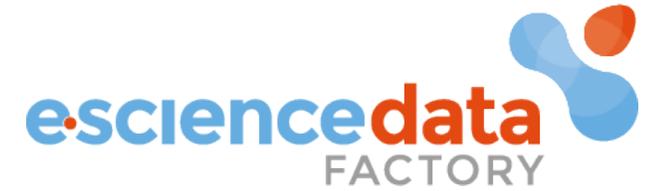




FAIRSFair
Fostering Fair Data Practices in Europe



FAIR Semantics

Building FAIR Ontologies

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ORCID: 0000-0003-4631-418X

CEO – e-Science Data Factory, Paris, France

About the speaker

- Background in Neuroscience, Computational Neurosciences and Machine Learning
- Expert in Semantic Web and Ontology design (10 years)

- Chairman of EUDAT Semantic Web Working Group



- Co-chairman of RDA Vocabulary and Semantic Services Interest Group



- Member of GoFAIR Implementation Network INTER – Cross-disciplinary Semantic Interoperability



- Task leader – FAIR Semantics



What is FAIR?

nature > scientific data > comment > article

MENU ▾

SCIENTIFIC DATA 

Comment | [OPEN](#) | Published: 15 March 2016

The FAIR Guiding Principles for scientific data management and stewardship

Mark D. Wilkinson, Michel Dumontier, IJsbrand Jan Aalbersberg, Gabrielle Appleton, Myles Axton, Arie Baak, Niklas Blomberg, Jan-Willem Boiten, Luiz Bonino da Silva Santos, Philip E. Bourne, Jildau Bouwman, Anthony J. Brookes, Tim Clark, Mercè Crosas, Ingrid Dillo, Olivier Dumon, Scott Edmunds, Chris T. Evelo, Richard Finkers, Alejandra Gonzalez-Beltran, Alasdair J.G. Gray, Paul Groth, Carole Goble, Jeffrey S. Grethe, Jaap Heringa, Peter A.C 't Hoen, Rob Hooft, Tobias Kuhn, Ruben Kok, Joost Kok, Scott J. Lusher, Maryann E. Martone, Albert Mons, Abel L. Packer, Bengt Persson, Philippe Rocca-Serra, Marco Roos, Rene van Schaik, Susanna-Assunta Sansone, Erik Schultes, Thierry Sengstag, Ted Slater, George Strawn, Morris A. Swertz, Mark Thompson, Johan van der Lei, Erik van Mulligen, Jan Velterop, Andra Waagmeester, Peter Wittenburg, Katherine Wolstencroft, Jun Zhao & Barend Mons  - [Show fewer authors](#)

Scientific Data **3**, Article number: 160018 (2016) | [Download Citation](#) ↓



FAIR Principles have been internationally endorsed (G8, G20, European Commission, NIH, ...)

What is FAIR?



Comment | [OPEN](#) | Published: 15 March 2016

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Scientific Data 3, Article number: 160018 (2016) | [Download Citation](#) ↓



FAIR Principles have been internationally endorsed (G8, G20, European Commission, NIH, ...)

Increasing interest from governments and industry stakeholders

How to implement FAIR? Leveraging graph data

- Different formats for data

- Tabular databases: SQL/RDBMS
- CSV (Comma Separated Values) and spreadsheets
- PDF, Text (txt, docx,...)

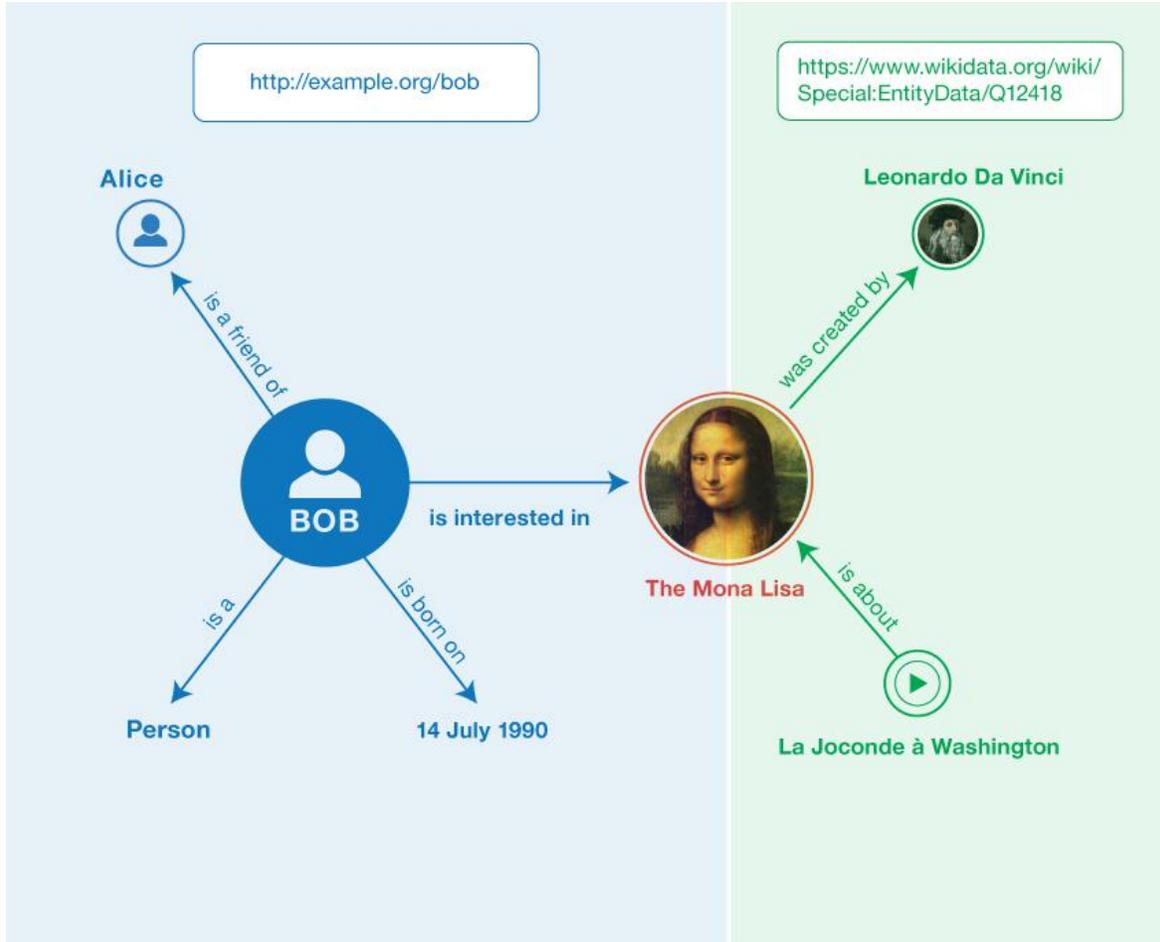
- The advantages of graph data

- Faster than using SQL and associated JOIN operations
- Better suited to integrating data from heterogeneous sources and with heterogeneous formats
- Better suited to situations where the data model is evolving

- Emerging role for knowledge graphs as the basis for integration and governance across the enterprise

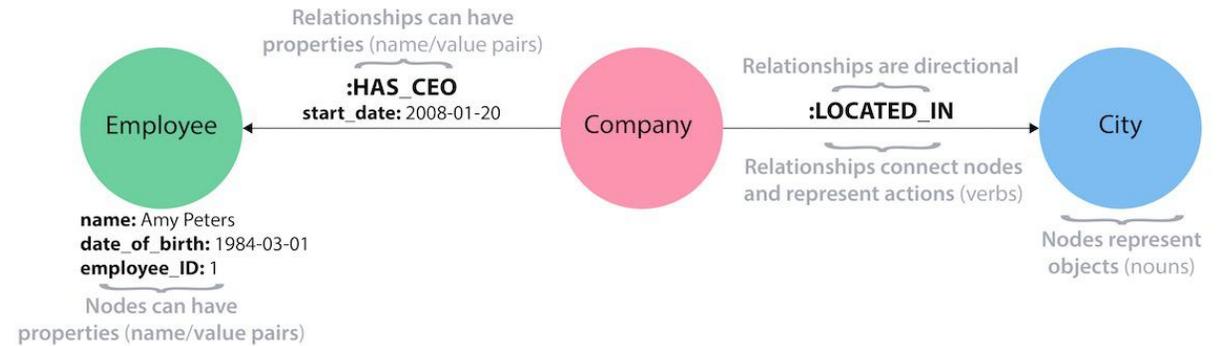
Different types of directed graphs

Named Graph



From <https://www.w3.org/TR/rdf11-primer/>

Property Graph



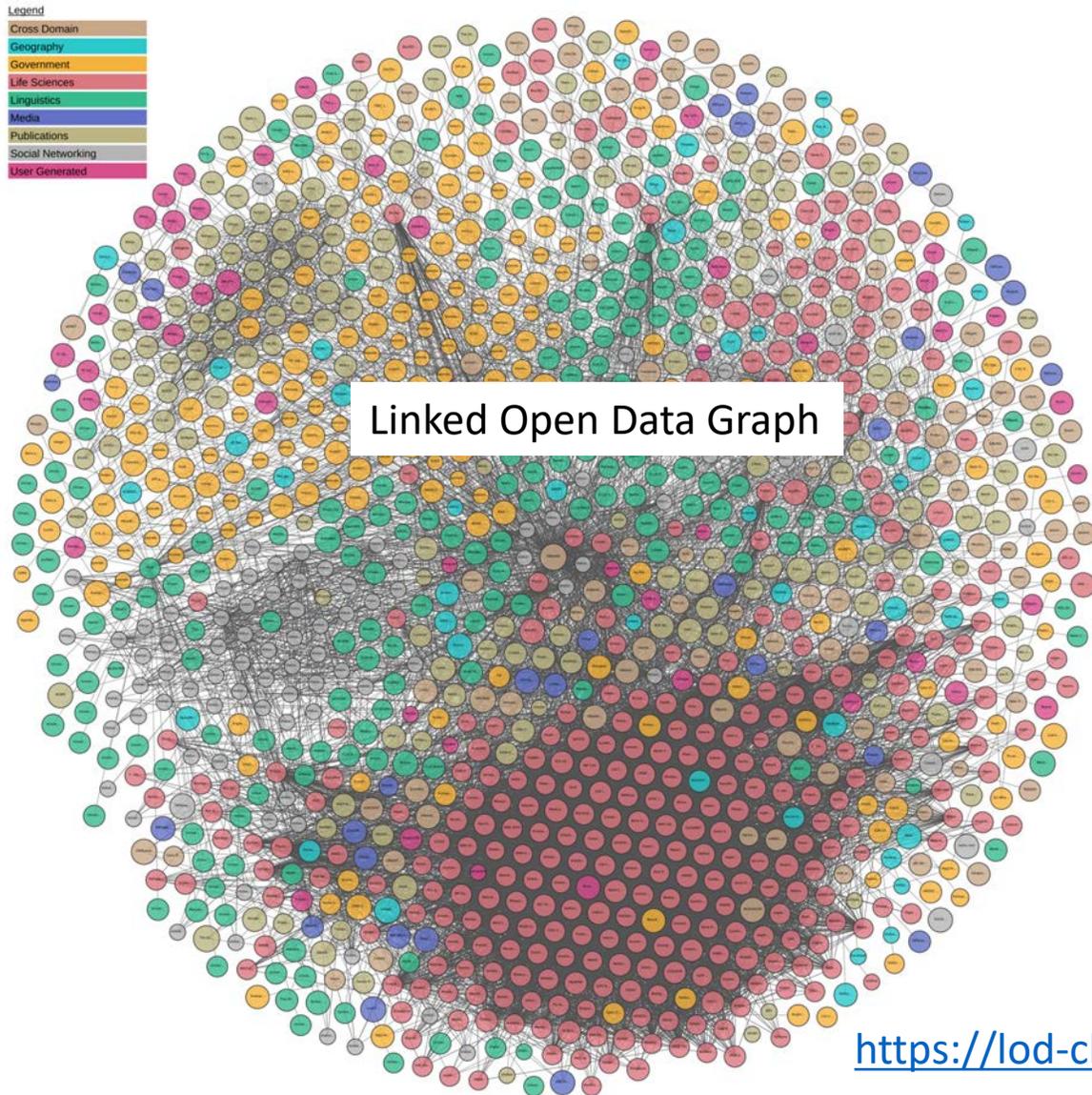
From <https://neo4j.com/developer/graph-database/>

W3C's suite of standards for graph data

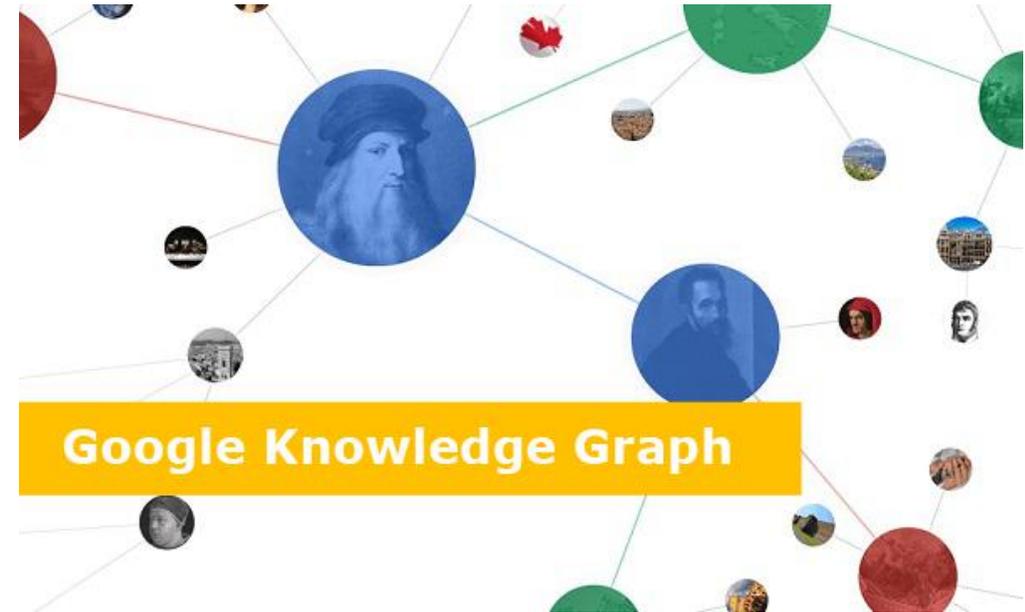


- Binary named directed relationships between concepts
 - `<subject, predicate, object>`, e.g. Mary loves Jack
- Global identifiers for concepts and predicates
 - HTTP URLs and URNs e.g. `urn:tdm:aws:property:switch`
- HTTP based identifiers can be dereferenced for more information
 - HTTP content negotiation to select between different formats (e.g. HTML, RDF/XML, Turtle, N3, JSON-LD, ...)
- New work underway on a higher level framework (Easier RDF)
- RDF as basis for mapping between different Property Graph solutions

Real life examples of data graphs



<https://lod-cloud.net/>



From <https://seopressor.com/blog/why-is-everyone-talking-about-google-knowledge-graph/>

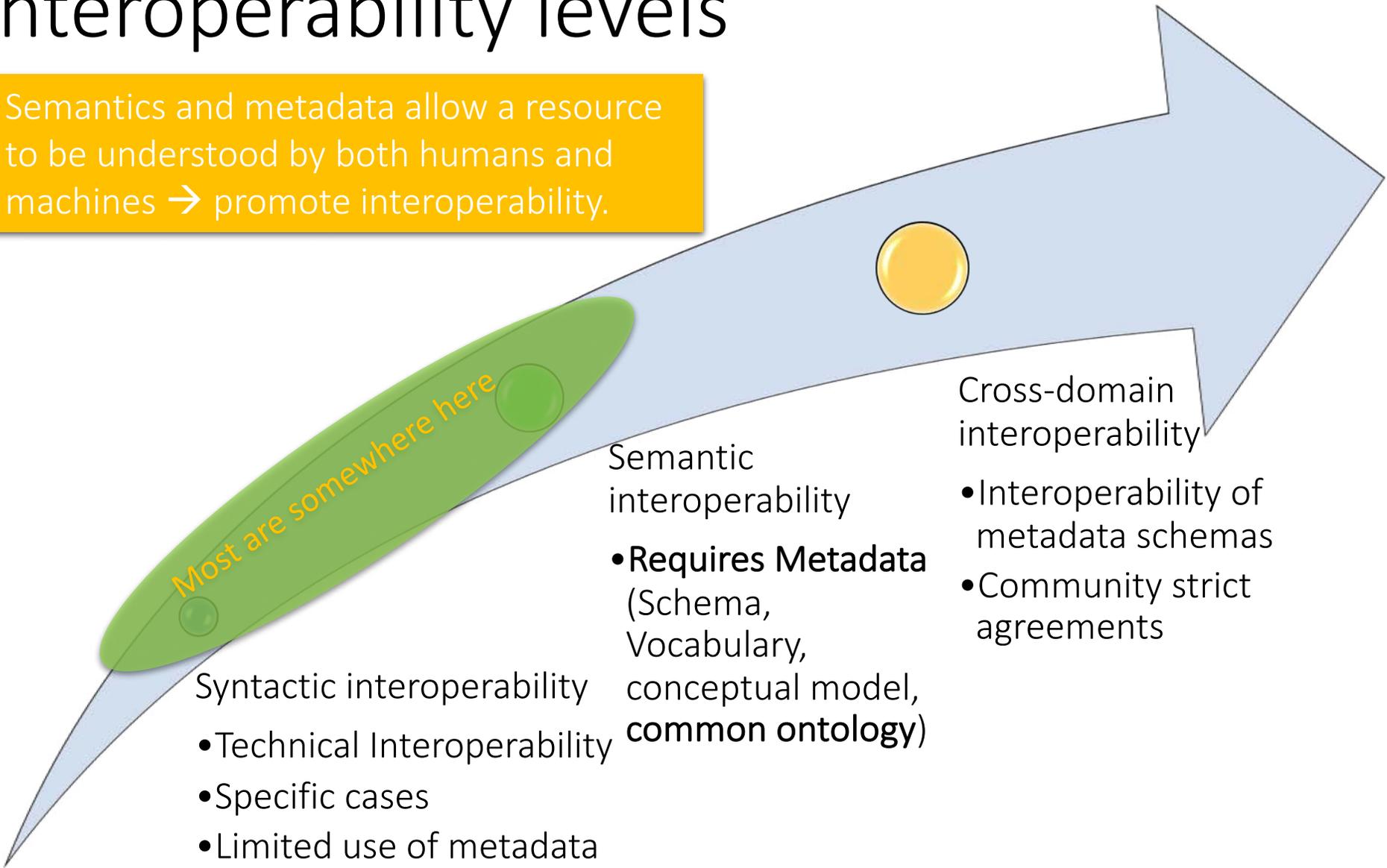
Semantics: How do I know what you mean?

- Interoperability requires agreement at multiple levels, including protocols, data formats and the meaning of data
 - Example: a sensor reading that is a floating point number that denotes a temperature value in degrees Kelvin. We also need to know what this measurement applies to, e.g. “reactor chamber 7”.
- We can state this information as metadata using agreed vocabularies of terms – also known as “ontologies”
 - Ontologies describe relationships between terms to support reasoning over data
- Different ontologies may be at widely varying levels of maturity and designed for different needs
 - Reaching agreement on criteria for attaining different levels of maturity
 - Making it easier to share knowledge and re-use existing work when appropriate



Interoperability levels

Semantics and metadata allow a resource to be understood by both humans and machines → promote interoperability.



Most are somewhere here

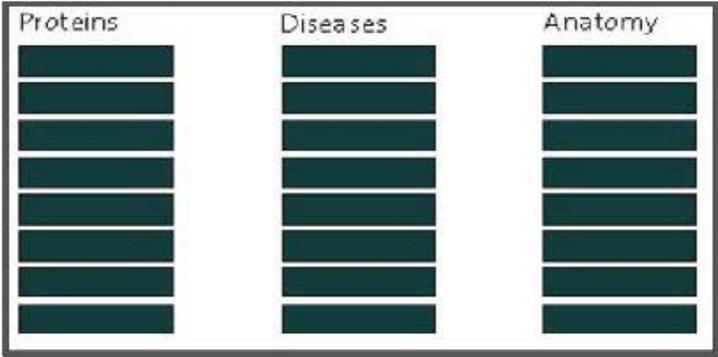
- Syntactic interoperability
- Technical Interoperability
 - Specific cases
 - Limited use of metadata

- Semantic interoperability
- **Requires Metadata** (Schema, Vocabulary, conceptual model, **common ontology**)

- Cross-domain interoperability
- Interoperability of metadata schemas
 - Community strict agreements

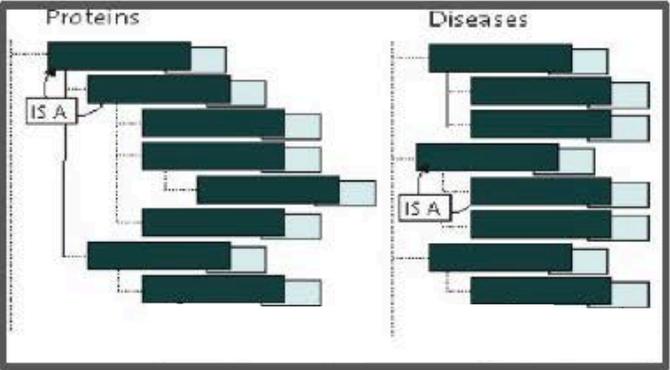
In practice, what is Semantics?

Controlled Vocabulary (CV):
An authoritative list of terms



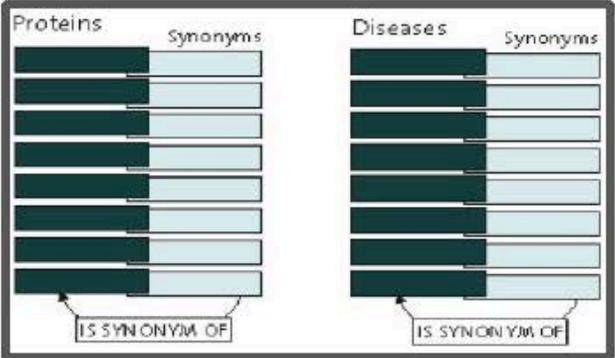
Taxonomy:

A CV with a tree-hierarchical (parent/child term) structure



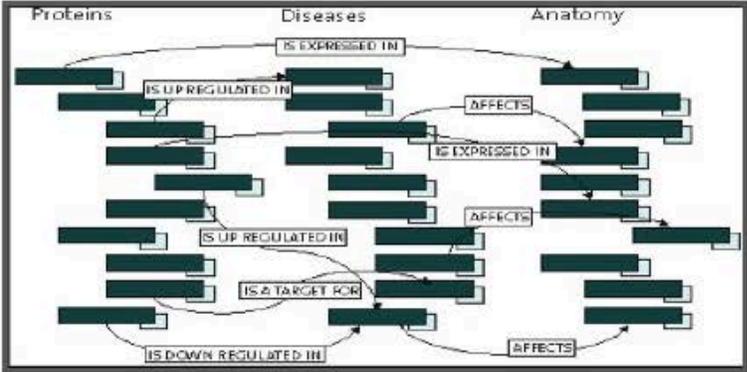
Thesaurus:

A kind of taxonomy with structure and specific types of relationships between terms



Ontology:

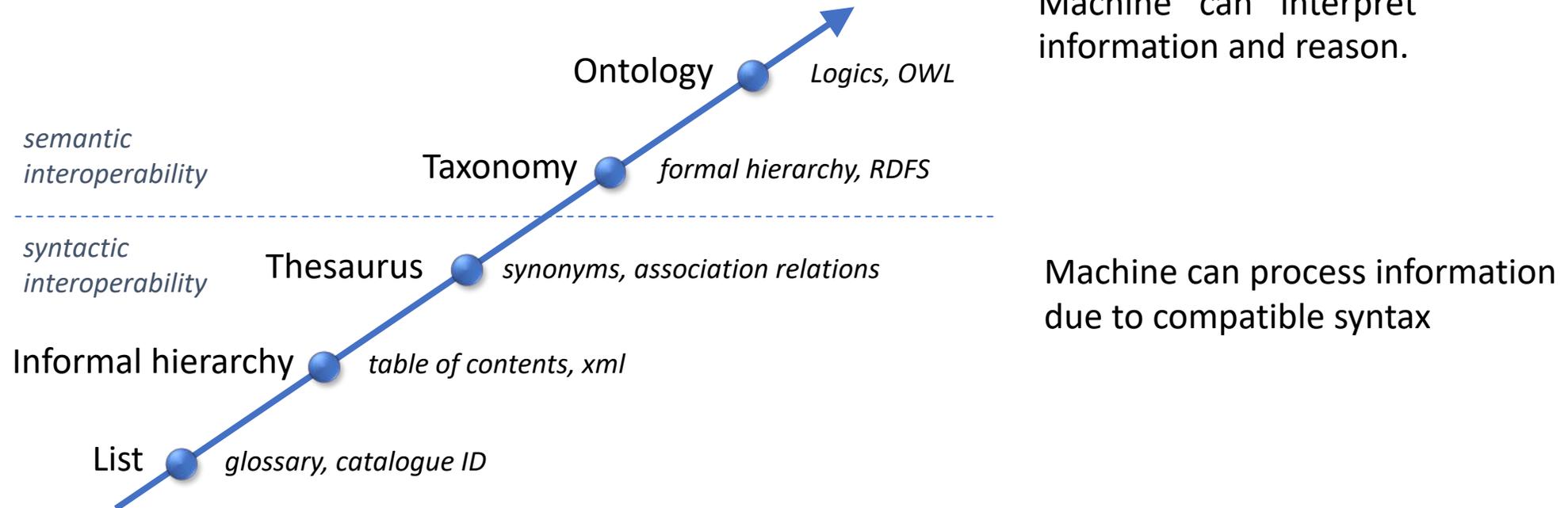
is a kind of taxonomy, but the types of relationships are greater in number and more specific in their function





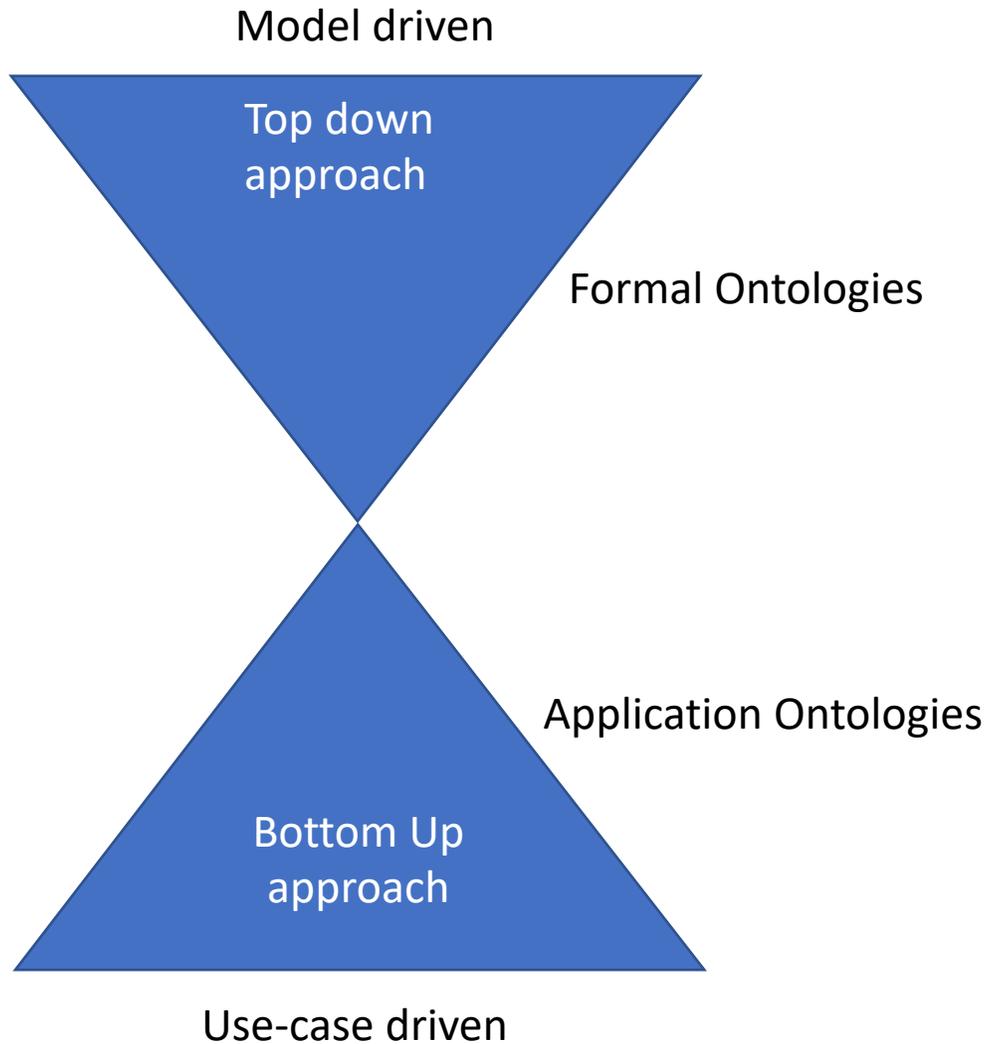
Semantic Spectrum of Knowledge Organization Systems

Semantics and metadata allow a resource to be understood by both humans and machines → promote interoperability.



Adapted from:
Leo Obrst "The Ontology Spectrum". Book section in of Roberto Poli, Michael Healy, Achilles Kameas "Theory and Applications of Ontology: Computer Applications". Springer Netherlands, 17 Sep 2010.

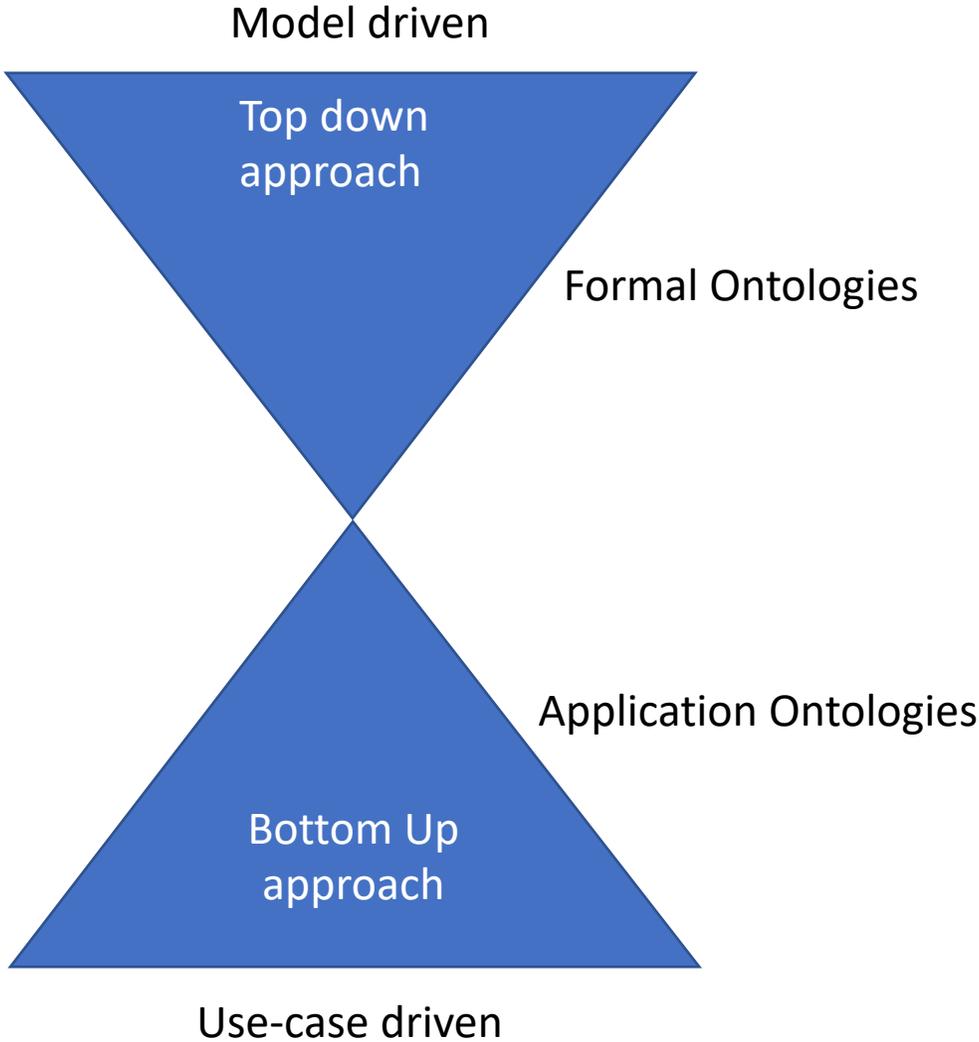
How to build ontologies?



Ontology editors

The screenshot shows the Protege ontology editor interface. The main window displays the 'pizza' ontology. The left pane shows a class hierarchy starting with 'Thing' and 'DomainConcept', leading to 'Food' and 'IceCream', which includes 'Pizza'. The right pane shows the 'Description' for 'Pizza', including 'Equivalent To' (CheesyPizza EquivalentTo Pizza and (hasTopping some CheeseTopping)), 'SubClass Of' (Food, PizzaBase), and 'Disjoint With' (IceCream, PizzaTopping). The bottom status bar indicates 'To use the reasoner click Reasoner->Start reasoner' and 'Show Inferences'.

How to build ontologies?



Ontology editors

The screenshot shows the Protege ontology editor interface. On the left, a class hierarchy for 'Pizza' is visible, including subclasses like 'CheesyPizza', 'MeatyPizza', and 'VegetarianPizza'. On the right, a 'FAIR Competencies Terminology - Master Spreadsheet' is displayed, which is a table with columns for 'Original FAIR4S term name', 'New Atomic Competency Term', 'Context', 'Competency Type', 'Reasoning/Comments', 'Definition of the New Atomic Competency Term', 'Comments on the definition', and 'Previous definitions from'. The table contains several rows of data, including terms like 'Plan' and 'Project'.

Original FAIR4S term name	New Atomic Competency Term	Context (i.e. project or organisation)	Competency Type (skills / knowledge / attitudes)	Reasoning/Comments /Relationships	Definition of the New Atomic Competency Term Determined by #Terms4FAIRskills	Comments on the definition (e.g. needs sharpening)	Previous definitions from https://eoscpiot.eu/competency-terms4FAIRskills-and-capabilities	Alternative name synonym
Plan							Planning and design of data, research software and other outputs. This will include all relevant steps including identifying requirements of research output users, the organisation and research funders, establishing effective approaches to meet their requirements, then reviewing this planning.	
		Project						
Plan stewardship and sharing of FAIR outputs	data stewardship planning		skill		Plan on the findability, access, archive and reuse of data/code in the project, employing proper techniques to make these actionable for project objectives.		Planning and design of data, research software and other outputs. This will include all relevant steps including identifying requirements of research output users, the organisation and research funders, establishing effective approaches to meet their requirements, then reviewing this planning.	Demonstrate how to access reuse code in domain employ appropriate technical actions the curriculum purpose by training into a workflow clean normal a standard re-con code to prepare reuse, approaches to meet their requirements, then reviewing this planning.

W3C's suite of standards for semantics

- Mature suite of standards, e.g. RDF core, OWL, SKOS, SPARQL, Turtle, SHACL
- Lots of work at W3C and elsewhere on ontologies
- Recent W3C Workshop on Graph Data focused on bridging SQL, Property Graph* and Semantic Web/Linked Data communities
 - W3C is launching a W3C Business Group to progress this

* Property Graphs – both nodes and edges can be associated with sets of named property values

Semantics, a key component of Knowledge Graphs and FAIR implementation

- Rapid increase of the number of ontologies and semantic repositories

Biomedical domain

The screenshot shows the BioPortal homepage. At the top, there is a navigation bar with links for Ontologies, Search, Annotator, Recommender, Mappings, and Resource Index, along with Login and Support buttons. The main heading reads "Welcome to BioPortal, the world's most comprehensive repository of biomedical ontologies". Below this, there are two search boxes: "Search for a class" and "Find an ontology". To the left, there is a section titled "Ontology Visits (March 2019)" with a horizontal bar chart showing visits for various ontologies. To the right, there is a "BioPortal Statistics" table.

Category	Count
Ontologies	771
Classes	9,419,364
Resources Indexed	48
Indexed Records	39,537,360
Direct Annotations	95,468,433,792
Direct Plus Expanded Annotations	144,789,582,932

The screenshot shows the EMBL-EBI Ontology Lookup Service (OLS) homepage. At the top, there is a navigation bar with links for Home, Ontologies, Documentation, and About. The main heading reads "Ontology Lookup Service". Below this, there is a search box with the text "Search OLS..." and a search button. To the right, there is a "Data Content" section with statistics: "Updated 28 May 2019 16:48", "229 ontologies", "5,454,804 terms", "23,402 properties", and "481,948 individuals". Below the search box, there are three sections: "About OLS", "Related Tools", and "Contact Us".

About OLS
The Ontology Lookup Service (OLS) is a repository for biomedical ontologies that aims to provide a single point of access to the latest ontology versions. You can browse the ontologies through the website as well as programmatically via the OLS API. OLS is developed and maintained by the Samples, Phenotypes and Ontologies Team (SPOT) at EMBL-EBI.

Related Tools
In addition to OLS the SPOT team also provides the OxO, Zooma and Webulous services. OxO provides cross-ontology mappings between terms from different ontologies. Zooma is a service to assist in mapping data to ontologies in OLS and Webulous is a tool for building ontologies from spreadsheets.

Contact Us
For feedback, enquiries or suggestion about OLS or to request a new ontology please contact ols-support@ebi.ac.uk. For bugs or problems with the code or API please report on [GitHub issue](#). For announcements relating to OLS, such as new releases and new features sign up to the [OLS announce mailing list](#).

Semantics, a key component of Knowledge Graphs and FAIR implementation

- Rapid increase of the number of ontologies and semantic repositories

Biomedical domain

Agriculture and Food



Welcome to BioPortal, the world's most comprehensive repository of biomedical ontologies

Search for a class

Advanced Search

Find an ontology

Browse Ontologies

BioPortal Statistics

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Ontology Visits (March 2019)

More



Welcome to the EMBL-EBI Ontology L

Examples: [diabetes](#), [GO:0098743](#)

About OLS

The Ontology Lookup Service (OLS) is a repository for biomedical ontologies that aims to provide a single point of access to the latest ontology versions. You can browse the ontologies through the website as well as programmatically via the OLS API. OLS is developed and maintained by the Samples, Phenotypes and Ontologies Team (SPOT) at EMBL-EBI.

Related

In addition to OLS provides the OxO, Webulous services: cross-ontology mappings, Zooma is a service mapping data to c Webulous is a tool ontologies from s



Use AgroPortal to access and share ontologies. You can [create ontology-based annotations for your own text](#), [link your own project that uses or relations between terms in different ontologies](#), review and comment on ontologies and their components as you [browse](#) them. [Sign in to AgroP](#) comments on ontologies or add ontology mappings.

Search all ontologies

Advanced Search

Search

Find an ontology

Browse Ontologies >

Explore

Ontology Visits (April 2019)

FoodOn (FOODON)	124
AGROVOC (AGROVOC)	106
TAXREF-LD (TAXREF-LD)	56
AnaEE Thesaurus (ANAEETHES)	51
Plant Ontology (PO)	49

[More](#)

Statistics

Ontologies	106
Classes	1,740,978
Individuals	1,963,716
Projects	35

Latest Notes

[\(Agri-Food Experiment Ontology\)](#)
15 days ago by ee good

[Terms in double \(Wheat Ontology\)](#)
about 2 years ago by jonquet
A bunch of the terms in this branch are in double. Is this normal ?

[Un peu d'histoire \(Banana Anatomy\)](#)
over 3 years ago by antoulet
Inflorescence est un mot d'origine latine qui signifie "fleurer". Il est le même en français et e...

[Is spadice a kind of inflorescence for banana? \(Banana Anatomy\)](#)
over 3 years ago by jonquet
Can we consider spadice an appropriate inflorescence for banana?

Semantics, a key component of Knowledge Graphs and FAIR implementation

- Rapid increase of the number of ontologies and semantic repositories

Biomedical domain

Agriculture and Food

The screenshot shows the BioPortal homepage. At the top, there is a navigation bar with links for Ontologies, Search, Annotator, Recommender, Mappings, and Resource Index, along with Login and Support buttons. The main heading reads "Welcome to BioPortal, the world's most comprehensive repository of biomedical ontologies". Below this, there are two search boxes: "Search for a class" and "Find an ontology". To the left, there is a bar chart titled "Ontology Visits (March 2019)" showing visits for various ontologies like CPT, MEDDRA, SNOMEDCT, RXNORM, and NDDP. To the right, there is a "BioPortal Statistics" table.

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The screenshot shows the OLS website. It features a navigation bar with Home, Ontologies, and Docs. A search bar is present. Below the navigation, there is a section titled "Abi" with a description: "The Ontology aims to provide the latest browse the website as the OLS AI maintains and Ontology EBI."

The screenshot shows the ISA² website. The header includes the European Commission logo and the text "Interoperability solutions for public administrations, businesses and citizens". Below the header is a navigation menu with links for ABOUT, INTERIM EVALUATION, EIF, ACTIONS, SOLUTIONS, S&R AWARDS, DASHBOARD, LIBRARY, EVENTS, NEWS, BLOG, and CONTACT. The main heading is "Core Vocabularies". Below this, there is a section titled "Simplified, reusable and extensible data models" with an image of a modern office interior. To the right, there is a box labeled "e-Gouvernement". Below the image, there is a section titled "When is this solution for you?" with a list of bullet points: "Develop new systems", "Enable the information exchange", "Integrate data", and "Publish data". At the bottom, there is a section titled "What can we offer you?" with a paragraph describing the benefits of Core Vocabularies.

e-Gouvernement

When is this solution for you? As a public administration, you want to:

- **Develop new systems** from a conceptual and logical data model
- **Enable the information exchange** between systems
- **Integrate data** from various sources
- **Publish data** in a common export format

What can we offer you? Core Vocabularies are simplified, reusable, and extensible data models that capture the fundamental characteristics of an entity, such as a person or a public organisation, in a context-neutral manner. Public administrations can use and extend the Core Vocabularies in the following contexts:

Semantics, a key component of Knowledge Graphs and FAIR implementation

- Rapid increase of the number of ontologies and semantic repositories

Biomedical domain

Agriculture and Food

The screenshot shows the BARTOC.org website interface. At the top, there is a navigation bar with links for 'Home', 'About', 'Contact', and 'Help'. Below this, the BARTOC.org logo is prominently displayed, along with the tagline 'Basel Register of Thesauri, Ontologies & Classifications'. The main content area is divided into several sections:

- Search:** A search bar with a 'GO' button and a 'Search for' dropdown menu.
- Browse:** A section with dropdown menus for 'DDC' and 'EuroVoc', and a table with columns for 'Language', 'KOS Types Vocabulary', 'Location', and 'Format'.
- Content by discipline:** A table listing various disciplines and their corresponding counts.
- What can we offer you?:** A section describing the benefits of Core Vocabularies.

Discipline	Count
Social sciences	1,031
General works, Computer science and Information	598
Technology	484
History and Geography	472
Pure Science	413
Arts and Recreation	307

What can we offer you? Core Vocabularies are simplified, reusable, and extensible data models that capture the fundamental characteristics of an entity, such as a person or a public organisation, in a context-neutral manner. Public administrations can use and extend the Core Vocabularies in the following contexts:

- **Develop new systems** from a conceptual and logical data model
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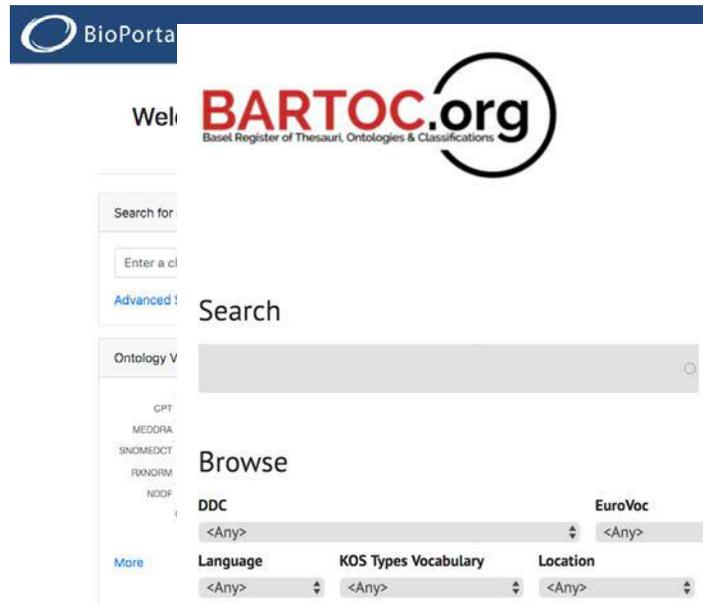
Social Science and Humanities

e-Gouvernement

Semantics, a key component of Knowledge Graphs and FAIR implementation

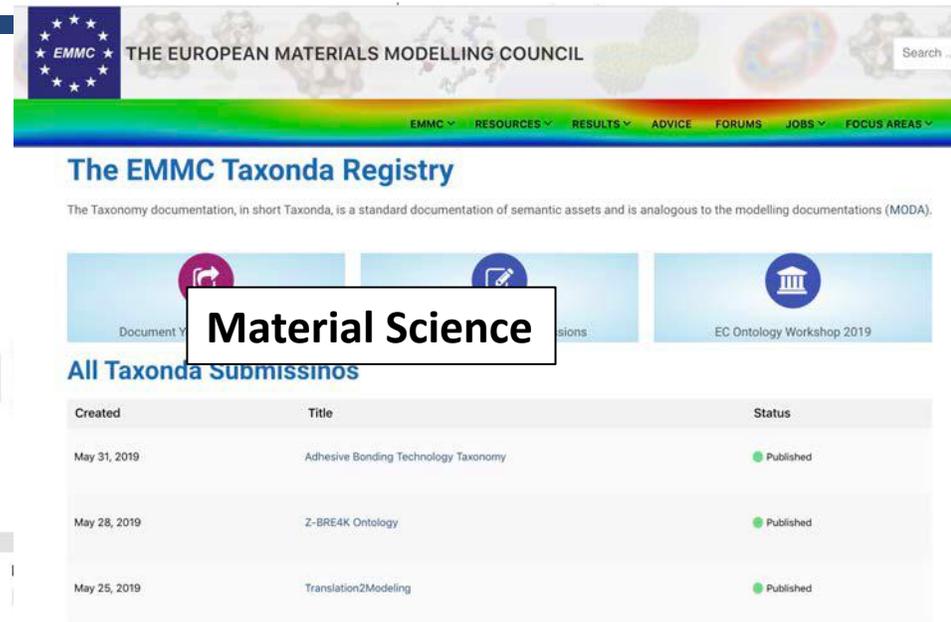
- Rapid increase of the number of ontologies and semantic repositories

Biomedical domain



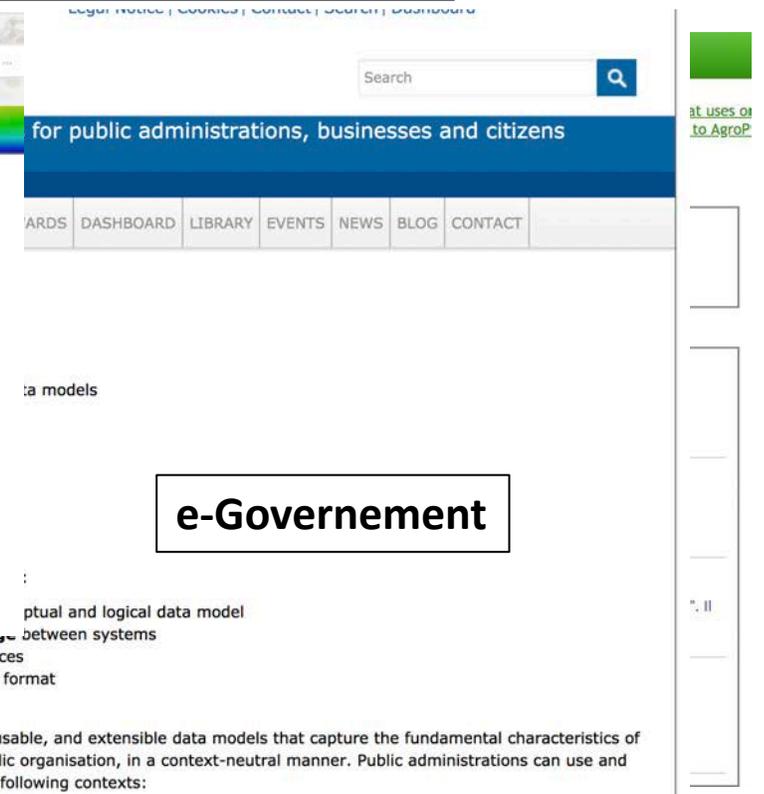
The screenshot shows the BARTOC.org website, which is the Base Register of Thesauri, Ontologies & Classifications. It features a search bar, a navigation menu, and a list of ontologies. The 'Biomedical domain' label is placed over the top part of the page.

Social Science and Humanities



The screenshot shows the EMMC Taxonda Registry website, which is the Taxonomy documentation of semantic assets. It features a search bar, a navigation menu, and a list of taxonomies. The 'Material Science' label is placed over the top part of the page.

Agriculture and Food



The screenshot shows the e-Government website, which is a platform for public administrations, businesses, and citizens. It features a search bar, a navigation menu, and a list of services. The 'e-Government' label is placed over the top part of the page.

Semantics, a key component of Knowledge Graphs and FAIR implementation

- Rapid increase of the number of ontologies and semantic repositories
- Need for a harmonized semantic landscape
- FAIR principles should be applied to semantic artefacts (controlled vocabularies, thesauri, ontologies,...)

FAIR Semantics: new opportunities



- Standardized ontology design based on expert-driven recommendations and good practices
- Improved discoverability and reusability of semantic artefacts
 - Reduction of ontology development cost
 - Reduction of semantic ambiguity (duplication of concepts)
- Extend the capabilities of semantically-enabled tools to leverage multi-disciplinary semantics
- Improved Semantic Interoperability enables the creation of multi-disciplinary knowledge graphs (easier integration of heterogeneous and distributed sources)
- Enables the creation of a framework to analyse semantic usage, overlap,...

How can we make Semantics FAIR?



- Findable**
 - Publish ontologies in dedicated repositories
 - Minimum Ontology metadata
 - Use unique Ids to identify concepts, relations and ontologies
- Accessible** → Licenses
- Interoperable**
 - Use common practices at syntactic level
 - Use common structure for concepts and relations
 - Use logical interoperability
- Reusable** → Reuse existing related ontologies to avoid ambiguity

Example of “Syntactic” interoperability for ontologies

URI/Identifier Space

Each class and relation (property) in the ontology must have a unique URI identifier. The URI should be constructed from a base URI, a prefix that is unique within the Foundry (e.g. GO, CHEBI, CL) and a local identifier (e.g. 0000001).

Example: http://www.exampleontology.com/onto_XXXXXXX

Naming convention

- Write labels, synonyms, etc as if writing in plain English text. ie use spaces to separate words, only capitalize proper names (e.g. Parkinson disease).
- Do not use CamelCase, do_not_use_underscores
- Spell out abbreviations. Abbreviations can be included as a separate property.

<http://www.obofoundry.org/>



Why FAIR Semantics is useful ?



GO TO EUDAT WEBSITE



Search records for... Q SEARCH

<https://b2note.eudat.eu>

Login

RECORDS → 6346E397365B42D2886B043B5251E732

Climate_ENES reduced data set rico_gcsc exper

by Rajapakse, Asela;

Nov 27, 2017

Description: ONLY FOR TESTING PURPOSES/INCOMPLETE DATA: Model output data archive of a rico_gcsc experiment (<http://journals.ametsoc.org/doi/10.1175/JAS-D-16-0326.1>). Reduced to the li climate variable over 61 time steps only. Tar archive has been split into four parts and needs to be c can be unpacked.

Disciplines: 3.3.14 → Earth sciences → Meteorology;

DOI: [XXXX/b2share.6346e397365b42d2886b043b5251e732](https://doi.org/10.1111/10.1175/JAS-D-16-0326.1)

PID: [0000/6346e397365b42d2886b043b5251e732](https://doi.org/10.1111/10.1175/JAS-D-16-0326.1)

Files

Name	Size
▼ rico_gcsc_xy_lwp_1h.tar.partaa	4.00GB
Checksum: md5:833b03a8fdad1bb61e91bdd821f39fd4	
PID: 0000/rico_gcsc_xy_lwp_1h.tar.partaa	
<input type="button" value="Annotate in B2Note"/>	
▶ rico_gcsc_xy_lwp_1h.tar.partab	4.00GB
▶ rico_gcsc_xy_lwp_1h.tar.partac	4.00GB
▶ rico_gcsc_xy_lwp_1h.tar.partad	3.13GB

Basic metadata

Open Access

License

Contact Email

The B2NOTE interface overlay shows a user profile for 'Testman3' with search, download, and share icons. It features three tabs: 'Semantic tag', 'Free-text keyword', and 'Comment'. Below the tabs is a text input field 'Type-in to select a tag.' and a 'Create' button. A dropdown menu shows 'All my annotations' and 'All annotations about this file'. At the bottom is a blue button that says 'Let us know what you think'.

B2NOTE: a semantic annotator

- Use index of semantic concepts for auto-completion
- Restricted to biomedical domain concepts
- Could be extended to other scientific domains

Why FAIR Semantics is useful?



 Semantic lookup service

Login with Google  Login with GitHub  Login with LinkedIn 

Log in to register or manage your ontology repository.

Repository	Description	Domain	API	API doc
AgroPortal	Use AgroPortal to access and share ontologies	agronomy	REST API	Link to the doc
BioPortal	the world's most comprehensive repository of biomedical ontologies	biology	REST API	Link to the doc
EBI-OLS	The Ontology Lookup Service (OLS) is a repository for biomedical ontologies that aims to provide a single point of access to the latest ontology versions.	biomedical	REST API	Link to the doc

This work has been supported by EUDAT, funded by the European Union under the Horizon 2020 programme - DG CONNECT e-Infrastructures (Contract No. 654065).

Semantic Look Up Service

- Provide a unique centralized access point to multi-disciplinary semantic resources
- Support access, reuse and analytics on semantics resources.
- FAIR Semantic to lower the cost of adding new semantic resources

Conclusions



FAIRSFAIR
Fostering Fair Data Practices in Europe

Our objectives

- ✓ Break domain-specific semantic silos
- ✓ Improve discoverability and reuse of domain specific semantic resources
- ✓ FAIR Ontologies by design

Why?

- ✓ Achieve cross-disciplinary semantic interoperability e.g. material science for biomedical research
- ✓ Extend scope of semantic tooling
- ✓ FAIR Semantics for FAIR data

How?

- ✓ Bring domain-specific semantic experts together
- ✓ Evaluate existing recommendations and good practices for ontology design
- ✓ Extend with pragmatic recommendations from Knowledge Modeling practitioners

Want to contribute to FAIR Semantics?

**Join us for our first workshop co-located
with RDA 14th Plenary on October 22nd in
Finland**

Thanks



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Questions? Comments? Ideas? Contact me: ylefranc@esciencefactory.com