Implementing semantic interoperability

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Thomas Hadlich

Outline

1. Why do we talk about semantic interoperability?

2. What is semantic interoperability?

3. IEC 62832 – Digital Factory Framework

4. Implementing the Digital Factory Framework

5. Conclusions

Step

1. **Why do we talk about semantic interoperability?**

2. What is semantic interoperability?

3. IEC 62832 – Digital Factory Framework

4. Implementing the Digital Factory Framework

5. Conclusions

Lifecycle of a production system

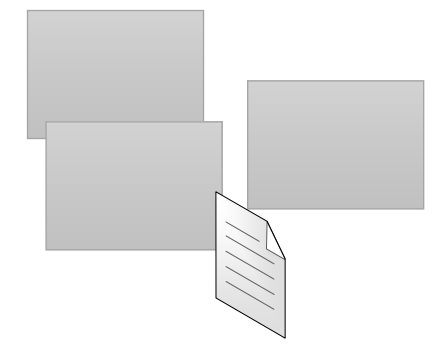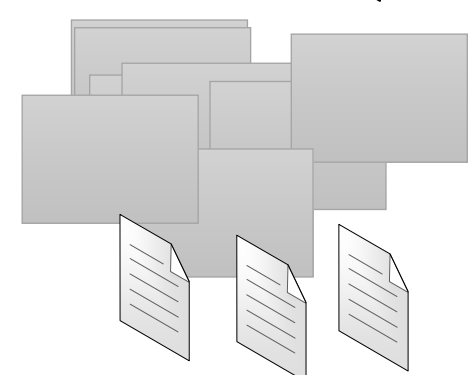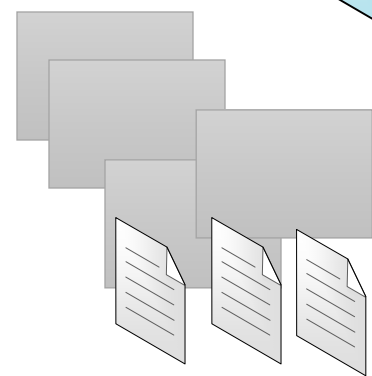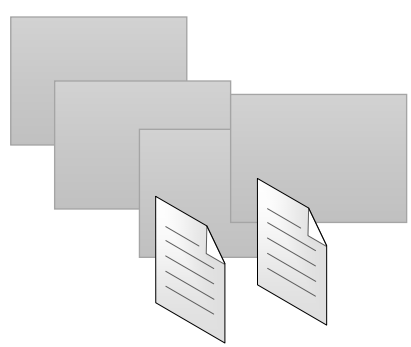Basic Engineering → Production Engineering → Construction & Commissioning → Operation & Maintenance → De-Commissioning
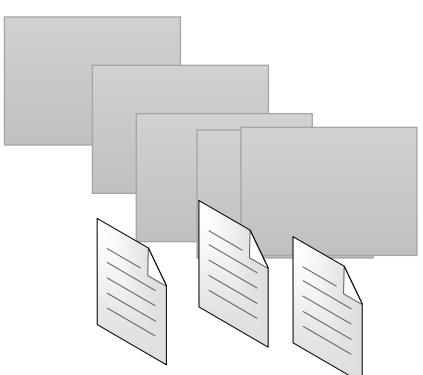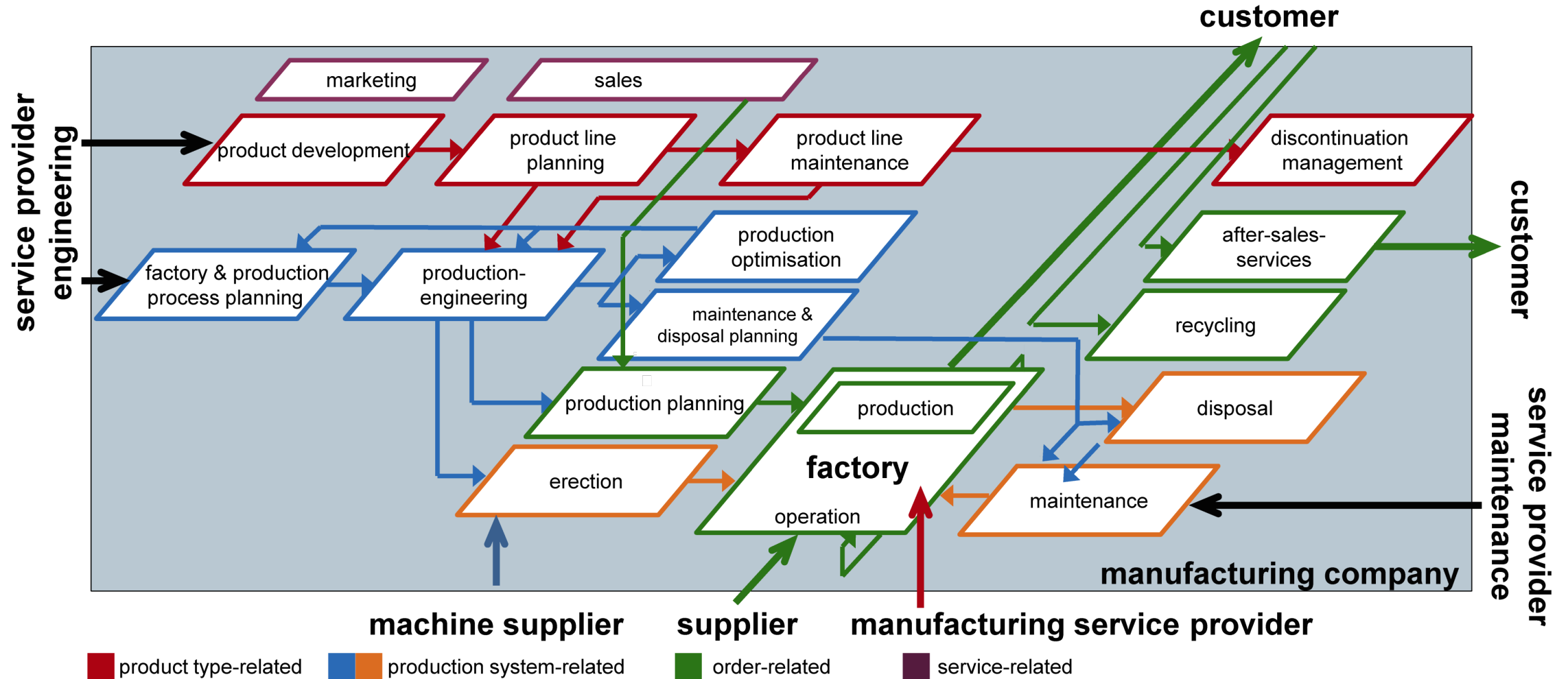
Process planning tool

Mechanical CAD tool

Commissioning tool

Maintenance tool

Value creation networks

Source: VDI Status report "Seamless and Dynamic Engineering of Plants"

5

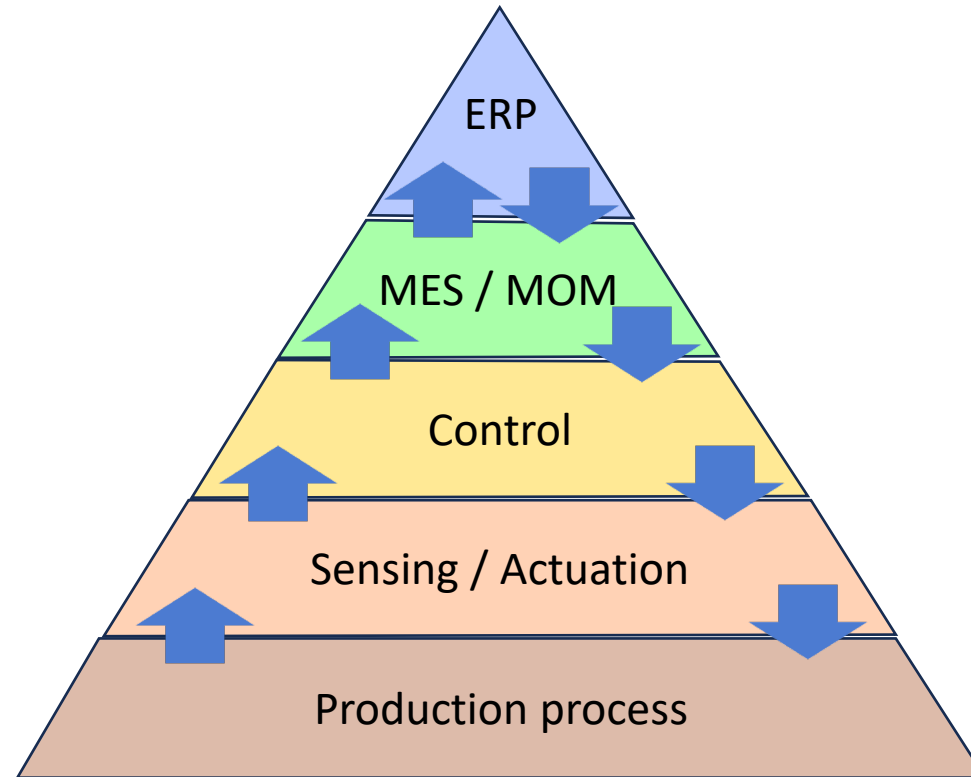# Value creation networks

Enterprise model(s)

Purdue Enterprise Reference Architecture

Automation Pyramid

Source of image: PCA-MIMOSA Reference Architecture Framework for Integrated Engineering and Operations
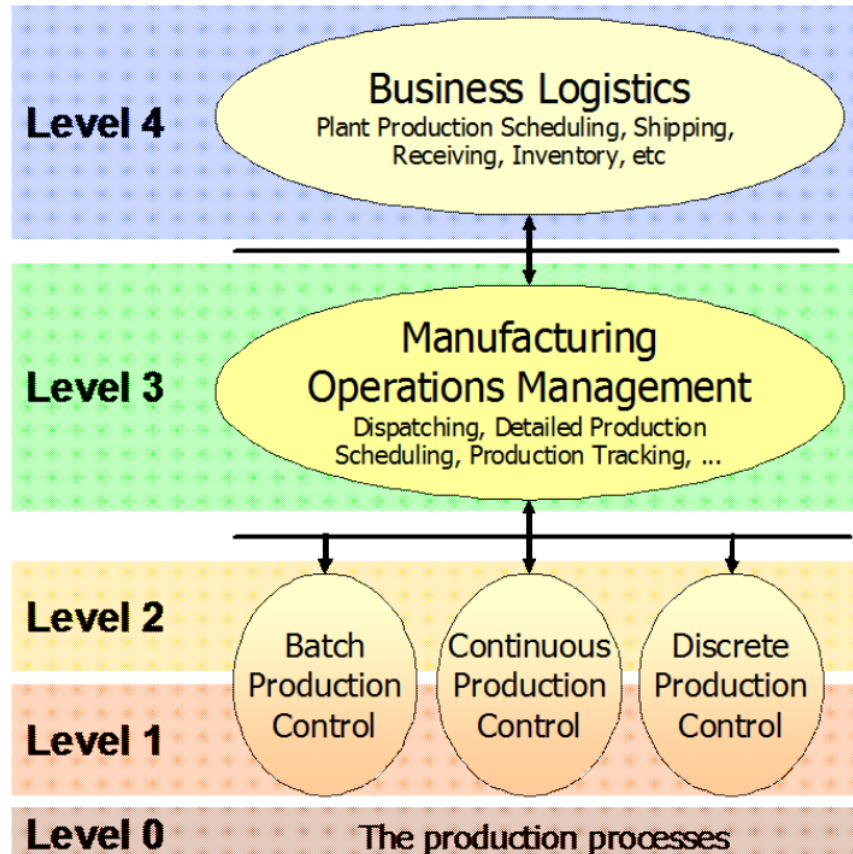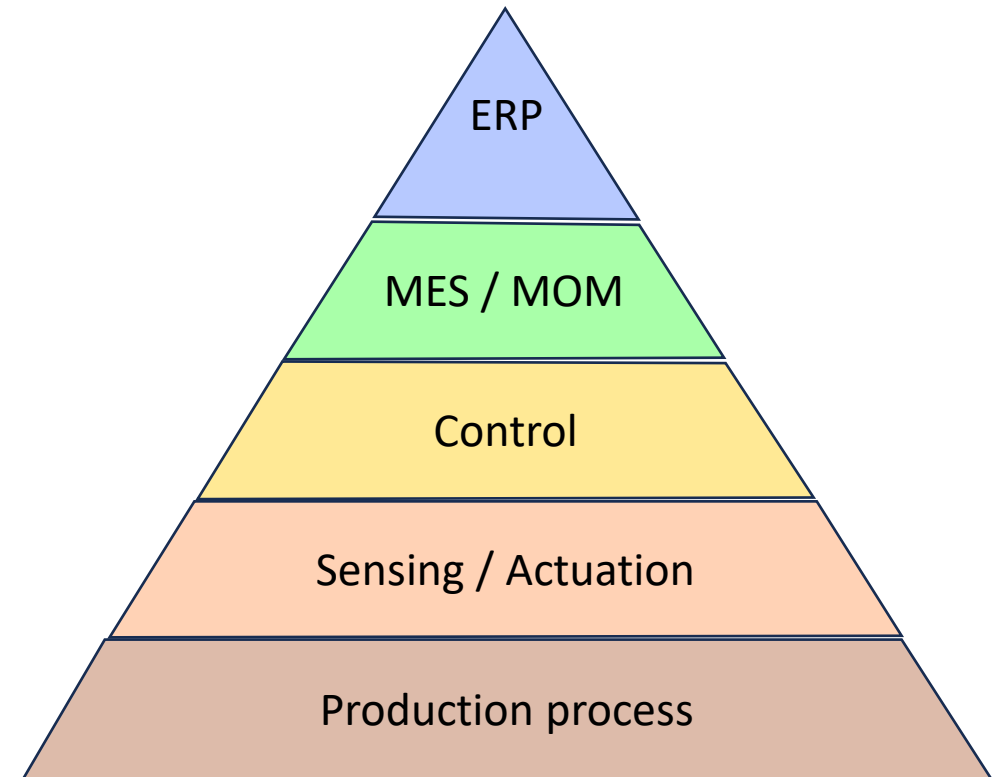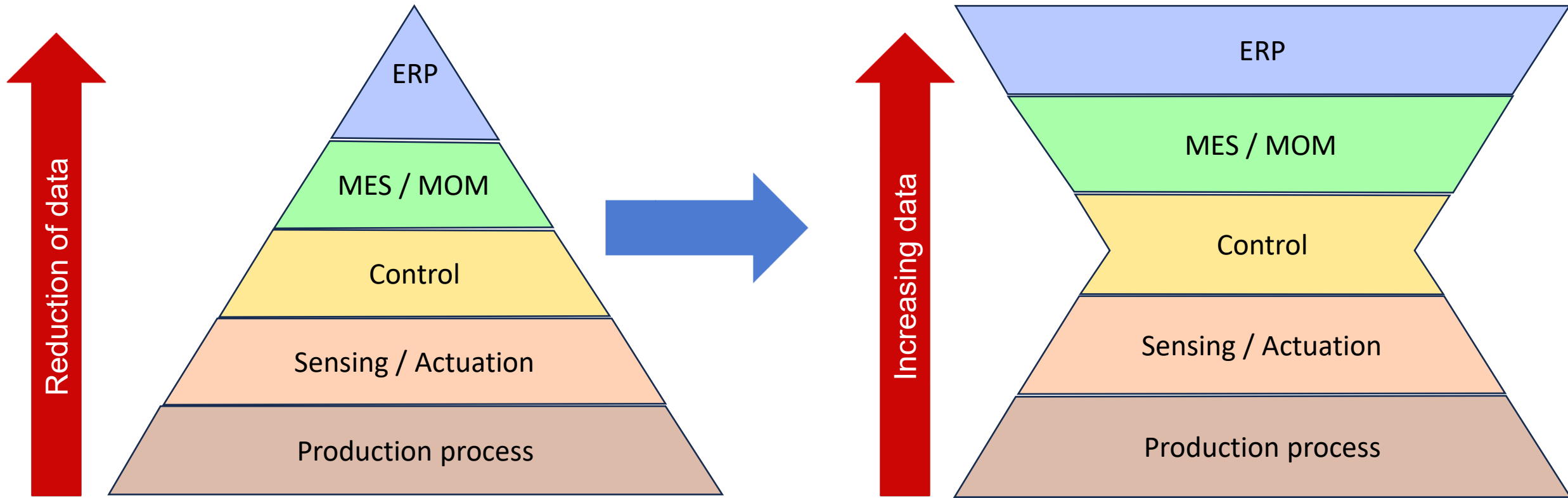
Data exchange within the company

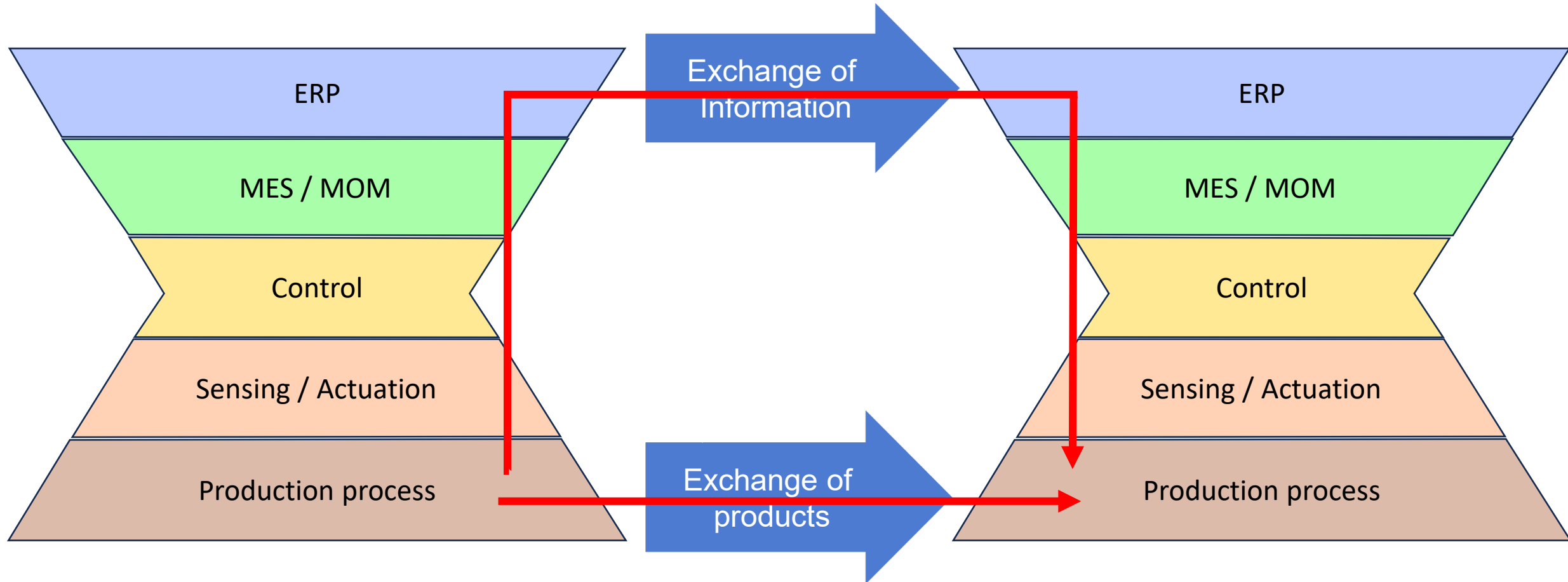# Development of information exchange within a company

In a connected enterprise more and more information from the production process is passed to the management levels.

Vogel-Heuser et al., "Global Information Architecture for Industrial Automation," *atp*, 1-2, 2009.

Information exchange between companies

Cooperating companies exchange more and more information (traditionally via ERP level or along with products)
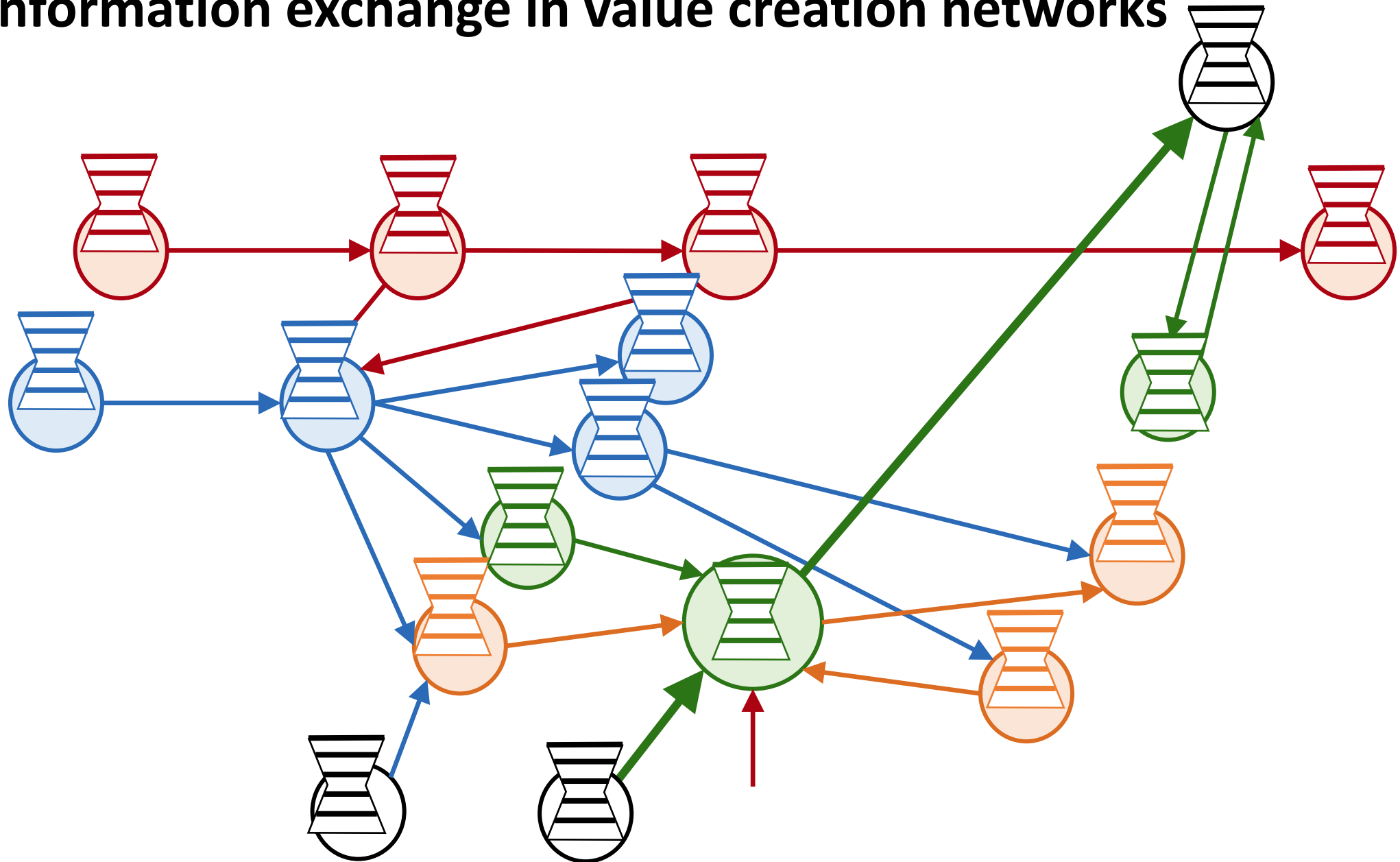
Development of information exchange between companies
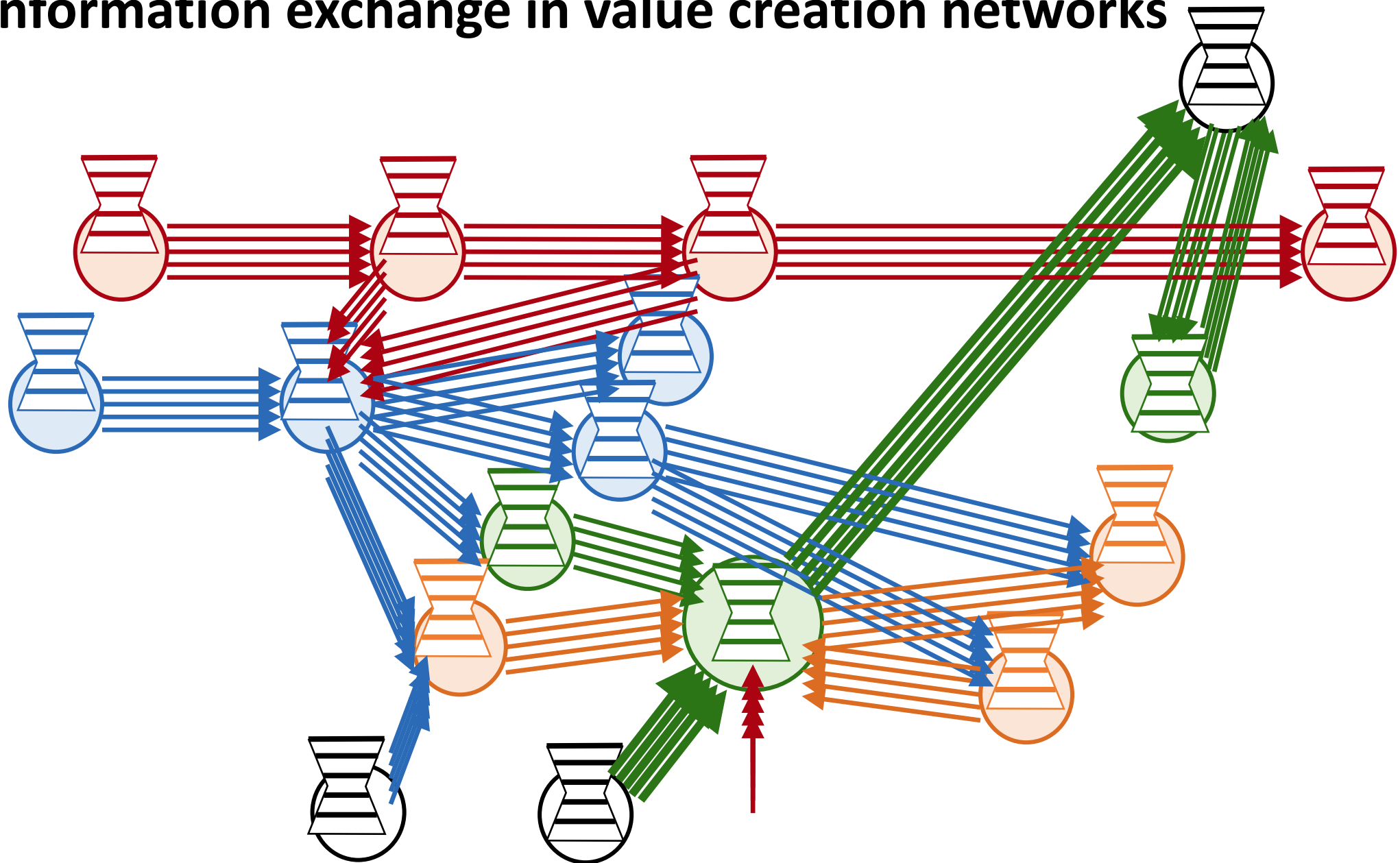
Vision of Industrie 4.0: Information exchange on all levels of enterprise hierarchy
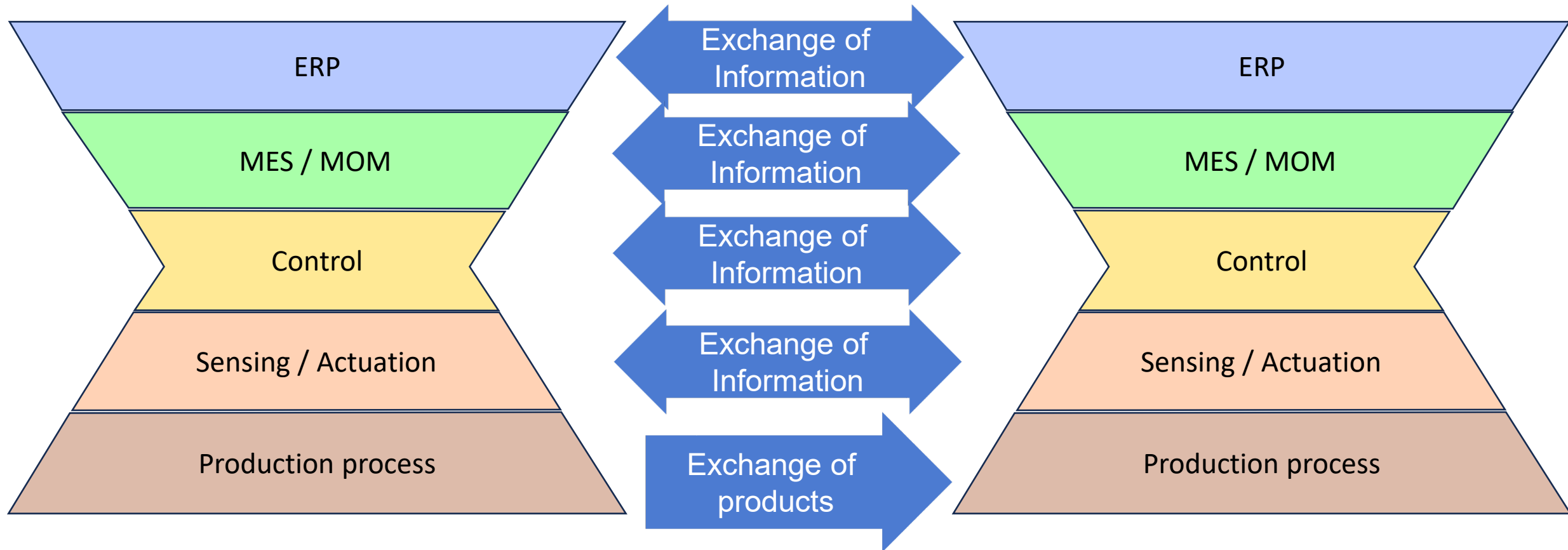
Information exchange in value creation networks

Information exchange in value creation networks

Contents

Interoperability

… the ability of two or more participants to exchange data.
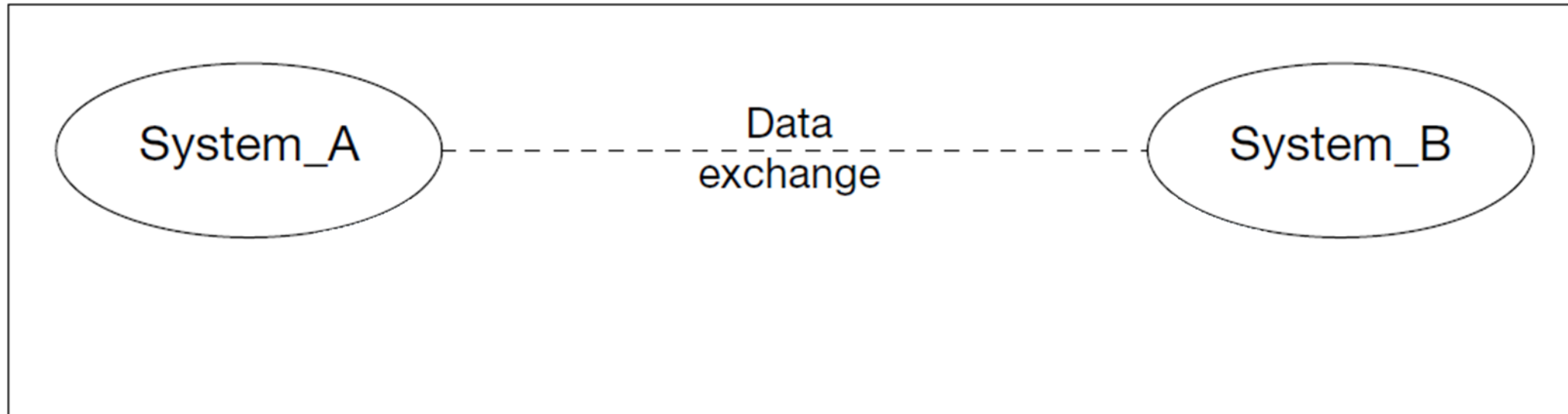
Based on: IEC, "Semantic interoperability: challenges in the digital transformation age: White paper," Oct. 2019.

Aspects of semantic interoperability
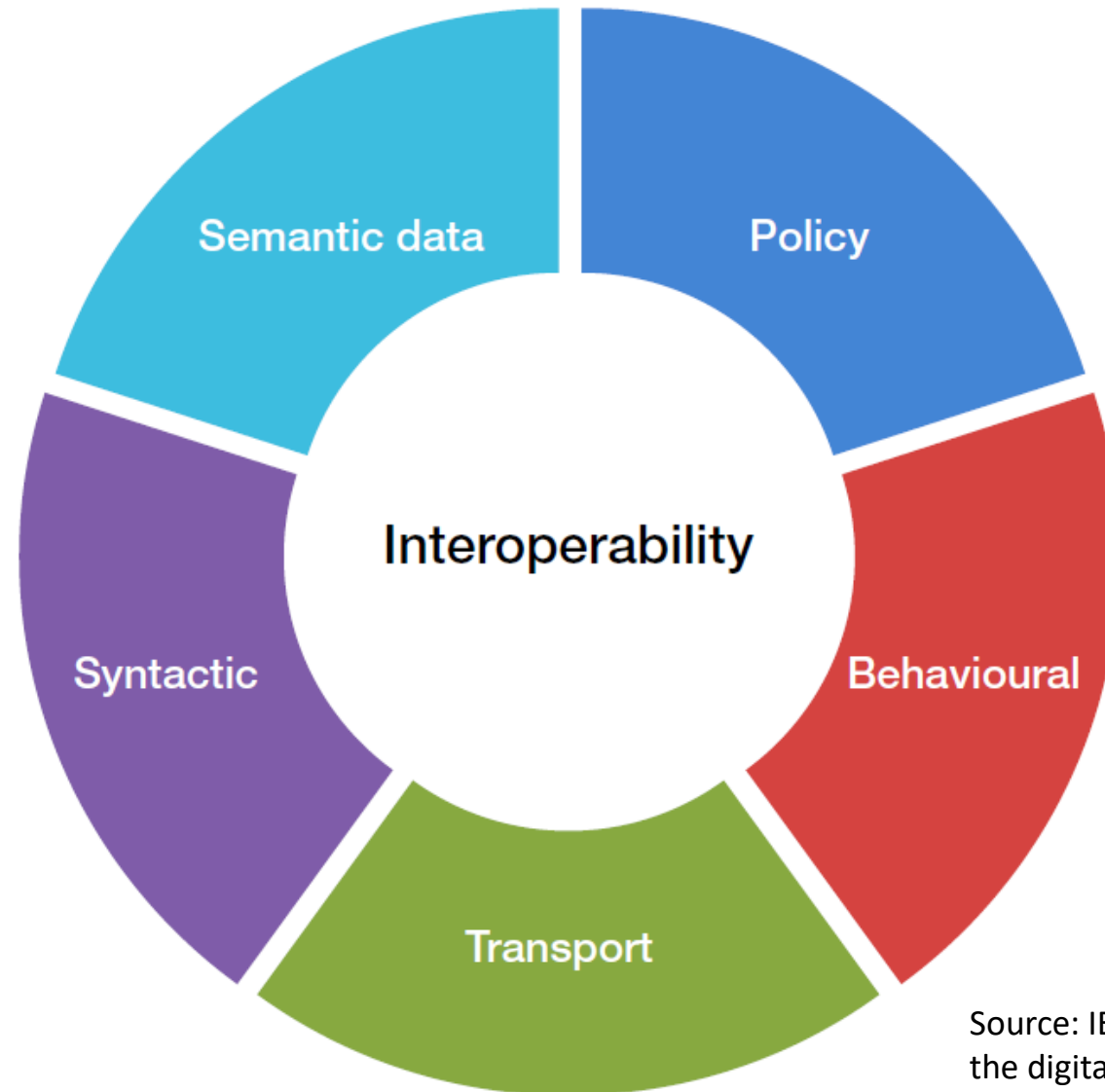
Source: IEC, "Semantic interoperability: challenges in the digital transformation age: White paper," Oct. 2019.

16

"Understanding"

How do machines understand?

Data

Context

Machine

Information model

Context

Semantic interoperability

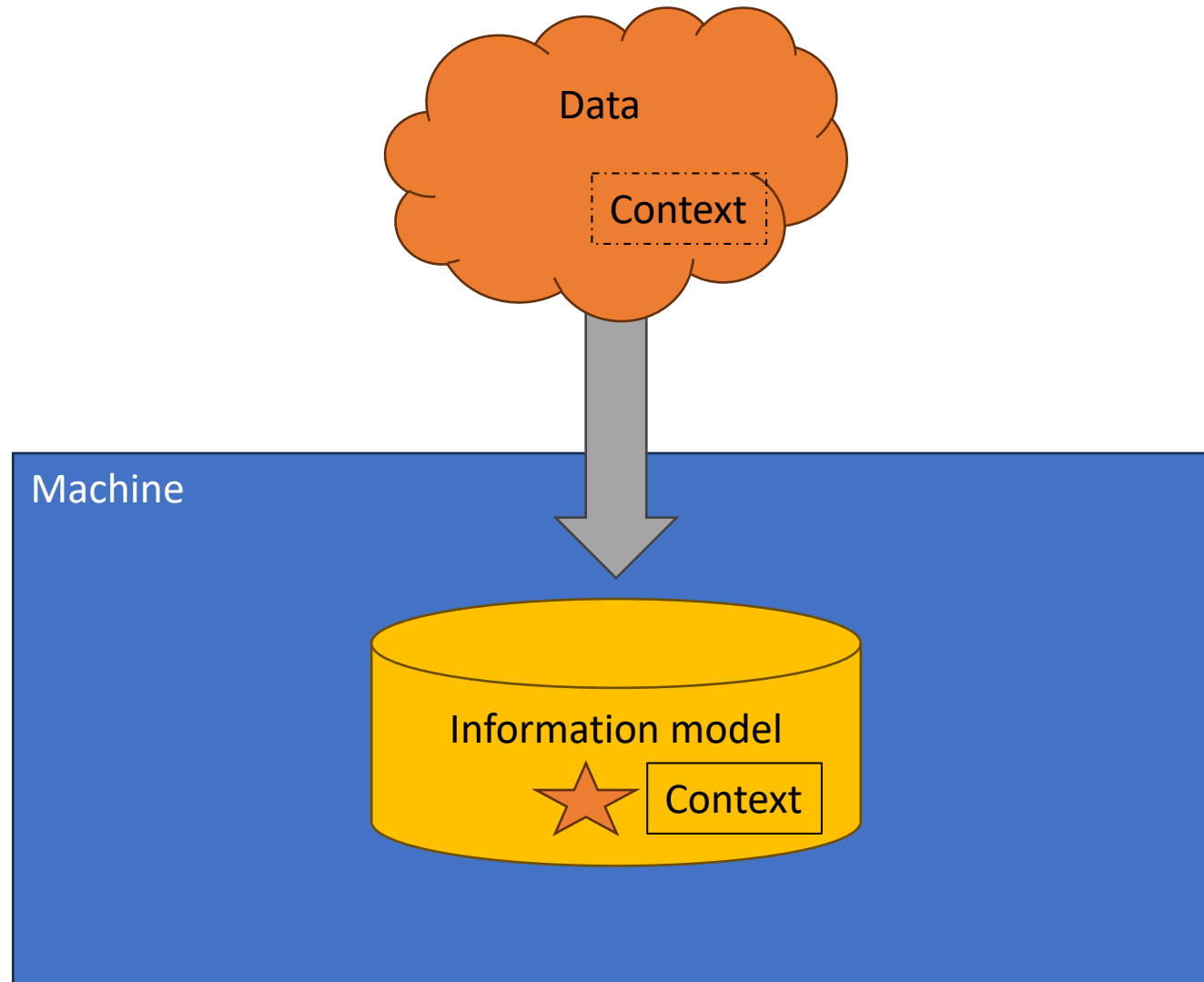... the ability of two or more participants to exchange and <u>understand</u> each other's data correctly.

Contents

Purpose of Digital Factory Framework

- Define a common base for describing the meaning of engineering data

- Provide a reference for digitization of data related to production systems

- Common rules for utilizing data based on computer-understandable attributes and classifications

→ Use of dictionaries for describing engineering data

Video https://www.linkedin.com/feed/update/urn:li:activity:6757632501352677376
INF Document https://assets.iec.ch/public/tc65/65_840e_INF.pdf

Engineering supported by property-based information

3 levels of information modelling

Meta	General agreements on how to represent possible meaning of data	Ontologies, Taxonomies, **Dictionaries**
Type	Representation of • pre-defined requirement descriptions (role types) and • of potentially available equipment (product types)	Catalogues, **Libraries**
Instance	Representation of • defined requirement descriptions (roles, measurement points, actuation points) and • of planned or existing components or systems	Construction plans, **Digital Factory**

DF Framework overview
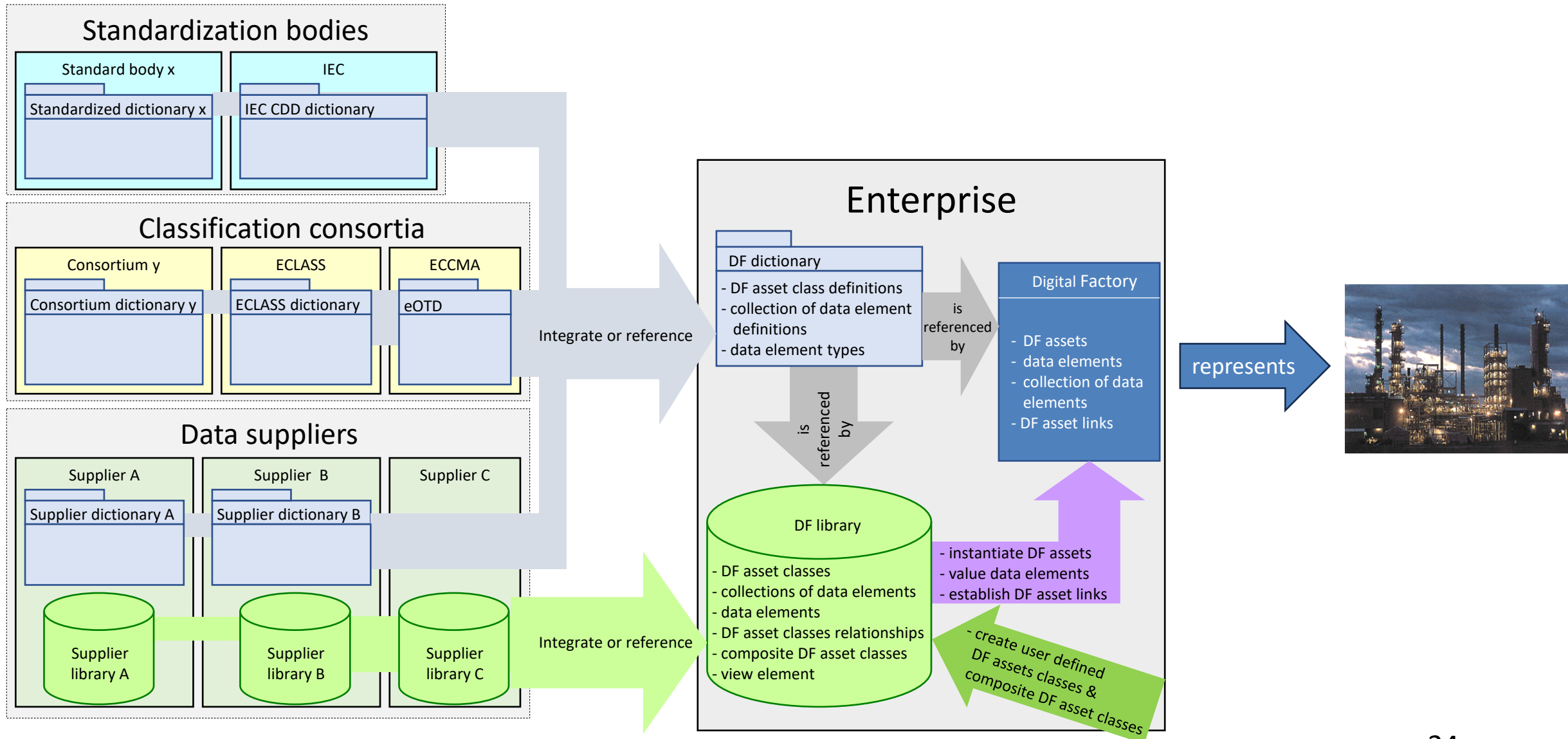
Example DF Asset „Valve" with Technical Disciplines

DF Asset "Valve"

class identifier
e.g. AAB010

Technical Discipline: Network

Communication Interface

DF Asset Link

Master

Bus No 2

Technical Discipline: Power Installation

Drive

DF Asset Link

L1 L2 L3 N

Valve

Technical Discipline: Pipe Installation

Pipe1

DF Asset Link

Pipe2
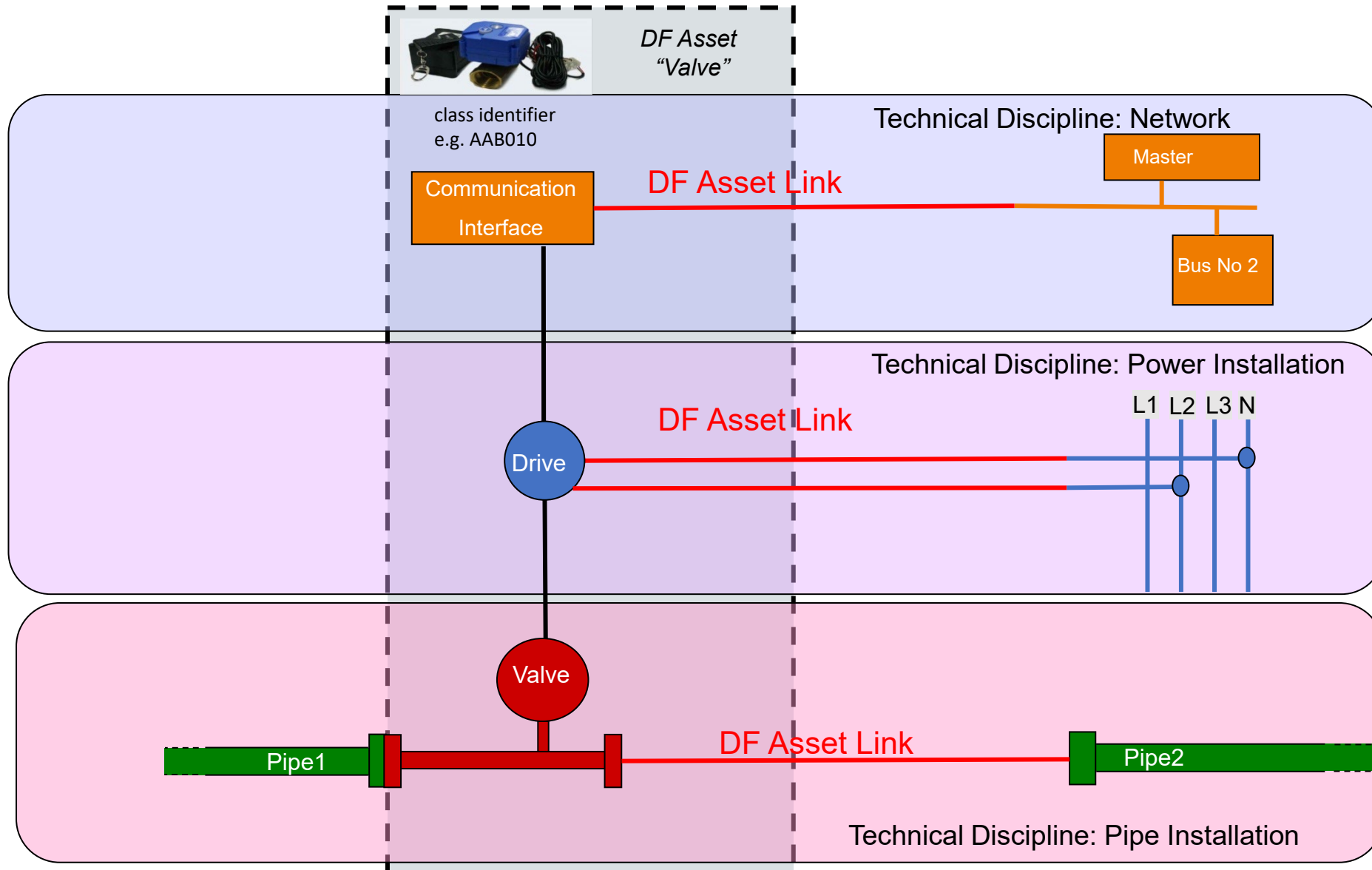
Example DF Asset „Valve" with Technical Disciplines + data elements
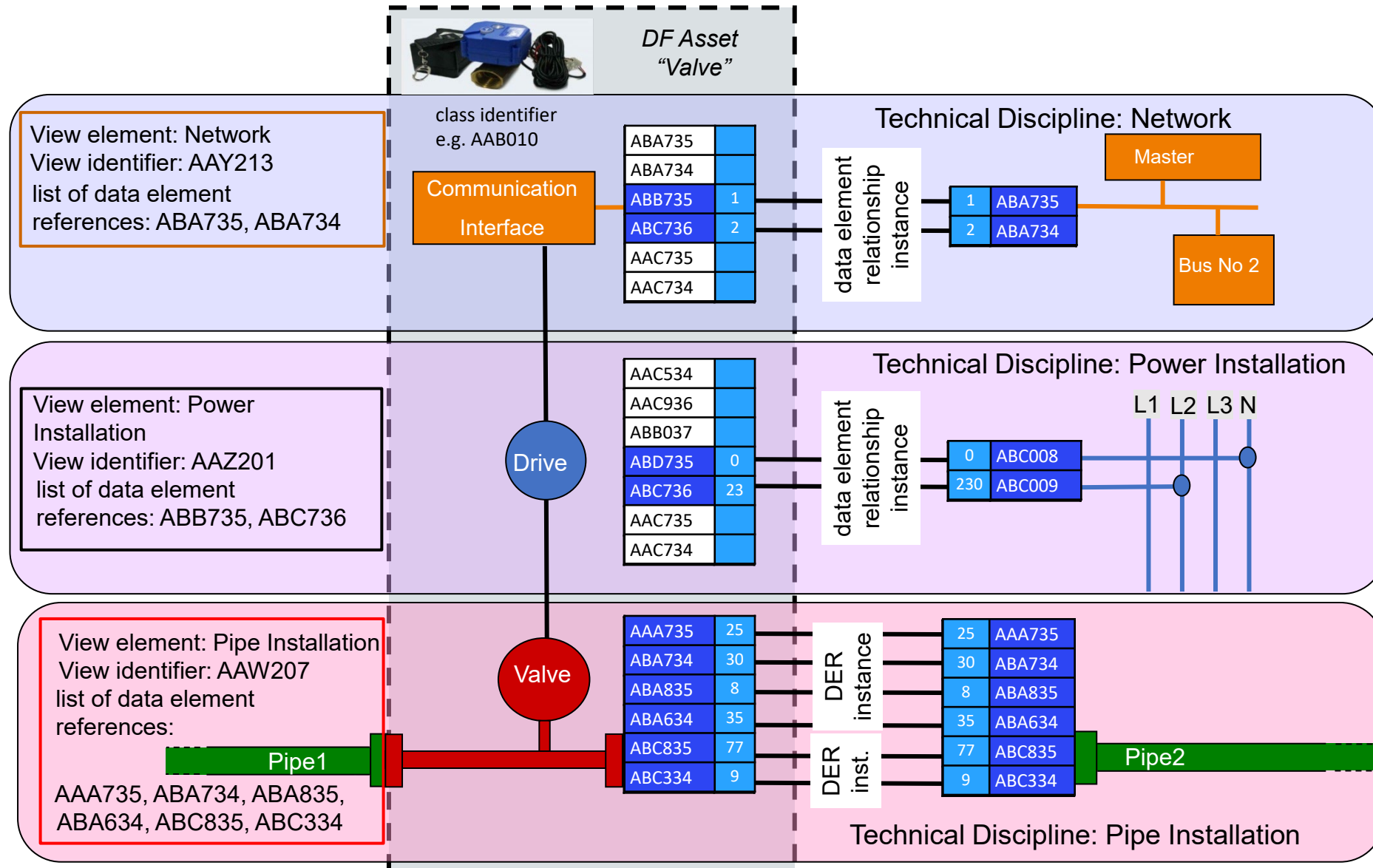
IEC 62832: Data Element Relationship

DF asset class header	Name	FlowSensorX
	Element identifier	...
	DF asset class definition ref.	FlowSensor definition

DF asset class body	Data element Id11	
	Data element Id12	230
	Data element Id13	3,5
	Data element Id14	
	Data element Id15	True
	Data element Id16	True
	Data element Id17	20
	Data element Id18	24
	...	

DF asset class association

PipeTypeY	Name	DF asset class header
Transp032		
...	DF asset class definition ref.	

	...	DF asset class body
230	Data element Id41	
66	Data element Id42	
True	Data element Id43	
	Data element Id44	
23	Data element Id45	
	Data element Id46	
True	Data element Id47	
55	Data element Id48	
	...	

DER

DER

Thread diameter
Thread pitch
Thread form
Thread direction
Thread design
Thread lock
Type of thread
...

Source: IEC 62832-1

27

Fundamental common requirements

- Semantic meta-information is provided by means of concept dictionaries

- Different requirements for description of product type and product instances

- Identification of context for data
  - Data describing a component needs to be provided together with context (e.g. for which part of equipment applies the property)
  - Data from a measurement point needs to be provided together with context information (e.g. from which functional unit)
  - Annotation of data values (e.g. with time stamp and quality information)

Contents

Standards landscape
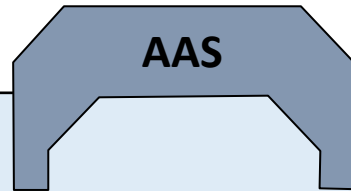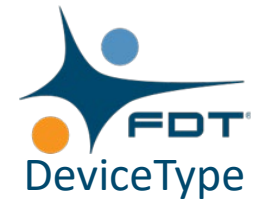
ECLASS and IEC CDD

- ECLASS (https://eclass.eu/en/eclass-standard/search-content)
- Provided by ECLASS association
- One dictionary
- Yearly update

- IEC CDD (https://cdd.iec.ch/)
- Provided by IEC
- Several data dictionaries, e.g.
  - IEC 61360-7 – General items
  - IEC 61987 – Process automation
  - IEC 62683 – Low voltage switch gear
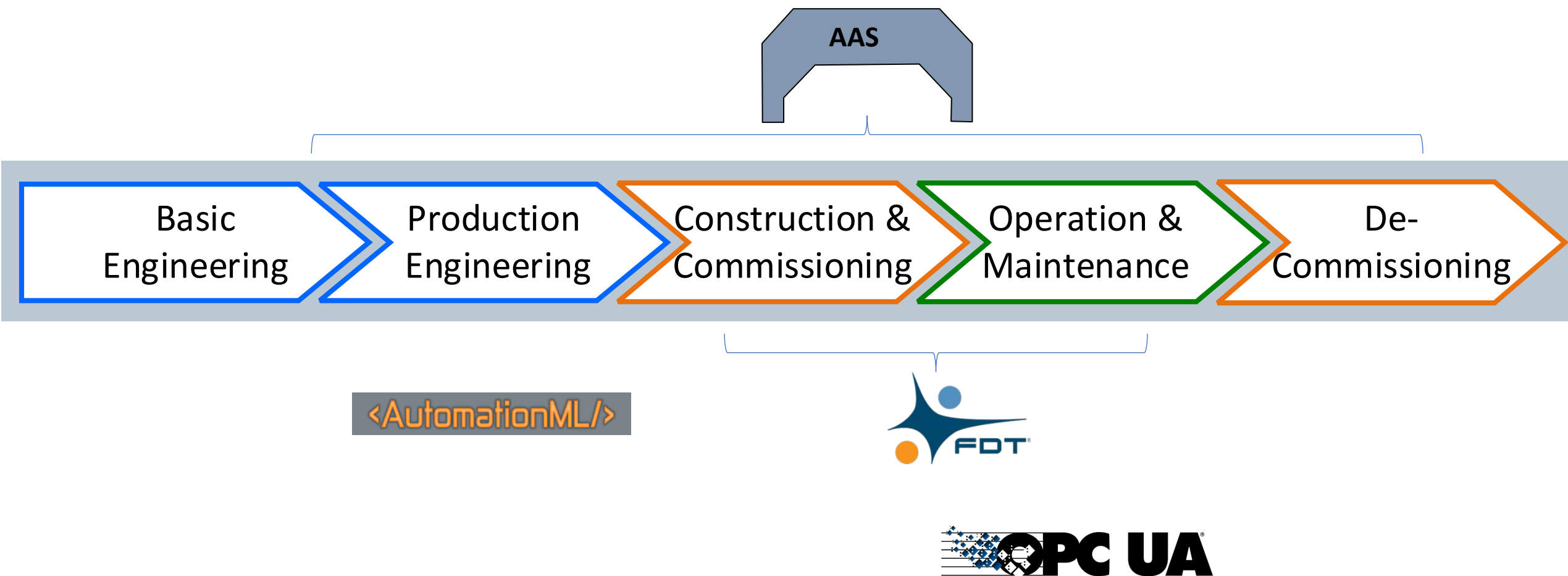- Continuously updated (depending on IEC projects)

ECLASS and IEC CDD – Common features

- Dictionaries based on IEC 61360-2
- Dictionaries provide
  - Classification of products
  - Concept definitions for description of products
- IRDI as concept identifier
- Concepts include
  - Item Classes (e.g. for description of products, of product features)
  - Properties (e.g. for description of product characteristics)
  - Property values and value ranges
- Definitions for product descriptions are organized hierarchically (in the classifications)
- Definitions for product descriptions may be structured

IEC 61360 Information model

Reference to a class

SuperClass

+described by

1

+applicable data element type

+defined by   +classifying data element type

Data element type

1   1

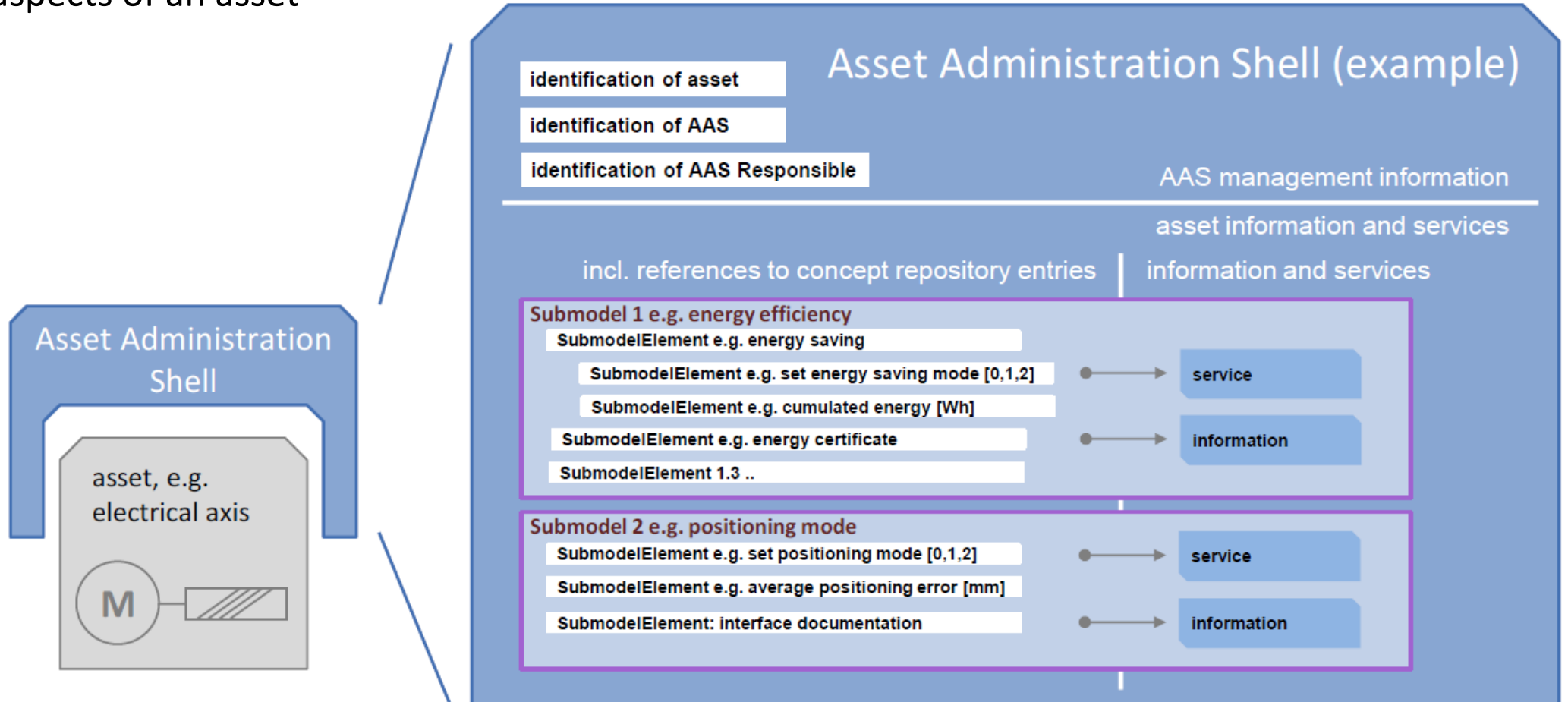+applicable data element type   *

SubClass

+described by

1

33
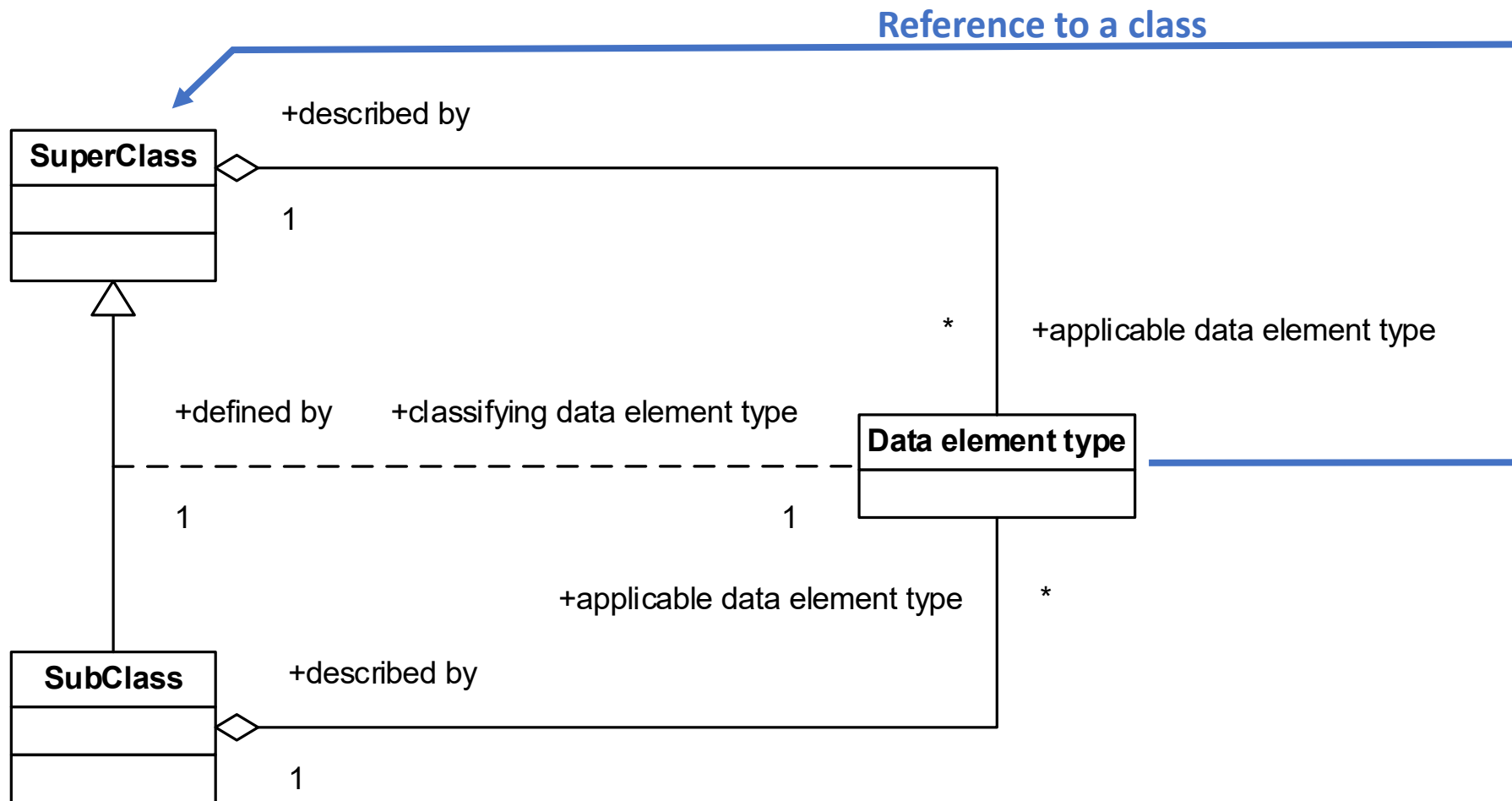
Usage phases of AAS, Automation ML, FDT and OPC UA

IEC 63278-1: AAS structure

The Asset Administration Shell (AAS) is a standardized digital representation of an asset with Submodels representing aspects of an asset
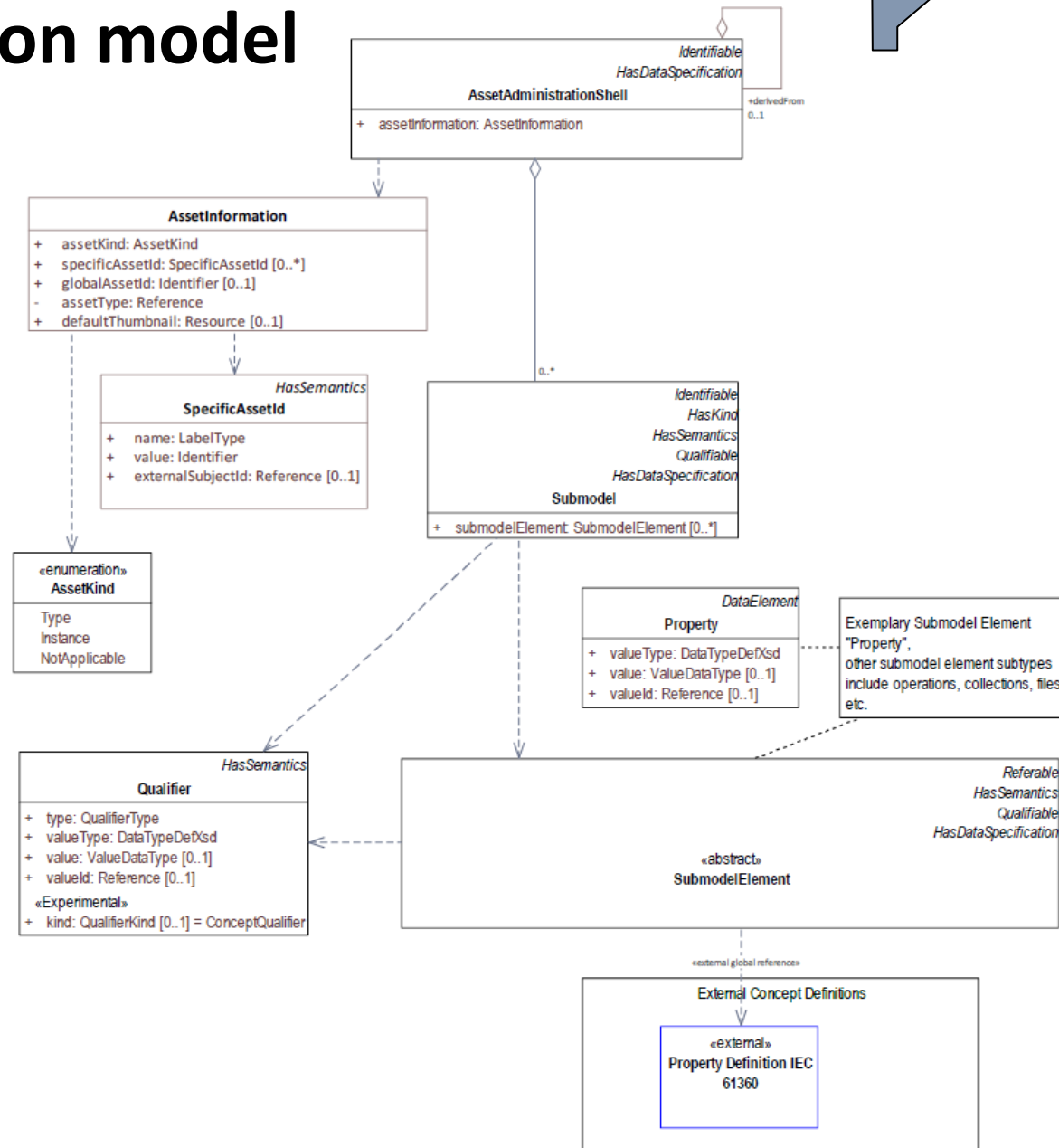
IEC 63278-1: Detailed AAS structure

Concept repositories provide structured concept repository entries (e.g. classes, properties, relations, units of measurement) with an unambiguous identifier (e.g. IRDI) which can be referenced by Submodel templates or Submodels of an AAS. IEC CDD is a concept repository.
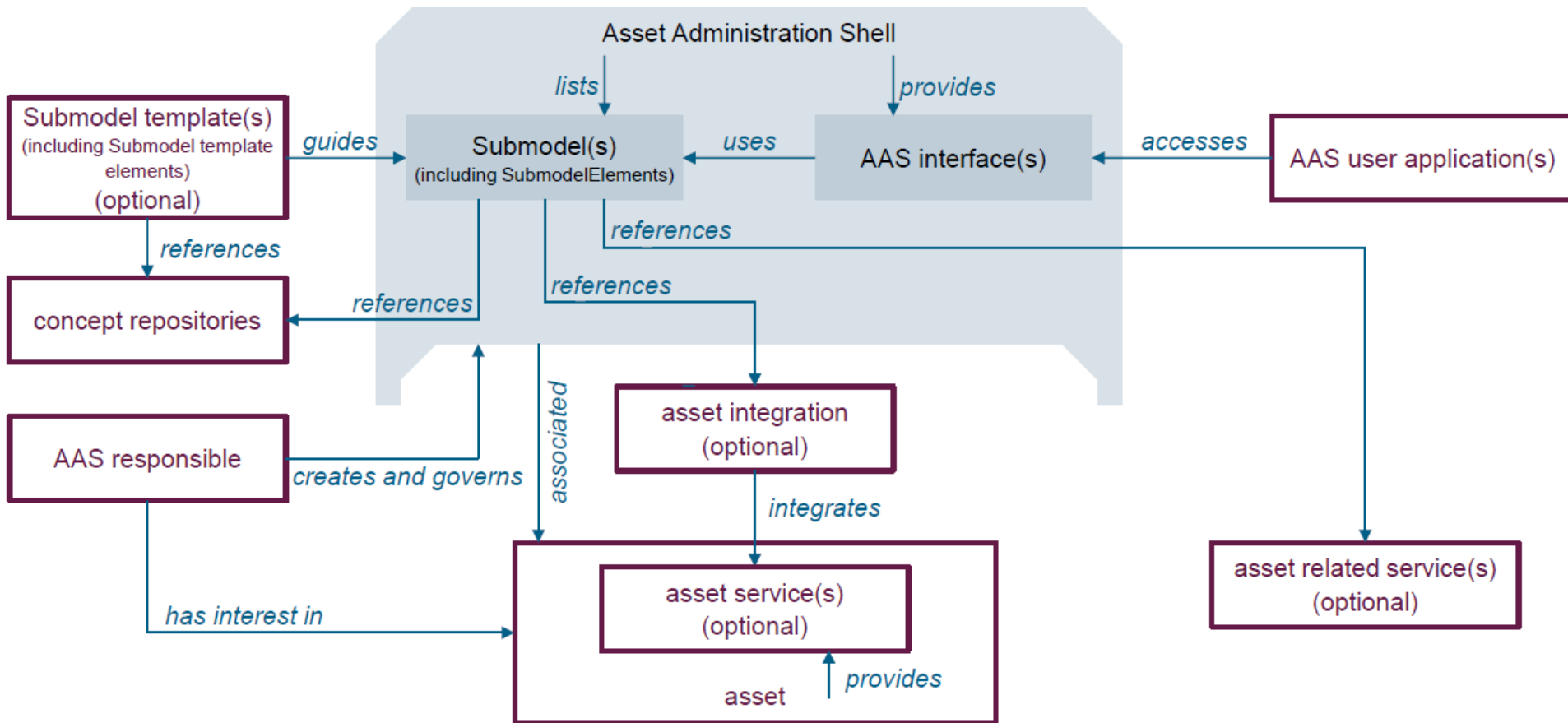
IEC 63278-2: AAS Information model

IEC 62751: AutomationML

IEC 62751: AutomationML Information model
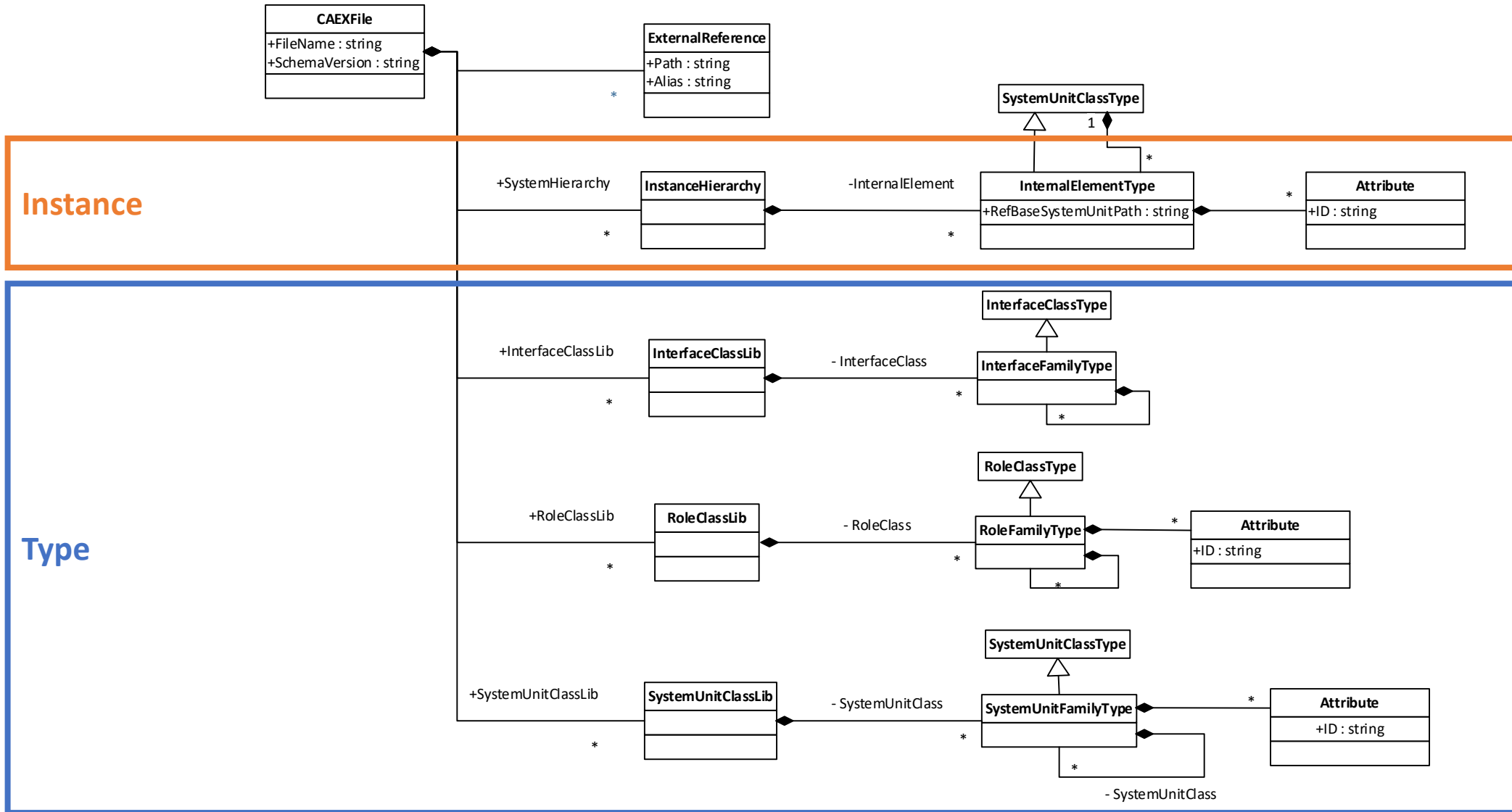
AutomationML - Dictionary References

Whitepaper AutomationML Part 6 – AutomationML Component (2020)
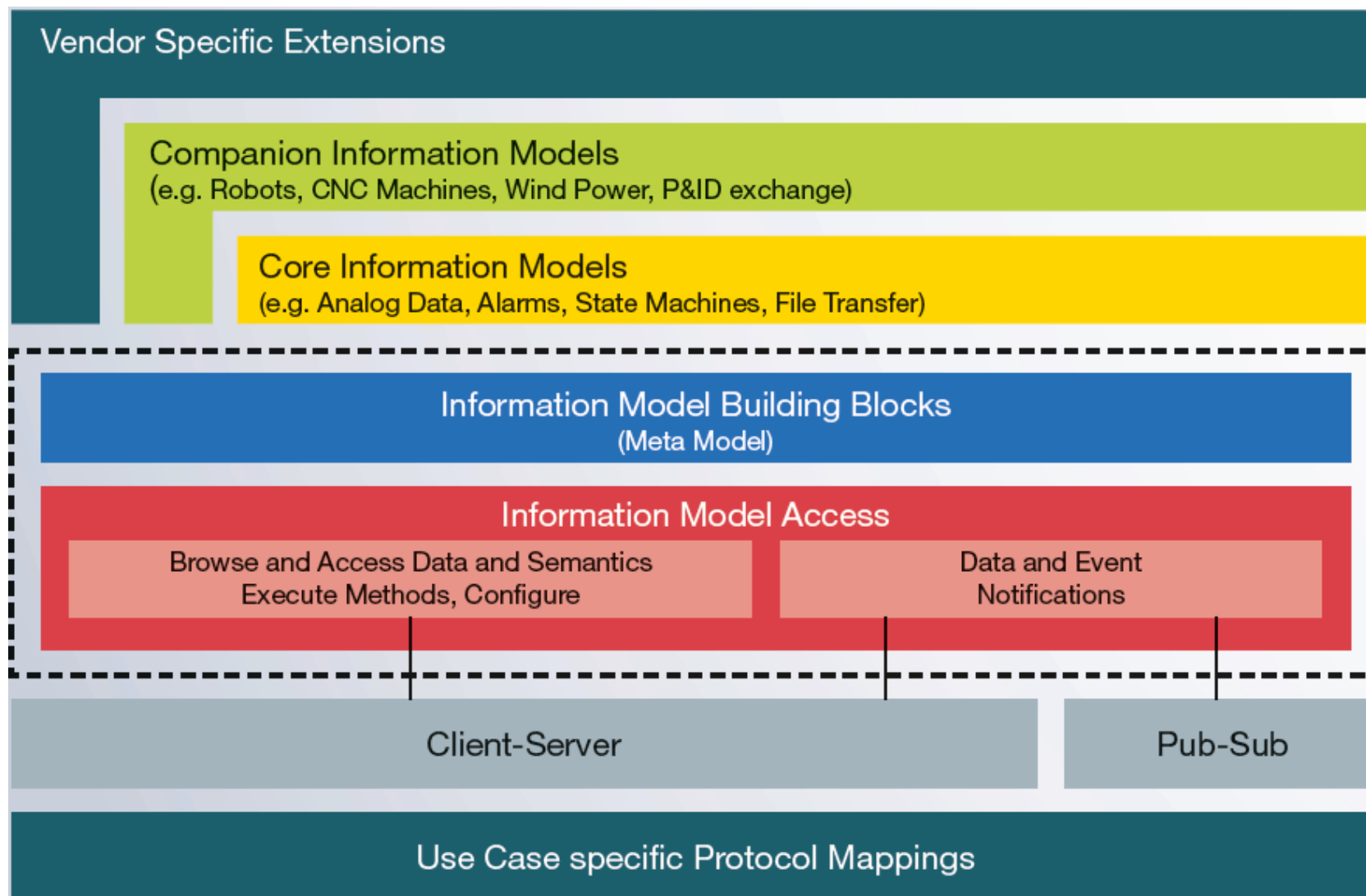
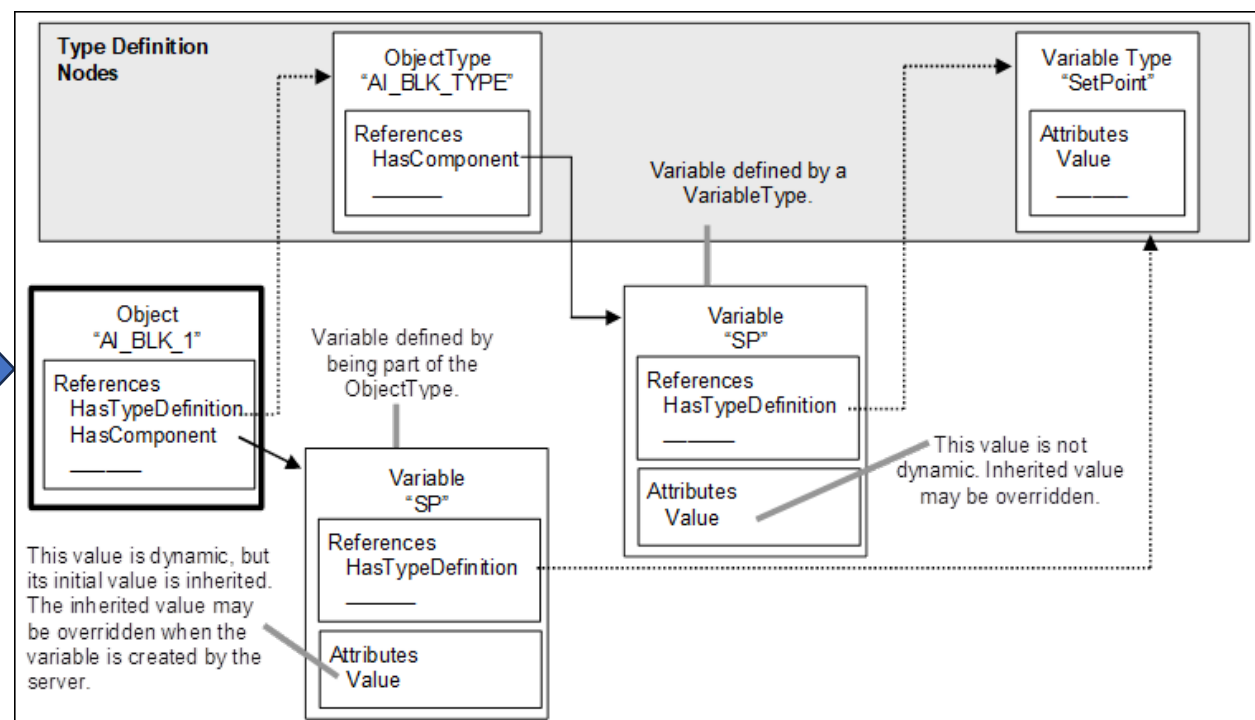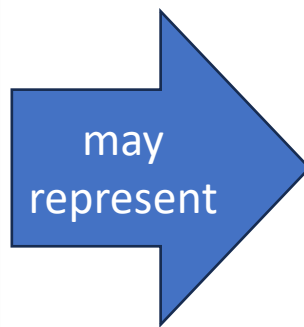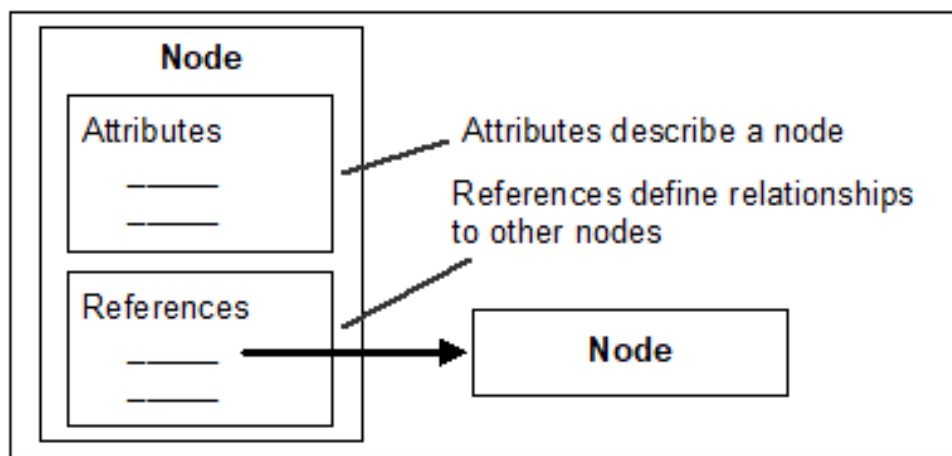**White paper AutomationML and ECLASS integration (2021)**
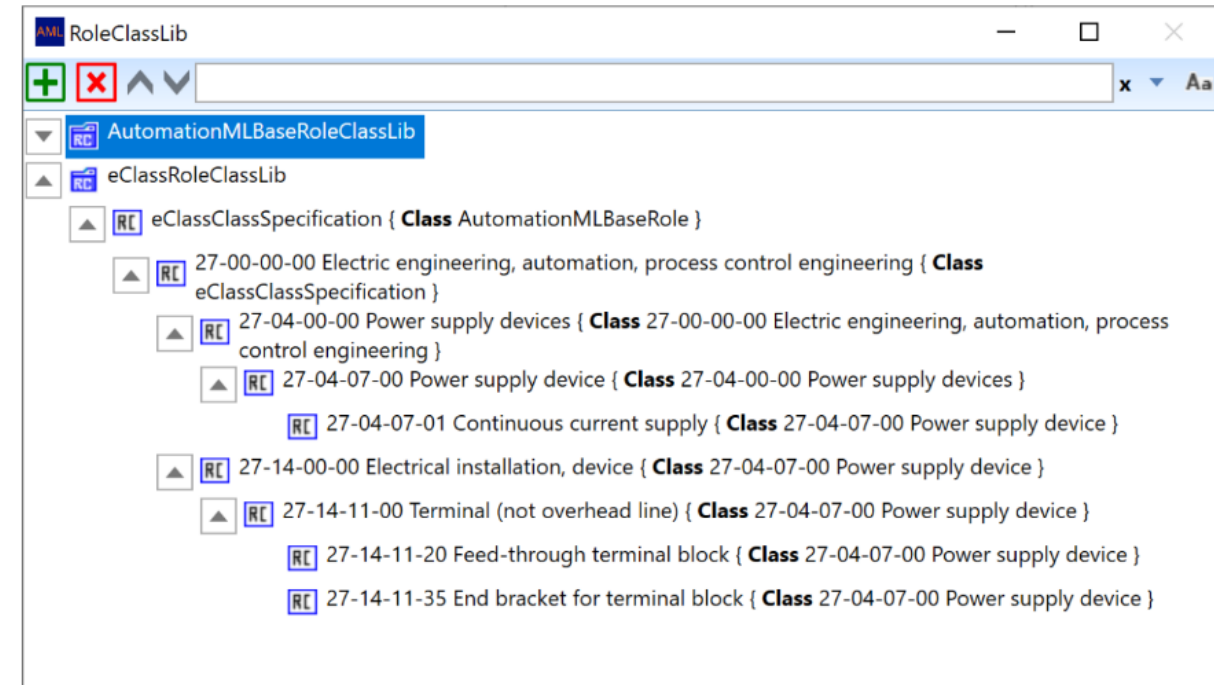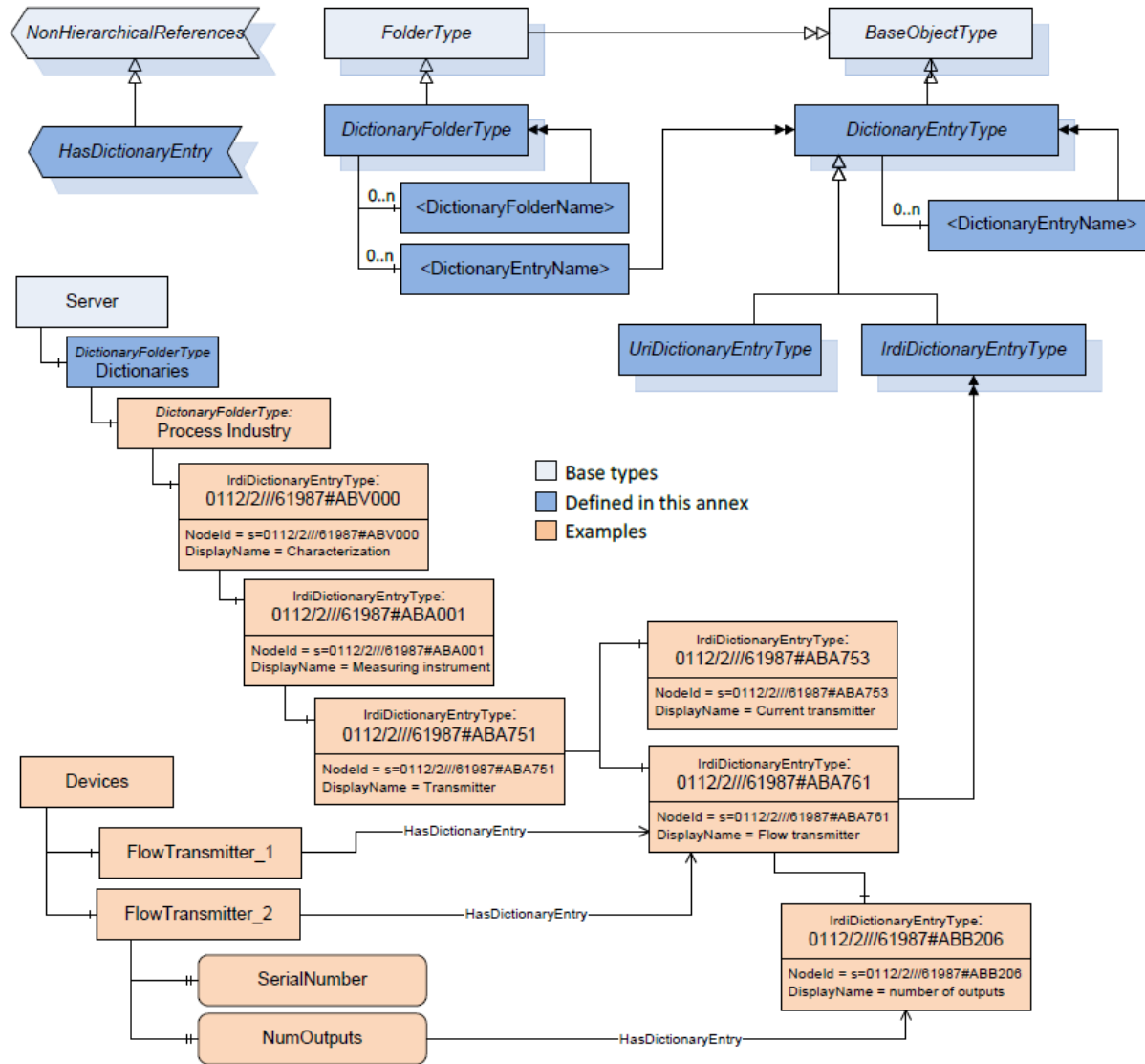

Figure 24 – Example Role Class

40

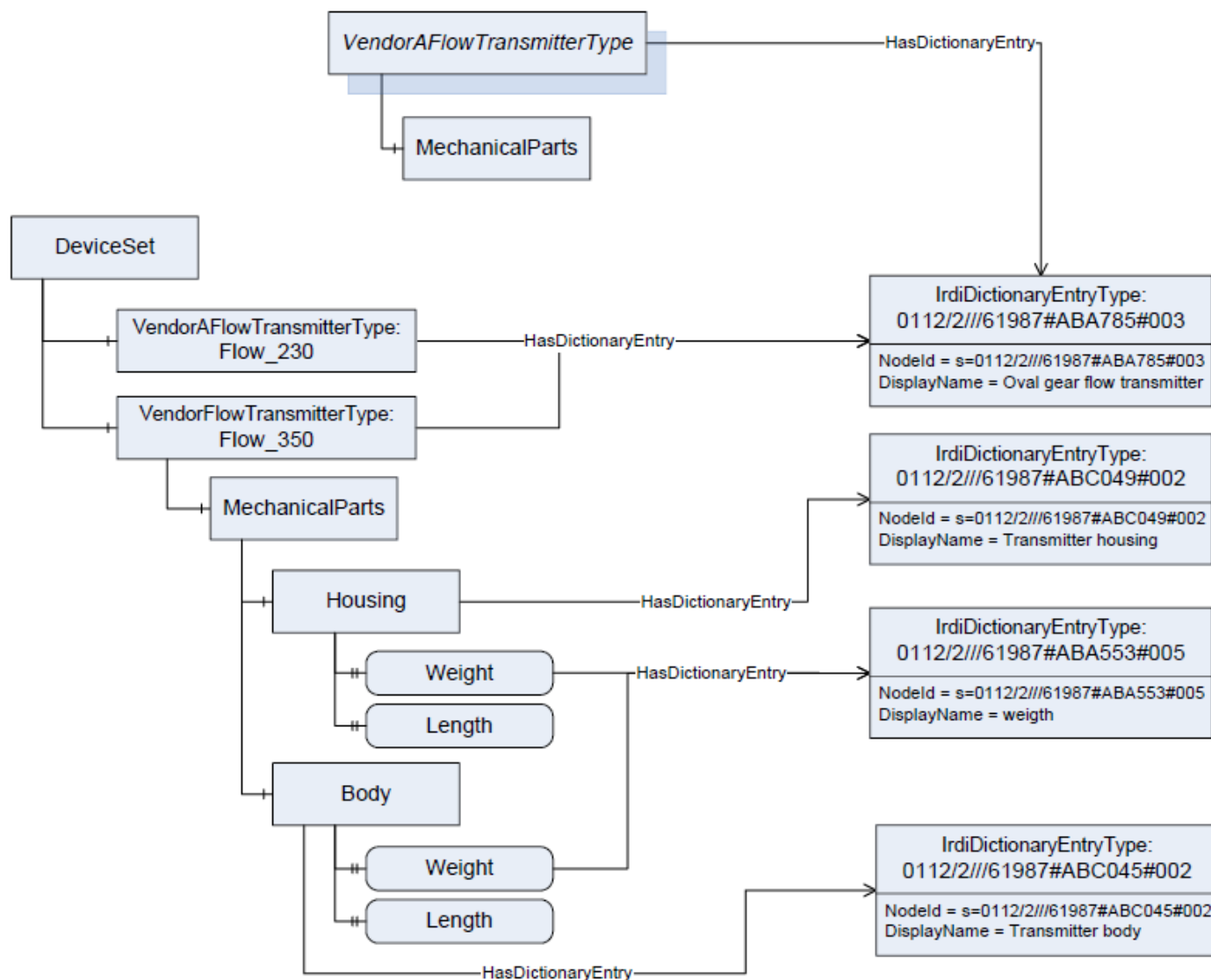# IEC 62451: OPC Unified Architecture

IEC 62451: OPC UA Information model

OPC UA Part 19 – Dictionary Reference
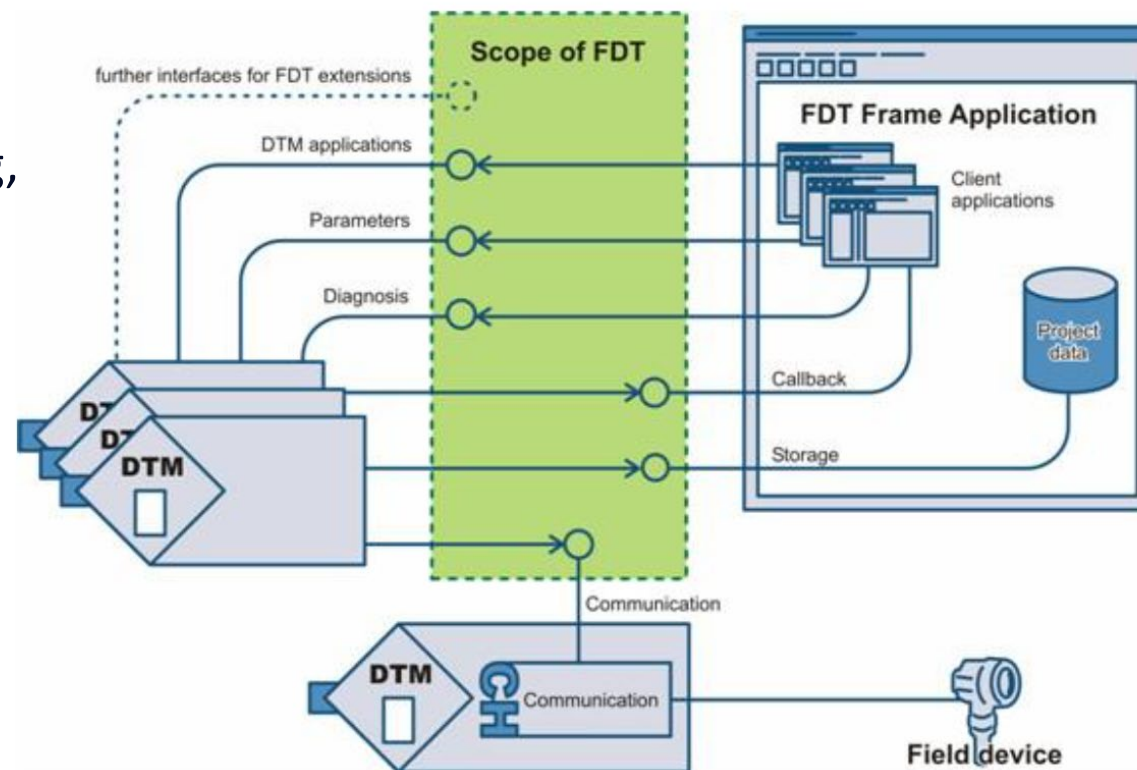
OPC UA Part 19 – Dictionary Reference Example

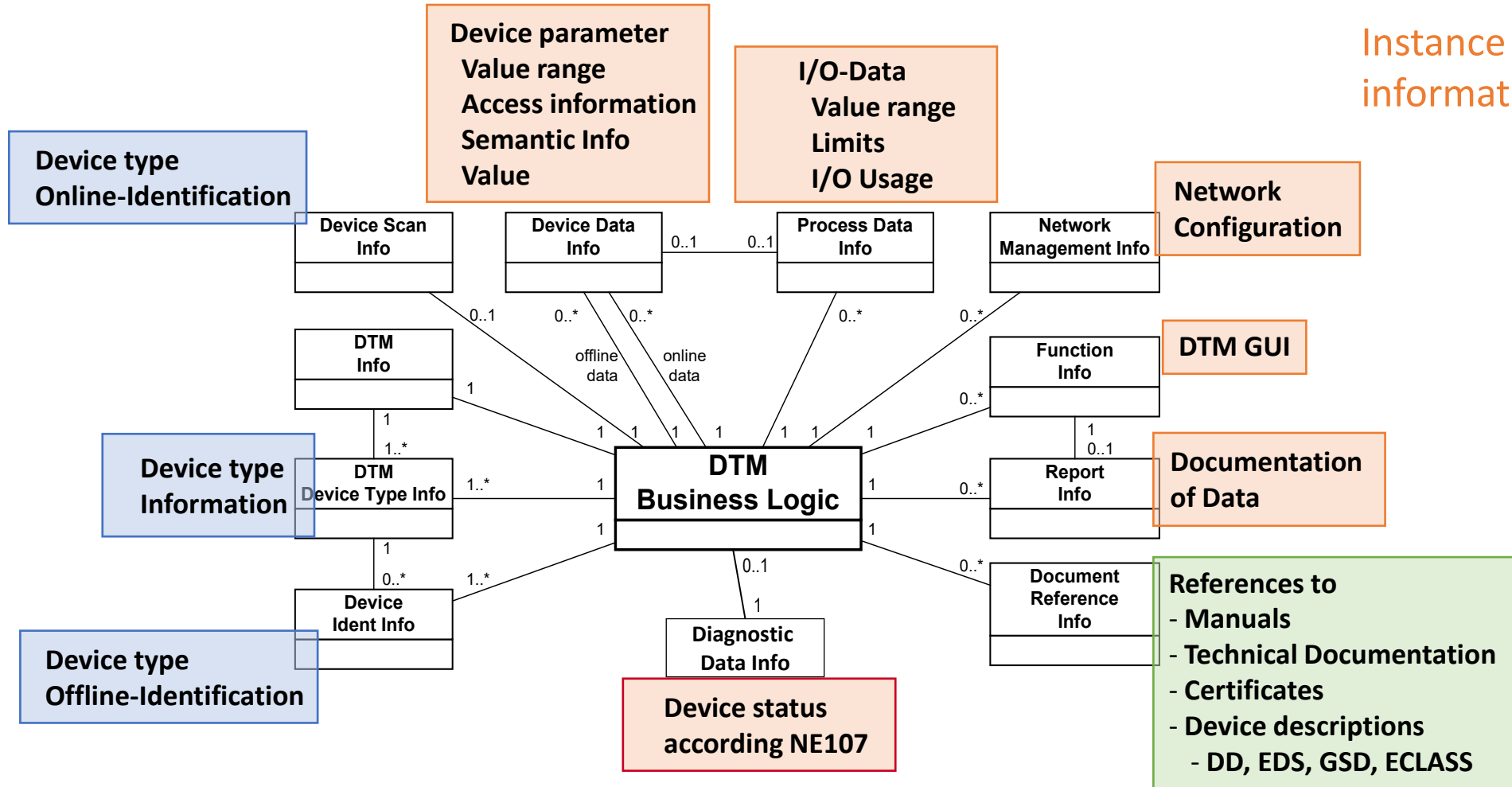# IEC 62453: Field Device Technology (FDT)

- open and non-proprietary standardized interface
- for the integration of field devices with engineering, automation and asset management systems

- Support for field device integration:
  - Monitoring
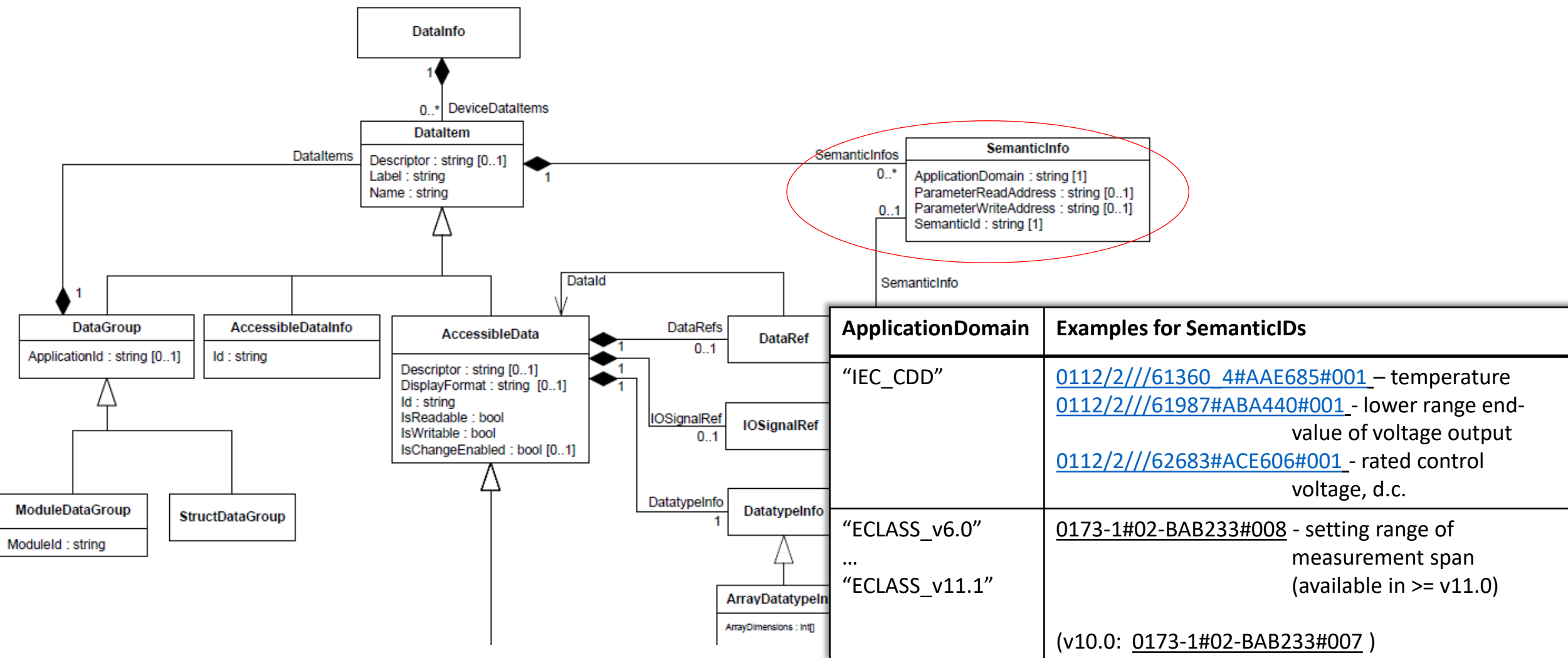 - Diagnosis
  - Parameterization
  - Optimization

IEC 62453: FDT DTM Information model

51

IEC 62453: SemanticInfo provides dictionary references

ApplicationDomain	Examples for SemanticIDs
"IEC_CDD"	0112/2///61360_4#AAE685#001 – temperature 0112/2///61987#ABA440#001 - lower range end-value of voltage output 0112/2///62683#ACE606#001 - rated control voltage, d.c.
"ECLASS_v6.0" ... "ECLASS_v11.1"	0173-1#02-BAB233#008 - setting range of measurement span (available in >= v11.0) (v10.0: 0173-1#02-BAB233#007)

52

IEC 62453-71: FDT OPC Server architecture

53
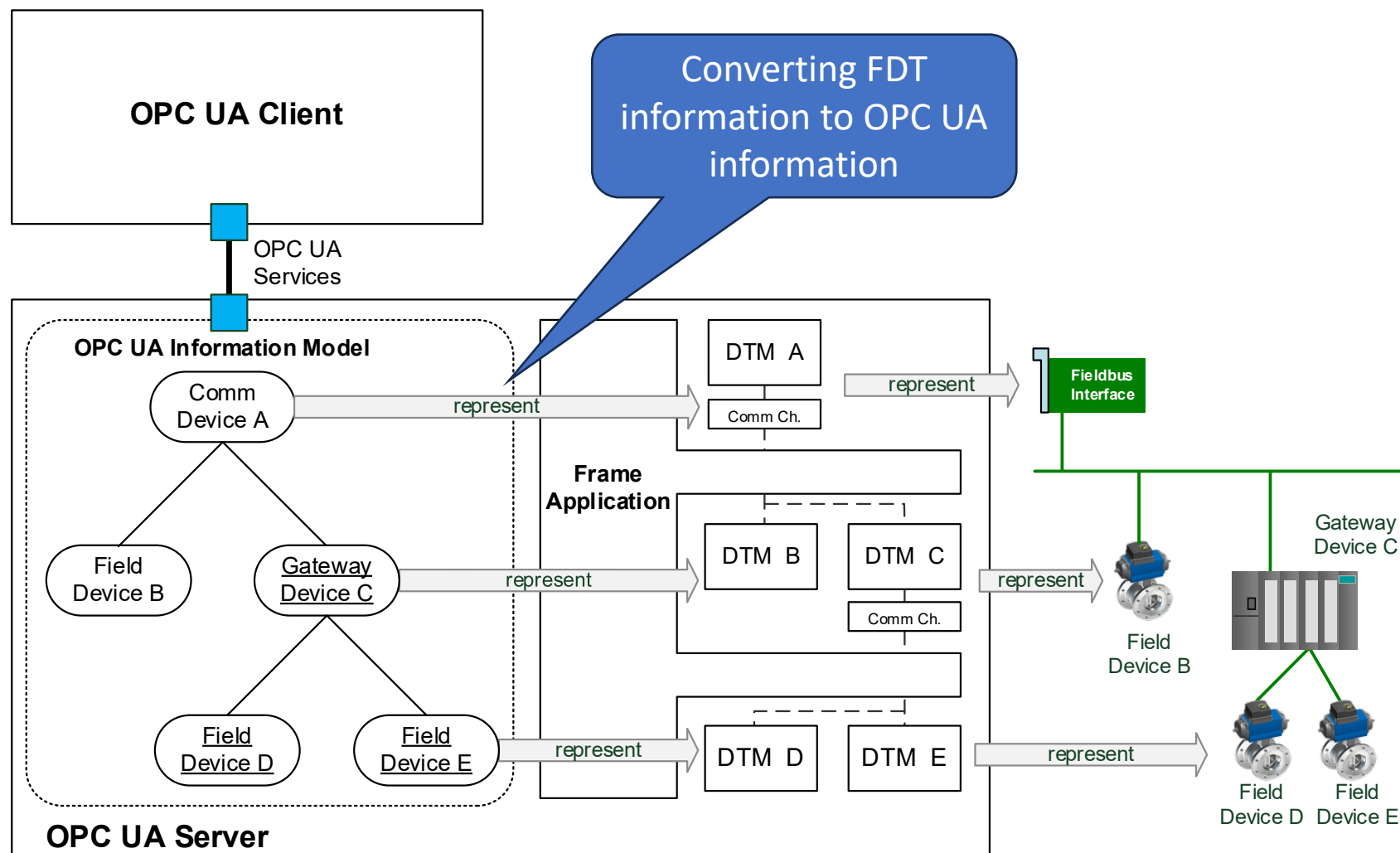
Overview - model elements from different standards

	IEC 61360	IEC 62832	IEC 62714 AML	IEC 62541-100 OPC UA DI	IEC 62453 FDT
Meta	• (Dictionary) • ItemClass • Property	• Dictionary • DFassetClassDefinition • CDELdefinition • DataElementType (constant, variable)			
Type	• Object • Object property	• Library • DFassetClass • CDEL • DataElement	• SystemUnitClassLibrary / RoleLibrary • SystemUnitClass / RoleClass • Attribute	• Type namespace • Device type • Folder • Variable	• DeviceTypeInfo (member attributes) • Documents • DeviceIdentInfo (member atttributes)
Instance	• Object • Object property	• DigitalFactory • DFasset • CDEL • DataElement	• InstanceHierarchy • InternalElement • Attribute	• Instance namespace • Device • Folder • Variable	• DeviceScanInfo (member attributes) • INetworkData • DeviceStatus • Instance data • DataGroup • FdtParameter

Contents

Conclusions

- Semantic interoperability is important to improve cooperation across value chains

- Standards support the implementation of semantic interoperability
  - Established standards
  - Standards under development

- Full benefits of semantic interoperability can be reached only if all participants in the value chain provide support

Thank you

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