Ontologies:

Technologies for domain modeling, knowledge re-purposing and knowledge sharing

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The century of complexity

I think the next [21st] century will be the century of complexity. We have already discovered the basic laws that govern matter and understand all the normal situations. We don't know how the laws fit together, and what happens under extreme conditions. But I expect we will find a complete unified theory sometime this century. The is no limit to the complexity that we can build using those basic laws.

Stephen W. Hawking, interview in San Jose Mercury News 23 Jan 2000

[Answer to question: Some say that while the twentieth century was the century of physics, we are now entering the century of biology. What do you think of this?]

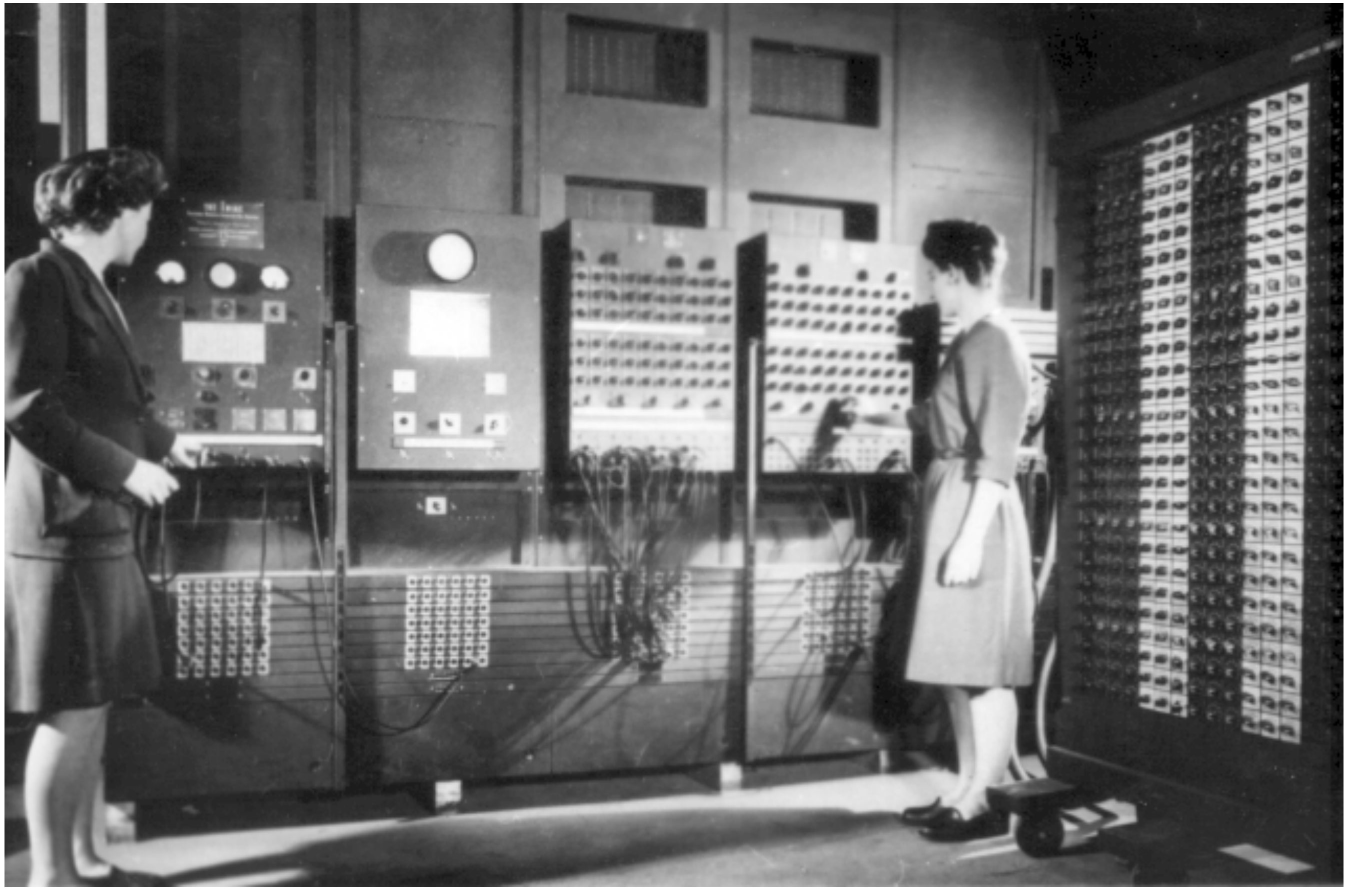
Complexity and computers

Human Computers

NACA High Speed Flight Station "Computer Room" (1949)

Source: Wikimedia Commons

Complexity and computers



Jean Jennings Bartik (left) and Frances Bilas Spence (right) preparing for the public unveiling of ENIAC, February 1946.

U. S. Army Photo

Computational Thinking

- Computational thinking changes other fields
  - Machine Learning to Statistics
  - Computational Biology to Biology
  - Computational Game Theory to Economics
  - Nanocomputing to Chemistry
  - Quantum Computing to Physics
- Computation changes the way scientists think

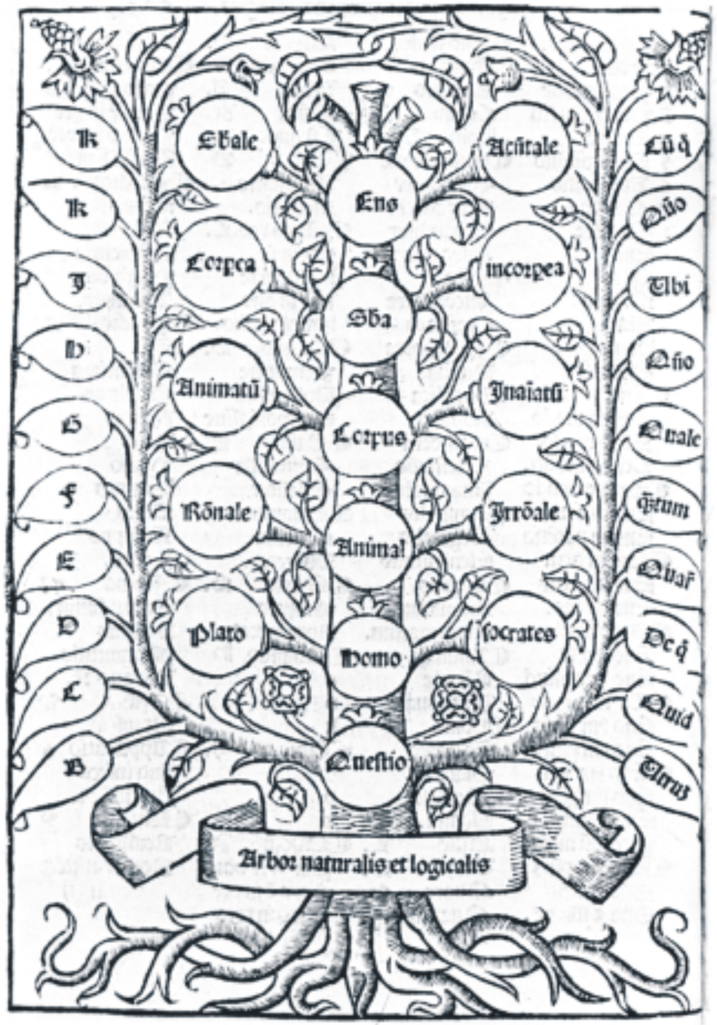
Computational Thinking

- *Computational thinking involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science.*

- *Thinking like a computer scientist means more than being able to program a computer. It requires thinking at multiple levels of abstraction.*

Jeannette M. Wing. 2006. Computational thinking.
Commun. ACM 49, 3 (March 200 6), 33-35.

Knowledge Representation



- Introduced in Artificial Intelligence
- Underlies any automatic information processing task

Knowledge Representation

Knowledge representation is a multidisciplinary subject that applies theories and techniques from three other fields:

- *Logic provides the formal structure and rules of inference.*
- *Ontology defines the kinds of things that exist in the application domain.*
- *Computation supports the applications that distinguish knowledge representation from pure philosophy.*

John F. Sowa, *Knowledge Representation: Logical, Philosophical, and Computational Foundations*, Brooks Cole Publishing Co., Pacific Grove, CA, 2000

Semantic Web: the Web of data

The ultimate goal of the Web of data is to enable computers to do more useful work and to develop systems that can support trusted interactions over the network. The term "Semantic Web" refers to W3C's vision of the Web of linked data. Semantic Web technologies enable people to create data stores on the Web, build vocabularies, and write rules for handling data. Linked data are empowered by technologies such as RDF, SPARQL, OWL, and SKOS.

http://www.w3.org/standards/semanticweb/

Semantic Web: the Web of data

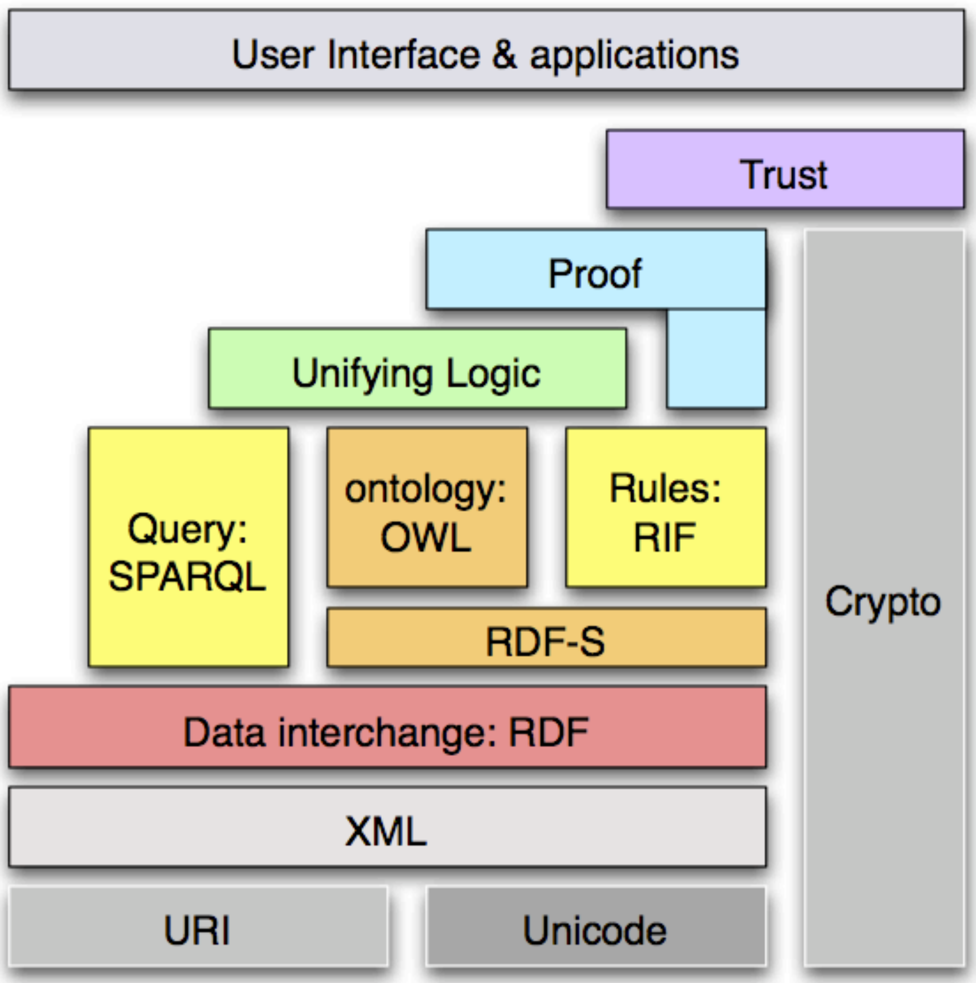
The Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation.

Tim Berners-Lee, James Hendler and Ora Lassila. The Semantic Web. Scientific American May 2001.

…A set of formats and languages that find and analyze data on the World Wide Web, allowing consumers and businesses to understand all kinds of useful online information.

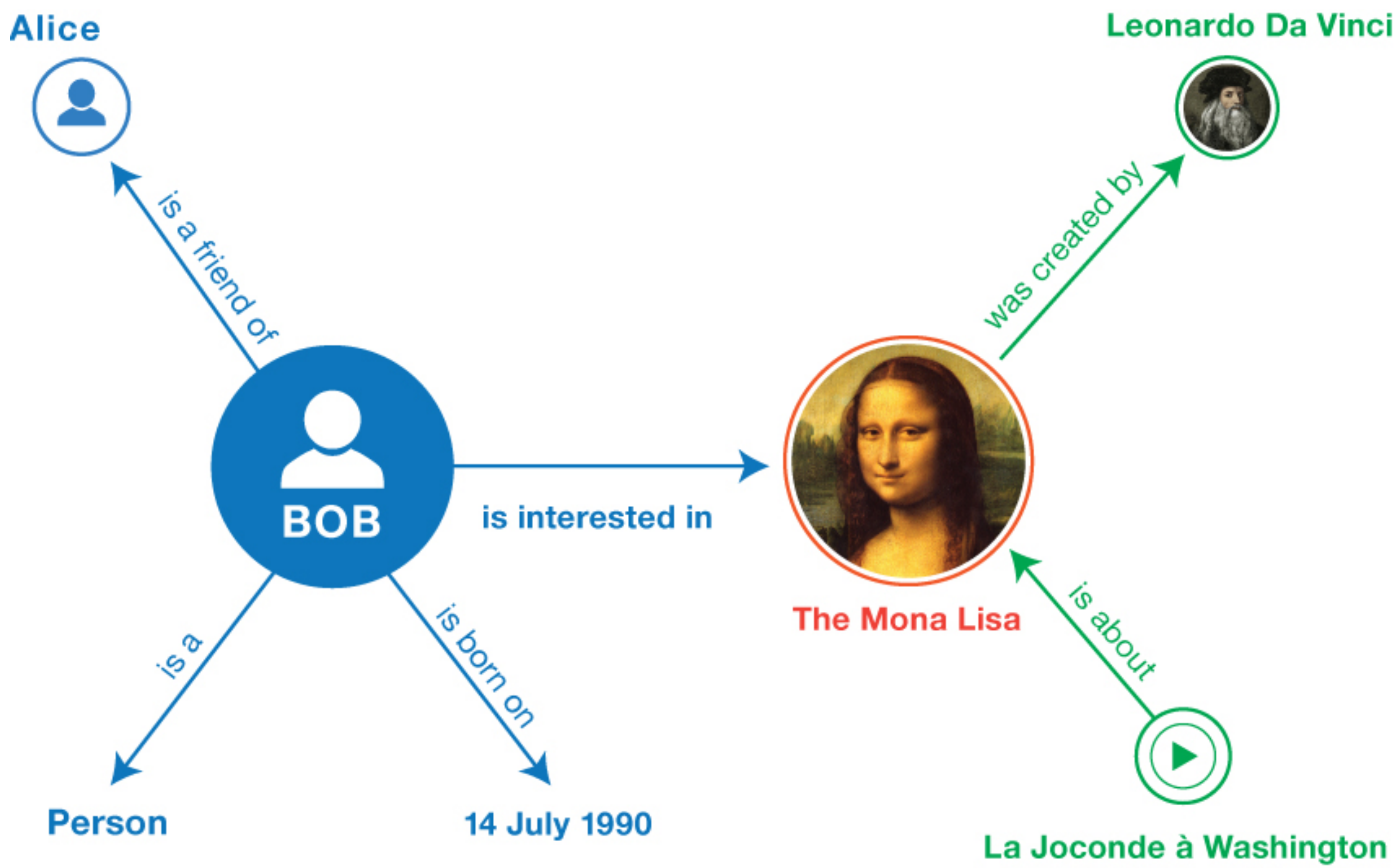
Lee Feigenbaum, Ivan Herman, Tonya Hongsermeier, Eric Neumann and Susie Stephens. The Semantic Web in Action. Scientific American 2007

The Semantic Web technology stack



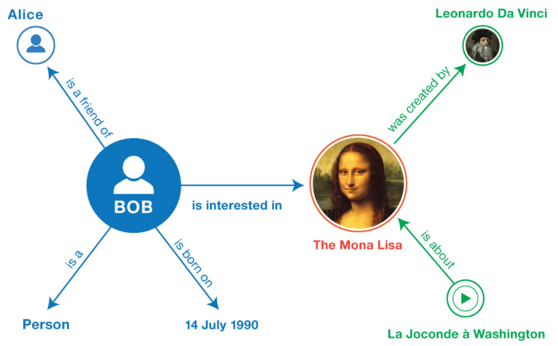
http://www.w3.org/2006/Talks/1023-sb-W3CTechSemWeb/#(19)

Resource Description Framework—RDF



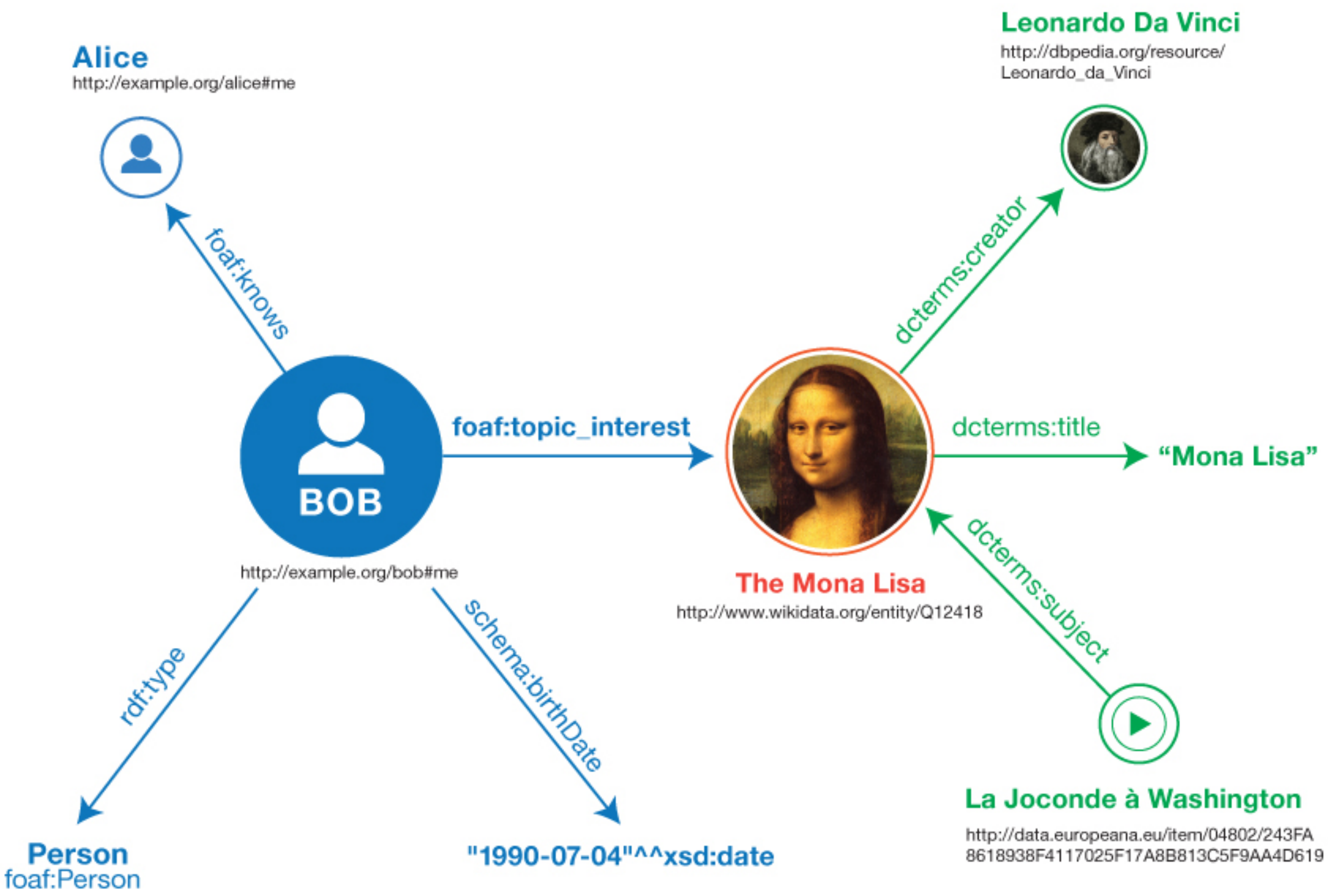
http://www.w3.org/TR/2014/NOTE-rdf11-primer-20140225/

Resource Description Framework—RDF



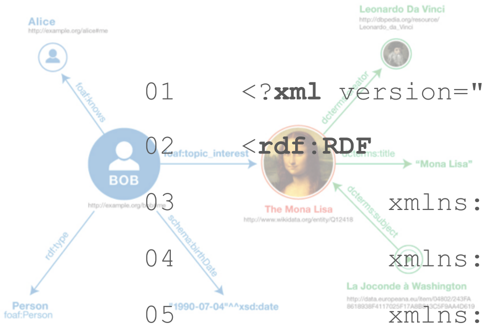

```
<Bob> <is a> <person>.
<Bob> <is a friend of> <Alice>.
<Bob> <is born on> <the 4th of July 1990>.
<Bob> <is interested in> <the Mona Lisa>.
<the Mona Lisa> <was created by> <Leonardo da Vinci>.
<the video 'La Joconde à Washington'> <is about> <the Mona Lisa>
```

Resource Description Framework—RDF



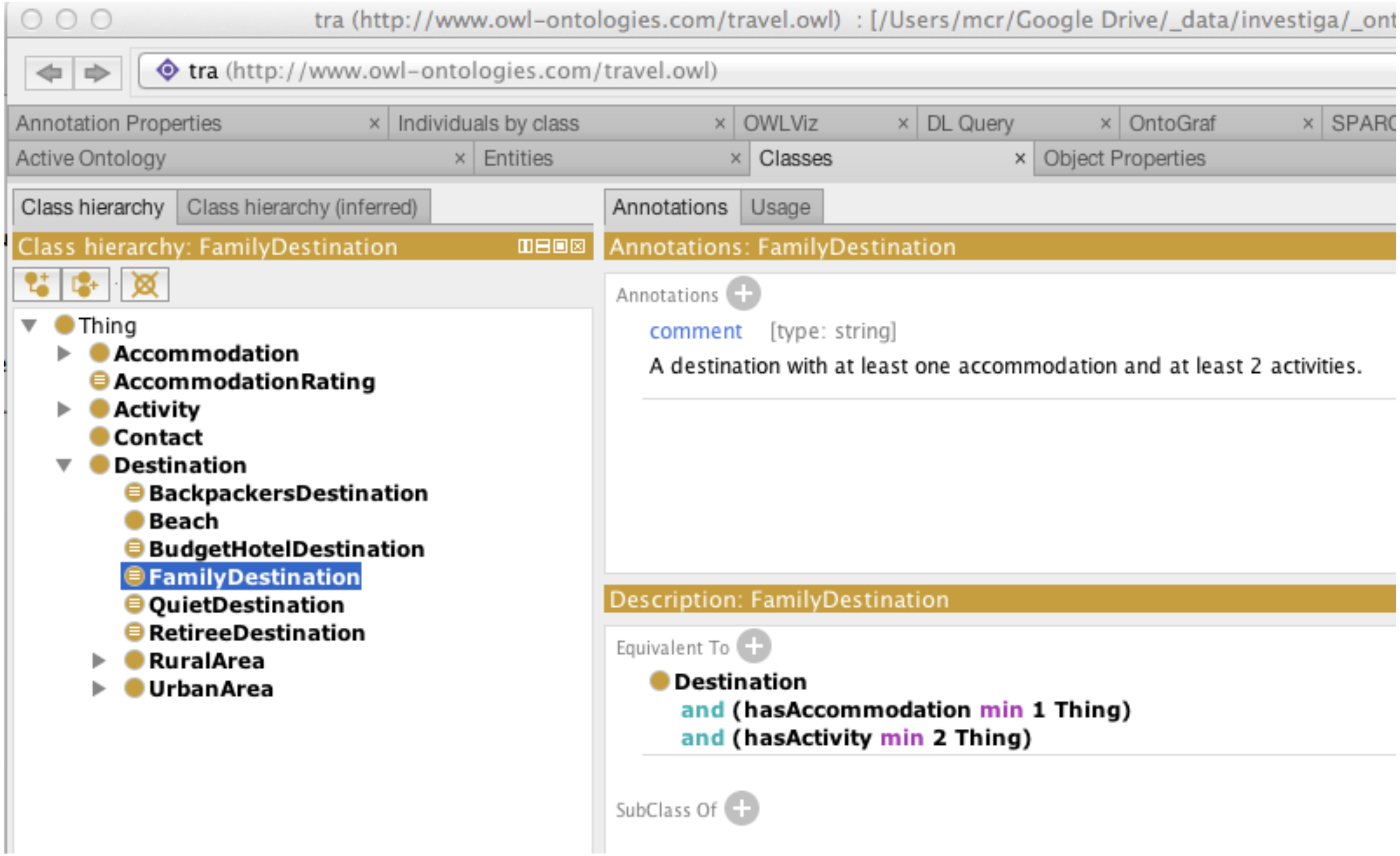
http://www.w3.org/TR/2014/NOTE-rdf11-primer-20140225/#fig4

RDF in XML

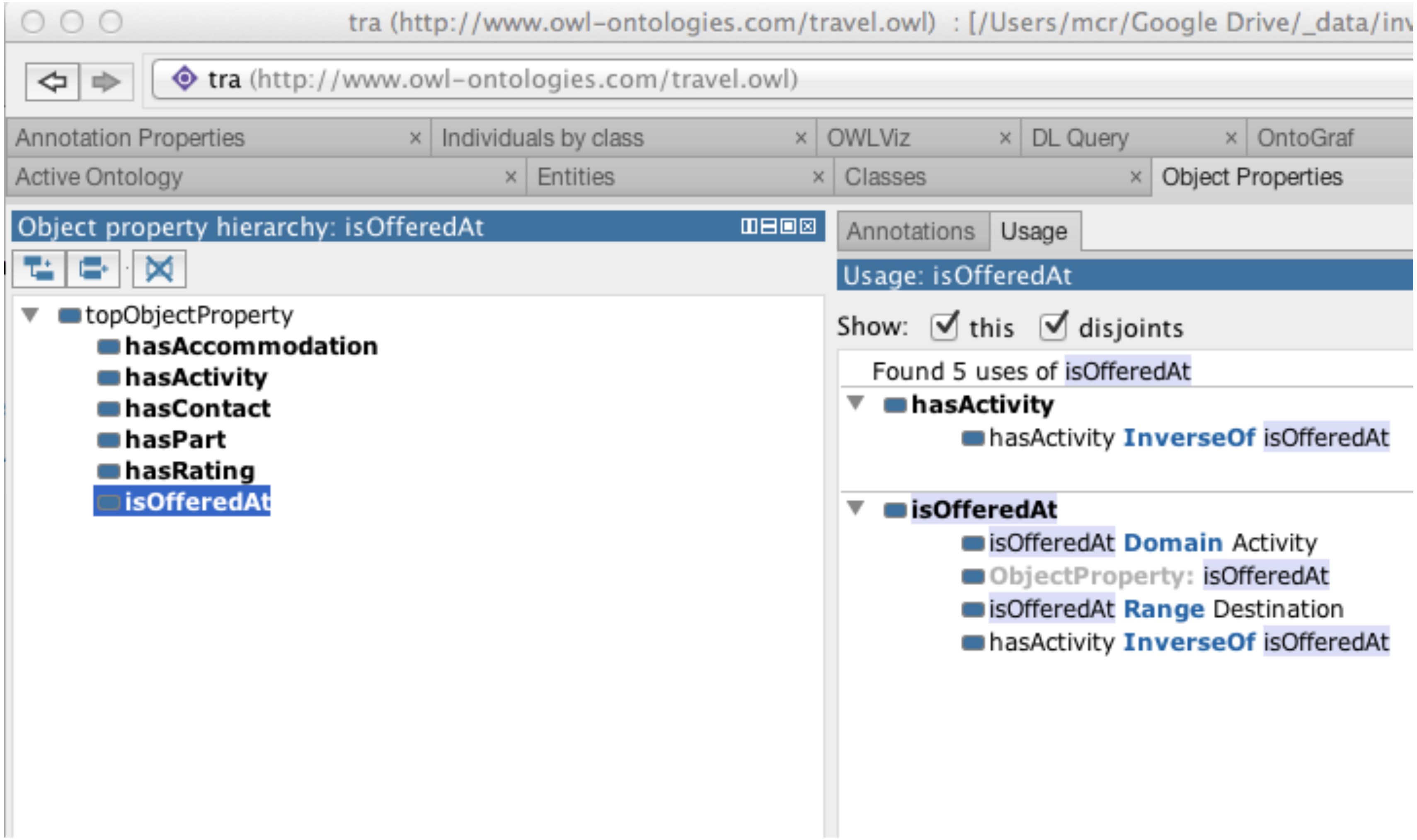



```
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF
         xmlns:dcterms="http://purl.org/dc/terms/"
         xmlns:foaf="http://xmlns.com/foaf/0.1/"
         xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:schema="http://schema.org/">
   <rdf:Description rdf:about="http://example.org/bob#me">
      <rdf:type rdf:resource="http://xmlns.com/foaf/0.1/Person"/>
      <schema:birthDate rdf:datatype="http://www.w3.org/2001/XMLSchema#date">1990-07-04   …
      <foaf:knows rdf:resource="http://example.org/alice#me"/>
      <foaf:topic_interest rdf:resource="http://www.wikidata.org/entity/Q12418"/>
   </rdf:Description>
   <rdf:Description rdf:about="http://www.wikidata.org/entity/Q12418">
      <dcterms:title>Mona Lisa</dcterms:title>
      <dcterms:creator rdf:resource="http://dbpedia.org/resource/Leonardo_da_Vinci"/>
   </rdf:Description>
…
```

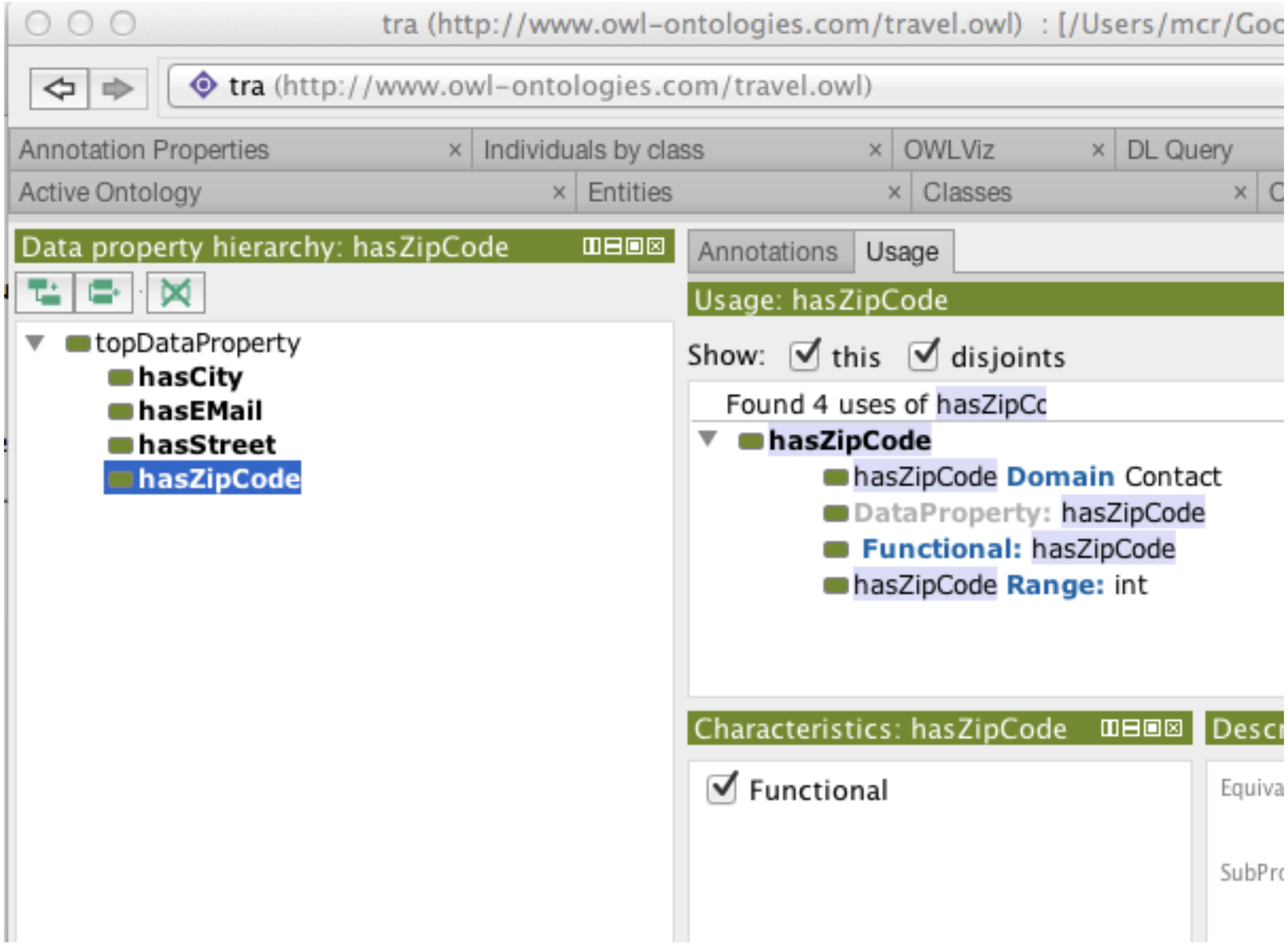
OWL: Classes


tra (http://www.owl-ontologies.com/travel.owl) : [/Users/mcr/Google Drive/_data/investiga/_ont
tra (http://www.owl-ontologies.com/travel.owl)
Annotation Properties
Individuals by class
OWLViz
DL Query
OntoGraf
Active Ontology
Entities
Classes
Object Properties
Class hierarchy
Class hierarchy (inferred)
Annotations
Usage
Class hierarchy: FamilyDestination
Annotations: FamilyDestination
Annotations
comment [type: string]
A destination with at least one accommodation and at least 2 activities.
Thing
Accommodation
AccommodationRating
Activity
Contact
Destination
BackpackersDestination
Beach
BudgetHotelDestination
FamilyDestination
QuietDestination
RetireeDestination
RuralArea
UrbanArea
Description: FamilyDestination
Equivalent To
Destination
and (hasAccommodation min 1 Thing)
and (hasActivity min 2 Thing)
SubClass Of

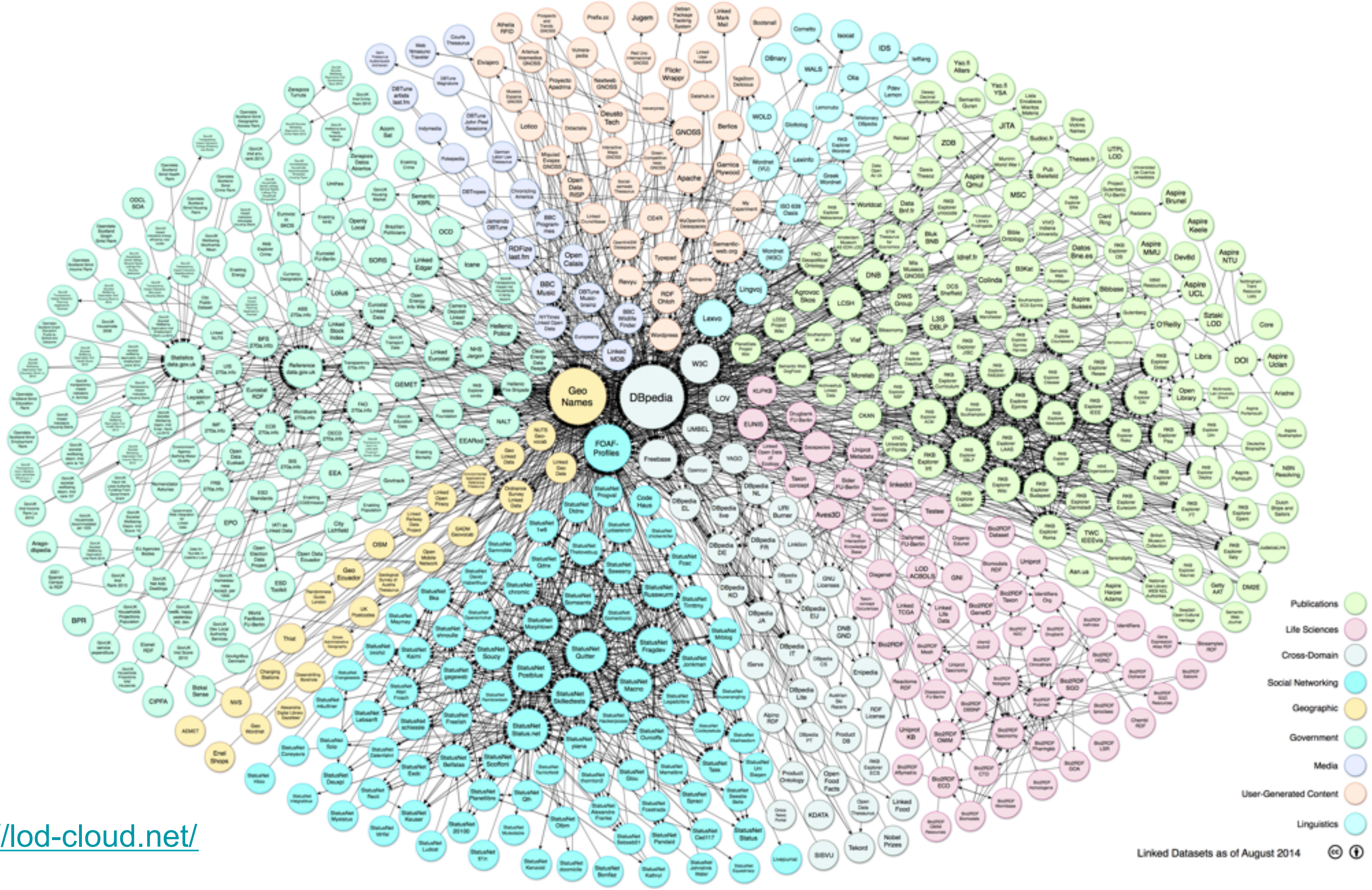
OWL: Object Properties



OWL: DataProperties

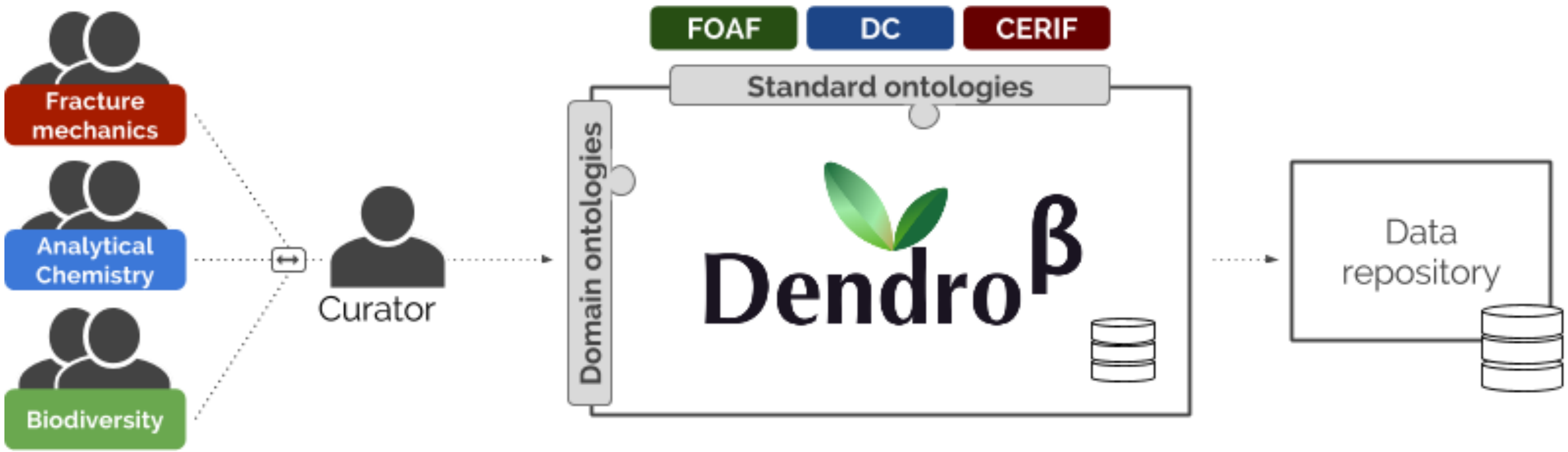


Linked Open Data



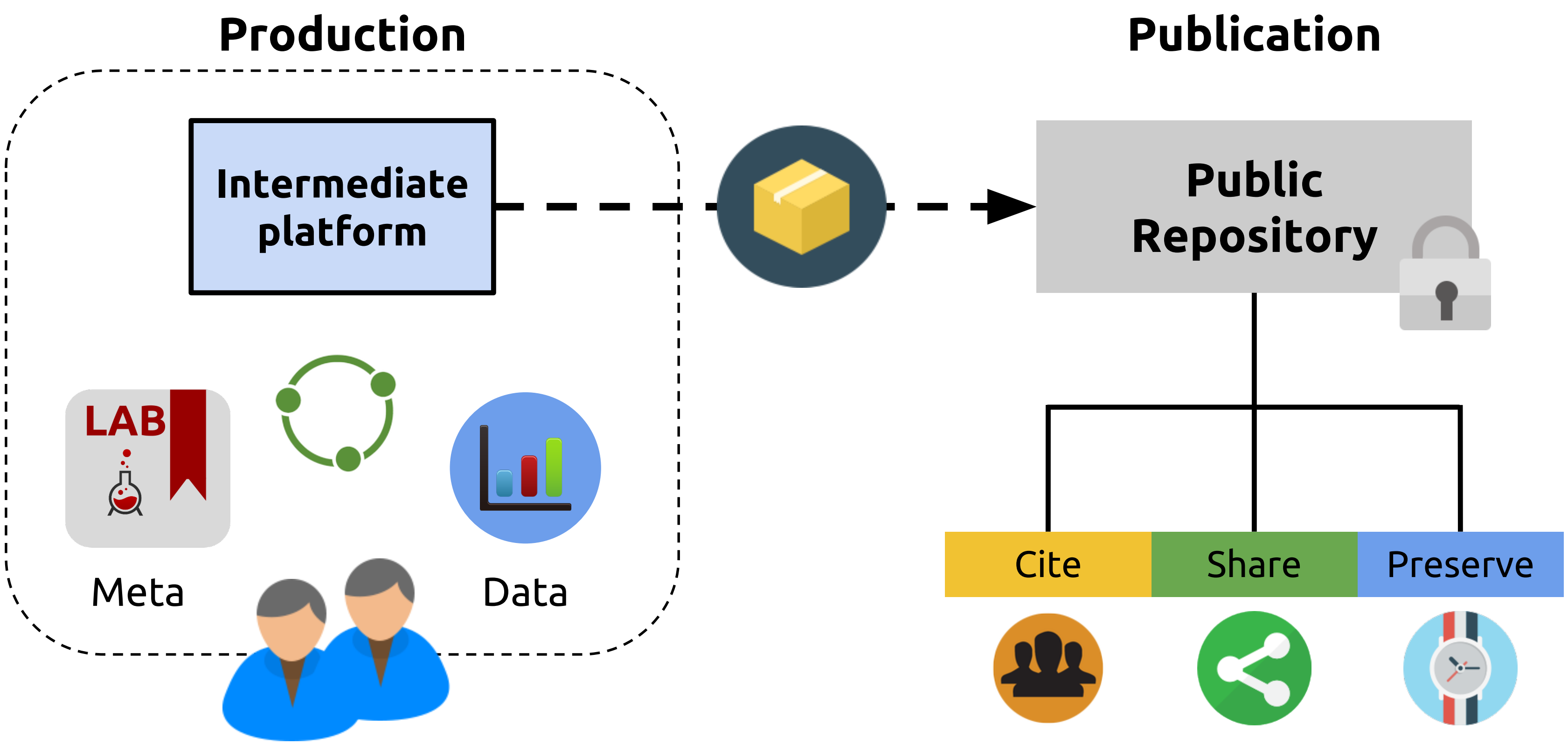
http://lod-cloud.net/

Application: Research Data Management

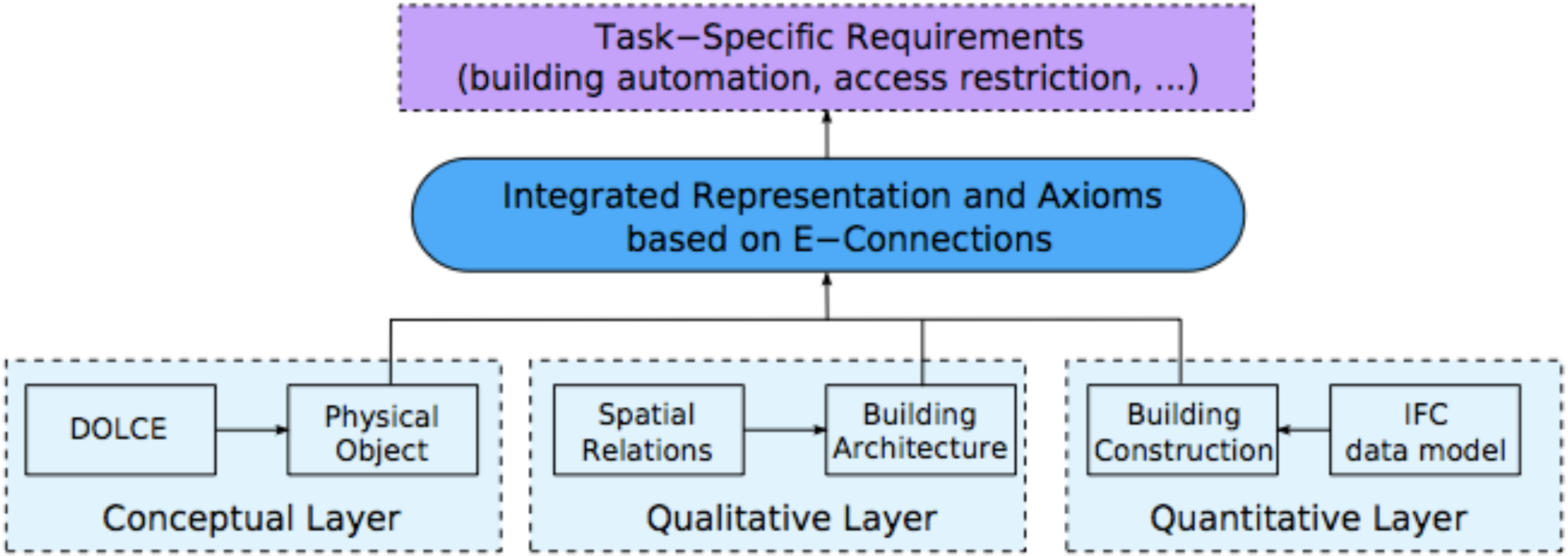


- Reuse existing knowledge: generic ontologies (ex: Dublin Core
- Add your own: specific ontologies to capture the domain

Repositories and preservation



Ontologies for Architecture



Source: J. Hois, M. Bhatt, O. Kutz. Modular Ontologies for Architectural Design. In Formal Ontologies Meet Industry, 2009

Open World vs Closed World Assumption

- Closed: if it is true, it is known
- Closed: if you cannot prove it, it is false

- Open: it may be true but not known
- Deal with incomplete knowledge

Unique name assumption: associated with CWA

Sources

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  - **Jeannette M. Wing. 2006. Computational thinking. Commun. ACM 49, 3 (March 2006), 33-35. DOI=http://dx.doi.org/10.1145/1118178.1118215**
- Knowledge Representation
  - **John F. Sowa*, Knowledge Representation: Logical, Philosophical, and Computational Foundations*, Brooks Cole Publishing Co., Pacific Grove, CA, 2000**
- Semantic Web
  - **http://www.w3.org/standards/semanticweb/**
- Linked Open Data
  - **http://linkeddata.org/**

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