Linked Data and the Semantic Web: the Basics

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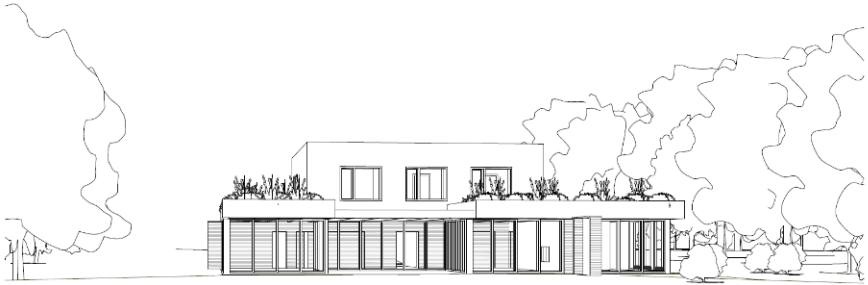
LDAC Summer School

17 June 2019

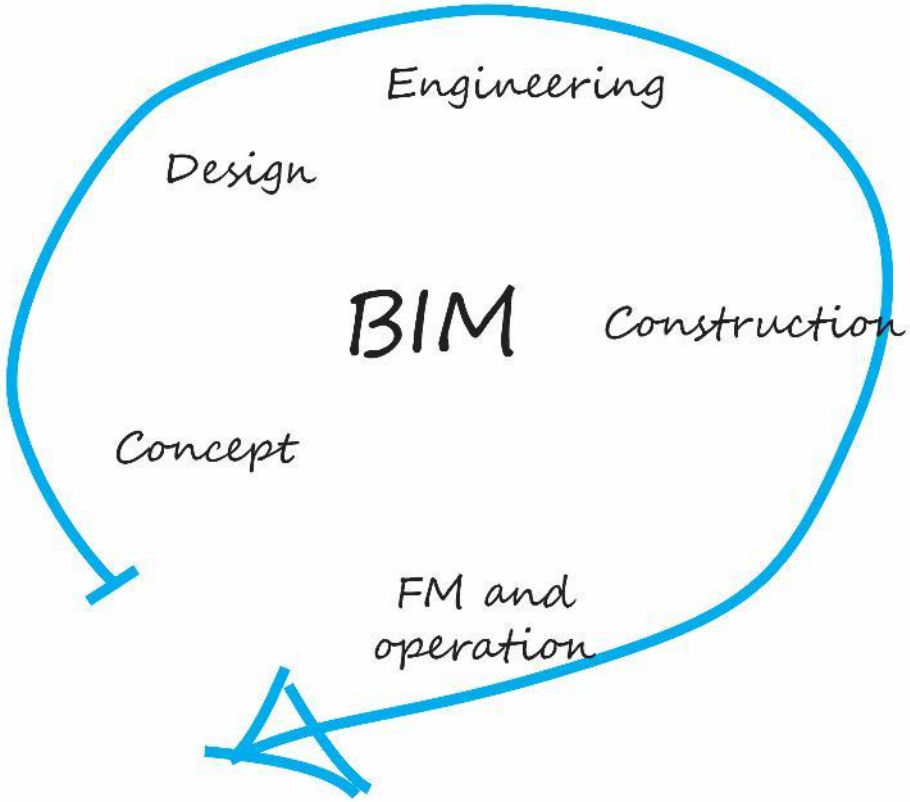
Outline

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



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8. Resource definition data schemas
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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**

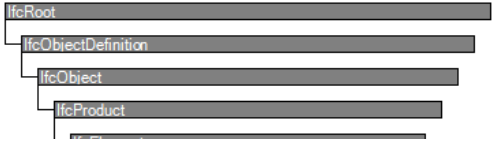
#	Attribute	Type	Cardinality	Description	G
9	PredefinedType	IfcAlarmTypeEnum	?		X

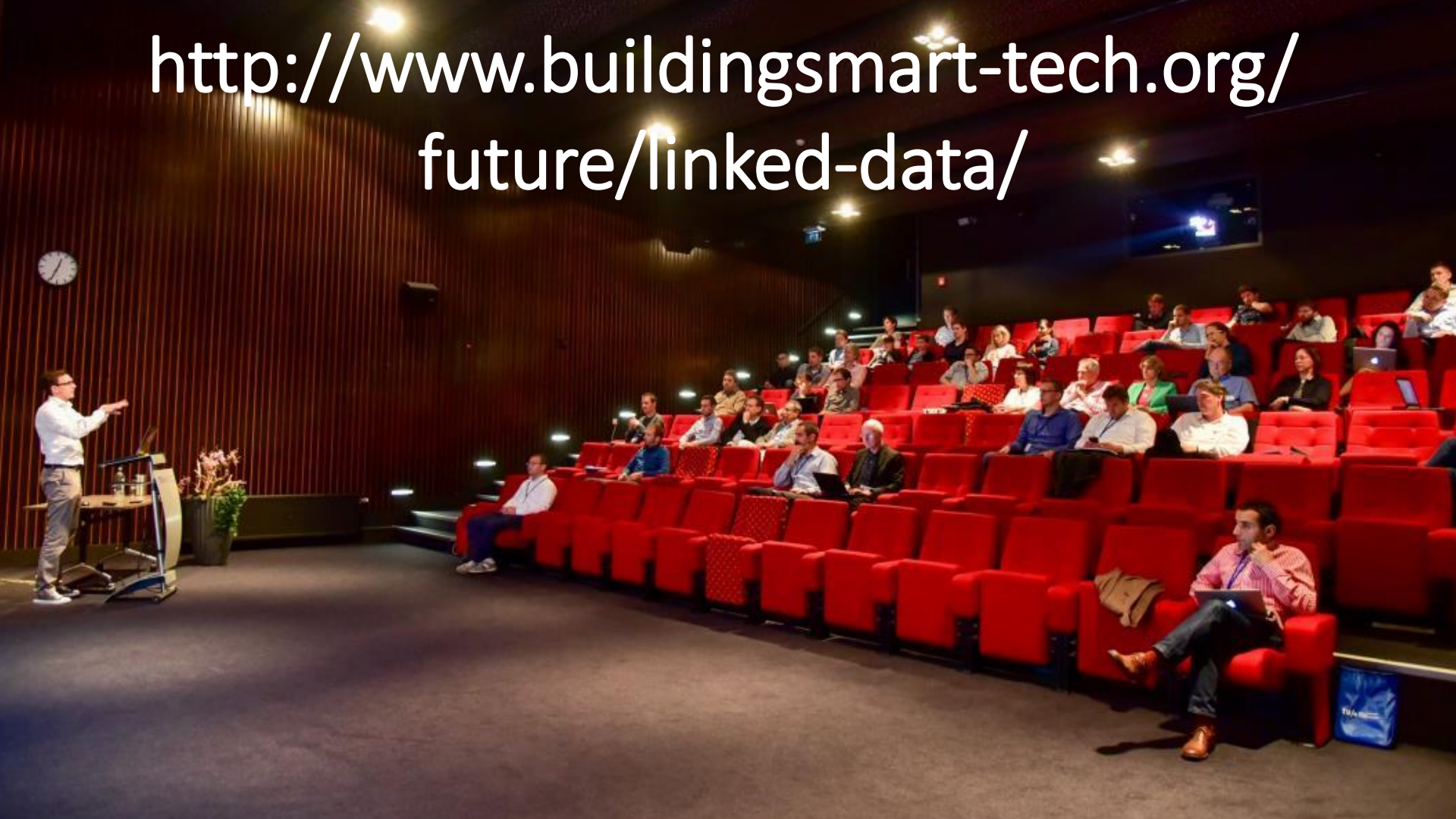
▼ **Formal Propositions**

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

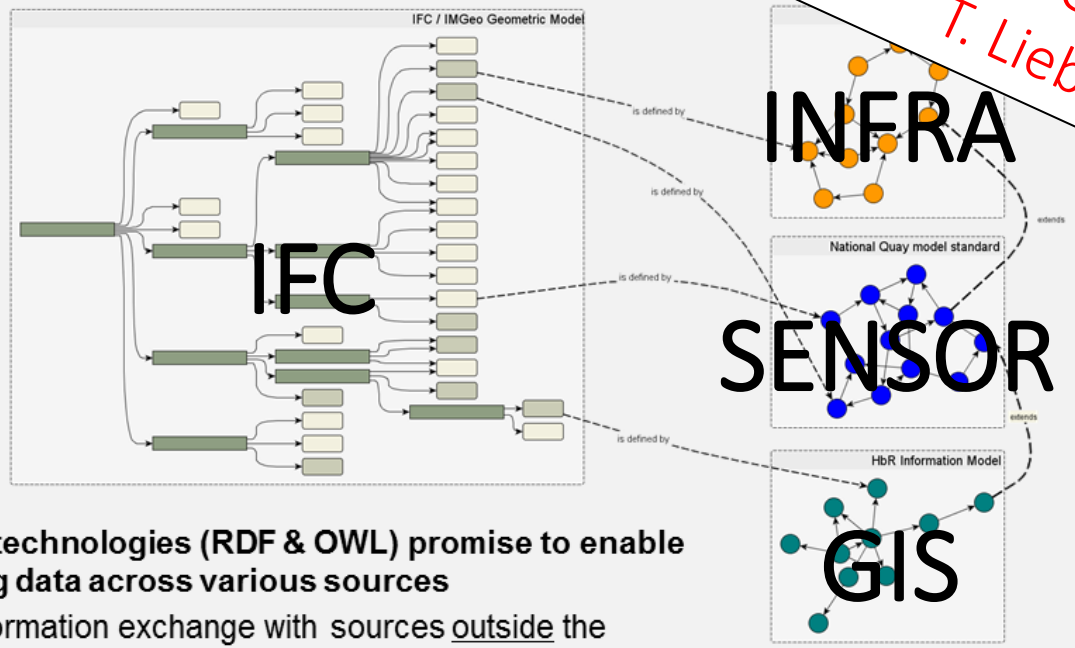
▼ **Entity inheritance**




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

Goal of Linked Data in Construction

Toronto Oct. 2014
T. Liebich

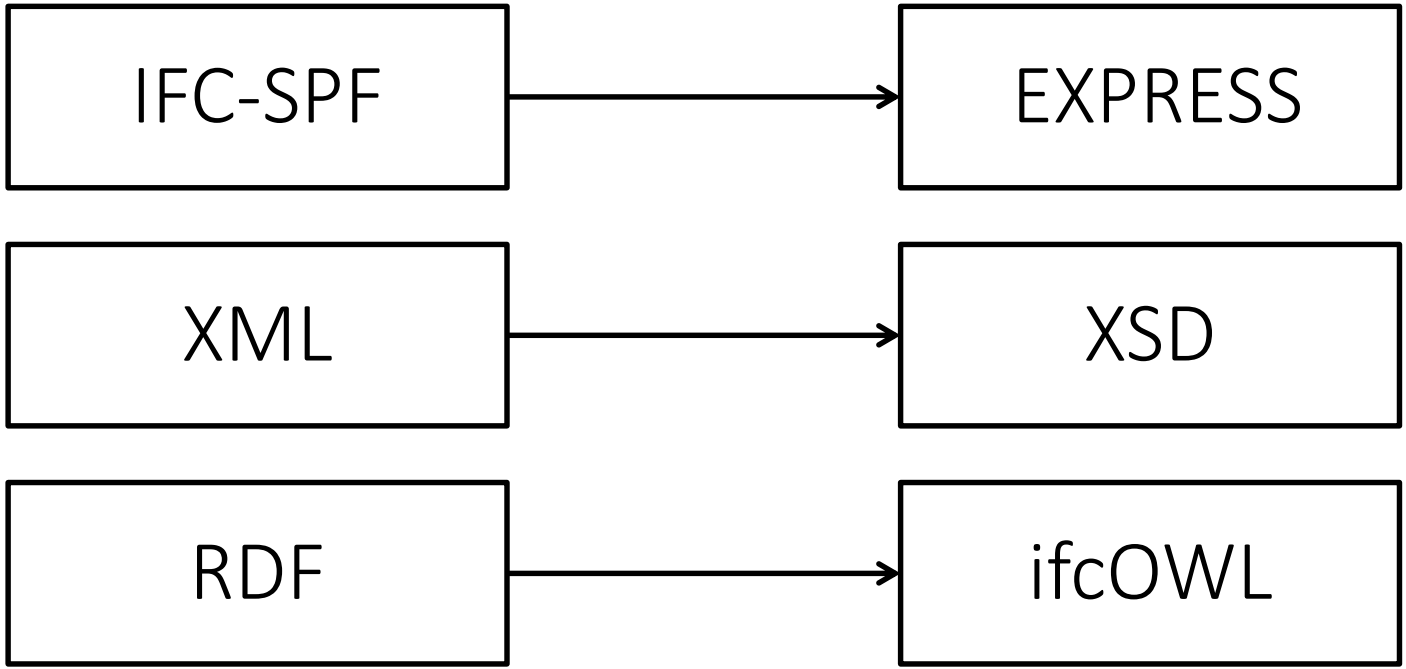


Semantic web technologies (RDF & OWL) promise to enable linking building data across various sources

⇒ 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

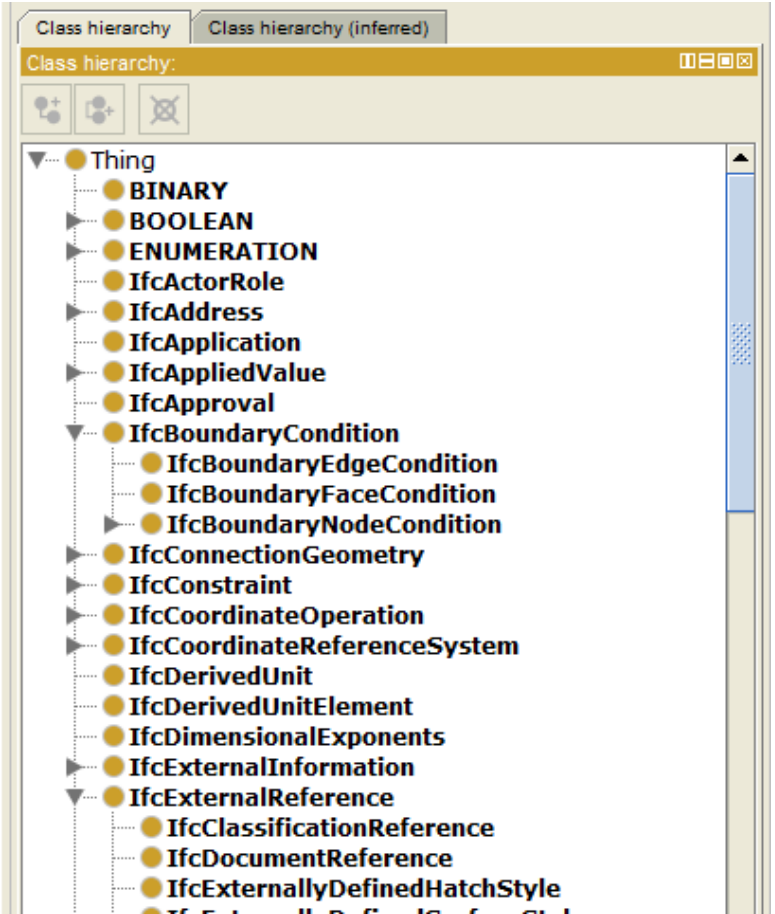
Ifc2x_all_lf.exp	not supported
IFC2X2_ADD1.exp	not supported
IFC2X2_FINAL.exp	not supported
IFC2X2_PLATFORM.exp	not supported
IFC2X3_Final.exp	IFC2X3_Final.owl / .ttl
IFC2X3_TC1.exp	IFC2X3_TC1.owl / .ttl
IFC4.exp	IFC4.owl / .ttl
IFC4_ADD1.exp	IFC4_ADD1.owl / .ttl

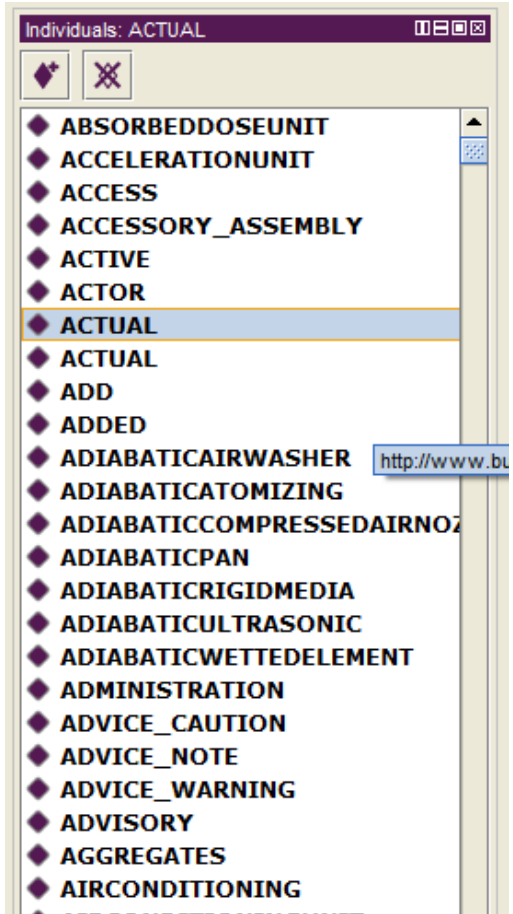
http://ifcowl.openbimstandards.org/IFC4_ADD1
http://ifcowl.openbimstandards.org/IFC4
http://ifcowl.openbimstandards.org/IFC2X3_Final
http://ifcowl.openbimstandards.org/IFC2X3_TC1

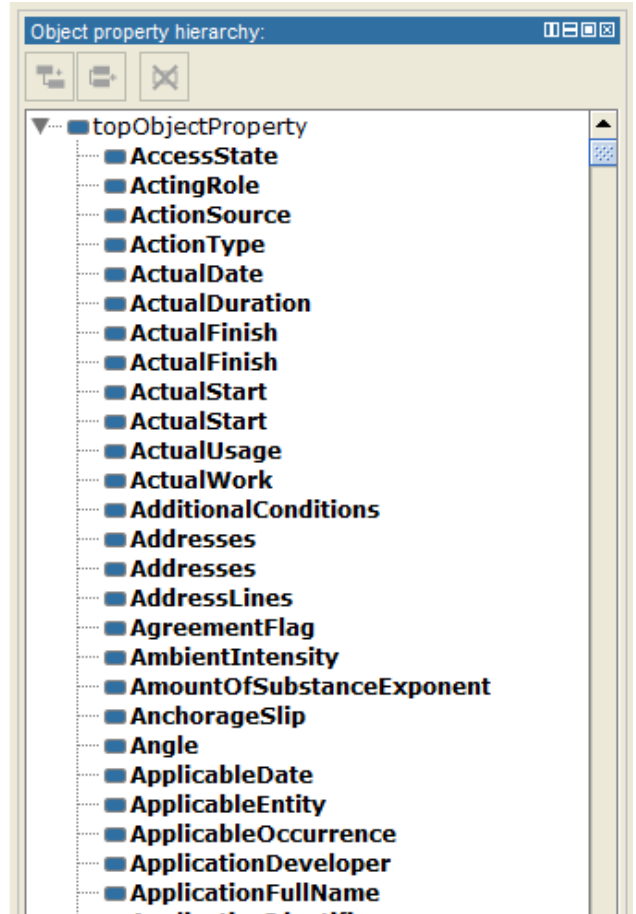
CLASSES

INDIVIDUALS

OJECT PROPERTIES





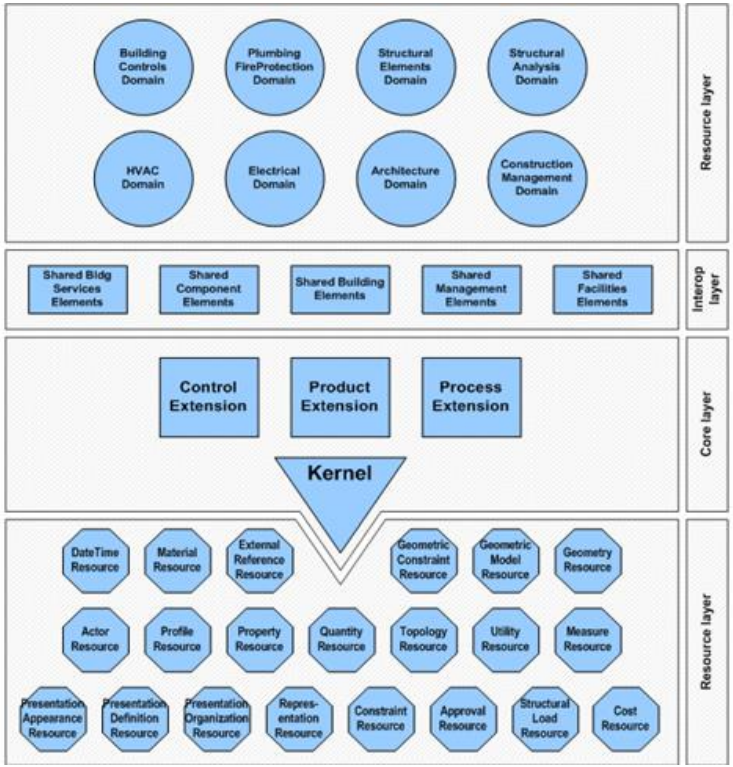


Industry Foundation Classes (IFC)

There exists a standard, but:

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

- AND not Web-compliant !



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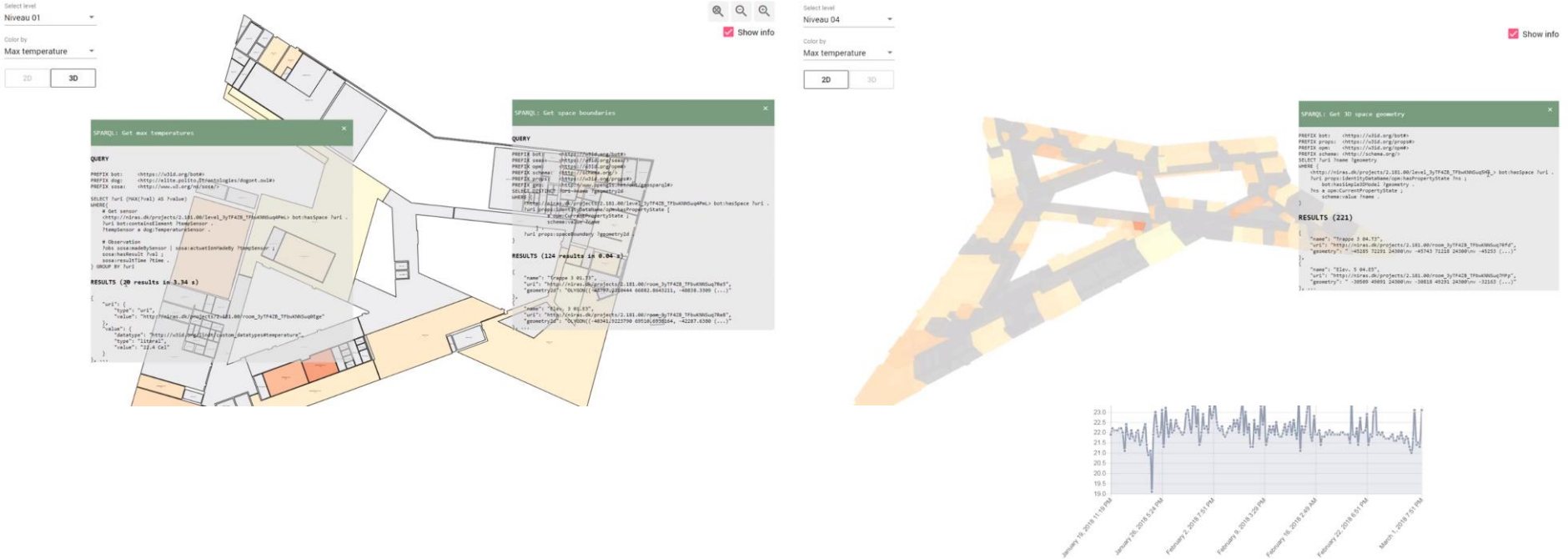
BOT + SOSA + geometry

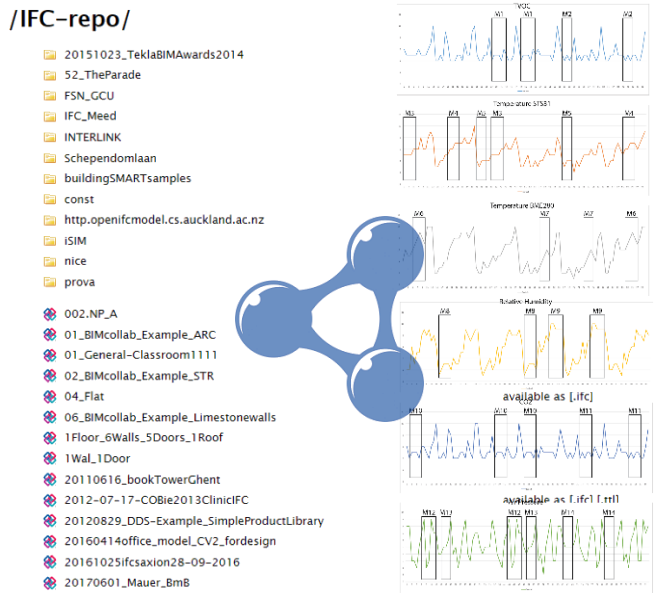


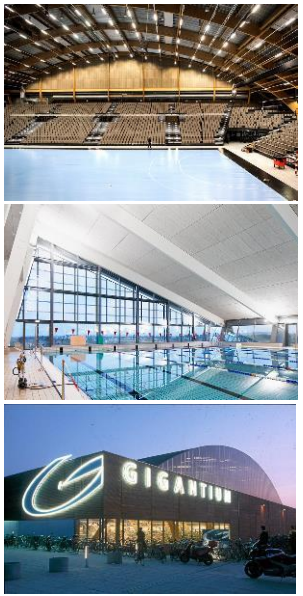
Mads Holten Rasmussen, Christian Aaskov Frausing, Christian Anker Hviid Jan Karlshøj, Integrating Building Information Modeling and Sensor Observations using Semantic Web, Semantic Sensor Networks Workshop, https://youtu.be/P_38gIvrbmg

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

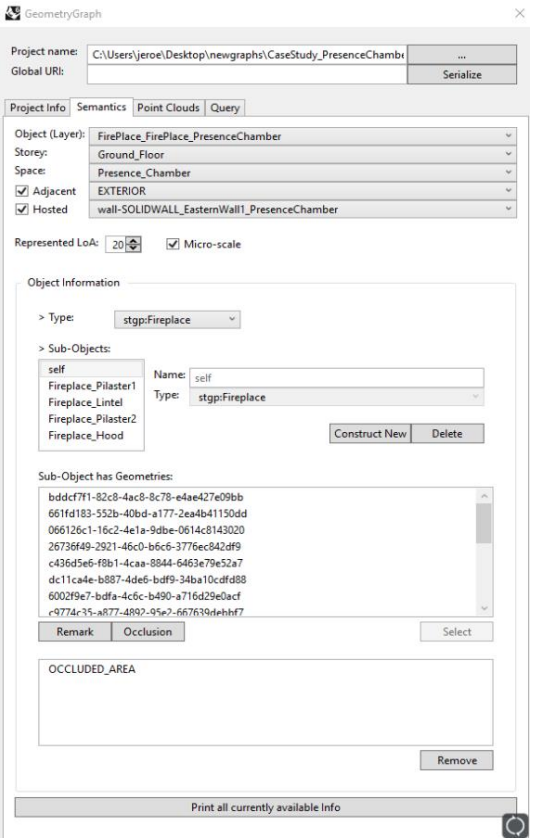


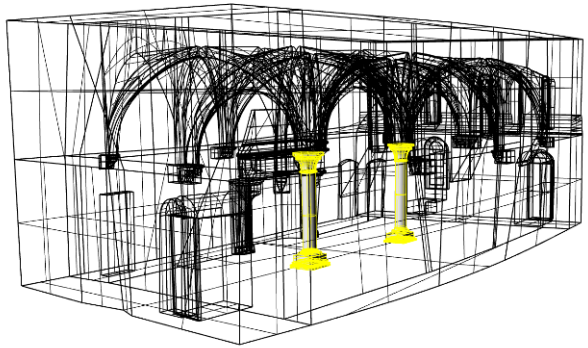


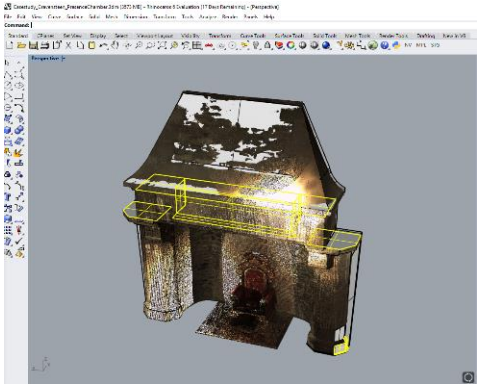
converted from http://smartlab1.elis.ugent.be:8889/IFC-repo/
to LBD using https://github.com/jyrkioraskari/IFCtoLBD

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





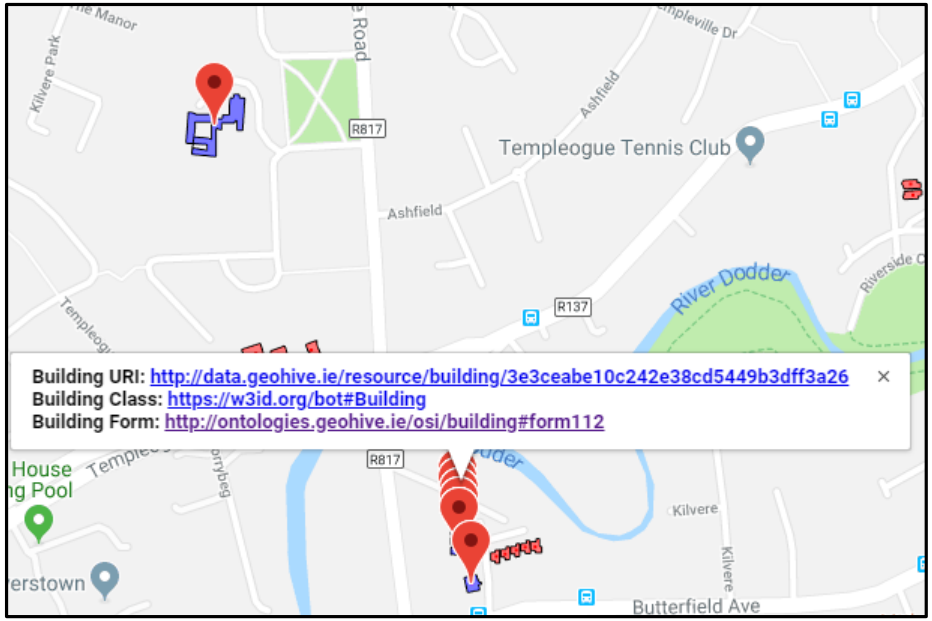


Jeroen Werbrouck, Semantic enrichment of the existing building geometry. Master Thesis 2018, Ghent University.

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

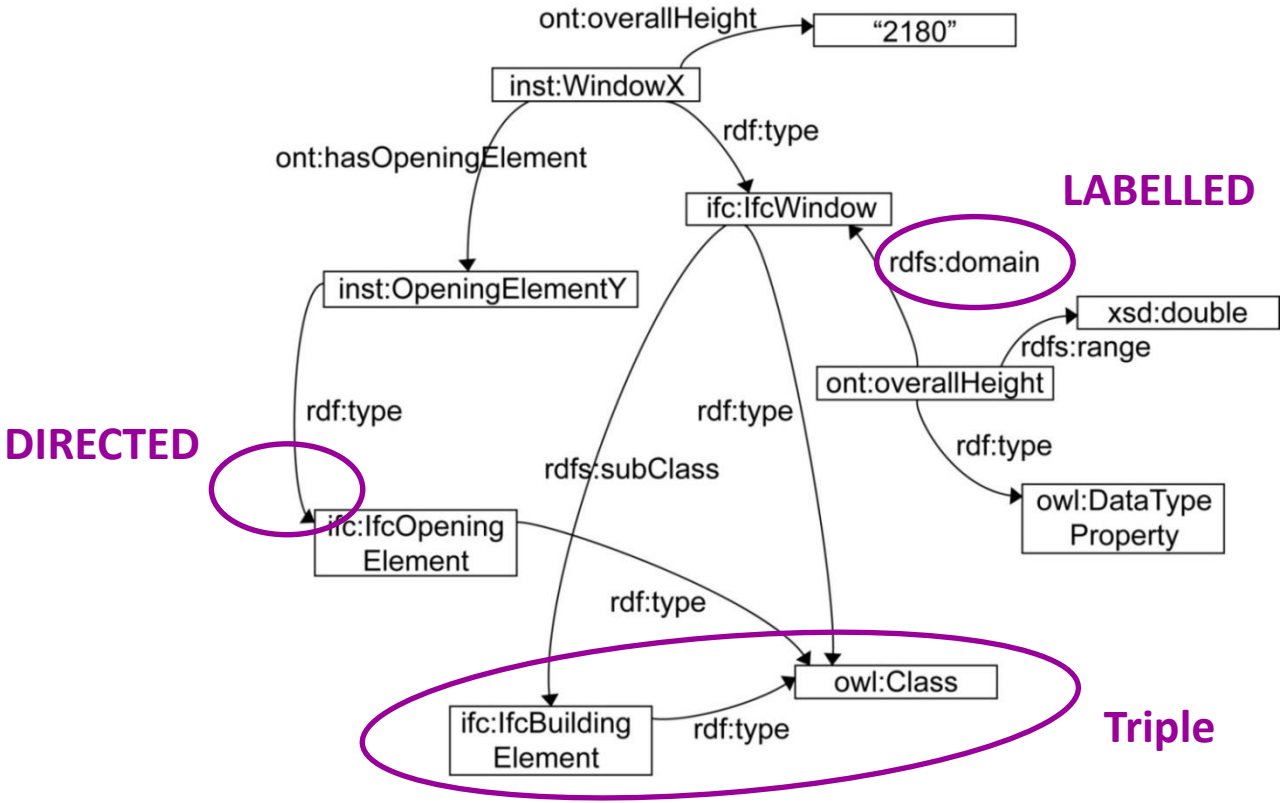
- RDF stands for Resource Description Framework
- RDF is a standard data model for describing web resources
  - Note: 'web resources' can make statements about anything in the real world: DBPedia, geography, building information, sensors, … anything goes
- RDF is designed to be read and understood by 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

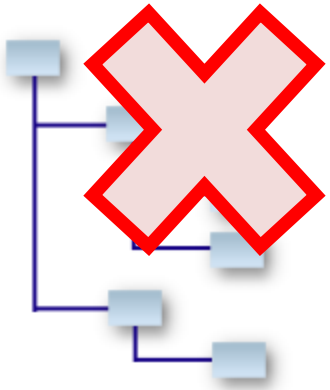
http://www.w3schools.com/webservices/ws_rdf_intro.asp

RDF Graphs, what are they?

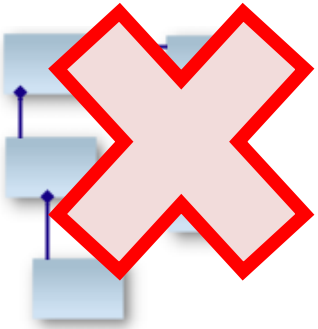


RDF Graphs, what are they not?

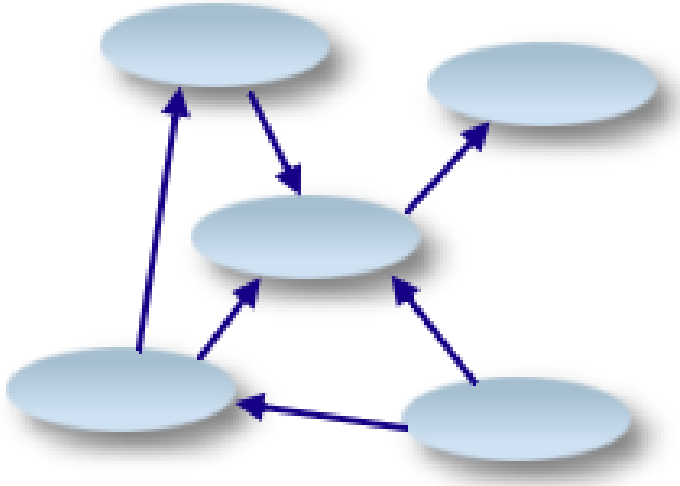
Hierarchies (cfr. XML)



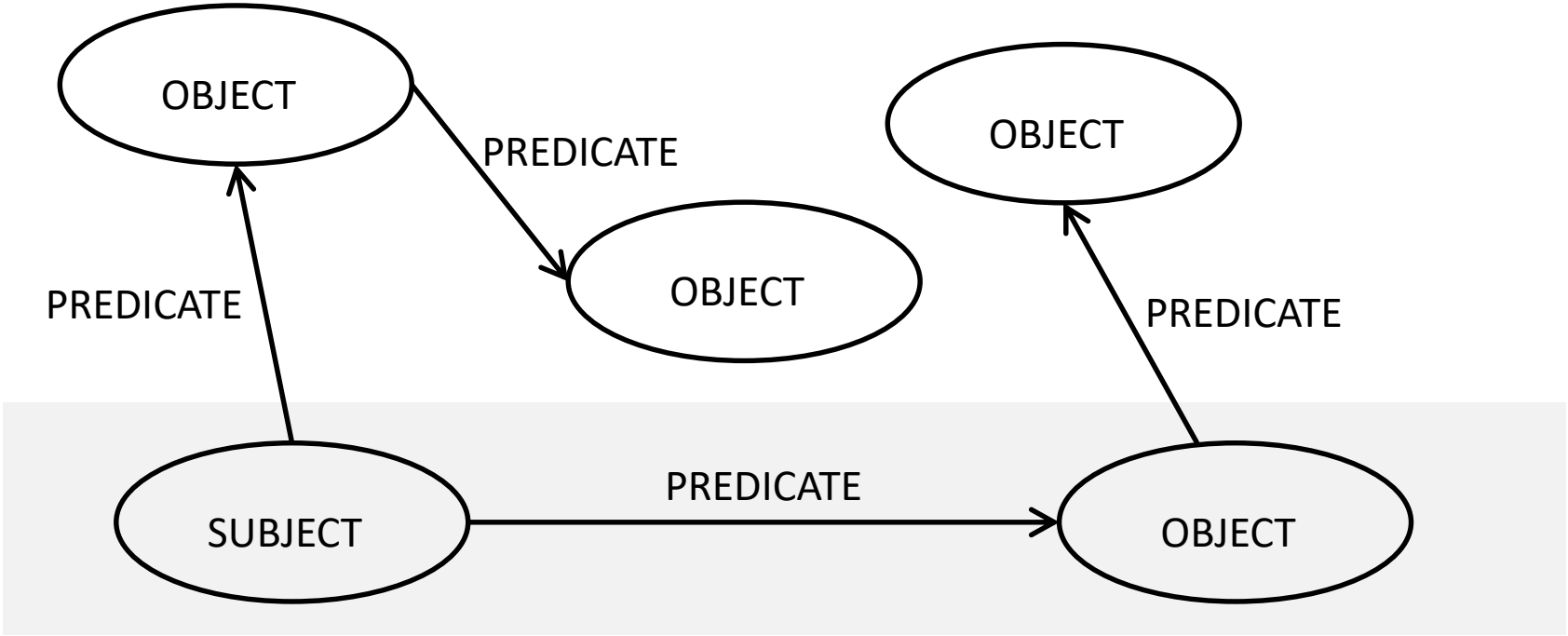
Relational databases (cfr. SQL)

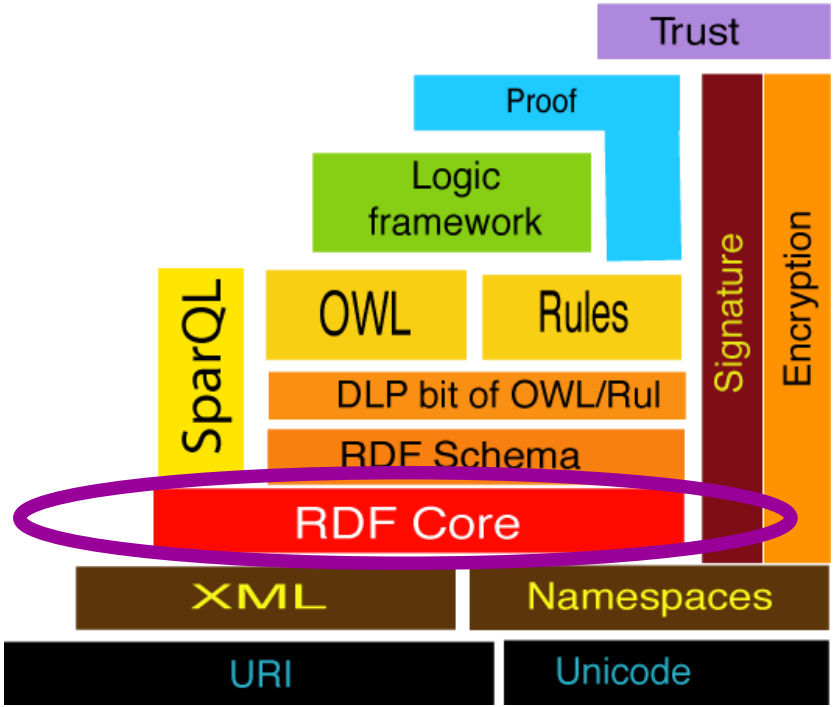


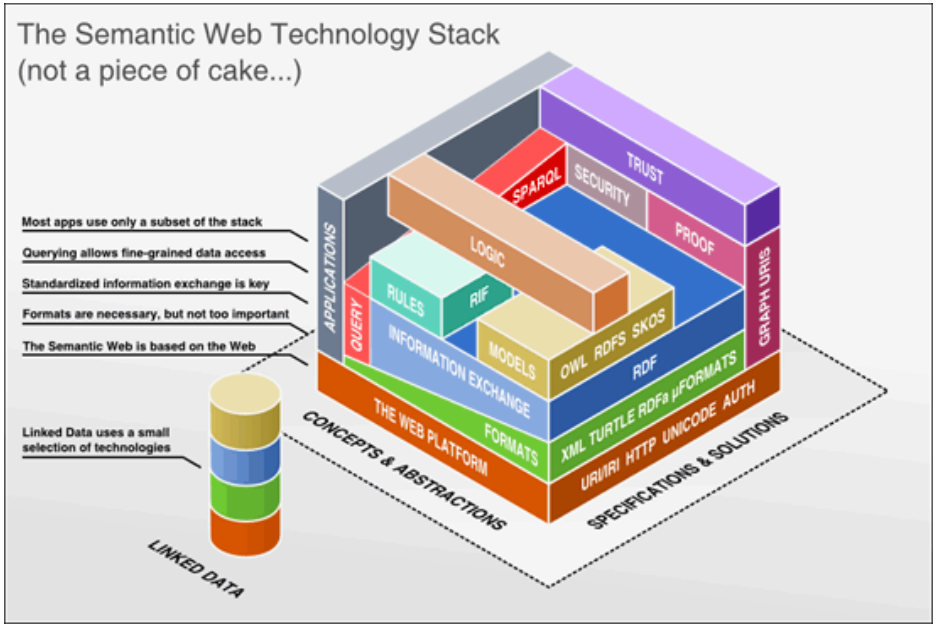
RDF graphs are DIRECTED, LABELLED GRAPHS



Connecting Triples







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

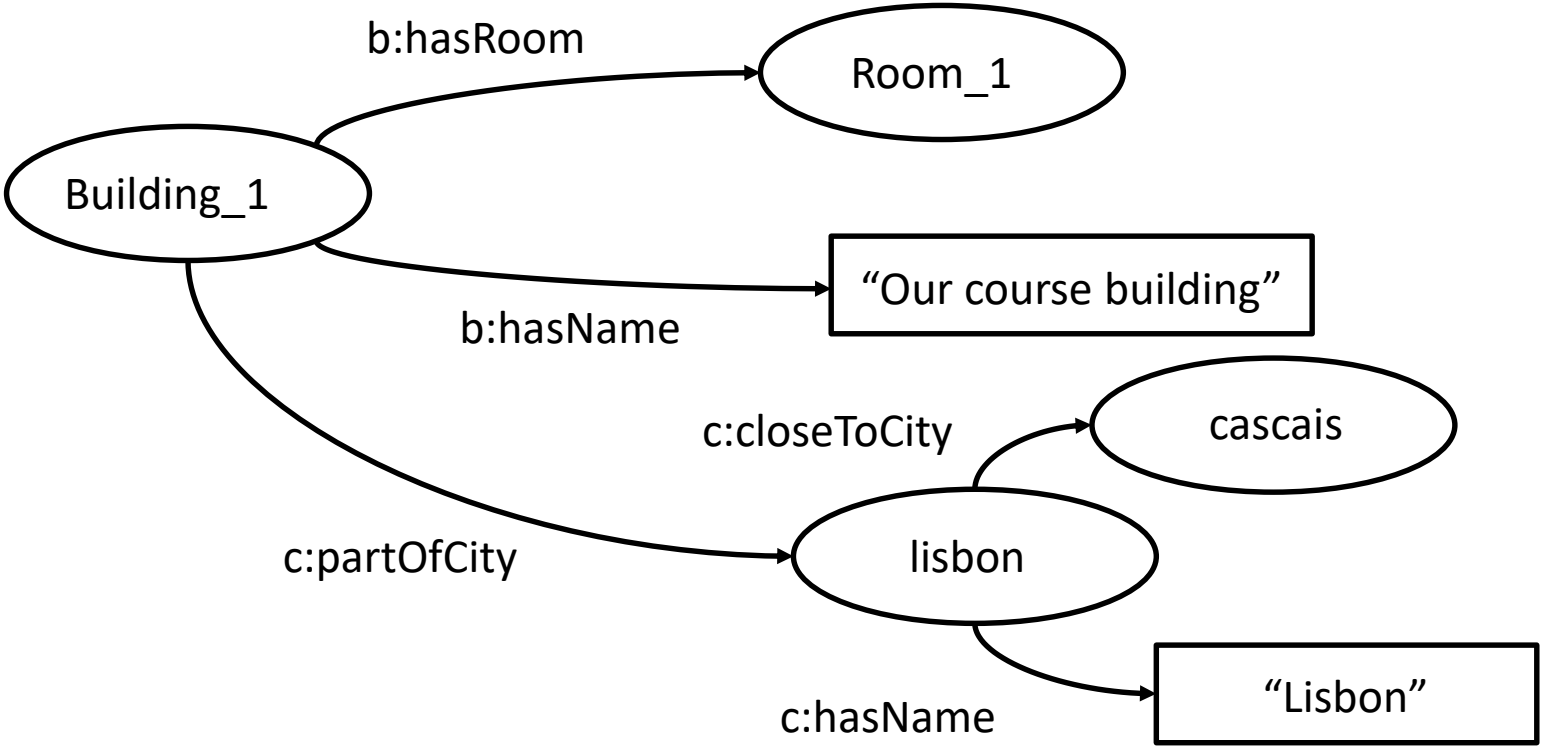
Example RDF graph

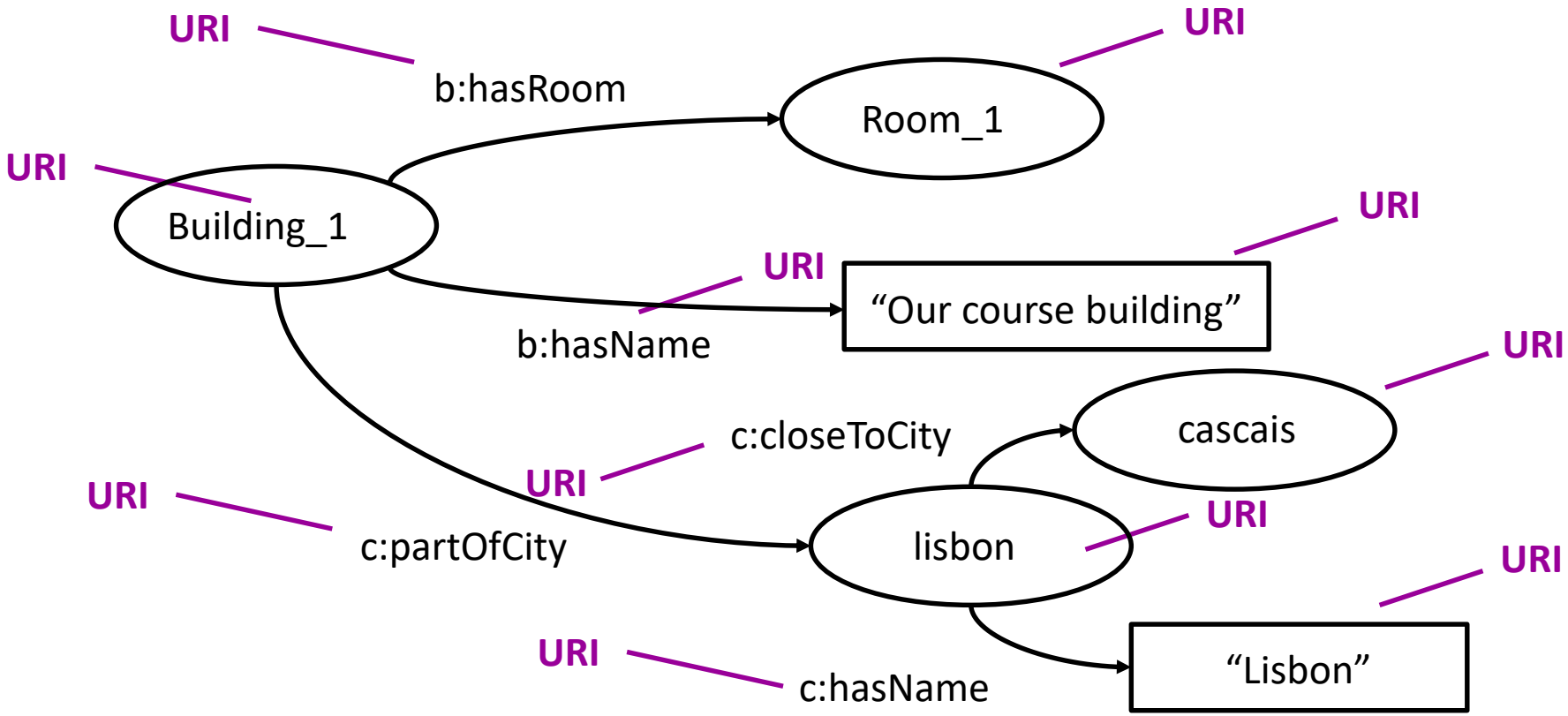
```
@prefix b: <http://www.beta-i.com/building#> .
@prefix c: <http://www.beta-i.com/city#> .

<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/#copenhagen> .

<http://cities.com/#copenhagen>
        c:closeToCity <http://cities.com/#malmo> ;
        c:hasName “Copenhagen” .
```

Example RDF graph




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

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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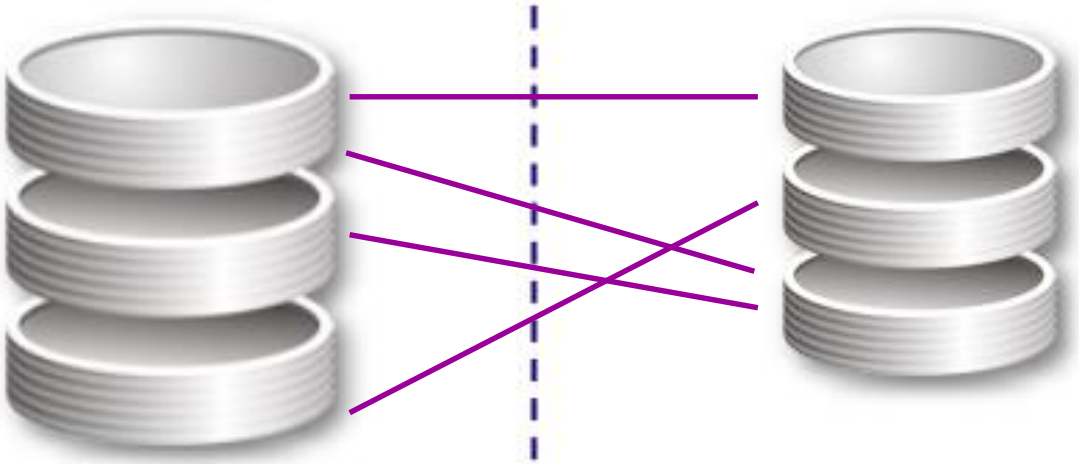
Data integration now possible



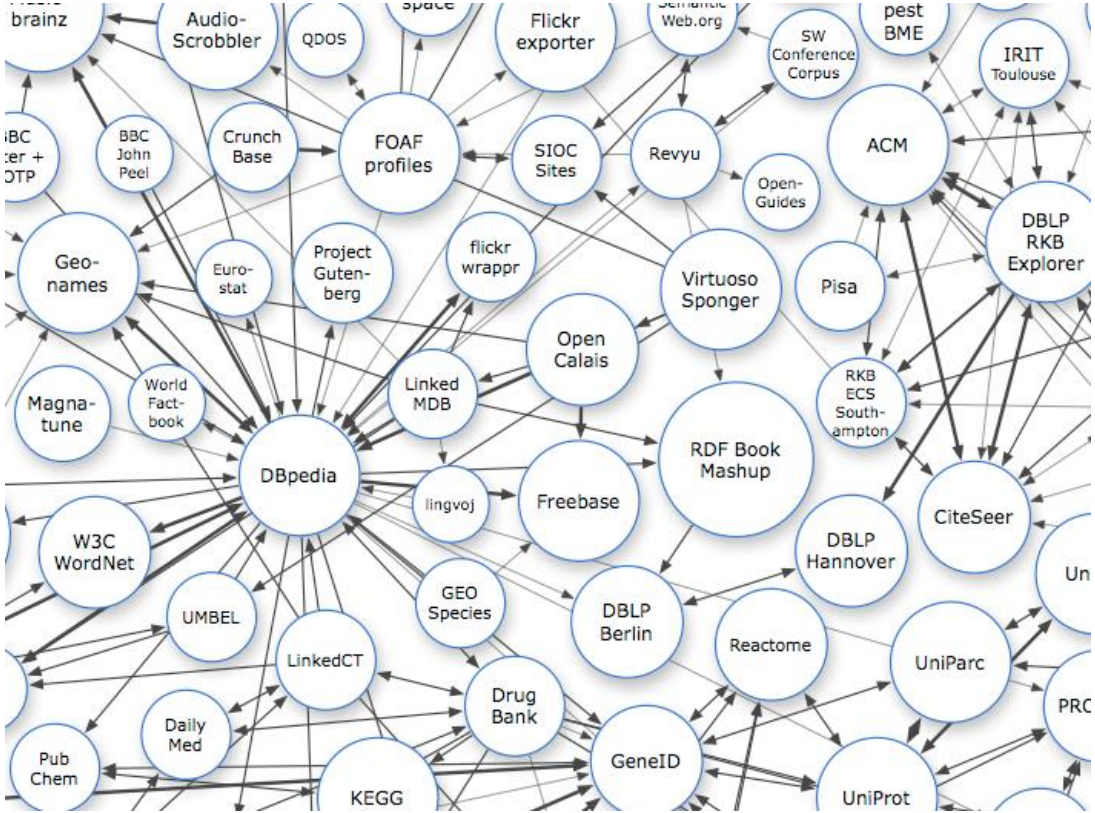
MyBuilding

Cities

Main principles

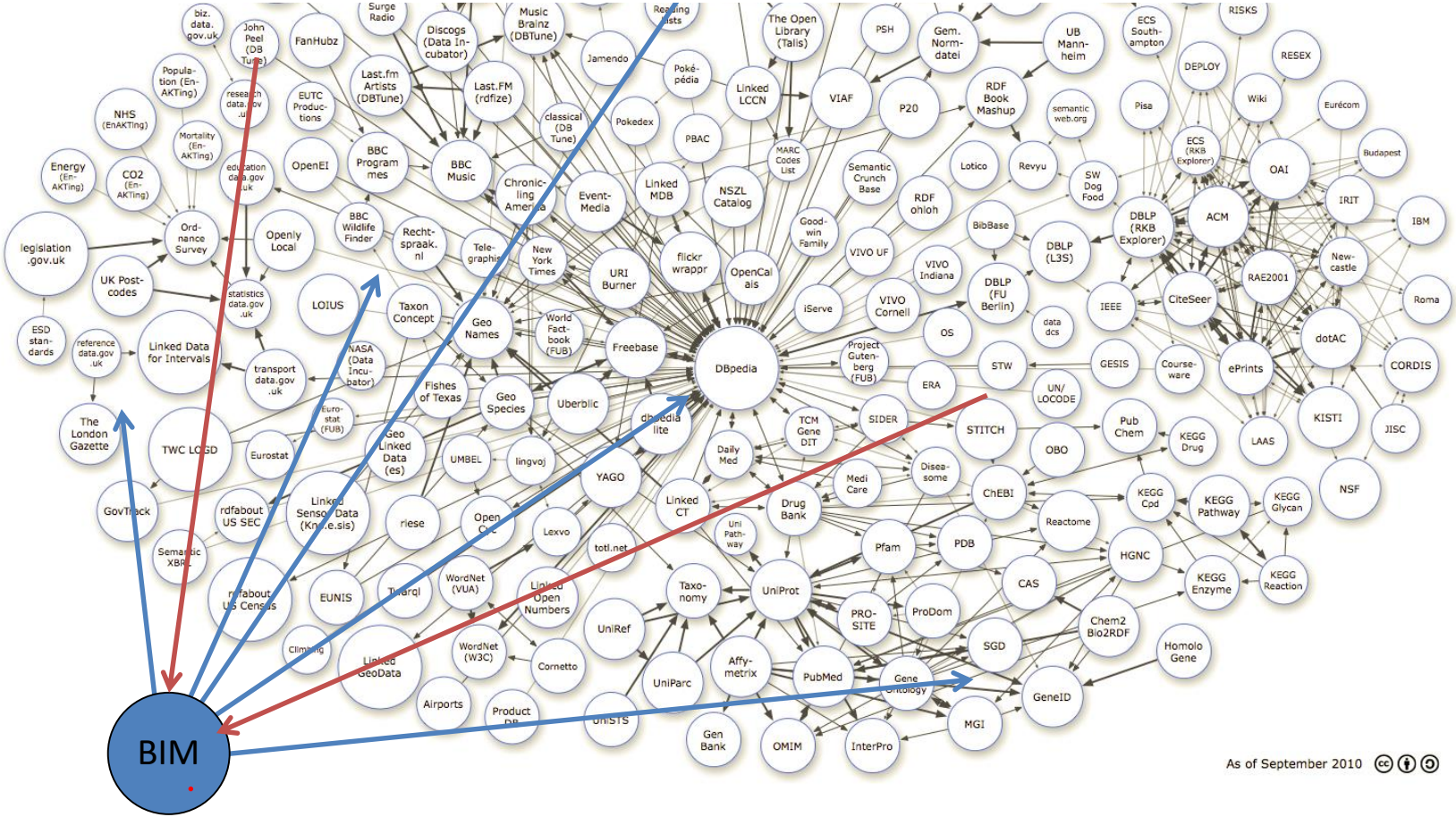
- distributed / decentralised information management
- interactive information search and reasoning over the web
- sharing partial data

Linked Open Data cloud (LOD)

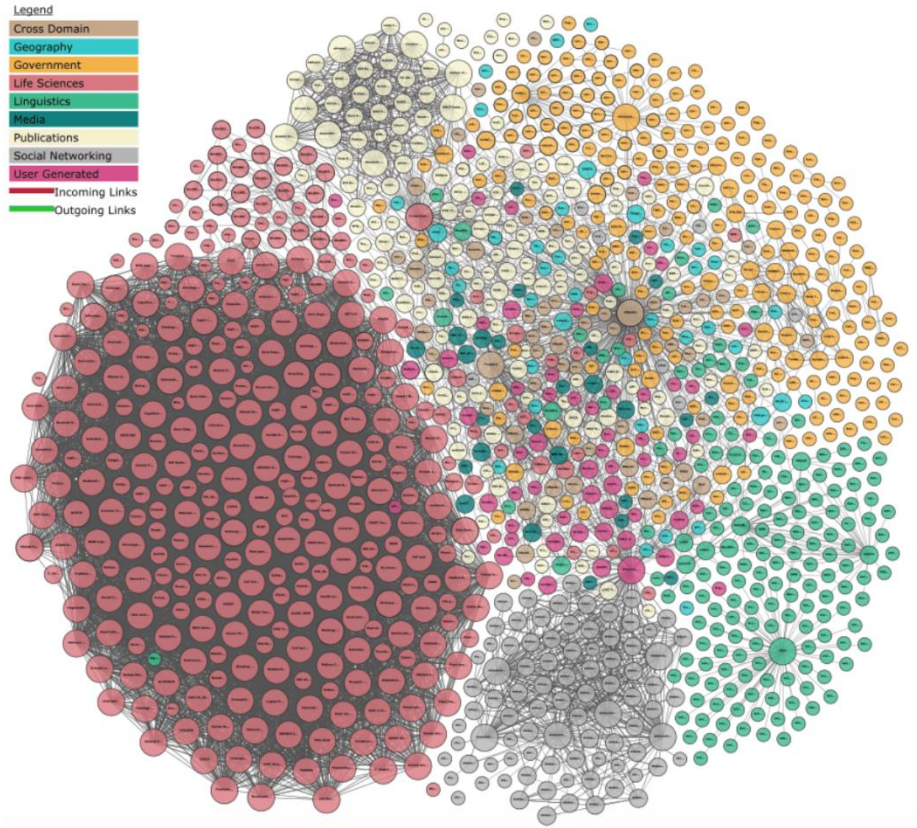


http://tomheath.com/blog/2009/03/linked-data-web-of-data-semantic-web-wtf/

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/

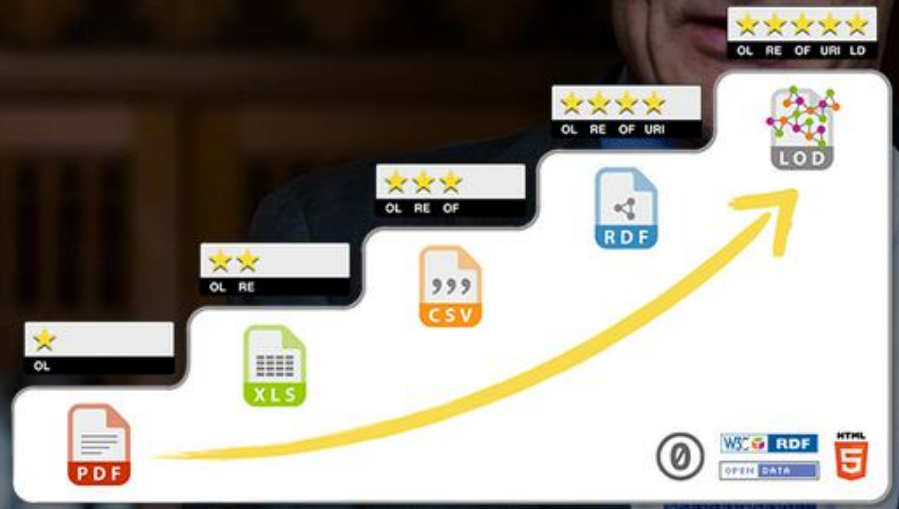
5stardata.info/en/

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

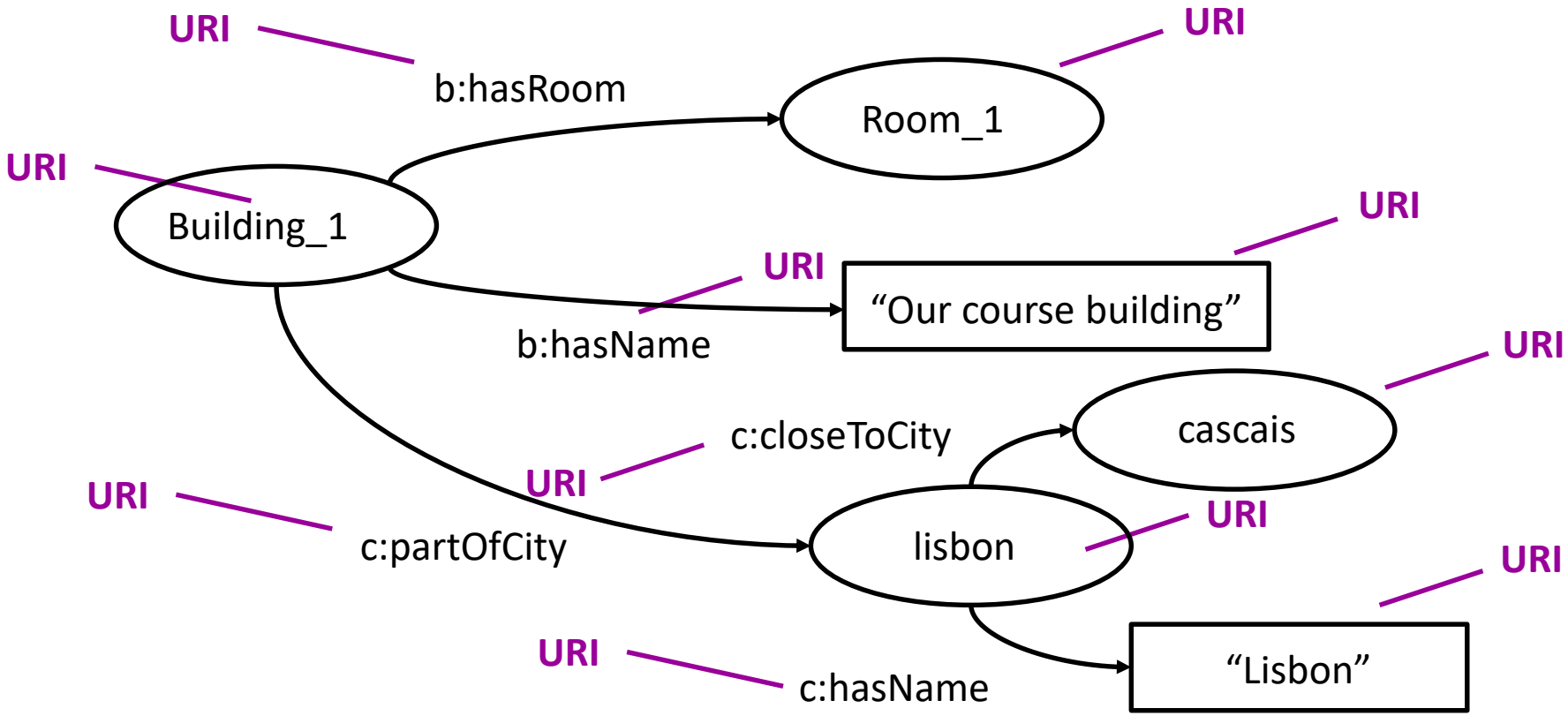
Abstract model and simplified view of some phenomenon in the world that we want to represent

Machine-readable

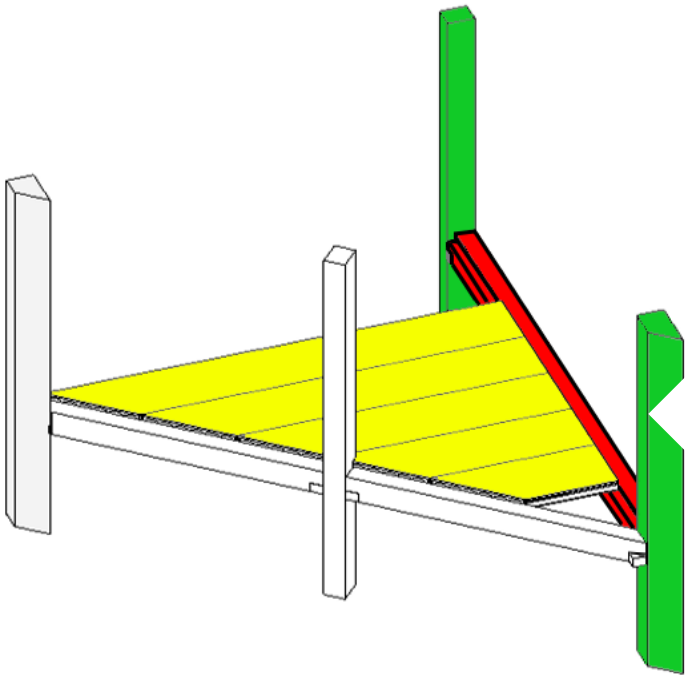
Concepts, properties, relations, functions, constraints, axioms

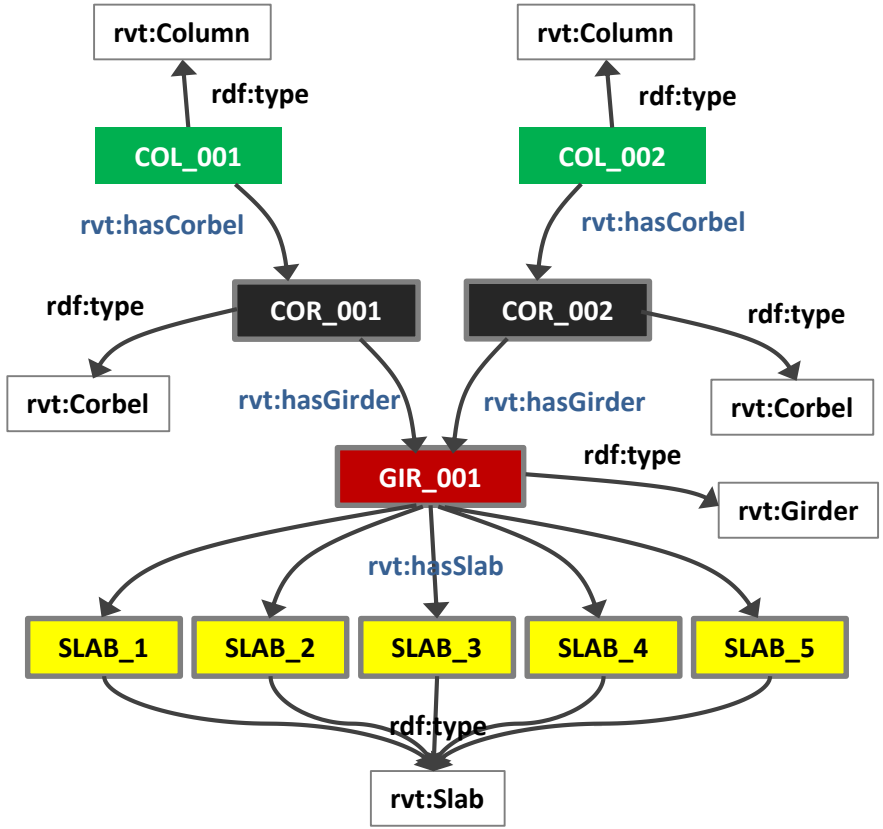
Consensual knowledge

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

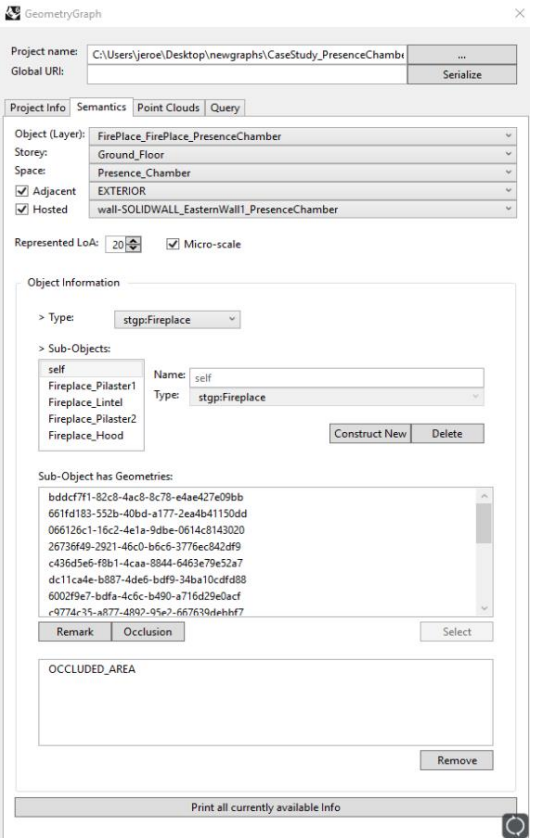
Standard vocabulary (1)

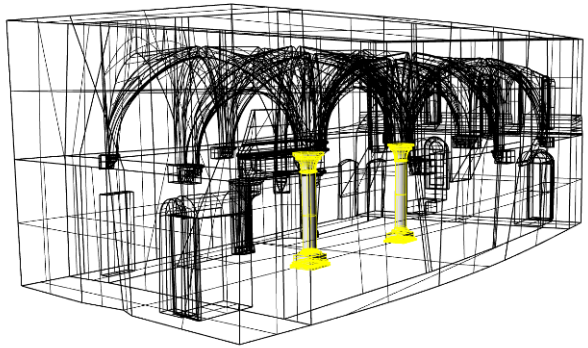


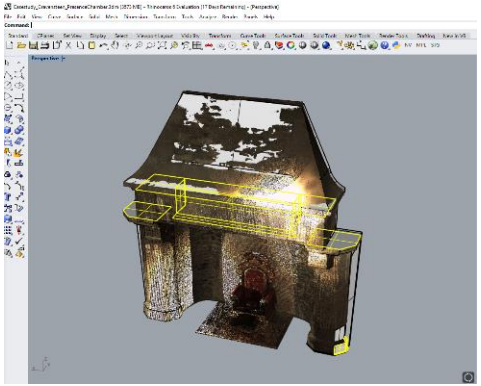


G. Costa, P. Pauwels. Building product suggestions for a BIM model based on rule sets and a semantic reasoning engine. Proceedings of the 32rd international CIB W78 conference. 2015. p.98-107.

Choose your ontologies wisely







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

Outline

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