Getting Started

Getting Started

- **Overview of OPC Foundation and OPC UA**

  - https://opcfoundation.org/about/opc-technologies/opc-ua/

- **OPC UA and IJT Overview**

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

- **OPC UA IJT Group Presentation:**
  - Refer to the **OPC UA IJT Group Presentation.pdf/pptx.**
  - https://github.com/umati/UA-for-Industrial-Joining-Technologies/tree/main/IJT_Documents

- **Specifications/Online Reference**

  - **Joining:** https://reference.opcfoundation.org/IJT/Base/v100/docs/

  - **Tightening:** https://reference.opcfoundation.org/IJT/Tightening/v200/docs/

- **OPC UA IJT Prototypes/Reference Implementations**

  - https://github.com/umati/UA-for-Industrial-Joining-Technologies

OPC UA for Industrial Joining Technologies (IJT)
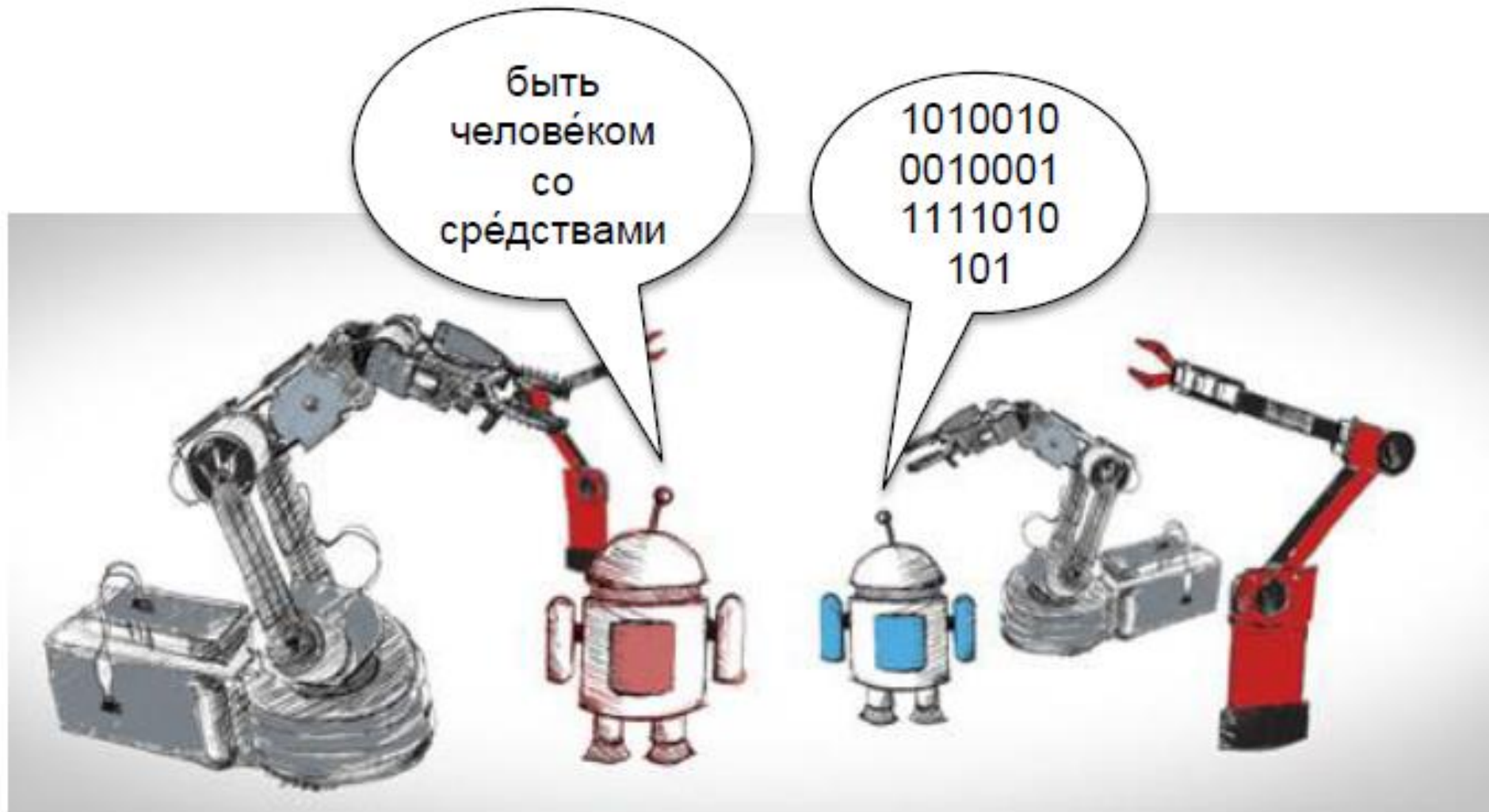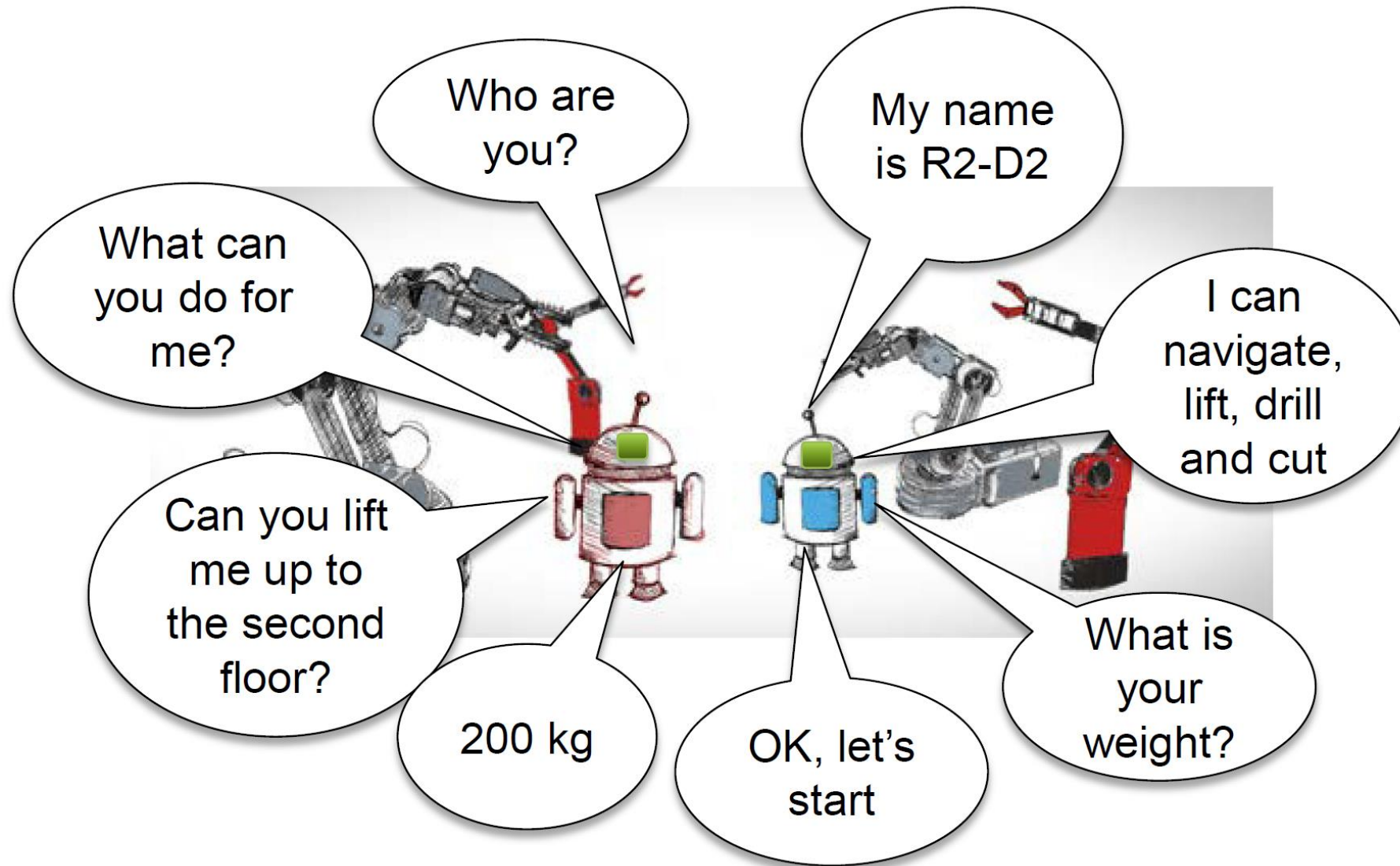
Joining and Tightening System Overview

Agenda

» OPC UA Overview

» Industrial Joining Technologies (IJT) Overview

» IJT Use Cases

» Technical Overview of Models

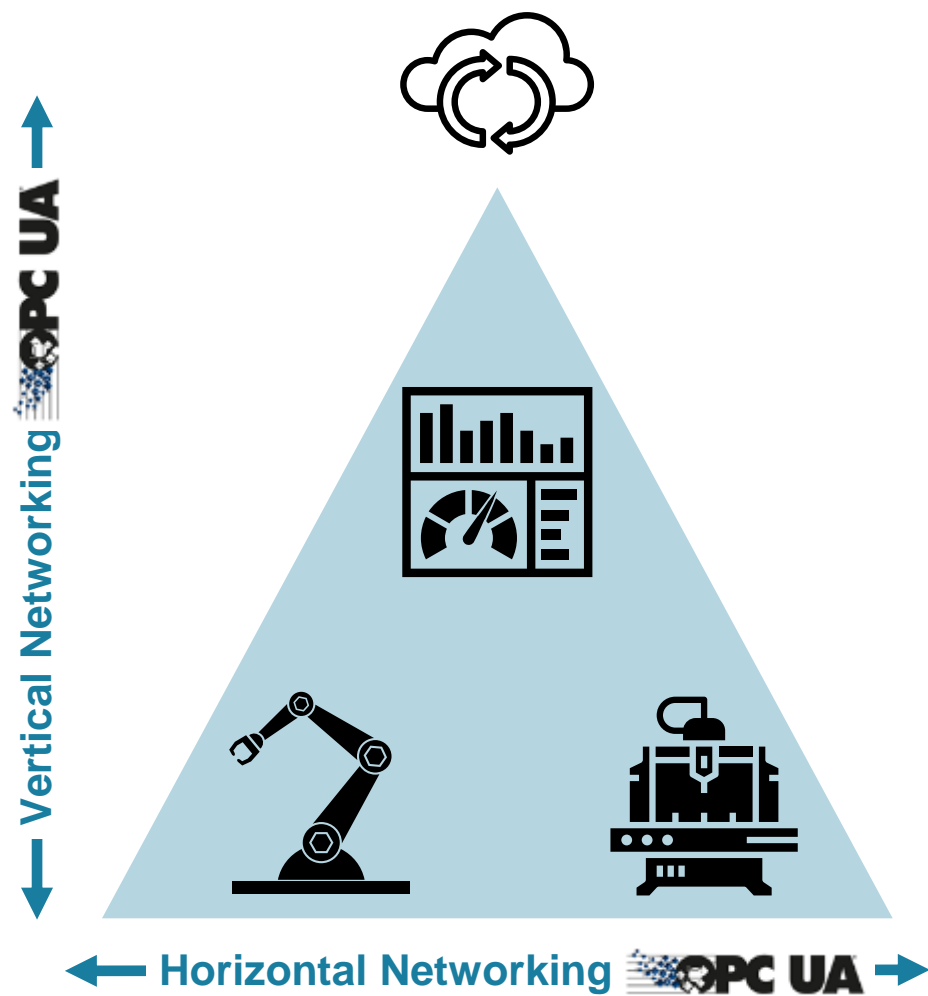» Demonstration

» Questions

Quick OPC UA and IJT Overview

Interoperability Issues

Source: OPC Foundation

Interoperability Solution

OPC UA – Field to Cloud

Vertical Networking **OPC UA**

Horizontal Networking OPC UA

- Open source
- Security
- Two transport mechanisms with various protocols
- Scalable
- Global acceptance
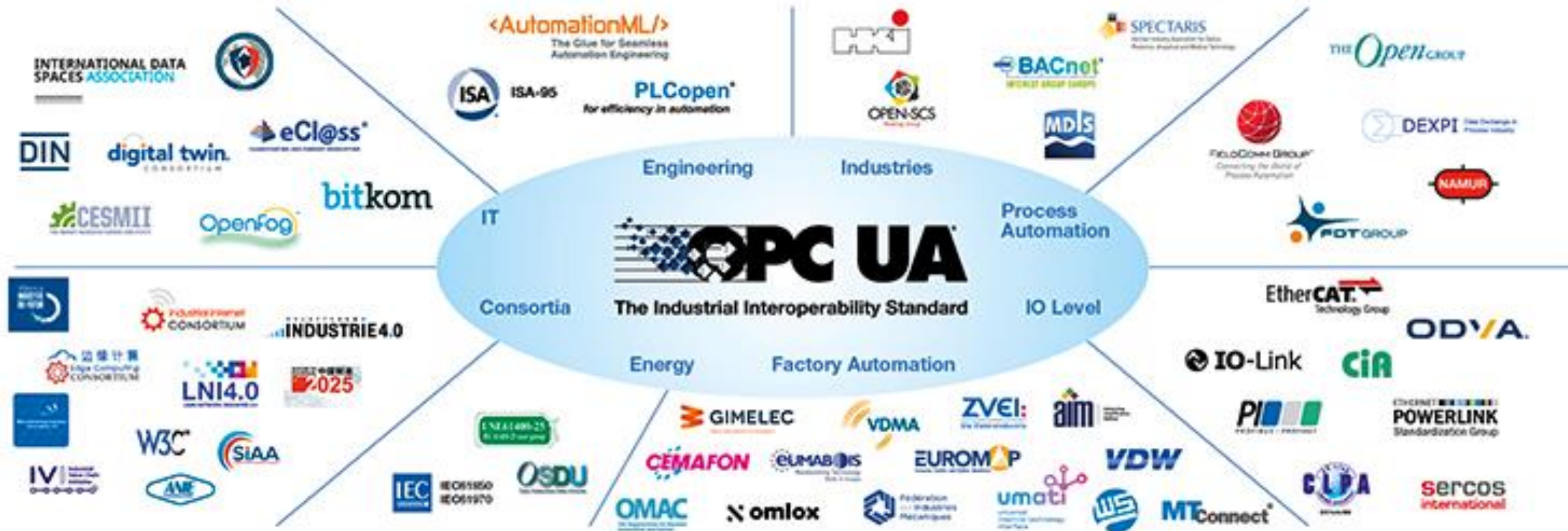- Semantic information models

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  - Client/Server – service-oriented, request/response, on demand.
  - Publish/Subscribe – multicast, unidirectional, cyclic.

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  - UADP – MQTT/AMQP based, JSON, Cloud, optional broker.

- **PLUS – Discovery and Security**

Interoperability Solution Summary

(OPC UA + Companion Specs) = Promise for Interoperability

- **OPC UA: Collection of technology bricks**
  - Connectivity, different protocols
  - Security
  - ...

+

HOW to communicate

"speak the same language"

- **Companion Specifications: Collection of bricks for different markets**
  - Information modelling to describe the specific market
  - ...

=

WHAT to communicate

"use the same dictionary"

- **OPC UA + Companion Specification drives towards Interoperability**
  - Mandatory bricks guarantee interoperability
  - Optional bricks allow flexibility
  - ...

semantic interoperability

"understand each other"

Source: OPC Foundation

OPC UA Layered Architecture

Vendor Specific Extensions

Companion Information Models
(e.g. Robots, CNC Machines, Wind Power, P&ID exchange)

Core Information Models
(e.g. Analog Data, Alarms, State Machines, File Transfer)

Information Model Building Blocks
(Meta Model)

Information Model Access

Browse and Access Data and Semantics
Execute Methods, Configure

Data and Event
Notifications

Client-Server

Pub-Sub

Use Case specific Protocol Mappings

IJT Standard Data Models

OPC Foundation Responsibility

Source: OPC Foundation

VDMA

Industrial Joining Technologies (IJT) Overview

- History

- Long term vision

- Status

- Taxonomy

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

Integrated Assembly Solutions OPC UA Initiative
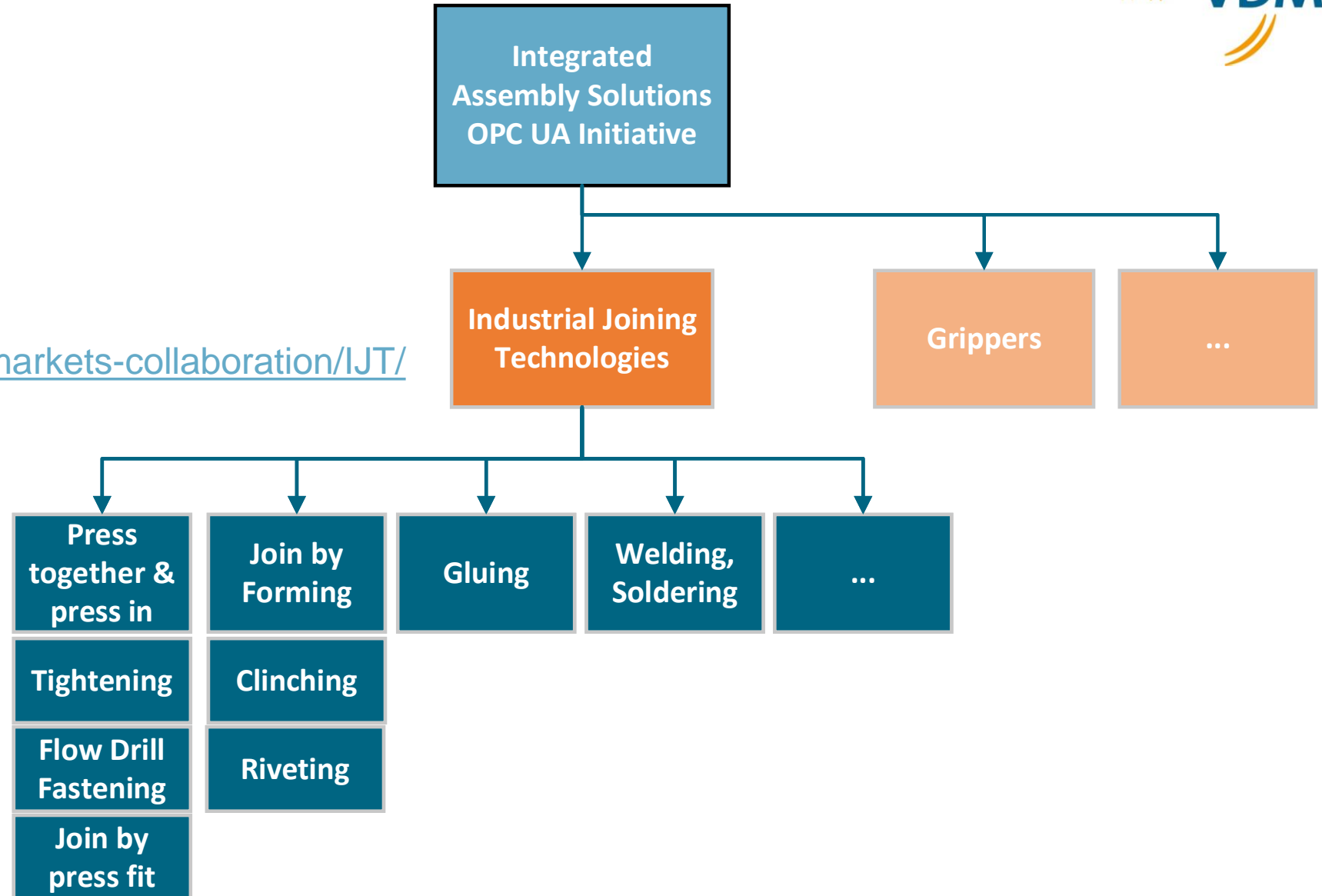
Industrial Joining Technologies | **Grippers** | **...**

Press together & press in | **Join by Forming** | **Gluing** | **Welding, Soldering** | **...**

Tightening | **Clinching**

Flow Drill Fastening | **Riveting**
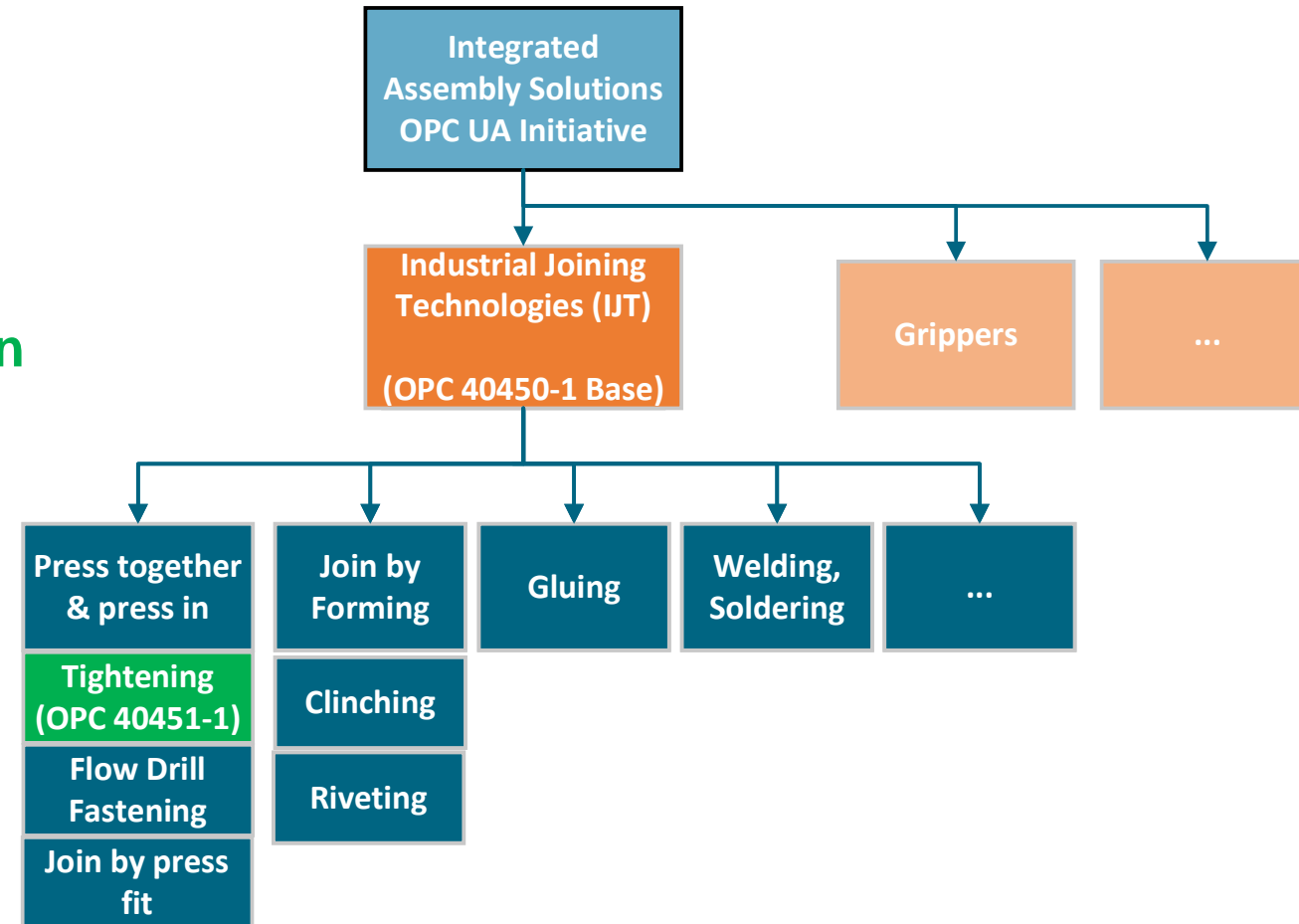
Join by press fit

IJT Working Group Members

IJT Specification(s) Overview

- **OPC 40450-1** for Joining Systems **version 1.0**
  - Common elements of various joining technologies.
  - http://opcfoundation.org/UA/**IJT/Base**/
  - Opc.Ua.**Ijt.Base**.NodeSet2.xml

- **OPC 40451-1** for Tightening Systems **version 2.0**
  - **Version 1.0** was published in October 2021.
  - Moved common models to the base specification.
  - http://opcfoundation.org/UA/**IJT/Tightening**/
  - Opc.Ua.**Ijt.Tightening**.NodeSet2.xml

Integrated Assembly Solutions OPC UA Initiative

Industrial Joining Technologies (IJT) (OPC 40450-1 Base)

Grippers

...

Press together & press in

Join by Forming

Gluing

Welding, Soldering

...

Tightening (OPC 40451-1)

Clinching

Flow Drill Fastening

Riveting

Join by press fit

Reuse of Harmonized Specifications

NamespaceUri	Description	Use	Namespace Index	Example
http://opcfoundation.org/UA/	OPC UA Base	Mandatory	0	0:EngineeringUnits
http://opcfoundation.org/UA/DI/	OPC UA for Devices (OPC 10000-100).	Mandatory	2	2:DeviceRevision
http://opcfoundation.org/UA/AMB/	OPC UA for Asset Management Basics (OPC 10000-110).	Mandatory	3	3:IRootCauseIndicationType
http://opcfoundation.org/UA/Machinery/	OPC UA for Machinery Basic Building Blocks (OPC 40001-1).	Mandatory	4	4:MachineIdentificationType
http://opcfoundation.org/UA/Machinery/Result/	OPC UA for Machinery Result Transfer (OPC 40001-101).	Mandatory	5	5:ResultManagementType

Use Cases Overview

VDMA

Asset Management

Overview and Identification of physical assets in the given system.

Example:

Manufacturer, Serial number, Software Revision…

Condition Monitoring

Acquisition and processing of information that indicate the state of an asset over time.

Example:

Health status, temperature…

Result Management

Primary process output of the tightening operation.

Example:

Single Result, Batch Result, Job Result, Multi-spindle Result, etc.

Event Management

Various types of events with standard payload and filter criteria.

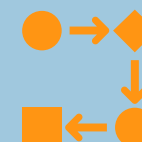**Example:**

Tool Connected, Maintenance Events, etc.

Commands

Asset Management control mechanisms.

Joining Process Management.

Example:
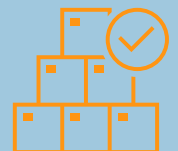
Select Program, Send Program, Enable Tool, etc.

Joint Management

Provides joint data.

Example:

Joint with associated Programs, etc.

The Key to Reducing Costs: Data Interoperability

We need…

1. A common **Interface** (Analogy: A Book)

2. A common **Data Format** (Analogy: A Latin Alphabet)

3. A common **Data Model** (Analogy: Then English Language)

4. Common **Semantics** (Analogy: The Plot and Characters of the Novel)

Only when all 4 things are present, we can truly understand each other!

Interoperability Example for OPC UA-enabled Assets

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3. **Data Model:** OPC UA Information Model
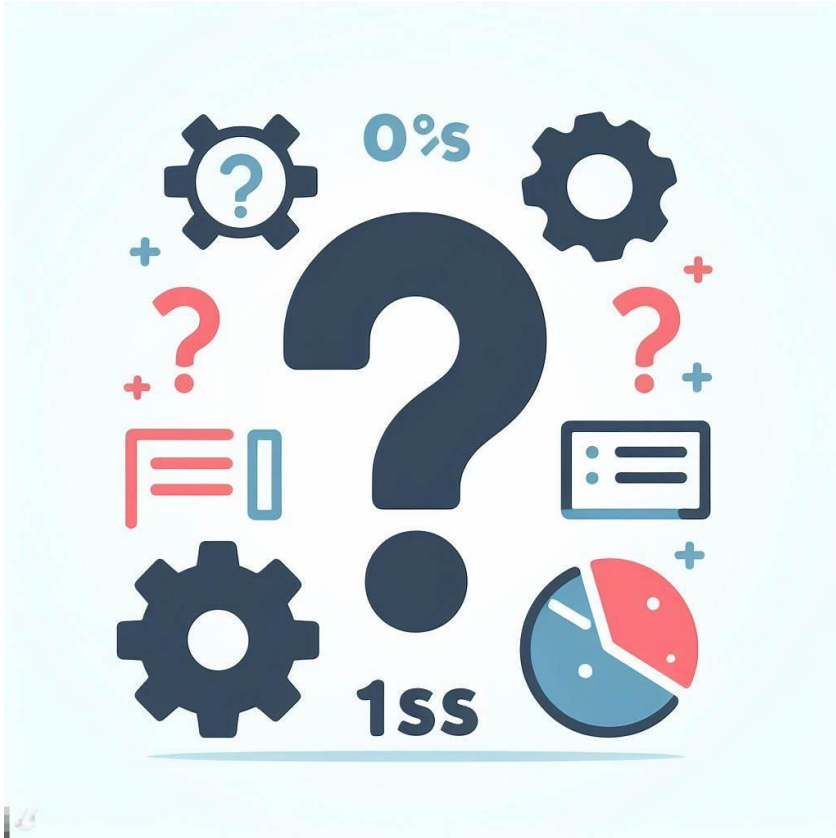
4. **Semantics:** OPC UA IJT Companion Specification

VDMA

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- **OPC UA and IJT Overview**

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

- **Specifications**

  - https://opcfoundation.org/developer-tools/documents/view/343

  - https://opcfoundation.org/developer-tools/documents/view/341

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- **OPC UA Online Reference**

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OPC UA Overview
(IEC 62541)

Problem Statement

- **I4.0 Challenges for Communication**
 - Interoperability
  - Security
  - …

Traditional Solution – Custom Protocol Converter – Before OPC

Custom software is built through an extensive collaboration of both system's vendors.

» Enabled tightly controlled communication between the source and destination regardless of complexity.
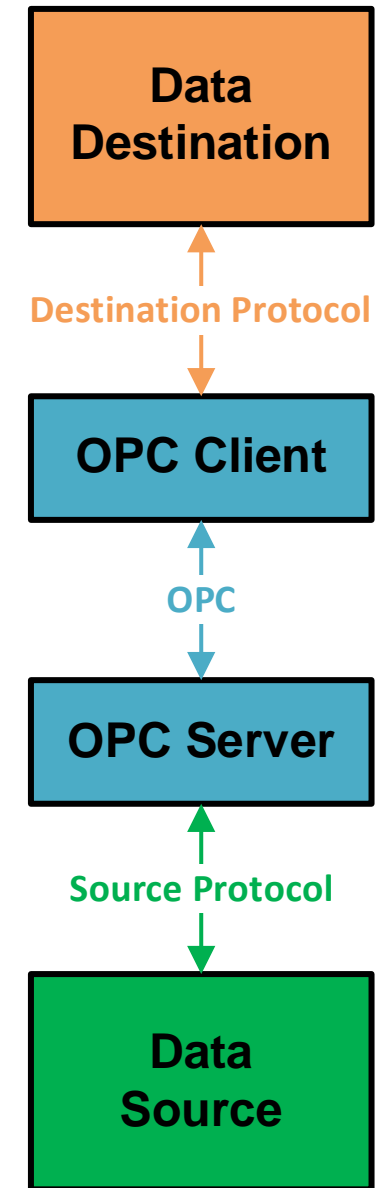
But it has the following limitations:
- Vendor Specific
- Costly to produce
- Costly to manage
- Proprietary Data Paths
- Little Integration
- Each application had custom drivers

Data Destination

↑↓ **Destination Protocol**

Custom Protocol Translator

↑↓ **Source Protocol**

Data Source
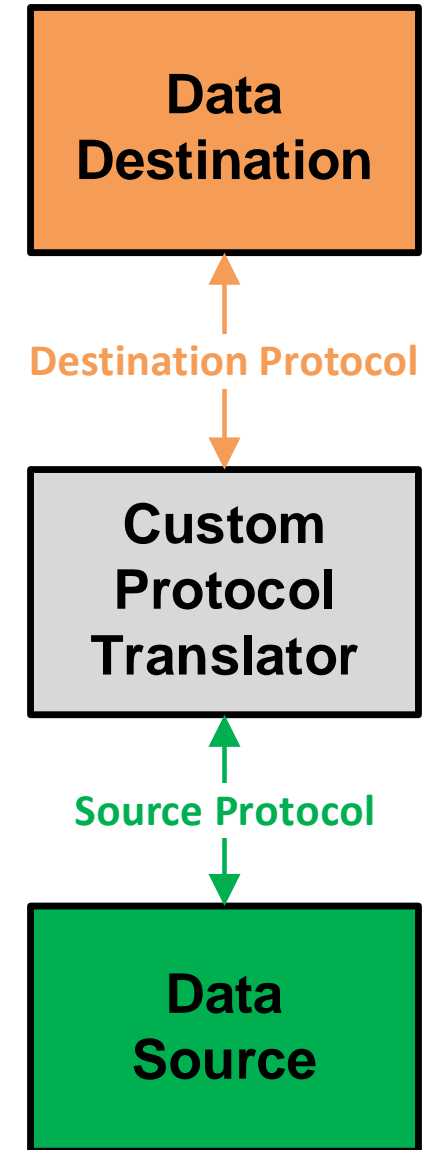
OPC Connectivity – OPC Classic Data Path

- All OPC Data Paths will consist of these four components.

- More complex architectures will consist of many OPC Data Paths.

- Understanding the OPC Data Path will enable understanding all OPC Solutions
  - Architecting
  - Implementing
  - Troubleshooting
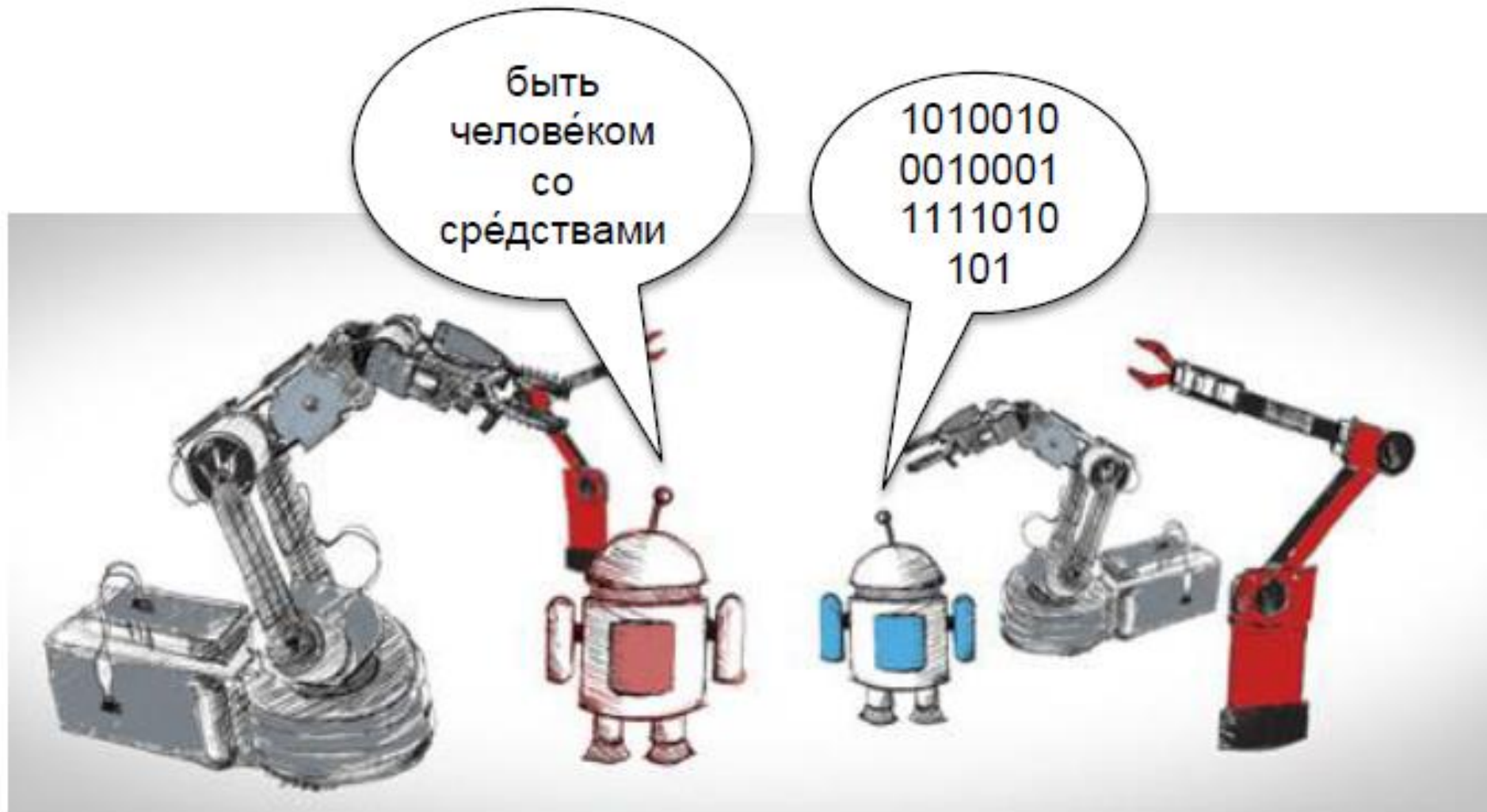
Data Destination

↕ Destination Protocol

OPC Client

↕ OPC

OPC Server

↕ Source Protocol

Data Source

Today's Interoperability Issues

Today's Interoperability Solution

Source: OPC Foundation

VDMA

OPC UA – Field to Cloud

Vertical Networking OPC UA

Horizontal Networking OPC UA
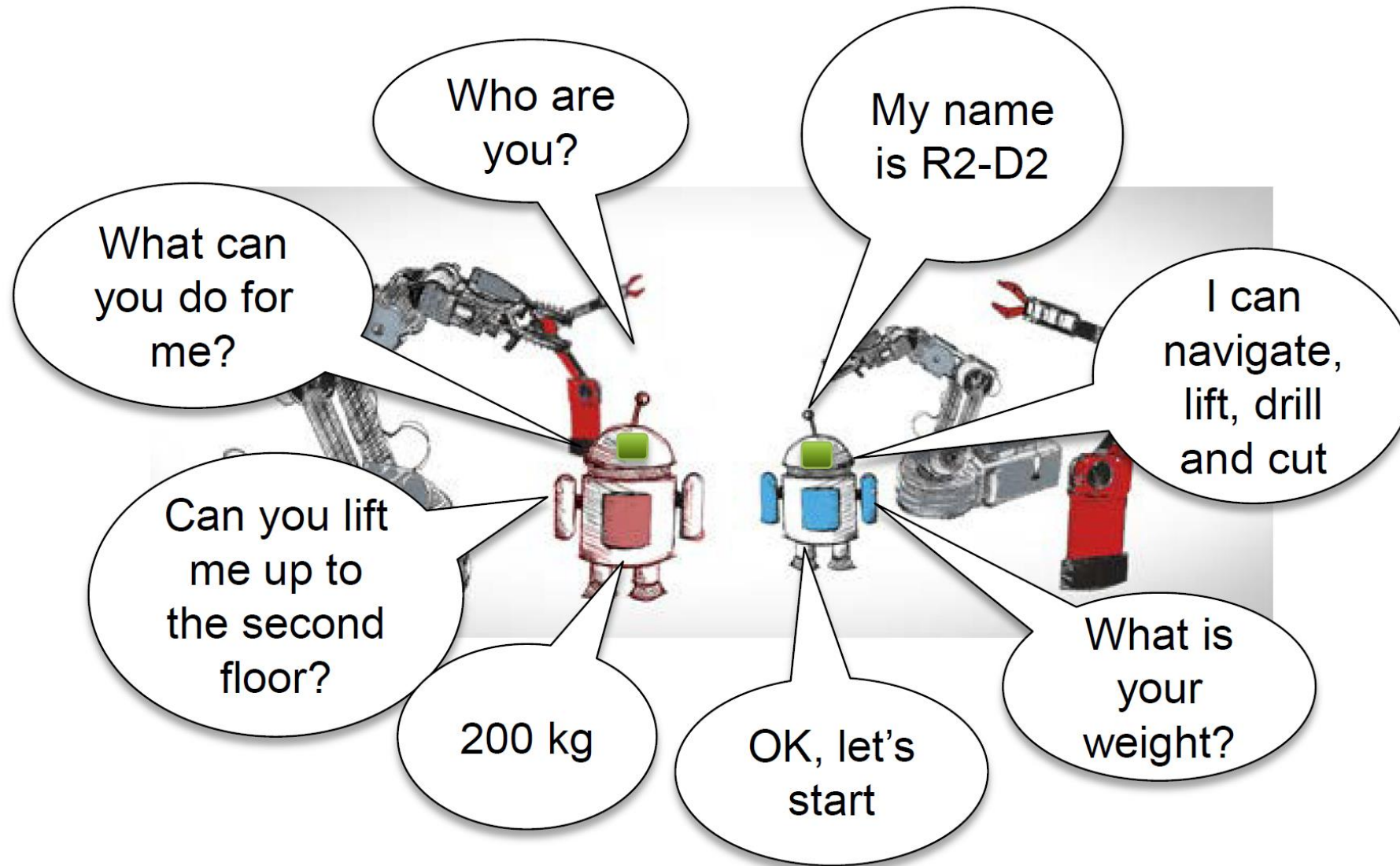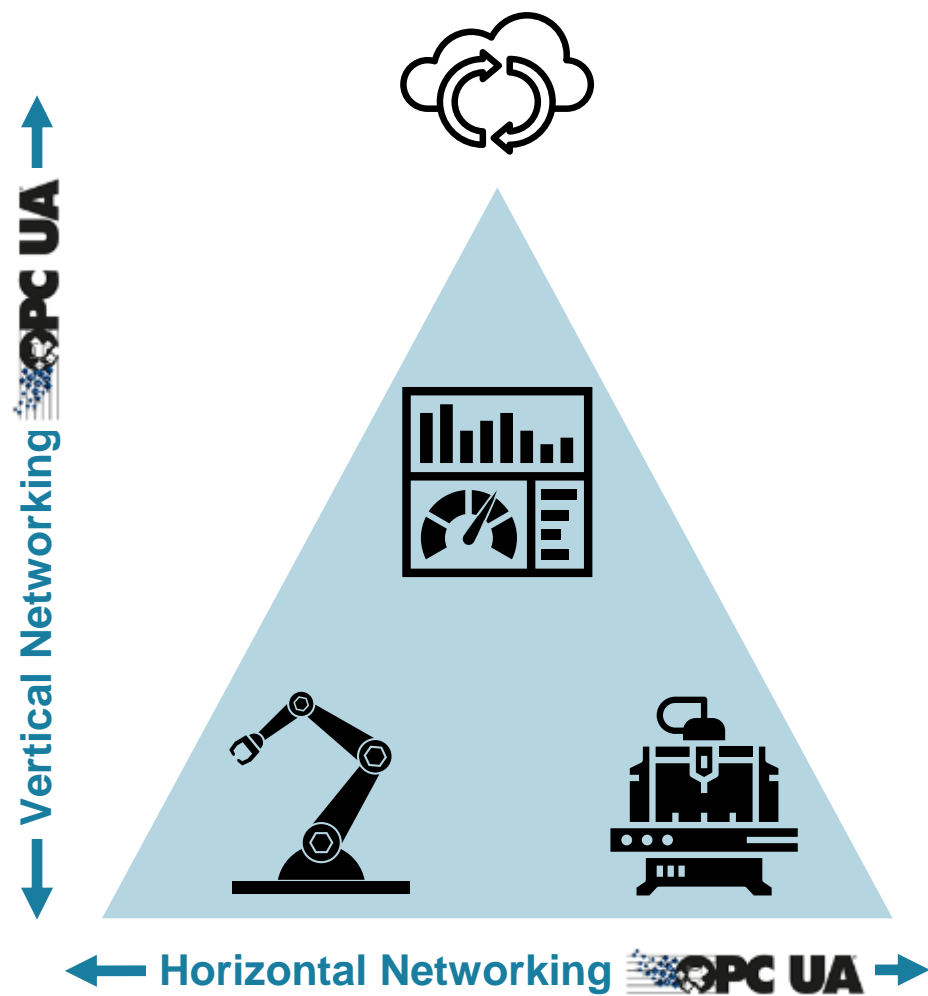
Open source

Security

Two transport mechanism with various protocols

Scalable

Global acceptance

Semantic information models

From Automation Pyramid to Information Network
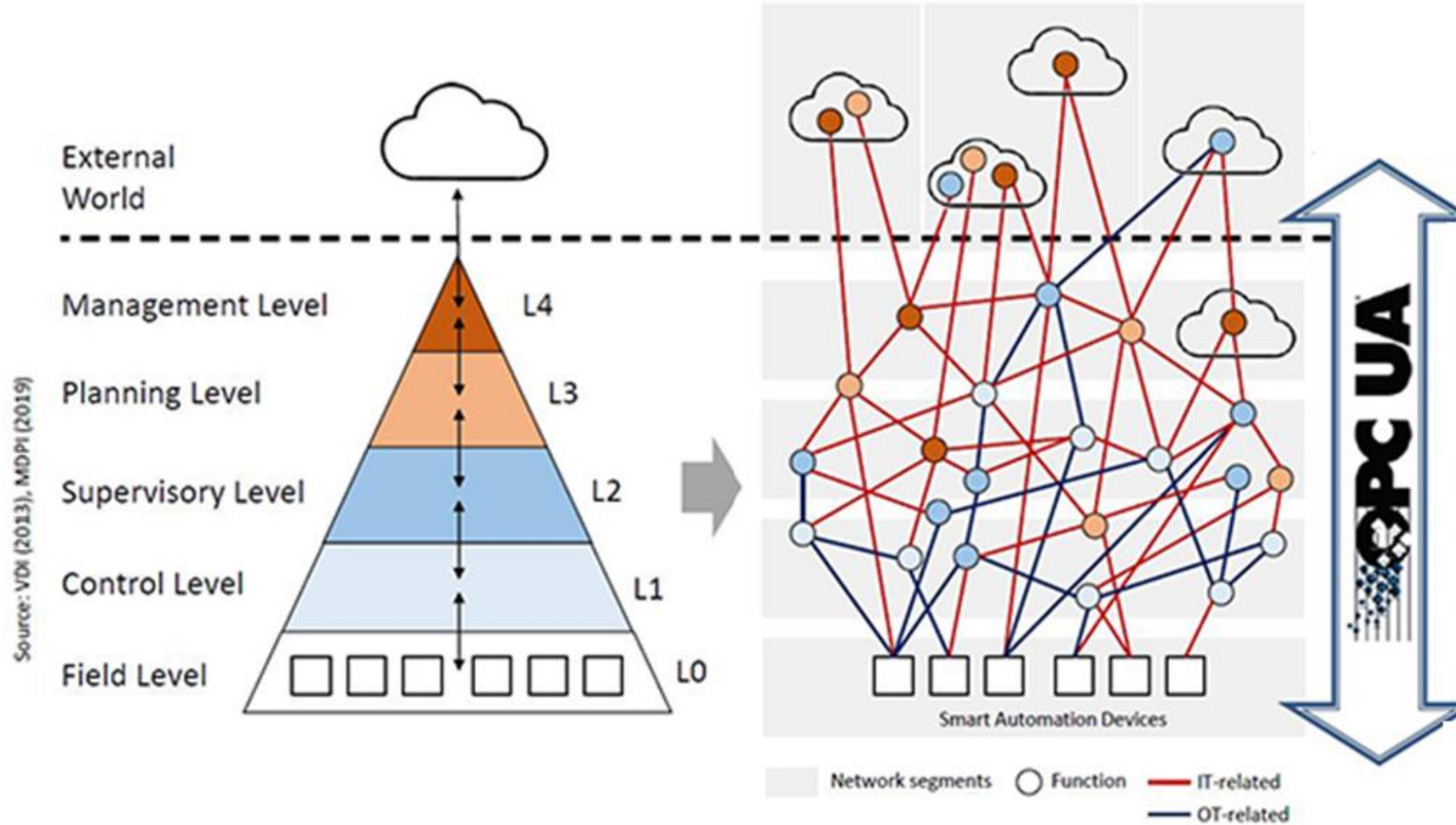
OPC UA Factory Network

Source: OPC Foundation

VDMA

OPC UA Layered Architecture

Vendor Specific Extensions

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OPC UA Deployment Scenarios

Platform Independence

Hardware
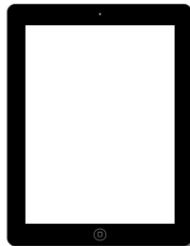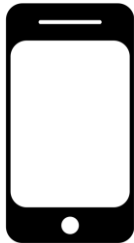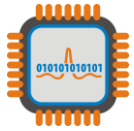
Operating Systems

Real **T**ime **O**perating **S**ystem

OPC UA Client/Server Architecture

Device 1
OPC UA Client

Device 2
OPC UA Server

Client/Server

» Client accesses information from the server via a permanently configured connection

Example: Request → Response

» Device 1 requests information from Device 2

» Device 2 replies to Device 1

Analogy

» Letter service with registered mail and advice of receipt.

OPC UA – Client/Server Architecture
Communication via Subscription Notify

Device 1
OPC UA Client

Cloud

0100100100
1010011010101
01010010010
010011010

10100110101

Device 2
OPC UA Server

Device 3
OPC UA Server

Quelle: VDMA Leitfaden Industrie 4.0 Kommunikation mit OPC UA

Client/Server

» Client accesses information from the server via a permanently configured connection

Example: Subscription → Notify

» Device 1 subscribes to the information from Device 3

» Device 3 informs Device 1 as soon as information changes

Analogy

» Registration to football live ticker with feedback on special events via SMS

OPC UA Pub/Sub Architecture

Device 1
OPC UA Subscriber

Cloud

Device 2
OPC UA Subscriber

Device 4
OPC UA Subscriber

Device 3
OPC UA Publisher
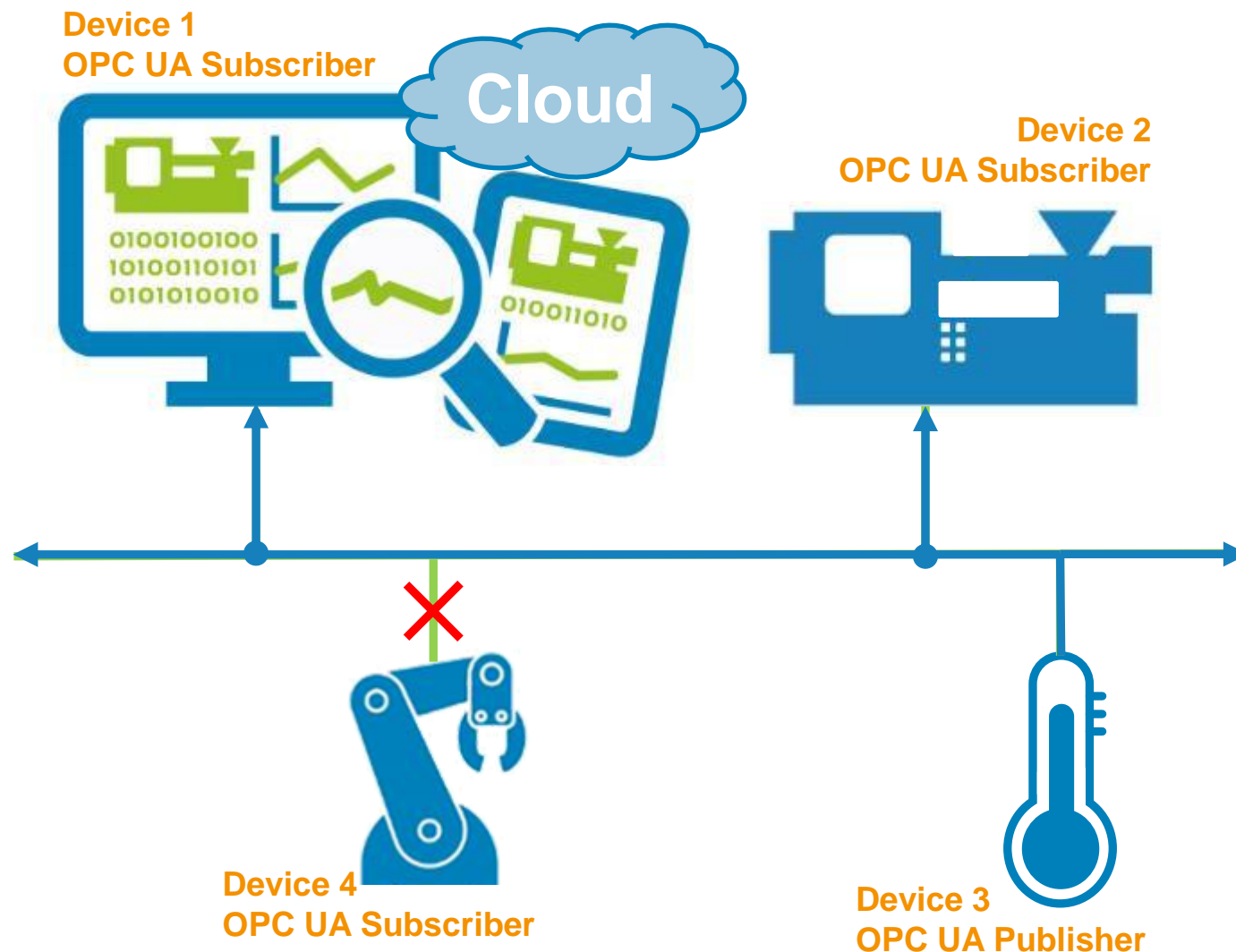
Publisher/Subscriber

» Publisher sends to unknown subscribers without a fixed connection

» Application example:
  – 1:n - Sensor publishes data used by different systems

Example: Pub/Sub

» Device 3 continuously sends information to the network

» Device 1 and 2 have subscribed to the information

» Device 4 has not subscribed to the information

Analogy

Setting a radio frequency

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- **PLUS – Discovery and Security**

OPC UA Security

Security

Security is incorporated into OPC UA at all levels!

◦ Confidentiality and integrity of communication is only part of the solution

▸ End-to-End Communication Security

▸ User Authentication

▸ Roles and role Management

▸ Audit logging

▸ Certificate management infrastructure

OPC UA Security Objectives – Trusted Information (CIA Triad)

Confidentiality

» Keep private data private.

Integrity

» Data remains unchanged from sender to receiver.

Availability

» Availability, by restricting the message size and returning no security related codes

OPC UA Security Objectives – Access Control (AAA Framework)

Authentication

» Proof of Identity based on something the entity is, has or knows.

Authorization
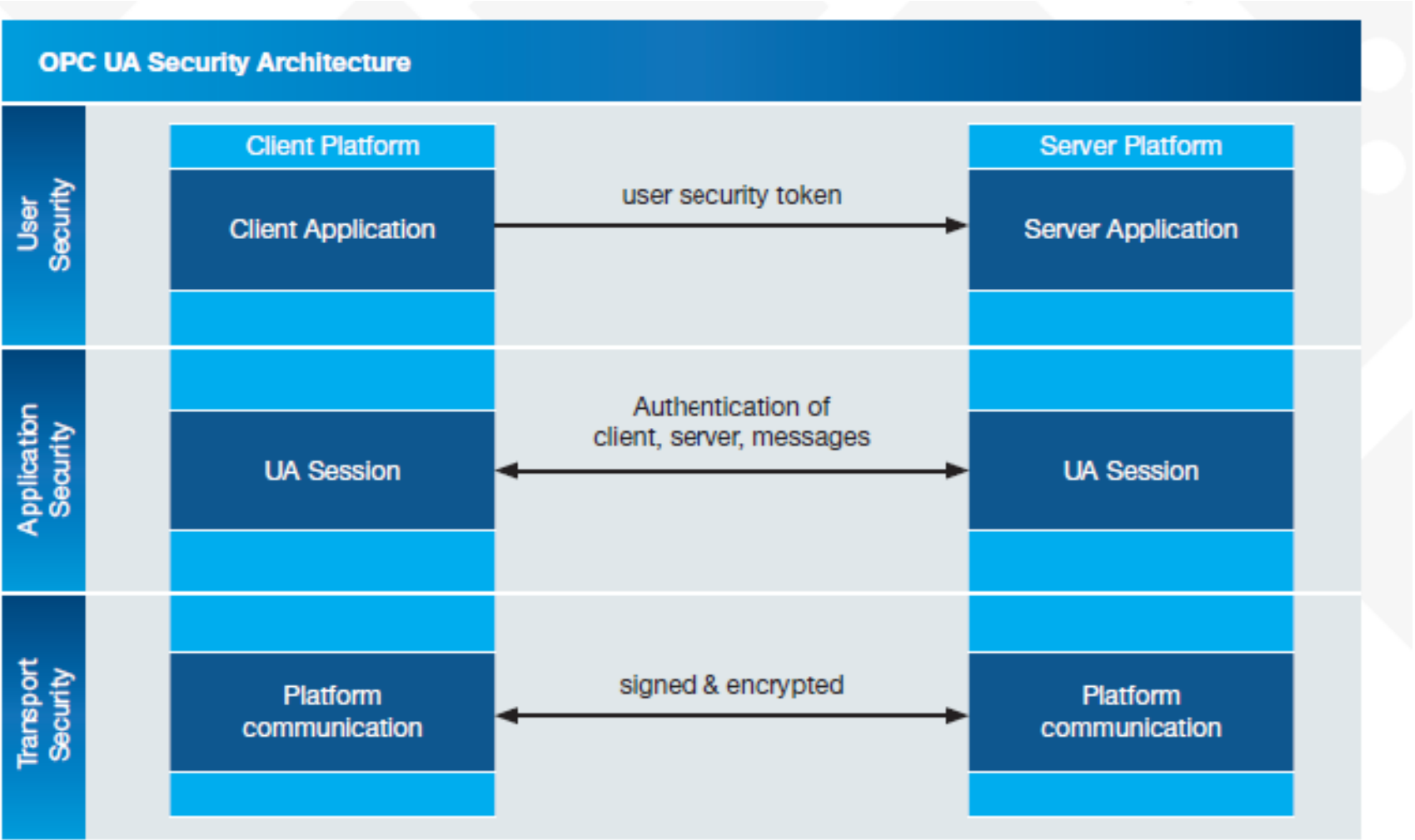
» Not specifically in the OPC UA specification but is vendors choice to implement.

Auditability

» Provide evidence that the system functions as specified and identify initiators of certain actions.

Security Architecture

The Connection Process

Secure Session

- Application layer connection.
- The session uses the algorithms defined for the channel and assigns an identity to the connection.

Transport Layer

- Protocol determined by the UA Stack.
- Security not required, but may be implemented by the protocol, i.e. HTTPS.

Secure Channel

- Long-running logical connection between single client and server.
- Ensures *Confidentiality* and *Integrity* of the messages exchanged.
- Supports three *SecurityModes*: None, Sign, and SignAndEncrypt.
- Latest security algorithms.

Auditing and Events

- AuditEvents are Events that are generated as a result of an action taken on the Server by a Client of the Server.
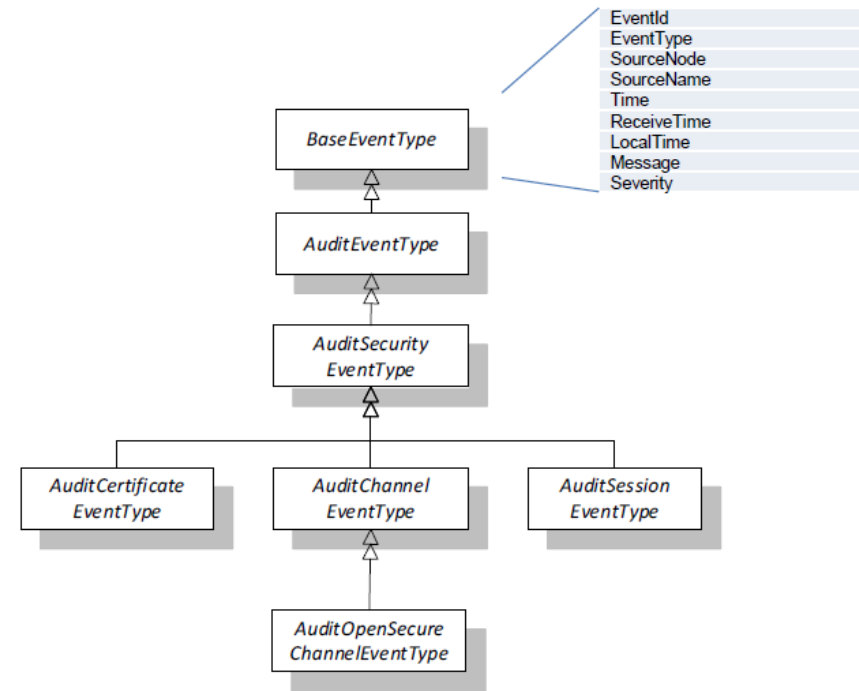
- AuditSecurityEvents are Events related to Security such as validating a Certificate or UserIdentityToken.

- AuditEvents may be reported vis Subscriptions, PubSub or via non-UA mechanisms such as SYSLOG.

- The structure and semantics of the events is the same no matter how they are reported.

Roles And Permissions

▸ Roles are associated with a Session

▸ Permissions are associated with a combination of a Role and a Node.

▸ A Session will have access to a Permission if the one or more of its Roles has the Permission.

▸ Mapping Rules are used to determine which Roles are available for a Session

Role	Mapping Rules	Description
Anonymous	Identities = Anonymous Applications = Endpoints =	An identity mapping rule that specifies the Role applies to anonymous users.
AuthenticatedUser	Identities = AuthenticatedUser Applications = Endpoints =	An identity mapping rule that specifies the Role applies to authenticated users.
Operator1	Identities = User with name 'Joe' Applications = urn:OperatorStation1 Endpoints =	An identity mapping rule that specifies specific users that have access to the Role with a application rule that restricts access to a single Client application.
Operator2	Identities = Users with name 'Joe' or 'Ann' Applications = urn:OperatorStation2 Endpoints =	An identity mapping rule that specifies specific users that have access to the Role with a application rule that restricts access to a single Client application.
Supervisor	Identities = User with name 'Root' Applications = Endpoints =	An identity mapping rule that specifies specific users that have access to the Role
Administrator	Identities = User with name 'Root' Applications = Endpoints = opc.tcp://127.0.0.1:48000	An identity mapping rule that specifies specific users that have access to the Role when they connect via a specific Endpoint.

OPC UA Global Discovery Server (GDS)

Problem: How do we ensure certificate management in a factory?

» OPC UA specifies a Global Discovery Server

OPC UA Global Discovery Server (GDS)

» provides the necessary infrastructure to provide enterprise-wide administration of OPC UA Servers.

» handles discovery of registered OPC UA servers.

» **…but also handles certificate management.**

Major organizations have implementations of OPC UA GDS.

» Example: OPC Vault from Microsoft

OPC UA Companion Specifications

Purpose of Companion Specification

- OPC UA Companion Specifications are developed for various reasons:
  - To publish specific information models (e.g., for specific industries, specific devices, specific use cases).
  - To specify how to use OPC UA in specific environments.
  - **Examples:**
    - OPC UA standard for Robotics (OPC 40010), Vision Systems (OPC 40100), Joining Systems (OPC 40450 and 40451), etc.

- **New Information Models** can be created based on the OPC UA Data Model and eventually derived from OPC UA **Base** Information Models.
  - Companion specifications of such Information Models are often called "**Industry standard models**" because they typically address a dedicated industry problem.
  - The synergy of the OPC UA infrastructure to exchange such industry information models enables interoperability at the semantic level.

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Harmonization and Reuse

- The purpose of harmonization is to ensure that several companion standards reuse common building blocks. Several use cases could be common for various domains.
  - **Examples:** Asset Identification, Asset States, etc.

- OPC Foundation and partner organizations such as VDMA enable the reuse of common elements across domains.

- There are several OPC Harmonization groups where representatives of different companion specifications participate and harmonize the information models.
  - **Examples:** Device Integration, Machinery Building Blocks, Machinery Result Transfer, Asset Management Basics, Relative Spatial Location, and many more...

- Any new companion specification planned to be developed is recommended to be reviewed in the OPC Harmonization Group.

- This approach helps in avoiding reinvention of the wheel.

Ways to produce companion specifications

OPC Foundation differentiates **three** ways of producing companion specifications:

- INTERNAL: These are specifications created by OPC-internal working groups.

- JOINT: These are specifications that are created in a joint working group between the OPC Foundation and another organization.
  - These joint specifications represent the majority. The JOINT working group program is defined here: https://opcfoundation.org/joint-working-groups/
  - **Example:** IJT Working Groping is a Joint Working Group of OPC Foundation, VDMA and various vendors. VDMA hosts the IJT Working Group.

- EXTERNAL: Companion specifications can also be created independent of the OPC Foundation.

The Key to Reducing Costs: Data Interoperability

We need…

1. A common **Interface** (Analogy: A Book)

2. A common **Data Format** (Analogy: A Latin Alphabet)

3. A common **Data Model** (Analogy: Then English Language)

4. Common **Semantics** (Analogy: The Plot and Characters of the Novel)

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2. **Data Format:** OPC UA Binary or JSON

3. **Data Model:** OPC UA Information Model

4. **Semantics:** OPC UA IJT Companion Specification
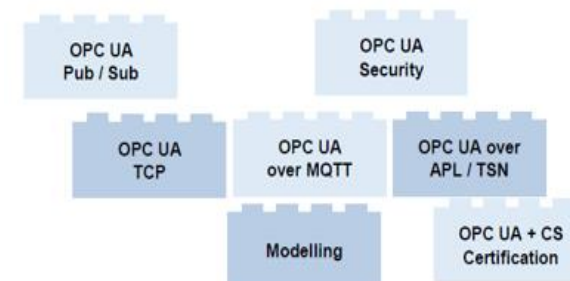
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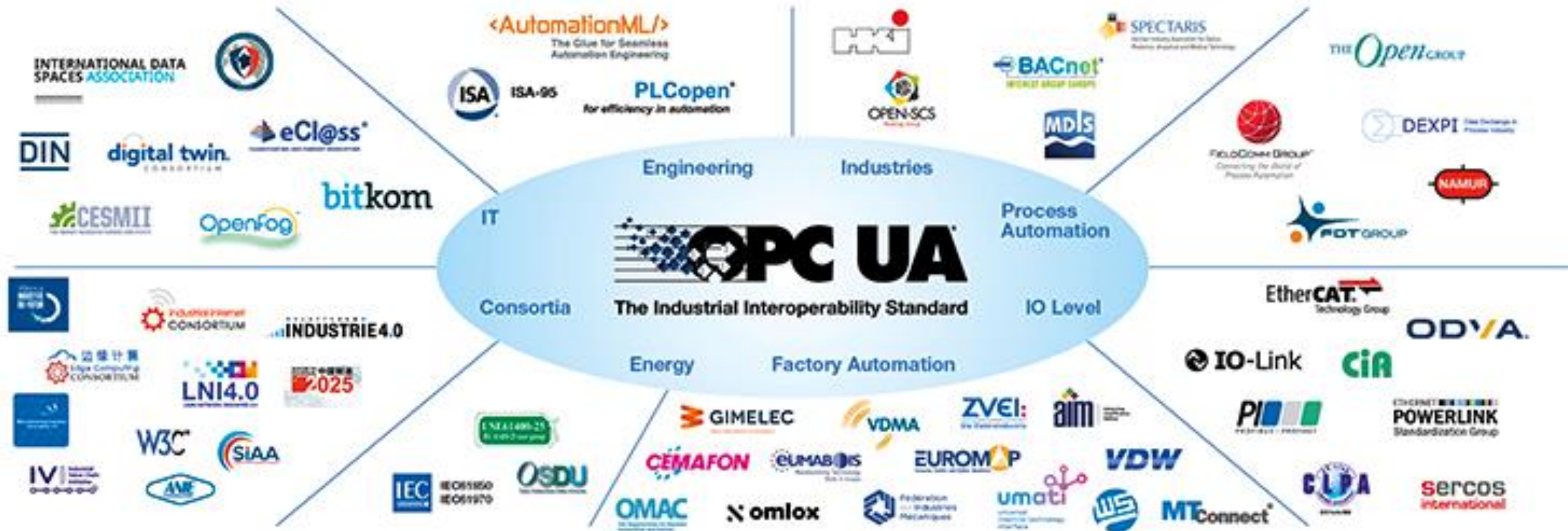 - ...

semantic interoperability
"understand each other"

Source: OPC Foundation

OPC UA Stack/SDK

Layered Architecture

Vendor Specific Extensions

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Use Case specific Protocol Mappings

CS Responsibility

OPC Foundation
Responsibility

Source: OPC Foundation

VDMA

OPC UA Stack and SDKs

- OPC UA SDKs are available in various programming languages.
  - Ansi C, C++, C#, Java, Python, JavaScript, etc.

- The core functionality of OPC UA is handled as part of OPC UA SDK.

- OPC Foundation and other organizations provide various frameworks.
  - Open Source
  - Commercial

OPC UA Profiles and Certification
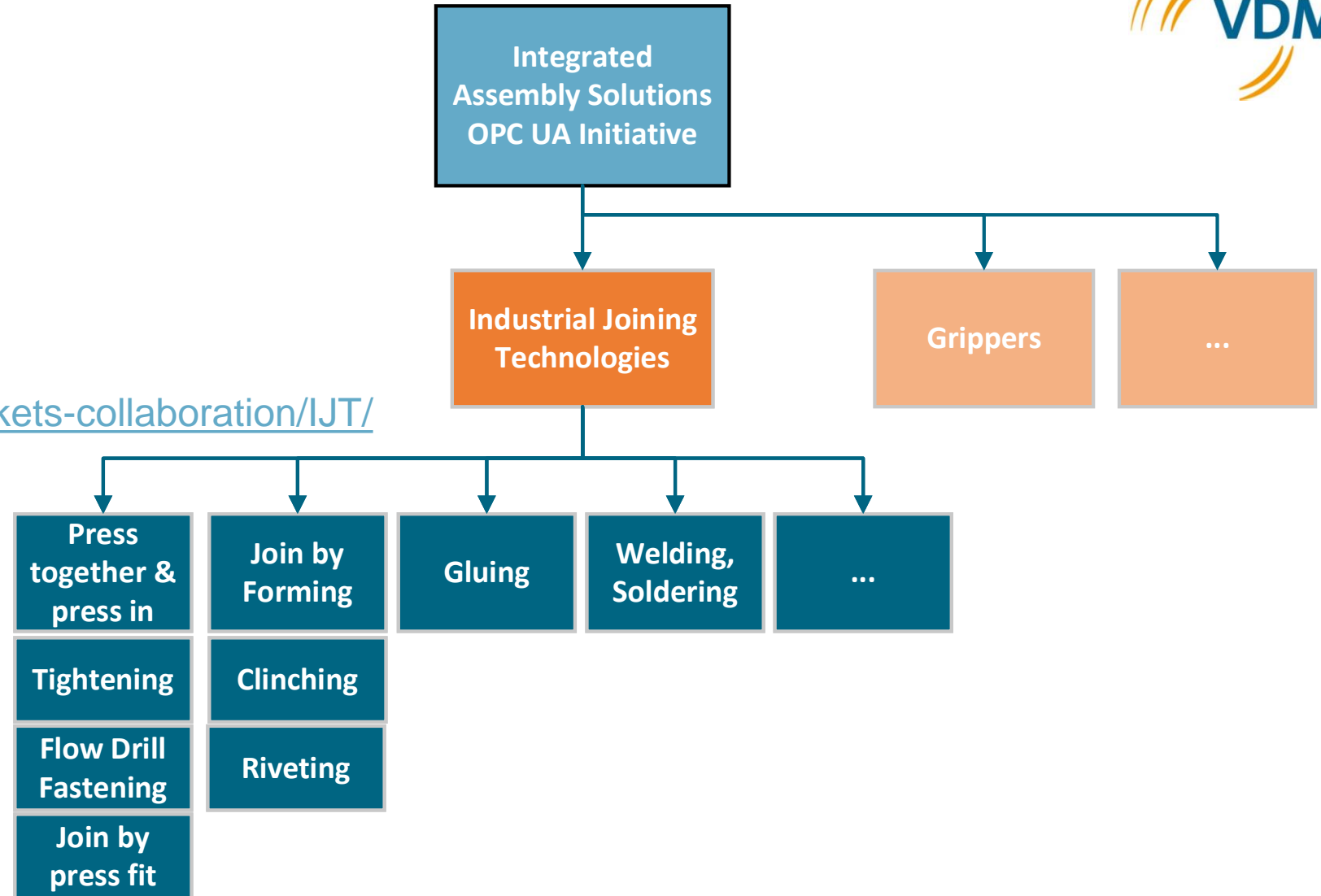
OPC UA Profiles and Certification

- **What is OPC Certification?**

    - https://opcfoundation.org/certification/overview-benefits/

    - https://opcfoundation.org/products/?certified=yes

- **Compliance Test Tools (CTT)**

    - OPC Foundation provides tools which can validate OPC UA Core functionality.

    - https://opcfoundation.org/developer-tools/certification-test-tools

- **Companion Specification Certification**

    - OPC Foundation provides support in testing CS manually or also helps in defining the automated test cases based on collaboration.

    - **Working Group Responsibility:** Definition of Profiles, CUs, Facets, and Test Cases.

- **OPC UA Profiles**

    - Terms and Definitions: https://reference.opcfoundation.org/Core/Part7/v105/docs/3.1

    - Profile reporting tool: https://profiles.opcfoundation.org/

Industrial Joining Technologies (IJT) Overview

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- History

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- Status

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IJT Working Group Members

History and Milestones

| Start Published | Release 1 RC | Release 1 published | Release 2 Start | Result and Events Extension | Commands, Joints, Harmonization | Release 2 RC | Publish Release 2 | Release 3 Kick-off |

May 2019 — Till June 2020 — Oct 2021 — Nov 2021 — Till June 2022 — June – Dec 2022 — Q3 2023 — 2024…

Release 1 Prototypes

Release 2 Prototypes
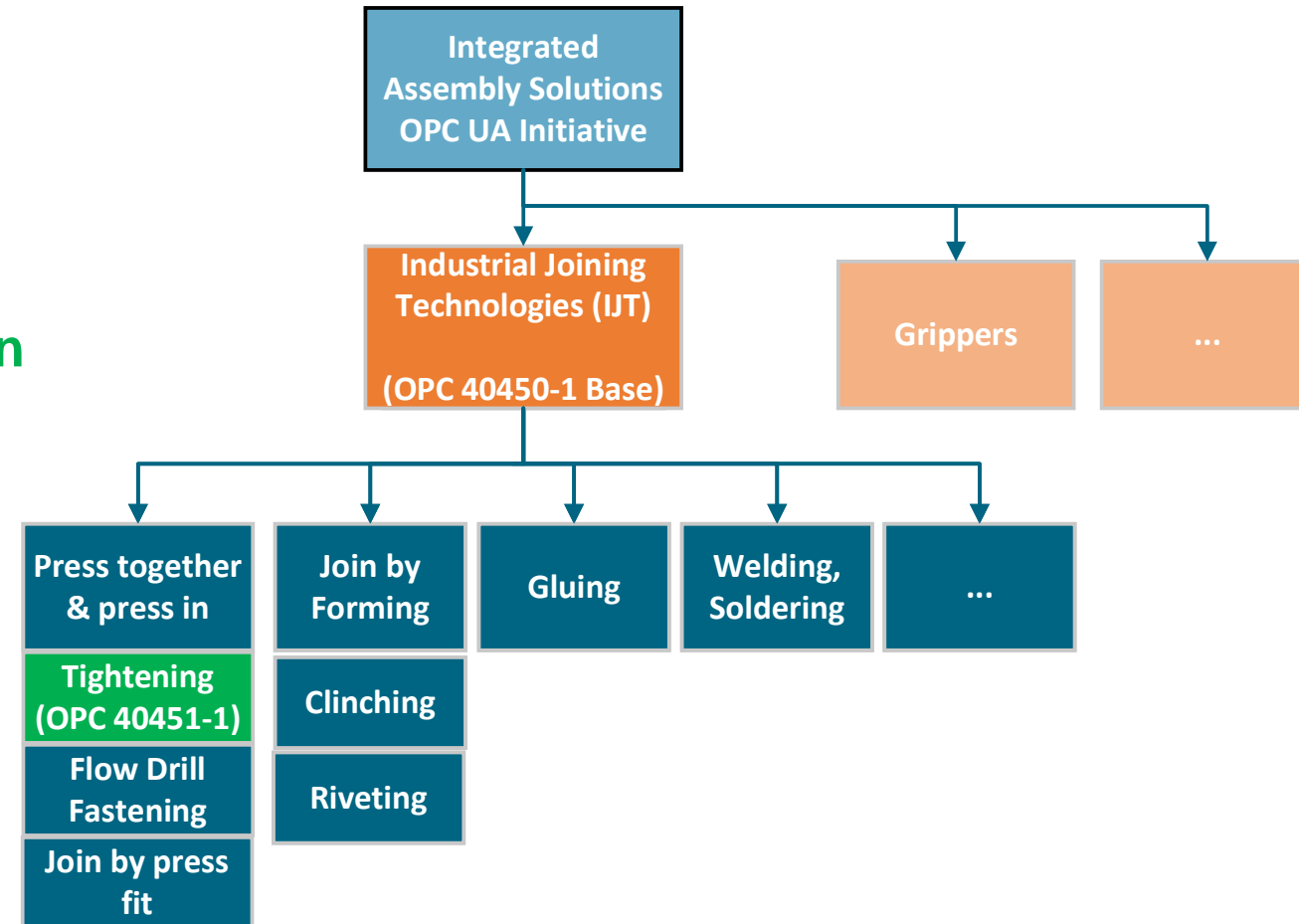
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- **OPC 40450-1** for Joining Systems **version 1.0**
  - Common elements of various joining technologies.
  - http://opcfoundation.org/UA/**IJT/Base**/
  - Opc.Ua.**Ijt.Base**.NodeSet2.xml

- **OPC 40451-1** for Tightening Systems **version 2.0**
  - **Version 1.0** was published in October 2021.
  - Moved common models to the base specification.
  - http://opcfoundation.org/UA/**IJT/Tightening**/
  - Opc.Ua.**Ijt.Tightening**.NodeSet2.xml

Integrated Assembly Solutions OPC UA Initiative

Industrial Joining Technologies (IJT) (OPC 40450-1 Base)

Grippers

...

Press together & press in

Tightening (OPC 40451-1)

Flow Drill Fastening

Join by press fit

Join by Forming

Clinching

Riveting

Gluing

Welding, Soldering

...

Reuse of Harmonized Specifications

NamespaceUri	Description	Use	Namespace Index	Example
http://opcfoundation.org/UA/	OPC UA Base	Mandatory	0	0:EngineeringUnits
http://opcfoundation.org/UA/DI/	OPC UA for Devices (OPC 10000-100).	Mandatory	2	2:DeviceRevision
http://opcfoundation.org/UA/AMB/	OPC UA for Asset Management Basics (OPC 10000-110).	Mandatory	3	3:IRootCauseIndicationType
http://opcfoundation.org/UA/Machinery/	OPC UA for Machinery Basic Building Blocks (OPC 40001-1).	Mandatory	4	4:MachineIdentificationType
http://opcfoundation.org/UA/Machinery/Result/	OPC UA for Machinery Result Transfer (OPC 40001-101).	Mandatory	5	5:ResultManagementType

IJT Use Cases

Use Cases Overview

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Asset Management

Overview and Identification of physical assets in the given system.

Example:

Manufacturer, Serial number, Software Revision…

Condition Monitoring

Acquisition and processing of information that indicate the state of an asset over time.

Example:

Health status, temperature…

Result Management

Primary process output of the tightening operation.

Example:

Single Result, Batch Result, Job Result, Multi-spindle Result, etc.

Event Management

Various types of events with standard payload and filter criteria.

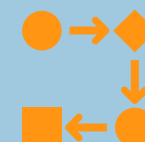**Example:**

Tool Connected, Maintenance Events, etc.

Commands

Asset Management control mechanisms.

Joining Process Management.

Example:

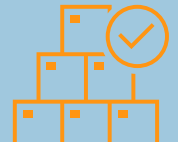Select Program, Send Program, Enable Tool, etc.

Joint Management

Provides joint data.

Example:
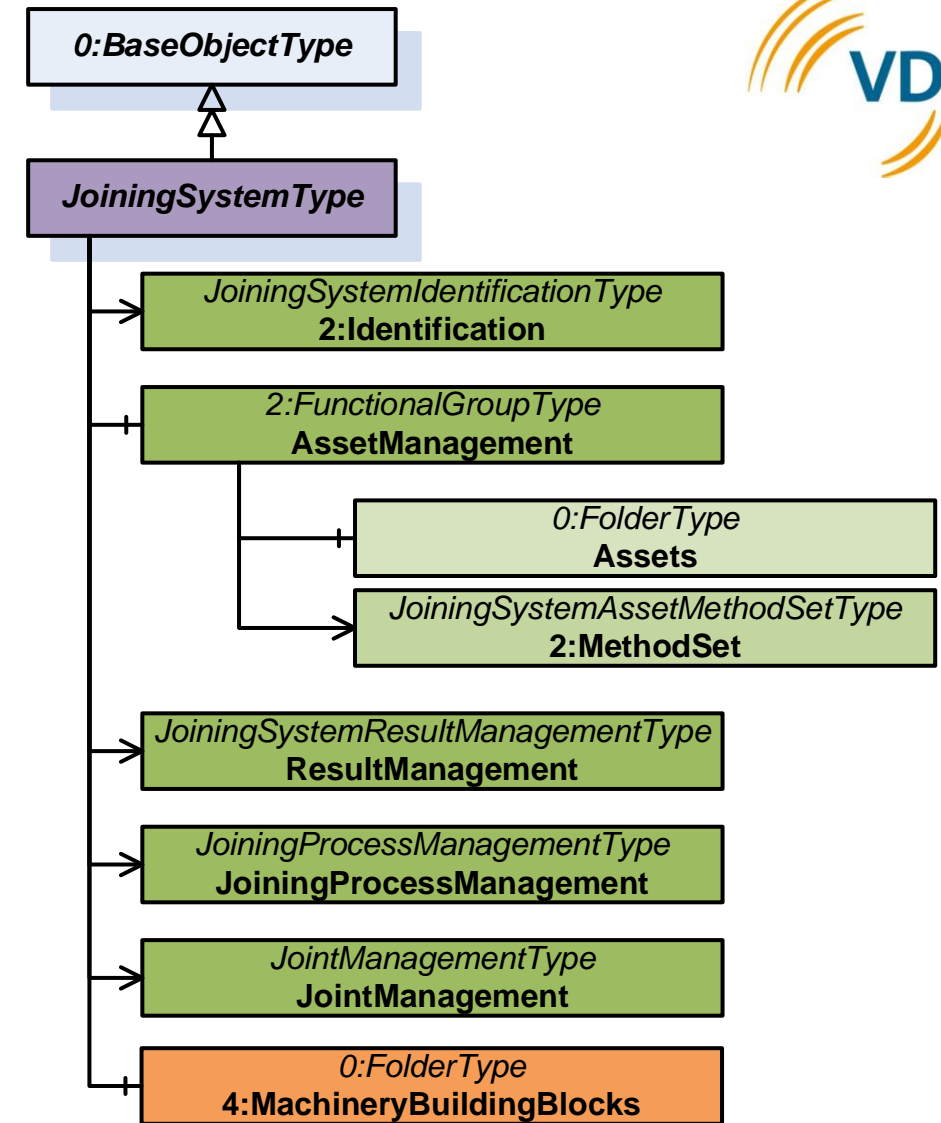
Joint with associated Programs, etc.

Technical Overview of Models

Joining System Overview

- Standard entry point for a joining system.

- Common interface for any joining system.

- Top-level structure with building blocks for the

  use cases discussed such as:

  - Asset Management

  - Result Management

  - Joining Process Management

  - Joint Management

  - …

Asset Management

Asset Management Overview

- Definition of assets building blocks.

- Diverse systems – Flexible asset management model to build different systems.
  - Fixtured, Handheld, Pneumatic, Multi-Channel, Single Channel

- Reuse of Machinery Building Blocks and Asset Management Basics.

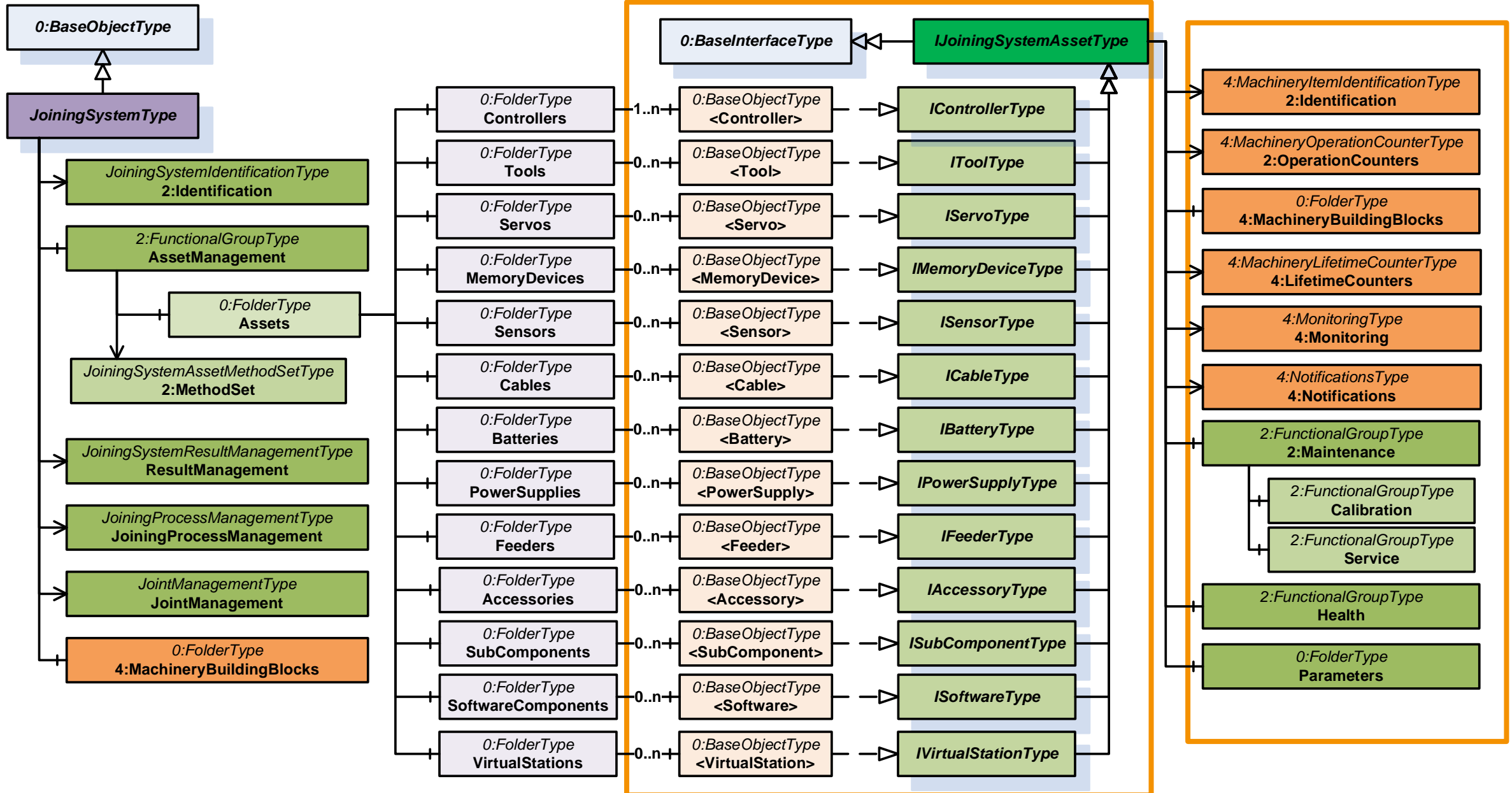- Future Extensibility with the usage of Interfaces and Add-Ins instead of concrete types.

Joining System

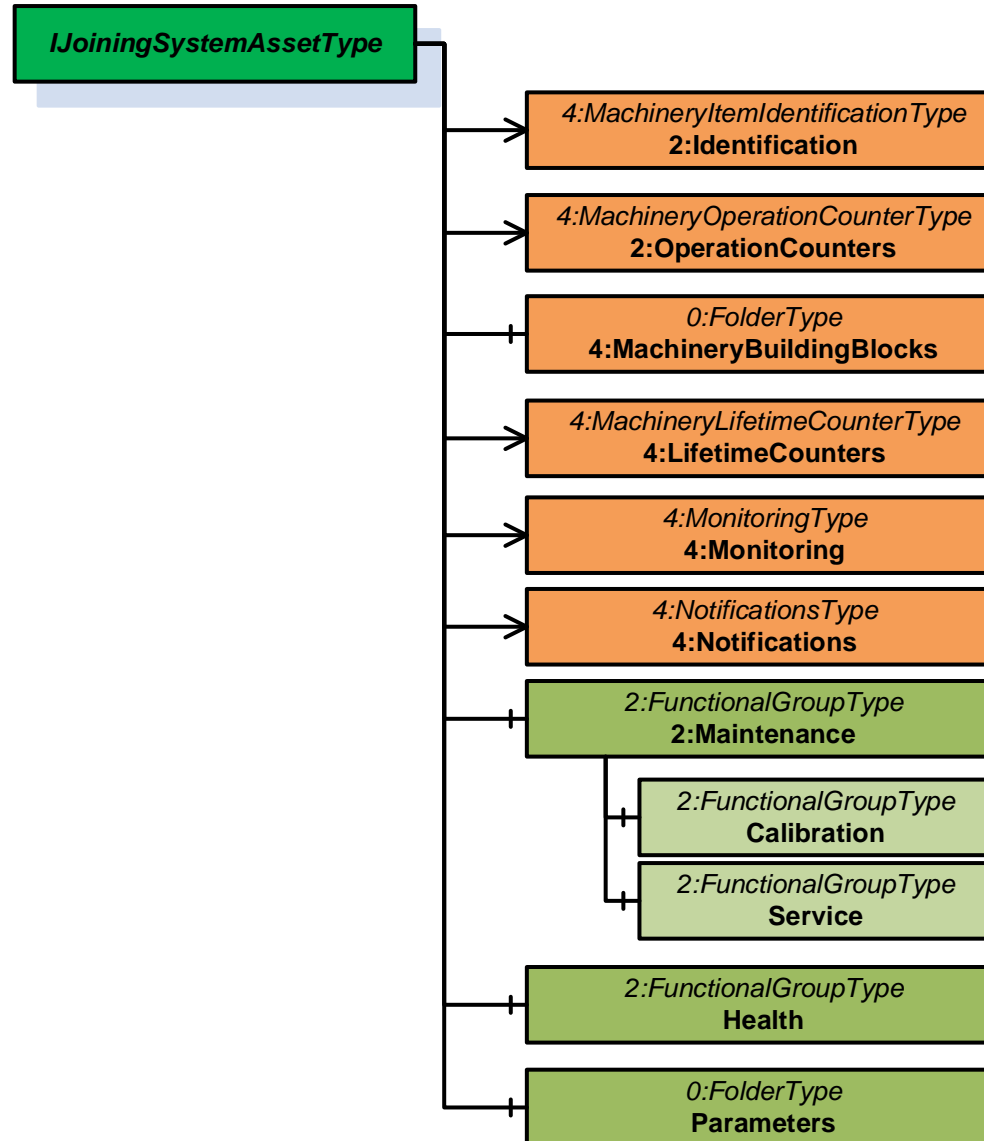|					
Controller	Tool	Servo	Feeder	Battery	Software
Accessory	Memory Device	Cable	Power Supply	Sub-Component	Virtual Station

Asset Management

Flexible Asset Model…
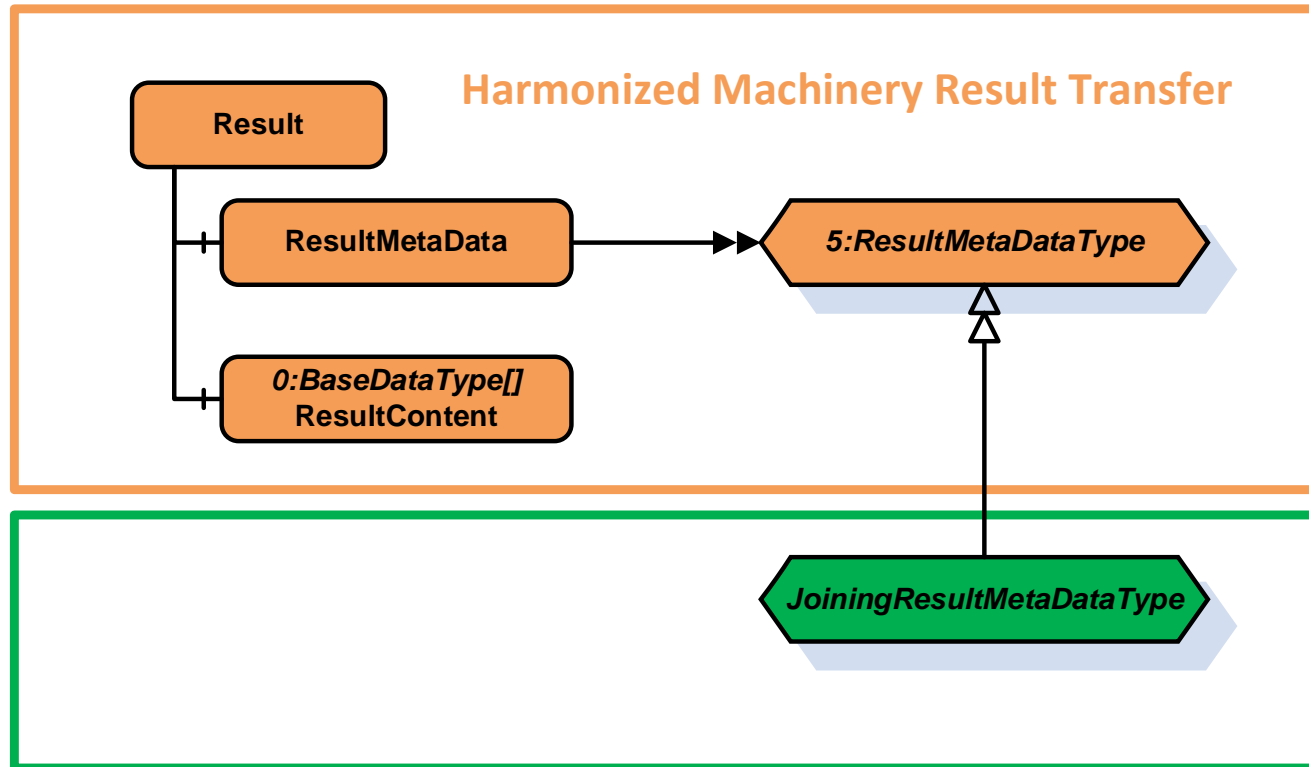
Common Asset Data…

Common Asset Data

Result Management

Result Overview

Structure

Example

Harmonized Machinery Result Transfer

Result
ResultMetaData → *5:ResultMetaDataType*
0:BaseDataType[] ResultContent

JoiningResultMetaDataType

Result
ResultMetaData
ResultId
CreationTime
...
JoiningResultMetaData
Classification
SequenceNumber
...
ResultContent

It can be Joining Result, Set of Sub-Results, Vision Result, Quality Result, etc.
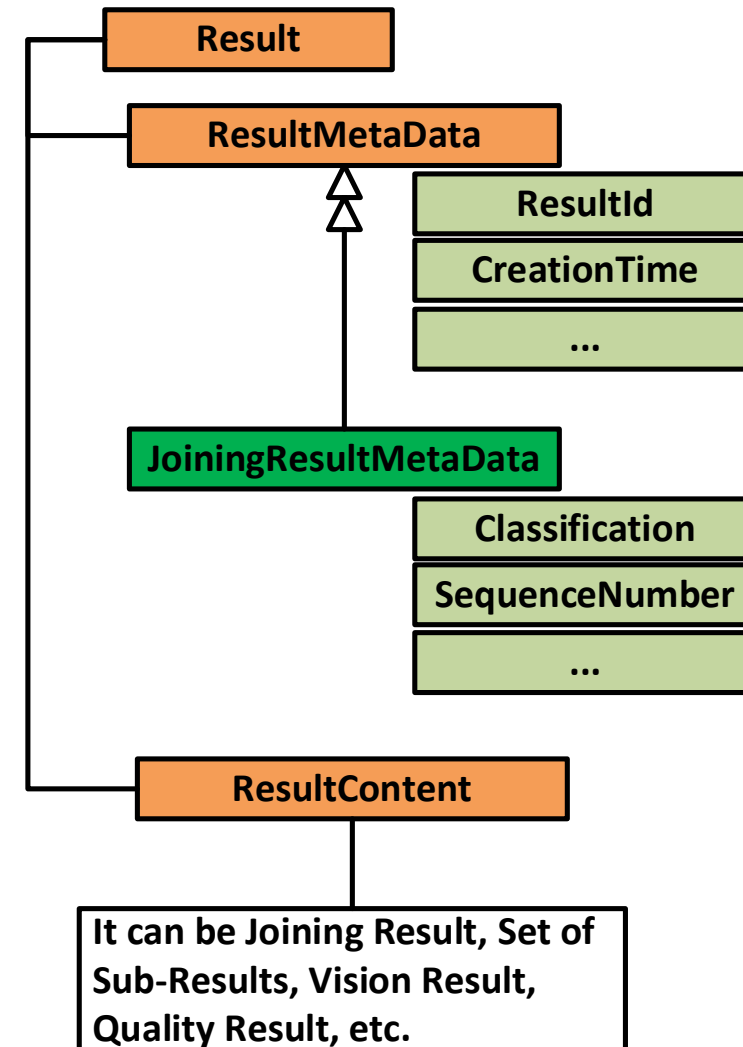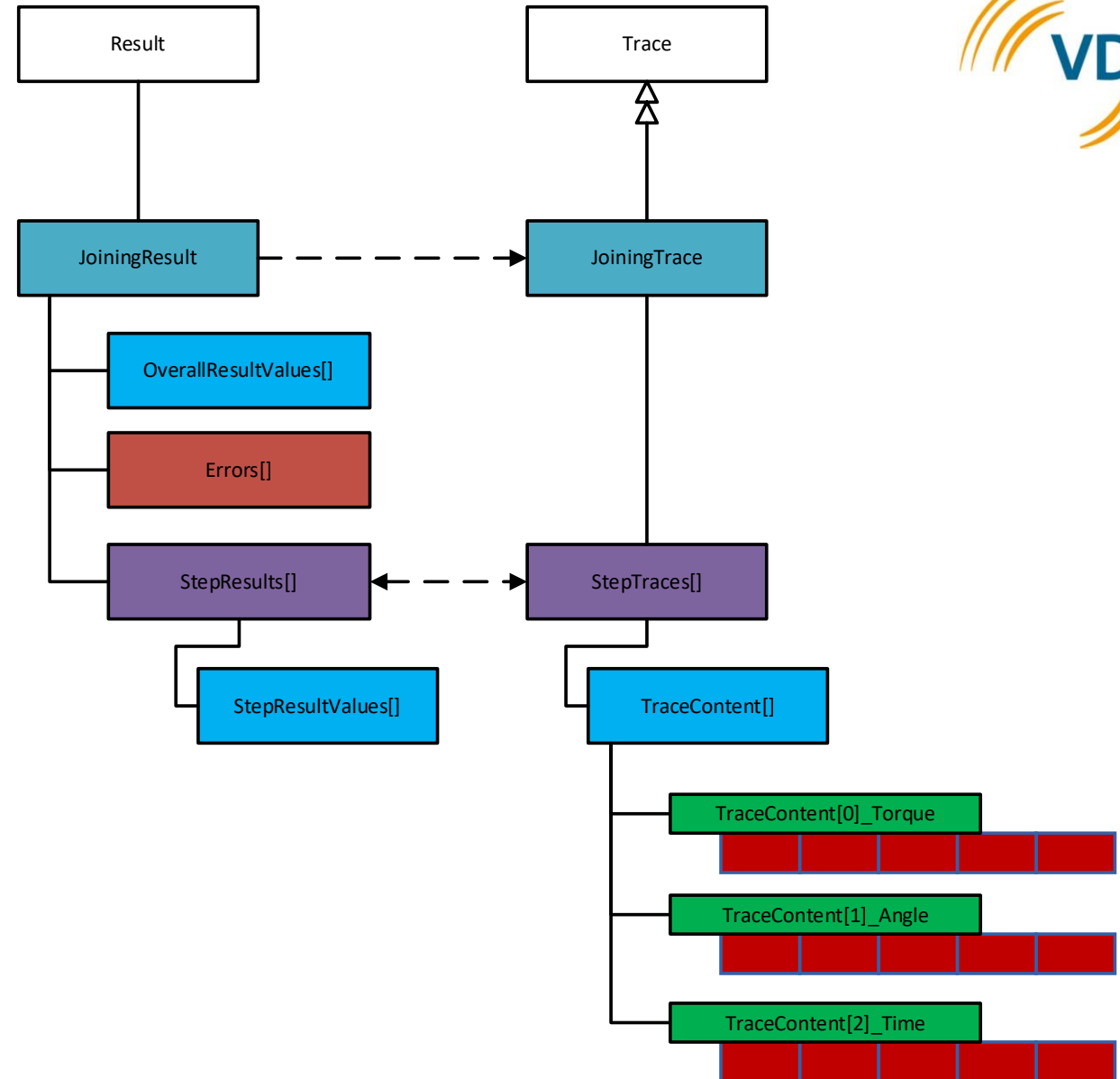
Single Joining Result Content

- Joining Result

  - Global values

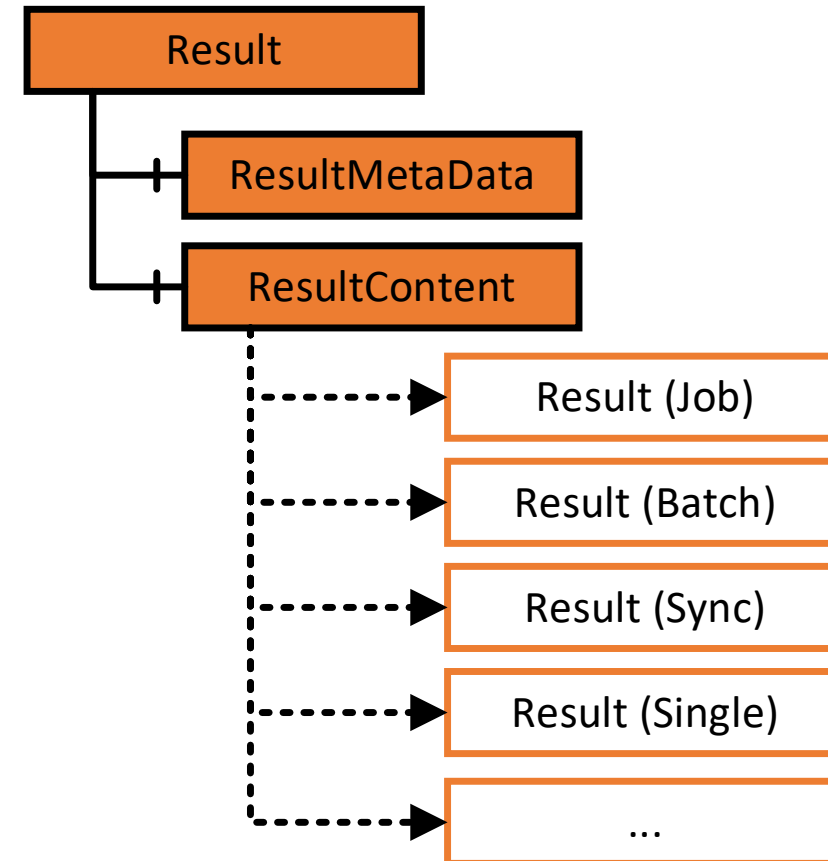 - Step Results

  - Errors

  - Traces

Result Classification – Multiple Use Cases
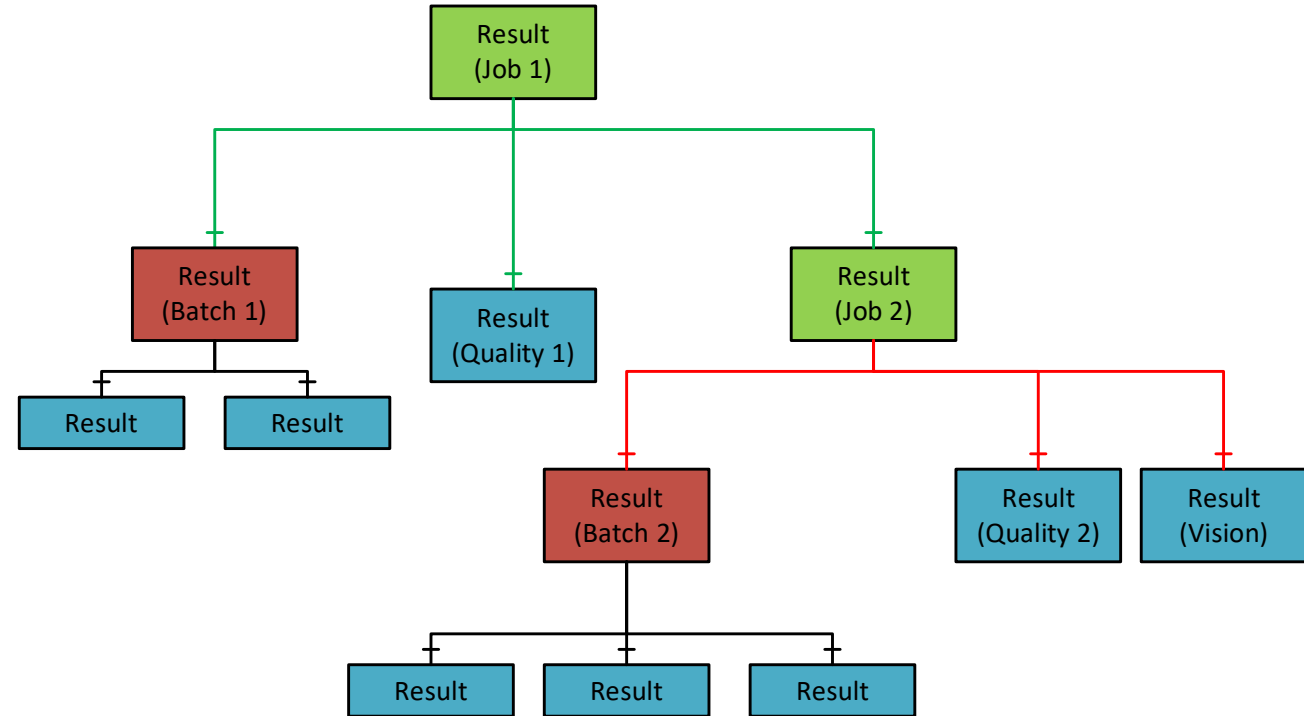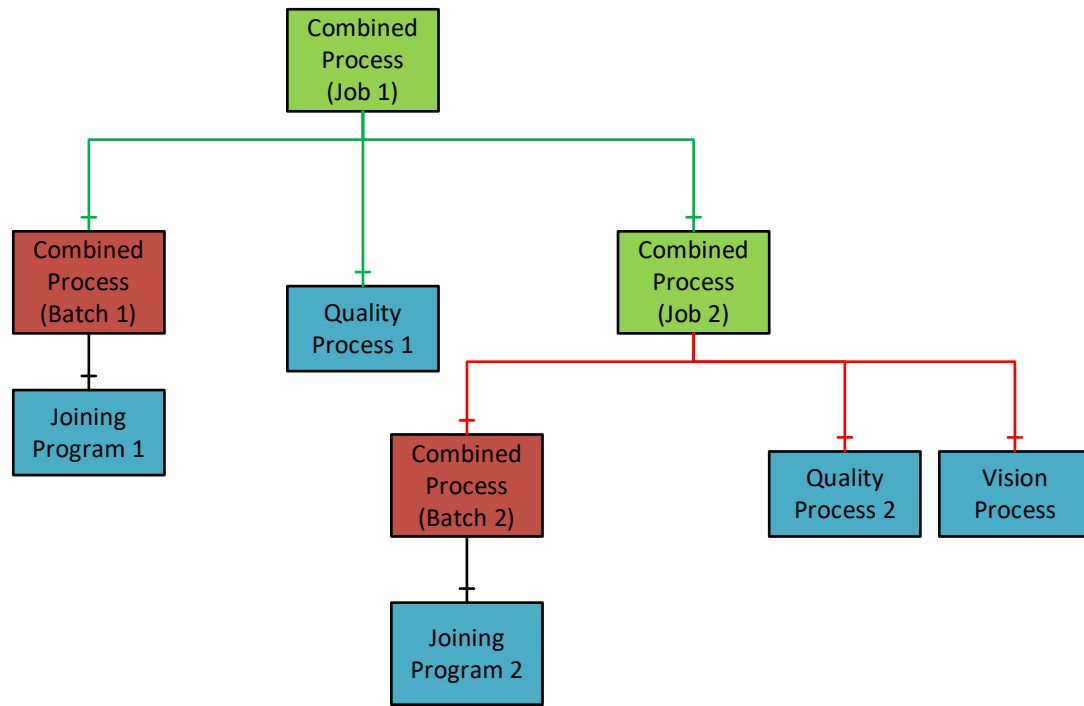
- Result

  - Common Joining Meta Data

- Result Content

  - Single Result

  - Batch Result

  - Job Result

  - Sync (Multi-spindle) Result

  - Stitching Result

RESULT MODEL

Combined Results – Job Result Example

Parent and Child Results - Options

- Results can be sent in different ways:

- **Case 1:** Parent and Child results separately

- **Case 2:** Parent result with payload of child results

Batch Result Example

SR - SINGLE RESULT
BR - BATCH RESULT

Case 1: Batch Result and Single Results separately. Single Result with reference to parent Batch Result

SR=OK	SR=OK	SR=OK	SR=OK	SR=OK	BR=OK
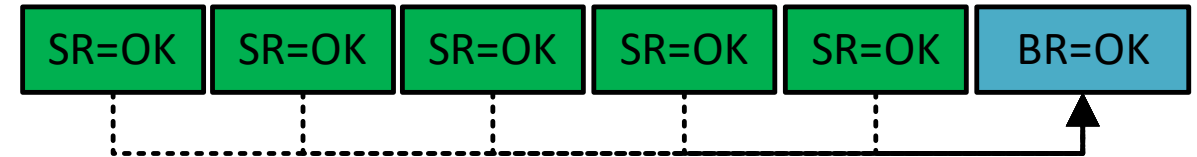
Case 2: Batch Result and Single Results together

BR=OK

SR=OK	SR=OK	SR=OK	SR=OK	SR=OK

VDMA
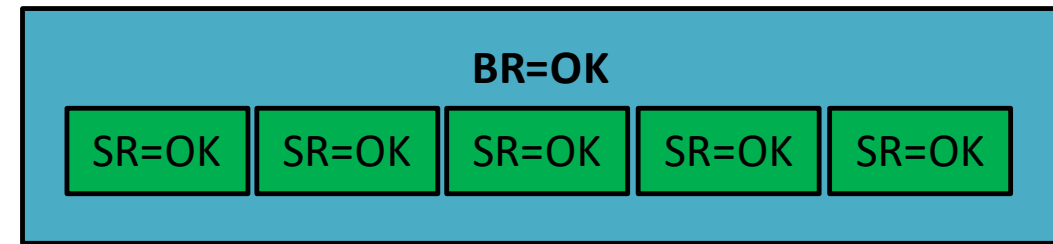
Event Management

Event Management

Event and Condition with **standard payload** from a joining system.

- **Event**

  - Simple transient information sent from the underlying system.

  - Fire and forget from the sender's perspective.

- **Condition**

  - Have a State associated.

  - Can be acknowledged by the client.

Condition Classes

- **Condition Classes**
  - Reuse from base specifications.
- **Condition Sub Classes**
  - Defined in the IJT Working Group.

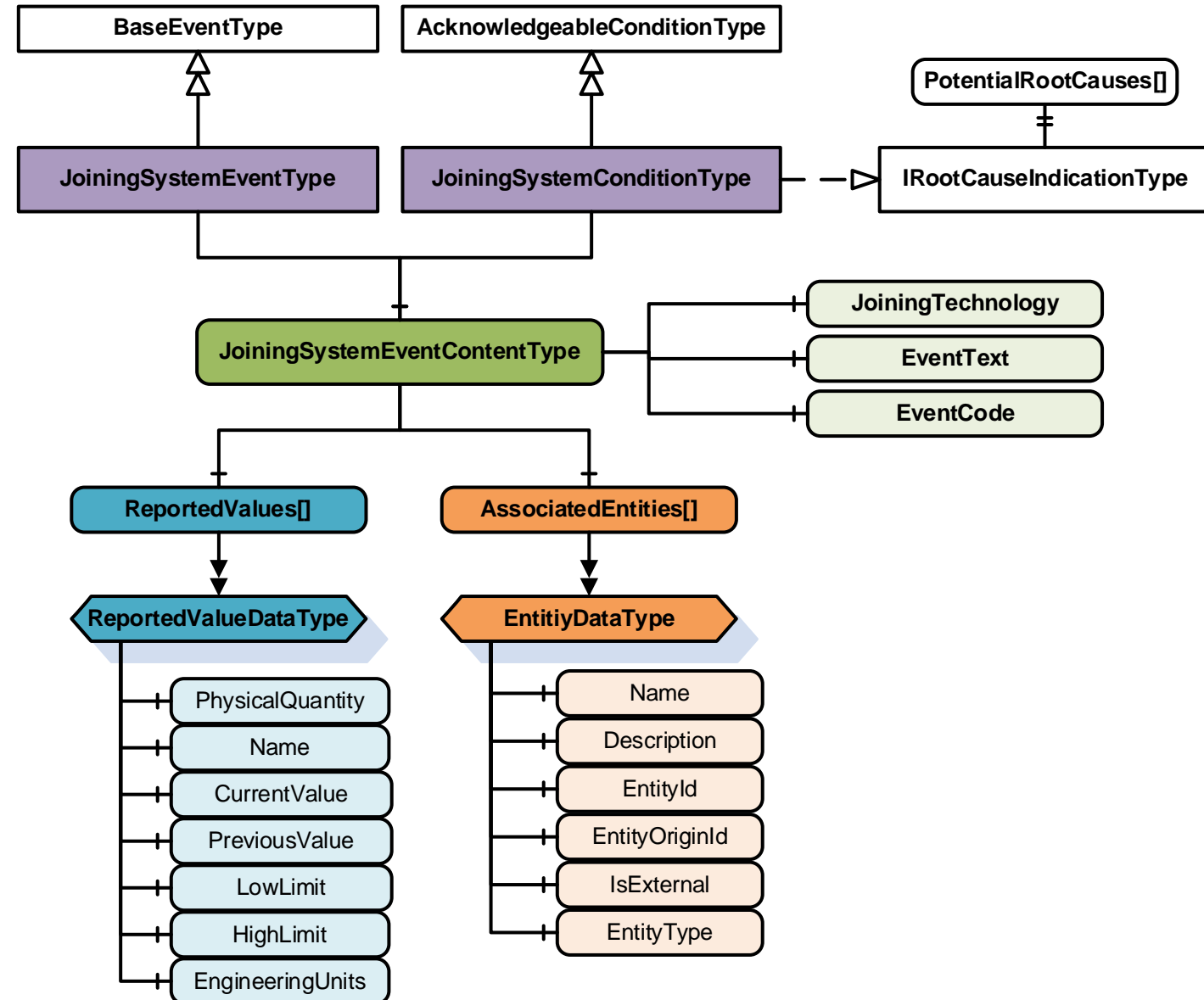- **Example 1: Tool Disconnected**
  - **ConditionClass** = SystemConditionClass
  - **ConditionSubClass** = AssetDisconnectedConditionClass

- **Example 2: The tool is out of range from the station.**
  - **ConditionClass** = SystemConditionClass
  - **ConditionSubClass** = LocationOutOfZone

- **Example 3: Software Expired**
  - **ConditionClass** = SystemConditionClass
  - **ConditionSubClass[0]** = SoftwareConditionClass
  - **ConditionSubClass[1]** = ExpiredConditionClass

Condition Classes in Base Specifications	Condition Classes in IJT Specification(s)
OPC UA Base	
BaseConditionClass	AssetConnectedConditionClass
ProcessConditionClass	AssetDisconnectedConditionClass
MaintenanceConditionClass	AssetEnabledConditionClass
SystemConditionClass	AssetDisabledConditionClass
SafetyConditionClass	ThresholdViolationConditionClass
HighlyManagedAlarmConditionClass	ThresholdViolationResolvedConditionClass
TrainingConditionClass	JoiningSystemUserLoggedInConditionClass
StatisticalConditionClass	JoiningSystemUserLoggedOutConditionClass
TestingConditionClass	LocationInRangeConditionClass
Asset Management Basics	LocationOutOfRangeConditionClass
ConnectionFailureConditionClass	AssetLocationConditionClass
OverTemperatureConditionClass	DataValidationFailureConditionClass
CalibrationDueConditionClass	InputValidationFailureConditonClass
SelfTestFailureConditionClass	ConfigurationChangeConditionClass
FlashUpdateInProgressConditionClass	ErrorConditionClass
FlashUpdatedFailedConditionClass	SoftwareConditionClass
BadConfigurationConditionClass	HardwareConditionClass
OutOfResourcesConditionClass	CertificateConditionClass
OutOfMemoryConditionClass	LicenseConditionClass
InspectionConditionClass	MissingEntityConditionClass
ExternalCheckConditionClass	ExpiredEntityConditionClass
ServicingConditionClass	InvalidEntityConditionClass
ImprovementConditionClass	IncompatibleEntityConditionClass
RepairConditionClass	AcceptedEntityConditionClass
	RejectedEntityConditionClass
	AddedEntityConditionClass
	UpdatedEntityConditionClass
	RemovedEntityConditionClass
	ReceivedEntityConditionClass

Joining Process Management

Joining Process

- Generic container for any type of Joining Process.

  - **Examples:** Joining Program, Joining Batch, Joining Job, etc.

- A concrete definition of the process is vendor-specific.

- The specification defines the interface to access the required processes.
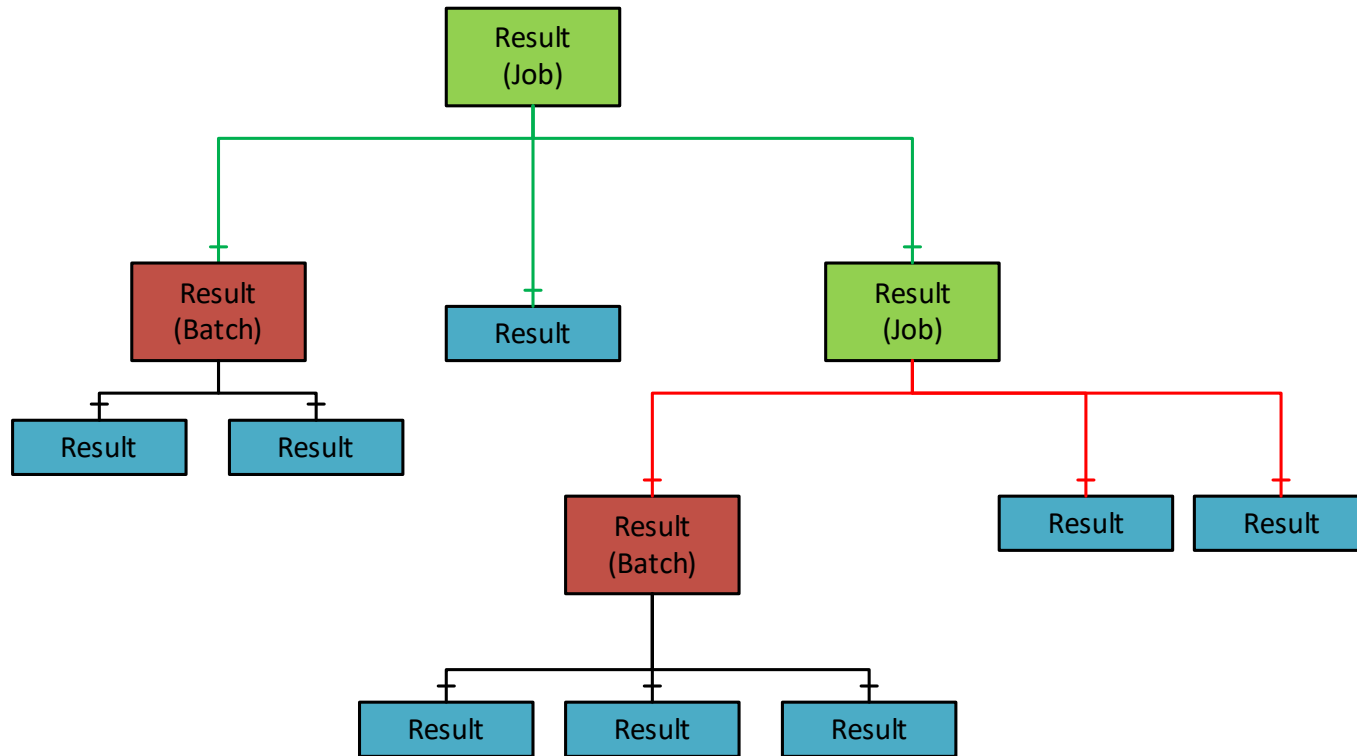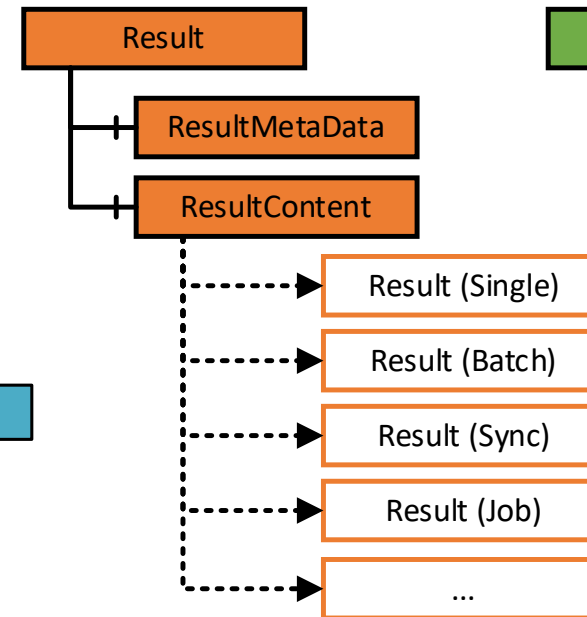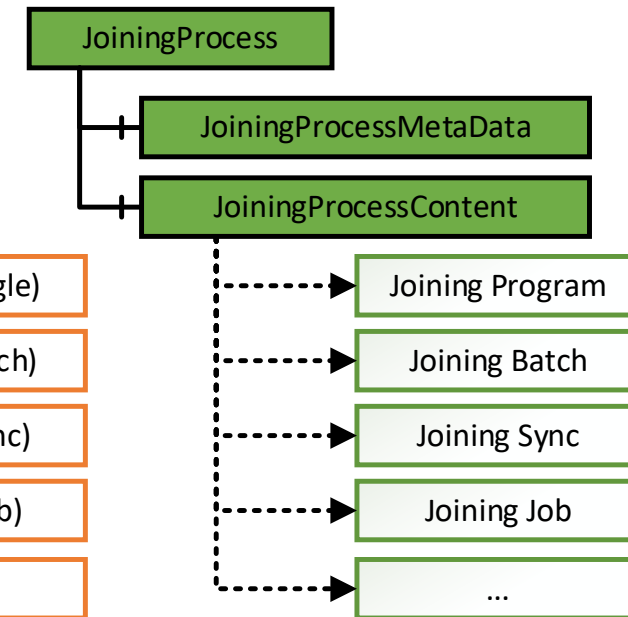
Joint Management

Joint Management

- **Use Case:** The user could send information on **what** type of joint needs to be done instead of **how** the joining operation should be executed.

- Definition of Bolt, Rivet is vendor-specific.

Joining System Method List (Commands)

Joining System Method List

Note: Result Management Methods are reused from **Machinery - Result Transfer.**

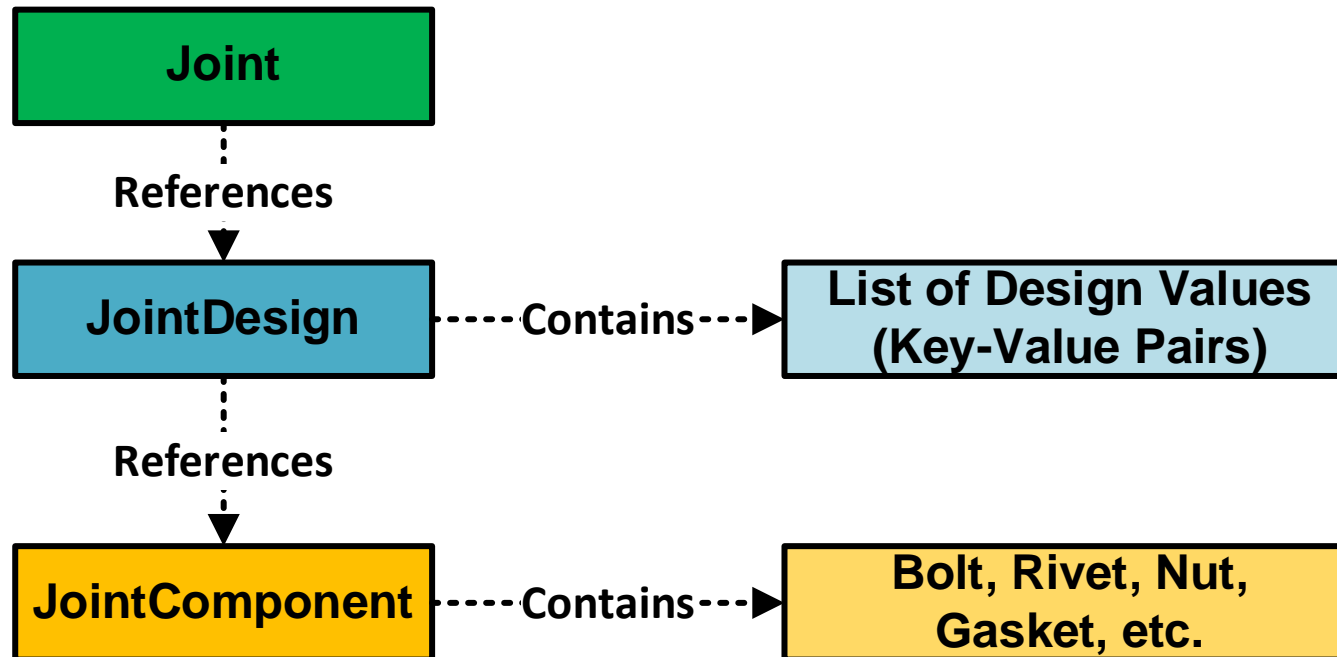| Asset Management	Result Management	Joining Process Management	Joint Management
SetCalibration	GetLatestResult	SendJoiningProcess	SendJoint
EnableAsset	GetResultById	GetJoiningProcess	SendJointDesign
DisconnectAsset	GetResultIdListFiltered	GetJoiningProcessList	SendJointComponent
RebootAsset	ReleaseResultHandle	GetJoiningProcessRevisionList	GetJointList
SendFeedback	AcknowledgeResults	SetJoiningProcessMapping	GetJointRevisionList
GetFeedbackFileList	RequestRequests	SelectJoiningProcess	GetJointDesignList
SetOfflineTimer	RequestUnacknowledgedResults	DeselectJoiningProcess	GetJointComponentList
SetTime		IncrementJoiningProcessCounter	GetJoint
SendIOSignals		DecrementJoiningProcessCounter	GetJointDesign
GetIOSignals		SetJoiningProcessCounter	GetJointComponent
SendIdentifiers		SetJoiningProcessSize	SelectJoint
SendTextIdentifiers		ResetJoiningProcess	DeleteJoint
GetIdentifiers		AbortJoiningProcess	DeleteJointDesign
ResetIdentifiers		StartJoiningProcess	DeleteJointComponent
ExecuteOperation		StartSelectedJoining	
GetErrorInformation		DeleteJoiningProcess	
		GetSelectedJoiningProgram	

IJT Profiles Overview

IJT Certification Overview

- OPC UA Specifications define a set of rules that are needed for a product to be certified.
  - It is done using the definition of Conformance Units, Facets and Profiles.

- The following image provides an overview of profiles defined in IJT specifications.

CU/Facet	Facet/Profile
Joining System Base	Basic Joining System Facet
Result Server Facet	
Asset Management Assets Server Facet	
Basic Joining System Facet	General Joining System Facet
Joining Result Server Facet	
Trace Server Facet	
Identifiers Methods Server Facet	
Event Management Server Facet	
Joining Process Base Server Facet	
Result Content	
Result Internal Identifiers	
Result External Identifiers	
Method Input Argument	

Independent Selectable Features
RESULTS
Batch Result Server Facet
Sync Result Server Facet
Job Result
Partial Consolidated Result
Self Contained Consolidated Result
Consolidated Result with references
Result Value FINAL Tag
ASSET METHODS
Asset Connection Server Facet
Enable Tool Server Facet
JOINTS
Joint Server Facet
Joint Design Server Facet
Joint Component Server Facet
JOINING PROCESS
General Process Operations Server Facet
Sequential Process Operations Server Facet
Start Joining Process
MISC.
Engineering Units

Status

- The specifications were formally released and published in March 2024.

- OPC 40450-1 UA CS for Joining Systems **1.00.0**

  - https://reference.opcfoundation.org/nodesets?u=http://opcfoundation.org/UA/IJT/Base/

- OPC 40451-1 UA CS for Tightening Systems **2.00.0**

  - https://reference.opcfoundation.org/nodesets?u=http://opcfoundation.org/UA/IJT/Tightening/

  - Release 1 was published in **October** 2021.

Prototypes / Simulators and Demonstration

Prototypes / Simulators / Reference Implementation

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- The following portal contains simulators and prototypes for both Clients and Servers.

  - https://github.com/umati/UA-for-Industrial-Joining-Technologies

  - **OPC_UA_Servers/Release1**

    - Available

  - **OPC_UA_Servers/Release2**

    - Available

  - **OPC_UA_Clients/NodeOPCUA_IJT_Client**

    - A client to connect to the OPC UA IJT CS model.

  - The reference implementations are updated regularly.

Demonstrations

- Demonstrations are done using umati infrastructure.

- **What is umati?**

  - It is a common dashboard connected to several machines from various vendors using a standard information model.

  - Refer to https://umati.org/ for more information.

- Demonstration: https://umati.app/

  - Done in automatica 2022 and 2023.

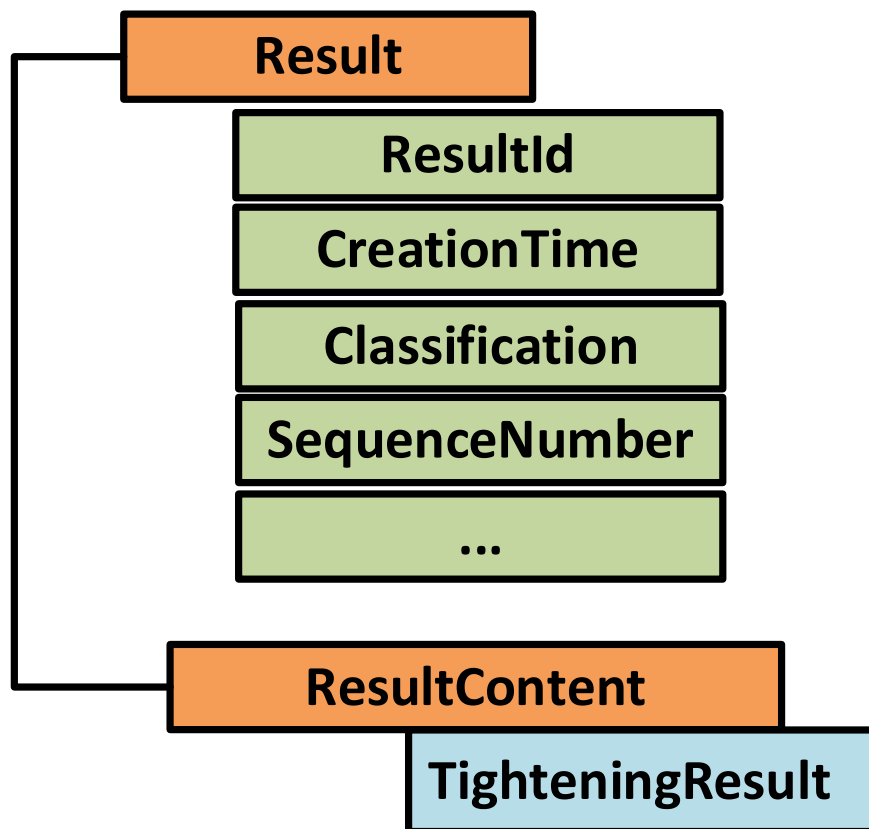# Release 1 and Release 2 Differences

Overview

- **Release 1** was **only** for Tightening Domain.
  - OPC 40451-1 UA CS for Tightening Systems **1.00.0.**

- During **Release 2** work, most of the use cases are generalized for various joining systems.

  Hence, the models were **extended** and **moved** to a new **base** specification.

  - OPC 40450-1 UA CS for Joining Systems **1.00.0.**

  - Tightening Specification is upgraded to OPC 40451-1 UA CS for Tightening Systems **2.00.0.**

- **Why is it a major version release?**

  - Most of the models from the Tightening Specification are generalized and moved to a new

    base specification.

Result Structure Changes

Release 1

Result
- ResultId
- CreationTime
- Classification
- SequenceNumber
- ...

ResultContent
- TighteningResult

Release 2

Result

ResultMetaData
- ResultId
- CreationTime
- ...

JoiningResultMetaData
- Classification
- SequenceNumber
- ...

ResultContent

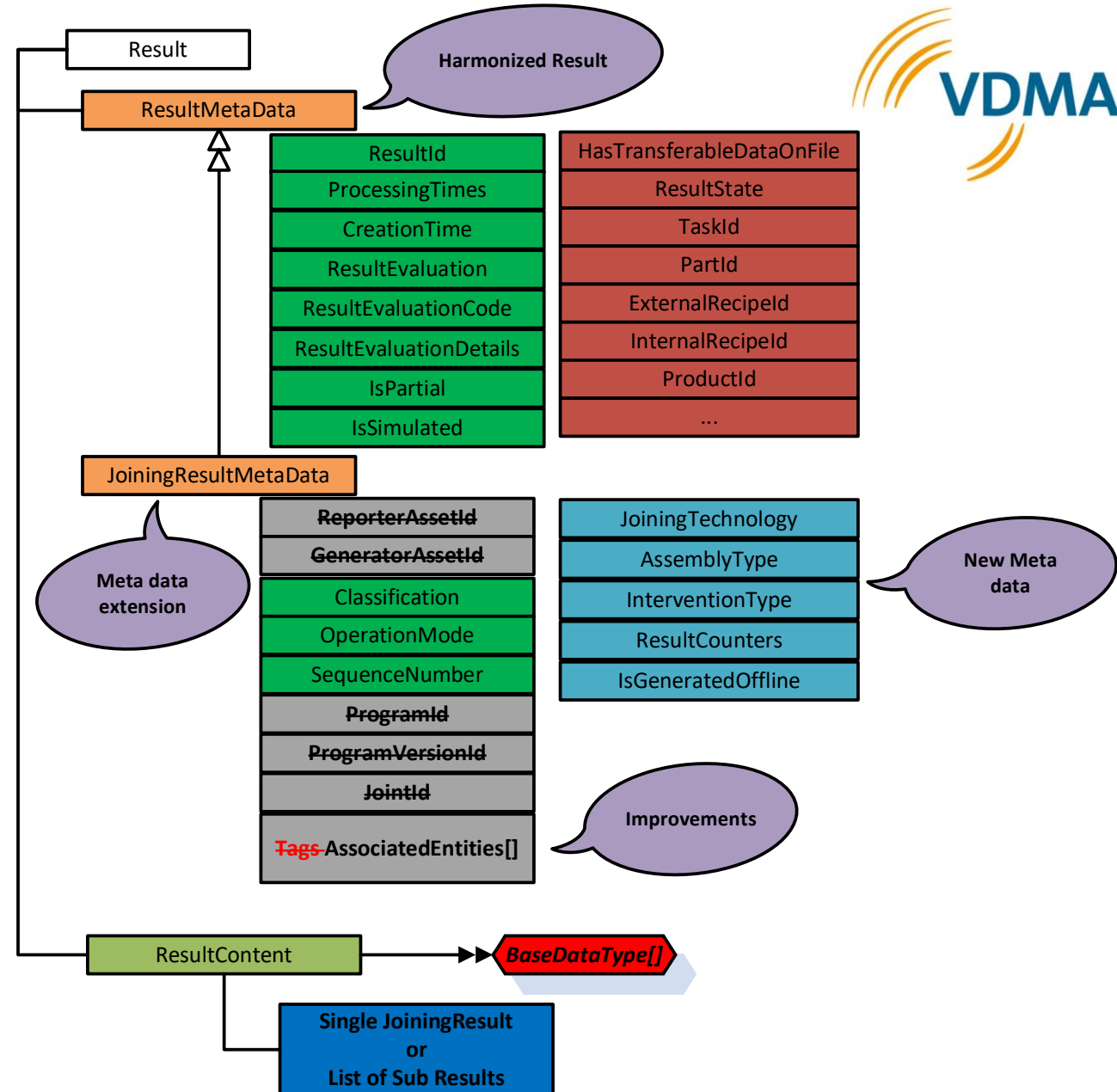It can be Joining Result, Set of Sub-Results, Vision Result, Quality Result, etc.
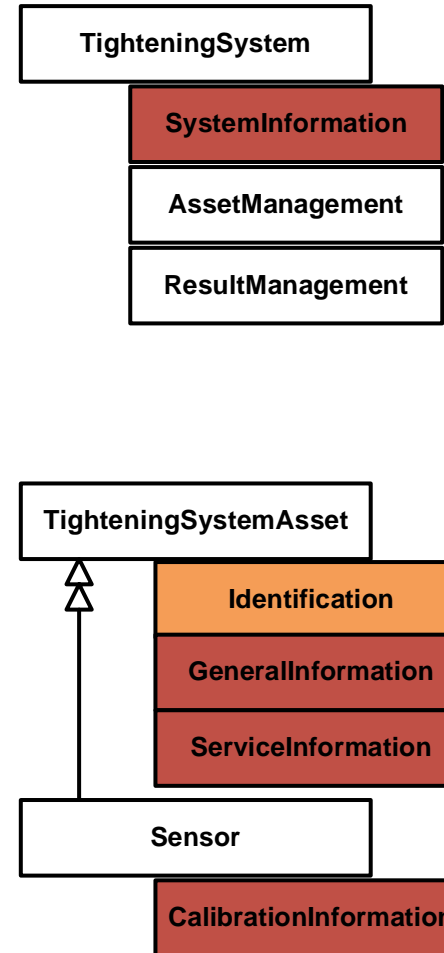
VDMA
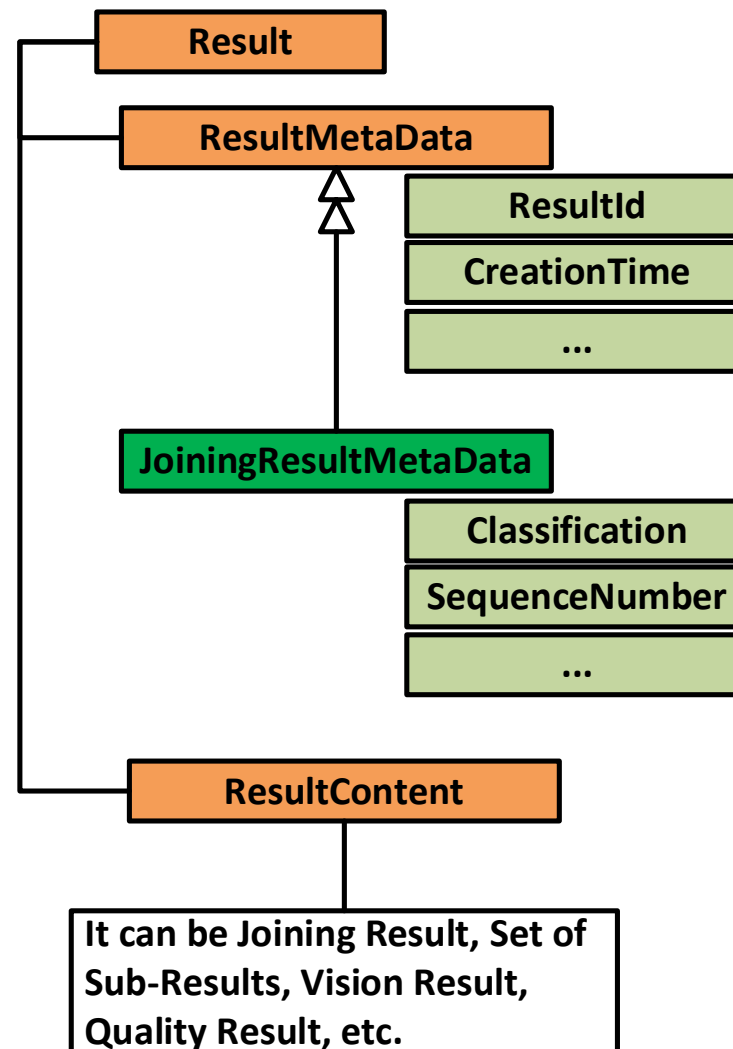
Result Data Changes

- **Machinery Result** Usage from Harmonization Group.
    - **Result** properties **grouped** as **ResultMetaData**.

- **Additional** set of properties to cover the use cases for Batch/Job/Sync Result, etc.

- **Generalization** of **Tightening** Result to **Joining** Result.
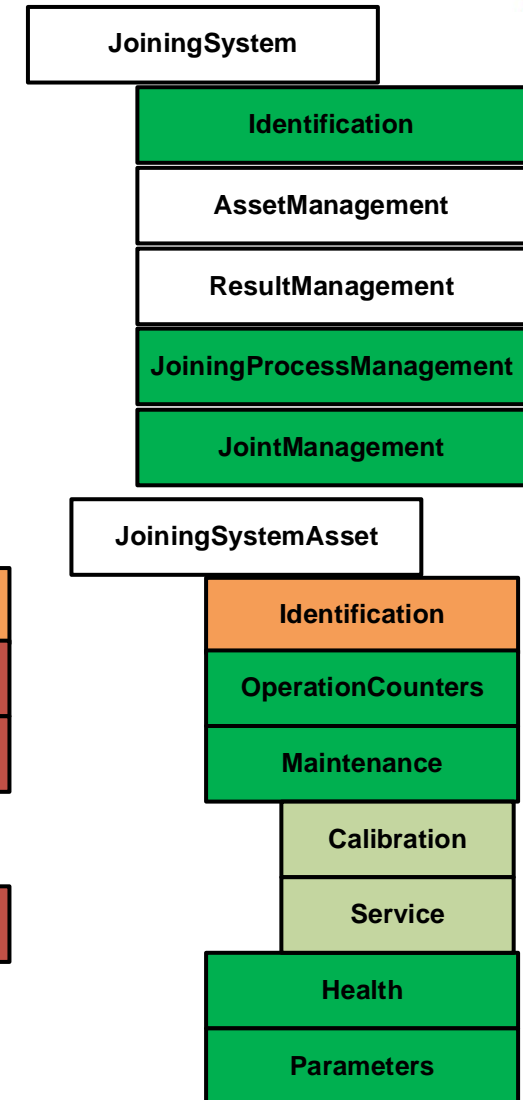
- **Uses** UA 1.05.02 Structures.

System, Asset and Event Changes

- **Improvement** in the Joining System for Identification AddIn.

- **Extension** of Joining System to include newer models.

- **Reorganization** and **Extension** of Asset Management Model.
    - Software and Virtual Station as new assets.

- **Extension** of Event model by **common joining payload** and **filtering** mechanism.

Release 1

TighteningSystem
SystemInformation
AssetManagement
ResultManagement

Release 2

JoiningSystem
Identification
AssetManagement
ResultManagement
JoiningProcessManagement
JointManagement

TighteningSystemAsset
Identification
GeneralInformation
ServiceInformation
Sensor
CalibrationInformation

JoiningSystemAsset
Identification
OperationCounters
Maintenance
Calibration
Service
Health
Parameters

Maintenance, Migration, Extensions

Extensions, Maintenance and Other Specifications

- The long-term vision to have a common base for various joining technologies is in place.

- In future, if there are very specific use cases needed for Riveting, Gluing, etc. which are not covered in the joining base specification, the specification can be defined.

- **Possible Future Use Cases**
  - Reuse of Network Structure for Assets from other harmonization groups.
  - Reuse of Location models.
  - Definition of Part, Product, etc.
  - Definition of Threaded Fastener/Bolts.
  - Issues in the existing specification.
  - …

Greenfield vs Brownfield in Joining Domain

- For **brownfields**, a phased migration can be done. It **depends** on the use case and other factors.
    - **Example:** For control mechanisms, existing legacy protocols can be used and OPC UA can be deployed for data acquisitions.

- For **greenfields**, it is recommended to use OPC UA with IJT Companion Standard.

- **OPC UA** and **other** protocols can **coexist** together.

Reference Links

- **OPC UA IJT Overview:**
  - https://opcfoundation.org/markets-collaboration/IJT/

- **Specifications/Online Reference**

  - https://reference.opcfoundation.org/IJT/Base/v100/docs/

  - https://reference.opcfoundation.org/IJT/Tightening/v200/docs/

- **OPC UA IJT Prototypes/Reference Implementations**

  - https://github.com/umati/UA-for-Industrial-Joining-Technologies

- **Access to Specification Documents:**
  - **Formally** released specifications can be accessed for free from the OPC Foundation Portal. Use Online Reference to view the specifications in the browser without any login/registration.
  - **Release Candidate (DRAFT)** is **only** accessible for an OPC Foundation Member Company. The alternative is to download from the VDMA portal: https://vdma.org/der-verband
    - Search the portal with the specification number. **Examples:** 40450, 40451, etc.

Additional Slides

OPC Legacy and OPC UA History

- Refer to the following link which explains the Before and After OPC Scenarios:

- https://www.ia.omron.com/product/special/sysmac/nx1/opcua.html

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OPC UA Overview and Benefits

Industry 4.0 main contender for industrial interoperability standard

Core Characteristics:

- Service Oriented Architecture (Subscription, Methods, Events, etc.)

- Platform independent (Any hardware - operating system - programming language)

- Integrated security mechanisms (Message Encryption, Authentication, User Rights, Certificates)

- Standard discovery mechanisms (Discovering devices and management of certificates)

- Comprehensive information model

UA Cloud Initiative
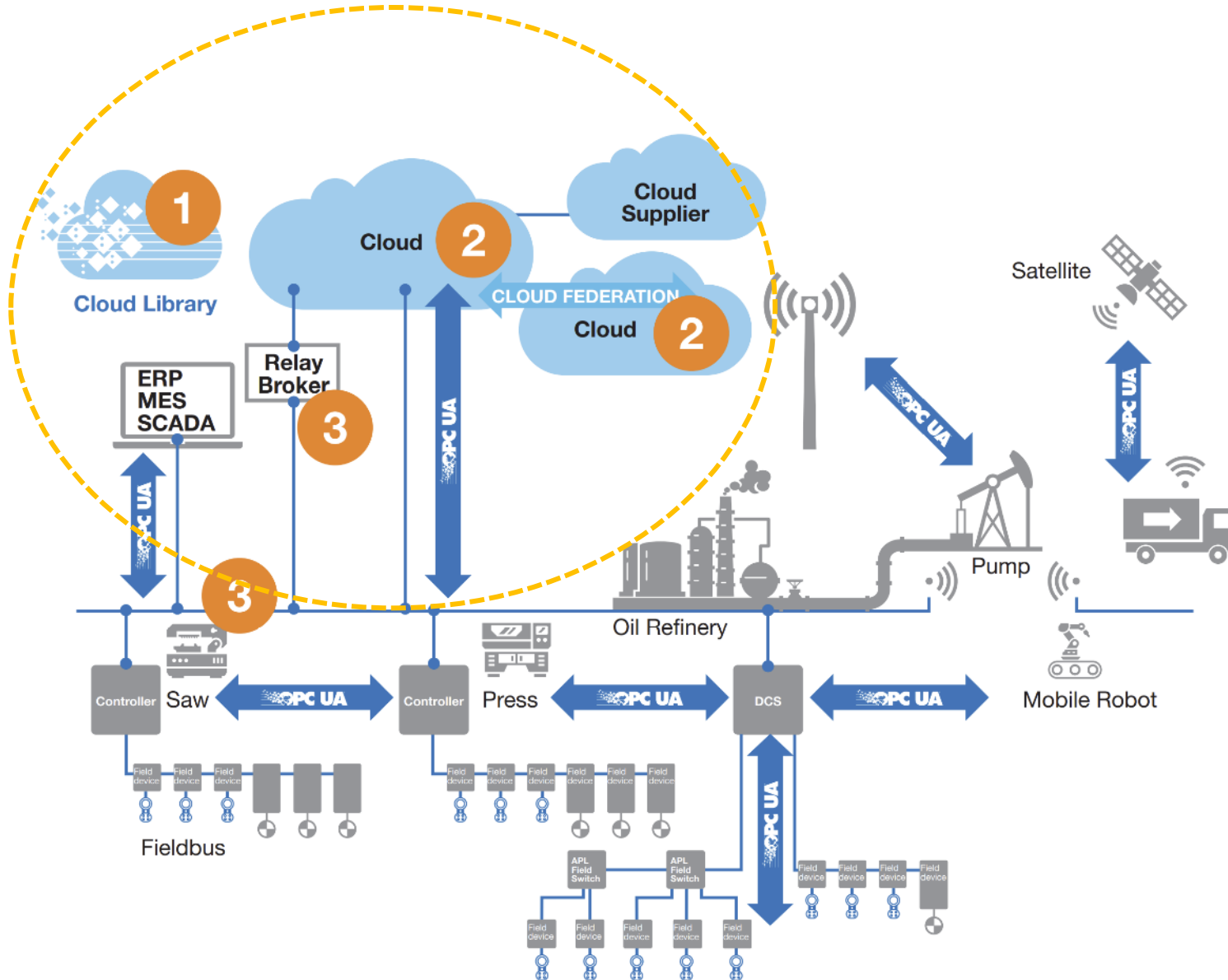
1 Cloud Library
- Repository for OPC UA based information models (IMs)
- Upload, store, search, download IMs

2 Cloud Federation
- Standardized communication
- Cloud to Cloud

3 Asset / Edge / Cloud
- Standardized communication
- Field to Cloud
- Cloud to Field

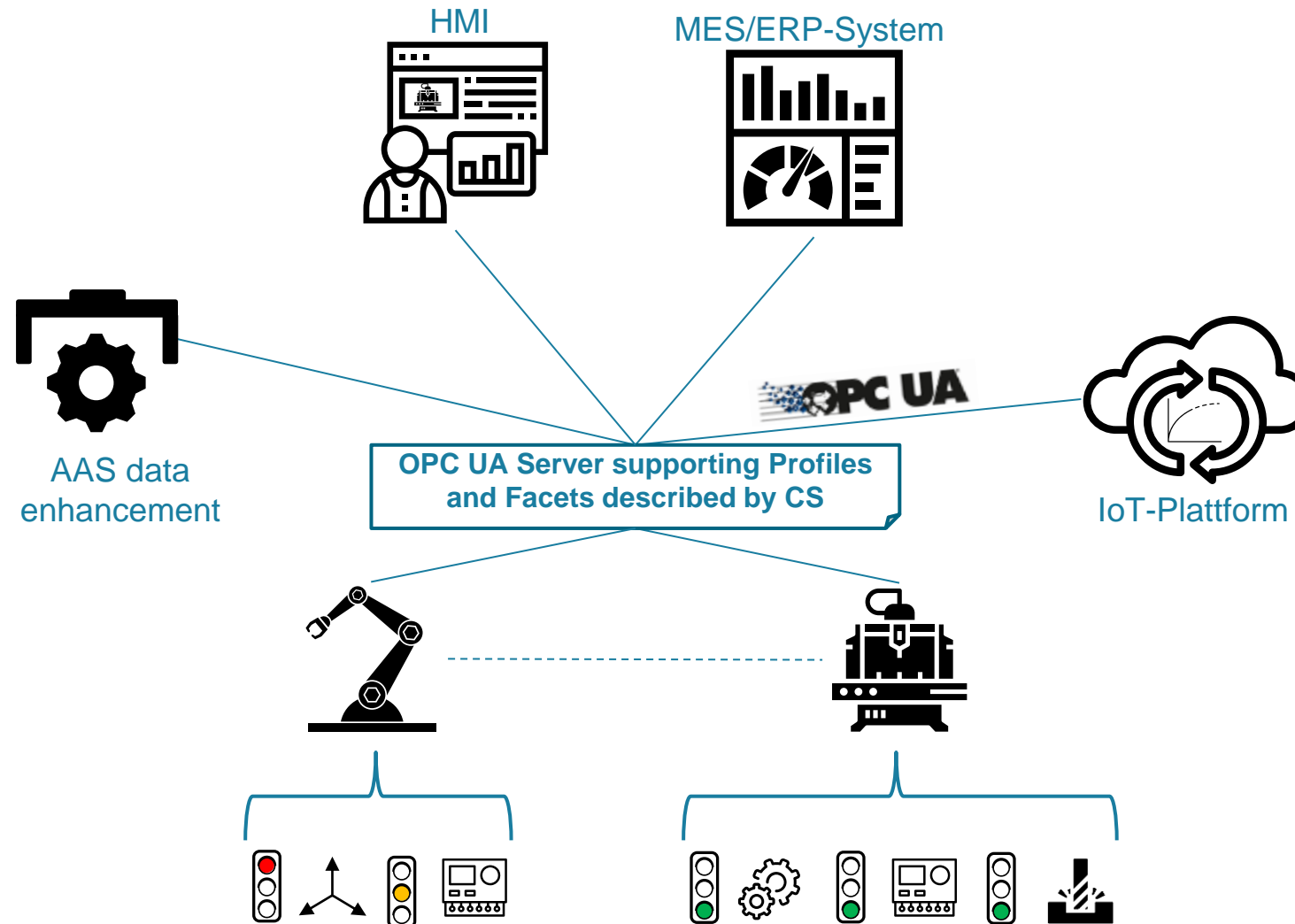**4 Education, IIOT Starter Kit**
- Success stories

Source: OPC Foundation

VDMA

OPC UA for Field eXchange (FX):
Extending OPC UA to the field incl. Determinism, Safety & Motion

OPC UA FX:
OPC UA Extensions for Field eXchange (FX)
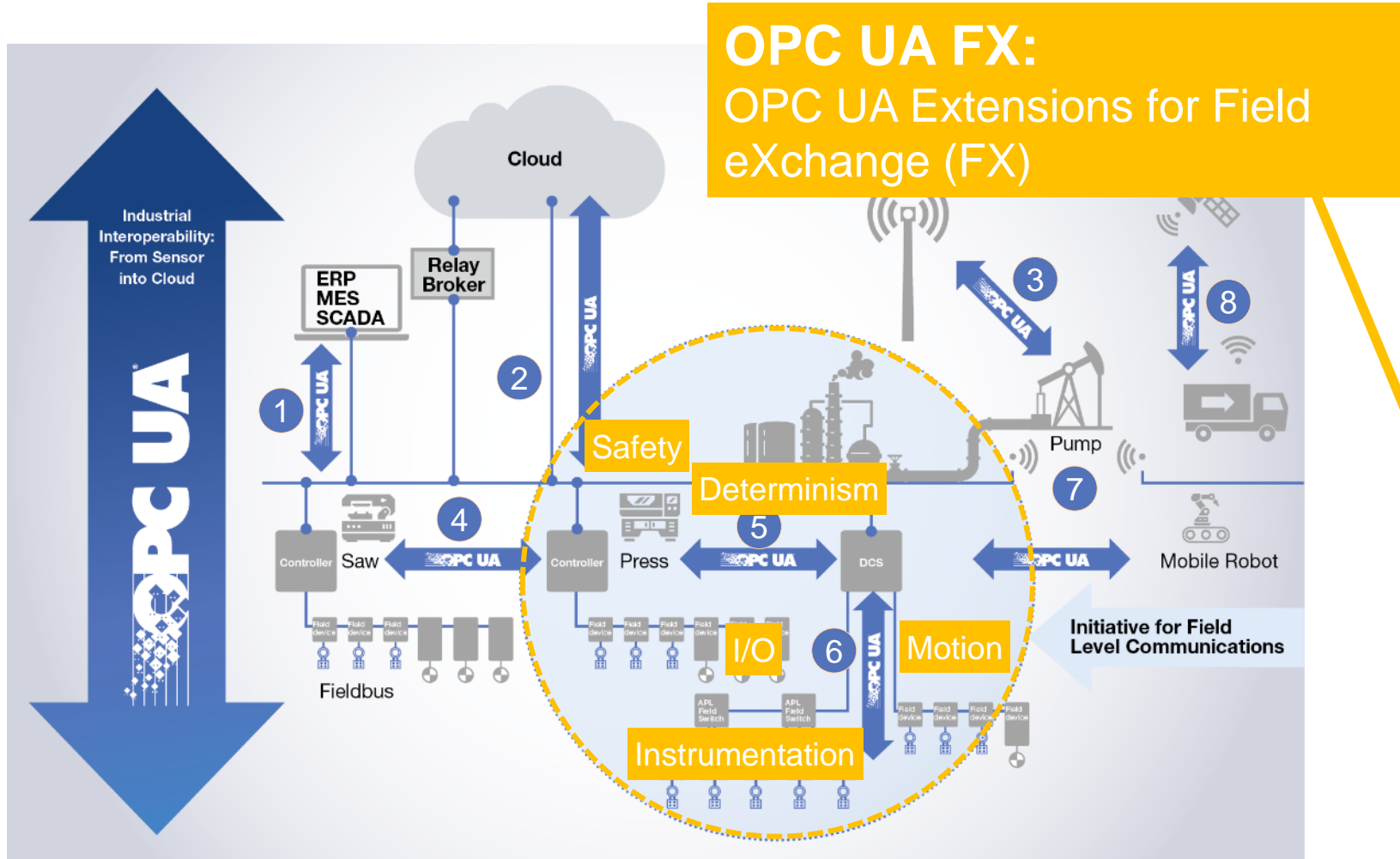
1. IT / OT Communication
2. Cloud Integration
3. Secure Remote Access
4. Local OT Communication
5. Controller to Controller
6. Controller to Device incl. Device to Device
7. Wireless Integration (5G)
8. Future Ready

Source: OPC Foundation

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OPC UA as the standardized communication interface of machines & components

HMI

MES/ERP-System

AAS data enhancement

OPC UA Server supporting Profiles and Facets described by CS

IoT-Plattform

Contact

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E-Mail   **mohit.agarwal@atlascopco.com**

Questions

Few Example Questions…

- Do we have a reference implementation?
  - Yes, refer to the link to the simulator in the presentation.

- When is the implementation planned for the Devices?
  - The respective device supplier could provide the plan.

- …