SEMIC conference

2. Cross-border Semantic Interoperability: From Models Discovery and Design to Implementation and Reuse

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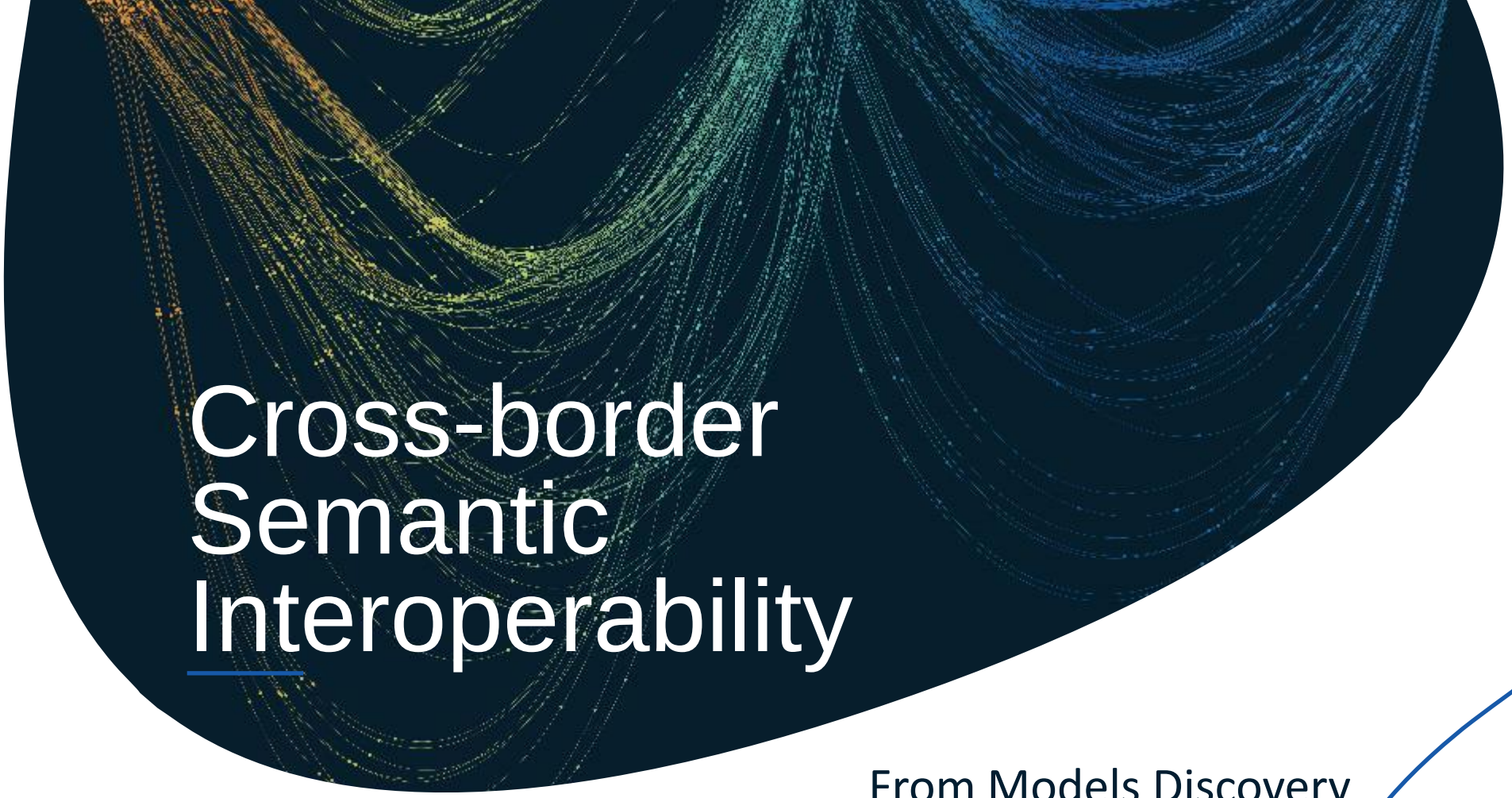
European Commission



Cross-border Semantic Interoperability

From Models Discovery and Design to Implementation and Reuse

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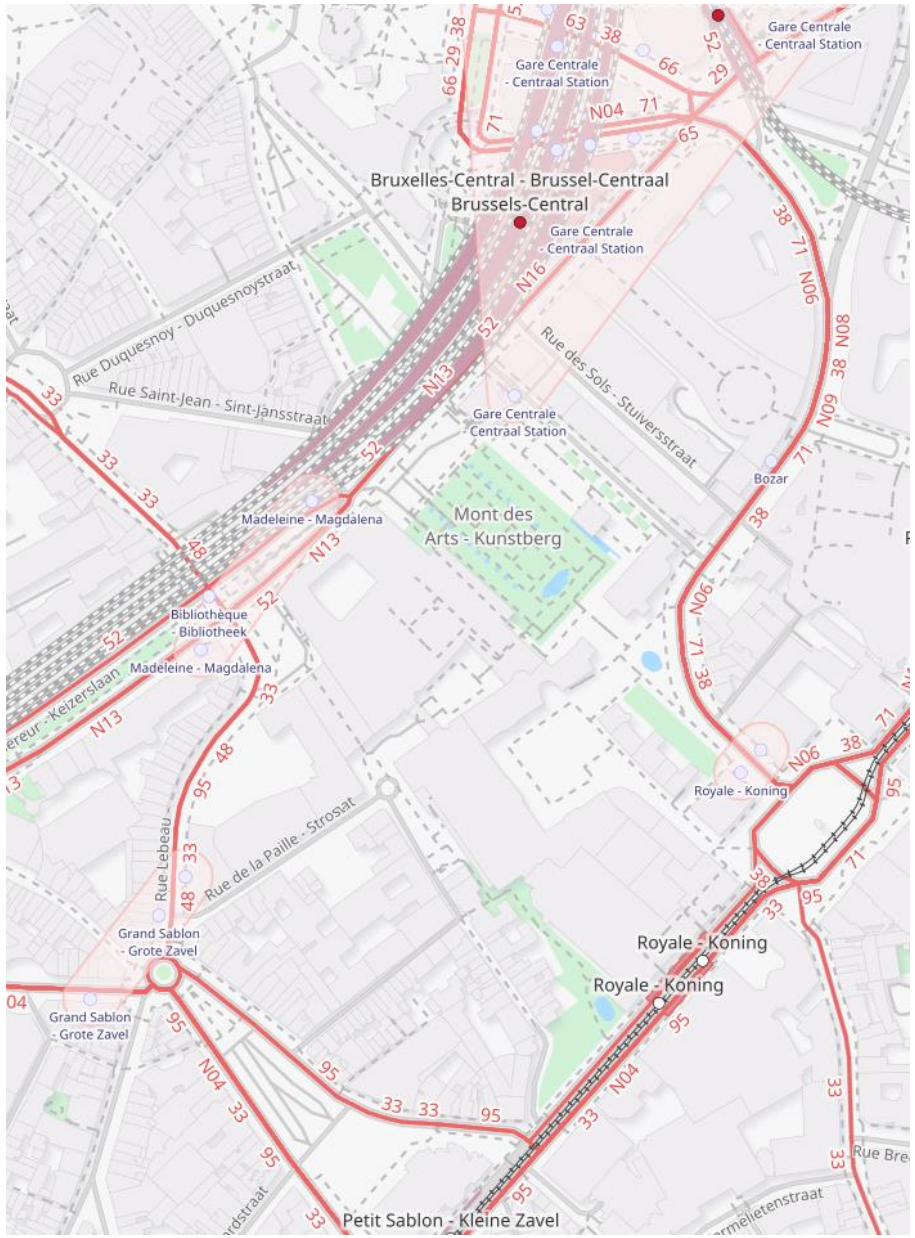
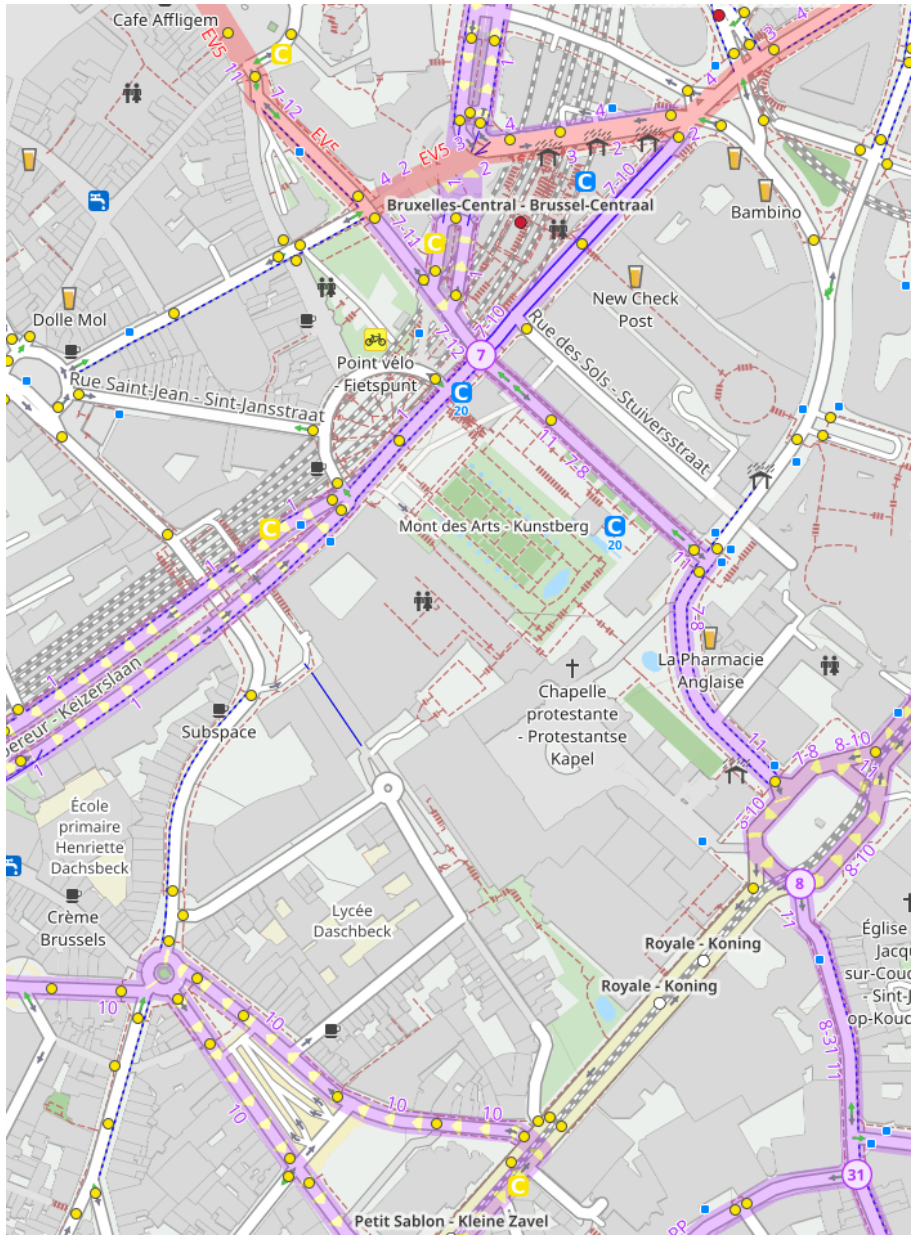
European Commission

“All models are wrong, but some are useful”

-George Box



OpenStreetMap - Transport map



OpenStreetMap - Cycle map


Ceci n'est pas une pipe.

Building *useful* cross-border models

Cohesion

Autonomy

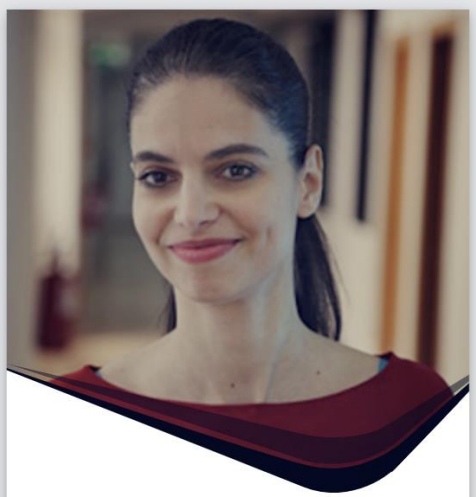
Formal agreement

Cohesion is reached by formal agreement through stakeholder participation

Emergent interoperability

Cohesion is reached by consensus emerging from discovery and adoption

Speakers Line Up



Giorgia
LODI
Technologist

Institute of Cognitive Sciences and Technologies of Italian National Research Council (CNR-ISTC)
Rome | Italy

Raf
BUYLE
Data & Innovation

athumi,Flemish Data Utility Company
Brussels | Belgium

Marc
PORTIER
Open Science Team Lead

VLIZ vzw
Oostende | Belgium

European collaboration on semantic interoperability

Towards European collaboration through sharing a vision and a practical example within the MareGraph project

European collaboration on semantic interoperability

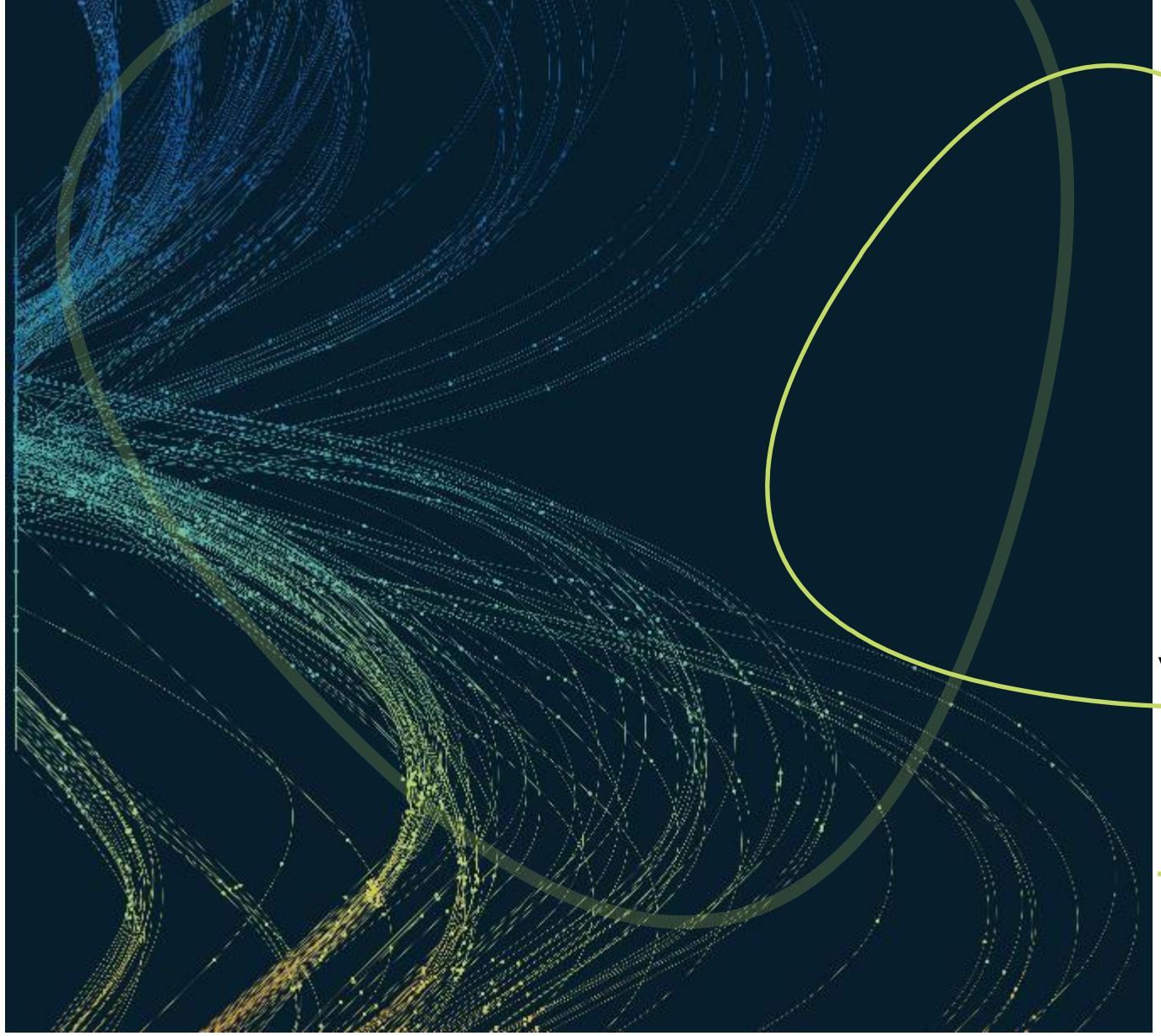
Towards European collaboration through sharing a vision and a practical example within the MareGraph project

Objective of the sessions

Through sharing ideas and examples of European collaboration on interoperability, the objective of the following two presentations is to think about and collectively explore the path towards European collaboration on interoperability, with your active participation.

Agenda

1. **Vision for European collaboration**
   - Raf Buyle - Digitaal Vlaanderen
2. **MareGraph**
   - Raf Buyle - Digitaal Vlaanderen
   - Giorgia Lodi - Institute of Cognitive Sciences and Technologies of the Italian National Research Council
3. **Q&A**

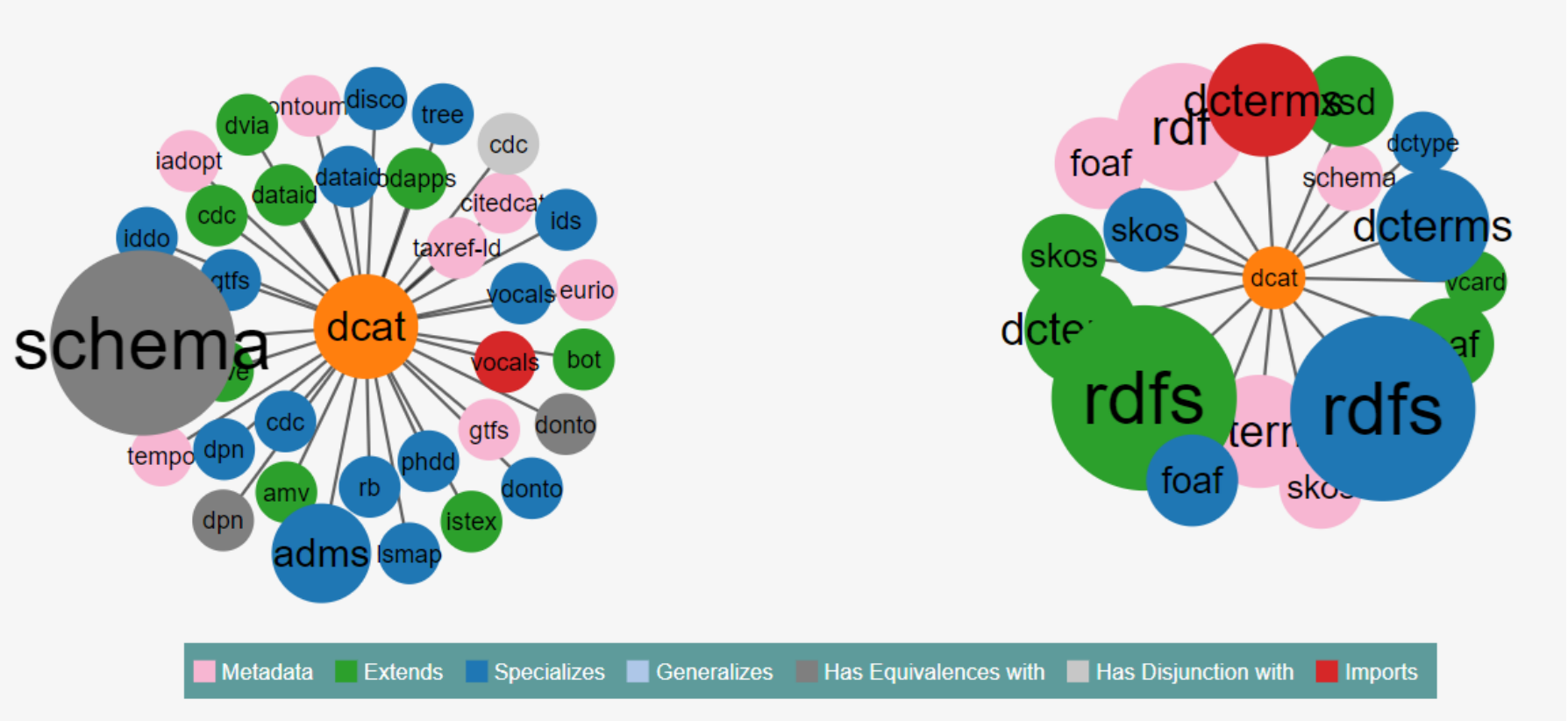


Vision for European Collaboration

1) Inspiration
2) Adoption
3) Contribution

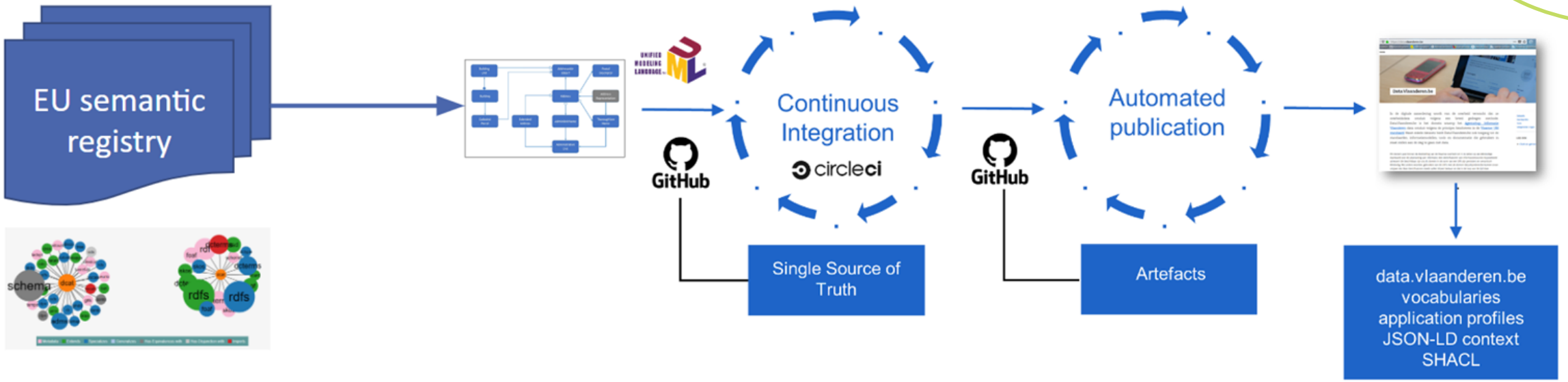
Vision for European Collaboration

1. Inspiration: EU wide semantic registry



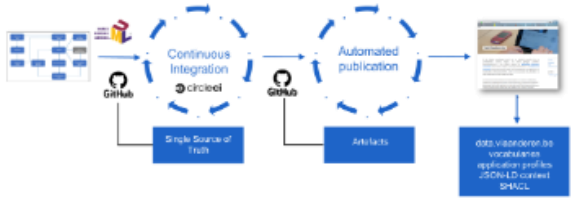
Vision for European Collaboration

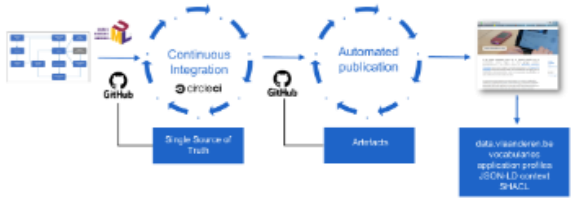
2. Adoption: workbench to extend existing voc's



Vision for European Collaboration

3. Contribution: add your assets to the EU registry





Metadata portal

Metadata portal

Metadata portal

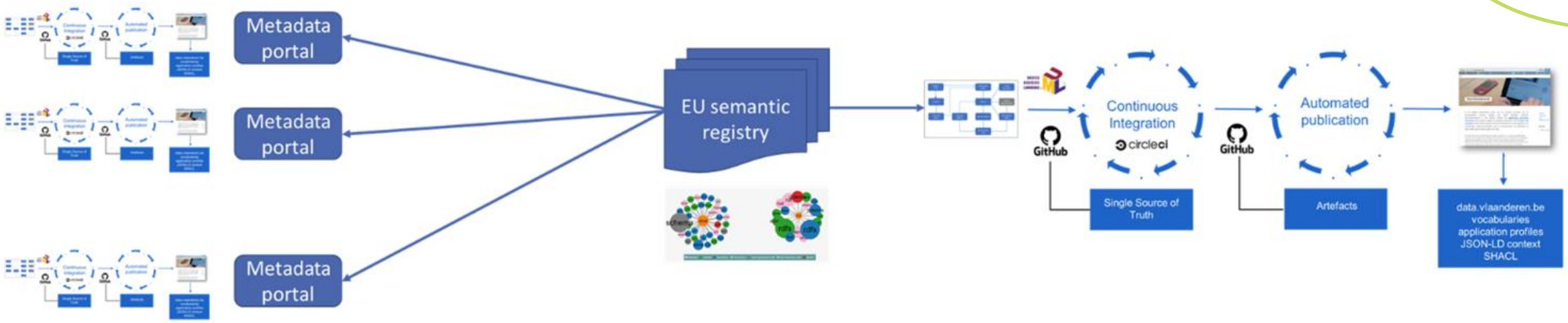
EU semantic registry

Share and reuse³:

“implies a shared process (governance) and method (collaboration environment)”

Vision for European Collaboration

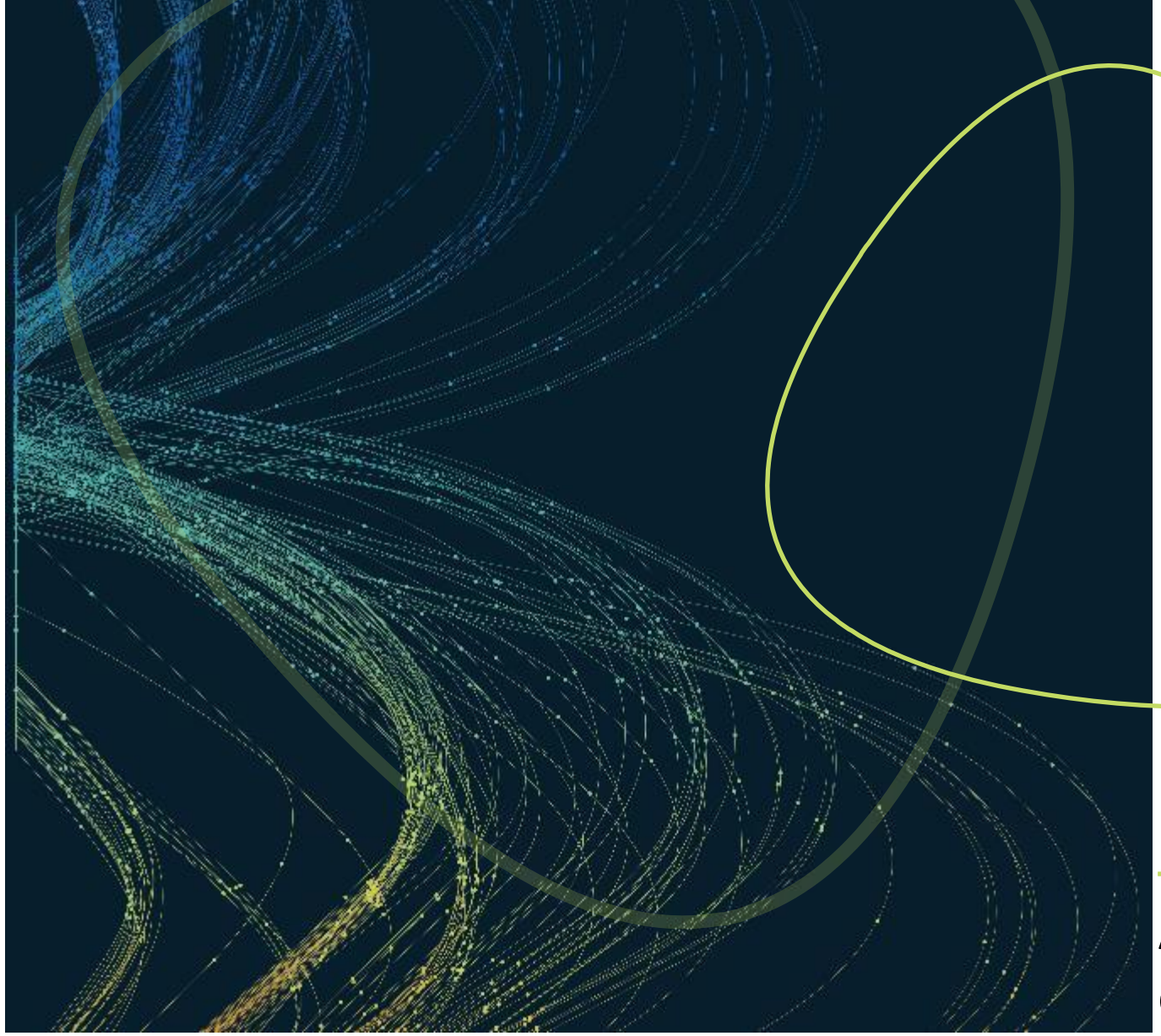
Share and reuse[3]:



contribute

inspire

adopt



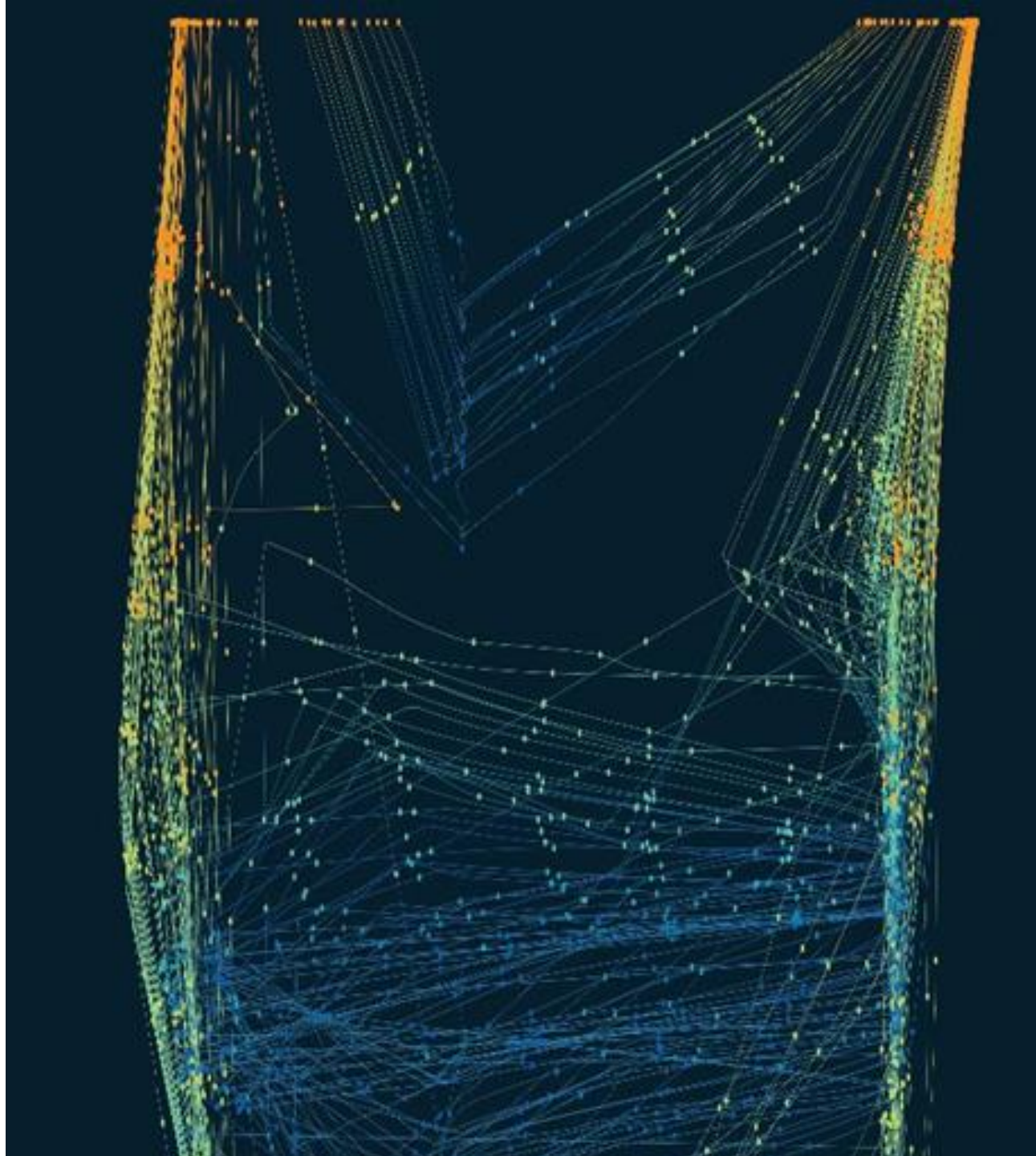
MareGraph
Towards an Interoperable
Marine Knowledge Graph

MareGraph 1/2

A practical example of a collaboration between Belgium and Italy

1

An introduction to OSLO




OSLO
=
Open Standards for Linked Organisations

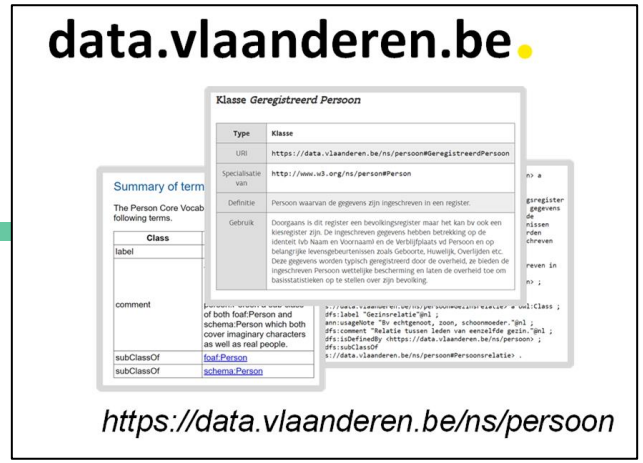
Bottom-up – since 2012

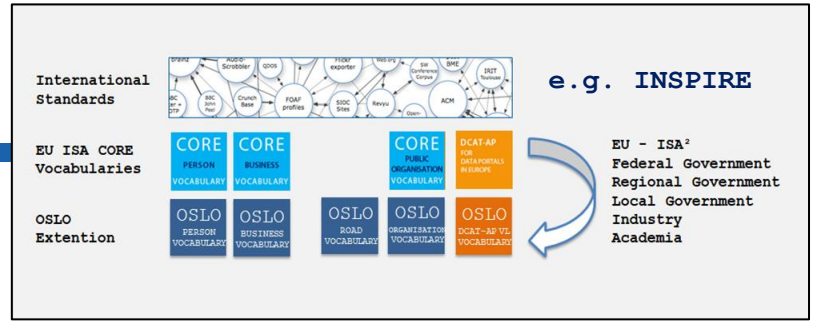
Semantic Standard

Feedback Sessions

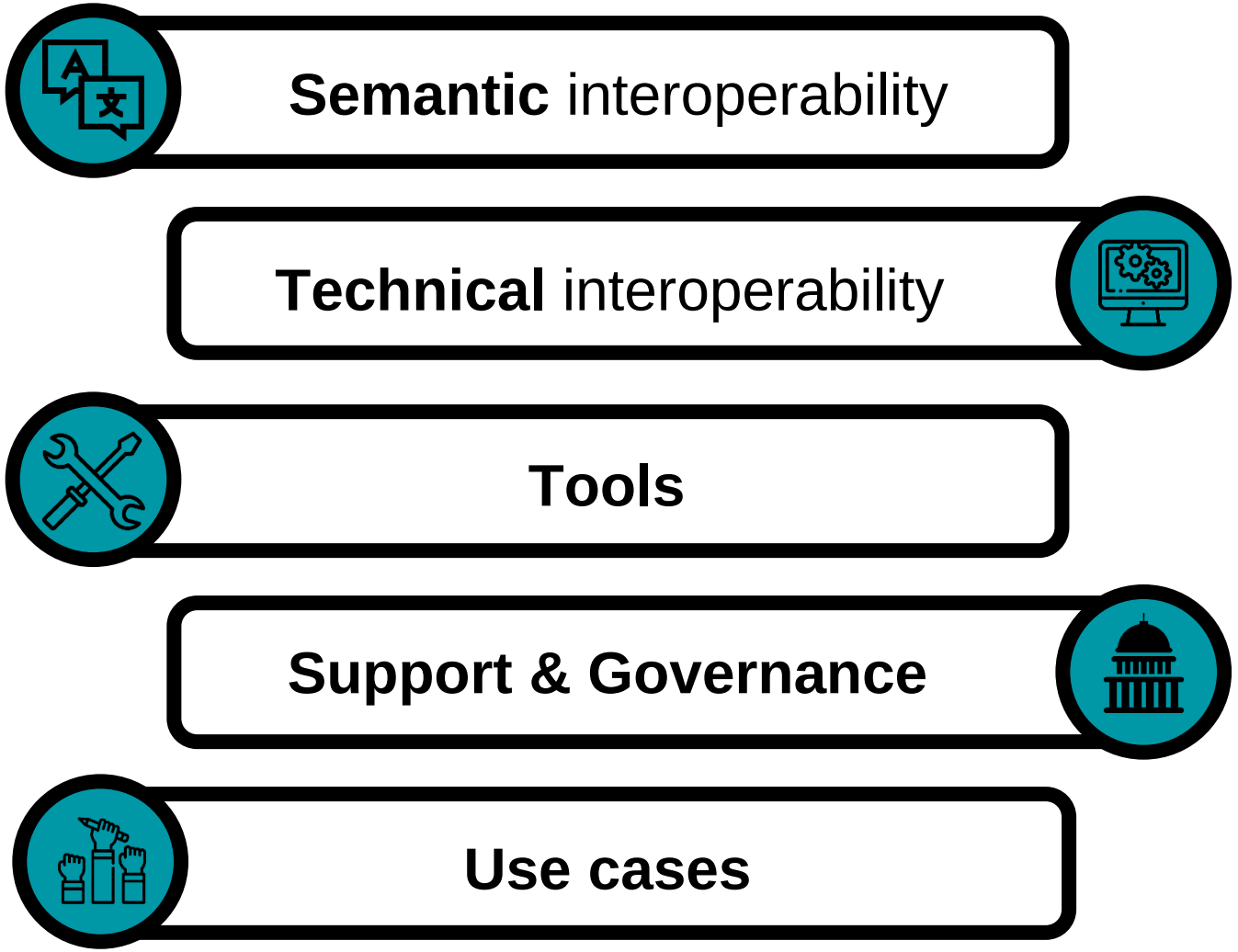
Existing Standards

Use Cases



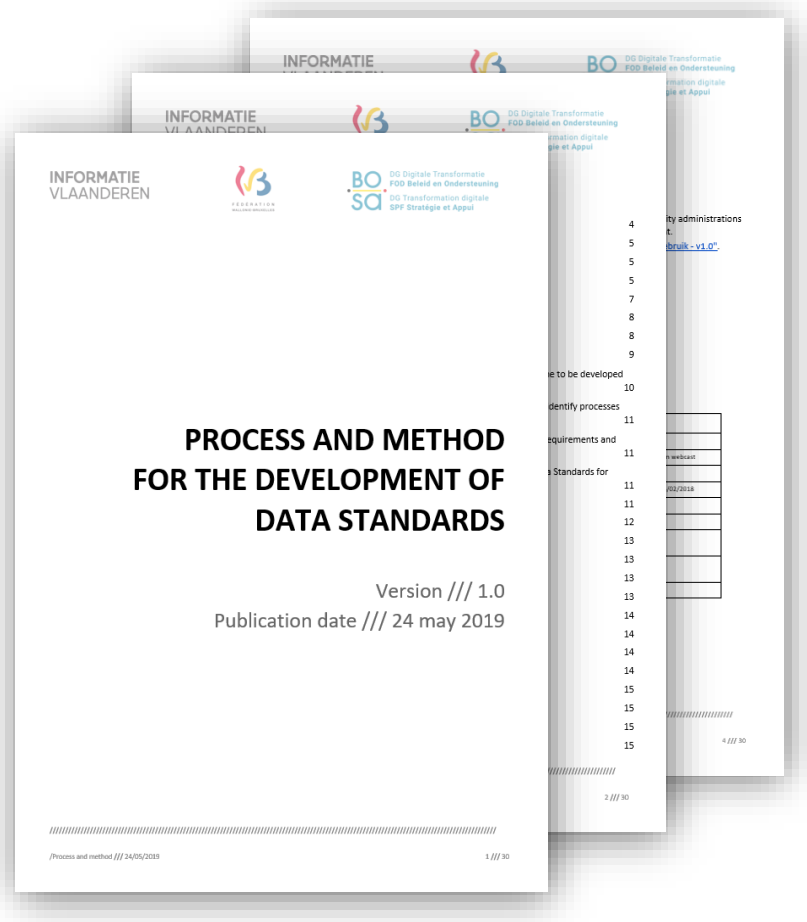


OSLO


Semantic interoperability
Technical interoperability
Tools
Support & Governance
Use cases

Process and method

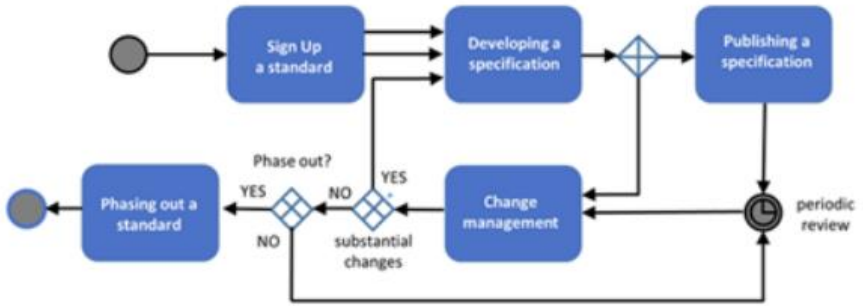
Scalable process for connecting, developing, adapting, and phasing out data standards based on international best practices from organizations such as ISA, W3C, and OpenStand.



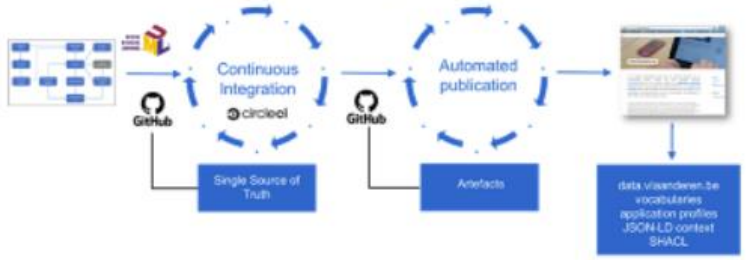
Process and method

1 formalise governance

2 Agree on a transparent process te reach semantic agreements

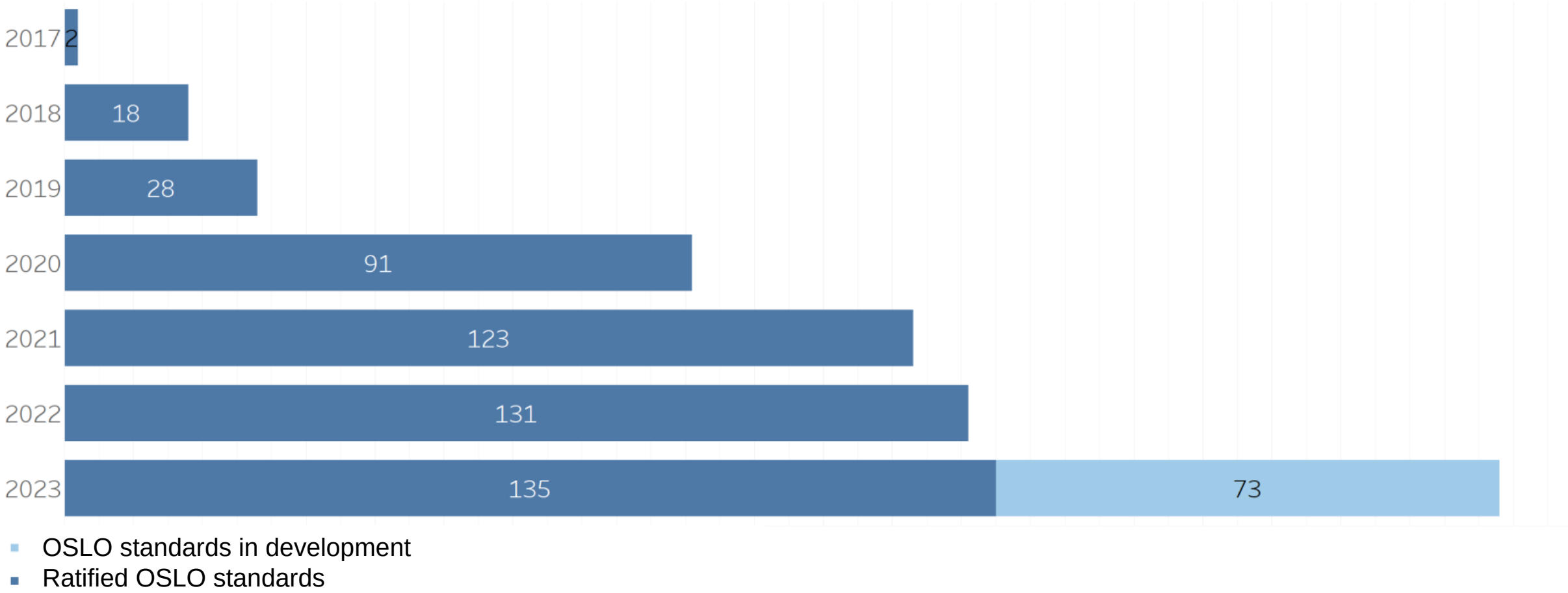


3 Install an end-to-end method based on the principles of Linked Data

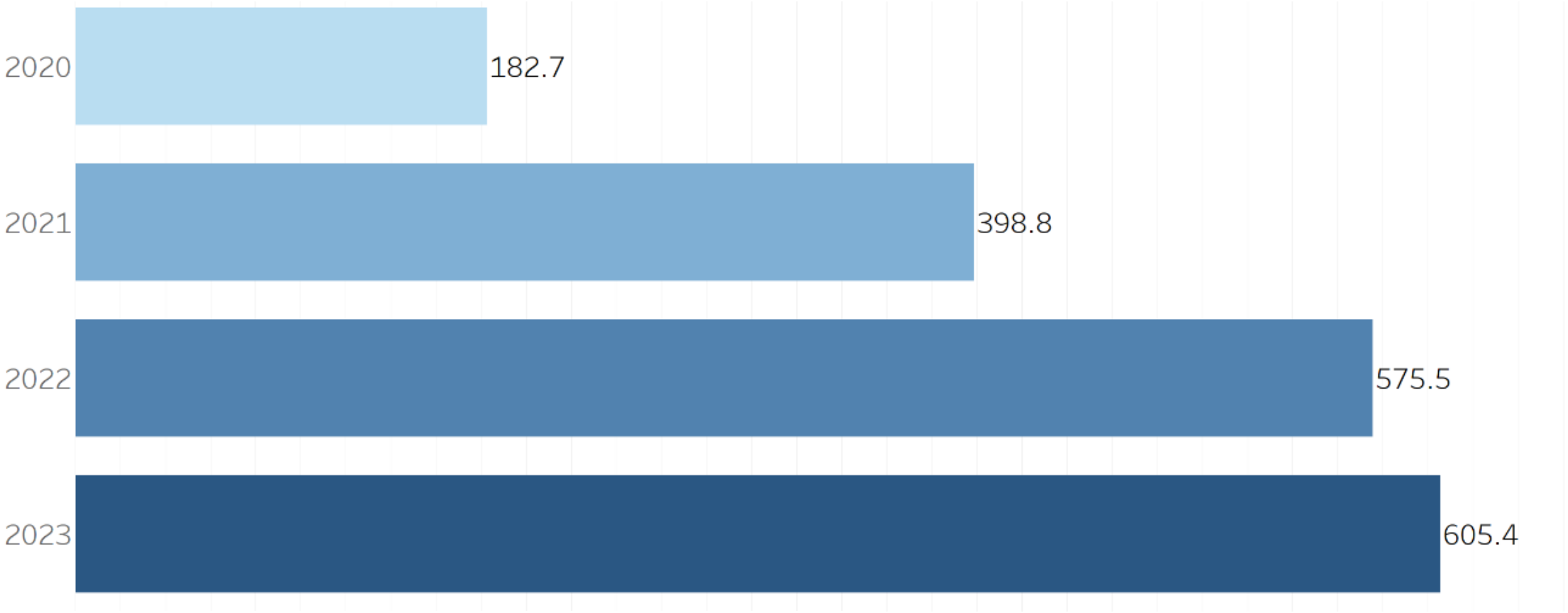


4 cocreate data standards

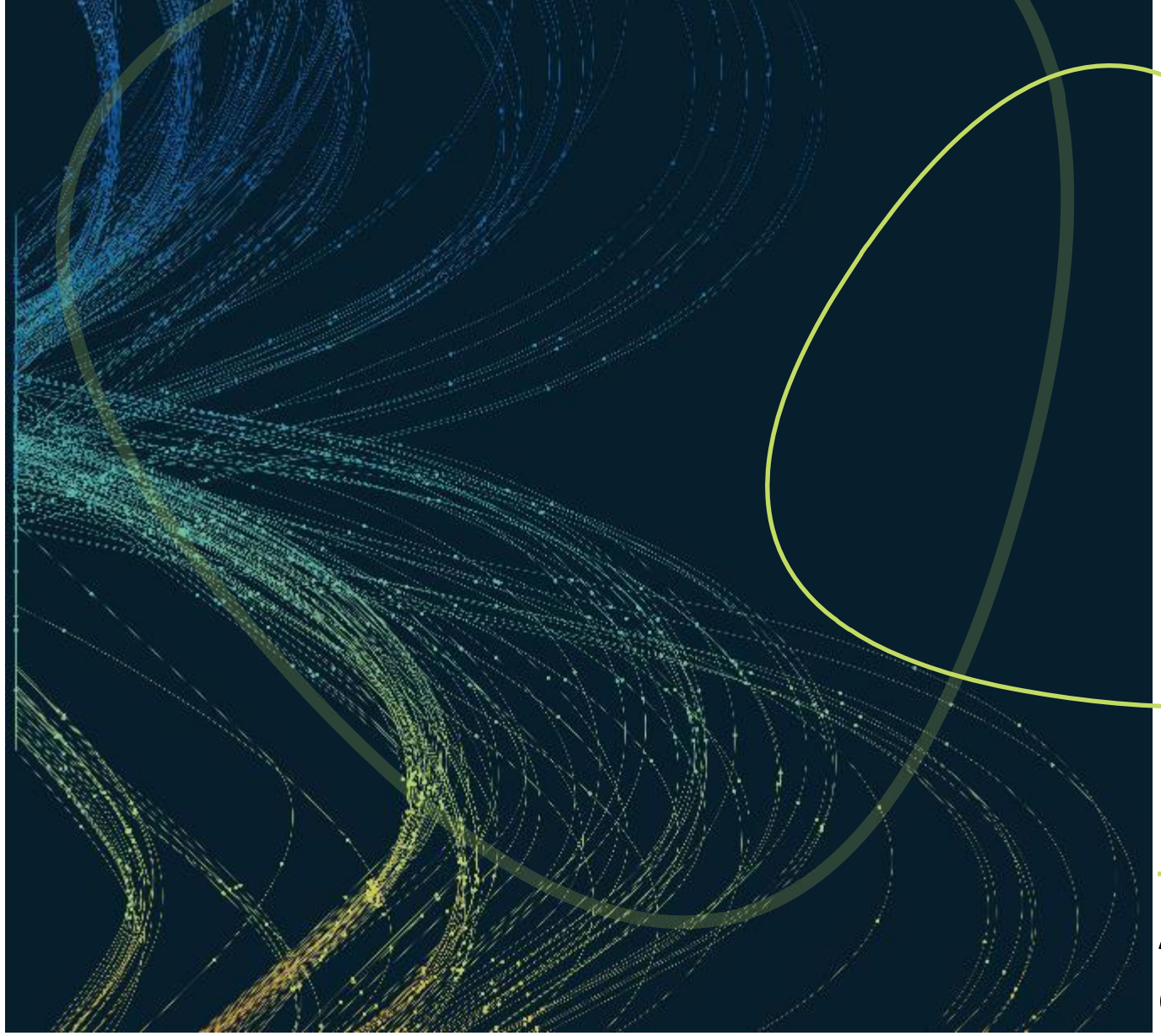
Impact: ratified OSLO standards



Impact: all local governments publish their legislation as Linked Open Data



Number of agenda items published according to Linked Data from 2020 to 2023 (x1000)



MareGraph
Towards an Interoperable
Marine Knowledge Graph

MareGraph 2/2

A practical example of a collaboration between Belgium and Italy

The MAREGRAPH project

Co-funded by the European Union

Funded under
Digital Europe Programme (DIGITAL)

Increase interoperability and openness of three High Value Datasets (HVDs) by creating a reference Marine Knowledge Graph

SPECIFIC GOALS

Semantic interoperability

Definition of a common semantics for the HVDs (ontologies and controlled vocabularies)

Technical interoperability

Better accessibility to data through different APIs (LDES, SPARQL)

Organisational interoperability

Identification of an EU-wide common process for creating and publishing semantic assets and datasets

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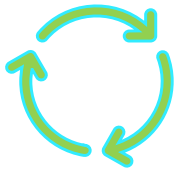
Organisational interoperability: objectives



Identify a **common process that could scale at the EU level** for the creation and publication of semantic assets and linked open datasets

How to **use the process to boost the feed of data spaces** at Member States (the case of data spaces in Belgium)

Propose **general guidelines** that could be used by other Member States **on the process and methodology** for creating and publishing semantic assets and linked open datasets

Organisational interoperability: in practice

SCENARIO

- The Flanders Region in **Belgium** has a well-defined formal methodology through the *OSLO* framework by Digitaal Vlaanderen
- **Italy**, through CNR, already uses a well-defined scientific methodology named *Agile eXtreme Design with Content Ontology Design Patterns*

Consiglio Nazionale delle Ricerche

APPROACH

- The two countries worked together to identify **common elements** and **unifying factors** of the two methodologies

The process for semantic assets creation/publication

Definition and publication of a charter

Identification of use cases and competency questions (CQs)

Identification of existing standards and Ontology Design Patterns

Graphical representation of ontologies, identification of controlled vocabularies, feedback

Production of source code of ontologies and controlled vocabularies with metadata

Publication in technical repositories

Public review

The process for linked open datasets creation/publication

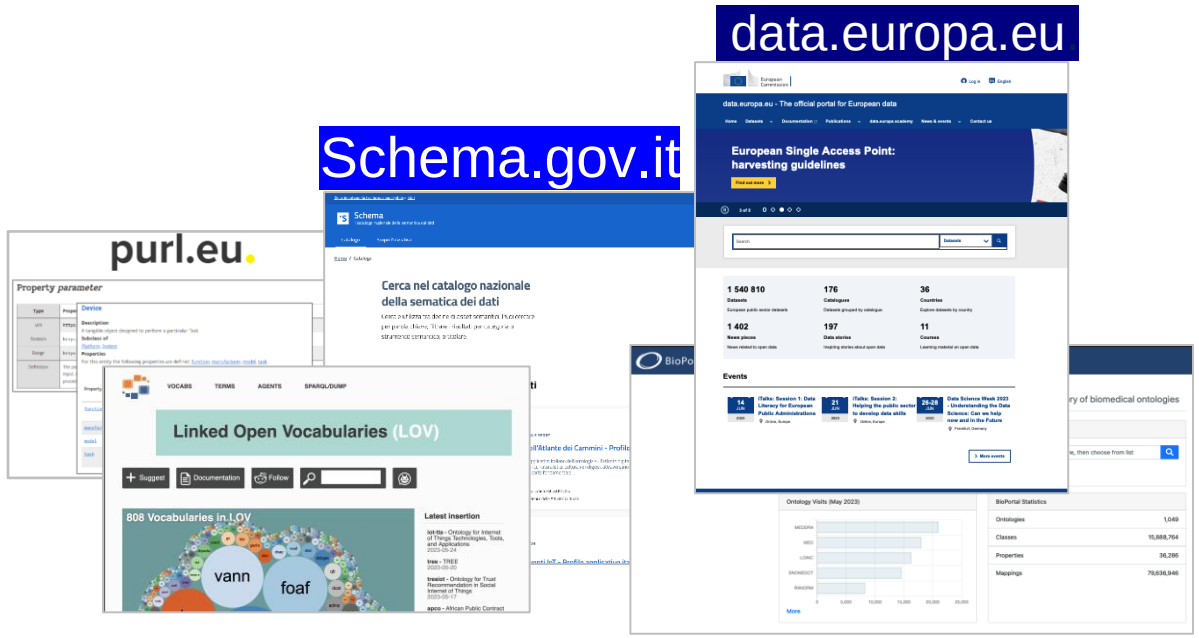
SHACL Shapes definition from ontologies
(leveraging OWL restrictions)

Automated processes for data instantiation
according to ontologies and controlled vocabs

DCAT-AP national extensions
metadata definition

LDES definition and publication,
data publication in SPARQL endpoints

Enable harvesting in national catalogues
for datasets and semantic assets



Lessons learnt: three dimensions

GOVERNANCE

ENGAGEMENT

TECHNICAL ASPECTS

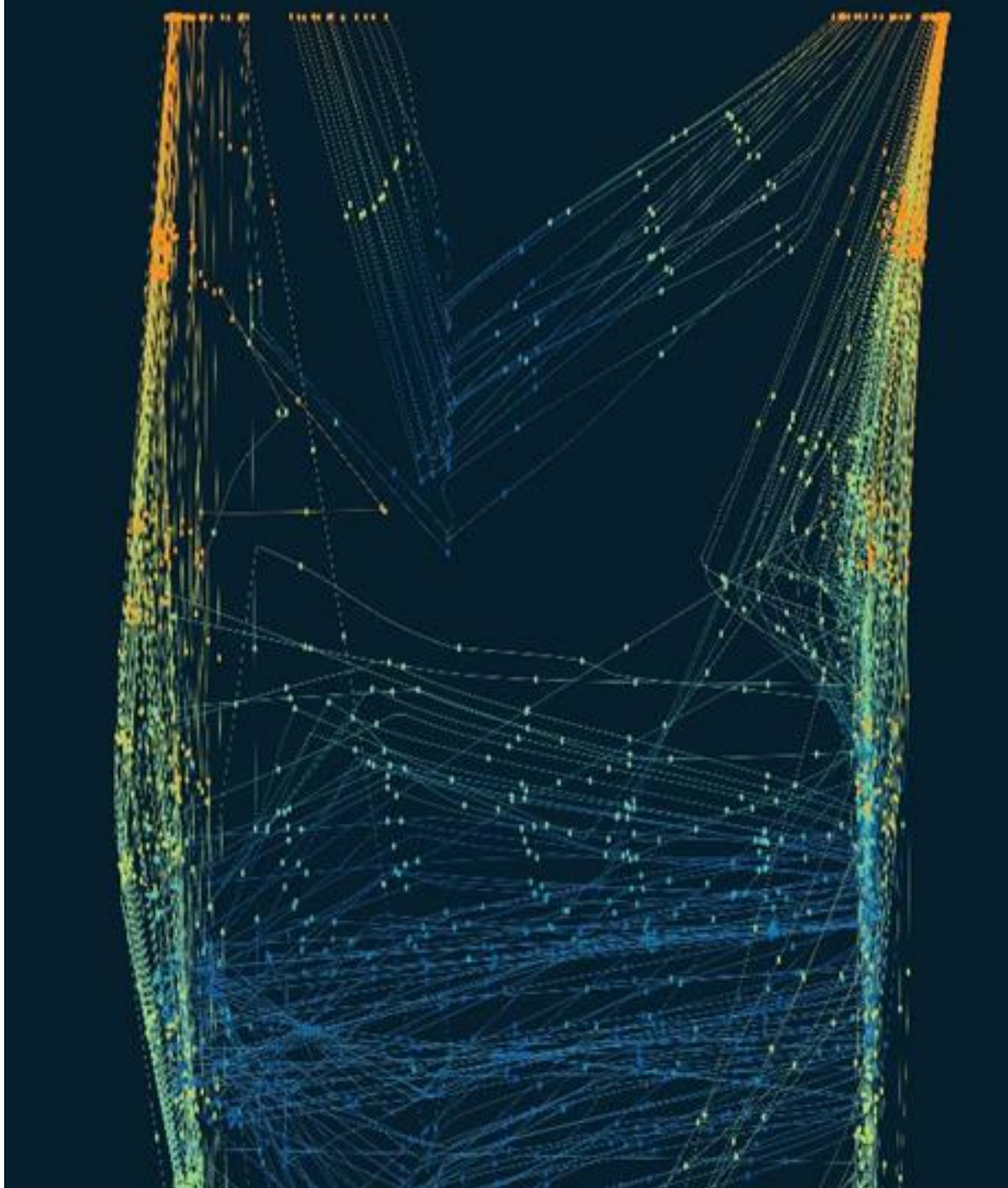
USER

GOVERNANCE

- **Belgium** has a **stronger governance** like standardisation bodies
- In **Italy**, Belgium's governance structure would not work
  - **Public Administrations are free to propose semantic assets** they create and have **full control on them** according to their users and own needs
- The charter is most often disregarded in the initial identified plans

CONSIDERATION

Set up a governance and balance it with single organisations' needs

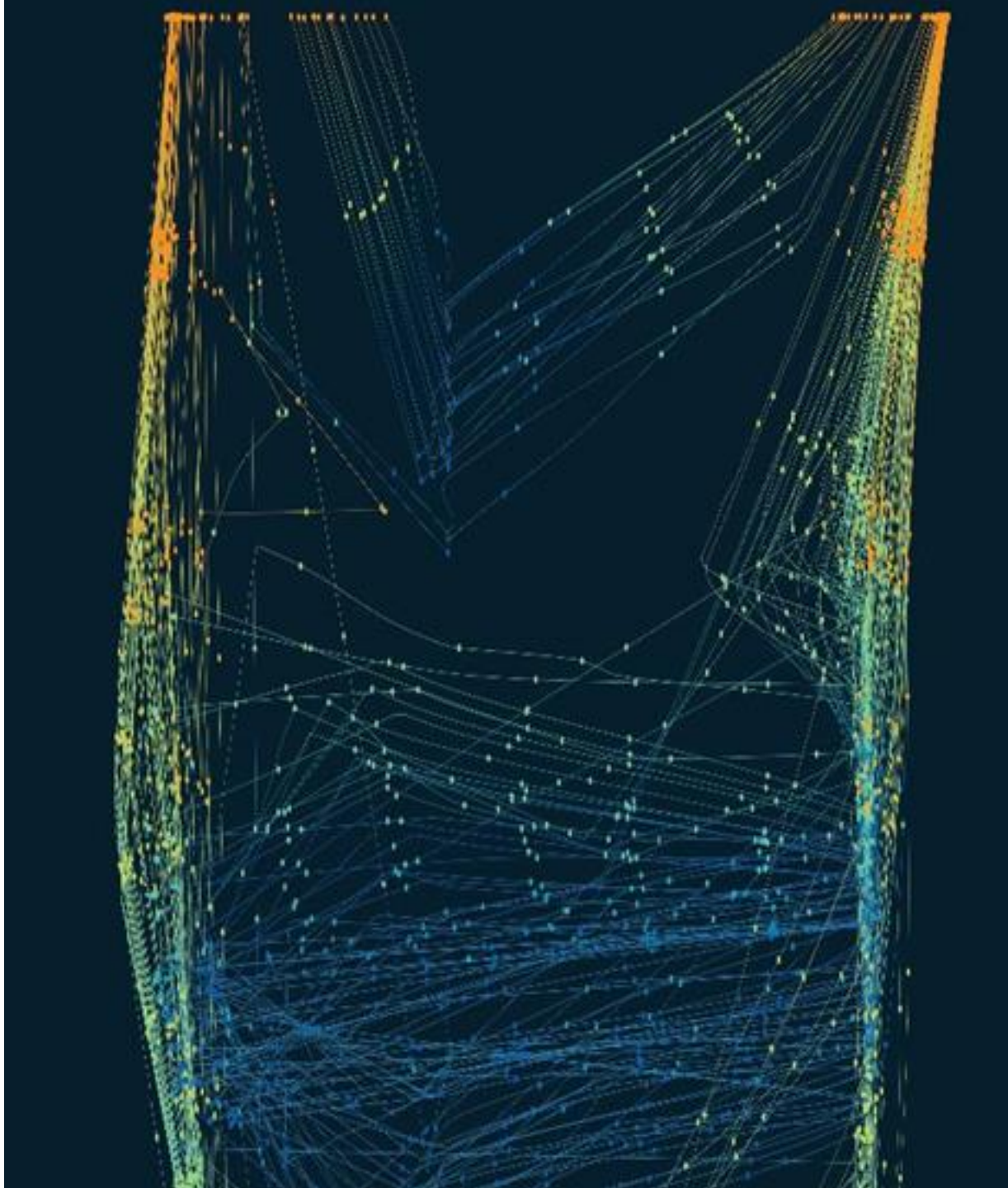


TECHNICAL ASPECTS (1)

- **Use tools** for drawing, creating, publishing and navigating semantic assets and datasets
  - engage with stakeholders (including end-users)
  - automate as much as possible all the creation and publication processes
- **Use of foundational ontologies** for
  - understanding what we are actually modelling
  - linking models among each other (6 stars)
- **Use of ontology design patterns (ODPs)** rather than looking for similar terms in other standards

CONSIDERATION

Constraining the process to the use of specific identified tools, often not open, **does not work properly** at large scale

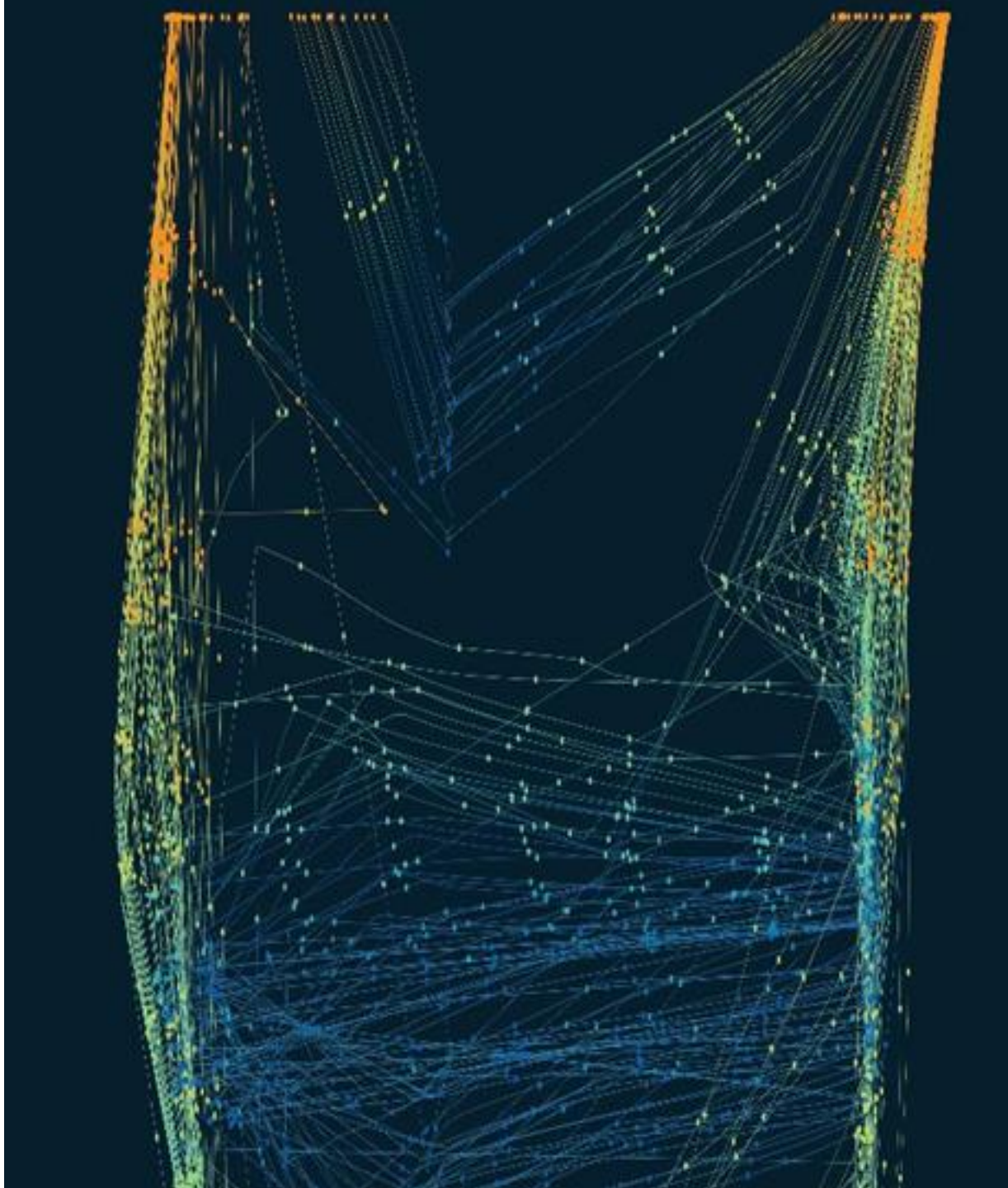


TECHNICAL ASPECTS (2)

- Have a **well-defined URI policy** that clearly describes the resource to be identified
- **Provide access to produced resources in different ways** to serve a plethora of possible users (not only “semantics people”)
- **Validation counts**
- **Rich metadata** of semantic assets and datasets **is important** for findability requirement
- **Publish** semantic assets and open datasets **in well-known** (national) **catalogues**

CONSIDERATION

Important role of catalogues to maximise reuse and sharing



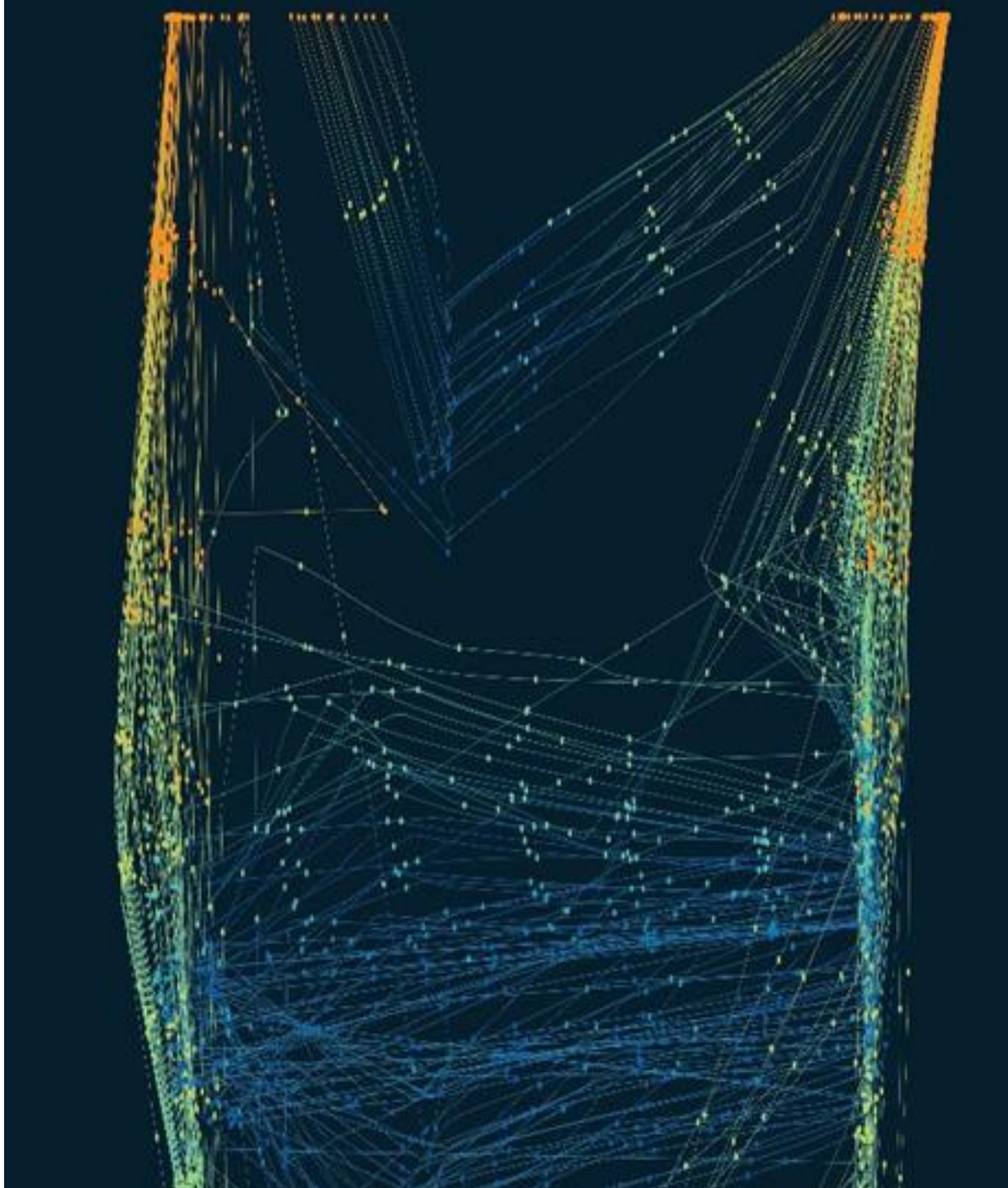
USER ENGAGEMENT

- **Engage with end-users** since the initial phases of the processes
- **Public reviews could be set up**
  - In Italy it lasts 1 month (by law for technical guidelines)
  - In Belgium it lasts 3 months

CONSIDERATIONS

Engaging with users is **huge effort**, not always successful

Public reviews of a month, possibly extendable, could be sufficient



Understanding your situation as-is

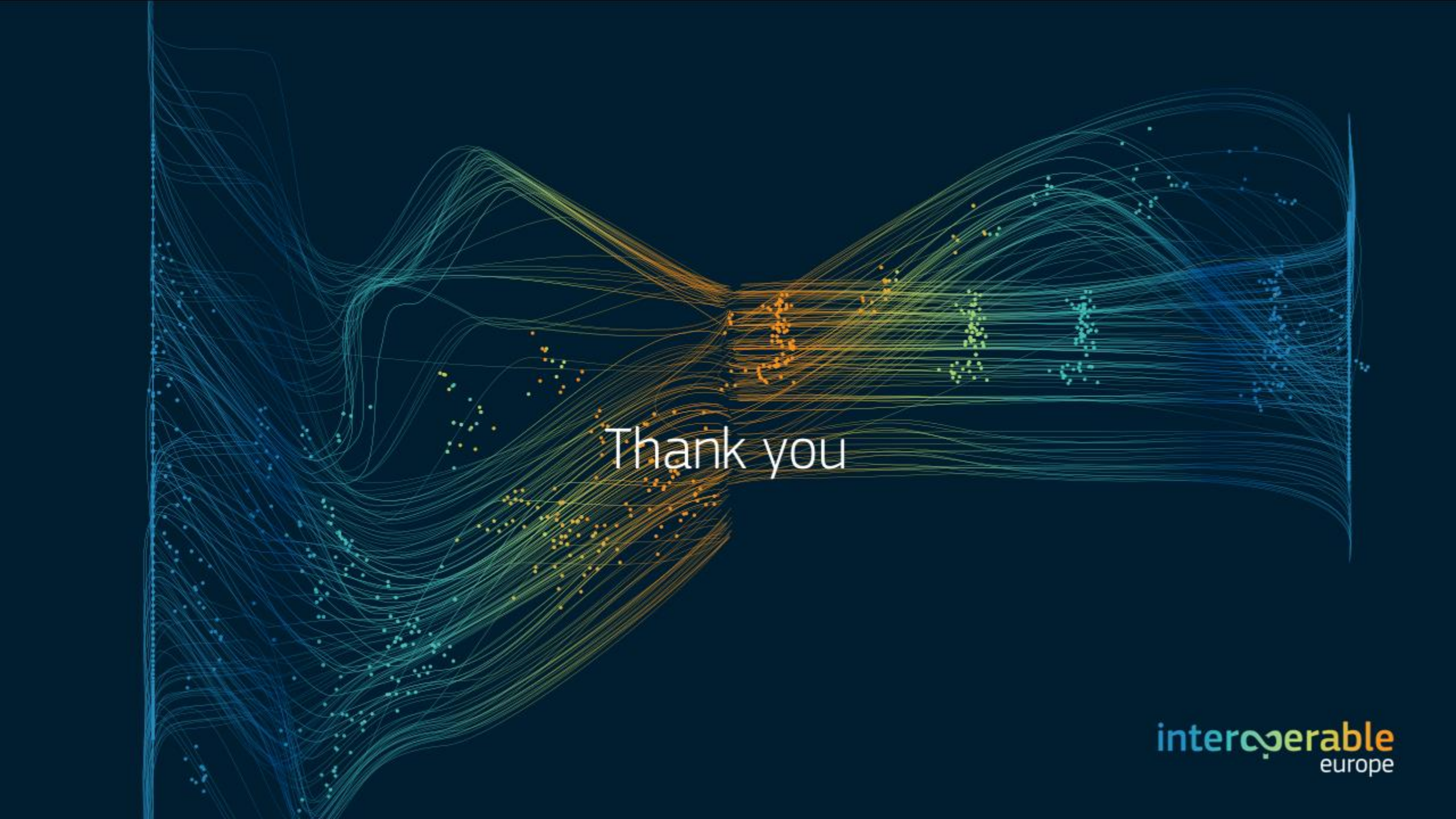
Do you have any current practices related to semantic interoperability and semantic assets creation and publication? If so:

- Do you have a local formal governance structure? If so, could you please briefly describe it?
- Could you briefly explain the main steps of the process you follow for the definition of semantic assets in your country, if any?
- Do you use specific tools in the process? If so, could you please list them?
- Do you reuse existing assets, also from other countries?
- Where do you publish the semantic assets you have produced? Do you have national catalogues? Do you use international catalogues (e.g., LOV, Bioportal, others)?

Your view on European Collaboration

How do you look at European wide collaboration?

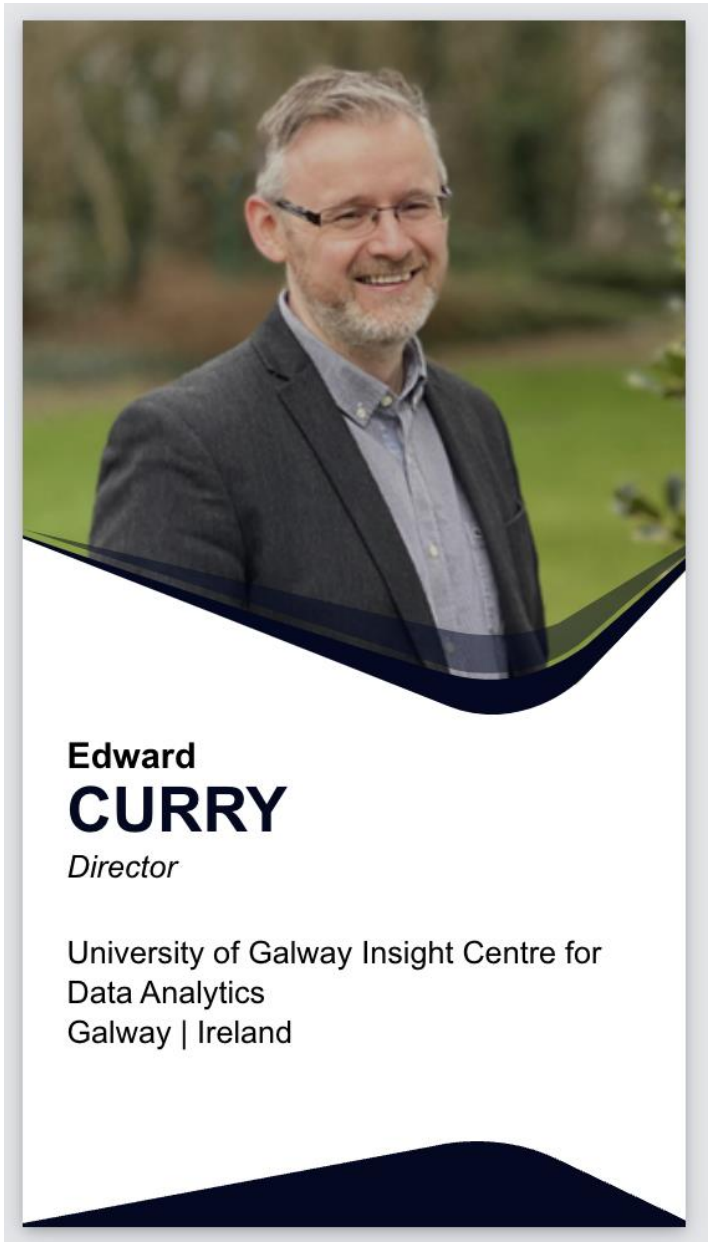
- What are your initial thoughts on the vision we've presented?
- What are the biggest pitfalls to be addressed when moving towards European collaboration for semantic assets creation and sharing?
- Do you have any suggestion regarding a European collaboration process for semantic assets creation and sharing?
- What are your ideas regarding a European repository of semantic assets? What shall it include?



interoperable europe

Give your feedback

Bit.ly/semic2024



Cross-border/domain Data Spaces: Opportunities Ahead

A World Leading SFI Research Centre

Science Foundation Ireland SFI For what's next

Cross-border/domain Data Spaces: Opportunities Ahead

Insight

SFI RESEARCH CENTRE FOR DATA ANALYTICS

Prof. Edward Curry
University of Galway
Insight SFI research Centre for Data Analytics

HOST INSTITUTIONS

DCU Dublin City University

Ollscoil na Gaillimhe University of Galway

UCC University College Cork, Ireland

UCD Dublin

PARTNER INSTITUTIONS

Maynooth University

Tyndall National Institute

Trinity College Dublin

University of Limerick

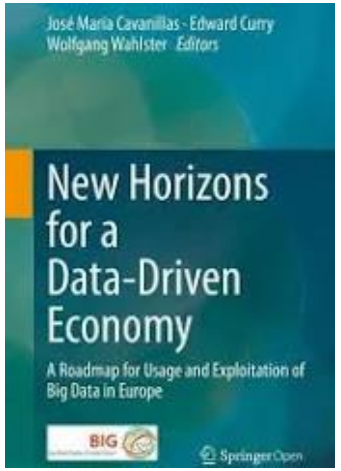
FUNDED BY:

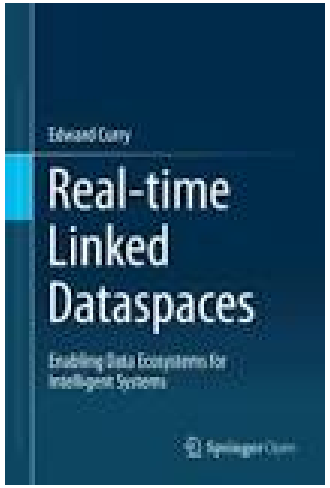
European Union European Regional Development Fund

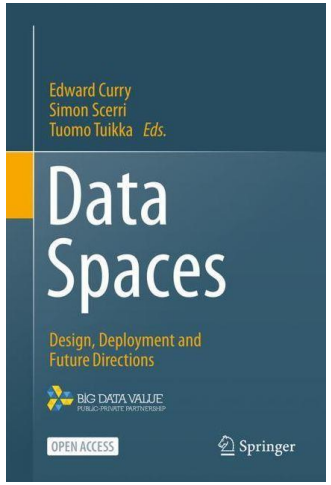
Science Foundation Ireland SFI For what's next

Edward Curry

I have been researching the underlying technology for data spaces for the last decade…







Ollscoil na Gaillimhe
University of Galway

Insight
SFI Research Centre for Data Analytics

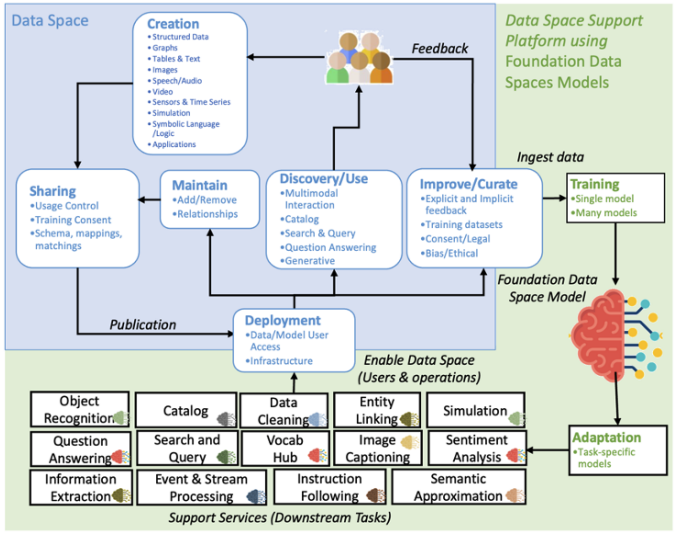
BDV
Big Data Value Association

The AI Data Robotics Association

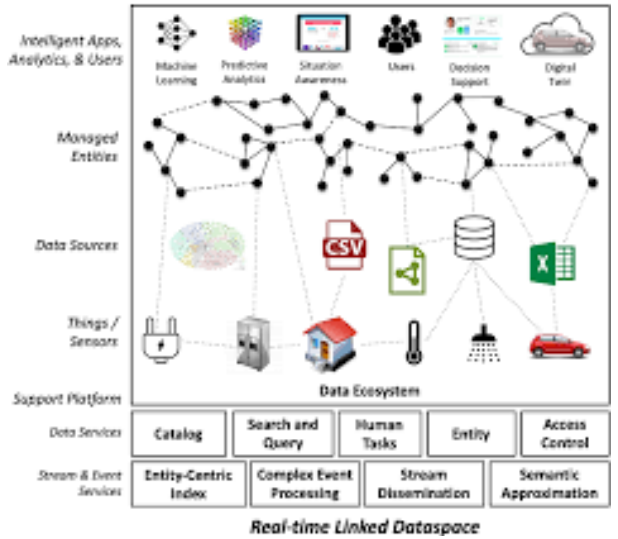
Data Space Research at Insight

DATA SPACES SUPPORT CENTRE

- Design Principles and Best Practices
- Interoperability
- Semantics
- Standards



- Foundation Data Space Models
- Multimodal Knowledge graphs for Data Spaces
- AI and Data Lifecycles
- Data and Model Cards

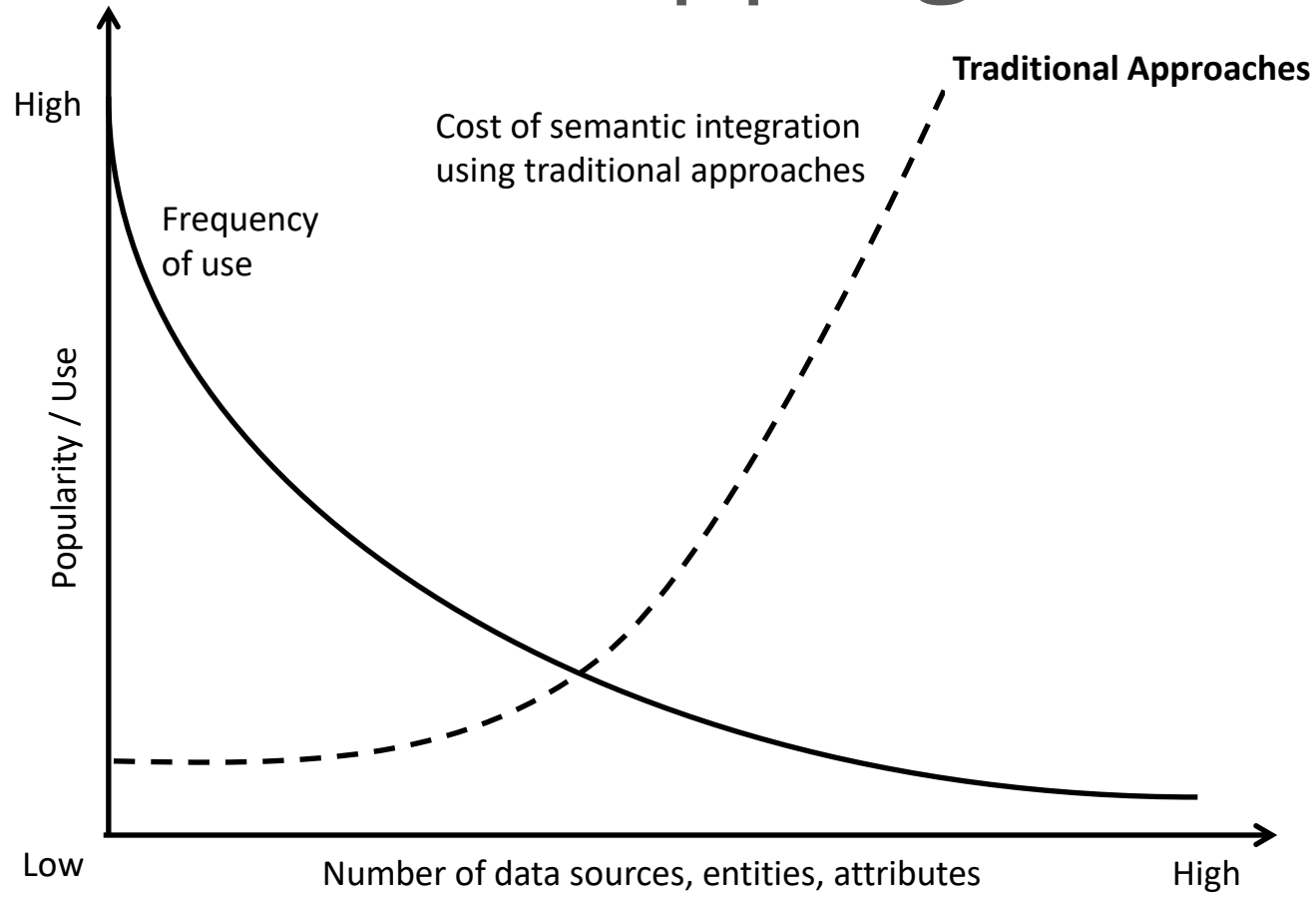


- Real-time Linked Data Spaces
- Pay as You Go Data Mgmt.
- Data space support services: Catalog, Entity Mgmt, Knowledge Graphs, querying, Discovery, Human in Loop, Question Answering, Event Processing

Insight

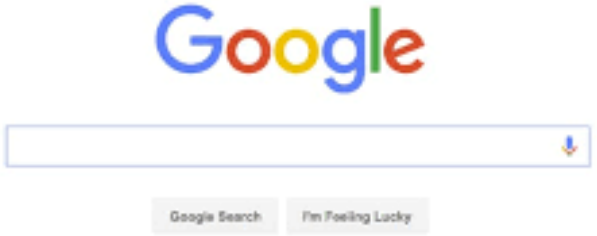
Cross-border Data Spaces need a data co-existence approach

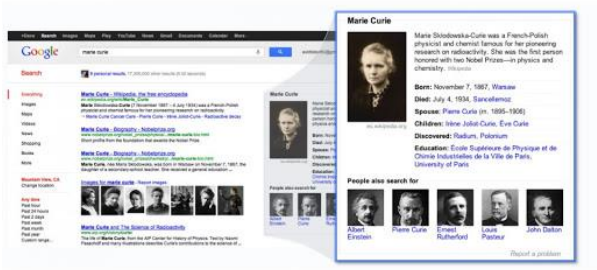
Long Tail Semantics continues to grow… and the cost of mapping increases….



The Long Tail of Data

A new paradigm for human-data Interaction……





From Structure → **to Search** → **to Knowledge Graph** → **to Conversations ?**

~1995
~100K Websites
Exact Results
Human Curated

~1998
~2.4M Websites
Approximate Results
Computed

~2012
~700M
Approximate Results + Exact
Computed + Crowd

~2023
~2B
Approximate Results ?
Content creation?

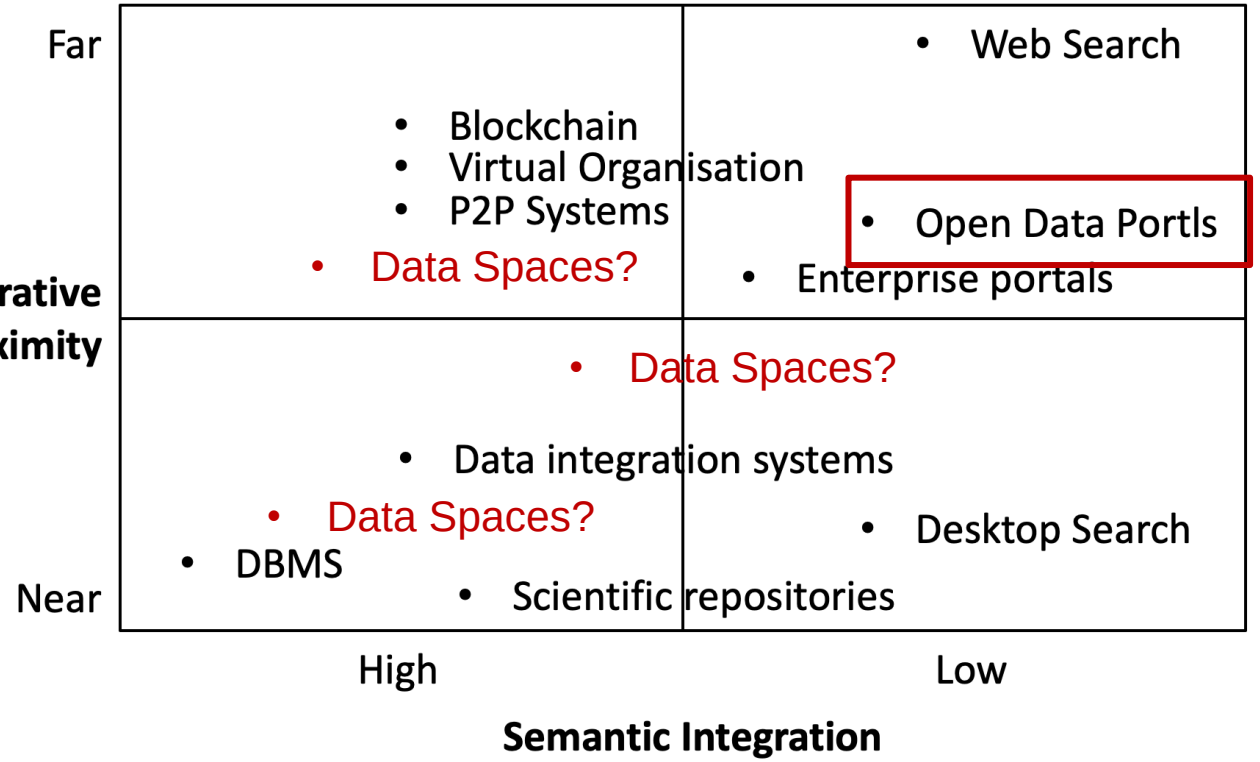
Control and Coordination

Administrative Proximity

- Close vs. Loose Coordination
- Assumptions concerning guarantees such as data, access, quality, and consistency,

Semantic Integration

- Degree to which data schemas are matched up (types, attributes, and names).



Halevy, A., Franklin, M. and Maier, D. 2006. Principles of dataspace systems. *25th ACM SIGMOD-SIGACT-SIGART symposium on Principles of database systems - PODS '06* (New York, New York, USA, 2006), 1–9.

DOI:10.1145/1953122.1953140

Article development led by acmqueue
queue.acm.org

In today's humongous database systems, clarity may be relaxed, but business needs can still be met.

BY PAT HELLAND

If You Have Too Much Data, then 'Good Enough' Is Good Enough

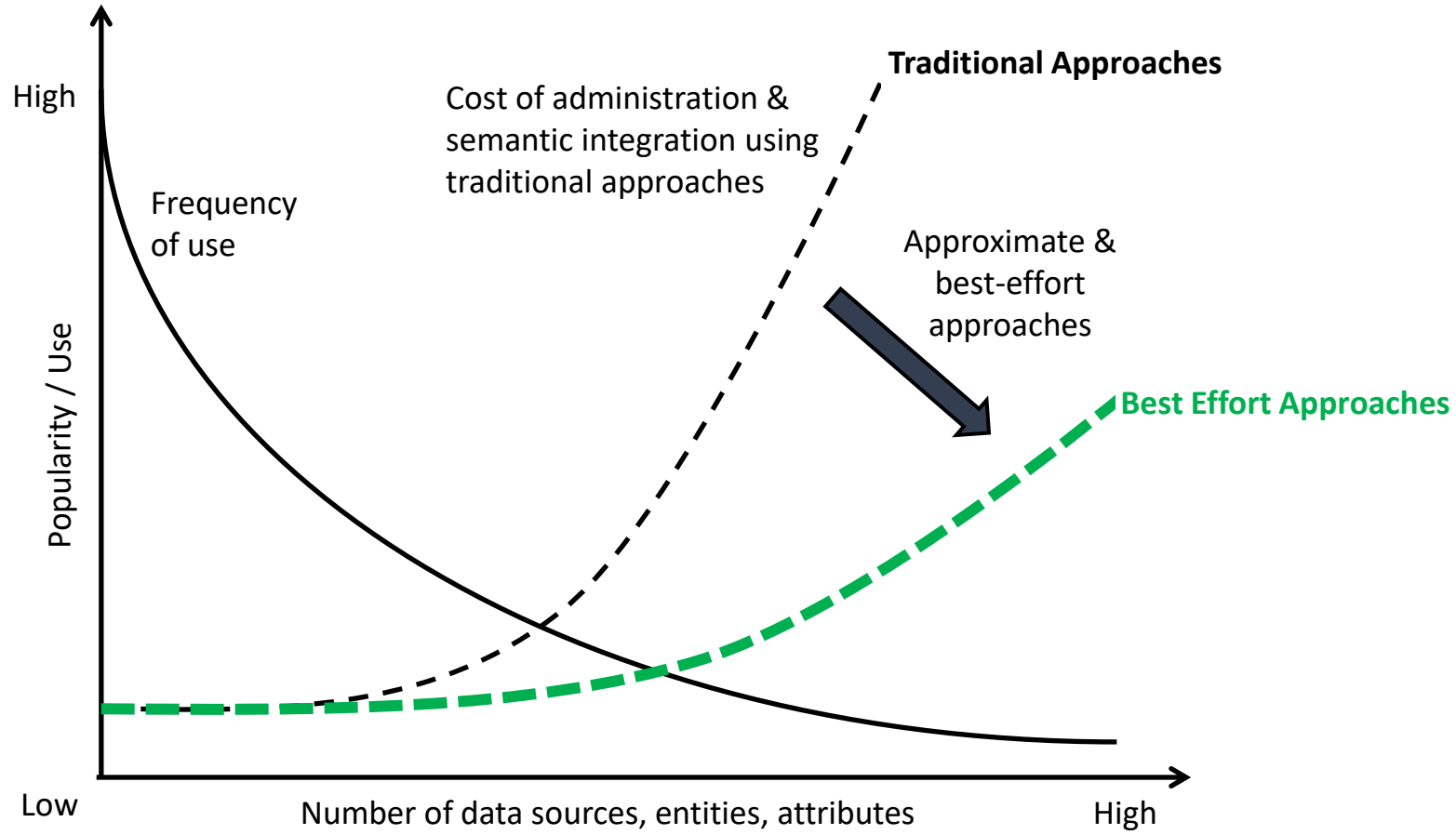
"We can no longer pretend to live in a clean world. SQL and its Data Definition Language (DDL) assume a crisp and clear definition of the data, but that is a subset of the business examples we see in the world around us. It's OK if we have lossy answers—that's frequently what business needs."

What is a Dataspace? (2006)

“Dataspaces are not a data integration approach; rather, they are more of a **data co-existence approach**. The goal of dataspace support is to provide base functionality over all data sources, regardless of how integrated they are.” (Halevy, A., Franklin, M. and Maier, D. 2006.)

Incrementalism, Approximate, Interactive

Approximate and Best Effort Approaches



The Long Tail of Data

Cross Border Data Spaces will need a marriage of neuro-symbolic approaches

Data Space Enablers

OPEN ACCESS

Data Space Support Platform (Halevy et al.)

- Must deal with **many different formats** of data.
- **Does not subsume** existing systems; they still provide individual access via their native interfaces.
- Queries in are provided on a **best-effort and approximate basis**.
- Must provide **pathways to improve the integration** among the data sources, including streams and events, in a pay-as-you-go fashion.

Data Space Support Services

- Catalog and Browse
- Search and Query
- Local Store and Index
- Discovery
- Enhancement
- Administration

Reusing Human Attention

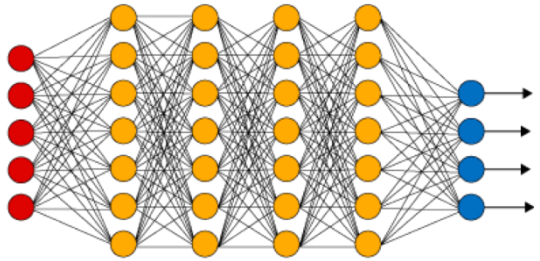
- Learn from users' activities
  - Create meaningful relationships between data sources
  - Enhance data sources

Data-and knowledge-driven AI Systems…

- Combing rules-based AI approaches (Knowledge Graphs) with statistical learning techniques (deep learning)

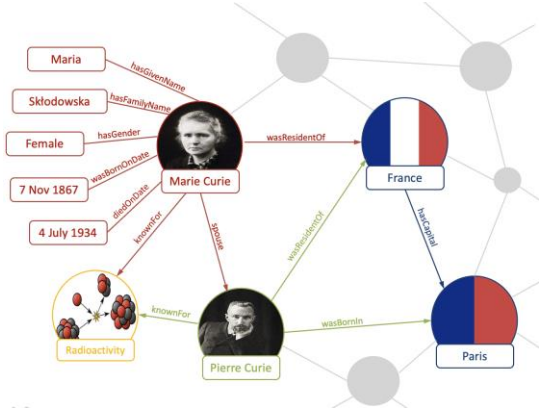
Neuro-Symbolic AI

Neural Networks
(Statistical Learning + Reasoning)



+

Knowledge Graphs
(Expert Knowledge + Reasoning)



Knowledge Graph	Propositional Logic	First-Order Logic	Programming Language	Symbolic Expression

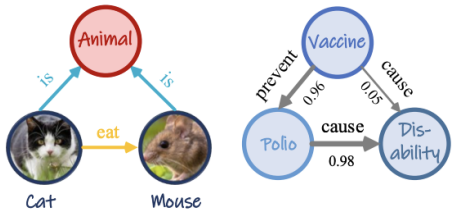
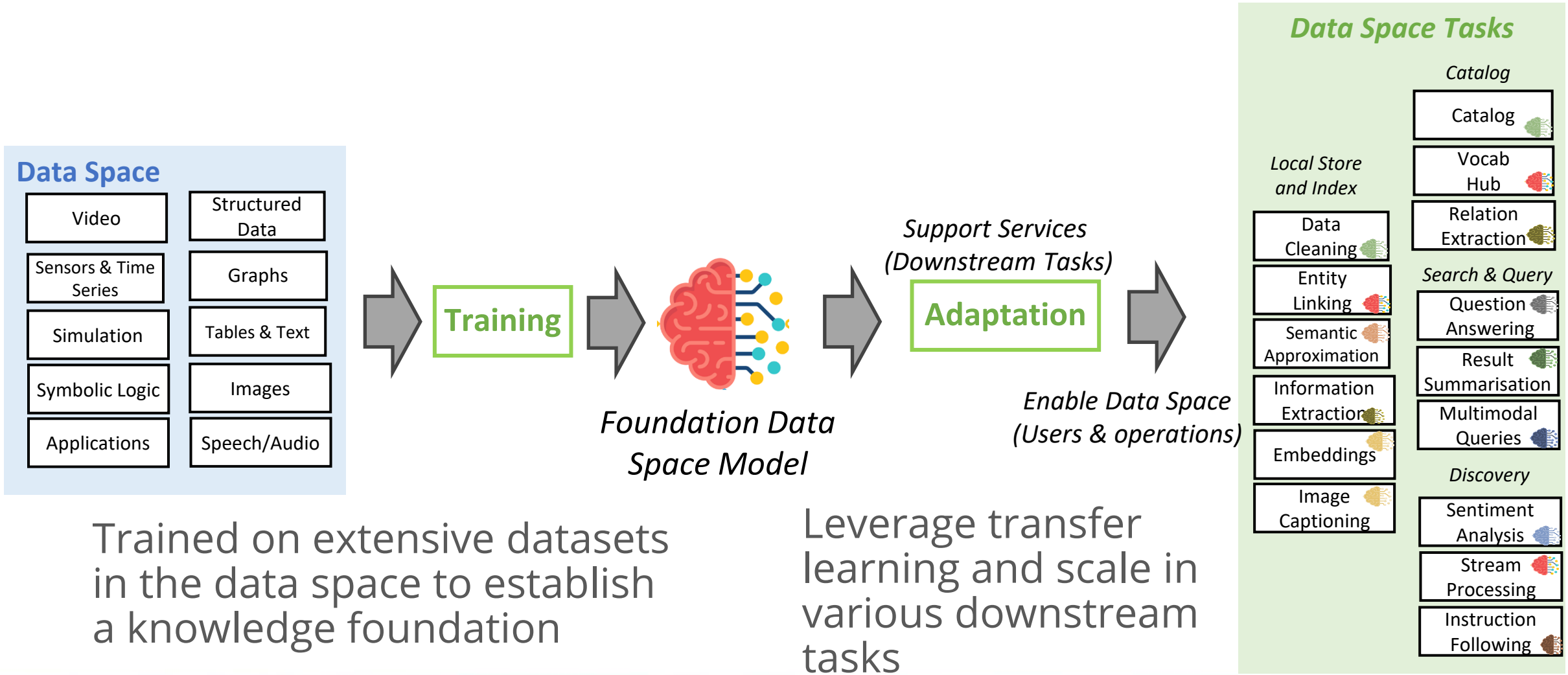
	Proposition A:
	cat is an animal
	Proposition B:
	cat is a living thing
	$A \wedge B$
	$A \vee B$
	$\neg A$
	$A \Rightarrow B$
		cat is an animal
		$\forall x\ \mathrm{Cat}(x) \Rightarrow \mathrm{Animal}(x)$
		everybody has a father
		$\forall x\ \exists y\ \mathrm{Father}(y,x)$
			`(machine lookalgo`
			`(state lookleft`
			`(running [robot move:[:msg|`
			`angular z: search]]))`
			`(state returnleft`
			`(running [robot move:[:msg|`
			`angular z: search negated]]))`
			`.....`
				$3+4\times(1+6)\div 2$
				$2x^2-\sin(3x)+1$
				How many cylinders are small?
				1. filter_shape(scene, cylinder)
				2. filter_shape(scene, small)
				3. count(scene)

Fig. 8. Illustrative overview of symbolic knowledge representations in NeSy.

Wang, Wenguan, and Yi Yang. "Towards data-and knowledge-driven artificial intelligence: A survey on neuro-symbolic computing." *arXiv preprint arXiv:2210.15889* (2022)

Insight

Foundation data space models



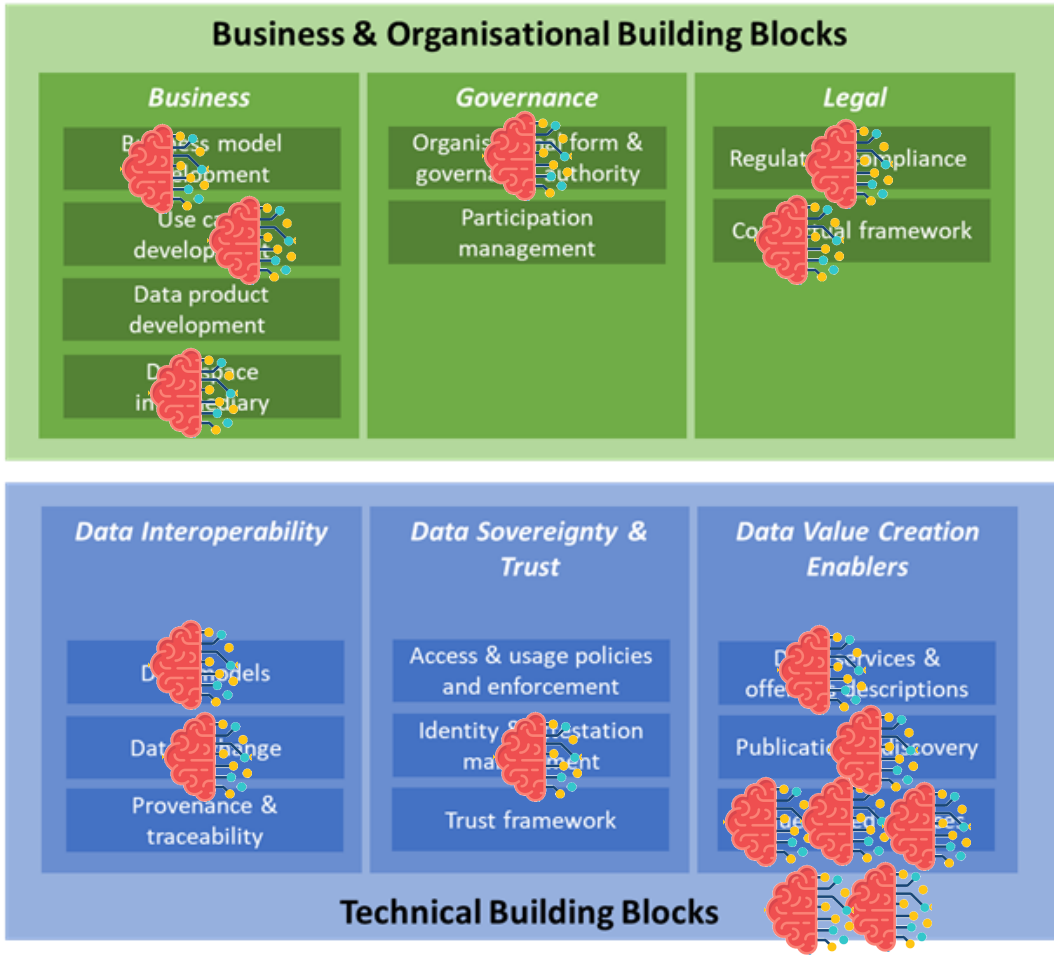
Trained on extensive datasets in the data space to establish a knowledge foundation

Leverage transfer learning and scale in various downstream tasks

E. Curry, M. Timilsina, T. Zaarour, M. Al-QATF, R. Haque, "Foundational Data Space Models: Bridging the AI and Data Ecosystems (Vision Paper), Proceedings of the *2023 IEEE International Conference on Big Data (Big Data)*, Sorrento, Italy, 2023

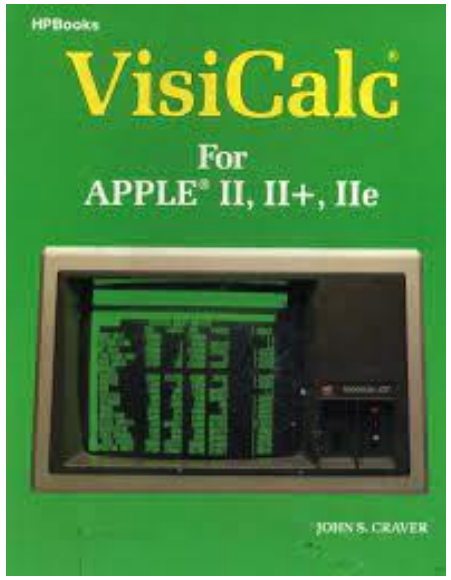
Neuro-symbolic approaches can *support tasks across the life cycle of the data space…*

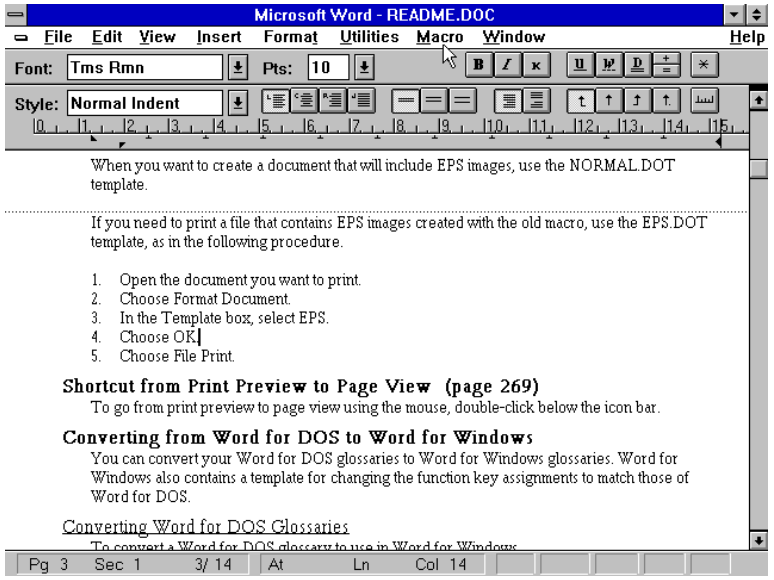
DATA SPACES SUPPORT CENTRE



Insight

Generative AI and Foundation models will be the Killer App for Data Spaces….

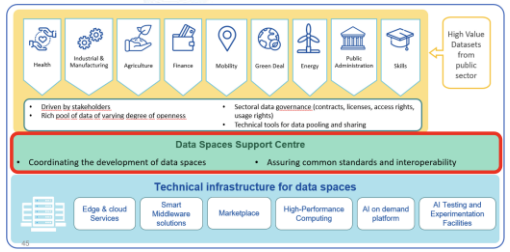


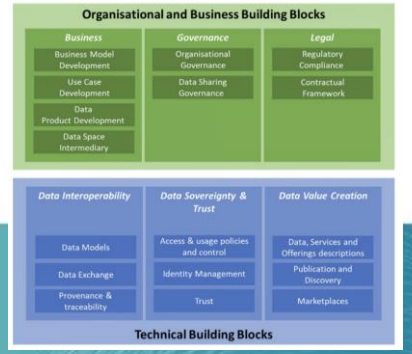


Insight

A Unified Lifecycle is needed between AI and Data

Symbiotic Relationship between Data Spaces and AI….





High Quality Data
Community of Data Users/Owners
Data Goverance/compliance

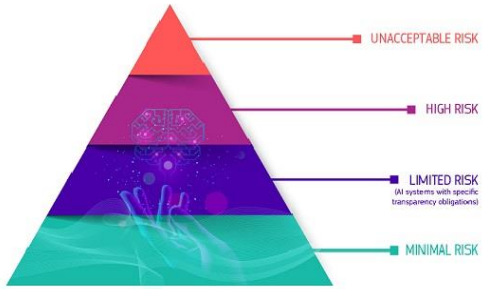
Provides training data
(Data Space 4 GenAI)

Data Space

Foundation / Generative AI

Provides models to enable
(GenAI 4 Data Space)

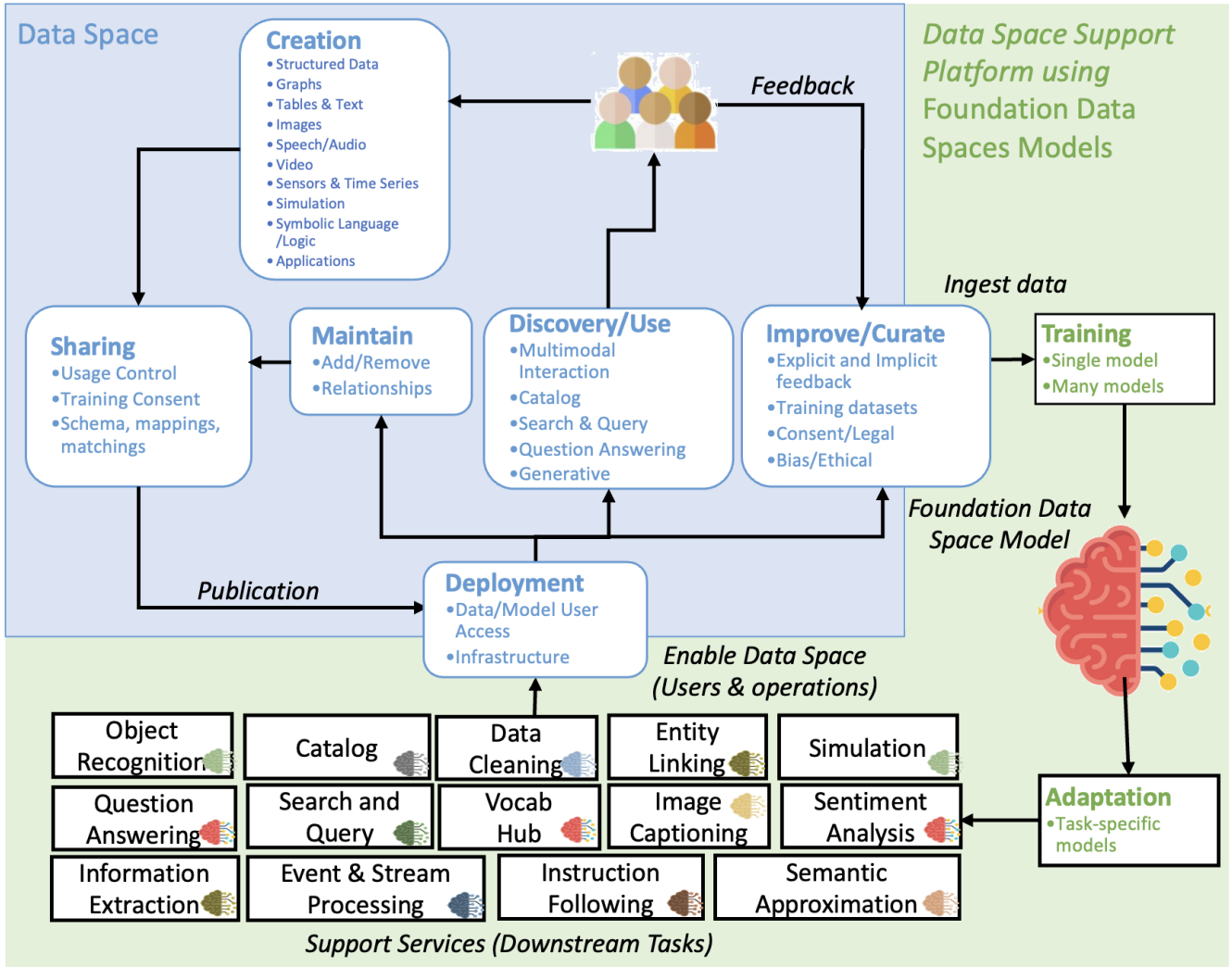
Extract Value from Data
Faster innovation cycles
Synthetic Data



The AI Data Robotics Association

Insight

We need Unified Data and AI Lifecycles

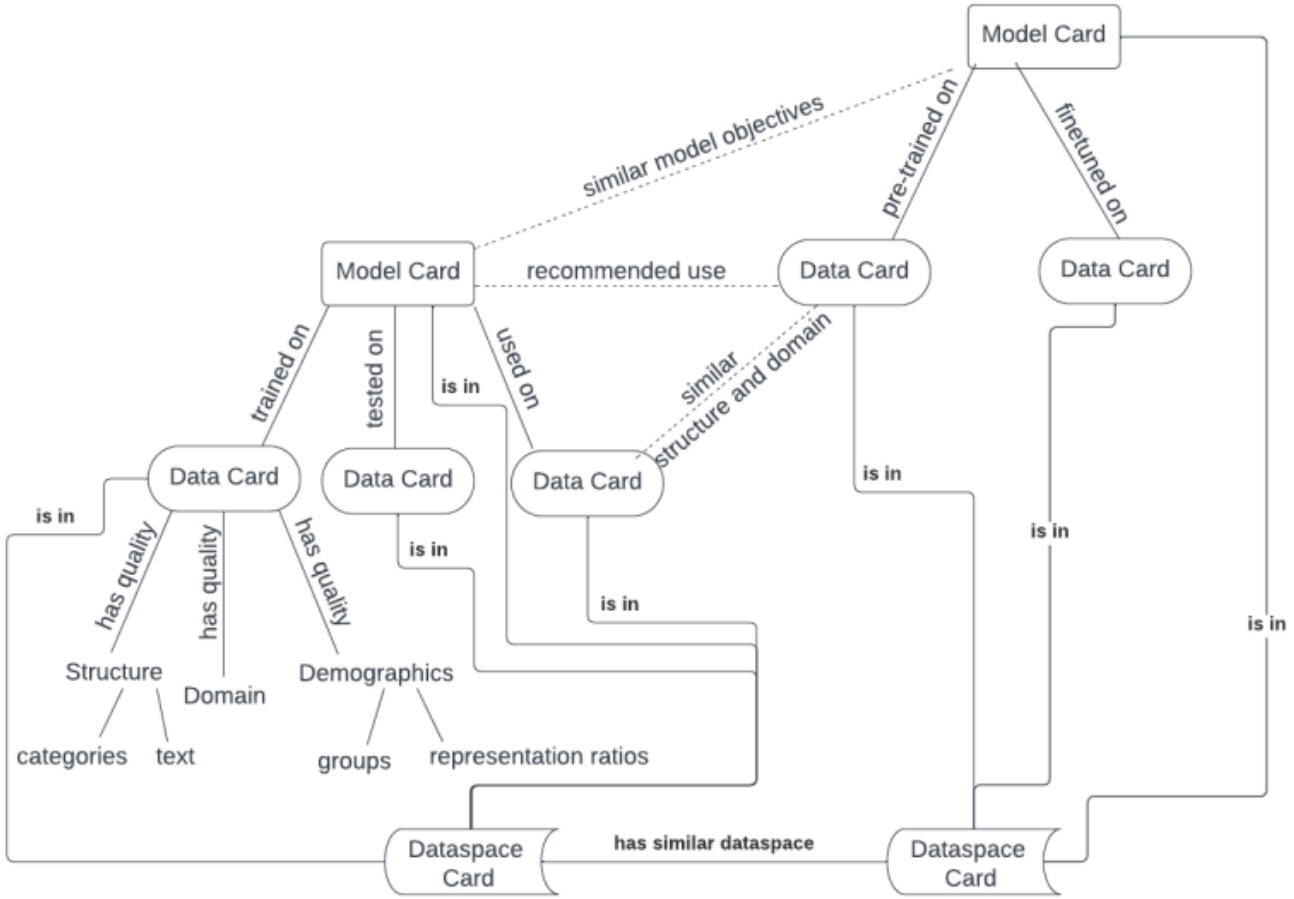


A unified lifecycle for data and AI models recognizes the **symbiotic relationship between both ecosystems** and can serve as the basis to simplify the development, operation, and use of data-intensive AI systems.

E. Curry, M. Timilsina, T. Zaarour, M. Al-QATF, R. Haque, "Foundational Data Space Models: Bridging the AI and Data Ecosystems (Vision Paper), Proceedings of the *2023 IEEE International Conference on Big Data (Big Data)*, Sorrento, Italy, 2023

Need for End-to-End Data and Model Management

- Broad standardization on Metadata is needed on data and model
- Interoperability at source
- Need to build on existing standards (i.e DCAT)



Donald, A., Galanopoulos, A., Curry, E., Muñoz, E., Ullah, I., Waskow, M.A., Dabrowski, M. and Kalra, M., 2023, April. Towards a semantic approach for linked dataspace, model and data cards. In Companion Proceedings of the ACM Web Conference 2023 (pp. 1468-1473).

Final Thought

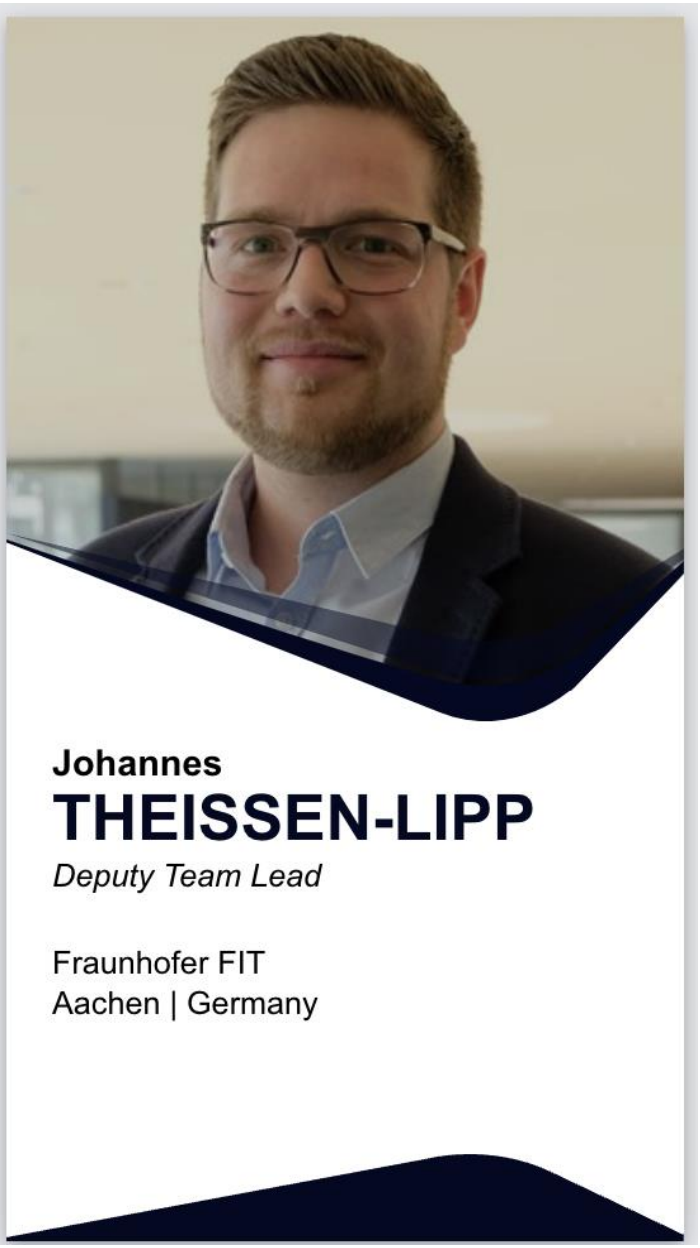
Data is the Red Queen

“It takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!”

Lewis Carroll's Through the Looking-Glass

Summary

- Cross-border Data Spaces need a data co-existence approach
- Cross Border Data Spaces will need a marriage of neuro-symbolic approaches
- A Unified Lifecycle is needed between AI and Data



Dataspace Interoperability Insights from the Data Spaces Support Centre

Fraunhofer FIT

Fraunhofer Institute for Applied Information Technology FIT

SEMIC Pre-Conference Workshop on *"Cross-border Semantic Interoperability: From Models Discovery and Design to Implementation and Reuse"*, Brussels, June 2024

Johannes Theissen-Lipp

Dataspace Interoperability

Insights from the Data Spaces Support Centre

Sci-fi Adventure: **Dataspace Wars - Return of the Semantics**

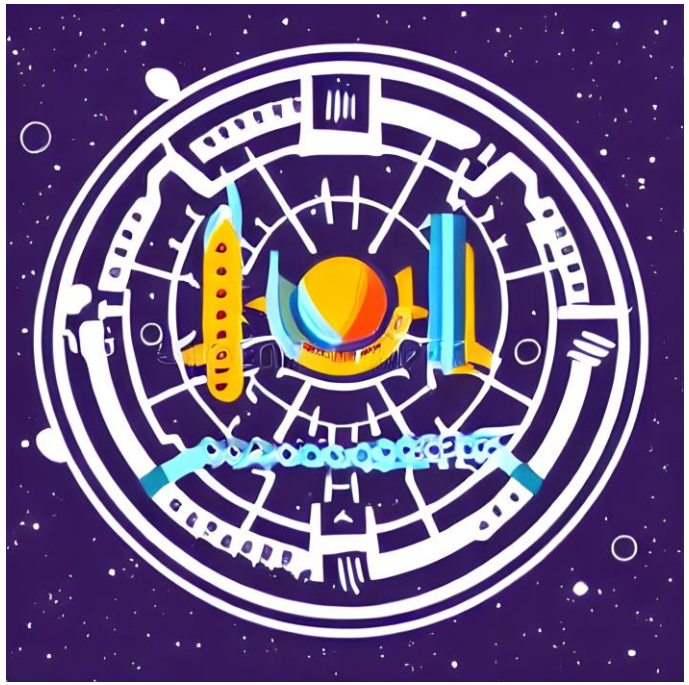
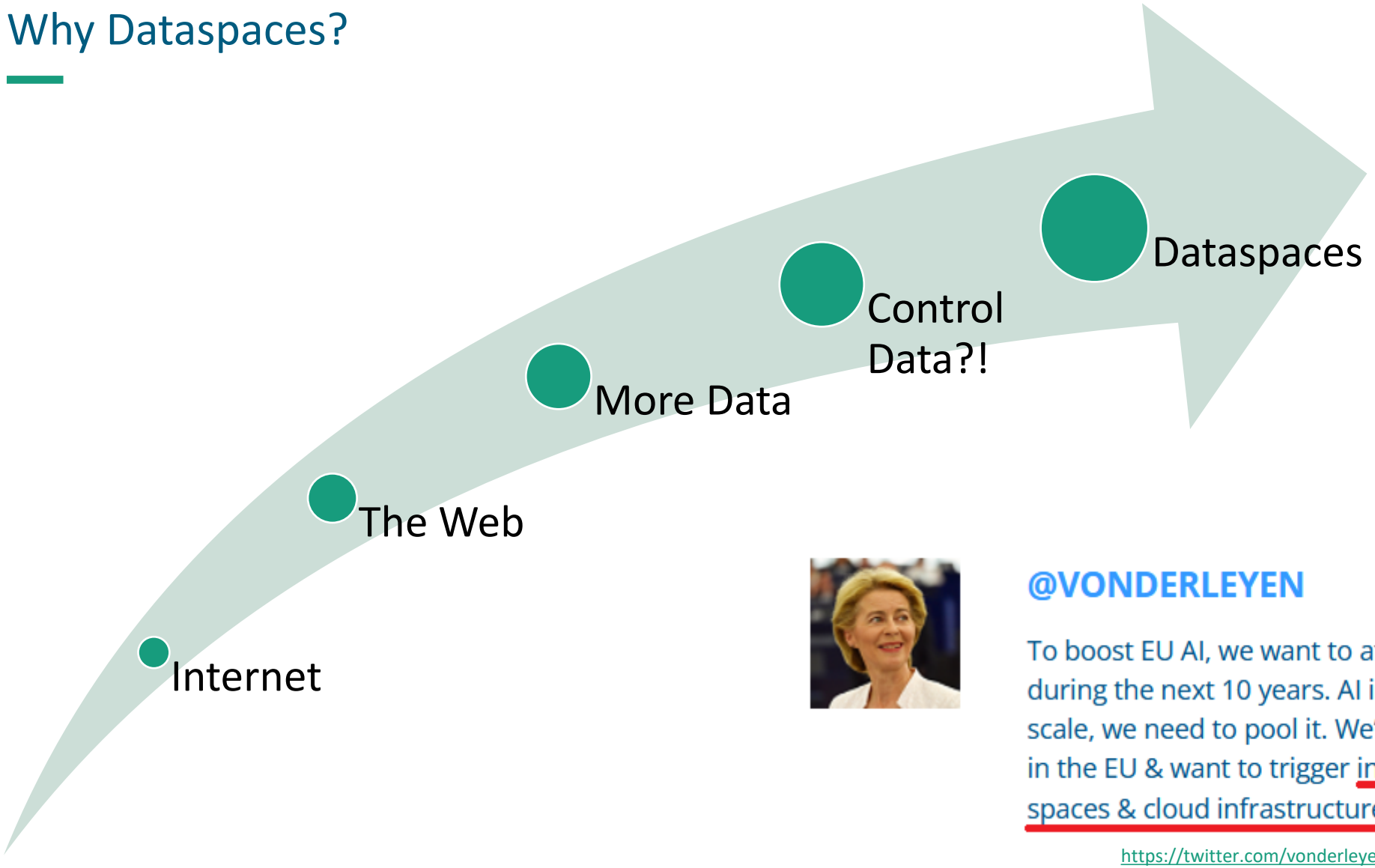


Image generated by https://deepai.org/machine-learning-model/logo-generator with prompt "Dataspace Wars - Return of the Semantics"

Image generated by https://deepai.org/machine-learning-model/fantasy-world-generator with prompt "A galaxy of data with starships connecting planets."

Data scope	= Galaxy
Participants	= Planets
Big Tech	= Trade Federation
Dataspaces	= Trusty trade routes
SW experts	= Jedis wielding lightsabers
LD/FAIR/KG/SEMIC	= The Force?

Why Dataspaces?



@VONDERLEYEN

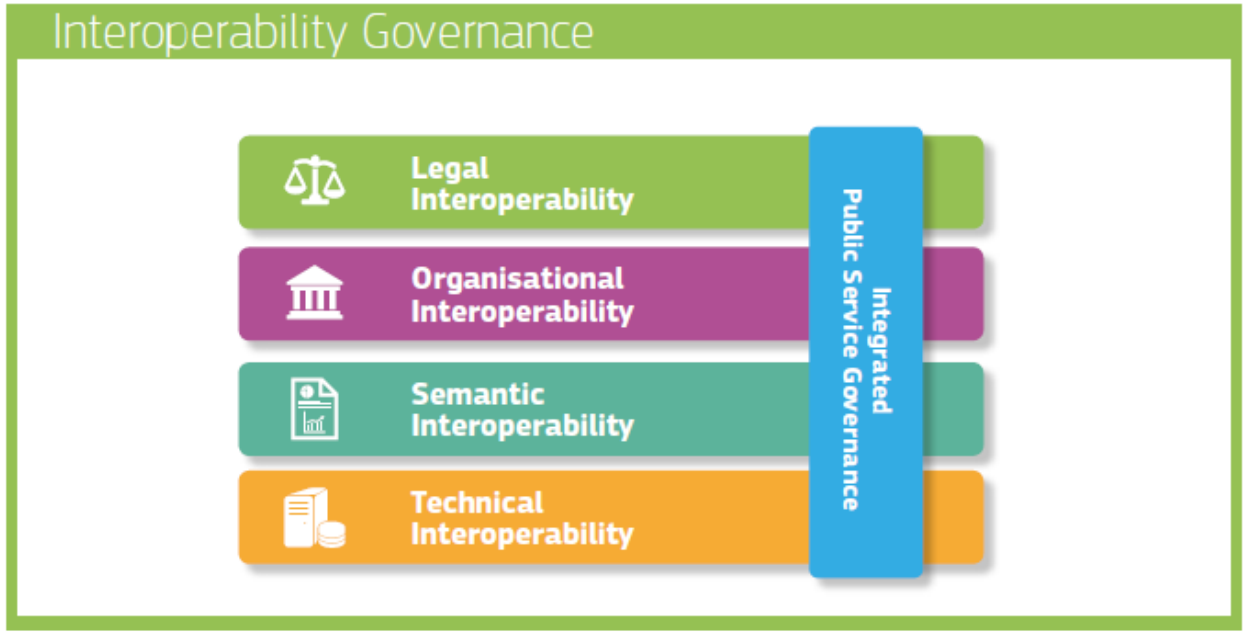
To boost EU AI, we want to attract more than €20bn/year during the next 10 years. AI is all about data. To use it at large scale, we need to pool it. We'll create a single market for data in the EU & want to trigger investments of €4-6bn in EU data spaces & cloud infrastructures

https://twitter.com/vonderleyen/status/1230098004281085952, February 2020

Dataspace Interoperability

"The ability of participants to seamlessly exchange and use data within a dataspace or between two or more dataspaces."

DSSC Blueprint v1.0



European Interoperability Framework https://ec.europa.eu/isa2/sites/isa/files/eif_brochure_final.pdf

Goal of this Talk

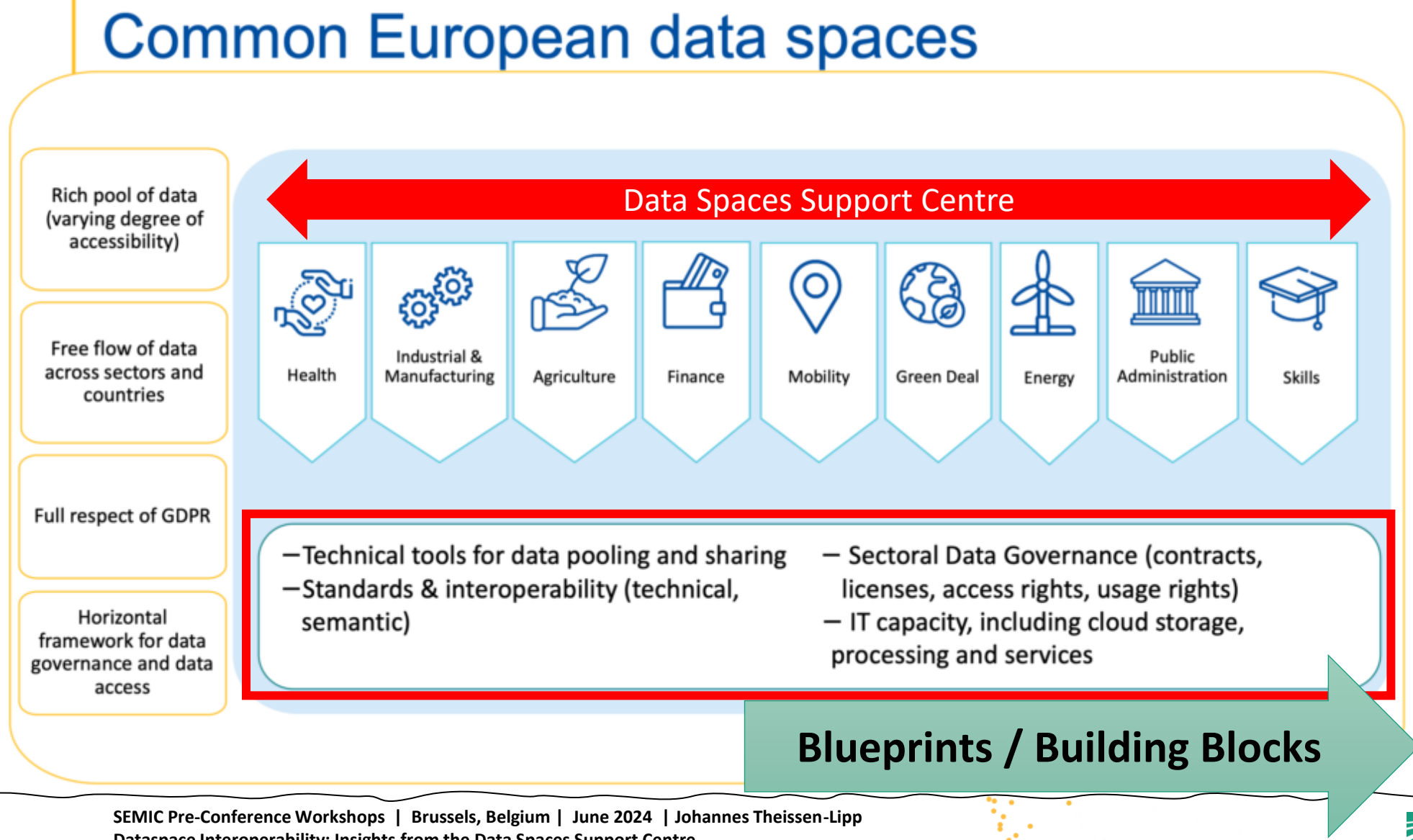
Dataspaces are important

Need for interoperability

The role of dataspaces?

Solutions for dataspace interoperability?

The Role of Dataspaces



Matthijs Punter, TNO

DATA SPACES SUPPORT CENTRE

Blueprint → Building Blocks

Business & Organisational

Technical

https://dssc.eu/page/knowledge-base

- ✓ Required capabilities
- ✓ Core design decisions
- ✓ Specifications & common standards
- ✓ Further reading

DATA SPACES SUPPORT CENTRE

What's new? 1.0

Business and organisational building blocks

Business

- ✓ Visual overview of business model ingredients
- ✓ Guidelines & templates to take business decisions

Governance

- ✓ Organisational form and governance authority
- ✓ Participation management
- ✓ Decision tree to organise and establish a data space
- ✓ Guidelines on/offboarding of participants

Legal

- ✓ Regulatory compliance checklist for data spaces
- ✓ Contractual framework for agreements:
  - Among participants
  - On data transactions

Matthijs Punter, TNO

DATA SPACES SUPPORT CENTRE

What's new? 1.0

Technical building blocks

Data interoperability

- ✓ **Vocabulary Hub** for common data models
- ✓ Approaches for **provenance & traceability**

Data sovereignty and trust

- ✓ Attestation & Identity Management based on **W3C Verifiable Credentials** (SSI)
- ✓ Role of Trust Frameworks
- ✓ Access and usage policies based on **W3C ODRL**

Data value creation enablers

- ✓ Usage of **DCAT** for specifying data products & services
- ✓ Role of **Value Added Services** in a data space (not only marketplaces!)

Matthijs Punter, TNO

DATA SPACES SUPPORT CENTRE

Building Block → Implementation

Functional overview of software components

Participant Agent (Dataspace Connector)

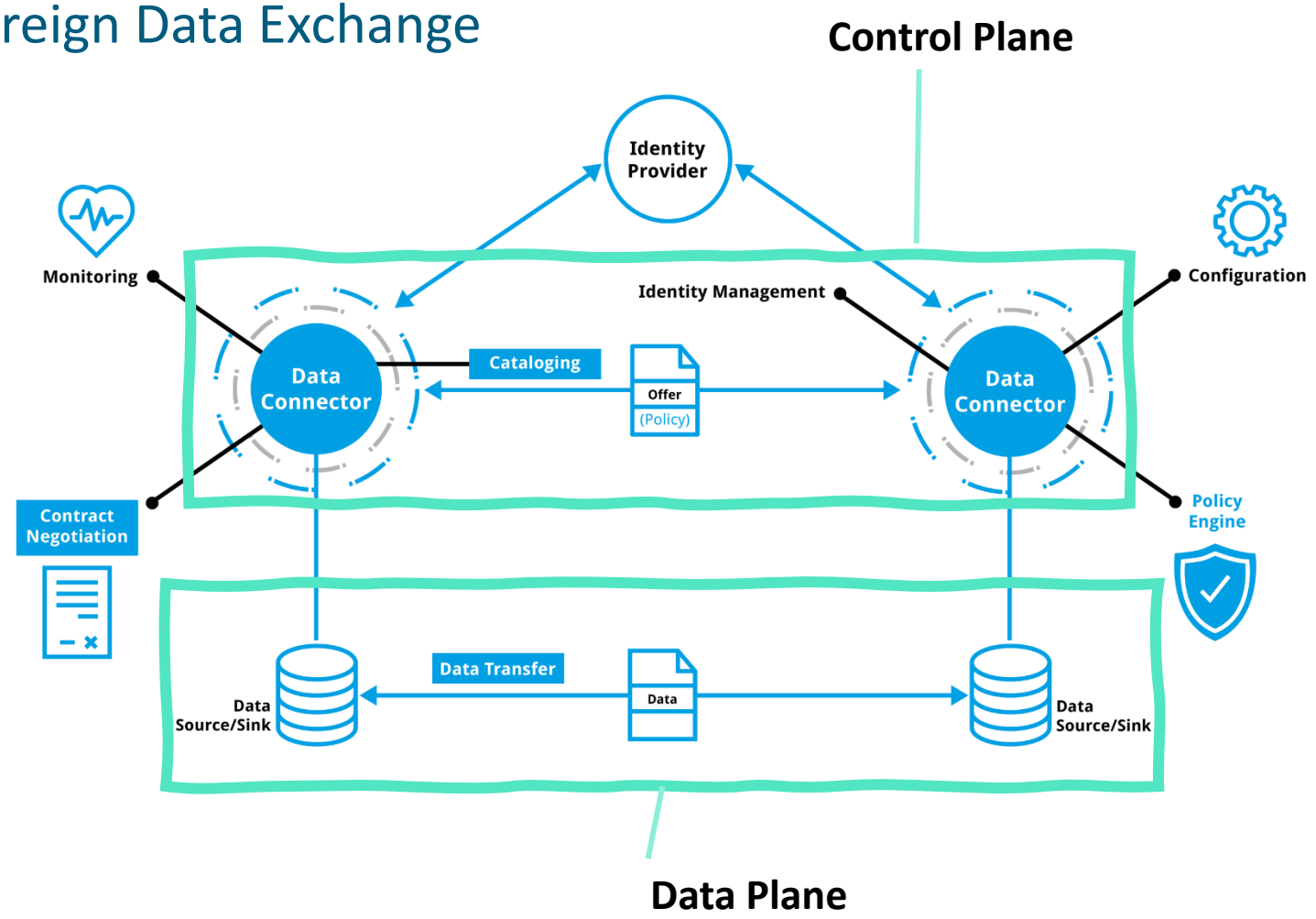
- ✓ Control plane vs. Data plane
- ✓ Participant Wallet
- ✓ Data, Services & Offerings Catalogue
- ✓ Contract Negotiation
- ✓ Transfer Process

Shared Services

- ✓ Data Space Wallet (participants registry)
- ✓ Catalogue
- ✓ Vocabulary Hub
- ✓ Notarization Service
- ✓ Value Added Services

IDS / Gaia-X: Sovereign Data Exchange

Sebastian Steinbuss, IDSA



Example: Eclipse Dataspace Components + “Trust Framework” extension for Gaia-X participants

Formal standardization (ISO/IEC) in progress: https://projects.eclipse.org/proposals/eclipse-dataspace-protocol

Gaia-X Credentials (Self Descriptions)

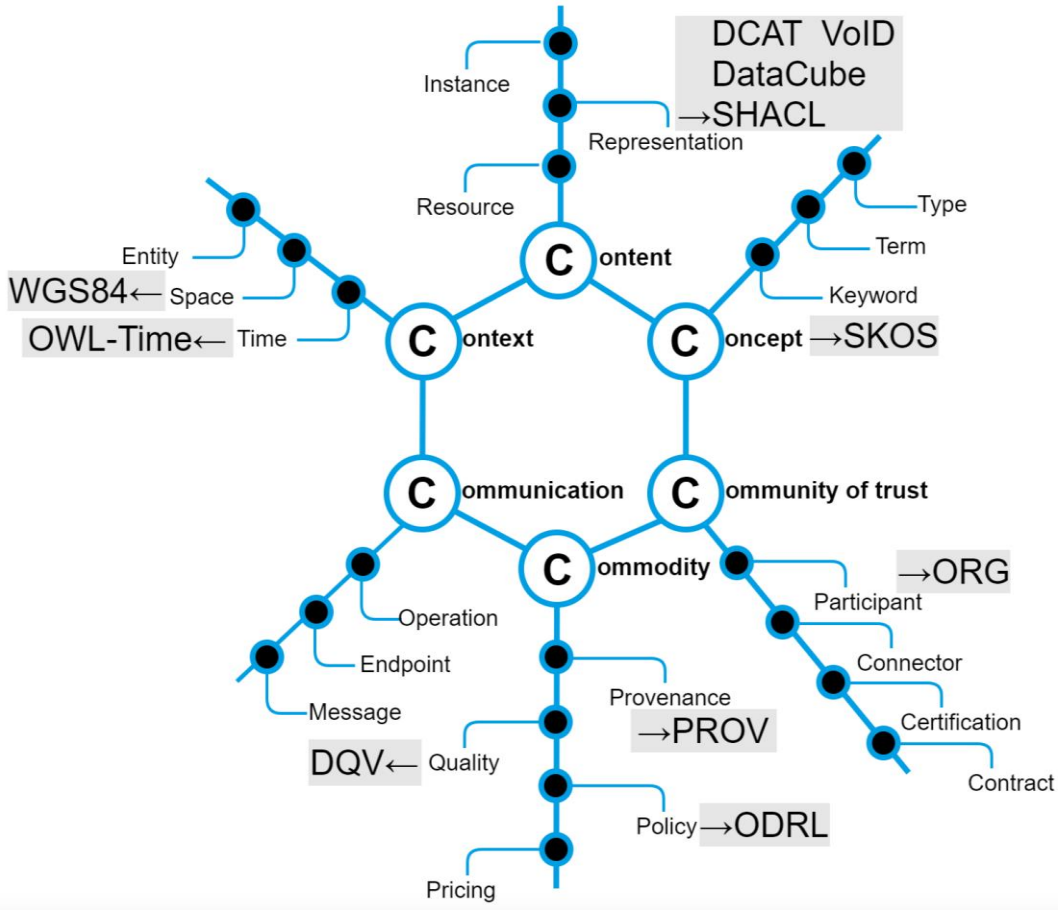
Documentation + Ontology + Validation + Examples + Tool Support

+ Trust:

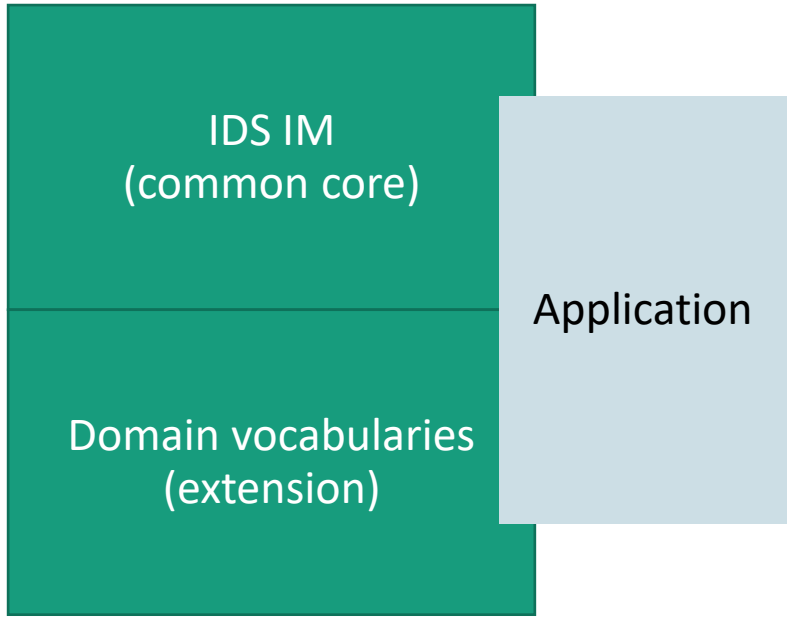
1. Claim something about myself.
2. Have it confirmed by third parties.
3. Present it to business partners.

IDS Information Model

Foundation for semantic interoperability



Domain application (combine 2 ways)



DATA SPACES SUPPORT CENTRE

Building Block → Implementation

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Shared Services

- ✓ Data Space Wallet (participants registry)
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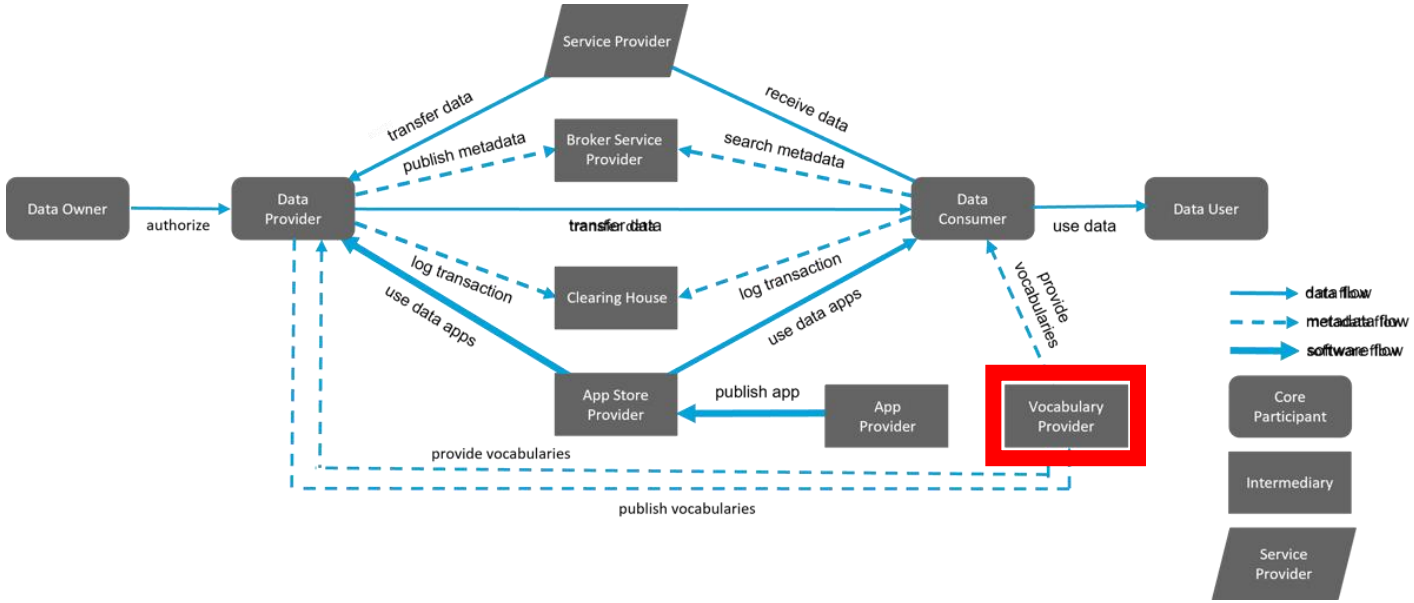
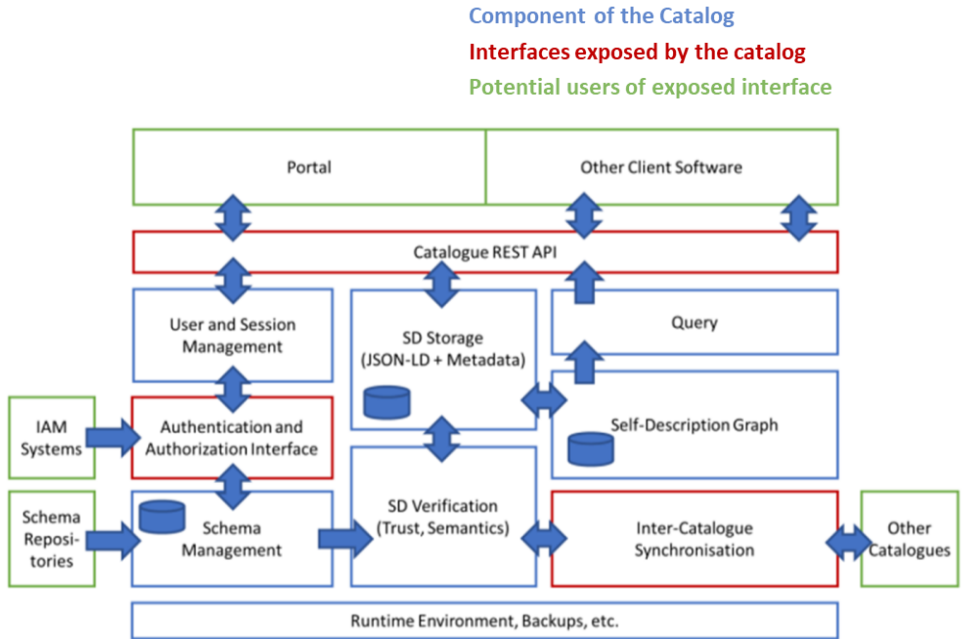
- ✓ Vocabulary Hub
- ✓ Notarization Service
- ✓ Value Added Services

Vocabulary Hubs

"IDS **Vocabulary Hubs** give the developer of domain-specific vocabularies the **tools and functions to create, improve, and publish their terms**." – IDS-RAM 4.0





Also included in the *Eclipse XFSC Federated Catalogue*

- https://gitlab.eclipse.org/eclipse/xfsc/cat/fc-service/-/wikis/home
- https://www.gxfs.eu/set-of-services/

Conclusion

Dataspaces

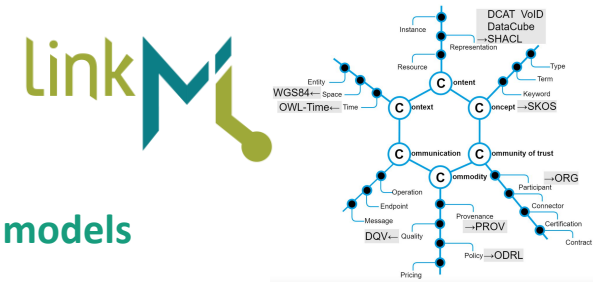
- Important for the EU's data sovereignty
- Reference models, growing members & impact

Data Spaces Support Centre

- Dataspace interoperability: Blueprints & building blocks
- Implementations: Agent / connector software & shared services
- Based on semantic models

Opinion on dataspace interoperability

- **Mutual understanding and common languages: Vocabulary hubs and semantic models**
- **Impact and interoperability: Tool support based on Web standards**



DCAT-AP 3.0

Contact

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Germany
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Fraunhofer FIT

Fraunhofer Institute for Applied Information Technology FIT

Backup

Introducing Myself

May 2024: “Semantic Foundations of Dataspaces”

Fraunhofer FIT

12/2019: Semantic Models & Dataspaces

04/2022: “Data Science & AI”

Computer Science 5 - Information Systems and Databases | RWTH AACHEN UNIVERSITY

04/2021: Semantic Web & FAIR Data

IMA Institute of Information Management in Mechanical Engineering | RWTH AACHEN UNIVERSITY

11/2017: M.Sc. on Ontology Evolution

IMA Institute of Information Management in Mechanical Engineering | RWTH AACHEN UNIVERSITY

01/2018: (Semantic) Data Integration

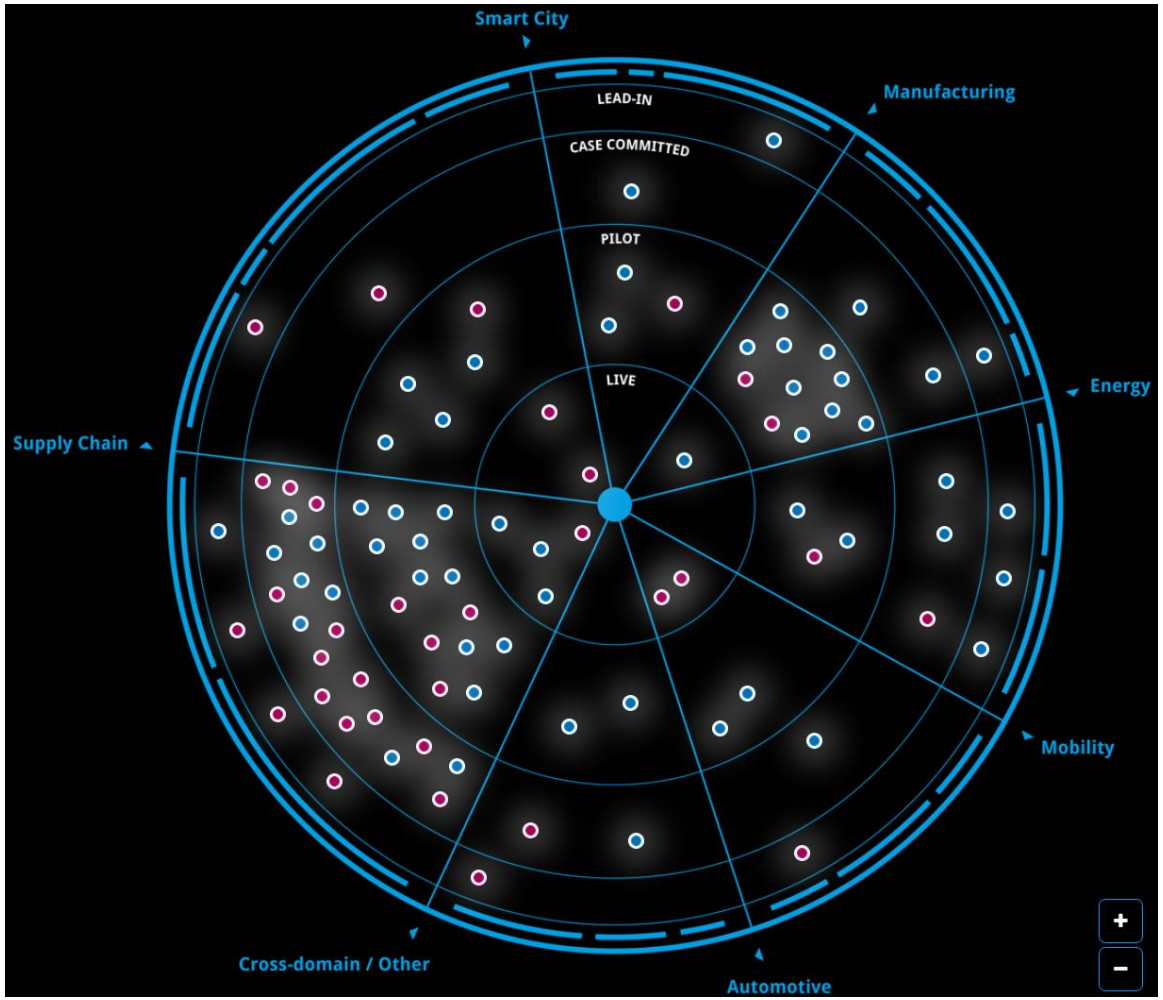
The Role of Dataspaces

INDUSTRIAL DATA SPACE

INTERNATIONAL DATA SPACES ASSOCIATION

International Data Spaces (IDS)

- Launched in 2014, renamed in 2018
- Architecture for sovereign data exchange
  - Semantics + FAIR principles
  - IDS Information Model as RDFS/OWL ontology
- IDS Reference Architecture Model
- Broad adoption



The Role of Dataspaces

Gaia-X

- Uses the IDS RAM as building block
- Align with the EU data strategy and European values
- “Federated […] data infrastructure, […] with users retaining control over their data”

- Machine-readable credentials (Self Descriptions)
- Federation services (https://www.gxfs.eu and https://gitlab.eclipse.org/eclipse/xfsc/)
- Adoption in ~~eight~~ ~~ten~~ 16 lighthouse projects

Gaia-X Dos and Don’ts

Gaia-X is

- A single point of definition of Gaia-X architecture & rules
- Making available an open implementation to all
- A qualification authority for Gaia-X compliance

Gaia-X Is Not

- A formal standardization body
- A SW or HW product or cloud platform
- A runtime implementation of any Gaia-X service

Specify specs, develop code, notarize participants

XFSC and Gaia-X: FIT is Doing LinkML

Gaia-X Credentials are validated against SHACL shapes, but the schemas are defined in the relatively human-friendly, text-based LinkML language.

```
DatacenterAllocation:
   title: 'datacenter allocation'
   description: 'Details specific situation within the datacenter where the service ca be acc sed.'
   attributes:
     refersTo:
       title: 'refers to'
       description: 'Datacenter where the service can be accessed.'
       required: true
       multivalued: false
       range: Datacenter
     floor:
       title: 'datacenter floor'
       description: 'The floor number of the datacenter where the  ccessed.'
       multivalued: false
       range: string
     rackNumber:
       title: 'datacenter rack number'
       description: 'The Id of the datacenter rack number where th accessed.'
       multivalued: false
       range: string
     patchPanel:
       title: 'datacenter patch panel'
       description: 'The Id of the datacenter patch panel where the service can be accessed.'
       multivalued: false
       range: string
     portNumber:
       title: 'datacenter port number'
       description: 'The port number on the patch panel where the service can be accessed.'
       multivalued: false
       range: integer
```

LinkML generator

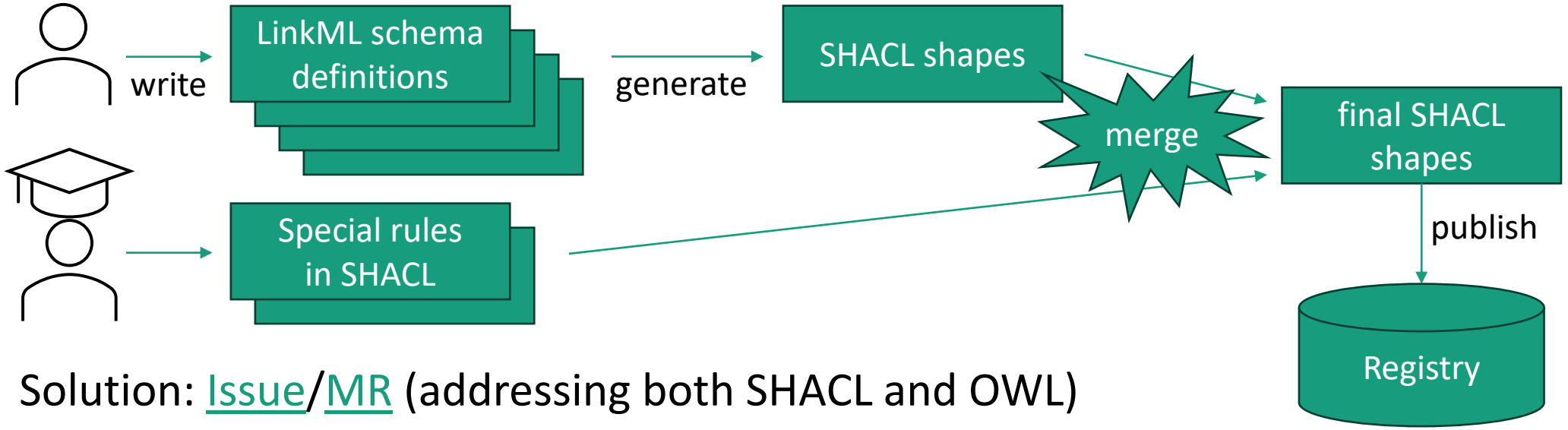
```
@prefix sh: <http://www.w3.org/ns/shacl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix gx: <https://www.gxfs.eu/glossary/ontology> .

gx:DatacenterAllocationShape a sh:NodeShape ;
    sh:closed false ;
    sh:description "Details specific situation within the datacenter where the service can be accessed." ;
    sh:ignoredProperties ( rdf:type ) ;
    sh:name "datacenter allocation" ;
    sh:property [ sh:datatype xsd:string ;
            sh:description "The Id of the datacenter rack number where the service can be accessed." ;
            sh:maxCount 1 ;
            sh:name "datacenter rack number" ;
            sh:nodeKind sh:Literal ;
            sh:order 2 ;
            sh:path gx:rackNumber ],
        [ sh:datatype xsd:integer ;
            sh:description "The port number on the patch panel where the service can be accessed." ;
            sh:maxCount 1 ;
            sh:name "datacenter port numb
            sh:nodeKind sh:Literal ;
            sh:order 4 ;
            sh:path gx:portNumber ],
        [ sh:class gx:Datacenter ;
            sh:description "Datacenter
            sh:maxCount 1 ;
            sh:minCount 1 ;
            sh:name "refers to" ;
            sh:nodeKind sh:BlankNodeOrIRI ;
            sh:order 0 ;
            sh:path gx:refersTo ],
        [ sh:datatype xsd:string ;
            sh:description "The Id of the datacenter patch panel where the service can be accessed." ;
            sh:maxCount 1 ;
            sh:name "datacenter patch panel" ;
            sh:nodeKind sh:Literal ;
            sh:order 3 ;
            sh:path gx:patchPanel ],
        [ sh:datatype xsd:string ;
            sh:description "The floor number of the datacenter where the service can be accessed." ;
            sh:maxCount 1 ;
            sh:name "datacenter floor" ;
            sh:nodeKind sh:Literal ;
            sh:order 1 ;
            sh:path gx:floor ] ;
    sh:targetClass gx:DatacenterAllocation .
```

XFSC and Gaia-X: FIT is Doing LinkML

There are [further] constructs that …

… LinkML‘s modelling language as well as SHACL/OWL support, but the LinkML→SHACL/OWL generators not yet.

… LinkML might never, or will not easily support ever (e.g., alternative paths, SPARQL queries, complex OWL axioms, multilingual labels)



Solution: Issue/MR (addressing both SHACL and OWL)

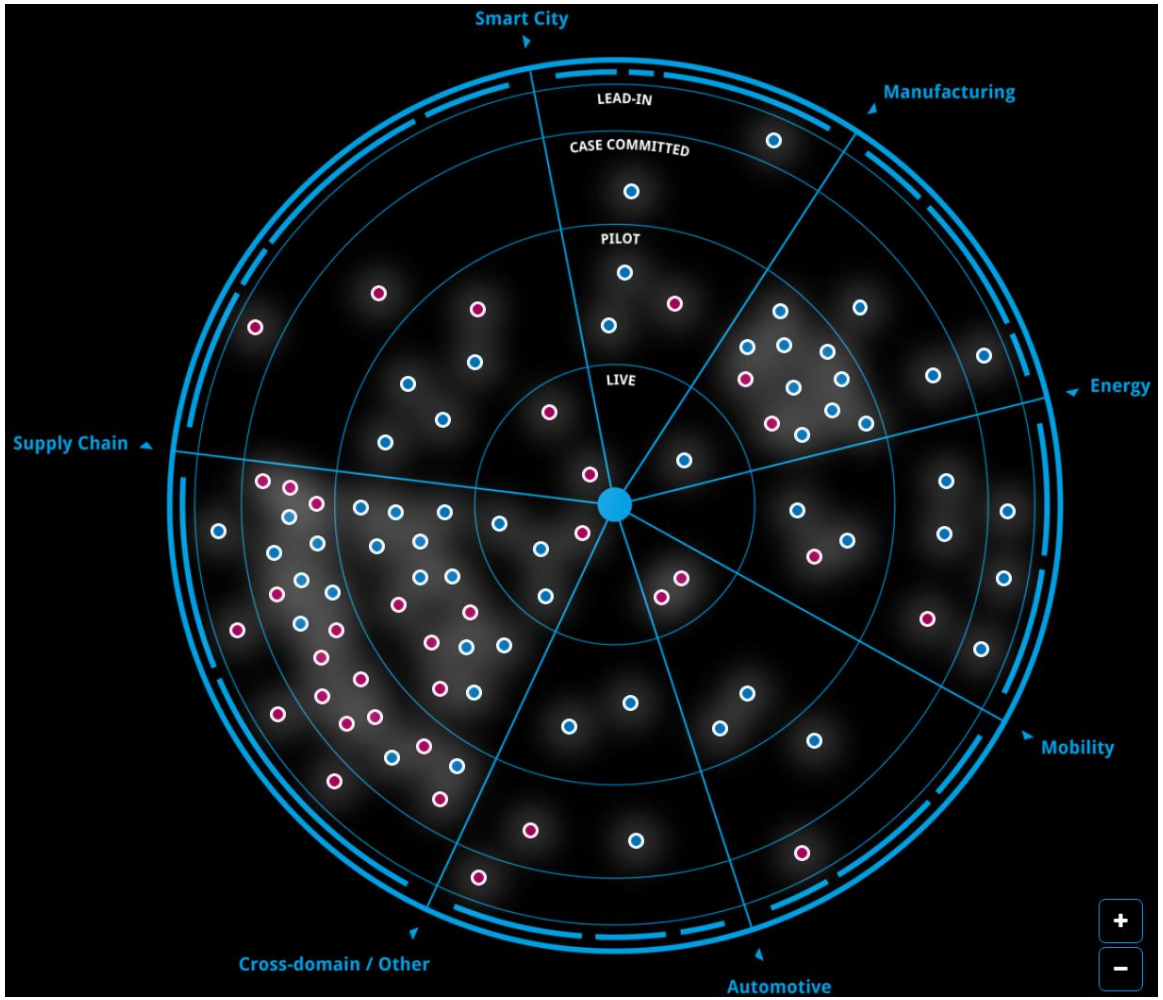
Dataspace Efforts in the Wild (1/4)

INDUSTRIAL DATA SPACE

INTERNATIONAL DATA SPACES ASSOCIATION

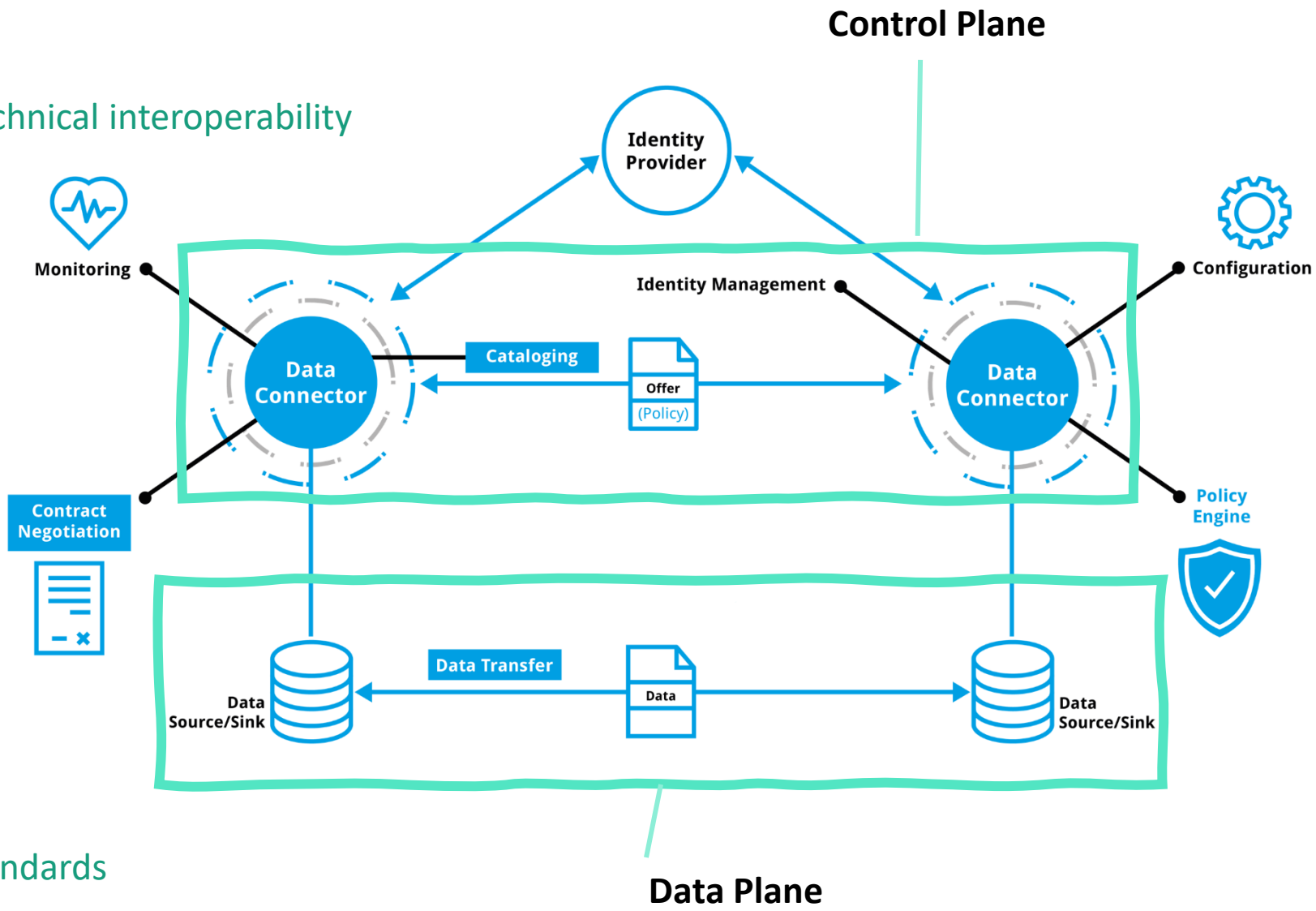
International Data Spaces (IDS)

- Launched in 2014, renamed in 2018
- Architecture for sovereign data exchange
  - Semantics + FAIR principles
  - IDS Information Model as RDFS/OWL ontology
- IDS Reference Architecture Model
- Broad adoption



IDSA Dataspace Protocol

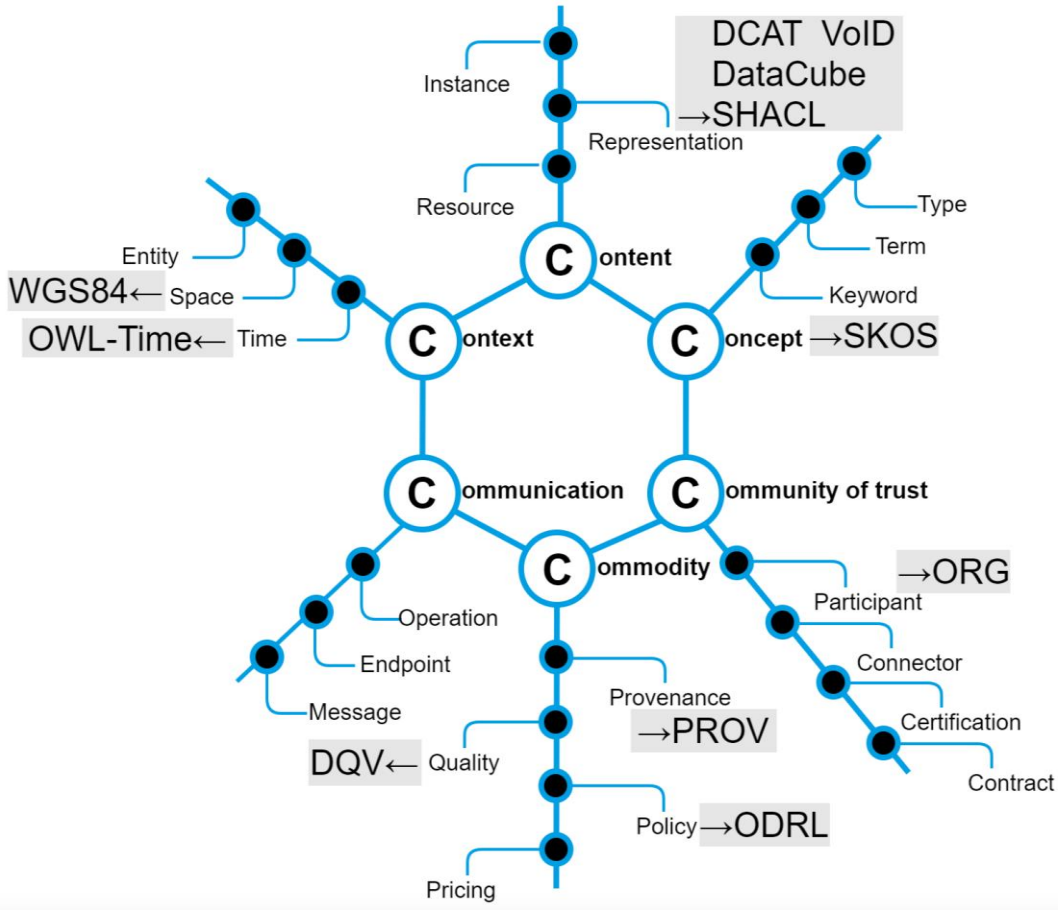
Foundation for technical interoperability



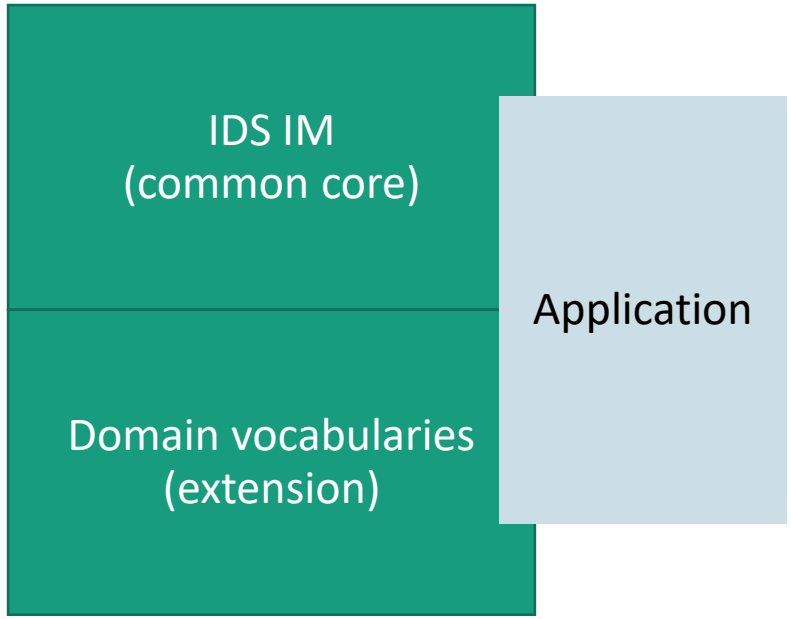
Based on W3C standards

IDS Information Model

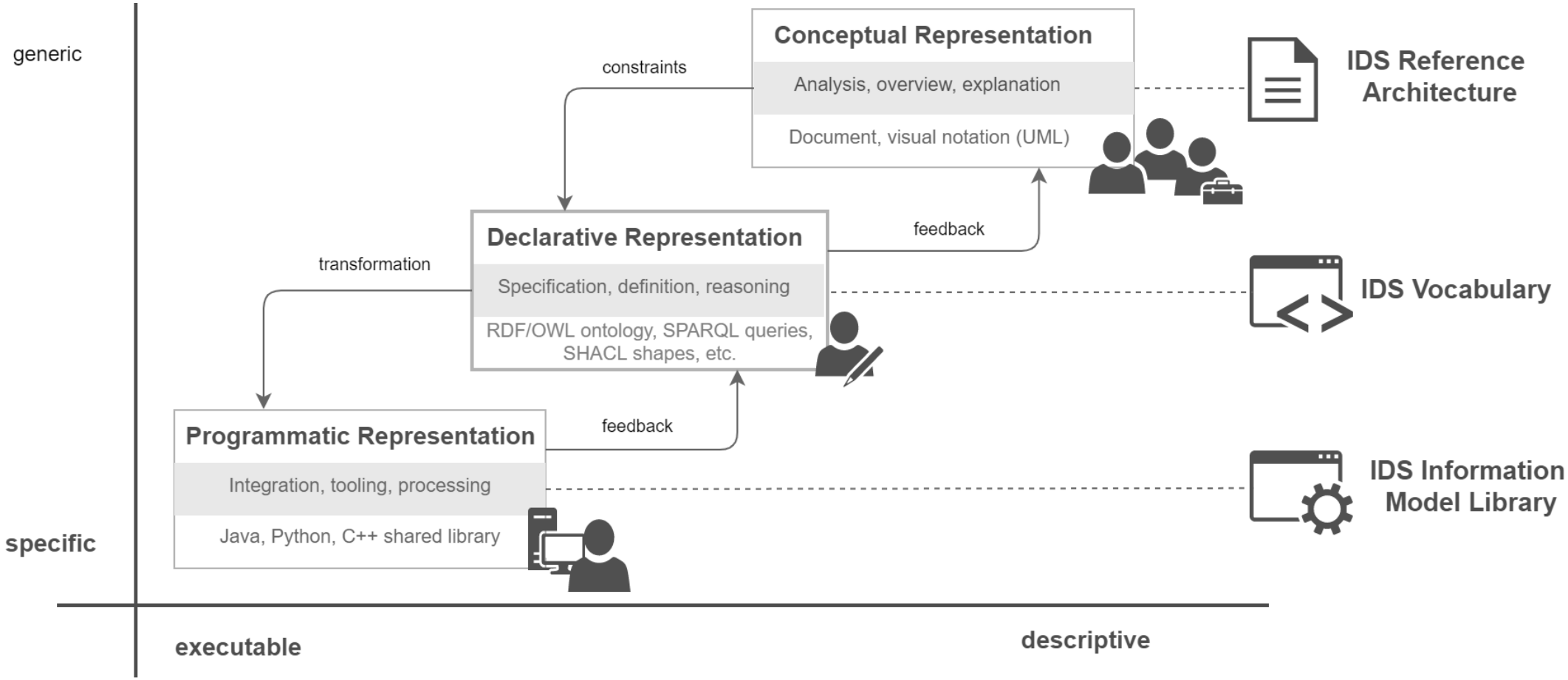
Foundation for semantic interoperability



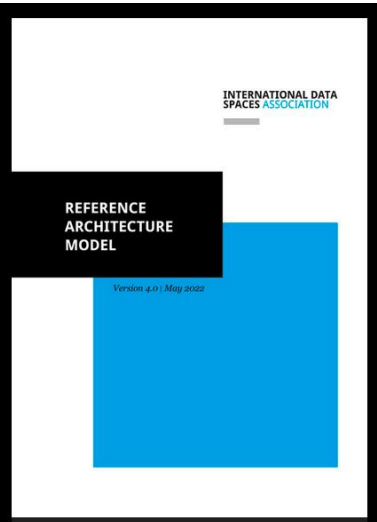
Domain application



IDS Information Model



IDS: Most Important Documents

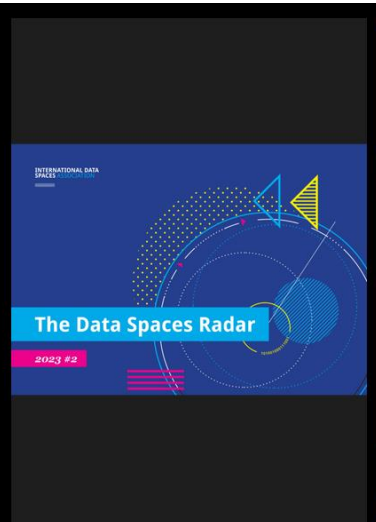


IDS Reference Architecture Model

Version 4.0 | 2022

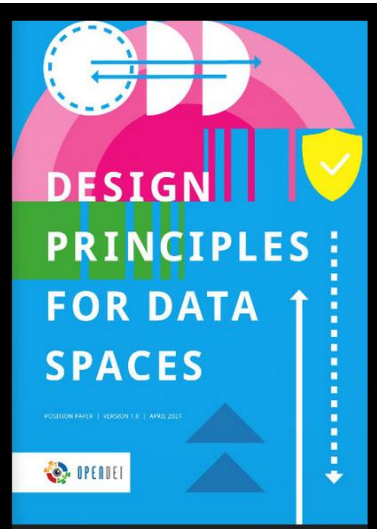
IDSA Rulebook

White Paper | 2023



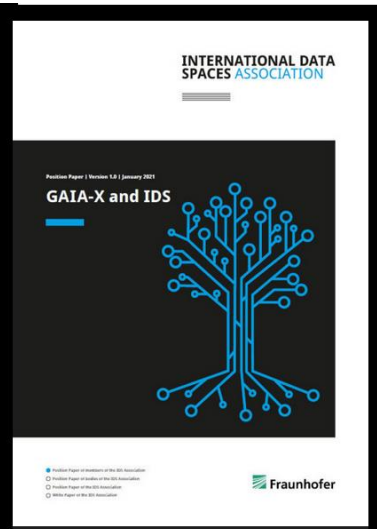
The Data Spaces Radar

Version 2 | July 2023



Design Principles for Data Spaces

Position Paper 2021



GAIA-X and IDS

Position Paper 2021 | Version 1.0

Implementing the European Strategy on Data - Role of the IDS

GitHub as collaboration platform

Dataspace Efforts in the Wild (2/4)

Gaia-X

- Uses the IDS RAM as building block
- Align with the EU data strategy and European values
- “Federated […] data infrastructure, […] with users retaining control over their data”

- Machine-readable credentials (Self Descriptions)
- Federation services (https://www.gxfs.eu and https://gitlab.eclipse.org/eclipse/xfsc/)
- Adoption in ~~eight~~ ten lighthouse projects

Gaia-X Dos and Don’ts

Gaia-X is

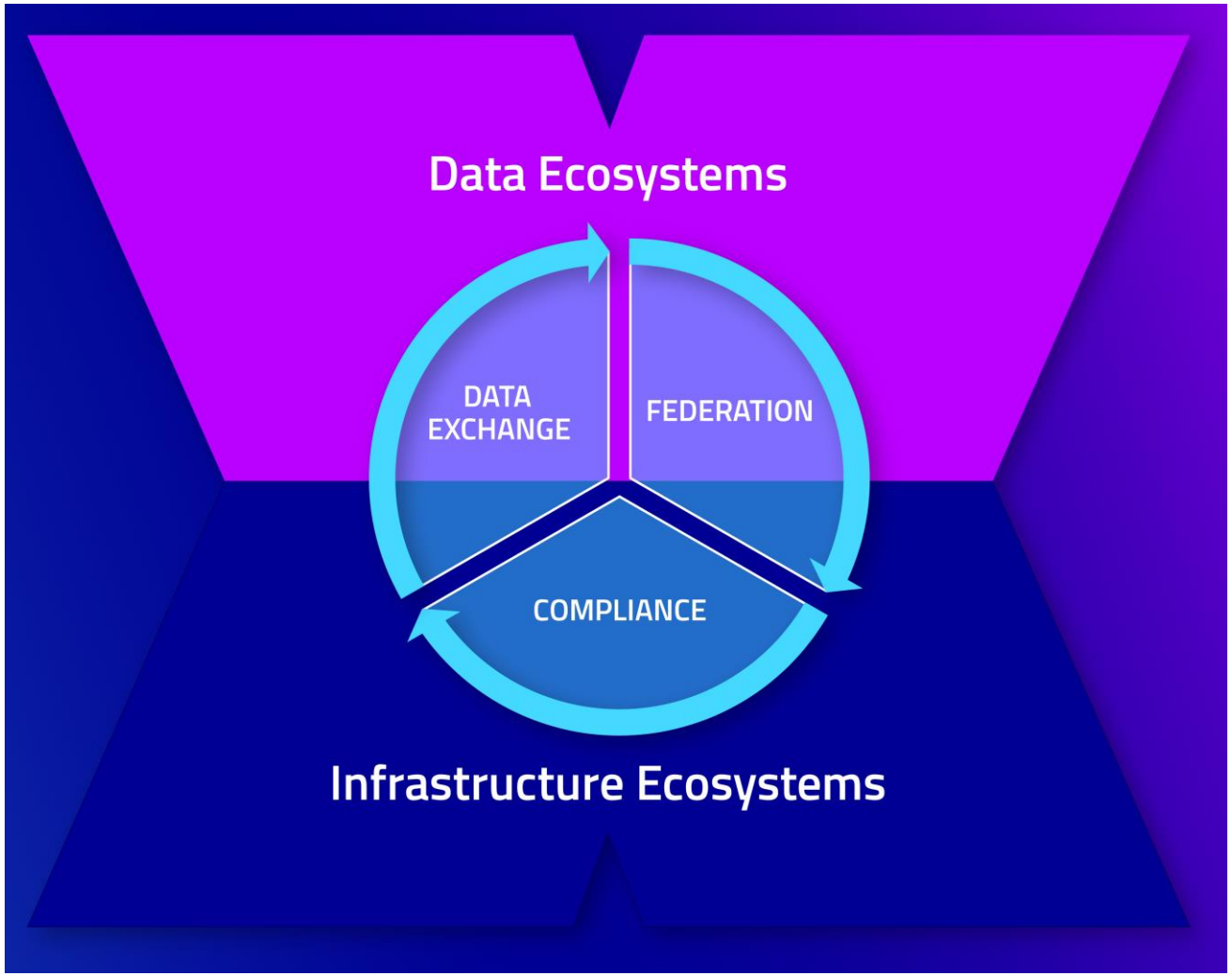
- A single point of definition of Gaia-X architecture & rules
- Making available an open implementation to all
- A qualification authority for Gaia-X compliance

Gaia-X Is Not

- A formal standardization body
- A SW or HW product or cloud platform
- A runtime implementation of any Gaia-X service

Specify specs, develop code, notarize participants

Gaia-X Framework (Simplified)



https://gaia-x.eu/gaia-x-framework/

Gaia-X Self Descriptions

Documentation + Ontology + Validation + Examples + Tool Support

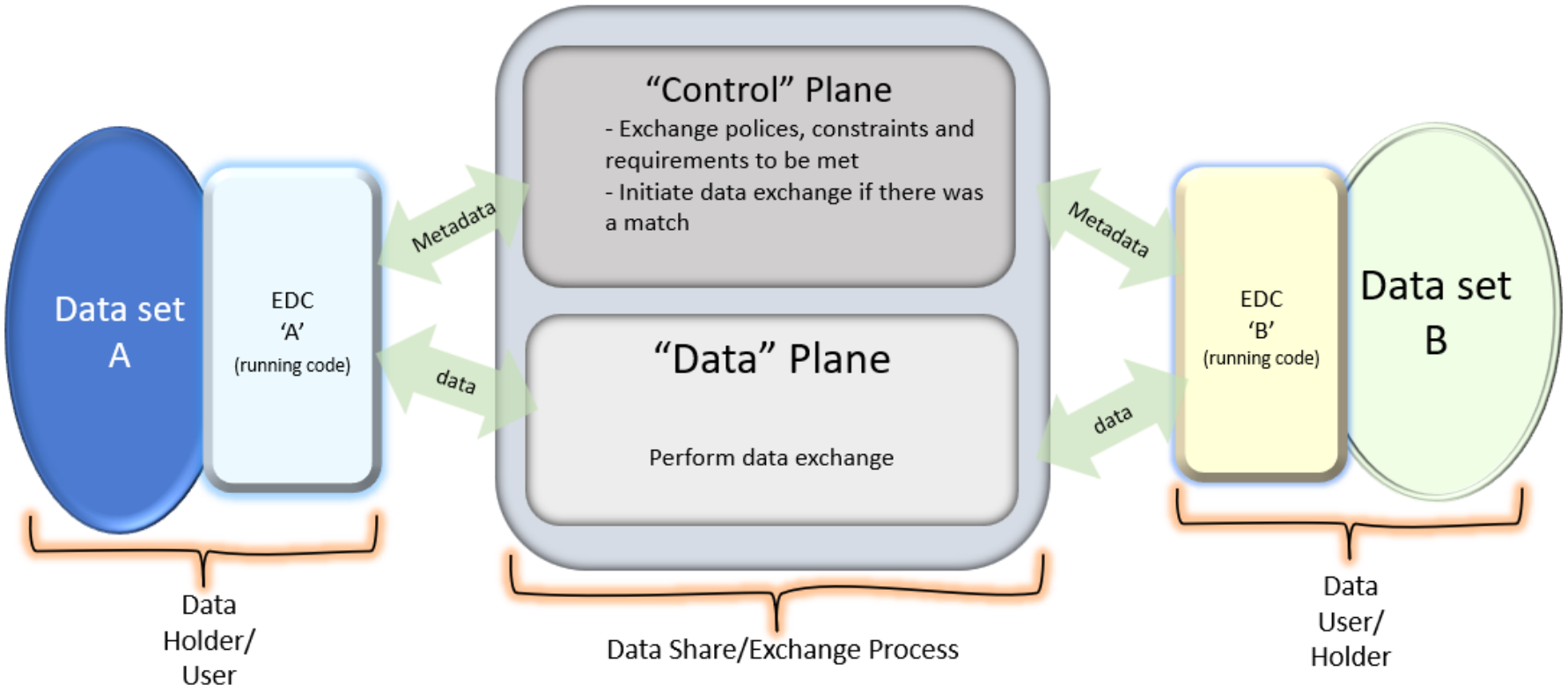
+ Trust:

1. Claim something about myself.
2. Have it confirmed by third parties.
3. Present it to business partners.

Gaia-X: Sovereign Data Exchange

Example: Eclipse Dataspace Components

+ “Trust Framework” extension for Gaia-X participants



https://github.com/eclipse-edc/Publications/blob/main/Dataspaces/Dataspaces%20Vocabulary%20and%20Operations.md

Dataspace Efforts in the Wild (3/4)

German National Research Data Infrastructure (NFDI)

- Develop solutions and services for RDM
- FAIR principles as key element

European Open Science Cloud

- Ecosystem funded by EU member states and associates
- Provide services and resources for Open Science
- Builds on Semantic Web efforts, Linked Data, FAIR principles

FAIR Data Spaces

- Integrate NFDI and Gaia-X components
- Provide dataspace building blocks for science and industry
- Compliant with the FAIR principles

Dataspace Efforts in the Wild (4/4)

SOcial LInked Data (SOLID)

- Initiated by Tim Berners-Lee at MIT
- Data sovereignty for organizations and individuals
- Follow Linked Data and Semantic Web standards

Data Spaces Support Centre (DSSC)

- Funded by the European Commission as part of the Digital Europe Program
- Explore needs of dataspace initiatives
- Define common requirements
- Establish best practices

All major efforts agree on some use of semantic technologies.

Role of Semantics in Dataspaces?

Semantics / SW Technologies: Scope

The Semantic Web

- Identifiers
- Vocabularies and ontologies
- Query
- Rules, inference, reasoning
- Validation
- Data mapping

Evolving Semantic Web Standards

- Linked Data
- FAIR Principles
- Knowledge Graphs

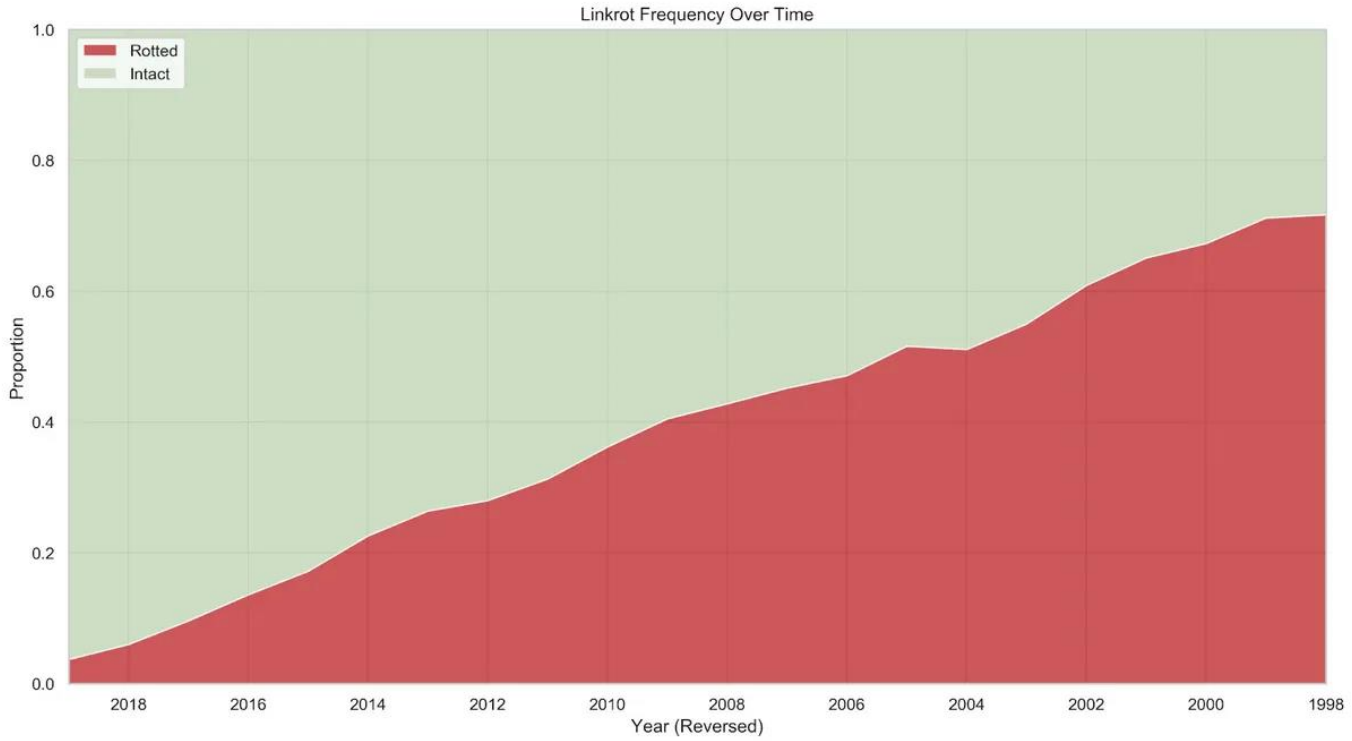
Semantics in Dataspaces (1/2)

Challenges for dataspaces

- Availability, durability, reliability
- Interoperability: Technical & semantic
- Maintainability of components & vocabularies

Identifiers

- Link rot is critical
- Persistent identifiers (PIDs)
- *“Persistence is purely a matter of service.”*



John Bowers, Clare Stanton, and Jonathan Zittrain, *“What the ephemerality of the Web means for your hyperlinks”*, 2021

Semantics in Dataspaces (2/2)

Shared vocabularies and standards

- Vocabularies and semantic annotation foster common understanding
- Rich metadata enables interoperability
- Support both human and machine

Semantics are essential for dataspaces

- Standards and technologies
- Domain-specific schemas / vocabularies
- IDS RAM 4.0 recently focuses on a *Vocabulary Hub*
- The *XFSC Federated Catalog* supports schema management

How to get Involved?

Insights on Limitations in Dataspaces

Dataspace developers and users are unfamiliar with SW solutions

Common language for heterogeneous users

Choice of SW solutions unclear → Bare usage → Unused potential

Inner content of data is not FAIR

Trust for data policies is organizational

How to get Involved

Gaia-X

- National hubs: https://gaia-x.eu/who-we-are/hubs/
- Community calls: https://gaia-x.eu/who-we-are/community/
- Tech workshops, e.g. https://www.eco.de/event/gxfs-tech-workshop-4/
- Git repositories: Gaia-X, Open-Source Software, Federation Services

DSSC

- Communities for practice, stakeholders, and liaisons: https://dssc.eu/space/DC/28016695/Communities

IDSA

- Working groups: https://internationaldataspaces.org/make/working-groups-and-task-forces/
- GitHub for code & docs: https://github.com/International-Data-Spaces-Association/idsa

SEMIC

- SEMIC conference 17th – 18th October: https://semic2023.eu/

Semantics in Dataspaces Workshop

- 1st happened on TheWebConf ’23: https://dbis.rwth-aachen.de/SDS23/

Conclusion

Dataspaces

- Important for the EU's data sovereignty
- Academia: Keep data at source, include semantics
- Practitioners: Reference models, growing members & impact, agree on some use of semantics

Semantics in dataspaces

- Common understanding through metadata & standards
- Broad user base → SW solutions not fully utilized

How to get involved

- Make identifiers, FAIR and Linked Data more accessible
- Participate in events & community work
- Joint declaration & vision paper

What are Dataspaces?

Dataspaces

"An abstraction for data management in an identifiable scope"
(Halevy, 2006)

"Interlinking data towards loosely connected (global) information"
(Heath, 2011)

Dataspaces

"A multi-sided data platform connecting participants in an ecosystem" (Otto, 2019)

Common rough idea

Design vs. implementation

Diverse goals & communities

Specific domains

Incompatible solutions

High entry barriers

*"A distributed system defined by a **governance framework** that enables trustworthy **data transactions** between **participants** while supporting trust and **data sovereignty**"*
(DSSC Blueprint 0.5, 2023)

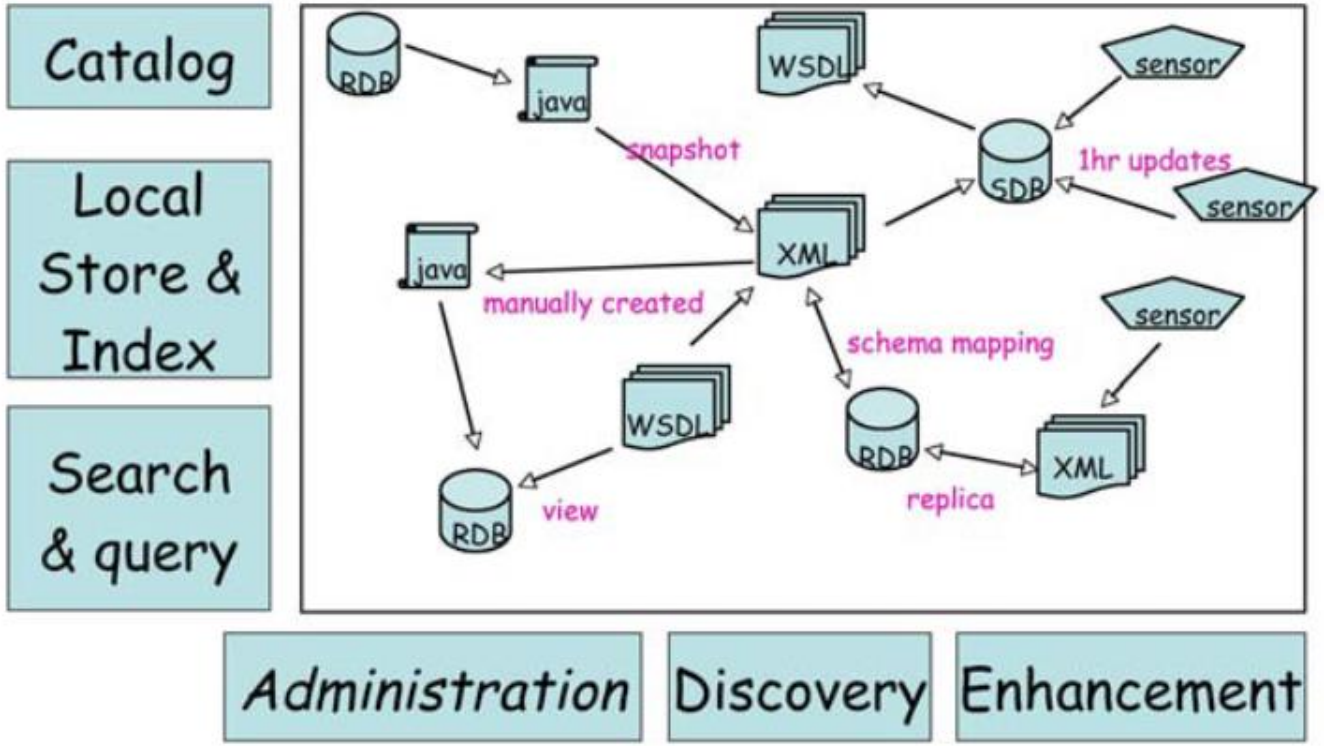
Design Principles for Dataspaces (1/2)

Original concept by Franklin, Halevy and Maier in 2005 – 2006

- In contrast to relational databases
- Keep every data source as is
- Provide services over dataspaces

Multiple definitions have emerged since then

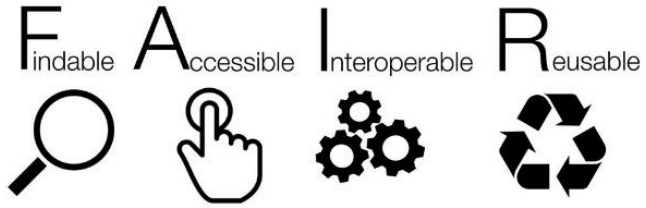
No general definition of a dataspace



Design Principles for Dataspaces (2/2)

Semantics are a core design principle

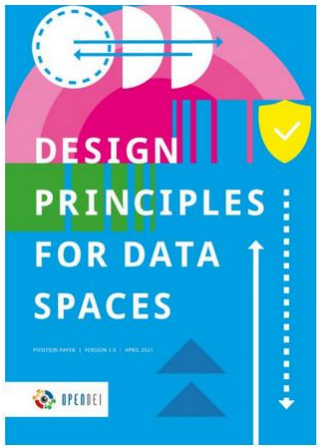
- FAIR and Linked Data principles
- Semantic descriptions
- Ontologies



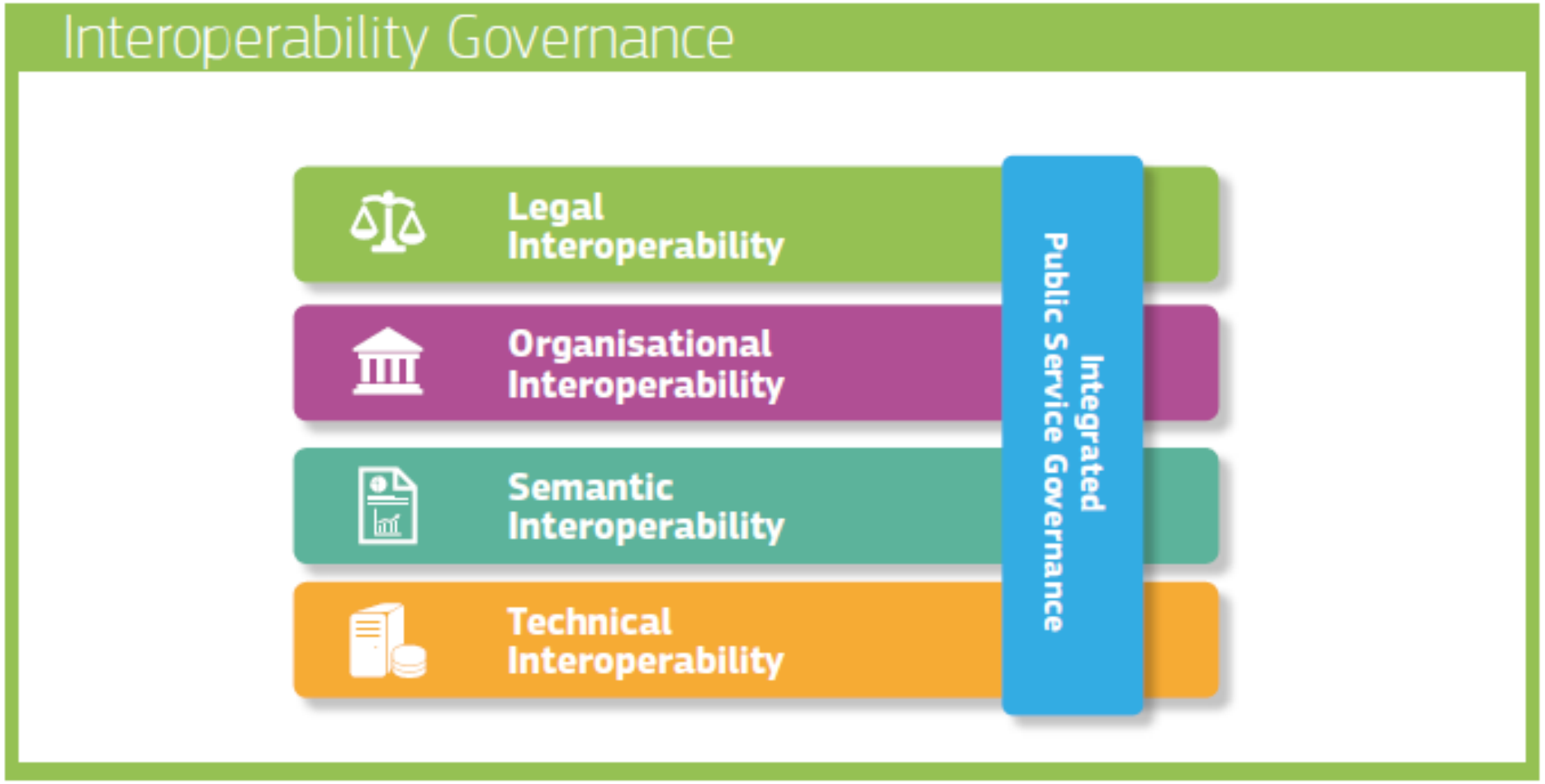
The OpenDEI project aligns dataspace initiatives

- Data sovereignty
- Interoperable implementations
- Low entry barriers

OPENDEI



New European Interoperability Framework



https://ec.europa.eu/isa2/sites/isa/files/eif_brochure_final.pdf

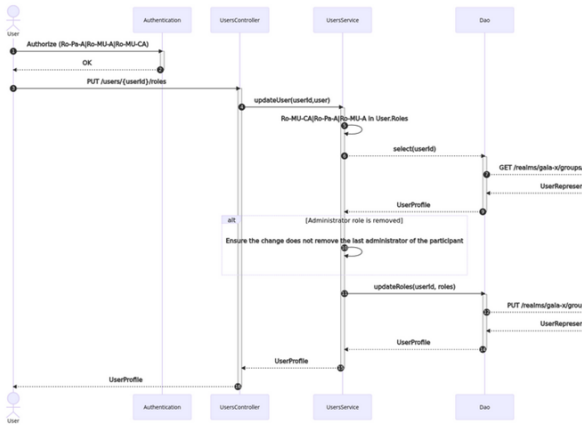
Catalogue Overview

Table of Contents

5.2.11. Changing the Roles of a User

This may change depending on SSO implementation.

Role ID	Can be given by
Ro-MU-CA	Ro-MU-CA
Ro-MU-A	Ro-MU-CA, Ro-MU-A
Ro-SD-A	Ro-MU-CA, Ro-MU-A, Ro-Pa-A (if not self)
Ro-Pa-A	Ro-MU-CA, Ro-MU-A, Ro-Pa-A



https://gitlab.eclipse.org/eclipse/xfsc/cat/fc-service/-/wikis/home

- ✓ SD Management
- ✓ Schema Management
- ✓ SD Verification
- ✓ Query
- ✓ Participant, User, Role, Session Management
- ✓ REST API for each block

Component of the Catalog

Interfaces exposed by the catalog

Potential users of exposed interface

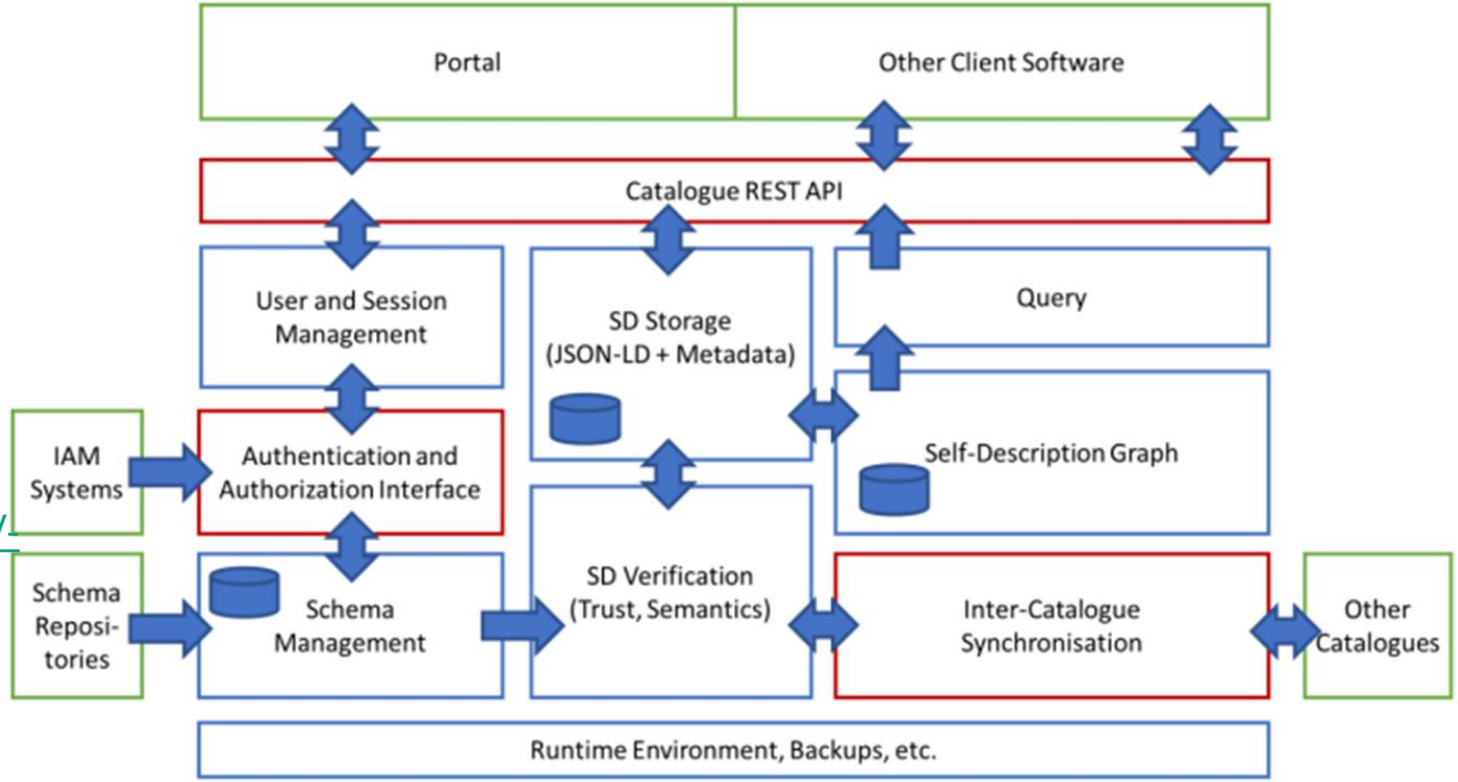


***Figure 1**: High-Level Architecture of the Gaia-X Catalogue.*

Backup

Definitions of a Dataspace

DSSC Blueprint 0.5:

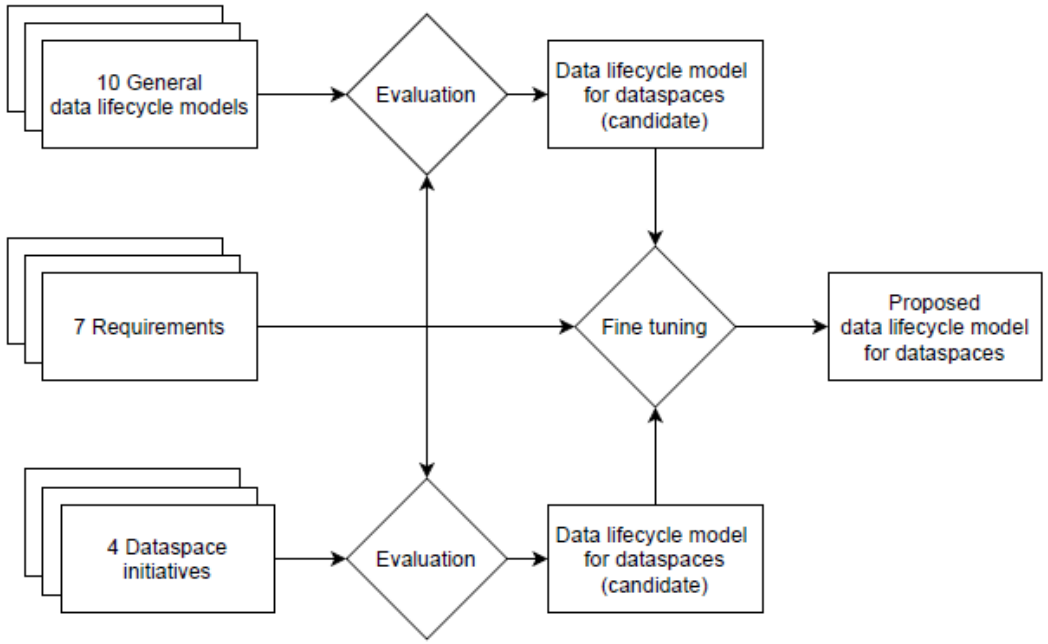
*„A dataspace is a distributed system defined by a **governance framework** that enables trustworthy **data transactions** between **participants** while supporting trust and **data sovereignty**.*

Initiative	Goal
IDSA	*"...create the future of the global, digital economy with IDS, a secure, **sovereign** system of **data sharing** in which all participants can realize the **full value** of their data."* [24]
Gaia-X	*"... create an **open, transparent**, and secure federated **digital ecosystem**, where **data and services** respond to common rules and can be securely built, collated, and shared."* [25]
NFDI	*"...**valuable data** from science and research are systematically **accessed, networked** and made **usable** in a sustainable and qualitative manner for the entire German science system."* [26]
Mobility Data Space	*"...an **open** data space is now being created which offers **access** to real-time traffic data and sensitive **mobility data** beyond their secure exchange, and which **links existing data** platforms to each other."* [27]
EOSC	*"...provide European researchers, innovators, companies and citizens with a **federated and open** multi-disciplinary environment where they can **publish, find and re-use data, tools and services** for research, innovation and educational purposes."* [28]

Research Questions

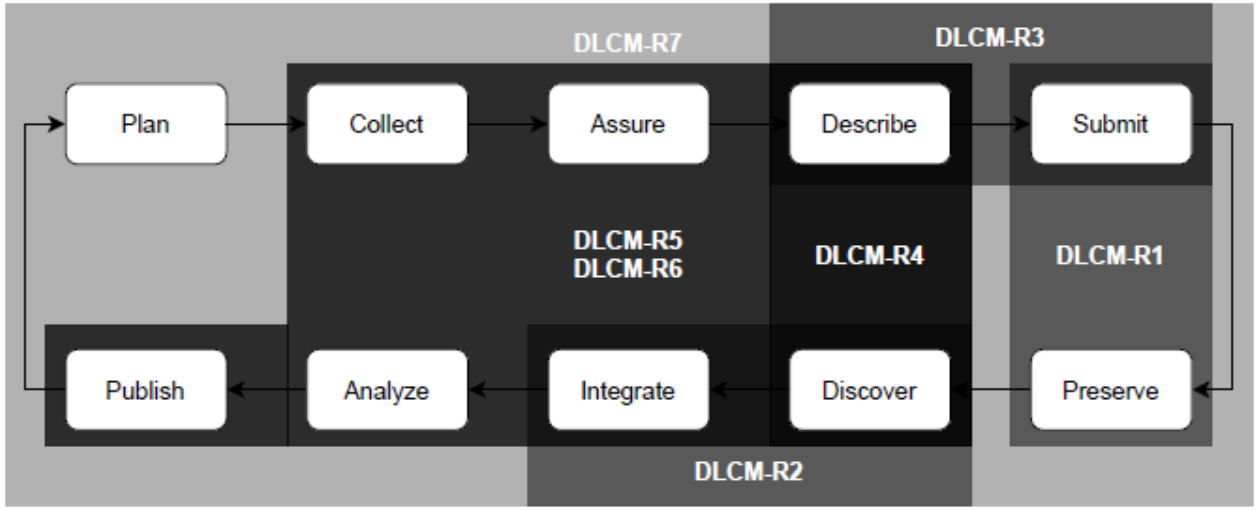
RQ1	**Data lifecycle model for dataspaces?**
RQ2	**Common understanding on general dataspace concepts?**
RQ3	**Data access from heterogeneous sources?**
RQ4	**Valuable reuse of data and knowledge?**

RQ1: Data Lifecycle Model for Dataspaces



DS Initiative	R1	R2	R3	R4	R5	R6	R7
IDSA	++	++	++	++	+	+	++
Gaia-X	++	++	++	++	+	+	++

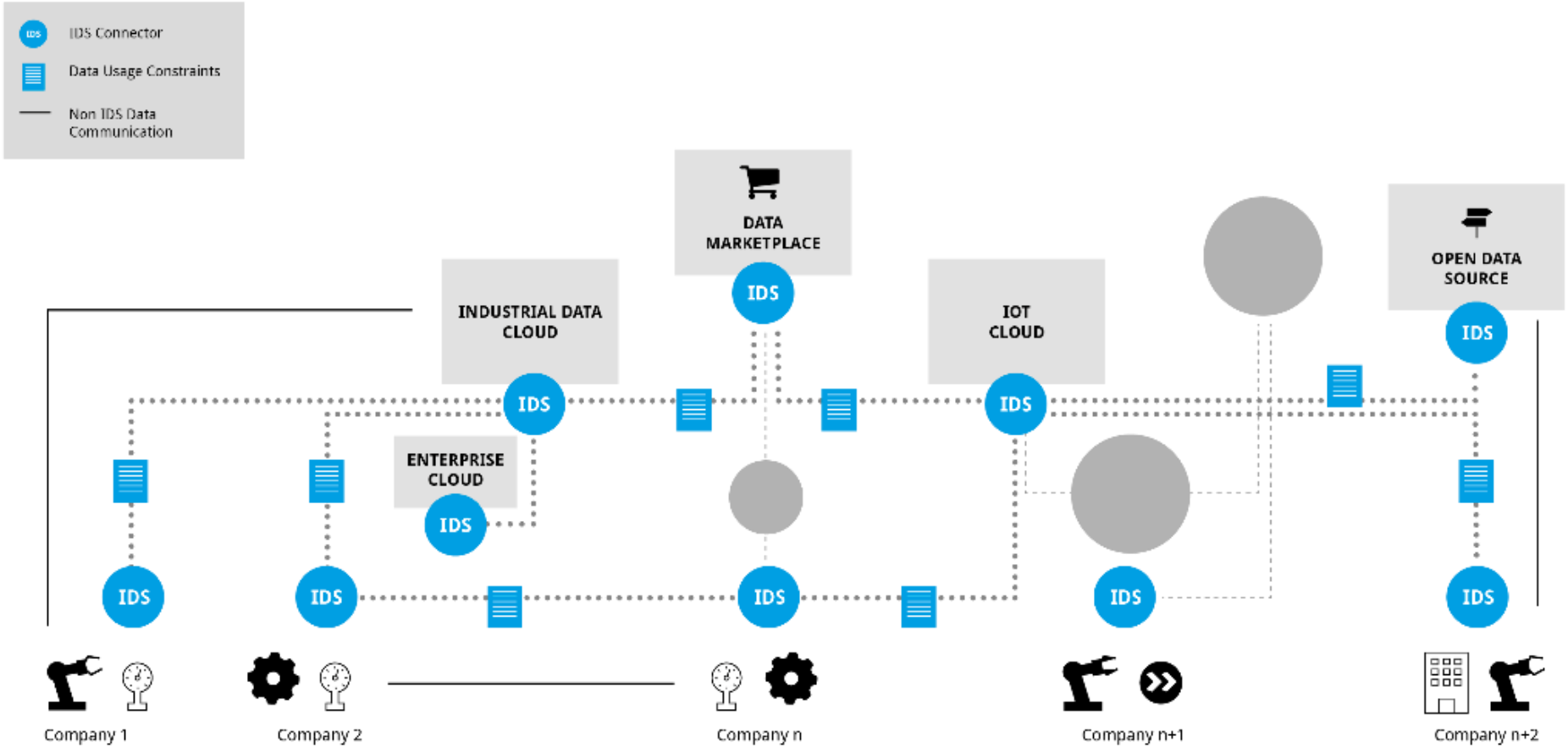
DLCM	R1	R2	R3	R4	R5	R6	R7
ANDS Data Sharing Verbs	x	x	x	x		x	
Data Documentation Initiative			x		x		x
Linked Data Life Cycle			x	x	x	x	x
Capability Maturity Model			x	x	x	x	
DataONE	x		x		x	x	x
Digital Curation Centre	x	x	x		x		x
GFBio	**x**	**x**	**x**		**x**	**x**	**x**
Data Lifecycle for **MSE!** (**MSE!**) Projects		x	x		x		
UK Data Archive		x	x				x
Data Science Institute of Columbia University	x		x				



Julia Pampus,
Fraunhofer ISST

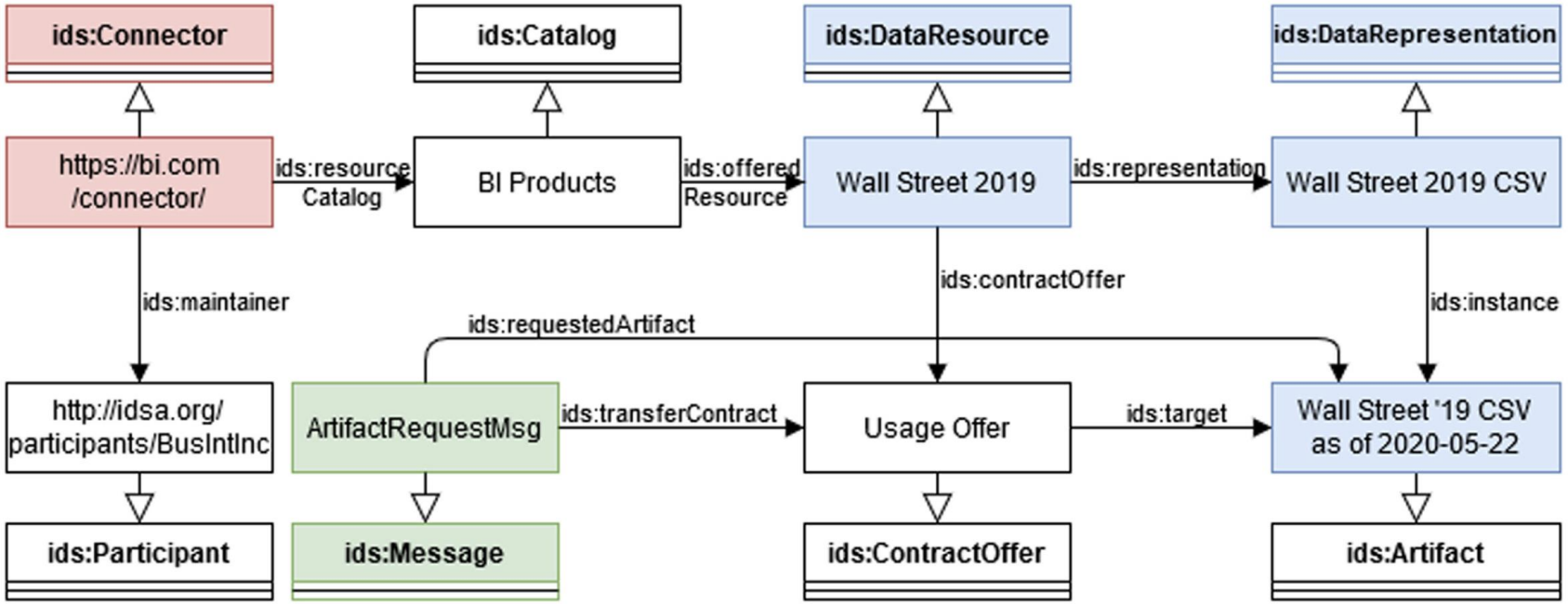
IDSA Dataspace Protocol

Foundation for technical interoperability



IDS Information Model

IDS core classes and their instances in a FinTech example



Since 2022: Substitute ids: with odrl:, dcat:, …

Bader, Sebastian, et al. "The International Data Spaces Information Model – An Ontology for Sovereign Exchange of Digital Content." *International Semantic Web Conference*. Cham: Springer International Publishing, 2020.

Dataspace Efforts in the Wild

Pierre Gronlier, Gaia-X

gaia-x

- To build a Dataspace, we need:
  - A governance which can be operationalised.
  - Infrastructures adopting the governance.
  - Parties adopting the governance, using the infrastructures "*to access and use data in a fair, transparent, proportionate and/non-discriminatory manner with clear and trustworthy data governance mechanisms.*"[1]

- Problems/Opportunities:
  - Sharing data is not new and there are 1000's of existing setups that could qualify as "dataspace"
  - They are not discoverable
  - Governance and infrastructure interoperabilities are hard - if not impossible - to assess
  - Scaling is expensive

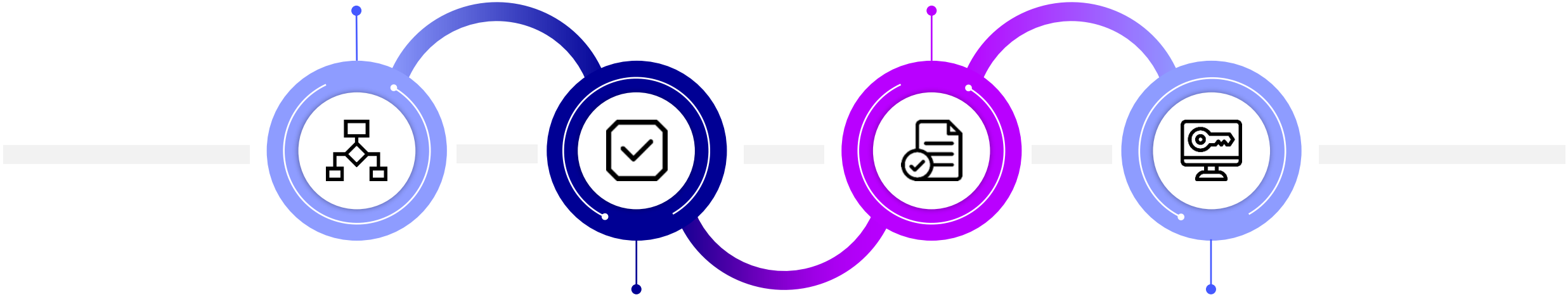
[1]: https://joinup.ec.europa.eu/collection/semic-support-centre/data-spaces

European Strategy For Data

A Common European Data Space, A Single Market For Data

Data can flow within the EU and across sectors

European rules and values are fully respected

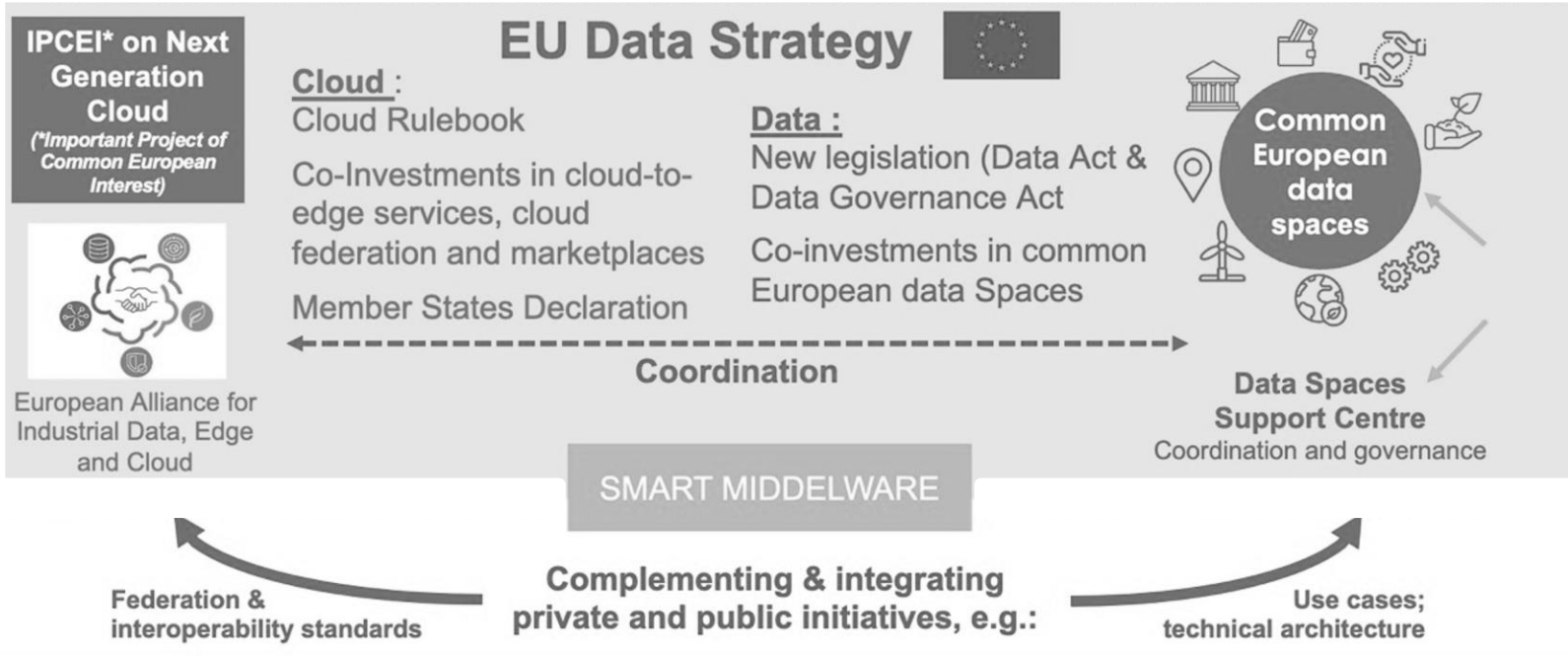


Availability of high-quality data to create and innovate

Rules for access and use of data are fair, practical and clear

Source: European Commission

Gaia-X vs. European Data Strategy



Gaia-X Lighthouse Projects

This is the project with the strongest industry drive. Fraunhofer ISST is involved; IAIS(.EIS) and FIT are in touch. ↓

Not a lighthouse, but of → national significance. Connection between data infrastructures for industry (Gaia-X) and research (NFDI). Coordinated by Fraunhofer FIT

FAIR Data Spaces

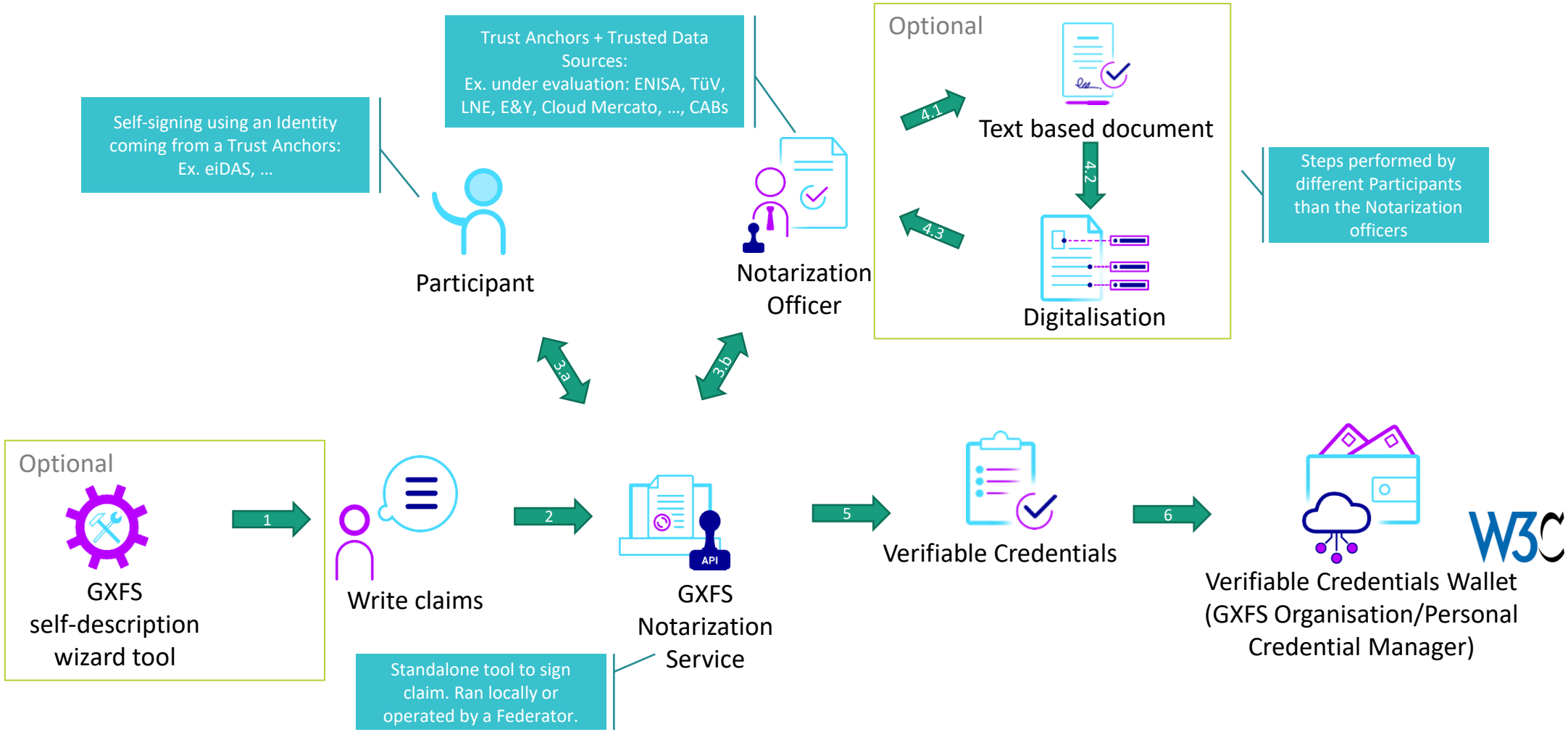
New

agdatahub Agriculture	Catena-X Automotive Network https://catena-x.net/en/ Automotive Supply Chain	market-x ELINOR-X THE URBAN DATA COOPERATIVE Urban Data Cooperative	market-x EONA-X Mobility, Transport & Tourism	market-x omega-x Energy
market-x EuPro Gigant https://euprogigant.com/en/ Manufacturing, Industry 4.0	market-x Mobility Data Space https://mobility-dataspace.eu/ Mobility	smart connected supplier network https://smart-connected.nl/en Electronics Supply Chain	market-x Structura-X https://bit.ly/3aJYgZL Cloud Services	market-x GAIA-X 4 Future Mobility Mobility, Transport

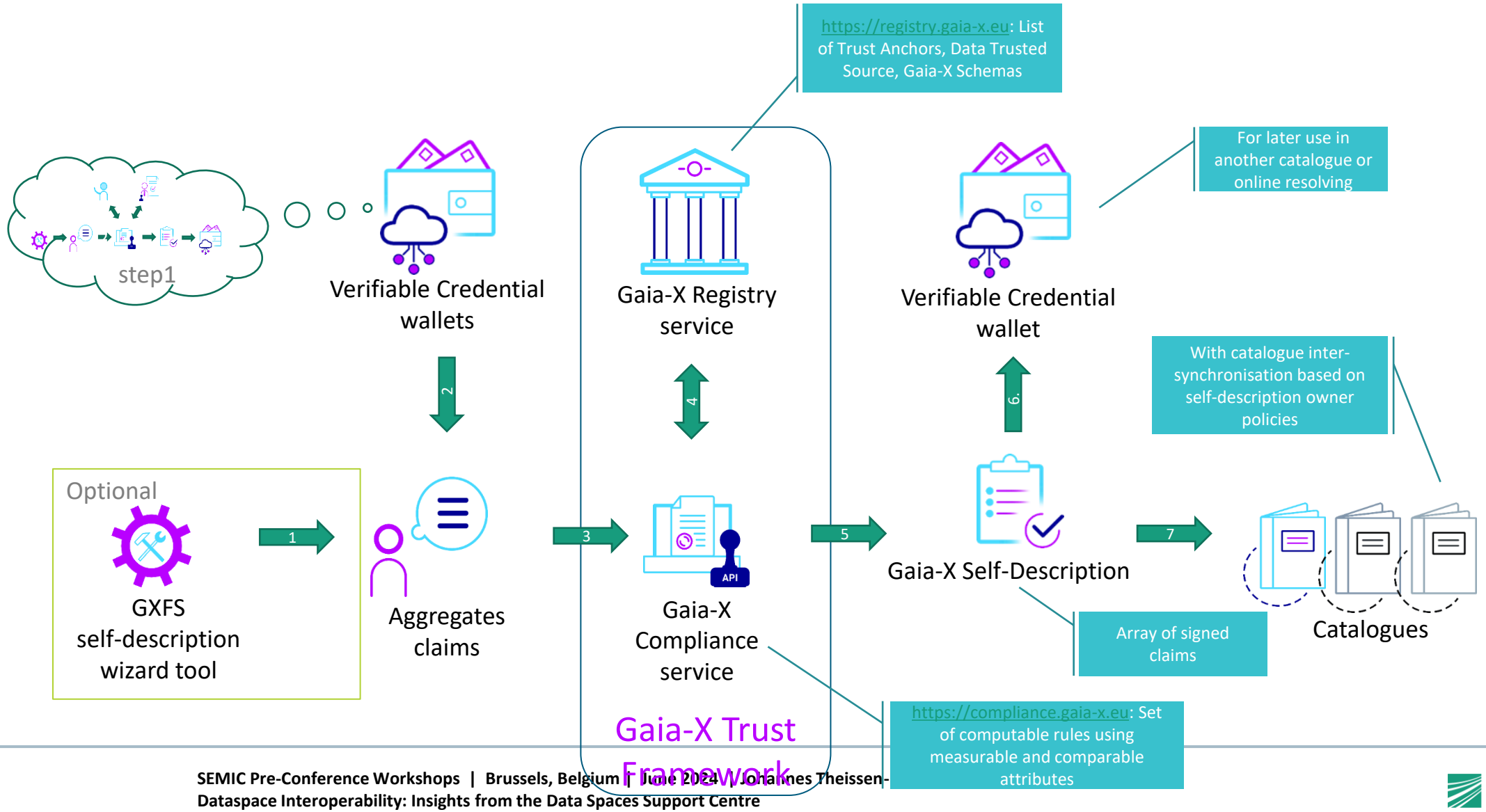
↑ Fraunhofer IAIS and FIT contributed components (but IDS-based, before they evolved towards Gaia-X)

↑ Fraunhofer FIT is in one of the 6 Future Mobility Projects (“Advanced Mobility Services”)

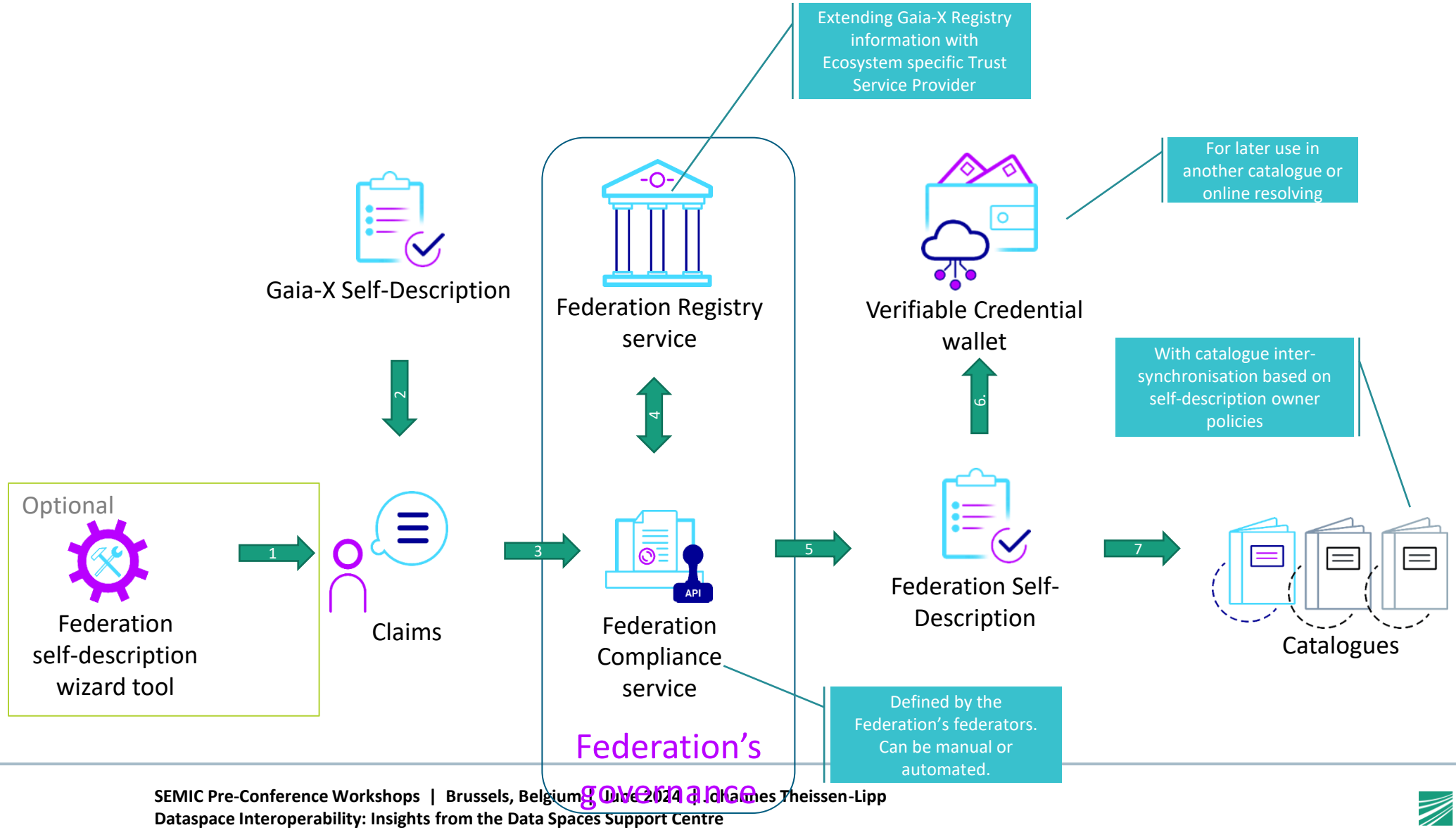
Gaia-X: Trust and Claims



Step 2/3: Create Gaia-X Self-Descriptions

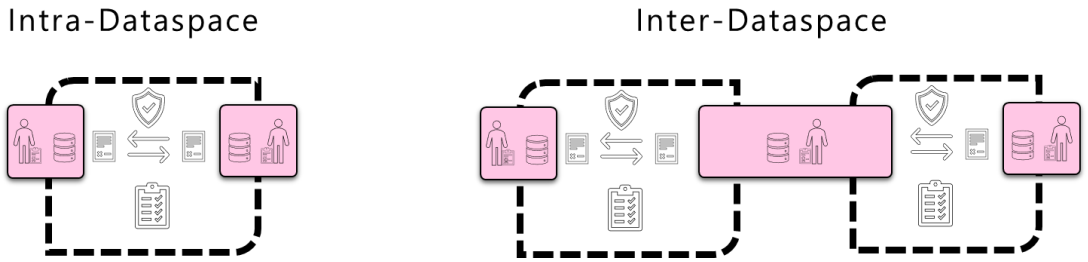


Step 3/3: Federation governance extension



Global Alignment & Interoperability

Peter Koen, Microsoft
Sebastian Steinbuss, IDSA



- ***Intra data space interoperability,*** between the data space authority, processing, and data sharing building blocks within a single data space instance
- ***Inter data space interoperability,*** between multiple data space instances at each of the functional levels

Pierre Gronlier, Gaia-X

The use of an ontology for implementing the governance and the semantic interoperability of the descriptions.

Small technical footprints based on existing open standards to implement the exchange across dataspaces and federations.

Future Directions (1/2)

More areas of life

- Domain vocabularies
- Tool support
- Participant roles

Non-expert users

- Human-centricity
- Convenient interfaces
- Expressiveness & scalability

Global scope

- Inter-dataspace integration
- New legal or social concerns

Future Directions (2/2)

Scalable data exchange

- (Interconnected) data for machine learning

Data sovereignty and control

- Federated and distributed ML models
- Privacy-aware analysis

Stakeholder collaboration

- Science: Research evidence
- Politics: Common values and technical aspects
- Practice: Effective dataspaces for the broad population

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Service Designer

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Matteo
FORTINI
Expert

Dipartimento per la Trasformazione Digitale
Cento | Italy

SCHEMA.GOV.IT Fostering Interoperability Adoption

DIPARTIMENTO
PER LA TRASFORMAZIONE
DIGITALE

SEMIC 2024

schema.gov.it

Fostering semantic interoperability adoption

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Matteo Fortini
Open Source project leader
m.fortini@innovazione.gov.it

26/06/2024

DIPARTIMENTO
PER LA TRASFORMAZIONE
DIGITALE

ITALIAN CASE STUDY ON SEMANTIC INTEROPERABILITY

Increasing the adoption of semantic assets within italian public administrations and beyond

- Achieving adoption of semantic interoperability with design approach
- Beyond documentation: Semantic APIs making data exchanges more understandable

01

Interoperability ecosystem: tools for semantic interoperability **schema.gov.it**

DIPARTIMENTO
PER LA TRASFORMAZIONE
DIGITALE

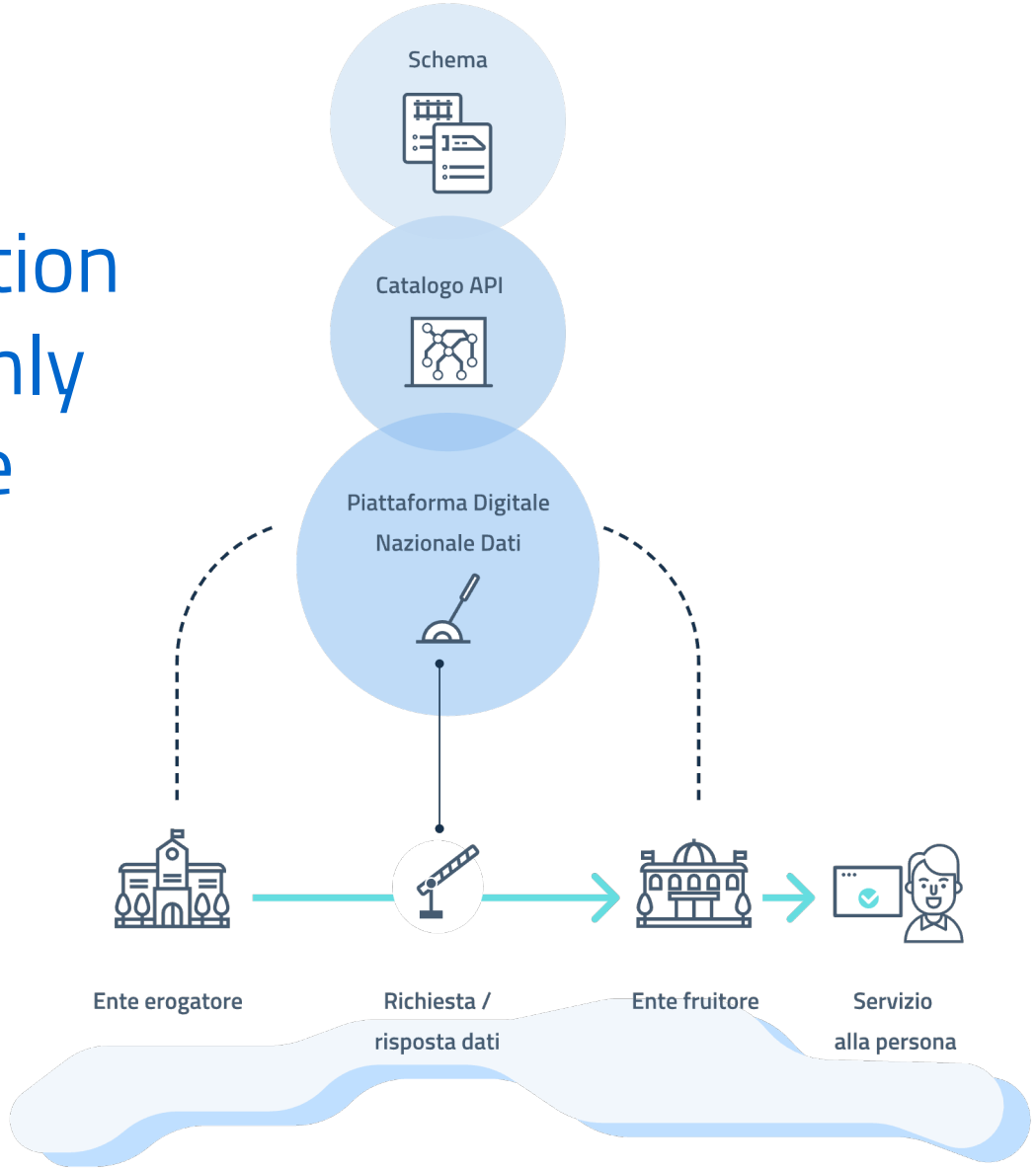
GOAL: ACHIEVING INTEROPERABILTY AMONG PUBLIC ADMINISTRATIONS

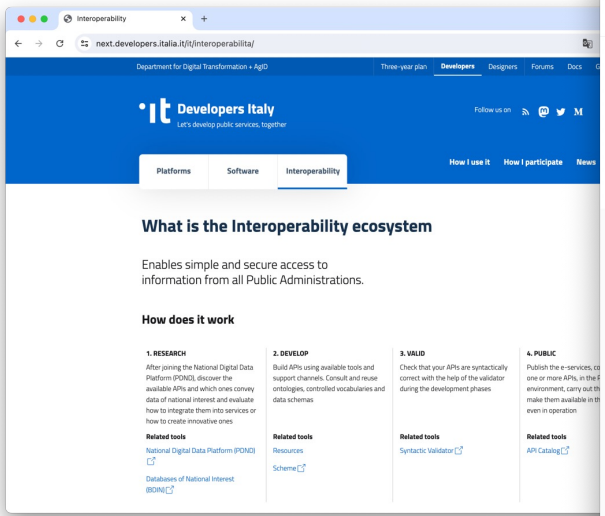
A wider strategy of interoperability

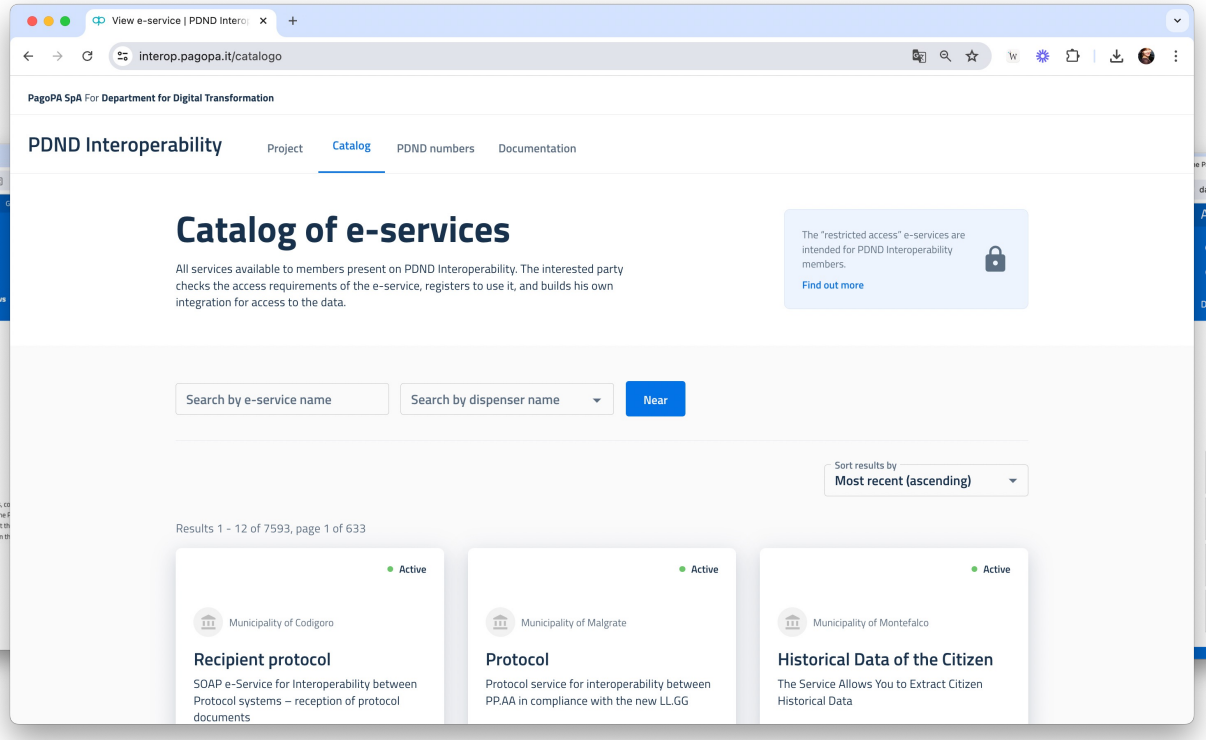
making exchanged data and information interoperable, implement the once only principle, with structured data, stable and unambiguous descriptions.

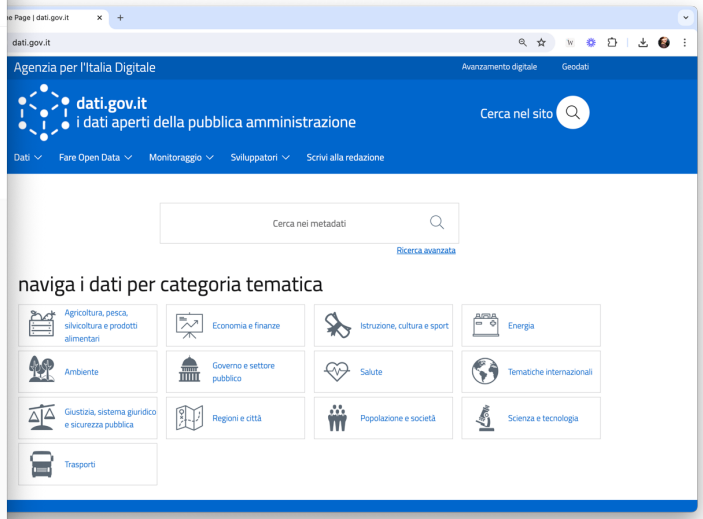
Maximize the value of public sector information through interoperability, enabling simple public services that adhere to the once-only principle.

National Digital Data Platform and National Data Catalog are funded by **Next generation EU**









Developers Italia – Main reference Public Administration software
https://developers.italia.it/

National Digital Data Platform - Italian Interoperability platform https://www.interop.pagopa.it/

Open data catalogue
https://dati.gov.it/

National Data Catalogue

schema.gov.it

Department for digital transformation and Istat

Schema

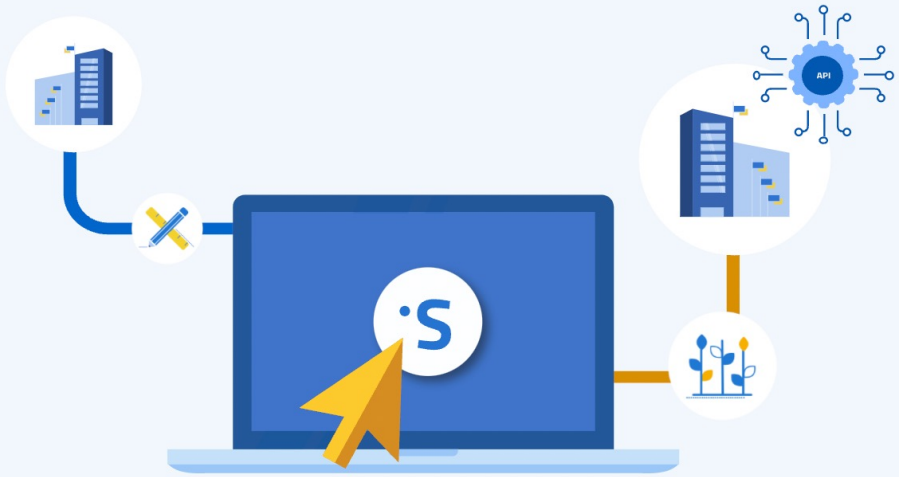
The National Catalog of Data Semantics

Catalog | The initiative | Frequent questions

The national catalog for the exchange of semantic assets between public administrations

Schema is the ever-evolving catalog that harmonizes and standardizes shared data models and ensures that the format and meaning of exchanged information is preserved and understood during exchanges.

Explore the catalogue



Search by keyword

Write one or more keywords here

Search

*Enter keywords, for example "ship types"

TOOLS FOR SEMANTIC INTEROPERABILITY

Schema.gov.it makes semantics assets available to foster (also) the development of semantically and syntactically interoperable APIs

The catalog serves both public and private entities which exchange data and information through the National Digital Data Platform - Italian Interoperability platform. The goal is to ensure that both the format and the meaning of the exchanged information are preserved and understood during exchanges.

Milestone and how it's going

2017

Ontopia repository
AGID

December 2021

~ 80 resources
MVP Phase
Concept and catalogue MVP

Department for digital Transformation, CNR and AGID

June 2022

~ 80 resources
Catalogue is online
Milestone 1 of NRRP

Department for digital Transformation, CNR and AGID
ISTAT - Institute of Statistics

June 2023

~ 100 resources
New resources
+ National Registry and INAIL (work accident) semantic resources

Department for digital Transformation, CNR
ISTAT - Institute of Statistics

April 2024

~ 200 resources
New resources
+ ISPRA (environment), MUR (secondary educ. university), INPS (social security), LEO (livestock)

Department for digital Transformation, CNR
ISTAT - Institute of Statistics

January – December 2024

Infrastucture Consolidation
New functional architecture, functionalities, improved infrastucture, new tools for contributors, improved user experience.

Department for digital Transformation, CNR
ISTAT - Institute of Statistics

December 2026

DIPARTIMENTO PER LA TRASFORMAZIONE DIGITALE

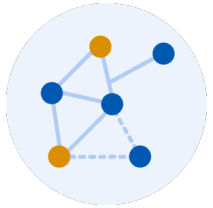
SEMANTIC RESOURCES NUMBERS

up to 21/06/2024

102

Controlled vocabularies

[See Controlled vocabularies >]



60

Ontologies

[See ontologies >]

40

Data schemas

[See data schemas >]

19

Contributors

Public Administrations

VALUE PROPOSITION FOR USERS

Contributors

Public administrations that contribute to the catalog with their own semantic resources and publish APIs on PDND.

- ➔ Making semantic resources available to enhance information value.
- ➔ Ensuring effective and efficient public services and better data quality.
- ➔ Supporting data standardization.

Contributors can also be users at the same time

Users

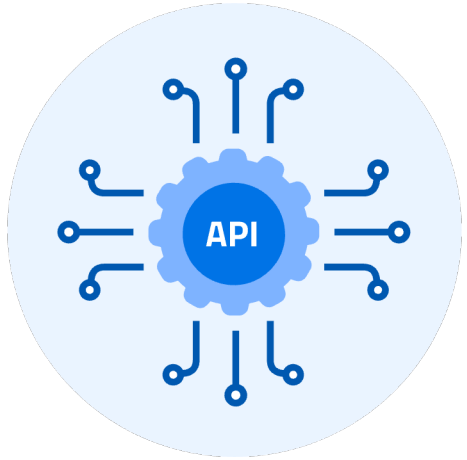
Public administrations that want to use the resources to develop applications and digital public services.
Research institutions to support scientific research.

- ➔ Facilitating the consultation, search, and use of semantic resources.
- ➔ Enabling integration and interoperability between data from different sources and implementing the once-only principle.
- ➔ Facilitating the implementation of data portability (GDPR right).
- ➔ Allowing the use of public information assets for the creation of business models (if private).

Users: Developers

Technicians (in-house, suppliers) who develop and manage the lifecycle of an administration's e-services.

- ➔ Supporting data standardization.
- ➔ Facilitating the development of new information systems.
- ➔ Supporting the definition of e-services for data exchange in the interoperability ecosystem, implementing NDDP and the Single Digital Gateway.



How it works if you develop APIs

01
Identify Resources

Browse and navigate among available semantic assets, that may apply to the context of the application.

What you can do…
Browse, filter, navigate semantic assets

02
Implement the APIs

Create an API aligned with domain semantics using existing concepts, attributes, and controlled vocabularies.
Expand the semantics where necessary.
Ensure that the data can be transformed unambiguously and rigorously from the OpenAPI specification.

03
Verify the APIs

Ensure the APIs are syntactically and semantically (coming soon) correct with the help of checkers, during the development phases.

What you can do…
Use available tools to verify your applications to check conformity.

04
Publish your APIs on NDDP

Publish the e-services, in the NDDP testing environment, conduct tests, and finally make them available on the catalog for operational use.

What you can do…
Share your API aligned with semantic.

ONBOARDING

The catalog is a federated system of semantic resources, **published by contributing entities** in public repositories and gathered through an **harvesting** process.

Model and publish semantic resources
in public repositories following the guidelines.
In Italy, public entities generally have a low level of semantic expertise. Therefore, we provide support services to assist these administrations in modeling and publishing, with our semantic experts handling the resource modeling.

How it works if you wants to contribute

01
Analyze the Resources to be Created/Modified

Assess the resources to be modeled or evaluate potential modifications for resources that are already listed in the catalog.

What you can do…
Browse semantic assets, read the guideline

02
Identify contribution Method

Identify the most suitable contribution method for your specific case, possibly requesting support from semantic experts.

What you can do…
Model resources on your own, following the guidelines or ask for support for modeling.

03
Kick-off Meeting

Contact administrators to formally request to contribute. After contact is made, a kick-off meeting will be organized to evaluate.

What you can do…
Configure repository, adjust modeling, validate metadata before harvesting, perform syntax verification.

04
Harvest semantic Resources

Test and harvest semantic resources, which has as its data sources the repositories of appropriately configured semantic resources. Following their first harvesting, contributors can continuously expand their set of semantic resources.

What you can do…
Publish your resources, and continue improving and expanding semantic assets

02

How we did it

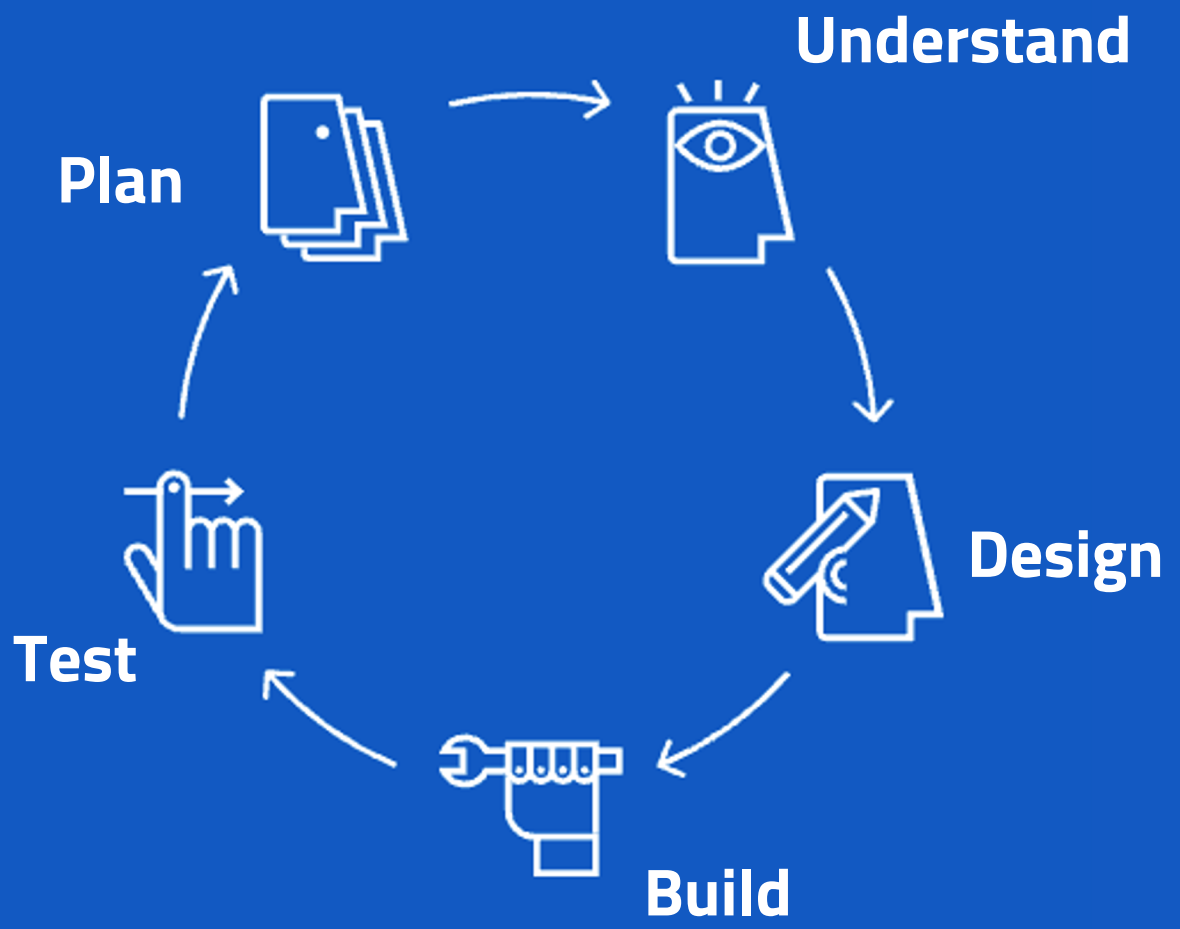
design tools for semantic interoperability and developer experience

DIPARTIMENTO
PER LA TRASFORMAZIONE
DIGITALE

Le linee guida di design per i siti internet e i servizi digitali della PA

https://designers.italia.it/

Designing a simple, accessible, and secure experience for all citizens by applying user experience design principles.

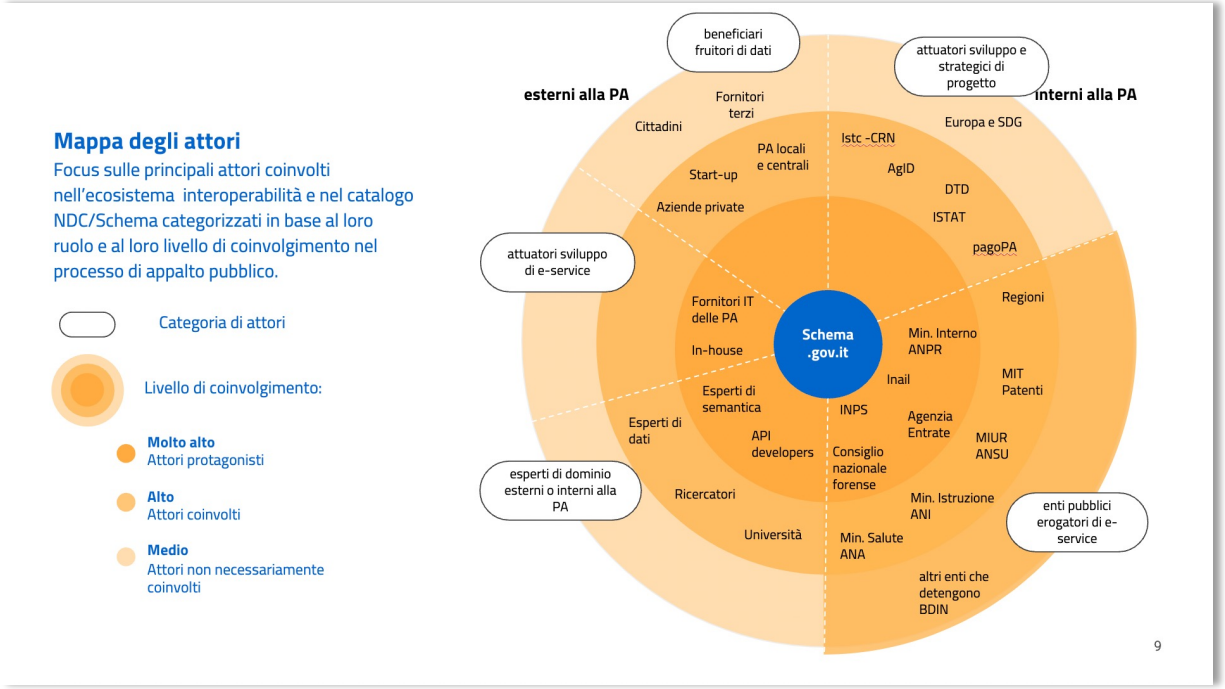


approach: systemic | User centered | Co-designed | iterative

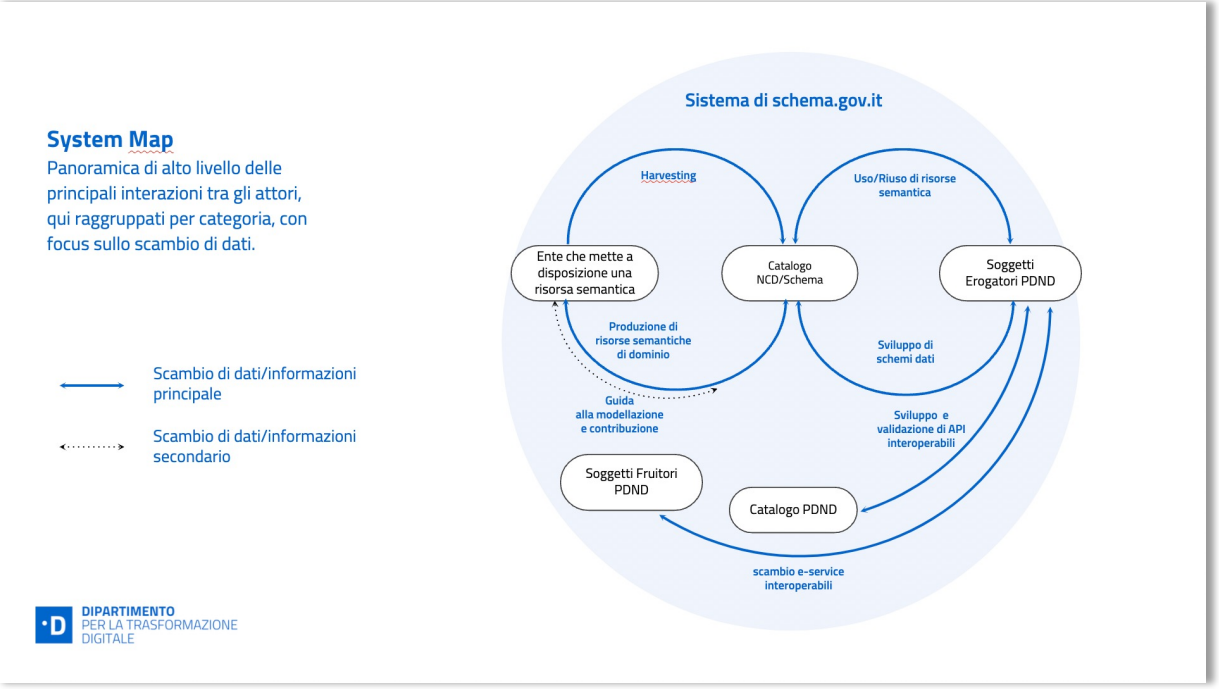
principles: accessibility | transparency | privacy | mobile first | open source

DIPARTIMENTO PER LA TRASFORMAZIONE DIGITALE

Identify your stakeholders and how the system should work



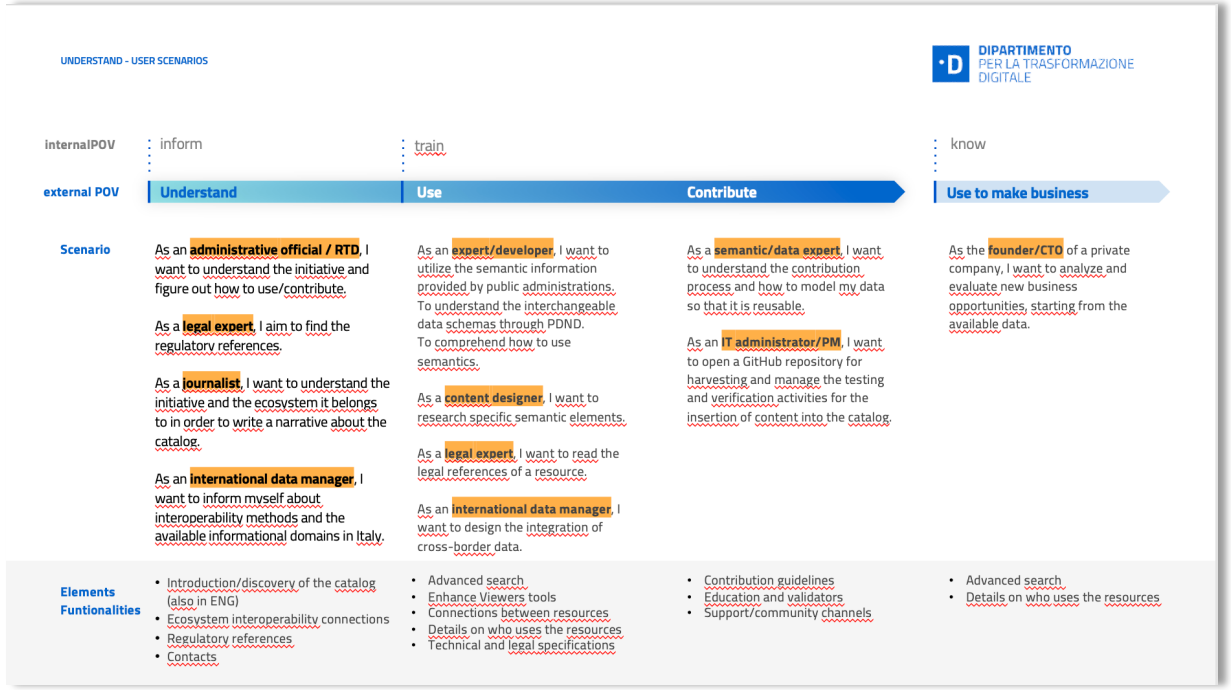
Map your stakeholders and main actors



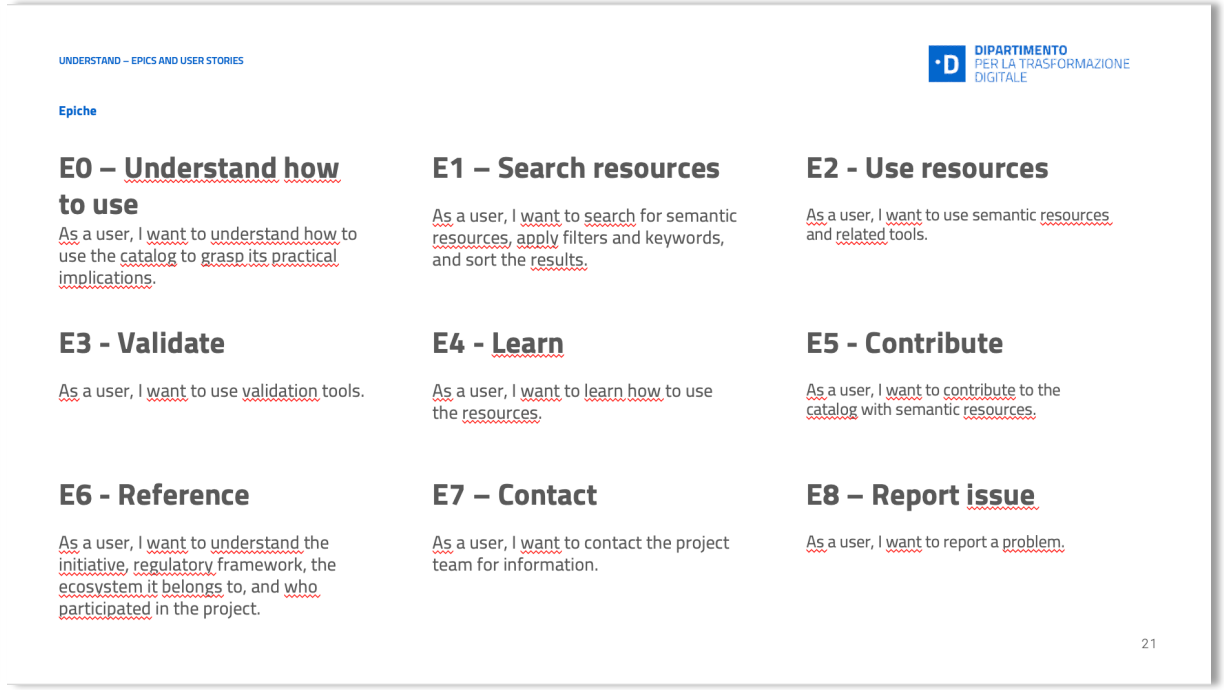
Map how your system should

DIPARTIMENTO PER LA TRASFORMAZIONE DIGITALE

Identify use scenarios based on user needs, build epics and user stories



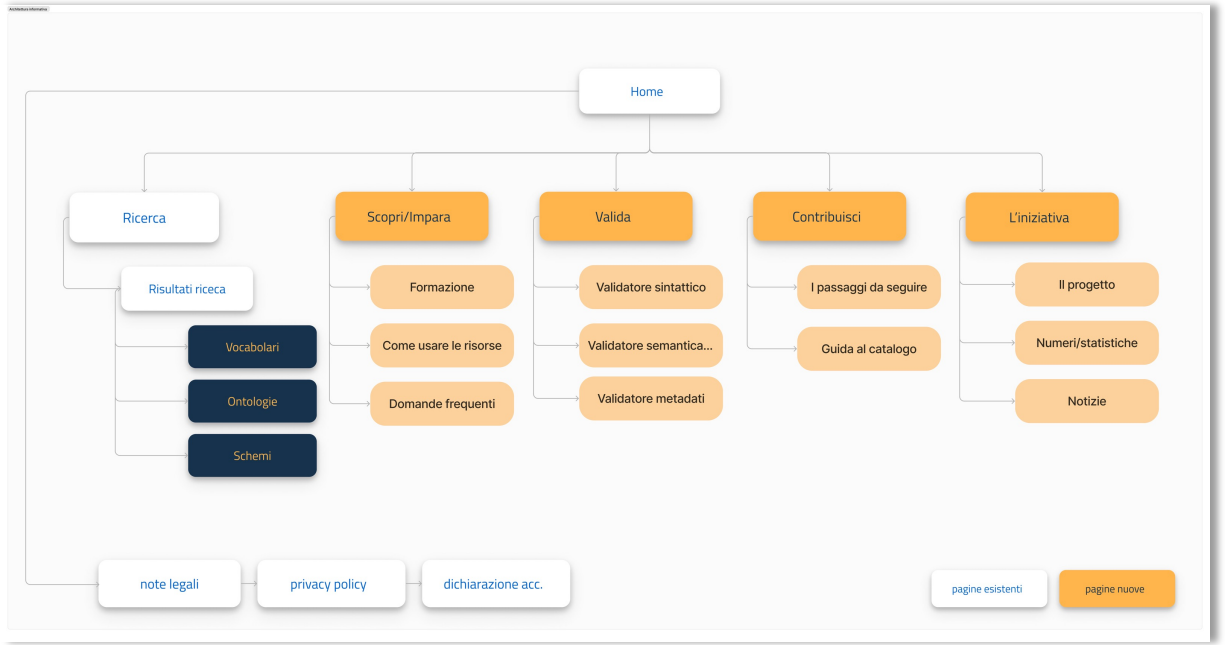
Define how users will interact with your service



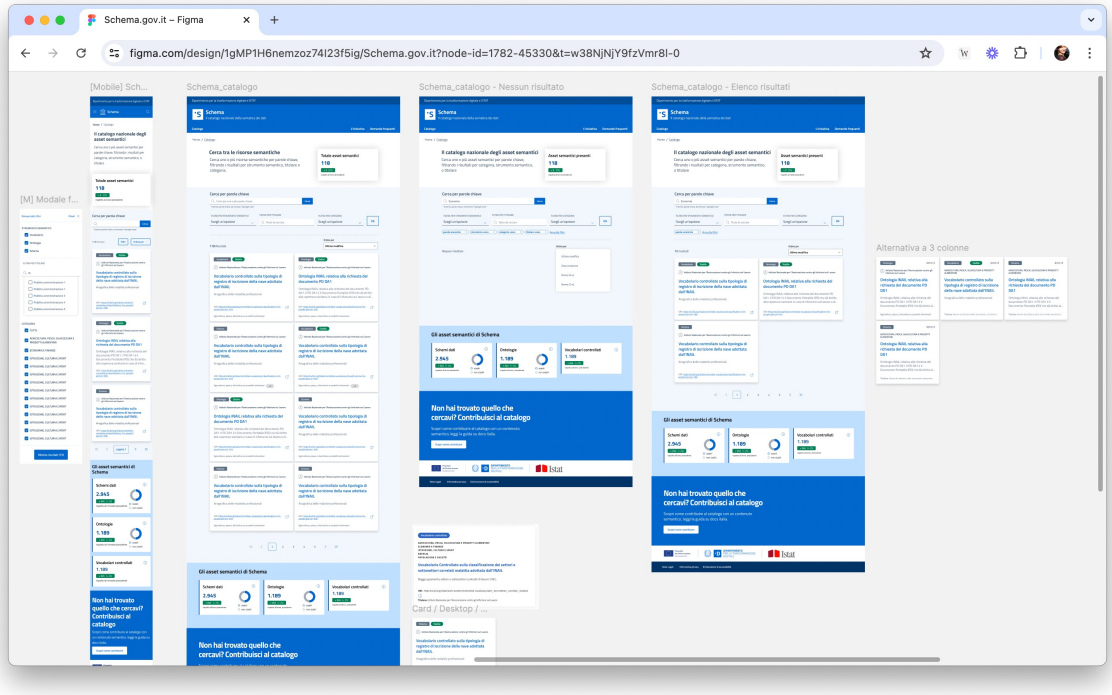
Map how your system should

DIPARTIMENTO PER LA TRASFORMAZIONE DIGITALE

Design information architecture and build prototype to test with users



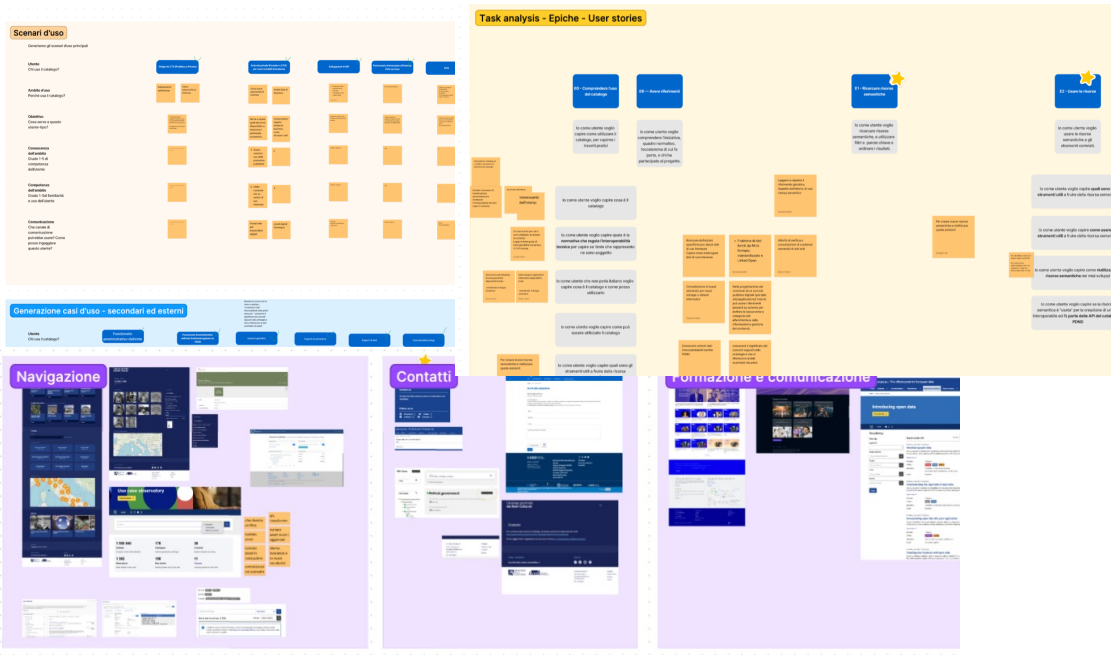
Define Information architecture



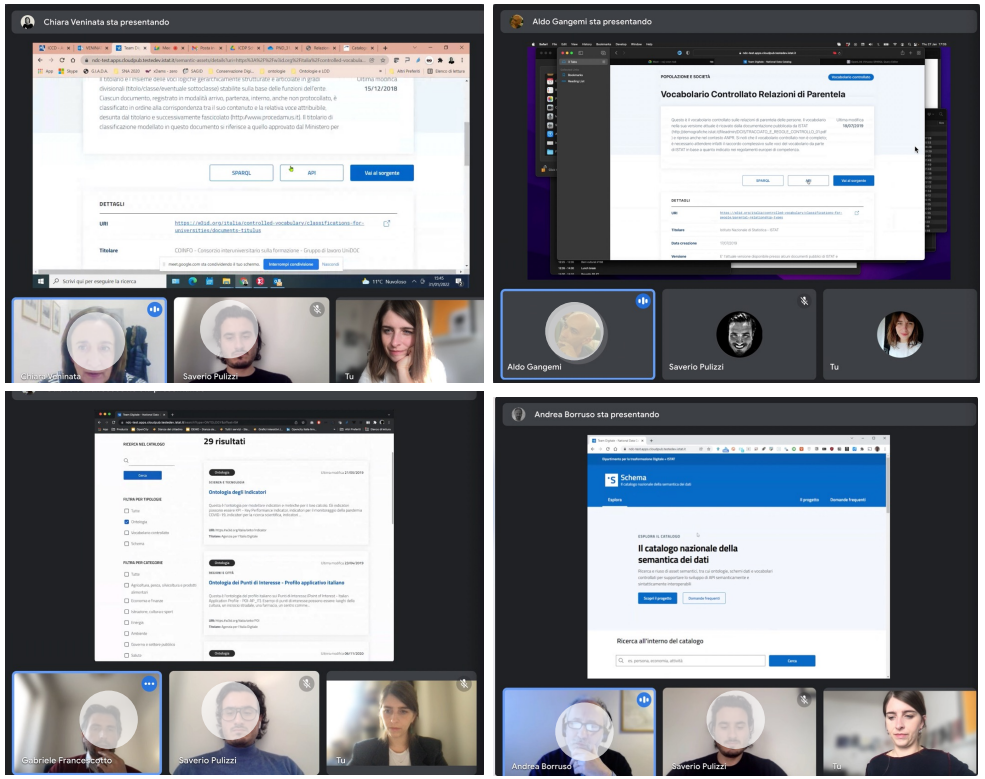
Design prototipe and test it

DIPARTIMENTO PER LA TRASFORMAZIONE DIGITALE

Make it iterative and collaborative, and perform qualitative research



Make it collaborative session, to bring different perspective together



Ask users, perform usability test > 89% if users performed succesfully task

03

Beyond documentation: **Semantic APIs**

Pilot Study on Semantic APIs

Enabling the reuse of semantic resources allows the development of APIs on the NDDP that are semantically and syntactically interoperable.

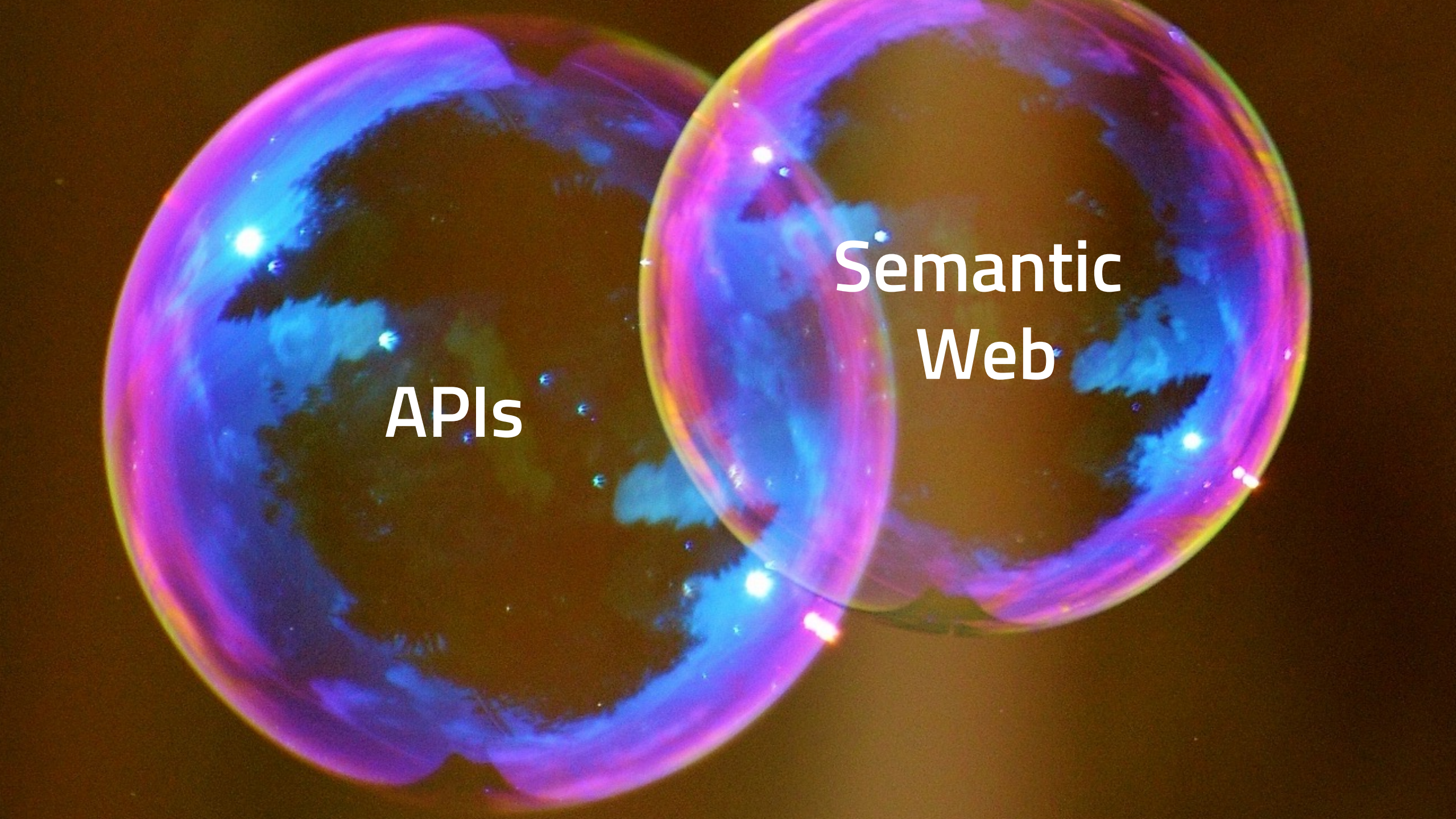
The semantic approach in the definition of data schemas improves the interoperability of APIs and the integration of services.

Goal: publish semantic APIs

Create an API aligned with domain semantics using existing concepts, attributes, and controlled vocabularies, expanding the semantics where necessary, and ensuring that the **data can be transformed unambiguously and rigorously from the OpenAPI specification.**

Proposal: connecting syntax to semantics with OAS

Use ontologies to describe the problem and OAS to define the solution (data schemas, operations, input, and output). **Design the schemas based on the domain knowledge of the ontologies and add ontological references for machine-readable semantics.**


APIs
Semantic
Web

Publish a Semantic API

Develop APIs which build upon their data domain semantics

- ❑ using existing concepts and controlled vocabularies in the semantics
- ❑ expanding semantics where needed
- ❑ exchanging data which can be consistently transformed to its linked data counterpart by using its OpenAPI specification

JSON-LD is the natural semantic extension of JSON:

- It contains the original JSON
- It adds **context**, which can be specified separately
- It adds object **types**
- It adds object **ids**, or IRIs, which enable dataset interoperability

DIPARTIMENTO PER LA TRASFORMAZIONE DIGITALE

JSON: simple, terse, efficient, eco (146 Bytes)

```
{
 "nome":"Mario",
 "cognome":"Rossi",
 "comune_nascita":"Roma",
 "CF":"RSSMRA75L01H501A",
 "data_nascita":"1975-12-01",
 "email":"mariorossi75@miaemail.it"
}
```

Same information content

- For APIs we want to maximize the variable parts over costant ones
- The corresponding JSON-LD adds costant elements with context to intepret data correctly

Development

- Start from an existing JSON, then map it to its JSON-LD counterpart
- Start from JSON-LD, then remove constant parts and useless nesting

JSON-LD: semantic, linked, complete (708 Bytes – 4,85x)

```
{
  "@context": {
    "CPV": "https://w3id.org/italia/onto/CPV/",
    "SM": "https://w3id.org/italia/onto/SM/",
    "nome": "CPV:givenName",
    "cognome": "CPV:familyName",
    "CF": "CPV:taxCode",
    "data_nascita": "CPV:birthDate",
    "comune_nascita": {
      "@type": "@id",
      "@id": "CPV:hasBirthPlace",
      "@context": {
        "@base": "https://w3id.org/italia/controlled-vocabulary/territorial-
classifications/cities/"
      }
    },
    "email": "SM:emailAddress"
  },
  "@type": "CPV:Person",
  "@id": "https://w3id.org/italia/data/CPV/Person/taxCode/RSSMRA75L01H501A",
  "nome": "Mario",
  "cognome": "Rossi",
  "comune_nascita": "Roma",
  "CF": "RSSMRA75L01H501A",
  "data_nascita": "1975-12-01",
  "SM:hasContactPoint": {
    "SM:hasOnlineContactPoint": {
      "SM:hasEmail": {
        "@type": "SM:Email",
        "@id": "https://w3id.org/italia/data/SM/Email/emailAddress/mariorossi75@miaemail.it",
        "email": "mariorossi75@miaemail.it"
      }
    }
  }
}
```

DATA INTEROPERABILITY

JSON to JSON-LD conversion

- ❑ Restructure JSON data so that it defines objects with proper nesting as defined in the ontology
- ❑ Define "@context"
- ❑ Map JSON elements to corresponding ontology concepts or controlled vocabularies
- ❑ Define objects' "@type"
- ❑ Define objects' "@id"

@id-s are important

Defining universal @id-s for objects allows consistent references from any data source.
An @id is an IRI which will contain the **minimum number of elements** that can identify a single object. In E-R terms, we're looking for the primary key of the concepts table.

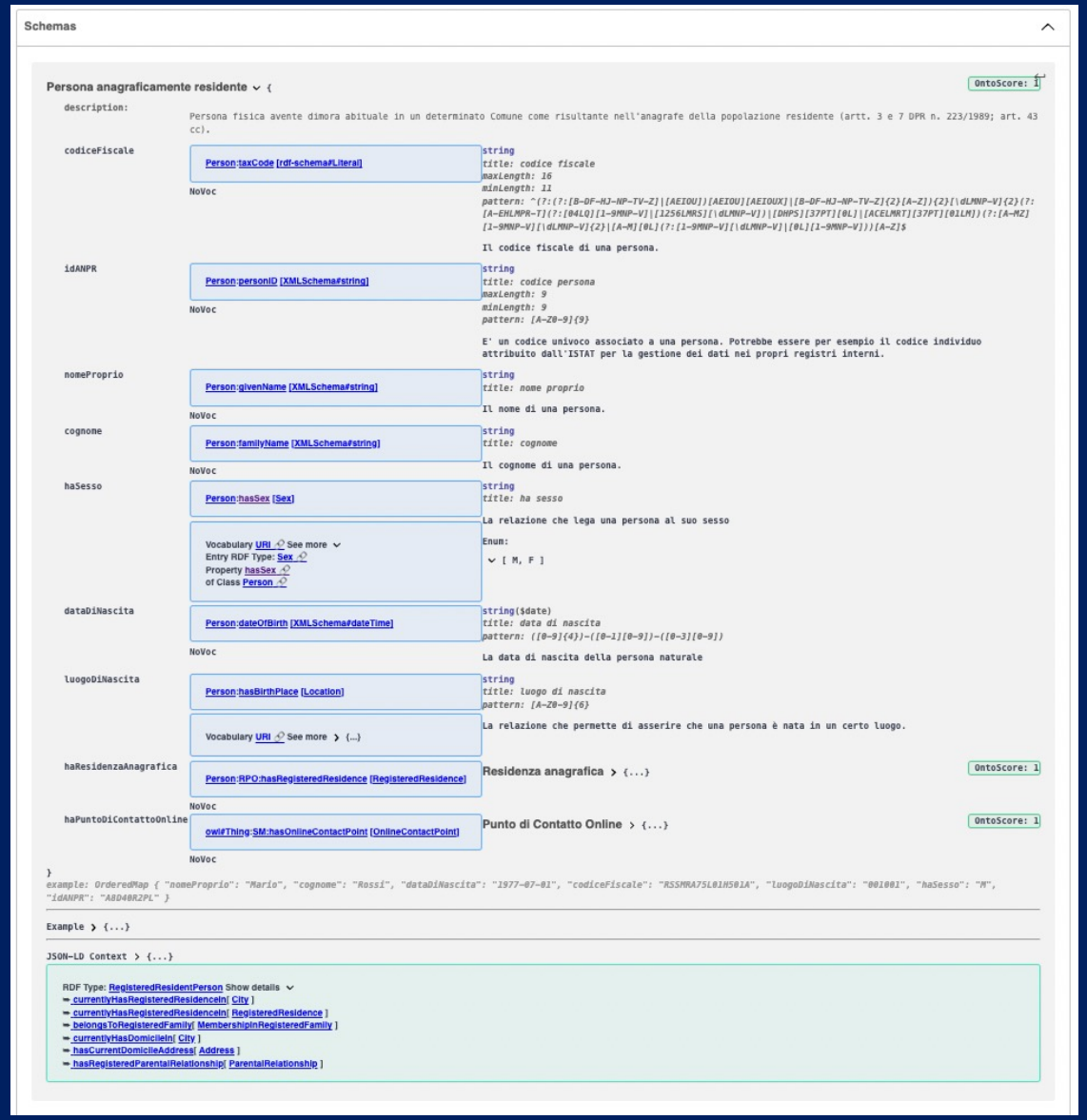
OAS EXTENSION

Semantic extension to OpenAPI specification (proposal)

The proposal involves adding custom extended fields to schema definitions in the OAS:

- "**x-jsonld-context**" will specify the "@context" that will be applied to an object. This can be used: to link each field to its corresponding attribute in the ontology or to expand a controlled vocabulary element to its IRI
- "**x-jsonld-type**" allows to add a "@type" to an object

```yaml
title: Persona anagraficamente residente
  description: |
   Persona fisica avente dimora abituale in un determinato Comune
   come risultante nell'anagrafe della popolazione residente (artt. 3 e 7 DPR n. 223/1989; art. 43 cc).
  type: object
  x-jsonld-type: "https://w3id.org/italia/onto/RPO/RegisteredResidentPerson"
  x-jsonld-context:
    "@vocab": "https://w3id.org/italia/onto/CPV/"
    RPO: https://w3id.org/italia/onto/RPO/
    SM: https://w3id.org/italia/onto/SM/
    codiceFiscale: "taxCode"
    idANPR: "personID"
    nomeProprio: "givenName"
    cognome: "familyName"
    haSesso:
      "@id": hasSex
      "@type": "@id"
      "@context":
        "@base": "https://w3id.org/italia/controlled-vocabulary/classifications-for-people/sex/"
    dataDiNascita: dateOfBirth
    luogoDiNascita:
      "@id": hasBirthPlace
      "@idtype": "@id"
      "@context":
        "@base": "https://w3id.org/italia/controlled-vocabulary/territorial-classifications/cities"
    haResidenzaAnagrafica: "RPO:hasRegisteredResidence"
    haPuntoDiContattoOnline: "SM:hasOnlineContactPoint"
  properties:
    codiceFiscale:
[…]
```



☞ We want to attract and engage a wide range of contributors from public entities, beyond just law enforcement, to enhance the catalog's usefulness for users.

☞ We want to effectively engage developers in the semantic domain, to develop semantically interoperable APIs, and make the documentation easy to understand.

Ciao, grazie!

Know more

https://schema.gov.it

Start searching

RTFM

DIPARTIMENTO
PER LA TRASFORMAZIONE
DIGITALE

María
POVEDA-VILLALÓN
Associate Professor

Universidad Politécnica de Madrid
Torrejón de Ardoz | Spain

Reusing Ontologies: current practices and challenges

Reusing Ontologies: current practices and challenges

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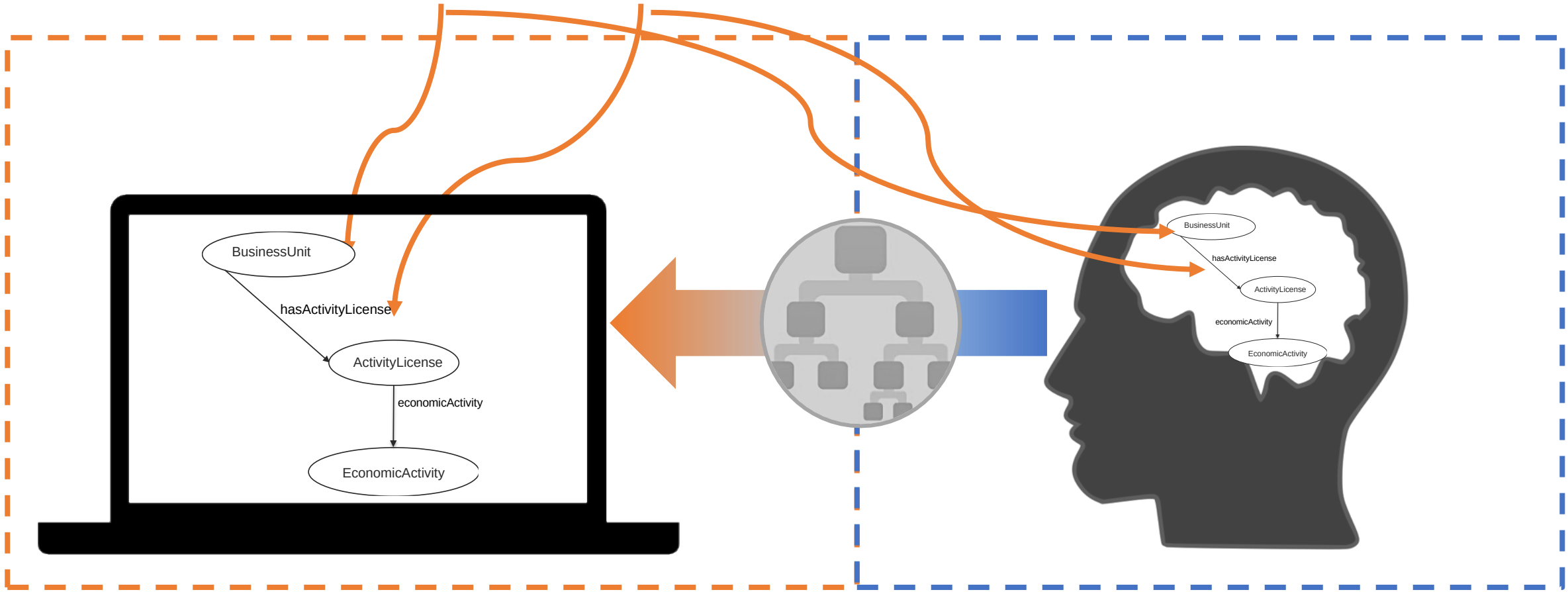
26/06/2024 SEMIC, Brussels

The AURORAL project receives funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement No. 101016854.

(https://www.w3.org/standards/semanticweb/ontology)

A vocabulary defines the **concepts** and **relations** used to describe and represent a **domain** of interest



- Increase interoperability
- Reduce development time & resources

Within organizations (e.g. OEG)

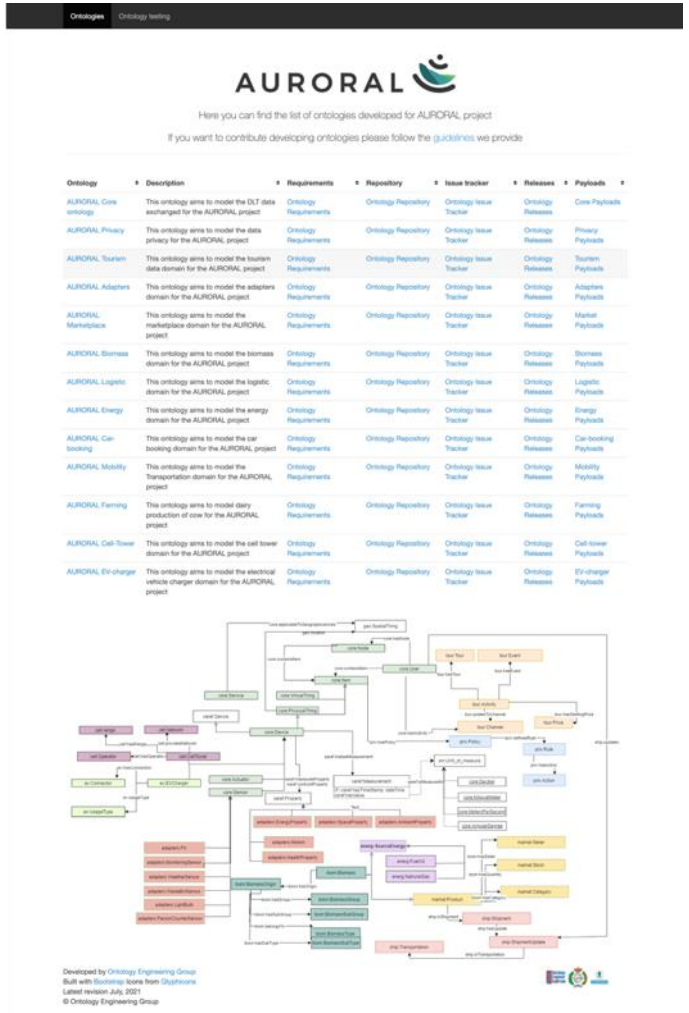
AURORAL COGITO

BIMERR RENOVATION 4.0

DELTA

VICINITY 2020

CIUDADES ABIERTAS



Specific portals per project, organization

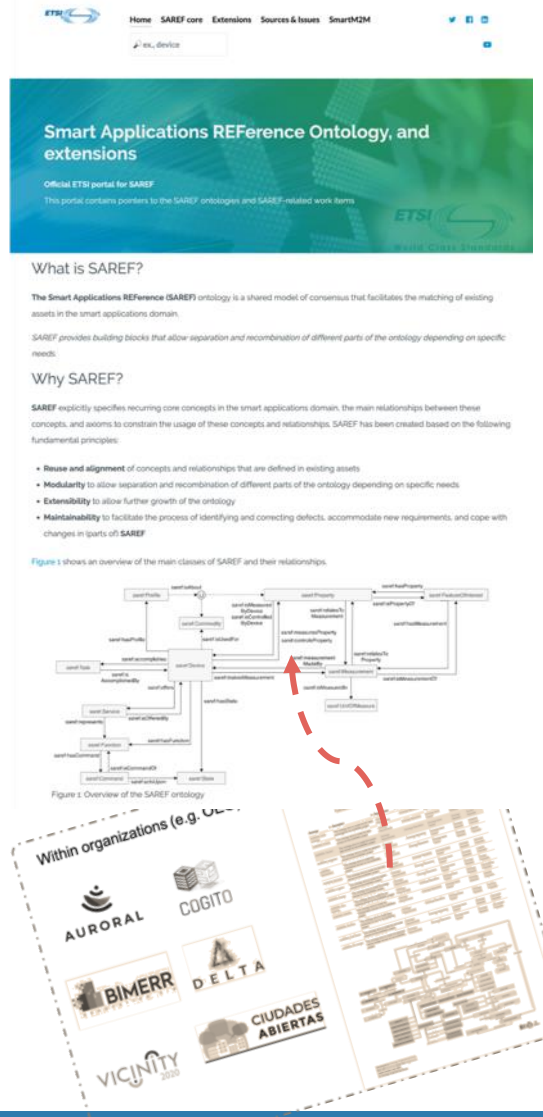
joinup

OGC® Making location count.

W3C Word Wide Web Consortium

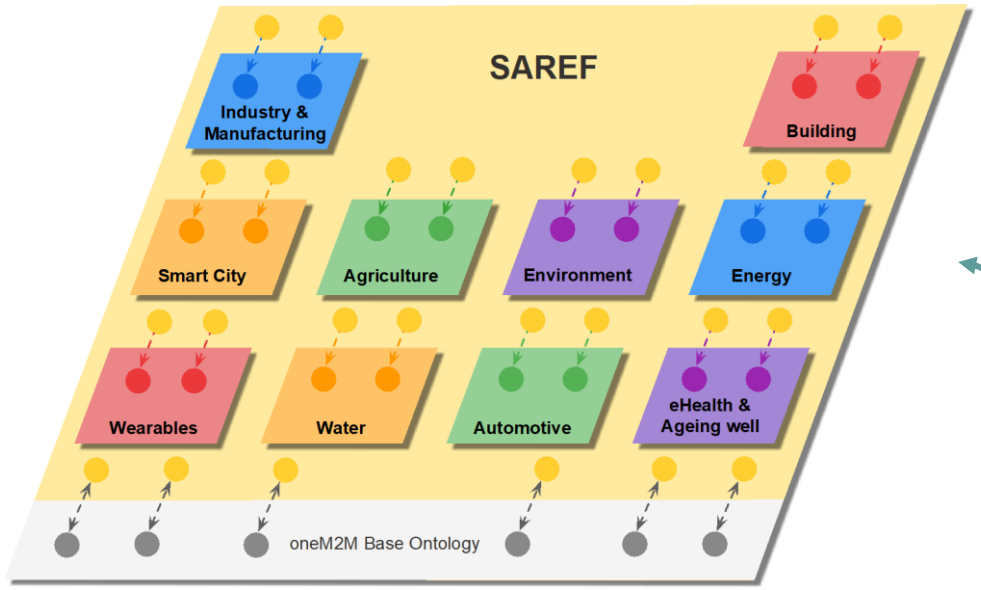
ETSI

- Increase interoperability
- Reduce development time & resources



Within standardization bodies

ETSI



joinup

ISO

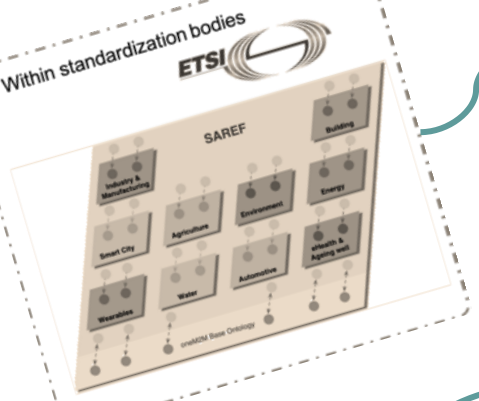
W3C
Word Wide Web Consortium

FIWARE

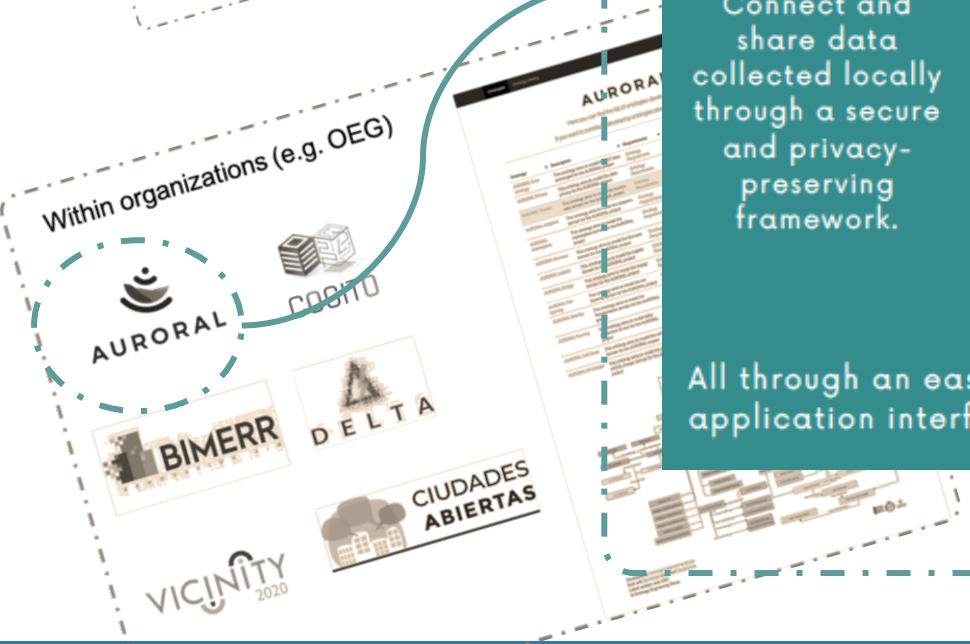
OGC®
Making location count.

- Increase interoperability
- Reduce development time & resources

Within standardization bodies



Within organizations (e.g. OEG)



Within community efforts / Open Calls

Connect and share data collected locally through a secure and privacy-preserving framework.

Engage with external technology and application providers in exploiting their data by offering advanced horizontal services.

Participate in digital marketplaces as commodities services and platforms.

All through an easy-to-implement interoperable way and open application interfaces (APIs) based on open standards.

AURORAL

Open Calls

joinup

ISO

W3C Word Wide Web Consortium

FIWARE

OGC® Making location count.

How – We need to publish the vocabularies to be reused

w3.org/TR/swbp-vocab-pub/

W3C Working Group Note

W3C

Best Practice Recipes for Publishing RDF Vocabularies

W3C Working Group Note 28 August 2008

This version:
http://www.w3.org/TR/2008/NOTE-swbp-vocab-pub-20080828/
Latest version:
http://www.w3.org/TR/swbp-vocab-pub/

W3C Style

Cool URIs don't change

What makes a cool URI?
A cool URI is one which does not change.
What sorts of URI change?
URIs don't change: people change them.

There are no reasons at all in theory for people to change URIs (or stop maintaining documents), but millions of reasons in practice.

In theory, the domain name space owner owns the domain name space and therefore all URIs in it. Except insolvency, nothing prevents the domain name owner from keeping the name. And in theory the URI space under your domain name is totally under your control, so you can make it as stable as you like. Pretty much the only good reason for a document to disappear from the Web is that the company which owned the domain name went out of business or can no longer afford to keep the server running. Then why are there so many dangling links in the world? Part of it is just lack of forethought. Here are some reasons you hear out there:

We just reorganized our website to make it better.

https://www.w3.org/Provider/Style/URI

https://arxiv.org/pdf/2003.13084

Best Practices for Implementing FAIR Vocabularies and Ontologies on the Web

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María Poveda-Villalón[2][0000−0003−3587−0367]

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dgarijo@isi.edu
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mpoveda@fi.upm.es

Abstract. With the adoption of Semantic Web technologies, an increasing number of vocabularies and ontologies have been developed in different domains, ranging from Biology to Agronomy or Geosciences. However, many of these ontologies are still difficult to find, access and understand by researchers due to a lack of documentation, URI resolving issues, versioning problems, etc. In this chapter we describe guidelin and best practices for creating accessible, understandable and reusab ontologies on the Web, using standard practices and pointing to exi ing tools and frameworks developed by the Semantic Web communi We illustrate our guidelines with concrete examples, in order to h researchers implement these practices in their future vocabularies.

Keywords: Ontology metadata · Ontology publication · Ontology a cess · FAIR principles · Linked Data principles.

1 Introduction

In the last decade, a series of initiatives for open data, transparency a science have led to the development of a myriad of datasets and linke

Permanent Identifiers for the Web

Secure, permanent URLs for your Web application that will stand the test of time.

Content

- Purpose
- Management
- System Operations
- **Creating a New Identifier**
- Naming Policy
- W3ID Community
- Disclaimer

Purpose

The purpose of this website is to provide a secure, permanent URL re-direction service for Web applications. This service is run by the W3C Permanent Identifier Community Group.

Web applications that deal with Linked Data often need to specify and use URLs that are very stable. They utilize services such as this one to ensure that applications using their URLs will always be re-directed to a working website. This website operates like a switchboard, connecting requests for information with the true location of the information on the Web. The switchboard can be reconfigured to point to a new location if the old location stops working.

Management

A growing group of organizations have pledged responsibility as a consortium to ensure the operation of this website. These organizations are:

https://w3id.org/

Ontology

https://ontology.linkeddata.es/

- **Increase interoperability**
  - **Soft reuse (link to URIs (names))**
- Reduce development time & resources

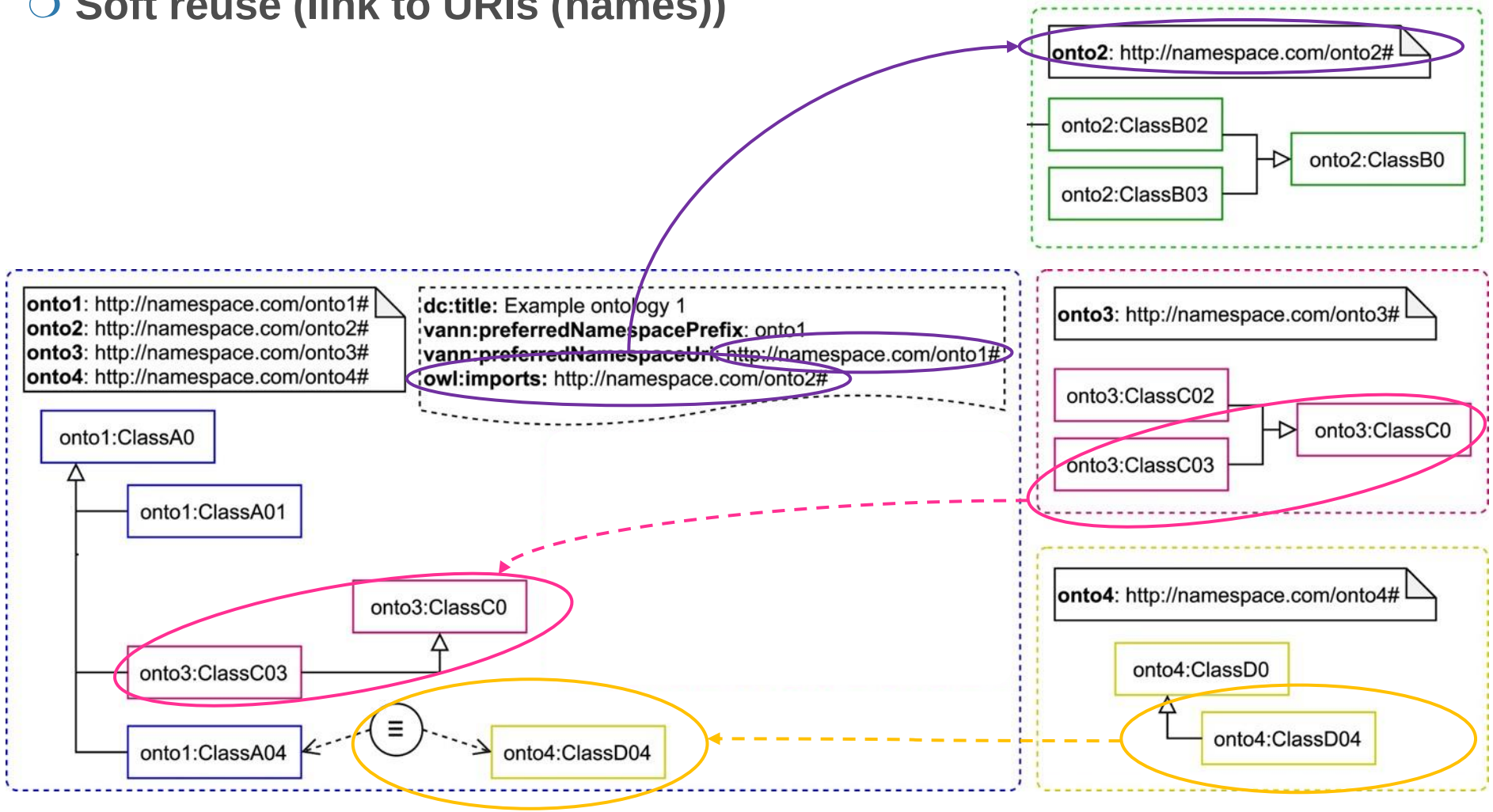


Image taken from “Poveda-Villalón, M., Fernández-Izquierdo, A., Fernández-López, M., & García-Castro, R. (2022). LOT: An industrial oriented ontology engineering framework. Engineering Applications of Artificial Intelligence, 111, 104755.” DOI: https://doi.org/10.1016/j.engappai.2022.104755

- **Increase interoperability**
  - Soft reuse (link to URIs (names))
  - **Hard reuse (import whole ontology)**
- Reduce development time & resources

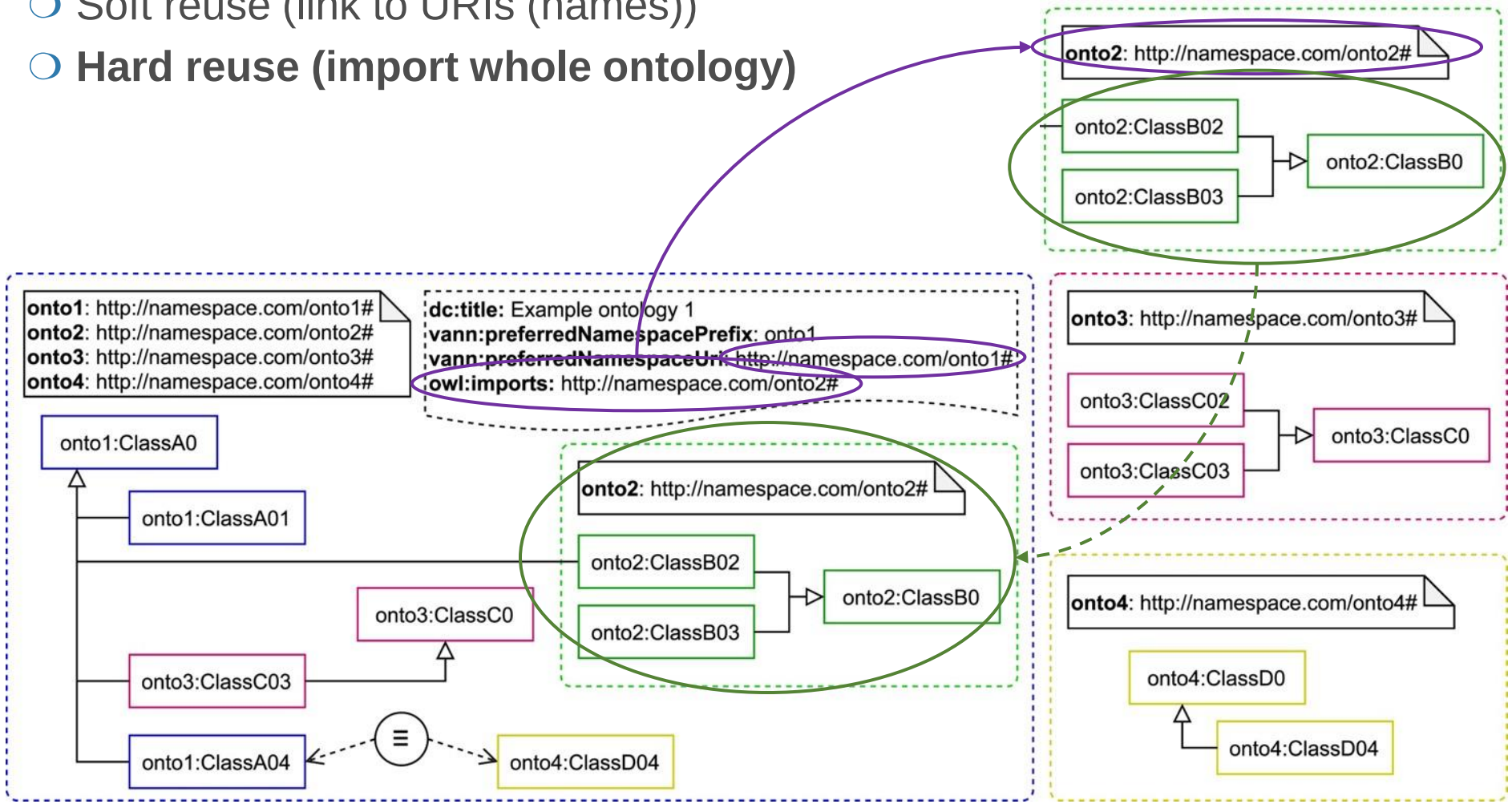


Image taken from “Poveda-Villalón, M., Fernández-Izquierdo, A., Fernández-López, M., & García-Castro, R. (2022). LOT: An industrial oriented ontology engineering framework. Engineering Applications of Artificial Intelligence, 111, 104755.” DOI: https://doi.org/10.1016/j.engappai.2022.104755

- Increase interoperability
- Reduce development time & resources

Hard reuse
(import whole ontology)

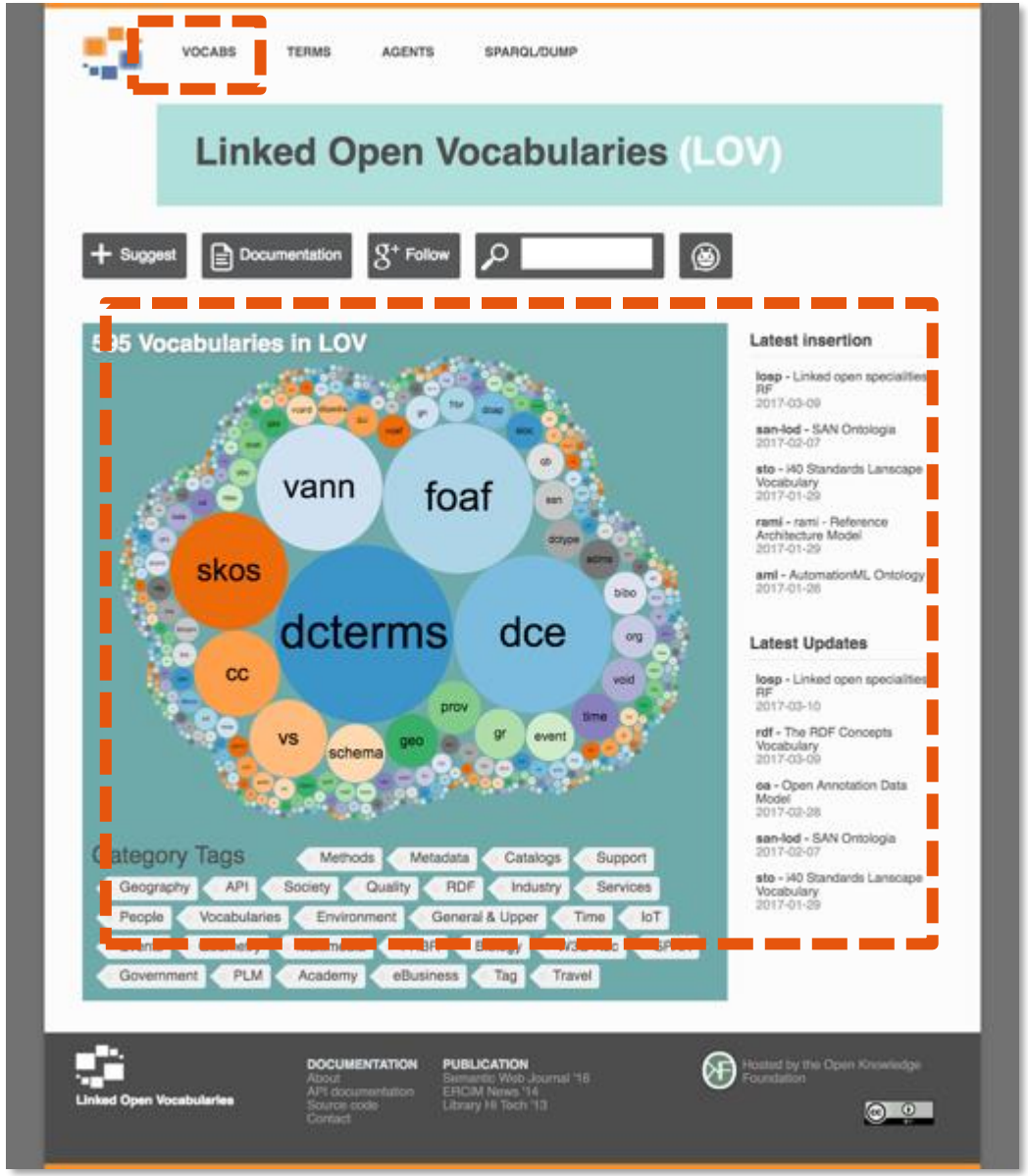
- **Import** ontologies available in the Web
- Everything declared/modeled in the imported ontology is included in your ontology
  - **Strong commitment**
- Extend the ontology if needed: define new concepts, relations, restrictions or specialization to fulfil the requirements
- If the original ontology changes one is not notified → Use version URIs

Soft reuse
(link to URIs (names))

- Declare classes and properties
  - **Weak commitment**
- Establish equivalences / subclass of
- Restrict the original definitions
- Specialize the original definitions
- If the original ontology disappears one wouldn't notice

- **Mission: promote and facilitate the reuse of well documented vocabularies in the Linked Data ecosystem**

- Vocabularies registry and index
  - http://lov.linkeddata.es/
- Datalift (original project)
  - http://datalift.org/
- Started at 2011
- Hosted by OEG



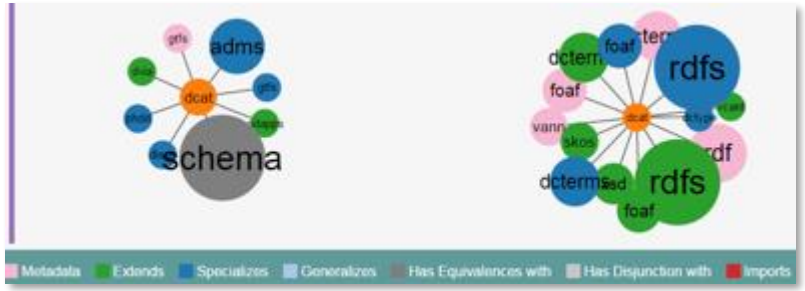
Data Catalog Vocabulary (dcat)

Metadata

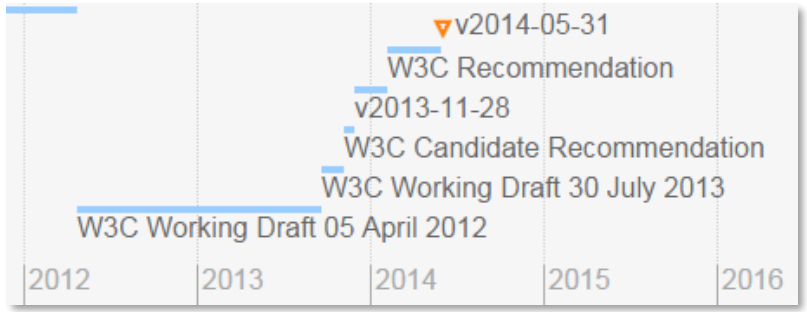
URI	http://www.w3.org/ns/dcat
Namespace	http://www.w3.org/ns/dcat#
homepage	http://www.w3.org/TR/vocab-dcat/
Description	DCAT is an RDF vocabulary designed to facilitate interoperability between data catalogs published on the Web @en
Language	Arabic ar, Greek el, English en, Spanish es, French fr, Japanese ja
Contributor	Richard Cyganiak http://google.com/+RichardCyganiak; Phil Archer https://plus.google.com/103670676337547906055; Fadi Maali

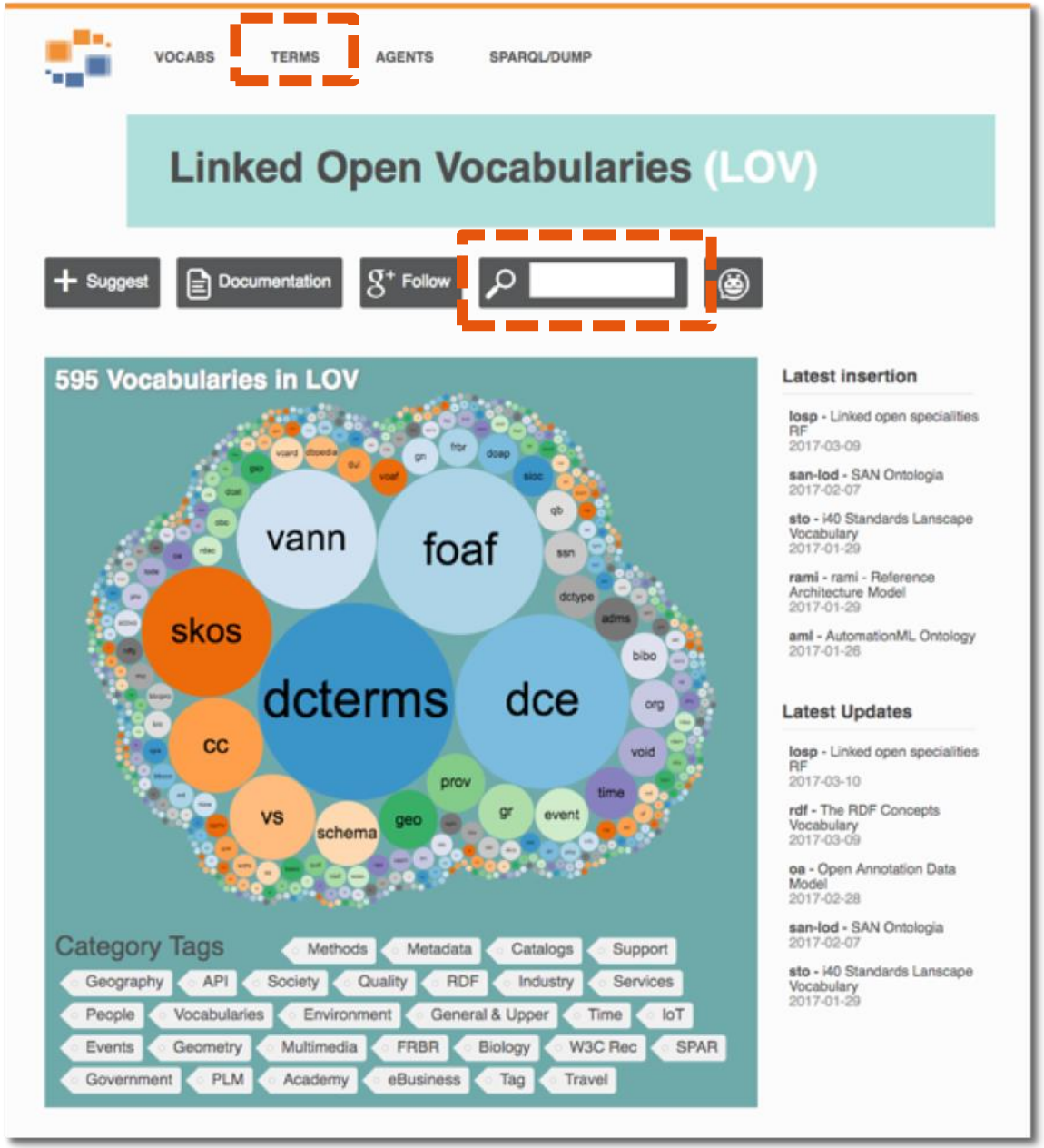
Connection with other applications

Relationships

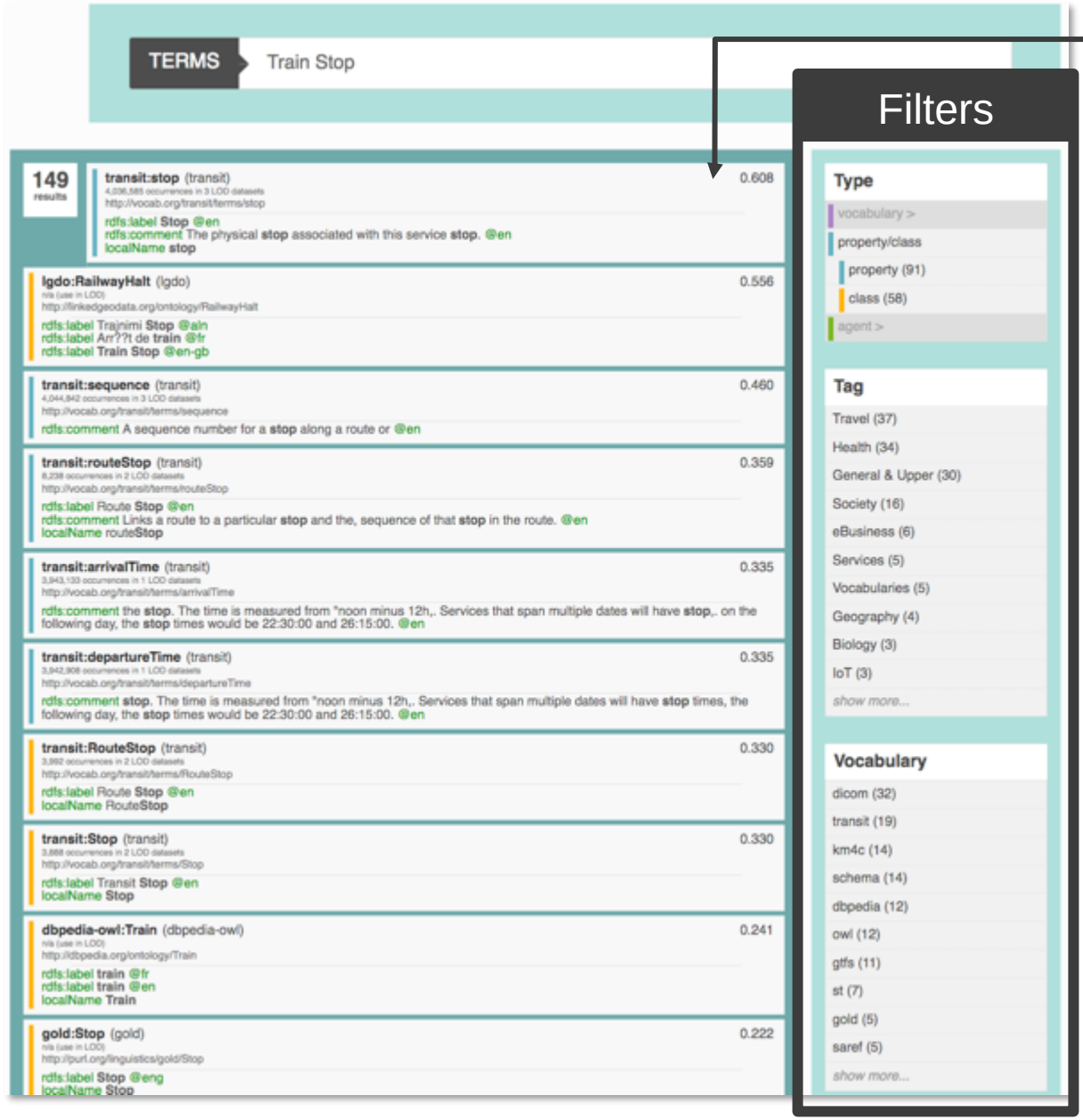


Versions




VOCABS
TERMS
AGENTS
SPARQL/DUMP
Linked Open Vocabularies (LOV)
Suggest
Documentation
Follow
595 Vocabularies in LOV
vann
foaf
skos
dcterms
dce
cc
vs
schema
geo
prov
gr
event
time
void
org
bibo
dctype
adms
ssn
qb
sioc
doap
Latest insertion
losp - Linked open specialities RF
2017-03-09
san-lod - SAN Ontologia
2017-02-07
sto - i40 Standards Lanscape Vocabulary
2017-01-29
rami - rami - Reference Architecture Model
2017-01-29
ami - AutomationML Ontology
2017-01-26
Latest Updates
losp - Linked open specialities RF
2017-03-10
rdf - The RDF Concepts Vocabulary
2017-03-09
oa - Open Annotation Data Model
2017-02-28
san-lod - SAN Ontologia
2017-02-07
sto - i40 Standards Lanscape Vocabulary
2017-01-29
Category Tags
Methods
Metadata
Catalogs
Support
Geography
API
Society
Quality
RDF
Industry
Services
People
Vocabularies
Environment
General & Upper
Time
IoT
Events
Geometry
Multimedia
FRBR
Biology
W3C Rec
SPAR
Government
PLM
Academy
eBusiness
Tag
Travel

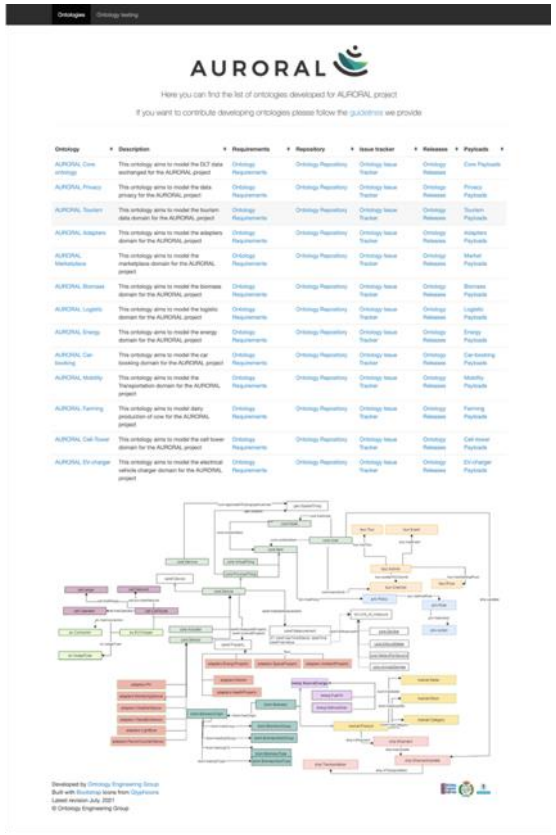
Search terms

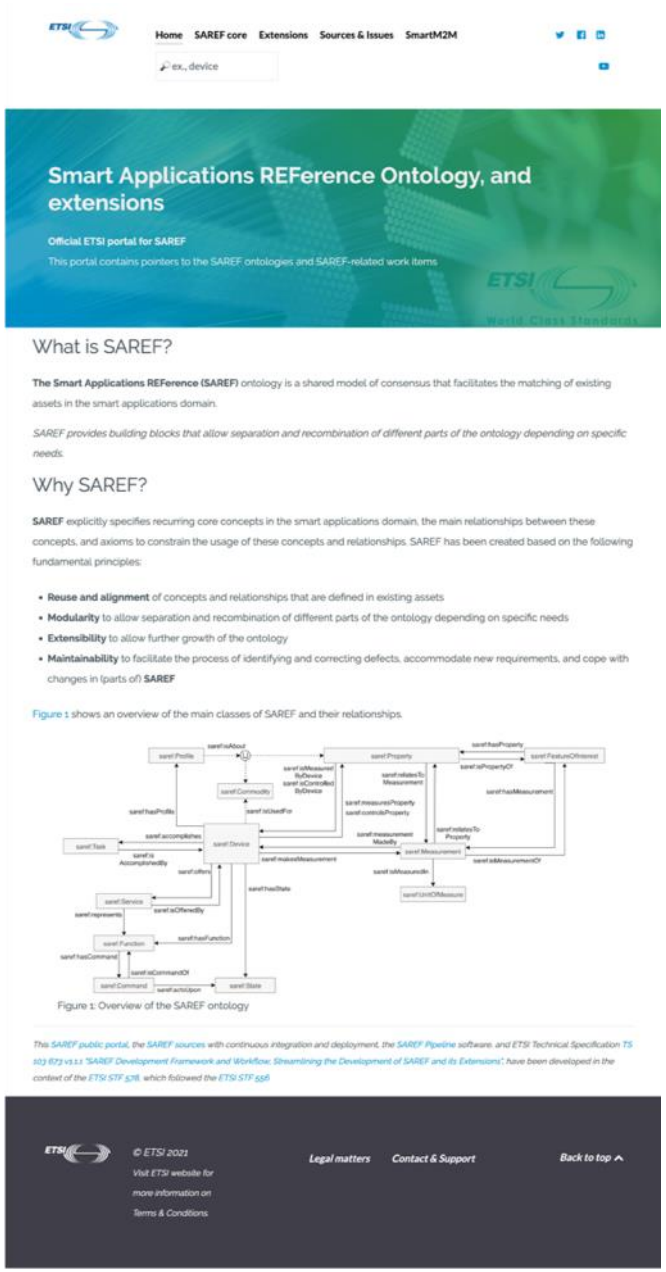


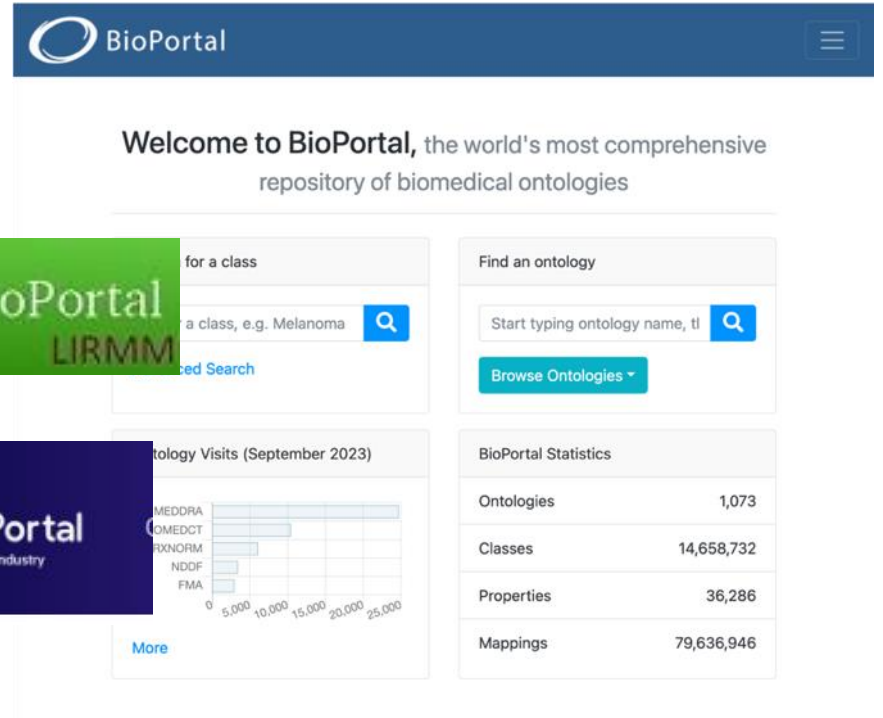
Ranked

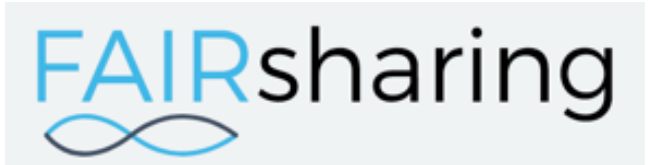
- Term appearing in primary and secondary annotations
- Vocabulary popularity in LOV
- Term use in LOD

Other registries







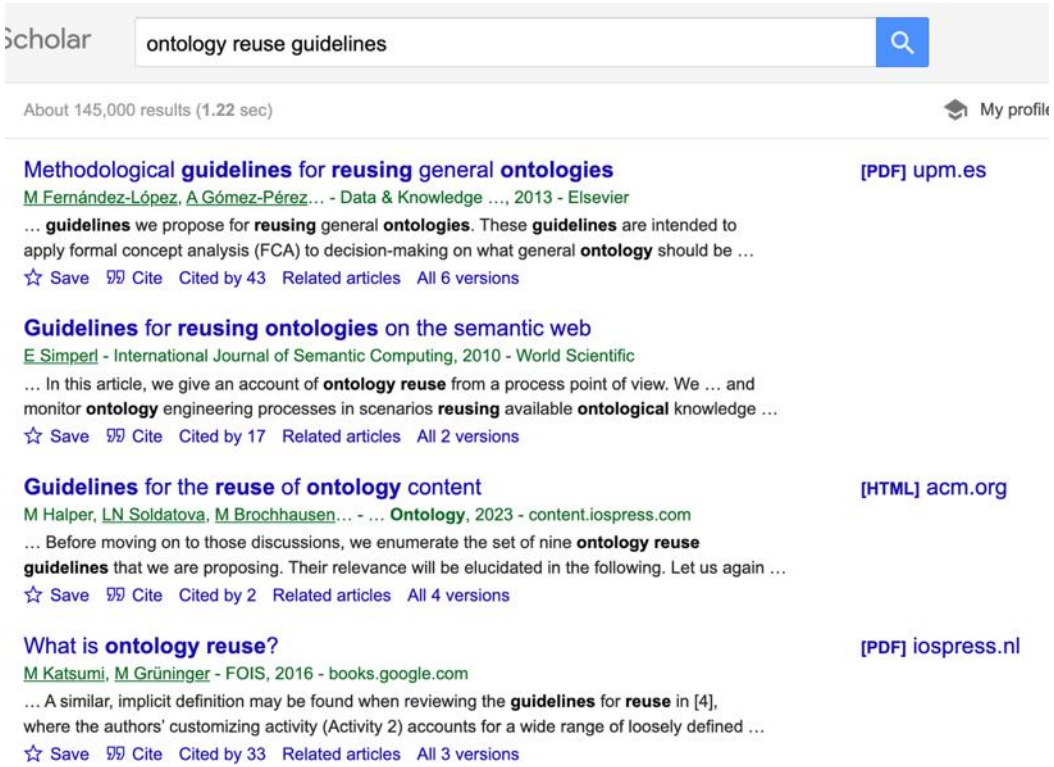


- Increase interoperability

In theory

- **Reduce development time & resources**

- **High learning curve** for understanding existing (external) ontologies. From my experience:
  - No documentation
  - No good documentation
  - No diagrams!!! (btw, there is not even a standard for ontology diagrams)
  - No examples
  - No requirements



- Increase interoperability

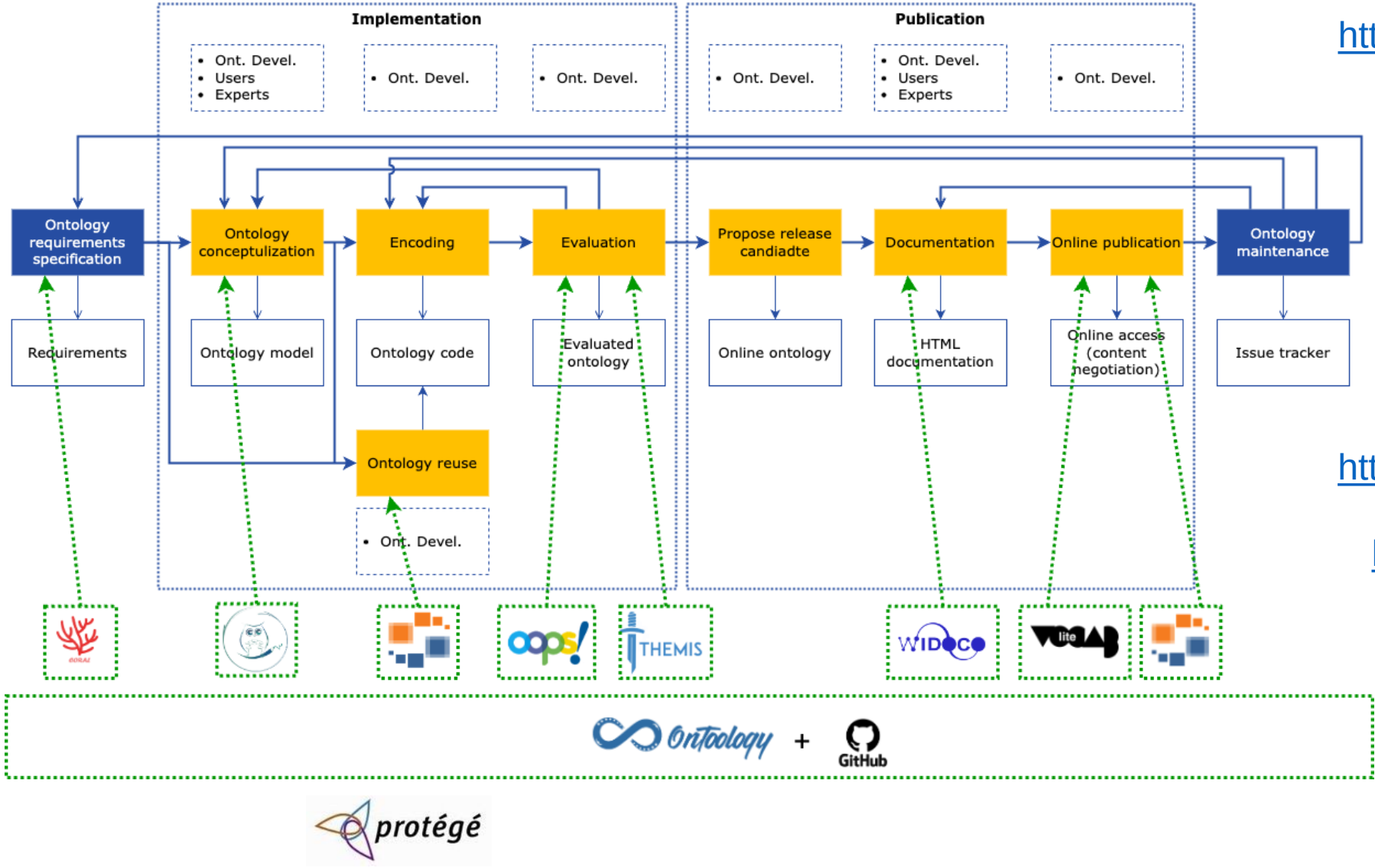
- **Reduce development time & resources**

  - Fernández-López, M., Poveda-Villalón, M., Suárez-Figueroa, M. C., & Gómez-Pérez, A. (2019). **Why are ontologies not reused across the same domain?.** Journal of Web Semantics, 57, 100492. (https://doi.org/10.1016/j.websem.2018.12.010)
    - **Heterogeneity** between the **concepts** in a given domain. For example, in Spain, the notion of College does not exist
    - **Heterogeneity** in the natural **language** used. The translation from English to Spanish had required an additional time in the process of reuse.
    - **Deficiencies** in the **documentation**.
    - **Lots** of **information** due to an imported ontology that is not available.
    - **Unavailable license**

How – Technological landscape

https://lot.linkeddata.es/

https://doi.org/10.1016/j.engappai.2022.104755



https://coralcorpus.linkeddata.es/

https://chowlk.linkeddata.es/

https://lov.linkeddata.es/

https://oops.linkeddata.es/

https://themis.linkeddata.es/

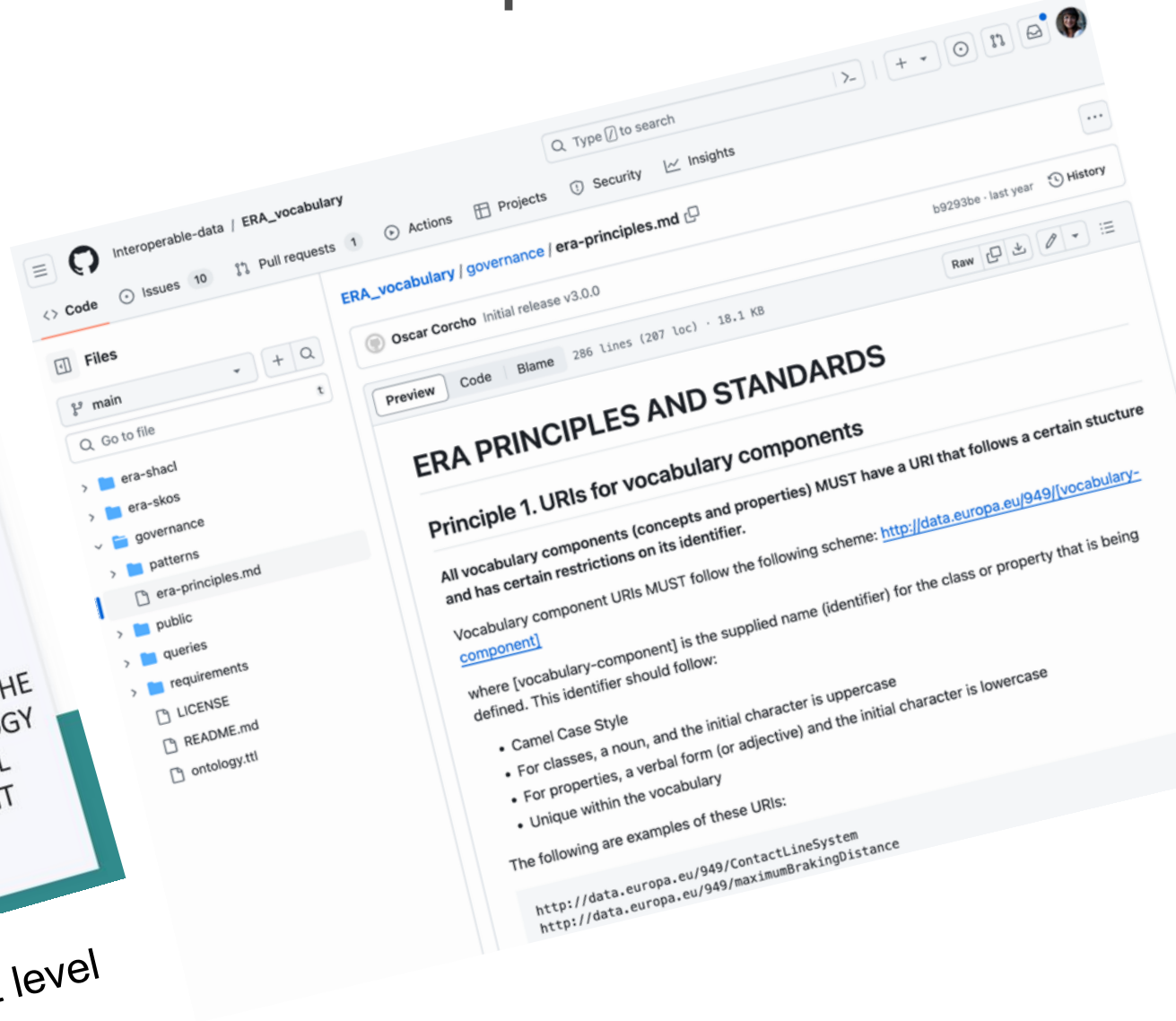
https://github.com/dgarijo/Widoco

https://ontoology.linkeddata.es/

- Increase interoperabilit

- **Reduce development time & resources**

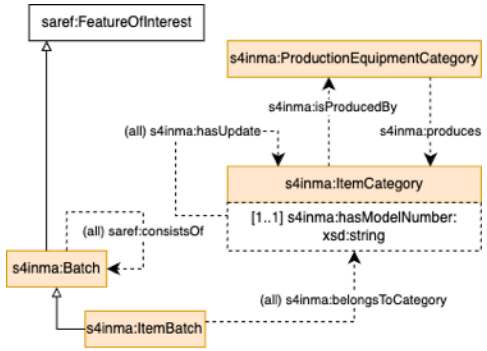
Project level



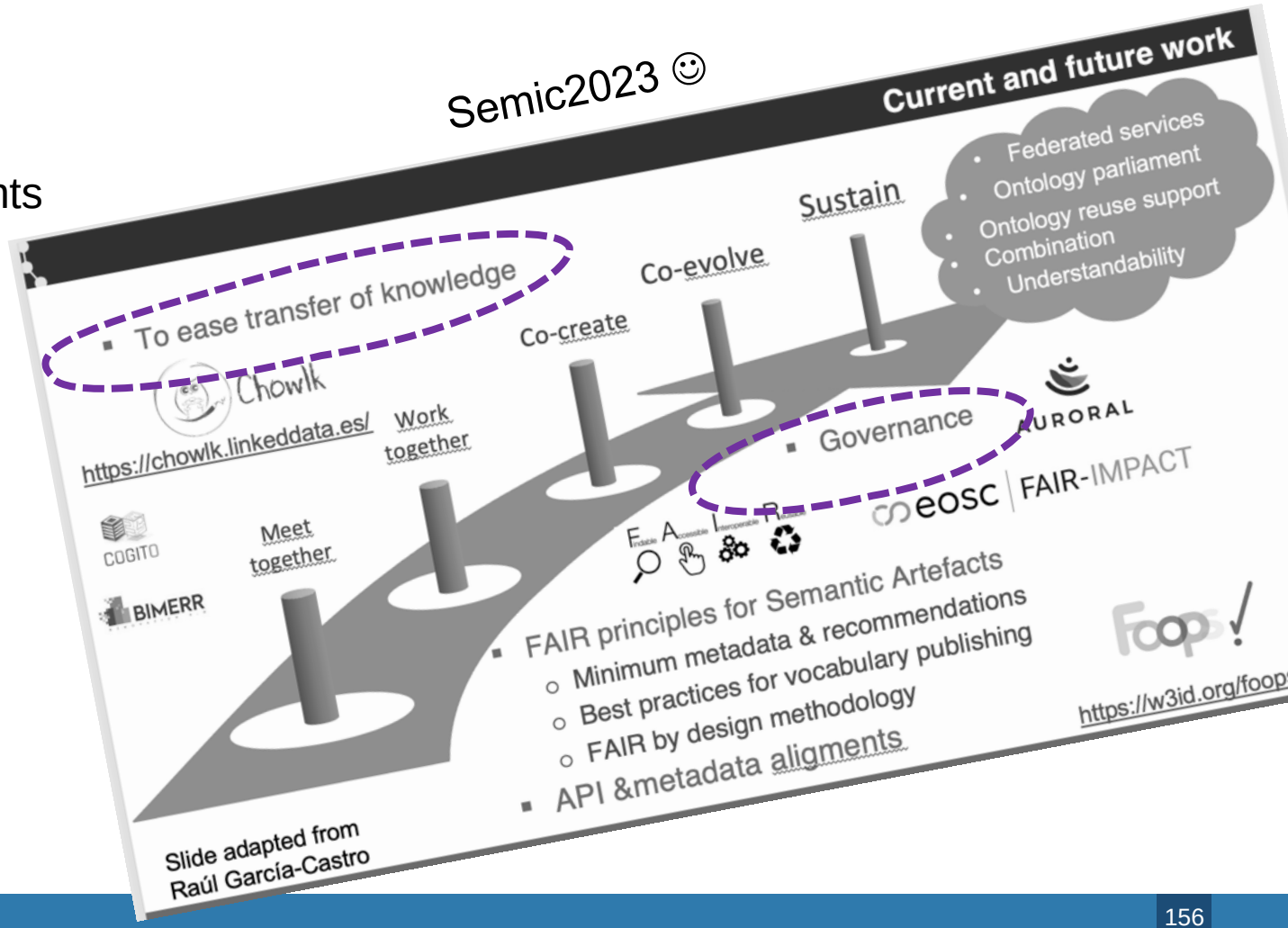
The technological solutions/components are (mostly) there, but ontology reuse is still tedious

- **Need to ease knowledge transfer**
  - (inter) (intra) organizations
  - Based on good **documentation**
    - But not only this

Chowlk Reusable graphical components



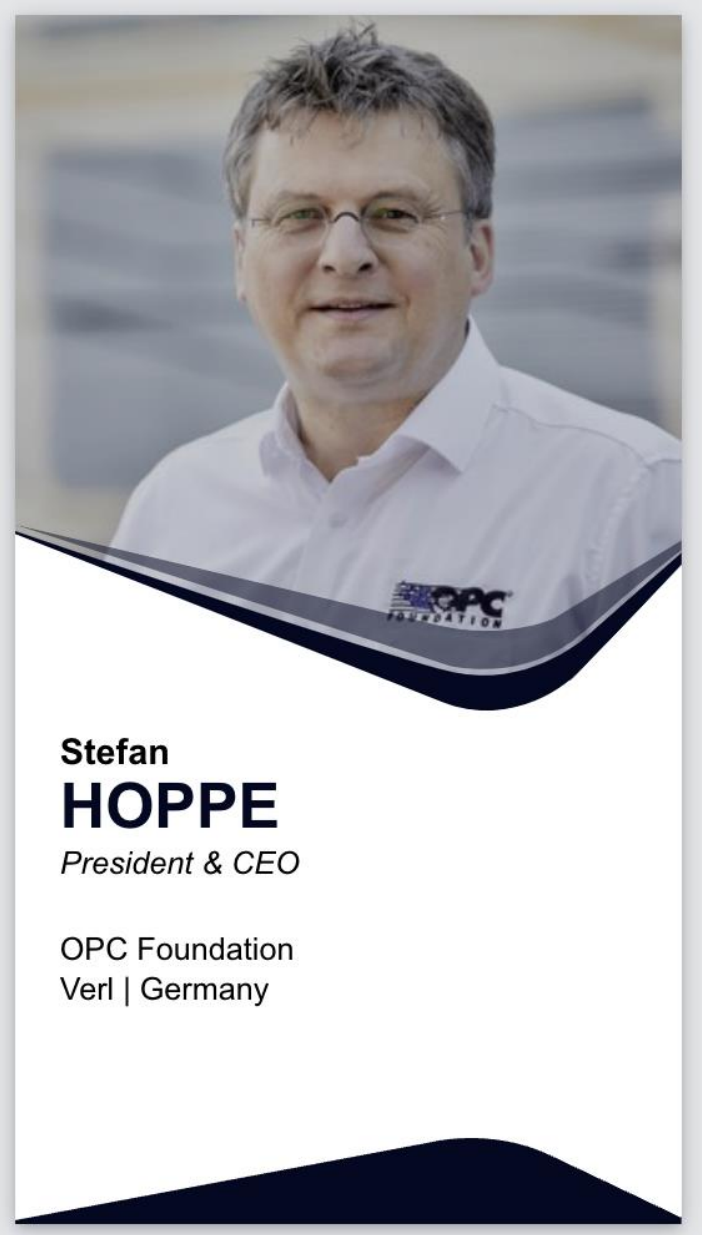
- **Vital to develop governance models**
  - Within organizations
  - Considering **dataspaces** environments



Thanks!

Acknowledgments: Raúl García-Castro

Image by tartila / Freepik



Secure, Semantic, Industrial Interoperabilty

for Industrial Automation, Energy, and …
scaling from Sensor to IT/Cloud (Digital Twin, DataSpaces, ..)

Secure, Semantic, Industrial Interoperabilty

for Industrial Automation, Energy, and …
scaling from Sensor to IT/Cloud (Digital Twin, DataSpaces, ..)

SEMIC pre-conference June 26, 2024

Cross-border Semantic Interoperability: From Models Discovery and Design to Implementation and Reuse - part 2

Stefan Hoppe
President & Executive Director OPC Foundation
stefan.hoppe@opcfoundation.org

The Organization: OPC Foundation

The world largest ecosystem for cross-vendor, cross-domain industrial interoperability

The Technology: OPC Unified Architecture (OPC UA)

The promise for secure, semantic, industrial interoperability

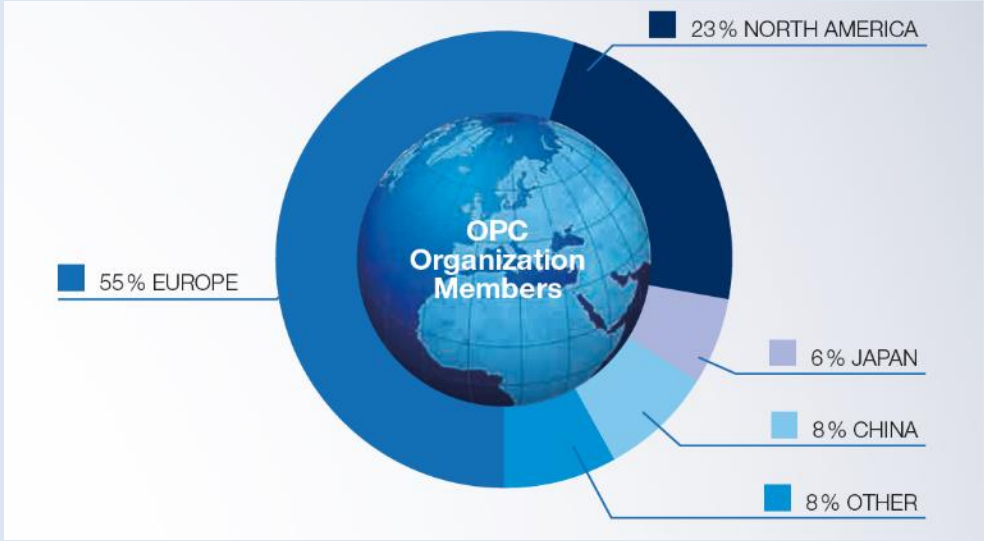
OPC Foundation

https://opcfoundation.org

- Vision
  - Secure & reliable
  - Vendor, platform, and domain agnostic
  - Interoperability from sensor to enterprise and beyond
- Global Profile
  - Non-profit organization (founded 1995)
  - Companies from Automation & IT
  - Internationally recognized: OPC UA is IEC62541
- Deliverables
  - Specifications: openly available
  - Tools and code examples for faster, easier adoption
  - Certification: OPC Labs open to everyone
- Ecosystem with toolkits and education
- Modern IPR policy

Organizational Overview

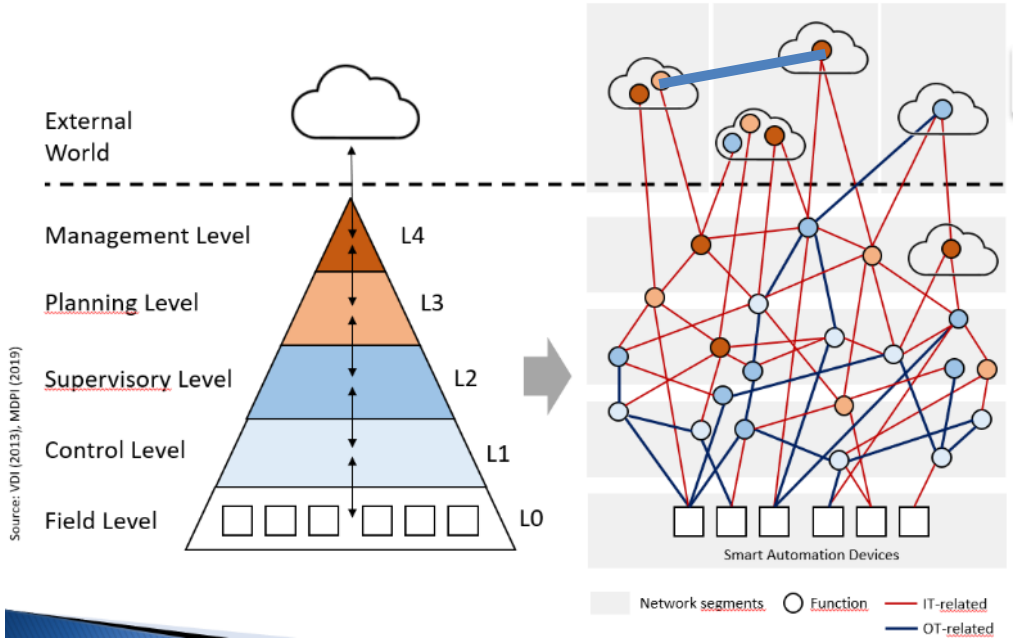
Membership: 1001 (June 26th, 2024)



Board of Directors 2024

Microsoft	Honeywell	Rockwell
SAP	Yokogawa	Schneider
Siemens	Mitsubishi	ABB
Beckhoff	Ascolab	VDMA

From Automation Pyramid to Information Network



Universal Industrial Network

OPC UA

OPC UA is not a protocol!

Instead it is a collection of technologies to ensure a secure exchange of standardized information from the sensor to the cloud (and back).

OPC UA over …
TCP, UDP, MQTT, … APL, SPE, 5G, TSN, …

- Challenge to transformation from an Automation Pyramid (with proprietary protocols between all layers) to an Information Network (providing standardized information exchanged secured end-to-end and be able to bypass layers)
- OPC UA is an open framework delivering end-to-end secured, standardized information exchange
  Openess is key: Open Specs, Open source (GitHub) and Open Labs for certification (without be paying member)
- OPC Foundation is the „Collaboration Organization“: together with 60 partner associations we created 150+ standardized information models for verikals like pumps, motors, robots, injection moulding machines,
  … coffee machines, vending machines,…

OPC FOUNDATION

OPC UA in a simplified view – at a glance

Modelling

- Object Oriented
- For data and interfaces
- For devices and services
- Supported structured data
- Support type validation

Transport

- **2 Communication mechanism: Client/Server & Publisher/Subscriber**
- **Effective encoding: Binary, JSON**
- **Protocol agnostic: TCP, HTTPS, UDP, AMQP, MQTT, WebSocket**
- **REST interface & File tranfer**
- **Infrastructure agnostic & extendable: Ethernet, Ethernet APL, TSN, 5G, WiFi6**

Security

Security

- **Integrated by Design**
- **Proven by international experts**
- **End-to-End security**
- **Transport Encryption and Signing**
- **Authentication for applications and users**
- **Authorization on data points level**
- **Audit concepts integrated**

Extendable

- **Flexible information model**
- **Companion models**
- **Custom models**

Scalable

- **From field to cloud / cloud to cloud cloud to field / field to field**
- **Micro embedded to mainframe**
- **All industrial domains**
- **Multiple connectivity scenarios**
- **High speed, low bandwith**

International

- **OPC UA is IEC62541 National standard in China (GB/T 33863.x) Singapore, Korea, …**
- **1000+ members IT and OT worldwide**
- **International Leadership – elected annually**

Independent

- **Open standard, open source, open specs**
- **No proprietary technologies**
- **Multi vendor / Cross platform**
- **Multiple domains**
- **Modern IPR**

OPC UA 2003 – 2023: 20th Anniversary standardization of OPC UA

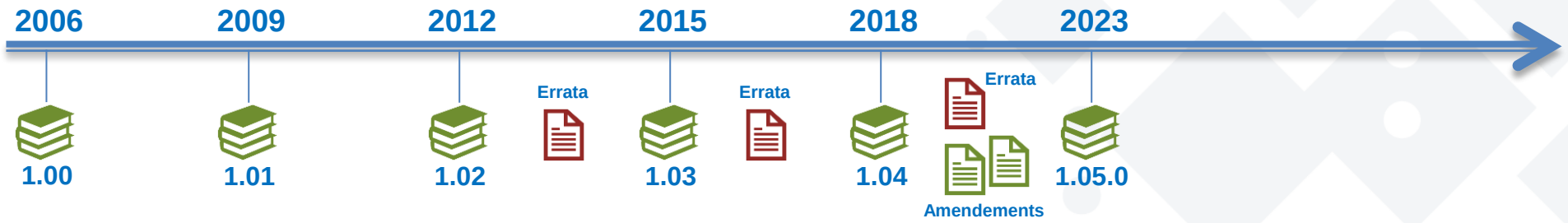
2003

Start of OPC UA

OPC Unified Architecture (OPC UA), comprising of 13 separate parts, is created by the OPC Foundation.
The first OPC UA working group meeting was held on November 3-7, 2003.
The original OPC specification is now referred to as “Classic OPC” or “OPC Classic”.

Please share your important milestones of OPC history!
https://opcfoundation.org/about/opc-foundation/history/

OPC UA availability 2006 – 2024: 18 years of stability and backward compatibility



OPC UA Specifications (v1.05.03 today) and IEC62541

OPC UA specifications **are publicly accessible**
Also available as an **IEC standard series (IEC 62541)**

Currently the standard is comprised of 24 parts subdivided into three groups:

1. **Core specifications**
   The basic concepts, the security model, and an abstract description of the OPC UA metamodel and the OPC UA services.

2. **Access type specifications**
   Extensions of the information model for typical access to data, alarms, messages, historic data and programs.

3. **Utility type specifications**
   Additional solutions for finding of OPC UA-capable components and their access points in a network

OPC UA feature set is scalable!

- Perception: OPC UA is too big and too powerful!
  Question: Do all OPC UA functions always have to be provided in the OPC UA Server?
  Answer: No!



Examples:

- PLC controllers may not need a REST-Interface
- Edge devices may not require Ethernet-APL or TSN functionality
- Data Spaces, Digital Twin … may not required TCP, UDP but REST , „OPC UA over MQTT“ and file transfer
- ….

OPC UA:

Comprehensive Security Concept

Addressing Industrial Needs

Reviewed by Security Experts

Enabling Technology

Transport Layer Security

- → **Confidentiality**
  message encryption
- → **Integrity**
  message signing
- → **Application Authentication**
  Mutual authentication with x509

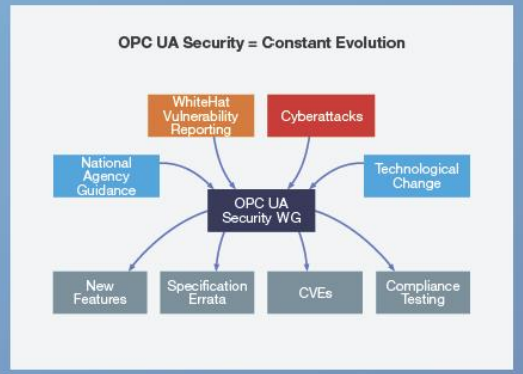
Application Layer Security

- → **User Authentication**
  Anonymous, User Name/Password, Certificate, Single-Sign-On
- → **User Authorization**
  Role based access for read, write, browse, execute
- → **Auditability**
  Supports threat detection and forensic analysis
- → **Availability**
  always remain functional

Central & Decentral Certificate Management

- → Standards based centralized key management
- → PKI infrastructure with Certificate Authorities and Chain of Trust
- → Global Certificate Management Services, Pull and Push Model
- → Pre-shared key server for PubSub

Continuous Monitoring



OPC UA Security Working Group

- → 25+ security experts from the leading automation manufacturers and IT companies, meet weekly
- → Reactive: cyberattacks, discovered vulnerabilities
- → Proactive: technological change, national security agency guidance
- → Selected Standards: AES, RSA, ECC, SHA, …, evolving

Continuous Improvement

- → Constant contact with the leading Security Vulnerability Reasearch Centers
- → Living the CVE process: investigate, fix, publish and inform
- → Advise for implementers and users
- → Support for hacker events such as PWN2OWN

Educational & Guidance

Guidance for Implementers

- → Advice 3rd party crypto-library e.g. OpenSSL
- → Guidance on Windows-Security updates

Guidance for Users

- → Create whitepapers, best praxis and guidelines
- → Scope of the Security Model

Concrete answers about

- SecurityMode
- Selection of cryptographic algorithms
- User authentication
- Certificate and private key storage
- Using certificates
- Managing and maintaining certificates

OPC Foundation members and partners have published the whitepaper "Practical Security Recommendations".
OPC UA is secure
opcfoundation.org/security

Analyzed by Experts

January, 2017: First Security Analysis by German Office for Information Security (BSI)
OPC UA is secure
opcfoundation.org/security

February, 2022: Second Security Analysis by German Office for Information Security (BSI)

OPC UA:
Industrial Interoperability

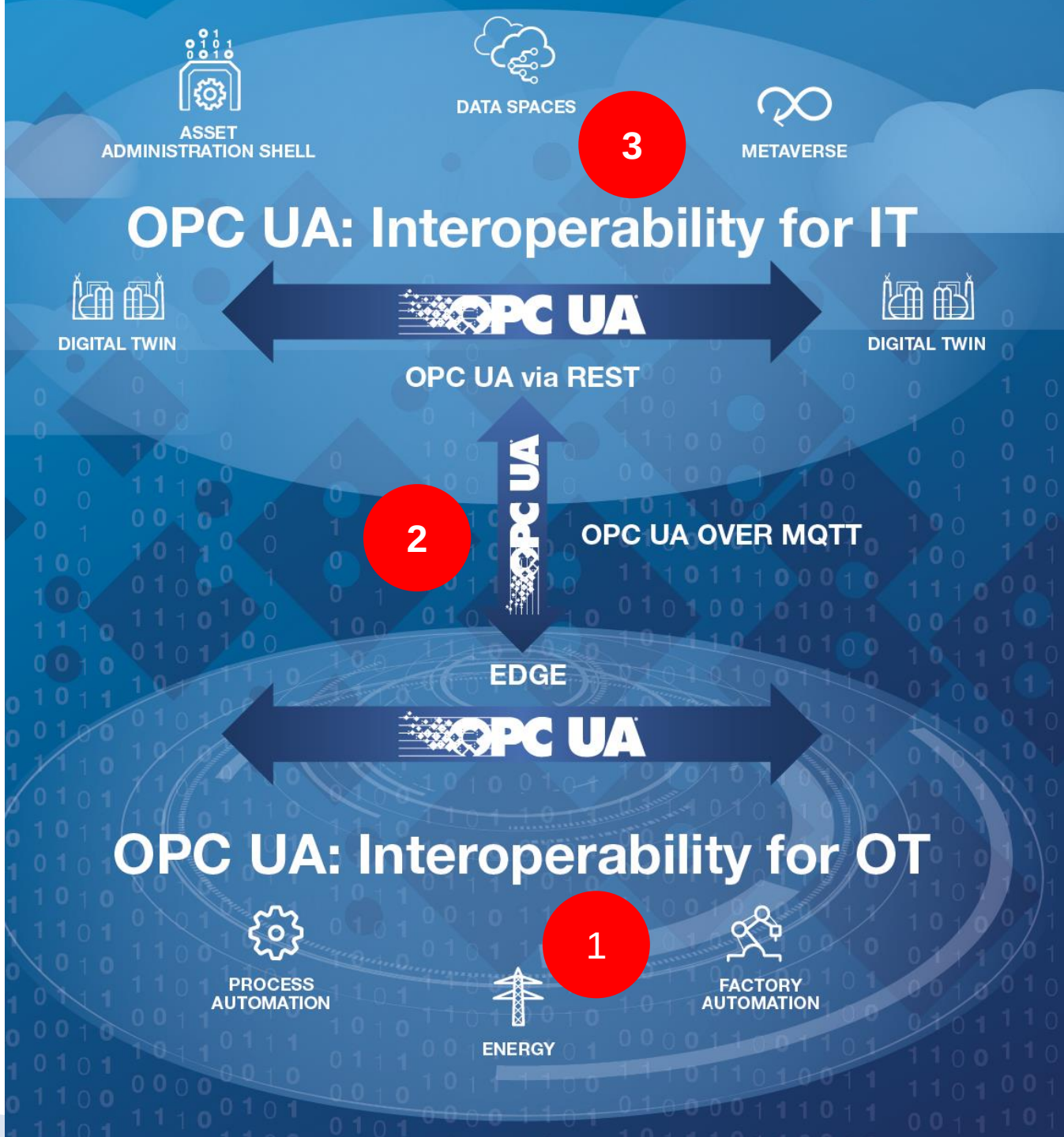
One harmonized solution for OT and IT

Including:

… rich modeling language
- complex data
- inheritance

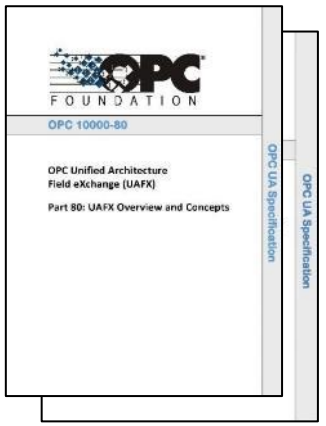
… flexible transport
- TCP/IP, UDP, MQTT
- File Transfer (since 2013)
- REST interface (since 2016)

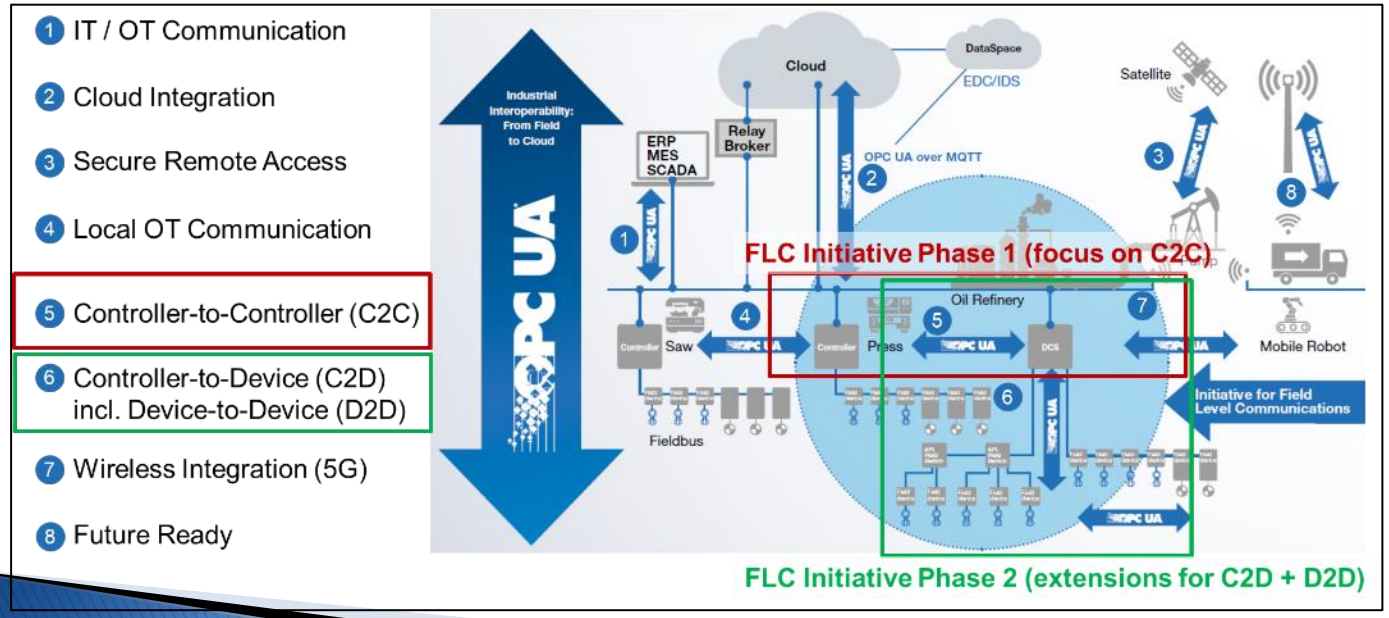
… security
- for accessing information
- for transport of information
- onboarding
- infrastructure certificate management



OPC UA FX (Field eXchange) specifications: Extending OPC UA down to the field level for FA & PA

Members of the Field Level Communication (FLC) Initiative's Steering Committee





<u>OPCF FLC Initiative</u> (started in November 2018)

- Extra support from 25 leading automation companies & technology providers
- Overall, more than 320 technical experts from more than 65 member companies of the OPC Foundation have been active so far in the different Technical Working Groups.

<u>OPC UA FX Specifications (OPC UA extensions)</u>

- Spec numbers „OPC 10000-080“, -81, -82, ...
- Harmonized solution for Factory and Process Automation, supporting Determinism, Safety, Motion, I/O, Instrumentation
- Information models for Controllers and Field devices
- Offline / Online configuration
- Mapping to enabling communication technologies, such as Ethernet TSN and APL
- Interactions: Controller-to-Controller (C2C), Controller-to-Device (C2D), Device-to-Device (D2D)
- and much more

UAFX Multi-Vendor Demos for Controller-to-Controller

- Three multi-vendor demo walls have been realized for North America, Europe and Asia.
- Approx. 50% of the controller prototypes already support UAFX features (!)

Companies participating in OPC UA FX C2C Demos:

ABB, Beckhoff, B&R, Bosch Rexroth, Cisco, Emerson, Festo, Hirschmann-Belden, Honeywell, Huawei, Keba, Kuka, Lenze, Mitsubishi Electric, Molex, Moxa, Omron, Phoenix Contact, Rockwell Automation, Schneider Electric, Siemens, Unified Automation, Wago, Yokogawa

OPC UA over MQTT: One IEC standard for multi vendor cloud solutions

- **Technology OPC UA over MQTT**
  - **… support JSON and BINARY encoding**
  - **… is an IEC standard published in Feb 2018**
- **Largest ecosystem**
  - **OPC UA over MQTT supported by**
  - **53+ automation companies (Beckhoff, KUKA, PhoenixContact, Siemens, …)**
  - **and top cloud vendors Amazon, Microsoft**
- **Simple IT integration**

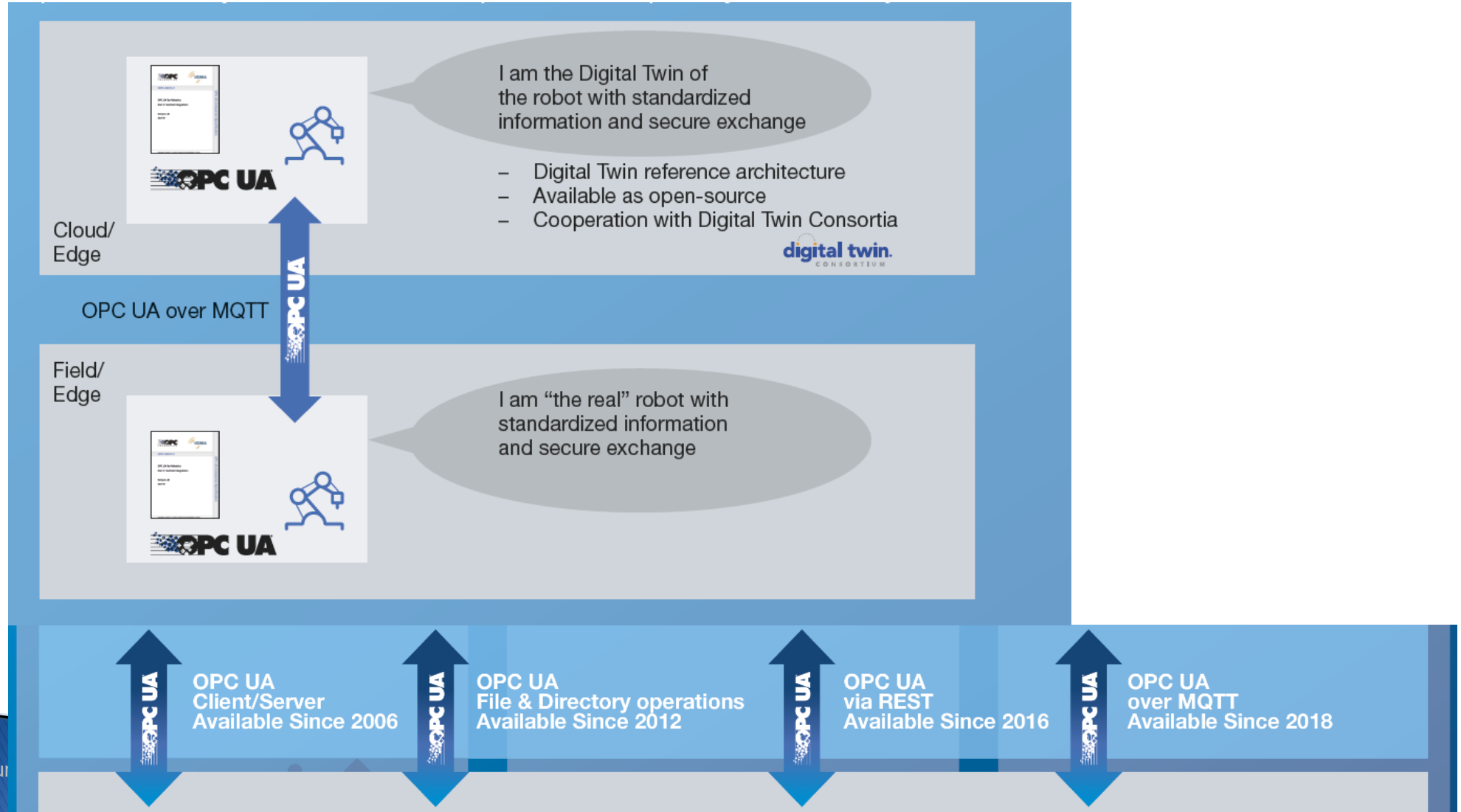
  Automatic encoding of OPC UA information models to OPC UA PubSub JSON and direct ingestion into all major cloud services, no expensive data conversion at the edge or in the cloud
- **Cost effective**

  License free, openly available spec.
- **Built-in security**

  Support for authentication and encryption.

Digital Twin powered by OPC UA

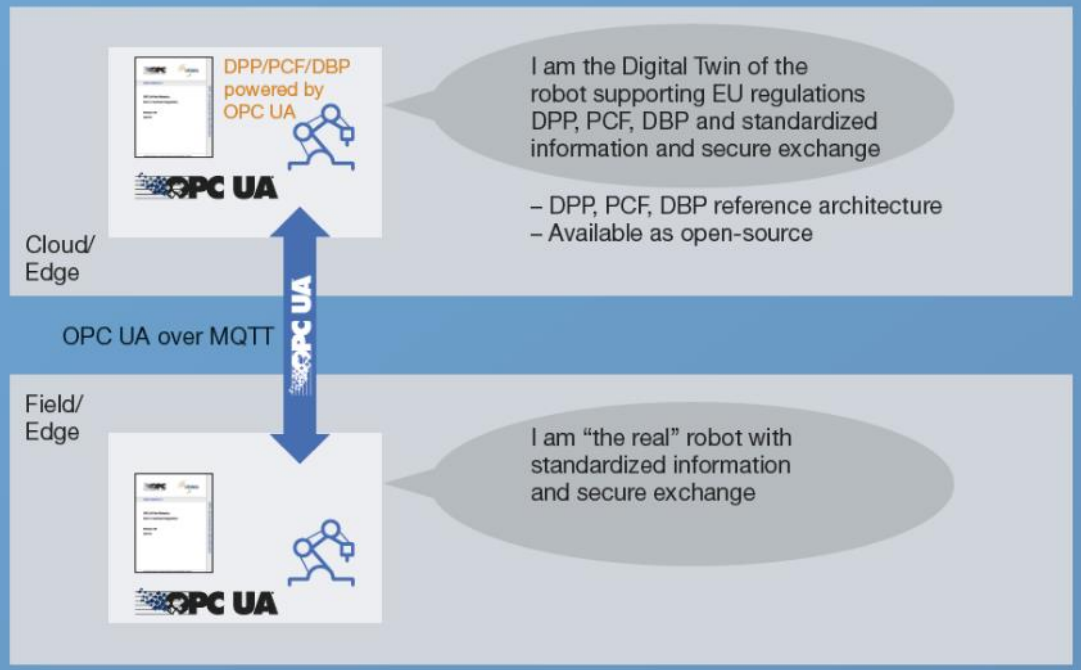
Definition: A digital twin is a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity.



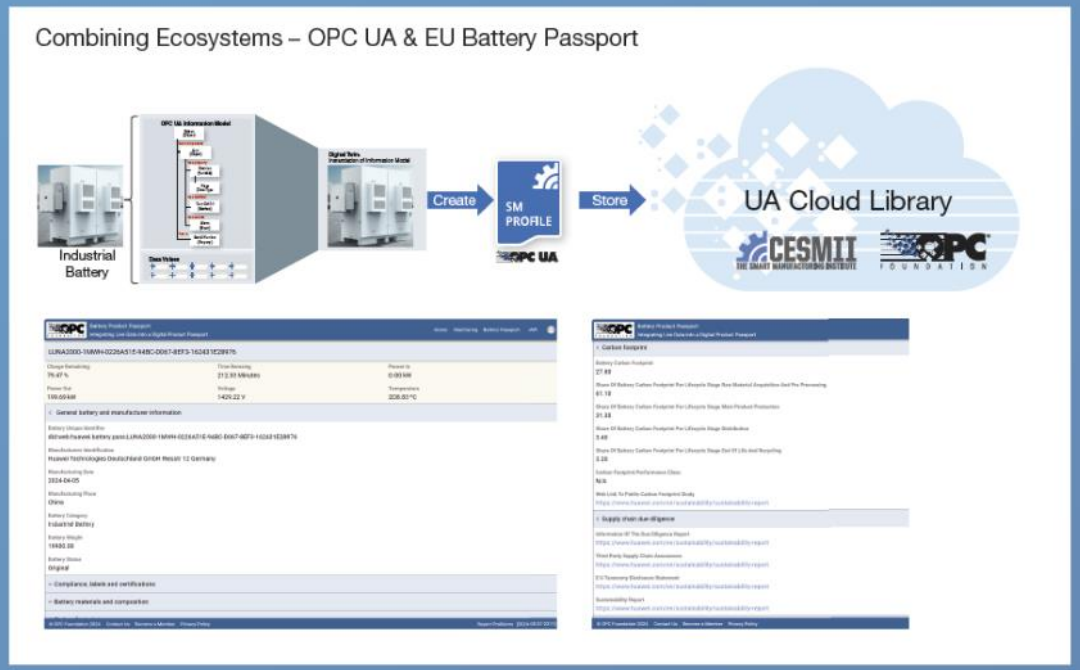
OPC FOUNDATION

Product Carbon Footprint (PCF) and Digital Battery Passport (DBP) powered by OPC UA

- OPC UA used for information modeling
- OPC UA used for file transfer
- OPC UA REST used for interface



- OPC UA technology is ready to host AAS, DPP, PCF and DBP
- Can be hosted in OPC UA server in field, edge, cloud



OPC UA
OPC UA Client/Server Available Since 2006

OPC UA
OPC UA File & Directory operations Available Since 2012

OPC UA
OPC UA via REST Available Since 2016

OPC UA
OPC UA over MQTT Available Since 2018

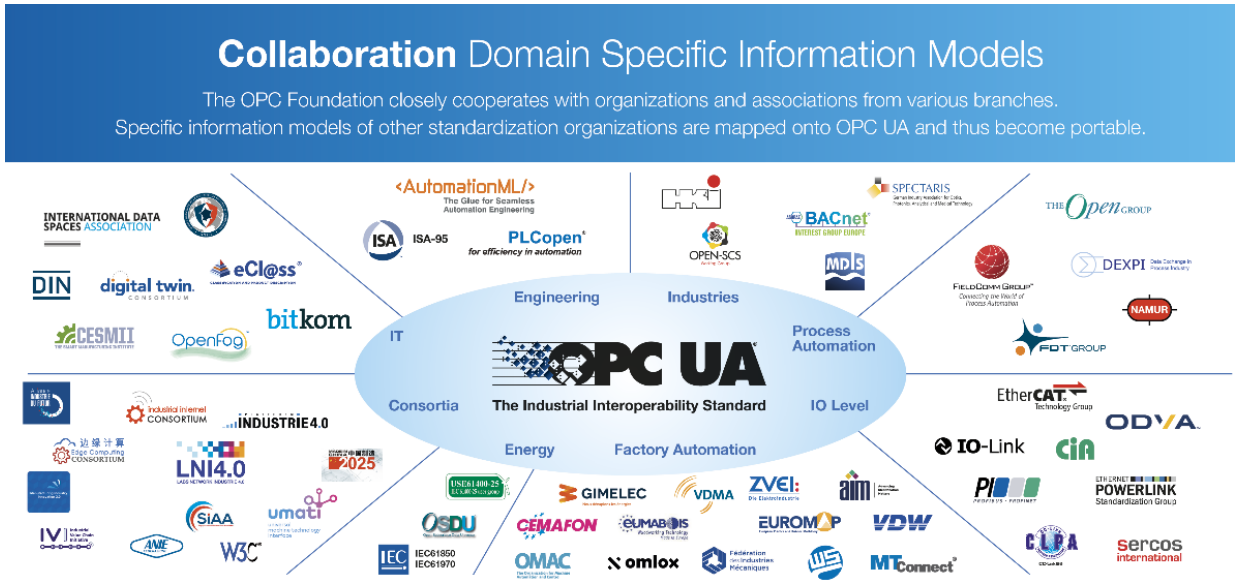
OPC Foundation Cloud Initiative

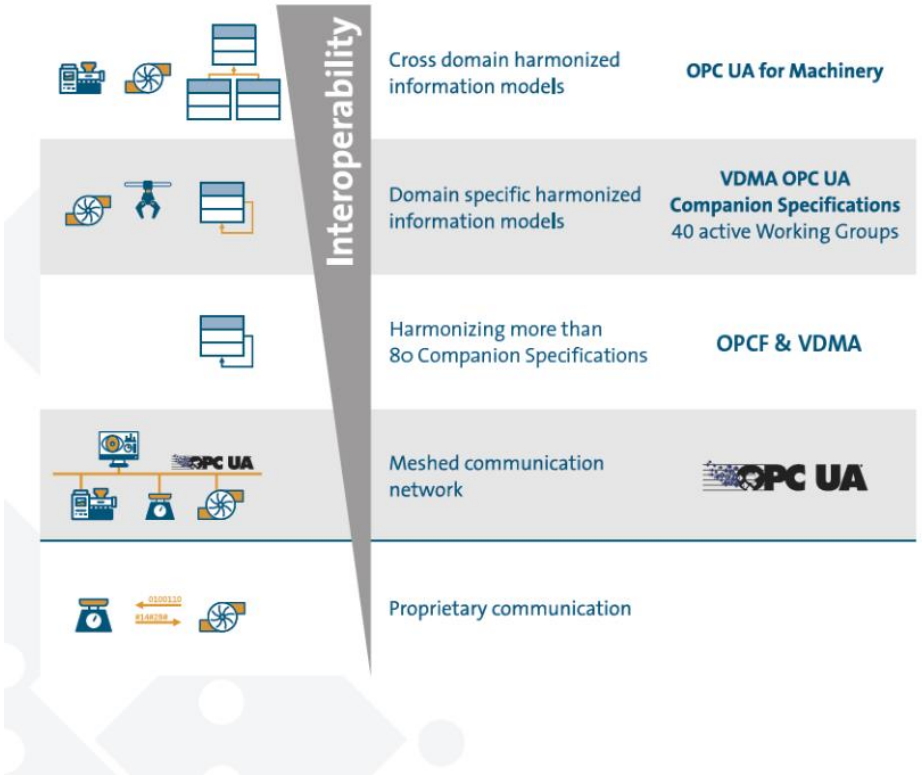
- **Major goals**
  - **Standardized transport between OT / IT**
  - **Keep context of information models in cloud**
  - **Create Protected Identity “OPC UA CX” for validation / certification**

- **Existing cloud-related working groups**
  - **UA Cloud Library** – A query-able online store of OPC UA Information Models
  - **OPC UA over MQTT** – secure transport from edge to cloud and cloud to cloud.
  - **OPC UA REST Interface** – cloud-based OPC UA server access
  - **OPC UA WoT Connectivity** – standardized industrial connectivity software configuration
  - **OPC UA Industrial Metaverse** – reference architecture to combine the virtual and the physical world
  - **OPC UA AI** - Leveraging Large Language Models

Harmonized information models

Concept and process for harmonization is available since years





Semantic Harmonization between 151+ groups

OPC UA Companion spec:

- **Domain specific agreement on semantic and behavior**
- **Delivered in 2 parts – free of charge**
  - **PDF: human readable (OPC web)**
  - **XML: machine-readable (open, browsable web repository) https://reference.opcfoundation.org/**

SEMANTIC Interoperability: The key for the digitalization

Generic Device Models: Controller, Field Device, Process Device

- OPC 10000-100 – UA for Devices
- OPC 10020 – UA for Analyzer Devices
- OPC 30000 – UA for PLCs based on IEC 61131-3
- OPC 30001 – UA for IEC 61131-3 Function Blocks
- OPC 30010 – UA for AutoID Devices
- OPC 30081 – UA for Process Automation Devices (PA-DIM)
- OPC 30400 – UA for Cloud Library
- OPC 30500 – UA for Laboratory & Analytical Device Standard (LADS)*
- OPC UA for Analytical System Integration (CAISI)*
- OPC UA for Cloud Federation*
- OPC UA for Global Positioning*
- OPC UA for Non-destructive Evaluation
- OPC UA for Power Consumption Management*
- OPC UA for Secure Elements

Energy

- OPC 10040 – UA for IEC 61850 – Electrical Substation Automation (Release Candidate)
- OPC 30020 – UA for MDIS
- OPC UA for Wind Power Plants (IEC61400-25)*
- Power Consumption*
- OPC UA for Carbon Capture, Storage and Reporting*
- OPC UA for Solar PV Operations and Maintenance (SPOM)*

Building

- OPC 30030 – UA for BACNET (Release Candidate)

Miscellaneous

- OPC 30060 – UA for Tobacco Machines
- OPC 30200 – UA for Commercial Kitchen Equipment

Manufacturing Devices: Robots, Machines, Machine Tools

- OPC 30070-1 – UA for MTConnect, Part 1: Device Model
- OPC 40001-1 – UA for Machinery – Basic Building Blocks
- OPC 40001-2 – UA for Machinery – Process Values
- OPC 40001-3 – UA for Machinery – Job Management
- OPC 40001-100 – UA for Machinery – Result Transfer
- OPC 40010 – UA for Robotics
- OPC 40020 – UA for Cranes & Hoists
- OPC 40083 – UA for Plastics Rubber – General Types
- OPC 40077 – UA for Plastics Rubber – Injection Moulding Machines to MES
- OPC 40079 – UA for Plastics Rubber – Injection Moulding Machines to Robot
- OPC 40082-1…n – UA for Plastics Rubber – <device>
- OPC 40084-1….n – UA for Plastics Rubber – Extrusion
- OPC 40100 – UA for Machine Vision
- OPC 40200 – UA for Weighing Technology
- OPC 40210 – UA for Geometrical measuring Systems
- OPC 40223 – UA for Pumps and Vacuum Pumps
- OPC 40250 – UA for Compressed Air Systems
- OPC 40301 – UA for Flat Glass Processing
- OPC 40400 – UA for Powertrain*
- OPC 40444 – UA for Textile Testing Devices*
- OPC 40450 – UA for Joining Systems Base
- OPC 40451 – UA for Tightening Systems
- OPC 40501 – UA for Machine Tools
- OPC 40502 – UA for Computerized Numerical Control (CNC) Systems
- OPC 40530 – UA for Laser Systems
- OPC 40550 – UA for Woodworking Machinery
- OPC 40560 – OPC 40569 – UA for Mining
- OPC 40740 – UA for Process Air Extraction and Filtration Systems (PAEFS)*
- OPC UA for Cable Harness Manufacturing
- OPC UA for High Pressure Die Casting*
- OPC UA for Intralogistics Communication*
- OPC UA for Surface Technology*

Enterprise, Asset Mgmt, Packaging

- OPC 10030 – UA for ISA-S95
- OPC 10031-4 – UA for ISA-95 Job Control
- OPC 30050 – UA for PackML (OMAC)
- OPC 30260 – UA for OpenSCS Serialization Model
- OPC 30261 – UA for OPEN SCS – Job Order Profiles
- OPC 40600 – UA for Weihenstephan Standards
- OPC UA for Asset Administration Shell – AAS*
- OPC UA for Mimosa CCOM*

Engineering

- OPC 30040 – UA for AutomationML
- OPC 30250 – UA for DEXPI

Field Device Integration

- OPC 30080 – UA for Field Device Integration (FDI)
- OPC 30090 – UA for Field Device Tool (FDT)

Field Communication

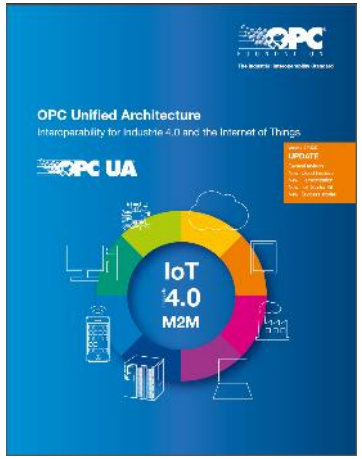
- OPC 30100 – UA for SERCOS Devices
- OPC 30110 – UA for POWERLINK
- OPC 30120 – UA for IO-Link Devices and IO-Link Masters
- OPC 30130 – UA for Control & Communication System Profile (for Machine) CSP + (CCLink)
- OPC 30140 – UA for PROFINET
- OPC 30141 – UA for PROFIenergy
- OPC 30142 – UA for PROFINET Remote IO
- OPC 30143 – UA for PROFI-Encoder
- OPC 30144 – UA for PROFINET-GSD
- OPC UA for CIP Devices*

- **151+ groups with domain experts have defined the semantics for their verticals**
- **Largest eco-system for information models for the automation world**
- **Landing page with complete overview here: [www.opcfoundation.org -> About -> Working Groups-> List of Working Groups]**
- **Available free of charge**

OPC FOUNDATION

OPC Foundation Offerings

- Official Certification Test Lab and Compliance tools: Self-testing tools (CTT)
- Open Source (GitHub) with major sponsors (ABB, Microsoft, SAP)
  https://opcfoundation.org/developer-tools/samples-and-tools-unified-architecture/net-stack-and-sample-applications/
- IIoT Starter Kit: easy quick start for OPC UA over MQTT
  https://github.com/OPCFoundation/UA-IIoT-StarterKit
- OPC UAcademic program: Free of charge lecture for professors
  https://opcfoundation.org/resources/opcuacademic/
- Success stories by end users
  Like equinor, Renault, Miele, Rosendahl, Procter & Gamble, etc
  https://opcfoundation.org/resources/case-studies/
- Podcast with interesting guests
  https://opcfoundation.org/resources/podcast/
- Marketplace
  https://opcfoundation.org/products/



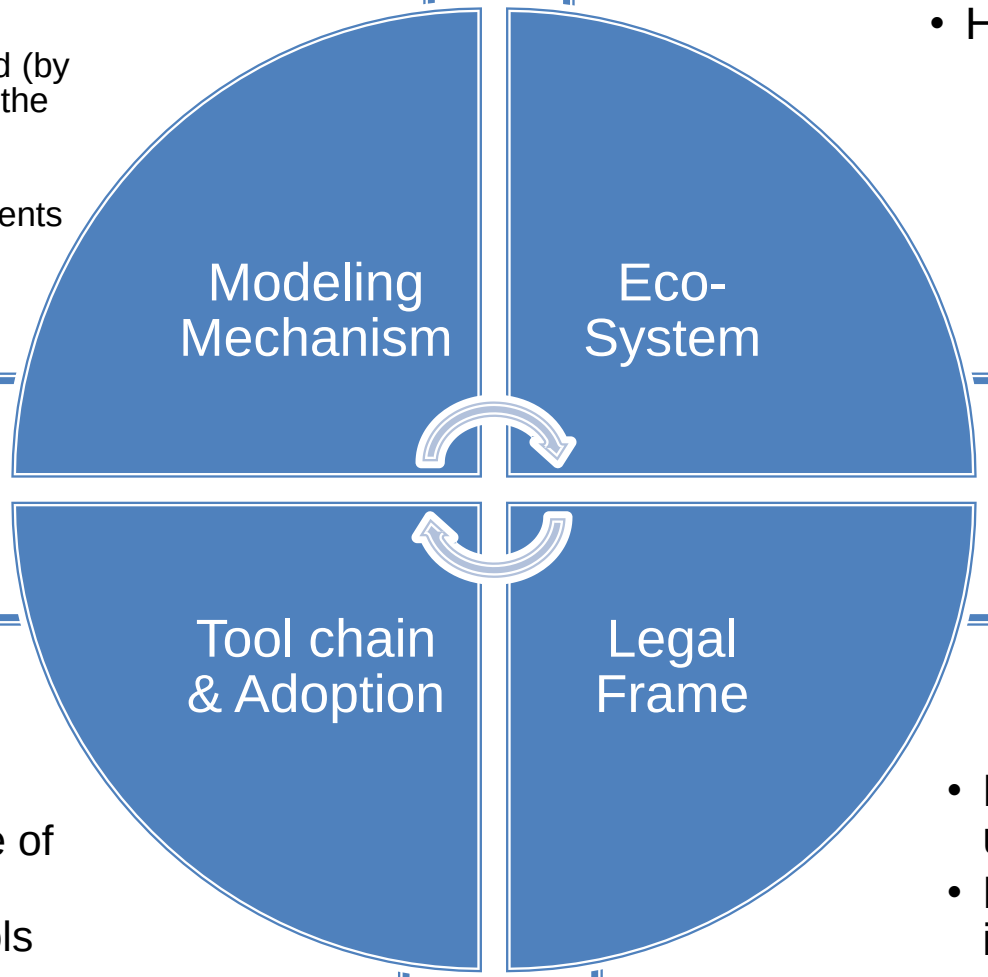
OPC UA brochure on OPCF web

https://opcfoundation.org/resources/brochures/

OPC UA Modeling: The large world modeling eco-system in IA

- Extrem powerfully
- Allow any real-world system to be modelled in a natural way, without compromises or limitations
- Allow a standard model to be extended (by vendors) in a way that does not break the conformity to the standard model.
  - Allow vendor extensions to be discoverable and interpretable by Clients without a priori knowledge of the extension.

- Over 151 domain information models
- Harmonized layers



- Validation tools
- Models public available – free of charge
- 10+ commercial modeling tools available on the market

- Models under modern IPR umbrella
- Protection for members, integrator and users
- unique in the automation world

OPC Foundation: United Nations for Industrial Automation

Independent / Neutral ground to work together / No company, no country can dominate OPC Foundation
Standards can only develop together

Controversal, polarizariting, unpopular and political incorrect statements

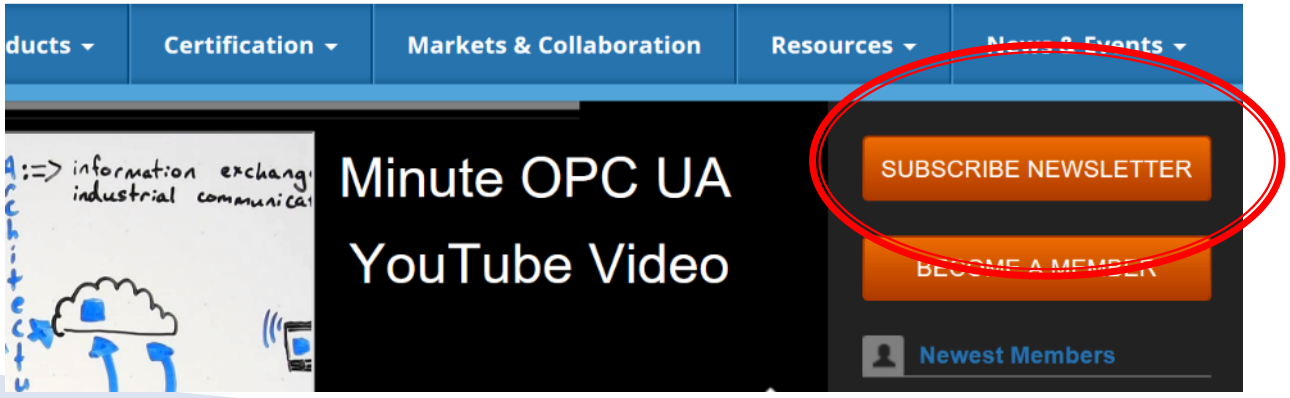
What are the major challenges for the introduction of digital twins and data spaces in industrial automation? (multiple choice)
❑ Lack of knowledge about EU regulations in general
❑ Unawareness of the data sharing business model
❑ Unclear definition of data spaces and digital twins
❑ Academic, but not industrial approach to state-funded projects
❑ Ignorance of existing and adopted standards
❑ Lack of relevance for the industry

OPC Foundation: The United Nations for Industrial Automation

Thank you! - Questions?

Stefan Hoppe
President & Executive Director OPC Foundation
Stefan.hoppe@opcfoundation.org

Looking for more information?
https://opcfoundation.org/



2. Cross-border Semantic Interoperability: From Models Discovery and Design to Implementation and Reuse

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