# Linked Data and the Semantic Web: the Basics

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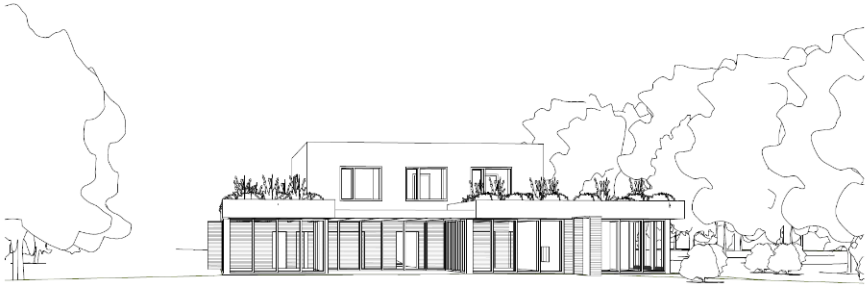
LDAC Summer School

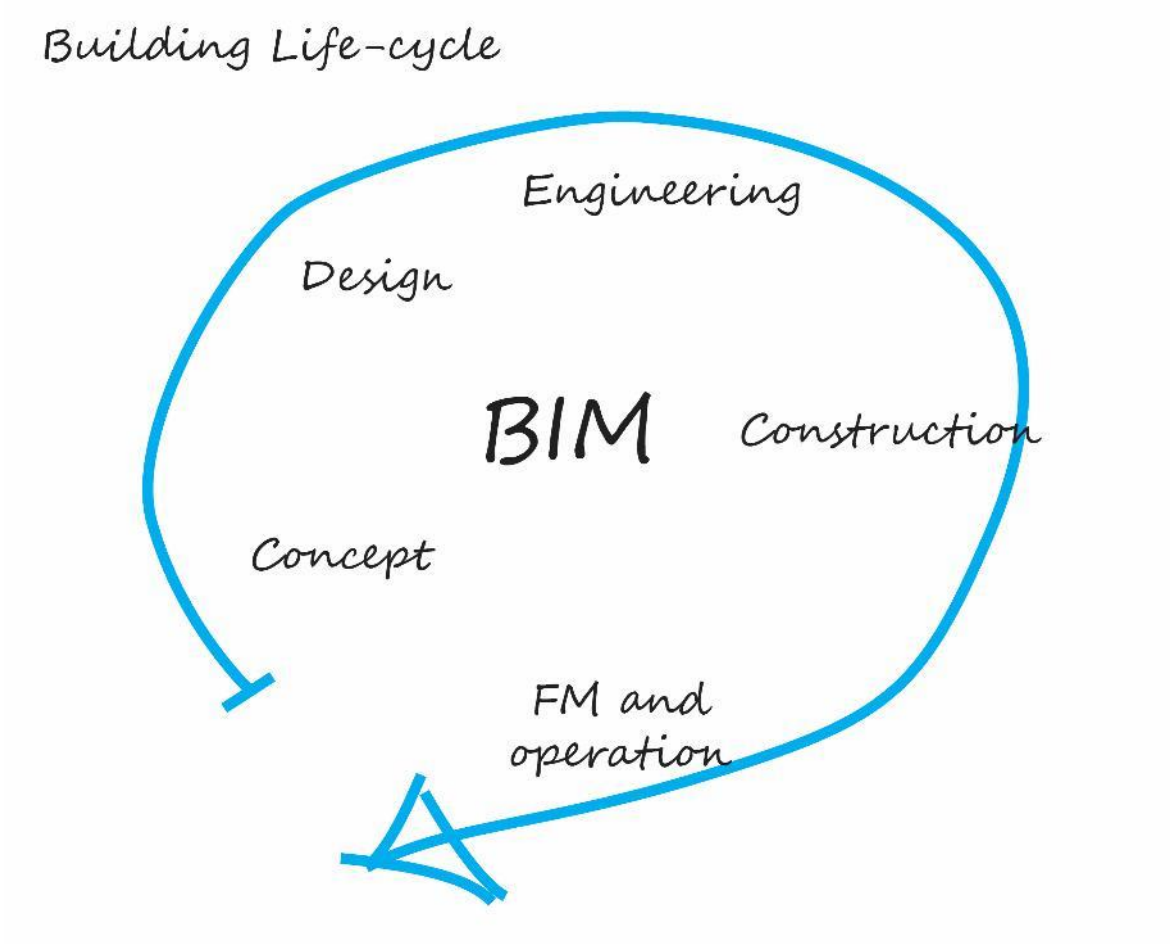
17 June 2019

# Outline

1. Information exchange and the AEC industry
2. LBD in practice!
3. Some technical basics
4. Scaling up the graph
5. Exercises

# Building Information Modelling




Building Life-cycle
Engineering
Design
BIM
Construction
Concept
FM and
operation

## 7.2.3.3 IfcAlarm

### ▶ Natural language names

### ▶ Change log

### 7.2.3.3.1 Semantic definitions at the entity

#### ▼ Entity definition

An alarm is a device that signals the existence of a condition or situation that is outside the boundaries of normal expectation or that activates such a device.

Alarms include the provision of break glass buttons and manual pull boxes that are used to activate alarms.

HISTORY New entity in IFC4

#### ▼ Attribute definitions

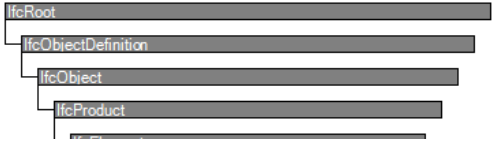
| # | Attribute | Type | Cardinality | Description | G |
|---|---|---|---|---|---|
| 9 | PredefinedType | IfcAlarmTypeEnum | ? | | X |

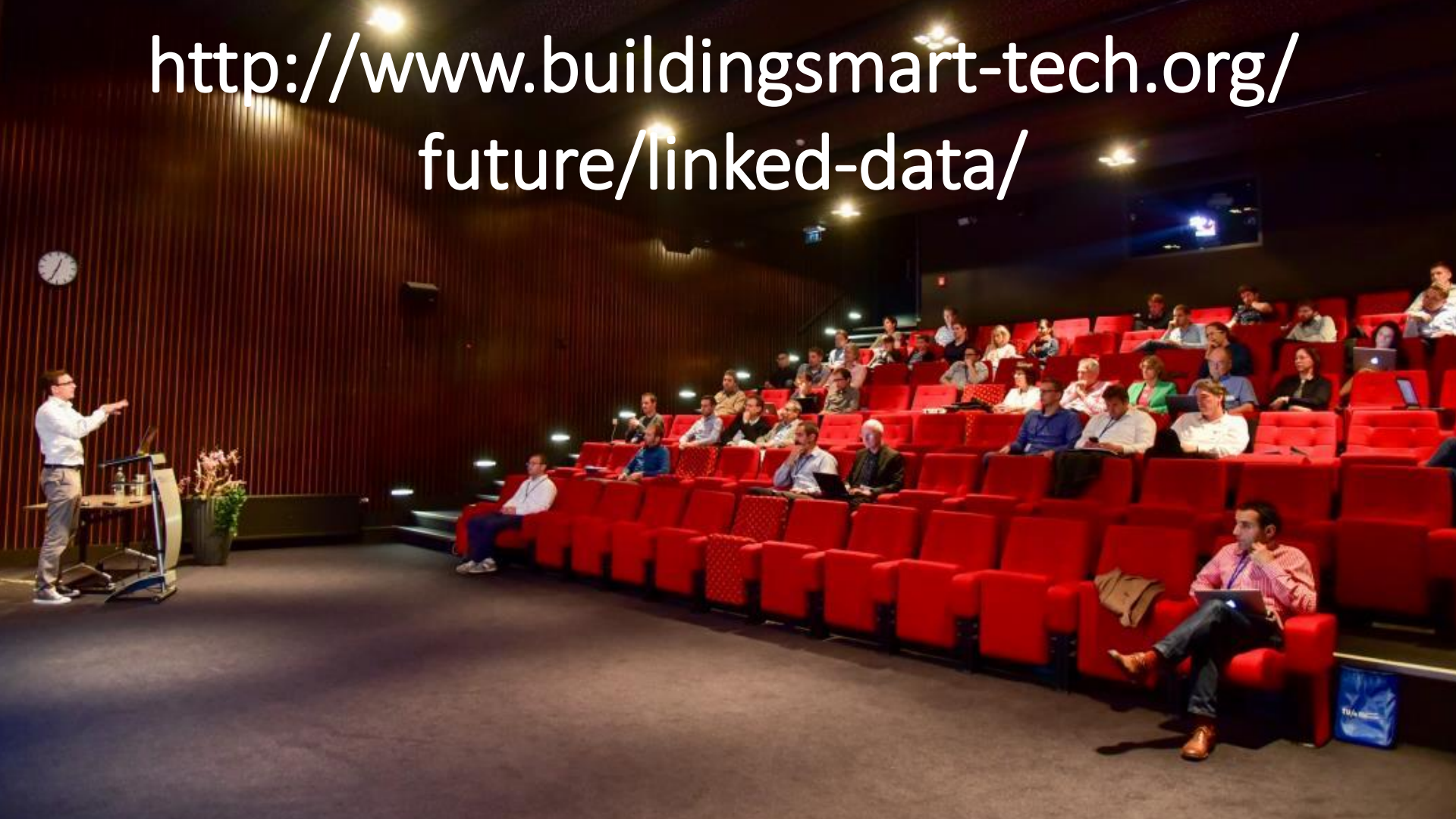
#### ▼ Formal Propositions

| Rule | Description |
|---|---|
| CorrectPredefinedType | Either the *PredefinedType* attribute is unset (e.g. because an IfcAlarmType is associated), or the inherited attribute *ObjectType* shall be provided, if the *PredefinedType* is set to USERDEFINED. |
| CorrectTypeAssigned | Either there is no alarm type object associated, i.e. the *IsTypedBy* inverse relationship is not provided, or the associated type object has to be of type IfcAlarmType. |

### 7.2.3.3.2 Inherited definitions from supertypes

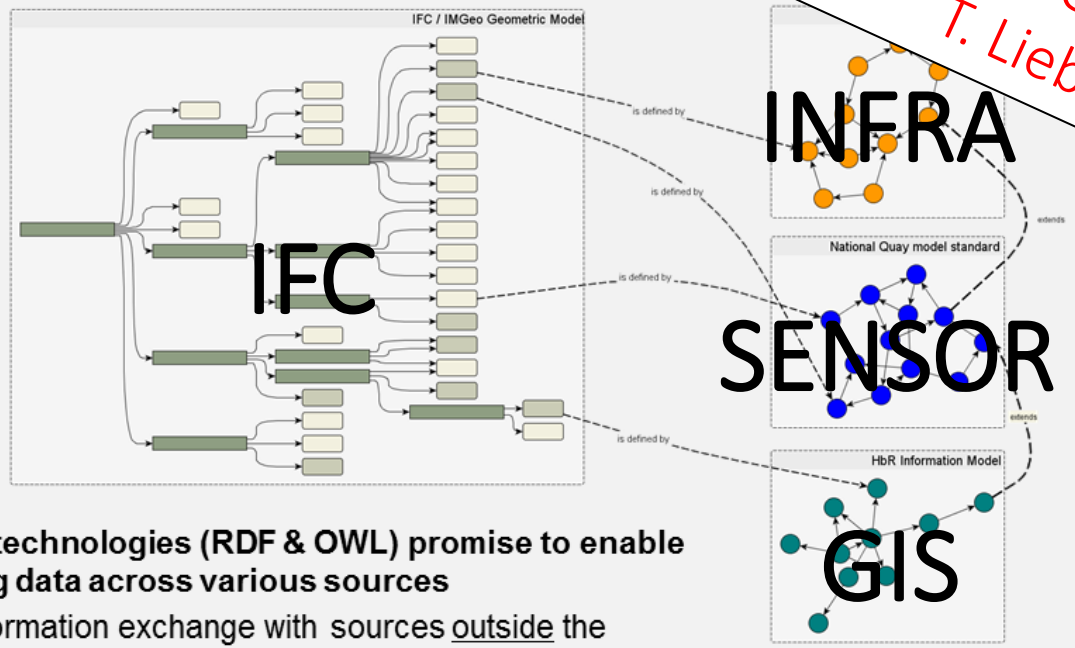
#### ▼ Entity inheritance




http://www.buildingsmart-tech.org/
future/linked-data/

# Goal of Linked Data in Construction

Toronto Oct. 2014
T. Liebich



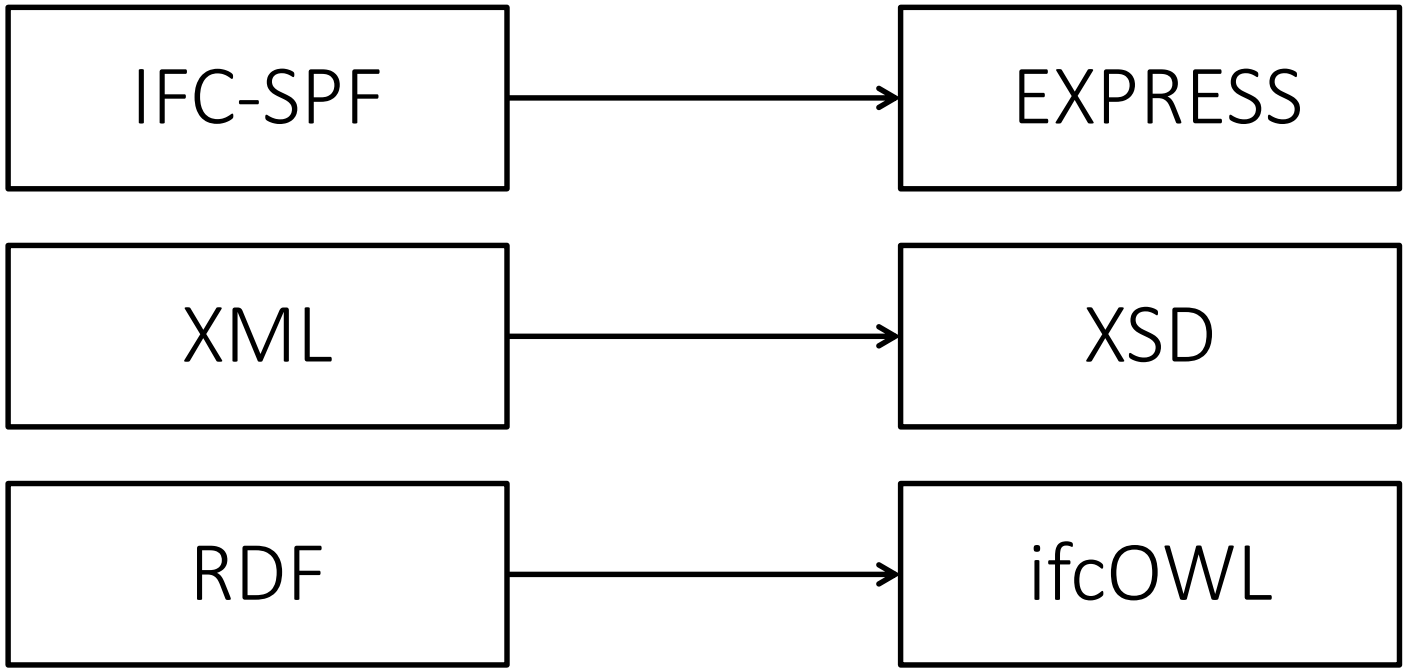

**Semantic web technologies (RDF & OWL) promise to enable linking building data across various sources**

⇒ improved information exchange with sources outside the traditional BIM environments, additional to the already existing techniques



Image courtesy: Jakob Beetz, TU Eindhoven

# Different serializations of the same data model




Pieter Pauwels, Walter Terkaj. EXPRESS to OWL for construction industry: Towards a recommendable and usable ifcOWL ontology. Automation in Construction 63 (2016) 100-133.

# ifcOWL ontologies available

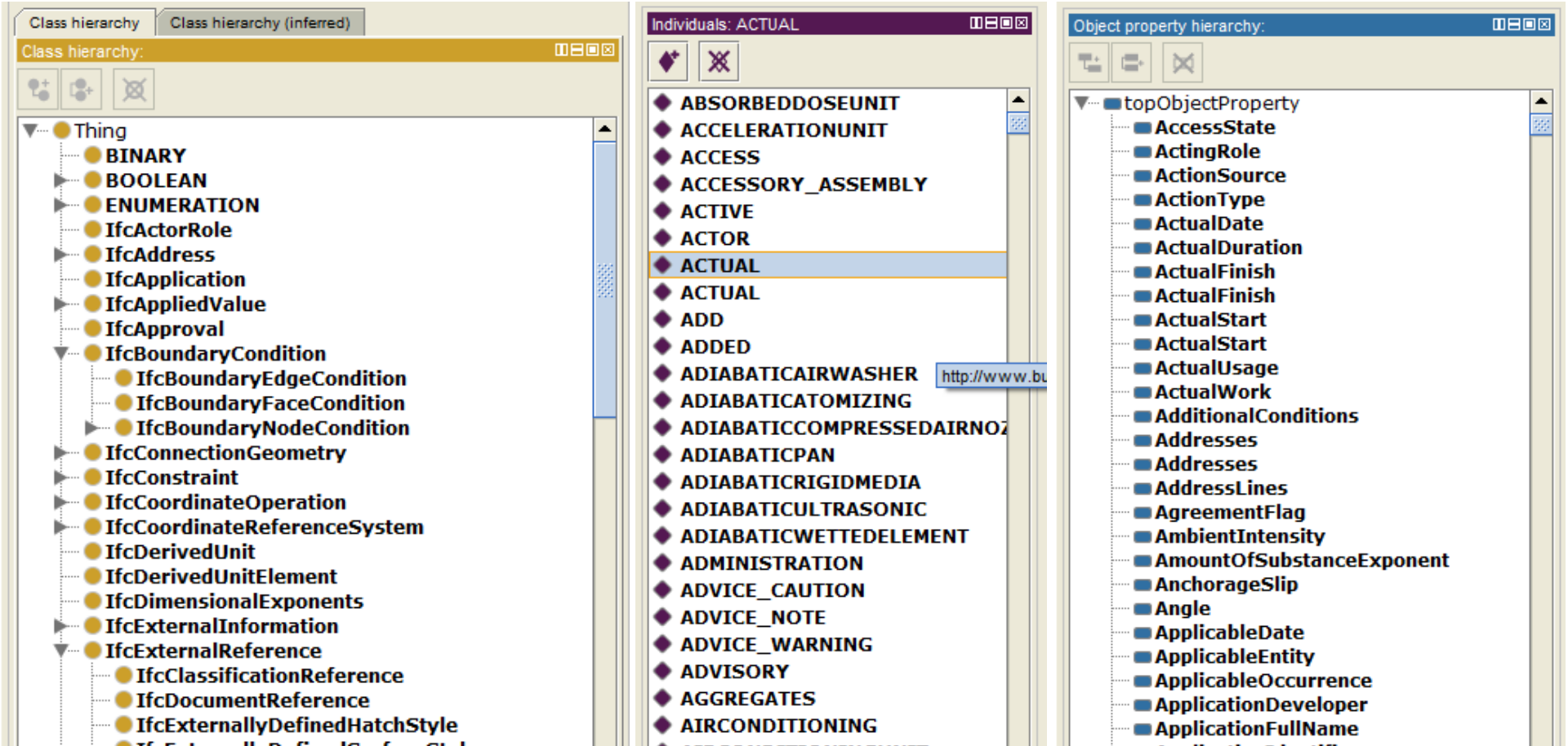
| | |
|---|---|
| Ifc2x_all_lf.exp | not supported |
| IFC2X2_ADD1.exp | not supported |
| IFC2X2_FINAL.exp | not supported |
| IFC2X2_PLATFORM.exp | not supported |
| IFC2X3_Final.exp | IFC2X3_Final.owl / .ttl |
| IFC2X3_TC1.exp | IFC2X3_TC1.owl / .ttl |
| IFC4.exp | IFC4.owl / .ttl |
| IFC4_ADD1.exp | IFC4_ADD1.owl / .ttl |

http://ifcowl.openbimstandards.org/IFC4_ADD1
http://ifcowl.openbimstandards.org/IFC4
http://ifcowl.openbimstandards.org/IFC2X3_Final
http://ifcowl.openbimstandards.org/IFC2X3_TC1

CLASSES

INDIVIDUALS

OJECT PROPERTIES

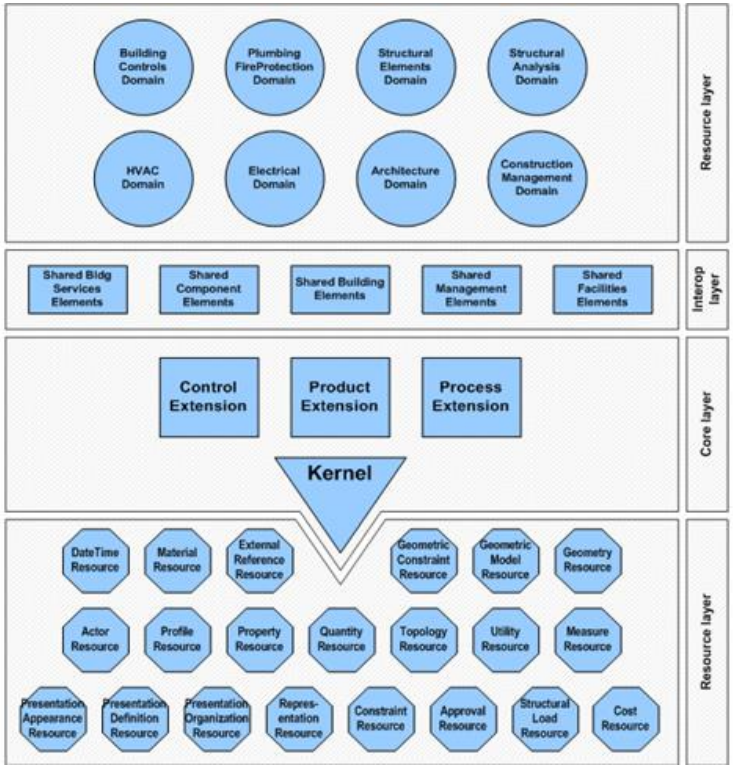


# Industry Foundation Classes (IFC)

There exists a standard, but:

- not modular
- not extensible
- not simple enough to use

- AND not Web-compliant !



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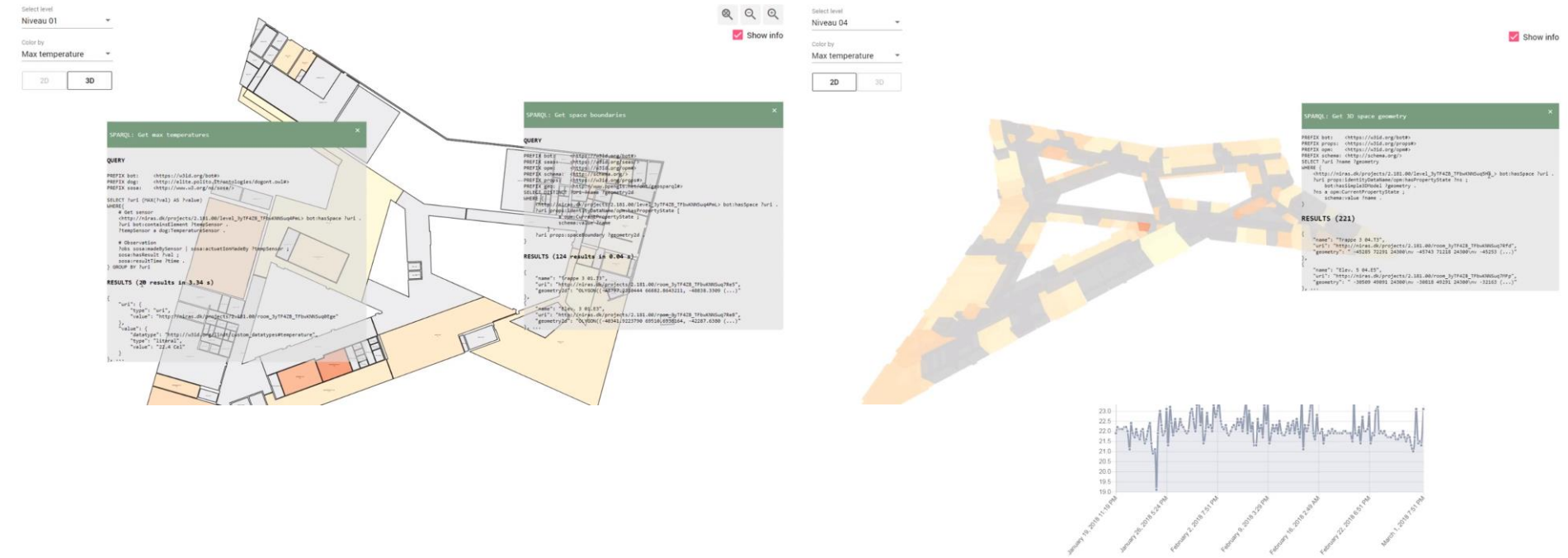
# BOT + SOSA + geometry

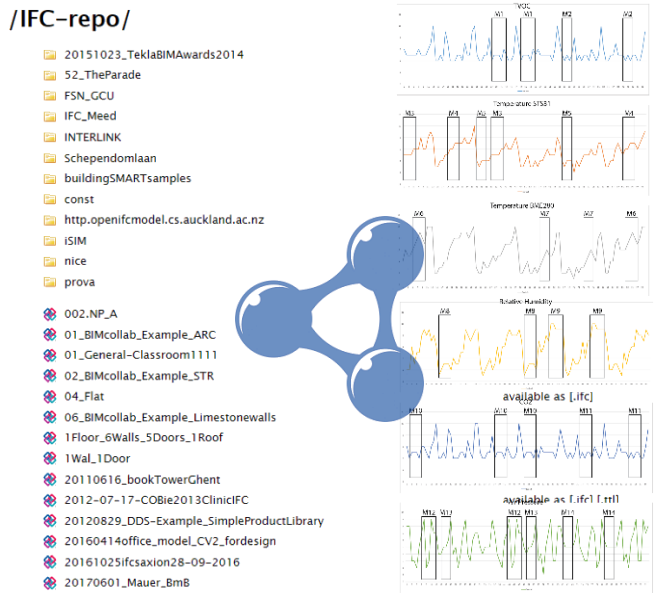


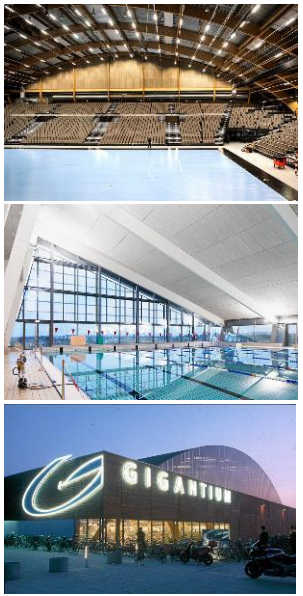

Mads Holten Rasmussen, Christian Aaskov Frausing, Christian Anker Hviid Jan Karlshøj, Integrating Building Information Modeling and Sensor Observations using Semantic Web, Semantic Sensor Networks Workshop, https://youtu.be/P_38gIvrbmg

# Implementation @Gigantium Denmark - Combination with sensor data

Repo of 531 LBD building graphs

- 36 million triples in total
- 372 bot:Building instances
- 3,523 bot:Zone instances
- 2,117 bot:Space instances
- 615,452 bot:Element instances

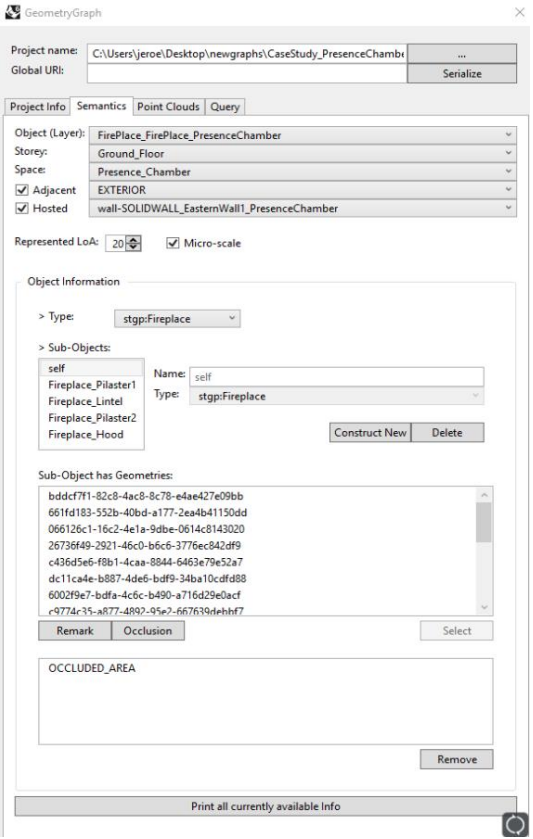


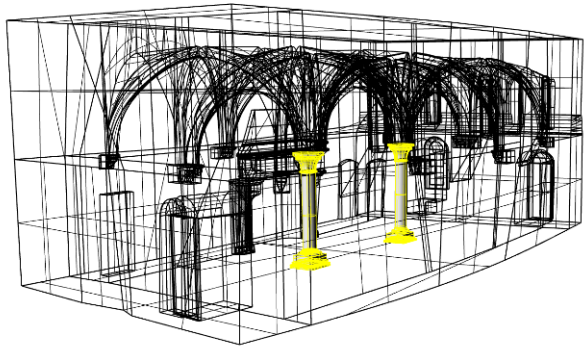



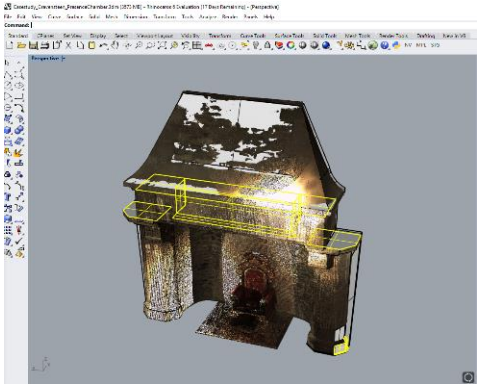

converted from http://smartlab1.elis.ugent.be:8889/IFC-repo/
to LBD using https://github.com/jyrkioraskari/IFCtoLBD

Ekaterina Petrova, Pieter Pauwels, Kjeld Svidt, Rasmus Lund Jensen, Towards data-driven sustainable design: decision support based on knowledge discovery in disparate building data, Architectural Engineering and Design Management (2018) p.1-23

# Scan to LBD Graph



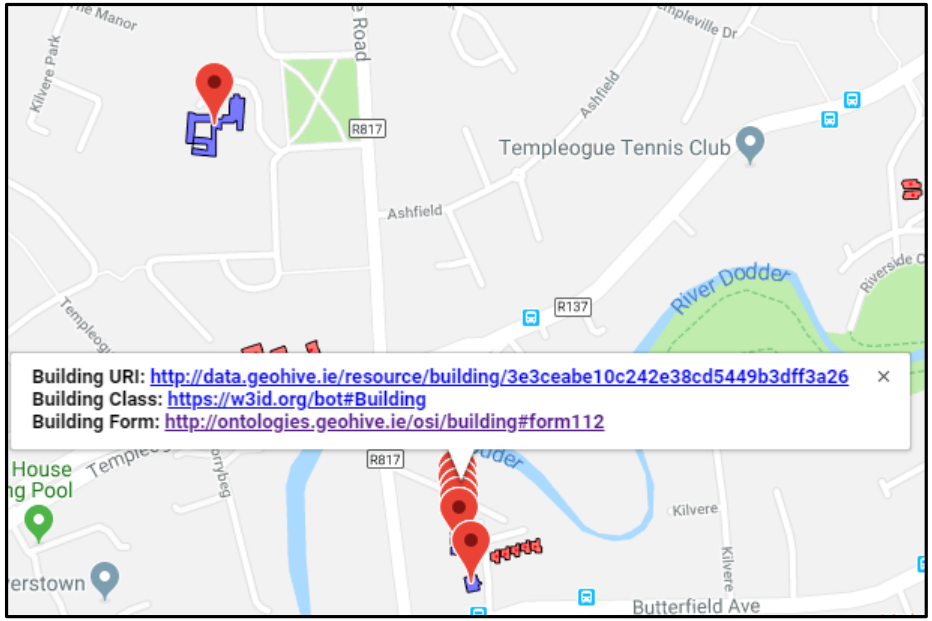


Jeroen Werbrouck, Semantic enrichment of the existing building geometry. Master Thesis 2018, Ghent University.

# BOT and geospatial data

- Using BOT to interlink Ordnace Survey Ireland building data (>3.5 million buildings)
- Provide a registry of authoratative URI's for Irish building stock.

- http://geovis.adaptcentre.ie/
  - Username: odef_adapt
  - Password: geo123




Kris McGlinn, BOT and geospatial data, https://www.scss.tcd.ie/~mcglink/video/tutorial/geovis/geovis.html

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# The cool and awesome intro movies


https://vimeo.com/36752317

https://www.youtube.com/watch?v=4x_xzT5eF5Q

https://www.youtube.com/watch?v=OM6XIICm_qo

# Resource Description Framework

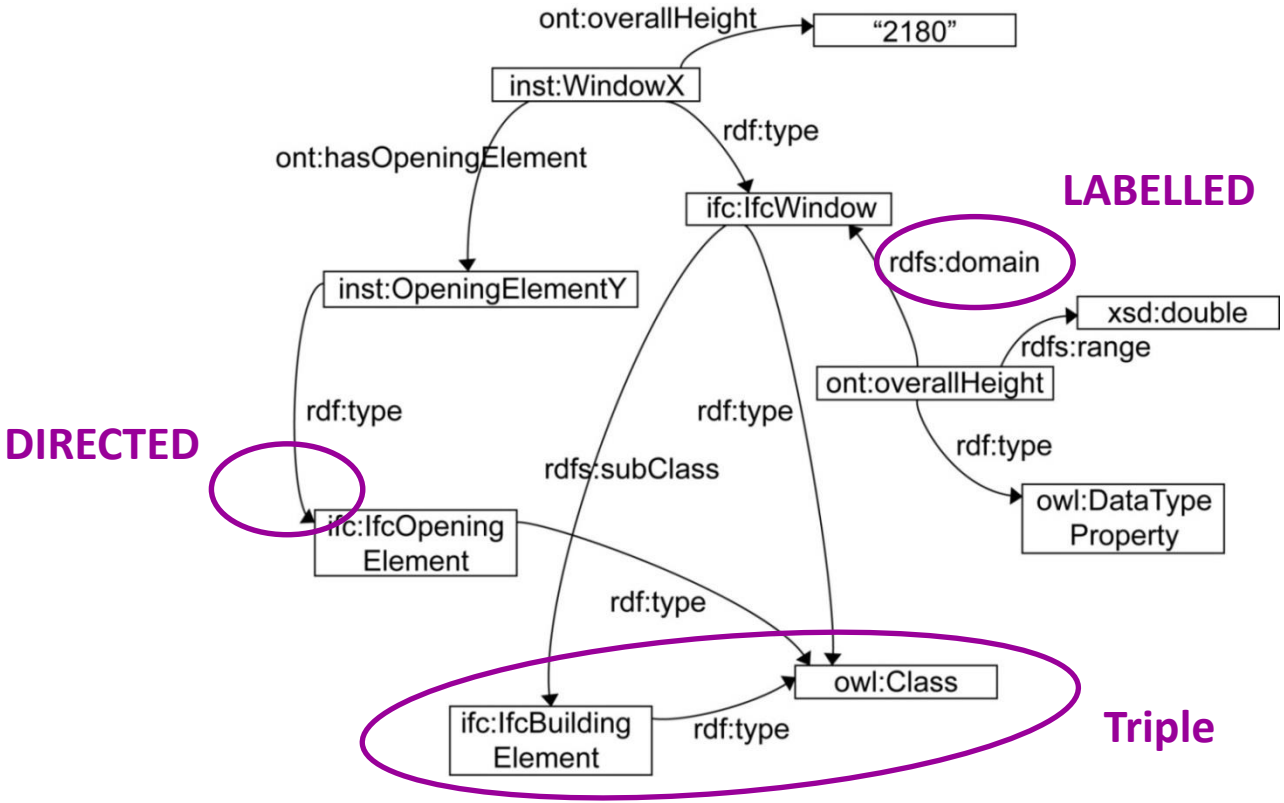
- RDF stands for Resource Description Framework
- RDF is a standard data model for describing web resources
  - Note: 'web resources' can make statements about anything in the real world: DBPedia, geography, building information, sensors, … anything goes
- RDF is designed to be read and understood by computers
- RDF is not designed for being displayed to people
- RDF is written in XML usually
- RDF is a W3C Recommendation -> standardisation

**easily used**

**not a file format, not a syntax, not a schema, … => a data model**

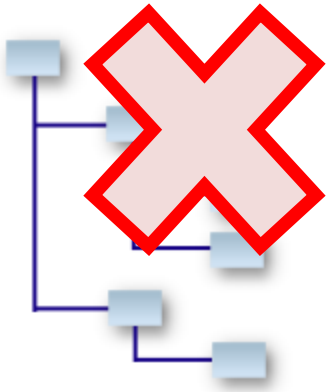
http://www.w3schools.com/webservices/ws_rdf_intro.asp

# RDF Graphs, what are they?

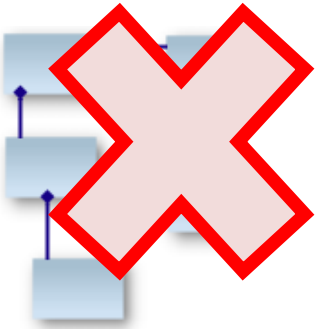


# RDF Graphs, what are they not?

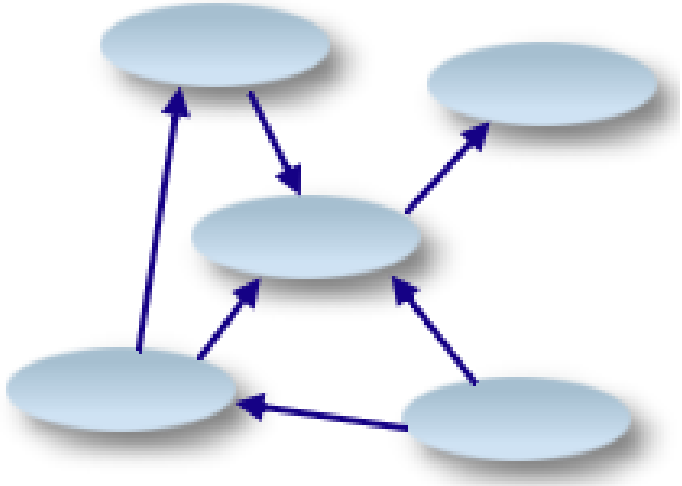
Hierarchies (cfr. XML)



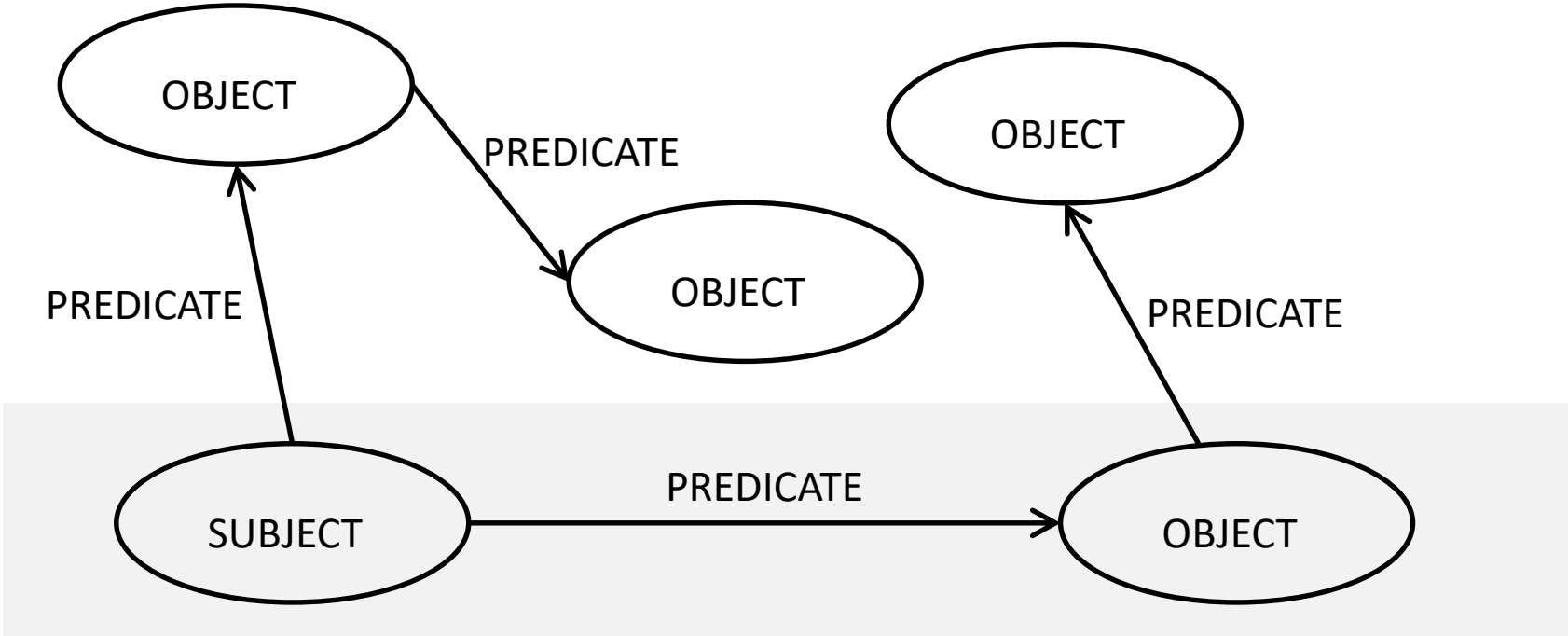
Relational databases (cfr. SQL)

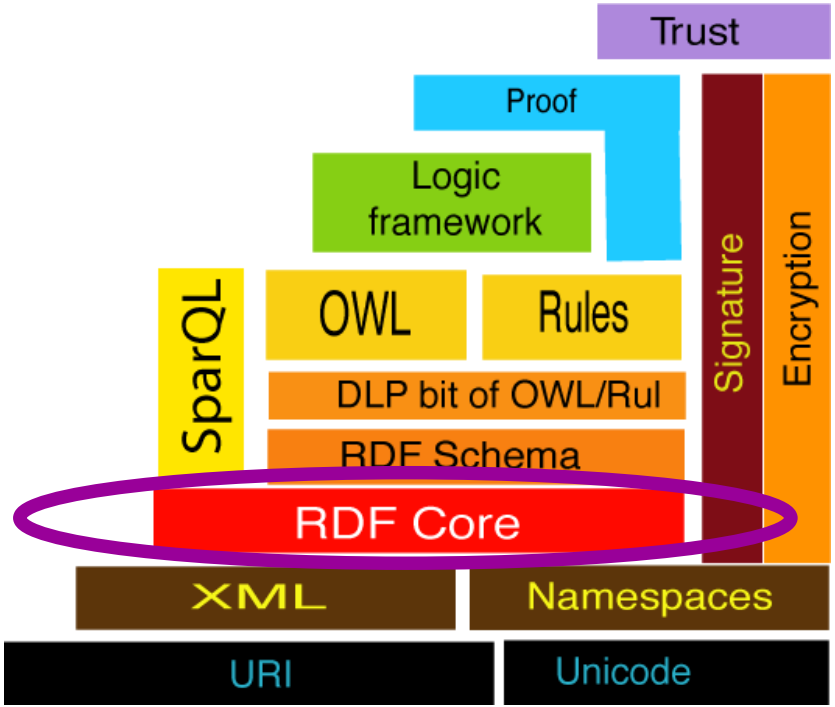


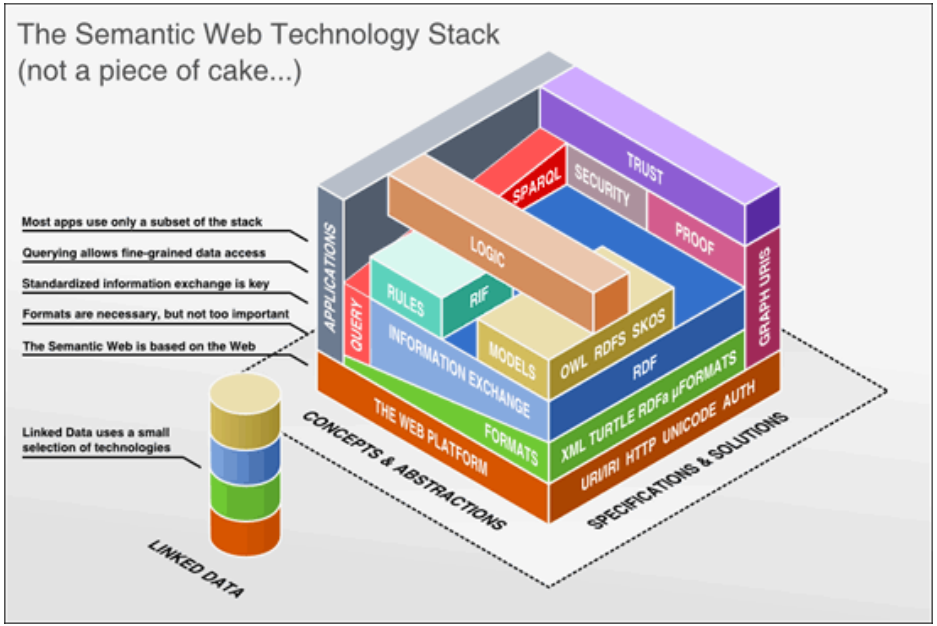
RDF graphs are DIRECTED, LABELLED GRAPHS



# Connecting Triples






Tim Berners-Lee. WWW past & future, 2003. http://www.w3.org/2003/Talks/0922-rsoc-tbl/.

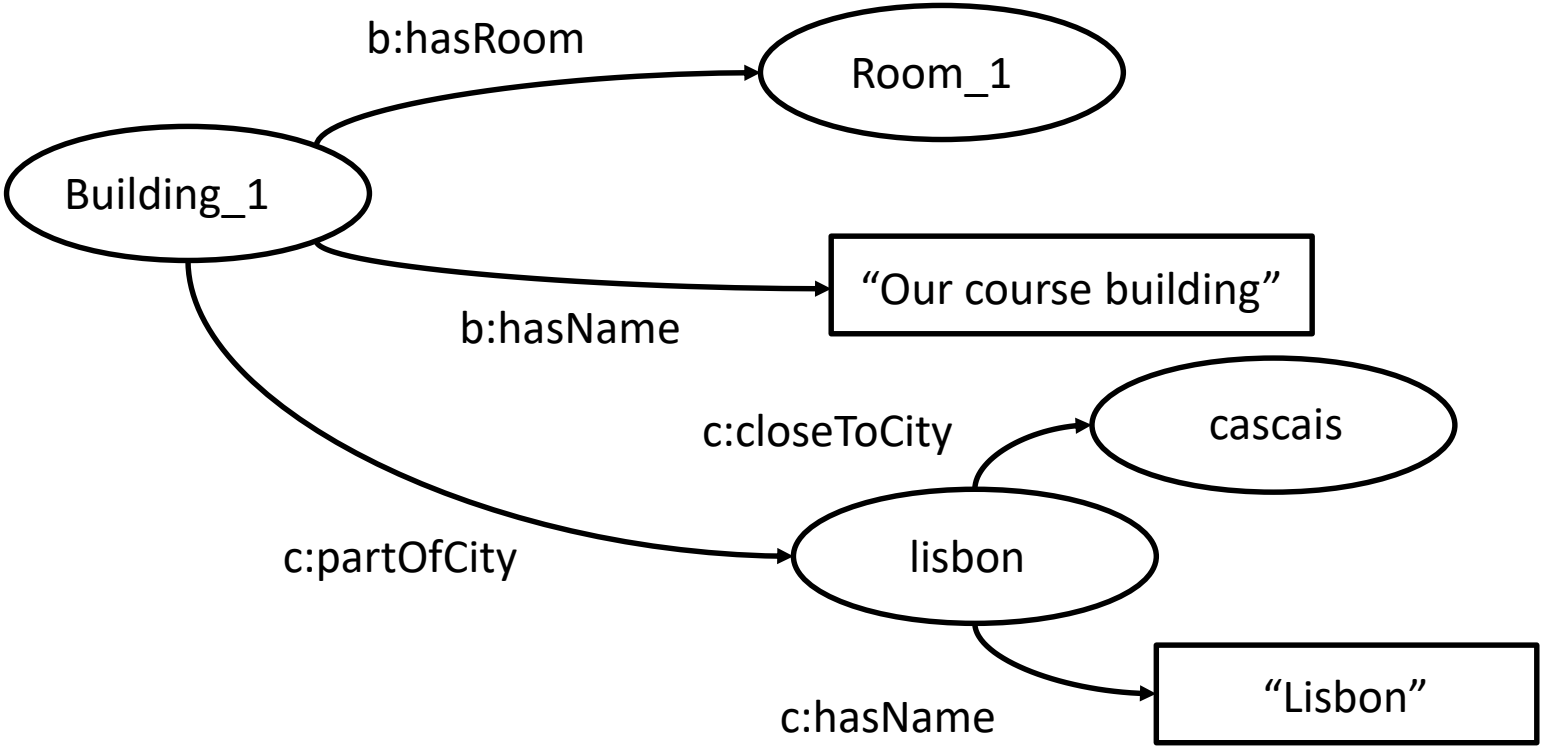
# Example RDF graph

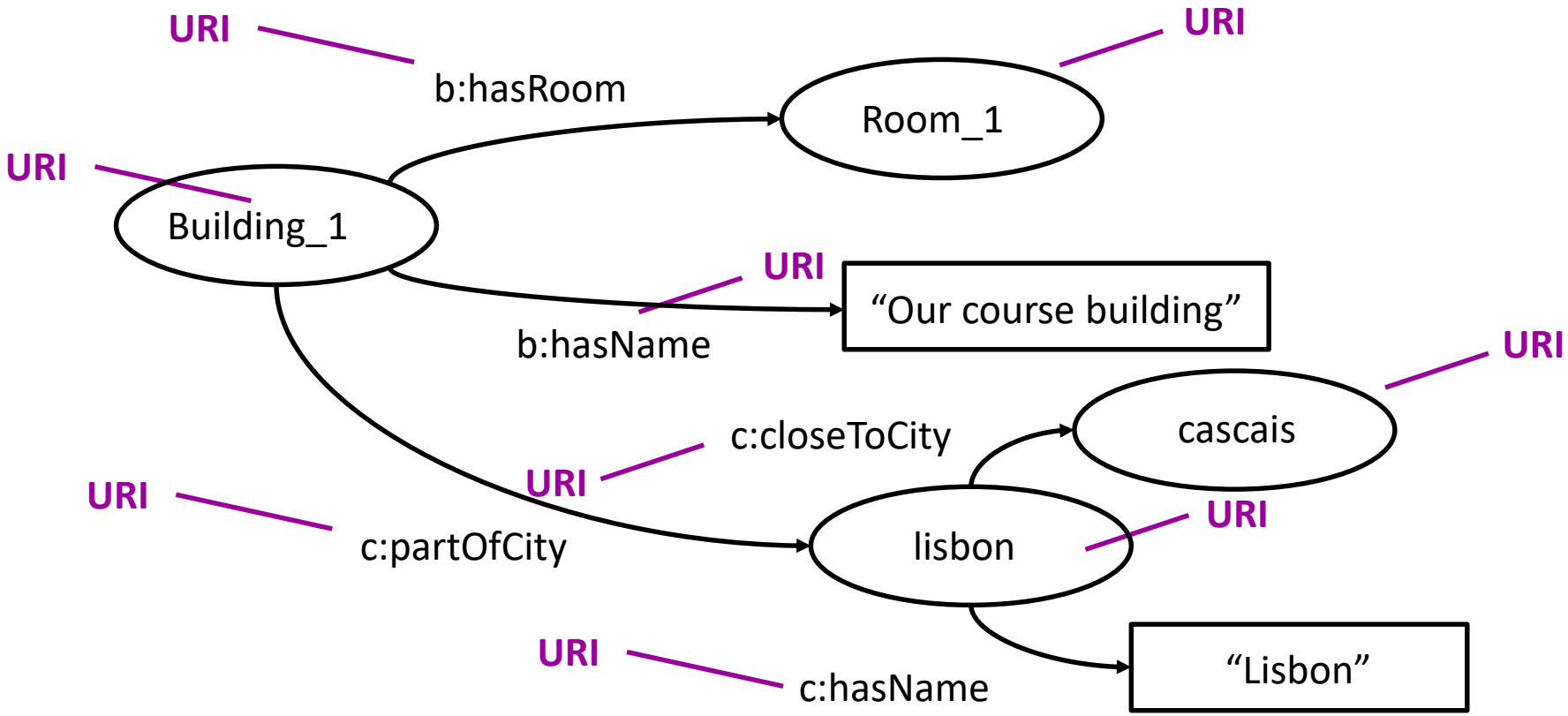
```
@prefix b: <http://www.beta-i.com/building#> .
@prefix c: <http://www.beta-i.com/city#> .

<http://www.beta-i.com/today#building_1>
        b:hasRoom <http://www.beta-i.com/today#room_1> ;
        b:hasName “Our course building";
        c:partOfCity <http://cities.com/#lisbon> .

<http://cities.com/#lisbon>
        c:closeToCity <http://cities.com/#cascais> ;
        c:hasName “Lisbon” .
```

# Example RDF graph




URI
b:hasRoom
URI
Room_1
URI
Building_1
URI
b:hasName
“Our course building”
URI
cascais
c:closeToCity
URI
URI
c:partOfCity
lisbon
URI
URI
c:hasName
“Lisbon”

# Uniform Resource Identifiers (URIs)

- URI stands for Uniform Resource Identifier
- Purpose: Obtain globally unique identifiers, so that information can be exchanged globally.
- Structure:

<http://www.beta-i.com/today#building_1>

**Namespace** **Name**

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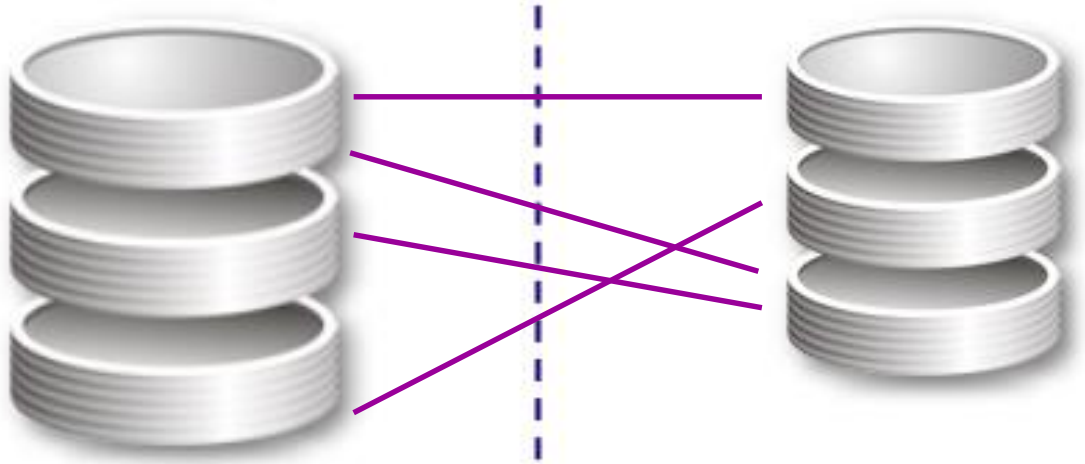
# Data integration now possible

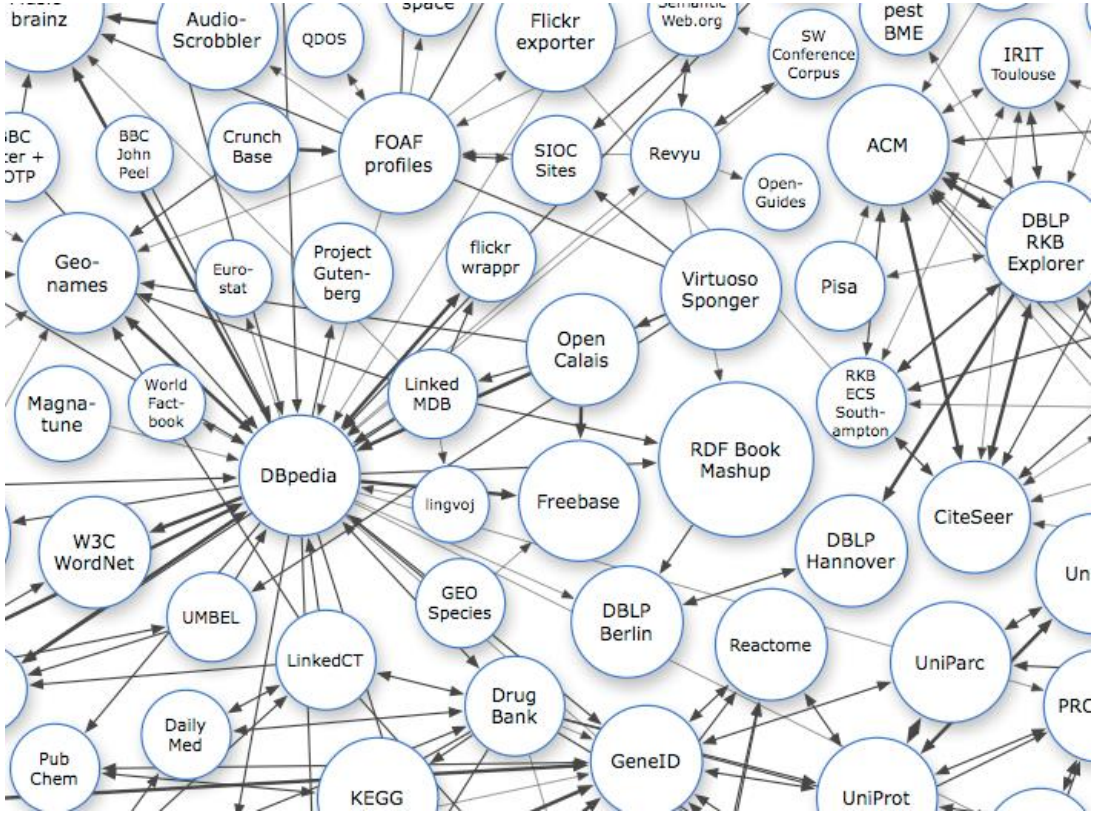


MyBuilding Cities

# Main principles

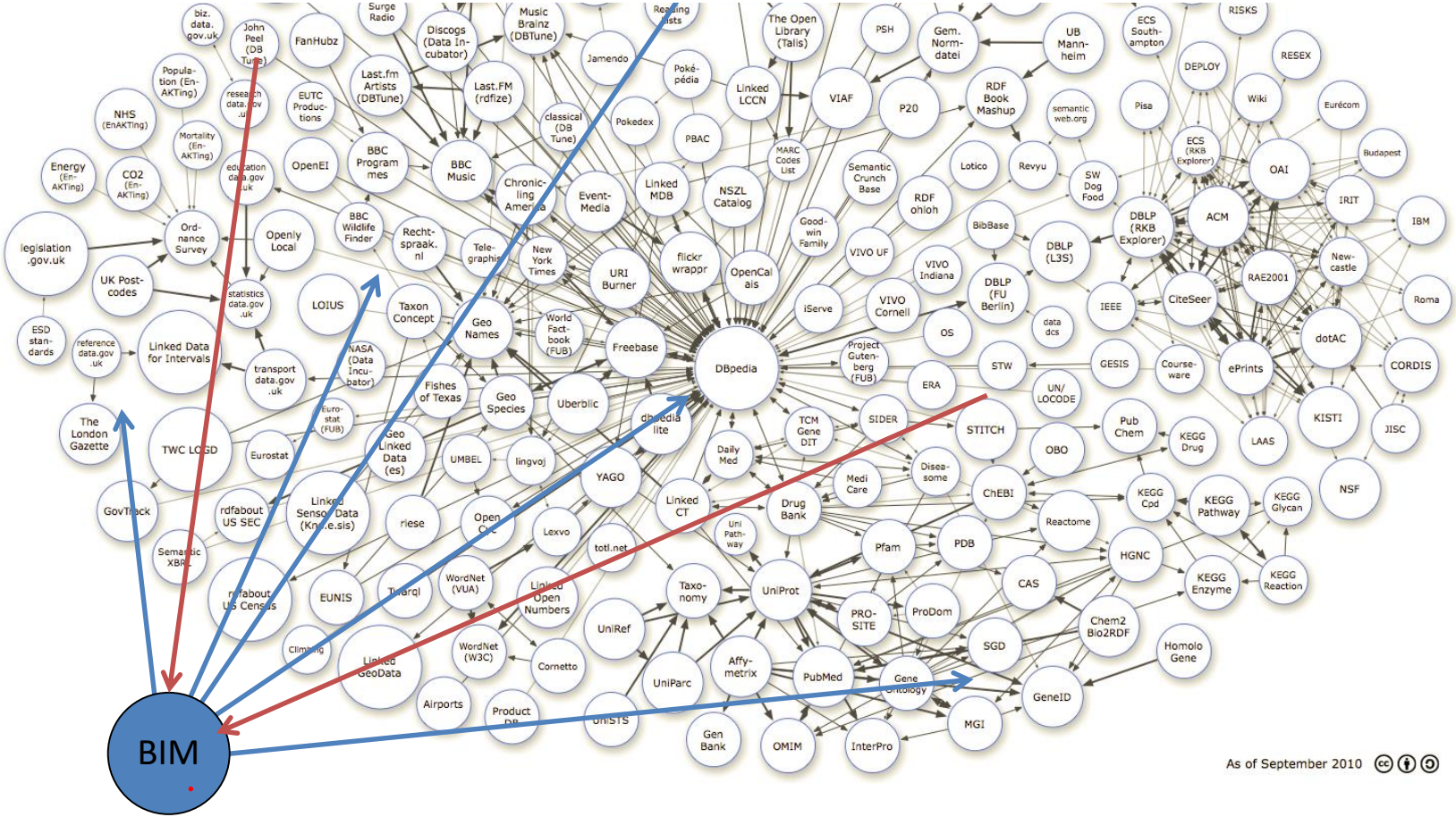
- distributed / decentralised information management
- interactive information search and reasoning over the web
- sharing partial data

# Linked Open Data cloud (LOD)

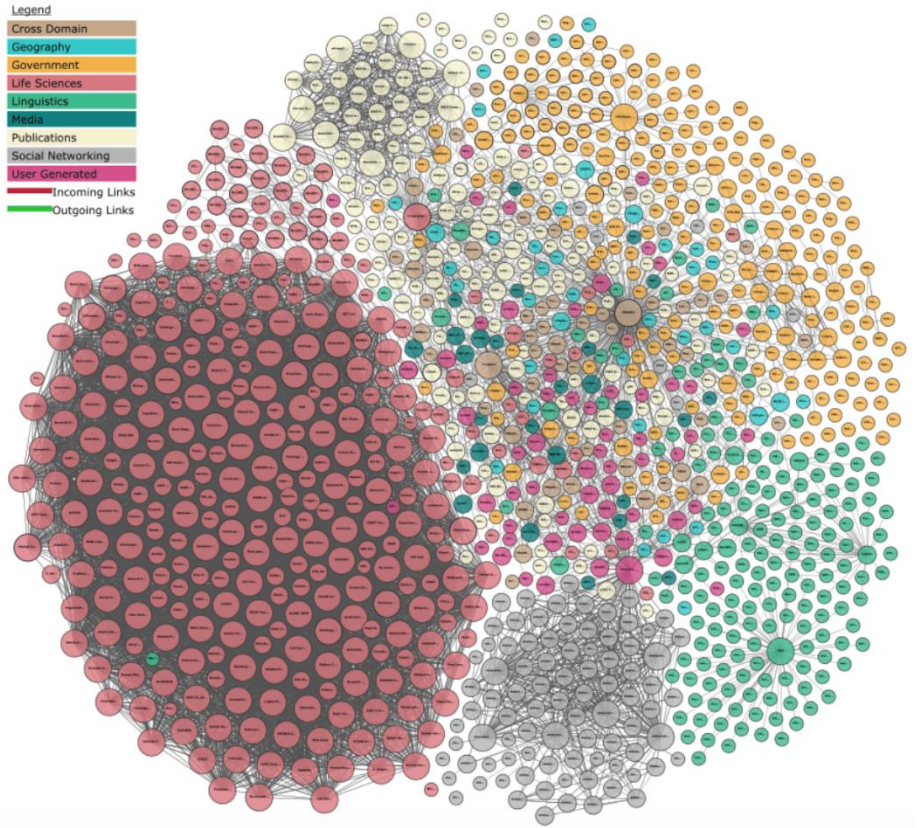



http://tomheath.com/blog/2009/03/linked-data-web-of-data-semantic-web-wtf/

# Bring BIM into the Semantic Web



# LOD cloud grouped per domain




Legend

- Cross Domain
- Geography
- Government
- Life Sciences
- Linguistics
- Media
- Publications
- Social Networking
- User Generated
- Incoming Links
- Outgoing Links

https://lod-cloud.net/

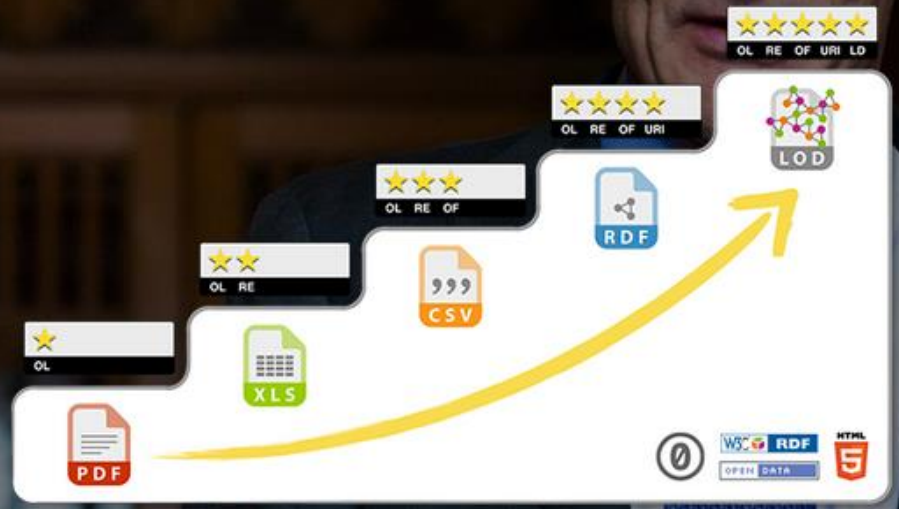
5stardata.info/en/

5 ★ OPEN DATA

BY EXAMPLE COSTS & BENEFITS SEE ALSO

# 5 ★ OPEN DATA

Tim Berners-Lee, the inventor of the Web and Linked Data initiator, suggested a 5-star deployment scheme for Open Data. Here, we give examples for each step of the stars and explain costs and benefits that come along with it.



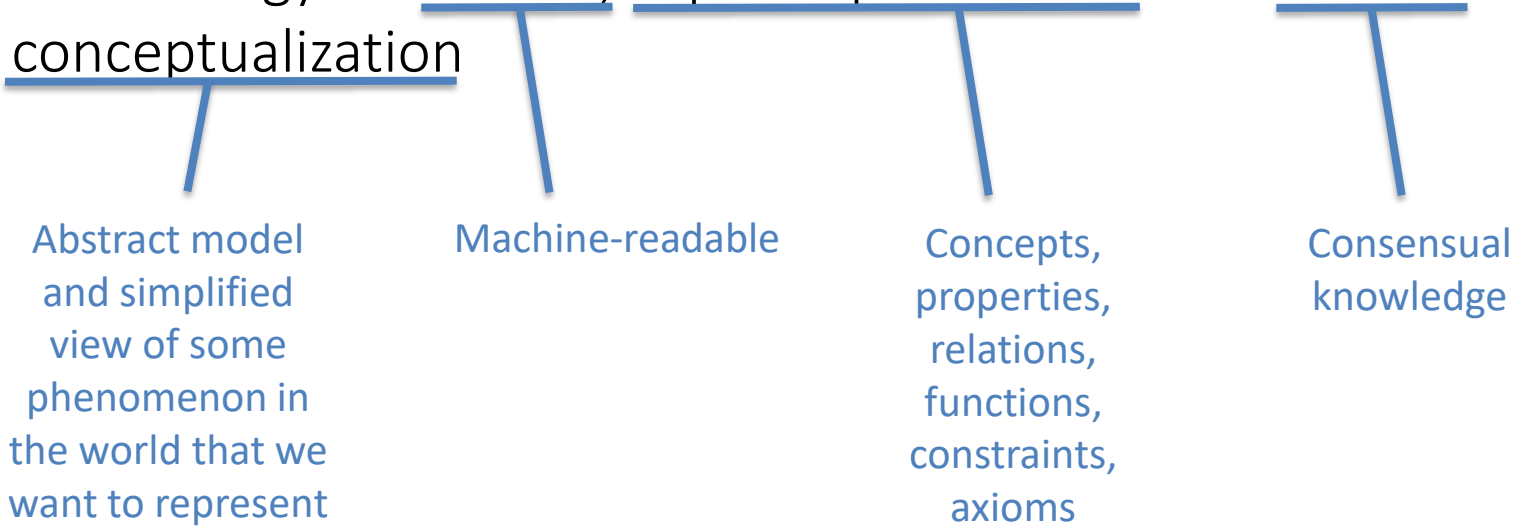
# BY EXAMPLE ...

Below, we provide examples for each level of Tim's 5-star Open Data plan. The example data used throughout is '*the temperature forecast for Galway, Ireland for the next 3 days*':

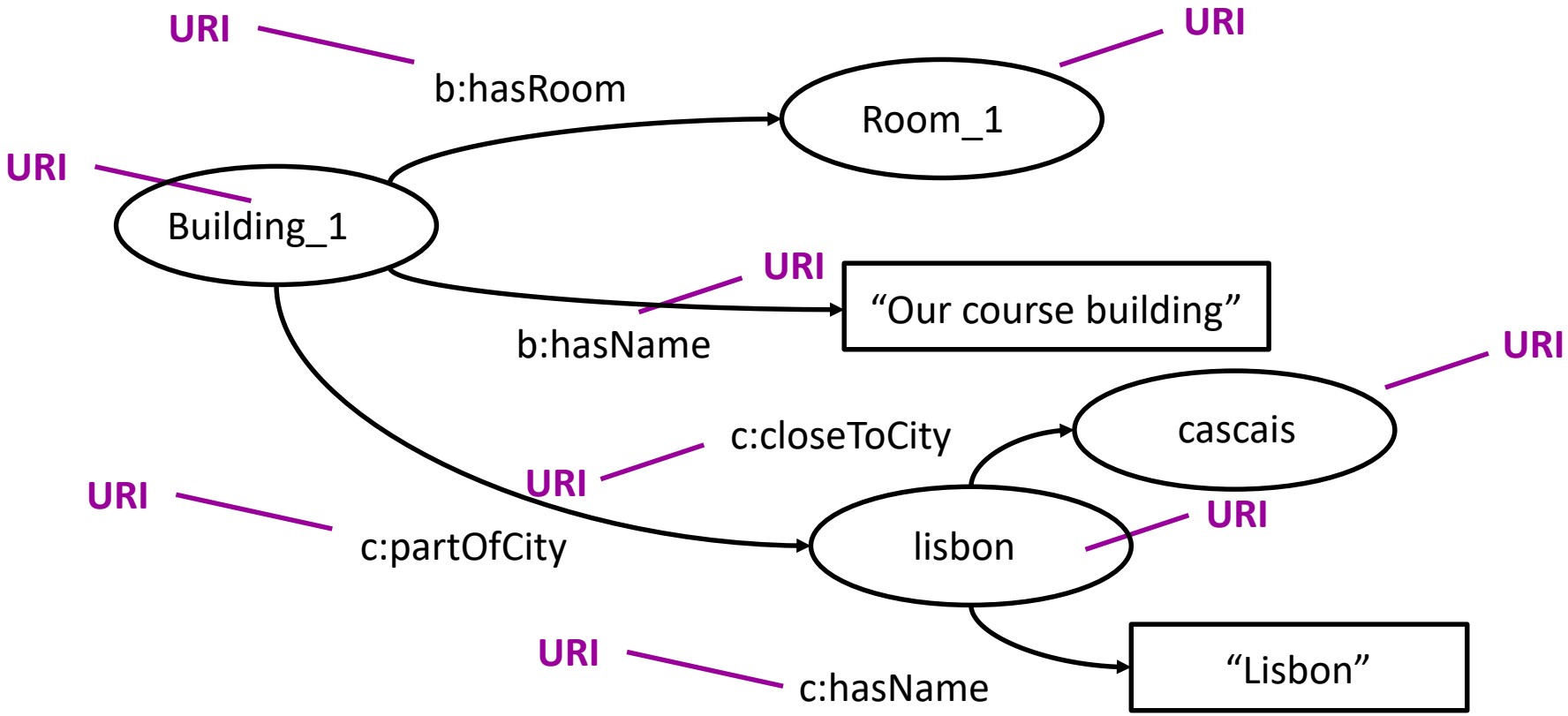
| | | |
|---|---|---|
| ★ | make your stuff available on the Web (whatever format) under an open license[1] | example ... |
| ★★ | make it available as structured data (e.g., Excel instead of image scan of a table)[2] | example ... |
| ★★★ | make it available in a non-proprietary open format (e.g., CSV as well as of Excel)[3] | example ... |
| ★★★★ | use URIs to denote things, so that people can point at your stuff[4] | example ... |
| ★★★★★ | link your data to other data to provide context[5] | example ... |

# What else?

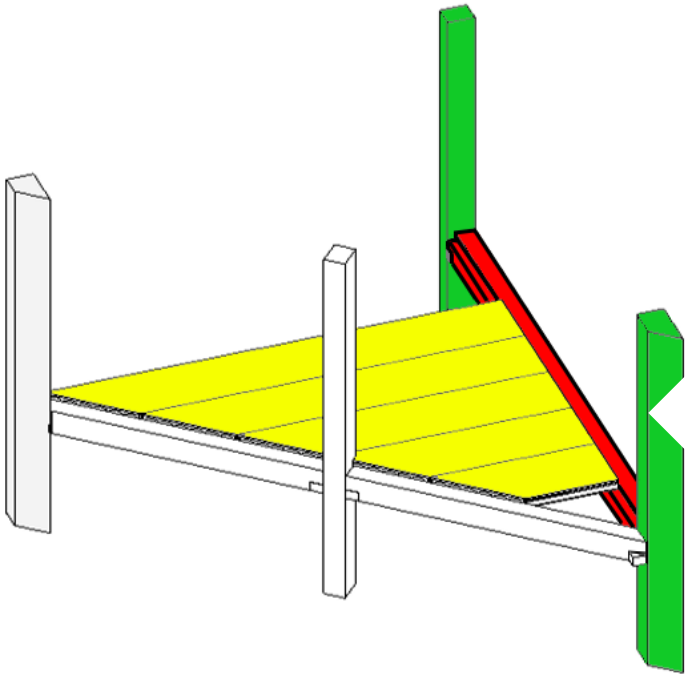
- Ontologies
- An ontology is a formal, explicit specification of a shared conceptualization

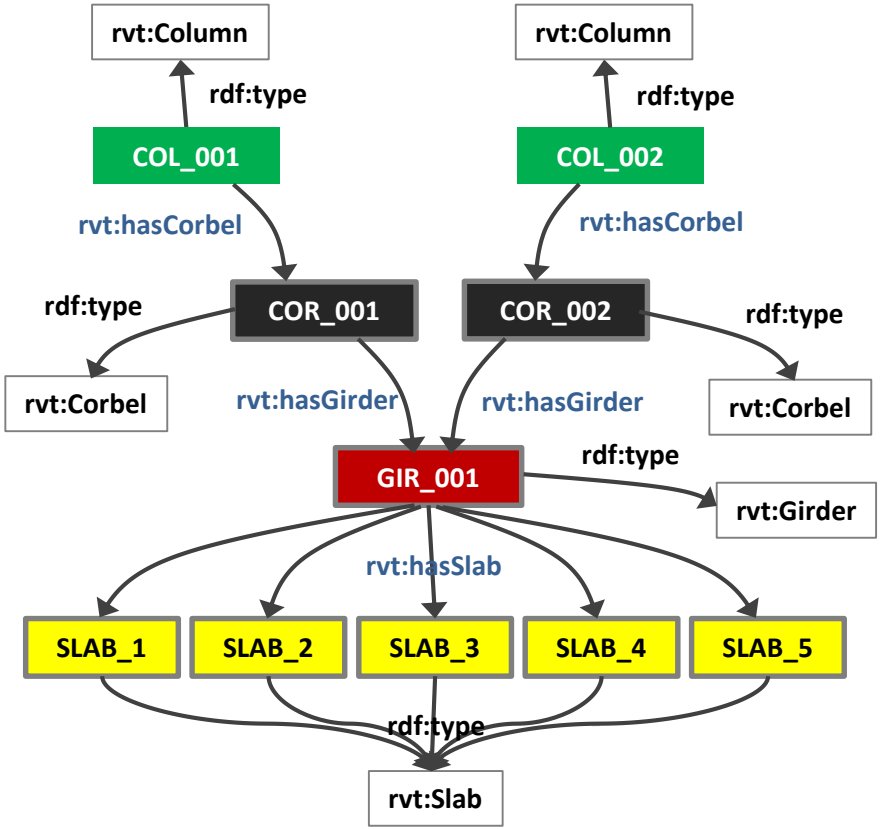



R. Studer, V.R. Benjamins, D. Fensel. Knowledge engineering: Principles and methods. Data & Knowledge Engineering 25(1-2): 1998. 161-197.
T.R. Gruber. A translation approach to portable ontology specifications. Knowledge Acquisition 5(2): 1993. 199-220.


URI
b:hasRoom
URI
Room_1
URI
Building_1
URI
b:hasName
“Our course building”
URI
cascais
c:closeToCity
URI
URI
c:partOfCity
lisbon
URI
URI
c:hasName
“Lisbon”

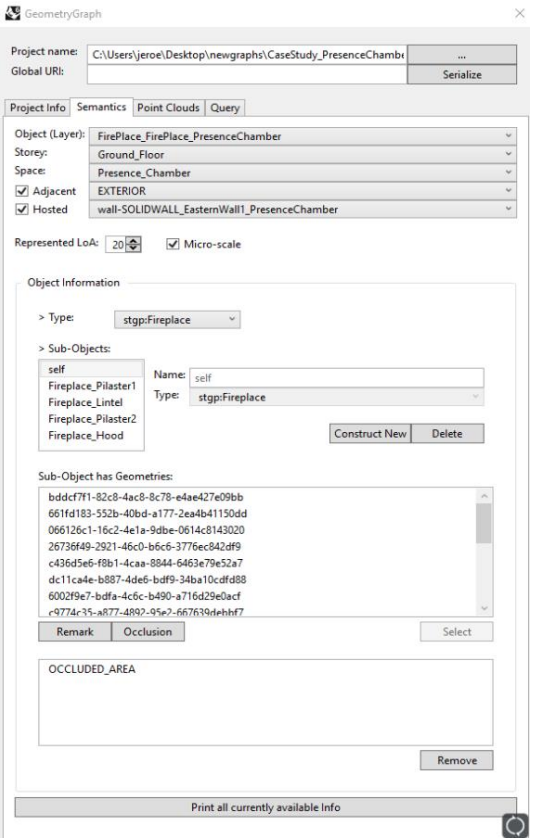
# Standard vocabulary (1)

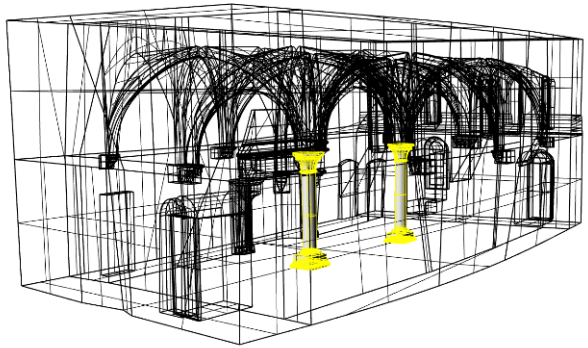


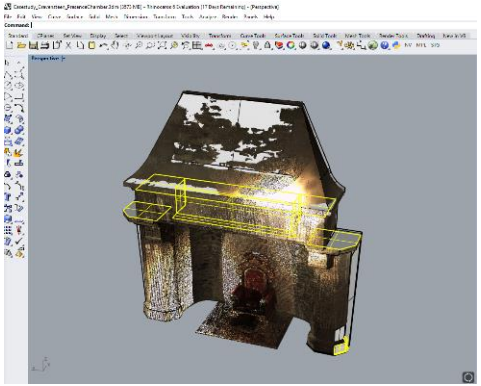



G. Costa, P. Pauwels. Building product suggestions for a BIM model based on rule sets and a semantic reasoning engine. Proceedings of the 32rd international CIB W78 conference. 2015. p.98-107.

# Choose your ontologies wisely





Jeroen Werbrouck, Semantic enrichment of the existing building geometry. Master Thesis 2018, Ghent University.

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# Thank you

Pieter Pauwels
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UNIVERSITEIT GENT