible for IT security issues of the German government
- Contact in IT security aspects for the German economy, science, society and citizens
- The BSI's mission statement is: "As the federal cyber security authority, the BSI shapes information security in digitalization through prevention, detection and response for the state, the economy and society."

Facts and Figures

- Founded on 1 January 1991
- Headquarters in Bonn, Germany
- Total budget is 197.16 million euros, as of 2022
- Total employees are 1350, as of 2022

Stakeholders

- Germany

Use Cases

- Protection of the federal government's networks, detection and defence against attacks on government networks
- Testing, certification and accreditation of IT products and services
- Warning of malware or security vulnerabilities in IT products and services
- IT security consulting for the federal administration and other target groups
- Information and sensitization of citizens to the topic of IT and Internet security (digital consumer protection)
- Information and sensitization of the business community to the topic of IT and Internet security
- Developing uniform and binding IT security standards
- Development of crypto systems for federal IT

Industry Sector

Cross-sector government organization

International Distribution

- Asia
- Europe
- North America
- Oceania

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Google Trends

Sources

https://www.bsi.bund.de/DE/Home/home_node.html

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CESMII (Clean Energy Smart Manufacturing Innovation Institute)

Connections to other Concepts

- Collaborates with OPC Foundation: leads working group OPC 30400-1+2 - OPC UA for Cloud Library
- Cooperates with Plattform Industrie 4.0 and LNI 4.0 (Labs Network Industrie 4.0)
- Cooperates with DTC (Digital Twin Consortium)
- Cooperates with IIC (Industry IoT Consortium)

Short Description

- Clean Energy Smart Manufacturing Innovation Institute
- Nonprofit institute designed to advance "smart manufacturing" (SM)
- Accelerate the development, adoption, and monetization of industrial IoT technologies, infrastructures, and solutions by bringing technology, solutions, skills, practice, and knowledge together
- Missions of CESMII is (by the numbers) • Double energy productivity in US manufacturing every 10 years • Halve the cost of deploying SM systems relative to state of the art in 5 years • Increase the SM workforce in US multi-fold in 10 years • Double the SM supply chain rate of increase in value and participation • Reduce U.S. energy use in 10 years while increasing manufacturing competitiveness

Facts and Figures

- Founded in 2016, in partnership with Department of Energy’s Office of Energy Efficiency and Renewable Energy (EERE) of the U.S. government with $70 million in funding
- The head office is located in Los Angeles, California, United States (University of California, Los Angeles)
- Five Regional Centers:
- North East (NY),
- South East (NC),
- Gulf Coast (TX),
- California (CA),
- Pacific North West (WA)

Stakeholders

- U.S. Government

Members of CESMII

Use Cases

- Breaking down barriers to progress by bringing technology, solutions, skills, practice, and knowledge together
- Making the power of information and innovation accessible to all who touch manufacturing
- For Industries like:
- Additive manufacturing
- Aerospace

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- Agriculture
- Automotive
- Cement
- Chemical
- Food
- Injection molding
- Machine tools
- Metal
- Pharma
- Pulp & paper
- Steel
- Supply chain & warehousing
- Thermal treatment

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Industry Sector

Automation Machinery Manufacturing

International Distribution

- North America

Google Trends

Sources

https://www.cesmii.org/about-us/

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Catena-X Automotive Network e.V.

Connections to other Concepts

- Implements specifications of GAIA-X AISBL
- Uses GAIA-X RAM
- Uses results of IDSA (International Data Spaces Association)

Short Description

- The Catena-X Automotive Network creates the first open and collaborative data ecosystem
- Catena-X is intended to be a rapidly scalable and extensible ecosystem in which all participants in the automotive value chain can participate equally
- The goal is to provide an environment for building, operating and collaboratively using end-to-end data chains along the entire automotive value chain
- Catena-X develops services and standards for a coordinated data exchange in the automotive sector using data spaces of GAIA-X

Facts and Figures

- Founded in May 2021
- Headquarters in Berlin, Germany

Stakeholders

- Founding members:
- BMW AG,
- Deutsche Telekom AG,
- Robert Bosch GmbH,
- SAP SE,
- Siemens AG
- ZF Friedrichshafen AG

Members of Catena-X

Use Cases

- Standardized and cross-company data exchange in the automotive sector
- Increase the resilience and flexibility of supply chains
- Create the first open and collaborative data ecosystem
- Data ecosystem is based on GAIA-X RAM and work of the IDSA (International Data Spaces Association)

Industry Sector

Automotive

International Distribution

- Asia

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- Europe

Google Trends

Sources

- https://catena-x.net/de/
- https://catena-x.net/en/vision-goals/gaia-x
- https://catena-x.net/en/vision-goals

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DTC (Digital Twin Consortium)

Connections to other Concepts

- Standardizes elements for the Digital Twin
- Cooperates with CESMII (Clean Energy Smart Manufacturing Innovation Institute)
- Cooperates with IDTA (Industrial Digital Twin Association e.V.) and Plattform Industrie 4.0
- Managed by the Object Management Group in parallel to IIC (Industry IoT Consortium)

Short Description

- The Digital Twin Consortium® is a coalition of industry, government, and academia to promote uniformity in the vocabulary, architecture, security, and interoperability of digital twin technology to drive the market for digital twins and demonstrate the value of the technology
- Members establish technical guidelines, publish reference frameworks, develop requirements for new standards, and share use cases to maximize the benefits of digital twins

Facts and Figures

- Established in May 2020
- Headquarters in Milford, Massachusetts, United States
- An Object Management Group® (OMG) program

Stakeholders

- Members:
- AirForce Research Lab
- AnimatedInsights
- Association of Asset Management Professionals
- Autodesk
- Bentley
- Cybertwin
- Dell
- Lendlease
- Microsoft

Members of the Digital Twin Consortium

Use Cases

- Build and establish an extensive multi-faceted ecosystem
- Identify and fill gaps in technology development
- Drive interoperability through frameworks and open-source code
- Develop and advocate consistent best-practice methodologies

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- Work to influence policy and standards requirements
- Publish and amplify architectures, statements, and viewpoints
- Advance scientific and technical research to expand the market

Industry Sector

Information Technology & Services

International Distribution

- North America

Google Trends

Sources

https://www.digitaltwinconsortium.org/

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ECLASS e.V.

Connections to other Concepts

- Publishes ECLASS standard
- The ECLASS standard can be used in most concepts/architectures of Industrie 4.0
- The ECLASS standard enables the digital exchange of product master data across industries, countries, languages or organizations
- Description of the ECLASS standard usage in Catena-X by Catena-X Automotive Network e.V.
- Example of usage in Asset Administration Shell with AAS Metamodel

Short Description

- Standardization repository for terminological interoperability in data exchange
- Classification standard for the unique description of products and services
- Digital representation of products
- Language-neutral, cross-industry

Facts and Figures

- Founded on 14 November 2000
- Headquarters in Köln, NRW, Germany
- a non-profit organization
- Over 150 members (as of 2020)
- A new release every year, latest version: ECLASS Release 13.0 (as of 2023)

Stakeholders

- Founders: Siemens, BASF, Audi / VW, EON, SAP, Bayer AG, Degussa, Wacker Chemie, Infraserv Chemfidence and Solvay.
- Key collaborations: Applia, FIR RWTH Aachen, International Electrotechnical Commission, IOTA, JEITA, SAP, Sparetech.io

Members of ECLASS e.V.

Use Cases

- PIM (Product Information Management)
- Electronic Marketplace
- Electronic Catalog
- Electronic procurement
- For Industries like:
- Industries such as construction, logistics, food, medicine, optics, automotive, laboratory technology and office supplies
- Trade
- Handcraft
- Service sector
- Large public sector organizations such as the state of North Rhine-Westphalia & the Austrian Federal Procurement Agency

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Industry Sector

IT Services and IT Consulting

International Distribution

- Asia
- Europe
- North America

Google Trends

Sources

https://eclass.eu/

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GAIA-X AISBL

Connections to other Concepts

- Catena-X Automotive Network e.V. develops implementation project
- Defines GAIA-X RAM
- Collaboration with IDSA (International Data Spaces Association)

Short Description

- The Gaia-X European Association for Data and Cloud AISBL (in French: Association Internationale Sans But Lucratif, short: AISBL, English: Nonprofit organization laws by jurisdiction) is an international non-profit organization, developing and operating Gaia-X
- GAIA-X is a project for the development of an efficient and competitive, secure and trustworthy data infrastructure for Europe, which is supported by representatives from business, science and administration from Germany and France, together with other European partners
- The goal of the organization is to develop federation cloud services within the existing cloud infrastructures
- To achieve this and to ensure an open and transparent character the Association facilitates the development of an open software infrastructure
- Communication partners have access to a strictly controlled, transparent and securely encrypted data exchange
- Data accesses and their authorizations can be tracked and understood

Facts and Figures

- It is an international non-profit association under Belgian law
- Founded January 2021, by 22 companies and organizations
- Headquarters in Brussels, Belgium
- More than 350 members (as of July 2022), more than 40% SMEs

Stakeholders

- The founding members of GAIA-X AISBL on the German side include Beckhoff Automation, BMW, Bosch, DE-CIX, Deutsche Telekom, German Edge Cloud, Deutsche Telekom, PlusServer, SAP, Siemens along with Fraunhofer Gesellschaft and the IDSA (International Data Spaces Association) and the European cloud provider association CISPE.
- On the French side, Amadeus, Atos, Docaposte, Électricité de France (EDF), Institut Mines-Télécom (IMT), Orange, Outscale, OVHcloud, Safran and Scaleway are among the French Founding Members
- California-based company Palantir, part of the military-industrial complex of the US was also a founding member. Members of Gaia-X AISBL

Use Cases

- Energy
- Finance
- Mobility
- Industry 4.0
- Smart Living
- Agriculture

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Industry Sector

Cloud data services (storage & sharing)

International Distribution

- Asia
- Europe
- North America

Google Trends

Sources

https://www.data-infrastructure.eu/GAIAX/Navigation/EN/Home/home.html https://gaia-x.eu/who-we-are/association/

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IDSA (International Data Spaces Association)

IDSA (International Data Spaces Association; International Data Spaces e.V.)

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Connections to other Concepts

- Collaboration with GAIA-X AISBL
- Develops IDS-RAM (International Data Spaces Reference Architecture Model)

Short Description

- International Data Spaces Association (IDSA); International Data Spaces e.V.
- The IDSA is on a mission to create the future of the global, digital economy with International Data Spaces (IDS), a secure, sovereign system of data sharing in which all participants can realize the full value of their data
- The IDSA strives to create global secure data spaces in which data owners can choose how their data is used and distributed within a given domain (e.g. manufacturing, energy, healthcare, logistics).
- IDS enables new "smart services" and innovative business processes that are designed to work across companies and industries
- Trusted, self-directed exchange of data.
- IDS provides reference architecture, formal standard, and reference implementations including sample code

Facts and Figures

- Founded in Berlin in 2016
- Headquarters in Dortmund, Germany
- A non-profit organization
- Certification of own standards DIN SPEC 27070
- 140+ organizations from 26 countries

Stakeholders

Members of IDSA

Use Cases

Industry Sector

IT Services and IT Consulting

International Distribution

- Europe

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Sources

https://internationaldataspaces.org/

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IDTA (Industrial Digital Twin Association e.V.)

Connections to other Concepts

- Designs Asset Administration Shell
- Cooperates with DTC (Digital Twin Consortium)
- Founded by VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.) and ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)
- Spinoff of Plattform Industrie 4.0

Short Description

- IDTA is to be the central point of contact for the Digital Twin (Asset Administration Shell])
- It is an alliance of active creators working together to make the Digital Twin (Asset Administration Shell]) practical for the industry using open technologies

Facts and Figures

- Founded September 2020 by VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.) and ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)
- Headquarters in Frankfurt am Main, Germany
- 74 member companies from 10 countries (as of 2022)

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Stakeholders

- Founding members:
- ABB
- Asentics
- Bitkom
- Bosch
- Bosch Rexroth
- Danfoss
- EndressHauser
- Festo
- Homag
- KUKA
- Lenze
- PepperlFuchs
- Phoenix Contact
- SAP
- Schneider Electric
- Schunk
- Siemens
- Trumpf
- Turck
- VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.)
- Volkswagen
- Wittenstein
- ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)

Members of the IDTA

Use Cases

- Remote commissioning of plants, (semi)automatic onboarding and initialisation of a Digital Twin in the Asset Management System
- Calculation of the Product Carbon Footprint (PCF) of own and purchased products along the entire value chain
- The discovery and secure sharing of data in multilateral corporate structures
- Seamless flow of information from supplier to customer and vice versa, for more efficiency in the value chain
- Installation of an AAS-based (Asset Administration Shell) system
- Cooperation between manufacturers of electric drives
- Energy consumption of a production at any time
- Automatic, updateable integration of all content relating to machine components and assemblies in an asset management solution from the development phase of a machine
- A quick replacement of a device, without engineering effort

Industry Sector

Automation Machinery Manufacturing

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International Distribution

- Europe

Google Trends

Quelle

https://industrialdigitaltwin.org/

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IEC (International Electrotechnical Commission)

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Connections to other Concepts

- Collaboration with ISO (International Organization for Standardization)

Short Description

- Responsible for norms and standards in the field of electrical engineering and electronics
- The global IEC platform to ensure that products work everywhere safely with each other by preparing and publishing globally relevant International Standards for the whole energy chain, including all electrical, electronic and related technologies, devices and systems
- IEC standards cover a vast range of technologies from power generation, transmission and distribution to home appliances and office equipment, semiconductors, fibre optics, batteries, solar energy, nanotechnology and marine energy as well as many others

Facts and Figures

- Founded in 1906, in Landon, United Kingdom
- Relocation to Geneva, Switzerland in 1948
- 1938 A multilingual international dictionary is published to standardize electrical engineering terms.

Statkeholders

Members of the IEC

Use Cases

Distribution of energy, electronics, magnetism and electromagnetism, electroacoustics, multimedia, telecommunications and medical technology as well as general disciplines such as technical vocabulary and symbols, electromagnetic compatibility, metrology and operational behavior, reliability, design and development, safety and environment

Industry Sector

Standards organization

International Distribution

- Africa
- Asia

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- Europe
- North America
- Oceania
- South America

Google Trends

Sources

https://iec.ch/homepage

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IIC (Industry IoT Consortium)

Connections to other Concepts

- Managed by the Object Management Group in parallel to DTC (Digital Twin Consortium)
- Cooperates with CESMII (Clean Energy Smart Manufacturing Innovation Institute)

Short Description

- The IIC, then "Industrial Internet of Things Consortium", was formed to accelerate the development, adoption and widespread use of networked machines and devices
- Serves as catalyst and coordinator for Industrial Internet priorities and enabling technologies
- Renamed from "Industrial Internet Consortium" to "Industry IoT Consortium" in 2020.

Facts and Figures

- Founded on March 27, 2014 by AT&T, Cisco, General Electric, IBM and Intel
- Headquarters in Massachusetts, United States
- 258 members
- The Industry IoT Consortium is a program of the Object Management Group (OMG)

Stakeholders

Members of the IIC

Use Cases

- Digital Transformation, Security, Testbeds
- For industries like:
- Healthcare, smart city, mobility, mining, manufacturing

Industry Sector

IT Services and IT Consulting

International Distribution

- Asia
- Europe
- North America

Google Trends

Sources

https://www.iiconsortium.org/

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ISA (International Society of Automation)

Connections to other Concepts

- Defines ISA-88 Batch control
- Defines ISA-95

Short Description

- The International Society of Automation (ISA) is a non-profit technical society for engineers, technicians, businesspeople, educators and students, who work, study or are interested in automation and pursuits related to it, such as instrumentation
- The organization develops widely used global standards
- Certifies industry professionals
- Provides education and training
- Publishes books and technical articles
- Posts conferences and exhibits
- Provides networking and career development programs for its members and customers around the world.

Facts and Figures

- Officially established as the Instrument Society of America on 28 April 1945, in Pittsburgh, Pennsylvania, United States
- Renamed in 2008 due to international scope
- Headquarters in Durham, North Carolina, United States
- Approximately 32,000 members from over 100 countries as of 2019

Stakeholders

Use Cases

- Standards & Certification
- Education & Training
- Publishing
- For Industries like:
- Instrumentation
- Automation
- Process Control
- Robotics
- Mechatronics
- Process control
- Energy
- Chemical engineering
- Water/wastewater
- Cybersecurity
- IIoT (Industrial Internet of Things)
- IoT (Internet of Things)
- Software engineering

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- Network engineering

Industry Sector

Automation Machinery Manufacturing

International Distribution

- Originally North America
- Africa
- Asia
- Europe
- Oceania
- South America

Google Trends

Sources

https://www.isa.org/

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ISO (International Organization for Standardization)

Connections to other Concepts

- Publishes ISO 23247 - Digital twin framework for manufacturing
- Publishes BIM (Building Information Modeling)

Short Description

- ISO (International Organization for Standardization) is an independent, non-governmental organization that develops standards to ensure the quality, safety and efficiency of products, services and systems
- Develops international standards in all fields except
- electrics and electronics, (see IEC (International Electrotechnical Commission))
- telecommunications (see [ITU])

Facts and Figures

- Established in 1926 as the International Federation of the National Standardizing Associations (ISA), which primarily focused on mechanical engineering
- But suspended in 1942 during World War II
- In October 1946, ISA and United Nations Standards Coordinating Committee (UNSCC) delegates from 25 countries met in London and agreed to join forces to create the International Organization for Standardization
- So the organization began it's operations on 23 February 1947
- Headquarters in Geneva, Switzerland
- 168 countries are represented in the ISO as of 2022

Stakeholders

Members of ISO

Use Cases

- Build customer confidence that the products are safe and reliable
- Meet regulation requirements, at a lower cost
- Reduce costs across all aspects of your business
- Gain market access across the world for the products & services

Industry Sector

Non-Governmental Organization (NGO) (International Trade and Development)

International Distribution

- Africa
- Asia
- Europe
- North America
- Oceania

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- South America

Google Trends

Sources

https://www.iso.org/

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LNI 4.0 (Labs Network Industrie 4.0)

Connections to other Concepts

- Cooperates with SCI 4.0 (Standardization Council Industrie 4.0)
- Cooperates with Plattform Industrie 4.0
- Cooperates with CESMII (Clean Energy Smart Manufacturing Innovation Institute)

Short Description

- Association for the support of German SMEs in their pioneering role in digitization
- Provision of test centers around Industrie 4.0 to learn about new technologies, innovations and business models, to try them out and to check their technical and economic feasibility before market launch
- The Organisation also conducts individualized workshops

Facts and Figures

- Founded by companies of the Plattform Industrie 4.0 together with the associations Bitkom, VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.) and ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)
- Headquarters in Berlin, Germany

Stakeholders

- Founding members of LNI4.0

Use Cases

- Industry 4.0 illustration Quality optimization with digital twin
- Quality optimization with digital twin administration shell
- Implementation of the administration shell
- Energy management with artificial intelligence
- Learning environment and training for digitized production
- Digital Manufacturing Workplace (DFAP)
- Virtual and mixed reality
- Smart control for urban commercial traffic
- Additive Manufacturing in Space 4.0
- Production 4.0 - agile planning and flexible processes
- Virtual assistants for semi-autonomous machines
- Tracking system for SME manufacturing
- 5G campus networks
- Testbed OPC UA
- AI and camera-guided autonomous vehicles
- Cross generation digital learning
- Testbed Administration Shell (AAS)
- Virtualized computing and management platform
- Assistance system for personnel development in factories

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Industry Sector

Automation Machinery Manufacturing

International Distribution

Google Trends

Sources

https://lni40.de/

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NAMUR- Interessengemeinschaft Automatisierungstechnik der Prozessindustrie e.V.

Connections to other Concepts

- Defines NOA (NAMUR Open Architecture)
- Collaboration with OPC Foundation

Short Description

- NAMUR, now "User Association of Automation Technology in Process Industries", is an international association of user companies and represents the interests of the process industry in the field of automation technology
- Results from the working groups are published as NAMUR Recommendations and Worksheets

Facts and Figures

- Founded in 1949
- Headquarters in Leverkusen, Germany
- Over 150 members

Stakeholders

- Members of NAMUR

Use Cases

- Maintenance, electrical engineering, training and safety of PCT (process control technology) equipment
- Solutions and systems for process control and plant control level
- Measurement/sensor technology and actuator technology
- Electrical engineering, training and safety of PCE equipment.

Industry Sector

Process Technology (Chemical Manufacturing)

International Distribution

- Africa
- Asia
- Europe
- North America
- South America

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Google Trends

Sources

https://www.namur.net

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OI4.0 (Open Industry 4.0 Alliance)

Connections to other Concepts

- It is based on RAMI 4.0 (Reference Architecture Model Industrie 4.0)

Short Description

- Is a partnership-based association of industrial companies that pragmatically participate in the implementation of cross-vendor Industry 4.0 solutions and services for manufacturing plants and automated warehouses
- The technological basis of the Open Industry 4.0 Alliance is an open architecture based on RAMI 4.0 (Reference Architecture Model Industrie 4.0), which is based on the four building blocks Device Connectivity, Edge, Operator Cloud and Cloud Central as well as a corresponding associated service offering
- One of the key features of the Open Industry 4.0 Alliance is Asset Automatic Onboarding through all 4 architecture layers using open standard interfaces based on the Asset Administration Shell

Facts and Figures.

- Launched in 2019
- Headquarters in Switzerland
- over 90 members

Stakeholders

- Members include Mircrosoft, Siemens, Festo, Fujitsu, SAP, Trumpf, etc.
- Members of OI4.0

Use Cases

- Business acceleration through the implementation of Industry 4.0 standards
- Vertical & horizontal integration of data and processes

Industry Sector

Association under Swiss law (Process Technology)

International Distribution

- Europe

Google Trends

Sources

https://www.bigdata-insider.de/alles-was-sie-ueber-die-open-industry-40-alliance-wissen-muessen-a-1093019/ https://openindustry4.com/

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PI (PROFIBUS & PROFINET International)

Connections to other Concepts

- OPC UA Companion Specifications OPC 30140 PROFINET
- OPC UA Companion Specifications OPC 30141 PROFIenergy
- OPC UA Companion Specifications OPC 30140 PROFI-RemoteIO
- Collaboration with OPC Foundation

Short Description

- Largest interest group in the fieldbus sector worldwide
- Responsible for PROFIBUS, PROFINET, IO-Link and omlox
- Global network of vendors, developers, System Integrators and end users in the scope of PROFIBUS and PROFINET
- Contact/imprint organization : PROFIBUS Nutzerorgansiation e.V. (PNO)
- Supporting automation of production processes and linking them to IT management systems with automation technology

Facts and Figures

- Founded 1989
- 1,700 members
- 24 regional PI associations

Stakeholders

Mmebers of PI

Use Cases

- Profibus
- Profinet
- IO-Link
- Omlox
- Open standards for all fields of application in industrial manufacturing

Industry Sector

Automation Machinery Manufacturing

International Distribution

- Europe

Google Trends

Sources

https://de.profibus.com/ https://www.profibus.com/pi-organization

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Plattform Industrie 4.0

Connections to other Concepts

- Designs Asset Administration Shell
- Cooperates with LNI 4.0 (Labs Network Industrie 4.0)
- Cooperates with CESMII (Clean Energy Smart Manufacturing Innovation Institute)
- Has spinoff IDTA (Industrial Digital Twin Association e.V.)
- Develops and publishes AAS Submodel Templates and Submodels_and_Submodels/AAS Submodel Templates and Submodels.md)

Short Description

- The Plattform Industrie 4.0 is the central network in Germany for shaping the digital transformation in production.
- In close cooperation between politics, business, science, trade unions and associations, over 400 stakeholders from more than 200 organizations actively participate in the platform.
- As one of the largest international and national networks, the platform supports German companies in implementing Industrie 4.0 - in particular by making existing Industrie 4.0 practical examples known to companies and bringing them to the wider public.
- Interoperability is an important field of action for the platform.
- Among other things, it has developed the Asset Administration Shell and is putting it into practice.

Facts and Figures

- Founded in 2013 by the BITKOM, VDMA and ZVEI associations
- Headquarters in Berlin, Germany
- Funded by the Federal Ministry for Economic Affairs and Climate Action (BMWK) and the Federal Ministry of Education and Research (BMBF)

Stakeholders

- VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.)
- ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)
- Bitkom
- Members of the Plattform Industrie 4.0

Use Cases

- Work Organization
- IT security and data protection
- Qualification of specialists
- Development of uniform norms and standards

Industry Sector

Automation Machinery Manufacturing

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International Distribution

- Europe

Google Trends

Sources

https://www.plattform-i40.de/IP/Navigation/DE/Home/home.html

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SCI 4.0 (Standardization Council Industrie 4.0)

Connections to other Concepts

- Cooperates with LNI 4.0 (Labs Network Industrie 4.0)

Short Description

- Standardization Council Industrie 4.0 (SCI 4.0)
- Is tasked with orchestrating standardization activities and acts as a central point of contact in the context of Industrie 4.0 for all standardization issues
- Defines the need for new projects and organizes international implementation
- Defines the standardization strategy for Industry 4.0 with the "Normungsroadmap Industrie 4.0"

Facts and Figures

- The work of SCI 4.0 is organized in six committees, in which approximately 300 representatives of companies, science, associations and standardization organizations are involved

Stakeholders

- SCI 4.0 was founded on the initiative of DIN, DKE, Bitkom, VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.) and ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie) in close coordination with the Plattform Industrie 4.0 and the BMWK.

Use Cases

- Multiple use cases related to Industrie 4.0

Industry Sectors

- Electronics industry
- Mechanical and plant engineering
- ICT
- Electrical trades
- Research
- Consulting

International Distribution

- International network of initiatives in Europe (at EU level and in individual countries), USA, China, Japan, South Korea and other countries.

Google Trends

Sources

https://www.sci40.com/

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VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.)

Connections to other Concepts

- Leads VDMA 40001 - OPC UA for Machinery
- Partner VDW (Verband Deutscher Werkzeugmaschinenfabriken e.V.)
- Collaboration with OPC Foundation

Short Description

- The association represents the common economic, technical and scientific interests of the mechanical engineering industry in Germany

Facts and Figures

- foundation in 1892
- approx. 3400 members
- over 500 employees

Stakeholders

- Mmebers of VDMA

Use Cases

- Artificial Intelligence
- Digital Twin
- Industry 4.0
- GAIA-X (GAIA-X AISBL, GAIA-X RAM)
- Mobility
- Digitalization
- OPC UA (Open Platform Communications Unified Architecture)
- Power-to-X
- Future Business
- Economic & social policy

Industry Sectors

- Discrete Manufacturing

International Distribution

- Africa
- Asia
- Europe
- North America
- South America

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Google Trends

Sources

https://pm20.zbw.eu/folder/co/0454xx/045469/about https://www.vdma.org/

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VDW (Verband Deutscher Werkzeugmaschinenfabriken e.V.)

Connections to other Concepts

- Partner VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.)
- Collaboration with OPC Foundation

Short Description

- German Machine Tool Builders' Association
- Spokesman for the German machine tool industry, cooperation with the international machine tool industry
- The VDW represents its members nationally and internationally vis-à-vis the public, politics, business partners and science.
- Organizes, among other things, trade fairs and symposia for the machine tool industry
- Representative and detailed association statistics as a service to its members
- Processing of the topics production, foreign trade, employees and business climate

Facts and Figures

- Founded in 1891 in Hannover, Germany
- About 300 members representing about 90% of the total turnover in the Industry Sector

Stakeholders

- Members of VDW

Use Cases

- Energy and resource efficiency
- Machine safety
- Environment
- Industry 4.0
- Standardization

Industry Sectors

- Discrete Manufacturing

International Distribution

- Europe

Google Trends

Sources

https://vdw.de/

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ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)

Connections to other Concepts

- Collaboration with OPC Foundation
- Development of Digital Nameplate
- Development of Digital Product Passport
- Development of I4.0 Component
- Development of RAMI 4.0 (Reference Architecture Model Industrie 4.0)
- Development of MTP (Module Type Package)
- Development of NOA (NAMUR Open Architecture)
- Member of LNI 4.0 (Labs Network Industrie 4.0)
- Member of IDTA (Industrial Digital Twin Association e.V.)

Short Description

- German Electrical and Electronic Manufacturers' Association
- Represents the economic, technological and environmental policy interests of the SME-based German electrical and digital industry

Facts and Figures

- 1600 members as of 2020
- 23 trade associations
- Industry Sector with 200 billion euros in sales (2021)
- Headquarters in Frankfurt am Main, Germany; offices in Berlin, Brussels and Beijing

Stakeholders

- Members of ZVEI

Use Cases

- Consumer
- Industry 4.0
- Digitization
- Sustainability
- Mobility
- Health care
- Buildings
- Energy Security
- Cybersecurity
- Society & Environment

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- Education & Research

Industry Sectors

Appliances, Electrical, and Electronics Manufacturing (Registered association)

International Distribution

- Asia
- Europe
- North America

Google Trends

Sources

https://www.zvei.org/

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prostep ivip Association

Connections to other Concepts

Short Description

- Offers solution approaches and standards for product data management and product creation
- Association, which develops approaches for end-to-end process, system and data integration and supports all product creation phases

Facts and Figures

- The association was founded in 1993 as ProSTEP Association for the Promotion of Product Data Standards
- By well-known IT managers from BMW, Bosch, Continental, Daimler, Delphi, Opel, Siemens, Volkswagen, and 30 others
- Renamed to ProSTEP iViP Association in 2002; written "prostep ivip" since 2017
- Headquarters in Darmstadt, Germany
- 180 member companies from industry, IT and research
- 40% of today's 180 member companies are manufacturing companies (manufacturers and suppliers)
- 40% are IT companies and service providers
- 20% are research institutions and other standardization bodies

Stakeholders

Members of prostep ivip

Use Cases

- Digital transformation in product creation and production

Industry Sector

IT Services and IT Consulting

International Distribution

- Asia
- Europe
- North America

Google Trends

Sources

https://www.prostep.org/

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umati (universal machine technology interface)

Connections to other Concepts

- Community around standardization and use of OPC UA Companion Specifications
- Collaboration with OPC Foundation

Short Description

- umati (universal machine technology interface) is an initiative of the mechanical and plant engineering industry and its customers for the dissemination and use of open interface standards based on OPC UA (Open Platform Communications Unified Architecture).
- It is designed to enable machines and plants to communicate with each other and to be easily integrated into customer- and user-specific IT ecosystems
- The aim is to provide:
- An OPC UA Companion Specification to define globally valid semantics for machine tools
- Communication standards (e.g. encryption, authentication, server settings (ports, protocols))
- Quality assurance through test specifications and tools, certification and ombudsman for disputes
- Marketing and a label for recognizability in the market by a global association of machine builders, suppliers and value-added service providers
- umati serves to exploit new potentials for manufacturing of the future by:
- Simplifying the effort for machine connection to customer-specific IT infrastructures and ecosystems
- Simplifying the effort for machine-to-machine and machine-to-device communication
- Reducing costs through faster realization of customer specific projects

Facts and Figures

- The project started in 2017 with 17 project partners under the leadership of the VDW (Verband Deutscher Werkzeugmaschinenfabriken e.V.)
- Headquarters in Frankfurt am Main, Germany
- 90 companies are now involved

Stakeholders

- VDW (Verband Deutscher Werkzeugmaschinenfabriken e.V.)
- VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.)
- Members of umati

Use Cases

- OPC UA Companion Specifications

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- Communication standard requirements for implementing an OPC UA environment (e.g., encryption, authentication, server settings (ports, protocols))
- Plug-and-play connectivity between machines and software
- Quality assurance through testing of specifications and tools
- For industries like:
- Robotics
- Machine Vision
- Machine Tools and Manufacturing Systems
- Rubber and Plastics Machinery

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Industry Sectors

Cross-sector initiative (Machinery Manufacturing)

International Distribution

Google Trends

Sources

https://umati.org/ https://vdw.de/technik-und-normung/umati/

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7. Technologies

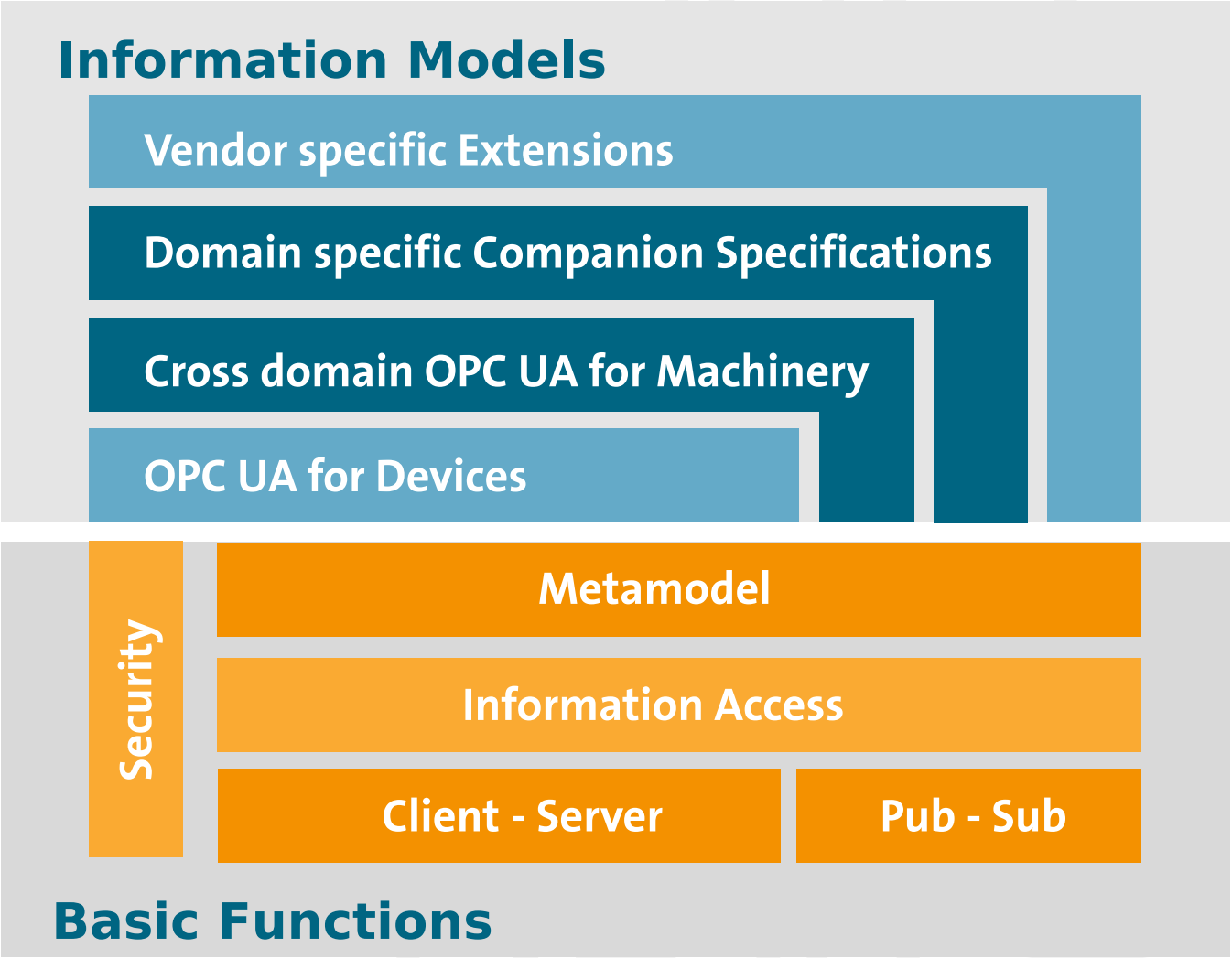
OPC UA (Open Platform Communications Unified Architecture)

Connections to other Concepts

- Defined by OPC Foundation
- Parts of the Architecture are OPC UA Information Models, OPC UA Communication Layer, OPC UA Information Models and OPC UA Companion Specifications
- Can be used in conjunction with the Asset Administration Shell, e.g. with AAS SMT OPC UA Server Datasheet_and_Submodels/AAS SMT OPC UA Server Datasheet.md)

Short Description

-



- OPC UA is a platform-independent standard through which various kinds of systems and devices can communicate by sending messages between Clients and Servers or Publishers and Subscribers over various types of networks
- OPC UA can be divided into an architecture consisting of several layers
- as base functionalities related to communication, the OPC UA Standard describes protocol bindings and encodings (e.g. HTTPS and XML) as well as communication schemes for Client-Server and Pub-Sub communication

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- another base functionality are the rules and conventions for information access. These include e.g. what data representations shall look like
- All OPC UA communication includes security options. This is true for the communication between different systems (encryption and authentication of services) and for the information access, that can be restricted if needed
- The information models contain specific data representations - they specify what to communicate using the OPC UA base functionalities
- Generic information models like the base information model and the Devices model contain general data representations that are applicable in a broad context and thus vague compared to the more specific data representations
- Domain specific Companion Specifications contain such more specific data representations: using and refining the generic types, they clarify what to communicate within a domain
- The OPC UA model allows for using and refining all information content, e.g. adding information that is relevant in special scenarios. Manufacturer specific extensions may thus add information, that is missing in the standards for their respective use case

Facts and Figures

- 2006 Release of V1.00
- Current version: 1.05.02 (April 2022)

Stakeholders

Responsible for OPC UA - OPC Foundation

Collaborations for Companion Specifications (incomplete list) - ISA (International Society of Automation) - NAMUR - PI (PROFIBUS & PROFINET International) - umati (universal machine technology interface) - VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.) - VDW (Verband Deutscher Werkzeugmaschinenfabriken e.V.) - ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie) - MTConnect - AML (AutomationML) - BACnet

Standardization - OPC UA is published as IEC 62541 IEC (International Electrotechnical Commission)

Use Cases

- Asset management
- Condition Monitoring
- Production monitoring
- Production control
- Direct control of a single machineplant

Industry Sectors

- Cross-sector communication standard

International Distribution

- Asia
- Europe
- North America
- Oceania
- South America

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Asset Administration Shell

Connections to other Concepts

- In RAMI 4.0, the Asset Administration Shell is part of the information layer
- An I4.0 Component is the sum of an Asset and its corresponding Asset Adeministration Shell
- An Asset Administration Shell aggregates AAS Submodel Templates and Submodels_and_Submodels/AAS Submodel Templates and Submodels.md)
- As an Asset Administration Shell aggregates different aspects of a real Asset. It can represent and make use of other technologies such as ECLASS , AML (AutomationML), JSON or HTTP

Short Description

- The general concept and the structure of the Asset Administration Shell is described in IEC 63278-1 as well as in the Specification of the Asset Administration Shell IDTA Number 01002-3-0 from the IDTA (Industrial Digital Twin Association e.V.)
- The Asset Administration Shell and the Asset are both uniquely identified
- The Asset Administration Shell is suitable for non-intelligent and intelligent Assets
- The Asset Administration Shell can provide services via an interface and a standardized API

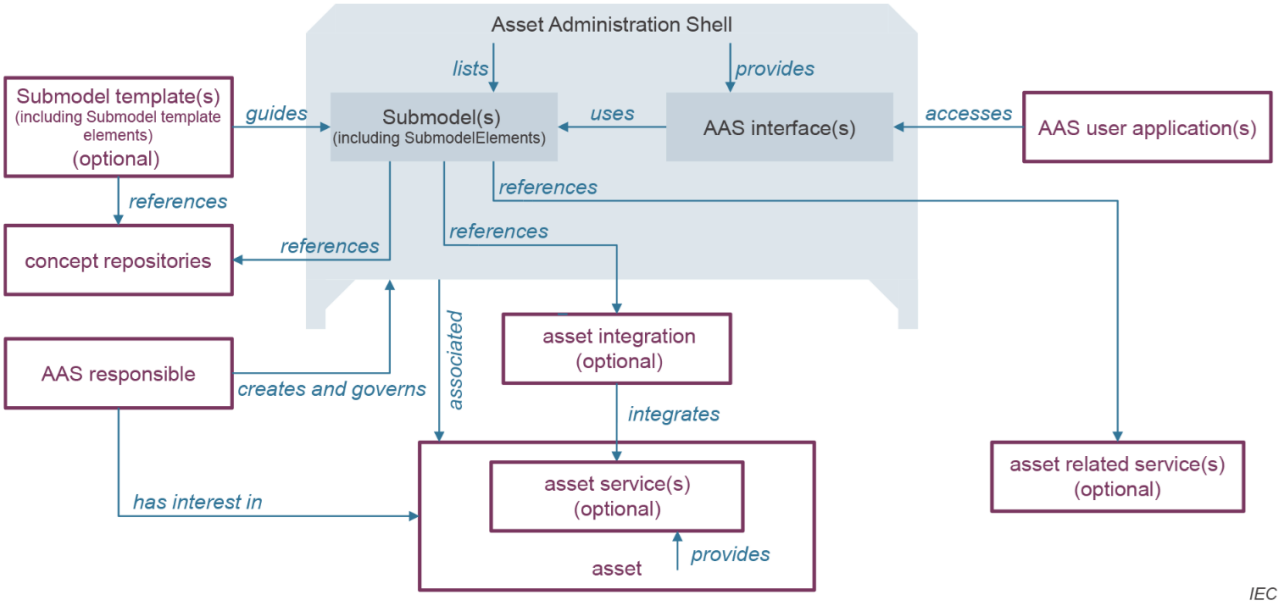

Figure 1 Asset Administration Shell and Related Roles (Source: IEC 63278-1)

Facts and Figures

- The Working Group ‘Open Technology’ of the IDTA (Industrial Digital Twin Association e.V.) is gradually developing the base specifications for the Asset Administration Shell
- The Working Grou 'Submodels' of the IDTA (Industrial Digital Twin Association e.V.) overseas the delevopment of all Submodel Templates by the Submodel Working Teams

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Stakeholders

- Plattform Industrie 4.0
- IDTA (Industrial Digital Twin Association e.V.)
- ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)
- VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.)

Use Cases

- Value Creation Networks
- Supply Chain Management
- Product Lifecycle Management

Industry Sectors

- Cross-sector concept

International Distribution

- Europe

Google Trends

Sources

- Katalog/Data/Documents/IDTA-01001-3-0_SpecificationAssetAdministrationShell_Part1_Metamodel.pdf
- https://www.eclass.eu/anwendung/verwaltungsschale.html

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Technologies

This part of the catalog contains information about various technologies used in interoperability in industrie 4.0.

Currently, the following entries are available:

- AML (AutomationML)
- BACnet
- MQTT (Message Queuing Telemetry Transport)
- MTConnect
- MTP (Module Type Package)
- NC-Link
- omlox
- TSN (Time-Sensitive Networking)

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AML (AutomationML)

Connections to other Concepts

- OPC UA Companion Specifications OPC 30040 AutomationML
- Describes OPC UA configuration information
- Mapping to STEP of prostep ivip Association
- Mapping to Asset Administration Shell
- Supports IEC62264 and B2MML for MES and ERP
- Published by IEC as IEC62714

Short Description

- Comprehensive XML based object-oriented data modeling language
- Neutral, XML-based data format for the storage and exchange of engineering data
- AutomationML incorporates different standards through strongly typed links across the formats:
- CAEX (IEC 62424) : Topology resp. structure, i.e. Properties and relations of objects in their hierarchical structure
- COLLADA (ISO/PAS 17506:2012) : Geometry and kinematics, i.e. Graphical attributes & 3D information and Connections and dependencies among objects to support motion planning
- PLCopen XML (IEC 61131-10) : Logic and discrete behavior of objects, i.e Sequences of actions, internal behavior of objects and I/O connections
- For future extensions, AutomationML is designed to integrate further formats using the same referencing mechanism

Facts and Figures

- Current version published 2018
- Defined in standards series IEC62714 (1-5)

Stakeholders

- AutomationML e.V.

Use Cases

- Exchange of engineering data regarding automation in a heterogeneous tool landscape

Industry Sectors

- Automobile
- Discrete Manufacturing
- Continous Manufacturing

International Distribution

- Europe

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https://www.automationml.org/wp-content/uploads/2021/11/WP_AutomationML_and_ECLASS_integration_V2.0.pdf

https://www.automationml.org/wp-content/uploads/2022/04/Asset-Administration-Shell-Representation-V1_0_0.zip

https://www.automationml.org/wp-content/uploads/2022/05/AR-Provisioning-for-MES-and-ERP-Edition-2.zip

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BACnet

Connections to other Concepts

- Interoperability with BIM (Building Information Modeling)

Short Description

- Building Automation and Control Networks (BACnet) is a data transmission protocol for building automation and building control
- Simplifies the communication between products of different manufacturers in building automation
- Continuous communication on management, automation and field level

Facts and Figures

- Developed by the American Society of Heating, Refrigeration and Air-Conditioning Engineers Inc. (ASHRAE)
- Published as an American standard in 1995
- ISO standard 16484-5 since 2003

Stakeholders

- BACnet Committee
- American Society of Heating, Refrigeration and Air-Conditioning Engineers Inc. (ASHRAE)

Use Cases

- Worldwide standardized data communication for building automation
- Independent of specific technologies and suppliers
- Comprehensive solution for building control and automation networks
- Compatibility with IT infrastructure and highly scalable solutions
- Validation at independent testing laboratories and product certification
- Continuously being maintained and upgraded while preserving current investments

Industry Sectors

- Heating, ventilation, and air conditioning
- Lighting control
- Elevator monitoring
- Access control
- Security and fire alarm systems monitoring and integration
- Energy management and energy services

International Distribution

- Africa
- Asia
- Europe
- North America

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- Oceania
- South America

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Sources

https://www.wago.com/de/bacnet https://bacnet.org/wp-content/uploads/sites/4/2022/06/2016-11-Cataldi-BIM.pdf

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MQTT (Message Queuing Telemetry Transport)

Connections to other Concepts

- Intended for use in OPC UA (Open Platform Communications Unified Architecture)
- Intended for use in Asset Administration Shell
- Mapping for use with MTConnect

Short Description

- Is a communication protocol, i.e. used for M2M communication
- Lightweight telemetry data and simple protocol
- Designed for connections with remote locations that have devices with resource constraints or limited network bandwidth, such as in the Internet of Things (IoT)
- Message-Broker protocol: distribution of messages to one or more recipients (publish/subscribe)
- Scalable - can be used with many communication participants
- Open source protocol

Facts and Figures

- 1999: Developed by IBM, it was used to monitor oil pipelines within the SCADA industrial control system
- Since 2013: Standardized by the Organization for the Advancement of Structured Information Standards (OASIS)
- In 2019, OASIS released the official MQTT 5.0 standard

Stakeholders

- IBM
- Arcom Control System
- OASIS (Organization for the Advancement of Structured Information Standards)

Use Cases

- Bidirectional communication
- Suitable for IoT, embedded systems, communication of networks, applications and middleware

Industry Sectors

- Automotive
- Logistics
- Manufacturing
- Smart home
- Transportation
- Consumer goods
- Oil and gas industries
- IoT, IIoT

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International Distribution

- Africa
- Asia
- Europe
- North America
- Oceania
- South America

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Sources

- https://mqtt.org/
- https://en.wikipedia.org/wiki/MQTT

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MTConnect

Connections to other Concepts

- OPC UA Companion Specifications OPC 30070-1
- Collaboration with OPC Foundation
- Mapping MQTT (Message Queuing Telemetry Transport)
- Overlaps in use cases with OPC UA (Open Platform Communications Unified Architecture)

Short Description

- MTConnect is a unidirectional communication standard, open-source, royalty-free communications protocol based on XML and HTTP Internet technology for data sharing between shopfloor equipment such as machine tools and computer systems
- It provides standardized models for device data structures, communication and assets
- Designed for easy integration

Facts and Figures

- 2008: Publication of the first MTConnect standard by the Association for Manufacturing Technology (AMT)
- 2009: MTConnect Institute founded
- Over 400 members

Stakeholders

- MTConnect Institute

Use Cases

- Factory floor monitoring
- OEE calculation
- Predictive analysis and maintenance
- Integration of manufacturing cells
- Scheduling and routing
- Unidirectional data exchange

Industry Sectors

- Machine Tools

International Distribution

- Asia
- Europe
- North America

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Sources

- https://www.mtconnect.org/
- https://en.wikipedia.org/wiki/MTConnect

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MTP (Module Type Package)

Connections to other Concepts

- NOA (NAMUR Open Architecture)
- Uses OPC UA (Open Platform Communications Unified Architecture)
- Uses AML (AutomationML)

Short Description

- Provides a framework for standardized equipment data models and description language to streamline interoperability
- Properties of process modules are described functionally
- Manufacturer and technology neutral
- Description of data objects
- Description of the operation screen
- Benifits:
- Reduces time and cost to integrate distributed process and reliability assets and equipment,
- Helps to accelerate time to market,
- Simplifies fulfillment of individualized customer requirements,
- Improves scalability and flexibility
- In future: description of services etc.

Facts and Figures

- Launched in 2012
- Developed by WAGO, NAMUR and ZVEI
- PI (PROFIBUS & PROFINET International) are responsible for the further development, quality assurance and international distribution of MTP.
- NAMUR and ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie) establish requirements in the continuing development for MTP

Stakeholders

- Wago
- NAMUR
- ZVEI e.V. (Zentralverband Elektrotechnik- und Elektroindustrie)

Use Cases

- Transferring data to higher-level systems such as visualization or process control systems (Process Orchestration Layer)
- "Plug and Produce"

Industry Sectors

- Process Technology

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International Distribution

- Asia
- Europe
- North America

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Sources

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- https://www.wago.com/global/digitization/adaptability
- https://www.phoenixcontact.com/en-us/industries/process-automation/modular-production

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NC-Link

Connections to other Concepts

- Overlaps in use cases with MTConnect
- Overlaps in use cases with certain OPC UA Companion Specifications, e.g. OPC 40502 - OPC UA for Machine Tools

Short Description

- NC-Link protocol for the transmission of process parameters, device status, operating sequence, cross-media information and other forms of information flow in the manufacturing process
- Communication and information standard
- Scalable, object-oriented model description
- JSON model representation and transmission

Facts and Figures

- 2016: Foundation of the NC-Link Alliance
- 2016: Start of the NC-Link project
- 2019: First use of the NC-Link protocol by Chinese companies
- Over 30 members
- Members: http://www.cmtba.org.cn/ewebeditor/attach/images/20190912103445588.jpg

Stakeholders

- China Machine Tool & Tool Builders' Association (CMTBA), Wuhan Huazhong Numerical Control Co Ltd., GSKCNC Equipment Co. Ltd., Kede Numerical Control Co. Ltd., Shenyang Gaojing Numerical Control Co. Ltd., J-Tech CNC Technology Co. Ltd.,
- Huazhong University of Science and Technology,
- Beihang University

Use Cases

- CNC machine tools
- AGV/RGV logistics equipment
- Flexible manufacturing systems
- RFID
- Robots
- Measuring equipment

Industry Sectors

Discrete Manufacturing

Internationale Verbreitung

- Asia
- South America

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Sources

http://www.cmtba.org.cn/level3en.jsp?id=4027

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TSN (Time-Sensitive Networking)

Connections to other Concepts

- Intended for use in OPC UA (Open Platform Communications Unified Architecture)

Short Description

- Describes a series of standards that define mechanisms for the transmission of data over Ethernet networks.
- A majority of the projects define extensions to the IEEE 802.1Q bridging standard.
- These extensions primarily address transmission with very low transmission latency and high availability.

Facts and Figures

- Developed by the Time-Sensitive Networking Task Group of the Institute of Electrical and Electronics Engineers.
- The task group evolved from the Audio/Video Bridging Task Group that existed in 2012

Stakeholders

- IEEE

Use Cases

- Converged networks with real-time audio/video streams and, in particular, real-time control streams, which are used e.g.
- In automobiles,
- In modern airplanes or
- Used for control in industrial plants
- Audio-video bridging (AVB) systems,
- Mobile fronthaul networks,
- Industrial automation,
- In-vehicle bus systems,
- Utility Networks

Industry Sectors

- Cross-sector technology, especially real-time applications

International Distribution

- Asia
- Europe
- North America

Google Trends

Sources

https://us.profinet.com/digital/tsn/

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omlox

Connections to other Concepts

- Planned OPC UA (Open Platform Communications Unified Architecture)
- Development of OPC UA Companion Specifications with OPC Foundation
- Part of PI (PROFIBUS & PROFINET International)
- Cooperation with IDTA (Industrial Digital Twin Association e.V.) on a asset location AAS Submodel_and_Submodels/AAS Submodel Templates and Submodels.md) for the Digital Twin

Short Description

- omlox is an open standard for precise real-time indoor tracking systems
- omlox focuses on defining open interfaces for an interoperable location system
- Enables different Industry Sectors to use a single infrastructure with different applications from different vendors

Facts and Figures

- Founded in 2020
- over 60 members
- The term omlox is derived from the Latin terms "omni" = omnipresent and "locus" = location.

Stakeholders

Main partners: - Trumpf - aws - GFT - ST - T-Systems - Siemens - BridgingIT - CEA-Leti - Cleanfix - Flowcate - NAiSE - Pepperl+Fuchs - SICK - Squadrone - SWAN - WZL Aachen - XETICS - ZIGPOS - Members: https://omlox.com/community

Use Cases

- Tracking things e.g. means of production, goods, tools, orders, vehicles or people, etc.
- Automatic posting and documentation of process progress in IT systems, e.g. for paperless production.
- Location-related information and control e.g. for a machine control or the maintenance of machines.
- Autonomous transport e.g. in the orchestration of internal plant traffic by autonomous transport robots .
- Security-related applications e.g. in lone worker protection in the process industry .

Industry Sectors

- Manufacturing & assembly
- Logistics:
- Warehouse Management (WMS),
- Yard-Management,
- AGV Fleet-Management,
- Truck Fleet-Management

International Distribution

- Europe

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