LEADING

LIS Education And Data Science Integrated Network Group

LEADING Boot camp

Monday, June 14, 2024

From whatever time Alex Poole finishes to 12:15 PM ET

Agenda:

1. How's everyone doing
2. Big metadata (brief comments)
3. Ontology / briefly linked data
   ~ Protégé
4. Other / open discussion (time permitting)

?

What is Metadata?

- Data about data, info. about information… *blah blah blah*
- Data that makes other data/information objects useful (Musik, 1997)
- Data supporting one or more function/action (discovery, rights/access, authenticity, preservation, linking, provenance tracking, validation…) (Greenberg, 2003, 2010, etc.)

Metadata is a first-class data object

Representation of a thing, event, activity…

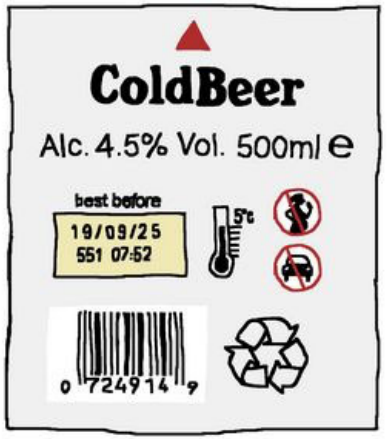
Assertions, statements (property/value)

Components of Metadata Standards

Data structure Standards (container, label, semantics)	**Data communication standards** (encoding, markup, data exchange)	**Data value standards** (authority files, ontologies, taxonomies, etc.)
Data syntax standards		
element/property ordering	think *grammar…*	*content syntax*
Metadata models		

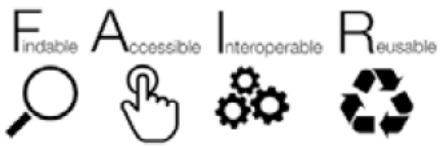
DATA

METADATA



Dataedo /cartoon

Piotr@Dataedo



FAIR Data Principles

FAIR Principles

- F1: (Meta) data are assigned globally unique and persistent identifiers
- F2: Data are described with rich metadata
- F3: Metadata clearly and explicitly include the identifier of the data they describe

Wilkerson, et al, (2016) The FAIR Guiding Principles for scientific data ...

Big Metadata

- Where there's big data, there's often metadata, or metadata is needed

ChatGPT

- "Overall, while "big metadata" is not a standard industry term, it can be understood as the management and analysis of metadata on a large scale in the context of big data."
- "…. the context of big data, metadata plays a crucial role in dealing with the massive volume, velocity, and variety of data."

Big Metadata

Table 1. The five Vs of big metadata.

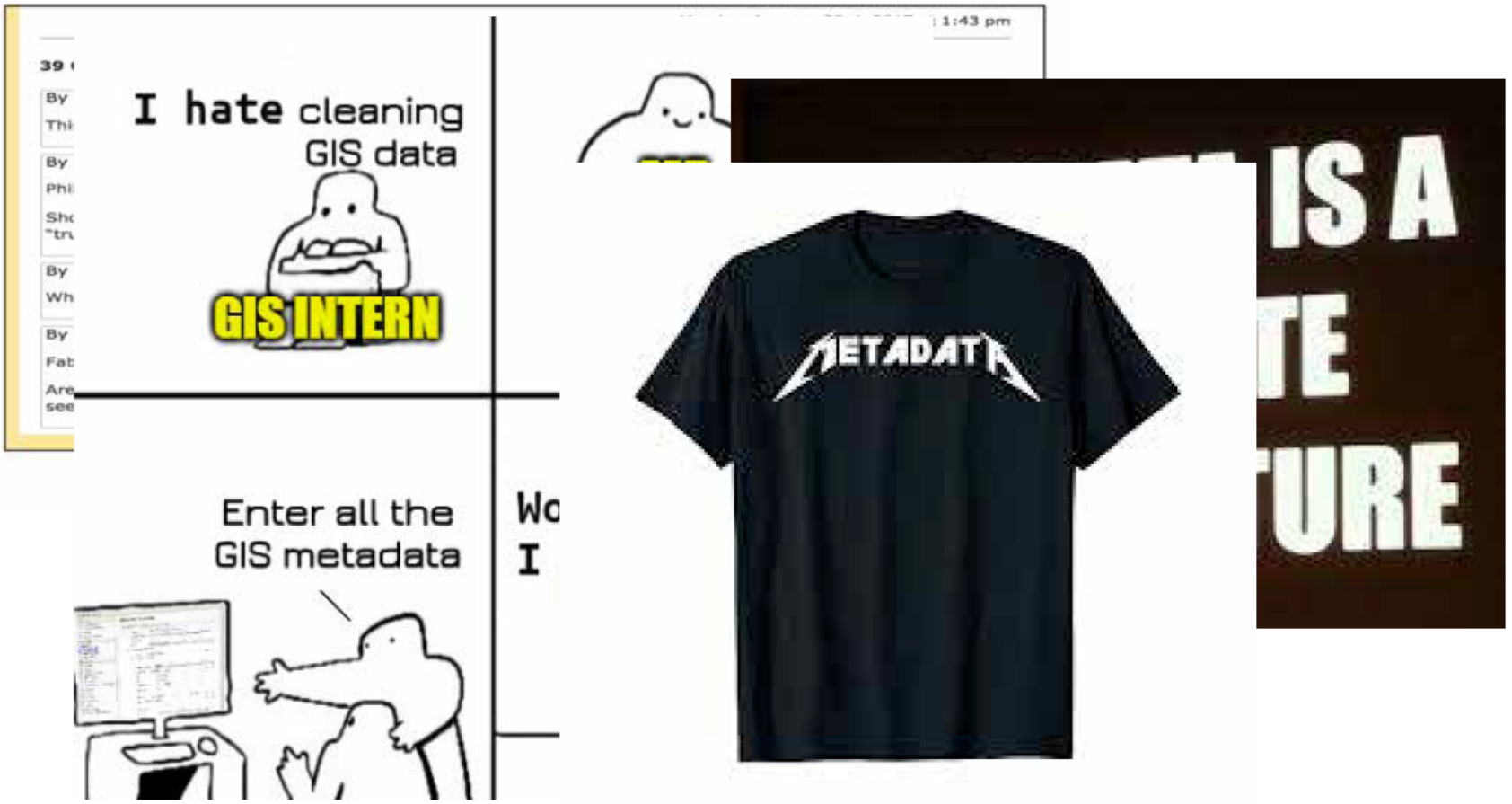
Five Vs	Definition
Volume	The quantity and usefulness of metadata generated daily confirms the existence of big metadata. At times metadata is less than or equal to the extent of the data it describes in size (bytes). During other times the metadata exceeds the data being described or tracked, due to the complexity of the data lifecycle activity. Linked data offers an example, with metadata renderings that can be larger than the volume of data object(s) being represented. Like big data, not all big metadata is useful, and a challenge is to identify the big metadata that is useful for data science and analytic endeavors.
Velocity	Metadata is generated via automatic processes at immense speed correlating with rate of digital transactions. For example, searching Google, answering an email, purchasing an item online, and day-to-day office activities such as word processing of all log data, as well as associated metadata.
Variety	Metadata reflects the wide variety of data formats, types, and genres along with the extensive range of data and metadata lifecycles. In addition, the different types of metadata (e.g. discovery, technical, preservation, etc.) as well as unique domain specific metadata requirements intensify the variety.
Variability	There is an unmistakable unevenness of metadata across the digital ecosystem. Lack of uniformity is extensive for data descriptions across different domains, systems, and processes. This unevenness can even be profound within domains, given economic factors supporting metadata generation, competing standards, or, simply, differing adoption policies. For example, two organizations may use the same metadata standard, but have different implementation practices. Even when standardization is imposed, an organization, process, and human activity can contribute to inconsistencies.
Value	*If data is the new black gold*—akin to petroleum requiring purification, but also a money maker, then metadata is the new platinum—a malleable substance that keeps its toughness, and can serve as a catalyst, sparking a reaction.* Metadata, as the *new platinum*, can be modified, while remaining a strong, independent data type. Metadata stands as a durable data object that triggers various functions—the catalyst, and achieves results—a reaction. Metadata is vital to accurate data interpretation and use by both humans and machines, and the value of metadata for data science endeavors cannot be overstated or diminished.

Note. *Singh (2013) identified data as the new black gold on Wired.com.

Greenberg, J. (2017): doi.org/10.1515/jdis-2017-0012

Not everyone like metadata, but it's integral to data science work and more…

Metadata has a bad reputation



Metadata ecosystem (complex)

Types of representation standards

Data structure standards

- The semantics, container

Data communication standards (the wrapper)

- Encoding (e.g., JSON, XML, etc.)

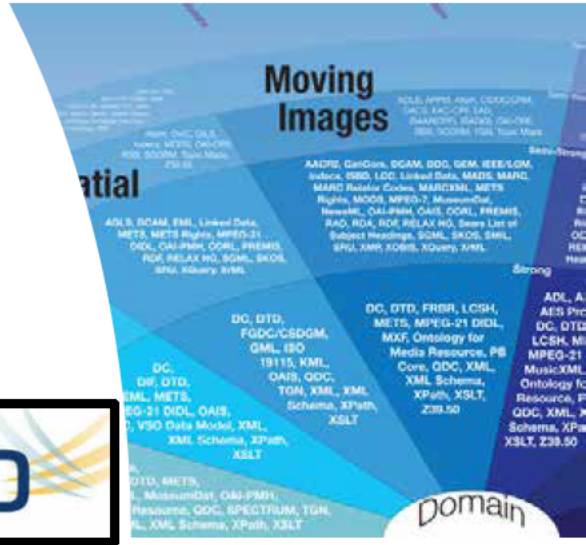
Data syntax standards

- Cuts across other standards (element ordering, content syntax, and encoding syntax)

Data value standards

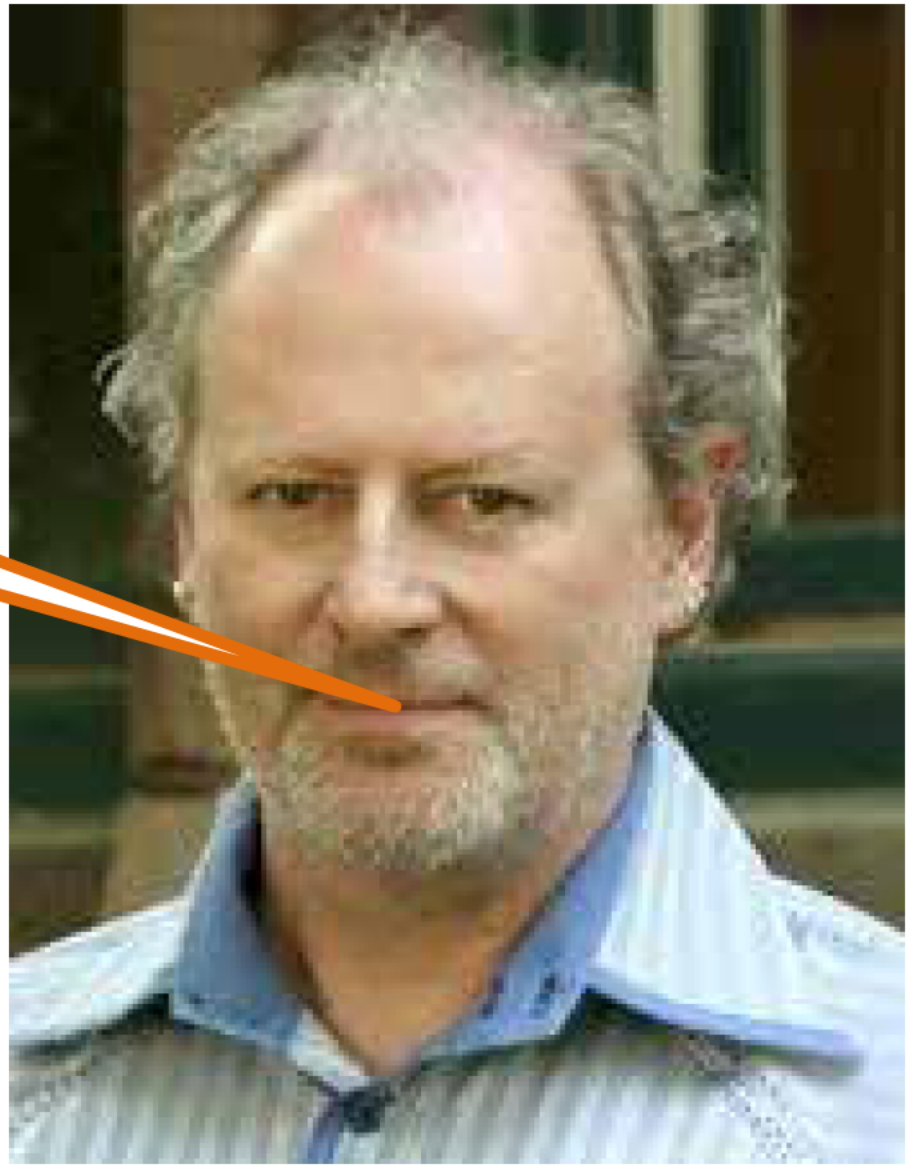
- Ontologies, thesauri, authority files, etc., KOS (Knowledge Organization Systems)

Models



Research Data Alliance Conference

Peter Fox, RDA, Sweden, 2014



Metadata: It's complicated, it's not always perfect….

Metadata challenges contributing to uncertainty/ impacting data science, AI,…etc.

Data challenges	System challenges	People challenges
• Massive amounts + wide variety (big metadata), • Metadata deserts • Ambiguity, not clearly labeled • Synonymy, polysemy • Noisy data (errors, unstructured) • Lacking standards, context, misinterpreted	• One and done ~ sort of (after fine tunning, on to the next project) (impact ROI)	
• Not just data – software, algorithms, research methods, modeling details		• Biases/subjectivity • Time constraints • Funding limitations

Accelerating approaches - addressing metadata challenges

Toward metadata best practices supporting workflows, RCR (reproducible computational research) and the FAIR principles

1. **Celebrate, build on, and adapt successes** (clear demonstrations)
2. **Explore hosting an embedded/feral metadata expert, software engineer/data scientist (cross-training)**
3. Establish metadata-related metrics (validation, uncertainty?)
   ~ Informetric values/entropy
4. Adopt or modify metadata workflows
5. Agree on semantics
6. Recognize there is a science of metadata, valid research topic

Establish metadata-related metrics (validation, uncertainty?)

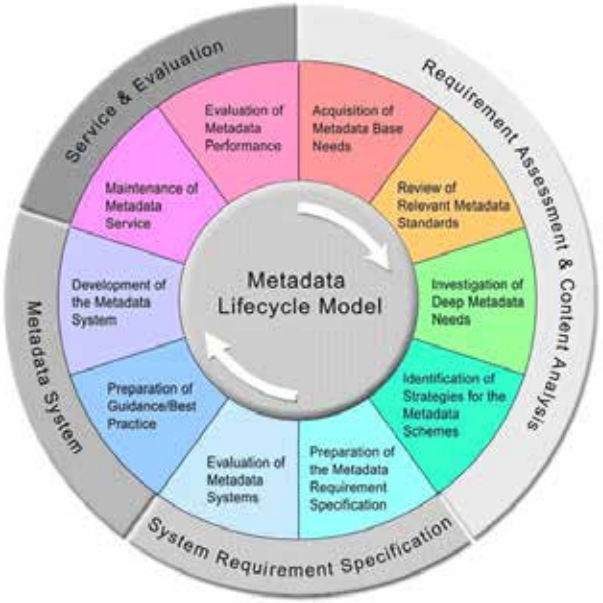
(Bruce& Hillmann, 2004 *to* Razzaghi, et al, 2023)

- **Completeness**
- **Provenance**
- **Accuracy**
- **Conformance to expectations**
- **Logical consistency / coherence**
- **Timeliness**
- **Accessibility**

HDR DQNN) (Greenberg, et al, 2021 2023)

- Metadata maturity model (RDA)

Adopt, or modify metadata workflows (



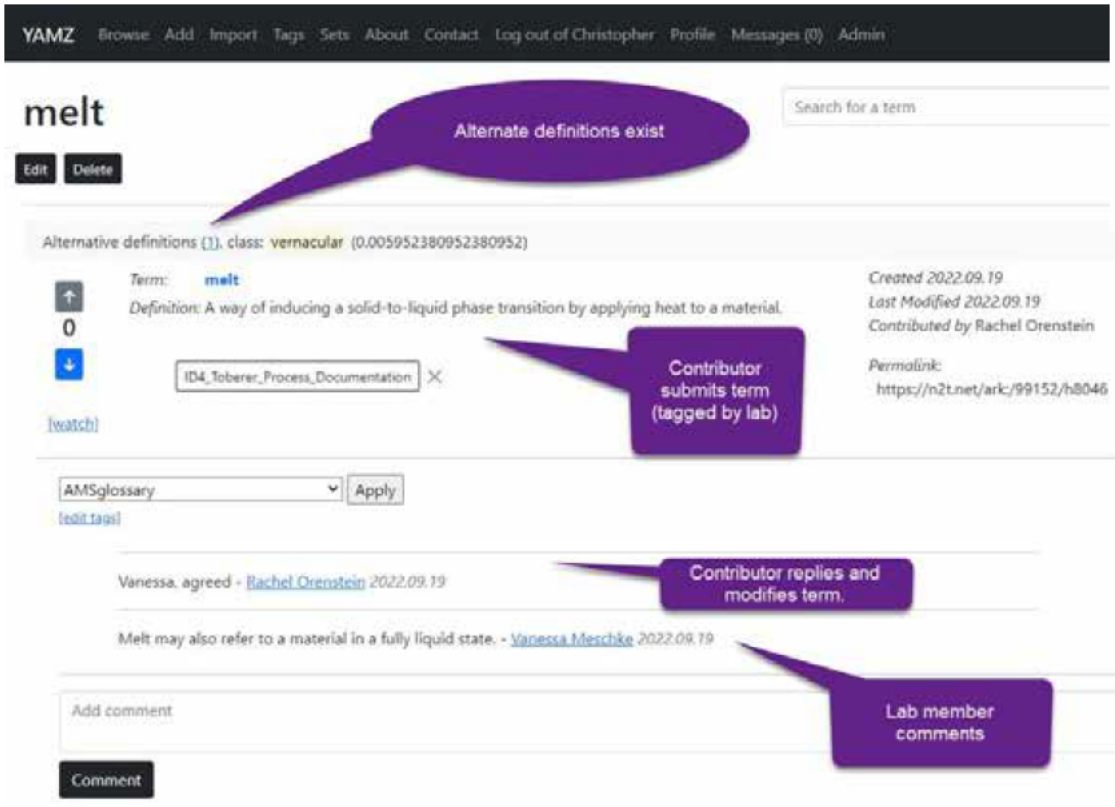
Metadata Architecture and Application Team (MAAT) "Metadata Lifecycle Model" for systematizing the metadata working procedure.

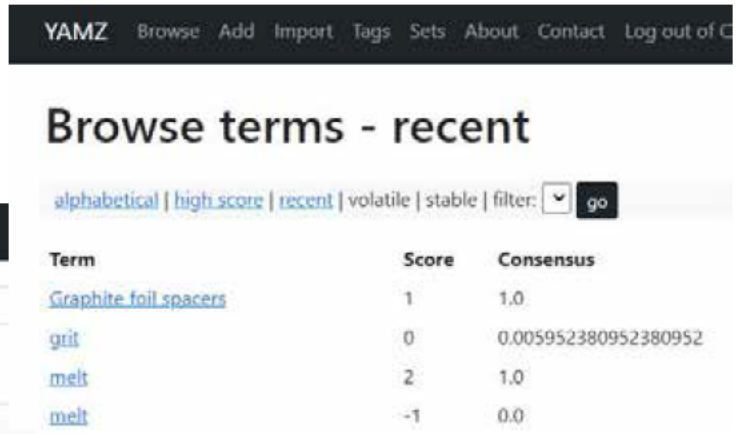
https://metadata.teldap.tw/design/lifecycle_eng.htm

Agree on semantics 👍 👍 👎

YAMZ

Yet Another Metadata Zoo





METADICTIONARY

A crowdsourced vocabulary builder

- Add terms and get permalinks (PIDs)
- Use and link controlled terms
- Share and refine project terms
- Cherry-pick terms for ontologies
- Dialog, test, and vote to consensus quickly

https://doi.org/10.1162/dint_a_00211

DIKW pyramid

https://en.wikipedia.org/wiki/DIKW_pyramid

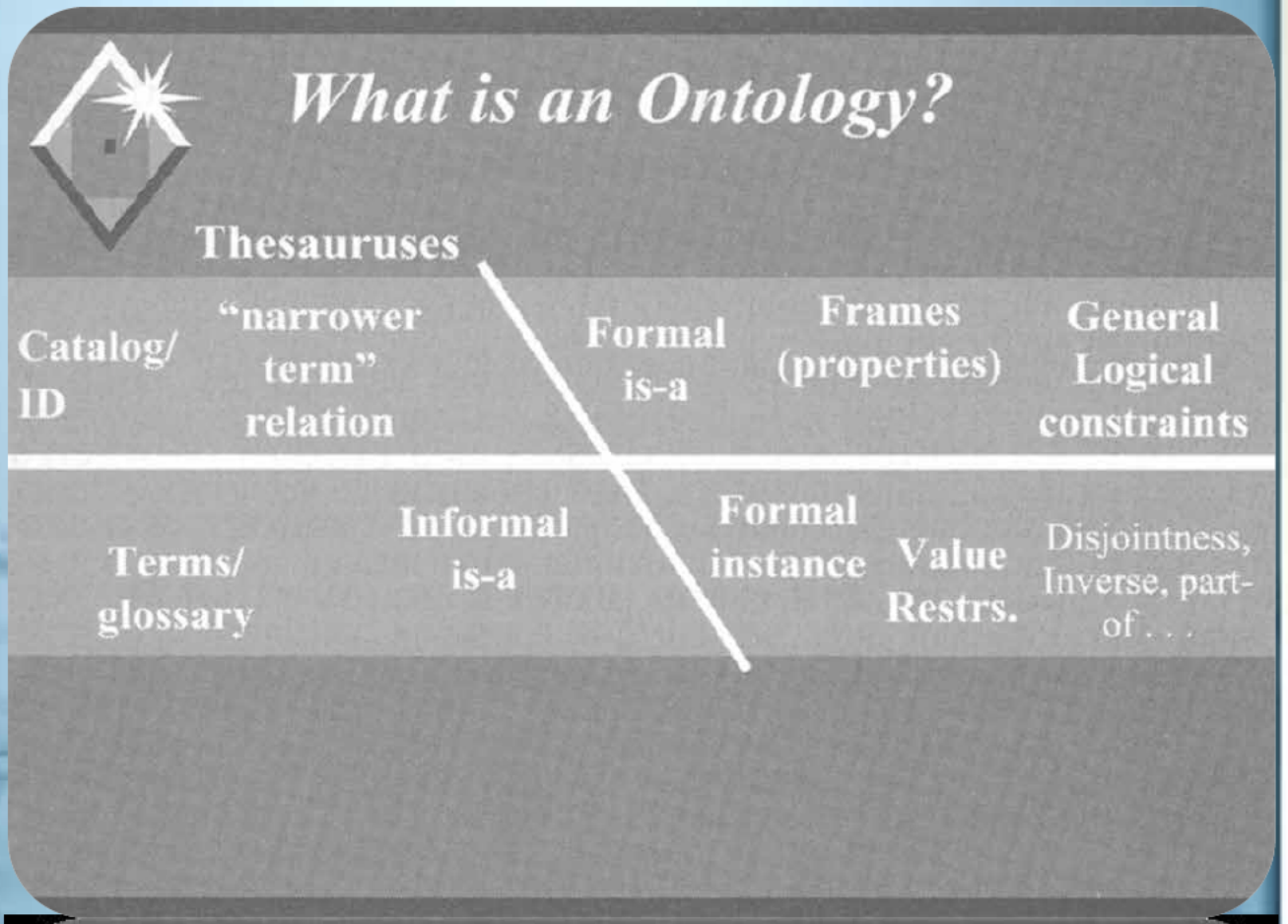
MetaDataCAPT'L

Recognize there is a science

Ontology

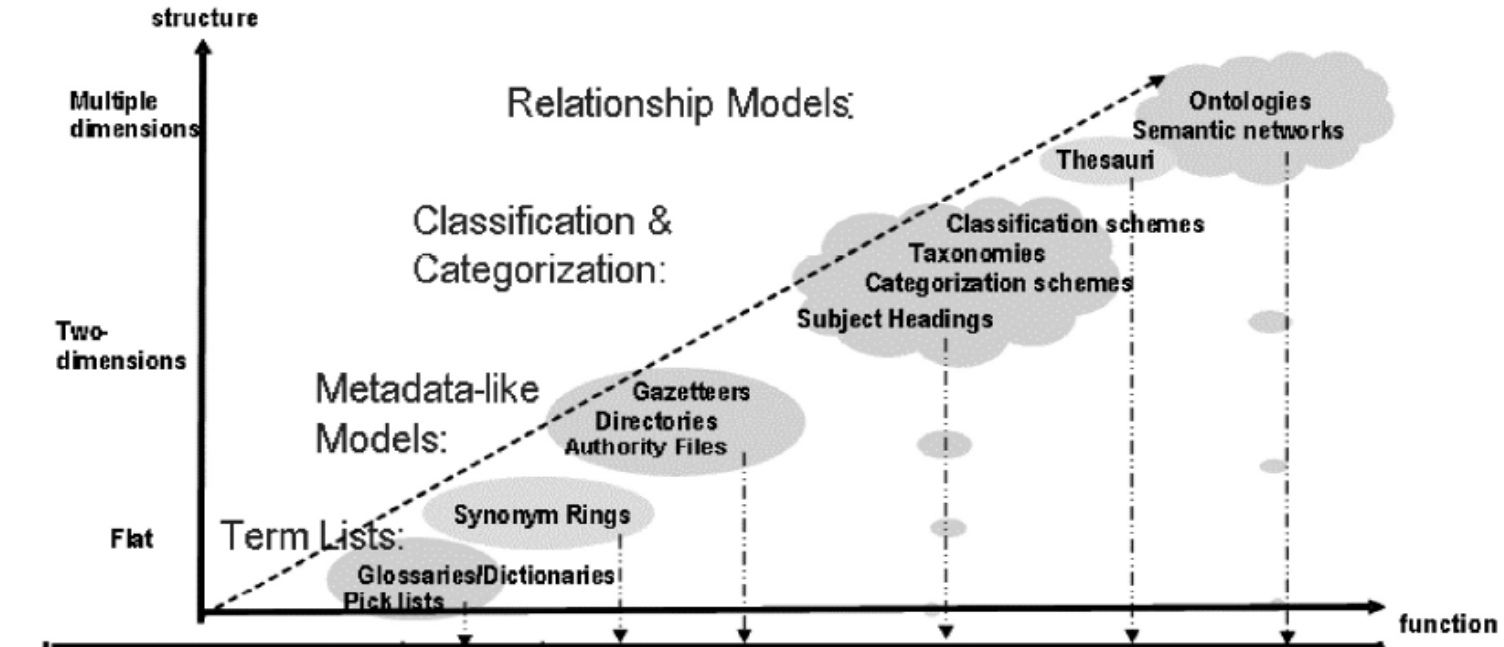
Ontology

(McGuinness, D. L. (2003). Ontologies Come of Age.
In Fensel, et al, *Spinning the Semantic Web*.
(Cambridge, MIT Press)



Ontologies and reality

A Taxonomy of KOS



Major functions

eliminating ambiguity	xxx		xxx	xx	xxxx	xx
controlling synonyms		xxxx	xxx	xx	xxxx	xx
establishing relationships: hierarchical			x	xxxx	xxx	xxx
establishing relationships: associative					xxxx	xxxxx
presenting properties						xxxxx

Zeng, Marcia Lei. 2008. "Knowledge Organization Systems". *Knowledge Organization* 35, nos. 2-3: 160-82.

Philosophy

Dates back to 5th Century B.C. when Empedocles divided the world into four elements – earth, fire, water and air.

Metaphysics: Defined by philosophers as the *nature of being or* ***existence***.

Aristotle · classification

Touches on "epistemology," which" is about knowledge and knowing

Ontology defined

Webster's dictionary

1. A science or study of being specifically, a branch of metaphysics relating to the nature and relations of being.
2. A theory concerning the kinds of entities and specifically the kinds of abstract entities that are to be admitted to a language system.

Thomas Gruber

"An ontology is a specification of a conceptualization"

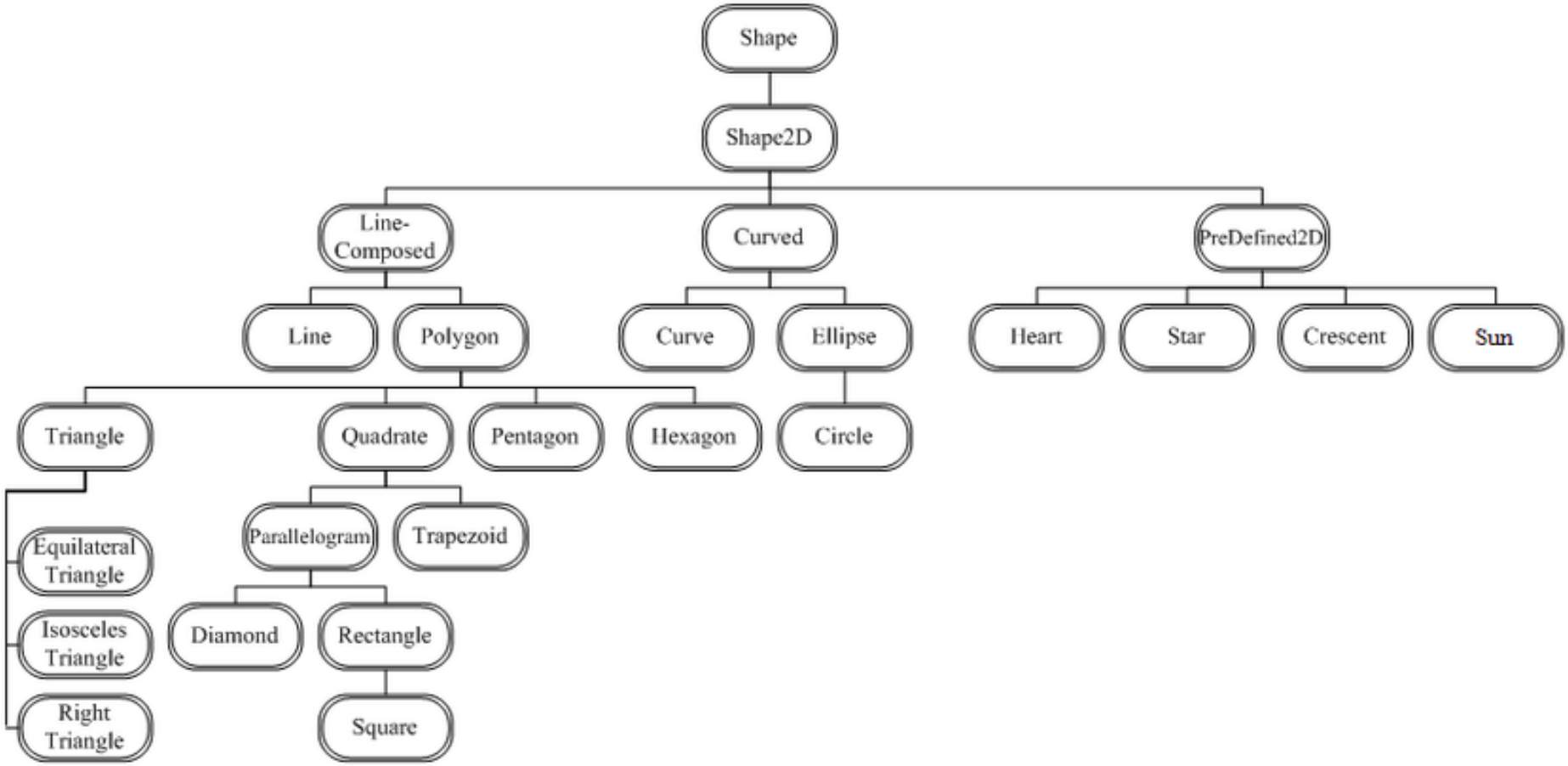
A must read!

Other important stuff

(comfy space)

- No exact definition
- *Generally speaking - ontology is* a WAY to convey a theory on how to represent a class of things and their relationships
- Knowledge representation, Knowledge organization (ILS)
- Blurry lines – w/database structure and knowledge graphs

AN ONTOLOGY OF SHAPES

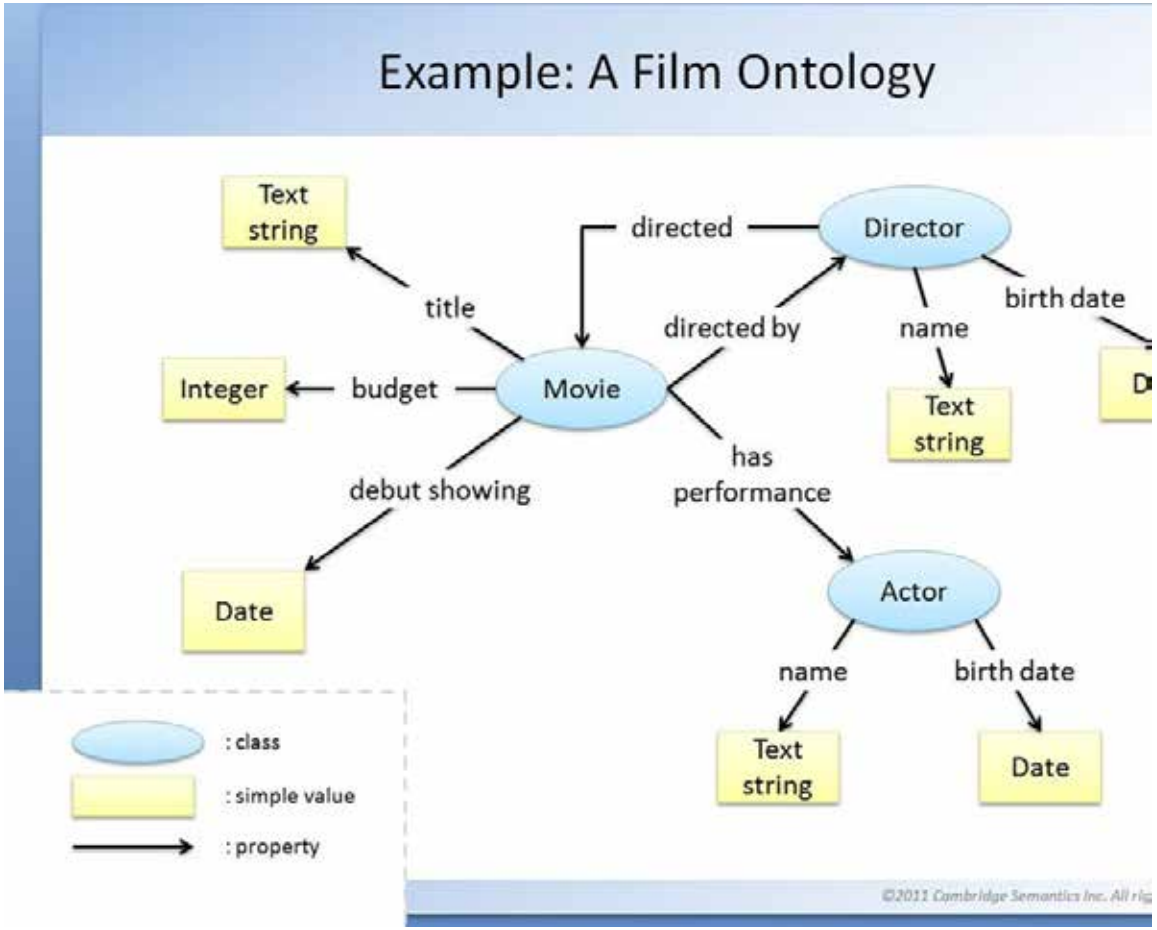


http://ceur-ws.org/Vol-812/paper9.pdf

Ontology

- National Center for Biological Ontologies: https://bioportal.bioontology.org/

- Example of a Film ontology à

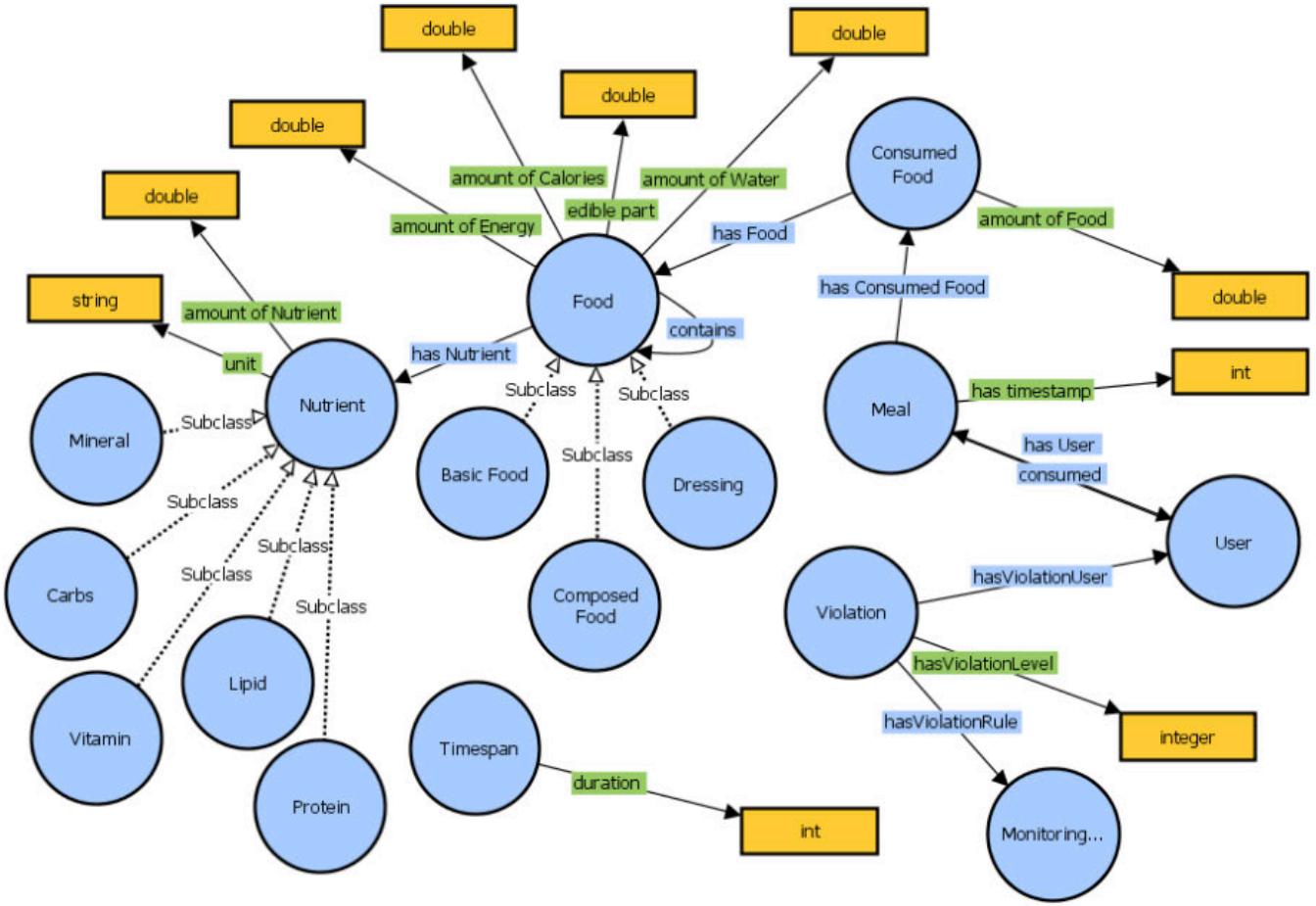


- Most ontologies structured as taxonomies, hierarchies
- People talk about ontologies in many, many, many… ways
- Basic ontology has two classes of elements: the entities and the relationships between them

- Class and sub-classes: Actor, Child actor
- Relationships
  - Is a type of
  - Movie "is directed by" director
  - Movie "has performance" actor

  This is more involved than a lexical-semantic thesaurus.
- More involved / RDF triples
  - Predicate (has a property of X)
  - E.g., Book has title
    - predicates are linguistic entities
  - Subject-predicate-object (think reverse ABC)
- Organized according to axioms or rules that control how the world will be defined.

AN ONTOLOGY OF FOOD



https://www.w3.org/community/owled/files/2016/11/OWLED-ORE-2016_paper_3.pdf

Important Facts

- What exists is only what is represented in the ontology
- Most ontologies focus on a specific area to conceptualize the world.
- Must be updated to keep up with dynamic world
- No set discipline or methodology!
- Joined together with instances, get closer toward knowledge graph… but fuzzy line

The Role of Ontology

Application areas

- Indexing
- Knowledge Sharing & Reuse
- Artificial Intelligence (AI)
- Enterprise Modeling
- Software Design
- Molecular Biology
- eCommerce
- Semantic Web….

Indexing, browsing, finding, visualizing…

A language, reliable sharing of information

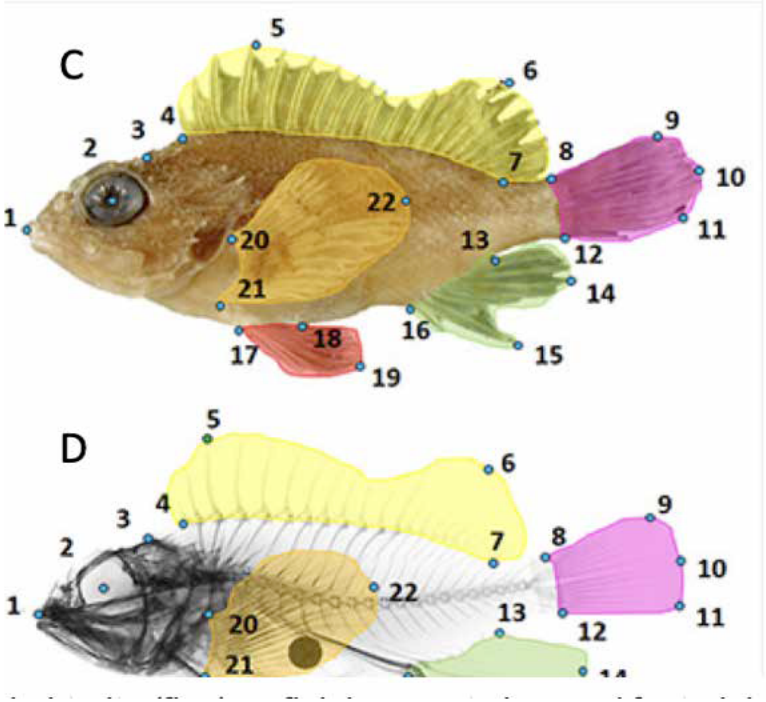
Enable reuse of domain knowledge

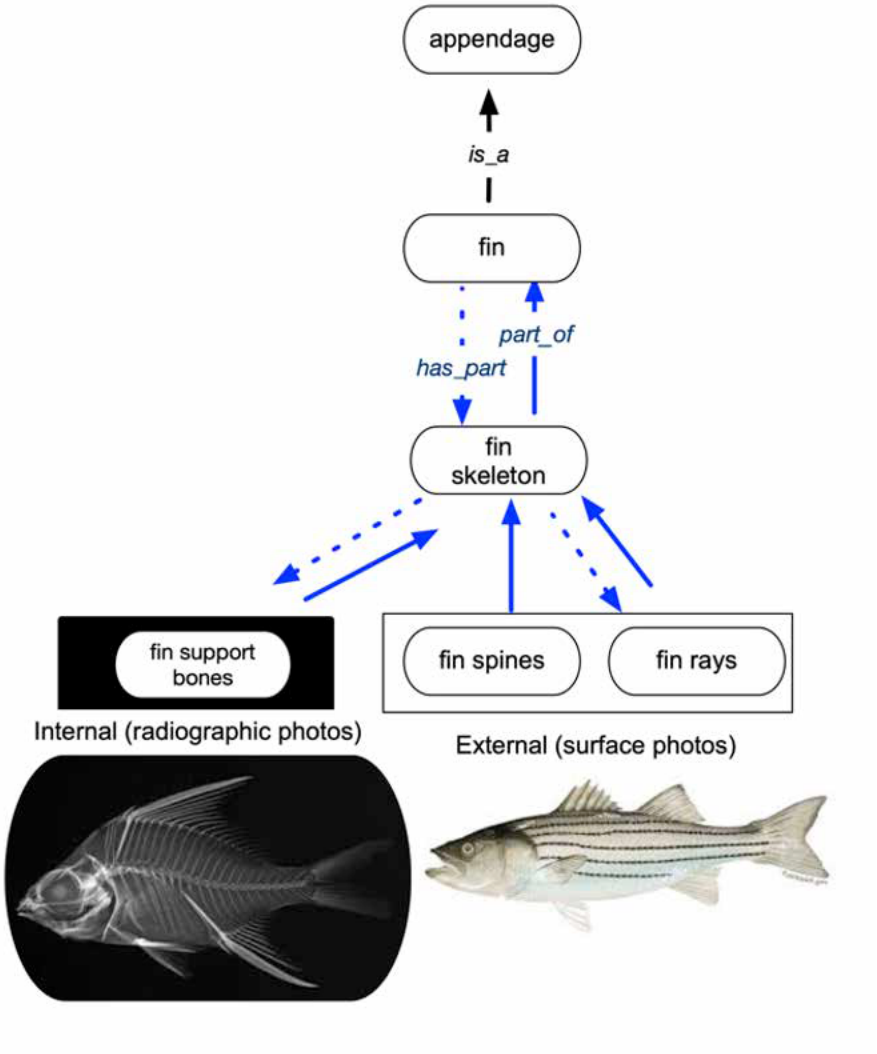
Makes assumptions more explicit

Analyze domain knowledge

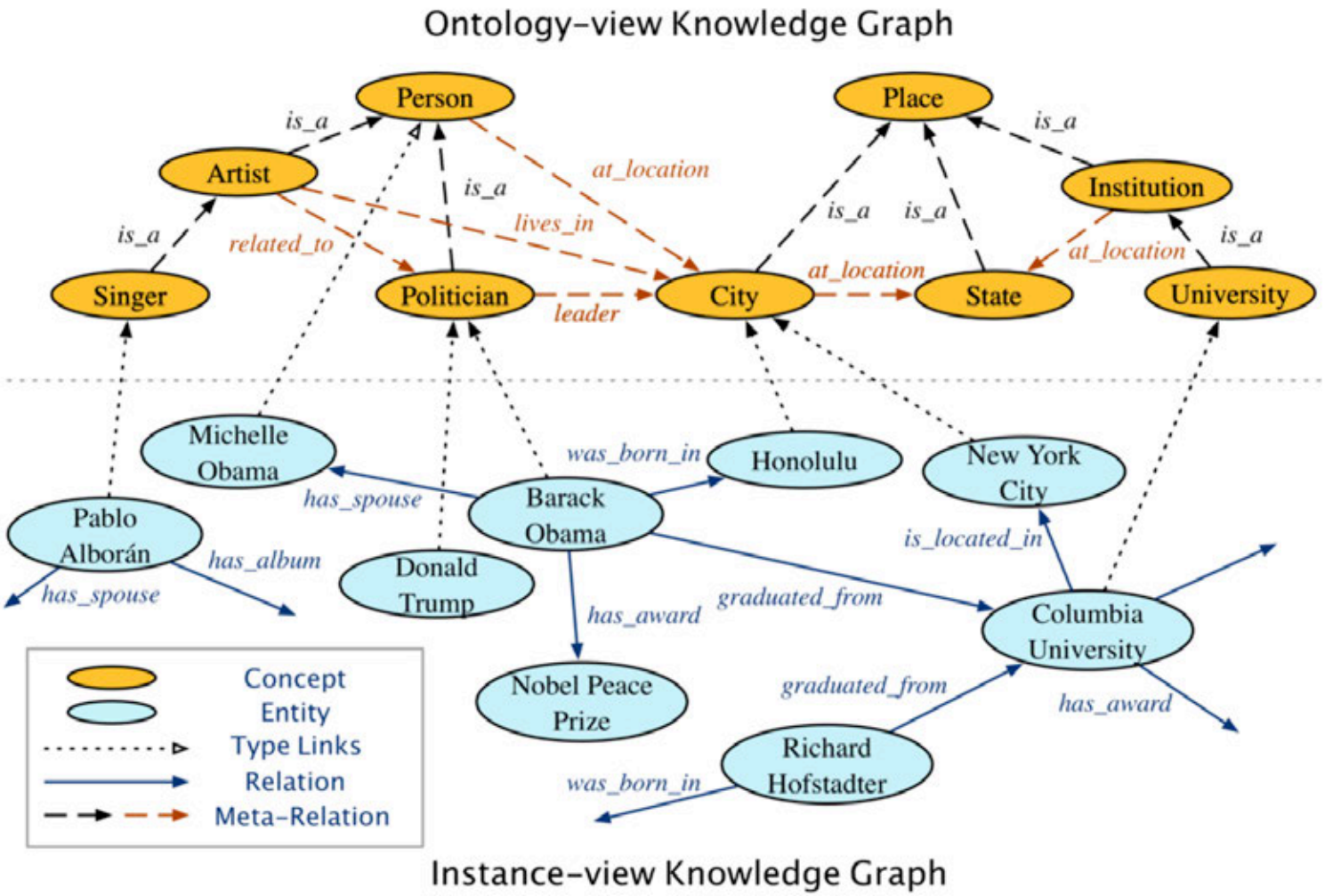
Reasoning

Reasoning to identify species variation





NSF-HDR Biology Guided Neural Networks (BGNN)



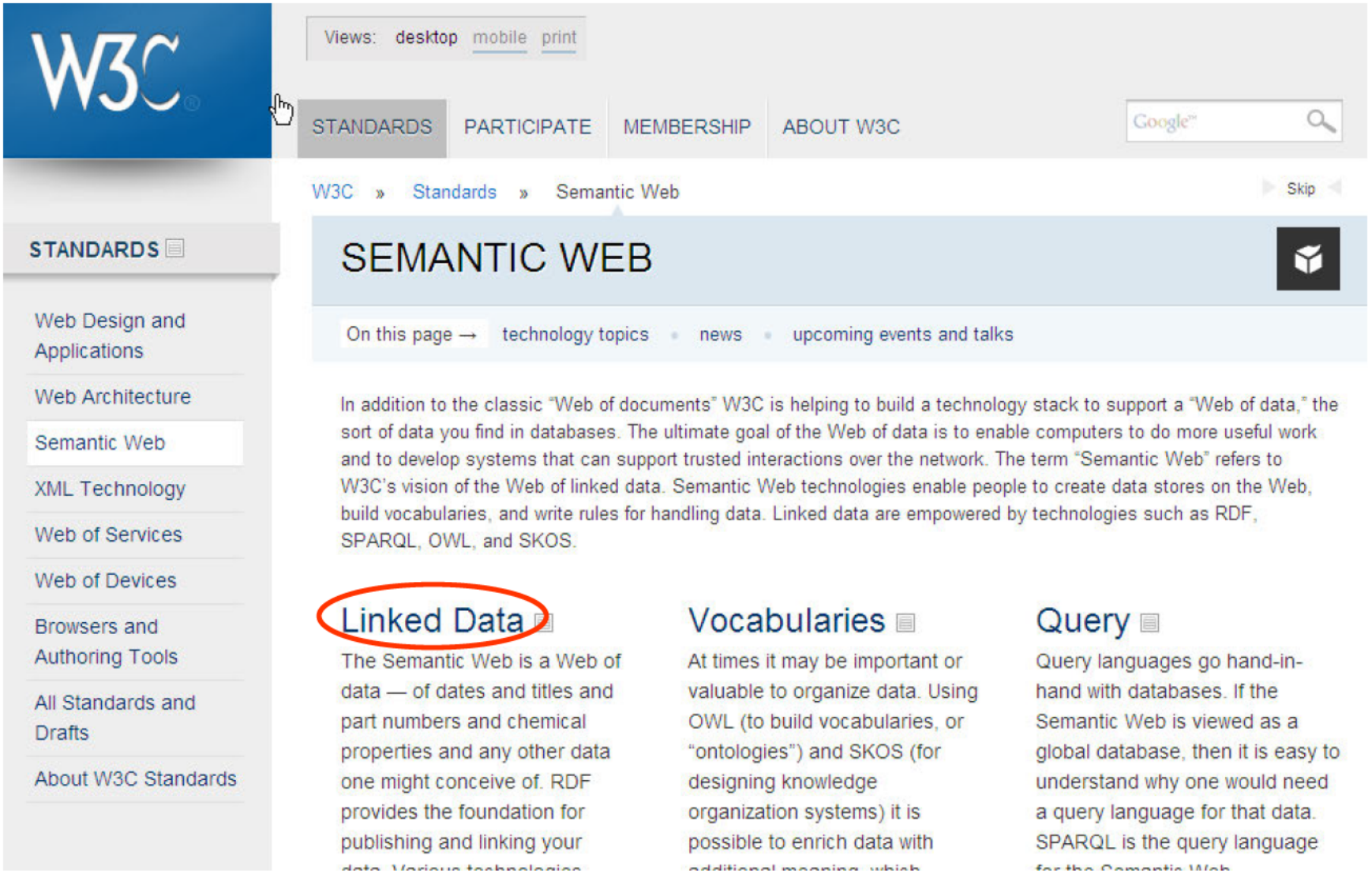
Publication: The 25th International ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD 2019)

https://www.haojunheng.com/project/joie-kdd/

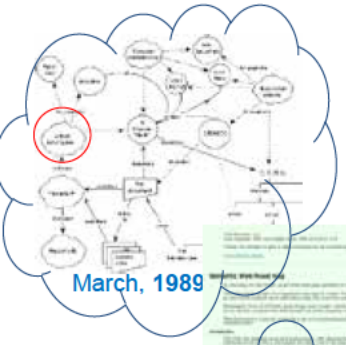
Linked data

- Strings and things
- Semantic Web vision
- Everything should have a unique ID, in fact a Persistent ID (PID)

Evolution of the Web http://www.w3.org



(E. Mendez, 2012)



Tim BL Roadmap on **Semantic Web** (Sept1998)

W3C Semantic Web Activity starts, 2001

FOAF (Early 2000)

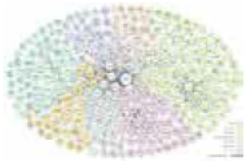
Berners Lee, Hendler & Lassila (May2001)

FOAF Voc. Spec (May2005)

1st **LOD Cloud** Cyganiak & Jentzsch (May2007)

Tim BL **LOD principles**

Tim BL TED Talks (Feb 2009 & Mar 2010)



Last **LOD Cloud** Cyganiak & Jentzsc (Nov2011)

OIL
DAML

DCMES (ISO-2003)

Tim BL **Linked Data** (July2006)

DCMI *Singapore Framework* (Aug2007)

1996 1998 2000 2002 2004 2006 2008 2010 2012

PICS W3C-REC–Oct96

RDFS (RDF Schema) 1st Draft –1998

RDF Model & Syntax 1st Draft–Oct97

RDF M&S W3C-REC, Oct99

MCF Meta Content Framework–Jun97

RDFS (RDF Schema) W3C-CR, March1998

RDFS Vocabulary Description Language

RDF M&S W3C-REC, Feb2004

SKOS 1st Draft (May2005)

W3C SKOS W3C-REC Aug2009

W3C Incubator Activity Library Linked Data XG (May 2010) Final Reports (Oct2011)

W3C SPARQL W3C-REC, Jan2008

W3C OWL OWL specifications W3C-REC, Feb2004

W3C OWL2 OWL2 specifications W3C-REC, Oct2009

W3C Linked Data Platform LDP XG (May2012)

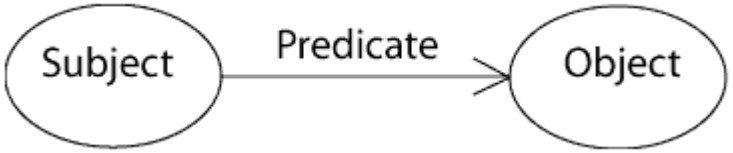
W3C RDFa In XHTML W3C-REC, Oct2008

Linked Data based on RDF data model

Is similar to Entity-Relationship or Class diagrams, statements about resource in subject-predicate object expressions called "triples".

subject= resource

predicate=traits or aspects of the resource and expresses a relationship between the subject and the object.



http://www.w3.org/TR/rdf-concepts/

The sky has the color blue

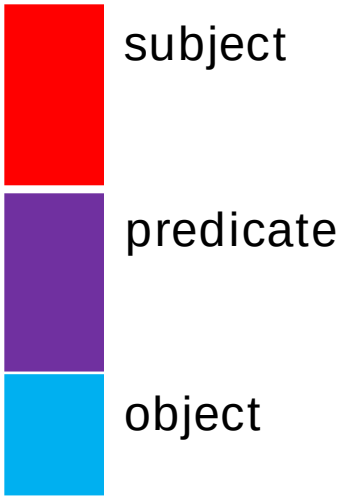
RDF triple:

- A subject denoting "the sky"
- A predicate denoting "has the color"
- An object denoting "blue"

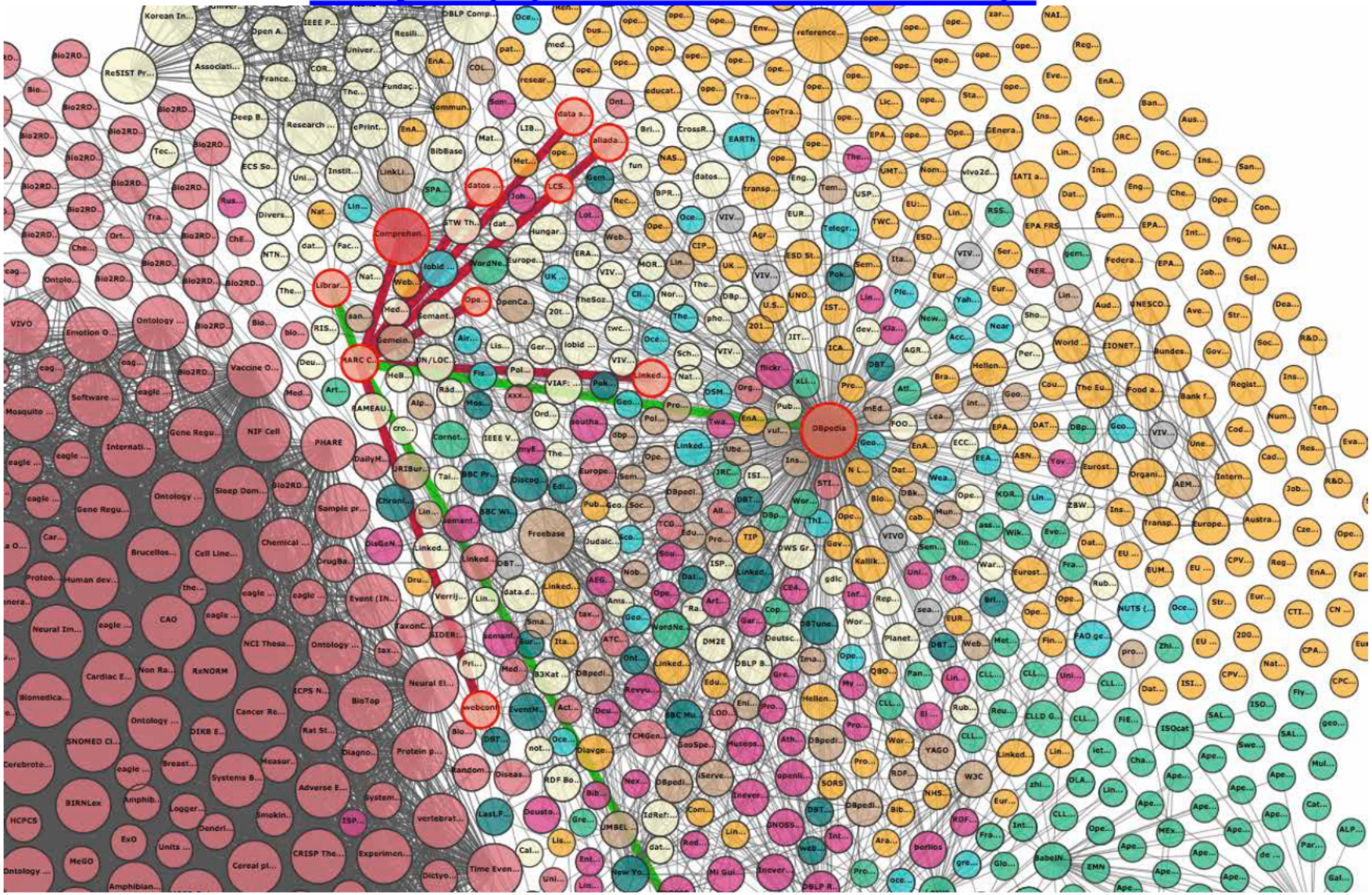
Example of RDF

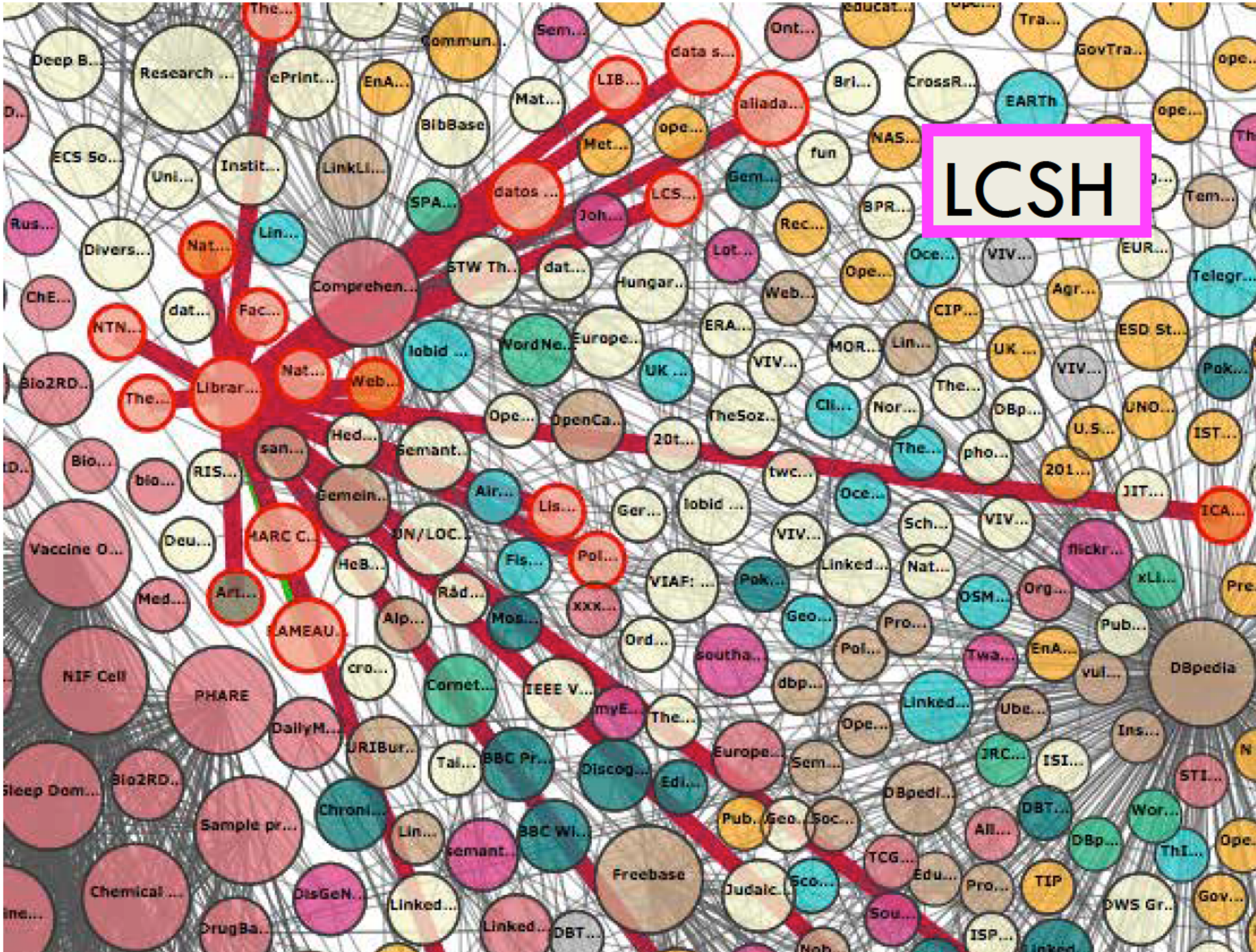
```
<rdf:RDF
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:dc="http://purl.org/dc/elements/1.1/">
<rdf:Description
rdf:about="https://www.sciencemag.org/news/2020/07/during-pandemic-students-do-field-and-lab-work-without-leaving-home">
<dc:title>During the pandemic, students do field...
</dc:title>
  </rdf:Description>
</rdf>
```

https://www.sciencemag.org/news/2020/07/during-pandemic-students-do-field-and-lab-work-without-leaving-home



https://lod-cloud.net/

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VIV...
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MOR...
ESD St...
UK ...
Pok...
Bio2RD...
Librar...
The...
VIV...
Ope...
OpenCa...
TheSoz...
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Deu...
HARC C...
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Fis...
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Pok...
OSM...
Org...
Pre...
RAMEAU...
Alp...
Mos...
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Ord...
Geo...
Pro...
Pub...
NIF Cell
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IEEE V...
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DBpedia
DailyM...
URIBur...
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Linked...
Ube...
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Tai...
BBC Pr...
Discog...
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JRC...
ISI...
STI...
Sample pr...
Chroni...
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BBC Wi...
Pub...
Geo...
Soc...
DBpedi...
DBT...
All...
Wor...
Semant...
Freebase
TCG...
DBp...
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Linked...
Judaic...
Sco...
Edu...
Pro...
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Gov...
DrugBa...
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ISP...
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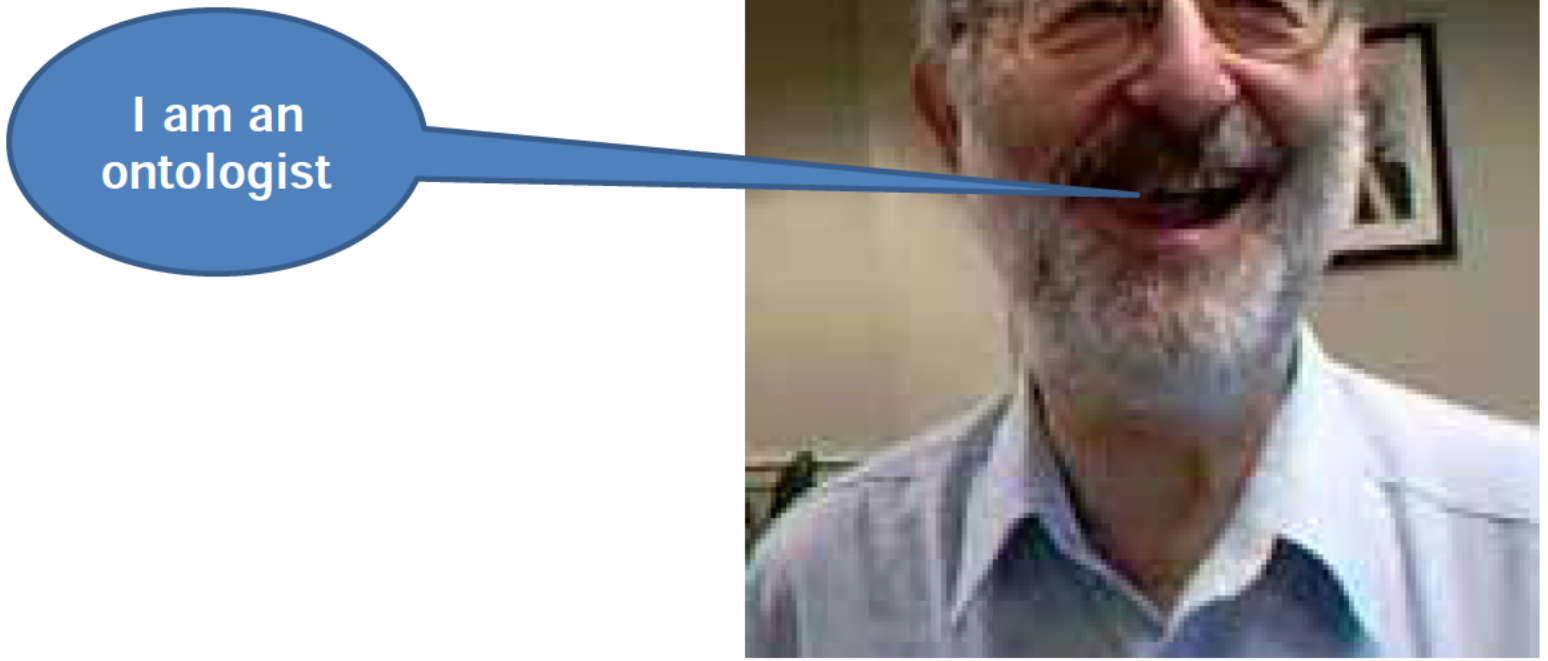
Ontologies as "structured terminologies"

- An island "is a type of" land area
- A nation "is a type of" geopolitical area

Relationships

- *Is at type of*
- *Causes*
- *Synonyms*



Dagobert Soergel, ACM/CL, 1997
http://nkos.slis.kent.edu/busch/summary.pdf