1 Introduction

1.1 About Course

Course Organization

https://cw.fel.cvut.cz/wiki/courses/b4m36osw

1.2 Motivation

1.2.1 Scenario 1: What is a dataset about?

What is inside a dataset?

See OpenData portal of Prague OpenData portal of Prague

What is a building?

But things are worse ...

What is a building?

1. ... is a **construction** which is **heated**.

2. ... is a **construction** to provide **protection** to their users or internal equipment and is typically **closed** and has a **permanent position**.

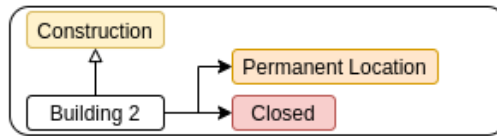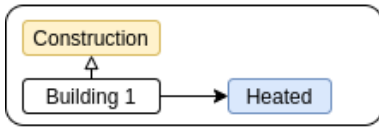ČSN EN 15643-5 -Sustainability of construction works

Building

3. ... is a **construction above ground** which is **spatially-compact** and **closed by walls and roof**.

Act 256/2013 Coll., Cadastral Law

4. ... is a **construction above and below ground** which is **spatially-compact** and **closed by walls and roof** and is **heated or cooled**.
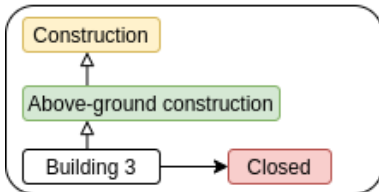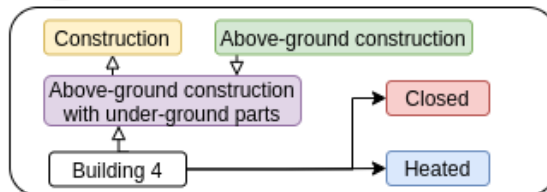
Act 406/2000 Coll., on Energy Management

What is a building?

Building

New knowledge can be inferred
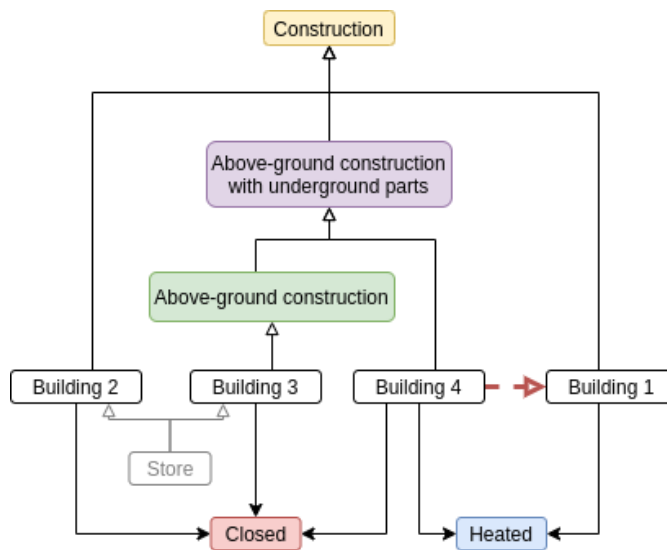
1.2.2 Scenarios: Examples of misunderstanding

One event or two events?

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

What is the trend of Runway Incursion incidents at an airline operator ?
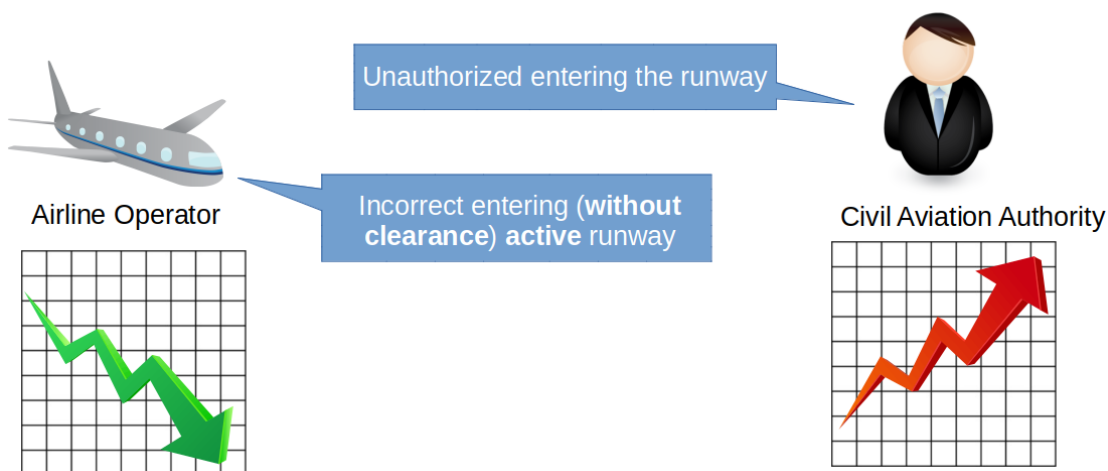
1.2.3 From Conceptual Models to Ontologies

Ontological Conceptual Modeling

- a way to **capture** and **explain** meaning.

- the language must be understandable to non-experts (UML max)

- the language must be computable – we want to use the models to infer new knowledge or validate data

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

1.3 Overview of Ontologies

First, People Need to Understand Each Other

Vocabularies, term definitions, relationship definitions
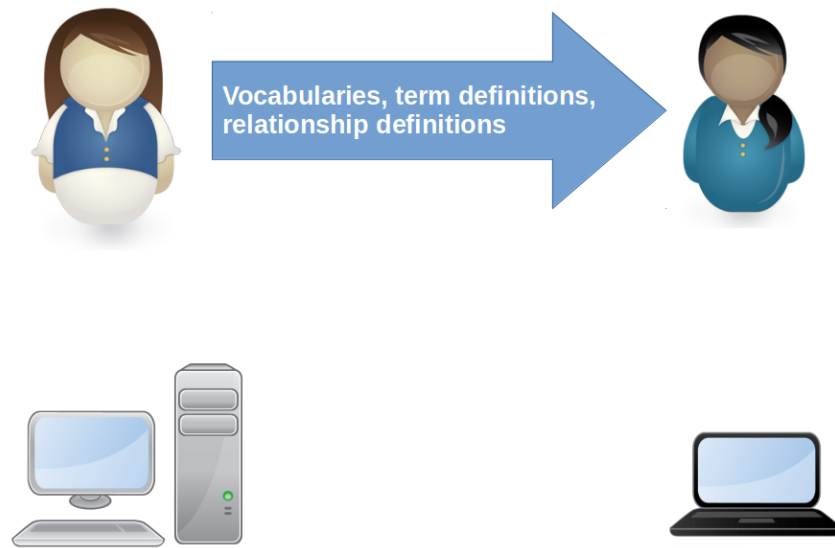
Second, People Need to Explain Things to Computers

Formalization (logics), etc.

Formalization (logics), etc.
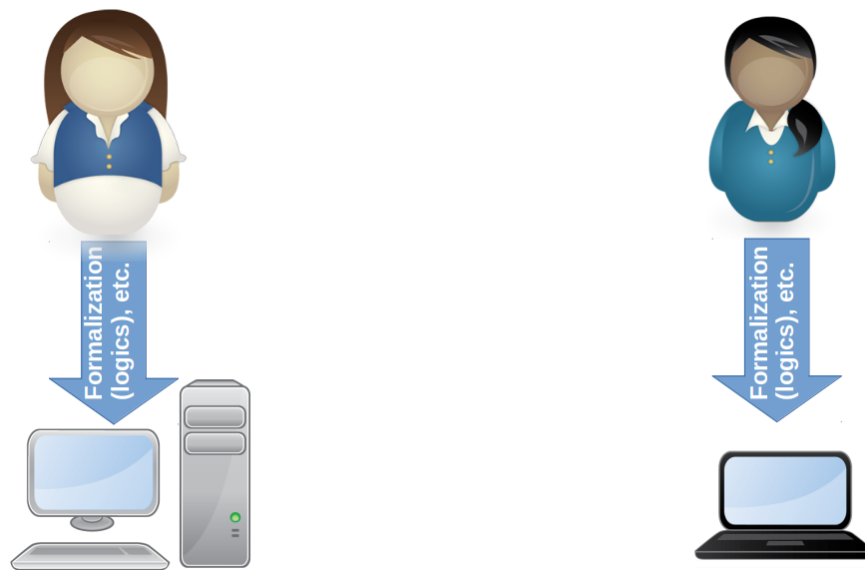
Third, Computers Can Understand One Another

Automated Reasoning
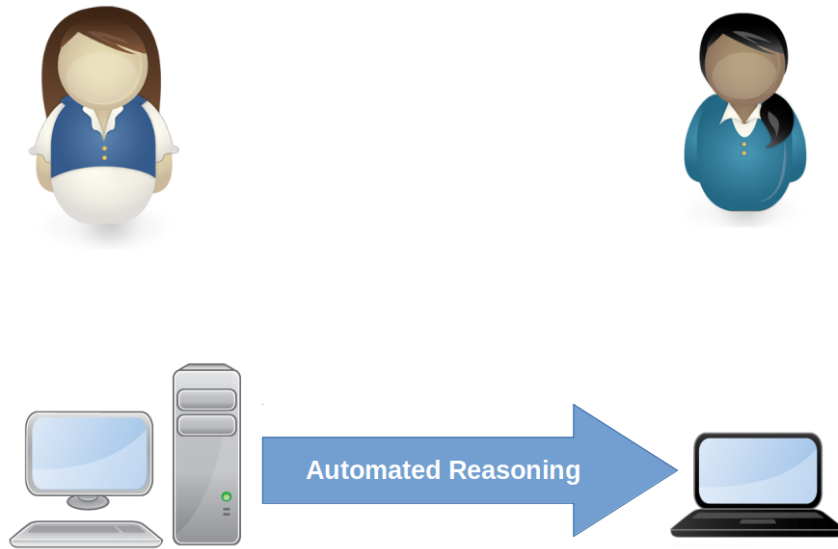
Solution = Ontology

Explicit Conceptualization of Shared Meaning
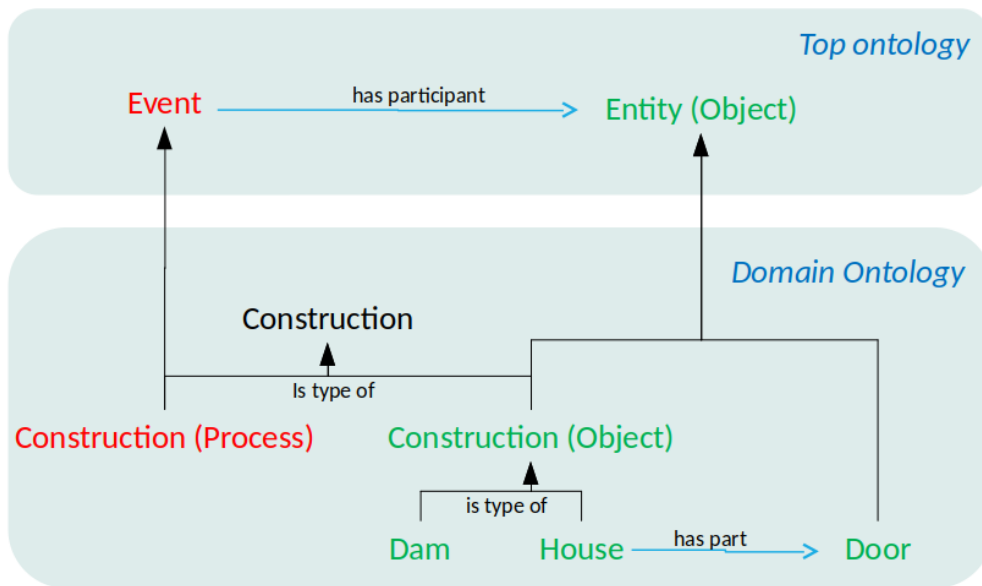
Example Top-Level Ontology

Small part of Unified Foundational Ontology (UFO)
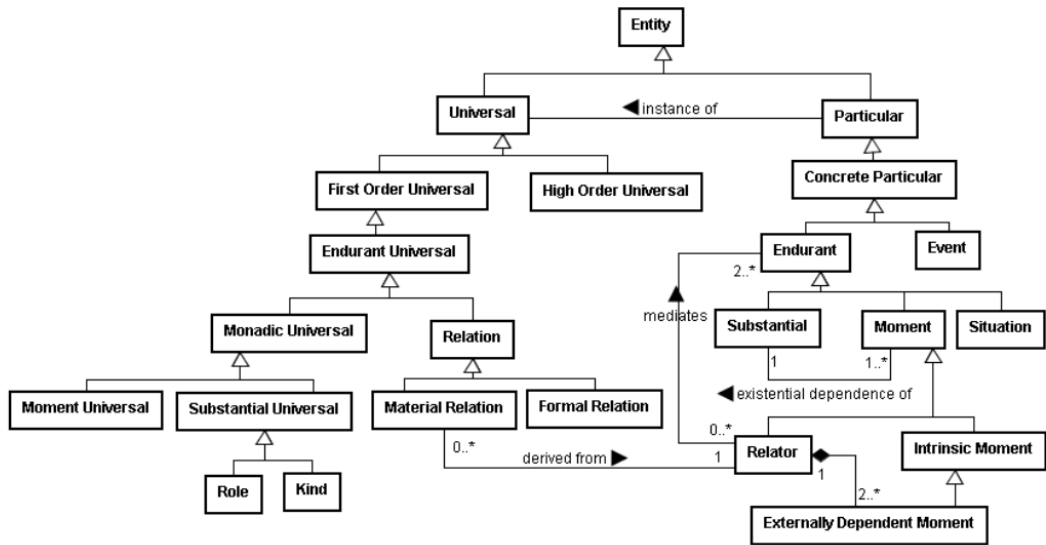
Example Ontology Hierarchy

Each helicopter is also an aircraft.
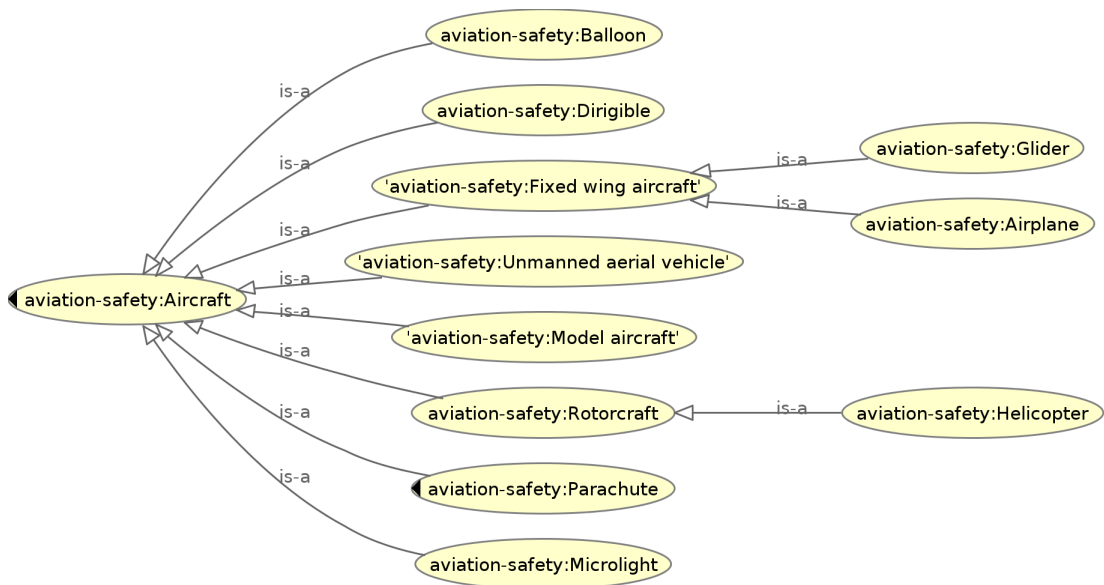
Ontologies ≠ Taxonomies

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)

1.4 Use-case: Data Integration

Data Integration Scenario

- Different data schemas
- Different communication speeds
- Different names for a concept
- Different concepts for one term

Data Integration Scenario

- Different data schemas
- Different communication speeds
- Different names for a concept
- Different concepts for one term
- What if another data source gets registered ?
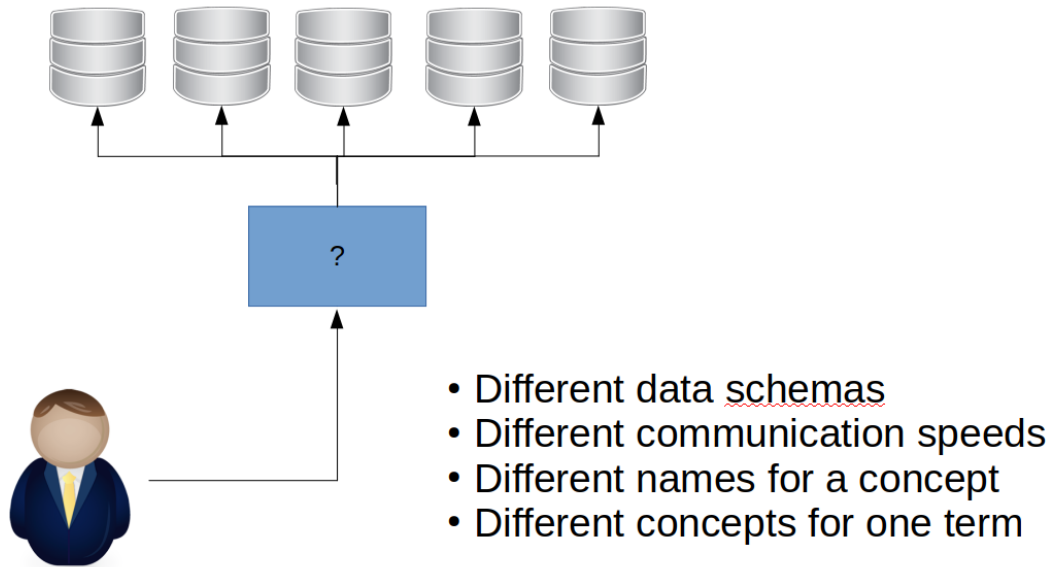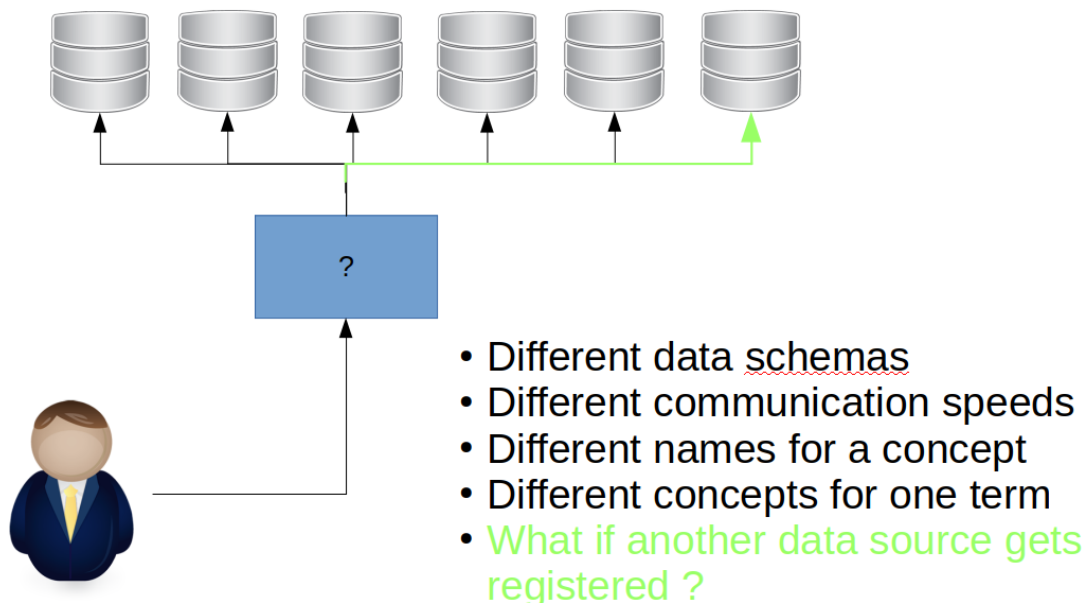
Use-case – HealthCare Data Integration
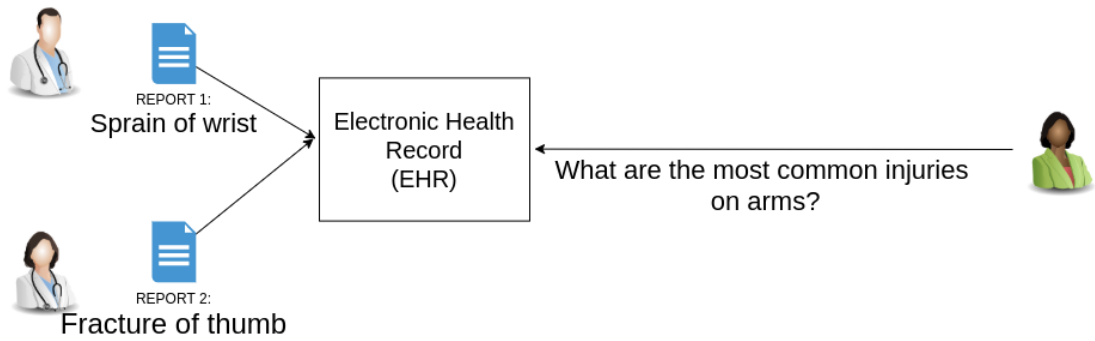
SNOMED-CT
Systematized Nomenclature of Medicine - Clinical Terms

- $\sim 300k$ clinical concepts

- international standard – adopted e.g. in UK, USA, Australia

- uses ontology reasoning to classify/query the concepts

SNOMED-CT

Systematized Nomenclature of Medicine - Clinical Terms

```
https://browser.ihtsdotools.org/?perspective=full&conceptId1=
    70704007&edition=MAIN/2020-07-31&release=&languages=en
```

1.5 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 na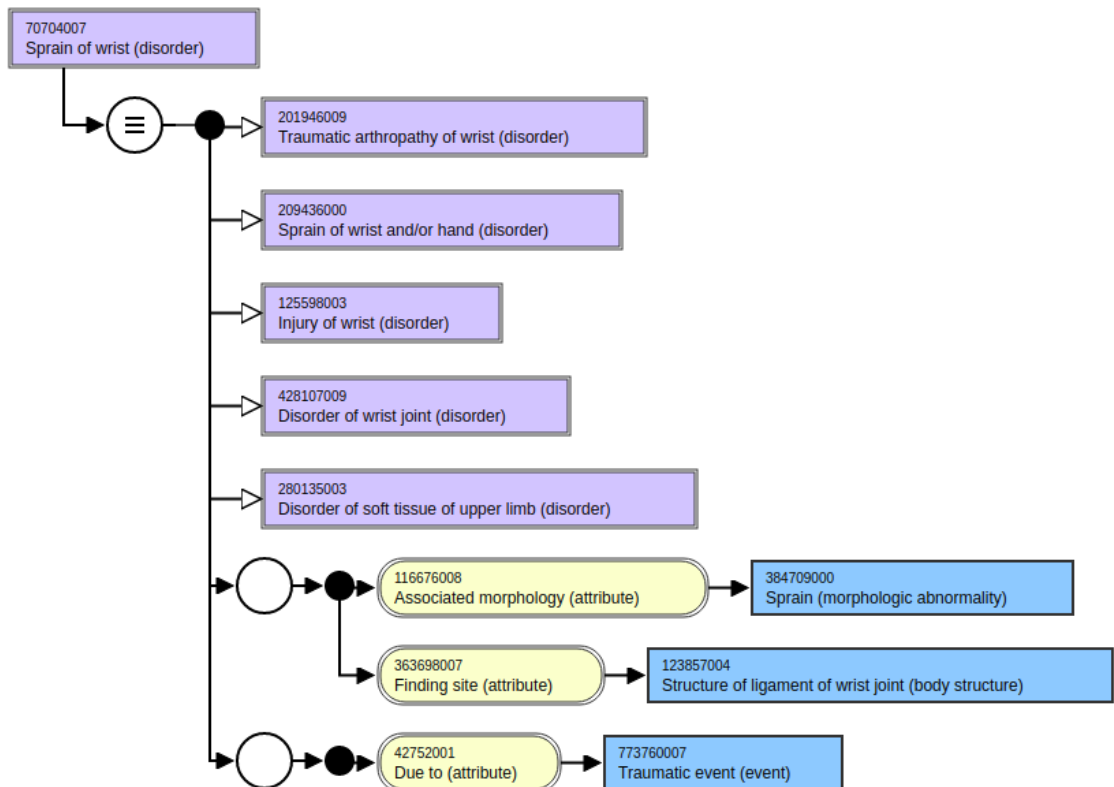tural language preprocessing methods, the search results contain lots of irrelevant results that need to be processed manually.

- 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
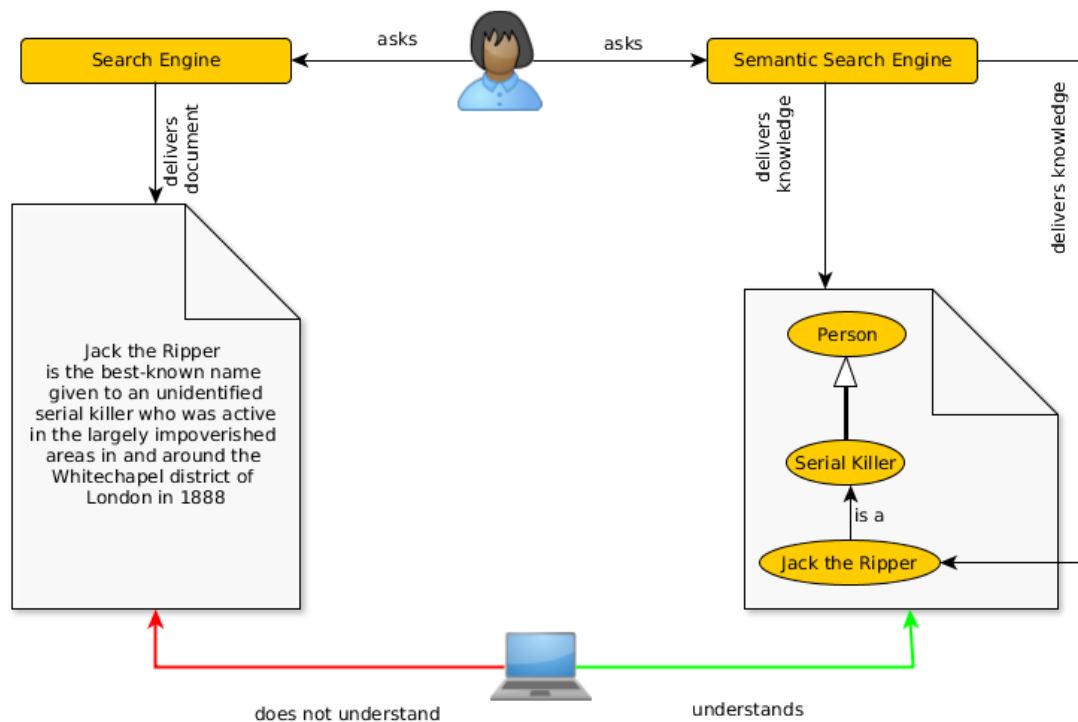
Ontologies and Semantic Web

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 adressing 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.
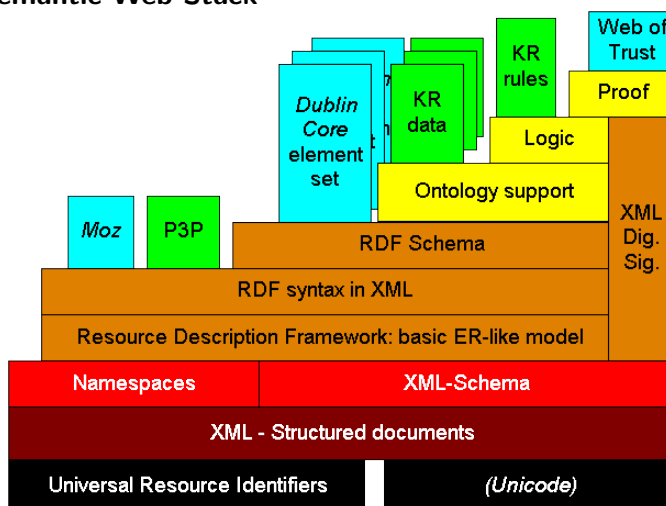
Open World Assumption

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.
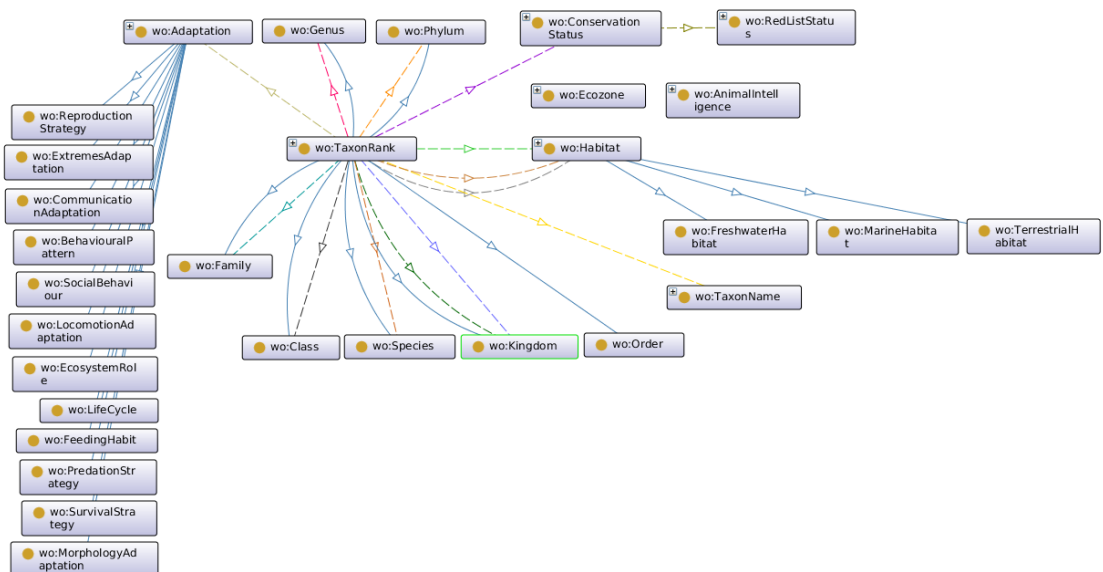
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1.5.1 Semantic Web Adopters

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)`

- 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

Ordnance Survery Linked Data

Kents Hill, Monkston and Brinklow

Map powered by OS OpenSpace

Zoom to: Country **County** District City Area City Street

© Crown copyright and database rights 2017 Ordnance Survey.

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

1.6 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**
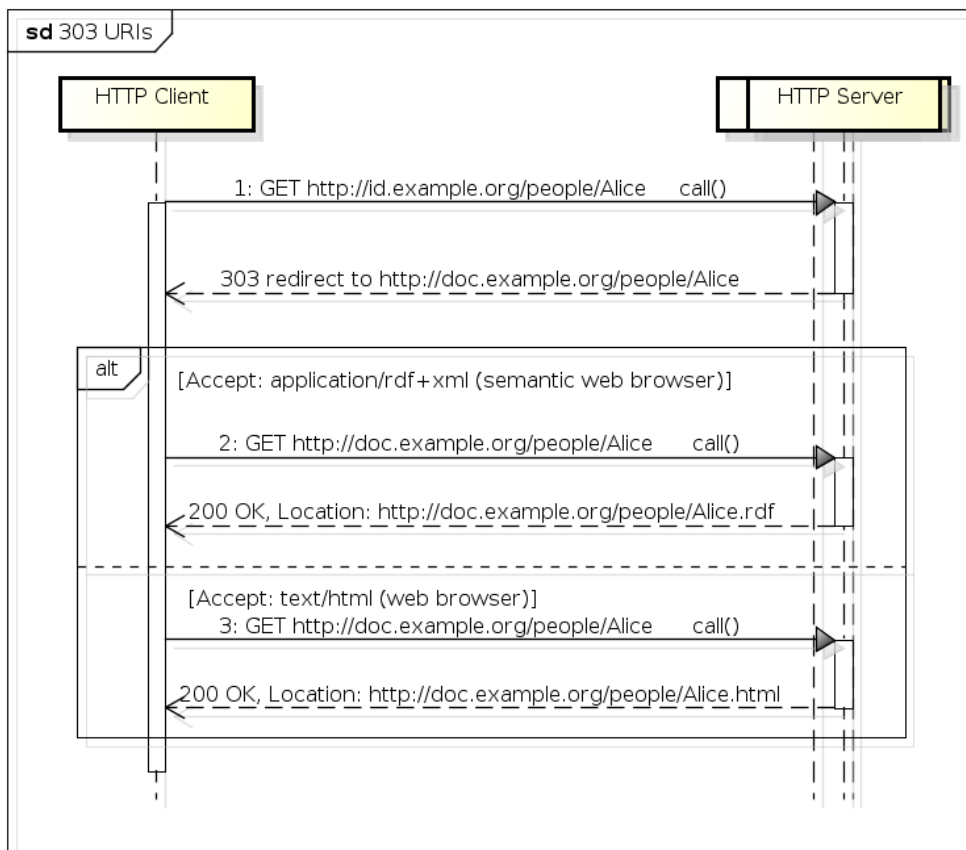
Example

```
@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.
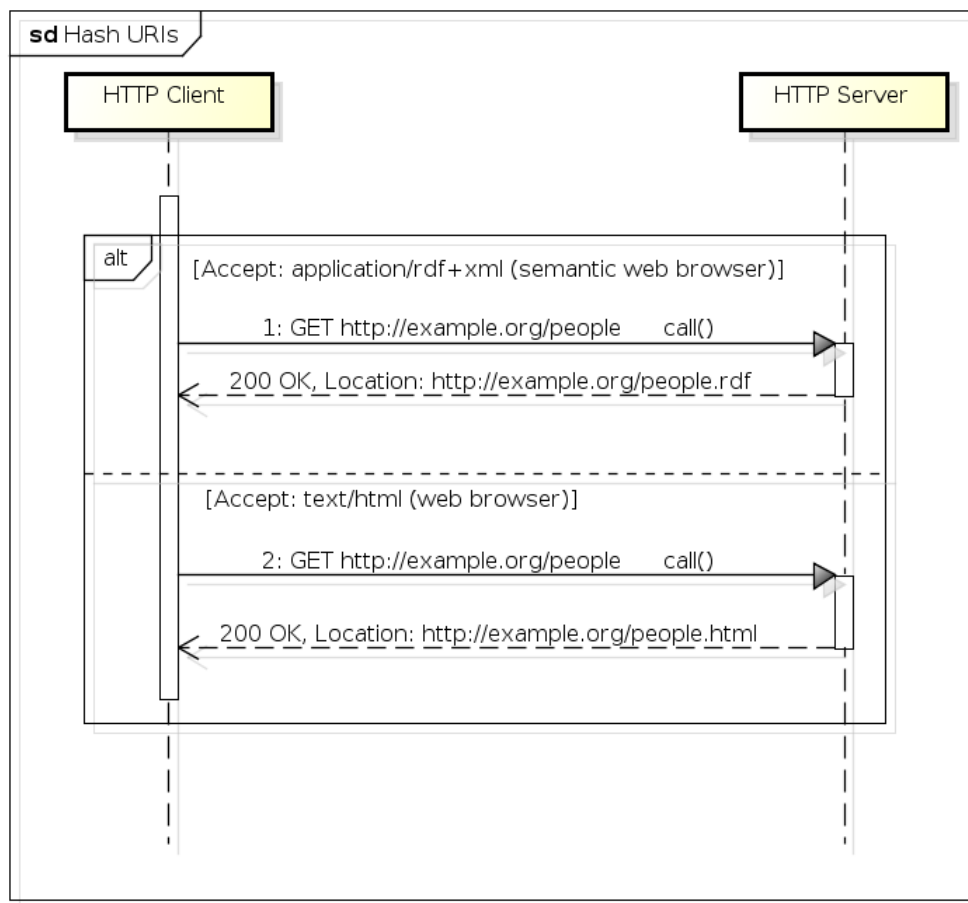
303 URIs

- 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.

sd Hash URIs

HTTP Client   HTTP Server

alt

[Accept: application/rdf+xml (semantic web browser)]

1: GET http://example.org/people   call()

200 OK, Location: http://example.org/people.rdf

[Accept: text/html (web browser)]

2: GET http://example.org/people   call()

200 OK, Location: http://example.org/people.html

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 performace.

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,

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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.

1.7 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-

mitted to the Linked Data Cloud.

Datasets search

`https://datahub.io/search?q=coronavirus`

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1 Introduction

Národní katalog otevřených dat (NKOD)

https://data.gov.cz/

Open Data Levels

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

Open Data Levels – description

⋆ 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

⋆⋆⋆   ⋆⋆⋆⋆

Aircraft (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

⋆⋆⋆   ⋆⋆⋆⋆

Aircraft (CAA)

s/n	type	**operator_ic**
1	Boeing 737	1234567
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Companies (Business Registry)

company_ic	company_name
1234567	Best Airlines
9876543	Funny Flight School

→

From Open Data to Linked Data (4*)
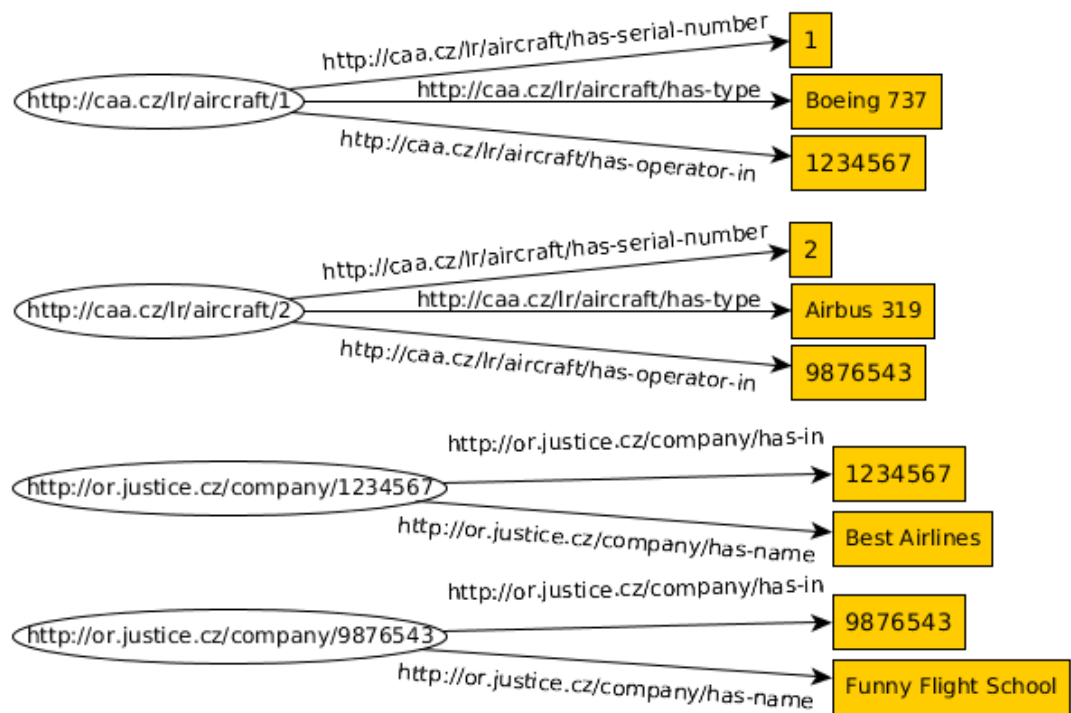
From Open Data to Linked Data (5*)

Linked Open Data Cloud

`http://lod-cloud.net/,2018`
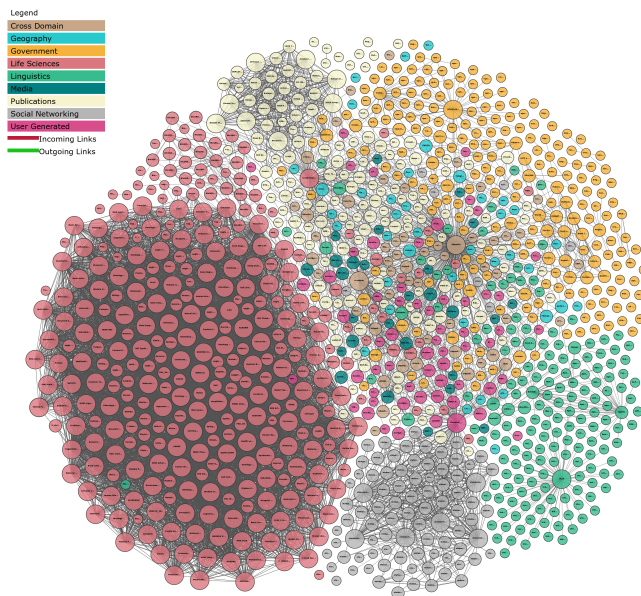
Linked Data vs. Open Data

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

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`

- 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/`