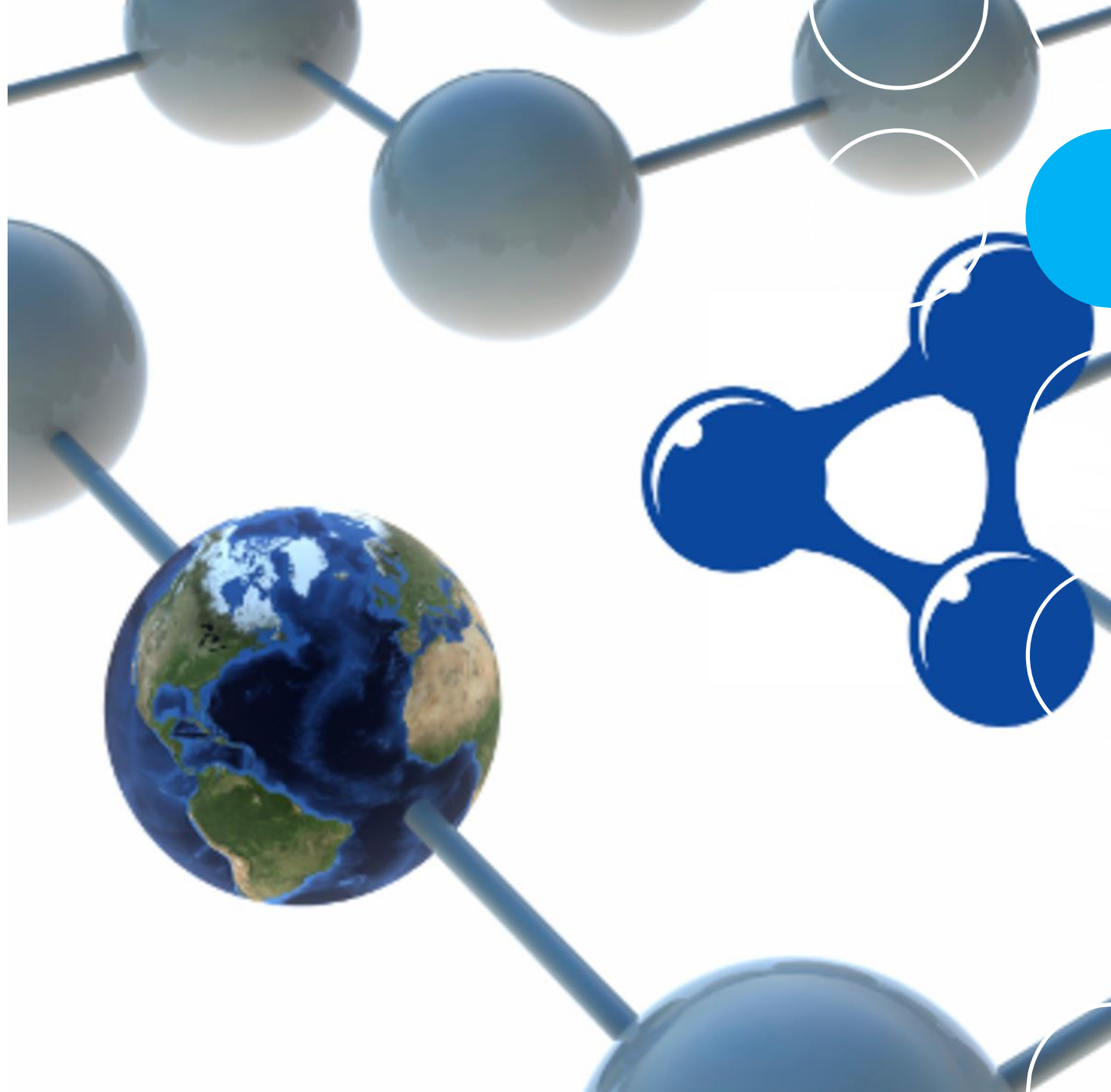


Semantic Web and Linked Data

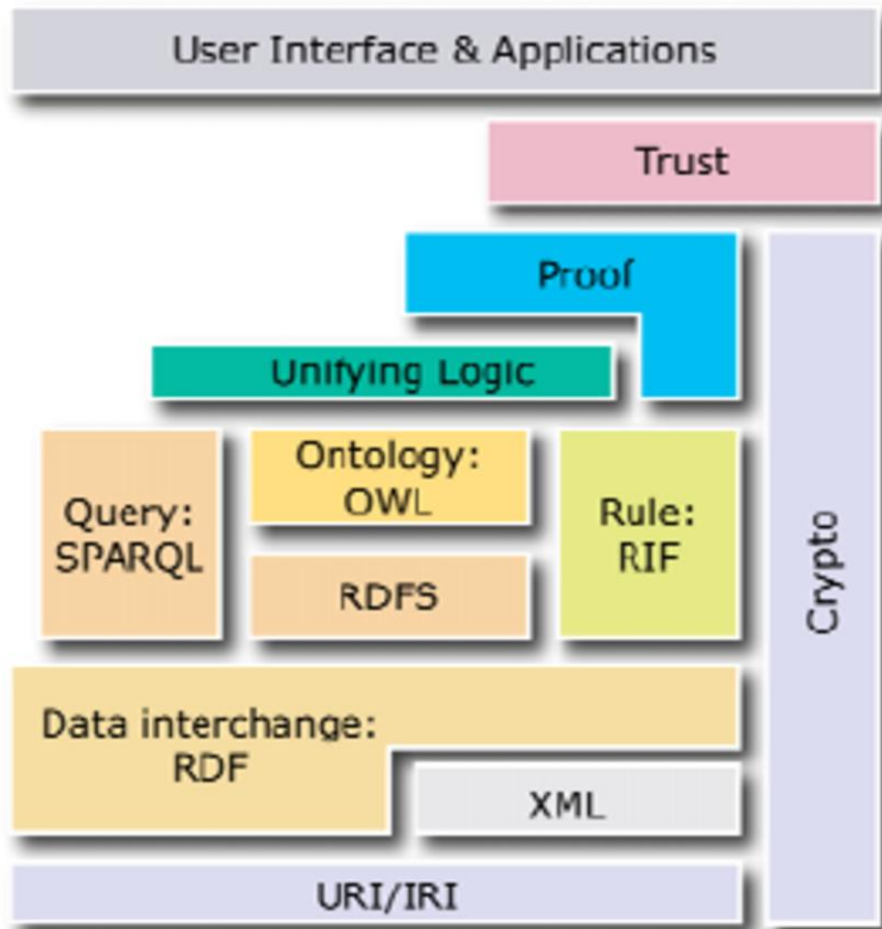
Liliana Ferreira

2022/23



Class 12: Learning Objectives

- Knowledge Representation on the Web: review and wrap-up!
 - Linked Data
 - Evaluating and Validating Ontologies and Knowledge Bases
-



The Semantic Web Layer

The Semantic Web: Motivation

- The Web was initially conceived to relate (pieces) of documents – a Web of Documents.
- We as humans can interpret the usually implicit relationships denoted by a hyperlinks, and facts contained in the contents.
- This is a difficult task for machines.


Faculdade de Engenharia da Universidade do Porto


🌐 1 língua ▾

Artigo Discussão

Ler Editar Ver histórico

Origem: Wikipédia, a enciclopédia livre.

 **Este artigo carece de reciclagem de acordo com o livro de estilo.** Sinta-se livre para editá-la para que esta possa atingir um nível de qualidade superior. *(Fevereiro de 2008)*

 **A neutralidade deste artigo foi questionada.** Discussão relevante pode ser encontrada na [página de discussão](#). *(Maio de 2010)*

A **Faculdade de Engenharia da Universidade do Porto (FEUP)**, é um estabelecimento de Ensino Superior da [Universidade do Porto](#) dedicado ao ensino da [Engenharia](#).

Na **FEUP** são ministrados diversos cursos de pré e pós graduação nos vários ramos da Engenharia. Com origens que datam do século XVIII, a Instituição passou a designar-se *Faculdade de Engenharia* em 1926. Todos os cursos são acreditados pela [Ordem dos Engenheiros](#).^[1]

A FEUP orgulha-se em ser a primeira instituição portuguesa com todos os cursos de Engenharia reconhecidos pela ENAAE (European Network for Accreditation of Engineering Education) através da atribuição da Marca de Qualidade EUR-ACE. São eles os Mestrados Integrados em Engenharia Mecânica, Engenharia Civil, Engenharia Química, Engenharia Informática e Computação, Engenharia Eletrotécnica e de Computadores, Engenharia Industrial e Gestão, Engenharia do Ambiente, Engenharia Metalúrgica e de Materiais, Bioengenharia e o Mestrado em Engenharia de Minas e Geo-ambiente. Esta qualificação coloca a FEUP num patamar inédito ao nível do ensino superior em Portugal, dando uma maior dimensão europeia aos diplomas da FEUP, o que deverá potenciar uma maior aceitação de engenheiros da FEUP por toda a Europa.^[2]

O lema da FEUP, partilhado com a [Faculdade de Ciências da Universidade do Porto](#), **Virtus Unita Fortius Agit** - *A união faz a força*, transpõe o sentimento comum a todos os alunos desta instituição pela mesma e pela vontade de aprender. A cor da FEUP é *cor de Engenharia*, cor esta um símbolo do que é ser Engenheiro: fazer.

Faculdade de Engenharia da Universidade do Porto



FEUP FACULDADE DE ENGENHARIA

 UNIVERSIDADE DO PORTO

FEUP	
Fundação	1926 (96 anos)
Instituição mãe	Universidade do Porto
Localização	Porto, Portugal
Diretor(a)	João Falcão e Cunha
Página oficial	www.fe.up.pt

The Semantic Web: Motivation

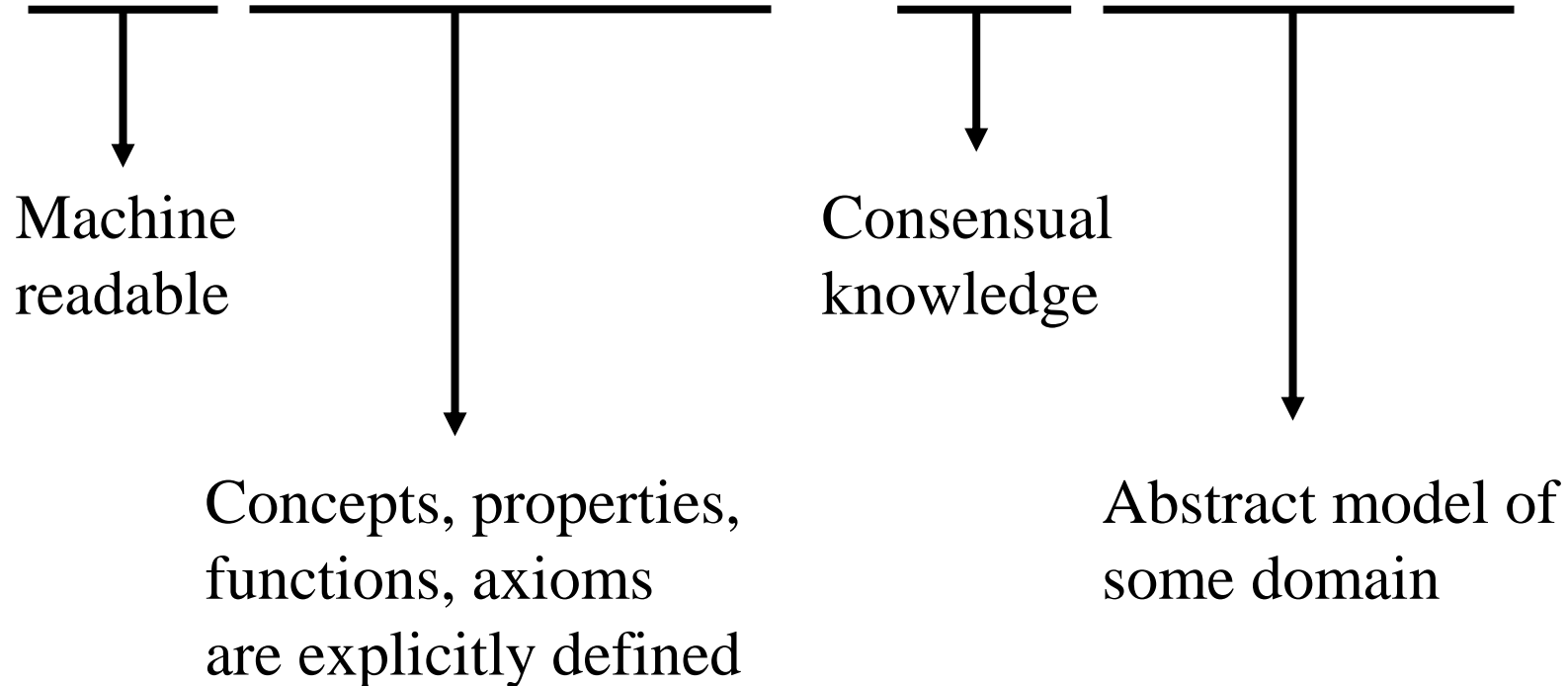
- How can we make information contained in these documents more meaningful for both humans and computers?
- *“The Semantic Web is an extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in co-operation.”*
- Instead of relating (pieces) of documents, we will be relating data contained in documents with explicit meaning (i.e., semantics).

```

C: > Users > liliana.ferreira > Downloads > sparql_2022-12-05_16-25-20Z.ttl
1  @prefix dbo:    <http://dbpedia.org/ontology/> .
2  @prefix dbr:    <http://dbpedia.org/resource/> .
3  dbr:Up          dbo:wikiPageWikiLink    dbr:University_of_Porto ;
4  |              dbo:wikiPageDisambiguates dbr:University_of_Porto .
5  dbr:Jean-Claude_Juncker dbo:wikiPageWikiLink    dbr:University_of_Porto .
6  dbr:Richard_Zimler  dbo:wikiPageWikiLink    dbr:University_of_Porto .
7  dbr:Jorge_de_Sena   dbo:education          dbr:University_of_Porto ;
8  |                 dbo:wikiPageWikiLink    dbr:University_of_Porto .
9  dbr:List_of_Portuguese_wine_grape_varieties dbo:wikiPageWikiLink    dbr:University_of_Porto .
10 dbr:Maria_de_Lourdes_Belchior_Pontes  dbo:wikiPageWikiLink    dbr:University_of_Porto .
11 dbr:Maria_Manuel_Mota  dbo:wikiPageWikiLink    dbr:University_of_Porto .
12 <http://dbpedia.org/resource/Ka\u00F0alza_de_Arriaga>  dbo:wikiPageWikiLink    dbr:University_of_Porto .
13 dbr:List_of_herbaria_in_Europe  dbo:wikiPageWikiLink    dbr:University_of_Porto .
14 dbr:List_of_pharmacy_schools    dbo:wikiPageWikiLink    dbr:University_of_Porto .
15 @prefix dbp:    <http://dbpedia.org/property/> .
16 dbr:Marcelo_Queiroga  dbp:almaMater    dbr:University_of_Porto ;
17 |                   dbo:almaMater    dbr:University_of_Porto ;
18 |                   dbo:wikiPageWikiLink    dbr:University_of_Porto .
19 dbr:Austrian-South-East_Asian_Academic_University_Network  dbo:wikiPageWikiLink    dbr:University_of_Por
20 dbr:Glass_battery     dbo:wikiPageWikiLink    dbr:University_of_Porto .
21 dbr:European_BEST_Engineering_Competition  dbo:wikiPageWikiLink    dbr:University_of_Porto .
22 <http://dbpedia.org/resource/Leandro_M\u00F0ller>  dbo:wikiPageWikiLink    dbr:University_of_Porto .
23 <http://dbpedia.org/resource/Jaime_Cortez\u00E3o>  dbo:wikiPageWikiLink    dbr:University_of_Porto .
24 dbr:Minerva_in_the_emblems_of_educational_establishments  dbo:wikiPageWikiLink    dbr:University_of_Por
25 dbr:Gabriela_Albergaria  dbo:wikiPageWikiLink    dbr:University_of_Porto .
  
```

Ontologies

Studer(98): Formal, explicit specification of a shared conceptualization



Linked Data?

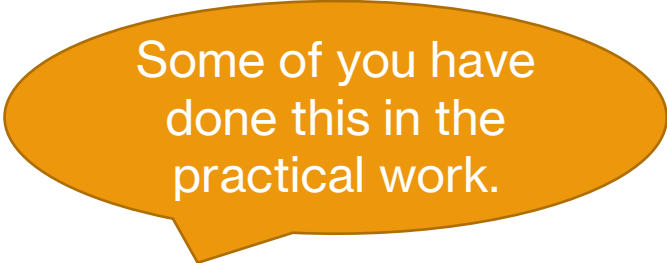
- We've covered some of the key technologies in the Semantic Web stack.
 - Linked Data is a type of Semantic Web.
 - Linked Data is the **name of an initiative** and the **name of a set of best practices and guidelines**.
 - These best practices and guidelines allow one to publish data on the Web in an interlinked and distributed manner, effectively creating a Web of Data.
-

What is Linked Data?

- It started as an initiative called the Linking Open Data project.
 - Linked Data is a global initiative to publish and interlink structured data on the Web using a clever combination of simple, standardized technologies.
 - Uniform Resource Identifiers – to name things;
 - Resource Description Framework – to represent things;
 - HTTP infrastructure – to obtain those representations.
-

What is Linked Data?

- Linked Data is also a community effort to publish (open) data sets as Linked Data on the Web (to which anyone can refer to)
- According to some “protocol”
- Interlink these data sets and ...
- Develop clients that consume Linked Data from the Web



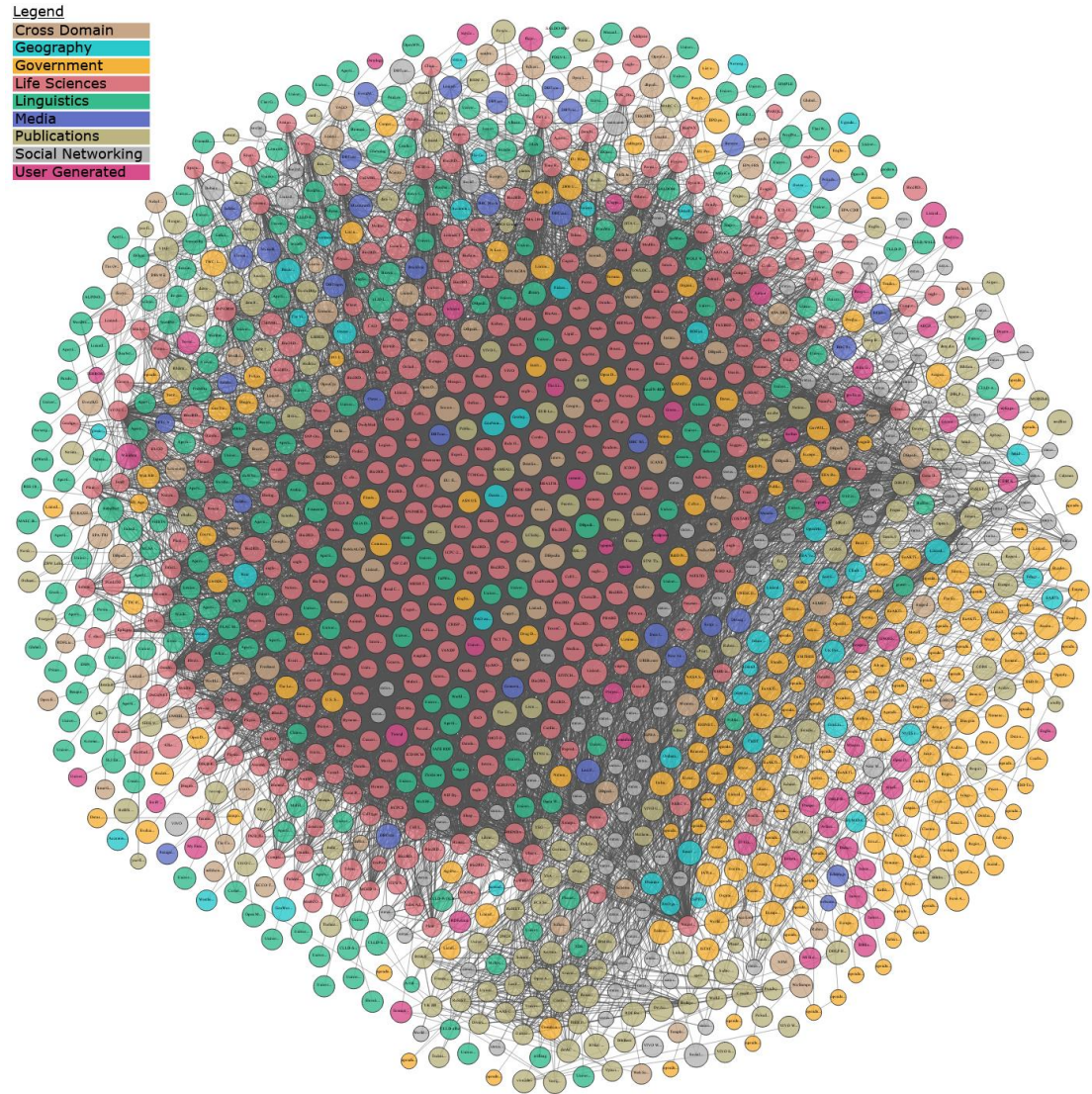
Some of you have done this in the practical work.

Towards a Web of Data

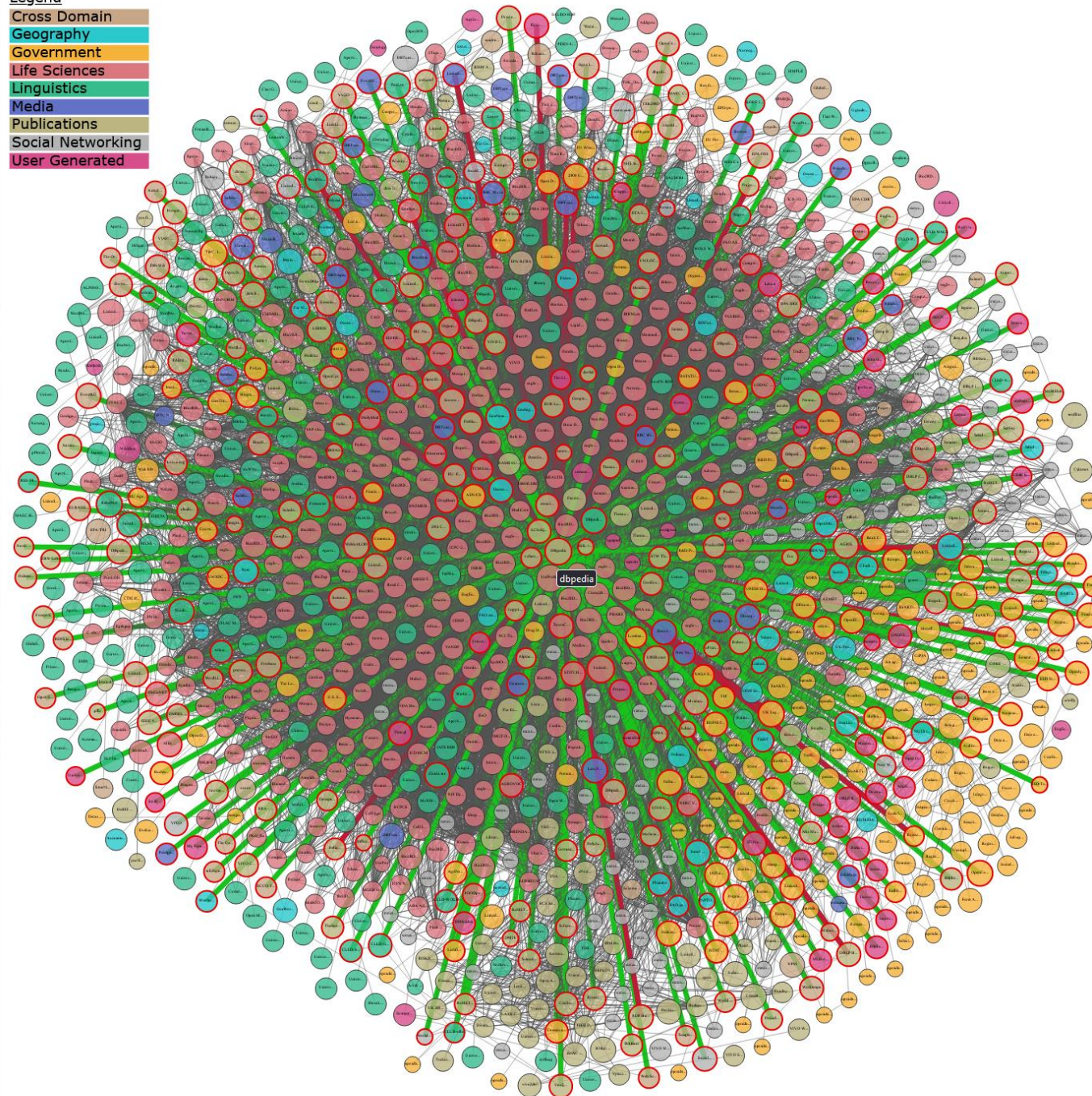
- We need appropriate methods (guidelines) and standards.
 - Tim Berners-Lee formulated four rules for creating and publishing Linked Data on the Web:
 - Use URIs as names for things.
 - Use HTTP URIs so that people can look up those names.
 - When someone looks up a URI, provide useful information using the standards.
 - Include links to other URIs, so that they can discover more things.
-

The Linked Open Data Cloud

<https://lod-cloud.net/>



- Legend**
- Cross Domain
 - Geography
 - Government
 - Life Sciences
 - Linguistics
 - Media
 - Publications
 - Social Networking
 - User Generated



Sources

- Berners-Lee, T., Hendler, J., Lassila, O.: The Semantic Web. Scientific American (5) (2001) pages 35–43
 - Berners-Lee. Design Issues: Linked Data
<http://www.w3.org/DesignIssues/LinkedData.html>
 - Bizer, C., Heath, T., Berners-Lee, T.: **Linked data – the story so far**. Int. J. Semantic Web Inf. Syst. 5(3), 1–22 (2009)
 - Jens Lehmann, Robert Isele, Max Jakob, Anja Jentzsch, Dimitris Kontokostas, Pablo N. Mendes, Sebastian Hellmann, Mohamed Morsey, Patrick van Kleef, Sören Auer, Christian Bizer: **DBpedia - A large-scale, multilingual knowledge base extracted from Wikipedia**. Semantic Web 6(2): 167-195 (2015)
-

Ontologies vs. Knowledge bases

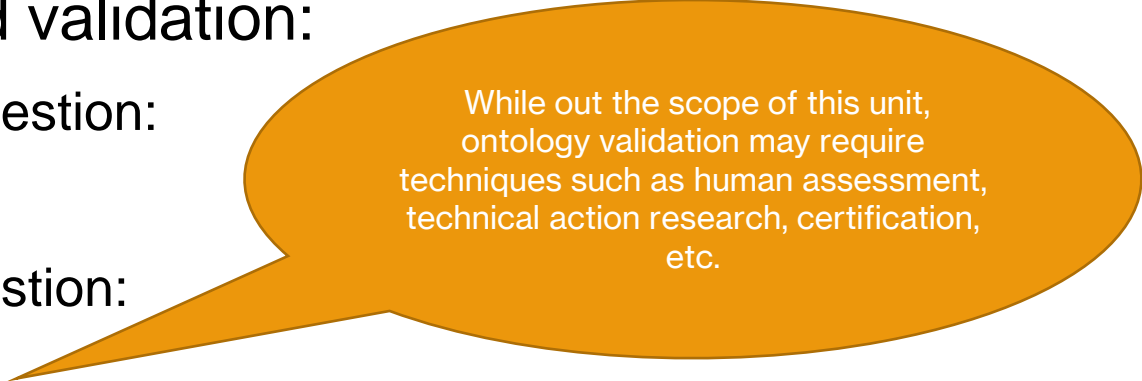
- Some argue there is a difference between ontologies and knowledge bases (e.g., Hepp 2008):
 - The ontology corresponds with the “schema”
 - The knowledge base corresponds with the ontology and instances
 - As always, there are “gray areas” where it makes sense to include some individuals in the ontology. Hepp proposes to differentiate between ontology individuals and data individuals.
-

Ontologies vs. Knowledge bases

- Independently of the separation, ontologies and knowledge bases are built, so they need to be evaluated.
 - Ontologies – however – have some unique challenges
 - Unlike software, ontologies cannot be compiled and run.
 - Ontologies can be used for different tasks.
 - Ontologies can be even used in unforeseen ways.
 - Ontologies can be used for the integration and reuse of heterogeneous data sources, which require mappings and the resulting KBs may produce different results.
-

Ontology Evaluation

- We distinguish between verification and validation:
 - Ontology verification aims to answer the question:
“Was the ontology built in the right way?”
 - Ontology validation aims to answer the question:
“Was the right ontology built?”
- Can you come up with examples of assessing both aspects?



While out the scope of this unit, ontology validation may require techniques such as human assessment, technical action research, certification, etc.

Ontology Evaluation

- Ontology evaluation is checking the technical quality of an ontology (or knowledge base) against a frame of reference and is a critical activity in ontology engineering projects (Poveda-Villalón, M et al., 2014)
-

Ontology Quality Criteria

Provide a framework
for assessing the
ontology.

Accuracy	Adaptability
Clarity	Completeness
Computational Efficiency	Conciseness
Consistency	Organizational Fitness

Ontology Quality Crit

Does the ontology comply with reality?
– Does the ontology capture the knowledge of domain experts (and users)?
– Truth vs. Consensus (Hepp 2008)

Accuracy	Adaptability
Clarity	Completeness
Computational Efficiency	Conciseness
Consistency	Organizational Fitness

Ontology Quality Crit

- Does the ontology anticipate its uses?
- Does the ontology provide the foundation for multiple tasks?
- Does it allow extension, integration and adaptation in a monotonic way?
(i.e., Can we extend an ontology without removing axioms?)

Accuracy	Adaptability
Clarity	Completeness
Computational Efficiency	Conciseness
Consistency	Organizational Fitness

Ontology Quality Crit

- Does the ontology effectively communicate the intended meaning of concepts, relations, and instances?
- Are the definitions documented (labels, comments, references, ...)?

Accuracy	Adaptability
Clarity	Completeness
Computational Efficiency	Conciseness
Consistency	Organizational Fitness

Ontology Quality Crit

- Is the UoD appropriately covered?
- Does the ontology meet the requirements?

Accuracy	Adaptability
Clarity	Completeness
Computational Efficiency	Conciseness
Consistency	Organizational Fitness

Ontology Quality Crit

- How easily / successfully can reasoners process the ontology?
- How efficient are certain reasoning tasks?

Accuracy	Adaptability
Clarity	Completeness
Computational Efficiency	Conciseness
Consistency	Organizational Fitness

Ontology Quality Criteria

Accuracy	
Clarity	Completeness
Computational Efficiency	Conciseness
Consistency	Organizational Fitness

– Are there logical contradictions?
 – Do formal and informal definitions of concepts match?
 – Minimal encoding bias – conceptualize at the knowledge level” and conceptualization should not depend on the encoding. – i.e., do not let the ontology language or encoding drive ontology engineering!
 • “Dirty hacks” for convenience?

Ontology Quality Criteria

Accuracy	
Clarity	Completeness
Computational Efficiency	Conciseness
Consistency	Organizational Fitness

- Used by the stakeholders? E.g., an organization
- Adequate method for ontology construction adopted?
- Is it properly shared among stakeholders?
 - Does it comply with legislation?
 - E.g., GDPR

OOPS!

- OntOlogy Pitfall Scanner! (<http://oops.linkeddata.es/>)
 - Poveda-Villalón, M., Gómez-Pérez, A., & Suárez-Figueroa, M. C. (2014). OOPS! (OntOlogy Pitfall Scanner!): An On-line Tool for Ontology Evaluation. International Journal on Semantic Web and Information Systems (IJSWIS), 10(2), 7-34.
doi:10.4018/ijswis.2014040102
 - Authors analysed hundreds of ontologies to identify various “pitfalls” and created a service that assesses one’s ontology w.r.t. their analysis.
 - Again, problems picked up by OOPS! need to be investigated; it may be that some problems were intentional.
-

Sources

- Knowledge Representation on the Web. Christophe Debruyne - ADAPT Centre, Trinity College Dublin & WISE Lab, Vrije Universiteit Brussel
-