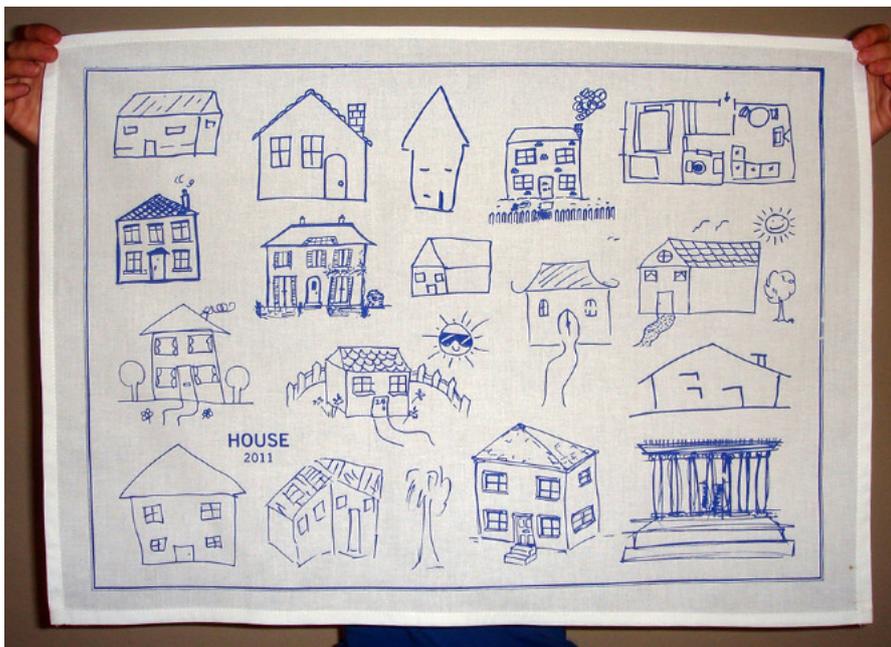


# 1 Introduction

## 1.1 Why this Course?

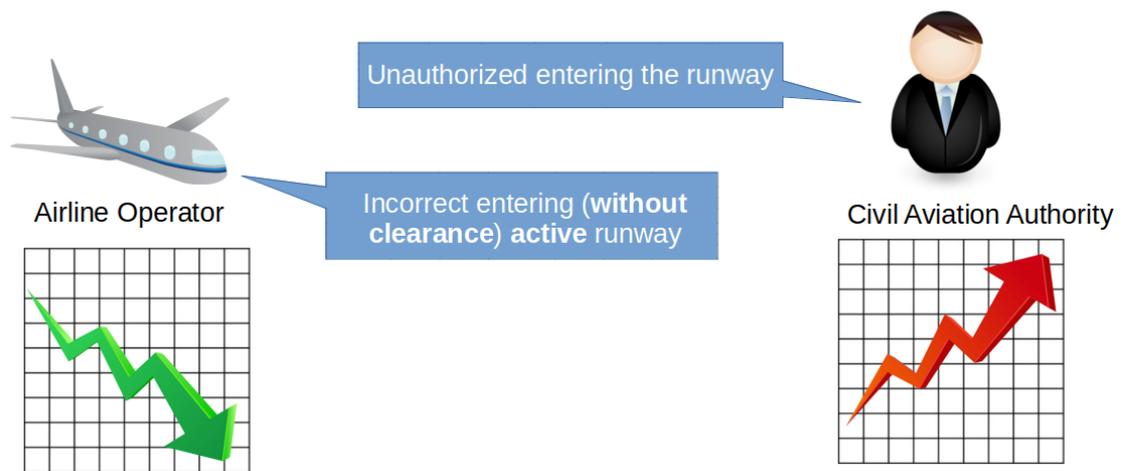
What is a house ?



Why to care ?

*What is the trend of **Runway Incursion** incidents at an airline operator ?*

## 1 Introduction



**Why to care ?**

# DID YOU KNOW



Awaken the mind.

Just months before 9/11, the World Trade Center's lease was privatized and sold to Larry Silverstein.

Silverstein took out an insurance plan that 'fortuitously' covered terrorism.

After 9/11, Silverstein took the insurance company to court, claiming he should be paid double because there were 2 attacks.

Silverstein won, and was awarded \$4,550,000,000.

What is an event ? How many events occurred at 9/11 – One or Two ?

## Knowledge Management

9/11 ... matter of billions of USD

source:<https://www.metabunk.org/larry-silversteins-9-11-insurance.t2375>

## 1 Introduction

### About Knowledge

Knowledge is all around. But what is the difference among different types of knowledge ? How about their *machine reusability (R)*/*interpretability (I)*/*expressive power (E)*?

Book	R—	I+++	E+++
Java program	R	I—	E—
R/Matlab Script	R	I—	E-
Relational Database	R+	I	E
Prolog Program	R++	I	E+
<b>Ontology</b>	<b>R+++</b>	<b>I++</b>	<b>E++</b>

### About ontologies

#### Ontologies

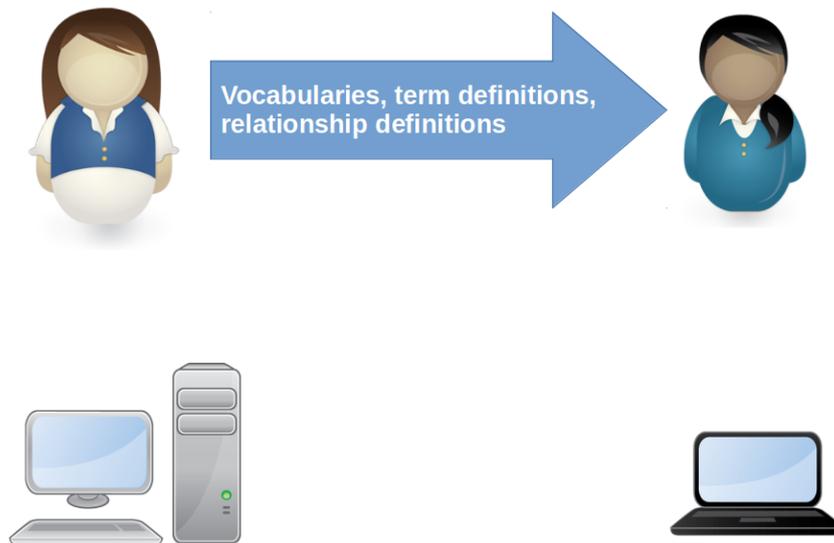
are **formal specifications of conceptualization.**

Ontologies help to stabilize the knowledge, to share meaning both among computers and among people. Use-cases include

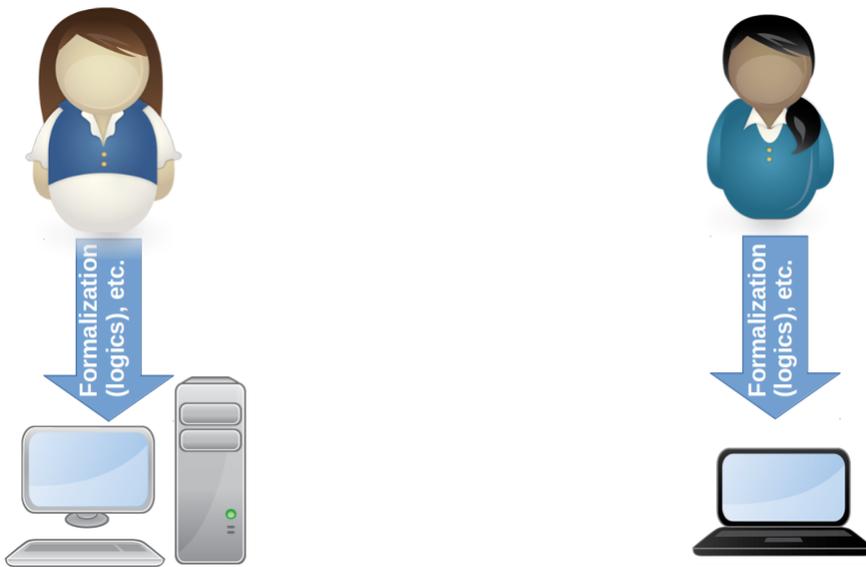
- Data Integration
- Semantic Web
- Open (Linked) Data

## 1.2 Overview of Ontologies

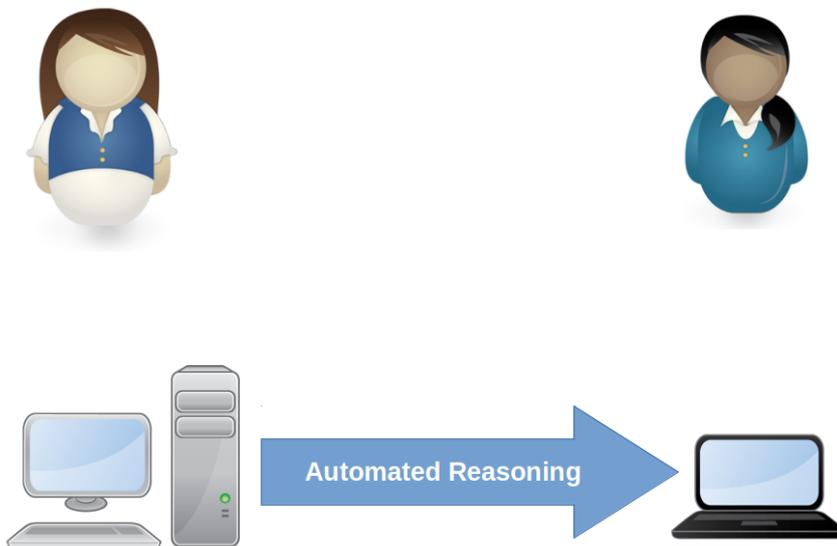
First, People Need to Understand Each Other



**Second, People Need to Explain Things to Computers**



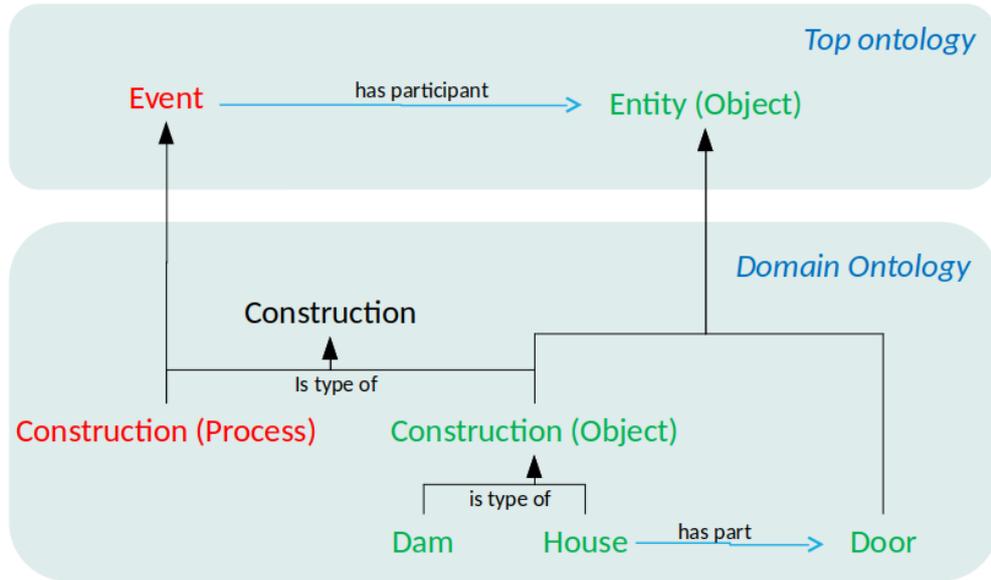
**Third, Computers Can Understand One Another**



**Solution = Ontology**

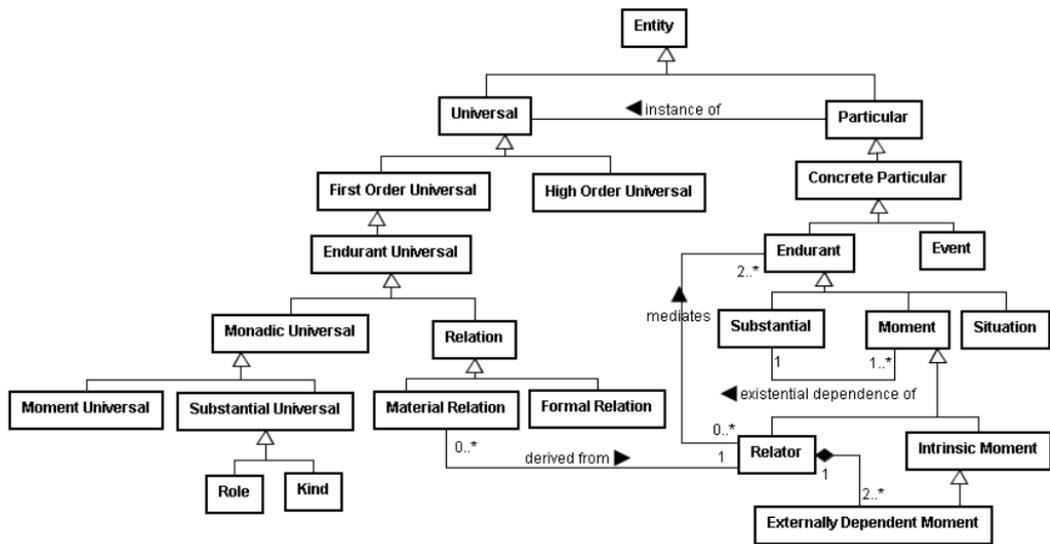
*Explicit Conceptualization of Shared Meaning*

# 1 Introduction



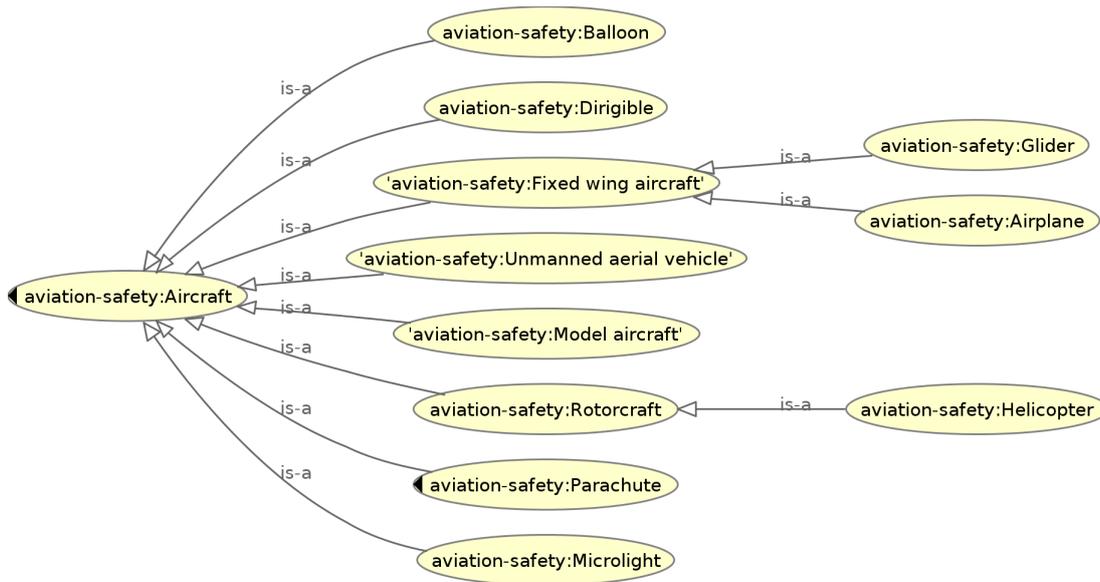
## Example Top-Level Ontology

*Small part of Unified Foundational Ontology (UFO)*



## Example Ontology Hierarchy

*Each helicopter is also an aircraft.*



### Ontologies $\neq$ Taxonomies

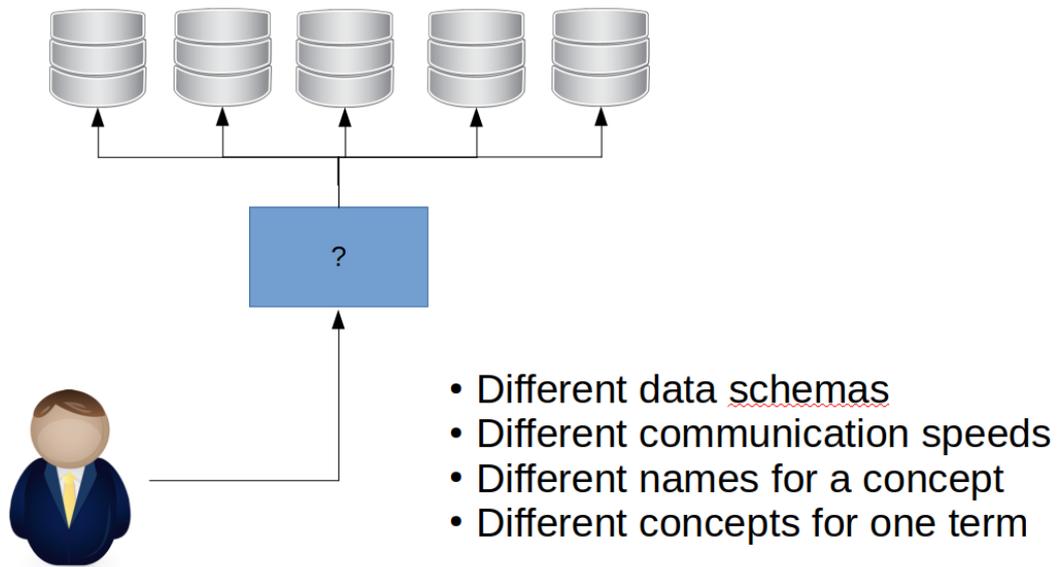
Taxonomies = just a single type of relationship.

- Construction** → broad meaning (object, construction site, process)
- Dam**
- House** → broad meaning (dwelling, construction)
- Door** → specific meaning (not type of house, but its part)

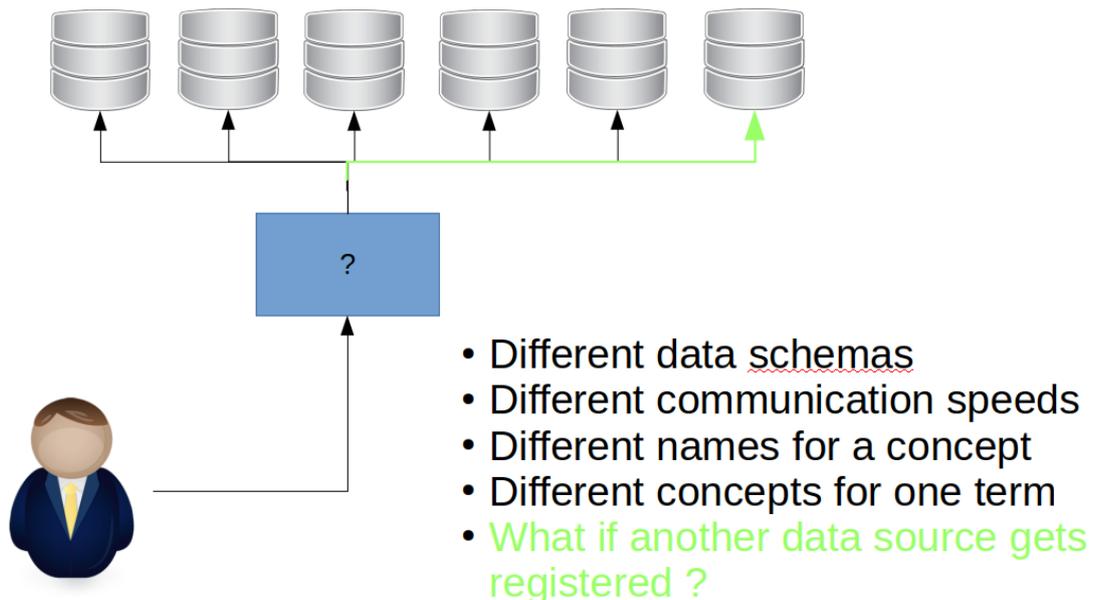
## 1.3 Data Integration

### Data Integration Scenario

## 1 Introduction



### Data Integration Scenario



### Ontologies for Data Integration

*Ontologies help to share data meaning.*

**Modeling and Inference** for different data schemas, different data quality

**OWL sameAs** for different naming of the same thing

**IRI identification** for different namings of the same thing

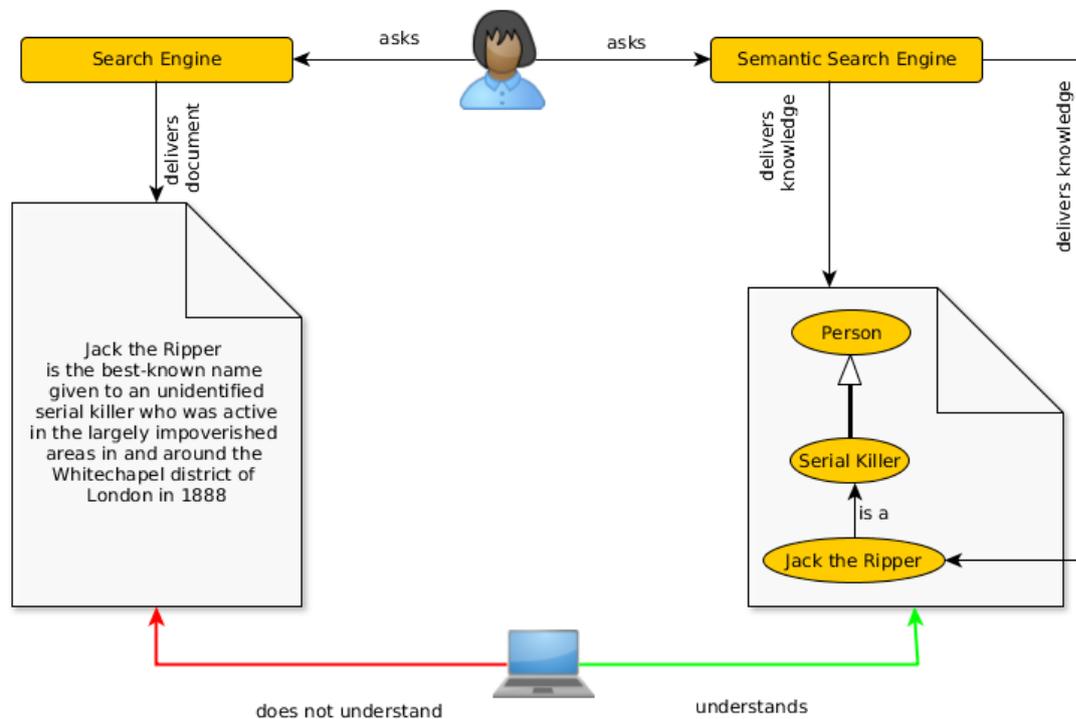
**Open World Assumption** to react on new data source emergence

## 1.4 Semantic Web

### Current Web vs. Semantic Web

- SoA – semistructured HTML or XML data. There is vast amount of search engines like Google, Yahoo, MSN, etc. Many of them are invaluable, but as the engines use just keywords and/or some natural language preprocessing methods, the search results contain lots of irrelevant results that need to be processed manually.
- How to make web search more efficient ?
  - more expressive power for web designers to capture complexities – SW languages (RDF(S), OWL),
  - more efficient search engines to handle SW languages – new inference techniques for these languages,
  - better search engines interfaces – more expressive query languages
- **the amount of (unstructured) data is steadily growing**

### Semantic search



## Ontologies and Semantic Web

**ontology** has many definitions, but let's consider it a **formal representation of a complex domain knowledge that is shared with others to ensure intelligent system interoperability,**

**semantic web** is *an extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation.* (cit. Semantic Web. Tim Berners-Lee, James Hendler and Ora Lassila, Scientific American, 2001)

## Idea of Semantic Web

- W3C web page - <http://www.w3.org/2001/sw>
- The data format will be either RDF(S) or OWL,
- Reasoners for RDF(S) can be used for partial derivation in OWL,
- Reasoners for OWL can be used for derivation in RDF(S)

## Unique Data Identification – URIs

Semantic web speaks about resources.

URI is a unique identifier for addressing web resources in the form

```
<scheme name> : <hier. part> [ ? <query> ] [ # <fragment> ]
```

. HTTP scheme is used typically.

URN a URI with *scheme name* equal to 'urn'; used e.g. in SWRL atom identification,

URL a URI that can be resolved to a content using the protocol (e.g. HTTP),

IRI generalization of URIs allowing non-ascii characters. IRI is the standard identifier for OWL.

## Open World Assumption

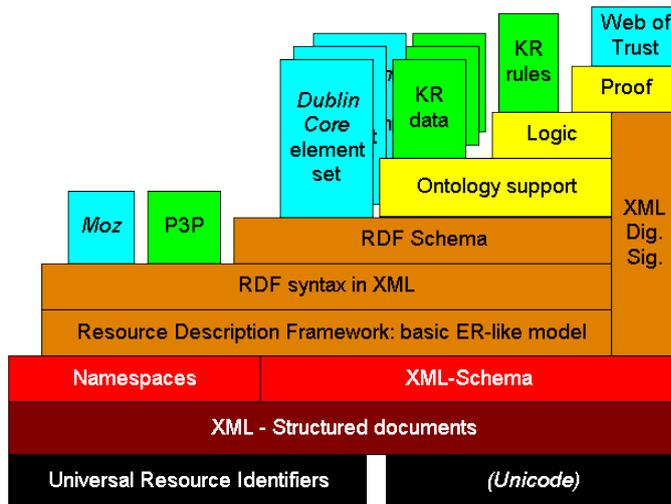
The semantic web inference must take into account that we handle *incomplete knowledge*.

## Description

Open world (OWA): Everything that cannot be proven is unknown, Closed world (CWA): Everything that cannot be proven is false.

Statement : "John is a Man." Query: "Is Jack a Man ?" OWA Answer: "I don't know." CWA Answer: "No."

## Semantic Web Stack



Taken from <http://www.w3.org/2000/Talks/0906-xmlweb-tbl/slide9-0.html>, by Tim Berners Lee.

### 1.4.1 Semantic Web Adopters

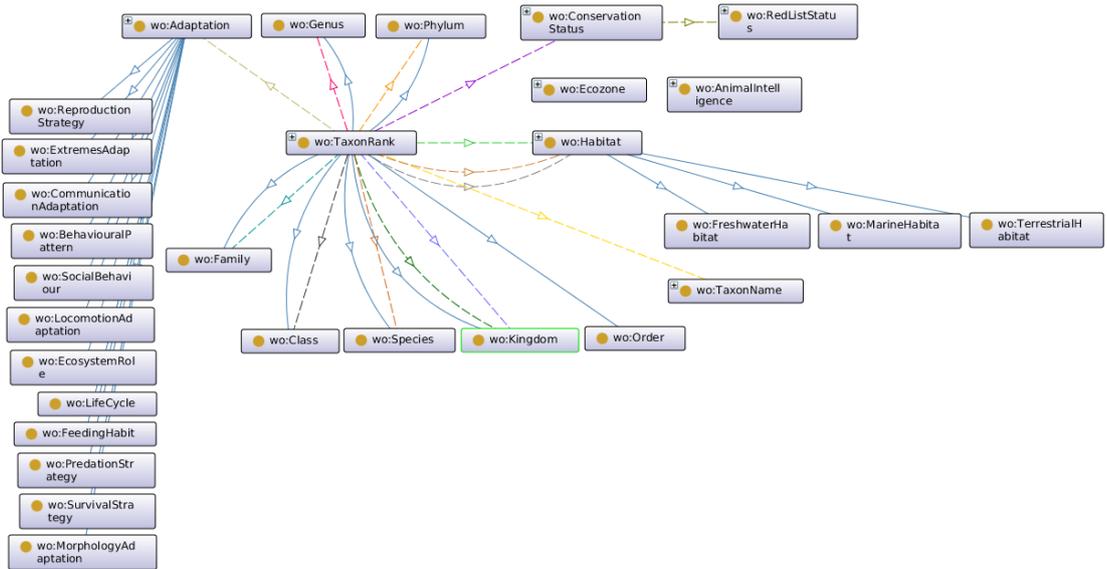
#### Who is Using Semantic Web Technologies

Let's name a few:

- Google – *Knowledge Graph* (although they do not name it Semantic web – [http://semanticweb.com/google-just-hi-jacked-the-semantic-web-vocabulary\\_b29092](http://semanticweb.com/google-just-hi-jacked-the-semantic-web-vocabulary_b29092))
- Microsoft – Satori, <http://research.microsoft.com/en-us/projects/trinity/query.aspx>
- Facebook – Open Graph Protocol <http://ogp.me/>
- BBC – various datasets in RDF – <http://www.bbc.co.uk/developer/technology/apis.html>
- Ordnance Survey – geographic datasets in RDF – <http://data.ordnancesurvey.co.uk>

#### BBC Wildlife Ontology

# 1 Introduction



## Ordnance Survey Linked Data Kents Hill, Monkston and Brinklow



Kents Hill, Monkston and Brinklow is a Parish in Milton Keynes.

Objects related to "Kents Hill, Monkston and Brinklow"	
Extent	41649-49
In European Region	South East
Within	Milton Keynes
In District	Milton Keynes
Touches	Walton Broughton Old Woughton Milton Keynes Wavendon
Same As	E04001285

Core facts about "Kents Hill, Monkston and Brinklow"	
Type	Parish
Label	Kents Hill, Monkston and Brinklow
Pref Label	Kents Hill, Monkston and Brinklow
Alt Label	Kents Hill, Monkston and Brinklow CP
Northing	238013.803835
Easting	489602.596729
Lat	52.0333028515
Long	-0.695254366017
Area Code	CPC
Gss Code	E04001285

## 1.5 Linked Data

### How to publish data related to other ?

Based on semantic web principles, Linked Data provide means to efficiently connect data created by different publishers.

- Web of Documents – WWW
  - webpage – readable by human
  - identifiers – IRI
  - transfer protocol – HTTP
  - unified language – HTML
- Web of Data – Linked Data
  - webpage – readable by machine
  - identifiers – IRI
  - transfer protocol – HTTP
  - unified language – RDF

*Linked Data* [Heath2011] is a method for publishing structured and interlinked data on the web, building up on URIs, HTTP and RDF technologies.

### Linked Data Principles

1. Use URIs as names for things.
2. Use HTTP URIs so that people can look up those names.
3. When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL).
4. Include links to other URIs, so that they can discover more things.

(Tim Berners-Lee, 2009 – <http://www.w3.org/DesignIssues/LinkedData.html>)

URIs satisfying the third point are **dereferencable**.

### Document vs. its Content

When designing a URI scheme it is necessary to ensure proper distinction between a **document** and its **content**

#### Example

```
@prefix people: <http://example.com/people/>
people:John people:likes people:Mary
```

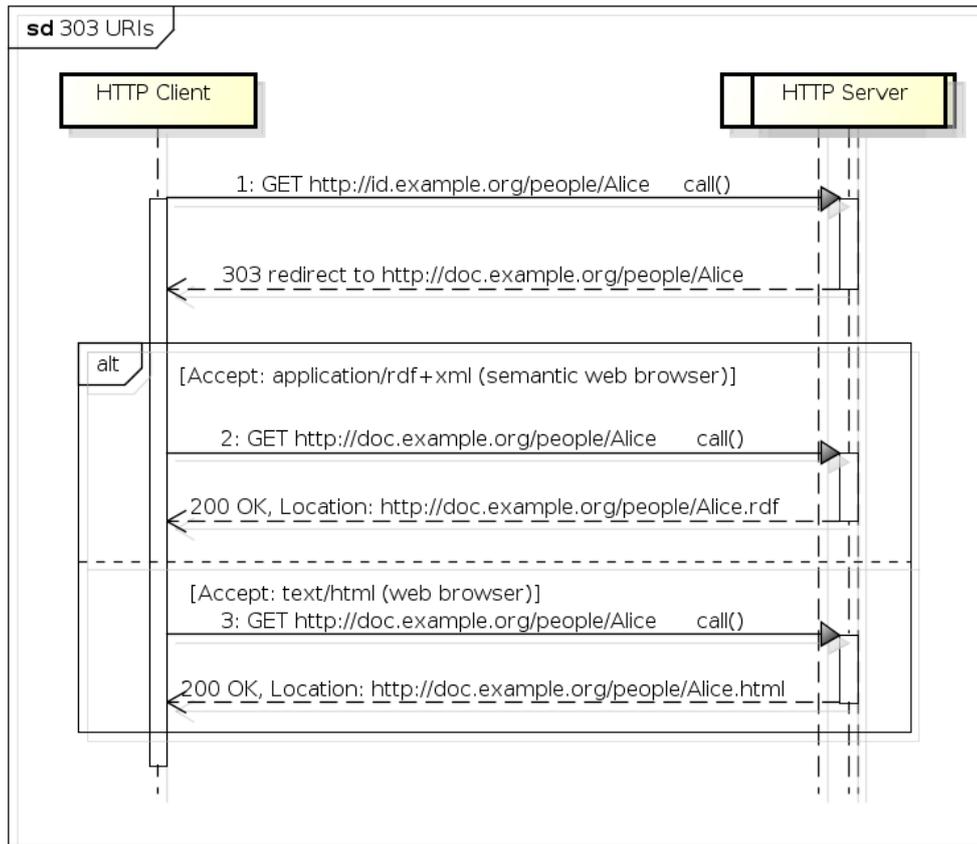
Is <http://example.com/people/Mary> a web document or a resource ? (Consider semantic consequences of each option).

This is handled by two strategies – 303 URIs and Hash URIs, each being suitable for different scenarios.

## 1 Introduction

### 303 URIs

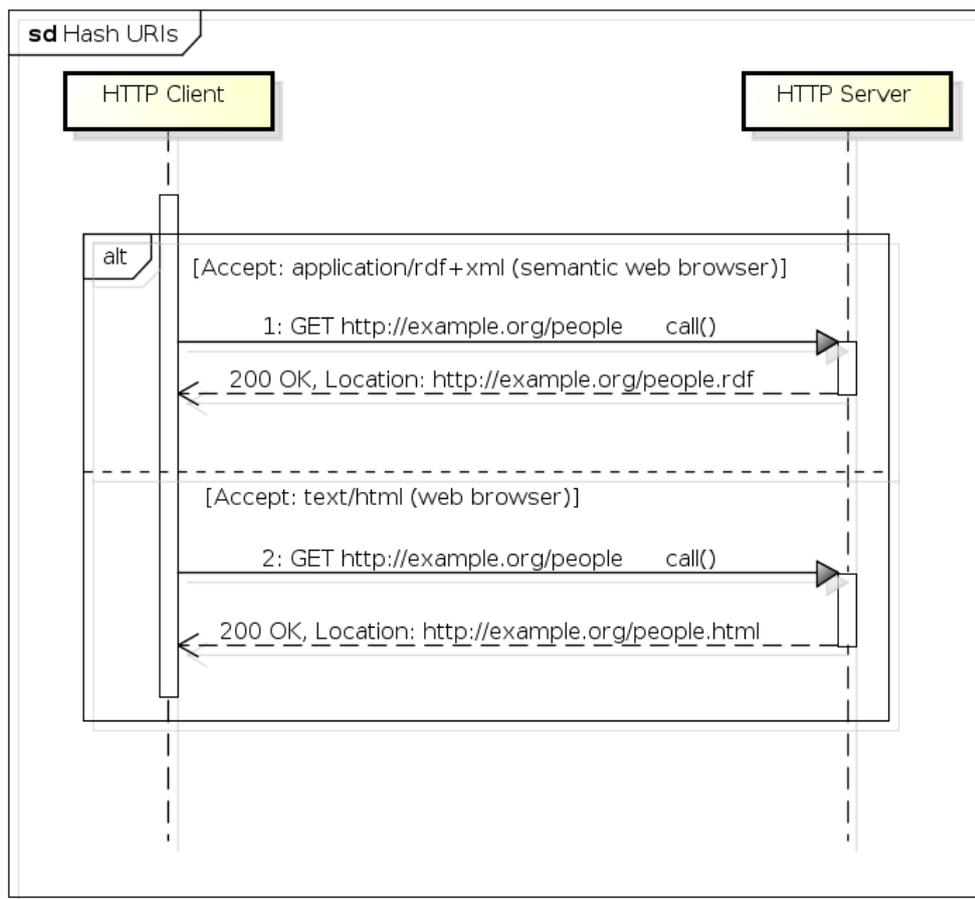
- 303 URIs are of the form `http://id.example.org/people/Alice`
- HTTP server sends 303 redirect to the corresponding **document** of the requested **resource**.
- HTTP client makes another request, based on Accept headers, the RDF/HTML version is delivered.



powered by Astah

### Hash URIs

- Hash URIs are of the form `http://example.org/people#Alice`
- HTTP server sends the whole **document** of either RDF or HTML type based on Accept headers.
- Within the document, the HTTP client gets the particular entity after the hash symbol.



powered by Astah

### 303 URIs vs. Hash URIs

**Hash URIs** are suitable for small datasets that will hardly grow up,

**303 URIs** are suitable for large datasets for the sake of good performance.

#### Reason

The fragment part of an URL (after #) is evaluated on the HTTP client (not the HTTP server), so the HTTP client must fetch all data first and then filter them for the subsequent use locally.

### Linked Data Platforms

**Pubby** is a simple Linked Data publication server connectable to SPARQL endpoints,

**Callimachus** is an application server for linked data applications. To be explored in the tutorials,

## 1 Introduction

**Marmotta** is a platform for publishing Linked Data (contributed from Linked Media Framework),

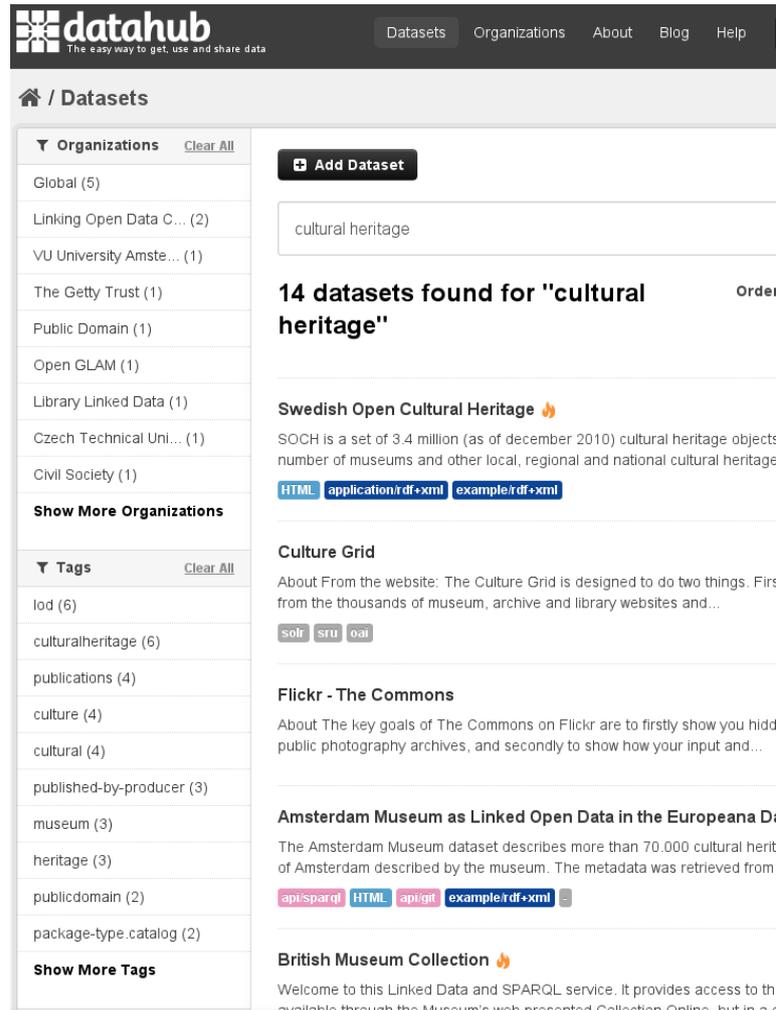
**D2R** is a platform for publishing relational database data in the form of Linked Data.

## 1.6 Use-case: Open Data

### CKAN and DataHub

CKAN (<http://ckan.org/>) is an open-source data portal for publishing, sharing and search of datasets.

It is prominently hosted at <http://datahub.io>. Datasets on DataHub can be sub-



The screenshot shows the DataHub website interface. At the top, there is a navigation bar with the DataHub logo and the tagline "The easy way to get, use and share data". The main content area is titled "Datasets" and features a search bar with the query "cultural heritage". Below the search bar, it displays "14 datasets found for 'cultural heritage'". The first result is "Swedish Open Cultural Heritage" with a flame icon, described as a set of 3.4 million cultural heritage objects. Below this, there are sections for "Culture Grid", "Flickr - The Commons", "Amsterdam Museum as Linked Open Data in the Europeana D", and "British Museum Collection". The left sidebar contains filters for "Organizations" and "Tags".

mitted to the Linked Data Cloud.

### Datasets search

<http://datahub.io/dataset?q=cultural+heritage>

## Národní katalog otevřených dat (NKOD)

**OTEVŘENÁ DATA** Datové sady [Poskytovatelé](#) [Klíčová slova](#) [Další](#)

**Poskytovatelé (1)**

HLAVNÍ MĚSTO PRAHA (136)

**Klíčová slova (18)**

**Praha (136)**

Česká republika (3)

Digitální mapa Prahy (1)

Lítačka (1)

budovy (1)

district (1)

děti (1)

Zobrazit další

**Formáty (10)**

Esri Shape (98)

Zipped GML (95)

GeoJSON (80)

Vyhledat:

[Zobrazit pokročilé filtry](#) [Smazat filtry](#) [Název vzestupně](#)

136 datových sad nalezeno

**Praha**

**Absolutní výšky budov**  
HLAVNÍ MĚSTO PRAHA  
Klasifikovaný rastr vytvořený z digitálního modelu zástavby zobrazuje absolutní nadmořské výšky budov.  
[TIF](#) [Plain text](#)

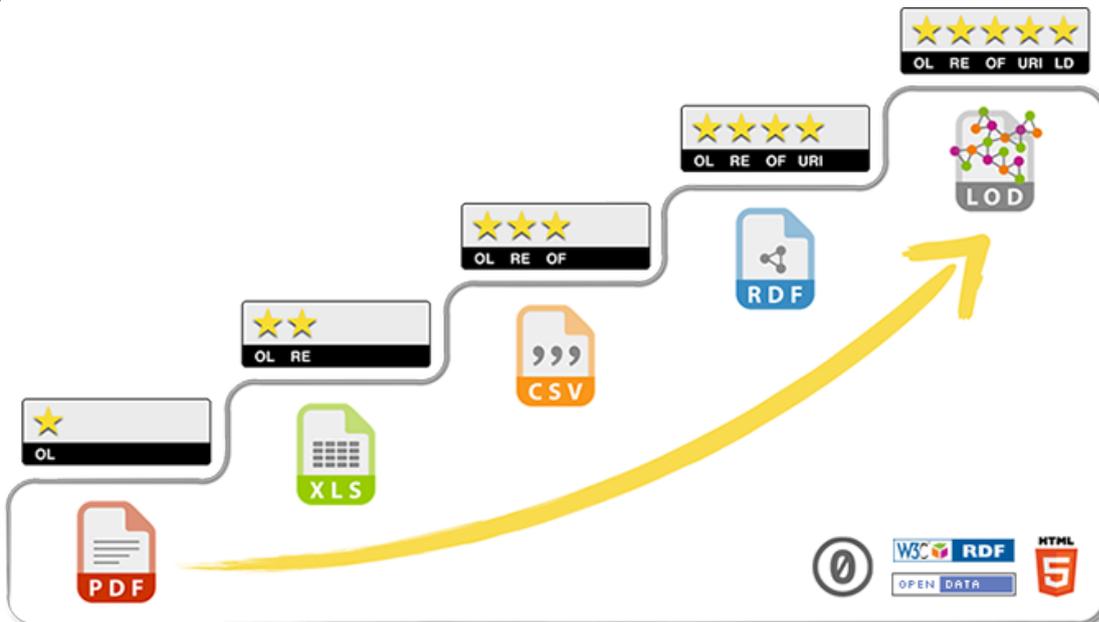
**Bonita klimatu**  
HLAVNÍ MĚSTO PRAHA  
Bonita klimatu - komplexní charakteristika dle všech hodnocených klimatologických hledisek Data byla vytvořena pomocí prostředku ArcGIS 9.2, Spatial Analyst. Vrstva byla převedena z rastrové vrstvy bonita, s horizontálním rozlišením 25m. Pro realizaci této mapy byla využita tato data: Digitální referenční mapa Praha-bloková mapa budov...  
[GeoJSON](#) [Zipped GML](#) [Esri Shape](#) [ZIP](#)

**Bonita klimatu z hlediska míry zastavěnosti území**  
HLAVNÍ MĚSTO PRAHA  
Data byla vytvořena pomocí prostředku ArcGIS 9.2, Spatial Analyst. Vrstva byla převedena z rastrové vrstvy bonita, s horizontálním rozlišením 25m. Pro realizaci této mapy byla využita tato data: Digitální referenční mapa Praha-bloková mapa budovy Liniová vrstva uličních úseku Vektorová data tematické vrstvy Úpn-doprava-liniová vrstva...  
[GeoJSON](#) [Zipped GML](#) [Esri Shape](#) [ZIP](#)

gov.cz/

https://data.

## Open Data Levels



Taken from <http://5stardata.info/cs/>.

## Open Data Levels – description

## 1 Introduction

- \* Available on the web (whatever format) but with an open licence, to be Open Data
- \*\* Available as machine-readable structured data (e.g. excel instead of image scan of a table)
- \*\*\* All the above, plus – Non-proprietary format (e.g. CSV instead of excel)
- \*\*\*\* All the above, plus – Use open standards from W3C (RDF and SPARQL) to identify things, so that people can point at your stuff
- \*\*\*\*\* All the above, plus – Link your data to other people’s data to provide context

(Tim Berners-Lee, 2009 – <http://www.w3.org/DesignIssues/LinkedData.html>)

### From Open Data to Linked Data

\*\*\*

\*\*\*\*

#### Aircrafts (CAA)

s/n	type	operator_ic
1	Boeing 737	1234567
2	Airbus 319	9876543

→ ?

#### Companies (Business Registry)

company_ic	company_name
1234567	Best Airlines
9876543	Funny Flight School

### From Open Data to Linked Data

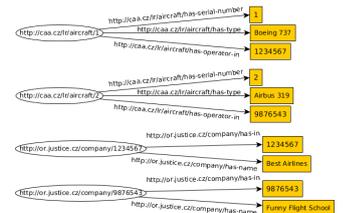
\*\*\*

\*\*\*\*

#### Aircrafts (CAA)

s/n	type	operator_ic
1	Boeing 737	1234567
2	Airbus 319	9876543

→



#### Companies (Business Registry)

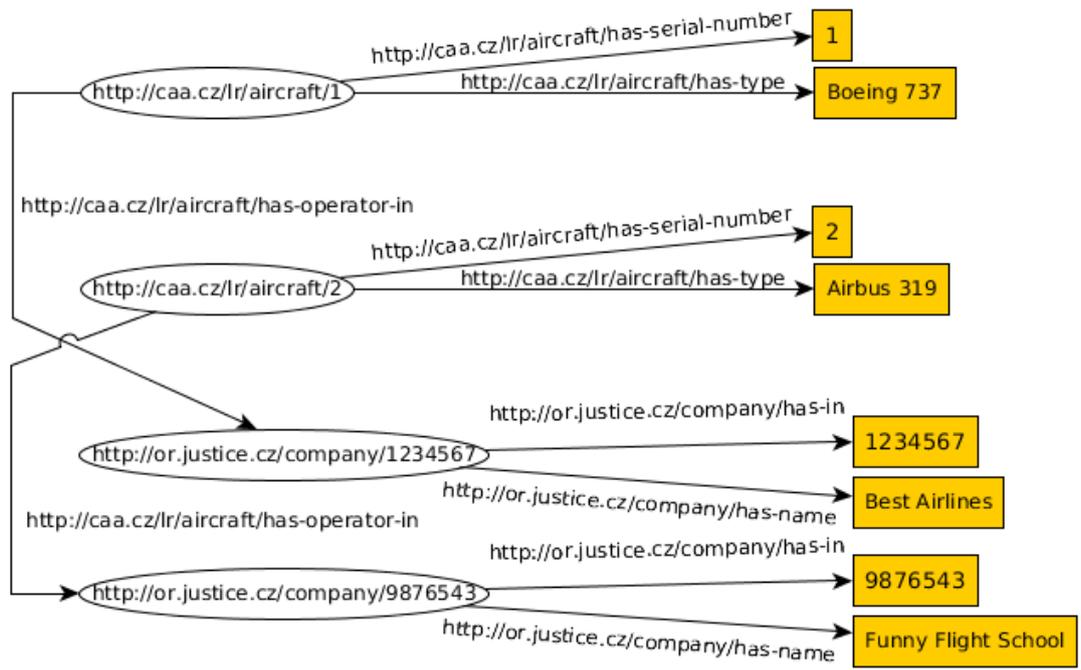
company_ic	company_name
1234567	Best Airlines
9876543	Funny Flight School

### From Open Data to Linked Data (4\*)

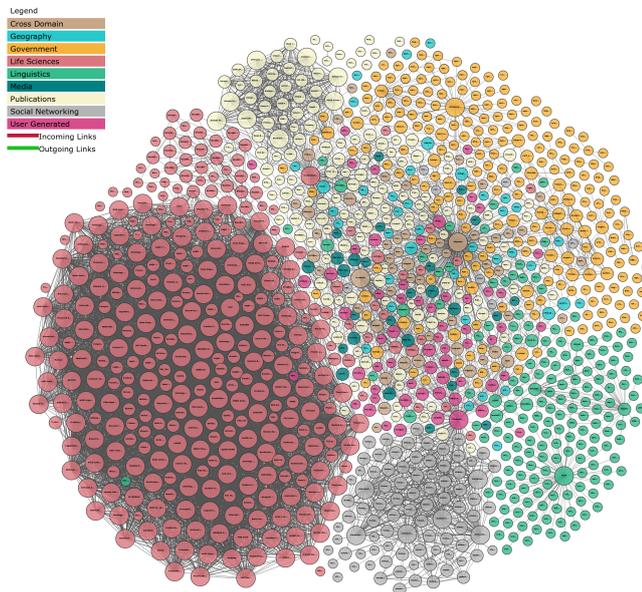


**From Open Data to Linked Data (5\*)**

# 1 Introduction



## Linked Open Data Cloud



<http://lod-cloud.net/>, 2018

## Linked Data vs. Open Data

**linked, not open** – enterprise data, master data

**linked, open** – 5\* data

**not linked, open** – typical case in OpenData

**not linked, not open** – we do not care

### 1.6.1 Licensing Open Data

#### Open Definition (OD)

Choosing an appropriate license is a crucial point influencing possibilities of future reuse of your data as well as defining your responsibility for the data. Linked data can be used for enterprise (closed) data, as well as open data. Let's discuss licensing of the latter.

**Open Definition** – A piece of data or content is open if anyone is free to use, reuse, and redistribute it — subject only, at most, to the requirement to attribute and/or share-alike. – cit. from <http://opendefinition.org>

#### Selected OD-Conformant Creative Commons Licenses

The following licenses apply to both *data* (in the sense of a full database), as well as their *content* (in the sense of particular single statements from these databases).

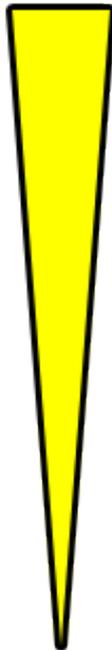
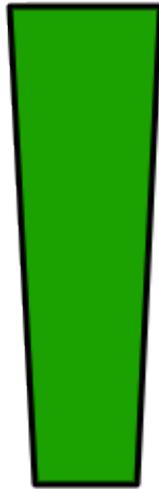
**attribution (BY)** using the data/content requires to give proper credit to the author of the original data/content,

**share-alike (SA)** derivative works require using the same license as their original,

**no-derivative (ND)** forbids making derivative works,

**non-commercial (NC)** forces non-commercial derivation/redistribution.

**MOST OPEN**



CC0



BY



BY



SA



BY



ND



BY



NC



BY



NC



SA



BY



NC



ND

**LEAST OPEN**

(from <http://creativecommons.org/examples>)

### Creative Commons Licenses

**Creative Commons CCZero (CC0)** license<sup>1</sup> enforces neither attribution, nor share-alike.

- e.g. Europeana, <http://datahub.io/dataset/europeana-sparql>

<sup>1</sup><http://creativecommons.org/publicdomain/zero/1.0/legalcode>

**Creative Commons Attribution (CC-BY-4.0)** license<sup>2</sup> enforces attribution, but not share-alike.

- e.g. PLOS<sup>3</sup>, <http://datahub.io/dataset/plos>

**Creative Commons Attribution (CC-BY-SA-4.0)** license<sup>4</sup> enforces attribution, as well as share-alike.

- e.g. DBPedia<sup>5</sup>, <http://dbpedia.org>

### Selected Materials

- OSW pages – <https://cw.fel.cvut.cz/wiki/courses/osw>
- RDF Primer – <https://www.w3.org/TR/rdf11-primer/>
- SPARQL Query Language Spec – <https://www.w3.org/TR/2013/REC-sparql11-query-2013032>
- OWL Primer – <https://www.w3.org/TR/owl2-primer/>
- SKOS Primer – <https://www.w3.org/TR/skos-primer/>
- Description Logic Reasoning – P. Křemen, *Ontologie a Deskripční logiky*. In *Umělá inteligence VI.*, Academia, 2013.
- Linked Data – <http://linkeddata.org>
- Nice supplementary tutorial on RDF/OWL – <https://www.obitko.com/tutorials/ontologies-semantic-web/>

---

<sup>2</sup><http://creativecommons.org/licenses/by/4.0/>

<sup>3</sup>uses an older version of CC-BY

<sup>4</sup><http://creativecommons.org/licenses/by-sa/4.0/>

<sup>5</sup>uses an older version of CC-BY-SA