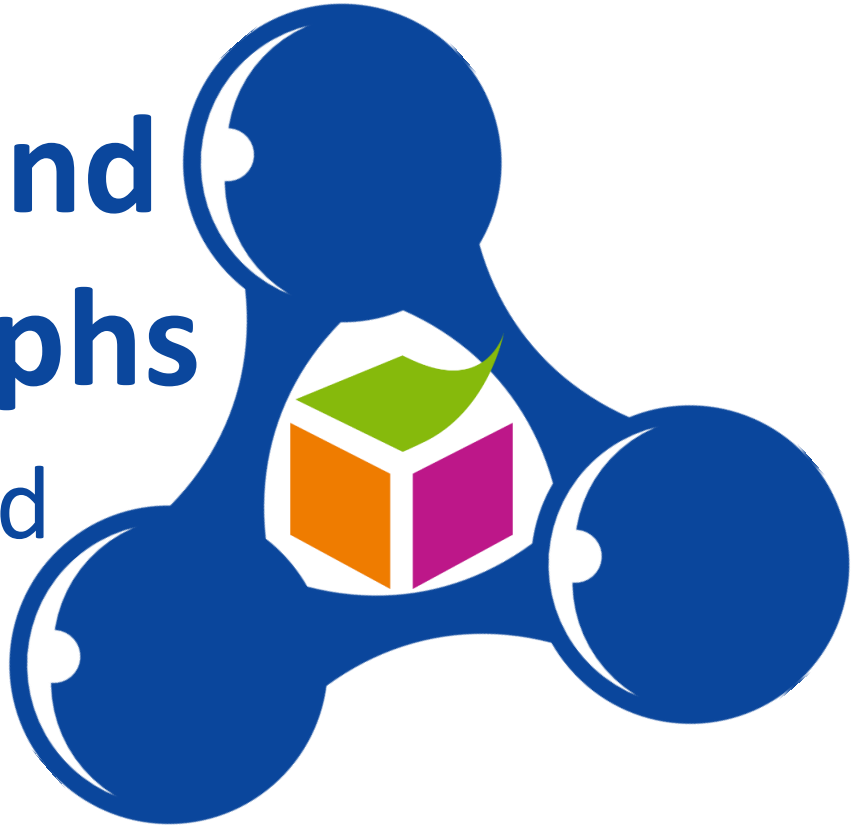
Semantic Web and Linked Data Graphs

or how to link data and schemas on the web



Fabien Gandon, http://fabien.info, @fabien_gandon

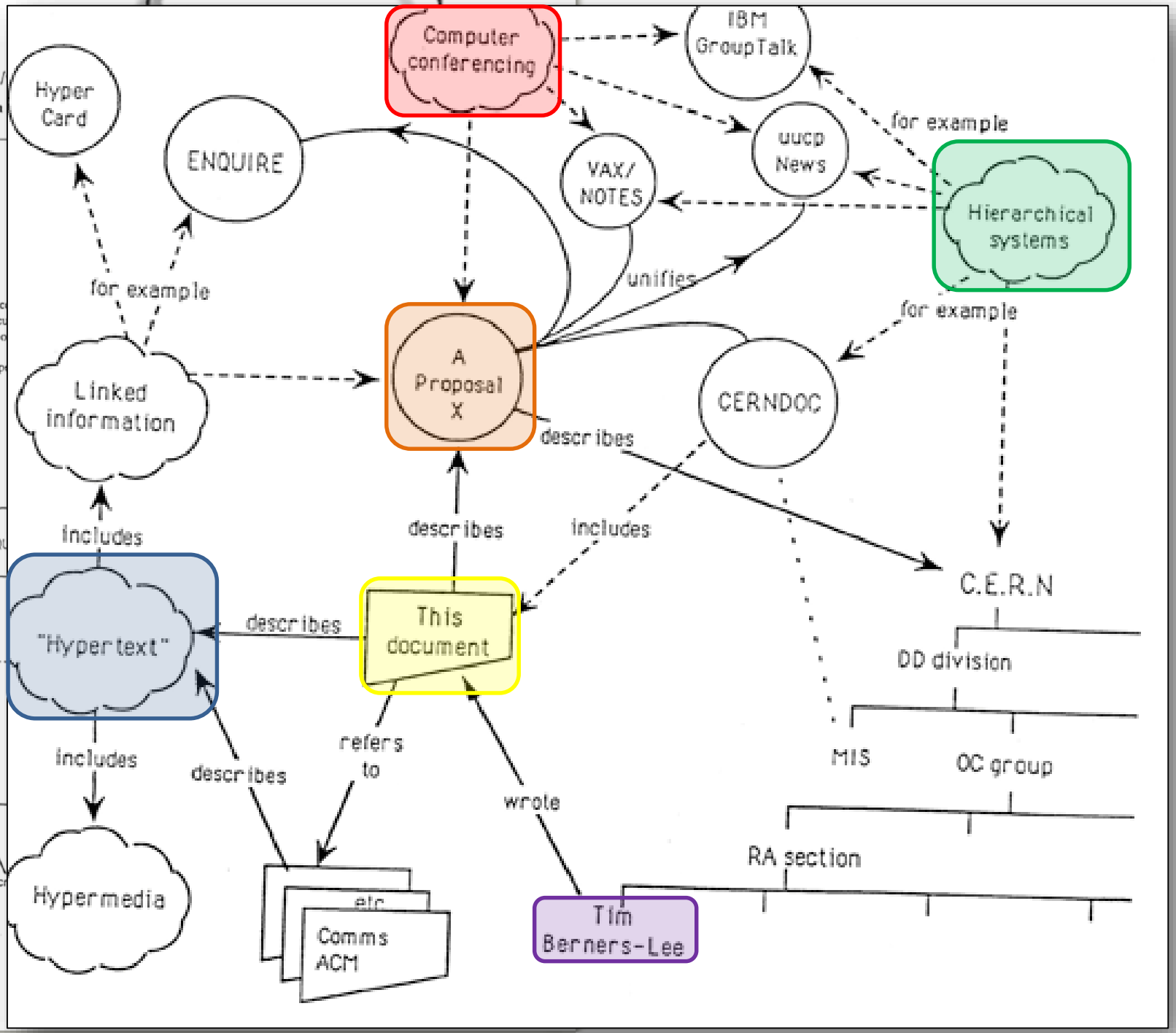
Inria informatics mathematics
i3s sophia antipolis
cnrs
Université Nice Sophia Antipolis
W3C MEMBER

CERN DD/

Information

This proposal c
CERN. It discu
solution based o

Keywords: Hyp
control



CERN DD/

Information

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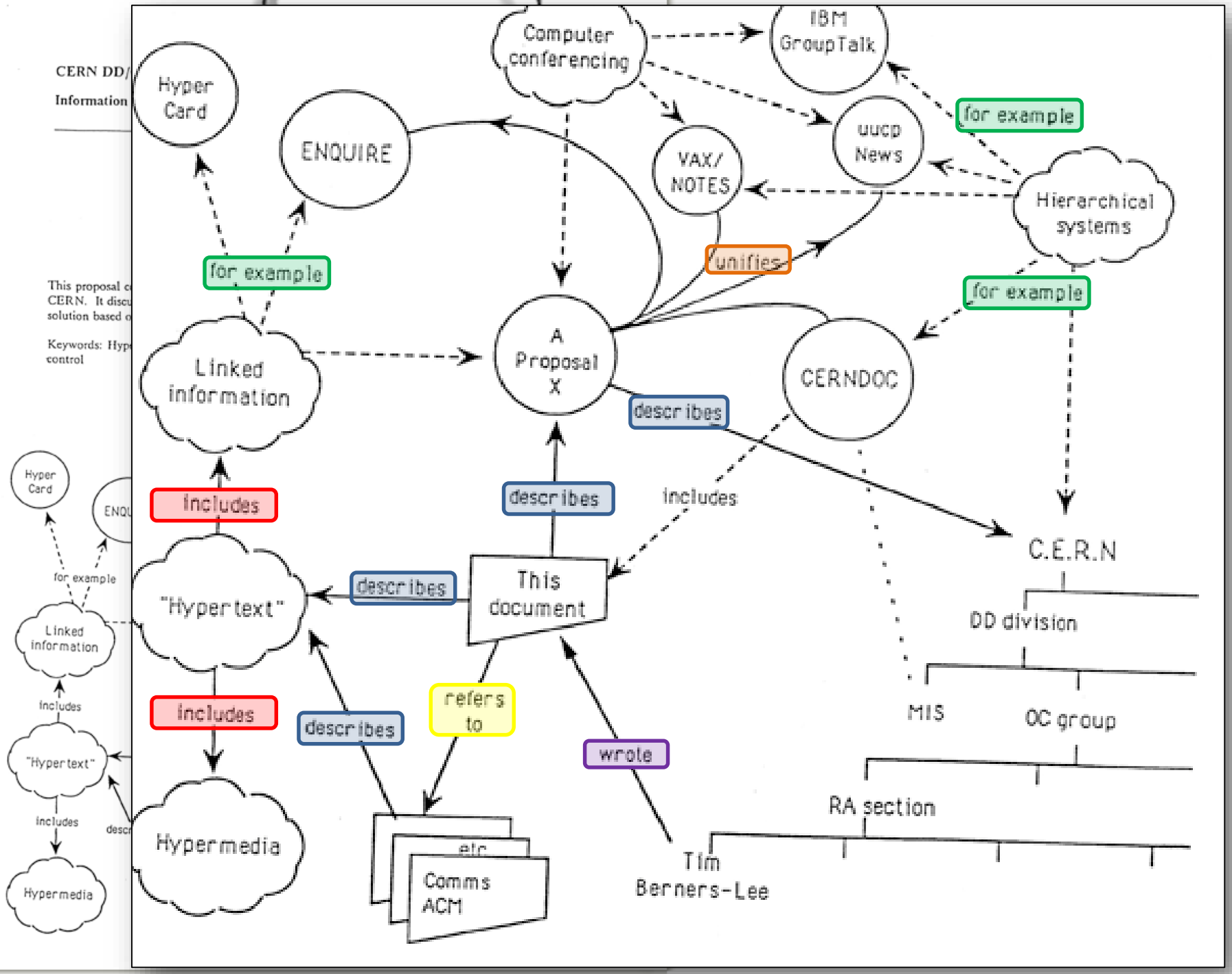
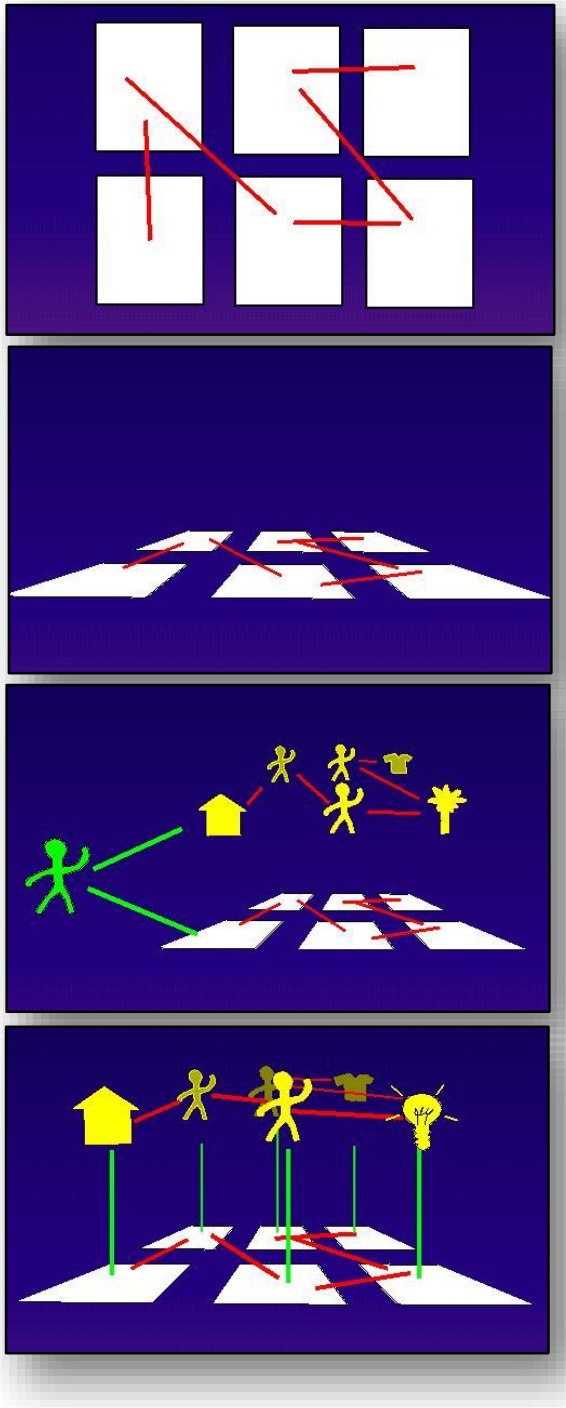


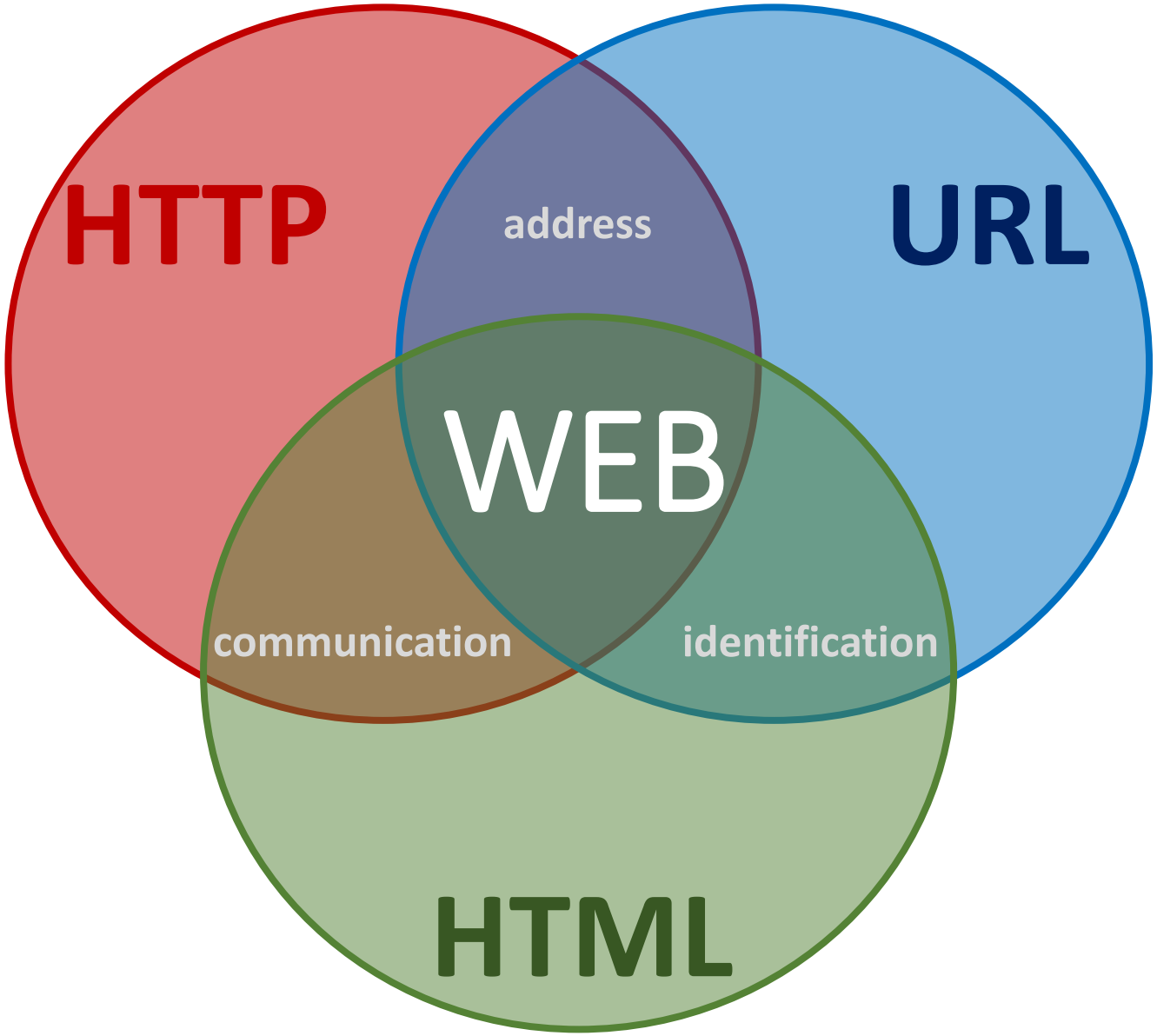
semantic web

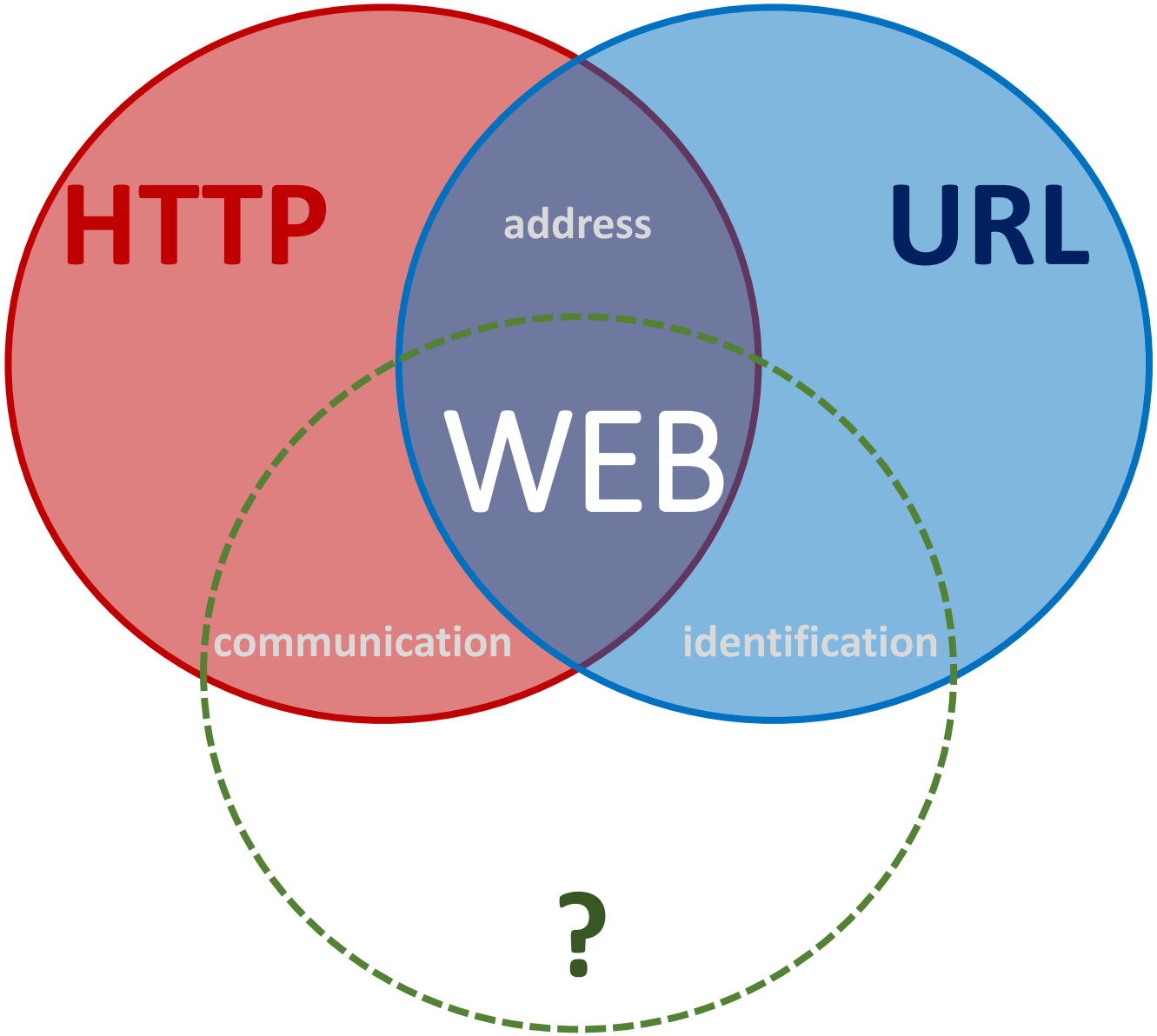
mentioned by Tim BL

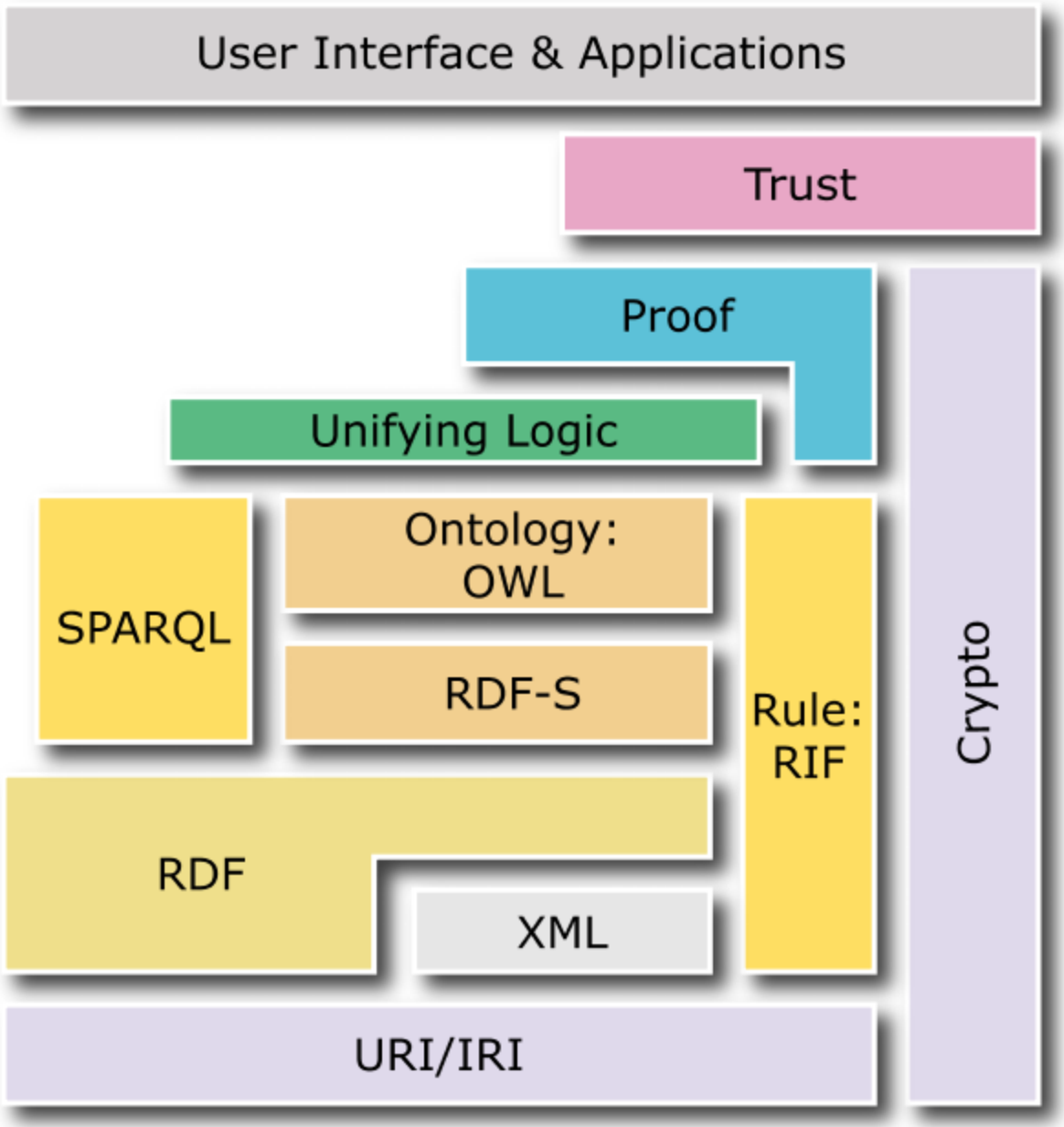
in **1994** at WWW



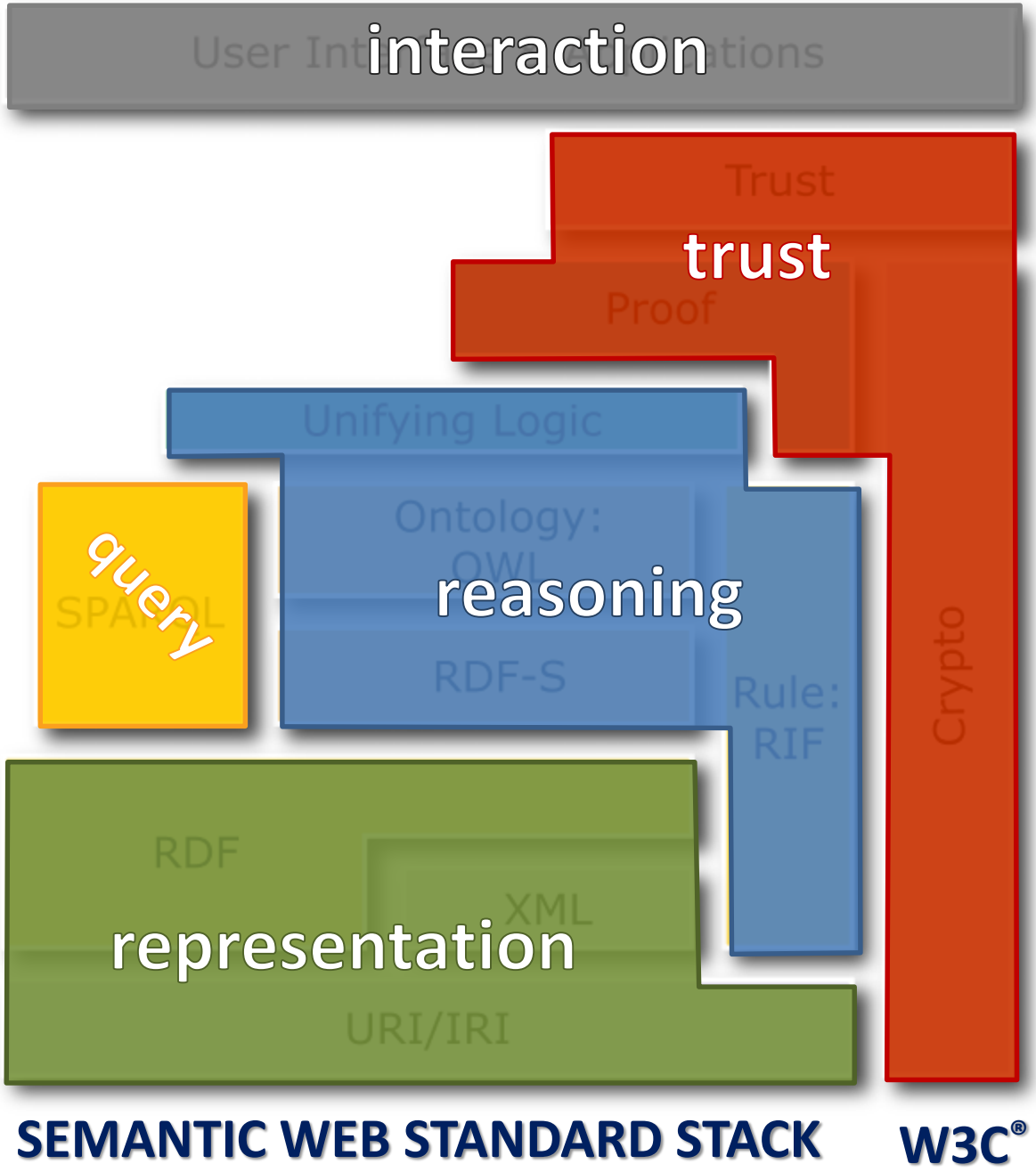
[Tim Berners-Lee 1994, http://www.w3.org/Talks/WWW94Tim/]

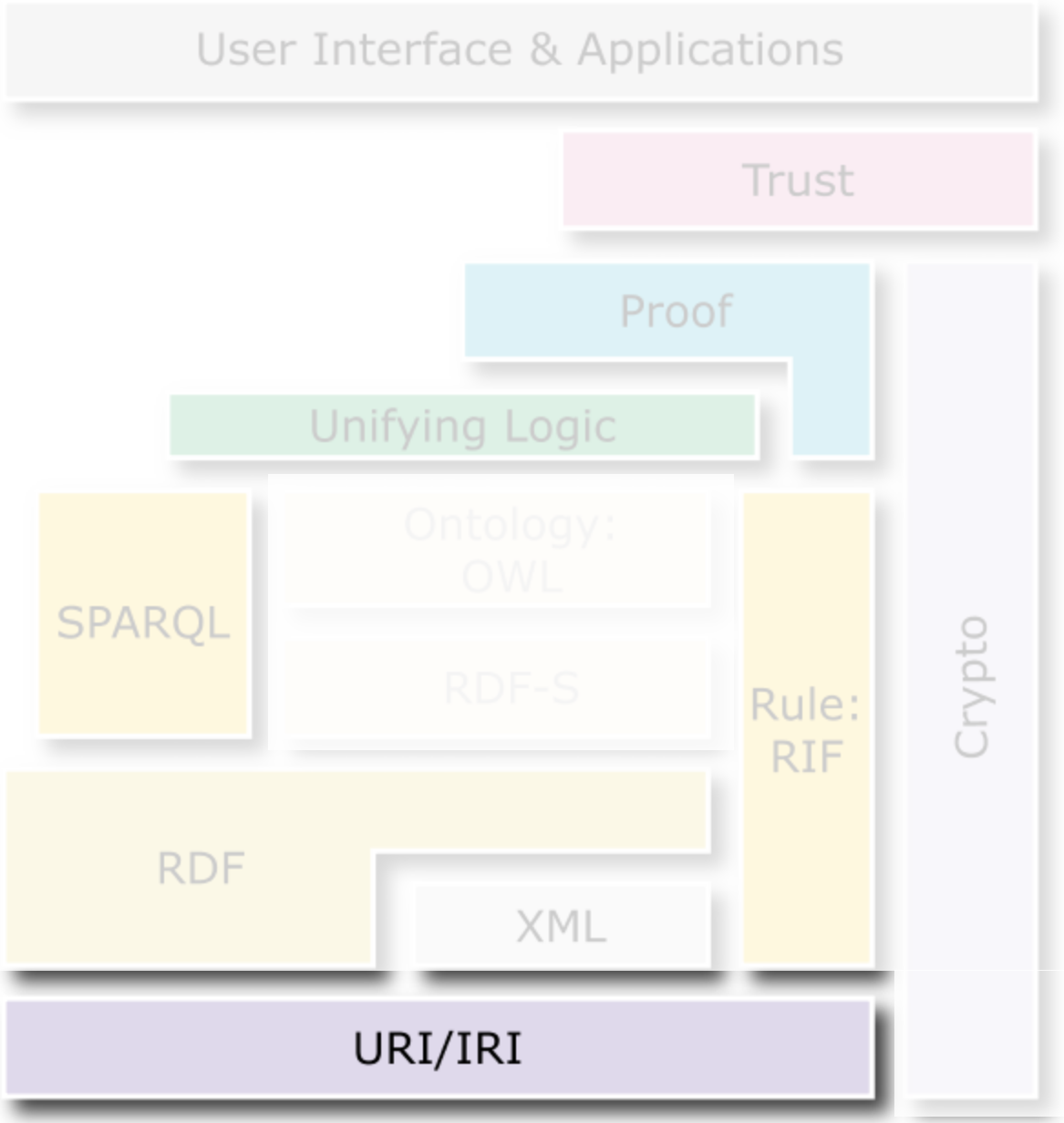

HTTP
address
URL
WEB
communication
identification
HTML


HTTP
address
URL
WEB
communication
identification
?



SEMANTIC WEB STANDARD STACK **W3C®**


interaction
trust
query
reasoning
representation
Crypto
SEMANTIC WEB STANDARD STACK
W3C®



A WEB OF RESOURCES

W3C®

URL

identify what
exists on the web.

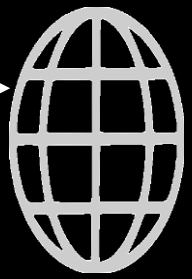
http://my-site.fr

URL → URI

identify what
exists on the web.

identify,
on the web,
what exists.

http://my-site.fr



http://animals.org/zebra#this

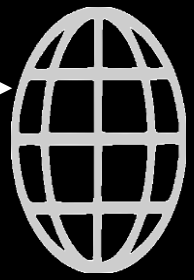
URL → URI → IRI

identify what exists on the web.

identify, on the web, what exists.

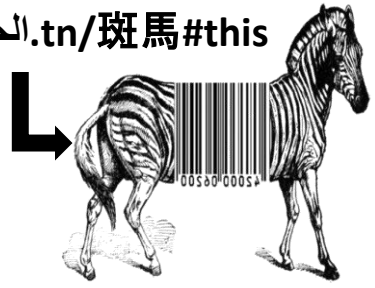
identify, on the web, in any language, what exists.

http://my-site.fr



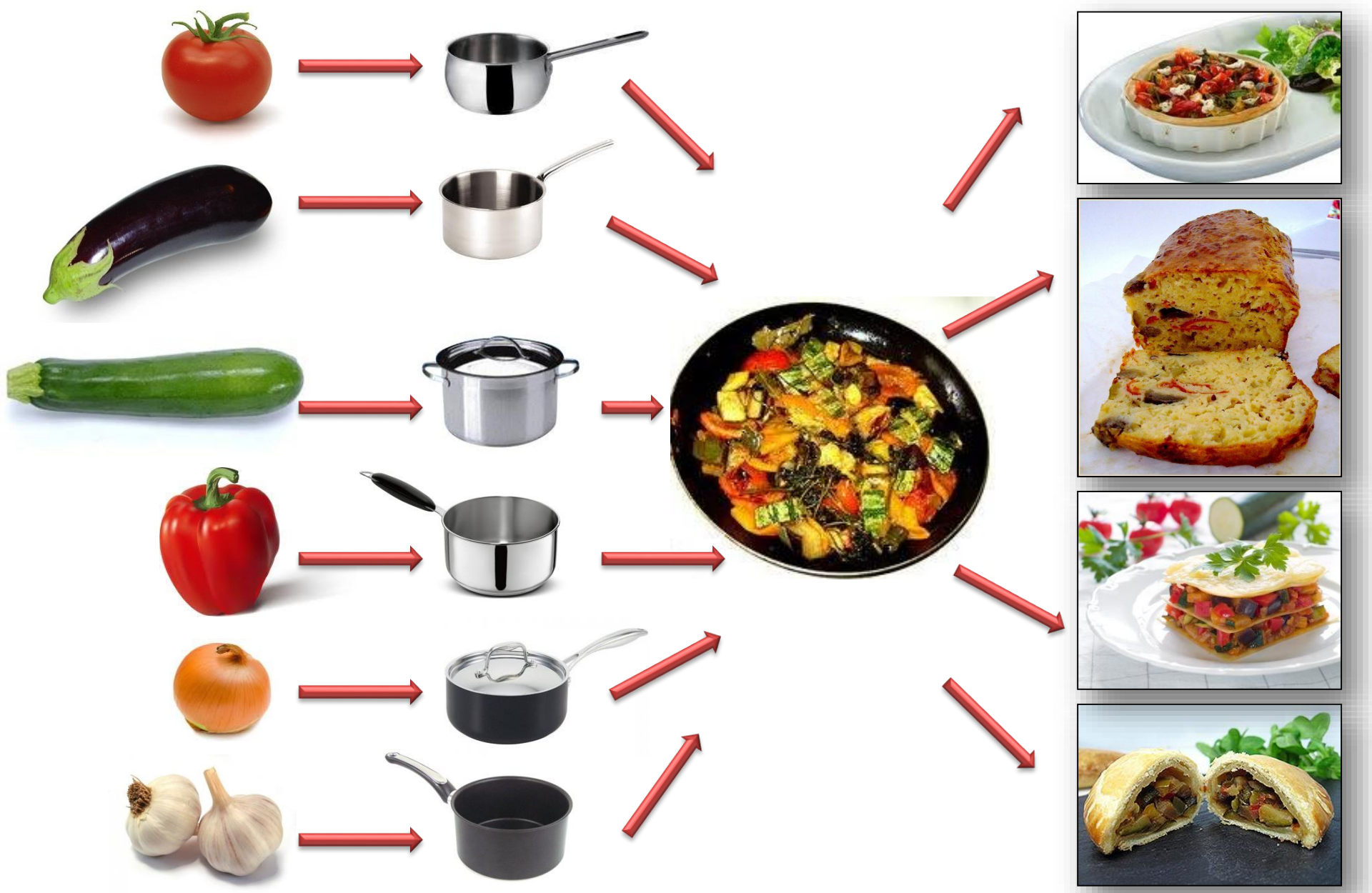
http://animals.org/zebra#this

http://الحيوانات.tn/斑馬#this

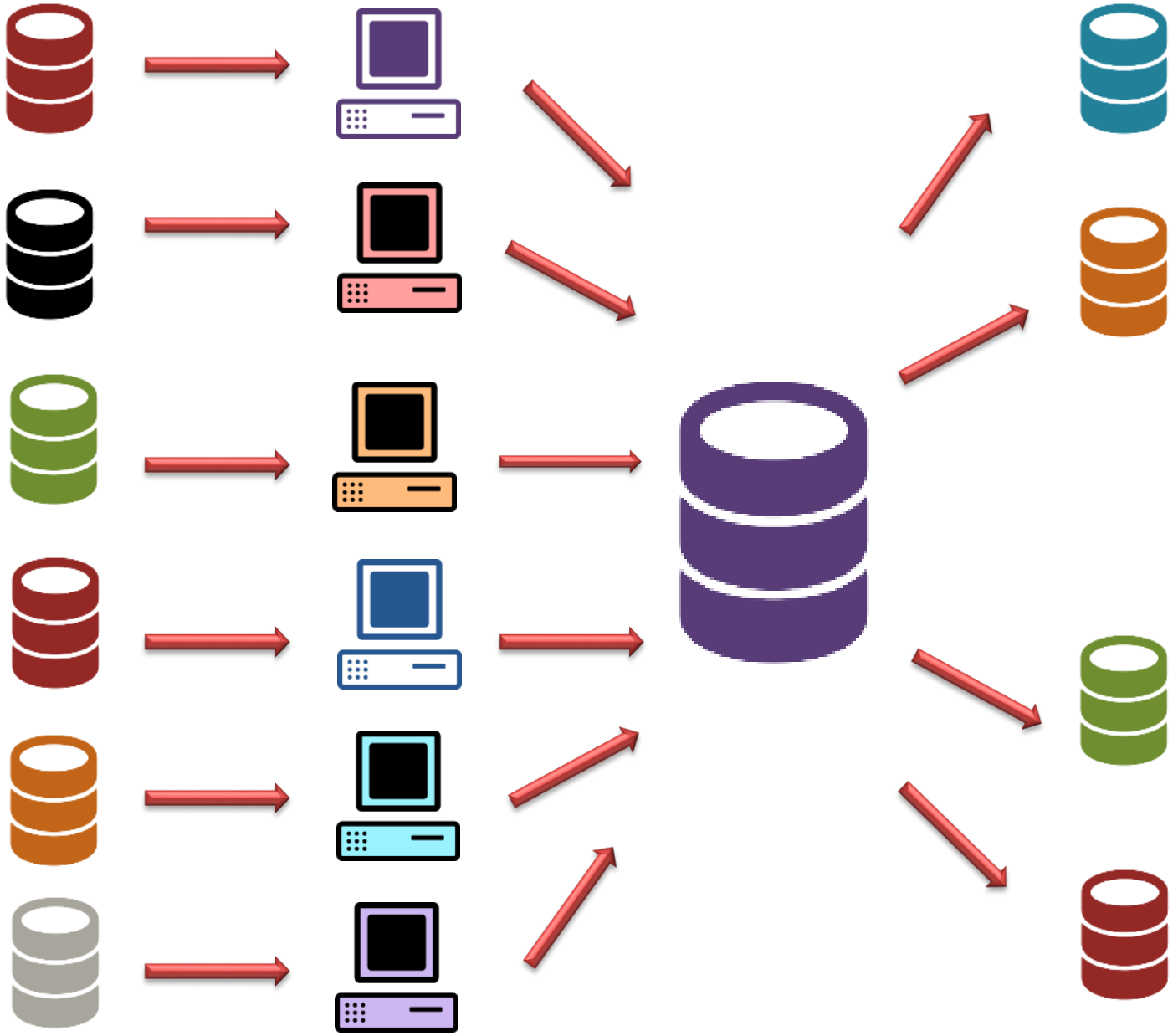


URL → URI → IRI

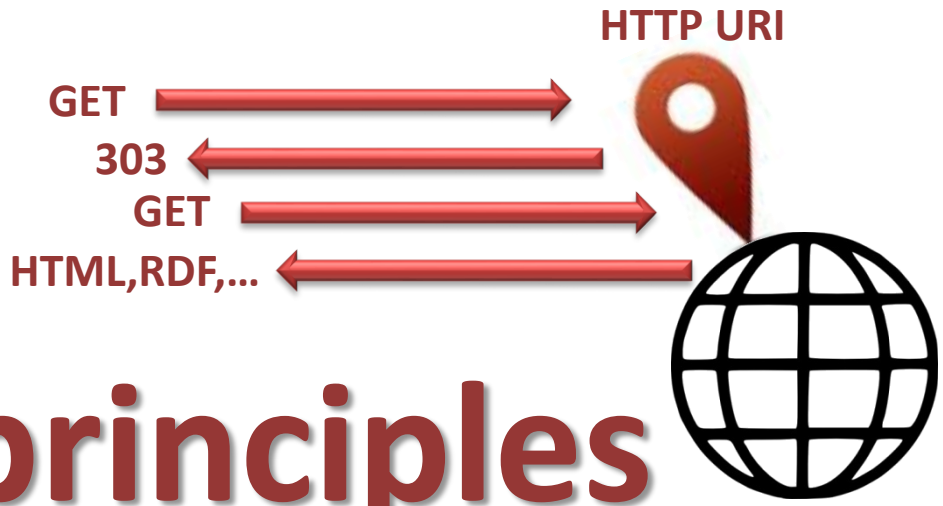
RESOURCE



ratatouille.fr



datatouille.fr

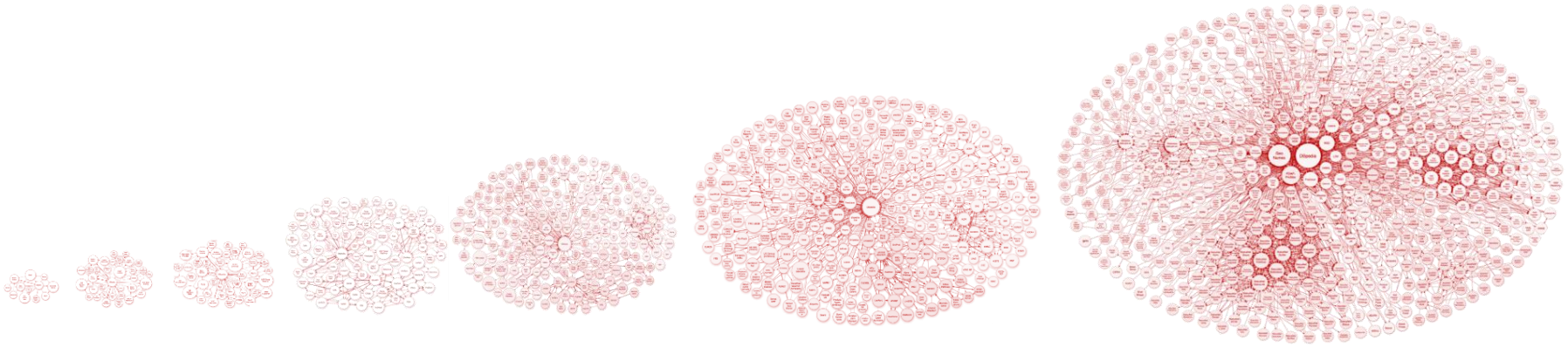


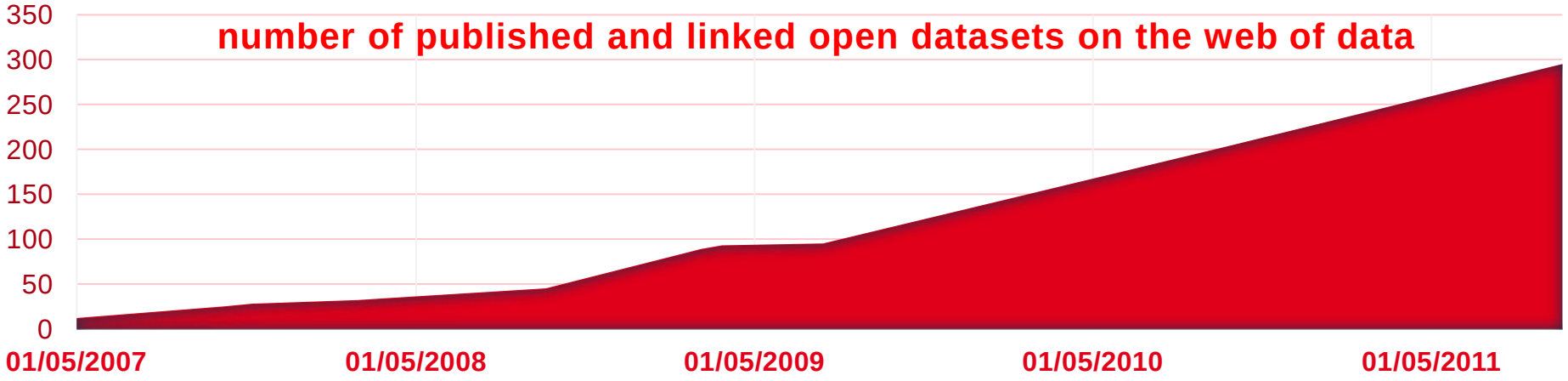
linked data principles

- Use **RDF** as data format
- Use **HTTP URI**s as names for things so that people can look up those names
- When someone looks up a URI, provide useful information (RDF, HTML, etc.) using **content negotiation**
- Include **links to other URIs** so that related things can be discovered

a web of linked data …

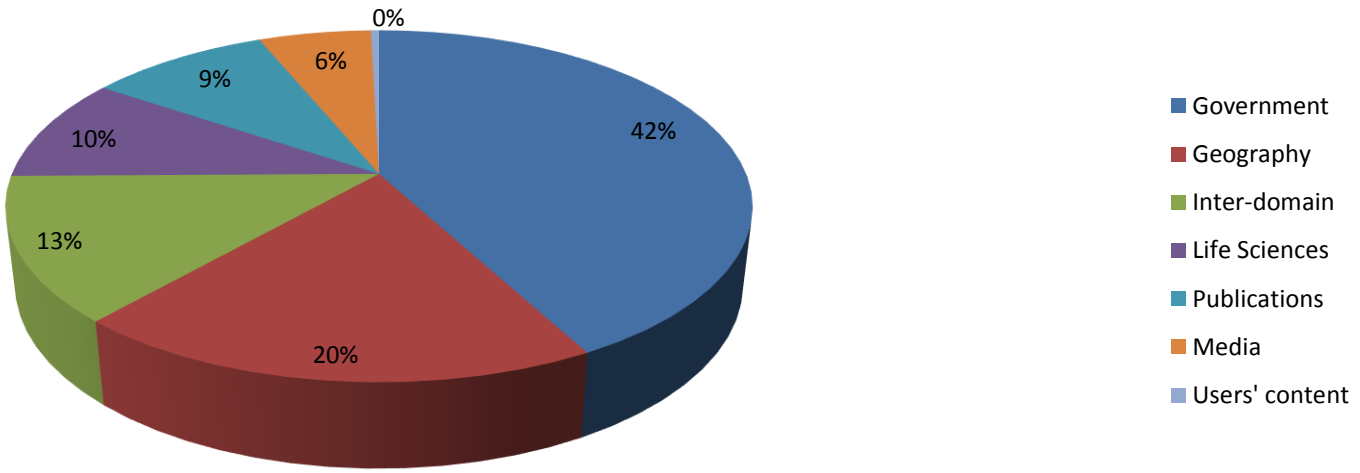
we publish and link structured resource descriptions



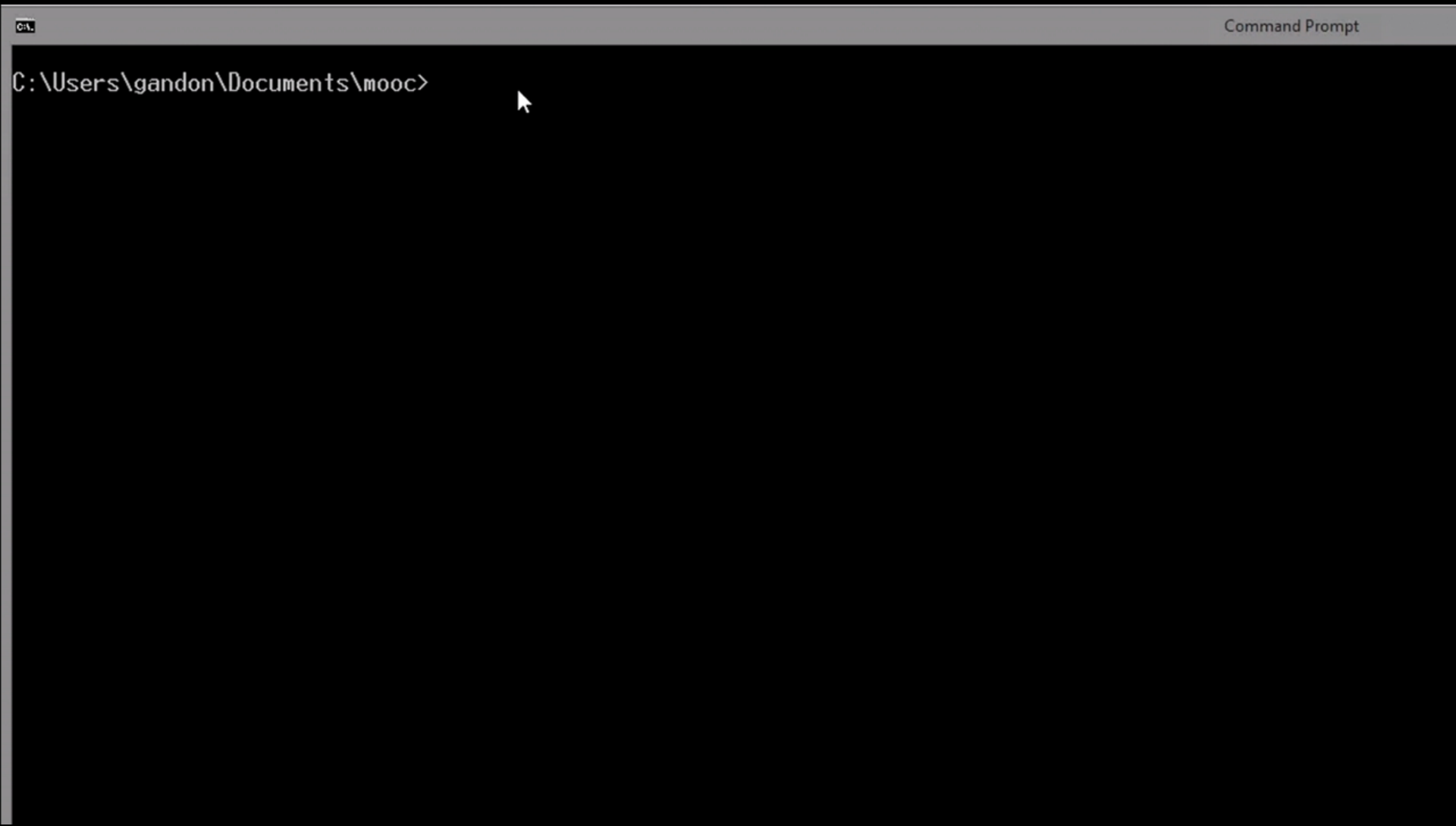


thematic content

Domains	Number of datasets	Number of Triples	%	Out links	%
Media	25	1 841 852 061	5,82 %	50 440 705	10,01 %
Geography	31	6145 532 484	19,43 %	35 812 328	7,11 %
Government	49	13 315 009 400	42,09 %	19 343 519	3,84 %
Publications	87	2 950 720 693	9,33 %	139 925 218	27,76 %
Inter-domain	41	4 184 635 715	13,23 %	63 183 065	12,54 %
Life Sciences	41	3 036 336 004	9,60 %	191 844 090	38,06 %
Users' content	20	134 127 413	0,42 %	3 449 143	0,68 %
	295	***31 634 213 770***		***503 998 829***	

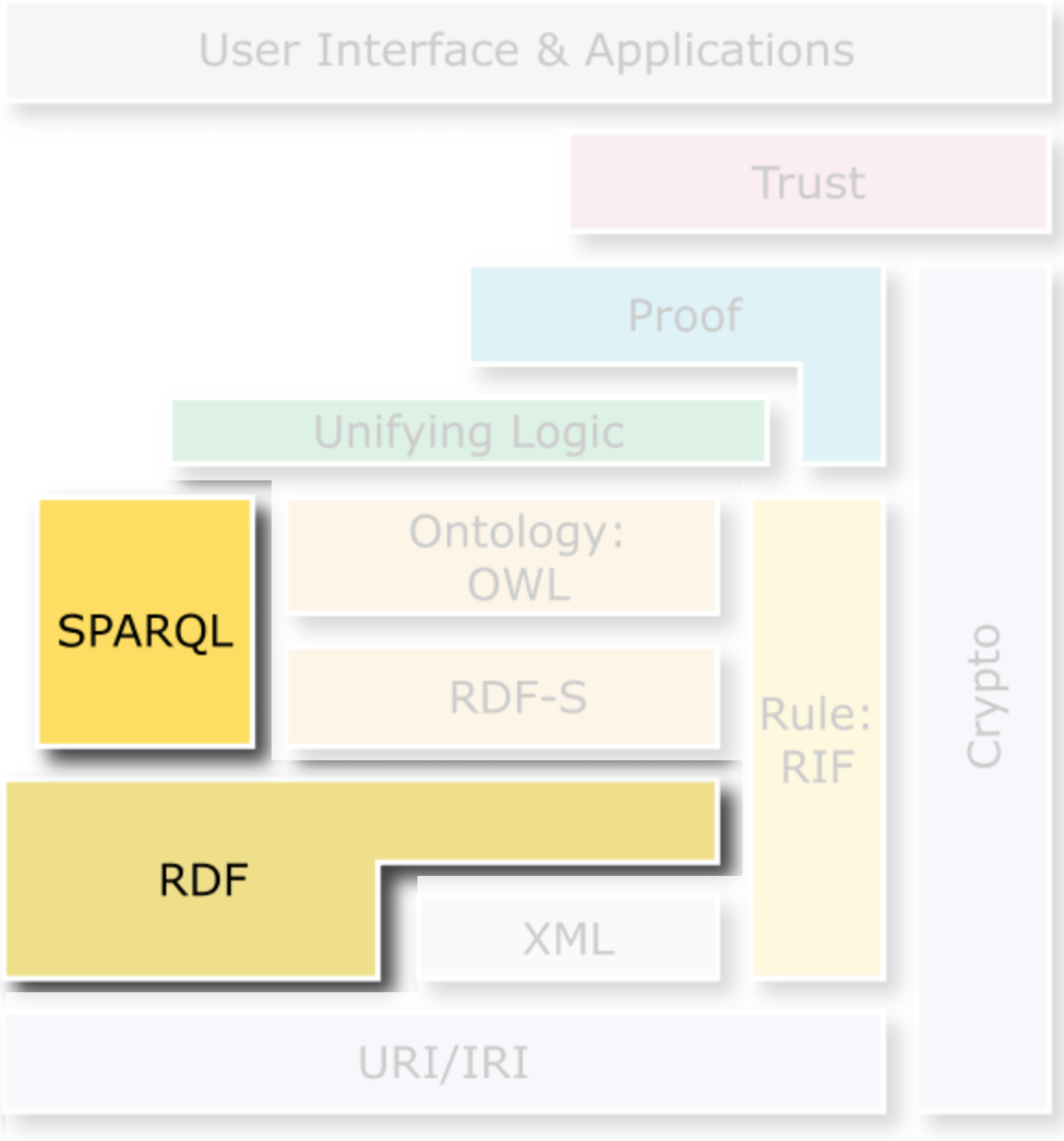


using CURL to fetch data



what is the latest identification standard on the Web?

A WEB OF LINKED DATA



W3C®

RDF stands for

Resource: *pages, dogs, ideas... everything that can have a URI*

Description: *attributes, features, and relations of the resources*

Framework: *model, languages and syntaxes for these descriptions*

RDF is a triple model *i.e.* every piece of knowledge is broken down into

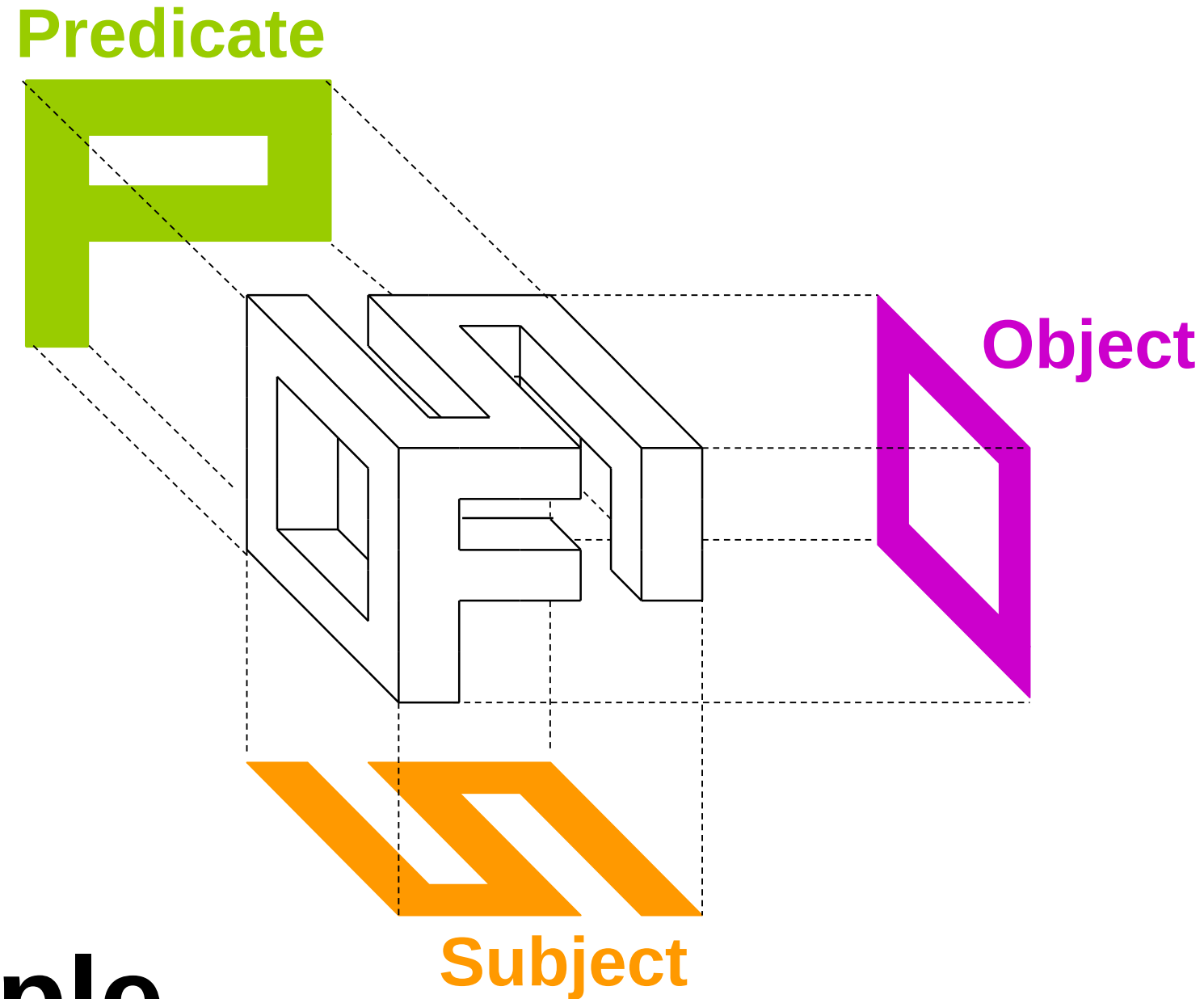
(subject , predicate , object)

doc.html has for author Fabien and has for theme Music

doc.html has for author Fabien
doc.html has for theme Music

(doc.html , author , Fabien)
(doc.html , theme , Music)

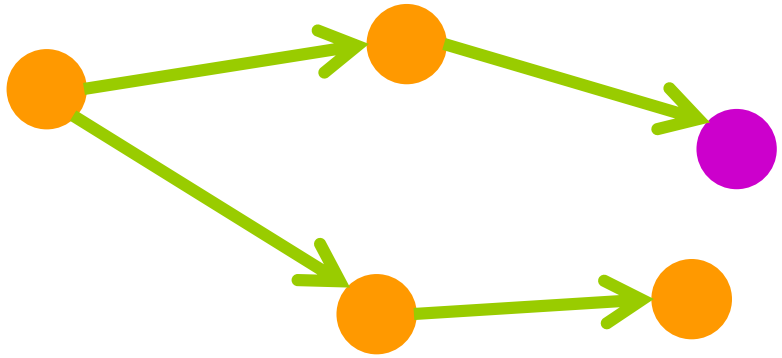
(subject , predicate , object)



a triple

the RDF atom

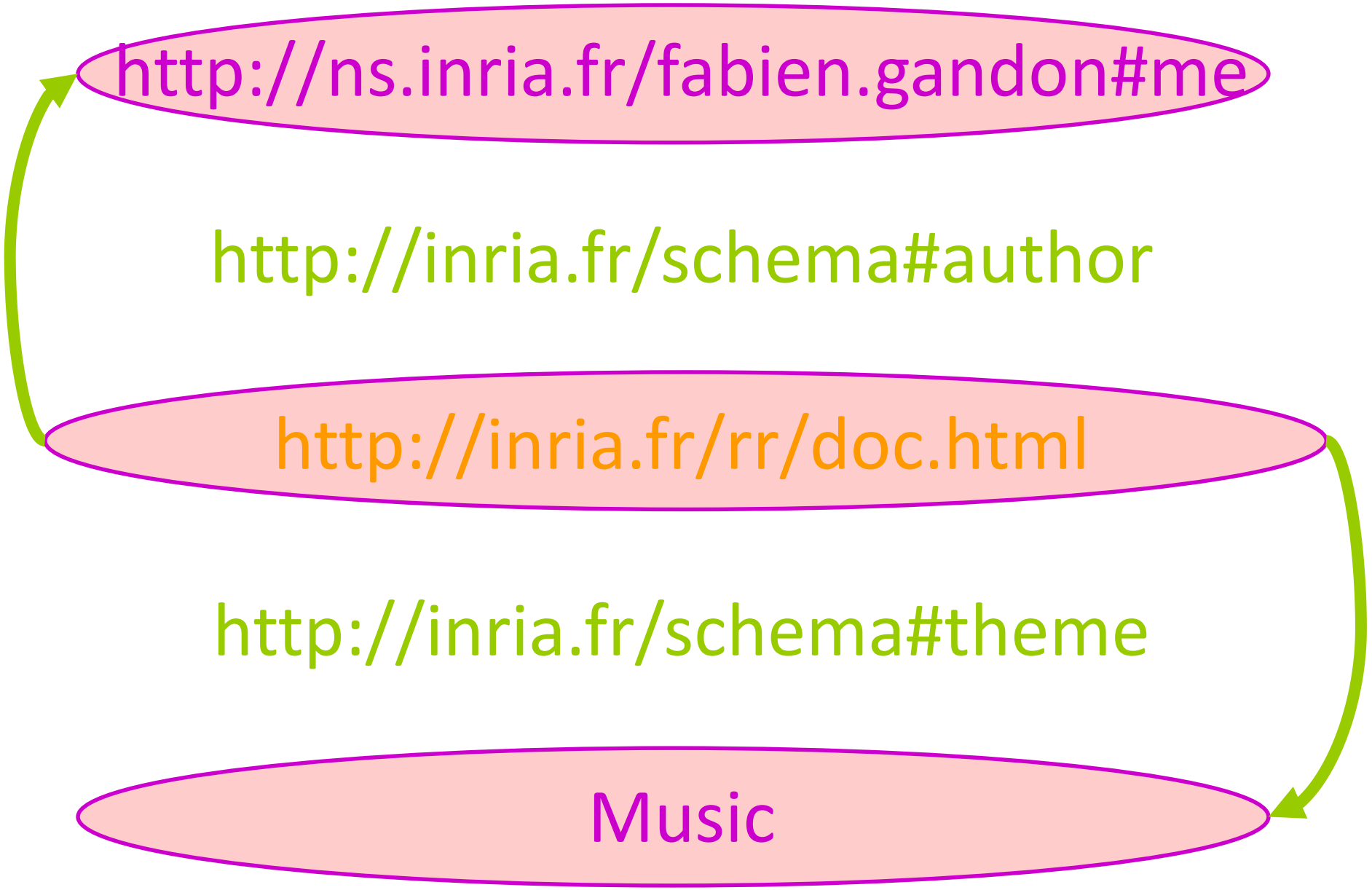
RDF is also a graph model
to link the descriptions of resources

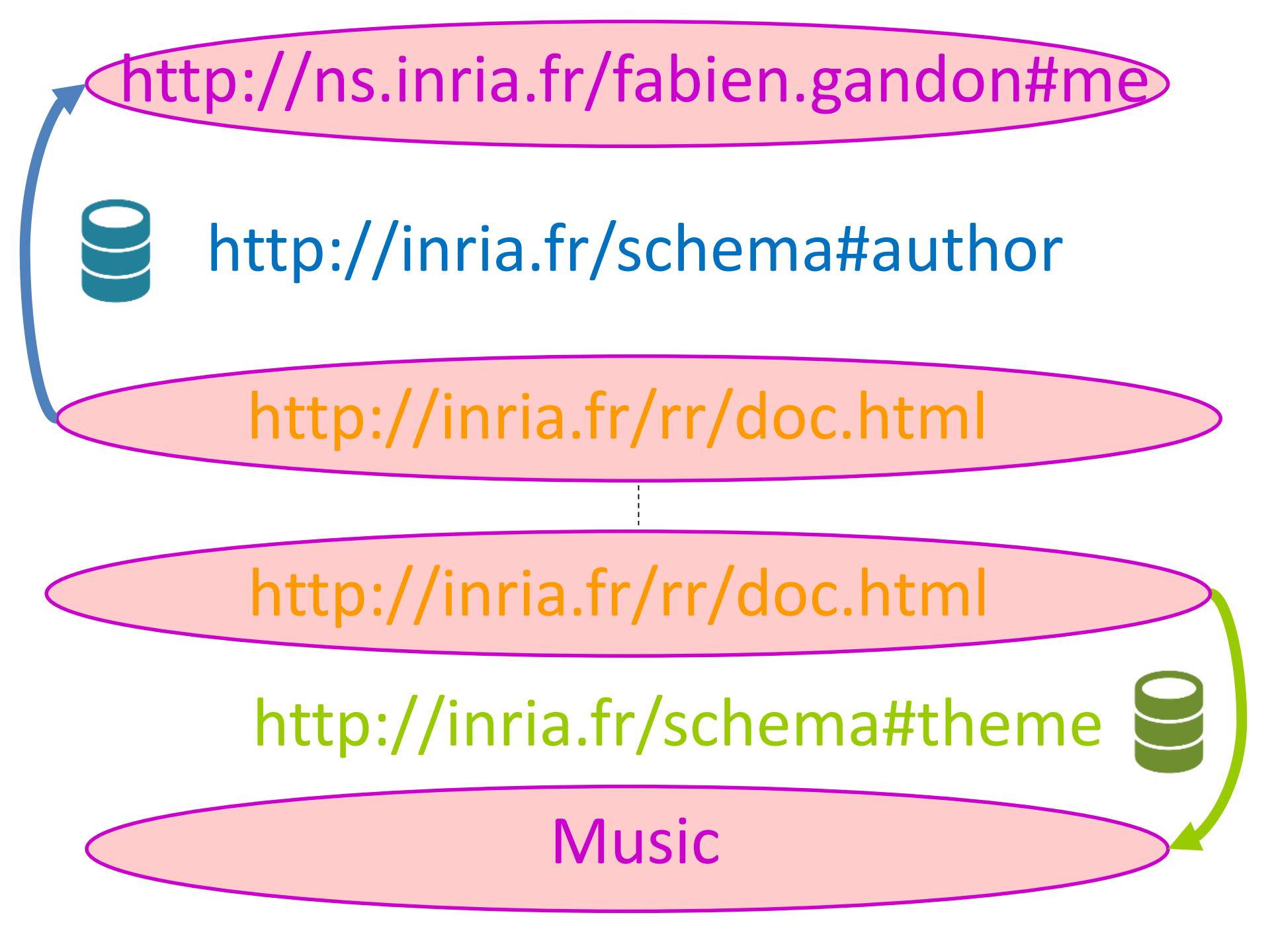


RDF triples can be seen as arcs of a graph (vertex,edge,vertex)

(doc.html , author , Fabien)
(doc.html , theme , Music)

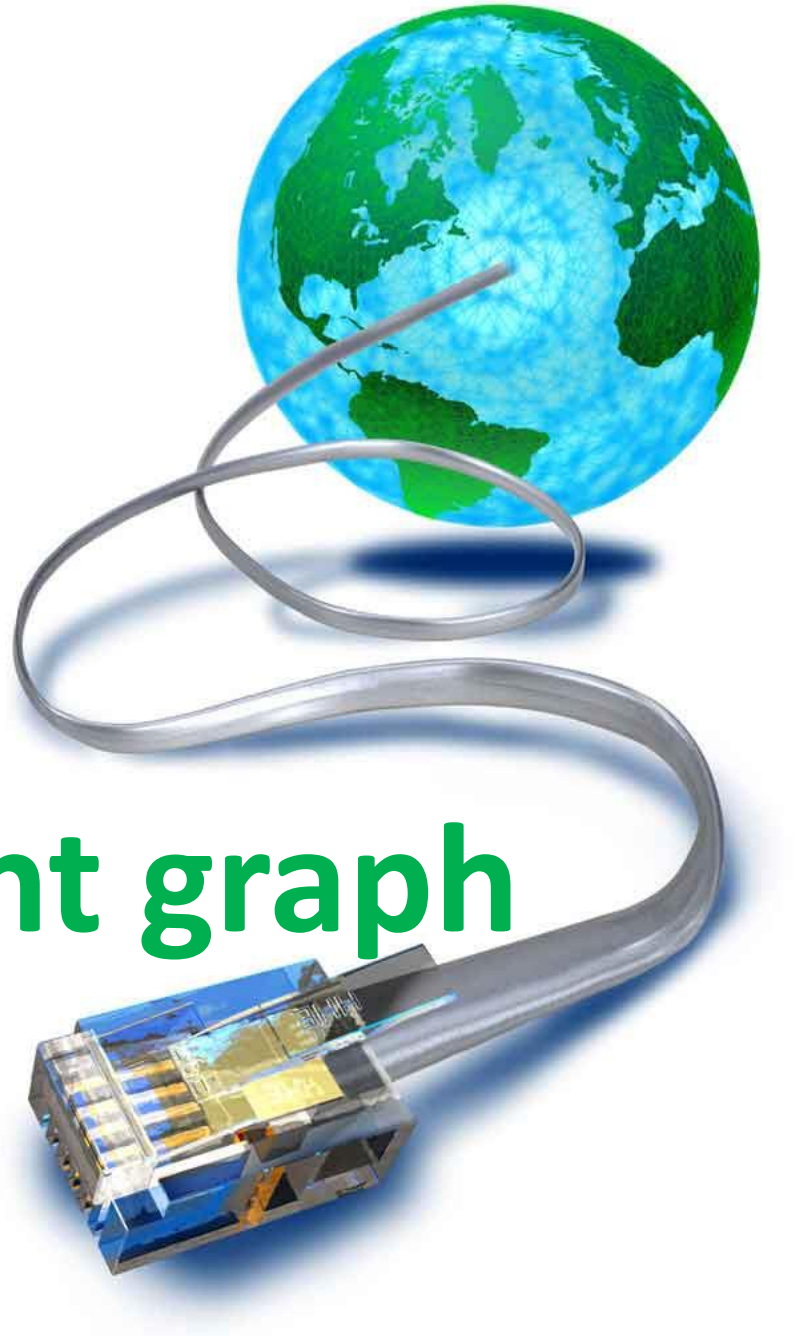

Fabien
author
doc.html
theme
Music


http://ns.inria.fr/fabien.gandon#me
http://inria.fr/schema#author
http://inria.fr/rr/doc.html
http://inria.fr/schema#theme
Music


http://ns.inria.fr/fabien.gandon#me
http://inria.fr/schema#author
http://inria.fr/rr/doc.html
http://inria.fr/rr/doc.html
http://inria.fr/schema#theme
Music

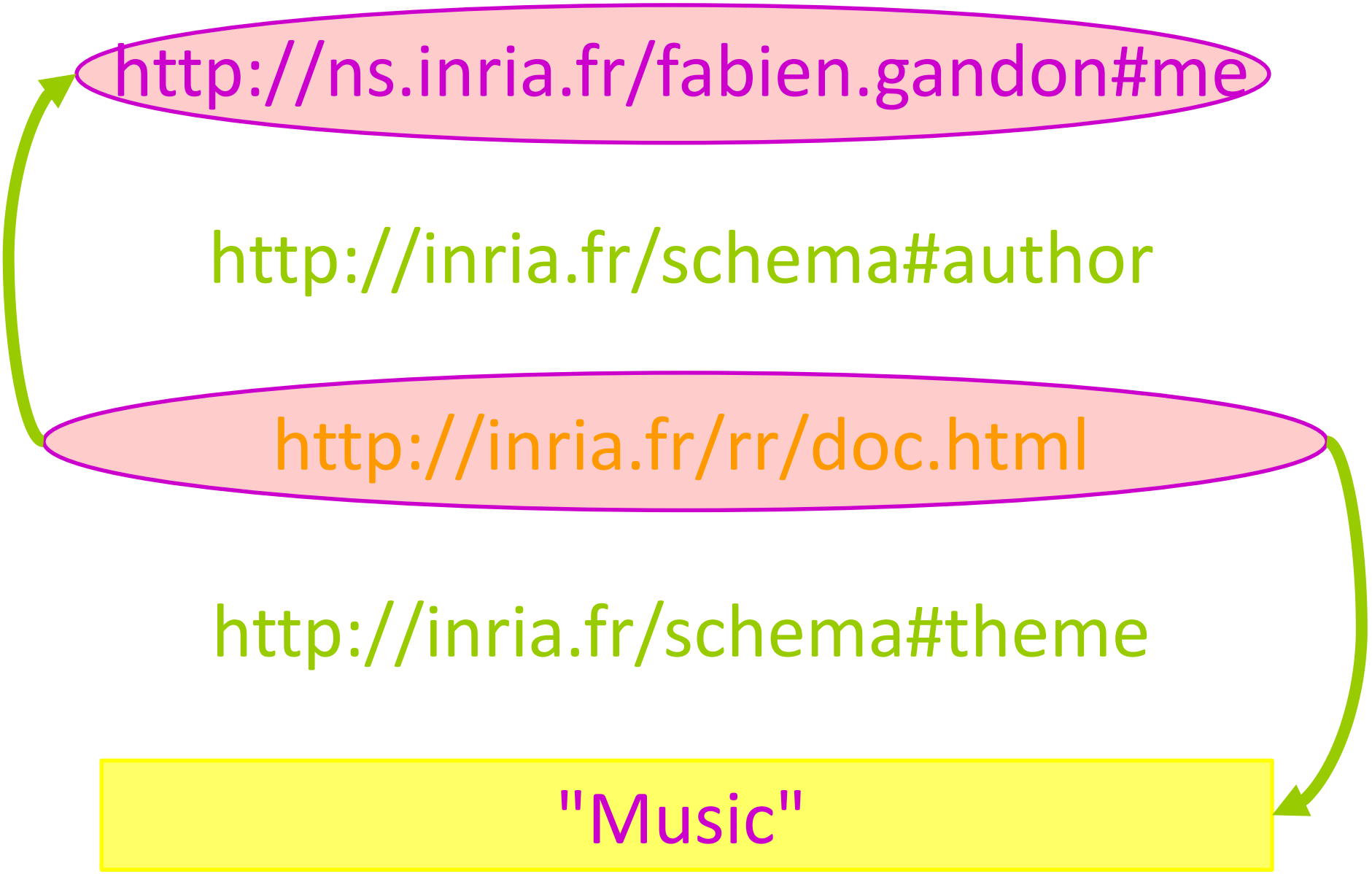
open and link data in a

global giant graph



in RDF values of properties can also be literals i.e. strings of characters

(doc.html , author , Fabien)
(doc.html , theme , "Music")


http://ns.inria.fr/fabien.gandon#me
http://inria.fr/schema#author
http://inria.fr/rr/doc.html
http://inria.fr/schema#theme
"Music"

< RDF /> has an XML syntax

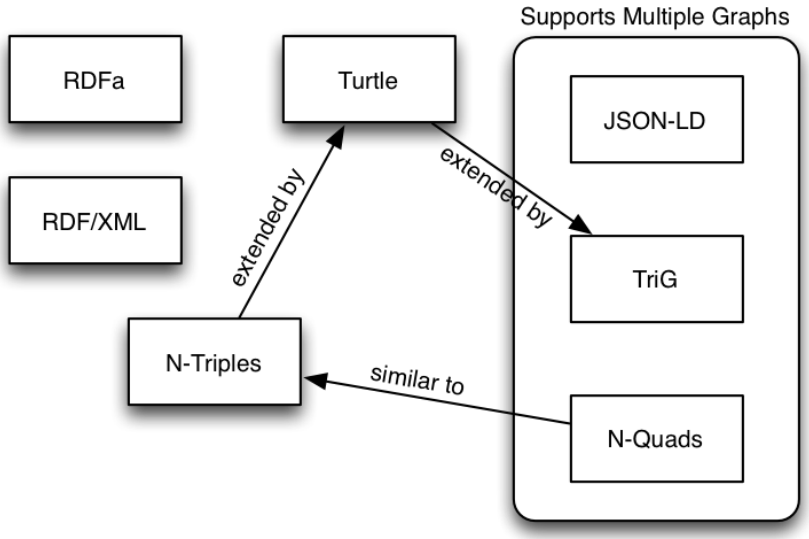
```
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-
  rdf-syntax-ns#"
  xmlns:inria="http://inria.fr/schema#" >


<rdf:Description
 rdf:about="http://inria.fr/rr/doc.html">
  <inria:author rdf:resource=
   "http://ns.inria.fr/fabien.gandon#me"/>
   <inria:theme>Music</inria:theme>
</rdf:Description>


</rdf:RDF>
```

RDF has other syntaxes

(Turtle, TriG, N-Triples, N-Quads, JSON, RDFa)



```
@prefix rdf:
  <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix inria: <http://inria.fr/schema#> .

<http://inria.fr/rr/doc.html>
 inria:author
   <http://ns.inria.fr/fabien.gandon#me> ;
 inria:theme "Music" .
```

Turtle

```
<http://inria.fr/rr/doc.html>
 <http://inria.fr/schema#author>
   <http://ns.inria.fr/fabien.gandon#me> .

<http://inria.fr/rr/doc.html>
 <http://inria.fr/schema#theme> "Music" .
```

N-Triples

writing rules for RDF triples

- the subject is always a resource (never a *literal*)
- properties are binary relations and their types are identified by URIs
- the value is a resource or a literal

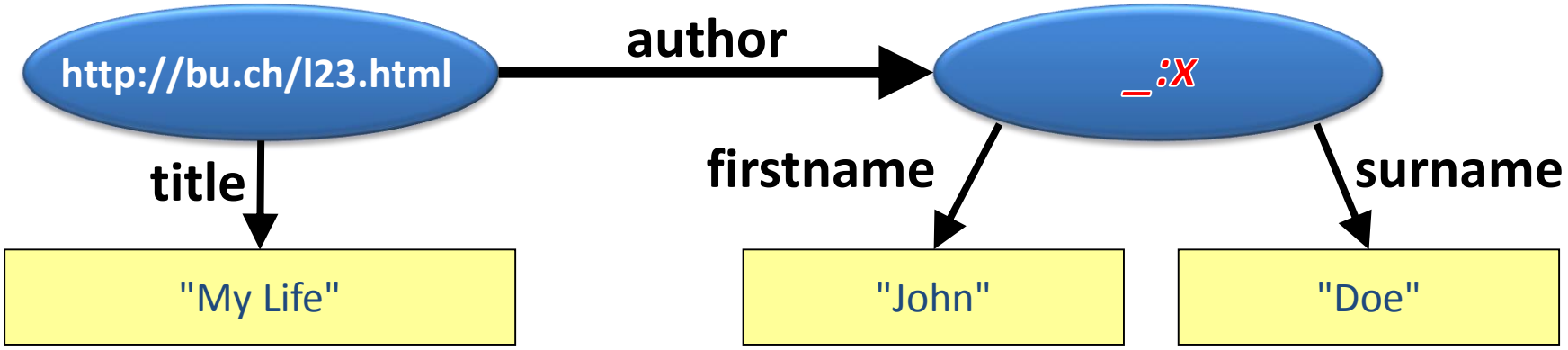
blank nodes (bnodes)

handy anonymous nodes (existential quantification)

there exist a resource such that… { ∃ r ; …}

```
<rdf:Description rdf:about="http://bu.ch/123.html ">
 <author>
  <rdf:Description>
   <surname>Doe</surname>
   <firstname>John</firstname>
  </rdf:Description>
 </author>
 <title>My Life</title>
</rdf:Description>
```

<http://bu.ch/123.html>
author
[surname "Doe" ;
firstname "John" .] ;
title "My Life" .



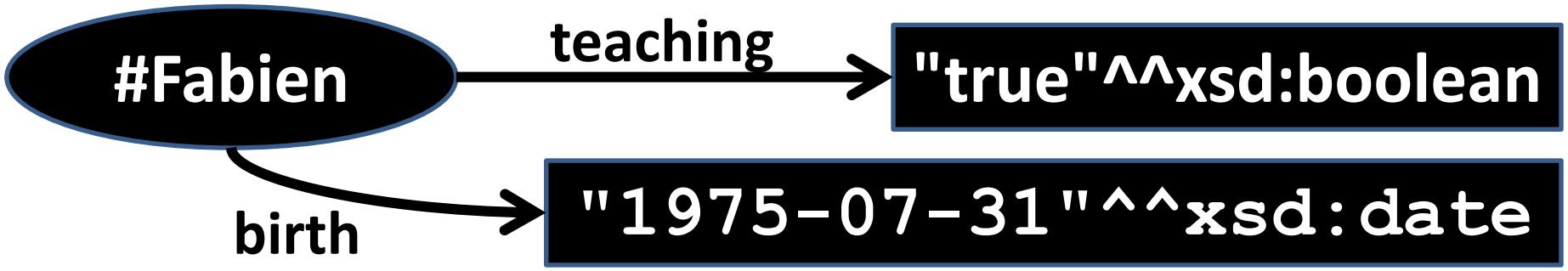
XML schema datatypes & literals

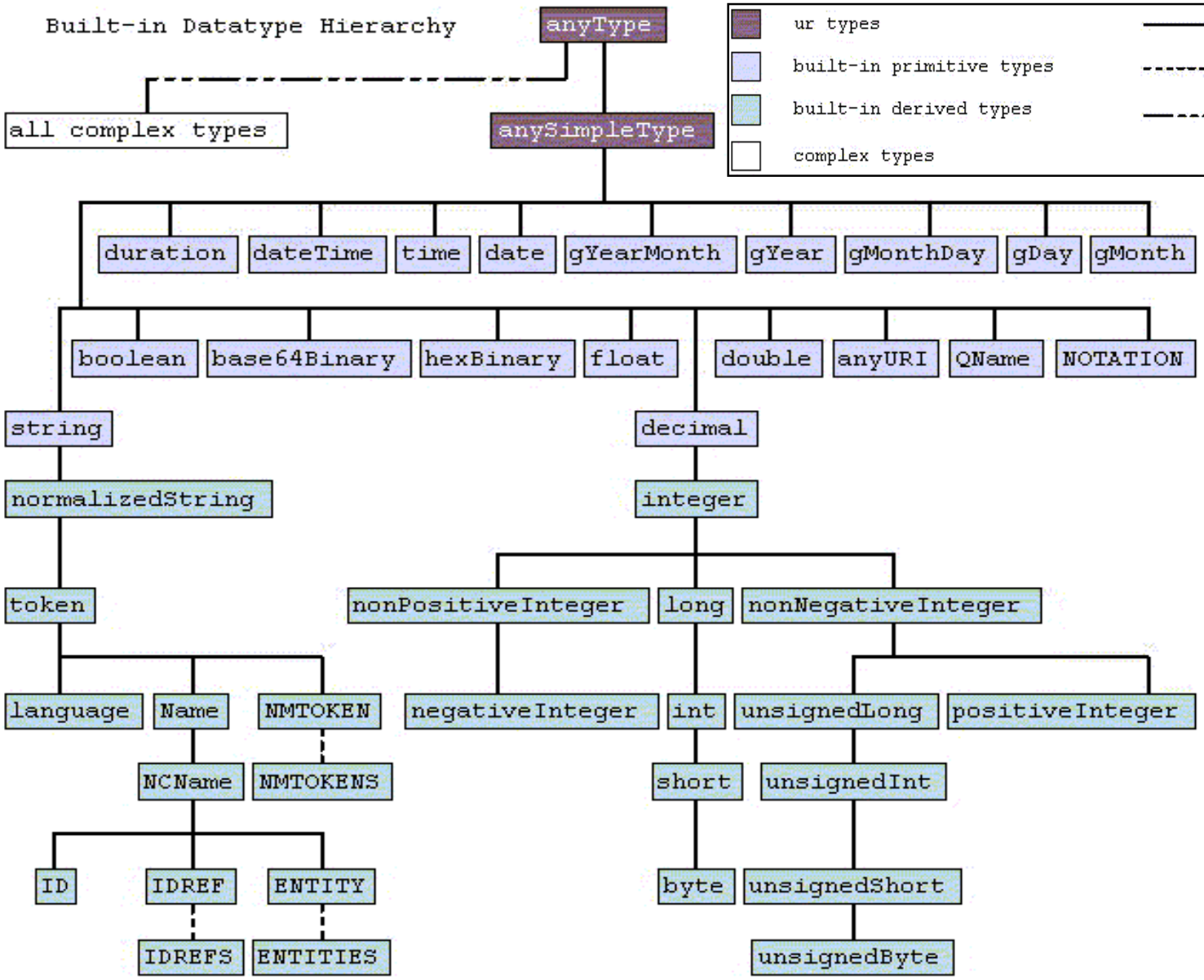
standard literals are xsd:string

type literals with datatypes from XML Schema

```
<rdf:Description rdf:about="#Fabien">
 <teaching rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">
  true</teaching>
 <birth rdf:datatype="http://www.w3.org/2001/XMLSchema#date">
  1975-07-31</birth>
</rdf:Description/>
```

```
#Fabien teaching "true"^^xsd:boolean ;
        birth "1975-07-31"^^xsd:date .
```





W3C - http://www.w3.org/TR/xmlschema-2/

XML Schema datatypes

```
<Book>
 <title xml:lang='fr'>Seigneur des anneaux</title>
 <title xml:lang='en'>Lord of the rings</title>
</Book>
```

```
<Book> title "Seigneur des anneaux"@fr ;
       title "Lord of the rings"@en .
```

literals with languages and without are disjoint

"Fabien" ≠ "Fabien"@en ≠ "Fabien"@fr

language

typing resources

using URIs to identify the types

```
<urn://~fgandon> rdf:type <http://www.inria.fr/schema#Person>
```

a resource can have several types

```
<urn://~fgandon> rdf:type <http://www.inria.fr/schema#Person>
<urn://~fgandon> rdf:type <http://www.inria.fr/schema#Researcher>
<urn://~fgandon> rdf:type <http://www.mit.edu/schema#Lecturer>
```

```
<rdf:Description rdf:about="urn://~fgandon">
 <rdf:type rdf:resource="http://www.inria.fr/schema#Person" />
 <name>Fabien</name>
</rdf:Description>
```

```
<in:Person rdf:about="urn://~fgandon">
  <name>Fabien</name>
</in:Person>
```

```
<urn://~fgandon>
 a in:Person ;
 name "Fabien" .
```

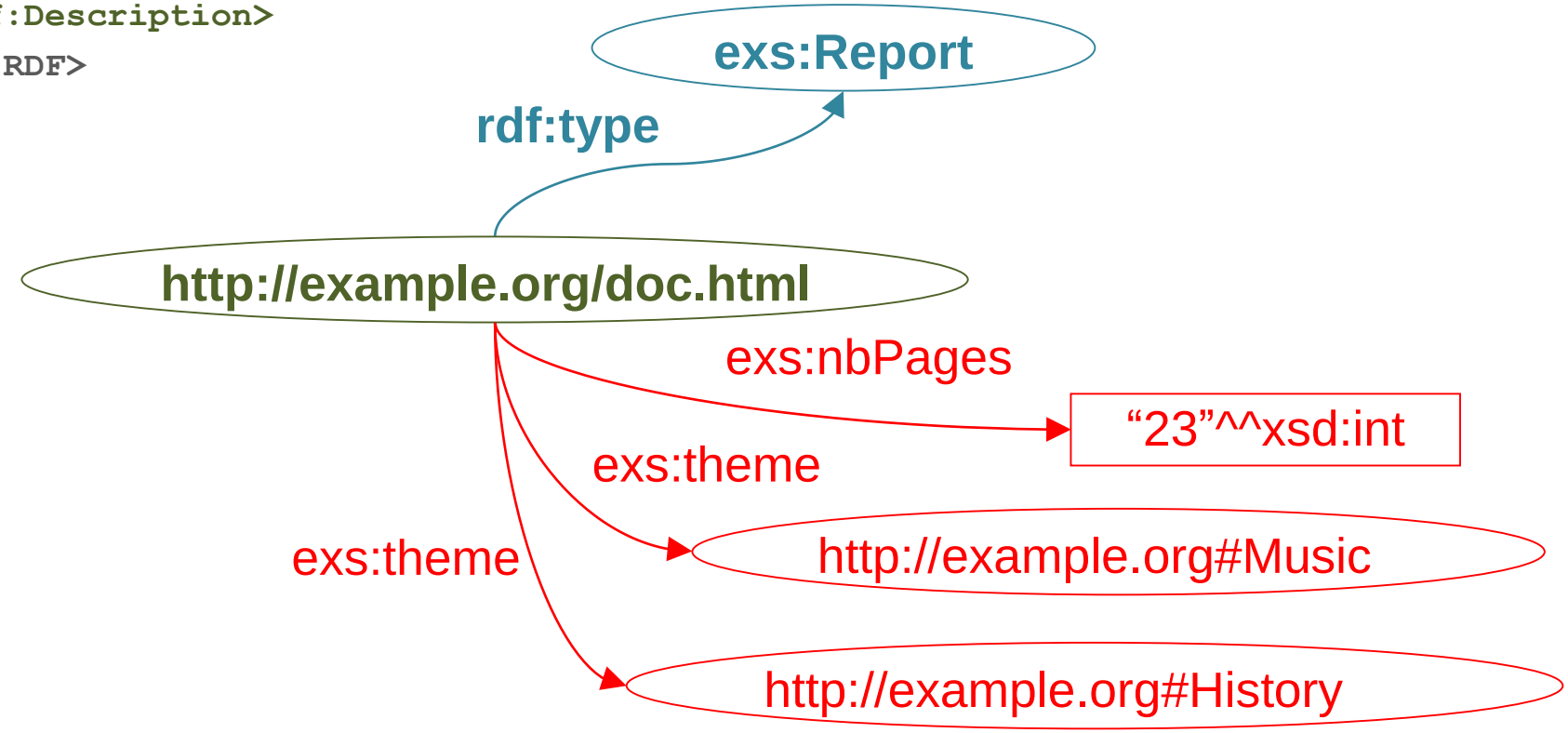
question:

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:exs="http://example.org/schema#">
 <rdf:Description rdf:about="http://example.org/doc.html">
  <rdf:type rdf:resource="http://example.org/schema#Report"/>
  <exs:theme rdf:resource="http://example.org#Music"/>
  <exs:theme rdf:resource="http://example.org#History"/>
  <exs:nbPages rdf:datatype="http://www.w3.org/2001/XMLSchema#int">23</exs:nbPages>
 </rdf:Description>
</rdf:RDF>
```

meaning ?

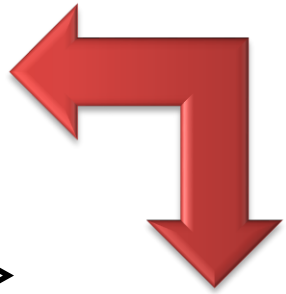
question:

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:exs="http://example.org/schema#">
 <rdf:Description rdf:about="http://example.org/doc.html">
  <rdf:type rdf:resource="http://example.org/schema#Report"/>
  <exs:theme rdf:resource="http://example.org#Music"/>
  <exs:theme rdf:resource="http://example.org#History"/>
  <exs:nbPages rdf:datatype="http://www.w3.org/2001/XMLSchema#int">23</exs:nbPages>
 </rdf:Description>
</rdf:RDF>
```



bags = unordered groups

```
<rdf:Description rdf:about="#">
 <author>
   <rdf:Bag>
     <rdf:li>Ivan Herman</rdf:li>
     <rdf:li>Fabien Gandon</rdf:li>
  </rdf:Bag>
 </author>
</rdf:Description>
```



```
<#> author [
 a rdf:Bag ;
 rdf:li "Ivan Herman" ;
 rdf:li "Fabien Gandon" . ] .
```

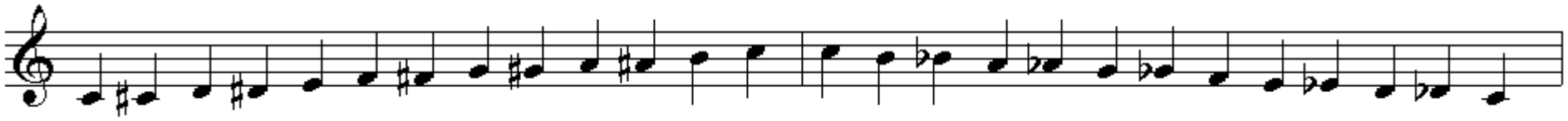
```
<#> author _:a
_:a rdf:_1 “Ivan Herman”
_:a rdf:_2 “Fabien Gandon”
```

sequence

ordered group of resources or literals

```
<rdf:Description rdf:about="#partition">
  <contains>
   <rdf:Seq>
    <rdf:li rdf:about="#C"/>
    <rdf:li rdf:about="#C"/>
    <rdf:li rdf:about="#C"/>
    <rdf:li rdf:about="#D"/>
    <rdf:li rdf:about="#E"/>
   </rdf:Seq>
  </contains>
</rdf:Description>
```

```
<partition>
 contains [
   a rdf:Seq ;
   rdf:li "C" ;
   rdf:li "C" ;
   rdf:li "C" ;
   rdf:li "D" ;
   rdf:li "E" .
] .
```

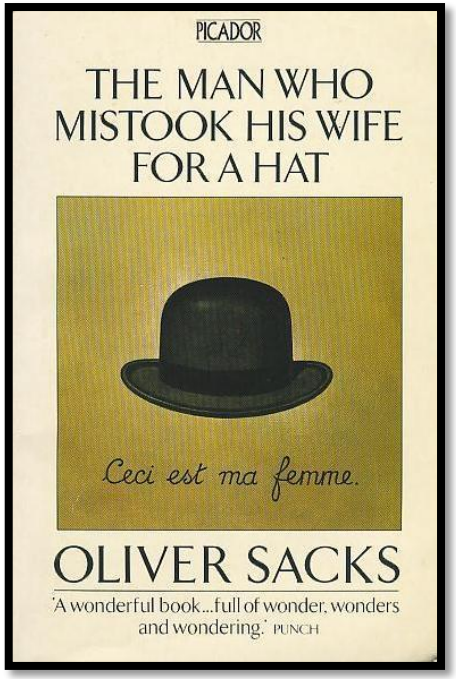


alternatives

e.g. title of a book in different languages

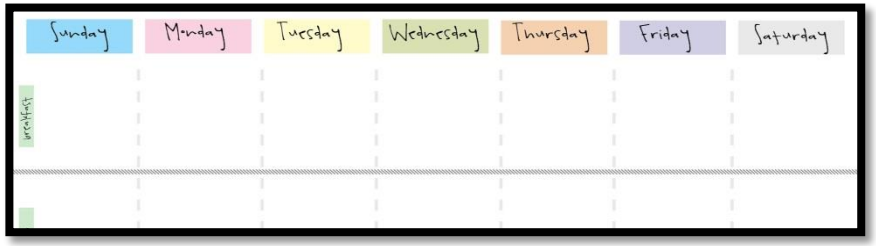
```
<rdf:Description rdf:about="#book">
  <title>
   <rdf:Alt>
    <rdf:li xml:lang="fr">l'homme qui prenait sa femme
                          pour un chapeau</rdf:li>
    <rdf:li xml:lang="en">the man who mistook his wife
                          for a hat</rdf:li>
   </rdf:Alt>
 </title>
</rdf:Description>
```

```
<#book>
 title [
  a rdf:Alt ;
  rdf:li "l'homme…"@fr ;
  rdf:li "the man…"@en .
] .
```

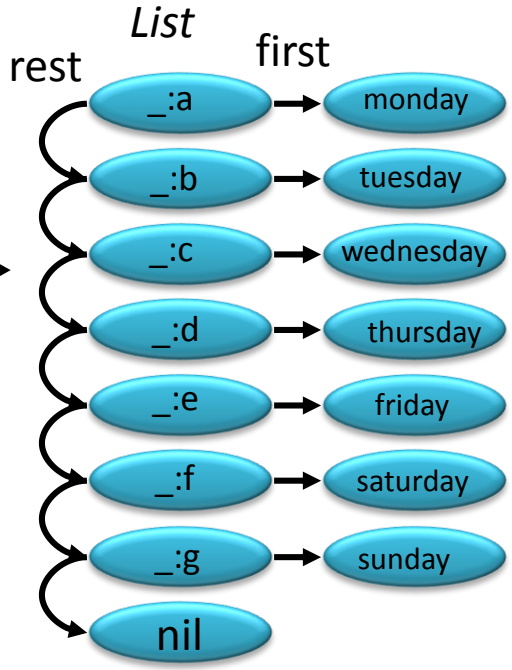


collection

exhaustive and ordered list




```
<rdf:Description rdf:about="#week">
 <dividedIn rdf:parseType="Collection">
  <rdf:Description rdf:about="#monday"/>
  <rdf:Description rdf:about="#tuesday"/>
  <rdf:Description rdf:about="#wednesday"/>
  <rdf:Description rdf:about="#thursday"/>
  <rdf:Description rdf:about="#friday"/>
  <rdf:Description rdf:about="#saturday"/>
  <rdf:Description rdf:about="#sunday"/>
 </devidedIn>
</rdf:Description>
```



```
<#week> dividedIn
 ( <#monday> <#tuesday> <#wednesday>
   <#thursday> <#friday> <#saturday> <#sunday>
  ) .
```

RDF (named) graphs

group triples in graphs named by IRIs

```
@prefix rdf:
  <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix inria: <http://inria.fr/schema#> .

GRAPH <http://inria.fr/people>
{ <http://inria.fr/rr/doc.html>
   inria:author
    <http://ns.inria.fr/fabien.gandon#me> .
}

GRAPH <http://inria.fr/topics>
{ <http://inria.fr/rr/doc.html>
 inria:theme "Music" .
}
```

TriG

```
<http://inria.fr/rr/doc.html>
 <http://inria.fr/schema#author>
   <http://ns.inria.fr/fabien.gandon#me>
    <http://inria.fr/people> .

<http://inria.fr/rr/doc.html>
 <http://inria.fr/schema#theme> "Music"
  <http://inria.fr/topics> .
```

N-Quads

http://my_domain.org/my_path/my_type

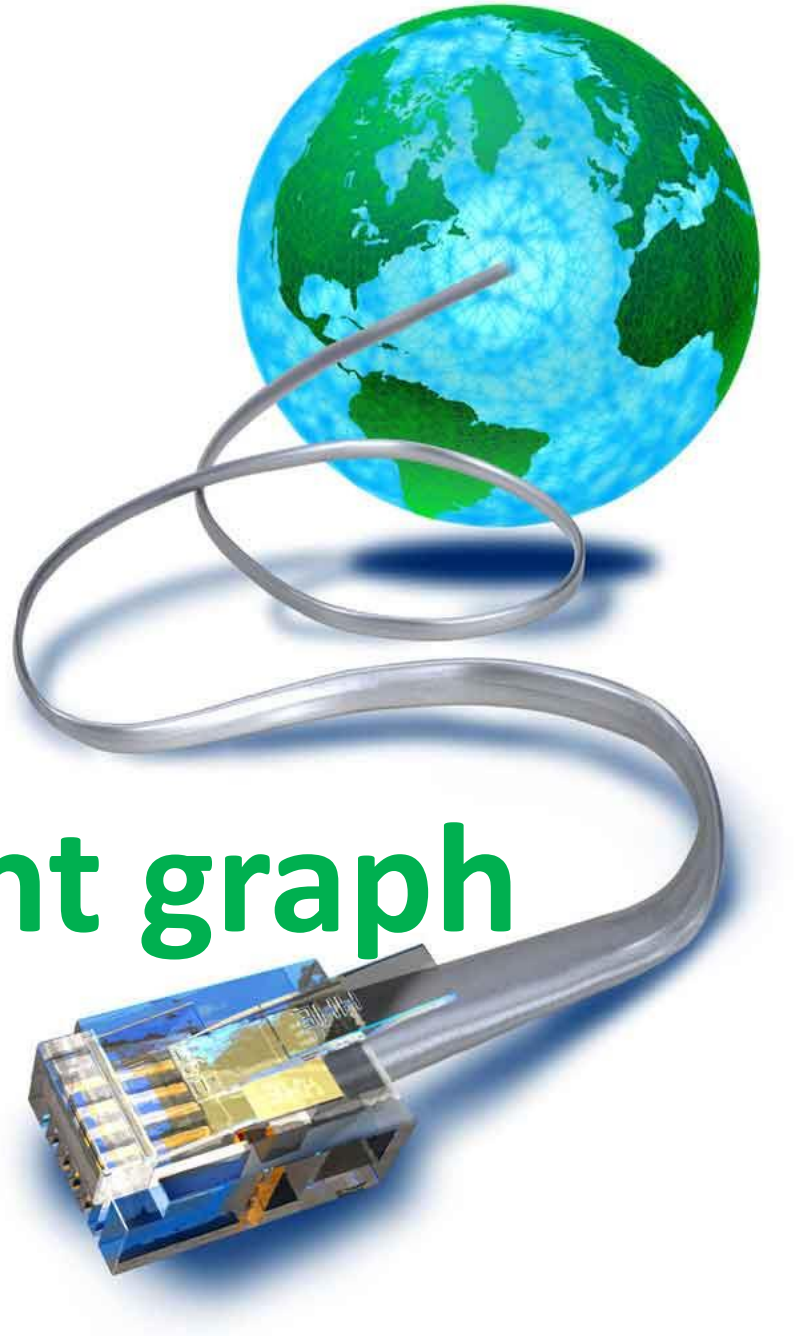
openmodel

- extensible vocabulary based on URIs
- anyone can say anything about anything


link
to the world

open and link data in a

global giant graph




apple

TOP NEWS STORY

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Live - Transfer deadline day

Cairo delight at African Cup win

Latest updates from first F1 test

- Transfer trio boost Celtic squad
- Ferguson praises 'maturing' Nani
- Terry left to sweat on captaincy
- Geremi completes Newcastle exit
- Benitez dismisses Juventus deal

Travel

Edit

from lonely planet

Spotlight

» AEROSPACE

Singapore air show eyes military sales

After a bad year for airlines, manufacturers at the Singapore air show have higher hopes for sales of military hardware than civilian aircraft.

- Gloom ahead of Asia's largest air show
- Planemakers eye depressed cargo market
- 'Manage flights' to cut emissions

Business & Money

Edit

» MARKET DATA MON, 1 FEBRUARY 2010 12:37:42 GMT

Dow Jones	10067.33	▼	-53.13
Nasdaq	2147.35	▼	-31.65
FTSE 100	5188.53	▲	0.01
Dax	5604.08	▼	-4.71
Cac 40	3729.43	▼	-10.03

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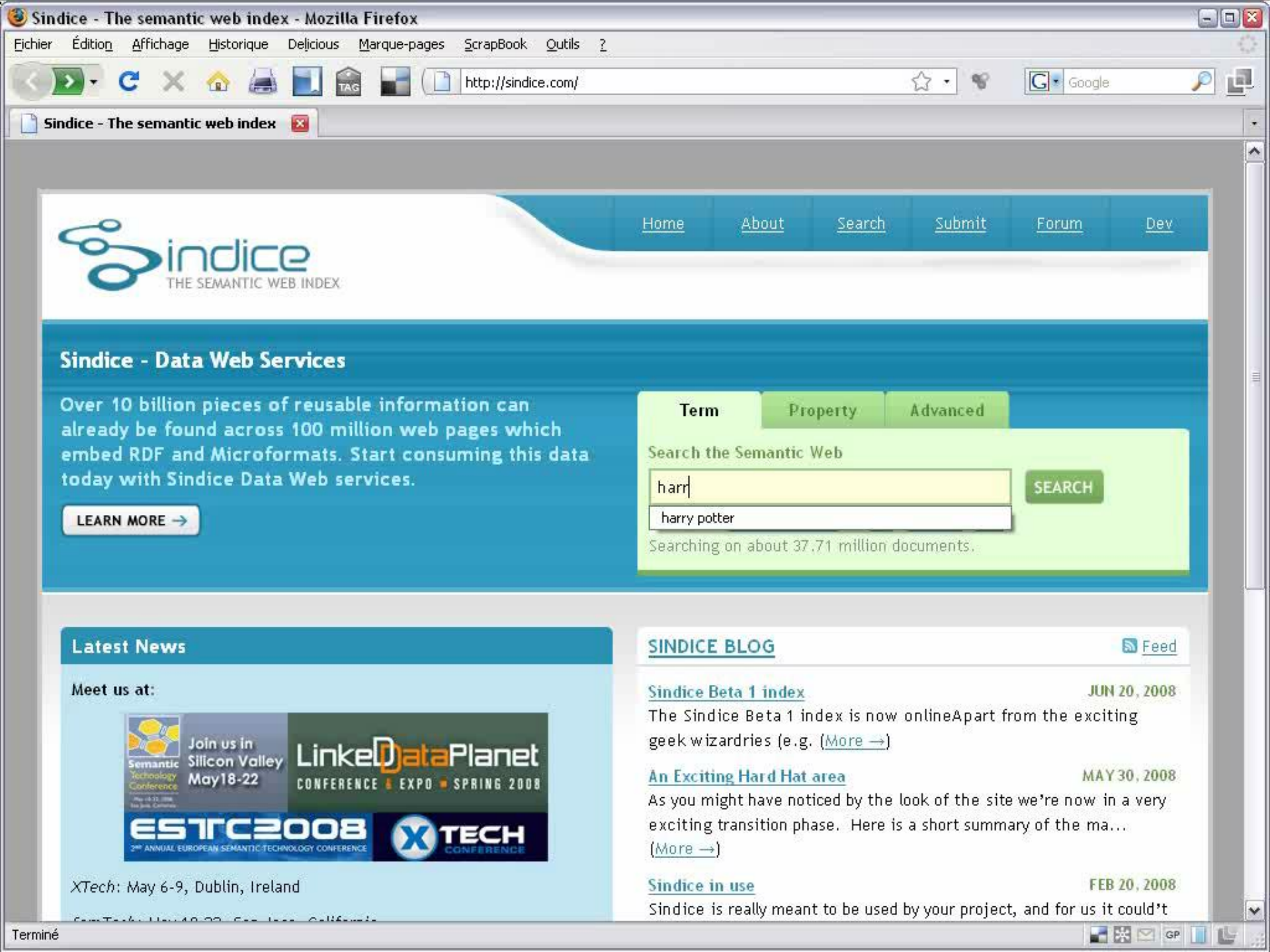
Sindice - The semantic web index - Mozilla Firefox
Fichier Édition Affichage Historique Delicious Marque-pages ScrapBook Outils ?
http://sindice.com/
Google
Sindice - The semantic web index
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XTech: May 6-9, Dublin, Ireland
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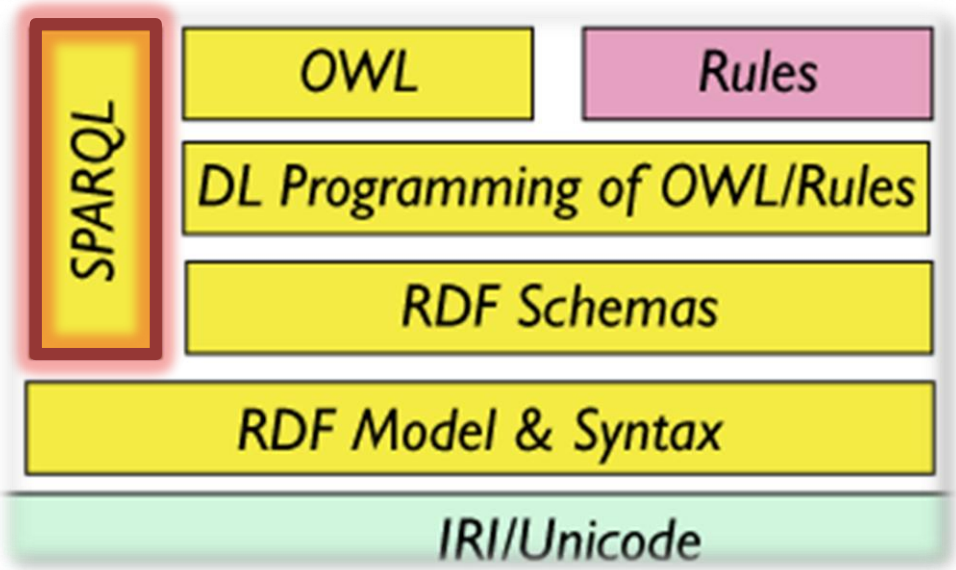
JUN 20, 2008
The Sindice Beta 1 index is now onlineApart from the exciting geek wizardries (e.g. (More →)
An Exciting Hard Hat area
MAY 30, 2008
As you might have noticed by the look of the site we're now in a very exciting transition phase. Here is a short summary of the ma...
(More →)
Sindice in use
FEB 20, 2008
Sindice is really meant to be used by your project, and for us it could't
Terminé


Vapsi

what is the mathematical structure of the RDF model?

query with SPARQL

SPARQL **P**rotocol and **R**DF **Q**uery **L**anguage



SPARQL in 3 parts

part 1: query language

part 2: result format

part 3: access protocol

SPARQL query

```
SELECT ...
FROM ...
WHERE { ... }
```

example

persons at least 18-year old

```
PREFIX ex: <http://inria.fr/schema#>
SELECT ?person ?name
WHERE {
  ?person rdf:type ex:Person .
  ?person ex:name ?name .
  ?person ex:age ?age .
  FILTER (?age > 17)
}
```

left(x,y) right(z,v)

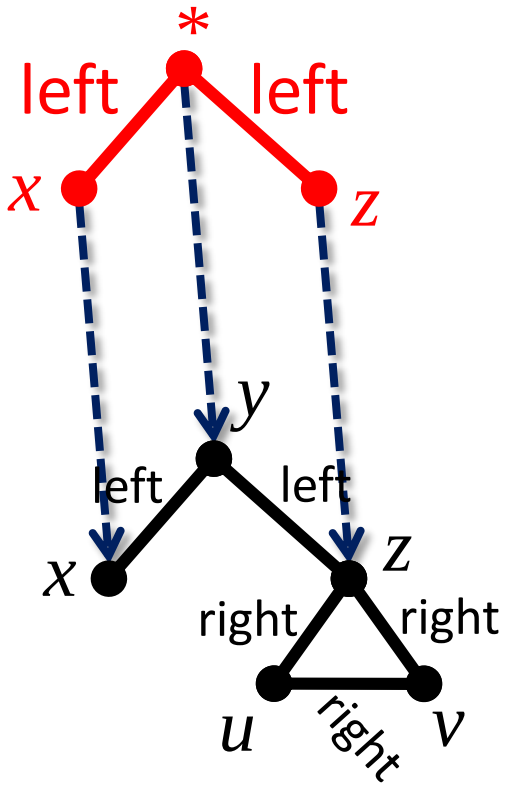
left(y,z) right(z,u)

right(u,v)

$\models$

left(x,?p) left(?p,z)

$\Leftrightarrow$



graph mapping / projection

classical three clauses:

- Select: clause to select the values to be returned
- Where: triple/graph pattern to match
- Filter: constraints expressed using test functions (XPath 2.0 or external)

SPARQL triples

- triples and question marks for variables:

```
?x rdf:type  ex:Person
```

- graph patterns to match:

```
SELECT ?subject ?proprerty ?value
WHERE {?subject ?proprerty ?value}
```

- a pattern is, by default, a conjunction of triples

```
SELECT ?x WHERE
{ ?x    rdf:type        ex:Person .
  ?x    ex:name         ?name . }
```

question:

- Query:

```
SELECT ?name WHERE {
 ?x name ?name .
 ?x email ?email .
}
```

- Base:

```
_:a name "Fabien"
_:b name "Thomas"
_:c name "Lincoln"
_:d name "Aline"
_:b email <mailto:thom@chaka.sn>
_:a email <mailto:Fabien.Gandon@inria.fr>
_:d email <mailto:avalandre@pachinko.jp>
_:a email <mailto:bafien@fabien.info>
```

x2

- Results ?

prefixes

to use namespaces:

```
PREFIX mit: <http://www.mit.edu#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?student
WHERE {
 ?student mit:registeredAt ?x .
 ?x foaf:homepage <http://www.mit.edu> .
}
```

Base namespace : `BASE <…>`

SPARQL result

failure/ success

values found

result formats

- a binding i.e. list of all the selected values (SELECT) for each answer found;
  (stable XML format ; e.g. for XSLT transformations)
- RDF sub-graphs for each answer found
  (RDF/XML format ; e.g. for application integration)
- JSON (eg. ajax web applications)
- CSV/TSV (eg. export)

example of binding

results for previous query in XML

```
<?xml version="1.0"?>
<sparql xmlns="http://www.w3.org/2005/sparql-results#">
 <head>
  <variable name="student"/>
 </head>
 <results ordered="false" distinct="false">
  <result>
   <binding name="student">
<uri>http//www.mit.edu/data.rdf#ndieng</uri></binding>
  </result>
  <result>
   <binding name="student">
<uri>http//www.mit.edu/data.rdf#jdoe</uri></binding>
  </result>
</sparql>
```

simplified syntax

triples with a common subject:

```
SELECT ?name ?fname
WHERE {
 ?x a Person;
    name ?name ;
    firstname ?fname ;
    author ?y . }
```

```
SELECT ?name ?fname
WHERE {
 ?x rdf:type Person .
  ?x name ?name .
  ?x firstname ?fname .
  ?x author ?y .
}
```

list of values

```
?x firstname "Fabien", "Lucien" .
```

blank node

```
[firstname "Fabien"] or [] firstname "Fabien"
```

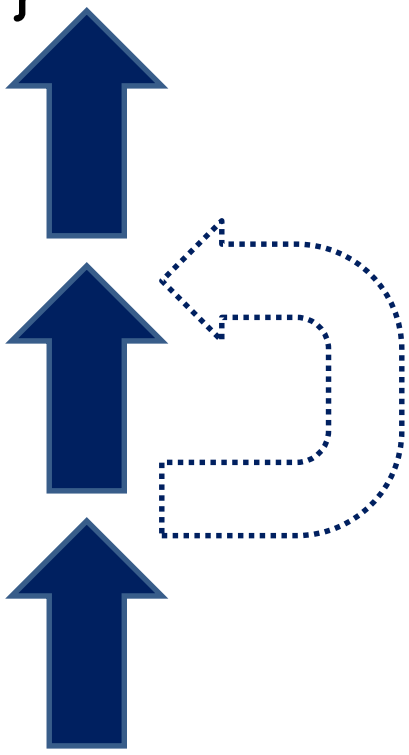
source

```
PREFIX mit: <http://www.mit.edu#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
FROM http//www.mit.edu/data.rdf
SELECT ?student
WHERE {
 ?student mit:registeredAt ?x .
 ?x foaf:homepage <http://www.mit.edu> .
}
```

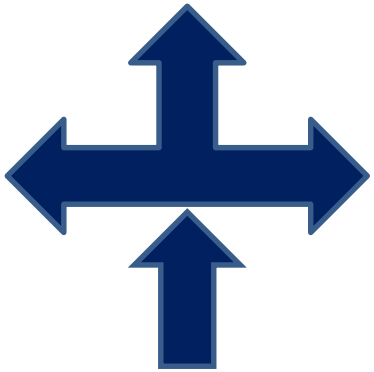
optional part

```
PREFIX mit: <http://www.mit.edu#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?student ?name
WHERE {
 ?student mit:registeredAt ?x .
 ?x foaf:homepage <http://www.mit.edu> .
 OPTIONAL {? student foaf:name ?name . }
}
```

possibly unbound



union



alternative graph patterns

```
PREFIX mit: <http://www.mit.edu#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?student ?name
WHERE {
  ?student mit:registeredAt ?x .
  {
    {
     ?x foaf:homepage <http://www.mit.edu> .
    }
    UNION
    {
     ?x foaf:homepage <www.stanford.edu/> .
    }
  }
}
```

what are the results of this query on this base?

```
SELECT ?name WHERE {
 ?x :name ?name ;
    :email ?email .
}
```

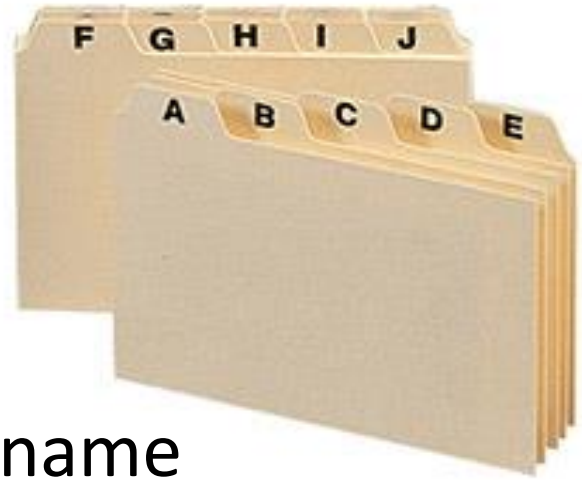
query

```
_:a :name "Fabien"
_:b :name "Thomas"
_:c :name "Lincoln"
_:d :name "Aline"
_:b :email <mailto:thom@chaka.sn>
_:a :email <mailto:Fabien.Gandon@inria.fr>
_:d :email <mailto:avalandre@pachinko.jp>
_:a :email <mailto:bafien@fabien.info>
```

base

sort, filter and limit answers

```
PREFIX mit: <http://www.mit.edu#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?student ?name
WHERE {
  ?student mit:registeredAt ?x .
  ?x foaf:homepage <http://www.mit.edu> .
  ?student foaf:name ?name .
  ? student foaf:age ?age .
  FILTER (?age > 22)
}
ORDER BY ?name
LIMIT 20
OFFSET 20
```



students older than 22 years sorted by name
results from number #21 to #40

operators

- Inside the FILTER:
  - Comparators: **`<, >, =, <=, >=,  !=`**
  - Tests on variables : **`isURI(?x), isBlank(?x), isLiteral(?x), bound(?x)`**
  - Regular expression **`regex(?x, "A.*")`**
  - Attributes and values: **`lang(), datatype(), str()`**
  - Casting: **`xsd:integer(?x)`**
  - External functions and extensions
  - Boolean combinations: **`&&, ||`**
- In the where WHERE: **`@fr , ^^xsd:integer`**
- In the SELECT: **`distinct`**

other functions (v 1.1)

`isNumeric(Val)` test it is a numeric value

`coalesce(val,…, val)` first valid value

`IRI(Str)/URI(Str)` to build an iri/uri from a string

`BNODE(ID)` to build a blank node

`RAND()` random value between 0 and 1

`ABS(Val)` absolute value

`CEIL(Val), FLOOR(Val), ROUND(Val)`

`NOW()` today's date

`DAY(Date), HOURS(Date), MINUTES(Date), MONTH(Date), SECONDS(Date), TIMEZONE(Date), TZ(Date), YEAR(Date)`
to access different parts of a date

`MD5(Val), SHA1(Val), SHA256(Val), SHA384(Val), SHA512(Val)` hash functions

string / literal functions (v1.1)

`STRDT(value, type)` build a typed literal

`STRLANG(value, lang)` build a literal with a language

`CONCAT(lit1,…,litn)` concatenate a list of literal

`CONTAINS(lit1,lit2)`, `STRSTARTS(lit1,lit2)`, `STRENDS(lit1,lit2)`

to test string inclusion

`SUBSTR(lit, start [,length])` extract a sub string

`ENCODE_FOR_URI (Str)` encodes a string as URI

`UCASE (Str)`, `LCASE (Str)` uppercase and lowercase

`STRLEN (Str)` length of the string

Aggregates

`group by` + `count`, `sum`, `min`, `max`, `avg`, `group_concat`, or **`sample`**

ex. average scores, grouped by the subject, but only where the mean is greater than 10

```
SELECT (AVG(?score) AS ?average)
WHERE { ?student score ?score . }
GROUP BY ?student
HAVING(AVG(?score) > 10)
```

question:

```
PREFIX ex: <http://www.exemple.abc#>
SELECT ?person
WHERE {
   ?person rdf:type ?type .
   FILTER(! ( ?type = ex:Man ))
}
```

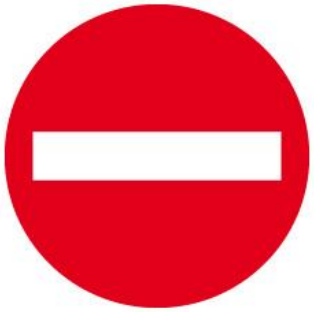
minus

substract a pattern

```
PREFIX ex: <http://www.exemple.abc#>
SELECT ?person
WHERE {
  { ?x rdf:type ex:Person }
   minus {?x rdf:type ex:Man}
}
```

not exist

check the absence of a pattern



```
PREFIX ex: <http://www.exemple.abc#>
SELECT ?person
WHERE {
  ?x ex:memberOf ?org .
  filter (not exists
    {?y ex:memberOf <Hell>})
}
```

if… then… else

```
prefix foaf: <http://xmlns.com/foaf/0.1/>
select * where {
 ?x foaf:name ?name ; foaf:age ?age .
 filter (
  if (langMatches( lang(?name), "FR"),
     ?age>=18, ?age>=21) )
}
```

test a value is `in` / `not in` a list

```
prefix foaf: <http://xmlns.com/foaf/0.1/>
select * where {
     ?x foaf:name ?n .
     filter (?n in ("fabien", "olivier",
                    "catherine") )
}
```

values

pre-defined bindings

```
select ?person where {
  ?person name ?name .
  VALUES (?name)
    { "Peter" "Pedro" "Pierre" }
}
```

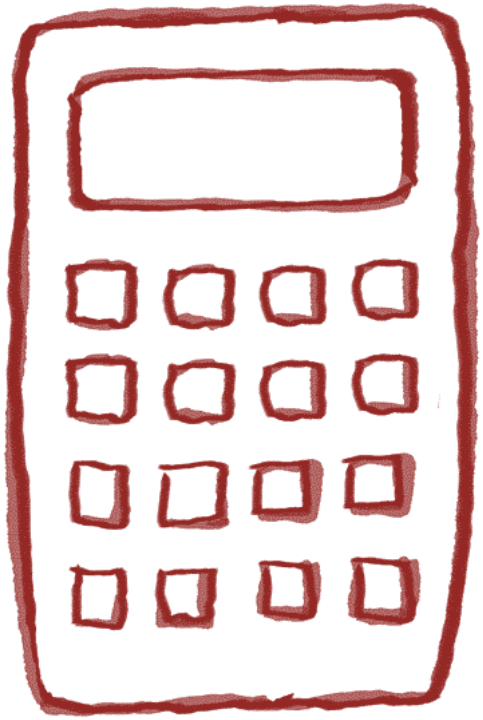
paths

/ : sequence
| : alternative
+ : one or several
*** : zero or several**
? : optional
^ : reverse
! : negation
{min,max} : length

```
prefix foaf: <http://xmlns.com/foaf/0.1/>
select ?friends_fab where {
 ?x foaf:name "Fabien Gandon" ;
    foaf:knows+ ?friends_fab ;
}
```

select expression

```
select ?x (year(?date) as ?year)
where {
  ?x birthdate ?date .
}
```

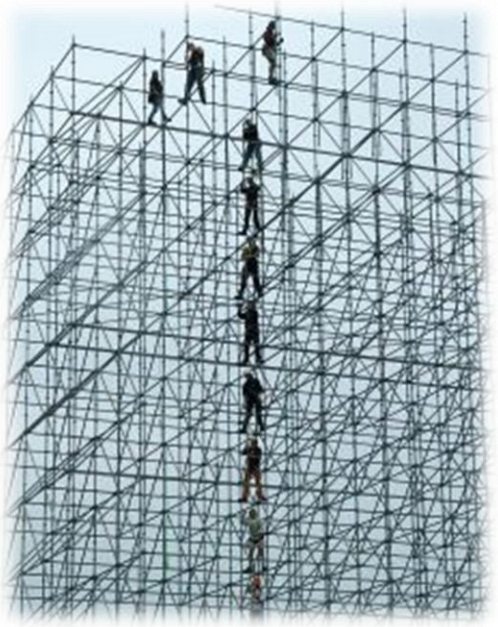


subquery / nested query

```
select ?name where {
  {select (max(?age) as ?max)
   where { ?person age ?age }
  }
  ?senior age ?max
  ?senior name ?name
}
```

construct RDF as result

```
PREFIX mit: <http://www.mit.edu#>
PREFIX corp: <http://mycorp.com/schema#>
CONSTRUCT
{ ?student rdf:type corp:FuturExecutive . }
WHERE
{ ?student rdf:type mit:Student . }
```



free description

```
PREFIX mit: <http://www.mit.edu#>
DESCRIBE ?student
{ ?student rdf:type mit:Student . }

or

DESCRIBE <…URI…>
```

SPARQL protocol

exchange queries and their results through the web

What does this query mean?

```
PREFIX ex: <http://www.exemple.abc#>
SELECT ?x
WHERE {
  ?x rdf:type ?type .
  FILTER(! ( ?type = ex:Man ))
}
```


apple

e.g. DBpedia

SPARQL Explorer for http://dbpedia.org/sparql

SPARQL:

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX : <http://dbpedia.org/resource/>
PREFIX dbpedia2: <http://dbpedia.org/property/>
PREFIX dbpedia: <http://dbpedia.org/>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
```

Results: Browse Go! Reset

Powered by OpenLink Virtuoso and dbpedia

Test on DBpedia

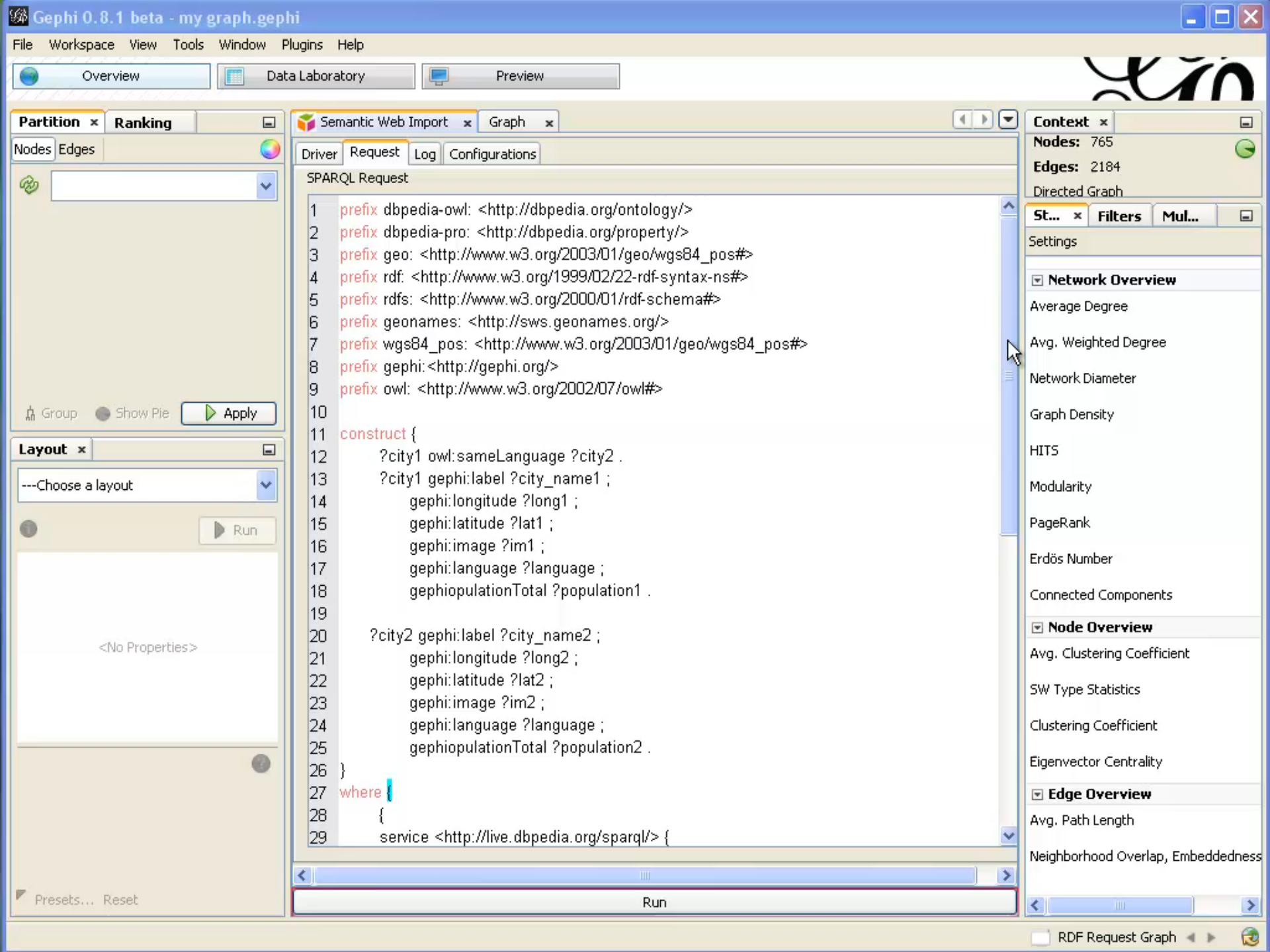
- Connect to:

  http://dbpedia.org/snorql/ or
  http://fr.dbpedia.org/sparql or …

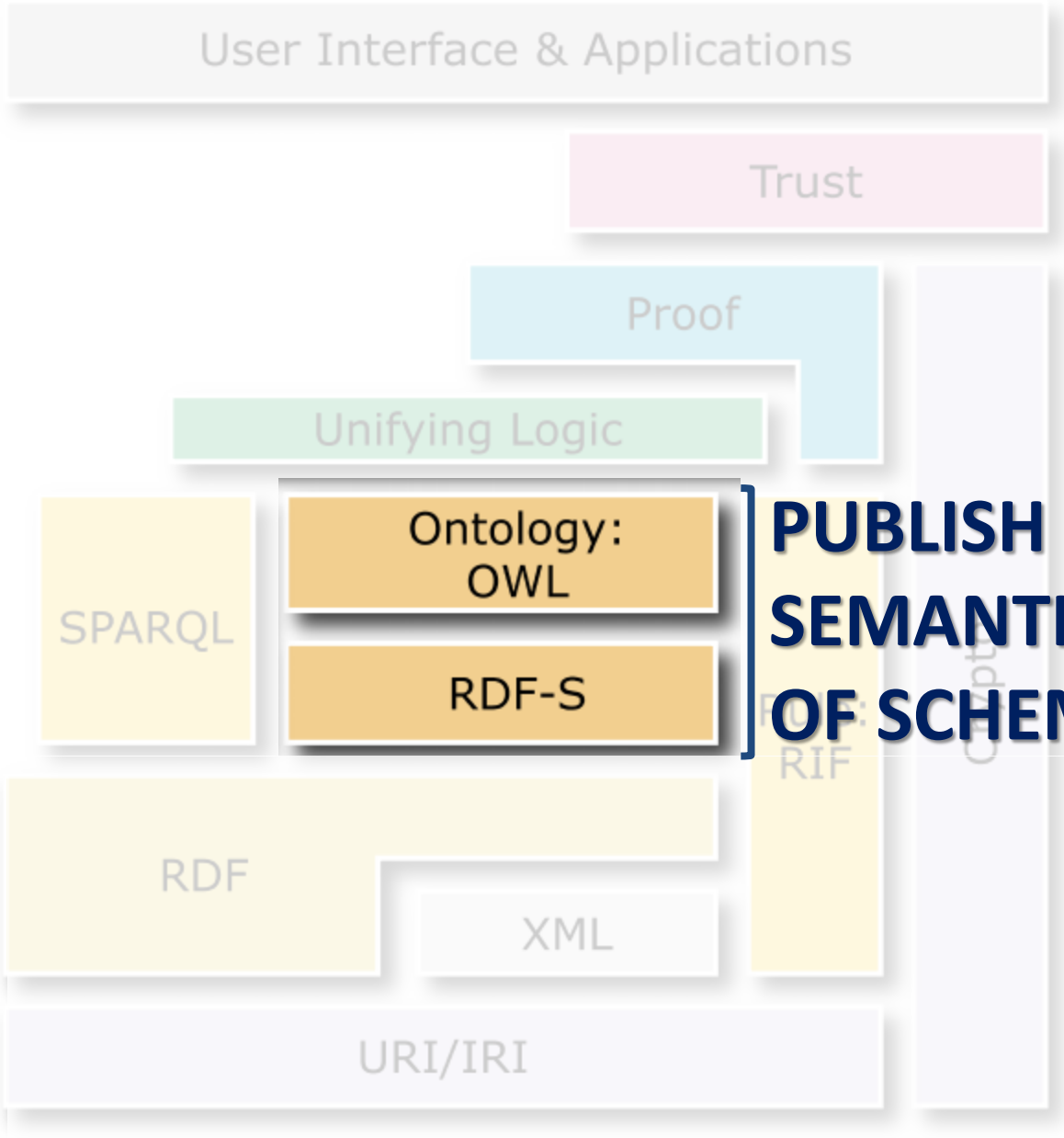
  http://wiki.dbpedia.org/Internationalization/Chapters

- Query:

```
SELECT * WHERE {
   ?x rdfs:label "Paris"@fr .
   ?x ?p ?v .
}
LIMIT 10
```


Gephi 0.8.1 beta - my graph.gephi
File Workspace View Tools Window Plugins Help
Overview
Data Laboratory
Preview
Partition
Ranking
Nodes Edges
Group
Show Pie
Apply
Layout
---Choose a layout
Run
<No Properties>
Presets... Reset
Semantic Web Import
Graph
Driver
Request
Log
Configurations
SPARQL Request
prefix dbpedia-owl: <http://dbpedia.org/ontology/>
prefix dbpedia-pro: <http://dbpedia.org/property/>
prefix geo: <http://www.w3.org/2003/01/geo/wgs84_pos#>
prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
prefix geonames: <http://sws.geonames.org/>
prefix wgs84_pos: <http://www.w3.org/2003/01/geo/wgs84_pos#>
prefix gephi:<http://gephi.org/>
prefix owl: <http://www.w3.org/2002/07/owl#>
construct {
?city1 owl:sameLanguage ?city2 .
?city1 gephi:label ?city_name1 ;
gephi:longitude ?long1 ;
gephi:latitude ?lat1 ;
gephi:image ?im1 ;
gephi:language ?language ;
gephiopulationTotal ?population1 .
?city2 gephi:label ?city_name2 ;
gephi:longitude ?long2 ;
gephi:latitude ?lat2 ;
gephi:image ?im2 ;
gephi:language ?language ;
gephiopulationTotal ?population2 .
}
where {
{
service <http://live.dbpedia.org/sparql/> {
Run
Context
Nodes: 765
Edges: 2184
Directed Graph
St...
Filters
Mul...
Settings
Network Overview
Average Degree
Avg. Weighted Degree
Network Diameter
Graph Density
HITS
Modularity
PageRank
Erdös Number
Connected Components
Node Overview
Avg. Clustering Coefficient
SW Type Statistics
Clustering Coefficient
Eigenvector Centrality
Edge Overview
Avg. Path Length
Neighborhood Overlap, Embeddedness
RDF Request Graph


Vapsi



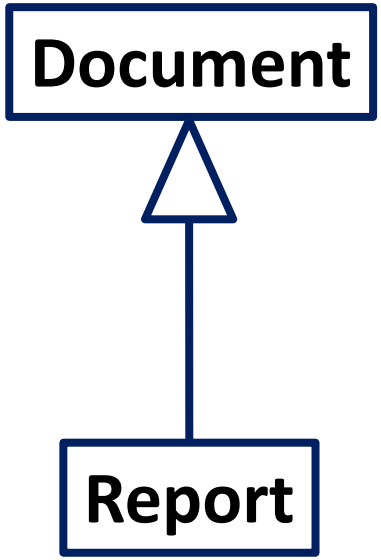
PUBLISH SEMANTICS OF SCHEMAS

W3C®

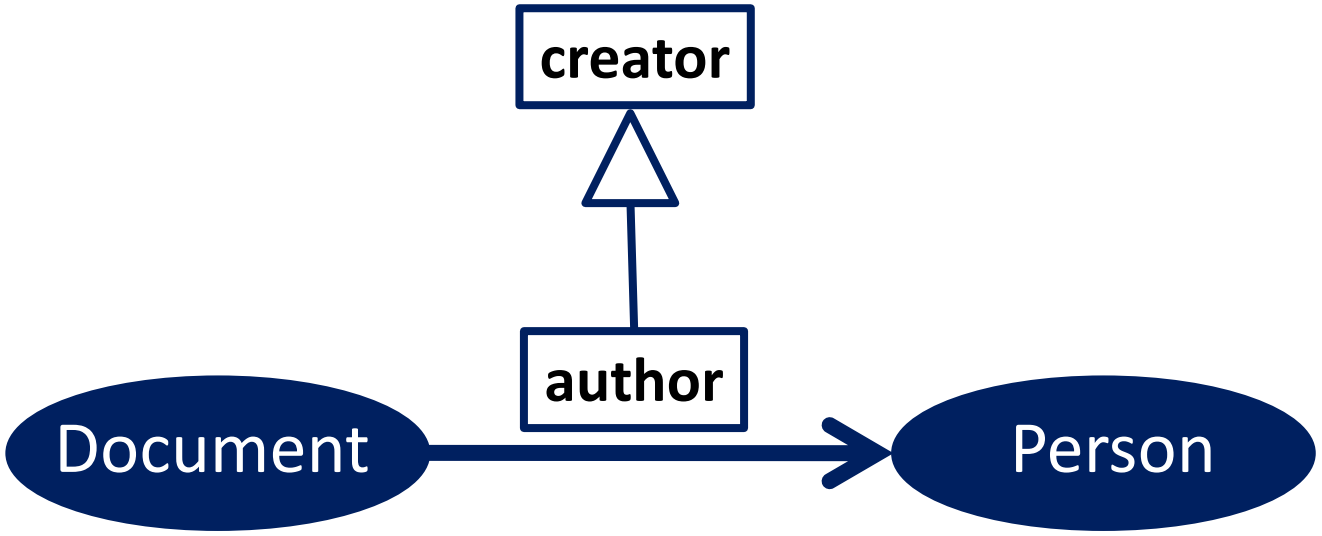
RDFS means RDF Schema

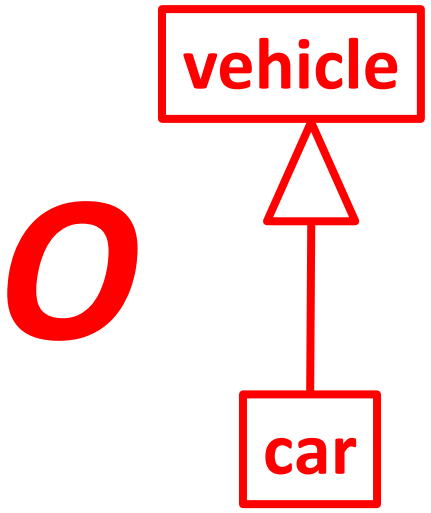
RDFS provides primitives to *W*rite lightweight ontologies

RDFS to define classes of resources and organize their hierarchy

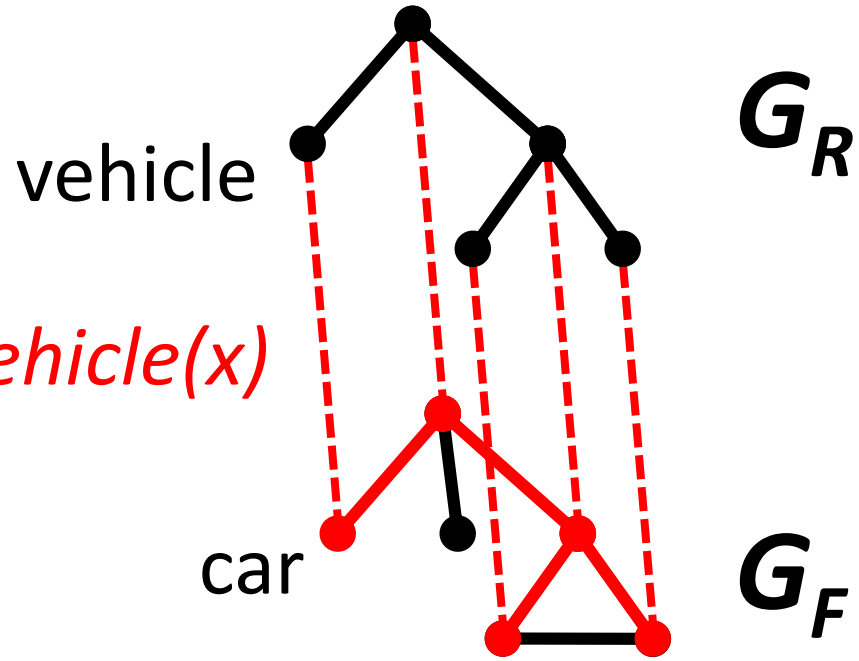


RDFS to define relations between resources, their signature and organize their hierarchy



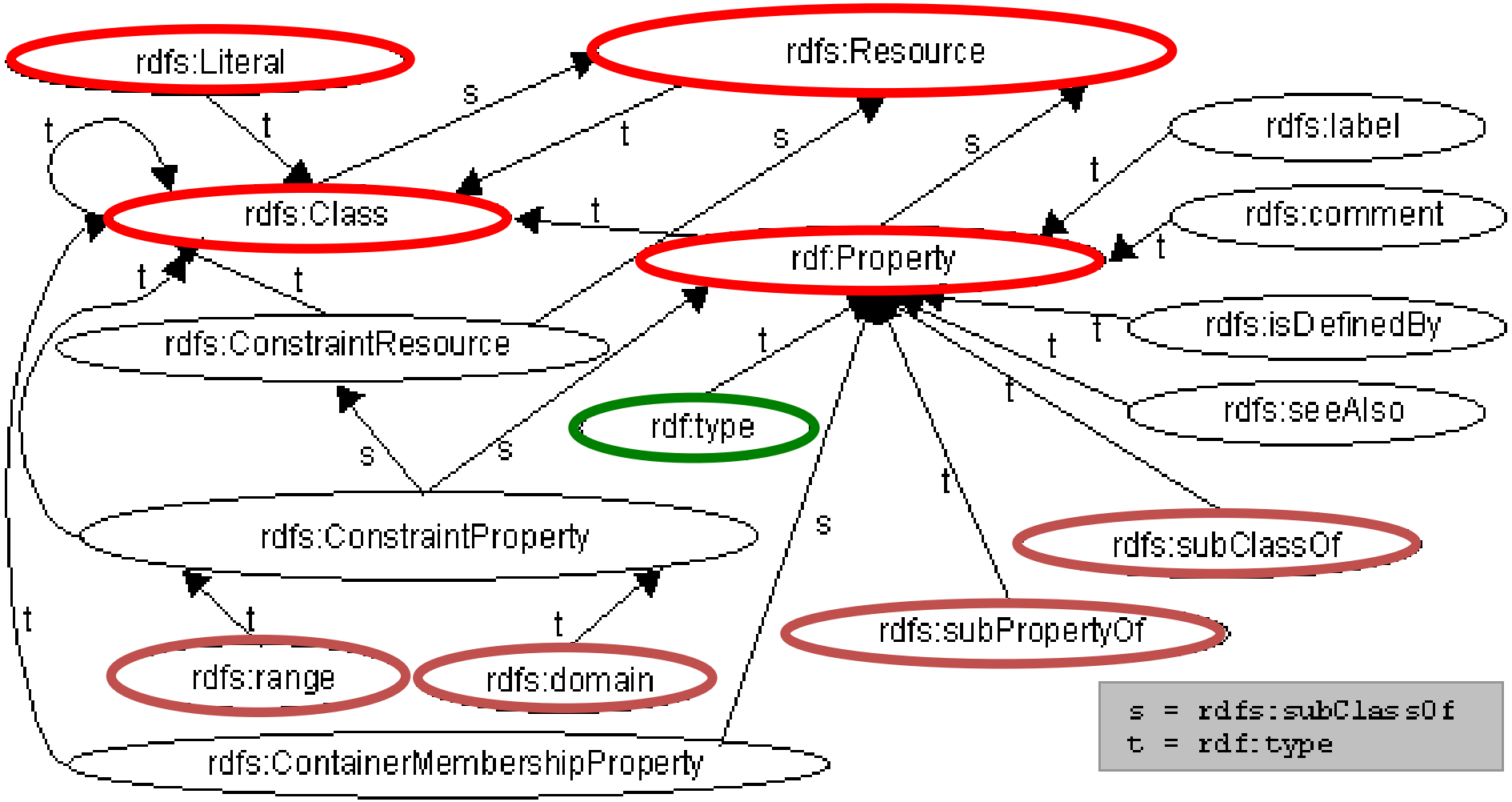


car(x)⇒vehicle(x)



$$F \wedge O \rightarrow R \Leftrightarrow G_F \leq G_R$$

mapping modulo an ontology



an old schema of RDFS

W3C http://www.w3.org/TR/2000/CR-rdf-schema-20000327/

example of RDFS schema

```
<rdf:RDF xml:base  ="http://inria.fr/2005/humans.rdfs"
 xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
 xmlns     ="http://www.w3.org/2000/01/rdf-schema#>
 <Class rdf:ID="Man">
  <subClassOf rdf:resource="#Person"/>
  <subClassOf rdf:resource="#Male"/>
   <label xml:lang="en">man</label>
   <comment xml:lang="en">an adult male person</comment>
 </Class>
```

<Man> a Class ; subClassOf <Person>, <Male> .

example of RDFS properties

```
<rdf:RDF xml:base  ="http://inria.fr/2005/humans.rdfs"
 xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
 xmlns     ="http://www.w3.org/2000/01/rdf-schema#>
 <rdf:Property rdf:ID="hasMother">
   <subPropertyOf rdf:resource="#hasParent"/>
   <range rdf:resource="#Female"/>
   <domain rdf:resource="#Human"/>
   <label xml:lang="en">has for mother</label>
   <comment xml:lang="en">to have for parent a female.
                                                  </comment>
 </rdf:Property>
```

```
<hasMother> a rdf:Property ;
  subPropertyOf <hasParent> ;
  range <Female> ; domain <Human> .
```

```
<rdf:RDF xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-
   syntax-ns#"
   xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
   xmlns="http://inria.fr/2005/humans.rdfs#"
   xml:base=" http://inria.fr/2005/humans.rdfs-instances" >

   <rdf:Description rdf:ID="Lucas">
      <rdf:type
   rdf:resource="http://inria.fr/2005/humans.rdfs#Man"/>
      <hasMother rdf:resource="#Laura"/>
   </rdf:Description>

   <Man rdf:ID="Lucas">
      <hasMother rdf:resource="#Laura"/>
   </Man>
```

```
<Luca> a Man; hasMother <Laura> .
```

example of RDF using this schema

rdfs:label

a resource may have one or more labels in one or more natural language

```
<rdf:Property rdf:ID='name'>
 <rdfs:domain rdf:resource='Person'/>
 <rdfs:range rdf:resource='&rdfs;Literal'/>
 <rdfs:label xml:lang='fr'>nom</rdfs:label>
 <rdfs:label xml:lang='fr'>nom de famille</rdfs:label>
 <rdfs:label xml:lang='en'>name</rdfs:label>
</rdf:Property>
```

```
<name> a rdf:Property ;
   range rdfs:Literal ; domain <Person> ;
   label "nom"@fr, "nom de famille"@fr, "name"@en .
```

rdfs:comment & rdfs:seeAlso

comments provide definitions and explanations in natural language

```
<rdfs:Class rdf:about='#Woman'>
  <rdfs:subClassOf rdf:resource="#Person"/>
  <rdfs:comment xml:lang='fr'>une personne adulte du
                              sexe féminin</rdfs:comment>
  <rdfs:comment xml:lang='en'>a female adult person
  </rdfs:comment>
</rdfs:Class>
```

```
<Woman> a rdfs:Class ; rdfs:subClassOf <Person> ;
  rdfs:comment "adult femal person"@en ;
  rdfs:comment "une adulte de sexe féminin"@fr .
```

see also…

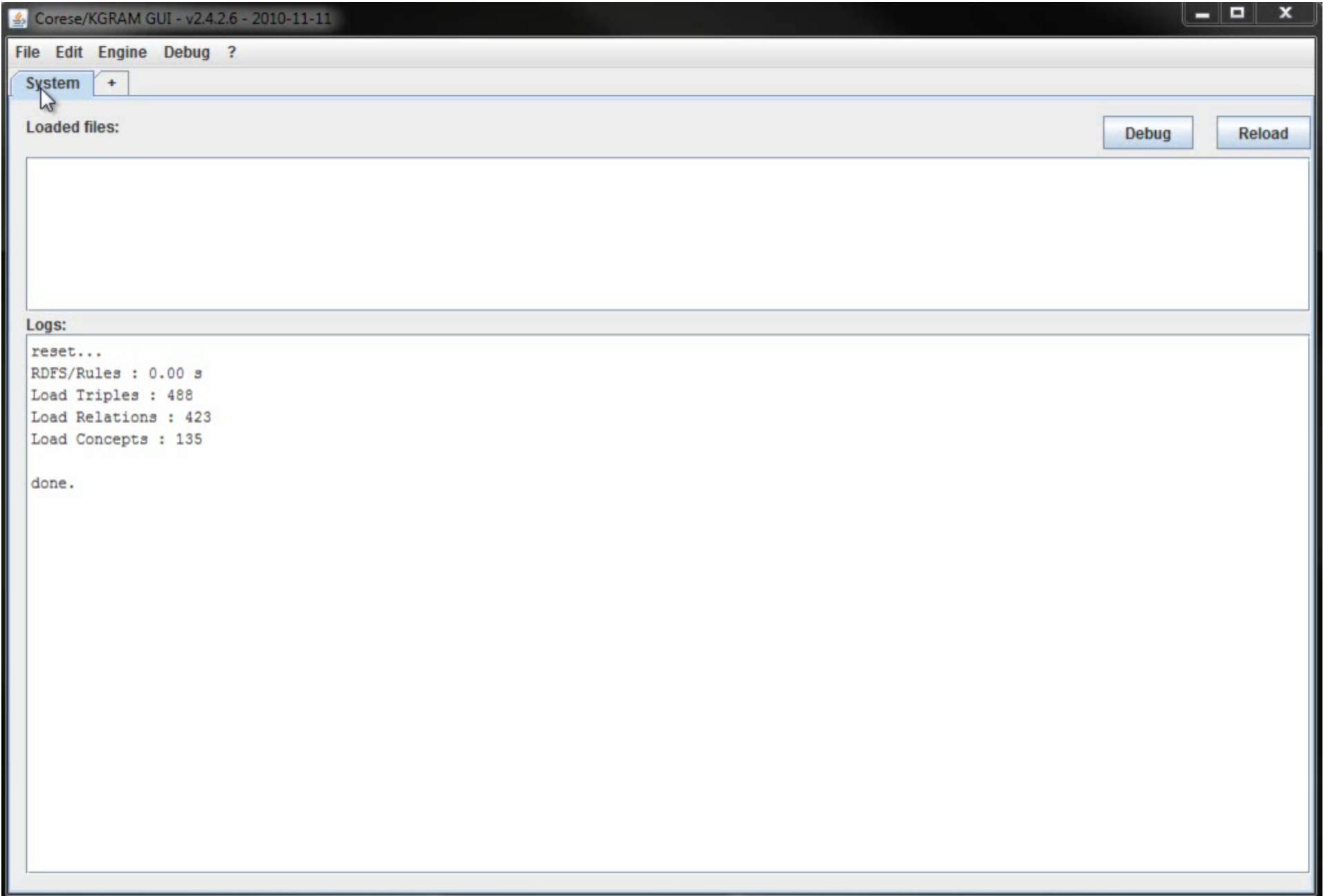
```
<rdfs:Class rdf:about='#Man'>
    <rdfs:seeAlso rdf:resource='#Woman'/>
</rdfs:Class>
```

```
<Man> a rdfs:Class ; rdfs:seeAlso <Woman> .
```

What are we defining here?

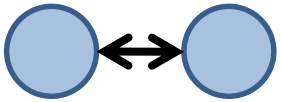
```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@base <http://inria.fr/2005/humans.rdfs>
<B> rdfs:subClassOf <A> .

<C> rdfs:subClassOf <A> .

<P> rdfs:domain <B> ;  rdfs:range  <C> .
```

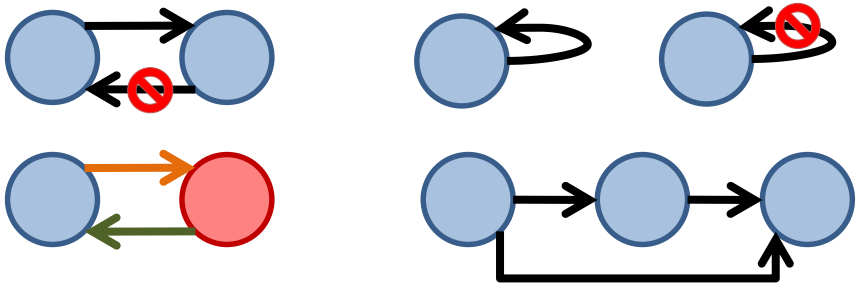
CORESE/ KGRAM

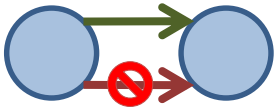


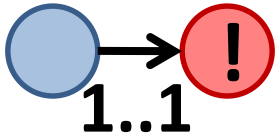
OWL provides **additional primitives** for heavyweight ontologies

OWL in one…

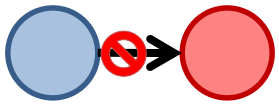

algebraic properties

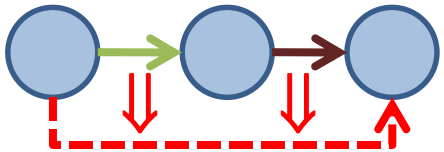



disjoint properties

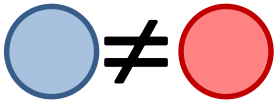


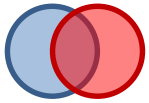
qualified cardinality

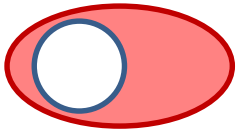

individual prop. neg

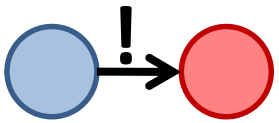

chained prop.


union

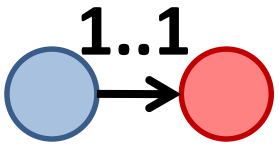

disjunction


intersection

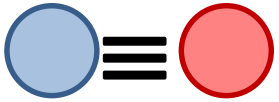

complement



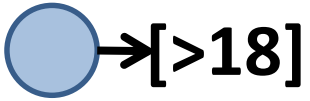
restriction



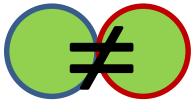
cardinality

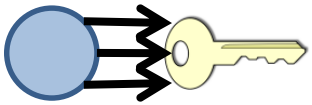

equivalence


enumeration



value restrict.


disjoint union

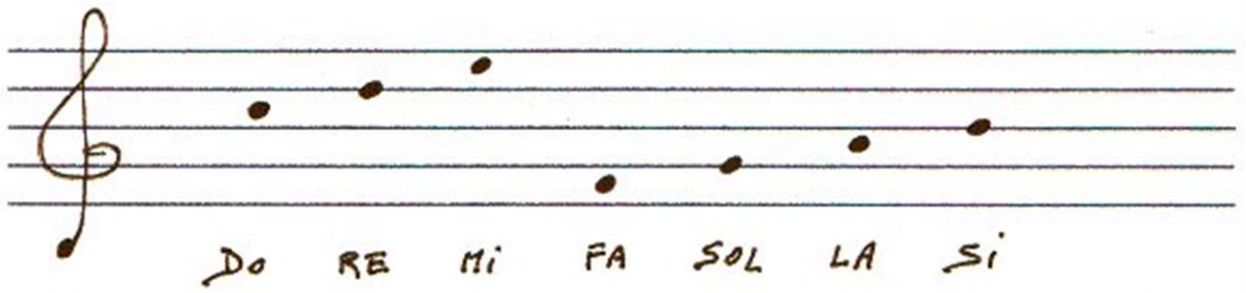

keys

…

enumerated class {a,b,c,d,e}

define a class by providing all its members

```
<owl:Class rdf:id="EyeColor">
    <owl:oneOf rdf:parseType="Collection">
      <owl:Thing rdf:ID="Blue"/>
      <owl:Thing rdf:ID="Green"/>
      <owl:Thing rdf:ID="Brown"/>
      <owl:Thing rdf:ID="Black"/>
    </owl:oneOf>
</owl:Class>
```

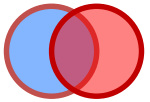


classes defined by union

of other classes

```
<owl:Class>
    <owl:unionOf rdf:parseType="Collection">
        <owl:Class rdf:about="#Person"/>
        <owl:Class rdf:about="#Group"/>
  </owl:unionOf>
</owl:Class>
```

classes defined by intersection



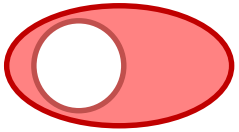
of other classes

```
<owl:Class rdf:ID="Man">
  <owl:intersectionOf rdf:parseType="Collection">
   <owl:Class rdf:about="#Male"/>
   <owl:Class rdf:about="#Person"/>
  </owl:intersectionOf>
</owl:Class>
```

complement and disjunction

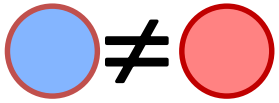
complement class

```
<owl:Class rdf:ID="Male">
   <owl:complementOf rdf:resource="#Female"/>
</owl:Class>
```

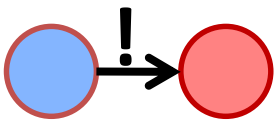


declare a disjunction

```
<owl:Class rdf:ID="Square">
  <owl:disjointWith rdf:resource="#Round"/>
</owl:Class>
```

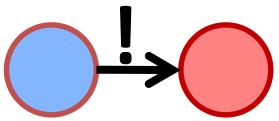


restriction on all values



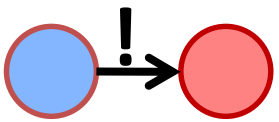

```
<owl:Class rdf:ID="Herbivore">
  <subClassOf rdf:resource="#Animal"/>
  <subClassOf>
   <owl:Restriction>
    <owl:onProperty rdf:resource="#eats" />
    <owl:allValuesFrom rdf:resource="#Plant" />
   </owl:Restriction>
  </subClassOf>
</owl:Class>
```

restriction on some values



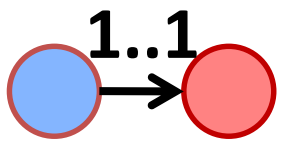

```
<owl:Class rdf:ID="Sportive">
 <owl:equivalentClass>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#hobby" />
   <owl:someValuesFrom rdf:resource="#Sport" />
  </owl:Restriction>
 </owl:equivalentClass>
</owl:Class>
```

restriction to an exact value




```
<owl:Class rdf:ID="Bike">
 <subClassOf>
   <owl:Restriction>
    <owl:onProperty rdf:resource="#nbWheels" />
    <owl:hasValue>2</owl:hasValue>
   </owl:Restriction>
 </subClassOf>
</owl:Class>
```

restriction on cardinality



how many times a property is used for
a same subject but with different values

- Constraints: minimum, maximum, exact number
- Exemple

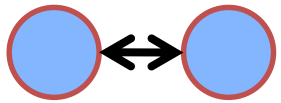
```
<owl:Class rdf:ID="Person">
 <subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#name" />
   <owl:maxCardinality>1</owl:maxCardinality>
  </owl:Restriction>
 </subClassOf>
</owl:Class>
```

types of properties

- `ObjectProperty` are relations between resources only
  e.g. hasParent(#thomas,#stephan)
- `DatatypeProperty` have a literal value possibly typed
  ex:hasAge(#thomas,16^^xsd:int)
- `AnnotationProperty` are ignored in inferences and used for documentation and extensions

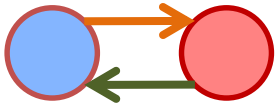
algebraic properties

- Symmetric property, xRy ⇒ yRx



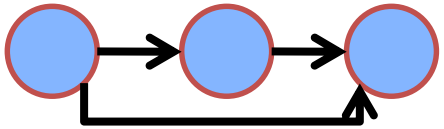
```
<owl:SymmetricProperty rdf:ID="hasSpouse" />
```

- Inverse property, $xR_1y \Leftrightarrow yR_2x$



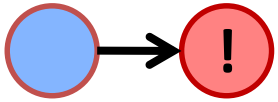
```
<rdf:Property rdf:ID="hasChild">
  <owl:inverseOf rdf:resource="#hasParent"/>
</rdf:Property>
```

- Transitive property, xRy & yRz ⇒ xRz



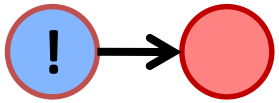
```
<owl:TransitiveProperty rdf:ID="hasAncestor" />
```

- Functional property, xRy & xRz ⇒ y=z




```
<owl:FunctionalProperty rdf:ID="hasMother" />
```

- Inverse functional property, xRy & zRy ⇒ x=z




```
<owl:InverseFunctionalProperty
rdf:ID="hasSocialSecurityNumber" />
```

equivalencies and alignment

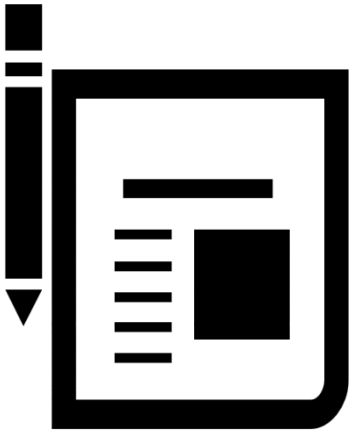
- equivalent classes : `owl:equivalentClass`
- equivalent properties: `owl:equivalentProperty`
- identical or different resources:

  `owl:sameAs`, `owl:differentFrom`

document the schemas

description of the ontology

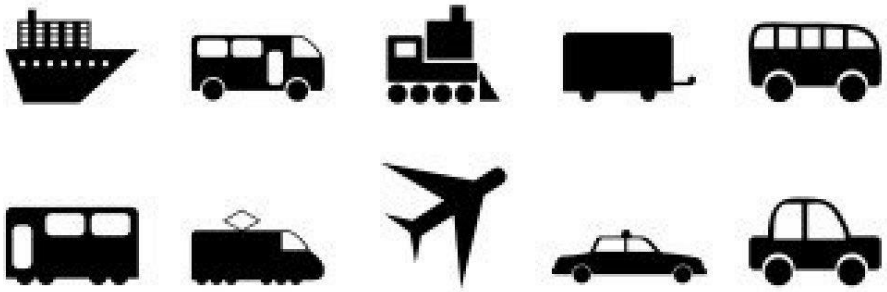
`owl:Ontology, owl:imports, owl:versionInfo, owl:priorVersion, owl:backwardCompatibleWith, owl:incompatibleWith`



versions of classes and properties

`owl:DeprecatedClass, owl:DeprecatedProperty`

OWL profiles



EL: large numbers of properties and/or classes and polynomial time.

QL: large volumes of instance data, and conjunctive query answering using conventional relational database in LOGSPACE

RL: scalable reasoning without sacrificing too much expressive power using rule-based reasoning in polynomial time

What are we defining here?

```
<A> owl:equivalentClass
 [  owl:intersectionOf ( <B> <C> )  ] .
```

- Dublin core
- Creative Commons
- FOAF

...

Linked Open Vocabularies (LOV)

developped by Pierre-Yves Vandenbussche

Welcome to LOV, your entry point to the growing ecosystem of linked open vocabularies (RDFS or OWL ontologies) used in the Linked Data Cloud. Here you will find vocabularies listed and individually described by metadata, classified by vocabulary spaces, interlinked using the dedicated vocabulary VOAF.
You will enjoy querying the LOV dataset either at vocabulary level or at element level, exploring the vocabulary content using full-text faceted search, and finding metrics about the use of vocabularies in the Semantic Web.
Not finding your favourite one? Suggest a new vocabulary to add to LOV!
Read more ...

RDF

Endpoint

Search

Metadata:

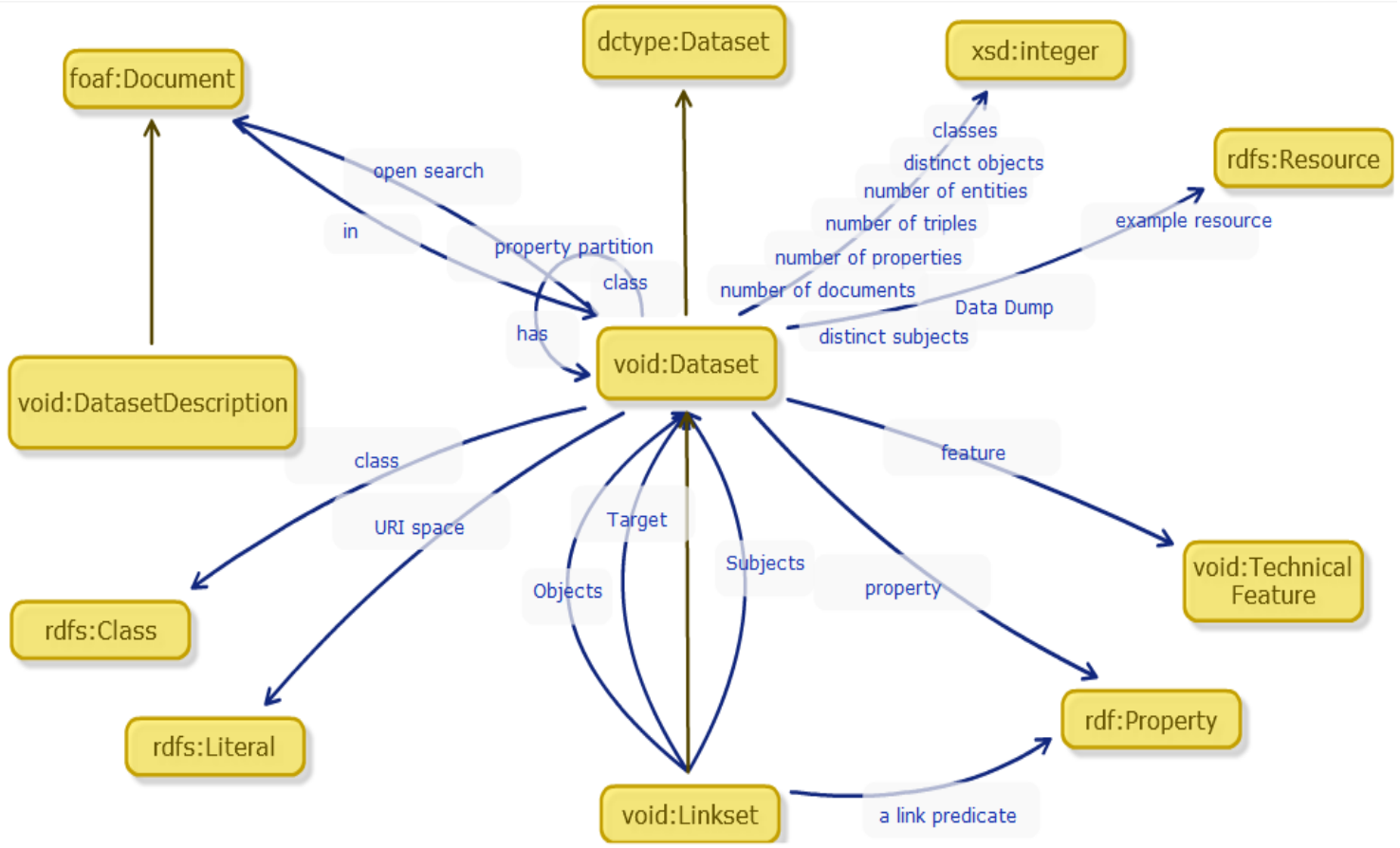
Property	Value
Creator	Bernard Vatant, Pierre-Yves Vandenbussche
Publisher	Mondeca
SPARQL Endpoint	http://lov.okfn.org/endpoint/lov
RDF dump File	http://lov.okfn.org/dataset/lov/lov.rdf
Last modified	2012-09-10
Status	Work in progress

Help us and suggest a new vocabulary !

Vocabulary spaces (285):

Classifying vocabularies is a brand new challenge for Library Science, and no existing classification scheme seems to fit the need so far. Unless we missed something, and in that case we are open to suggestions from the librarian community.

VoID: describing RDF datasets/linksets

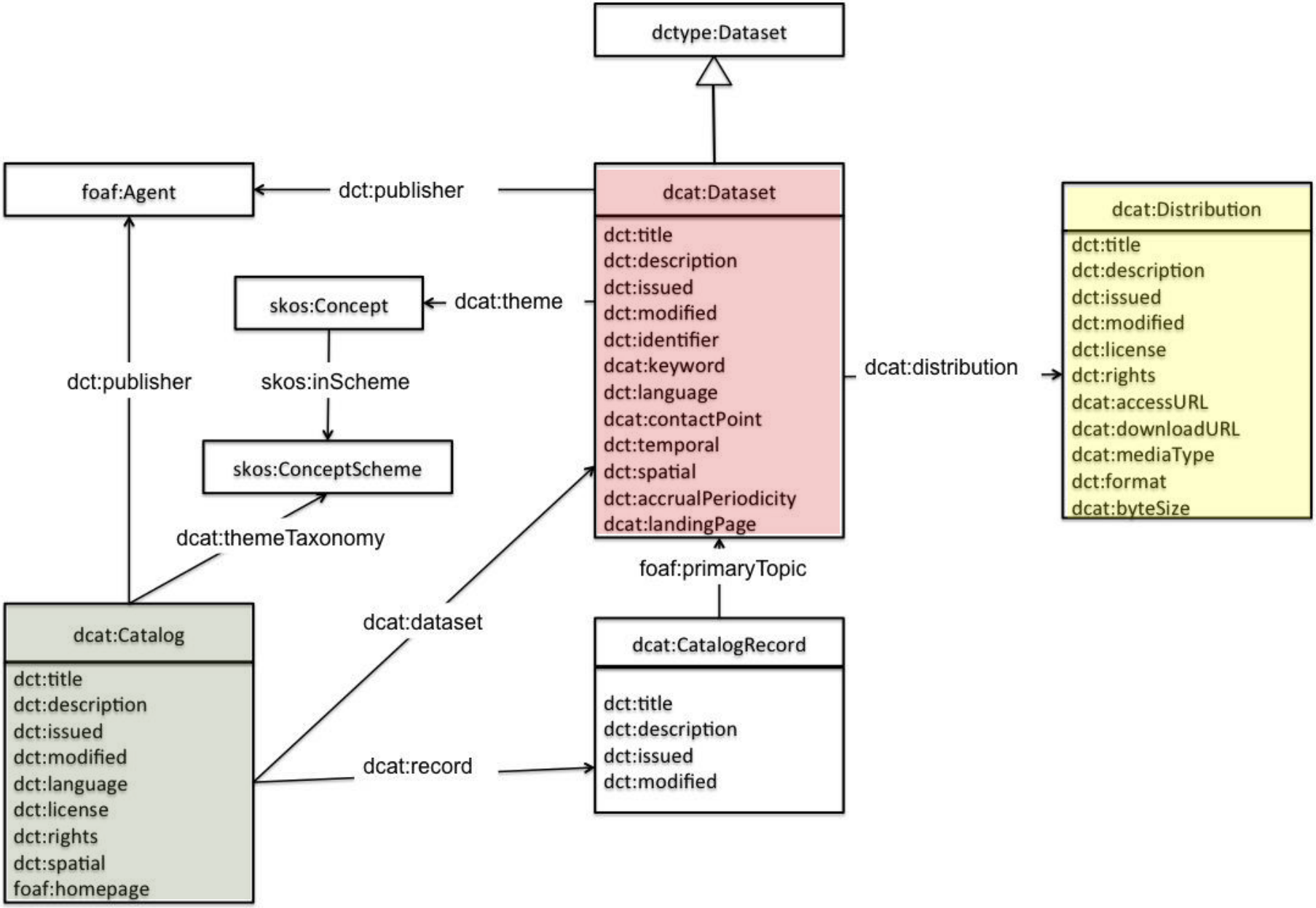


- void:class
- void:subset
  - void:propertyPartition
  - void:classPartition
- void:classes
- void:dataDump
- void:distinctObjects
- void:distinctSubjects
- void:documents
- void:entities
- void:exampleResource
- void:feature
- dct:isPartOf
  - void:inDataset
- void:linkPredicate
- void:target
  - void:subjectsTarget
  - void:objectsTarget
- void:openSearchDescription
- void:properties
- void:property
- void:rootResource
- void:sparqlEndpoint
- void:triples
- void:uriLookupEndpoint
- void:uriRegexPattern
- void:uriSpace
- void:vocabulary

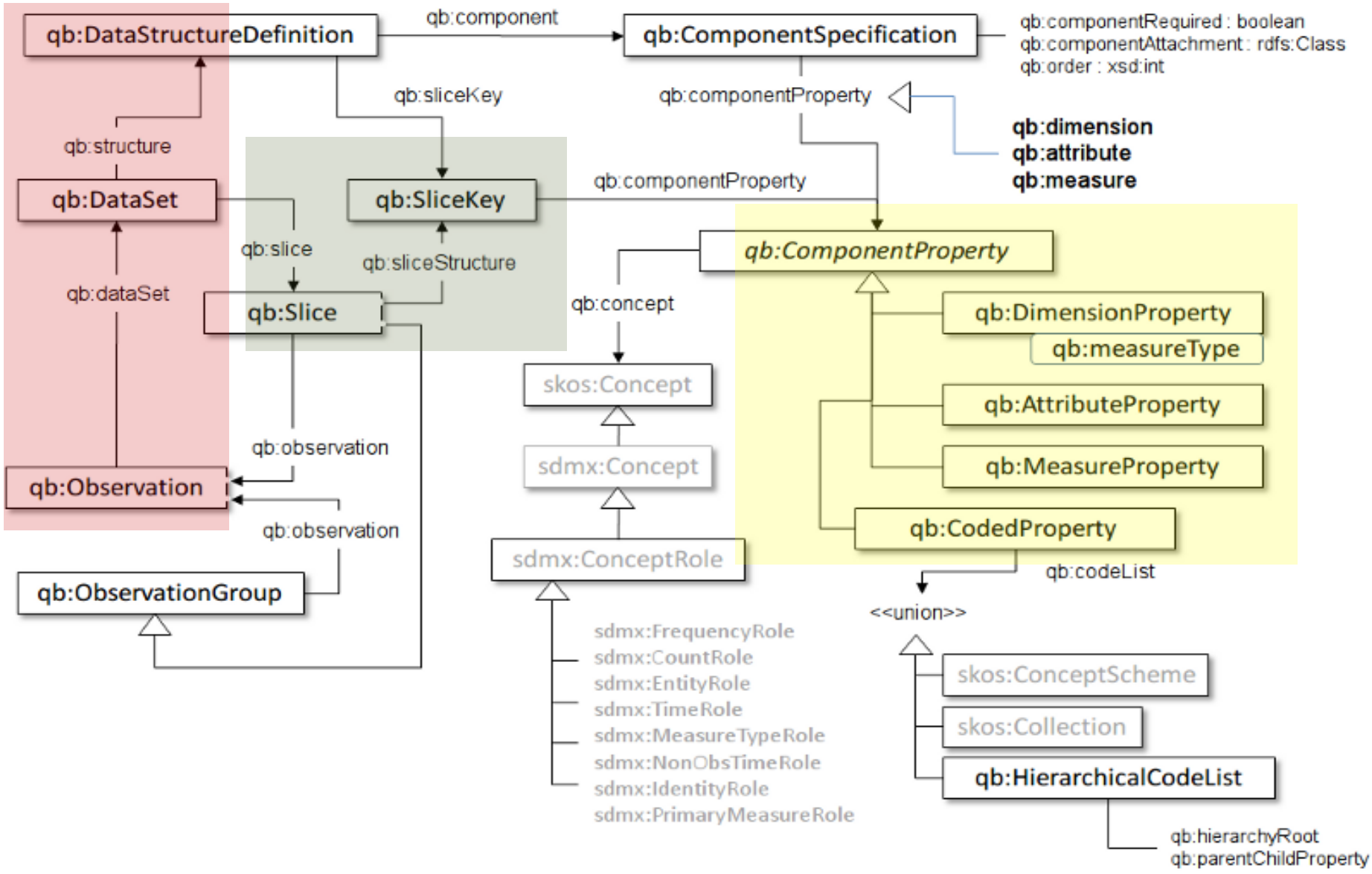
```
:DBpedia a void:Dataset;
 void:sparqlEndpoint <http://dbpedia.org/sparql>;
 void:feature :RDFXML ;
 void:subset :DBpedia2Geonames ;
 void:uriLookupEndpoint <http://lookup.dbpedia.org/api/search.asmx/KeywordSearch? QueryString=> ;
 dcterms:modified "2008-11-17"^^xsd:date;
 dcterms:title "DBPedia";
 dcterms:description "RDF data extracted from Wikipedia";
 dcterms:publisher :DBpedia_community;
 dcterms:license <http://creativecommons.org/licenses/by-sa/3.0/>;
 dcterms:source  <http://dbpedia.org/resource/Wikipedia>.

:Geonames a void:Dataset;
 void:sparqlEndpoint <http://geosparql.appspot.com/query>;
 void:triples "107983838"^^xsd:integer ;
 dcterms:subject <http://dbpedia.org/resource/Location> .

:DBpedia2Geonames a void:Linkset ;
   void:linkPredicate owl:sameAs ;
   void:target :DBpedia ;
   void:target :Geonames .
```

e.g. DBpedia dataset

DCAT: describing any dataset

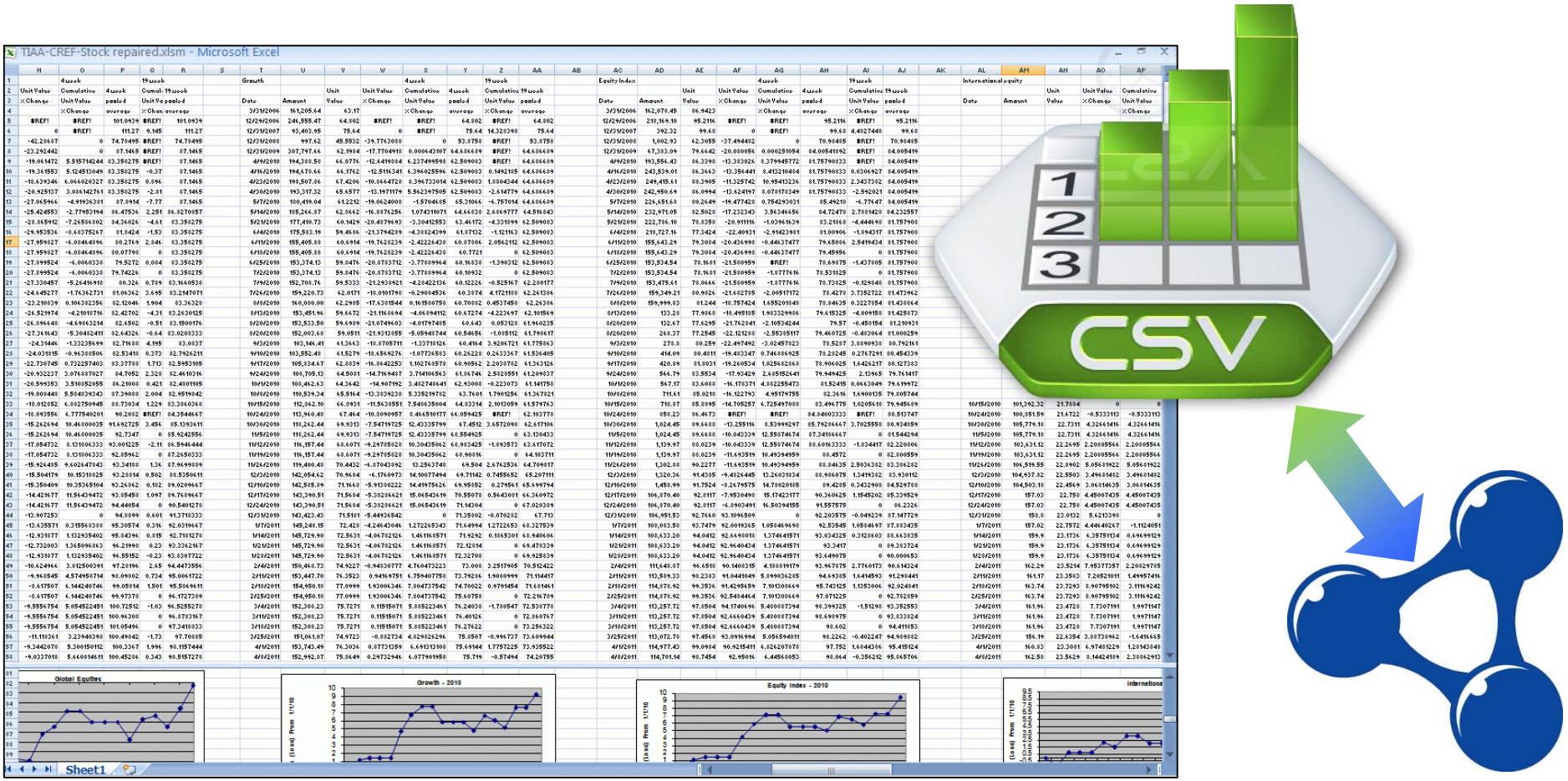


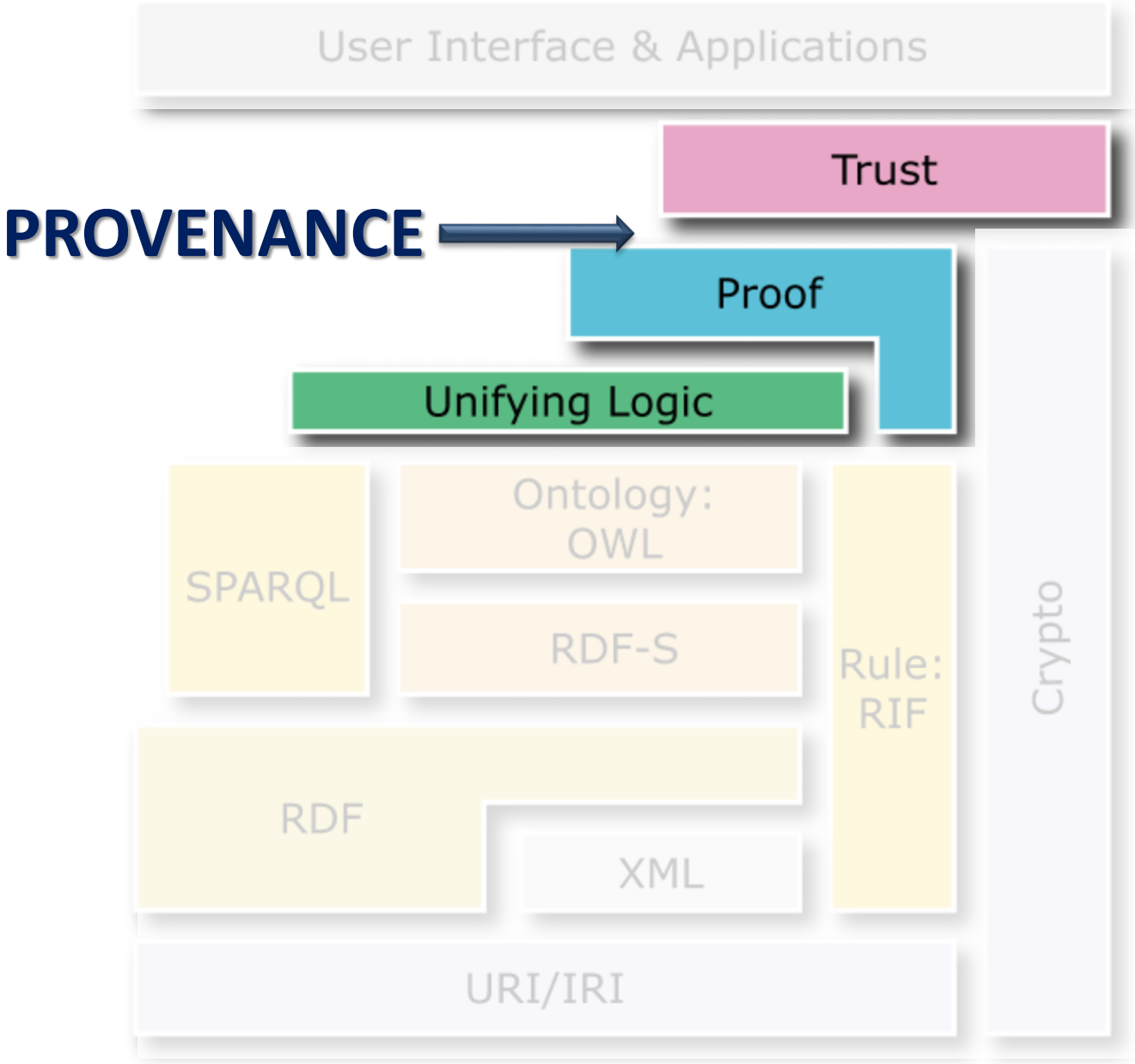
Data Cube: publish multi-dimensional data (statistics)



CSV-LD & Linked CSV

- contexts to interpret and generate CSV
- conventions for CSV to be linked in RDF



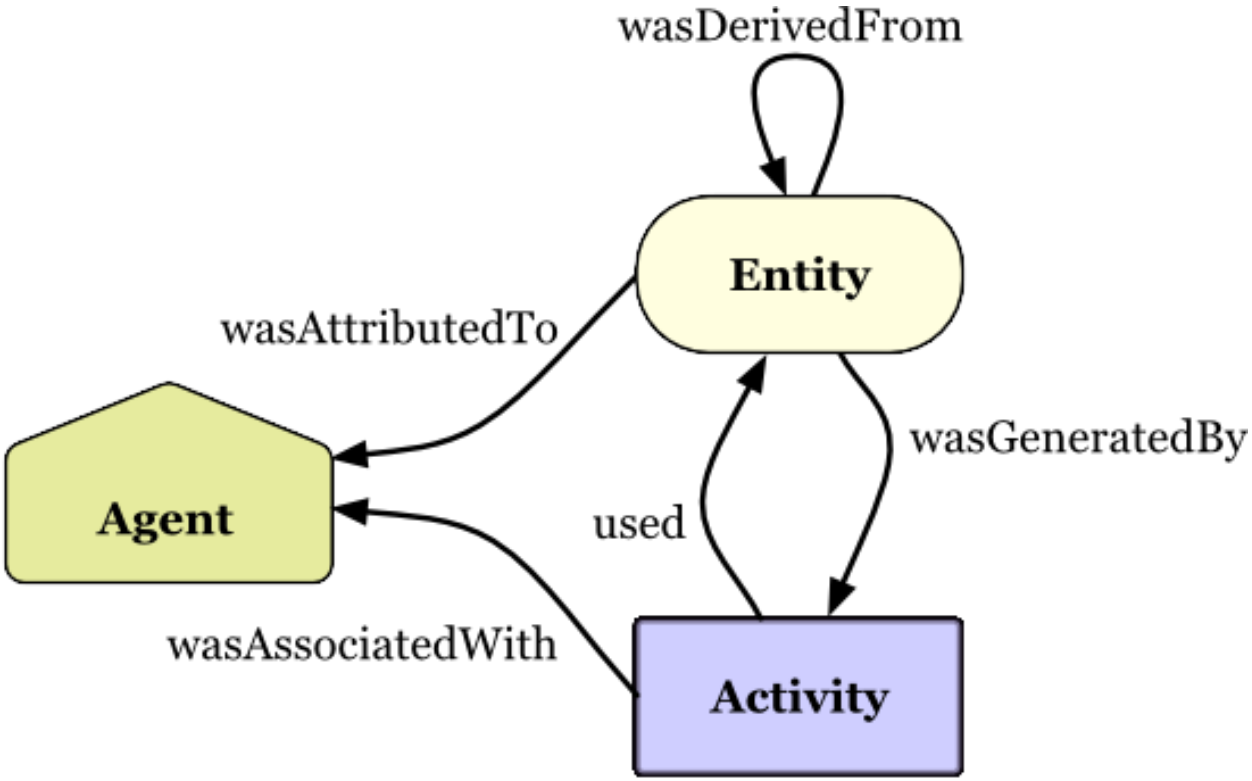

User Interface & Applications
Trust
PROVENANCE
Proof
Unifying Logic
SPARQL
Ontology:
OWL
RDF-S
Rule:
RIF
Crypto
RDF
XML
URI/IRI

W3C®

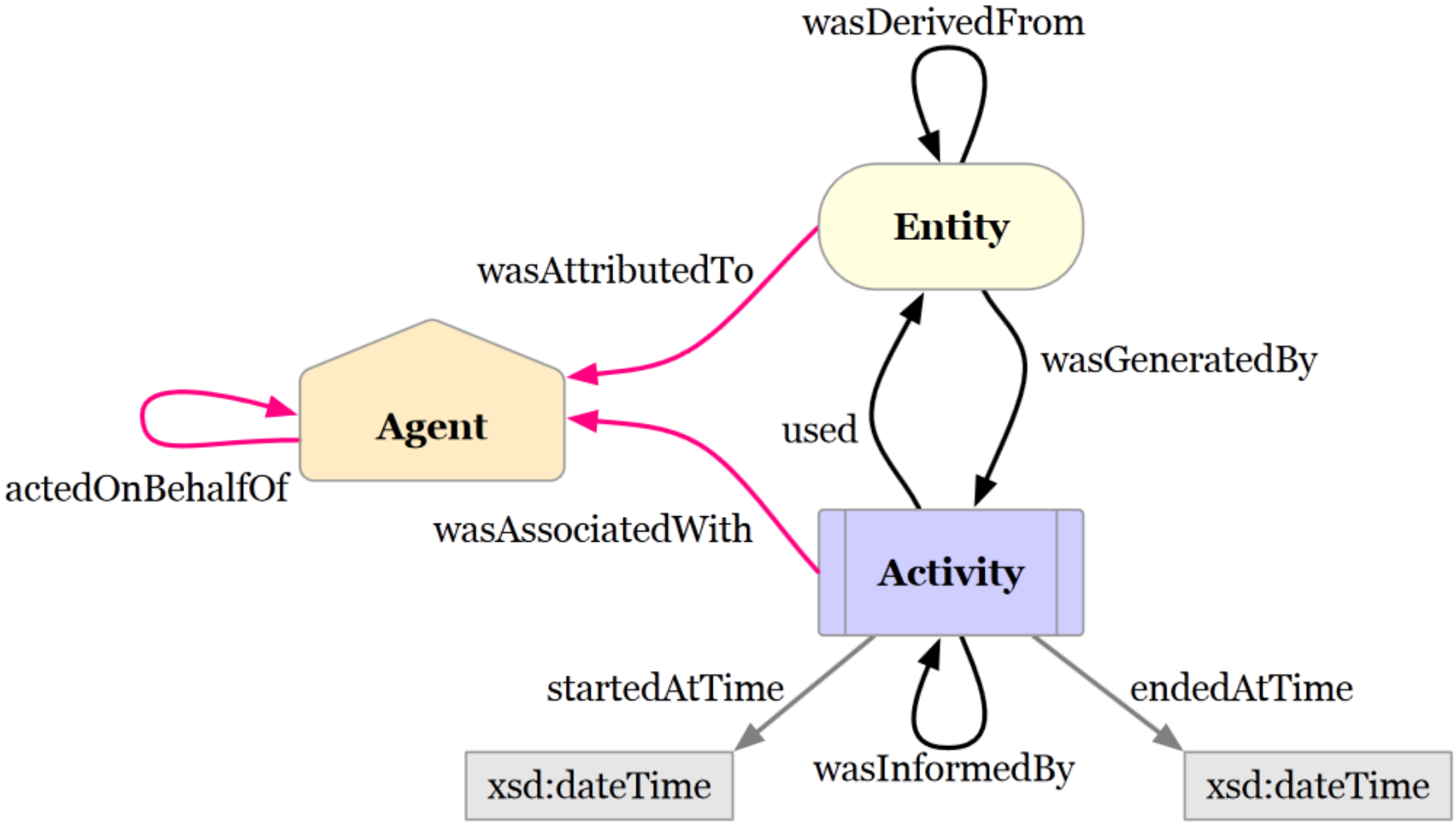
Provenance: PROV-DM & PROV-O

describe entities and activities

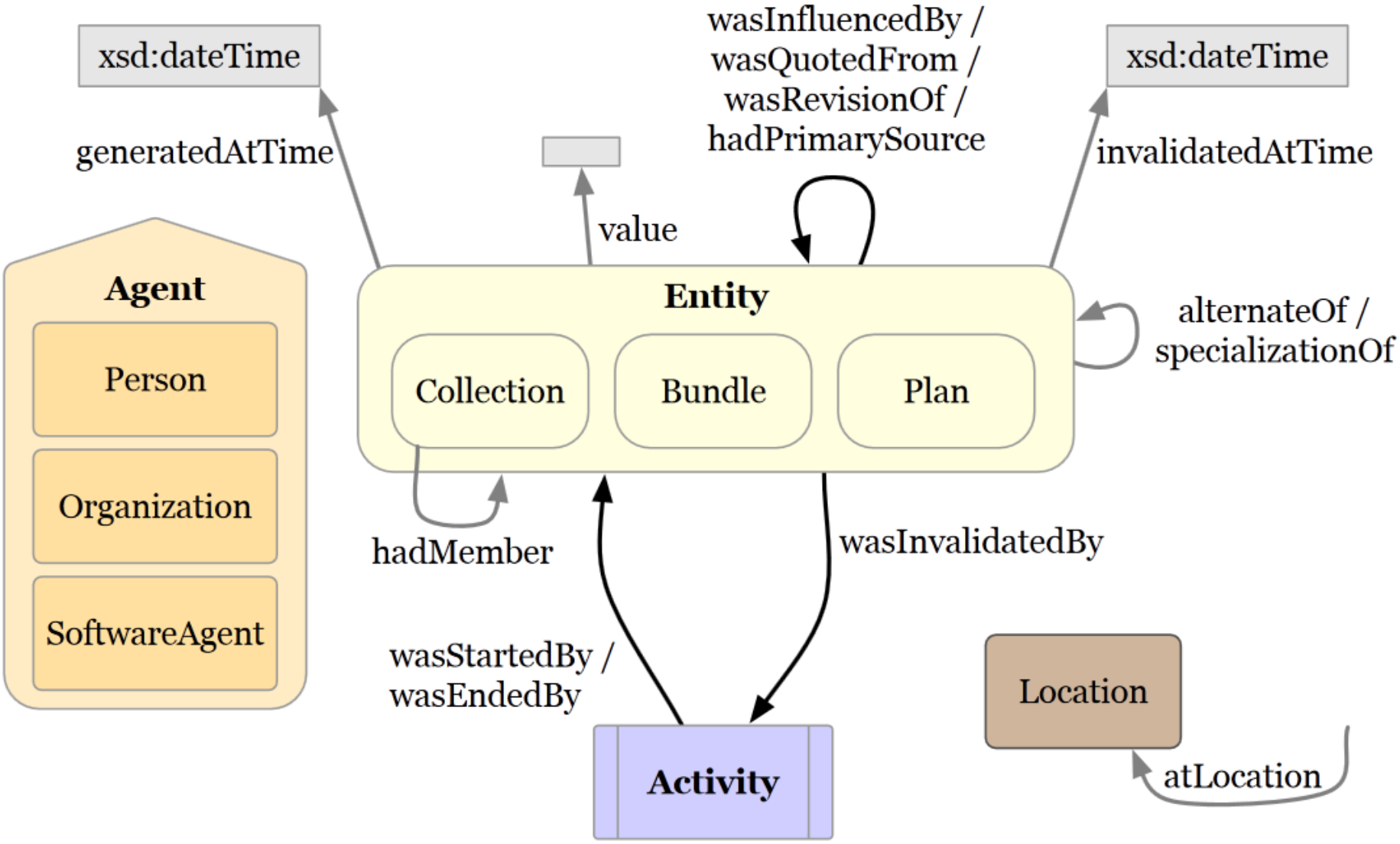
involved in providing a resource



PROV-O provenance ontology

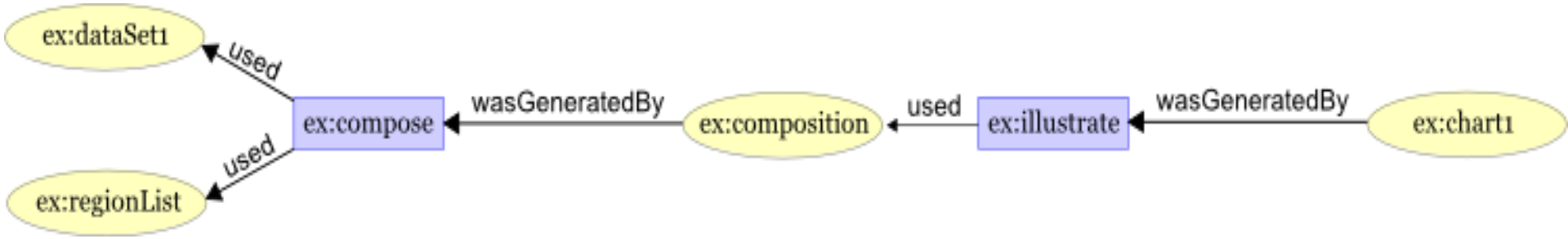


PROV-O provenance ontology

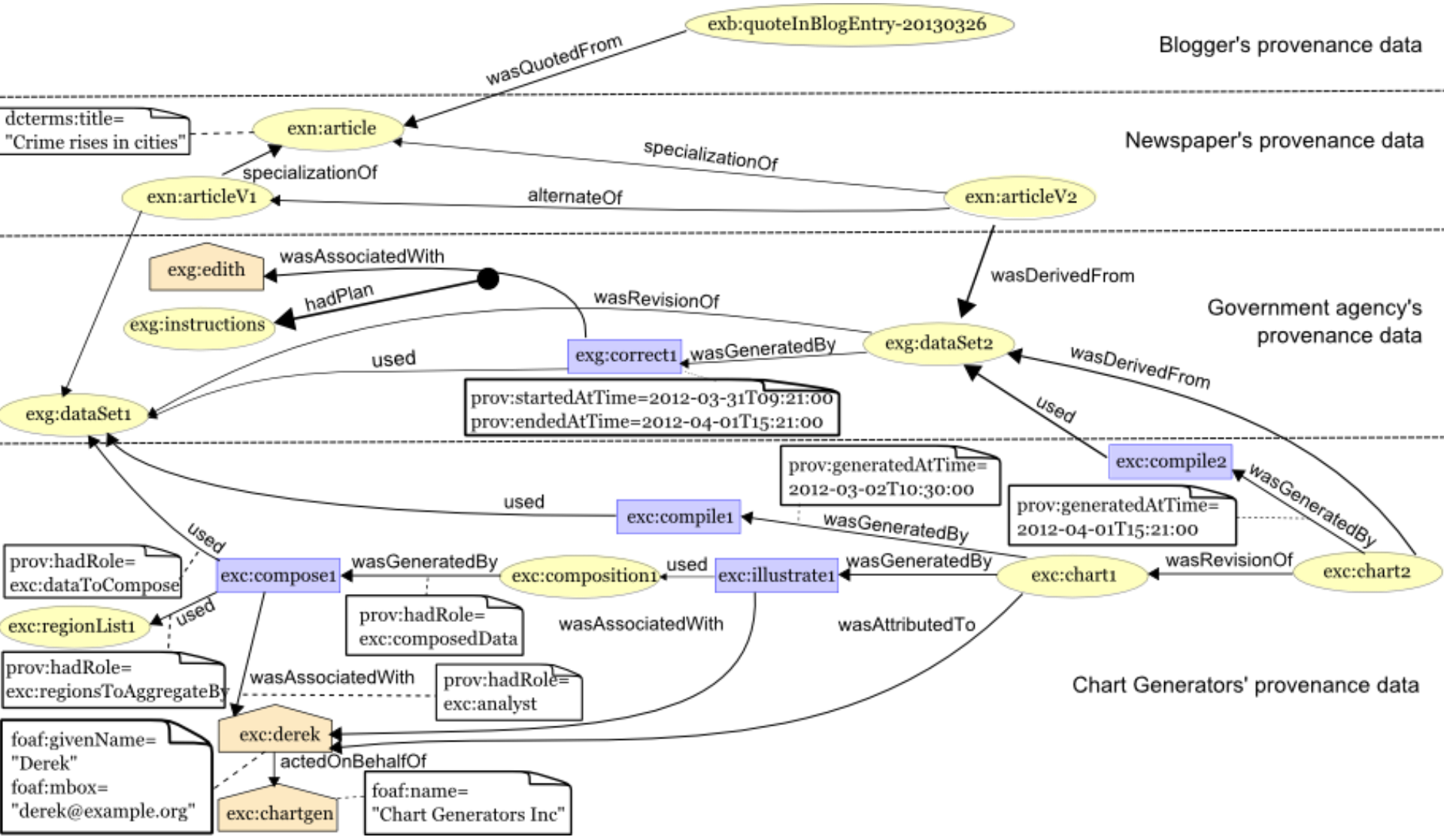


PROV-DM & PROV-O: primer example

```
ex:compose  prov:used ex:dataSet1 ;
            prov:used ex:regionList .
ex:composition prov:wasGeneratedBy ex:compose .
ex:illustrate prov:used ex:composition .
ex:chart1 prov:wasGeneratedBy ex:illustrate .
```



PROV primer full example



le doggy-bag
de la présentation

identify	URI
describe & link	RDF
query	HTTP, SPARQL, LDP
reasoning	RDFS & OWL
trace	PROV-O

GOALS AND MEANS

identify	http://fabien.fr#me
describe & link	#me type man
query	select * {?r type ?t}
reasoning	man subClassOf male
trace	wasAttributedTo #me

GOALS AND MEANS

Main Page
Recent changes
Tools
Books
Validators

Other W3C resources
Activity news
Publications
Logos, buttons
Activity home page

W3C RSS feeds

Account request

Navigation

Tools

Tools

Contents [hide]

Search for Tools

- Facets of tools
  - through tool categories
  - through programming languages
  - through Recommendations and Technologies
- All tools (with possibilities to edit the query)
  - seen as a table
  - seen as a list
- Misc
  - tool contributors' page

Semantic Web Development Tools

Overview

This Wiki contains a collection of tool references that can help in developing Semantic Web applications. These include complete development environments, editors, libraries or modules for various programming languages, specialized browsers, etc. The goal is to list such tools and *not* Semantic Web applications in general (the interested reader may consider looking at the W3C SW Use Case Collection for those.)

The tool content of this wiki is still to be maintained by the community and not by the W3C staff. If you are interested in adding to and/or modifying the relevant pages, please consult the separate Tool Contributors' page.

http://www.w3.org/2001/sw/wiki/Tools

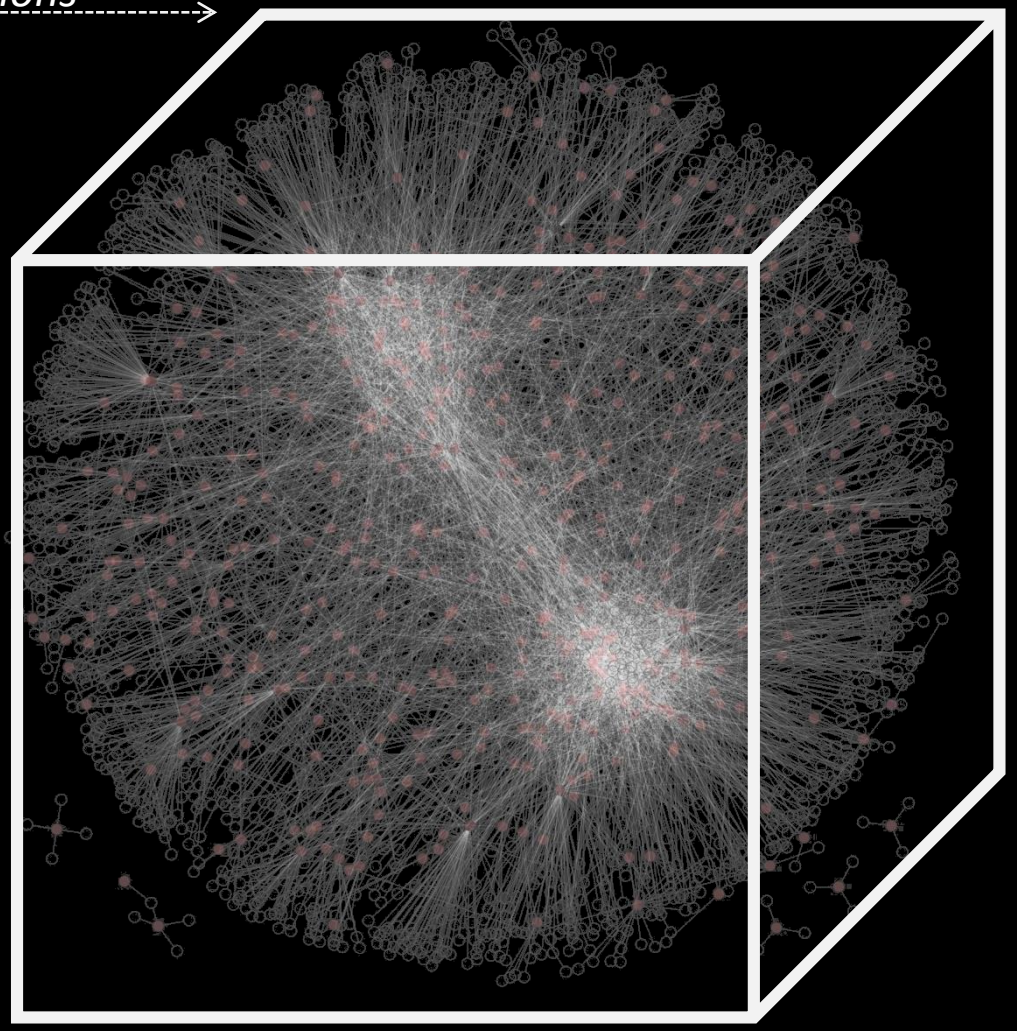
open your data

to those who could use them

66 FOAF primitives

x 52 millions

3 475 908 348 references (2)



“a small tree ruling a big graph”(1)

(1) Franck Van Harmelen, ISWC 2011

(2) Libby Miller, 2009

[C. Welty, ISWC 2007]

"semantic **web**"

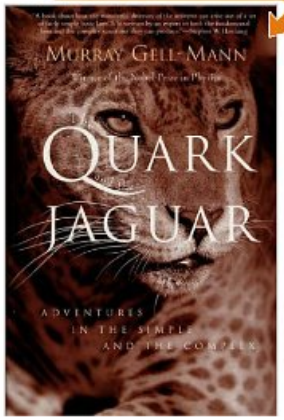
and not

"**semantic** web"

[J. Hendler, ISWC 2007]

"a lightweight ontology allows us to do lightweight reasoning"

amazon.com



The Quark and the Jaguar: Adventures in the Simple and the Complex [Paperback]

Murray Gell-Mann (Author)

(30 customer reviews)

Price: $13.59

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Ships from and sold by **Amazon.com**.

Formats	Amazon Price	New from	Used from
Hardcover	--	$13.67	$0.55
Paperback	$13.59	$10.01	$7.84

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Publisher: St. Martin's Griffin (September 15, 1995)

Language: English

ISBN-10: 0805072535

ISBN-13: 978-0805072532

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Shipping Weight: 1.2 pounds (View shipping rates and policies)

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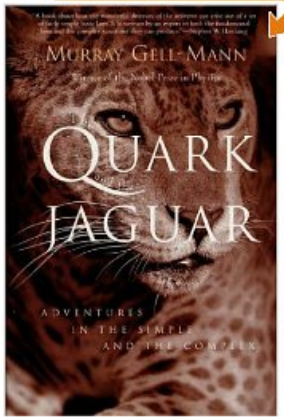

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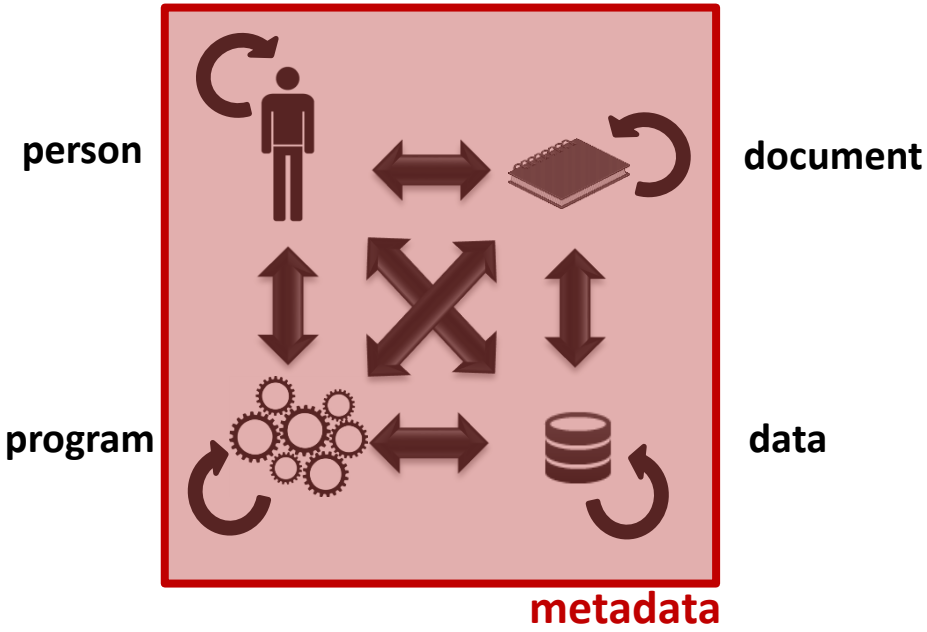
30 Reviews

5 star: (9)
4 star: (8)
3 star: (7)
2 star: (4)
1 star: (2)

Average Customer Review

(30 customer reviews)

one web…



he who controls metadata, controls the web

and through the *world-wide* web many things in our world.

fabien, gandon, @fabien_gandon, http://fabien.info

Inria informatics mathematics — i3s sophia antipolis — cnrs — Université Nice Sophia Antipolis — W3C MEMBER