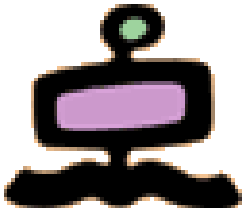
Corso di Biblioteche Digitali



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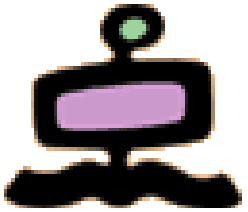
  - Office: 050 621 3115
  - Mobile: 348 397 2168
  - Skype: vittore1201

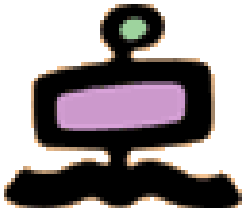
- “Ricevimento” at the end of the lessons or by appointment
- Final assessment
  - 70% oral examination
  - 30% project (development of a small digital library))
- Reference material:
  - Ian Witten, David Bainbridge, David Nichols, How to build a Digital Library, Morgan Kaufmann, 2010, ISBN 978-0-12-374857-7 (Second edition)
  - Material provided by the teacher
- **http://cloudone.isti.cnr.it/casarosa/BDG/**

Modules



- Computer Fundamentals and Networking
- A conceptual model for Digital Libraries
- Bibliographic records and metadata
- Information Retrieval and Search Engines
- Knowledge representation
- Digital Libraries and the Web
- Hands-on laboratory: the Greenstone system

Parallel evolution



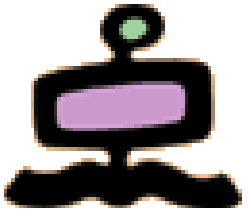
Libraries

- Description (documents)
  - Bibliographic records
  - MARC
- Interoperability
  - Z39-50
- Conceptual model (classes)
  - FRBR – LRM for Works, Expr., Manif.
- Information Retrieval
  - Full text (catalogue and documents)

The Web

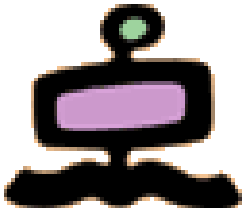
- Description (instances)
  - Metadata
  - Dublin Core
- Interoperability
  - OAI-PMH
- Conceptual model (classes)
  - **RDF and RDF Schema for all resources (ontologies)**
- Information Retrieval
  - Full text (web pages and resources)

Knowledge representation



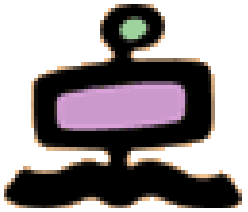
- FRBR: Functional Requirements for Bibliographic Records
  - LRM: Library Reference Model
- RDF: Resource Description Framework
- RDF Schema
  - LOD: Linked Open Data

Representation of knowledge



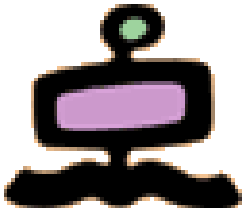
- Description of Information (resources) is an exercise in “knowledge representation”
- Description with metadata (such as Dublin Core) only captures the “syntactic” aspects of the resource
- It would be good to have also a “semantic” description (capturing our “knowledge” of the resource)
- Knowledge representation is the “Holy Graal” of Computer Science (Artificial Intelligence, Expert Systems, Ontologies, etc.)
- Many models/languages proposed in the last 50 years
  - Basically all of them are based on the “entity-relationship model”
- Most of the advances available today are due to “brute force” methods (computing power, today “neural networks”)
- Two conceptual models of interest to Digital Libraries:
  - FRBR
  - RDF Schema

RDF – Resource Description Framework



- Resource Description Framework (RDF) is a way to represent information about *resources* in the Web (in the World)
- A resource is anything that has identity. For example, a resource may be an electronic document, an image, a service (e.g., "today's weather report for Los Angeles"), and a collection of other resources. Not all resources are network "retrievable"; e.g., human beings, corporations, and bound books in a library can also be considered resources
- All resources are identified by a URI (Uniform Resource Identifier)
  - a string of characters that unambiguously identifies a particular resource
- *Resources* are described in terms of simple statements specifying properties and property values of resources

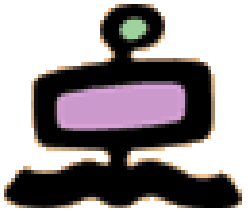
Resources and metadata



- Metadata can be associated with any resource: physical, digital, abstract resource, etc.
- The metadata set describing a resource is also a resource

- HTML documents
- digital images
- databases
- books
- museum objects
- archival records
- metadata records
- Web sites
- collections
- services
- physical places
- people
- institutions
- abstract “works”
- concepts
- events

RDF – Resource Description Framework



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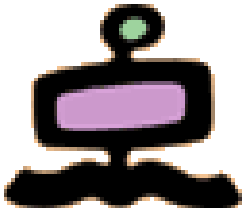
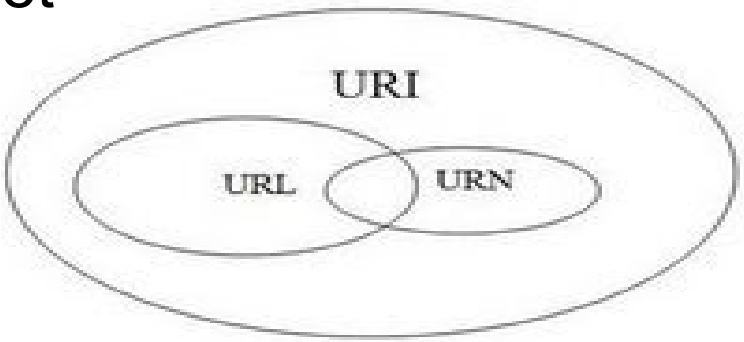
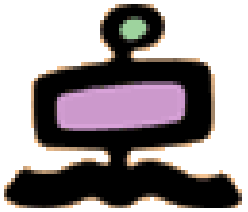
URI (IRI), URL, URN



- URL - Uniform Resource Locator
  is a subset of the URIs that include a network location
- URN - Uniform Resource Name
  is a subset of URIs that include a name within a given space, but no location
- URI - Uniform Resource Identifier
  identifies a resource (text document, image file, any other)
- IRI – International Resource Identifier
  is a URI with Unicode character set

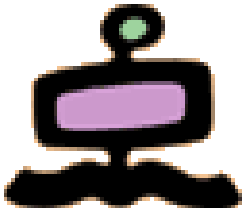


URLs



- URL (Uniform Resource Locator) is a a reference (an address) to a resource on the Internet; it is a specific type of URI; it has two parts:
  - protocol identifier (e.g. http, ftp)
  - resource name (its structure depends on the protocol)
  - very common for the protocol http is "host name" followed by "file name": http://www.example.com/index.html
- URLs started to be used at the beginning of the Web and are the actual links in Web pages

Several types of URIs
URI Syntax

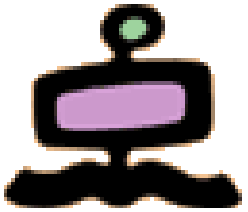


<scheme name> : <hierarchical part> [? <query>] [# <fragment>]

any://example.com:8042/over/there?name=ferret#nose
___/ _____________/ _____/ _____/ __/
scheme authority path query fragment

- ftp://ftp.is.co.za/rfc/rfc1808.txt
- **http://www.ietf.org/rfc/rfc2396.txt**
- ldap://[2001:db8::7]/c=GB?objectClass?one
- mailto:John.Doe@example.com
- news:comp.infosystems.www.servers.unix
- tel:+1-816-555-1212
- telnet://192.0.2.16:80/
- urn:oasis:names:specification:docbook:dtd:xml:4.1.2bb

RDF – Resource Description Framework



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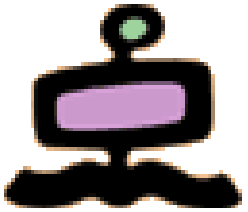
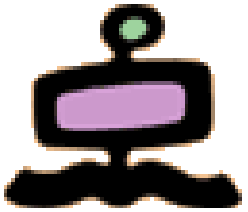
- All resources are identified by a URI (Uniform Resource Identifier)
  - a string of characters that unambiguously identifies a particular resource
- *Resources* are described in terms of simple statements specifying properties (attributes) and property values

RDF statements



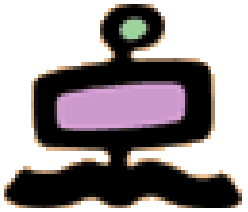
- Resources:
  - An object, an entity or anything we want to talk about (e.g. authors, books, publishers, places, people, facilities)
- Properties:
  - They codify relations (e.g. written-by, friend-of, located-in, …) and attributes (e.g. age, date of birth, length …)
- Statements:
  - Statements assert the properties of resources in the form of triples: subject-property-value (subject-predicate-object)
- Every resource and property has a URI (an URL or any other identifier)
- Values can be other resources (for relations) or literals (for attributes)

Simple RDF statement



- A statements is composed of three parts: a subject, a predicate (about the subject), an object (the value of the predicate)
- Example
  - http://www.example.org/index.html has a creator whose value is John Smith
- the subject is the resource identified by this URI: **`http://www.example.org/index.html`**
- the predicate is the phrase “has a creator"
- the object is the phrase "John Smith“
- To avoid “misunderstandings”, the three components of this statement should be indicated by URIs
  - Subject http://www.example.org/index.html
  - Predicate http://purl.org/dc/elements/1.1/creator
  - Object http://www.example.org/staffid/85740

Additional RDF statements (in natural language)

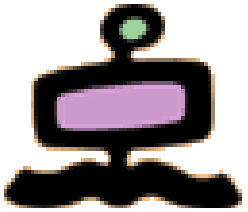


- http://www.example.org/index.html
  has a creator
  whose value is John Smith

- http://www.example.org/index.html
  has a creation-date
  whose value is August 16, 1999

- http://www.example.org/index.html
  has a language
  whose value is English

RDF statements as triples



Each statement corresponds to a “triple“

- <http://www.example.org/index.html>
- <http://purl.org/dc/elements/1.1/creator>
- <http://www.example.org/staffid/85740>

subject

predicate

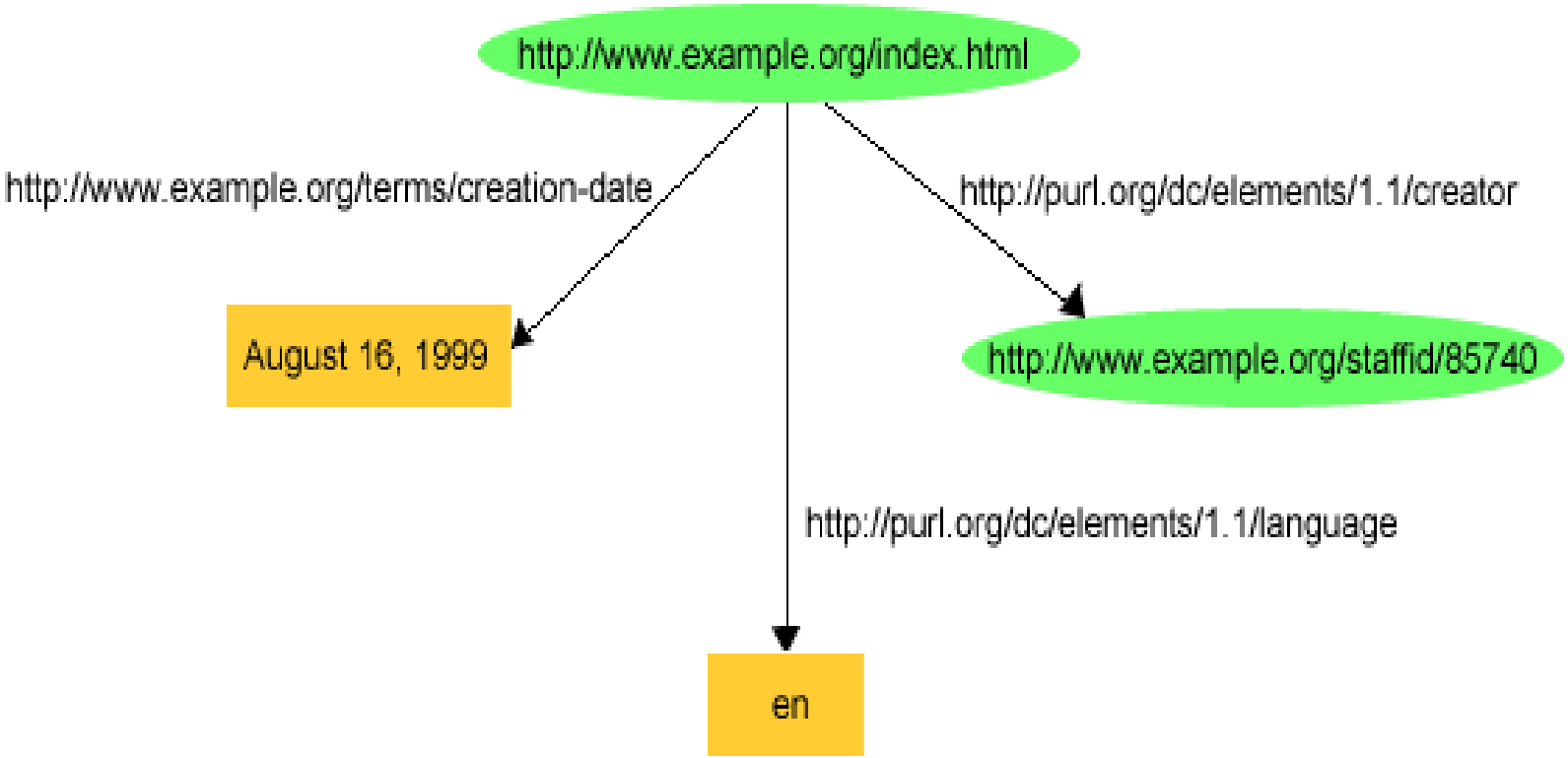
object

- <http://www.example.org/index.html>
- <http://www.example.org/terms/creation-date>
- "August 16, 1999" .

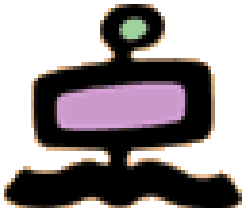
- <http://www.example.org/index.html>
- <http://purl.org/dc/elements/1.1/language>
- "en" .

RDF statements are graphs

Each triple corresponds to an arc in a graph

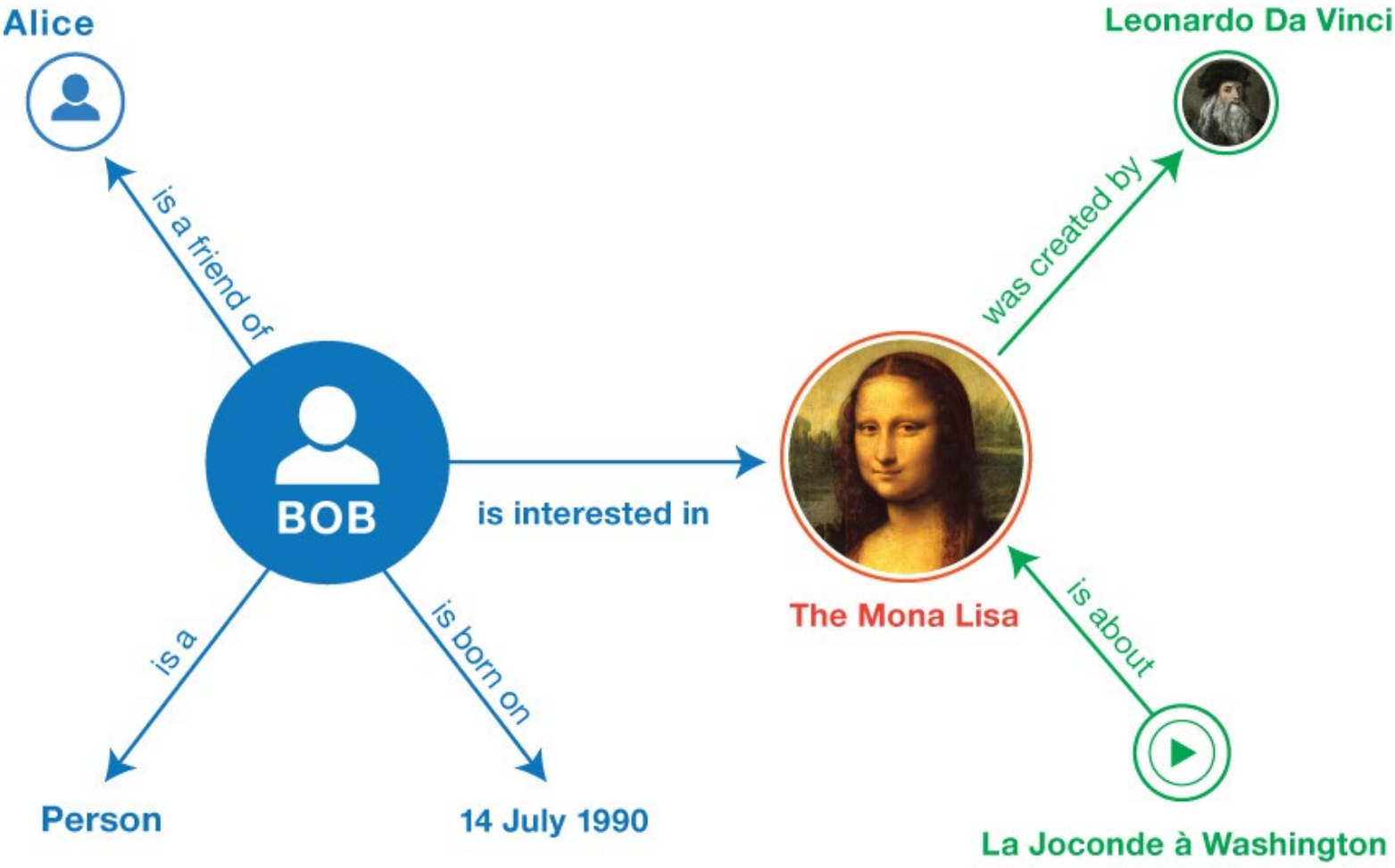


Another example of RDF triples

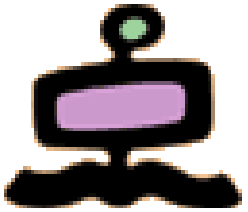


<Bob> <is a> <person>.
<Bob> <is a friend of> <Alice>.
<Bob> <is born on> <the 4th of July 1990>.
<Bob> <is interested in> <the Mona Lisa>.
<the Mona Lisa> <was created by> <Leonardo da Vinci>.
<the video 'La Joconde à Washington'> <is about>
<the Mona Lisa>

An RDF graph


Alice
is a friend of
BOB
is interested in
is a
Person
is born on
14 July 1990
Leonardo Da Vinci
was created by
The Mona Lisa
is about
La Joconde à Washington

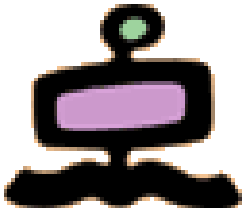
Abbreviation of URIs



URIs are usually long character strings. It is convenient to abbreviate them by defining prefixes of namespaces (the same idea as in XML)

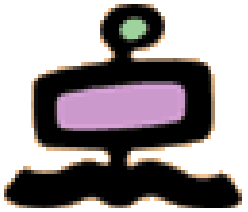
- prefix rdf:, namespace URI: http://www.w3.org/1999/02/22-rdf-syntax-ns#
- prefix rdfs:, namespace URI: http://www.w3.org/2000/01/rdf-schema#
- prefix dc:, namespace URI: http://purl.org/dc/elements/1.1/
- prefix xsd:, namespace URI: http://www.w3.org/2001/XMLSchema#
- prefix ex:, namespace URI: http://www.example.org/ (or http://www.example.com/)
- prefix exterms:, namespace URI: http://www.example.org/terms/
- prefix exstaff:, namespace URI: http://www.example.org/staffid/

Target name space



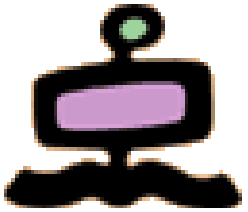
```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xs:targetNamespace="http://www.example.com/shiporderschema">
<xs:element name="shiporder">
  <xs:complexType>
    <xs:sequence>
      ................

    </xs:sequence>
    <xs:attribute name="orderid" type="xs:string" use="required"/>
  </xs:complexType>
</xs:element>
</xs:schema>
```

An XML schema



```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
<xs:element name="shiporder">
  <xs:complexType>
    <xs:sequence>
      ................
      <xs:element name="item" maxOccurs="unbounded">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="title" type="xs:string"/>
            <xs:element name="note" type="xs:string" minOccurs="0"/>
            <xs:element name="quantity" type="xs:positiveInteger"/>
            <xs:element name="price" type="xs:decimal"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
    <xs:attribute name="orderid" type="xs:string" use="required"/>
  </xs:complexType>
</xs:element>
</xs:schema>
```

RDF statements as triples



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- <http://www.example.org/index.html>
- <http://purl.org/dc/elements/1.1/creator>
- <http://www.example.org/staffid/85740>

subject

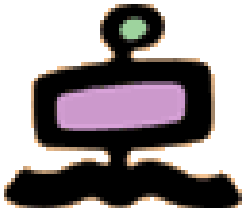
predicate

object

- <http://www.example.org/index.html>
- <http://www.example.org/terms/creation-date>
- "August 16, 1999" .

- <http://www.example.org/index.html>
- <http://purl.org/dc/elements/1.1/language>
- "en" .

Abbreviation of URIs



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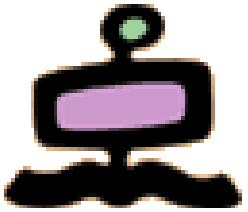
- prefix dc:, namespace URI: http://purl.org/dc/elements/1.1/
- prefix xsd:, namespace URI: http://www.w3.org/2001/XMLSchema#
- prefix ex:, namespace URI: http://www.example.org/ (or http://www.example.com/)
- prefix exterms:, namespace URI: http://www.example.org/terms/
- prefix exstaff:, namespace URI: http://www.example.org/staffid/

Abbreviated triples

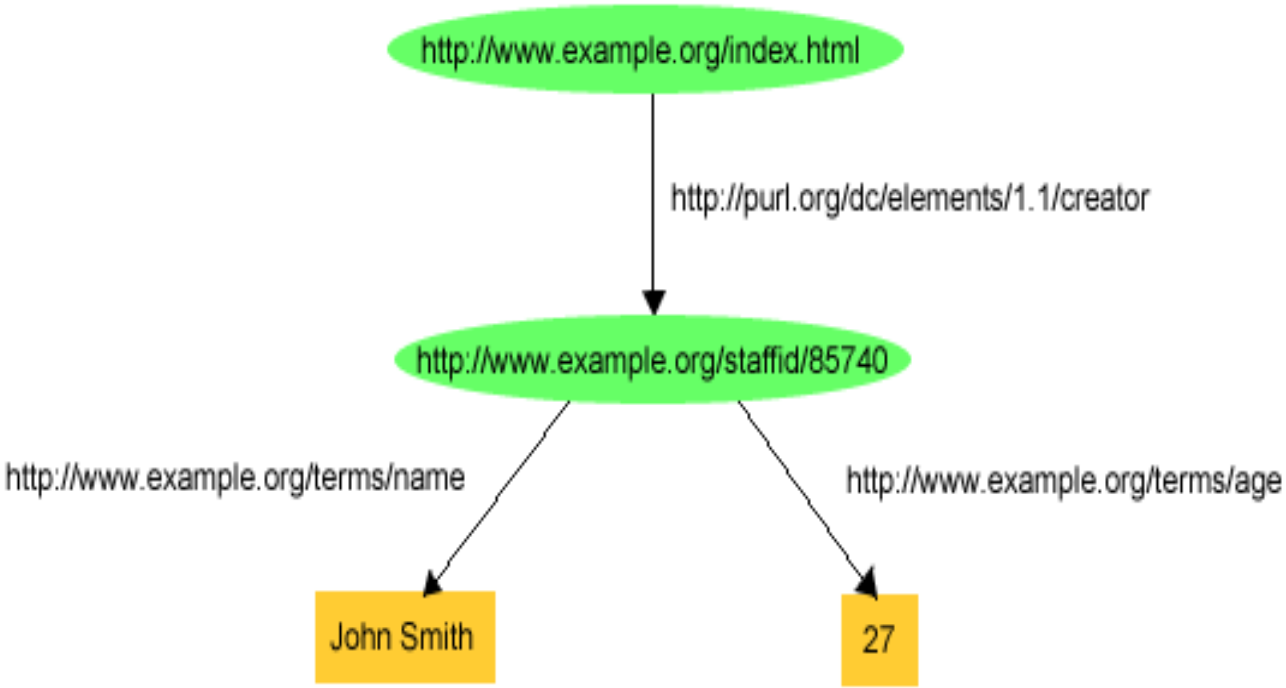


- ex:index.html
  dc:creator
  exstaff:85740 .

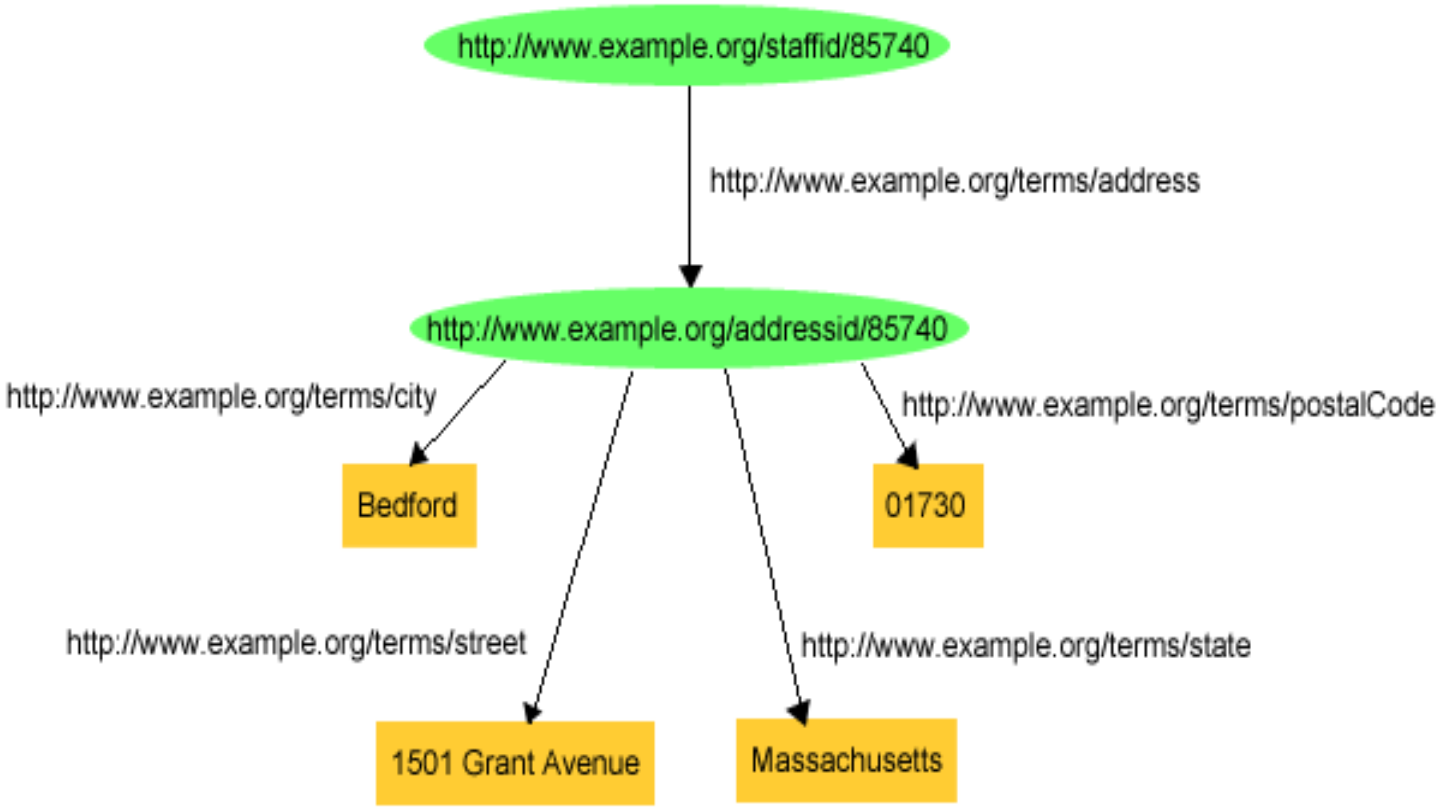
- ex:index.html
  exterms:creation-date
  "August 16, 1999" .

- ex:index.html
  dc:language
  "en" .

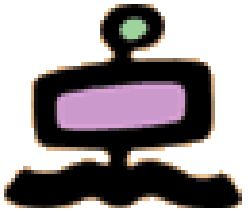
URI values can be subjects ...



... to any depth ...

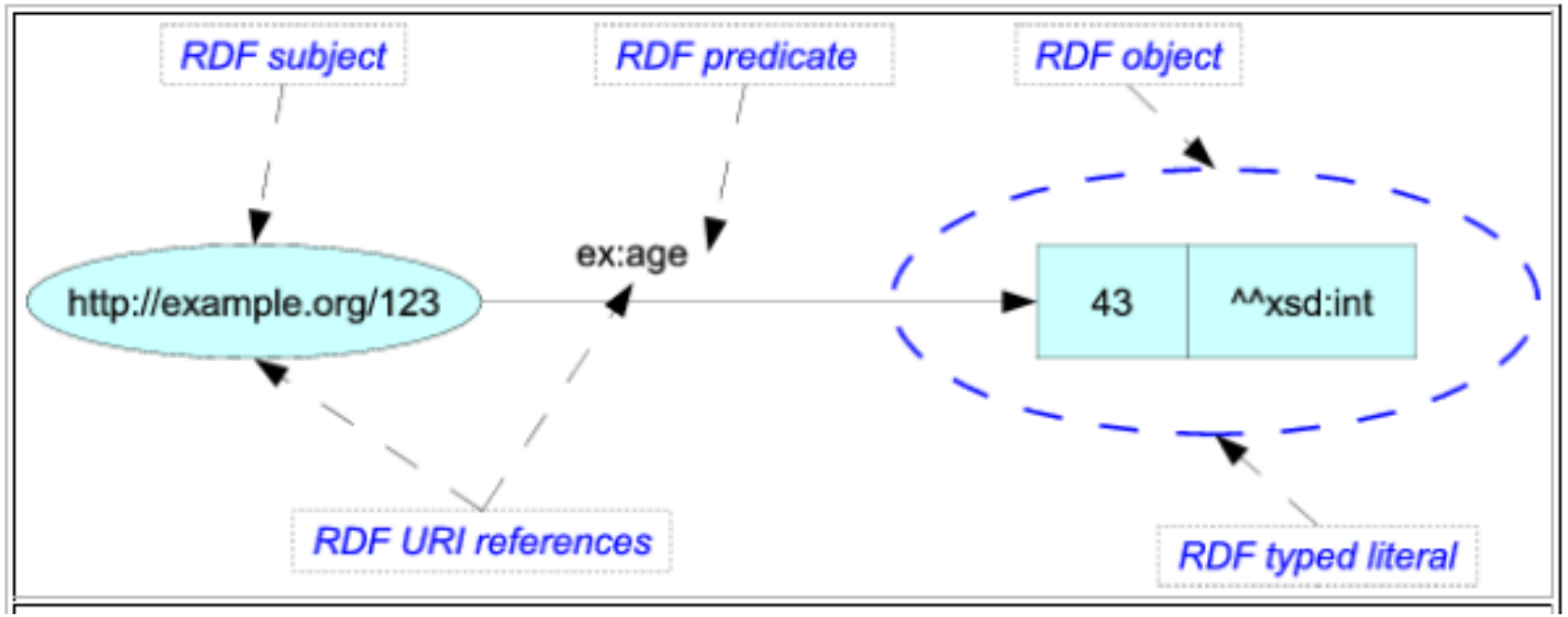

http://www.example.org/staffid/85740
http://www.example.org/terms/address
http://www.example.org/addressid/85740
http://www.example.org/terms/city
http://www.example.org/terms/postalCode
Bedford
01730
http://www.example.org/terms/street
http://www.example.org/terms/state
1501 Grant Avenue
Massachusetts

RDF summary

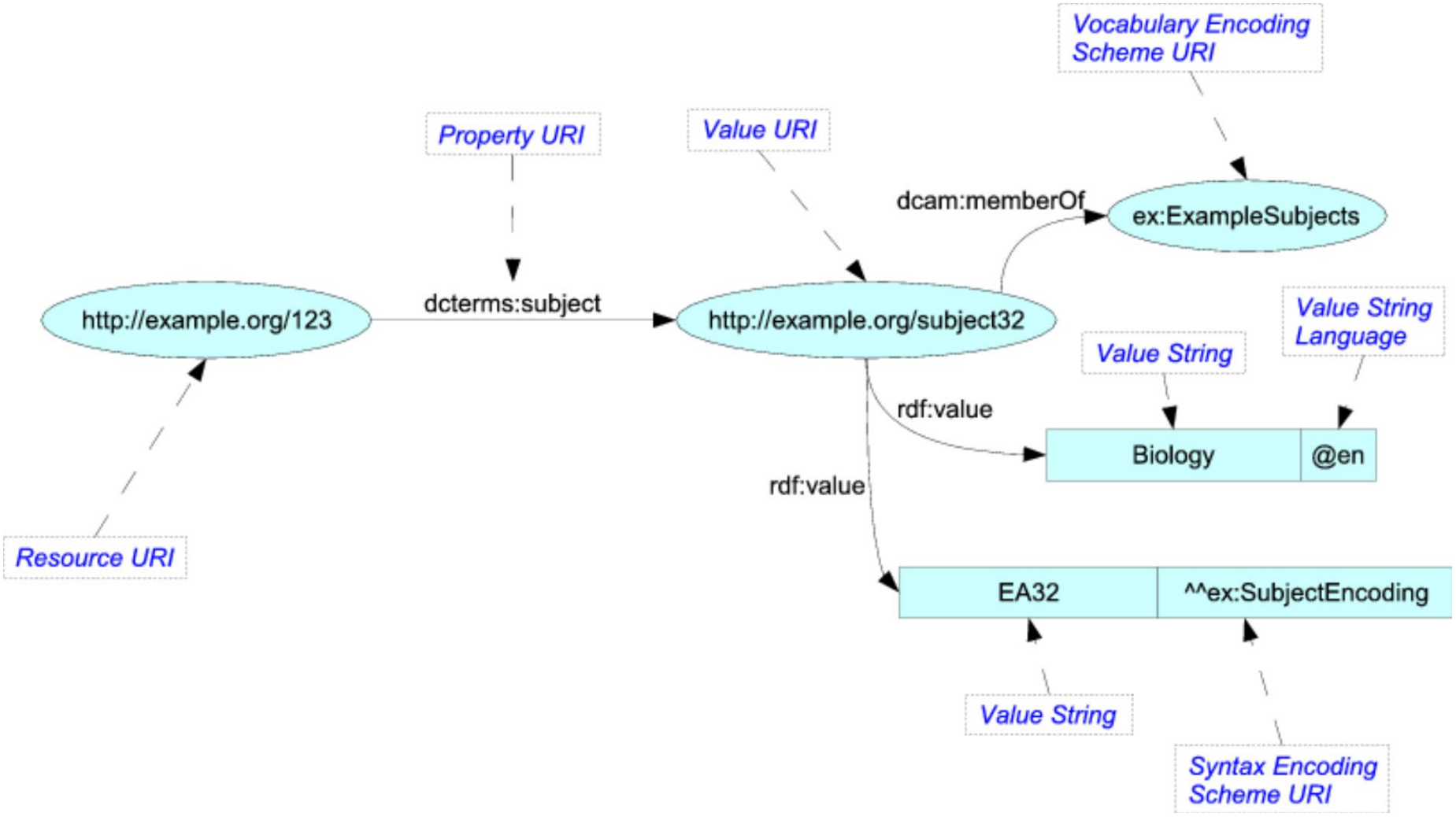


- A resource can be described by a set of RDF triples
- A set of RDF triples can be represented as a graph
- An RDF triple has three components
  - a **subject**, which is an RDF URI reference or a blank RDF node
  - a **predicate**, which is an RDF URI reference
  - an **object**, which is an RDF URI reference, a blank RDF node or an RDF literal
- An RDF literal can be of two kinds
  - an RDF plain literal is a character string with an optional associated language tag describing the language of the character string
  - an RDF typed literal is a character string with an associated RDF datatype URI. An RDF datatype defines the syntax and semantics of a set of character strings that represent data such as booleans, integers, dates, etc.

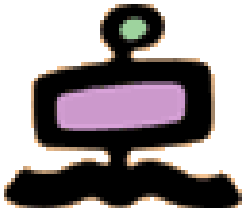
RDF example 1



RDF example 2



Serialization formats for RDF

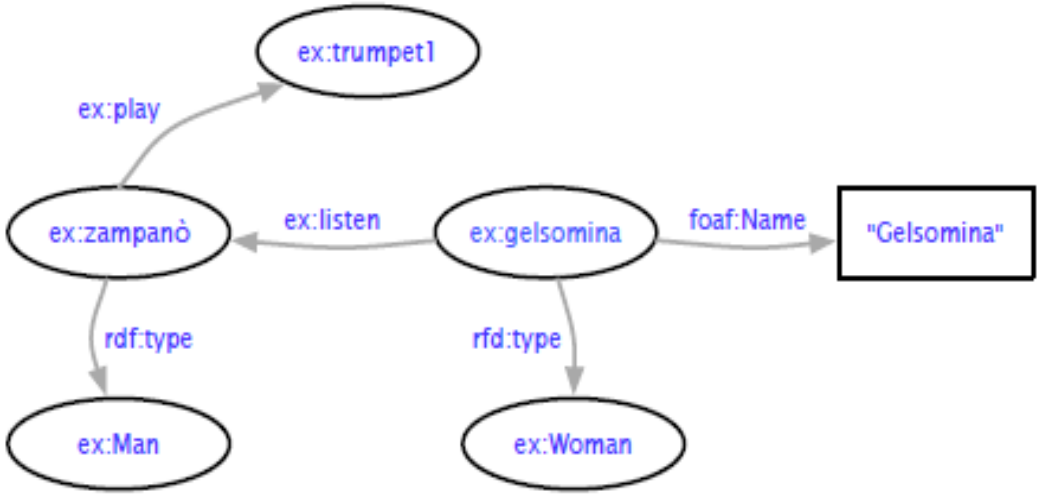


- Turtle and TriG
- JSON-LD (JSON based)
- RDFa (for HTML embedding)
- N-Triples and N-Quads
- RDF/XML

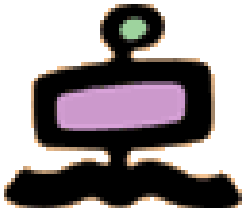
Turtle notation

```
@prefix ex: <http://www.example.org/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix foaf: <http://xmlns.com/foaf/spec/> .

ex:zampano     rdf:type      ex:Man .
ex:zampano     ex:play       ex:trumpet1 .
ex:gelsomina   rdf:type      ex:Woman .
ex:gelsomina   ex:listen     ex:zampano .
ex:gelsomina   foaf:name     "Gelsomina" .
```



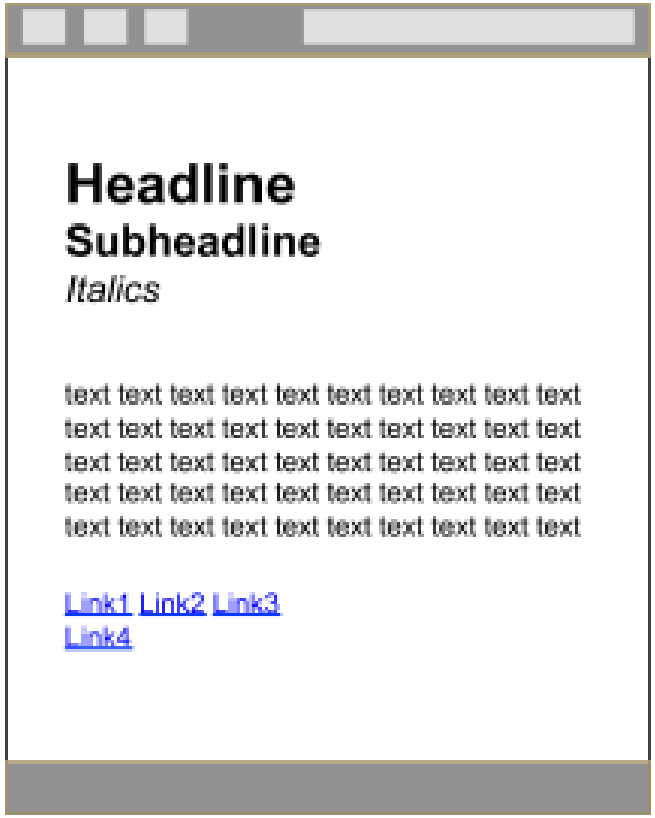
RDFa: RDF info in HTML



```
<body>
  ...
  <h2>Title of Book1</h2>
  <p>Date: 2011-09-10</p>
  ...
</body>
```

```
<body>
  ...
 <div resource="http://example.com/alice/books/Book1">
  <h2 property="http://purl.org/dc/terms/title">
       Title of Book1</h2>
   <p>Date:
      <span property="http://purl.org/dc/terms/created">
       2011-09-10</span>
   </p>
 </div>
  ...
</body>
```

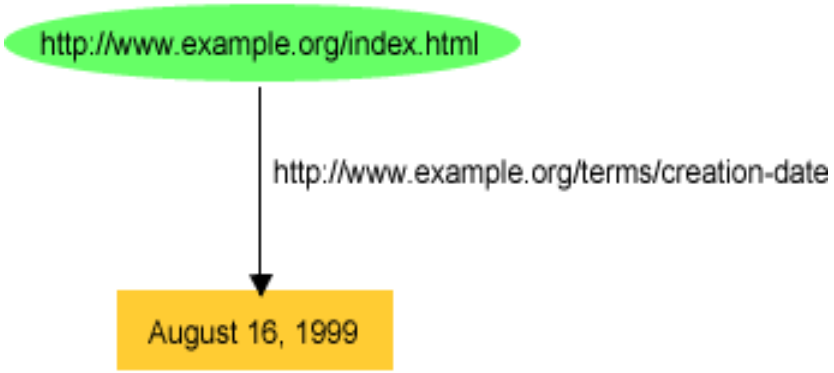
RDFa: browsers only “see” format



What browsers see

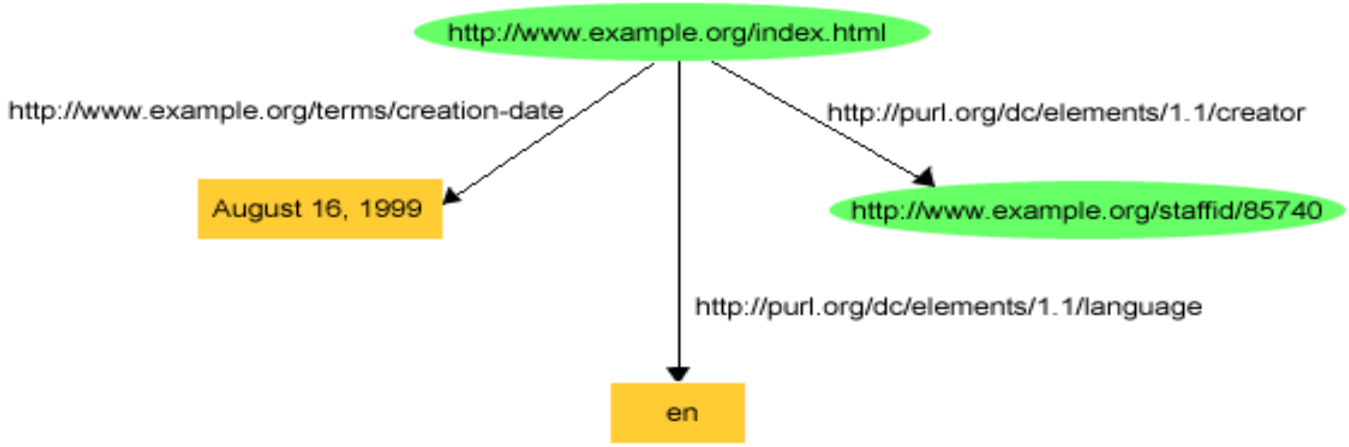
What humans see

RDF graphs represented in XML



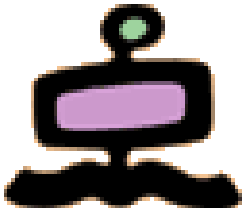

```
1. <?xml version="1.0"?>
2. <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
3.          xmlns:exterms="http://www.example.org/terms/">
4.   <rdf:Description rdf:about="http://www.example.org/index.html">
5.     <exterms:creation-date>August 16, 1999</exterms:creation-date>
6.   </rdf:Description>
7. </rdf:RDF>
```

RDF graph with abbreviated XML



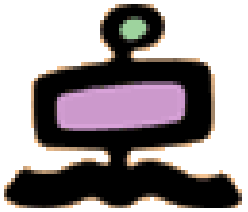

```
1.  <?xml version="1.0"?>
2.  <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
3.           xmlns:dc="http://purl.org/dc/elements/1.1/"
4.           xmlns:exterms="http://www.example.org/terms/">
5.    <rdf:Description rdf:about="http://www.example.org/index.html">
6.       <exterms:creation-date>August 16, 1999</exterms:creation-date>
7.       <dc:language>en</dc:language>
8.       <dc:creator rdf:resource="http://www.example.org/staffid/85740"/>
9.    </rdf:Description>
10. </rdf:RDF>
```

Knowledge representation



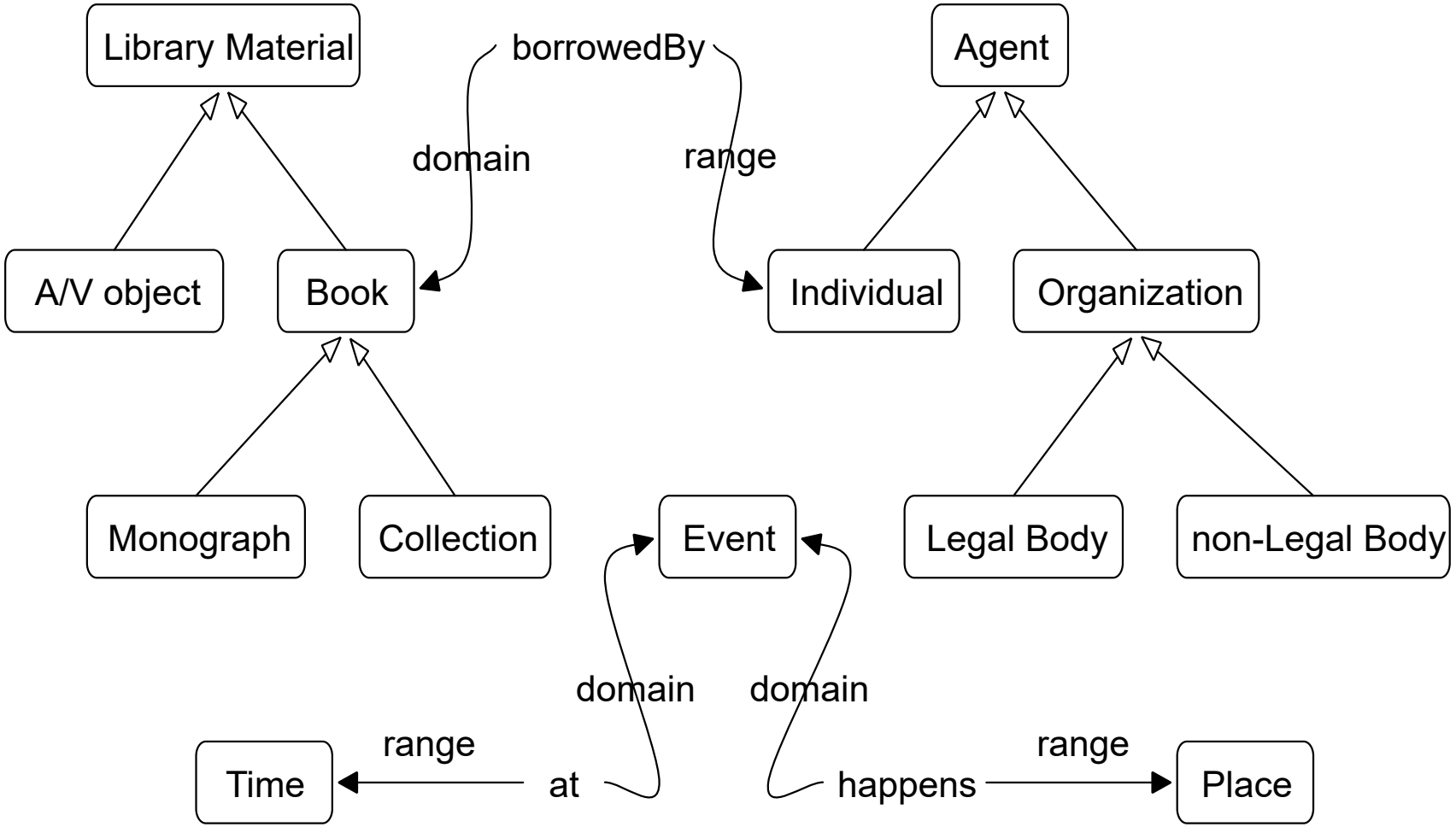
- FRBR: Functional Requirements for Bibliographic Records
  - LRM: Library Reference Model
- RDF: Resource Description Framework
- RDF Schema
  - LOD: Linked Open Data

RDF Schema

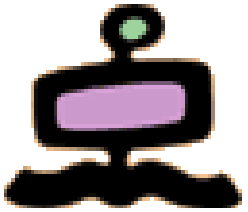


- RDF provides a way to express simple statements about resources, using “named” properties and values
- It is convenient to define the *vocabularies* (terms) that are going to be used in those statements, to indicate that they are describing specific kinds or classes of resources, and will use specific properties in describing those resources
- For example, to describe bibliographic resources we could define classes such as “Book” or “Journal Article”, and use properties such as “author”, “title”, “borrowedBy” to describe them
- RDF Schema defines the terms used in RDF descriptions by providing a **type system** to be used in the RDF descriptions
- In other words, it provides a way to represent a “conceptual model” of a (small) part of the world, by defining the main “concepts” (classes) in this part of the world, their properties and their relationships

Example of Classes and SubClasses

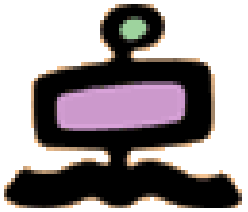


Basics of RDF Schema



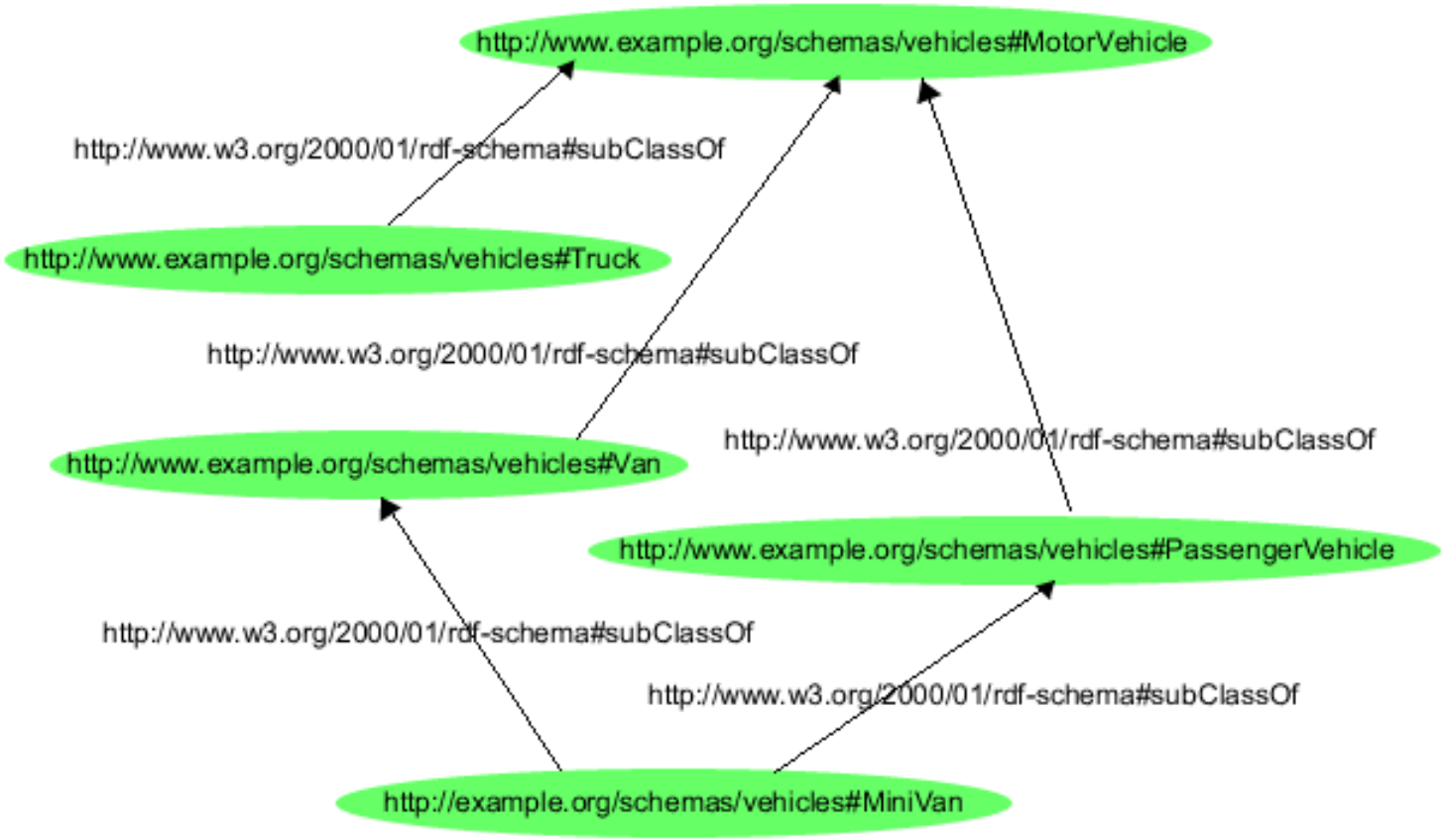
- In RDF Schema we have a way to express:
  - that something is a class or a property
  - that a class is a sub-class of another class
  - that a property is a sub-property of another property
  - that a class is the domain of a property
  - that a class is the range of a property

Main notions of RDF Schema



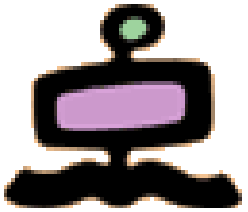
- The main notions of the RDF Schema are:
  - Classes, which can be organized in sub-classes, to any level (defining a taxonomy)
  - Properties, which also can be organized in sub-classes, to any level (defining another taxonomy)
- Vocabulary descriptions (schemas) written in the RDF Schema language are valid RDF graphs
- There is a close analogy with XML documents and XML schemas

Classes and subclasses



prefix ex:, http://www.example.org/schemas/vehicles#

Example of MotorVehicle



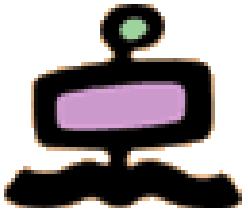
```
This is the "schema" (conceptual model)
ex:MotorVehicle          rdf:type          rdfs:Class
ex:PassengerVehicle      rdf:type          rdfs:Class
ex:Van                   rdf:type          rdfs:Class
ex:Truck                 rdf:type          rdfs:Class
ex:MiniVan               rdf:type          rdfs:Class

ex:PassengerVehicle      rdfs:subClassOf   ex:MotorVehicle
ex:Van                   rdfs:subClassOf   ex:MotorVehicle
ex:Truck                 rdfs:subClassOf   ex:MotorVehicle

ex:MiniVan               rdfs:subClassOf   ex:Van
ex:MiniVan               rdfs:subClassOf   ex:PassengerVehicle

This is an instance of the schema in the "real world"
Instance of a motor vehicle
exthings:johnSmithsCar rdf:type            ex:PassengerVehicle
```

Examples of properties



This is the "schema" (conceptual model)

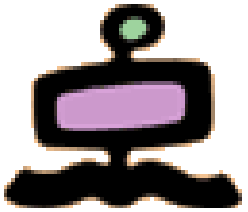
```
ex:registeredTo        rdf:type          rdfs:Property
ex:rearSeatLegRoom     rdf:type          rdfs:Property

ex:weight              rdf:type          rdfs:Property
ex:primaryDriver       rdf:type          rdfs:Property
```

These are instances of the schema in the "real world"

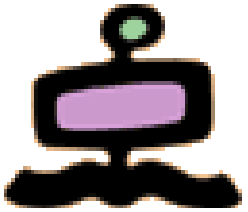
```
exthings:johnSmithsCar rdf:type              ex:PassengerVehicle
exthings:johnSmithsCar ex:registeredTo       exstaff:85740
exthings:johnSmithsCar ex:rearSeatLegRoom    "127"^^xsd:integer
exthings:johnSmithsCar ex:weight             "2500"^^xsd:integer
exthings:johnSmithsCar ex:primaryDriver      exstaff:85740
```

Domain and Range



- In the RDF schema properties are defined in order to describe the characteristics of the classes
- Properties can be arranged in a taxonomy by defining subProperties
- An important aspect of the RDF Schema is the possibility to define the domain and the range of a property
  - Domain is the class of entities that can be the subject of an RDF statement where the property is used as the predicate
  - Range is the class of entities that can be the object of an RDF statement where the property is used as the predicate

Examples of Domain and Range



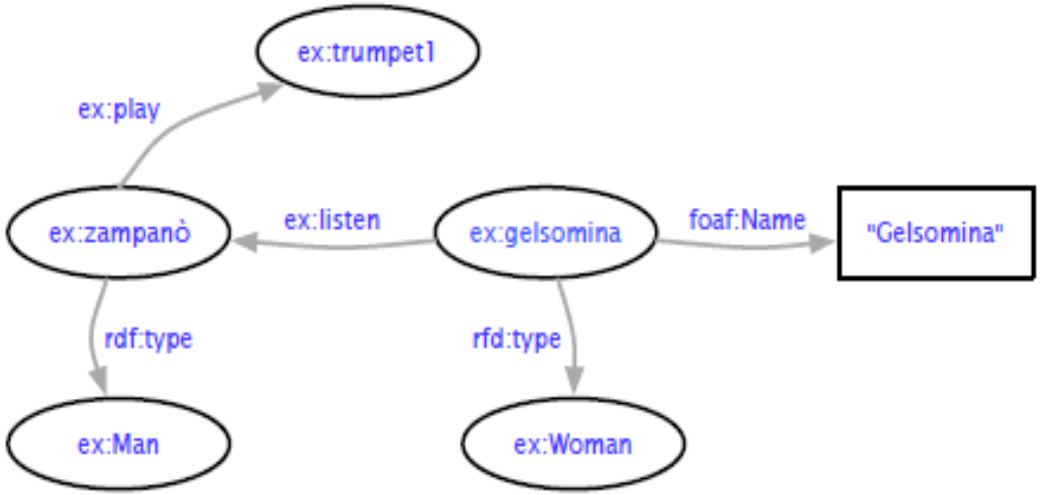
ex:Person	rdf:type	rdfs:Class
ex:Book	rdf:type	rdfs:Class
ex:hasAuthor	rdf:type	rdfs:Property
ex:hasAuthor	rdfs:domain	rdfs:Book
ex:hasAuthor	rdfs:range	rdfs:Person
ex:isAuthorOf	rdf:type	rdfs:Property
ex:isAuthorOf	rdfs:domain	rdfs:Person
ex:isAuthorOf	rdfs:range	rdfs:Book

With these definitions of domain and range we are saying that in our (simple) "model of the world" books can only be written by a person, and a person can only write books (unless there are other triples in the schema defining other objects that can be written by a Person)

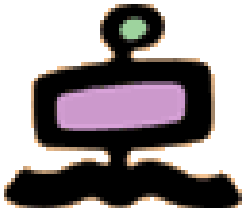
Turtle notation

```
@prefix ex: <http://www.example.org/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix foaf: <http://xmlns.com/foaf/spec/> .

ex:zampano     rdf:type      ex:Man .
ex:zampano     ex:play       ex:trumpet1 .
ex:gelsomina   rdf:type      ex:Woman .
ex:gelsomina   ex:listen     ex:zampano .
ex:gelsomina   foaf:name     "Gelsomina" .
```



Inference of Properties

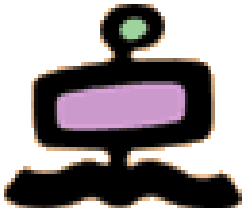


```
RDF schema of "La Strada"
ex:play    rdf:type       rdfs:Property
ex:play    rdfs:domain    ex:Person
ex:play    rdfs:range     ex:MusicalInstrument

Instance of Zampano'
ex:zampanò ex:play ex:trumpet

we can infer
ex:zampanò   rdf:type    ex:Person
ex:trumpet   rdf:type    ex:MusicalInstrument
```

Inference for answering queries



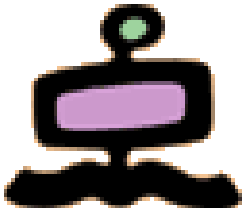
```
ex:hasMother rdf:type     rdfs:Property
ex:hasMother rdfs:range   ex:Female
ex:hasMother rdfs:range   ex:Person

exstaff:Frank ex:hasMother  exstaff:Mary
```

Mary (the mother of Frank) must be at the same time a person and a female

It is therefore possible to answer queries like: "List the names of all the females"
and Mary will be in the list, without having ever provided the information that Mary is a female

Summarizing the RDF Schema



- An RDF Schema is a simple “meta” vocabulary used to describe ontologies
  - Class, subClassOf, type
    - e.g., Person, Team
  - Property, subPropertyOf
    - e.g., playsFor
  - Domain (the **class for the subjects** of a particular *property*)
    - **Person** *playsFor* Team
  - Range (the **class for the values** of a particular *property*)
    - Person *playsFor* **Team**