Egyptian E-Learning University (EELU)
Faculty of Computers and Information Technology

The Web Engineering 3

Introduction to Semantic Web

Lecture 3

Semantic Web Technologies and Layered Approach

Presented by

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Course Topics

- Introduction to the semantic web.
- Semantic web technologies and layered approach.
- Structured web documents in XML.
- Describing web resources in basic elements of Resource Description Framework (RDF).
- Web Ontology Language: OWL.
- Ontologies Applications.

Course References

1. Grigoris Antoniou, Paul Groth, Frank van Harmelen, Rinke Hoekstra, "A Semantic Web Primer", 2012.

2. John Domingue, Dieter Fensel, James A. Hendler, "Introduction to the Semantic Web Technologies", 2011.

Lectures 3 and 4 Outlines

- Current Web Technologies and their Problems.
- What is the solution?
- Design Principles of the Semantic Web.
- Semantic Web Technologies.
  - Semantic Web Structure and layers.
  - Ontologies.
    - Ontologies definition.
    - Components of Ontologies.
    - Ontologies Languages.
- Semantic Web Agents.

Current Web Technologies

HTML

- Web content is currently formatted for human readers rather than programs.
- HTML (Hyper Text Markup Language) is the most basic building block of Web Pages.
- Vocabulary describes data item presentation (vocabulary-based structure).

An HTML Example

<h1>Agilitas Hospital</h1>
Welcome to the home page of the Agilitas Hospital. Do you feel pain? Have you had an injury? Let our staff Davenport, Townsend (our secretary) and Steve Matthews take care of your body and soul.
<h2>Consultation hours</h2>
Mon 11am - 7pm
Tue 11am - 7pm
Wed 3pm - 7pm
Thu 11am - 7pm
Fri 11am - 3pm<p>
But note that we do not offer consultation during the weeks of the State Of Origin games.

Problems with HTML

- **In using humans have no problem with this**

- **Problem 1**: web documents do not distinguish between information content and presentation shape (user interface).

- **Problem 2**: different web documents may be represented in different ways as separate pieces of information belonging to different sources.
  - This problem leads to hard performing of “intelligent” information search on the Web

A Better Representation

- A part of the problem "solved" by current technology
  - – stylesheets of (HTML, XML)
    - Stylesheets: method allows separating formats for different attributes (objects) from the presented information.
- XML: eXtensible Mark-up Language
- XML documents are written through a user-pre-defined set of tags
- Tags are used to express the "semantics" of the various pieces of information or data.

A Better Representation

```
<company>
    <treatmentOffered>Health care</treatmentOffered>
    <companyName>Agilitas Hospital</companyName>
    <staff>
        <therapist>Lisa Davenport</therapist>
        <therapist>Steve Matthews</therapist>
        <secretary>Kelly Townsend</secretary>
    </staff>
</company>
```

Limitations of XML

XML does not solve all the problems:

1) Inherit using of the existing HTML documents. (built based on existing HTML documents)
2) Different XML documents may express information with the same meaning using different tags.
3) Until now many XML documents do not share the "semantics" of information completely.

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What is the solution of these problems ?

- By explicit metadata of all datasets:
  - This representation is more easily data processable by machines.
  - Metadata: data about data
    - Metadata captures part of the meaning and classification of the other data.
  - Semantic Web does not rely on text-based manipulation, but rather on machine-processable metadata

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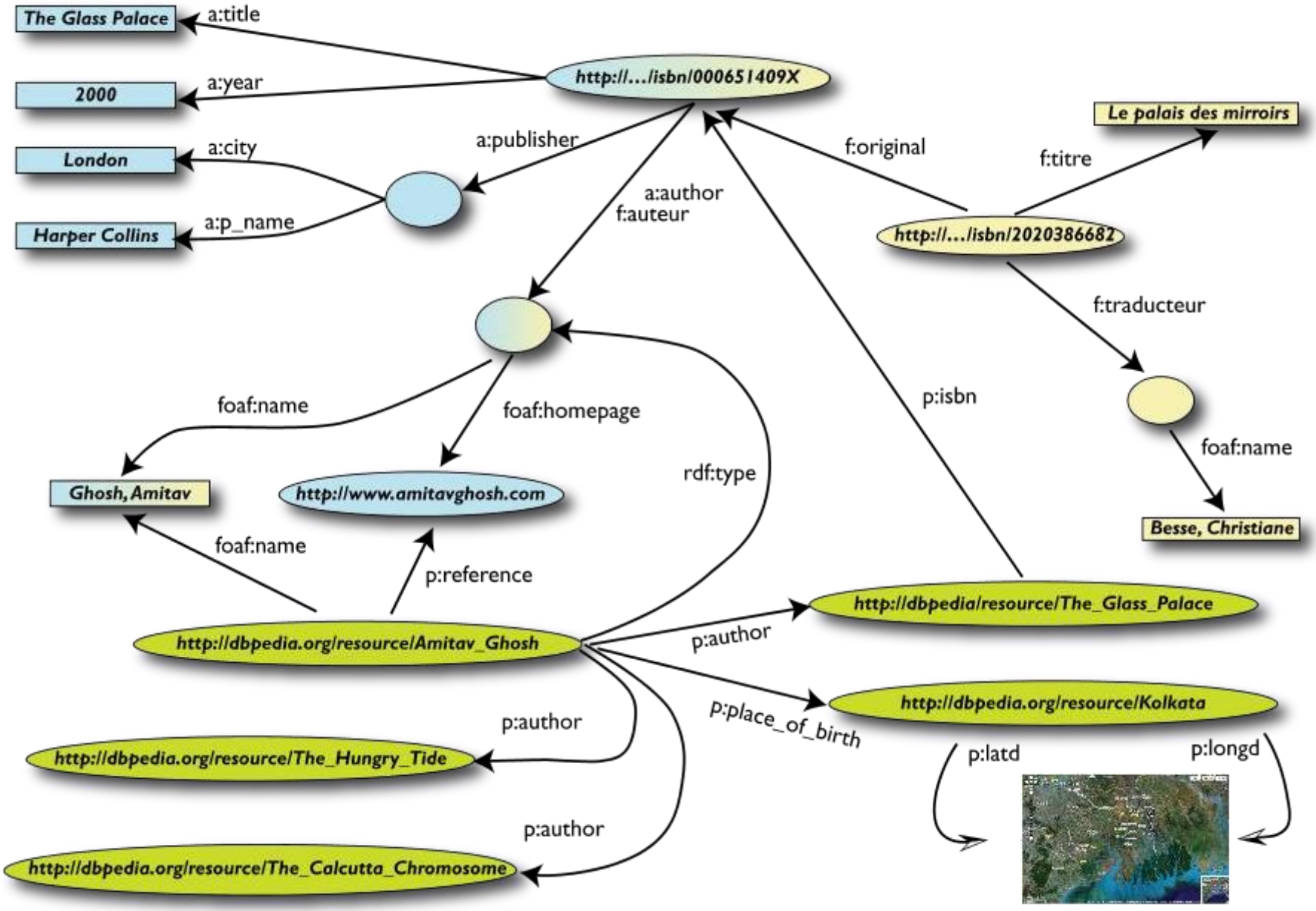
Design Principles of the Semantic Web

- There are three design principles to make semantic web real-time technology:

1. Use labeled graphs to build a data model for objects and their relations (objects represented as nodes in the graph and the edges in the graph represent relations between these objects).
   - Resource Description Framework (RDF) is used to formalism such graphs.
2. Use web identifiers (Uniform Resource Identifiers - URIs) to identify the individual data-items and their relations in different databases.
3. Use ontologies (hierarchical vocabularies describes types and relations).
   - RDF Schema and Web Ontology Language (OWL) are used for this purpose, again using URIs to represent the types and their properties.


The Glass Palace
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a:year
London
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a:author
f:auteur
f:original
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p:author
http://dbpedia.org/resource/The_Calcutta_Chromosome

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The Semantic Web Technologies

Goal:

to provide a common framework to facilitate sharing data on the Web effectively across application boundaries.

Main ideas to discuss:

- Semantic Web Structure and layers.
- Ontologies.
  - Ontologies definition.
  - Components of Ontologies.
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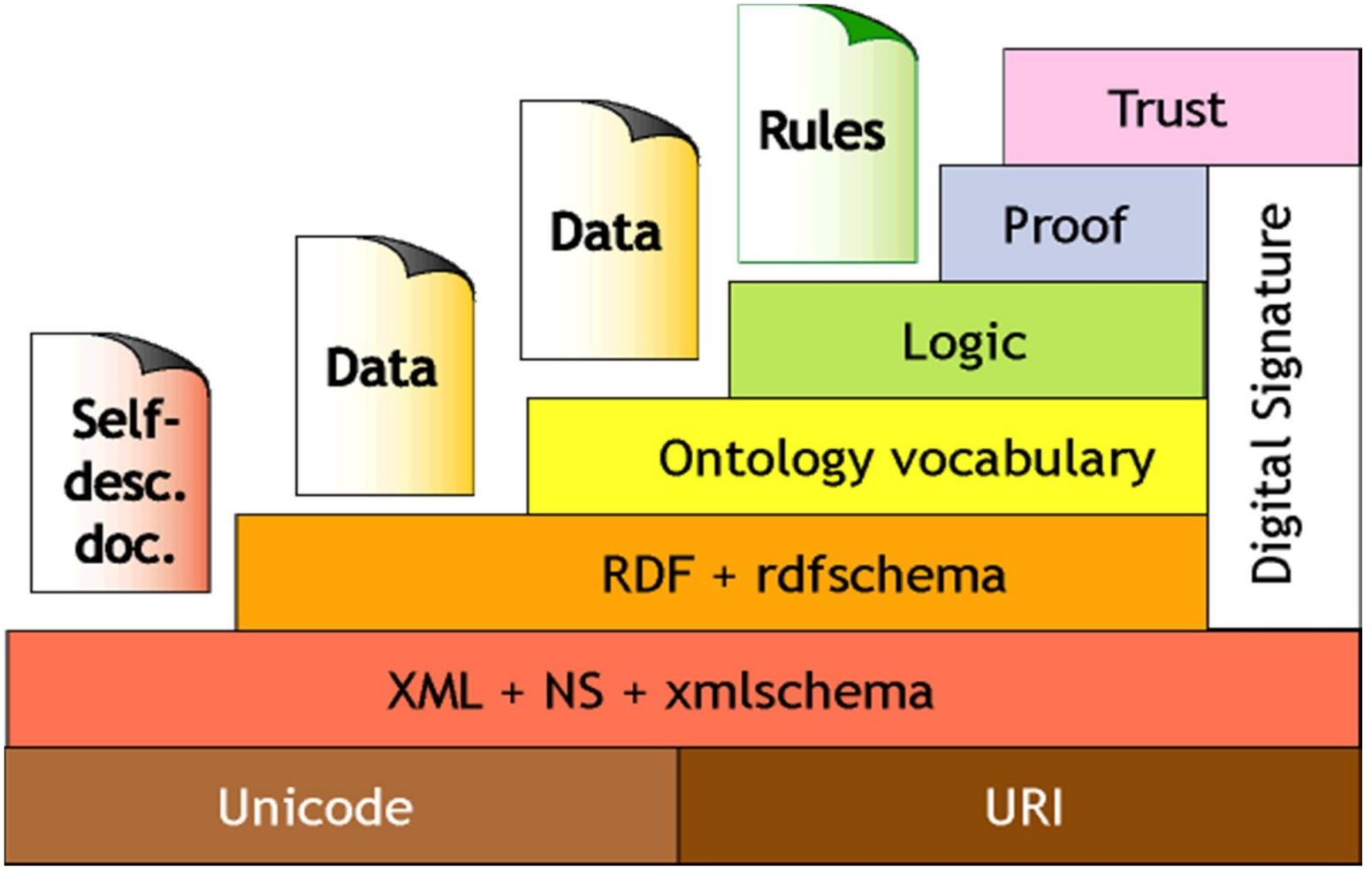
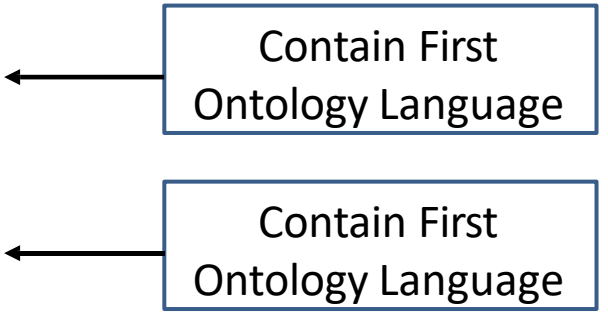
The Semantic Web Structure

- The development of the Semantic Web proceeds in steps.
- Each step builds a layer on top of another.



The Semantic Web Layers

1. XML layer.
2. RDF and RDF Schema layer.
3. Ontology layer.
4. Logical layer.
5. Proof-rule layer.
6. Trust layer.



1. The XML layer

- XML (eXtensible Markup Language)
  - user-definable and domain-specific markup using tags.
- URI (Uniform Resource Identifier)
  - universal naming for all web resources.
  - same URI = same resource.
  - URIs are the “ground terms” (basic) of the Semantic Web.
- W3C standards

2. The RDF + RDFS layer

RDF = a simple conceptual data model developed by W3C standard (1999)

RDF model = set of RDF triples

triple = expression means (statement)

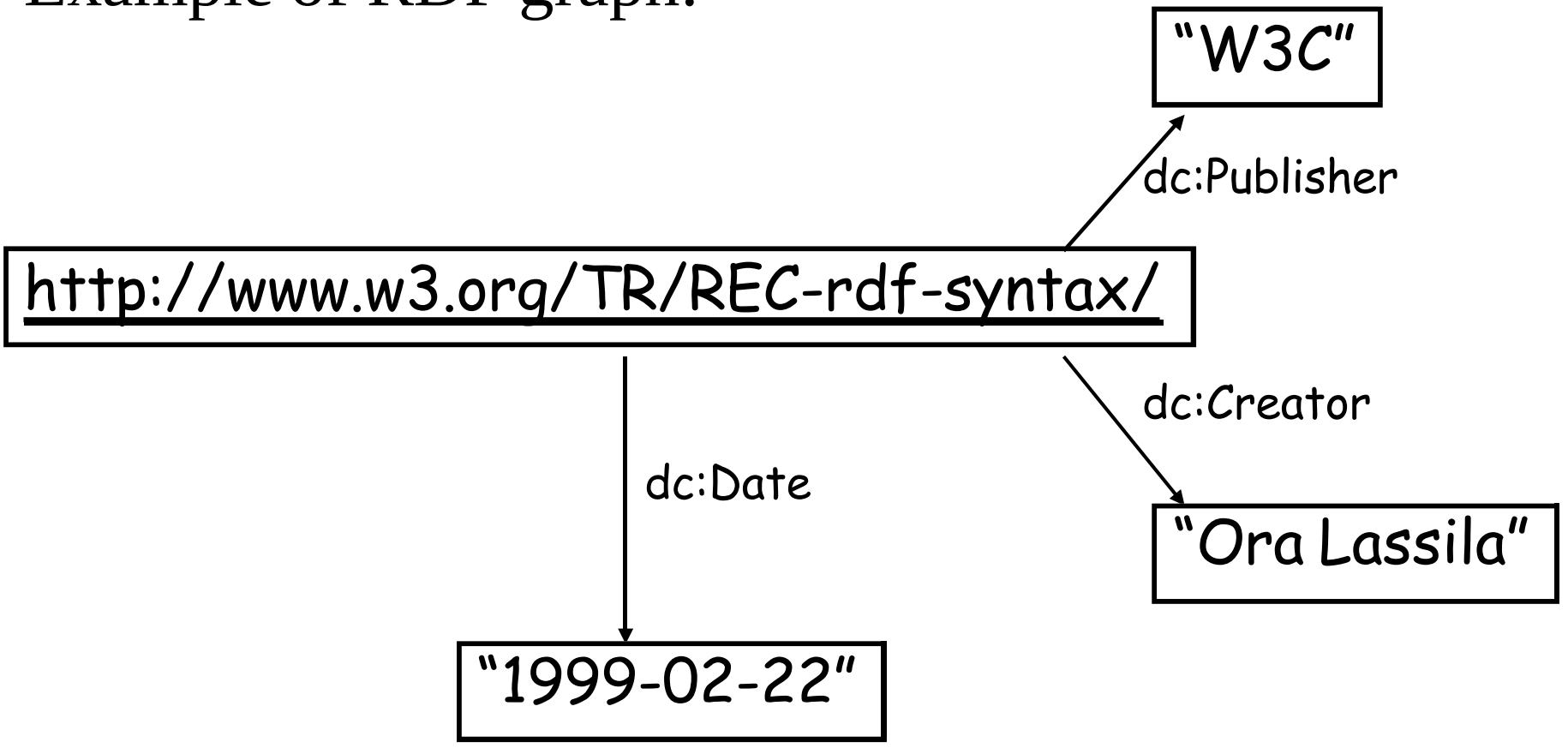
(subject, predicate, object)

- subject = resource
- predicate = ownership (of the resource)
- object = value (data item)

=> an RDF model is a **graphical model.**

2. The RDF + RDFS layer

Example of RDF graph:



RDF triples

- Let us begin to formalize what we did!
  - We attempt to "connected" the data…
  - but a simple connection is not enough… data should be named somehow
  - hence the RDF Triples: ***a labelled connection between two resources***

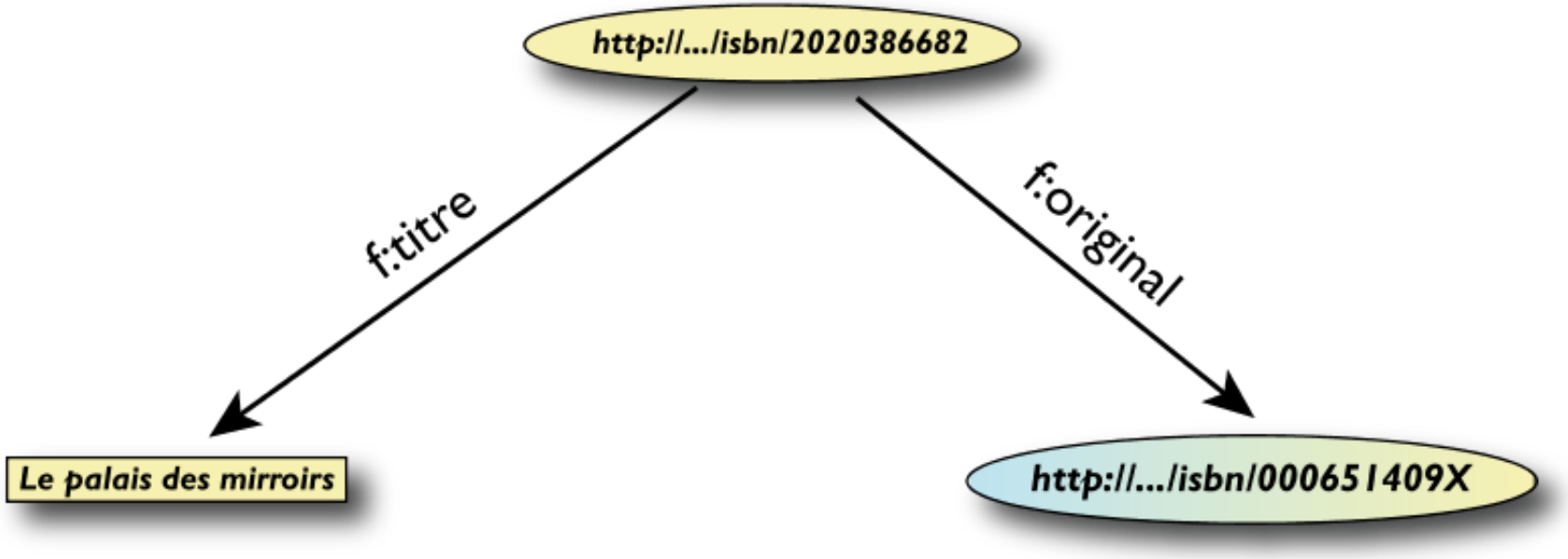
- An RDF Triple **(s,p,o)** is such that:
  - for example "**s**", "**p**" are URI-s for resources on the Web; "**o**" is a URI or a literal data source.
    - "**s**", "**p**", and "**o**" stand for "subject", "property", and "object"
  - here is the complete triple:

```
(<http://…isbn…6682>, <http://…/original>, <http://…isbn…409X>)
```

- *RDF* is a general model for such triples (with machine readable formats like XML, Turtle, N3, RXR, …)

RDF triples (cont.)

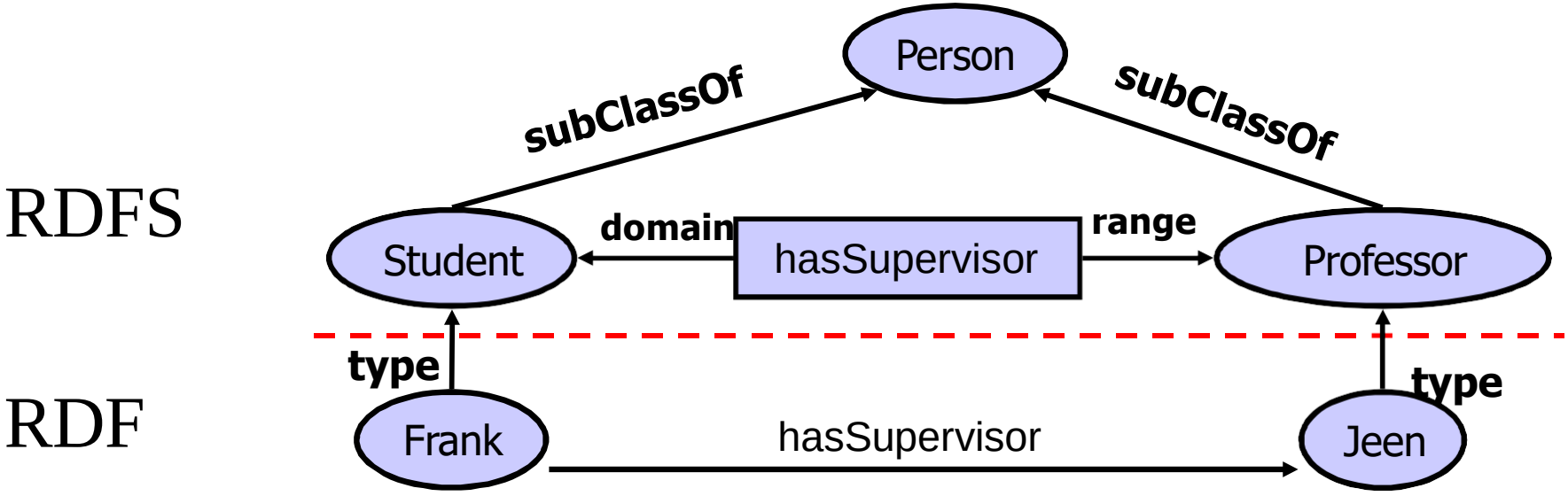
- Resources can use *any* URI, e.g.:
  - `http://www.example.org/file.xml#element(home)`
  - `http://www.example.org/file.html#home`
  - `http://www.example.org/file2.xml#xpath1(//q[@a=b])`




```
<rdf:Description rdf:about="http://…/isbn/2020386682">
    <f:titre xml:lang="fr">Le palais des mirroirs</f:titre>
    <f:original rdf:resource="http://…/isbn/000651409X"/>
</rdf:Description>
```

2. The RDF + RDF Schema layer

- RDF: represent the data objects itself.
- RDFS = RDF Schema: represents the general notation that represents the relational data structure for that objects.
- W3C standard (2004) example:



3. Ontology layer

Ontologies: are a set of concepts and categories in a specific subject or domain (Web) that shows their properties and the relations between them.

The term ontology from web point of view:

- An ontology is data model that represents knowledge as a set of concepts within a specific domain and the relationships between these concepts.

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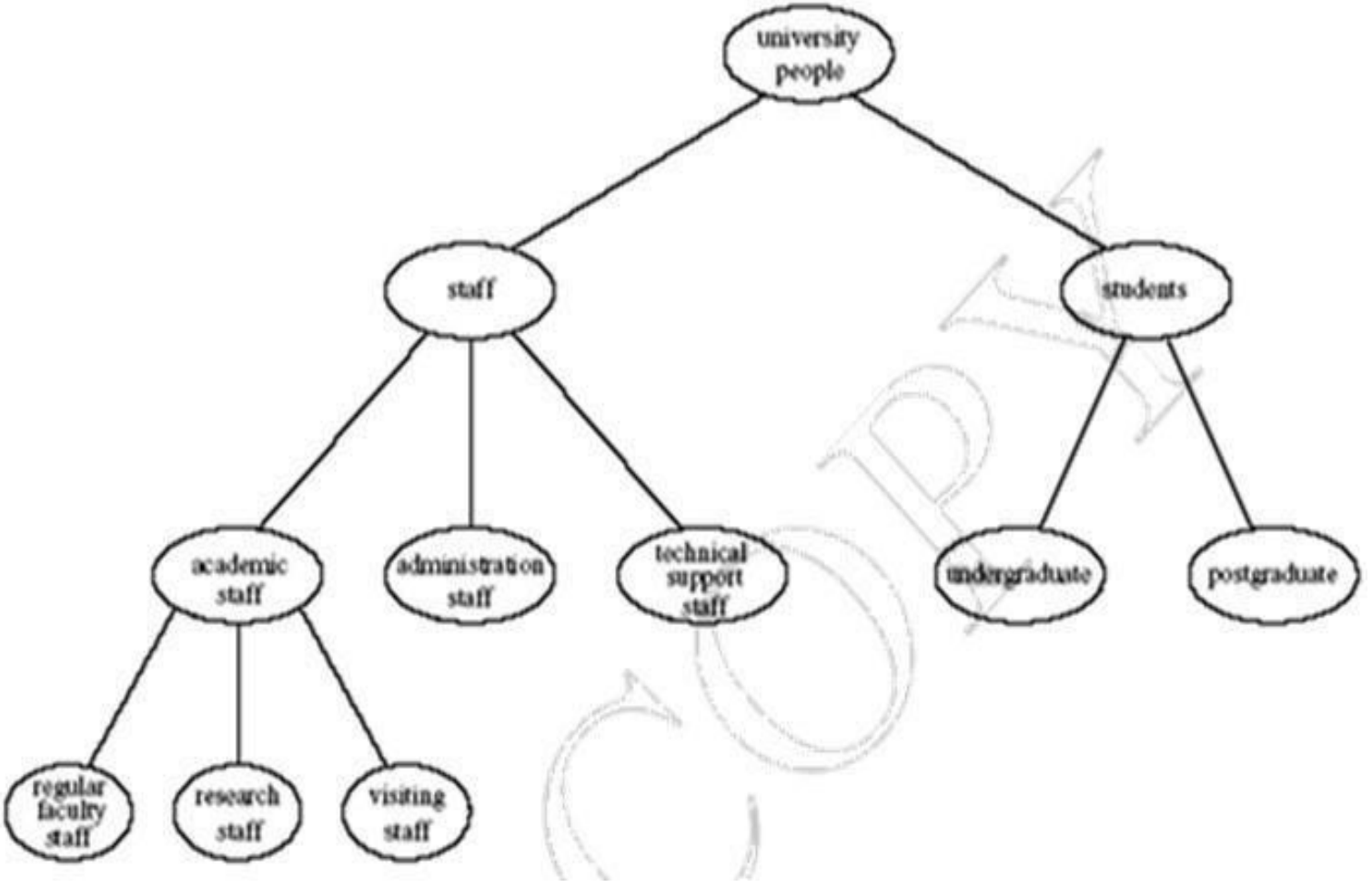
Components of Ontologies

- **Terms (Items):** refers to important data items (classes of objects) of a specific domain
  - e.g. Faculty database contains professors, staff, students, courses, departments
- **Relationships:** between these items: typically, class hierarchies
  - Class **A** is defined as a subclass of another class **B** if every object in **A** is also included in **B**
  - e.g. all professors are staff members.

Components of Ontologies

- **Properties:**
  - e.g. X teaches Y (professors teaches students)
- **Value restrictions**
  - e.g. only faculty members can teach courses.
- **Disjointness statements**
  - e.g. faculty and general staff are disjoint (two classes in an ontology are disjoint if they cannot share an instance)
- **Logical relationships between objects**
  - e.g. every department must include at least 10 faculty

Example of a Class Hierarchy



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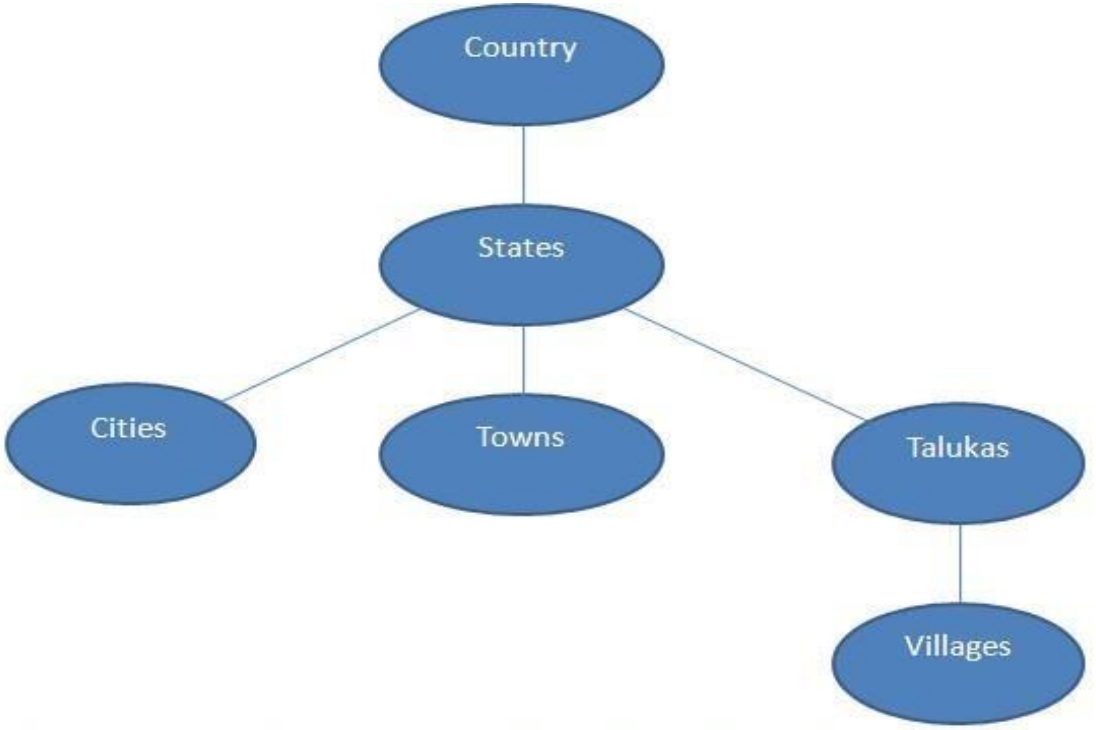

Ontology for a geography of a country , showing hierarchy of classes

https://thesemanticway.wordpress.com/2008/11/11/owl-ontology-example/

The Properties of Ontologies on the Web

- Ontologies provide a shared understanding (semantics) of a domain:
  - overcome differences in data item terminologies.
- Ontologies are useful for improving the accuracy of Web searches
  - search engines can look for pages that refer to a specific concept in an ontology.
- Web searches can exploit generalization or specialization information
  - If a query fails to find any relevant documents, the search engine may suggest to the user a more general query.
  - If too many answers are retrieved, the search engine may suggest to the user some specializations.

Thank you

Prof. Khaled Wassif