Arrowhead fPVN - flexible Production Value Networks

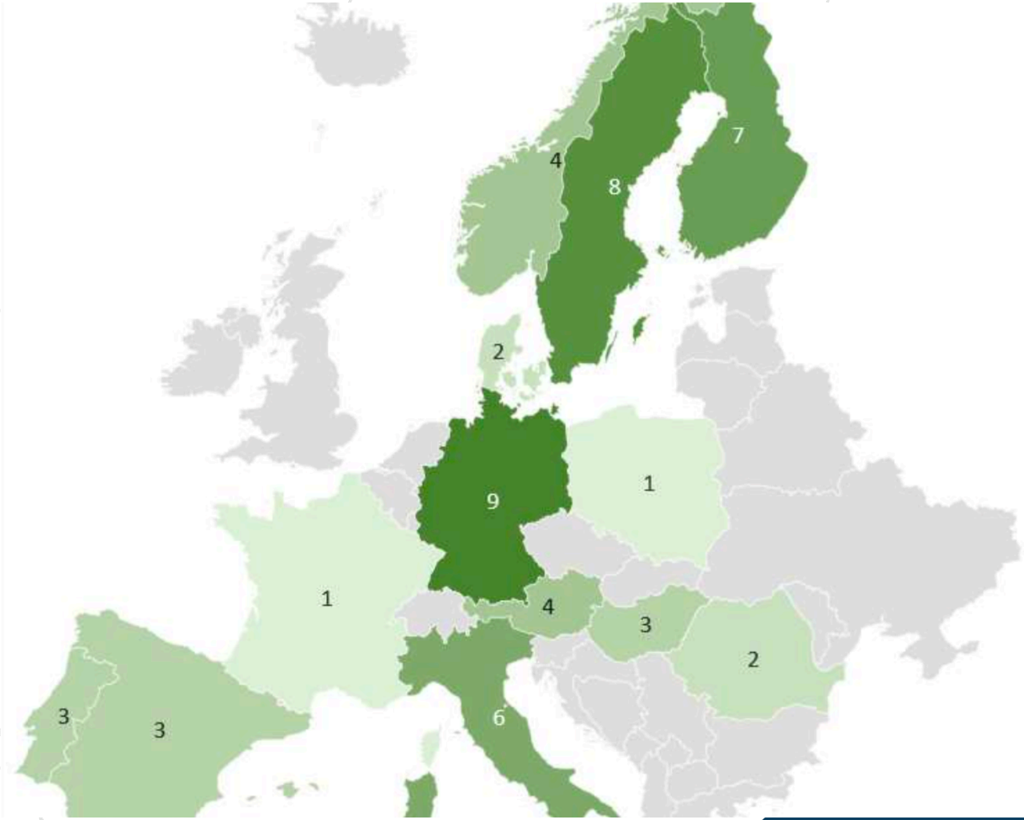
Overview

Arrowhead fPVN is a European project funded by the KDT-JU

- 30M€
- 43 Partners
- 12 Countries

Participants from

- Automotive services
- Aerospace services,
- Green energy conversion and
- Process industry production.



Our Vision

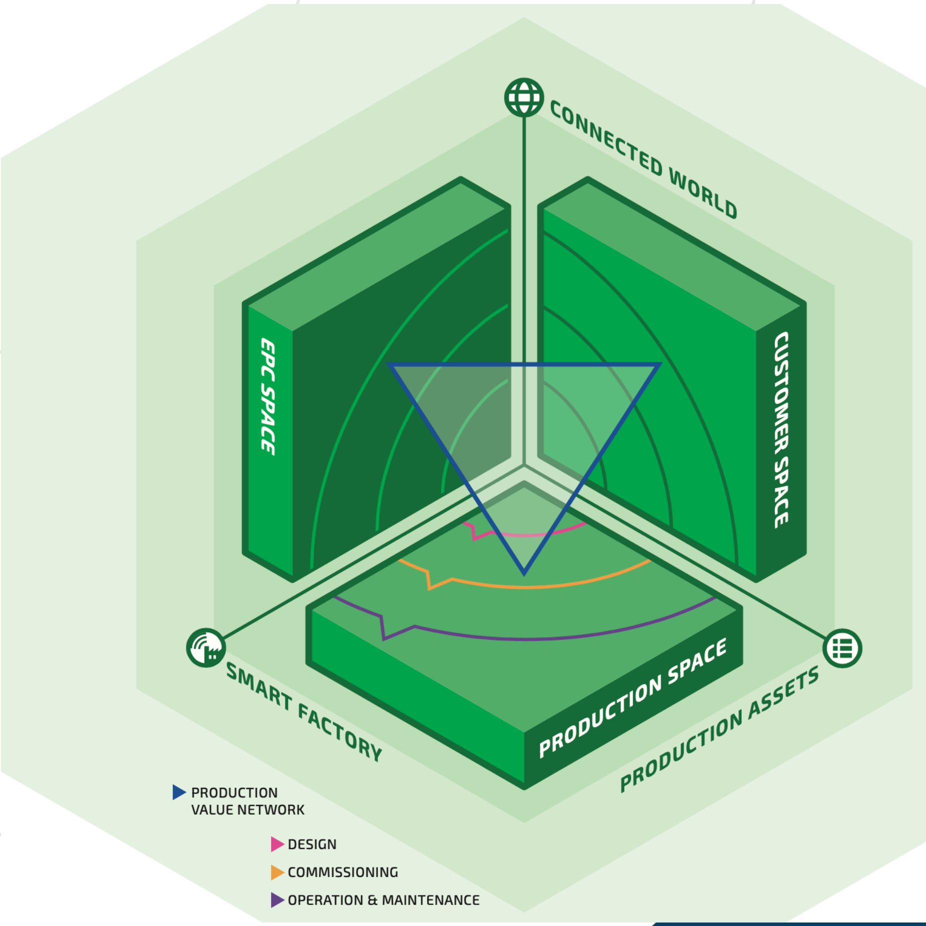
Doubling European industrial productivity by applying transformative, autonomous and evolvable information interoperability for resilient and adaptive production value networks.

Production Value Networks

Multi Stakeholder Operation
- Owner & Operators
- EPC (Engineering, Procurements & Consultancy) and Supply Chain
- Customers

Extensive Exchange of information between each other:
- Not standardized
- Re-engineered
- Time Consuming
- Inefficient

Business Logic and Ecosystems differs between Sectors



ARROWHEAD

Grand Challenge

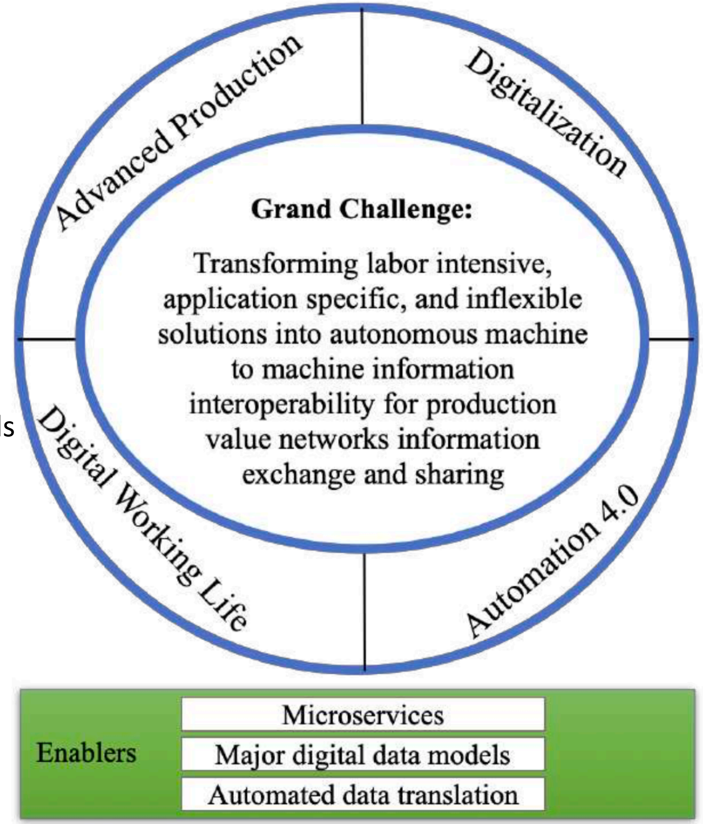
Key technology gaps identified:

Too many and non-interoperable standardized data models

Non-mature technology for machine translation in-between data models

Lack of open architectures and implementation platforms for interoperable fPVNs, having properties such as:

- Flexible,
- Secure,
- Scalable,
- Autonomous, and
- Evolvable



Technology Pillars

Arrowhead fPVN consortium has identified the following three technology pillars a combination of which can substantially boost the interoperability in PVNs:

- Microservice paradigm
  An open, extensible solution architecture with reference implementation platform enabling seamless information interoperability between involved entities, operational technologies (OT) and information technology (IT).

- Major industrial data models (preferably standardized)
  Promoting the data models of a few major standards, between which autonomous translation is enabled and integrated, to automation/digitalization solutions using the microservices architecture and associated implementation platform.

- Automated translations between data/information models
  Automated information model translation between the major data modelling languages enabling on the fly understanding of the entities in PVNs.

ARROWHEAD

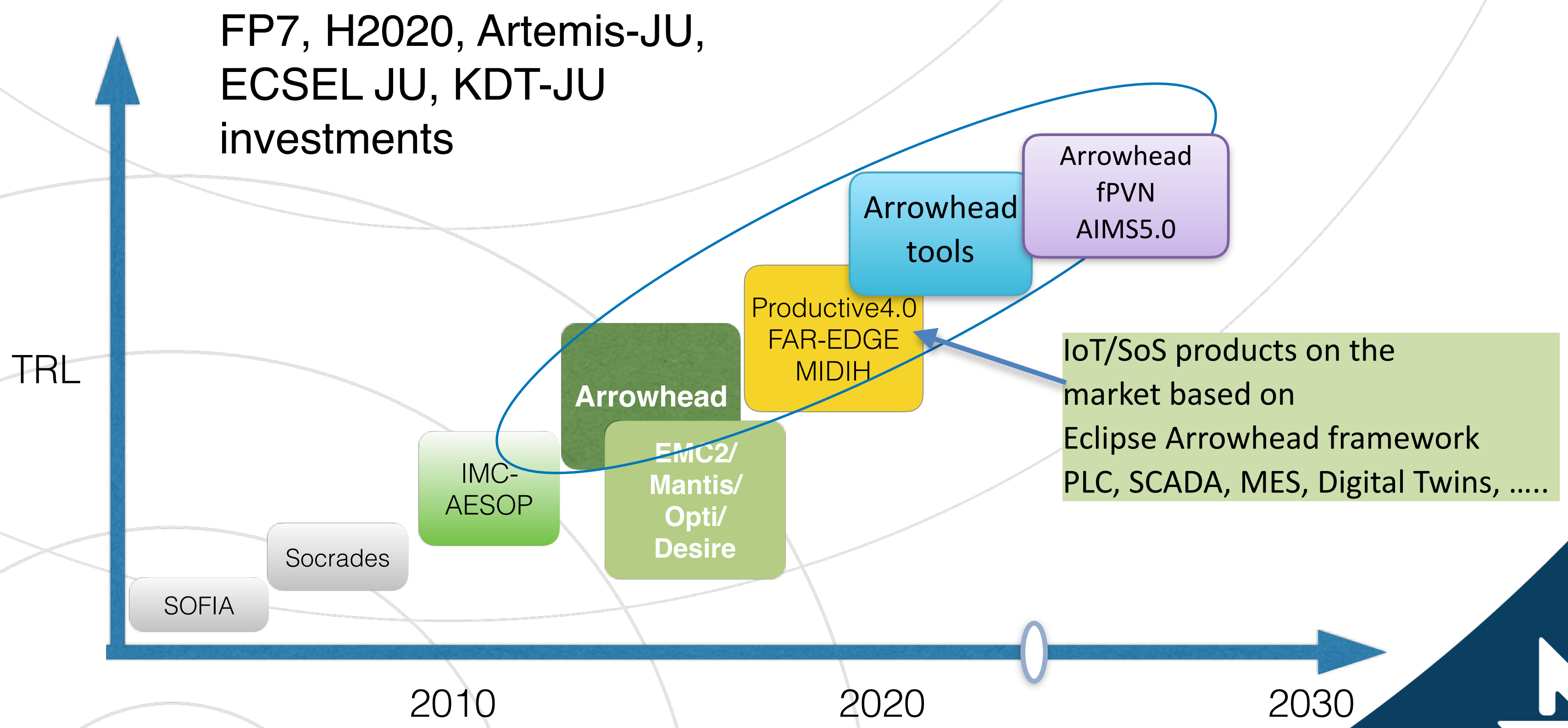
Our stepping stone
Arrowhead Tools, …

Coordinator Prof. Jerker Delsing

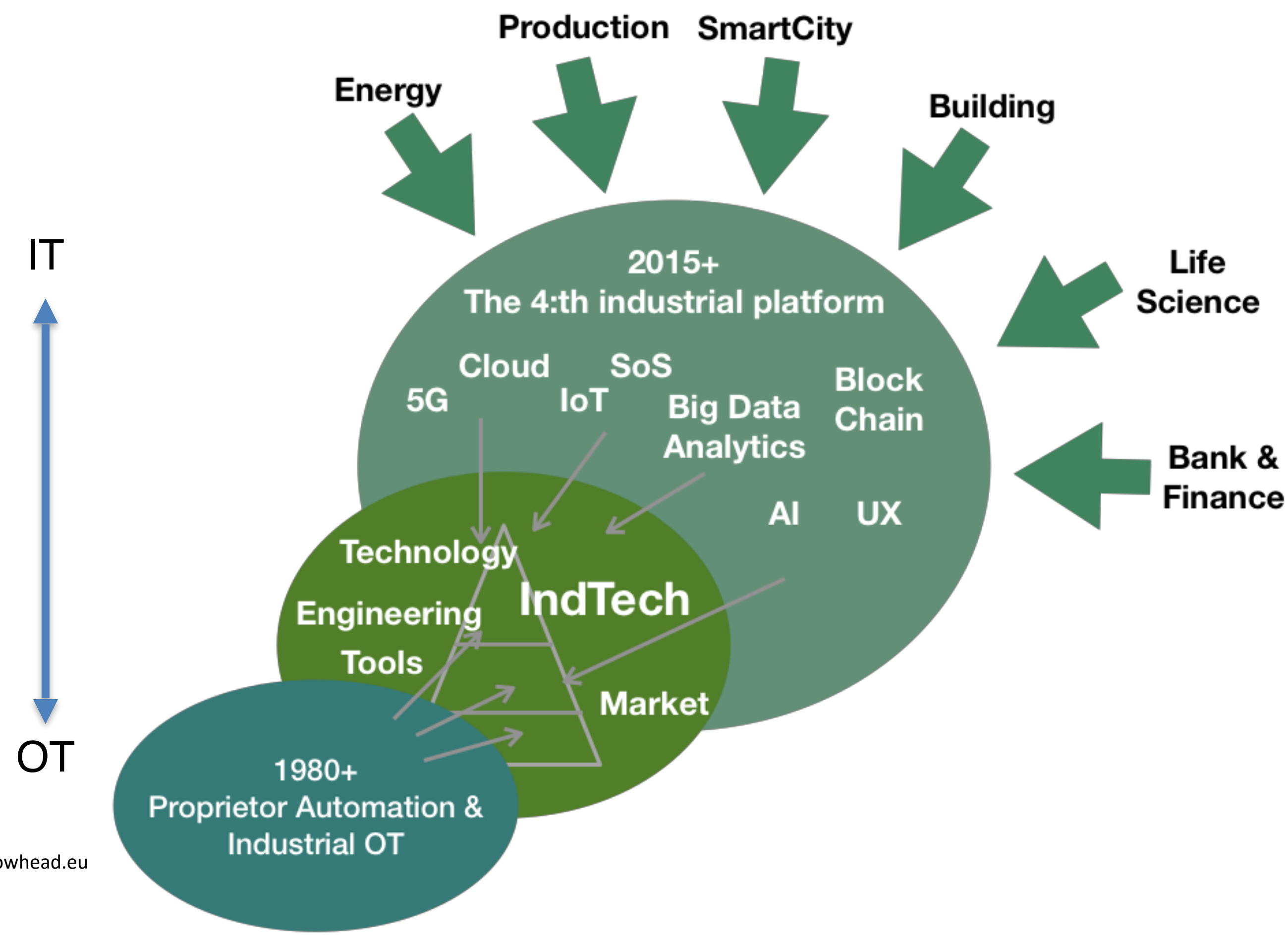
This research work has been funded by the European Commission, through the European H2020 research and innovation programme, ECSEL Joint Undertaking, and National Funding Authorities from 18 involved countries under the research project Arrowhead Tools with Grant Agreement no. 826452.

ARROWHEAD TOOLS

IoT/SoS and Industry 4.0/5.0 project time line



FLEXIBLE DIGITALISATION and AUTOMATION
OT meets IT



www.arrowhead.eu

ARROWHEAD TOOLS

Primary objective

20-50% reduction of engineering costs of automation and digitalisation solutions in industry

Microservice paradigm

Approach

- Highly modularised software with well defined microservice interfaces

Modularisation through

- Microsystems producing and consuming well defined microservices and associated interfaces

Starting point is:

- Eclipse Arrowhead architecture and reference implementation

Microservice paradigm capabilities

Discovery:

find the consumable services

Orchestration:

centrally managing what systems consume what services.

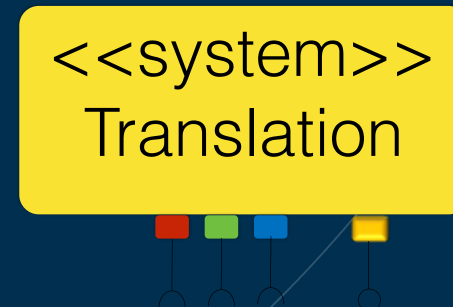
Authorisation:

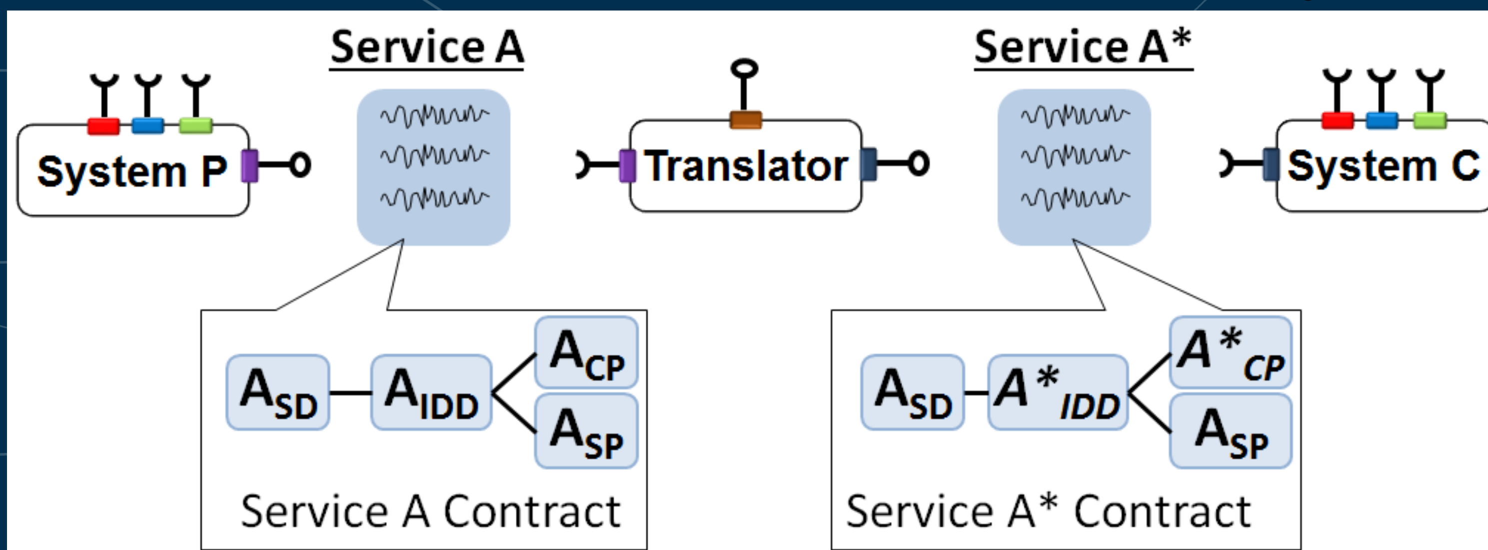
regulating how systems are allowed to consume what services,

Interoperability - Protocol translation

Translation between different protocols

HTTP, CoAP, MQTT, Websocket





Interoperability
Multi-protocol, multi-technology

Support core systems models

- Translator
  - HTTP (REST), CoAP, MQTT, (Websocket)
- Adaptors to other communication protocols
  - OPC-UA <-> Arrowhead
  - Modbus TCP <-> Arrowhead
  - Z-wave <-> Arrowhead
  - ZigBee <-> Arrowhead
  - IO-link <-> Arrowhead
  - Thing of Web <-> Arrowhead
- Datamodel adaptor
  - ISO 10303 - STEP AP-242

Datamodel interoperability

Very complex problem

ARROWHEAD
fPVN

Major industrial data models

Major industrial standards like:

ISO10303, ISO 15926, ISO 12006, …

Enabling data model interoperability and interaction reasoning

based on e.g. semantic web

How can major industrial standards be updates to enable wider interoperability?

Data model interoperability?

CPS A message:

```
[
  {"n": "OO_temp_sensor",
   "t": 318350,
   "u": "K",
   "v": 263.4948599934143}
]
```

CPS B message:

```
[
  {"bn": "temp_sensor", "bt": 321680},
  {"u": "Cel", "v": 20.97017853272450З},
  {"u": "Lon", "v": "1"},
  {"u": "Lat", "v": "-1"}
]
```


ARROWHEAD TOOLS

Data model interoperability

```
CPS A message:
[
  {"n": "OO_temp_sensor",
   "t": 318350,
   "u": "K",
   "v": 263.4948599934143}
]
CPS B message:
[
  {"bn": "temp_sensor", "bt": 321680},
  {"u": "Cel", "v": 20.970178532724503},
  {"u": "Lon", "v": "1"},
  {"u": "Lat", "v": "-1"}2020
]
```

Same ontology
Same data
Do not look the same!!

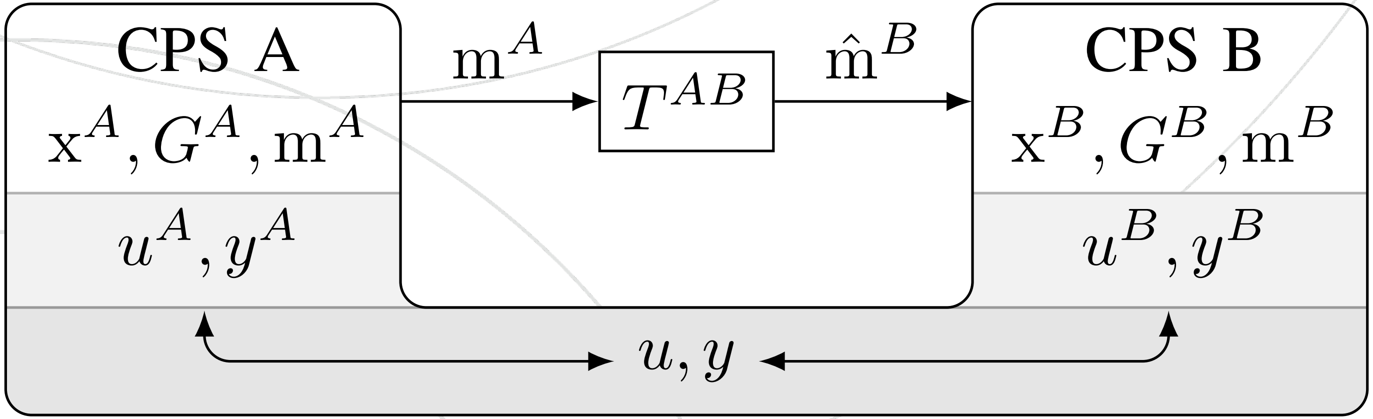
Automated translations between data/ information models

Approaches

- Super ontology
- ML/AI based translation
- Model based translation

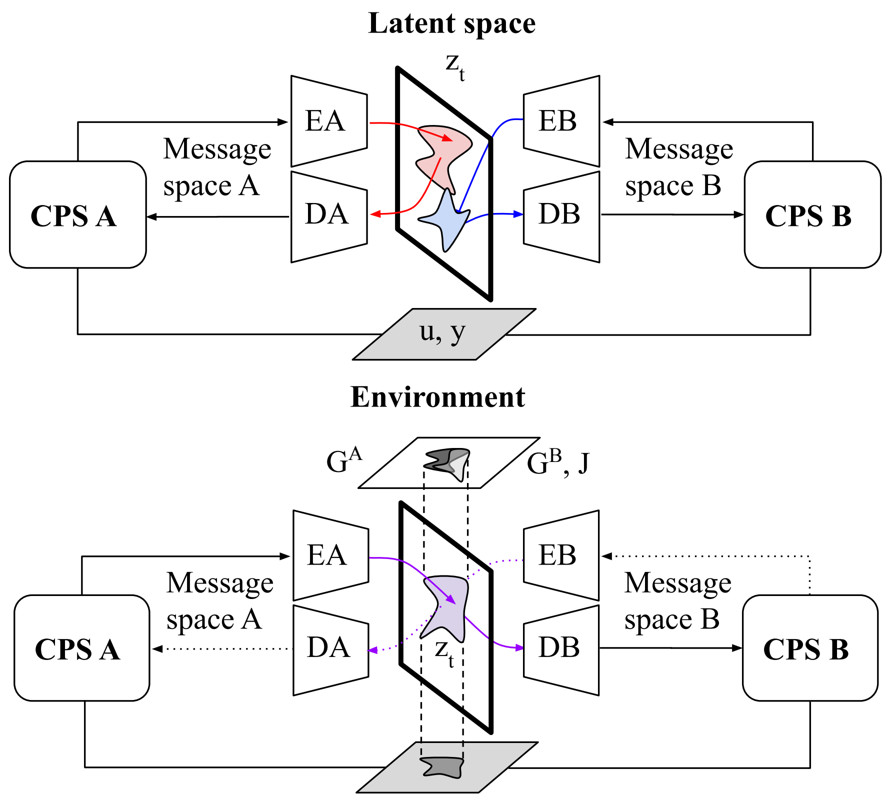
Automated translations between data/ information models

ML/AI based translation



J. Nilsson, F. Sandin and J. Delsing, "Interoperability and machine-to-machine translation model with mappings to machine learning tasks," 2019 IEEE 17th International Conference on Industrial Informatics (INDIN), Helsinki, Finland, 2019, pp. 284-289.

AI based data model translation



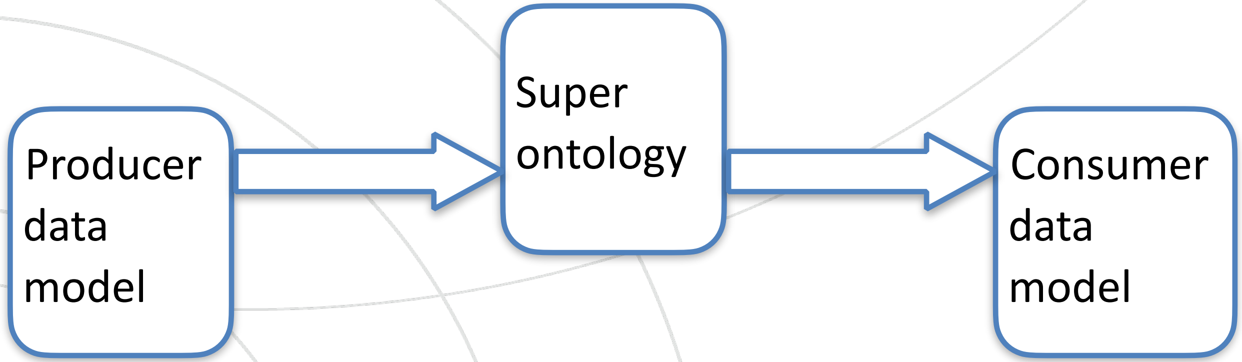
Nilsson, J. (2019). System of Systems Interoperability Machine Learning Model (Licentiate dissertation). Luleå University of Technology. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:ltu:diva-76229

ARROWHEAD TOOLS

Automated translations between data/ information models

Super ontology

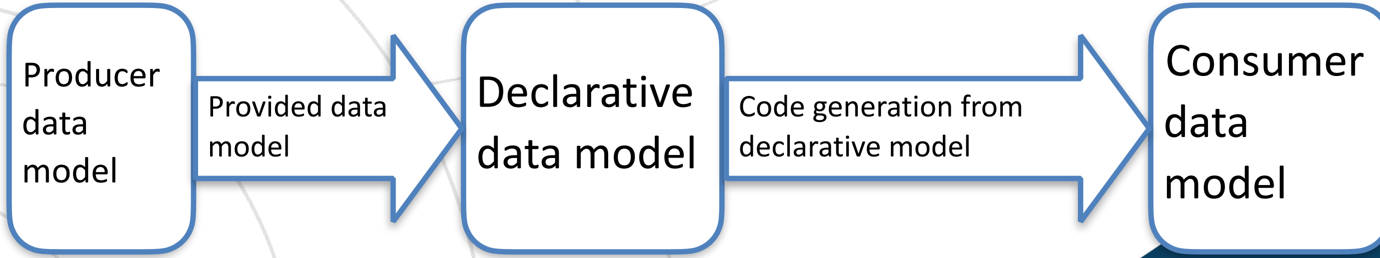
- From producer ontology based data model
- To super ontology based data model
- To Target ontology based data model



Automated translations between data/ information models

Model based approach

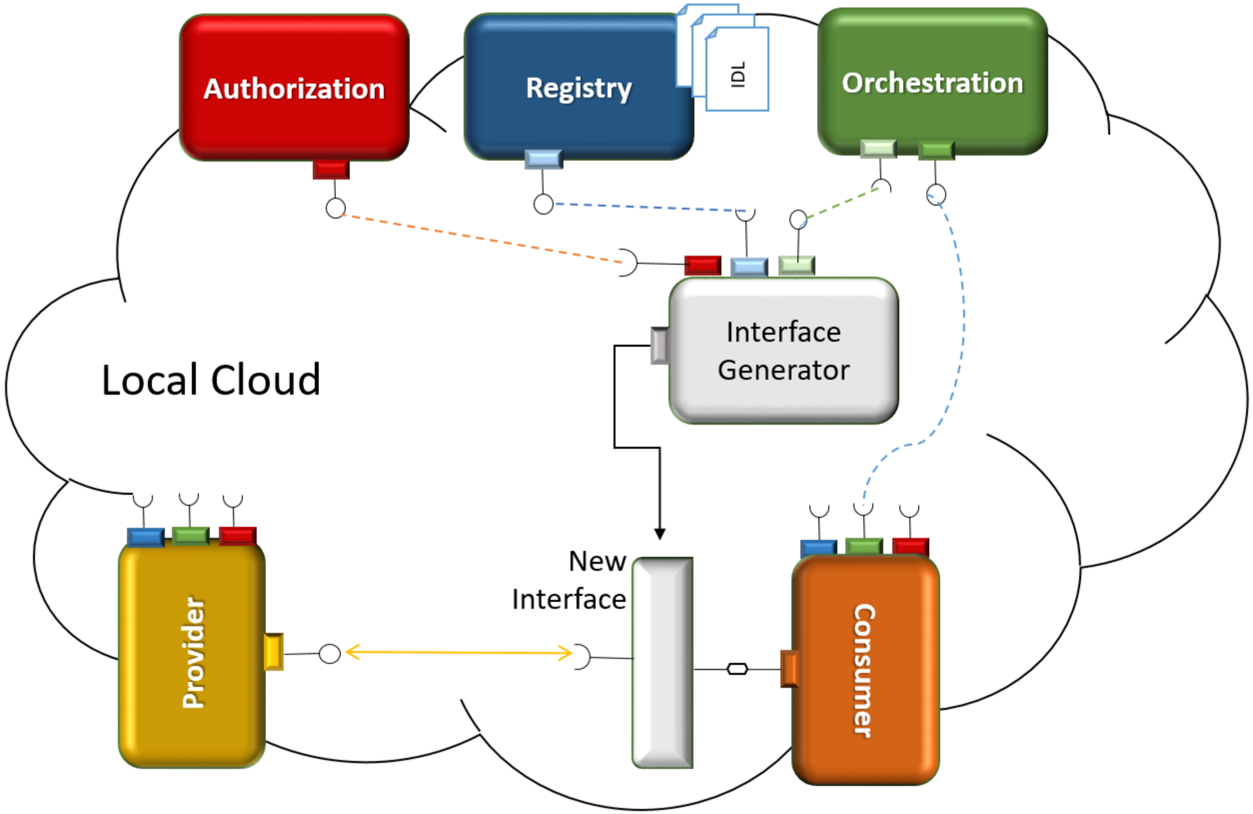
- Declarative programing model
  - declaring objective through models
  - based on UML/SysML capability of defining domain specific "declarative" languages
  - automated code generation form declarative models



Interoperability engineering

- Design time and run time
  - Write a situation specific and dedicated translator
  - Use of general translator
  - Autonomous translator engineering
    - Identifying service contract mismatches
      - Inject protocol and encoding translation
      - Inject missing consumer capabilities
      - Inject servitisation of legacy API

Dynamic interoperable interface injection



ARROWHEAD TOOLS

Expected Impact

The advancement beyond both scientific and industrial state of the art will be achieved by integrating three technological building blocks composing the pillars for interoperability

Integrating the building blocks' functionalities will enable the value creation related to the following:

- Asset information models
  Interoperable asset models enabled by unlocking digital and non-digital legacy OT asset information
- New technical functionality
  Autonomous handling of information between machines and people within PVNs, based on standards and open concepts
- Improved digital transformation management
  Evolvable interoperability accelerating uptake and change management of value network digitalization further along its lifecycle.

Validation and verification of common technologies in 4 industrial production domains and 8 use-cases

#1.6: Automotive Battery Innovation fPVN

#2.6: Humans in the interoperable System

#1.7: Interoperable intelligent management of production lines: Towards Model-based Enterprise

#2.7: Aircraft Health Management System (AHMS) for Trend Monitoring, Predictive

#1.8: System-Driven Modularisation and Digitalization for Offshore Renewables

#1.9 Pump Station Engineering

#2.9: Digital Twins that enable higher performance by interoperability in pulp mills & carton board mills

#3.9: Interoperability for technical information exchange in process industry

Conclusion

The ambition is that machines autonomously can translate between major standard data models!

We are starting June 1 2023

Close collaboration with AIMS5.0 project lead by Infineon