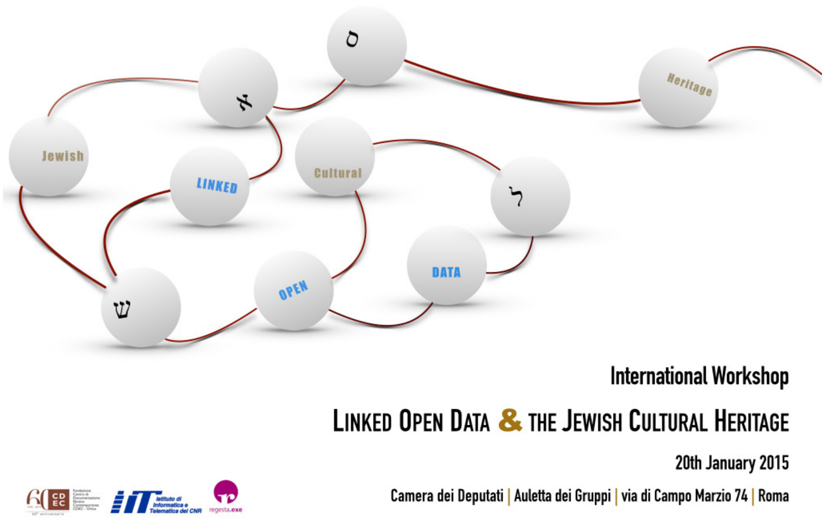


International Workshop

Linked Open Data & the Jewish Cultural Heritage

Rome, 20th January 2015

Linked Open Data: a short introduction

Oreste Signore

(W3C Italy)

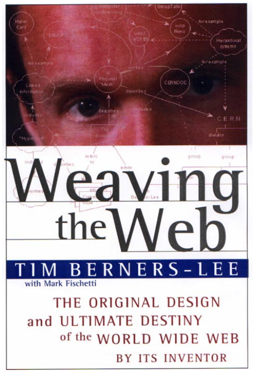
Slides at: http://www.w3c.it/talks/2015/lodjch/

World Wide Web Consortium Ufficio Italiano

ISTITUTO DI SCIENZA E TECNOLOGIE DELL'INFORMAZIONE "A. FAEDO"

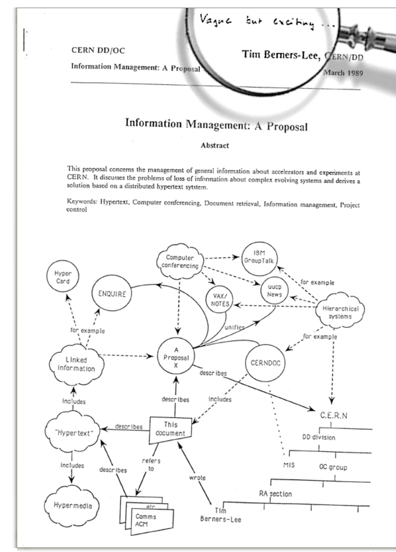
Talk layout

- The birth of Linked Open Data (LOD)
- Linked Open Data
  - ✓ benefits, principles, levels
- Web of Data & Semantic Web
  - ✓ Data integration
  - ✓ RDF (Resource Description Framework)
- One step forward: ontology
- Conclusion



Once upon a time…

- **1970(?) A boy was talking with his father:**
  - ✓ **How to make a computer intuitive, able to complete connections as the brain did**
- **1980, while at CERN:**
  - ✓ ***Suppose all the information stored on computers everywhere were linked. Suppose I could program my computer to create a space in which anything could be linked to anything… There would be a single, global information space.***



Vague but exciting…

CERN DD/OC

Information Management: A Proposal

Tim Berners-Lee, CERN/DD

March 1989

Information Management: A Proposal

Abstract

This proposal concerns the management of general information about accelerators and experiments at CERN. It discusses the problems of loss of information about complex evolving systems and derives a solution based on a distributed hypertext sytstem.

Keywords: Hypertext, Computer conferencing, Document retrieval, Information management, Project control

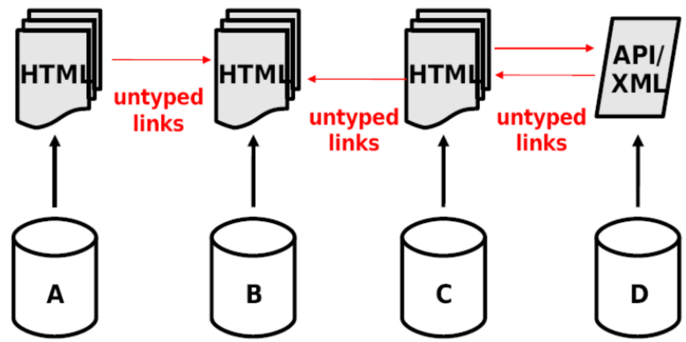
- **1989 Vague but exiciting**
- **…and there was the Web…**
- **1994**
  - ✓ **"The very first *International World Wide Web Conference*, at CERN, Geneva, Switzerland, in September 1994"**
    http://www.w3.org/Talks/WWW94Tim/
- **1999 Semantic Web Activity in W3C (now: Data Activity)**
- **2007 LOD (W3C Linking Open Data project)**

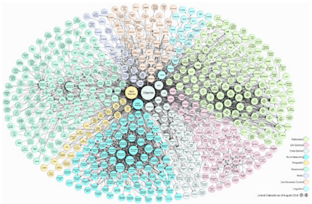
Web architecture

- Decentralization
- Basics
  - URI
    - The most fundamental innovation of the Web
    - Can address everything (resources, concepts)
  - HTTP
    - Format negotiation
    - Protocol to fetch resources
  - HTML
    - Structuring documents
- RDF (Resource Description Framework)
  - will be for the Semantic Web what HTML has been for the Web

LOD: the benefits (1)

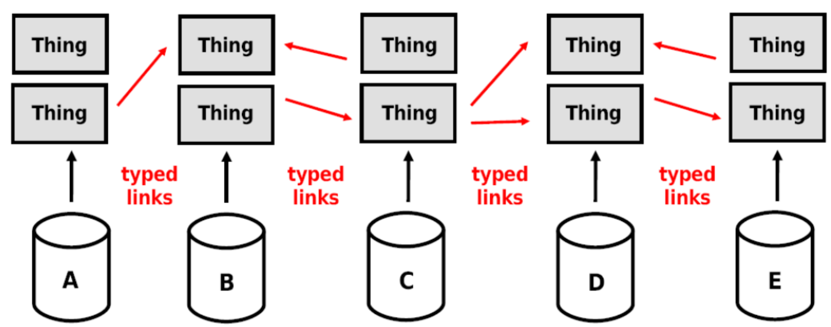
- **From the Web of Documents …**
  - ✓ A global filesystem
  - ✓ Documents are the primary objects
  - ✓ (Fairly structured) documents connected by untyped links
  - ✓ Implicit semantics of content and links
  - ✓ Designed for human consumption
  - ✓ Simplicity … but disconnected data





LOD: the benefits (cont.)

- … to the **Web of Data**
  - ✓ A global **database**
  - ✓ Primary objects: **Things** (or description of things)
  - ✓ **Typed links** between things (including documents)
  - ✓ High degree of **structure** in (description of) things
  - ✓ **Explicit semantics** of content and links
  - ✓ Designed for
    - **Machines** (first)
    - **Humans** (later)



LOD: the principles

> **Web of things in the world, described by data on the Web**

- **What does LOD mean?**
  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 2007

http://www.w3.org/DesignIssues/LinkedData.html

LOD: principle 1

Use URIs as names for things

- **URI identify:**
  - ✓ Documents and digital contents available on the Web
  - ✓ Real objects and abstract concepts
- **Only *HTTP URI*, not other schemas like URN or DOI, because:**
  - ✓ Provide a simple way to create globally unique names in a decentralized fashion, as every owner of a domain name, or delegate of the domain name owner, may create new URIreferences
  - ✓ They serve not just as a name but also as a means of accessing information describing the identified entity

LOD: principle 2

Use HTTP URIs so that people can look up those names

- **HTTP is the universal protocol to access Web resources**
- **All HTTP URI must be "*dereferenceable*"**
- **When URIs identify real objects, it's essential distinguish objects from documents that describe them**

LOD: principle 3

When someone looks up a URI, provide useful information, using the standards (RDF*, SPARQL)

- **Use a single data model to publish data on the Web: *RDF***
- **RDF data model is very simple and strictly coherent with Web architecture**

LOD: principle 4

Include links to other URIs, so that they can discover more things

- **Links (named *RDF links*) are "*typed*"**
- **Set *RDF links* towards other data sources on the Web**
  - ✓ **An external RDF link (having p and/or o defined in an external dataset) allows to access data on remote servers**
  - ✓ **The process is repeated in cascade**
  - ✓ ***External RDF links* are the glue that connects data islands into a global, interconnected data space**

The LOD five levels

★ On the web

Available on the web (whatever format) *but with an open licence, to be Open Data*

★★ Machine-readable data

Available as machine-readable structured data (e.g. excel instead of image scan of a table)

★★★ Non-proprietary format

as (2) plus non-proprietary format (e.g. CSV instead of excel)

★★★★ RDF standards

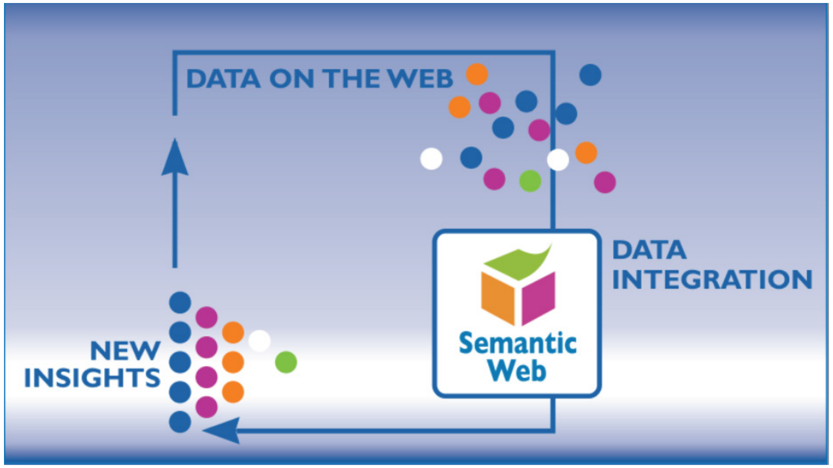
All the above plus, Use open standards from W3C (RDF and SPARQL) to identify things, so that people can point at your stuff

★★★★★ Linked RDF

All the above, plus: Link your data to other people's data to provide context

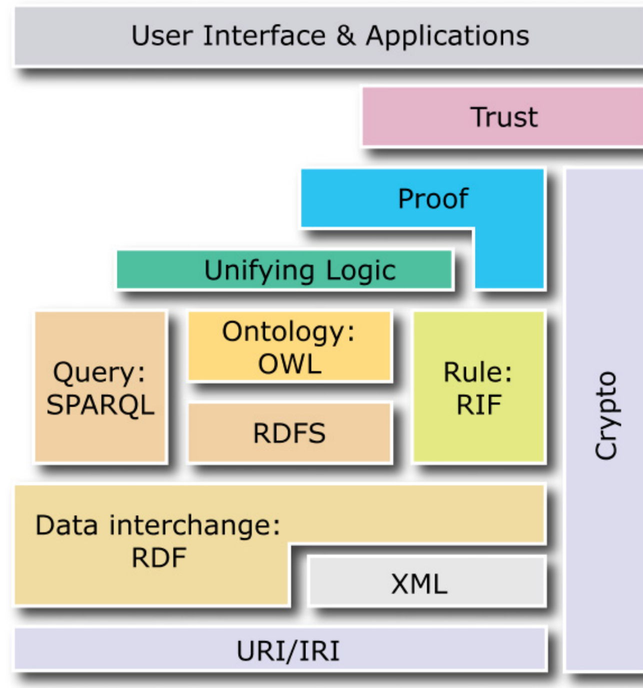
Web of Data and Semantic Web

- Semantic Web
  - Extends Web principles from documents to data
  - Creates the "*Web of Data*"
- Data (and not only data) can be
  - shared and reused in the Web
- RDF
  - Resource Description Framework
  - gives the abstraction layer to integrate data on the Web

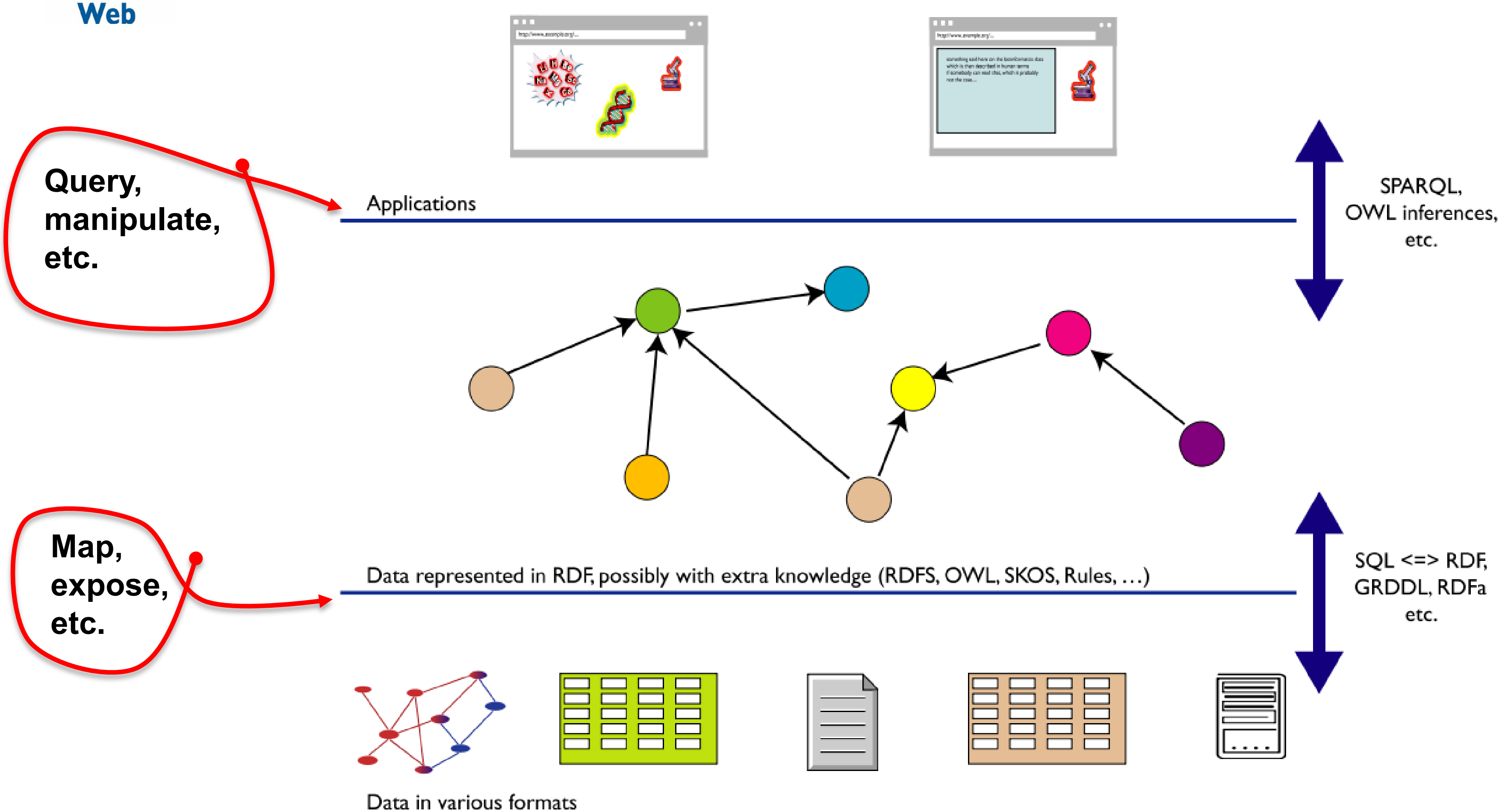


Semantic Web

- A "**Web of data**"
- Formalizing, exporting and **sharing** knowledge
- **Ontologies**
- **Inference** rules
- Data are **machine-understandable**
- Many technologies:
  - ✓ RDF, RDFS, OWL, ...



SW and Data Integration

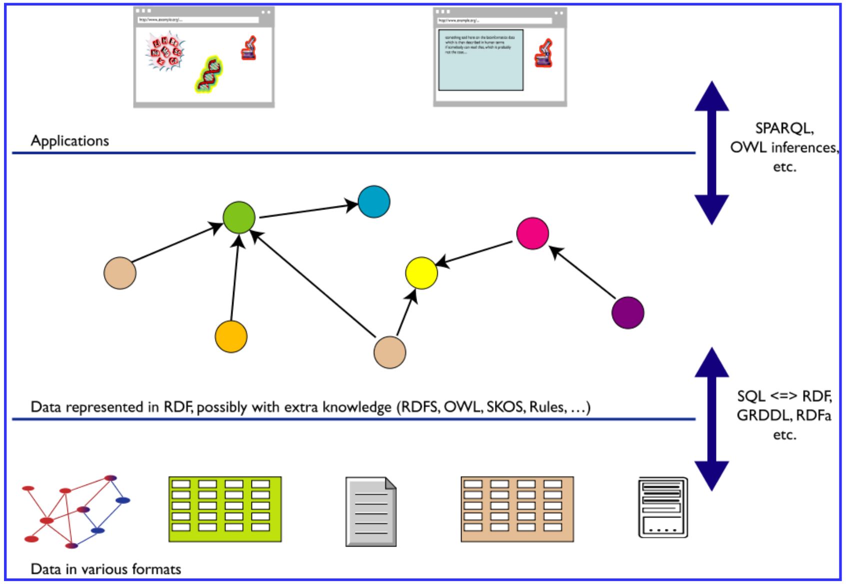


No need to put all your data in RDF!

SW and Data Integration: some advantages

- Representation as a graph
  - ✓ independent of the actual structure of the data
- Changes to the format of the local database, etc.
  - ✓ have no influence on the general level
  - ✓ affect only the level of the step of exporting data (schema independence)
- You can
  - ✓ add new data
  - ✓ add more connections

  seamlessly, regardless of the structure of other data sources

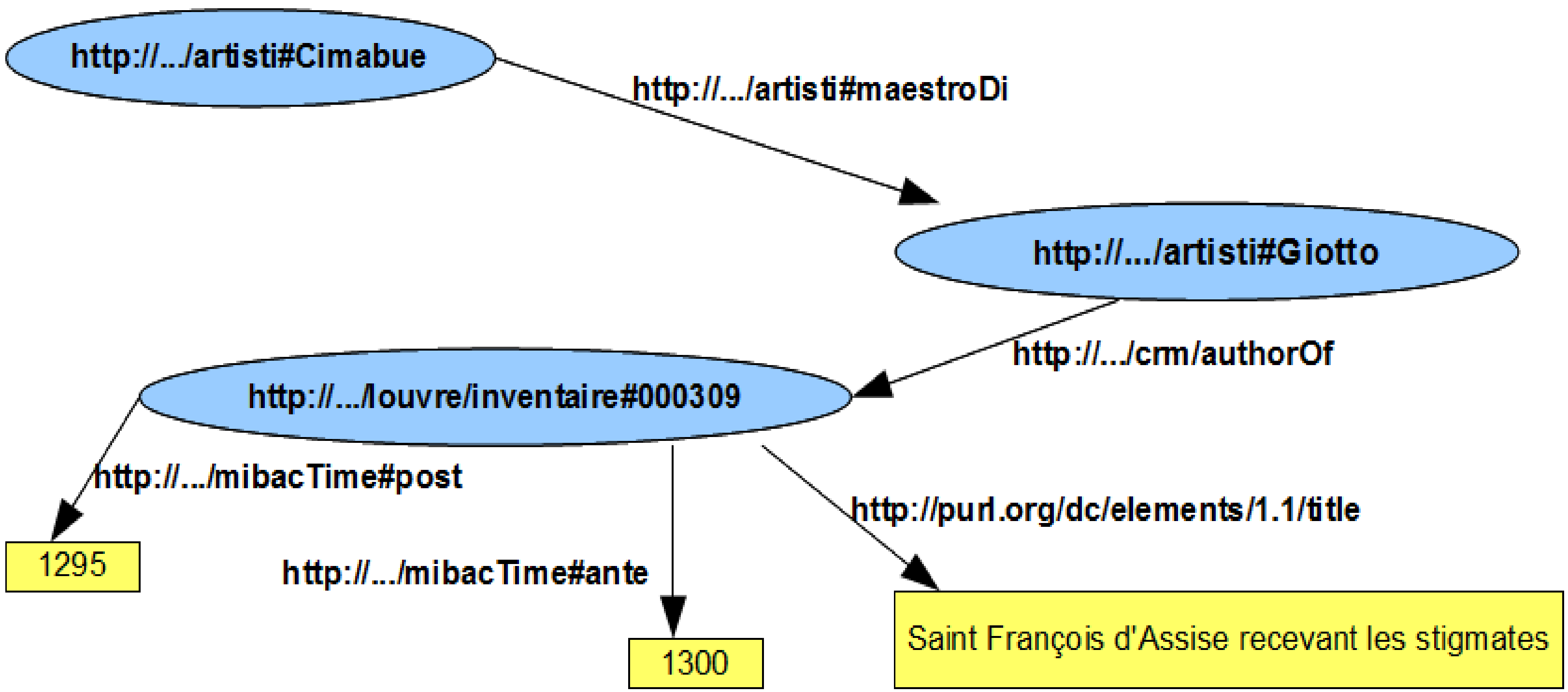


RDF in a nutshell

- **A RDF triple (s,p,o)**
  - ✓ is a *labelled connection between two resources*
  - ✓ is called *"triplet"*, or *"statement"*
- **The s, p, o resources are also called:**
  - ✓ *"subject"*, *"property"*, *"object"*
    or
    "subject", *"predicate"*, *"object"*
- **A RDF triple (s,p,o) is defined in a way such that**
  - ✓ "s", "p" are URI (resources on the Web)
  - ✓ "o" can be an URI or a "literal"
- **Names are denoted by URI**
- **Conceptually:**
  - ✓ "p" *connects (or states a relationship between)* "s" and "o"
- **Formally:**
  - ✓ RDF triples are *"directed, labelled graph"*
    (the best way to think about them!)

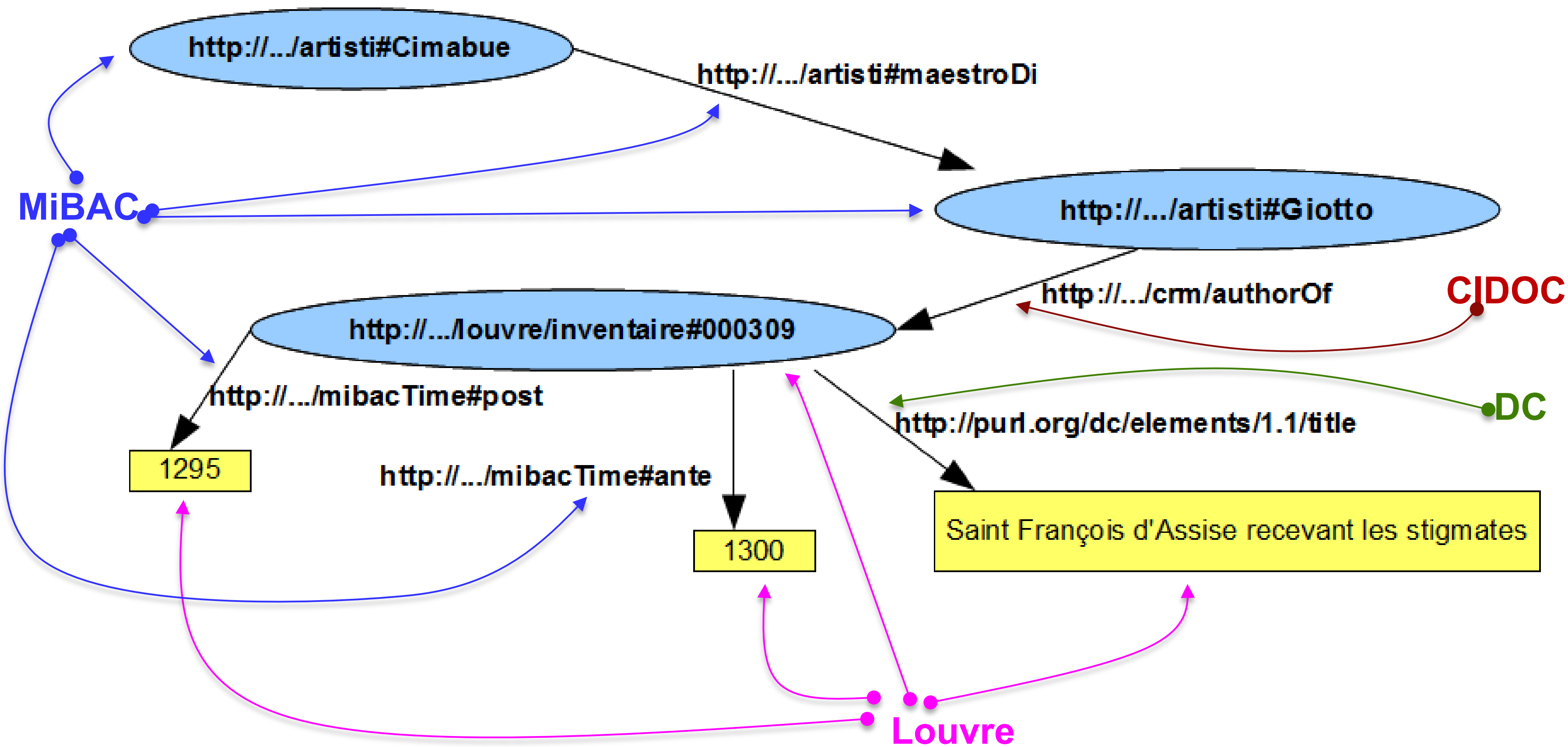
A RDF graph

...a set of s-p-o (subject-predicate-object) triples



A RDF graph (annotated)

...a set of s-p-o (subject-predicate-object) triples



Is RDF enough?

- RDF is a universal language to describe resources using your own vocabulary
- Syntactically correct RDF statements (s-p-o triples) can be meaningful or meaningless
  - ✓ Leonardo authorOf Gioconda ✓
    Cimabue masterOf Giotto ✓
    Michelangelo authorOf Leonardo ✗
- We need to express constraints
- Here come RDFS, OWL (Ontology languages)

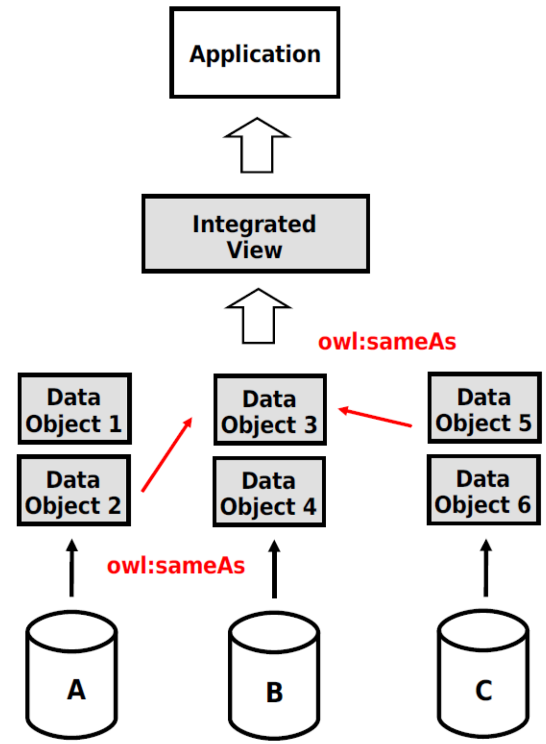
One step forward: ontology

- **Models knowledge in its:**
  - ✓ **Intension (terminological knowledge: definitions of concepts and roles)**
  - ✓ **Extension (assertional knowledge: instances or definitions of individuals)**
- **A simple definition (Jim Hendler)**
  - ✓ **A set of *knowledge terms*, including the vocabulary, the *semantic interconnections* and some *simple rules* of inference and logic for some particular topic**
- **Many definitions, but:**
  - ✓ **clear understanding**
  - ✓ **consensus among the ontology community**
- **An ontology includes:**
  - ✓ **terms *explicitly* defined**
  - ✓ ***knowledge* we can *infer***
- **An ontology aims to capture *consensual* knowledge, to reuse and *share* across software applications and by groups of people**
- **A shared ontology**
  - ✓ **Allows machines to understand data**
  - ✓ **Makes data really interoperable**

Reconciling differences

- **For classes:**
  - ✓ owl:equivalentClass: two classes have the same individuals
- **For properties:**
  - ✓ owl:equivalentProperty
- **For individuals:**
  - ✓ owl:sameAs: two URIs refer to the same concept (“individual”)
- **owl:sameAs**
  - ✓ is a main mechanism of “linking”
  - ✓

```
<http://louvre.fr/Michel-Ange>
    owl:sameAs  <http://mibac.it/Michelangelo> ;
```



Work done?

- The ontology (intension):
  - ✓ Models concepts and relationships
  - ✓ Supports multilinguality
  - ✓ Can be referenced by everybody
- Data (extension):
  - ✓ Available as RDF
  - ✓ Can be queried via SPARQL
  - ✓ Can be linked by everyone from everywhere
- No more a single information silo!

Five stars LOD?

Nobody's perfect!

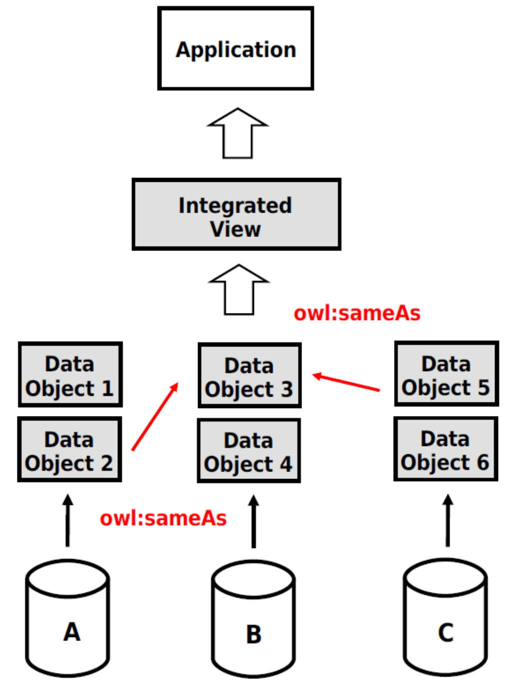
- Is the ontology a **shared** ontology?
- Does it make **reference** to well established ontologies?

Building ontologies: a methodology (or a rule of thumb?)

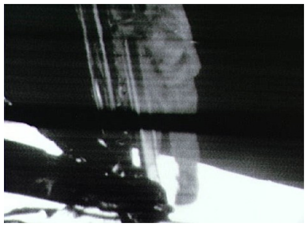
- Analyze and model your "world of interest"
- Check existing ontologies:
  - ✓ does one **fits** perfectly?
  - ✓ **extend** one with your own concepts?
  - ✓ **combine** several existing ontologies?
  - ✓ full **import** or just **refer** some class/properties?
- Based on my own experience:
  - ✓ creating your own ontology is **easier**, but **less** effective
  - ✓ using/combining/extending existing ontologies is **harder**, but **more** effective
  - ✓ keep **intensional** and **extensional** components **separated**

Content of this slide does not necessary reflect the W3C position

Ready to start?



- **User requirements**
  - ✓ Integrated view of information
- **Data fusion: some well known problems**
  - ✓ Schema mapping
  - ✓ Conflict resolution: inconsistencies
  - ✓ Trust / Information quality
- **Reuse issues**
  - ✓ Licences
- **Implementation issues**
  - ✓ How to publish
  - ✓ Platforms
- **Aim: five star dataset, rich and shared ontology. However:**
  - ✓ The best is the enemy of the good.
  - ✓ The important is to start, even with raw data
  - ✓ *"One small step for man. One giant leap for mankind."*



Conclusion

- LOD have been part of the Web since its inception
- The main benefit is to **share** and **improve** knowledge
- **RDF** is the basis
- SW technologies are crucial
- W3C (i.e. **W3C members**) is leading activities in the field
- **Share** ontologies (intension)!
- Keep data **decentralized** (extension)!
- START NOW

?
Questions

Thank you for your attention!

Slides at: http://www.w3c.it/talks/2015/lodjch/