



Everything you always wanted to know about Ontologies*

*but were afraid to ask

Prof. Dr. Harald Sack
PMD Ontologies Workshop
13. April 2021

14

14 m

— 14 m —

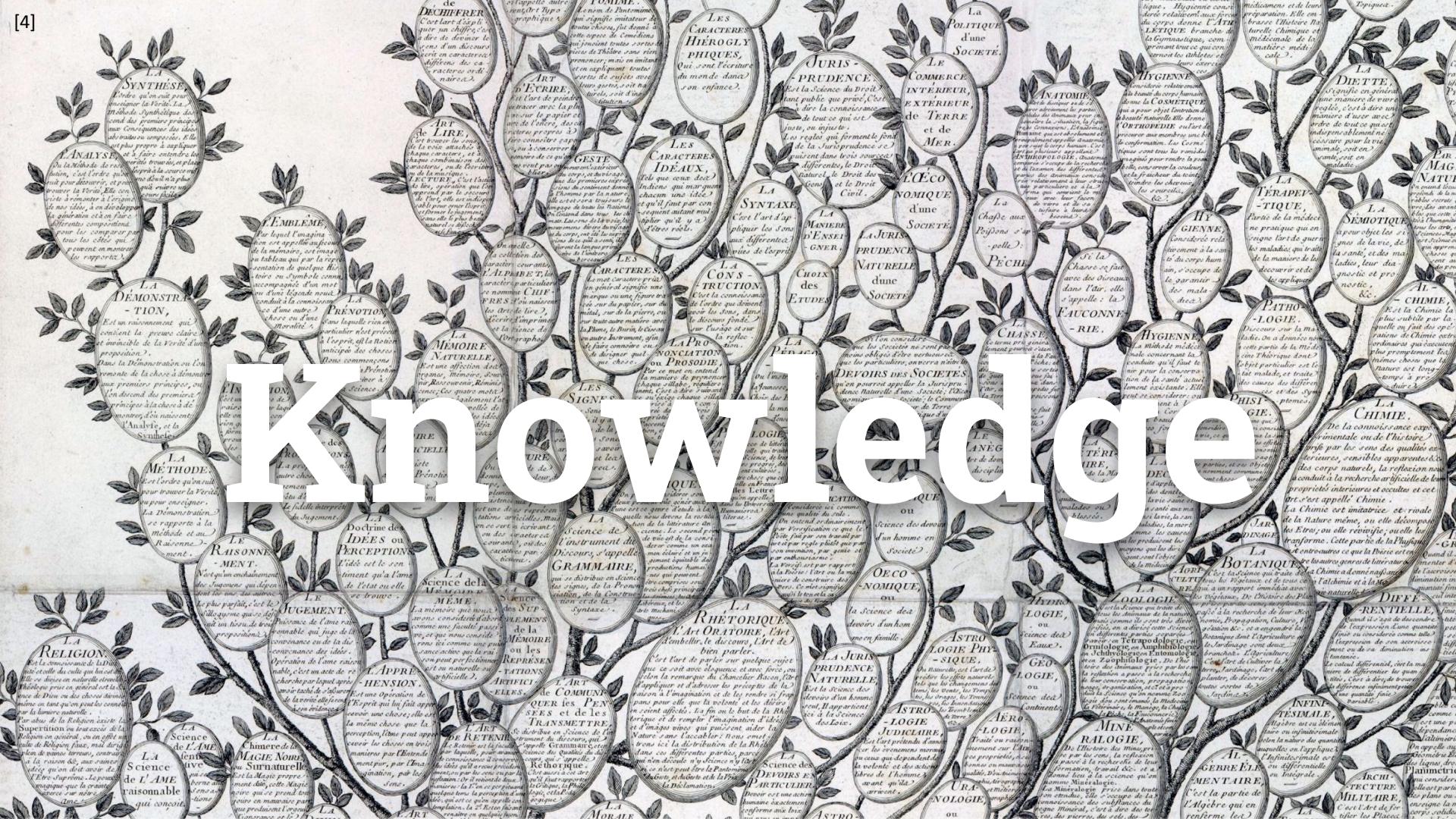
An aerial photograph of the g-2 Storage-Ring Magnet at Fermilab. The magnet is a large, blue, U-shaped structure forming a circular ring. Inside the ring, there is a complex arrangement of equipment, including several yellow and black control panels, various pipes, and a central platform where several people are working. The entire setup is located within a large industrial building with multiple levels and walkways.

14 m

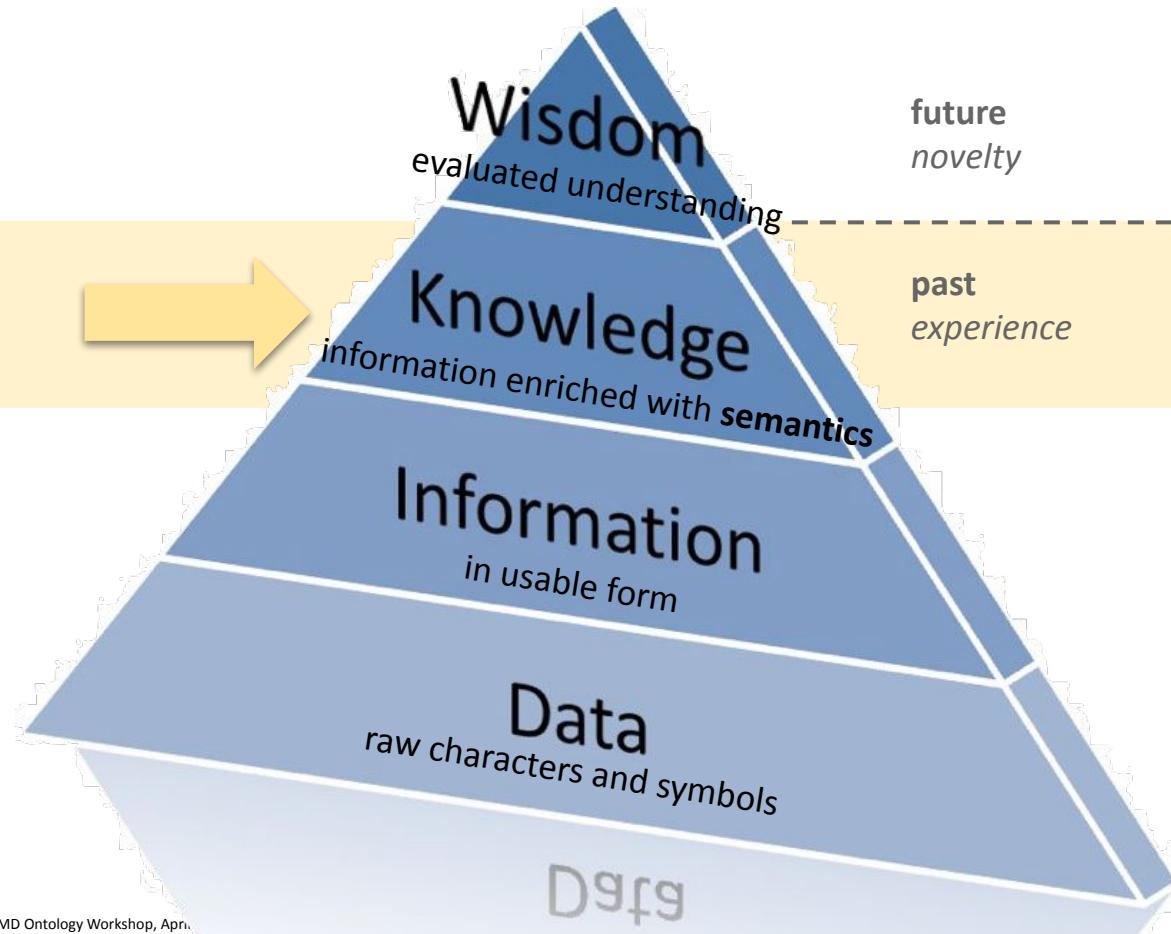
Data

Information

KONTOWECKI



From Data to Knowledge



DIKW Pyramid, Ackoff 1989



„People can't share knowledge if they don't speak a common language“

Thomas Davenport (1997)

...to speak a common Language:

- common symbols and concepts (**Syntax**)
- agreement about their meaning (**Semantics**)
- classification of concepts (**Taxonomy**)
- associations and relations of concepts (**Thesauri**)
- rules and knowledge about which relations are allowed and make sense (**Ontologies**)

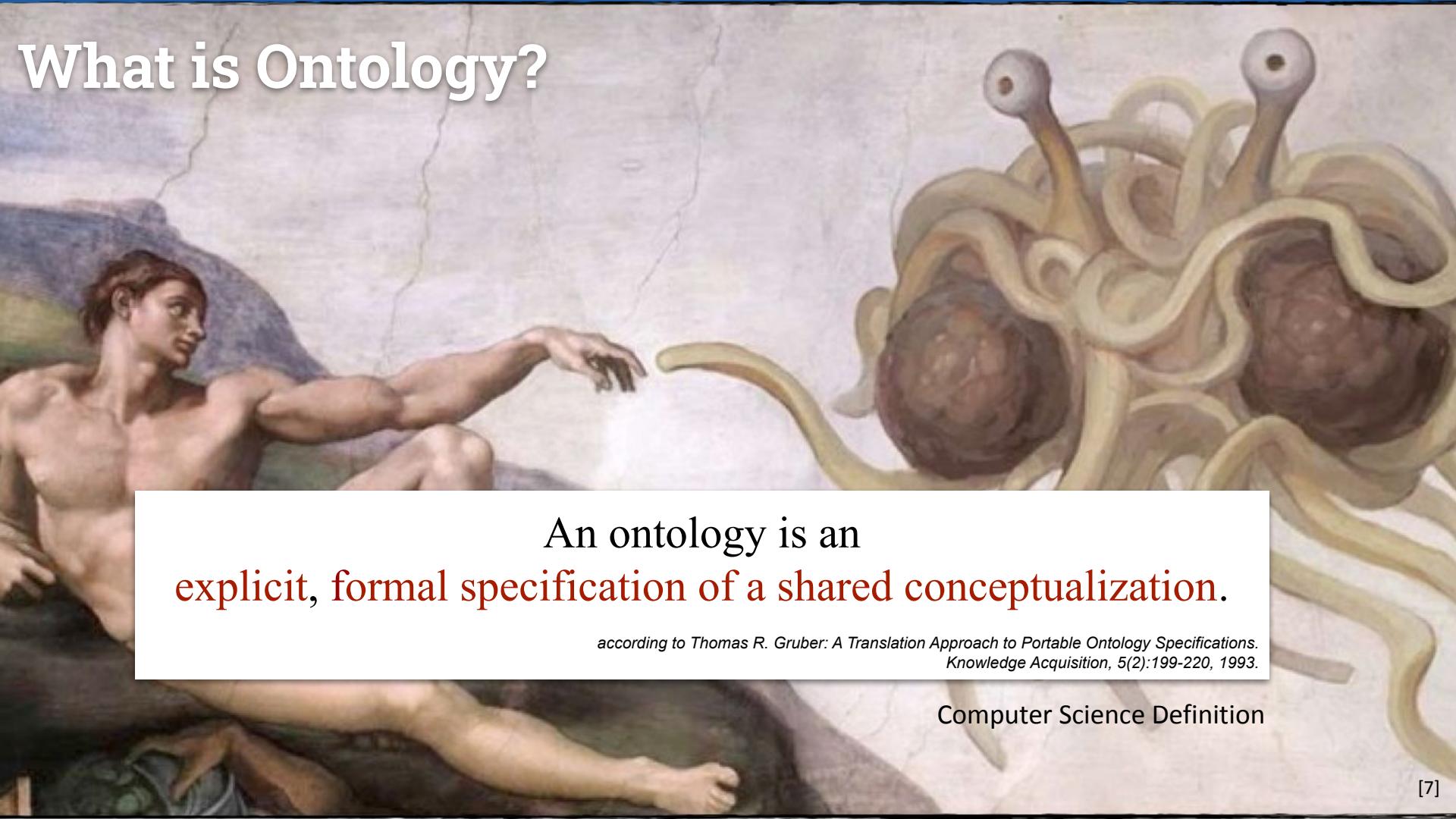
But what exactly are Ontologies?

What is Ontology?

„A **theory of being**, which tries to **explain the being itself**, by developing a **system of universal categories** and their intrinsic **relationships...**“

Philosophy Definition

What is Ontology?

A reproduction of Michelangelo's 'The Creation of Adam' fresco from the Sistine Chapel. It depicts the moment when Adam reaches out his hand towards the finger of the seated God. In the upper right corner, a large, multi-headed, tentacle-like creature with a textured, reddish-brown body and several small, dark eyes is visible, partially obscuring the scene.

An ontology is an
explicit, formal specification of a shared conceptualization.

*according to Thomas R. Gruber: A Translation Approach to Portable Ontology Specifications.
Knowledge Acquisition, 5(2):199-220, 1993.*

Computer Science Definition

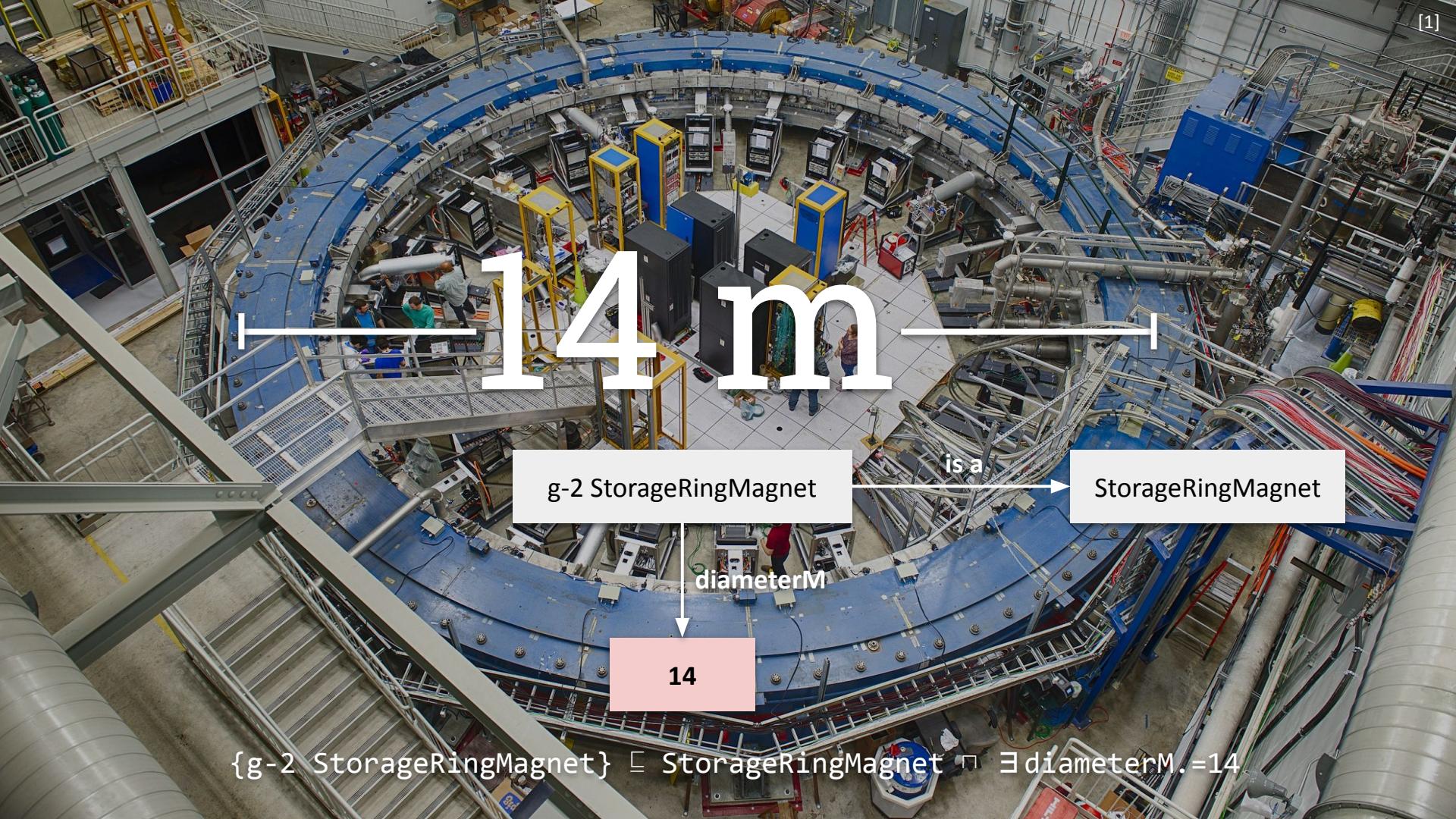
What is Ontology?

An ontology is an explicit, formal specification of a shared conceptualization.

*according to Thomas R. Gruber: A Translation Approach to Portable Ontology Specifications.
Knowledge Acquisition, 5(2):199-220, 1993.*

- | | |
|---------------------------|---|
| conceptualization: | abstract model
(domain, identified relevant concepts, relations) |
| explicit: | meaning of all concepts must be defined |
| formal: | machine understandable |
| shared: | consensus about ontology |

P A R E N T A L
A D V I S O R Y
E X P L I C I T S E M A N T I C S



14m

g-2 StorageRingMagnet

is a

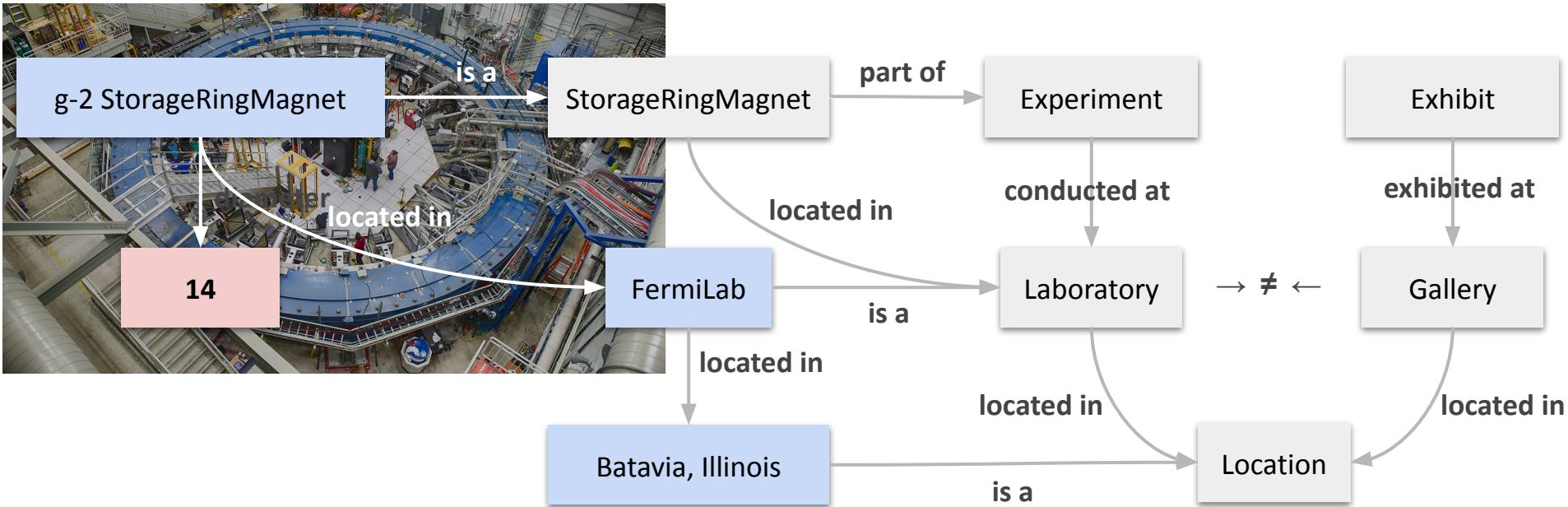
StorageRingMagnet

diameterM

14

{g-2 StorageRingMagnet} ⊑ StorageRingMagnet ⊓ ∃diameterM.=14

From Ontology to Knowledge Graphs



```

{g-2 StorageRingMagnet} ⊑ StorageRingMagnet ⊓ ∃diameterM.=14 ⊓ ∃locatedIn.{FermiLab}
{FermiLab} ⊑ Laboratory ⊓ ∃locatedIn.{BataviaIllinois}
Location(BataviaIllinois)
  
```

StorageRingMagnet ⊑ Thing
Laboratory ⊑ Thing
Gallery ⊑ Thing

locatedIn(Thing, Location)
partOf(StorageRingMagnet, Experiment)
Laboratory ⊓ Gallery ≡ ∅

conductedAt(Experiment, Laboratory)
exhibitedAt(Exhibit, Gallery)

From Ontology to Knowledge Graphs

Terminological Knowledge

Classes

StorageRingMagnet

rdfs:subClassOf
:partOf

SuperconductingStorageRingMagnet

logical
inference
:partOf

Experiment

Logical
Inference

Assertional Knowledge

Instances

"g-2 Storage Ring Magnet"

foaf:name

g-2 StorageRingMagnet

:locatedIn

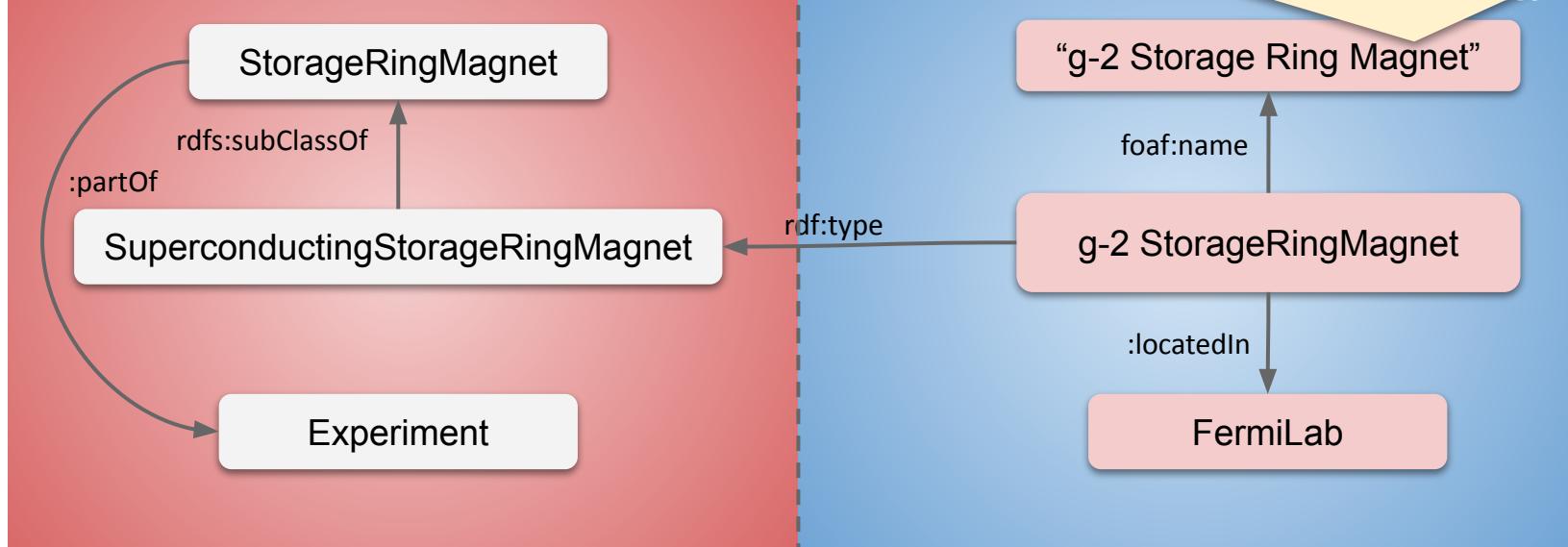
FermiLab



From Ontology to RDF

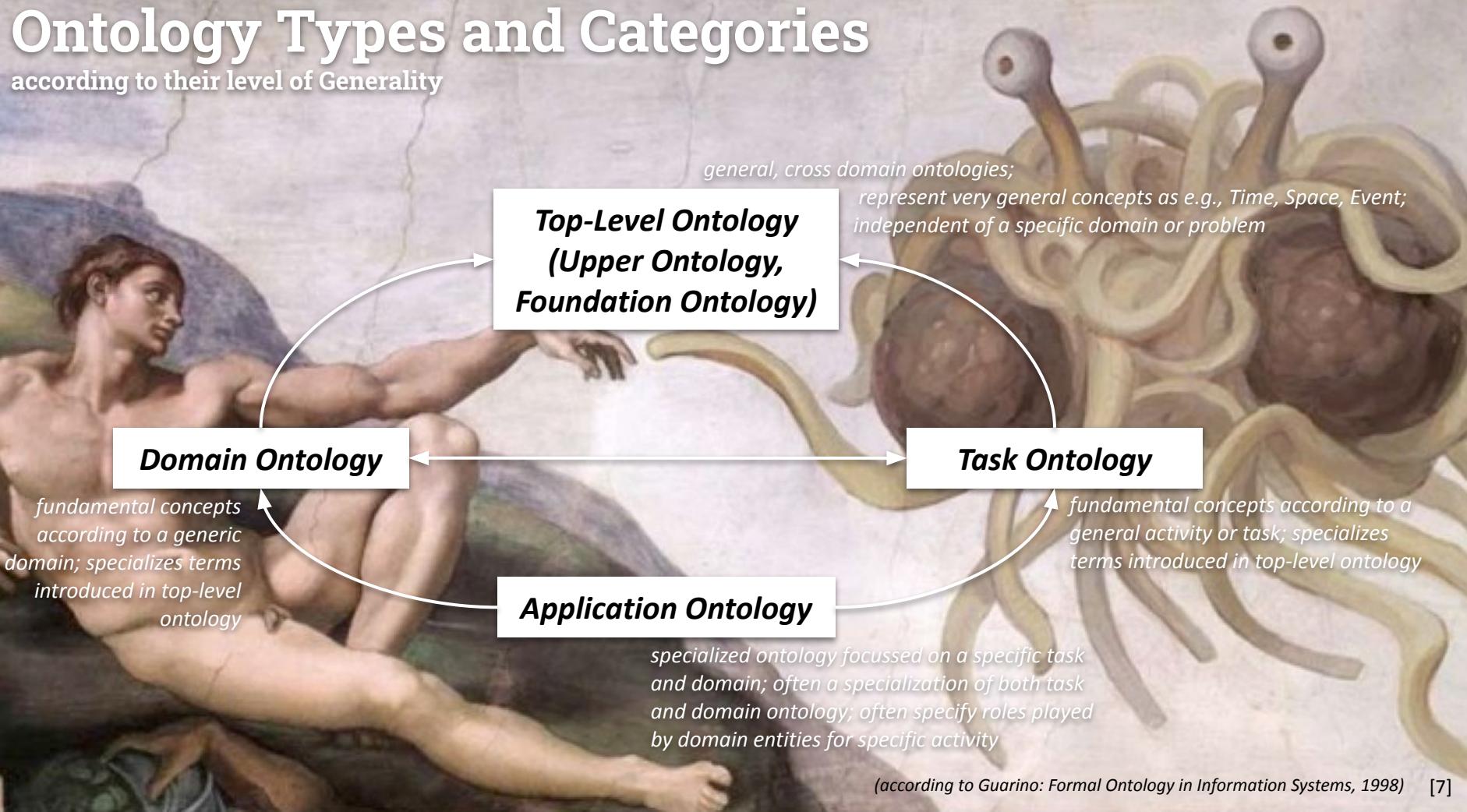
Terminological Knowledge

Classes



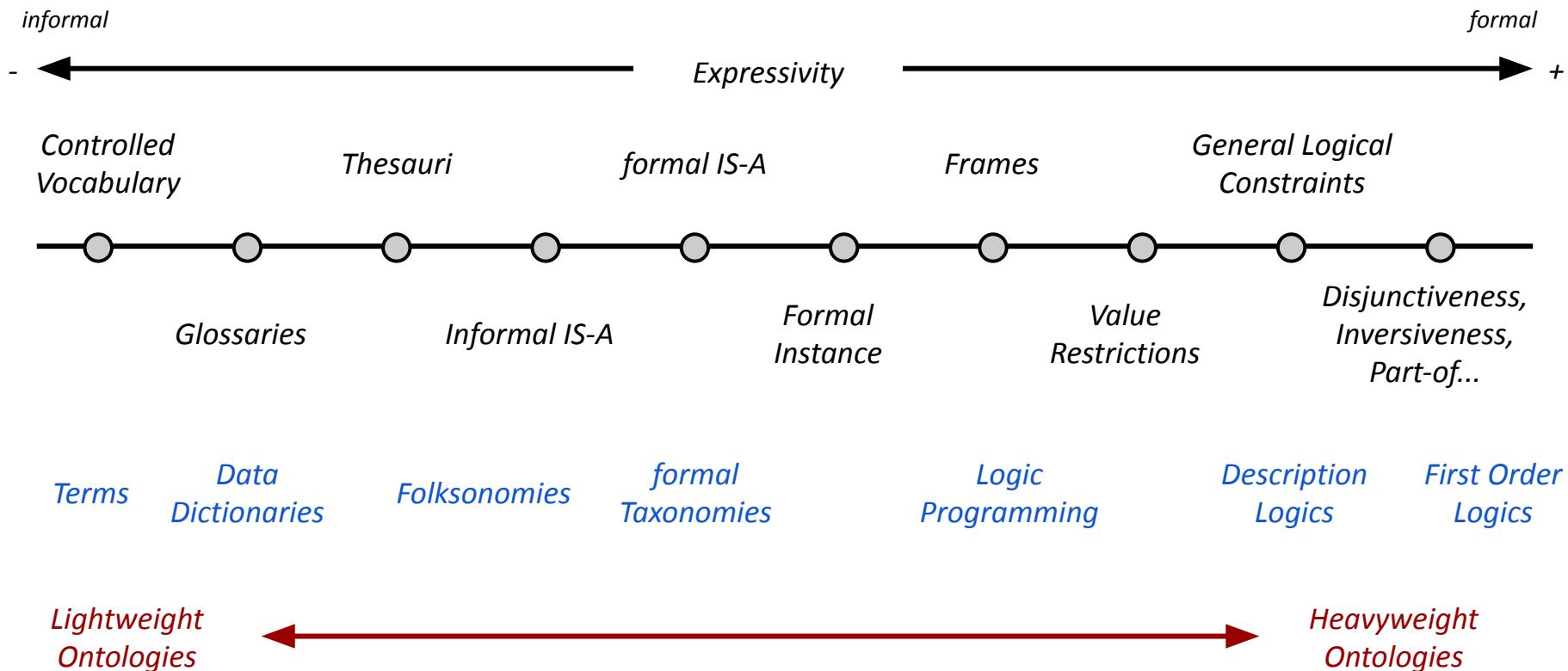
Ontology Types and Categories

according to their level of Generality



Ontology Types and Categories

according to their level of Semantic Expressivity



(according to Guarino: Formal Ontology in Information Systems, 1998)

(according to Lassila and McGuiness: The Role of Frame-Based Representation on the Semantic Web, 2001)



**"It does not do to leave a live dragon out of your calculations,
if you live near him."**

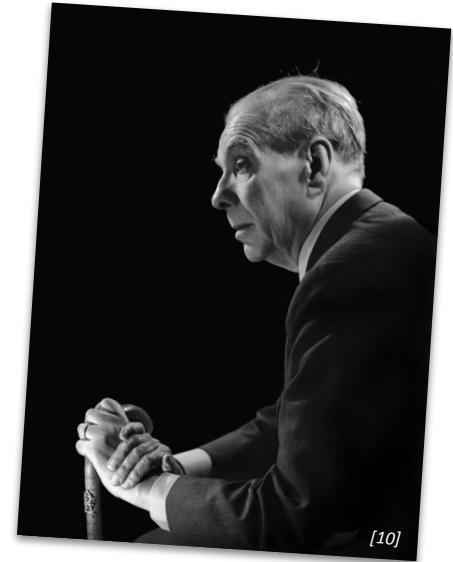
J.R.R. Tolkien, The Hobbit or There and Back again (1937)



Ontologies as Interpretations of Reality

Various categories of animals from "a certain Chinese encyclopedia"
according to Jorge Luis Borges:

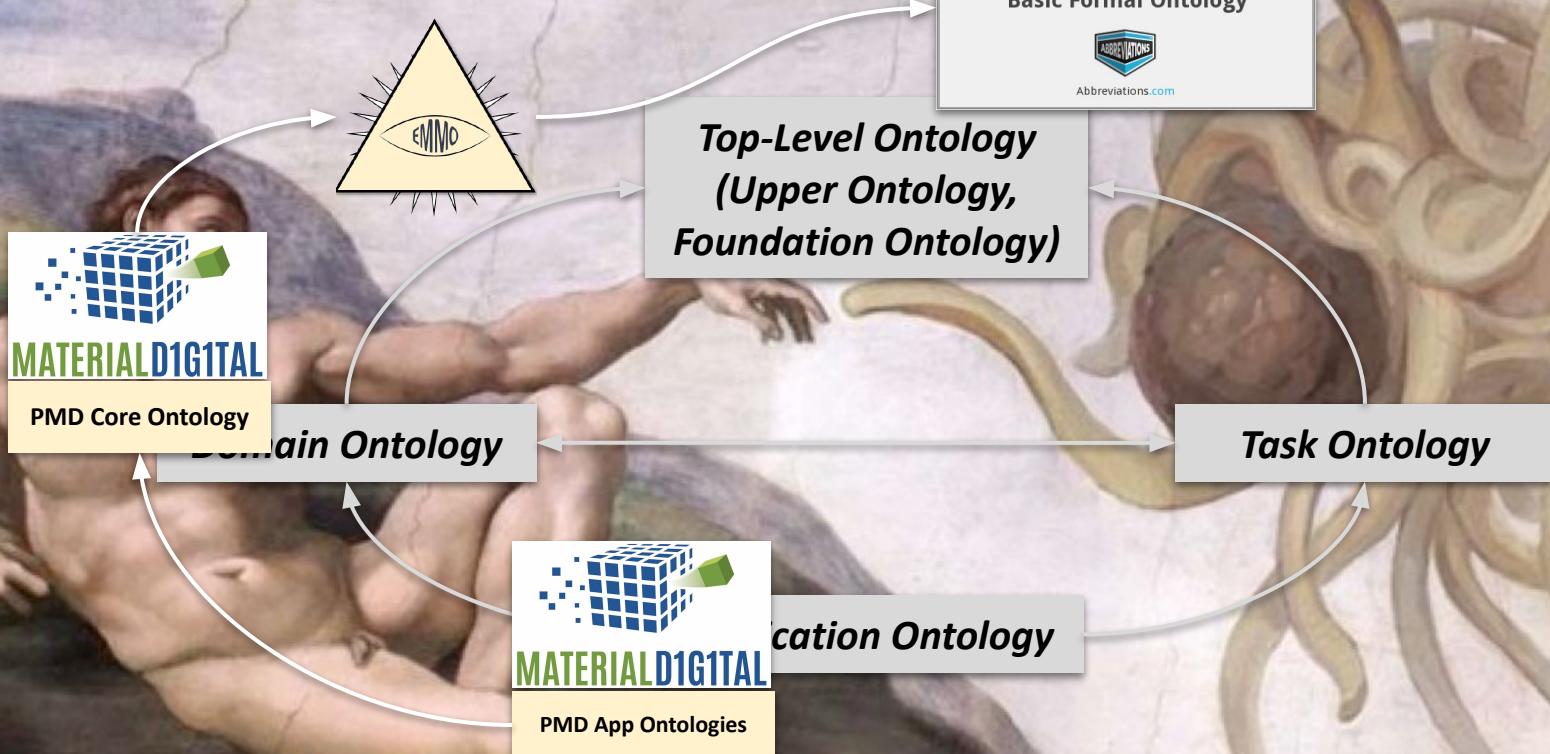
- Those that belong to the emperor
- Embalmed ones
- Those that are trained
- Suckling pigs
- Mermaids (or Sirens)
- Fabulous ones
- Stray dogs
- Those that are included in this classification
- Those that tremble as if they were mad
- Innumerable ones
- Those drawn with a very fine camel hair brush
- Et cetera
- Those that have just broken the flower vase
- Those that, at a distance, resemble flies



Jorge Luis Borges
(1899-1986)

Ontology Types and Categories

according to their level of Generality



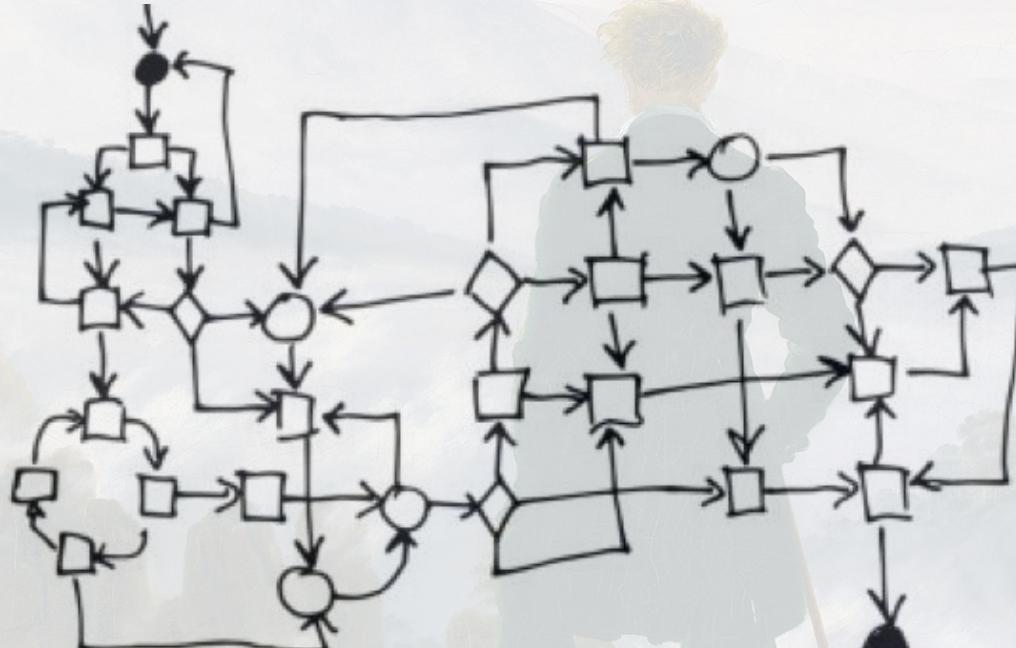
But how to get there...?



Caspar David Friedrich, *Wanderer über dem Nebelmeer*, 1818 [10]

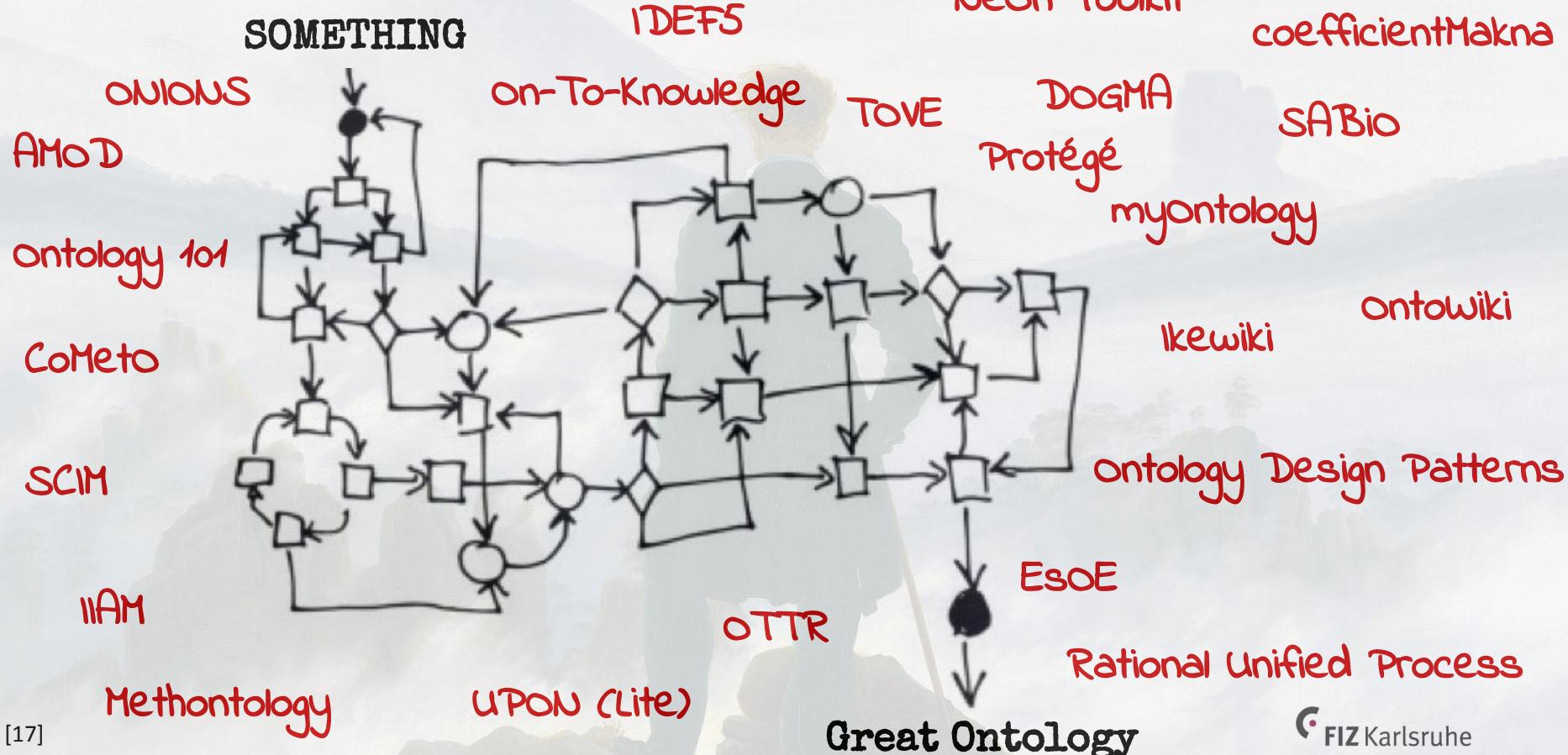
Follow an Approved Methodology

SOMETHING



Great Ontology

Follow an Approved Methodology

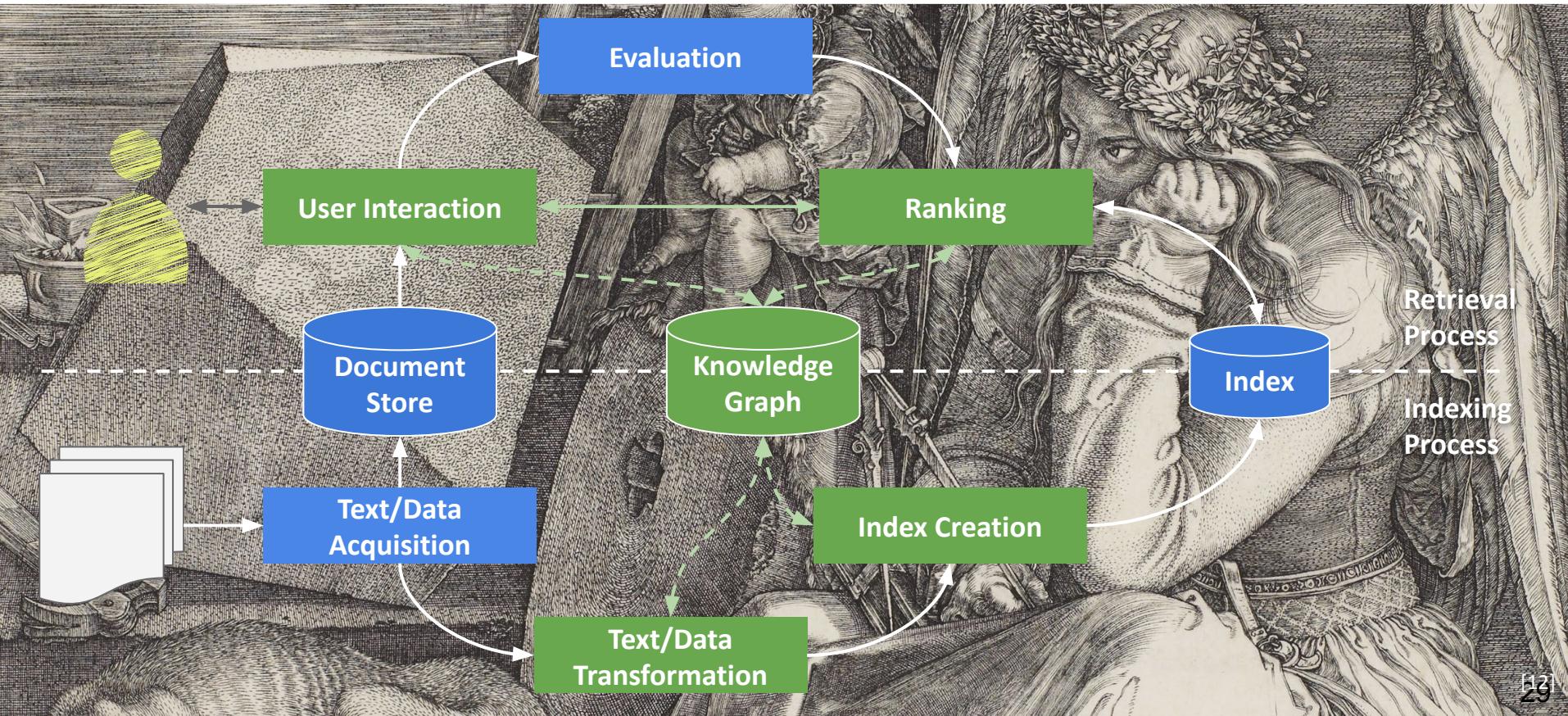


A detailed black and white woodcut by Albrecht Dürer. In the center, a gaunt, skeletal figure with a long, dark beard and a crown of human skulls sits on a pale horse. He holds a sword in his left hand and a small child in his right arm. To his right, a woman with long, dark hair is shown in profile, looking back over her shoulder with a distressed expression; she wears a laurel wreath and a large, flowing robe. Above them, a scale hangs from a beam, symbolizing the weighing of souls. In the background, a city with various buildings and figures is visible through a window-like frame. A calendar in the upper right corner shows the date as April 15, 1511.

What is the Purpose?
What will be the Application(s)?

Semantic Search & Retrieval

Application and Purpose of the Material Sciences Ontologies

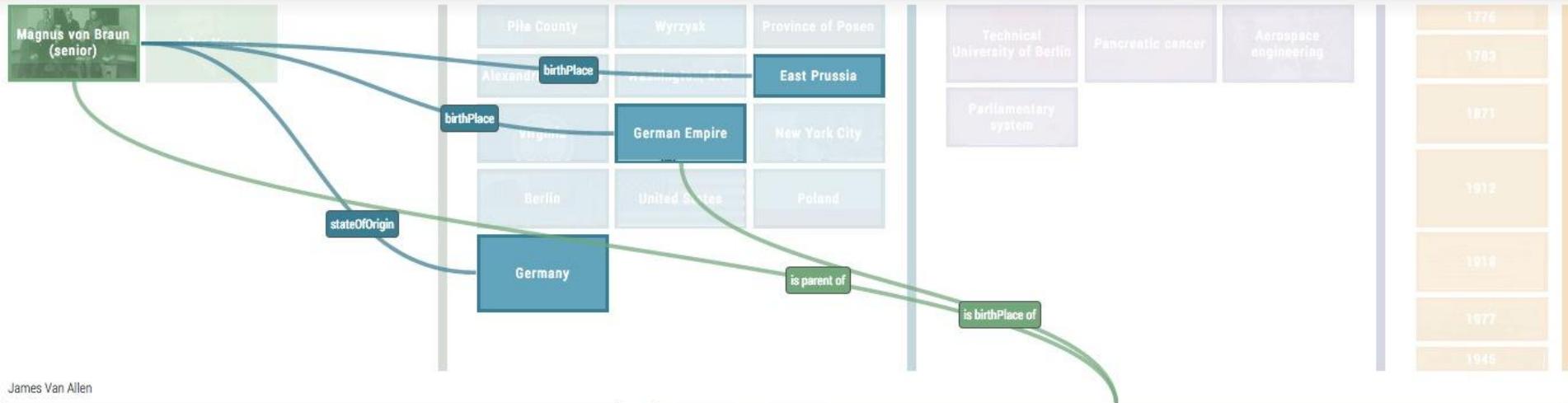


Exploration & Recommendation

Application and Purpose of the Material Sciences Ontologies



Relation Browser Timeline



James Van Allen

15 Recommended Articles:

- #1 Willy Ley Founder Of The German Rocket Society
- #2 The First Us Space Station Skylab
- #3 Hermann Oberths Dream Of Space Travel
- #4 Wolfgang Pauli And The Pauli Principle
- #5 Maria Goeppert Mayer And The Nuclear Shell Model
- #6 Oskar von Miller and the Deutsches Museum



Wernher von Braun
Wernher Magnus Maximilian, Freiherr von Braun (March 23, 1912 – June 16, 1977) was a German rocket engineer and space architect. He was one of the leading figures in the development of rocket technology in Germany during World War II and, subsequently, in the United States. He is credited as being the 'Father of Rocket Science'. In his 20s and early 30s, von Braun was the central figure in the Nazis' rocket development program, responsible for the design and realization of the V-2 combat rocket during World War II. After the war, he and some select members of his rocket team were taken to the United States as part of the then-secret Operation Paperclip. Von Braun worked on the United States Army intermediate range ballistic missile (IRBM) program before his group was assimilated by NASA. Under NASA, he served as

DBpedia: Wernher von Braun

e.g. via refer.cx WordPress Plugin at <http://scih.org/>

Consistency Checking & Prediction

Application and Purpose of the Material Sciences Ontologies





**“Technology presumes there's just one right way
to do things and there never is”**

Robert M. Pirsig, Zen and the Art of Motorcycle Maintenance (1974)

Prof. Dr. Harald Sack

*Everything you always wanted to know
about Ontologies*

**but were afraid to ask*

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PMD Ontology Workshop, 13 April 2021

were afraid to ask , PMD Ontology Workshop, April 13, 2021.



Image References:

- [1] The E989 storage-ring magnet at Fermilab, which was originally designed for the E821 experiment. Photo: Glucikov @ WikimediaCommons [cc-BY-SA 4.0]
[https://commons.wikimedia.org/wiki/File:Fermilab_g-2_\(E989\)_ring.jpg](https://commons.wikimedia.org/wiki/File:Fermilab_g-2_(E989)_ring.jpg)
- [2] Matrix Computer Screen, pixabay license <https://pixabay.com/illustrations/matrix-code-computer-pc-data-356024/>
- [3] UBC Library Card Catalog, Paul Joseph, cc-by-2.0, https://commons.wikimedia.org/wiki/File:2009_3544505541_card_catalog.jpg
- [4] Tree of knowledge based on the French Encyclopedie from 1780, public domain,
https://commons.wikimedia.org/wiki/File:Essai_d%27une_distribution_g%C3%A9n%C3%A9alogique_des_sciences_et_des_arts_principaux,_1780.jpg
- [5] Pieter Bruegel the Elder, The Tower of Babel, 1563, public domain,
[https://commons.wikimedia.org/wiki/File:Pieter_Bruegel_the_Elder_-_The_Tower_of_Babel_\(Vienna\)_-_Google_Art_Project_-_edited.jpg](https://commons.wikimedia.org/wiki/File:Pieter_Bruegel_the_Elder_-_The_Tower_of_Babel_(Vienna)_-_Google_Art_Project_-_edited.jpg)
- [6] Michelangelo Buonarrotti, Creazione di Adamo, c. 1512, public domain,
[https://en.wikipedia.org/wiki/The_Creation_of_Adam#/media/File:Michelangelo_-_Creation_of_Adam_\(cropped\).jpg](https://en.wikipedia.org/wiki/The_Creation_of_Adam#/media/File:Michelangelo_-_Creation_of_Adam_(cropped).jpg)
- [7] Niklas Jansson, Touched by His Noodly Appendage, public domain,
https://commons.wikimedia.org/wiki/File:Touched_by_His_Noodly_Appendage_HD.jpg
- [8] The Linked Data Cloud, 2019, cc-by, <https://lod-cloud.net>
- [9] A fantasy map of a flat earth. Photograph: Antar Dayal/Getty Images/Illustration Works <link>
- [10] Jorge Luis Borges by Annemarie Heinrich, 1967, https://commons.wikimedia.org/wiki/File:Jorge_Luis_Borges_byAnnemarie_Heinrich,_1967.jpg
- [11] Caspar David Friedrich, Wanderer über dem Nebelmeer, 1818, public domain,
https://upload.wikimedia.org/wikipedia/commons/b/b9/Caspar_David_Friedrich_-_Wanderer_above_the_sea_of_fog.jpg
- [12] Albrecht Dürer, Melancholia I, 1514, public domain, https://commons.wikimedia.org/wiki/File:D%C3%BCrer_Melancholia_I.jpg
- [13] Peter Brueghel the Younger, The Alchemist, photo:Rauantiques @ WikimediaCommons, CC BY-SA 4.0.,
https://commons.wikimedia.org/wiki/File:The_Alchemist_by_Pieter_Brueghel_the_Younger.jpg