Implementing FAIR

Consideration from Solid Earth Sciences

Daniele Bailo, EPOS IT Officer, INGV
Rossana Paciello, EPOS-ERIC, INGV



Topics

a) FAIR principles
b) FAIR «Topics»:
    a) Data, metdata, semantics, storage, PID, AAAI…
c) How to implement FAIR? Existing initiatives and tools
d) «The FAIR implementaiton process»:
   EPOS experience on how to implement FAIR in the real world

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The principles precede implementation.

They **act as a guide to data publishers** and stewards **to assist them in evaluating** whether their particular implementation choices are rendering their digital research artefacts Findable, Accessible, Interoperable, and Reusable.

Wilkinson, M. D. et al. The FAIR Guiding Principles for scientific data management and stewardship. Sci. Data 3:160018 doi: 10.1038/sdata.2016.18 (2016).

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FAIR: evaluation & best practices



https://www.rd-alliance.org/groups/fair-data-maturity-model-wg

FAIR Implementation Profile



From FAIR Leading Practices to FAIR Implementation and Back: An Inclusive Approach to FAIR at Leiden University Libraries

Authors: Kristina Maria Hettne, Peter Verhaar, Erik Schultes, Laurents Sesink

Papers: dicussion on Practices, training, consultancy



https://fairsharing.github.io/

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Europe Embraces FAIR principles

2018



1.7.2 Step 2: Implement – culture, technology and skills for FAI

- Rec. 4: Develop interoperability frameworks for FAIR sharing within disciplines an research
- Rec. 5: Ensure Data Management via DMPs
- Rec. 6: Recognise and reward FAIR data and data stewardship
- Rec. 7: Support semantic technologies
- Rec. 8: Facilitate automated processing
- Rec. 9: Develop assessment frameworks to certify FAIR services
- Rec. 10: Professionalise data science and data stewardship roles and train researchers
- Rec. 11: Implement curriculum frameworks and training

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RI Implementer perceptions

FAIR implementation
For system architect
and Engineers

DIY (Do It Yourself) activity



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Whah are FAIR principles really about?

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Fair Data principles

To be Findable:
F1. (meta)data are assigned a globally unique and persistent identifier
F2. data are described with rich metadata (defined by R1 below)
F3. metadata clearly and explicitly include the identifier of the data it describes
F4. (meta)data are registered or indexed in a searchable resource

To be Accessible:
A1. (meta)data are retrievable by their identifier using a standardized communications protocol
A1.1 the protocol is open, free, and universally implementable
A1.2 the protocol allows for an authentication and authorization procedure, where necessary
A2. metadata are accessible, even when the data are no longer available

To be Interoperable:
I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
I2. (meta)data use vocabularies that follow FAIR principles
I3. (meta)data include qualified references to other (meta)data

To be Reusable:
R1. meta(data) are richly described with a plurality of accurate and relevant attributes
R1.1. (meta)data are released with a clear and accessible data usage license
R1.2. (meta)data are associated with detailed provenance
R1.3. (meta)data meet domain-relevant community standards

Fair Data principles

Topics:

- Data

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Topics:

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Topics:

- Data
- Metadata
- Identifiers
- Protocols
- Authentication &Authorization

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Topics:

- Data
- Metadata
- Identifiers
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- Authe&Autho

Standards

Fair Data principles

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Standards

Semantics

Fair Data principles

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Semantics

policy & provenance

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Hidden Topics:

- services+databases

Topics:

- Data
- Metadata
- Identifiers
- Protocols
- Authe&Autho

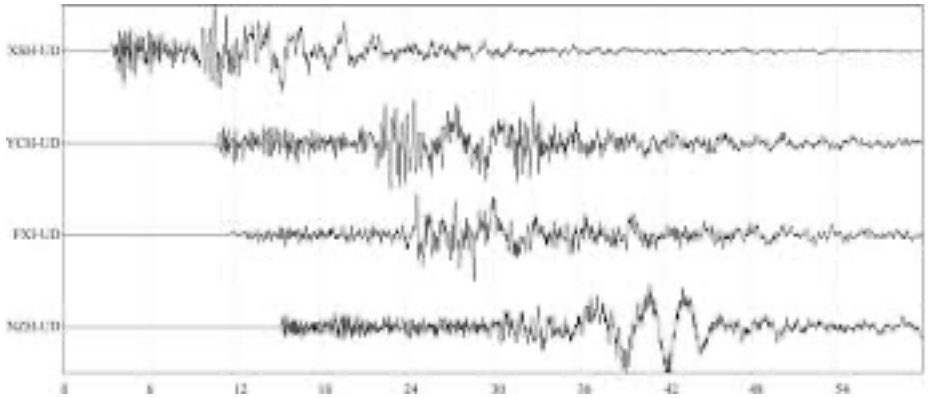
Standards

Semantics

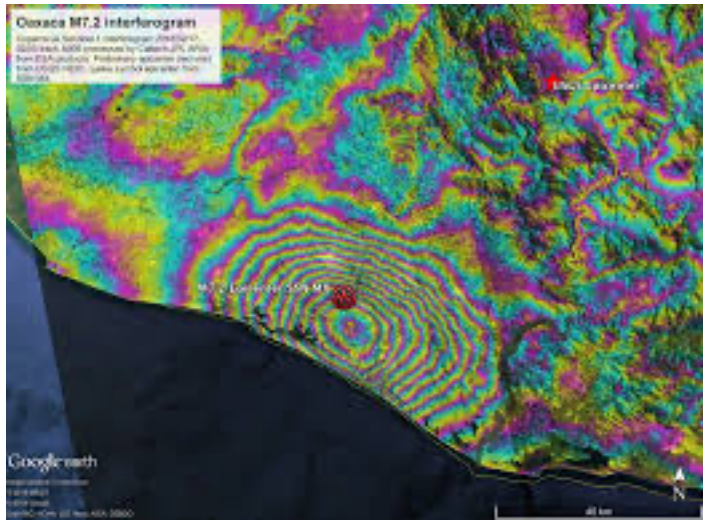
policy & provenance

FAIR Topics

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Seismic Waveform



InSAR image

Data

Our greatest wealth

Function

Describe (physical) phenomena

Related topics & Issues

- *Format, standards, harmonization*
- *Proliferation standards*
- *Continuous or atomic data?*
- *How to store data?*

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How to store data?



Lev. 1: Researcher Hard Disk



Lev. 2: Institutional Services

TRUST
Transparency Responsibilty User focus Sustainability Technology

CORE TRUST SEAL

Lev. 3a: Certified Repository

- Lin, D., Crabtree, J., Dillo, I. *et al.* The TRUST Principles for digital repositories. *Sci Data* **7,** 144 (2020). https://doi.org/10.1038/s41597-020-0486-7

- https://www.coretrustseal.org/

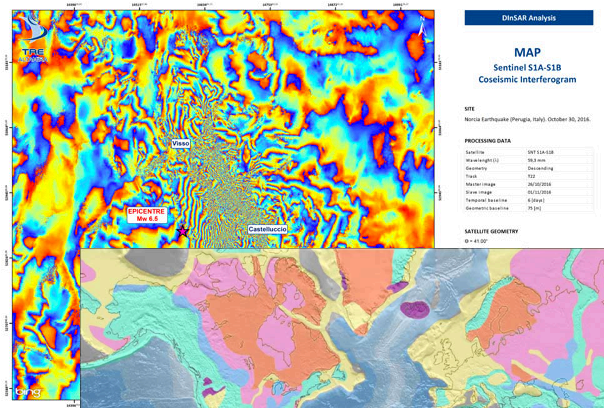
zenodo

Lev. 3b: 3rd party Repository

- https://zenodo.org/

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Static Data vs Dynamic Data



SAR images

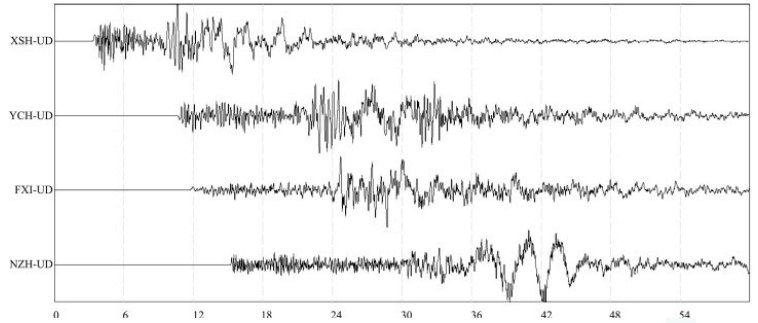


Geological maps

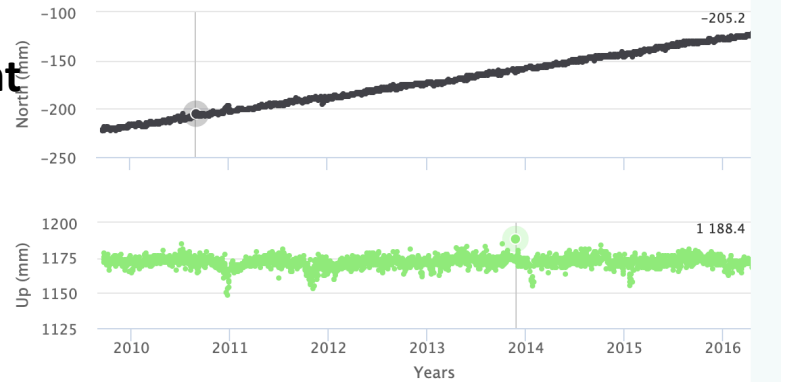
PDF

PDF files

Seismic Waveforms produced by stations



GNSS displacement time-series



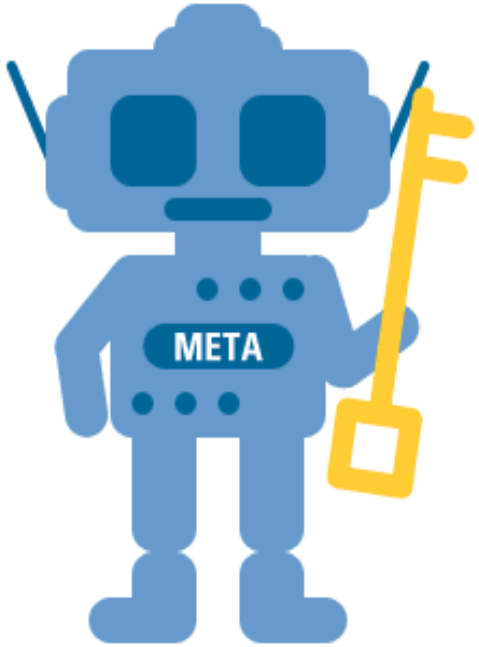
Different solutions for access and identification

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FAIR related Topics:

- ~~Data~~
- Metadata
- Identifiers
- Protocols
- Authentication & Authorisation
- Standards
- Semantics
- policy & provenance
- Services and databases

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Digital Object:

DO: *<data, metadata, handle>*

Metadata

Data about Data

Purposes

1. *Discovery (humans & machines)*
2. *Contextualization*
3. *Use it for processing or other advanced tasks*

Usually attached to D.O.

Related topics & Issues

- *Data or metadata?*
- *Many standards*
- *Catalogue*
- *Ontologies*

Kahn, R., & Wilensky, R. (2006). A framework for distributed digital object services. *International Journal on Digital Libraries*, *6*(2), 115–123. https://doi.org/10.1007/s00799-005-0128-x

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(Metadata) standards in speficic scientific domain

…a real story…

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(Metadata) standards in specific scientific domain

…a real story…



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Metadata

What is the best standard?

DEPENDS ON THE REQUIREMENTS

FAIR principles require

- *Rich metadata standard*
- *Usage of formal, accessible, shared, and broadly applicable language for knowledge representation.*

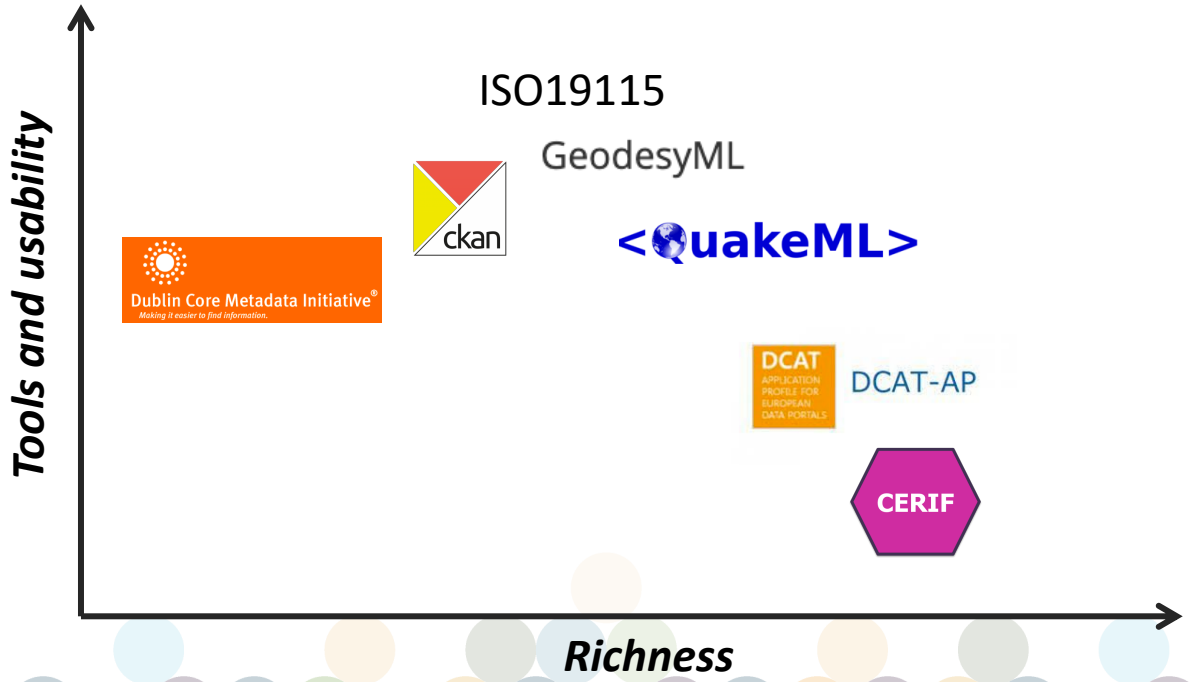
Serialization and format:
two different things (almost)

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Rich Metadata

1. including descriptive information about the **context**, **quality** and **condition**, or characteristics of the data.

2. someone should be able to **find data based on the information provided by their metadata**, even without the data's identifier



Book – Dublin Core example

```
<rdf:Description>
  <dc:creator>Peter Noeller</dc:creator>
  <dc:title>Algebra</dc:title>
  <dc:subject>mathematics</dc:subject>
  <dc:date>2008-04-23</dc:date>
  <dc:language>EN</dc:language>
  <dc:description>
     An Introduction to Algebra
  </dc:description>
</rdf:Description>
```

Person – DCAT-AP Example

```
<http://orcid.org/0000-0001-7750-7254> a schema:Person ;
        schema:identifier [ a schema:PropertyValue ;
                schema:propertyID  "orcid" ;
                schema:value   "0000-0001-7750-7254" ;
        ];
        schema:identifier [ a schema:PropertyValue ;
                schema:propertyID  "ScopusAuthorID" ;
                schema:value   "55861456000" ;
        ];
        schema:familyName "Trani" ;
        schema:givenName "Luca" ;
        schema:address [ a schema:PostalAddress ;
                schema:streetAddress "Utrechtseweg, 297" ;
                schema:addressLocality "De Bilt" ;
                schema:postalCode "3731GA" ;
                schema:addressCountry "The Netherlands" ;
        ];
        schema:email "luca.trani@private.com" ;
        schema:telephone "+3130220600297" ;
        schema:url  "http://orcid.org/0000-0001-7750-7254"^^xsd:anyURI ;
        schema:qualifications "Senior Advisor, Researcher" ;
        schema:affiliation <PIC:999518944> ;
        schema:contactPoint <http://orcid.org/0000-0001-7750-7254/legalContact> ;
        schema:contactPoint <http://orcid.org/0000-0001-7750-7254/scientificConta
        schema:contactPoint <http://orcid.org/0000-0001-7750-7254/financialContac
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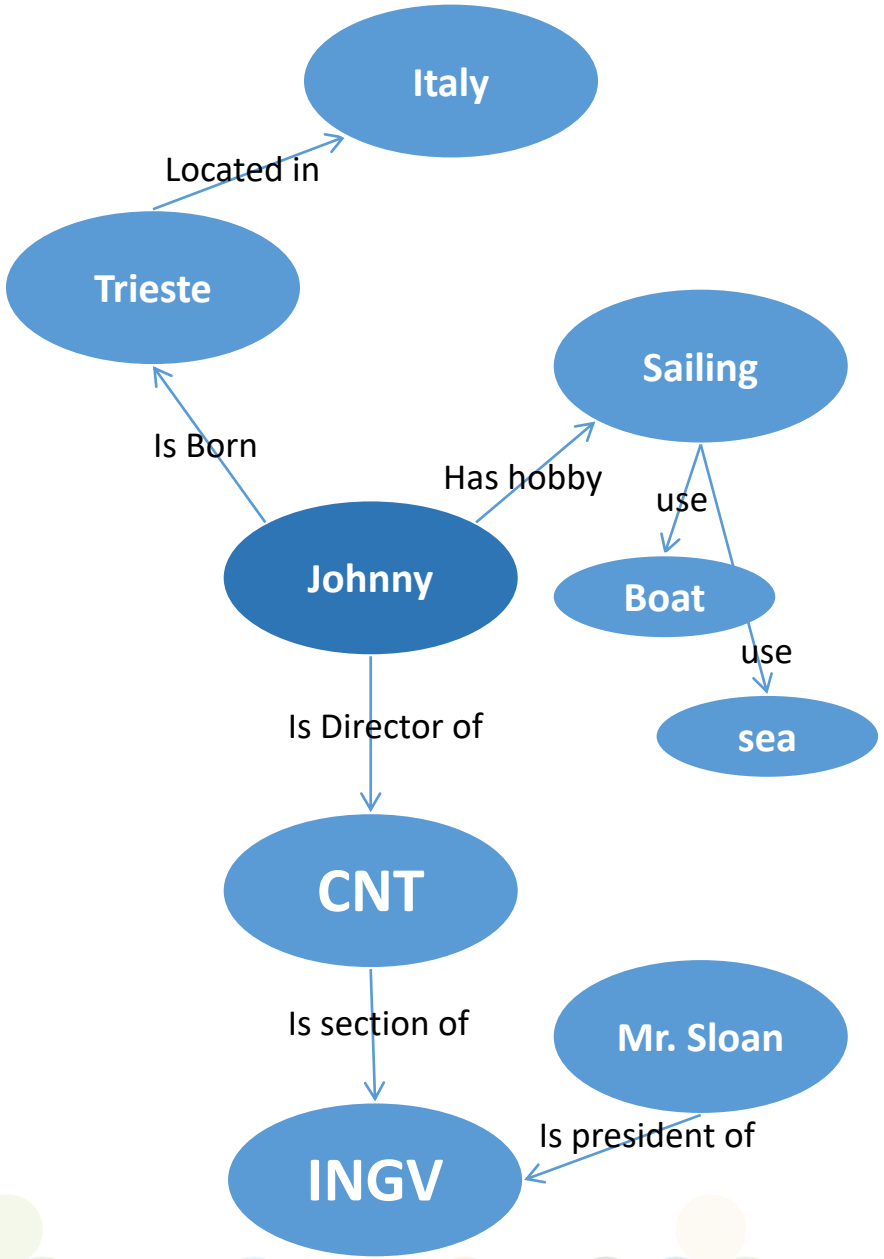

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Metadata: applicable language for knowledge representation

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Ontologies & semantics

Why an ontology?

It is the way machines manage “meaning”

How does it work?

1. *Connects concepts*
2. *Needs vocabulary*

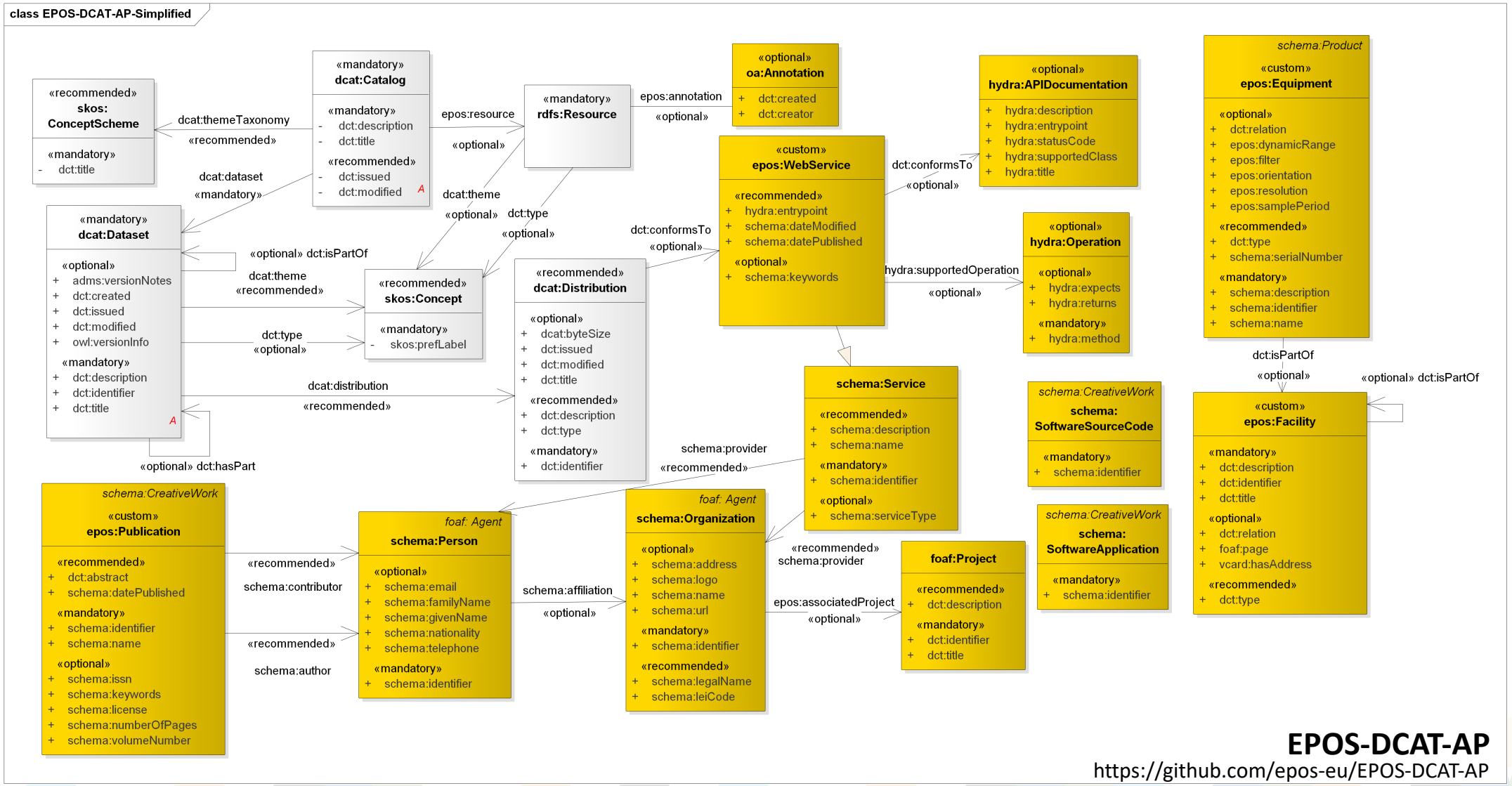
Issues

- Many ontologies exist
- Vocabulary Mapping

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Ontologies in real world (human - readable)

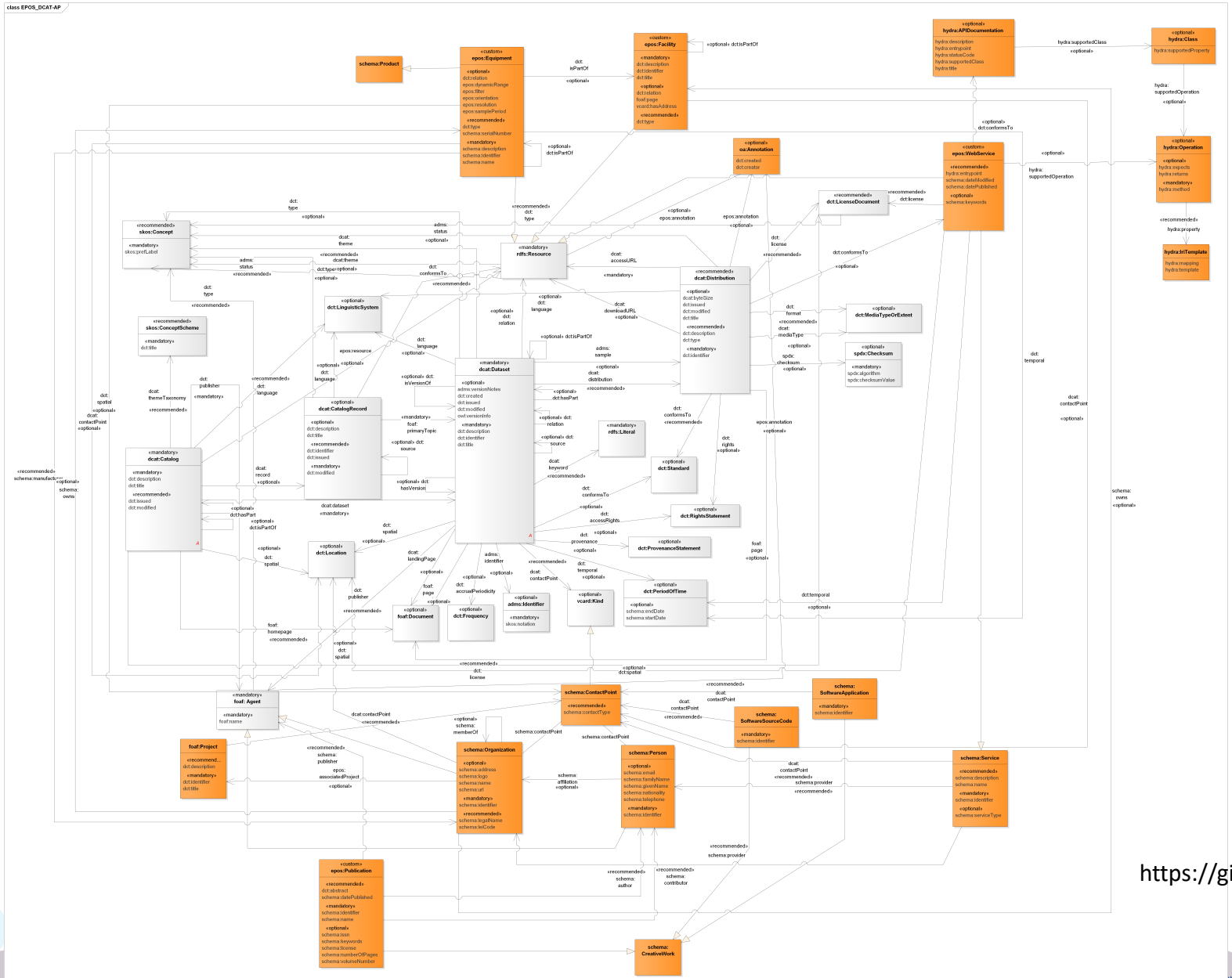
Metadata and ontologies



EPOS-DCAT-AP
https://github.com/epos-eu/EPOS-DCAT-AP

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Ontologies in real world (machine - readable)



EPOS-DCAT-AP
https://github.com/epos-eu/EPOS-DCAT-AP

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FAIR related Topics:

- ~~Data~~
- ~~Metadata~~
- Identifiers
- Protocols
- Authentication & Authorisation
- Standards
- ~~Semantics~~
- policy & provenance
- Services and databases

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http://dx.doi.org/doi:10.30/tqb
http://hdl.handle.net/hdl:13030/tqb
http://purl.org/tqb
... urn:13030:tqb
http://n2t.net/ark:/13030/tqb
http://OwlBike.example.org/ark:/13030/tqb

How to register/cite data or publications?

PID system

Purpose

- *DO / publication can be uniquely referenced*
- *Assign a PID at data creation times*

Issues

- *Dataset and publications are two different things*
- *Contracts with PID issuer*
- *How to identify data streams?*
- *Landing page problem*

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Protocols

web service example

<definition> «Protocol»
a **defined set of rules** and regulations that **determine how data is transmitted** in telecommunications and computer networking

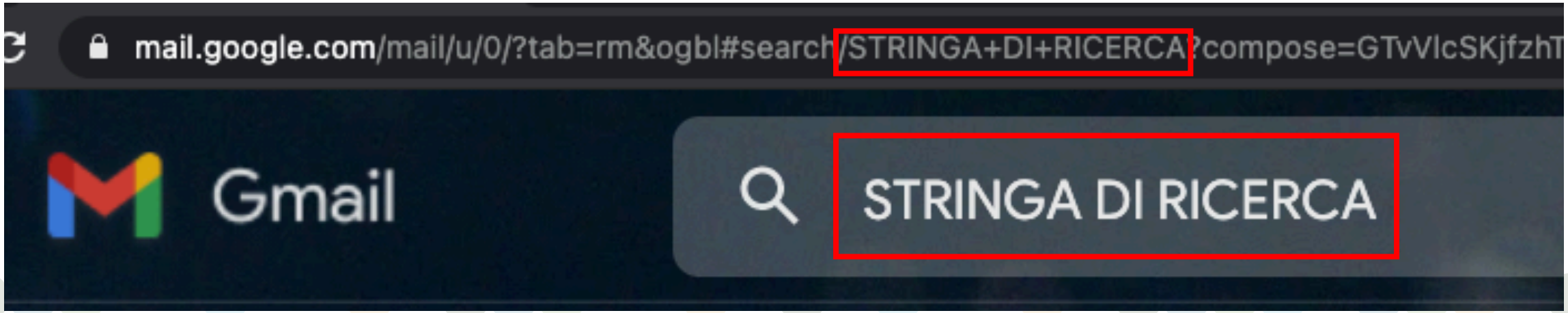
What is it?

server software running on a computer device, listening for requests and serving web documents (HTML, JSON, XML, images)

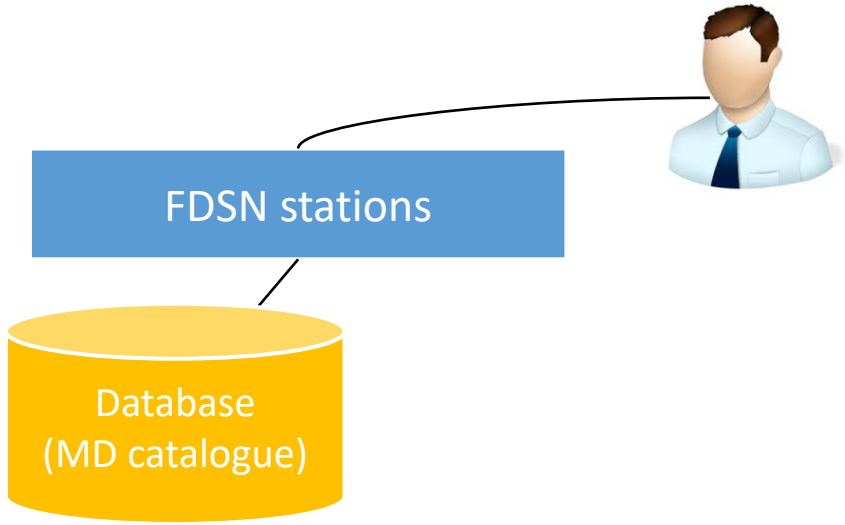
Base URL
service provider

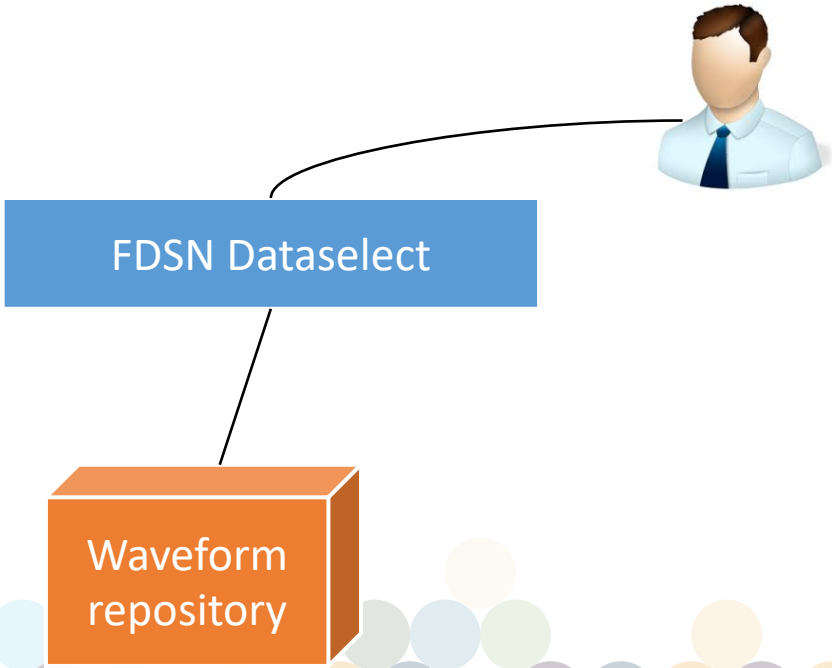
Methods / collections / etc.

Parameters



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Protocols

web service example

What is it?

server running on a computer device, listening for requests and serving web documents (HTML, JSON, XML, images)

A "thin layer"

We usually don't know what's under the hood

Examples

- *FDSN stations*
- *FDSN dataselect*

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System 1
GUI Client

Agreed protocol

Web API (FDSN)

Software

Database
(MD catalogue)

Datasets

System 2
(Black Box
model)

Protocols
Interoperability

What & Why

Enables 2 system to

1. *Exchange information*
2. *Understand information*

Usually achieved through:

- *Agreed language (protocols)*
- *Software "translators" interfaces → thin layers → webapis*
- *Standards (http, POP3, IMAP, ftp)*

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AARC

ORCID

Sign in with EGI CheckIn

eduGAIN

Google

facebook

How to access data?

AAI system
(federeated & distributed)

Purpose

- *Authenticate users*
- *Authorize users*

Topics

- *Identity Provider*
- *Federation*
- *Authorization*
- *AAI integration*

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FAIR AAAI - real life problems



I'm a Data Infrastructure Manager. How can I implement an AAI system?

Building in-house software can be resource consuming. Do off-the-shelf solutions exist?

my Data infrastructure

Photo by Christina @ wocintechchat.com on Unsplash

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FAIR AAAI - real life problems



Photo by Christina @ wocintechchat.com on Unsplash



NB: eduGAIN is here used merely as an example

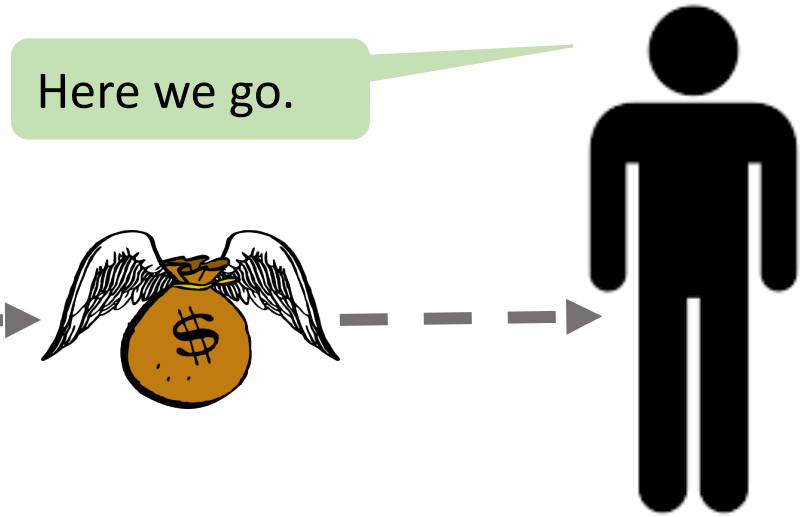
my Data infrastructure

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FAIR AAAI - real life problems



Identity Provider



Money flow

Identity Provider Infrastructure (e.g. eduGAIN)

AAAI connector

my Data infrastructure

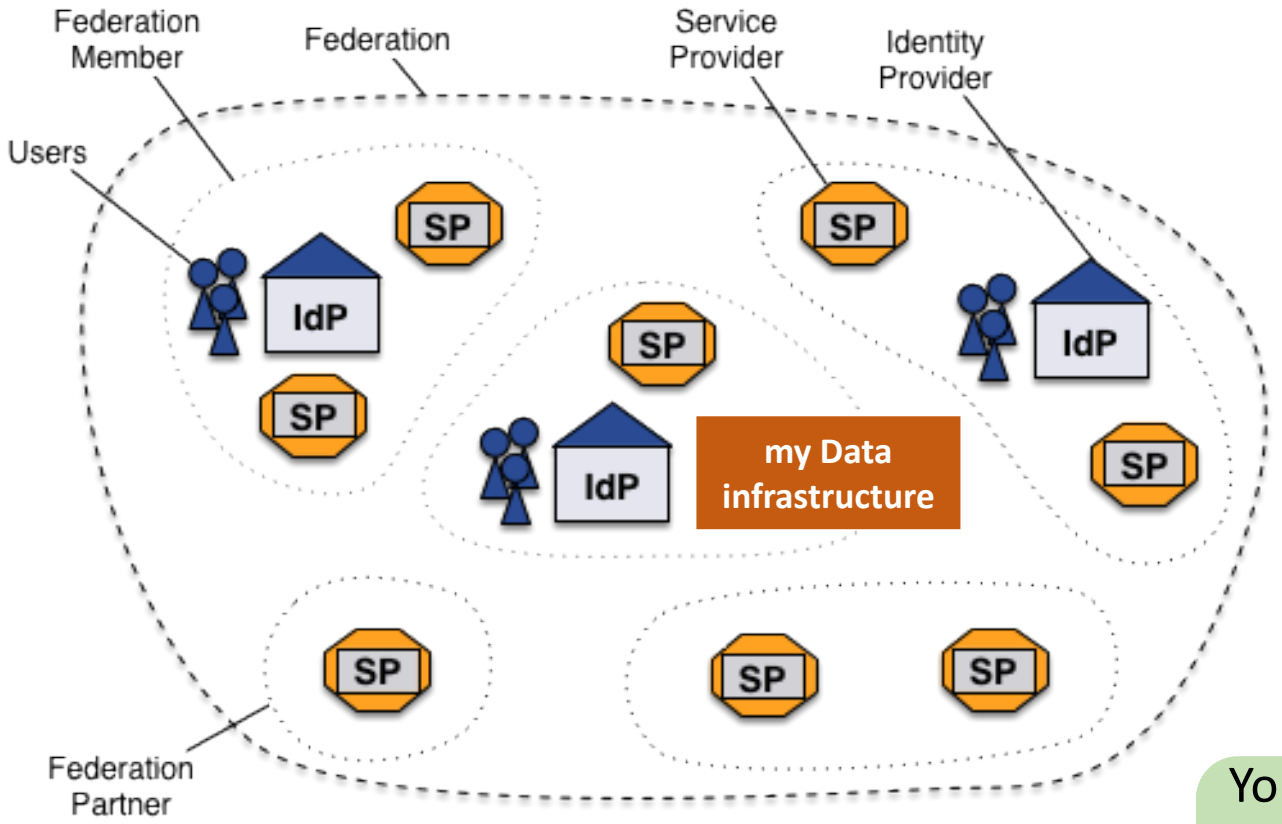
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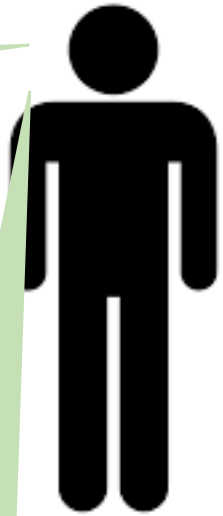
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FAIR AAAI - real life problems





Identity Provider



We can do more.

You can share resources (data) with other Organizations in the federation

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FAIR AAAI - real life problems



Sharing resources (data) with other Organizations in the federation

=

Defining common **authorization** schema, e.g.

#	Level	Required attributes	Requirements for user	Rights
0	untrusted (anonymous)	(none)	no email confirmation	just access metadata
1	normal user	user	email confirmation (not confirmed name)	access open resources (e.g services)
2	resource access (including workflows and sensor networks, TNA?)	user & access	trusted affiliation and name	access open resources and resources that require trusted users
3	access to embargoed resources	users & specific restricted access attribute (e.g. EPOS IP member)	trusted affiliation, name and user group	access to embargoed resources
4	processing	user & processing	trusted affiliation and user role	access to computational resources
5	admin	admin	manually added to admin group	



Requires discussion and definition of:

- Data policy
- GDPR
- …others

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- Services and databases

} Leave it open for now…

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How to implement FAIR?

State of the art

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FAIR Implementation in EU Initiatives

Projects and initiatives

- Metadata 4 Machines: metadata standard
- FAIR Implementation Profile working group: FAIR evaluation
- FAIR Data Point: metadata repository that provides access to metadata in a FAIR way

FAIRsFAIR - Fostering Fair Data Practices in Europe - aims to supply practical solutions for the use of the FAIR data principles throughout the research data life cycle.



Other initiatives exist. In general most initiatives are about:
Evaluations, metadata discussions, training, adoption of 3° party certification, best practices

Community specific initiatives

Promotes building of FAIR Ris in the environmental domain. This will enhance the efficiency and productivity of researchers, support innovation and connect the ENVRI Cluster to the EOSC.

FAIR implementation is delegated to the communities, with support in terms of best practices, tools, training

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Standards and Certification initiatives

RESEARCH DATA ALLIANCE

TRUST

https://doi.org/10.1038/s41597-020-0486-7

Transparency
Responsibility
User Focus
Sustainability
Technology

CORE TRUST SEAL

https://www.coretrustseal.org/
https://doi.org/10.5281/zenodo.3638211

Certification based on the DSA–WDS Core Trustworthy Data Repositories Requirements:

Access Rights Information, Appraisal Archive, Authenticity, Consumer, Curation, Data
Database, Dataset, Designated Community,
Digital Object, Digital Preservation ….

German Standards Committee (DIN) adopted ***DIN 31644 Information and documentation - Criteria for trustworthy digital archives.***

Consultative Committee for Space Data Systems released recommended practice on "**Audit and certification of trustworthy digital repositories**", published as *ISO 16363 2012* (**ISO,2012b**).

DigitalPreservationCoalition
https://www.dpconline.org/handbook

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Implementation in Literature (excerpt)

FAIR Principles: Interpretations and Implementation Considerations
Annika Jacobsen et al. Data Intelligence 2020 2:1-2, 10-29

The FAIR Principles: First Generation Implementation Choices and Challenges
Barend Mons et al. Data Intelligence 2020 2:1-2, 1-9
https://doi.org/10.1162/dint_e_00023

OSSE Goes FAIR - Implementation of the FAIR Data Principles for an Open-Source Registry for Rare Diseases.
Schaaf, J. et al. *Studies in Health Technology and Informatics*, *253*, 209–213. https://doi.org/10.3233/978-1-61499-896-9-209

Perspectives on the implementation of FAIR principles in solid Earth Research Infrastructures.,
Bailo, Daniele, et al.
FrEaS 8 (2020): 3. https://doi.org/ 10.3389/feart.2020.00003

Inputs for RI managers/implementers:
Best practices, discussion specific topics, experiences

Volume 2, No. 1-2 - Special Issue on Emergent FAIR Practices.
Issue Editors: Barend Mons, Erik Schultes & Annika Jacobsen

Implementation Articles

Unique, Persistent, Resolvable: Identifiers as the Foundation of FAIR
Nick Juty, Sarala M. Wimalaratne, Stian Soiland-Reyes, John Kui and Tim Clark
Data Intelligence Winter-Spring 2020, Vol. 2, No. 1-2, pp. 30–39
Abstract Full Text PDF (225 KB) PDF Plus (268 KB)

Making Data and Workflows Findable for Machines
Tobias Weigel, Ulrich Schwardmann, Jens Klump, Sofiane Bendo Quick
Data Intelligence Winter-Spring 2020, Vol. 2, No. 1-2, pp. 40–46
Abstract Full Text PDF (233 KB) PDF Plus (283 KB)

The "A" of FAIR – As Open as Possible, as Closed as Necessary
Annalisa Landi, Mark Thompson, Viviana Giannuzzi, Fedele Boni Labastida, Luiz Olavo Bonino da Silva Santos, and Marco Roos
Data Intelligence Winter-Spring 2020, Vol. 2, No. 1-2, pp. 47–55
Abstract Full Text PDF (244 KB) PDF Plus (293 KB)

A Generic Workflow for the Data FAIRification Process
Annika Jacobsen, Rajaram Kaliyaperumal, Luiz Olavo Bonino da Barend Mons, Erik Schultes, Marco Roos, and Mark Thompson
Data Intelligence Winter-Spring 2020, Vol. 2, No. 1-2, pp. 56–65
Abstract Full Text PDF (1154 KB) PDF Plus (325 KB)

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How to technically implement FAIR?



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The FAIR implementation process

a scalable approach from Solid Earth Domain

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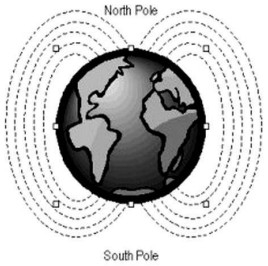
EPOS Data Integration

Community Specific

Data & Services



laboratory



Geomagnetic



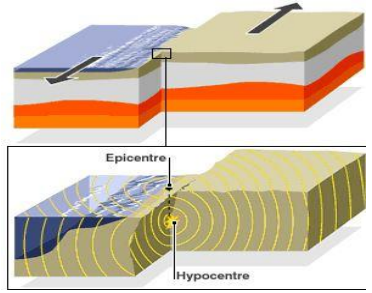
GPS



Volcanos



satellite



Seismolgy

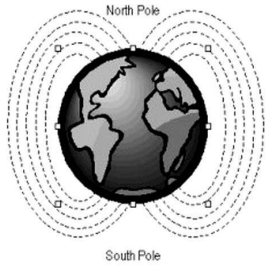
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EPOS Data Integration

Data & Services
Integration *in a central hub*



laboratory



Geomagnetic



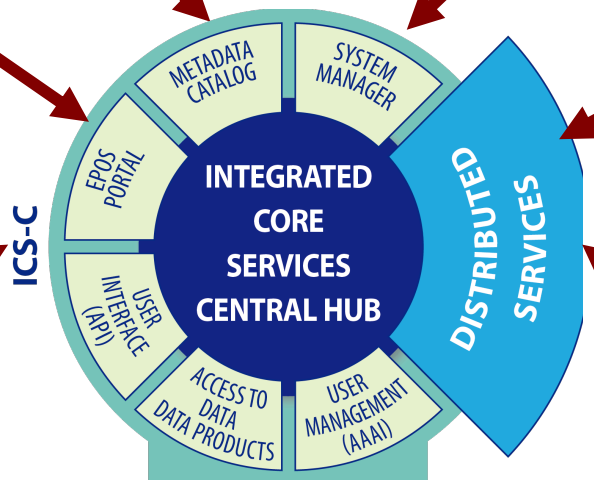
GPS

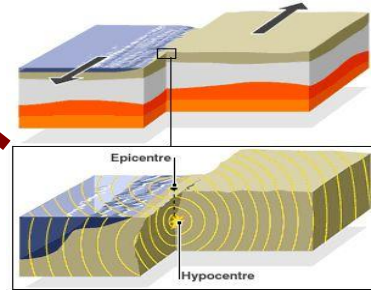


Volcanos



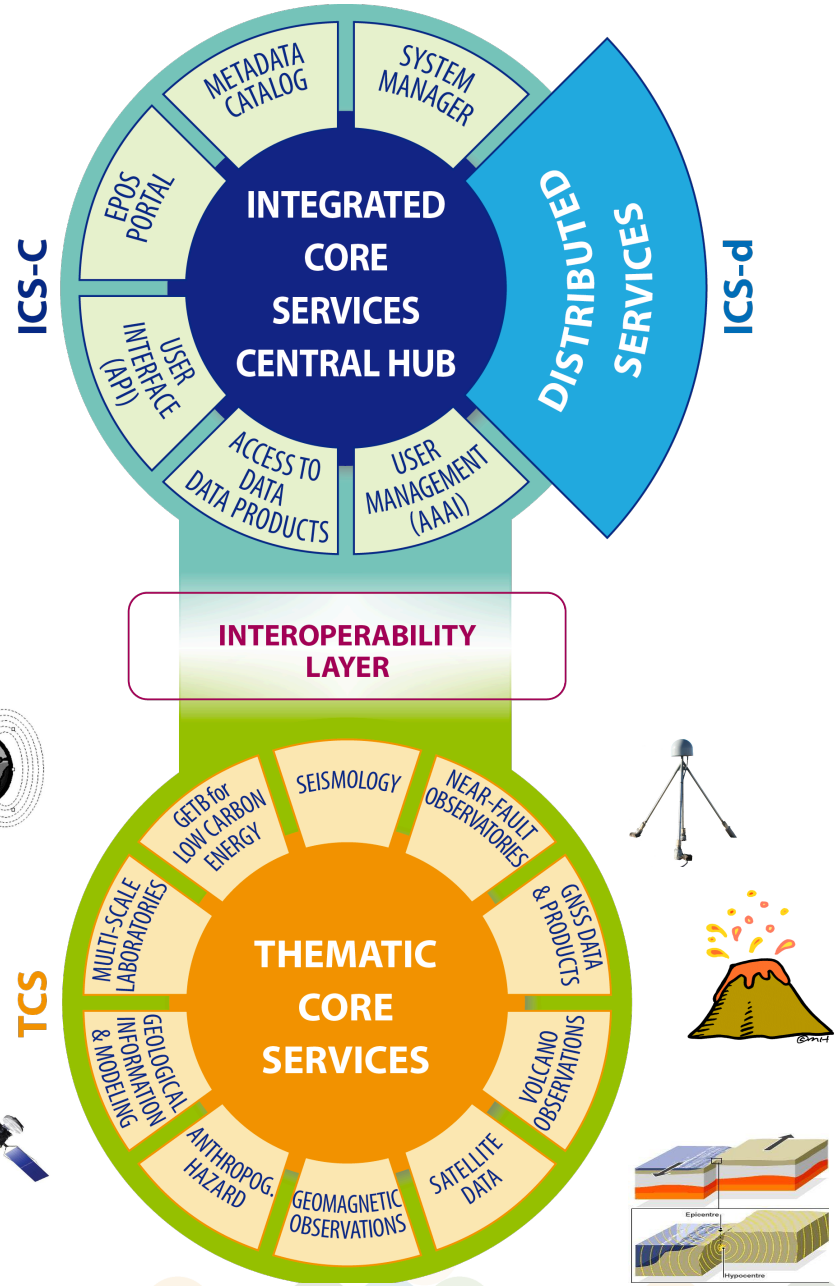
satellite





Seismolgy

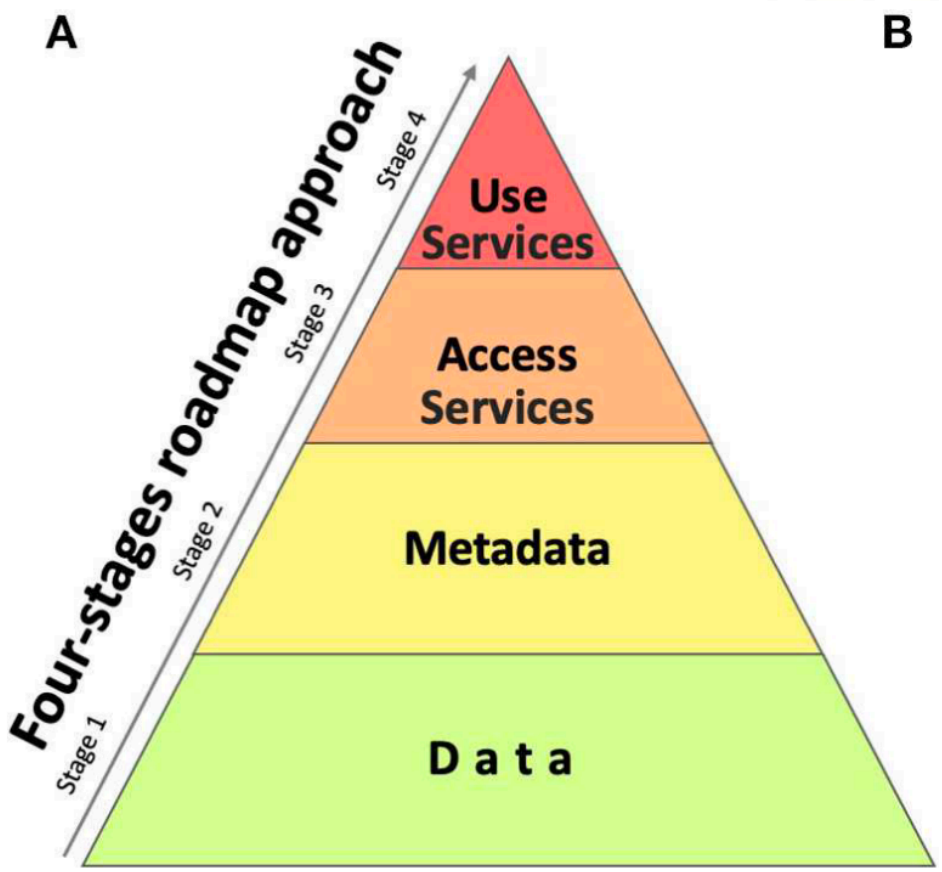
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FAIRness at Integration level

FAIRness at Community level

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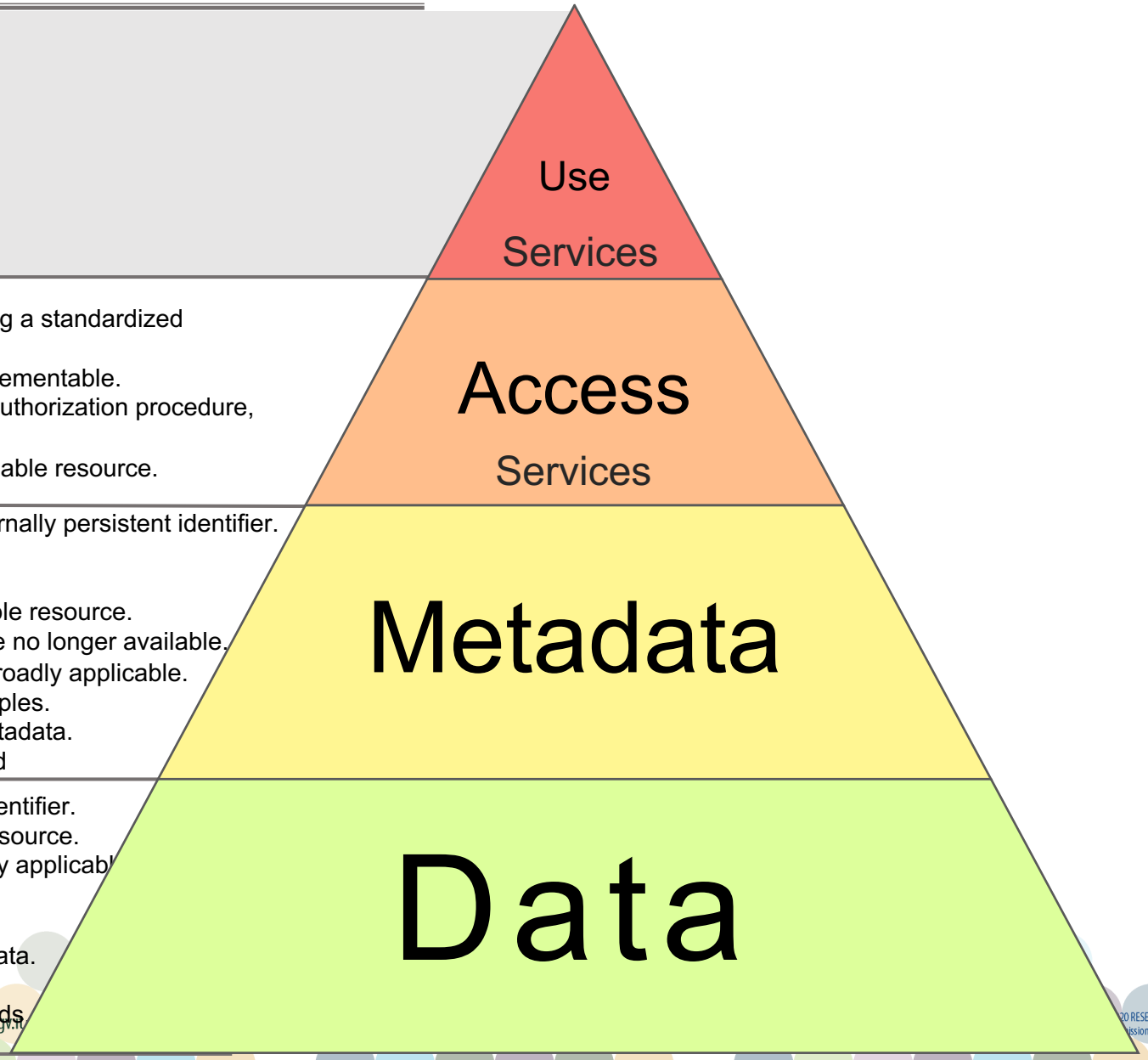


Process to achieve fairness

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FAIR PRINCIPLES

Step (a)



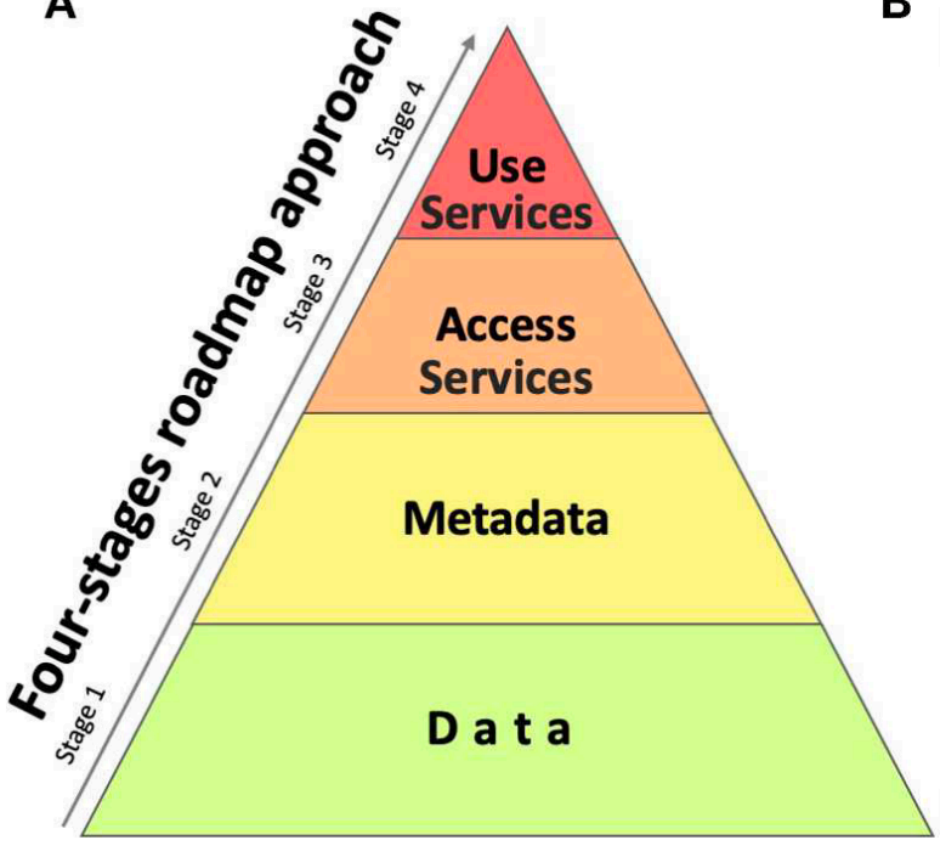
A1. (meta)data are retrievable by their identifier using a standardized communications protocol.
A1.1. the protocol is open, free, and universally implementable.
A1.2. the protocol allows for an authentication and authorization procedure, where necessary.
F4. (meta)data are registered or indexed in a searchable resource.

F1. Metadata are assigned a globally unique and eternally persistent identifier.
F2. data are described with rich metadata.
F3. metadata specify the data identifier.
F4. metadata are registered or indexed in a searchable resource.
A2. metadata are accessible, even when the data are no longer available.
I1. metadata use a formal, accessible, shared, and broadly applicable.
I2. metadata use vocabularies that follow FAIR principles.
I3. metadata include qualified references to other metadata.
R1 (R1.1 - R1.2 - R1.3) Metadata are richly described

F1. Data are assigned a globally unique persistent identifier.
F4. Data are registered or indexed in a searchable resource.
I1. Data use a formal, accessible, shared, and broadly applicabl
language for knowledge representation.
I2. Data use vocabularies that follow FAIR principles.
I3. Data include qualified references to other (meta)data.
R1.1. Data are released with a clear license.
R1.3. Data meet domain-relevant community standards.

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A



B

FAIRness assessment

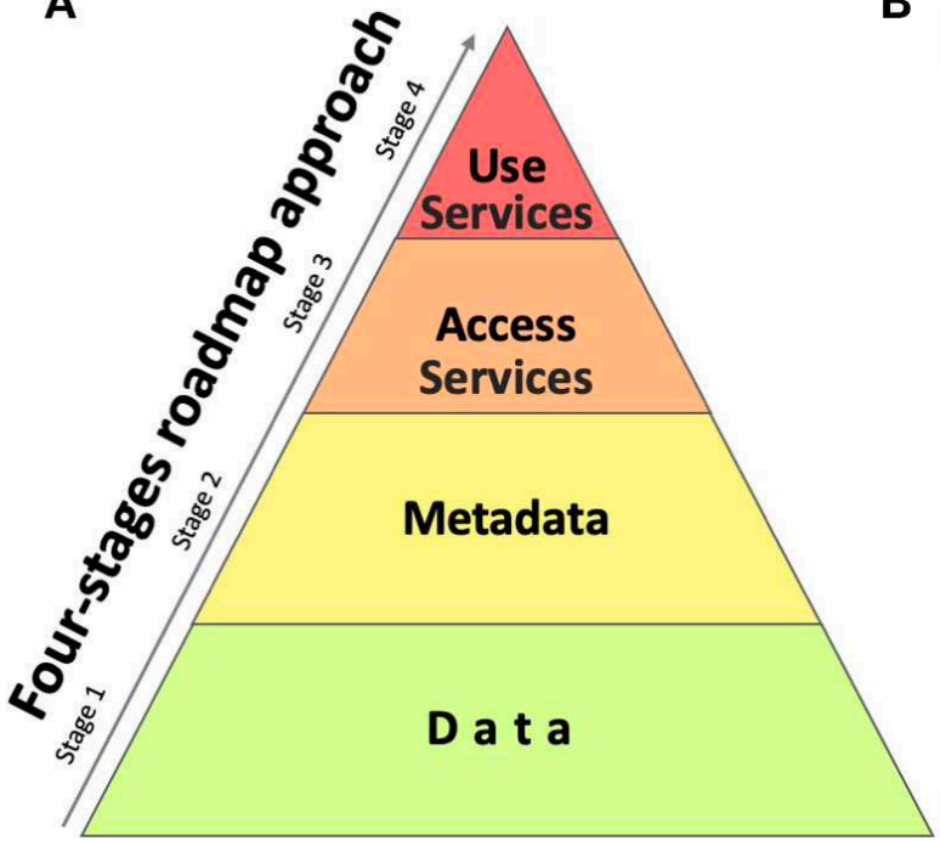
a) Evaluation of FAIR compliancy

b) Gap analysis

Existing evaluation frameworks can be reused, e.g. FIP

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A



B

FAIRness assessment

a) Evaluation of FAIR compliancy

b) Gap analysis

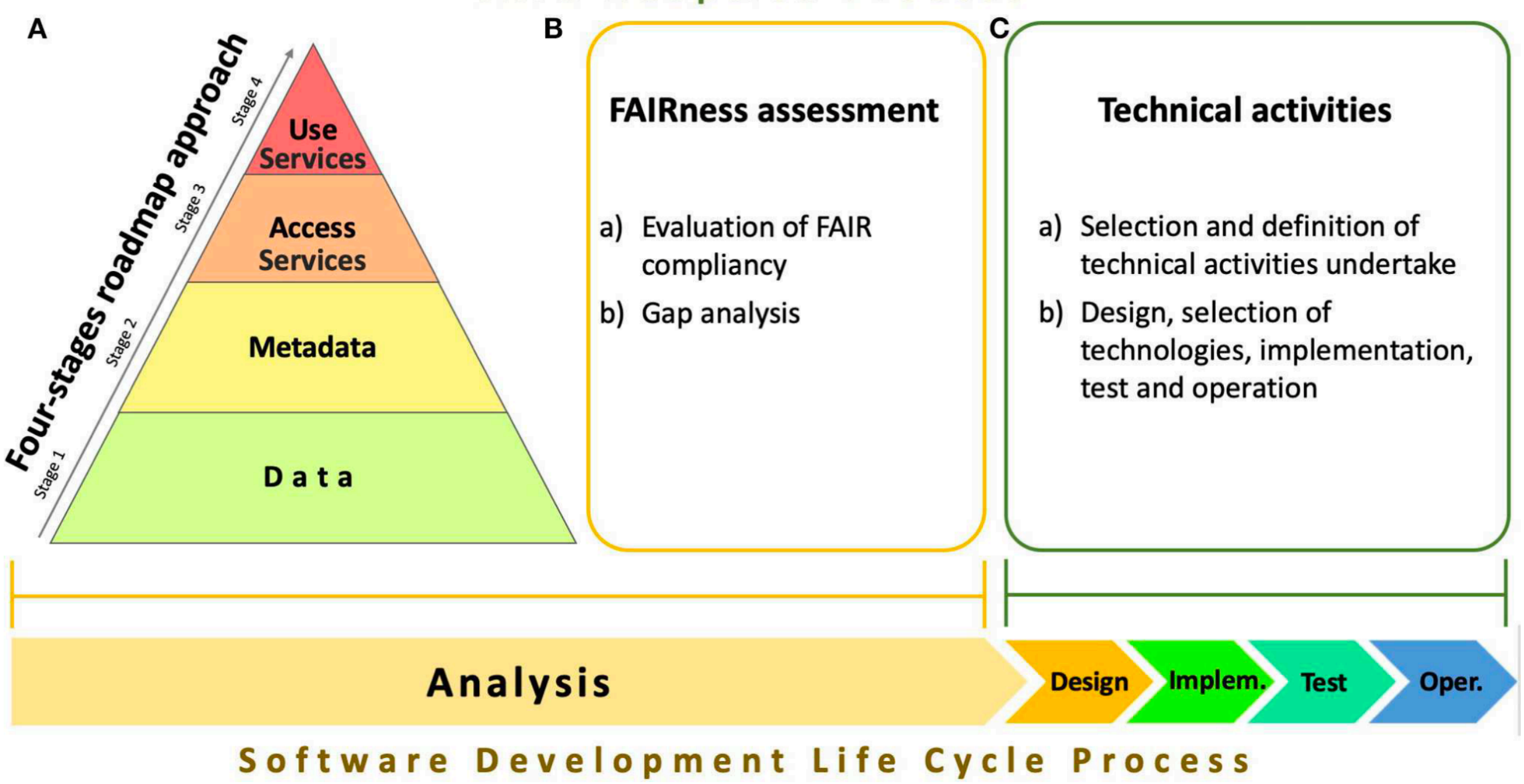
C

Technical activities

a) Selection and definition of technical activities undertake

b) Design, selection of technologies, implementation, test and operation

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[Perspectives on the Implementation of FAIR Principles in Solid Earth Research Infrastructures.
Bailo, D. et al. Frontiers in Earth Science, 8, 3. https://doi.org/10.3389/feart.2020.00003]

THEORY **REALITY**

FAIR PRINCIPLES	Researcher Mindset	TYPES of TECHNOLOGIES
	Use Services	Processing facilities Workflows Analysis or visualization tools
A1. (meta)data are retrievable by their identifier using a standardized communications protocol. **A1.1.** the protocol is open, free, and universally implementable. **A1.2.** the protocol allows for an authentication and authorization procedure, where necessary. **F4.** (meta)data are registered or indexed in a searchable resource.	Access Services	*Search/discovery service* *SOA, web services* *Standard communication Protocols* *Authentication, Authorisation, Accounting*
F1. Metadata are assigned a globally unique and eternally persistent identifier. **F2.** data are described with rich metadata. **F3.** metadata specify the data identifier. **F4.** metadata are registered or indexed in a searchable resource. **A2.** metadata are accessible, even when the data are no longer available. **I1.** metadata use a formal, accessible, shared, and broadly applicable. **I2.** metadata use vocabularies that follow FAIR principles. **I3.** metadata include qualified references to other metadata. **R1 (R1.1 - R1.2 - R1.3)** Metadata are richly described	Metadata	*Ontologies and Vocabularies* *Serialisation* *Persistent Identifier* *License handling* *Metadata Catalogue* *Provenance*
F1. Data are assigned a globally unique persistent identifier. **F4.** Data are registered or indexed in a searchable resource. **I1.** Data use a formal, accessible, shared, and broadly applicable language for knowledge representation. **I2.** Data use vocabularies that follow FAIR principles. **I3.** Data include qualified references to other (meta)data. **R1.1.** Data are released with a clear license. **R1.3.** Data meet domain-relevant community standards.	Data	*Standards Formats* *Data catalogue* *Persistent Identifiers* *License handling*

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Pyramid Stage	FAIR principle	Related technical activities
DATA (S1)	**I1**. data use a formal, accessible, shared, and broadly applicable language for knowledge representation. **R1.3**. data meet domain-relevant community standards **I2**. data use vocabularies that follow FAIR principles. **I3**. data include qualified references to other (meta)data.	***Selection or creation of a data model which provides a standard format for information resource description, supporting an ontology and providing standard vocabulary of terms.*** A main step for a FAIR data provision is its harmonization by adopting a standard format within a domain-specific community (e.g., shapefiles ESRI, 1998); need for harmonization frequently occurs typical "long-tail" contexts where data are produced by several different instruments on a per-sample basis, for instance in laboratories. Some formats embed in their serialization also an ontology (e.g. stationXML[f]); in such cases, appropriate FAIR, community-agreed ontologies need to be selected and adopted, possibly reusing or inheriting from existing ones (e.g., EnvO Buttigieg et al., 2016).
	F4. data are registered or indexed in a searchable resource.	***Selection of a Data catalog which supports discovery of datasets, and adoption of appropriate storage and preservation strategies.*** A system for data storage should be selected on the basis of data type, e.g., georeferenced layered data might need a database with GIS support, while other types of data might require filesystem with hierarchical folders or noSQL databases. Furthermore, Certification of Data repository (Dillo and de Leeuw, 2018) might be also considered.
	F1. data are assigned a globally unique and persistent identifier.	***Selection of a PID system which guarantees technical reliability, authority, and ensures a long-term viability.*** PIDs require dedicated machinery and software to be issued, resolved and managed. A common solution is to rely on organizations—e.g., Datacite (Jan, 2009), ePIC[g]—implementing the above, but other options might be considered (Sicilia et al., 2019).
	R1.1. data are released with a clear and accessible data usage license.	***Development and adoption a Data policy which ensures that data collected or created by the communities, once quality controlled, are made available under clear usage conditions licenses.*** From a technical point of view, licenses require rich enough information to be machine-readable and properly cited. A relevant example is creative commons which provide an easy way to choose a license and to share it in a machine-readable way[h]. Besides technical aspects, for establishing data policies community-wide agreements are needed and, according to the size of the community, they may require implementation of appropriate communication, community building, and organizational strategies.

Final Considerations

Need for a pragmatic approach to help and guide Data Providers

FAIR is not only about (examples):

→Defining metadata schemas

→Choosing a good ontology

→Select the serialization format

→Defining PID issuer

It has pragmatic aspects (examples):

→select an existing metadata standards with associated tools for metadata manipulation and management

→integrate PID services in the existing e-Infrastructure

→ Integrate AAAI system in the existing infrastructure

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Final Considerations

Generalistic repositories: do they serve the purpose?

Yes, when:

→You have few datasets

→Metadata is simply a list of tags

→Your data is linked to a publication

No, when:

→You have many datasets, or dynamic data

→You want to perform parameter-specific search (e.g CO2)

→You need an institutional-based approach

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Final Considerations

If we want FAIR to be implemented more clear technical directions are needed

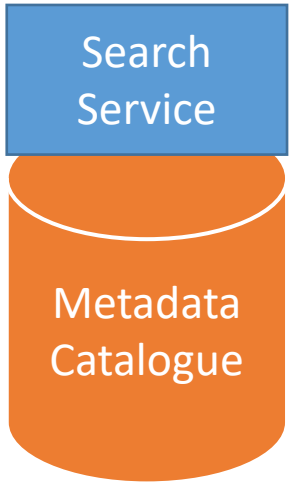
What tools or technical activities to satisfy specific principles?

Example: "***F4.*** *Data are registered or indexed in a searchable resource".*

→ *Need metadata catalogue (database)*

→ *Selection of a standard metadata format (need list of available standards)*

→ *Need a service to search into the catalogue (web service)*



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Final Considerations

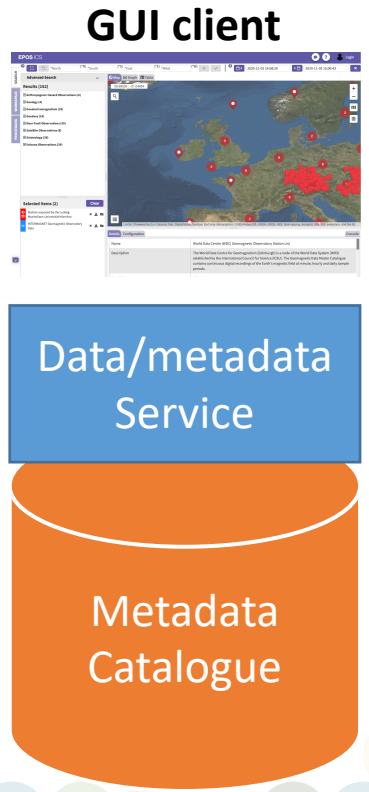
(web) Services are the «missing guest» in FAIR principles

Data is usually made available thorugh a «service»,

Example:

- RESTful web service
- SOAP web Services

Machines or GUI Client use such services



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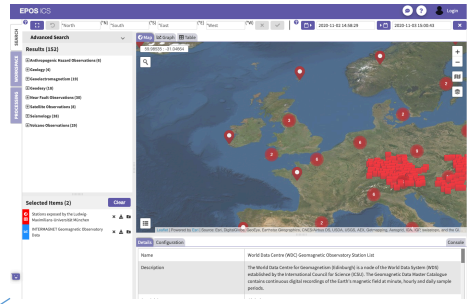
Final Considerations

Freedom of implementation vs. design guidelines

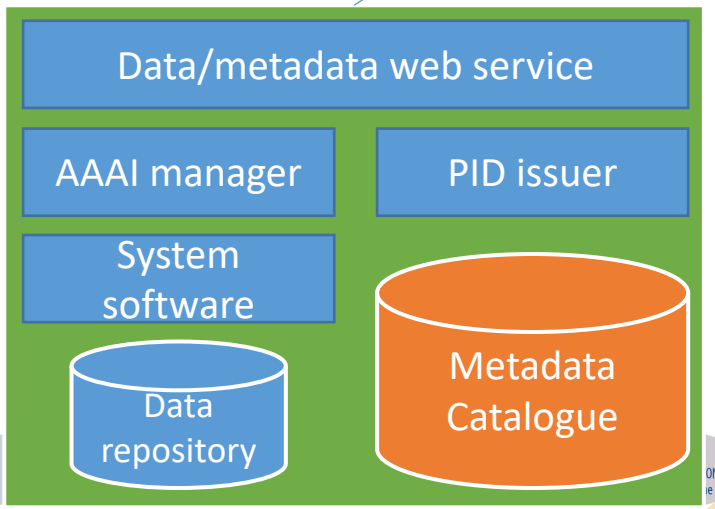
FAIR community is still too shy

→reference architectures and technology checklist might be provided

→Otherwise, risk of getting «ingested» by problem-solving companies or certification authorities



GUI Client



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Final Considerations

Technical Sustainability

Implementing a FAIR system for data stewardship requires **long term sustainability plan** which includes (at least):

→Technical aspects (e.g. maintanibility of the software)

→Financial aspects (e.g. funding for the long term mainteinance)

→Governance aspects (e.g. involvement of appropriate individulas or stakeholders from the organization)

It is sometimes (often?) preferable to «cluster» with existing initiatives that **tackle FAIR data stewardship at communty level**

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PERSPECTIVE ARTICLE
Front. Earth Sci., 31 January 2020 | https://doi.org/10.3389/feart.2020.00003

Perspectives on the Implementation of FAIR Principles in Solid Earth Research Infrastructures

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[https://www.frontiersin.org/articles/10.3389/feart.2020.00003/full]

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