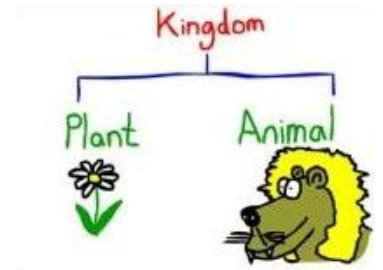


Ontologies, modeling languages, and hints on applications

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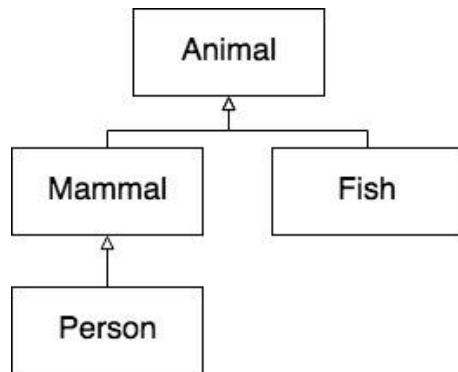
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Ontologies: how they look like

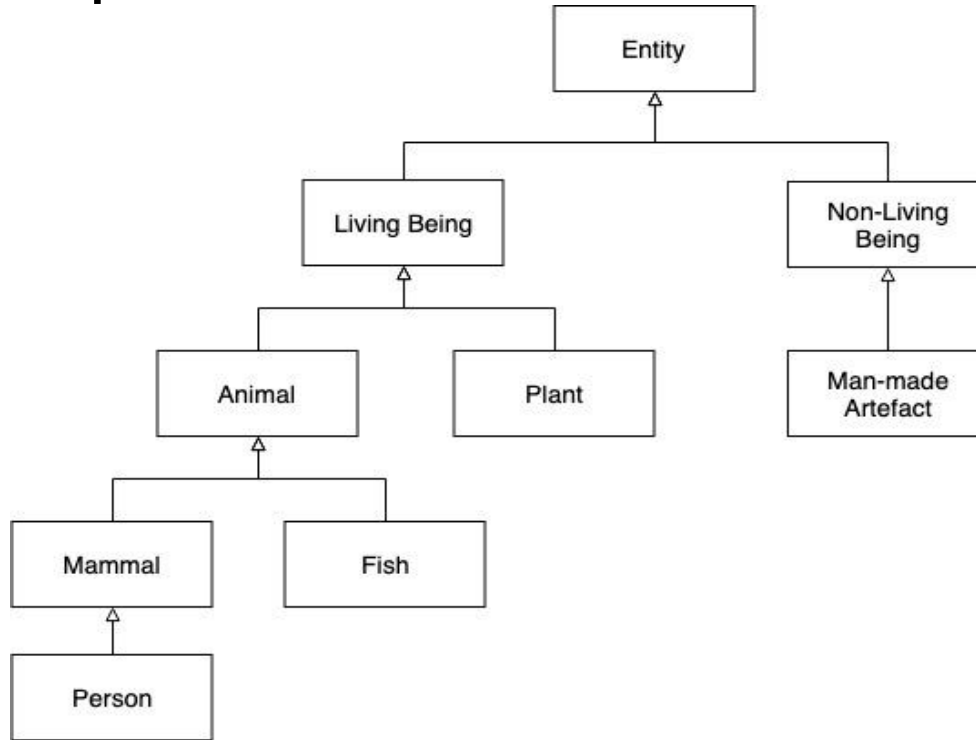
Taxonomy [basic structure]:

- **Classes:**
 - Categories of things sharing common traits
 - `Person` vs. `John`; `Dog` vs. `fido (my dog)`; `Pottery` vs. `pottery_on_my_desk`
- **Relation: IS-A** [subsumption]
 - `C1 IS-A C2` means that all instances of `C1` are instances of `C2`, too
 - E.g.: `Person IS-A Mammal`; `John instance-of Person`, therefore `John instance-of Mammal`



Recall that IS-A: **reflexive**, **anti-symmetric**, and **transitive** (partial order)

Example



Do **NOT** confuse:

- **IS-A** (`rdfs:subClassOf`): holds between classes (e.g., `Animal` and `Mammal`)
- **Instance-of**: holds between individuals and classes (`John` and `Person`)

Ontologies: how they look like (con't)

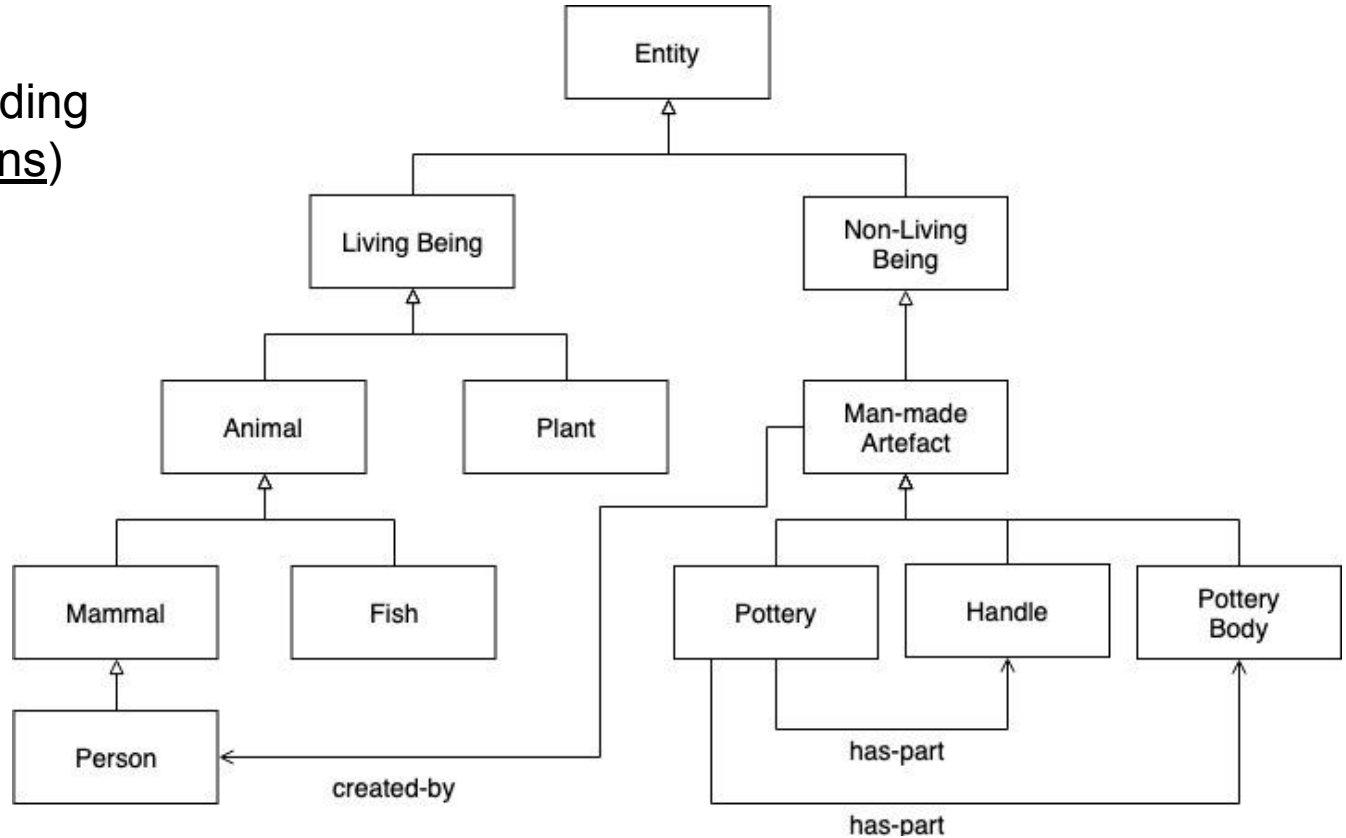
Taxonomy + horizontal relations

- **Classes**
- **Relations, e.g.,**
 - Man-Made Artefact **IS-A** Non-Living Being
 - Man-Made Artefact **created-by** Person
 - Pottery **IS-A** Man-Made Artefact
 - Pottery **has-part** Body
 - Pottery **has-part** Handle
 - etc.

Purpose: enhance the expressivity of the taxonomy by **making** more **explicit** the **intended semantics** of the terms

Example

taxonomy (including
horizontal relations)



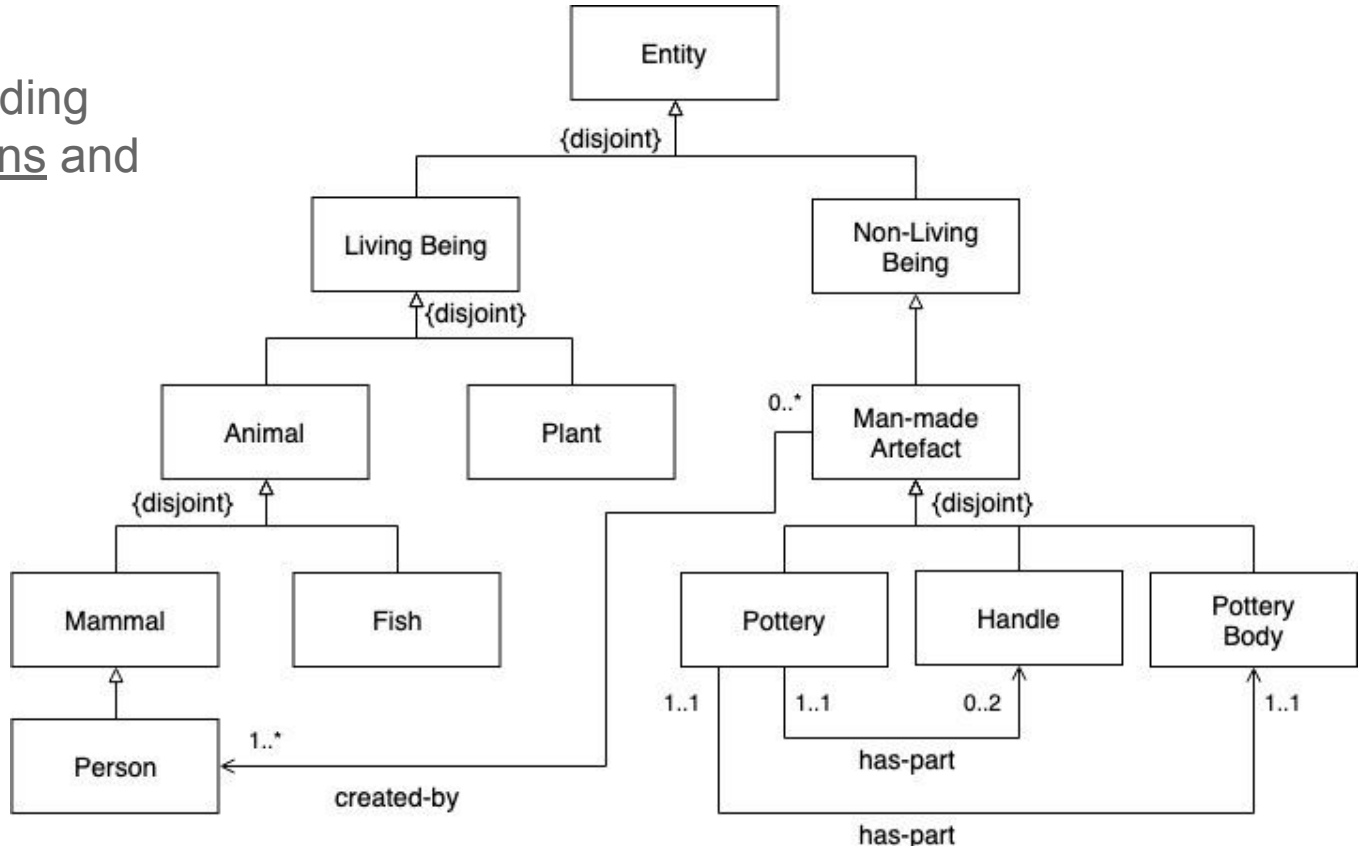
Ontologies: how they look like (con't)

Taxonomy + horizontal relations + restrictions (axioms)

- **Restrictions** (only some examples):
 - **Disjointness:** Non-Living Being **disjoint-with** Living Being, means that
 - Instances of Non-Living Being **cannot be** instances of Living Being, too.
 - **Cardinality:**
 - Each instance of Pottery is related via **has-part** to **at least one** instance of Body
 - Each instance of Pottery **may not** be related via **has-part** to any instance of Handle. If such a relation holds, a Pottery **has-part at most two** instances of Handle

Example

taxonomy (including horizontal relations and restrictions)



Good practice for ontology design

Pick up your classes and build first the IS-A taxonomy

Then add the horizontal relations between the classes and the restrictions (axioms) needed to grasp the intended semantics of your vocabulary

Pay attention to properly distinguish IS-A from other relations, e.g., part-of

XML tree:

```
<vase>
  <body> body_1 </body>
  <handle> handle_1 </handle>
  <handle> handle_2 </handle>
</vase>
```

IS-A Taxonomy:

Handle (proper-)part-of Vase
Body (proper-)part-of Vase

NOT

Body IS-A Vase
Handle IS-A Vase

Modeling languages for ontological analysis and ontology design

Common languages for ontology development

- Unified Modeling Language (**UML**) Class Diagram
- First-order logic (**FOL**)
- Description logics (**DL**)
- Semantic Web Languages [**W3C** standards]
 - Resource Description Framework (**RDF**)
 - RDF Schema (**RDFS**)
 - Web Ontology Language (**OWL**)



How to choose? Likely it depends on your requirements (e.g., foundational ontology vs. task ontology)

Minimal Mereology (MM) in FOL

```
% Axioms of Minimal mereology (MM) (temporally indexed)

all x all t (partOf(x,x,t)).
all x all y all t (partOf(x,y,t) & partOf(y,x,t) -> x=y).
all x all y all z all t (partOf(x,y,t) & partOf(y,z,t) -> partOf(x,z,t)).
% axioms of Ground Mereology (M)

all x all y all t (overlaps(x,y,t) <-> exists z (partOf(z,x,t) & part(z,y,t))).
% overlap
all x all y all t (properPartOf(x,y,t) <-> partOf(x,y,t) & -partOf(y,x,t)).
% proper parthood

all x all y all t (properPartOf(x,y,t) -> exists z (partOf(z,y,t) & -overlaps(z,x,t))).
% weak supplementation principle (WS):
% every proper part must be supplemented by another, disjoint part
% M + WS = MM
```

See: Borgo, S., & Masolo, C. (2009). *Foundational choices in DOLCE*. In Handbook on ontologies (pp. 361-381). Springer, Berlin, Heidelberg.

Casati, R., and Varzi, A.C. (1999). *Parts and places: The structures of spatial representation*. MIT Press.

THERE ARE MANY, MUCH MORE EXPRESSIVE MERELOGIES!

Mereology (??) in OWL

:partOf rdf:type owl:ObjectProperty,
owl:TransitiveProperty,
owl:ReflexiveProperty.

:overlaps rdf:type owl:ObjectProperty,
owl:SymmetricProperty,
owl:ReflexiveProperty.

:properPartOf rdf:type owl:ObjectProperty,
owl:TransitiveProperty.

Result:

- **Sacrifice expressivity** (e.g., **no ternary relations**, no anti-symmetry for *partOf*, no definition for *overlaps*, no weak supplementation, etc.)
- **Gain computational treatment!**

See: Keet, C. M., & Artale, A. (2008). *Representing and reasoning over a taxonomy of part-whole relations*. *Applied Ontology*, 3(1-2), 91-110.

Good practice for ontology design

For **ontological analysis**, use a **language** which allows you

- To formulate -- in a transparent way -- the intended meaning of your vocabulary
- **E.g., first-order logic:**
 - Well-known in Computer Science, (some) Human Sciences, Engineering, Cognitive Sciences, etc.
 - Sound and complete but undecidable

For **application purposes**:

- Formulate your ontology in the language which is the most suited for your application purposes (nowadays, **Semantic Web languages** are widely used)

Ontologies in use:

Semantic interoperability and data integration

Ontologies, what for...

- Data Management
 - Classification, **interpretation**, **sharing**, **integration**, retrieval
 - **Interoperability** at the semantic level
 - Etc.
- Knowledge representation (AI)
 - **Knowledge reuse**
 - **Automated reasoning**
 - Knowledge discovery
 - Computer-aided **decision making**
 - Planning
 - Etc.

Some references:

- Staab, S., & Studer, R. (Eds.). (2010). [Handbook on ontologies](#). Springer Science & Business Media.
- **Journals:**
 - [Applied Ontology](#)
 - [Semantic Web](#)
 - etc.
- **Conference Proceedings, see:**
 - [FOIS](#)
 - [JOWO](#)
 - [Some proceedings](#)
 - [ISWC](#)
 - [ESWC](#)
 - etc.

Semantic interoperability

The capability of two or more information systems to **exchange data** while **making explicit, preserving,** and **sharing** the intended meaning of the data.

“**Communication** is an **exchange of information** about entities and relations between between a **sender** and a **receiver**. Information is formulated in some **language**. A language consists of symbols arranged in a well defined manner. **The symbols of a language are not meaningful per se**. The meaning of a symbol needs to be made explicit by specifying its intended interpretation, i.e., by specifying to which entity (entities) or relation it refers to”.

(Bittner, T., Donnelly, M., & Winter, S. (2005). *Ontology and semantic interoperability*. Large-scale 3D data integration: Challenges and Opportunities, 139-160.)



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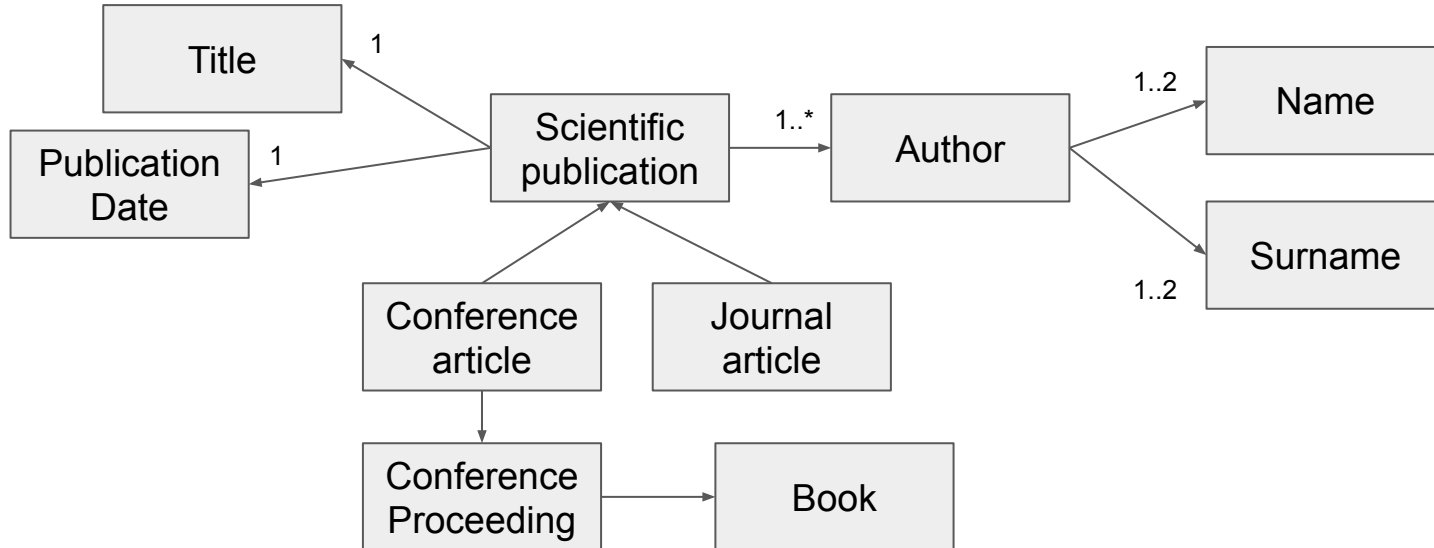
[BOOK] **Formal ontology** in information systems: **Proceedings** of the first international conference (FOIS'98), June 6-8, Trento, Italy

[PDF] vu.it

N Guarino 1998 books.google.com

Research on **ontology** is becoming increasingly widespread in the computer science community. While this term has been rather confined to the philosophical sphere in the past, it is now gaining a specific role in areas such as Artificial Intelligence, Computational ...

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By Lloyd, Jennifer T. *Annals of the New York Academy of Sciences* Volume 1216 Issue 1 Pages: 175 Published: 2014-Dec (Epub: 2014-Mar-20)
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3. **Active video games as an exercise tool for children with cyclic vomiting.**
By O'Donnovan, Susan, Grady, Peter, Garcia, David, et al. *Journal of Applied Gerontology* - official journal of the European-Centric Finnish Society Volume 39 Issue 3 Pages: 360 Published: 2014-May (Epub: 2013-Nov-05)
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4. **Family food involvement and frequency of family dinner meals among Australian children aged 10-14 years: Cross-sectional and longitudinal associations with dietary patterns**
By Lynch, Rebecca M., McHughon, Sarah A., Crawford, David A., et al. *APPETITE* Volume 75 Pages: 86-92 Published: APR 1 2014
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5. **Depressive symptoms and observed eating in youth**
By Murovic, Mira, Shmatat, Lauren B., Reina, Samantha A., et al. *APPETITE* Volume 75 Pages: 101-109 Published: APR 1 2014
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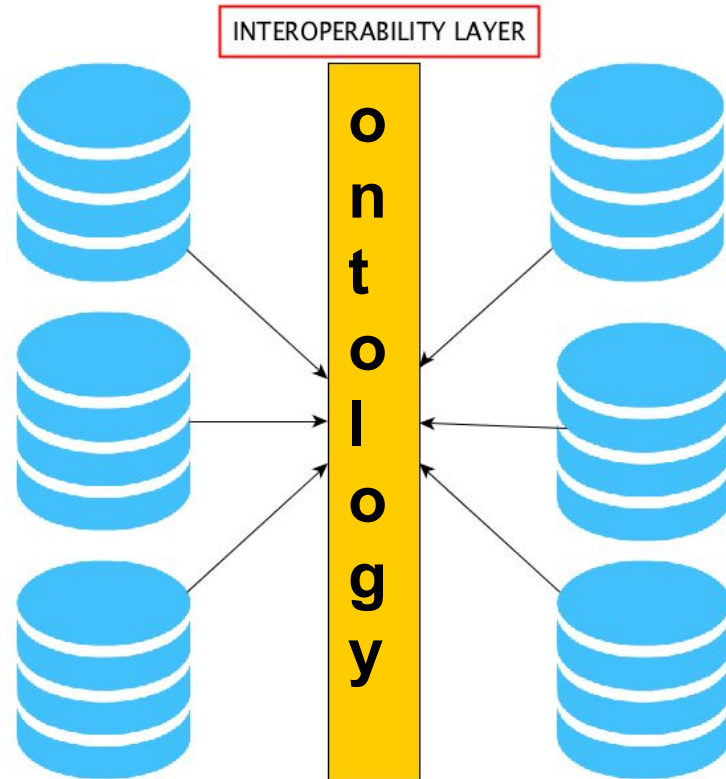
Book

Ontology as **interlingua** across multiple data sources

(**See:** Uschold, M., & Gruninger, M. (1996). Ontologies: Principles, methods and applications. *The knowledge engineering review*, 11(2), 93-136.)

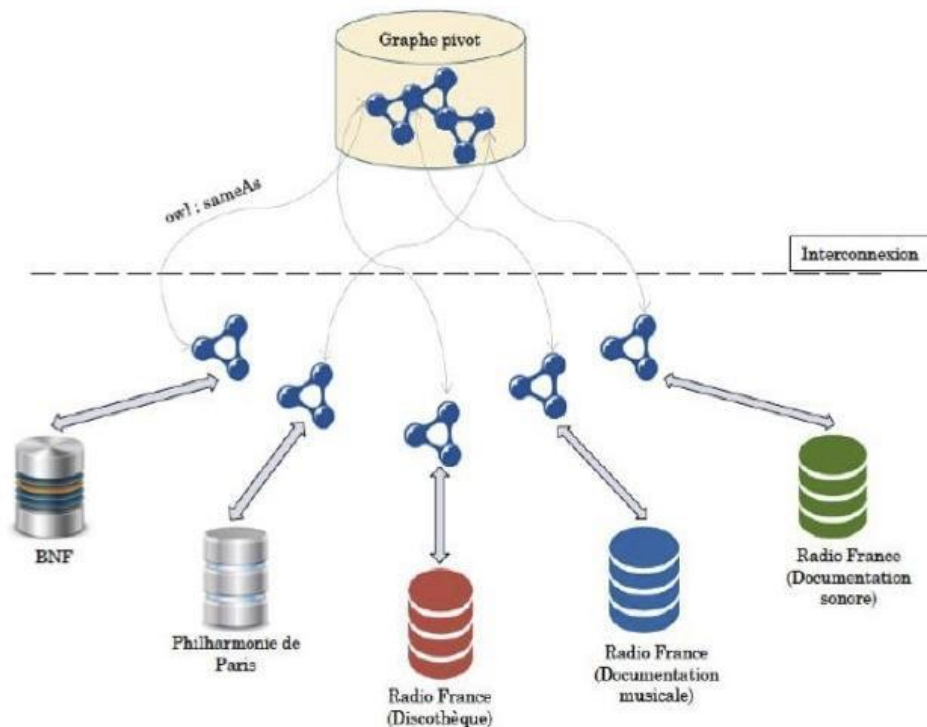
(**see:** Bittner, T., Donnelly, M., & Winter, S. (2005). Ontology and semantic interoperability. Large-scale 3D data integration: Challenges and Opportunities, 139-160.)

(**see:** Guarino, Oberle, Staab (2010), What is an ontology? In Handbook on Ontologies Springer Science & Business Media)



Data integration

Combine multiple datasets in a **meaningful** way



(From: Choffé & Leresche, F. (2016).

DOREMUS: connecting sources, enriching catalogues and user experience.

In 24th IFLA World Library and Information Congress)

DOREMUS

Project supported by French National Agency for Research (ANR) with

- National Library of France (BnF)
- Philharmonie de Paris
- Radio France ... + other partners for technical development

“[...] to provide cultural institutions, publishers and distributors [...] with **ontologies** and **shared multilingual controlled vocabularies**, **methods to publish, share, connect, enrich catalogues of musical works and events** in **the web of data** [...]”

(From: Choffé, P., & Leresche, F. (2016). *DOREMUS: connecting sources, enriching catalogues and user experience*. In 24th IFLA World Library and Information Congress)

The DOREMUS ontology

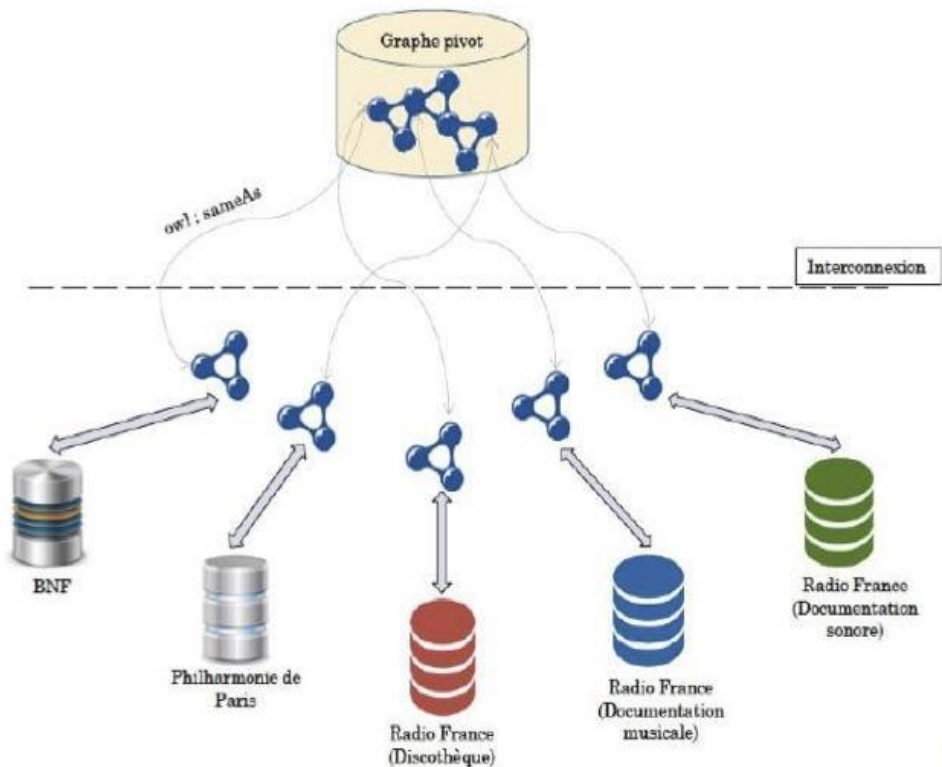


Figure from: Choffé, P., & Leresche, F. (2016)

Available at:

(<http://data.doremus.org/ontology>)

- Extends **CIDOC-CRM**, **FRBRoo**, and **PRESSoo** to model explicitly knowledge about music
- **Datasets** from BnF, Radio France, and Philharmonie
 - From **MARC** or **XML**
 - To **RDF**
 - Each dataset is modelled according to the same ontology, i.e., DOREMUS
- All datasets are **integrated** within a unique RDF knowledge base (called the **DOREMUS knowledge graph**)

DOREMUS SPARQL Endpoint

To access the DOREMUS knowledge graph:

- <http://data.doremus.org/> [general info, tools, etc.]
- <http://data.doremus.org/sparql> [SPARQL Endpoint based on [Virtuoso](#)]

“The DOREMUS dataset includes more than **16 million triples**, which describe
over **3 million distinct entities**”.

(**From:** Achichi, M., Lisena, P., Todorov, K., Troncy, R., & Delahousse, J. (2018). *DOREMUS: A graph of linked musical works*. In International Semantic Web Conference (pp. 3-19). Springer, Cham.)

Some general info

Ontology repositories

- Bio-Portal (<https://bioportal.bioontology.org/>)
- Agro-Portal (<http://agroportal.lirmm.fr/>)
- Industrial Ontology Foundry (IOF) (<https://www.industrialontologies.org/>)
- OntoHub (<https://ontohub.org/>)

International Association for Ontology and its Applications (IAOA)

- <https://iaoa.org/>
- Formal Ontology in Information Systems (FOIS)
 - **FOIS 2020**, 14-17 September 2020, Free University of Bolzano-Bozen (Italy), <https://fois2020.inf.unibz.it/>
 - **Interdisciplinary Summer School on Applied Ontology (ISAO)**

Applied Ontology: an emerging interdisciplinary area

- Applied Ontology builds on *philosophy, cognitive science, linguistics* and *logic* with the purpose of understanding, clarifying, making explicit and communicating ***people's assumptions*** about the nature and structure of the world.
- This orientation towards ***helping people understanding each other*** distinguishes applied ontology from philosophical ontology, and motivates its ***unavoidable interdisciplinary nature***.

Some references

Conceptual modeling:

- Olivé, A. (2007). *Conceptual modeling of information systems*. Springer Science & Business Media.

Applied Ontology:

- Borgo, S., & Masolo, C. (2009). Foundational choices in DOLCE. In *Handbook on ontologies* (pp. 361-381). Springer, Berlin, Heidelberg.
- Guarino, N., & Musen, M. A. (2005). Applied ontology: Focusing on content. *Applied Ontology*, 1(1), 1-5.
- Guarino, N. (Ed.). (1998). *Formal ontology in information systems: Proceedings of the first international conference (FOIS'98), June 6-8, Trento, Italy* (Vol. 46). IOS press.
- Guizzardi, Giancarlo. "[Ontological foundations for structural conceptual models.](#)" (2005).

Some references

Semantic Web:

- Hitzler, P., Krotzsch, M., & Rudolph, S. (2009), [Foundations of semantic web technologies](#). Chapman and Hall/CRC.

Description logics:

- Krötzsch, M., Simancik, F., & Horrocks, I. (2012). [A description logic primer](#). *arXiv preprint arXiv:1201.4089*.
- Baader, F., Calvanese, D., McGuinness, D., Patel-Schneider, P., & Nardi, D. (Eds.). (2003). *The description logic handbook: Theory, implementation and applications*. Cambridge university press.

Thank you!

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