



Modular Ontologies As A Bridge Between Human Conceptualization and Data

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Pascal Hitzler, Markus Krötzsch,
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Foundations of Semantic Web
Technologies

Chapman & Hall/CRC, 2010

**Choice Magazine Outstanding Academic
Title 2010 (one out of seven in Information
& Computer Science)**

<http://www.semantic-web-book.org>



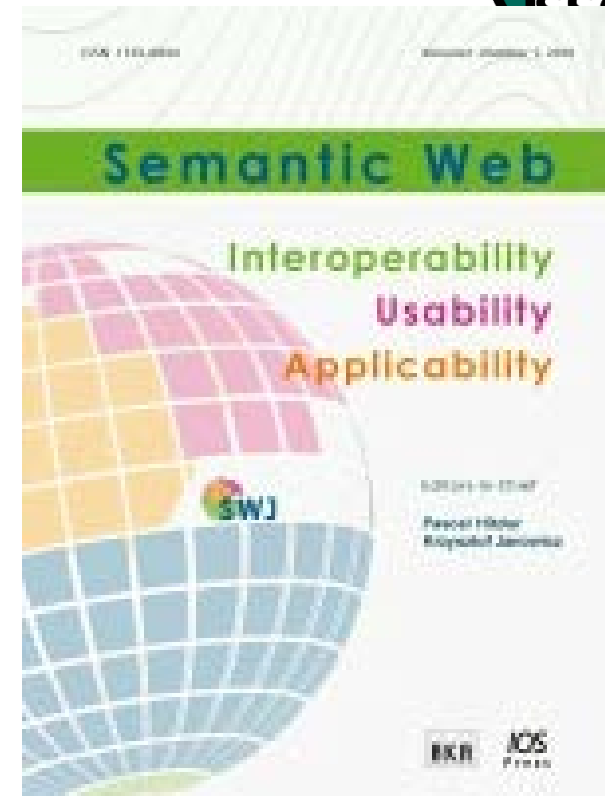


Pascal Hitzler, Markus Krötzsch, Bijan Parsia, Peter F. Patel-Schneider, Sebastian Rudolph

OWL 2 Web Ontology Language Primer (Second Edition)

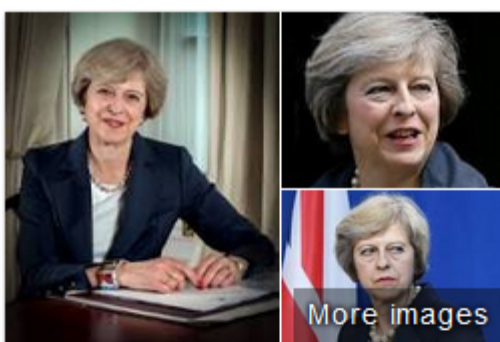
W3C Recommendation 11 December 2012.

- **EiCs:** Pascal Hitzler
Krzysztof Janowicz
- **Funded 2010**
- **2017 Impact factor of 2.889, top (with 1.3 distance) of all journals with “Web” in the title**
- **We very much welcome contributions at the “rim” of traditional Semantic Web research – e.g., work which is strongly inspired by a different field.**
- **Non-standard (open & transparent) review process.**



- **<http://www.semantic-web-journal.net/>**

A Brief Semantic Web History



More images

Theresa May



British Prime Minister



tmay.co.uk

Theresa Mary May is a British politician who has served as Prime Minister of the United Kingdom and Leader of the Conservative Party since July 2016, the second woman to hold both positions. [Wikipedia](#)

Born: October 1, 1956 (age 60), Eastbourne, United Kingdom

Height: 5' 8"

Party: Conservative Party

Spouse: Philip May (m. 1980)

Education: St Hugh's College, Oxford (1974–1977)

Previous offices: Home Secretary (2010–2016), [MORE](#) ▾

Profiles



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See photos

St Hugh's College, Oxford

College in Oxford, England

Website

Directions

St Hugh's College is one of the constituent colleges of the University of Oxford. It is located on a 14.5-acre site on St Margaret's Road, to the north of the city centre. [Wikipedia](#)

Address: St Margaret's Rd, Oxford OX2 6LE, UK

Principal: Elish Angiolini

Phone: +44 1865 274900

Founder: Elizabeth Wordsworth

Founded: 1886

Named for: Hugh of Lincoln

Undergraduates: 432 (2011–2012)

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4.1/5 [University Rooms](#) · 2,310 votes

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Notable alumni

[View 40+](#)



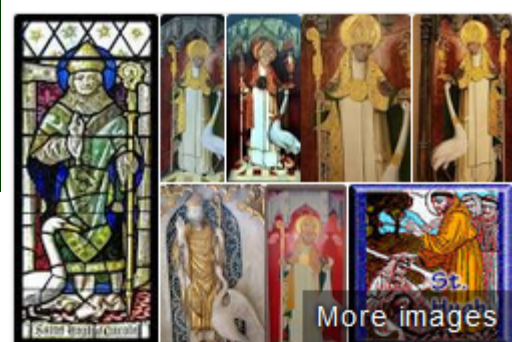
Theresa May



Aung San Suu Kyi



Barbara Castle



More images

Hugh of Lincoln



Saint

Hugh of Lincoln, also known as Hugh of Avalon, was a French noble, Benedictine and Carthusian monk, bishop of Lincoln in the Kingdom of England, and Catholic saint. [Wikipedia](#)

Born: 1140, Avalon, France

Died: November 16, 1200, London, United Kingdom

Feast: 16 November (R.C.C.); 17 November (Anglican)

Major shrine: Lincoln Cathedral

Attributes: a white swan

Patronage: sick children, sick people, shoemakers and swans

People also search for



Little Saint Hugh of Lincoln



Thomas More



William Howard, 1st Visco...

ab



Schema.org



- Collaboratively launched in 2011 by Google, Microsoft, Yahoo, Yandex.
2011: 297 classes, 187 relations
2015: 638 classes, 965 relations
- Simple schema, request to web site providers to annotate their content with schema.org markup. Promise: They will make better searches based on this.
- 2015: 31.3% of Web pages have schema.org markup, on average 26 assertions per page.

Ramanathan V. Guha, Dan Brickley, Steve Macbeth:
Schema.org: Evolution of Structured Data on the
Web. ACM Queue 13(9): 10 (2015)

- TrainTrip
- Organization
 - Airline
 - Corporation
 - EducationalOrganization
 - CollegeOrUniversity
 - ElementarySchool
 - HighSchool
 - MiddleSchool
 - Preschool
 - School
 - GovernmentOrganization
 - LocalBusiness
 - AnimalShelter
 - AutomotiveBusiness
 - AutoBodyShop
 - AutoDealer
 - AutoPartsStore
 - AutoRental
 - AutoRepair
 - AutoWash
 - GasStation
 - MotorcycleDealer
 - MotorcycleRepair
 - ChildCare
 - Dentist
 - DryCleaningOrLaundry
 - EmergencyService
 - FireStation
 - Hospital
 - PoliceStation
 - EmploymentAgency
 - EntertainmentBusiness
 - AdultEntertainment
 - AmusementPark
 - ArtGallery
 - Casino
 - ComedyClub
 - MovieTheater
 - NightClub
 - FinancialService
 - AccountingService
 - AutomatedTeller
 - BankOrCreditUnion
 - InsuranceAgency
 - FoodEstablishment
 - Bakery
 - BarOrPub
 - Brewery
 - CafeOrCoffeeShop
 - FastFoodRestaurant



- **First conceptual ideas since WWW inception and throughout the 90s.**
- **Ontologies as big hype early 2000s.**
- **Linked data (using RDF(S)) with focus on data and links starting ca. 2007.**
- **Ca. 2015, Google Knowledge Graph hype starts: Same essential structure as linked data (just without links), and (strangely) still controversial role of schema/ontology.**



- **Ontologies often conceived as either one of**
 - **Taxonomic trees on steroids**
 - **Types with a type logic**
 - **Knowledge bases (logic-based)**
 - **Whatever you do in OWL (W3C Standard 2004/2012: Web Ontology Language)**

- **An ontology is a shared conceptualization of a domain of interest.**

However, this is rather vague.

It is helpful to adhere to widely used standards when encoding them for digital use.

Helpful delineations, in the mindset of the dominating standard, the Web Ontology Language OWL:



- Distinguish ontologies from data.
 - Ontology: general terms (classes) and their complex relationships.
 - Data: Concerning individuals such as “Theresa May” or “St. Hugh’s College” and their properties.
- Restrict ontologies to unary and binary predicates and their relationships, expressed using formal logical axioms. (For OWL: Description Logics).

But what an “ontology” is (and what is not), is in a sense still a moving target.

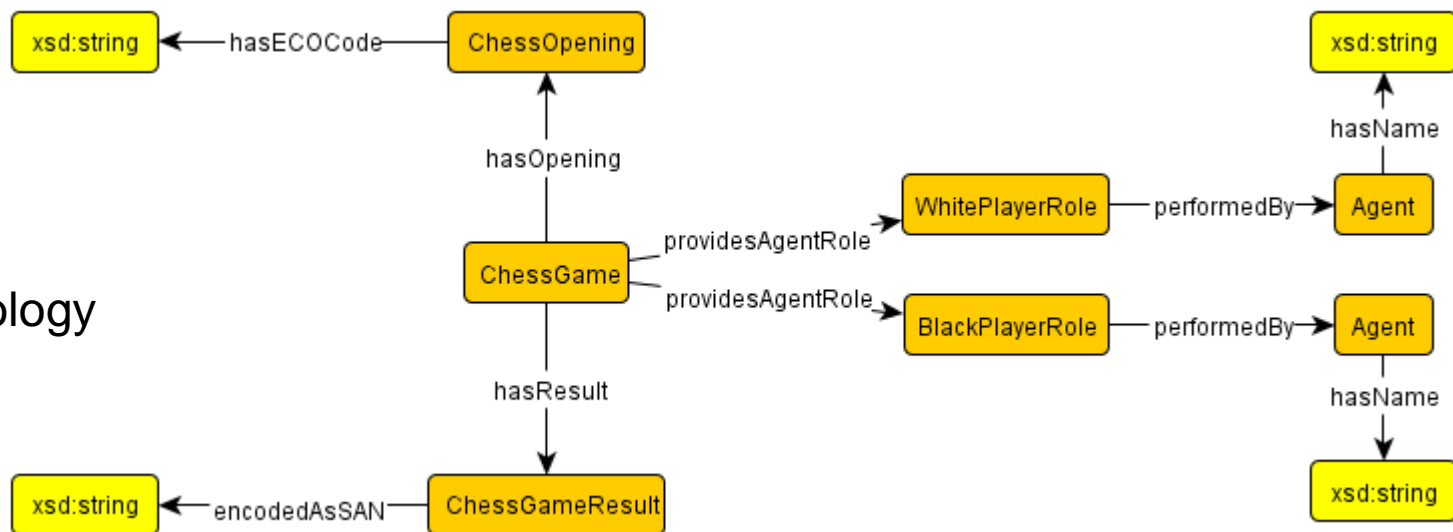
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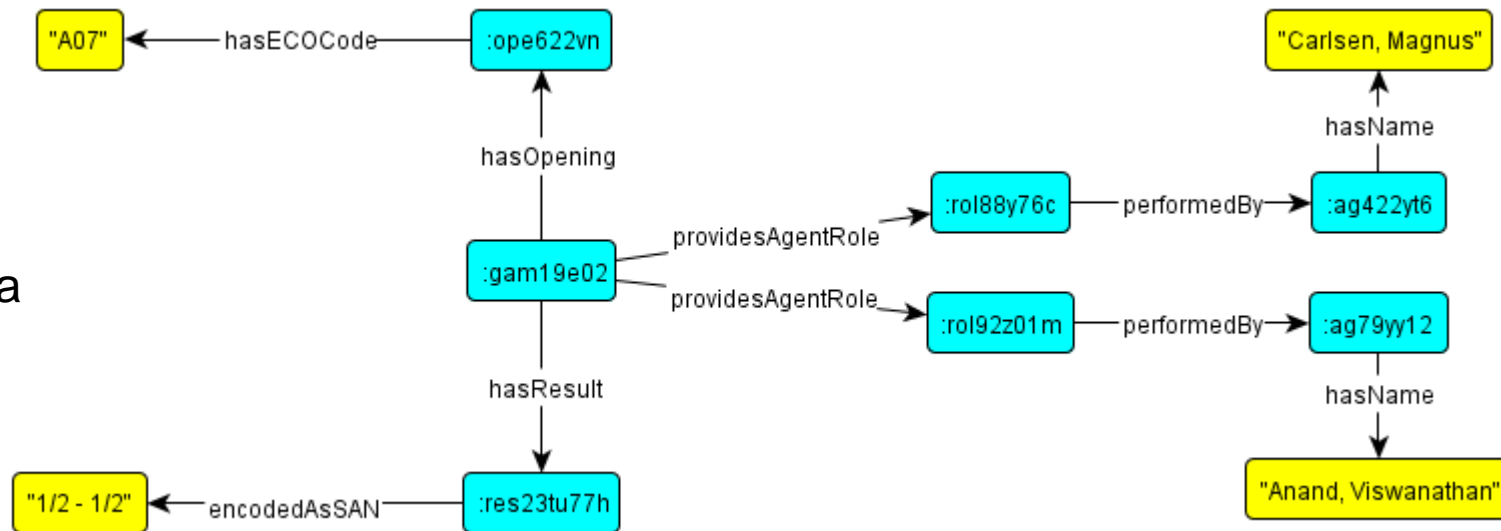
Data graph (with schema)



Ontology



Data





W3C Standard RDF (Resource Description Framework)

- A native standard for labelled, typed, directed, graphs.
- Identifiers are URIs, i.e. Web-compatible.
- Standardized serializations in
 - XML
 - Turtle (text-based, human readable “triple” format)
- Vocabulary for
 - expressing graphs
 - expressing types of entities
 - expressing very simple schema information

Number of Datasets

2017-01-26	1,146
2014-08-30	570
2011-09-19	295
2010-09-22	203
2009-07-14	95
2008-09-18	45
2007-10-08	25
2007-05-01	12

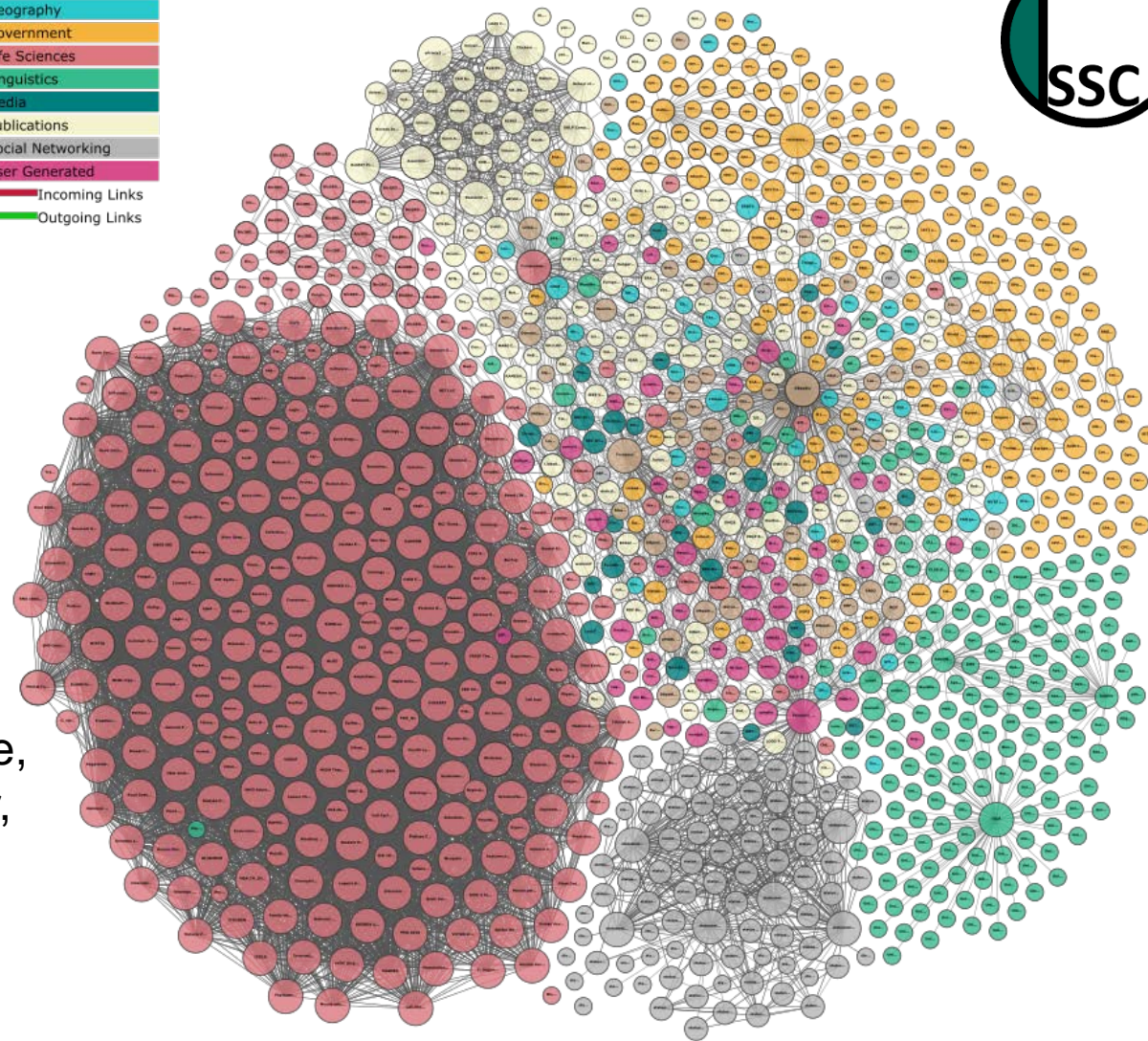


38.606.408.854 triples and counting!



LOD Laundromat

Some Linked Datasets 2017

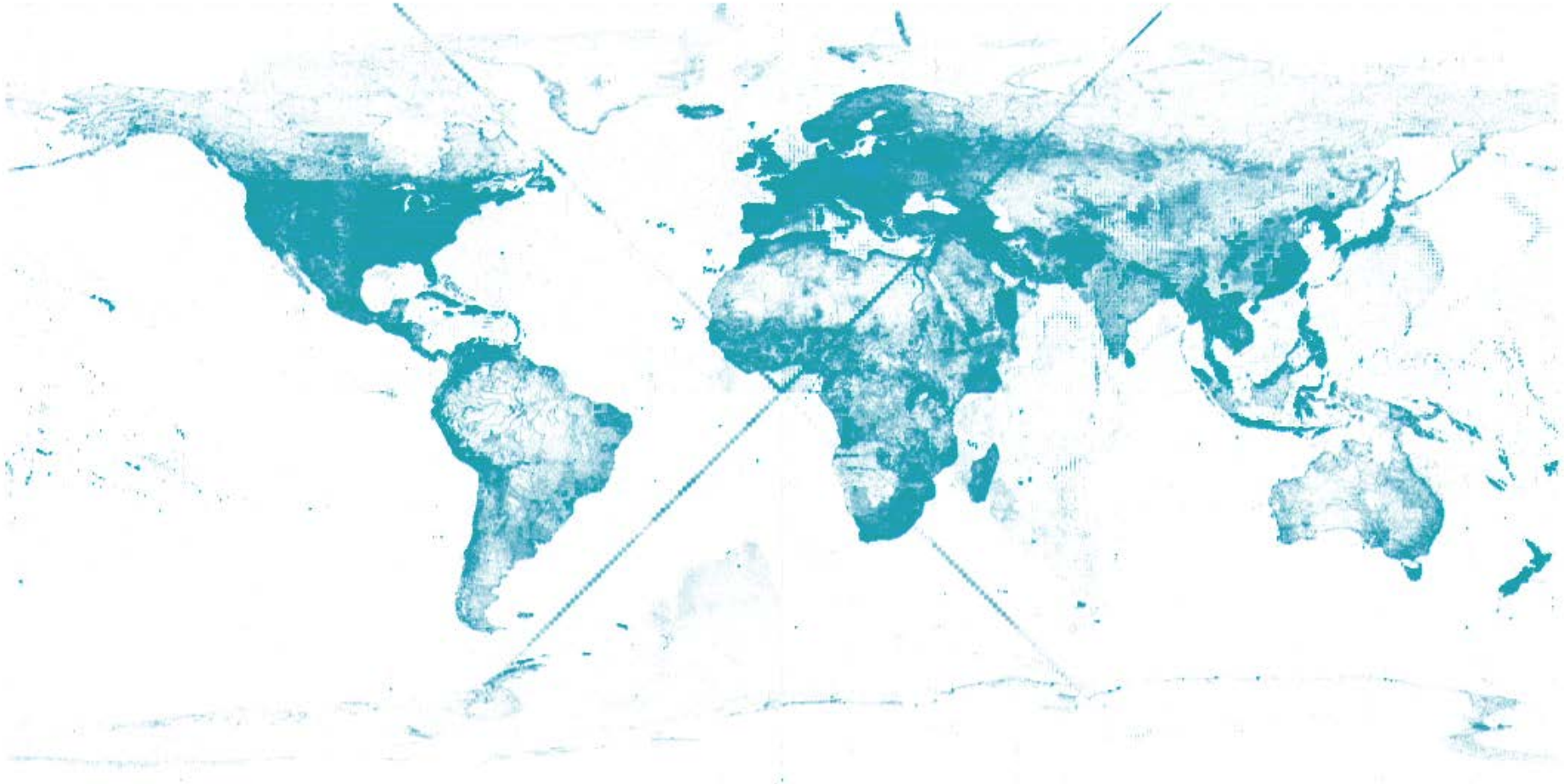


Linking Open Data cloud diagram 2017, by Andrejs Abele, John P. McCrae, Paul Buitelaar, Anja Jentzsch and Richard Cyganiak. <http://lod-cloud.net/>

Linked Data: Volume

Geoindexed Linked Data – courtesy of Krzysztof Janowicz, 2012

http://stko.geog.ucsb.edu/location_linked_data





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- Ca. 2015, Google Knowledge Graph hype starts: Same essential structure as linked data (just without links), and (strangely) still controversial role of schema/ontology.



- **Ad hoc graph organization, based on the believe that good things emerge if everybody simply publishes their data as is, means little shared principles.**
- **Unrestrained reuse of terms from other linked datasets dilutes meaning and introduces ambiguities.**
- **Very little consideration of schema (ontologies) led to data organization fit for single purpose only.**
- **No clear proof of added value of links.**

[There are many more – this is a very subjective selection.]



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- **Ca. 2015, Google Knowledge Graph hype starts: Same essential structure as linked data (just without links), and a new discussion on the role of schema/ontology.**

Knowledge Graph

RDF Graph

Labelled Directed Graph

Abox

Facts

Schema

Ontology / OWL

Type Logic

Tbox

Logical Theory



Ontology Modeling for Reuse



- **Anticipated ontology reuse, including extension of the schema. (As opposed, e.g., to “expert system” type of use cases driven by description logic reasoning.)**
- **Serves as data (knowledge graph) organization schema: Use competency questions and SPARQL queries based on them to check on adequacy of schema.**
- **Appeals to human conceptualization: Derive structure of ontology from key human domain concepts, and cast them into “modules”.**
- **Use modules as conceptual and technical units. Divide and conquer, relative independence makes understanding, modification, reuse easier.**
- **Borrow modules, snippets, patterns from everywhere, but model in your own namespace; keep mappings separate.**
- **Medium ontological commitments: incorporate different perspectives, use sound principles established by previous modelers.**
- **Strong logical axiomatization with purpose of disambiguating. Automated reasoning takes a less important role (but can be done over data + schema).**
- **Provide customized, simplified “views” facing data providers or data reusers, if needed.**



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**Enslaved: People of the Historic Slave Trade.
Matrix / Michigan State University,
funded by The Andrew W. Mellon Foundation**



Integrated data from many sources regarding the history of the slave trade.

<http://enslaved.org>

Data integration using a knowledge graph based on an extendable, reuseable ontology as underlying schema.

(DaSe Lab assists with the ontology design.)



Competency Questions

- Who were the relatives of Jack George, a slave who lived in New Orleans between the years 1811 and 1820.
- Who were the slaves of Thomas Jefferson at Monticello?
- What were the ethnic groups of slaves shipped from the port of Cabinda from 1751-1800?
- I am researching a slave named Mohammed who was a new arrival from West Africa in Charleston in 1776. Is there data about what slave ship he might have been on?





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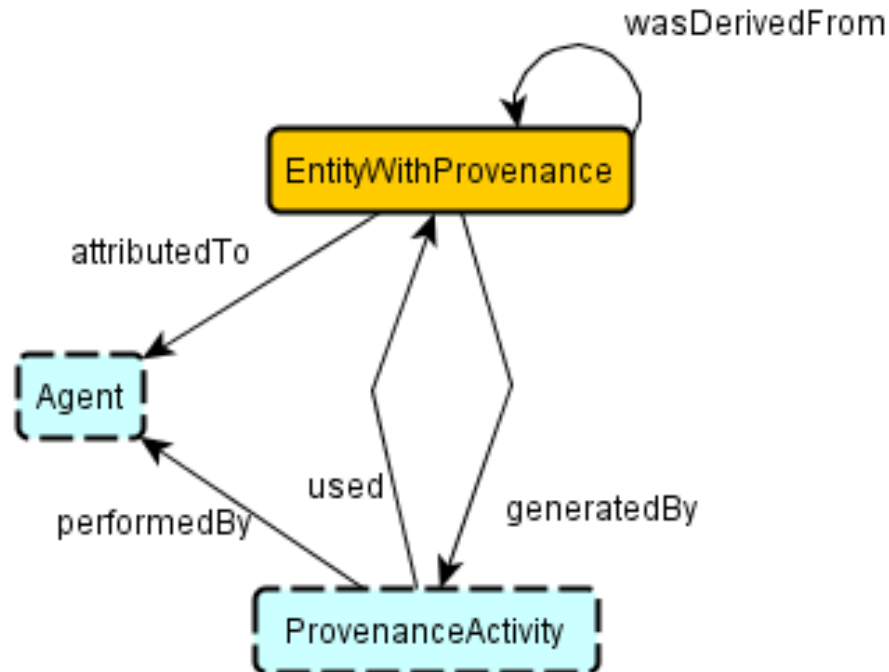
- **Persons**
- **Historic events**
- **Places**

- **Records about persons**
- **Time**
- **Provenance**

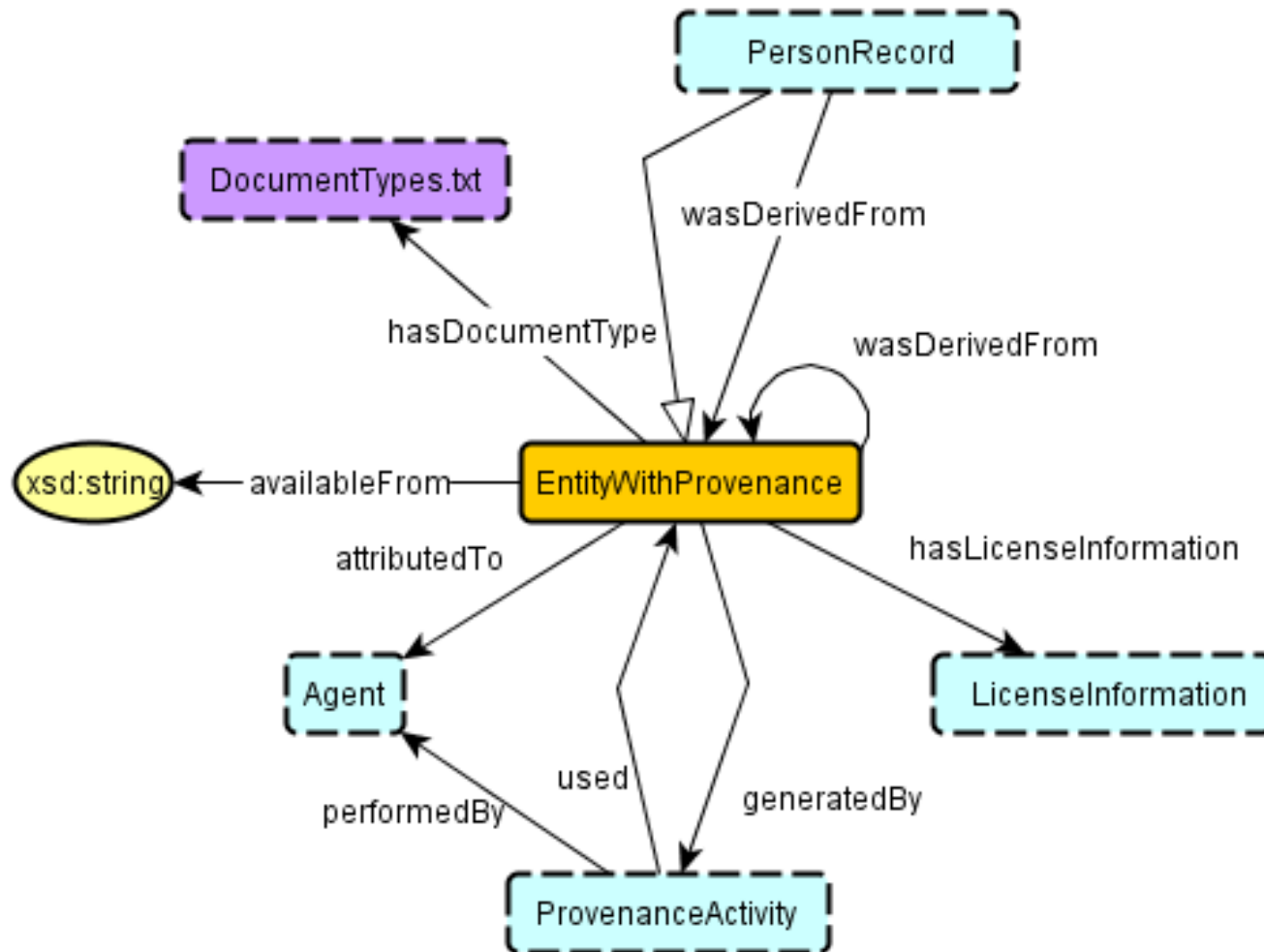
Each of these becomes a “module.”



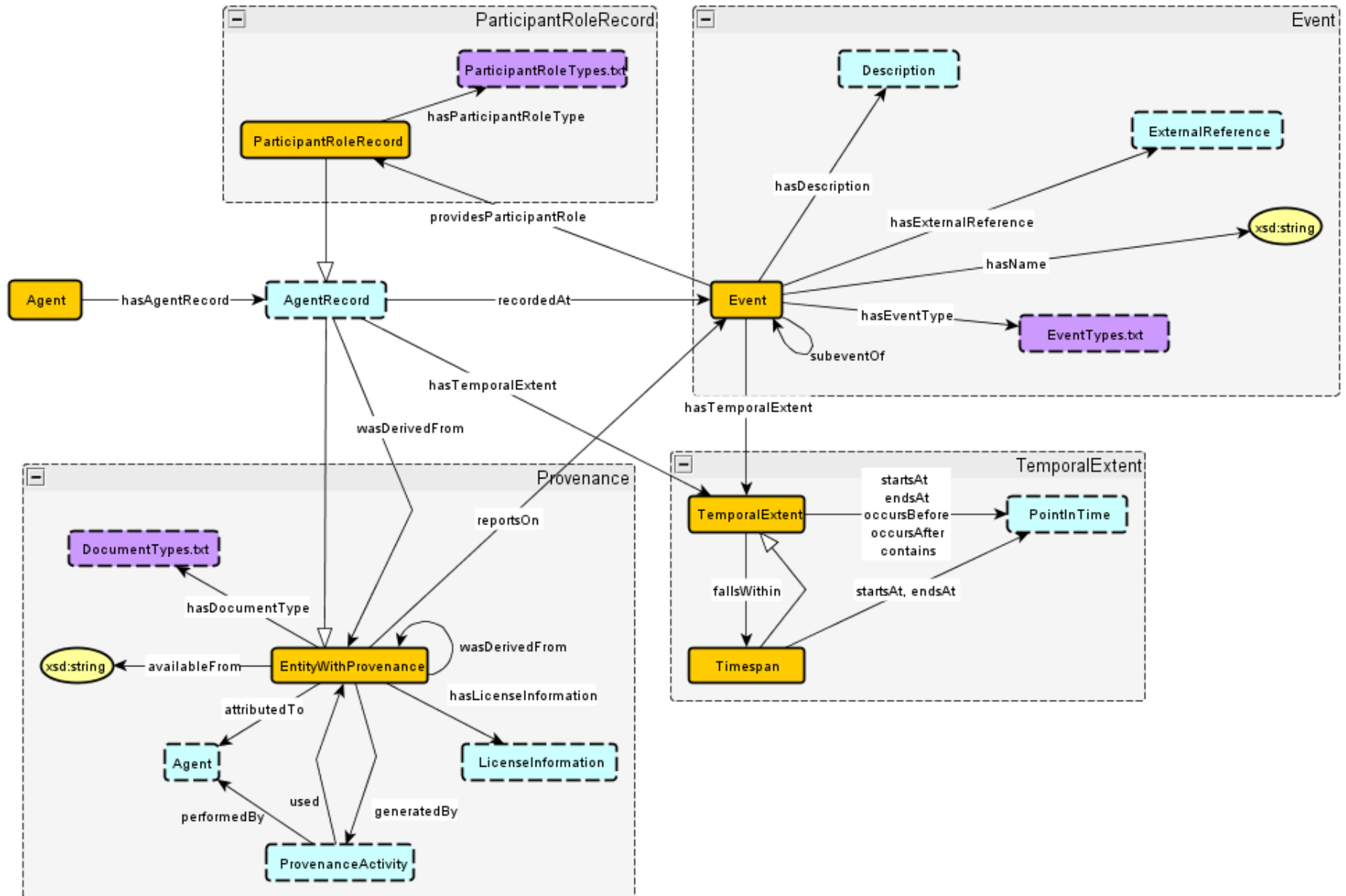
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Borrowed from PROV-O

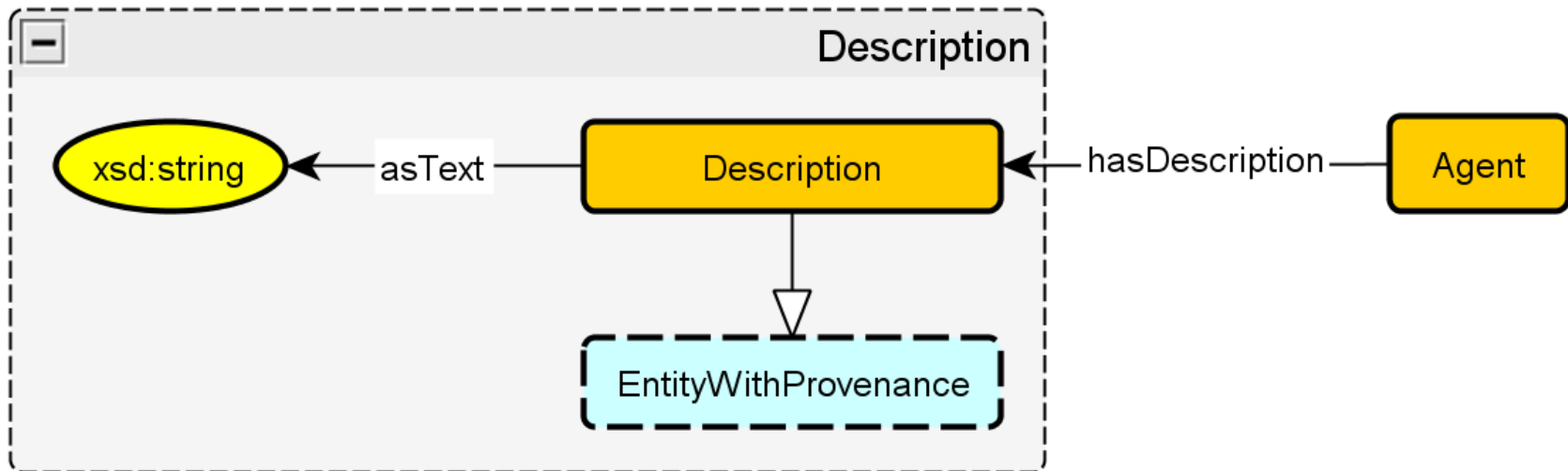


ParticipantRoleRecord





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We call this a “stub.”



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- An agent record is always directly derived from a most one entity with provenance.

$\text{AgentRecord} \sqsubseteq \leq 1 \text{wasDerivedFrom} . \text{EntityWithProvenance}$

- Every agent record is record of exactly one agent.

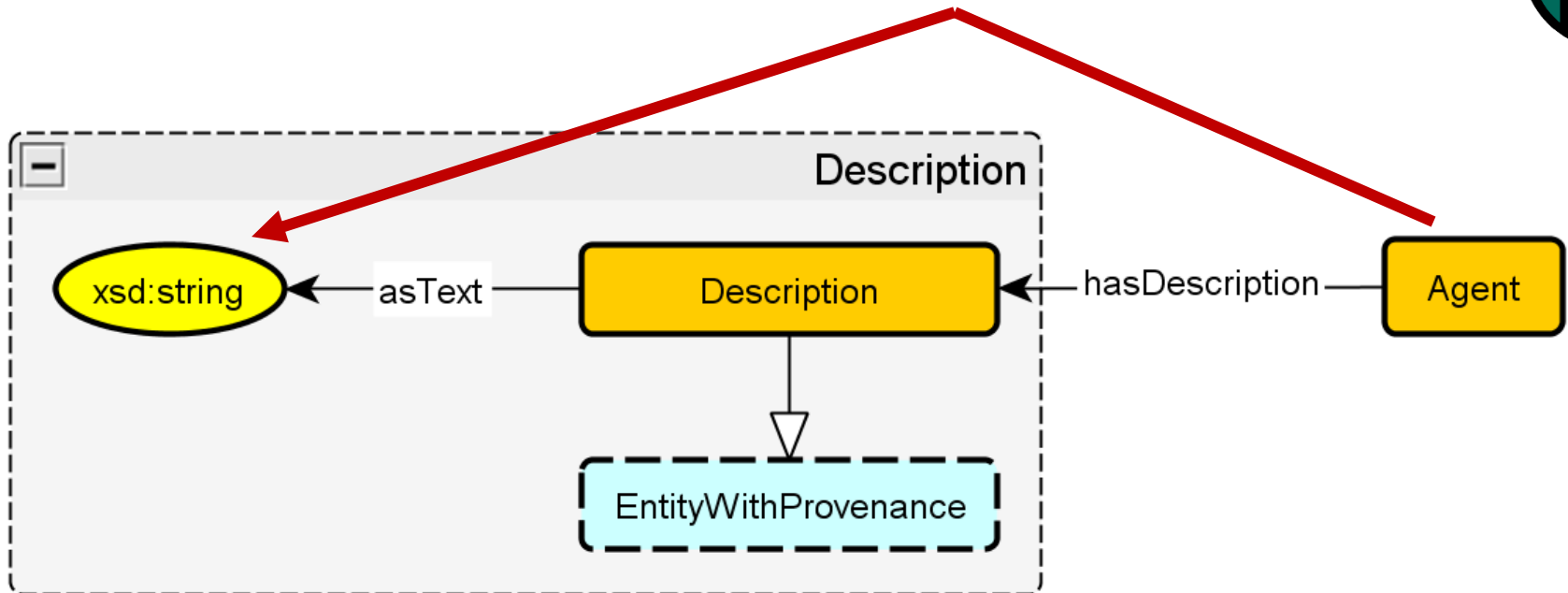
$\text{AgentRecord} \sqsubseteq = 1 \text{hasAgentRecord}^- . \text{Agent}$

Many potential axioms can be explored systematically (we cast this into a software tool).

Axiomatization disambiguates the ontology for use and reuse.



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We may only provide (or ask for) the string, if provenance information is irrelevant for the user.

**Some of our current research efforts regarding
modular ontology modeling**

(Some) ongoing efforts



- **Writing up and refining our methodology (Edited book on Ontology Engineering with Ontology Design Patterns: Foundations and Applications, 2016)**
- **OWL-based representation of modules, WOP 2017 (OPLa – Ontology Pattern Language)**
- **Expressive axiomatization plug-in for Protégé – visual interface for handling most of the frequently recurring axioms, ISWC 2016 and ESWC 2017 (OWLAx)**
- **User-friendly syntaxes for ontology axioms (ESWC 2017)**
- **Generation and use of schema diagrams for modeling with experts (forthcoming)**
- **Integrated tool suite, within Protégé, supporting modular ontology modeling (in progress)**

- **Michigan State Enslaved Project: Alicia Sheill, Seila Gonzalez, Catherine Foley, Dean Rehberger, Ethan Watrall, Walter Hawthorne, Duncan Tarr, Ryan Carty. OCLC: Jeff Mixer**
- **DaSeLab: Cogan Shimizu, Quinn Hirt, Michelle Cheatham. Now at Universitas Indonesia: Adila Krisnadhi**



Thanks!



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