

Introduction to a Web of Linked Data

The RDF Data Model

Towards a Global Knowledge Graph

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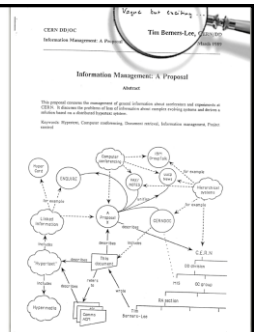
The RDF Data Model

1. Describing resources
2. A triple model and a graph model
3. Serialization syntaxes
4. Values, types and languages
5. Groups
6. Naming graphs
7. RDF schemas

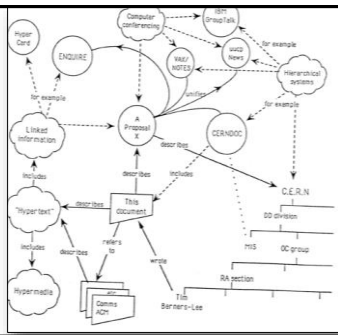
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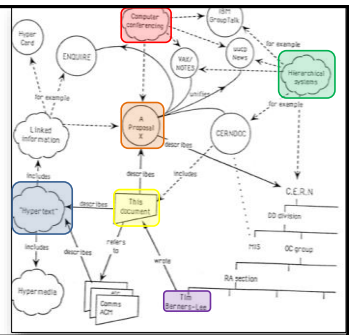
Original Proposal



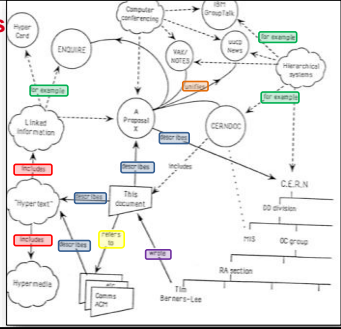
Schema



A Web of Resources

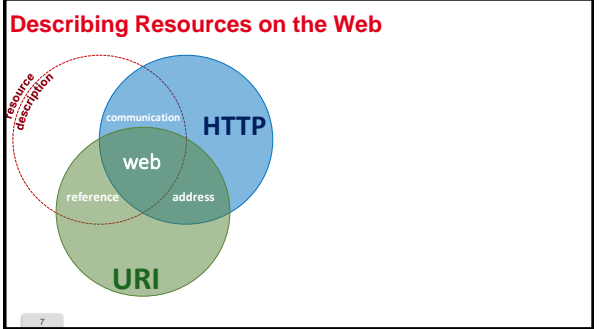


Various Kinds of Links



Describing Resources on the Web

A Venn diagram with two overlapping circles. The top circle is blue and labeled 'HTTP'. The bottom circle is green and labeled 'URI'. The intersection of the two circles is labeled 'web'. Within the intersection, the word 'communication' is positioned above 'web', and 'reference' is positioned to the left of 'web', while 'address' is positioned to the right of 'web'. A red dashed line forms a partial circle around the left side of the diagram, with the text 'resource description' written along its curve.



RDF: Basic Model

The diagram illustrates the Semantic Web Stack of standards W3C®. It consists of two main parts: a Venn diagram on the left and a layered diagram on the right.

Venn Diagram: Three overlapping circles represent the core components of the Semantic Web:

- RDF (Yellow):** Represented by the top-left circle.
- HTTP (Blue):** Represented by the top-right circle.
- URI (Green):** Represented by the bottom circle.

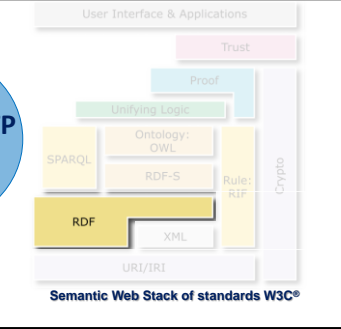
The intersections of these circles are labeled with their respective functions:

- communication:** The intersection of RDF and HTTP.
- reference:** The intersection of RDF and URI.
- address:** The intersection of HTTP and URI.
- web of data:** The central intersection of all three (RDF, HTTP, and URI).

Semantic Web Stack of standards W3C®: A layered diagram showing the stack of standards used in the Semantic Web. The layers are:

- User Interface & Applications:** The top layer, representing the user interface.
- Trust:** A layer below the user interface, representing trust mechanisms.
- Proof:** A layer below trust, representing proof mechanisms.
- Unifying Logic:** A layer below proof, representing unifying logic.
- Ontology: OWL:** A layer below unifying logic, representing ontology languages.
- SPARQL:** A layer below ontology, representing query languages.
- RDF-S:** A layer below SPARQL, representing schema languages.
- Rule: RIF:** A layer below RDF-S, representing rule languages.
- RDF:** A layer below rule languages, representing the core data model.
- XML:** A layer below RDF, representing the core data format.
- URI/IRI:** A layer below XML, representing the core data identifier.
- Crypto:** A layer at the bottom, representing cryptographic mechanisms.

The stack is interconnected, showing a complex web of dependencies between the various standards.



Stack of standards

User Interface & Applications

Trust

Proof

Unifying Logic

Ontology: OWL

RDF-S

SPARQL

Rule: RIF

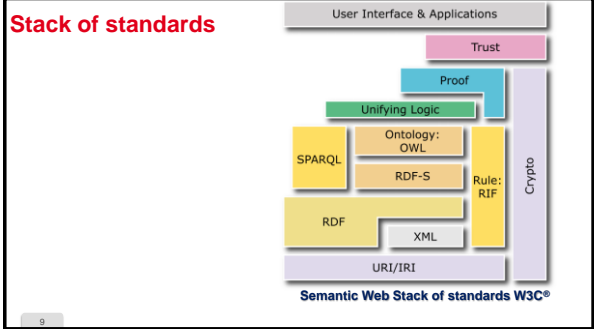
RDF

XML

URI/IRI

Crypto

Semantic Web Stack of standards W3C®



Stack of standards

User Interface & Applications

Trust

Proof

Unifying Logic

Ontology: OWL

RDF-S

SPARQL

RDF

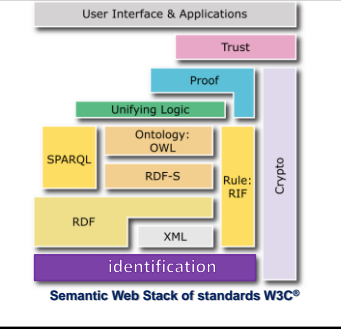
XML

Rule: RIF

identification

Crypto

Semantic Web Stack of standards W3C®



Stack of standards

User Interface & Applications

Trust

Proof

Unifying Logic

SPARQL

Ontology: OWL

RDF-S

Rule: RIF

representation

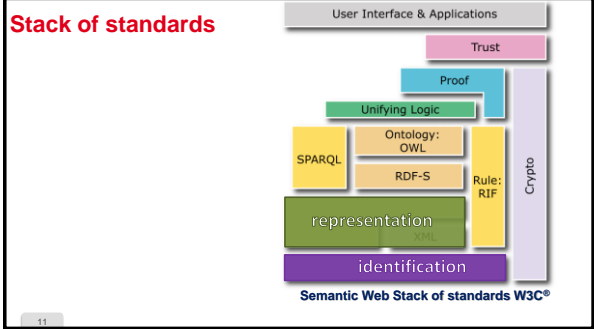
XML

identification

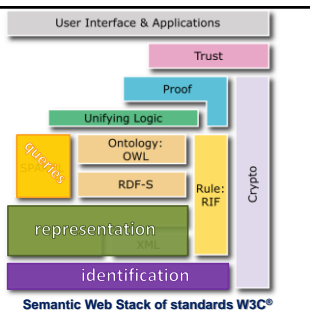
Crypto

Semantic Web Stack of standards W3C®

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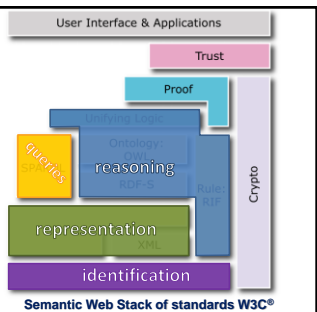


Stack of standards



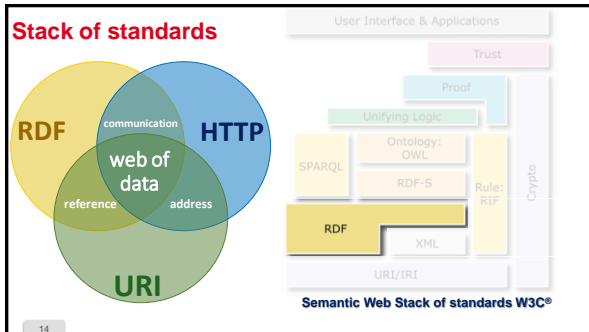
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Stack of standards



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Stack of standards



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RDF means

Resource

Description

Framework



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RDF means

Resource: pages, chairs, persons, ideas...
all that can have a URI

Description:

Framework



18

RDF means

Resource: pages, chairs, persons, ideas...
all that can have a URI

Description: attributes, characteristics,
and relations between resources

Framework



19

RDF means

Resource: pages, chairs, persons, ideas...
all that can have a URI

Description: attributes, characteristics,
and relations between resources

Framework: model, language and
syntaxes for these descriptions



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RDF decomposes descriptions into triples

(**subject** , **predicate** , **object**)



21

RDF decomposes descriptions into triples

(**subject** , **predicate** , **object**)

*E.g.: "doc.html has for authors Fabien,
Catherine and Olivier and has for topic
the Web of data"*



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RDF decomposes descriptions into triples

(**subject** , **predicate** , **object**)

E.g.: doc.html has for author **Fabien**
doc.html has for author **Catherine**
doc.html has for author **Olivier**
doc.html has for topic **Web of data**



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RDF decomposes descriptions into triples

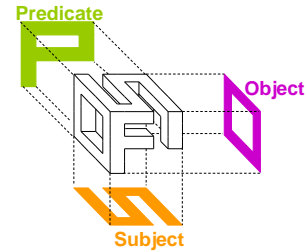
(subject , predicate , object)

(doc.html , author , Fabien)
(doc.html , author , Catherine)
(doc.html , author , Olivier)
(doc.html , topic , Web of data)



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RDF : triples are knowledge atoms



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Composition Rules for RDF Triples

1. The **subject** is always a resource (and not a literal)

(subject , ,)

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Composition Rules for RDF Triples

1. The **subject** is always a resource (and not a literal)
2. The type of the **binary property** is identified by a URI

(subject , predicate ,)

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Composition Rules for RDF Triples

1. The **subject** is always a resource (and not a literal)
2. The type of the **binary property** is identified by a URI
3. The **value** is a resource or a literal

(subject , predicate , object)

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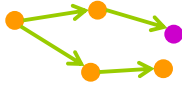
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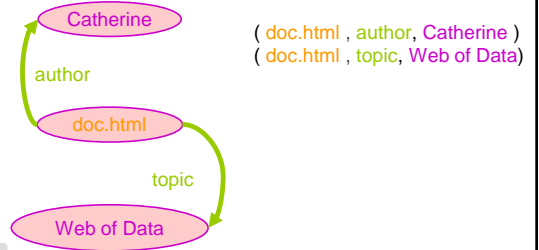
RDF: triples form graph edges

(subject , predicate , object)
→
(node , edge , node)



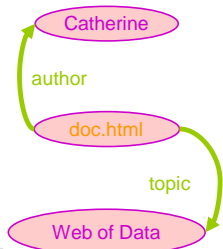
30

RDF is a graph model



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RDF is an oriented labeled multigraph model



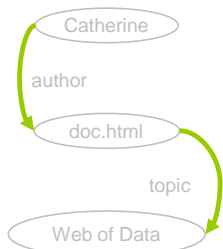
32

RDF is an oriented labeled **multigraph** model



33

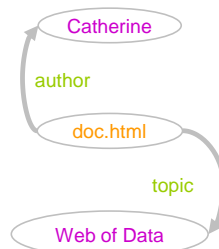
RDF is an **oriented** labeled multigraph model



edges are oriented:
the head is the object
the tail is the subject

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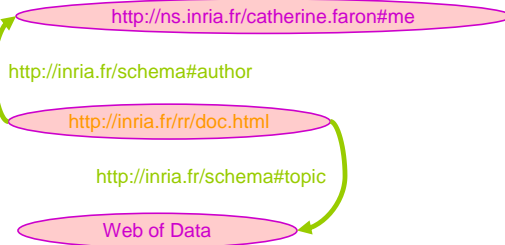
RDF is an oriented **labeled** graph multigraph model



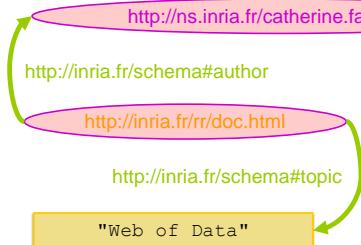
edges and nodes
are labeled

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RDF graphs are labeled by resources and literals

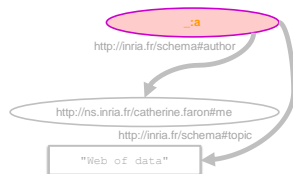


RDF graphs are labeled by resources and literals



RDF Graphs are labeled by resources and literals

A resource is either a URI or an **anonymous resource (blank node)**
Existential quantification: there is a resource such that... $\{ \exists r ; \dots \}$

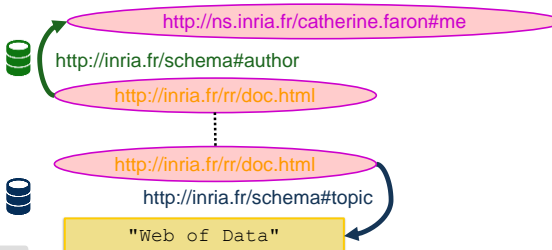


RDF is an Open Model

- Extensible vocabulary based on URIs
- Authorizes anyone to declare anything about any resource



RDF Global Giant Graph (GGG)



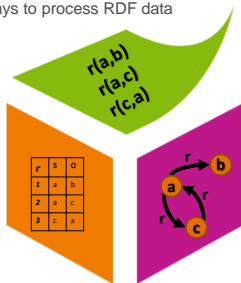
RDF Global Giant Graph (GGG)

Open and link data across the Web



Several Views on a Graph

There are many ways to process RDF data



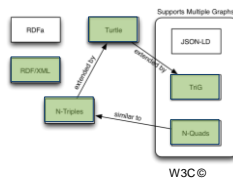
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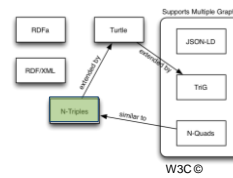
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RDF has a historical XML syntax and several other syntaxes: Turtle, TriG, JSON-LD, N-Triples, N-Quads



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RDF N-Triples: a minimalist syntax



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RDF N-Triples: easy parsing of triple lists

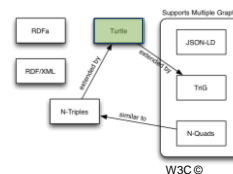
- URIs between less-than and greater-than signs
- Literal values between double quotes
- Triples separated by full stops

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

```
<http://inria.fr/rr/doc.html>
<http://inria.fr/schema#topic> "Web of Data" .
```

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RDF Turtle: the most popular RDF syntax



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RDF Turtle: a very concise syntax

```
@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/catherine.faron#me> ;  
  inria:topic "Web of data" .
```

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RDF Turtle: prefix declaration

```
@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/catherine.faron#me> ;  
  inria:topic "Web of data" .
```

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RDF Turtle: <URI> or qualified name

```
@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/catherine.faron#me> ;  
  inria:topic "Web of data" .
```

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RDF Turtle: one (.) or several properties (;) or values (,)

```
@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/catherine.faron#me> ;  
  inria:topic "Web of data", "Semantic Web" .
```

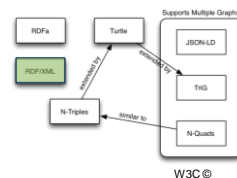
51

RDF Turtle: [anonymous resources]

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>  
@prefix inria: <http://inria.fr/schema#> .  
[ inria:author <http://ns.inria.fr/catherine.faron#me> ;  
  inria:topic "Web of data" . ]
```

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RDF/XML: the historical XML syntax



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RDF/XML: capturing graphs into trees

```
<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/catherine.faron#me"/>
  <inria:topic>Web of Data</inria:topic>
</rdf:Description>
```

```
</rdf:RDF>
```



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RDF/XML: a root

```
<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/catherine.faron#me"/>
  <inria:topic>Web of Data</inria:topic>
</rdf:Description>
```

```
</rdf:RDF>
```



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RDF/XML: descriptions of resources

```
<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/catherine.faron#me"/>
  <inria:topic>Web of Data</inria:topic>
</rdf:Description>
```

```
</rdf:RDF>
```



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RDF/XML: anonymous resources (blank nodes)

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

```
<rdf:Description>
  <inria:author rdf:resource=
    "http://ns.inria.fr/catherine.faron#me"/>
  <inria:topic>Web of Data</inria:topic>
</rdf:Description>
```

```
</rdf:RDF>
```



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RDF/XML: links between resources

```
<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/catherine.faron#me"/>
  <inria:topic>Web of Data</inria:topic>
</rdf:Description>
```

```
</rdf:RDF>
```



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RDF/XML: literal values

```
<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/catherine.faron#me"/>
  <inria:topic>Web of Data</inria:topic>
</rdf:Description>
```


```
</rdf:RDF>
```




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RDF/XML: many syntactic variations

```
<rdf:RDF (...) >
<rdf:Description rdf:about="http://inria.fr/rr/doc.html">
  <inria:author rdf:resource=
    "http://ns.inria.fr/catherine.faron#me"/>
</rdf:Description>
</rdf:RDF>
```



```
<rdf:RDF (...) >
<rdf:Description rdf:about="http://inria.fr/rr/doc.html">
  <inria:topic>Web of Data</inria:topic>
</rdf:Description>
</rdf:RDF>
```



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RDF/XML: many syntactic variations

```
<rdf:RDF (...) >
<rdf:Description rdf:about="http://inria.fr/rr/doc.html">
  <inria:author>
    <rdf:Description
      rdf:about="http://ns.inria.fr/catherine.faron#me"/>
    </inria:author>
  </rdf:Description>
</rdf:RDF>
```

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RDF/XML: many syntactic variations

```
<rdf:RDF (...) >
<rdf:Description rdf:about="http://inria.fr/rr/doc.html">
  <inria:author>
    <rdf:Description
      rdf:about="http://ns.inria.fr/catherine.faron#me">
      <inria:firstName>Catherine</firstName>
    </rdf:Description>
  </inria:author>
</rdf:Description>
</rdf:RDF>
```

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RDF/XML: many syntactic variations

```
<rdf:RDF (...) >
<rdf:Description rdf:about="http://inria.fr/rr/doc.html"
  inria:topic="Web Of Data"/>
</rdf:RDF>
```

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"XML Schema Datatypes" for Typing Literals

Literals are by default considered as character strings, of type xsd:string

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Indicating the Language of Textual Values

Literals can be associated to a language

```
@prefix (...)      Turtle
<http://inria.fr/rr/doc.html>
  inria:topic "Web of data"@en ;
  inria:topic "Web de données"@fr .

<rdf:RDF (...)>      RDF/XML
<rdf:Description rdf:about="http://inria.fr/rr/doc.html">
  <inria:topic xml:lang='en'>Web of Data</inria:topic >
  <inria:topic xml:lang='fr'>Web de données</inria:topic >
</rdf:Description>
</rdf:RDF>
```



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Typing Resources

Property **rdf:type** links the URIs of resources to the URIs of their classes

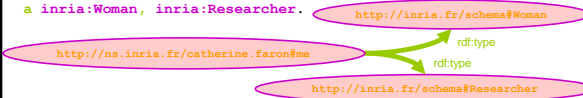


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Typing Resources

Property **rdf:type** links the URIs of resources to the URIs of their classes

```
@prefix (...)      Turtle
<http://ns.inria.fr/catherine.faron#me>
  a inria:Woman, inria:Researcher .
```

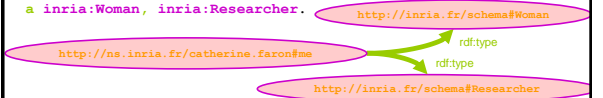


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Typing Resources

Property **rdf:type** links the URIs of resources to the URIs of their classes

```
@prefix (...)      Turtle
<http://ns.inria.fr/catherine.faron#me>
  a inria:Woman, inria:Researcher .
```



```
<rdf:RDF (...)>      RDF/XML
<inria:Researcher rdf:about="http://ns.inria.fr/catherine.faron#me">
  <rdf:type rdf:resource="http://www.inria.fr/schema#Woman" />
</inria:Researcher>
</rdf:RDF>
```

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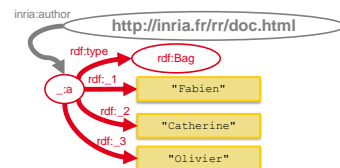
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Bags (rdf:Bag) of Resources or Literals

Simple groups, without any order



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Bags (rdf:Bag) of Resources or Literals

Simple groups, without any order

```
@prefix (...)      Turtle
<http://inria.fr/rr/doc.html> inria:author [ a rdf:Bag ;
  rdf:li "Fabien", "Catherine", "Olivier" . ] .
```

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Bags (rdf:Bag) of Resources or Literals

Simple groups, without any order

```
@prefix (...)      Turtle
<http://inria.fr/rr/doc.html> inria:author [ a rdf:Bag ;
  rdf:li "Fabien", "Catherine", "Olivier" . ] .

<rdf:RDF (...)>      RDF/XML
<rdf:Description rdf:about="http://inria.fr/rr/doc.html">
  <inria:author>
    <rdf:Bag>
      <rdf:li>Fabien</rdf:li> <rdf:li>Catherine</rdf:li>
      <rdf:li>Olivier</rdf:li>
    </rdf:Bag>
  </inria:author>
</rdf:Description>
</rdf:RDF>
```

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Sequences (rdf:Seq)

Ordered groups of resources or literals

```
@prefix (...)      Turtle
<http://inria.fr/rr/doc.html> inria:author [ a rdf:Seq ;
  rdf:li "Fabien", "Catherine", "Olivier" . ] .

<rdf:RDF (...)>      RDF/XML
<rdf:Description rdf:about="http://inria.fr/rr/doc.html">
  <inria:author>
    <rdf:Seq>
      <rdf:li>Fabien</rdf:li> <rdf:li>Catherine</rdf:li>
      <rdf:li>Olivier</rdf:li>
    </rdf:Seq>
  </inria:author>
</rdf:Description>
</rdf:RDF>
```

80

Alternatives (rdf:Alt)

E.g. the same value in different languages

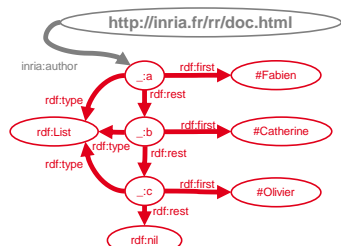
```
@prefix (...)      Turtle
<http://inria.fr/rr/doc.html> inria:theme [ a rdf:Alt ;
  rdf:li "Web of data"@en, "Web de données"@fr . ] .

<rdf:RDF (...)>      RDF/XML
<rdf:Description rdf:about="http://inria.fr/rr/doc.html">
  <inria:theme>
    <rdf:Alt>
      <rdf:li xml:lang='en'>Web of Data</rdf:li>
      <rdf:li xml:lang='fr'>Web de données</rdf:li>
    </rdf:Alt>
  </inria:theme>
</rdf:Description>
</rdf:RDF>
```

81

Collections

Exhaustive and ordered lists



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Collections

Exhaustive and ordered lists

```
@prefix (...)      Turtle
<http://inria.fr/rr/doc.html> inria:author
( <#Fabien> <#Catherine> <#Olivier> ) .

<rdf:RDF (...)>      RDF/XML
<rdf:Description rdf:about="http://inria.fr/rr/doc.html">
  <inria:author rdf:parseType="Collection">
    <rdf:Description rdf:about="#Fabien"/>
    <rdf:Description rdf:about="#Catherine"/>
    <rdf:Description rdf:about="#Olivier"/>
  </inria:author>
</rdf:Description>
</rdf:RDF>
```

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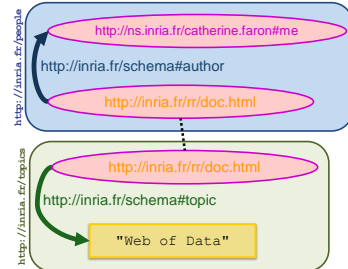
The RDF Data Model

1. Describing resources
2. A triple model and a graph model
3. Serialization syntaxes
4. Values, types and languages
5. Groups
6. Naming graphs
7. RDF Schemas

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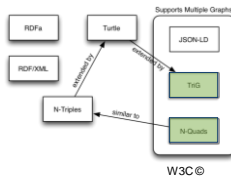
Named Graphs

Grouping triples in subgraphs identified by URIs



85

RDF has the TriG and N-Quads syntaxes to enable the representation of contexts



W3C ©

86

Named Graphs in TriG

```
@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/catherine.faron#me> .
}
```

```
GRAPH <http://inria.fr/topics>
{
  <http://inria.fr/rr/doc.html>
    inria:topic
    "Web of Data" .
}
```

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Named Graphs in N-Quads

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

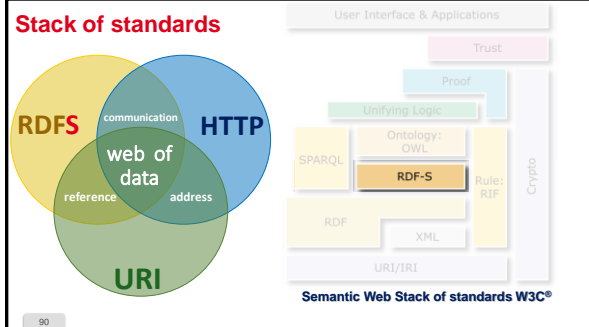
```
<http://inria.fr/rr/doc.html>
<http://inria.fr/schema#topic>
"Web of Data"
<http://inria.fr/topics> .
```

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The RDF Data Model

1. Describing resources
2. A triple model and a graph model
3. Serialization syntaxes
4. Values, types and languages
5. Groups
6. Naming graphs
7. RDF schemas

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RDFS Means RDF Schema

- RDFS provides standard vocabulary to declare *in RDF* vocabularies to be used in RDF descriptions
- RDFS reuses the vocabulary of RDF and introduces additional constructs
- An RDF vocabulary is a set of property declarations and class declarations

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Associating a Namespace to a Vocabulary

```

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@base <http://inria.fr/2005/humans.rdfs>
(...)

<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#"
  (...)
>/rdf:RDF>

```

92

Declaring Classes of Resources

- Naming classes
- Organizing them into hierarchies

```

graph BT
    Woman --> Person

```

93

Declaring Classes of Resources

```

@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@base <http://inria.fr/2005/humans.rdfs>
<Woman> a rdfs:Class ;
  rdfs:subClassOf <Person>, <Female> .

```

```

graph BT
    Woman --> Person

```

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Declaring Classes of Resources

```

@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@base <http://inria.fr/2005/humans.rdfs>
<Woman> a rdfs:Class ;
  rdfs:subClassOf <Person>, <Female> .

```

```

graph BT
    Woman --> Person

```

95

Declaring Classes of Resources

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@base <http://inria.fr/2005/humans.rdfs>
<Woman> a rdfs:Class ;
    rdfs:subClassOf <Person>, <Female> .

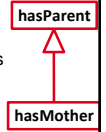
<rdf:RDF xml:base="http://inria.fr/2005/humans.rdfs"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">
  <rdfs:Class rdf:ID="Woman">
    <rdfs:subClassOf rdf:resource="#Person"/>
    <rdfs:subClassOf rdf:resource="#Female"/>
  </rdfs:Class>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



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Declaring Types of Properties

- Naming types of properties
- Organizing them into hierarchies

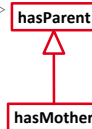


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Declaring Types of Properties

Class **Property** is in the RDF namespace since properties are the key of RDF triples

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@base <http://inria.fr/2005/humans.rdfs>
<hasMother> a rdf:Property ;
    rdfs:subPropertyOf <hasParent> .
```

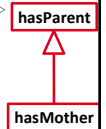


98

Declaring Types of Properties

Class **Property** is in the RDF namespace since properties are the key of RDF triples

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@base <http://inria.fr/2005/humans.rdfs>
<hasMother> a rdf:Property ;
    rdfs:subPropertyOf <hasParent> .
```



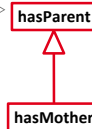
99

Declaring Types of Properties

Class **Property** is in the RDF namespace since properties are the key of RDF triples

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@base <http://inria.fr/2005/humans.rdfs>
<hasMother> a rdf:Property ;
    rdfs:subPropertyOf <hasParent> .

<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#">
  <rdfs:Property rdf:ID="hasMother">
    <rdfs:subPropertyOf rdf:resource="#hasParent"/>
  </rdfs:Property>
</rdf:RDF>
```

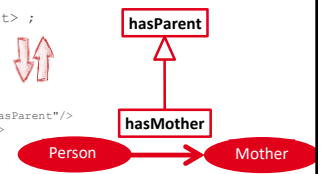


100

Declaring Property Signatures

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@base <http://inria.fr/2005/humans.rdfs>
<hasMother> a rdf:Property ;
    rdfs:subPropertyOf <hasParent> ;
    rdfs:domain <Person> ;
    rdfs:range <Woman> .

<rdf:RDF ... >
  <rdf:Property rdf:ID="hasMother">
    <rdfs:subPropertyOf rdf:resource="#hasParent"/>
    <rdfs:domain rdf:resource="#Person"/>
    <rdfs:range rdf:resource="#Woman"/>
  </rdf:Property>
</rdf:RDF>
```



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Documenting Class and Property Declarations

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@base <http://inria.fr/2005/humans.rdfs>

<Woman> a rdfs:Class ;
  rdfs:label "woman"@en ;
  rdfs:comment "an adult female person"@en .

<hasMother> a rdf:Property ;
  rdfs:label "has for mother"@en ;
  rdfs:comment "to have a woman for mother"@en .
```

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Referencing and Using Schemas

in the description of a resource

```
@prefix h: <http://inria.fr/2005/humans.rdfs#>
@base <http://inria.fr/2005/humans.rdfs-instances>

<Alice> a h:Woman; h:hasMother <Laura> .
```

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Referencing and Using Schemas

in the description of a resource

```
@prefix h: <http://inria.fr/2005/humans.rdfs#>
@base <http://inria.fr/2005/humans.rdfs-instances>

<Alice> a h:Woman; h:hasMother <Laura> .
```

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Referencing and Using Schemas

in the description of a resource

```
@prefix h: <http://inria.fr/2005/humans.rdfs#>
@base <http://inria.fr/2005/humans.rdfs-instances>

<Alice> a h:Woman; h:hasMother <Laura> .
```



```
<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:h="http://inria.fr/2005/humans.rdfs#"
  xml:base="http://inria.fr/2005/humans.rdfs-instances" >
  <h:Woman rdf:ID="Alice">
    <h:hasMother rdf:resource="#Laura"/>
  </h:Woman>
</rdf:RDF>
```

105

Introduction to a Web of Linked Data

Integration with Other Data Formats and Sources

Catherine Faron faron@unice.fr

Slides from Fabien Gandon fabien.gandon@inria.fr

A Web of "All" Data

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Integration With Other Data Formats and Sources

1. RDFa: a RDF syntax inside HTML
2. GRDDL: extract RDF from X(HT)ML
3. JSON-LD: JSON syntax for RDF
4. Tabular data and metadata (CSV)
5. R2RML: integration with databases
6. LDP: a REST API to linked data

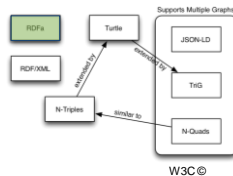
108

Integration with other Data Formats and Sources

1. RDFa: an RDF syntax inside HTML
2. GRDDL: extract RDF from X(HT)ML
3. JSON-LD: JSON syntax for RDF
4. Tabular data and metadata (CSV)
5. R2RML: integration with databases
6. LDP: a REST API to linked data

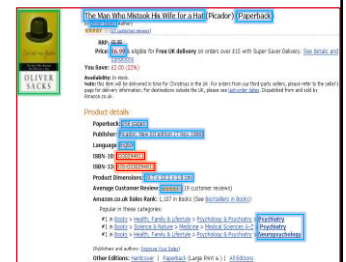
109

RDF has a historical XML syntax and several other syntaxes: Turtle, TriG, JSON-LD, N-Triples, N-Quads



110

A Lot of Data Inside HTML Pages



111

RDFa Means RDF in HTML Attributes

```
<body vocab="http://purl.org/dc/terms/">

<div resource="http://lib.com/books/0684853949">

  <h2 property="title">The Man Who Mistook His
    Wife For a Hat</h2>

  <h3 property="creator">Oliver Sacks</h3>
  ...
```



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RDFa Light Attributes...

- vocab:** default vocabulary for a section
- prefix:** declare other vocabularies
- resource:** identify a resource
- typeof:** type a resource using current vocab
- property:** link to a value or a resource

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RDFa Core Additional Attributes...

- content:** provide a specific value
- datatype:** to type values
- about:** change the subject of a property
- rel:** decompose object properties (list)

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HTML+RDFa Content

```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mailbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(.)
```

115

HTML+RDFa Content (in Browser)

```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mailbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(.)
```



116

HTML+RDFa Content (Read by RDFa Parser)

```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mailbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(.)
```

117

HTML+RDFa Content (Read by RDFa Parser)

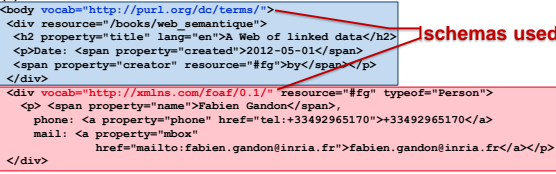
```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mailbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(.)
```



118

Anatomy of HTML+RDFa Content (Vocabularies)

```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mailbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(.)
```



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Anatomy of HTML+RDFa Content (Subjects)

```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(..)
```

subjects of triples

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Anatomy of HTML+RDFa Content (Typing)

```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(..)
```

type

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Anatomy of HTML+RDFa Content (Literals)

```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(..)
```

properties & values

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Anatomy of HTML+RDFa Content (Objects)

```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(..)
```

properties & objects

123

Anatomy of HTML+RDFa Content (Resource)

```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(..)
```

property & resource

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Anatomy of HTML+RDFa Content (href)

```
(.)
<body vocab="http://purl.org/dc/terms/">
<div resource="/books/web_semantique">
  <h2 property="title" lang="en">A Web of linked data</h2>
  <p>Date: <span property="created">2012-05-01</span>
  <span property="creator" resource="#fg">by</span></p>
</div>
<div vocab="http://xmlns.com/foaf/0.1/" resource="#fg" typeof="Person">
  <p> <span property="name">Fabien Gandon</span>,
    phone: <a property="phone" href="tel:+33492965170">+33492965170</a>
    mail: <a property="mbox" href="mailto:fabien.gandon@inria.fr">fabien.gandon@inria.fr</a></p>
</div>
(..)
```

property & href

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Schema.org: Vocabulary by Major Search Engines and Applications

schema.org

Person

A person (human, dead, unborn, or fictional).

Image: User:1,000,000 domains

Property	Expected type	Description
additionalName	Text	An additional name for a Person, can be used for a middle name.
address	PostalAddress, or Text	Physical address of the Person.
affiliation	Organization	An organization that this person is affiliated with, for example, a school, company, club, or team.
alumniOf	Organization	An organization that the person is an alumnus of, for example, a school.
award	Text	An award won by the Person, for example, a Nobel Prize.
awardDate	Text	Date of the award.
awardCategory	Text	Category of the award.
awardCountry	Text	Country of the award.
awardCity	Text	City of the award.
awardState	Text	State of the award.
awardZip	Text	Zip code of the award.
awardAddress	Text	Address of the award.
awardPhone	Text	Phone number of the award.
awardFax	Text	Fax number of the award.
awardEmail	Text	Email address of the award.
awardWebsite	Text	Website of the award.
awardImage	Image	Image of the award.
awardVideo	Video	Video of the award.
awardAudio	Audio	Audio of the award.
awardDocument	Document	Document of the award.
awardText	Text	Text of the award.
awardCode	Text	Code of the award.
awardColor	Text	Color of the award.
awardShape	Text	Shape of the award.
awardSize	Text	Size of the award.
awardWeight	Text	Weight of the award.
awardVolume	Text	Volume of the award.
awardArea	Text	Area of the award.
awardPerimeter	Text	Perimeter of the award.
awardRadius	Text	Radius of the award.
awardDiameter	Text	Diameter of the award.
awardCircumference	Text	Circumference of the award.
awardArea	Text	Area of the award.
awardPerimeter	Text	Perimeter of the award.
awardRadius	Text	Radius of the award.
awardDiameter	Text	Diameter of the award.
awardCircumference	Text	Circumference of the award.

Example of RDFa Using schema.org

```
<div vocab="http://schema.org/" typeof="Product">
  
  <span property="name">Dell UltraSharp 30" LCD Monitor</span>

  <div rel="hasAggregateRating" >
    <div type="http://schema.org/AggregateRating">
      <span property="ratingValue">87</span>
      out of <span property="bestRating">100</span>
    </div>
    based on <span property="ratingCount">24</span> user ratings
  </div>

  <div rel="offers" >
    <div type="http://schema.org/AggregateOffer">
      <span property="lowPrice">$1250</span>
      to <span property="highPrice">$1495</span>
      from <span property="offerCount">8</span> sellers
    </div>
  </div>
</div>
```

Example of RDFa Using schema.org

```
<div vocab="http://schema.org/" typeof="Product">
  
  <span property="name">Dell UltraSharp 30" LCD Monitor</span>

  <div rel="hasAggregateRating" >
    <div type="http://schema.org/AggregateRating">
      <span property="ratingValue">87</span>
      out of <span property="bestRating">100</span>
    </div>
    based on <span property="ratingCount">24</span> user ratings
  </div>

  <div rel="offers" >
    <div type="http://schema.org/AggregateOffer">
      <span property="lowPrice">$1250</span>
      to <span property="highPrice">$1495</span>
      from <span property="offerCount">8</span> sellers
    </div>
  </div>
</div>
```

Pilot Vanishing Point Collection Retractable Fountain Pen, Black with Rhodium Accents, Blue Ink, Medium Nib (B0242)

Only 10 left in stock (more on the way)

Want to know more? Visit the product page and see the shipping and return policy.

Shipping in select states

Click here to see the shipping and return policy.

Amazon.com: Pilot Vanishing Point Collection Retractable Fountain Pen, Black with Rhodium Accents, Blue Ink, Medium Nib (B0242) Office Products

Facebook OGP Code / "Like" button

```
<html xmlns="http://www.w3.org/1999/xhtml" dir="ltr" lang="en-US">
  <meta property="fb:app_id" content="YOUR_APP_ID" />
  <meta property="og:type" content="YOUR_NAMESPACE:recipe" />
  <meta property="og:title" content="Stuffed Cookies" />
  <meta property="og:image" content="http://example.com/cookie.jpg" />
  <meta property="og:description" content="The Turducken of Cookies" />
  <meta property="og:url" content="http://example.com/cookie.html" />
  <script type="text/javascript">
    function postCook() {
      FB.api('/me/YOUR_NAMESPACE:cook' + '?recipe=http://example.com/cookie.html','post', (..) );
    }
  </script>
  <form>
    <input type="button" value="Cook" onclick="postCook()" />
  </form>
</body>
</html>
```

Like

Cook

Like

RdFa Core Initial Context

Predefined prefixes that can be used without defining them

<https://www.w3.org/2011/rdfa-context/rdfa-1.1>

csvw, dcat, qb, grddl, ma, org, owl, prov, rdf, rdfs, ri, rr, sd, skos, skosxl, wdr, void, wdrs, xhv, xml, xsd, cc, ctag, dc, dcterms, dc11, foaf, gr, ical, og, rev, sioc, v, vcard, schema, ...

Linked Data in HTML

- <http://rdfa.info/play/>



These Data are Available to Everyone

If you apply an RDFa parser to these pages you will obtain these data



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Integration With Other Data Formats and Sources

1. RDFa: an RDF syntax inside HTML
2. GRDDL: extract RDF from X(HT)ML
3. JSON-LD: JSON syntax for RDF
4. Tabular data and metadata (CSV)
5. R2RML: integration with databases
6. LDP: a REST API to linked data

133

GRDDL Algorithmic Alternative to RDFa

- Means "Gleaning Resource Descriptions from Dialects of Languages"
- RDFa: markup
- \neq
- GRDDL: transformation



134

GRDDL Transformations

- Indicate a document can be transformed into RDF data (**profile**)
- Reference an RDF extraction algorithms from inside documents (**transformation**)
- Works for HTML and XML

135

Simple Example in HTML:

```
<head profile="http://www.w3.org/2003/g/data-view">
<title>The man who mistook his wife for a hat</title>
<link rel="transformation"
href="http://www.w3.org/2000/06/ dc-extract/dc-extract.xsl" />
<meta name="DC.Subject" content="clinical tales" />
(...)
```



136

Simple Example in HTML:

```
<head profile="http://www.w3.org/2003/g/data-view">
<title>The man who mistook his wife for a hat</title>
<link rel="transformation"
href="http://www.w3.org/2000/06/ dc-extract/dc-extract.xsl" />
<meta name="DC.Subject" content="clinical tales" />
(...)
```



137

Simple Example in XML: e.g. Excel XML Spreadsheet

```
<?xml version="1.0"?>
<?mso-application progid="Excel.Sheet"?>
<Workbook xmlns="urn:schemas-microsoft-com:office:spreadsheet"
  xmlns:grddl="http://www.w3.org/2003/g/data-view#"
  grddl:transformation="excel2rdf.xsl">
  (...)
  </Workbook>
```



138

Simple Example in XML: e.g. Excel XML Spreadsheet

```
<?xml version="1.0"?>
<?mso-application progid="Excel.Sheet"?>
<Workbook xmlns="urn:schemas-microsoft-com:office:spreadsheet"
  xmlns:grddl="http://www.w3.org/2003/g/data-view#"
  grddl:transformation="excel2rdf.xsl">
  (...)
  </Workbook>
```



139

GRDDL Agent Process: Direct Transformation

```
<head profile="http://www.w3.org/2003/g/data-view">
<title>The man who mistook his wife for a hat</title>
<link rel="transformation"
  href="http://www.w3.org/2000/06/ dc-extract/dc-extract.xsl" />
<meta name="DC.Subject" content="clinical tales" />
  (...)
</head>
```



source

140

GRDDL Agent Process: Direct Transformation

```
<head profile="http://www.w3.org/2003/g/data-view">
<title>The man who mistook his wife for a hat</title>
<link rel="transformation"
  href="http://www.w3.org/2000/06/ dc-extract/dc-extract.xsl" />
<meta name="DC.Subject" content="clinical tales" />
  (...)
</head>
```



source



GRDDL source
document

141

GRDDL Agent Process: Direct Transformation

```
<head profile="http://www.w3.org/2003/g/data-view">
<title>The man who mistook his wife for a hat</title>
<link rel="transformation"
  href="http://www.w3.org/2000/06/ dc-extract/dc-extract.xsl" />
<meta name="DC.Subject" content="clinical tales" />
  (...)
</head>
```



source



GRDDL source
document



source and
transformation



142

GRDDL Agent Process: Direct Transformation

```
<head profile="http://www.w3.org/2003/g/data-view">
<title>The man who mistook his wife for a hat</title>
<link rel="transformation"
  href="http://www.w3.org/2000/06/ dc-extract/dc-extract.xsl" />
<meta name="DC.Subject" content="clinical tales" />
  (...)
</head>
```



source



GRDDL source
document



source and
transformation



RDF

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GRDDL Agent Process: Indirect Transformation



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GRDDL Agent Process: Indirect Transformation



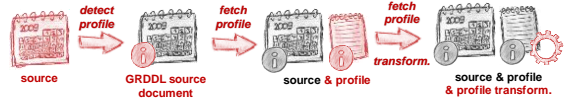
145

GRDDL Agent Process: Indirect Transformation



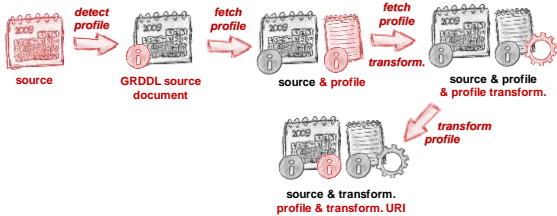
146

GRDDL Agent Process: Indirect Transformation



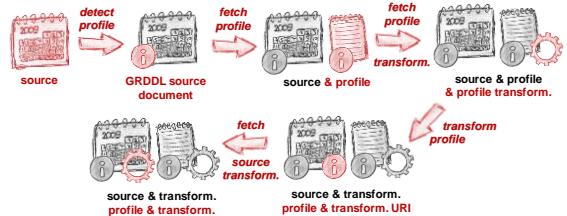
147

GRDDL Agent Process: Indirect Transformation



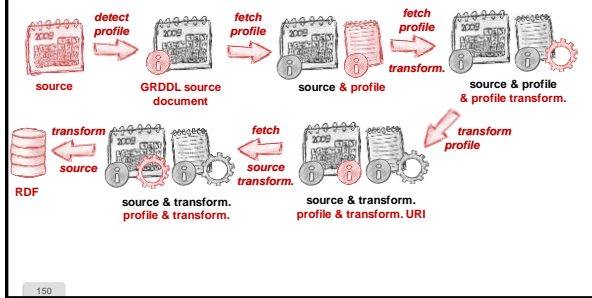
148

GRDDL Agent Process: Indirect Transformation

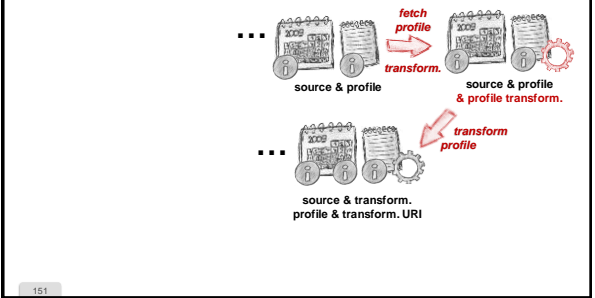


149

GRDDL Agent Process: Indirect Transformation



GRDDL Indirect Transformations: More Resilient

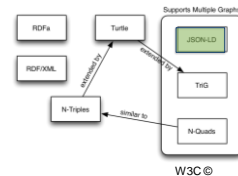


Integration With Other Data Formats and Sources

1. RDFS: an RDF syntax inside HTML
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4. Tabular data and metadata (CSV)
5. R2RML: integration with databases
6. LDP: a REST API to linked data

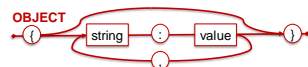
152

RDF has a historical XML syntax and several other syntaxes: Turtle, TriG, JSON-LD, N-Triples, N-Quads



JSON-LD: JSON syntax for RDF

1. JSON (JavaScript Object Notation)
 - Hierarchy of name-value pairs
 - Popular format for APIs on the Web.



JSON-LD: JSON syntax for RDF

1. JSON (JavaScript Object Notation)
 - Hierarchy of name-value pairs
 - Popular format for APIs on the Web



2. JSON-LD (JSON for Linked Data)

- Notion of "context" to provide a mapping from JSON model to an RDF model
- A context can be embedded in a JSON-LD document or in a separate file and referenced

155

Specific Reserved Names Prefixed by @

@context : define short names used in the document.
@id : identify resources with IRIs or blank nodes.
@value: specify the data value of a property
@language: specify the language for a string or the document.
@type: set the type of a value or a resource.
@vocab: prefix IRI to expand properties and values in @type.
@base: used to set the base IRI
@container: used to set the default container type for a term.
@index: specify a container is used to index information
@list: an ordered set of data.
@set: an unordered set of data
@reverse: express reverse properties.
@graph: indicate a graph.

156

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@index: specify a container is used to index information
@list: an ordered set of data.
@set: an unordered set of data
@reverse: express reverse properties.
@graph: indicate a graph.

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Example with these Data in Turtle

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
<http://ns.inria.fr/fabien.gandon#me> a foaf:Person ;
  foaf:family_name "Gandon"@fr ;
  foaf:givenname "Fabien"@fr ;
  foaf:age 40 ;
  foaf:birthday "--07-31"^^xsd:gMonthDay ;
  foaf:homepage <http://fabien.info> ;
  foaf:knows [ a foaf:Person ; foaf:name "Olivier Corby" ],
    [ a foaf:Person ; foaf:name "Catherine Faron" ].
```

158

Example with these Data in Turtle

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
<http://ns.inria.fr/fabien.gandon#me> a foaf:Person ;
  foaf:family_name "Gandon"@fr ;
  foaf:givenname "Fabien"@fr ;
  foaf:age 40 ;
  foaf:birthday "--07-31"^^xsd:gMonthDay ;
  foaf:homepage <http://fabien.info> ;
  foaf:knows [ a foaf:Person ; foaf:name "Olivier Corby" ],
    [ a foaf:Person ; foaf:name "Catherine Faron" ].
```

properties & values

159

Example with these Data in Turtle

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
<http://ns.inria.fr/fabien.gandon#me> a foaf:Person ;
  foaf:family_name "Gandon"@fr ;
  foaf:givenname "Fabien"@fr ;
  foaf:age 40 ;
  foaf:birthday "--07-31"^^xsd:gMonthDay ;
  foaf:homepage <http://fabien.info> ;
  foaf:knows [ a foaf:Person ; foaf:name "Olivier Corby" ],
    [ a foaf:Person ; foaf:name "Catherine Faron" ].
```

link to another resource

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Example with these Data in Turtle

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
<http://ns.inria.fr/fabien.gandon#me> a foaf:Person ;
  foaf:family_name "Gandon"@fr ;
  foaf:givenname "Fabien"@fr ;
  foaf:age 40 ;
  foaf:birthday "--07-31"^^xsd:gMonthDay ;
  foaf:homepage <http://fabien.info> ;
  foaf:knows [ a foaf:Person ; foaf:name "Olivier Corby" ],
    [ a foaf:Person ; foaf:name "Catherine Faron" ].
```

list of b-nodes values

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Simple JSON-LD Version

```
{
  "@id": "http://ns.inria.fr/fabien.gandon#me",
  "@type": "http://xmlns.com/foaf/0.1/Person",
  "http://xmlns.com/foaf/0.1/age": 40,
  "http://xmlns.com/foaf/0.1/birthday": {
    "@type": "http://www.w3.org/2001/XMLSchema#MonthDay", "@value": "--07-31" },
  "http://xmlns.com/foaf/0.1/family_name": { "@value": "Gandon", "@language": "fr" },
  "http://xmlns.com/foaf/0.1/givenname": { "@value": "Fabien", "@language": "fr" },
  "http://xmlns.com/foaf/0.1/homepage": { "@id": "http://fabien.info" },
  "http://xmlns.com/foaf/0.1/knows": [
    { "@type": "http://xmlns.com/foaf/0.1/Person",
      "http://xmlns.com/foaf/0.1/name": "Catherine Faron" },
    { "@type": "http://xmlns.com/foaf/0.1/Person",
      "http://xmlns.com/foaf/0.1/name": "Olivier Corby" }
  ]
}
```

162

Simple JSON-LD Version

```
{
  "@id": "http://ns.inria.fr/fabien.gandon#me",
  "@type": "http://xmlns.com/foaf/0.1/Person",
  "http://xmlns.com/foaf/0.1/age": 40,
  "http://xmlns.com/foaf/0.1/birthday": {
    "@type": "http://www.w3.org/2001/XMLSchema#MonthDay", "@value": "--07-31" },
  "http://xmlns.com/foaf/0.1/family_name": { "@value": "Gandon", "@language": "fr" },
  "http://xmlns.com/foaf/0.1/givenname": { "@value": "Fabien", "@language": "fr" },
  "http://xmlns.com/foaf/0.1/homepage": { "@id": "http://fabien.info" },
  "http://xmlns.com/foaf/0.1/knows": [
    { "@type": "http://xmlns.com/foaf/0.1/Person",
      "http://xmlns.com/foaf/0.1/name": "Catherine Faron" },
    { "@type": "http://xmlns.com/foaf/0.1/Person",
      "http://xmlns.com/foaf/0.1/name": "Olivier Corby" }
  ]
}
```

a resource
and its type

163

Simple JSON-LD Version

```
{
  "@id": "http://ns.inria.fr/fabien.gandon#me",
  "@type": "http://xmlns.com/foaf/0.1/Person",
  "http://xmlns.com/foaf/0.1/age": 40,
  "http://xmlns.com/foaf/0.1/birthday": {
    "@type": "http://www.w3.org/2001/XMLSchema#MonthDay", "@value": "--07-31" },
  "http://xmlns.com/foaf/0.1/family_name": { "@value": "Gandon", "@language": "fr" },
  "http://xmlns.com/foaf/0.1/givenname": { "@value": "Fabien", "@language": "fr" },
  "http://xmlns.com/foaf/0.1/homepage": { "@id": "http://fabien.info" },
  "http://xmlns.com/foaf/0.1/knows": [
    { "@type": "http://xmlns.com/foaf/0.1/Person",
      "http://xmlns.com/foaf/0.1/name": "Catherine Faron" },
    { "@type": "http://xmlns.com/foaf/0.1/Person",
      "http://xmlns.com/foaf/0.1/name": "Olivier Corby" }
  ]
}
```

a property and its
value in native datatype

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Simple JSON-LD Version

```
{
  "@id": "http://ns.inria.fr/fabien.gandon#me",
  "@type": "http://xmlns.com/foaf/0.1/Person",
  "http://xmlns.com/foaf/0.1/age": 40,
  "http://xmlns.com/foaf/0.1/birthday": {
    "@type": "http://www.w3.org/2001/XMLSchema#MonthDay", "@value": "--07-31" },
  "http://xmlns.com/foaf/0.1/family_name": { "@value": "Gandon", "@language": "fr" },
  "http://xmlns.com/foaf/0.1/givenname": { "@value": "Fabien", "@language": "fr" },
  "http://xmlns.com/foaf/0.1/homepage": { "@id": "http://fabien.info" },
  "http://xmlns.com/foaf/0.1/knows": [
    { "@type": "http://xmlns.com/foaf/0.1/Person",
      "http://xmlns.com/foaf/0.1/name": "Catherine Faron" },
    { "@type": "http://xmlns.com/foaf/0.1/Person",
      "http://xmlns.com/foaf/0.1/name": "Olivier Corby" }
  ]
}
```

verbose property names

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JSON-LD with Context (Prefixes)

```
{
  "@context": {
    "foaf": "http://xmlns.com/foaf/0.1/" ,
    "xsd": "http://www.w3.org/2001/XMLSchema#"
  },
  "@graph": [
    { "@id": "http://ns.inria.fr/fabien.gandon#me", "@type": "foaf:Person",
      "foaf:age": 40,
      "foaf:birthday": { "@type": "xsd:MonthDay", "@value": "--07-31" },
      "foaf:family_name": { "@value": "Gandon", "@language": "fr" },
      "foaf:givenname": { "@value": "Fabien", "@language": "fr" },
      "foaf:homepage": { "@id": "http://fabien.info" },
      "foaf:knows": [ { "@type": "foaf:Person", "foaf:name": "Olivier Corby" },
        { "@type": "foaf:Person", "foaf:name": "Catherine Faron" }
      ]
    }
  ]
}
```

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JSON-LD with Context (Qnames)

```
{
  "@context": {
    "foaf": "http://xmlns.com/foaf/0.1/" ,
    "xsd": "http://www.w3.org/2001/XMLSchema#"
  },
  "@graph": [
    { "@id": "http://ns.inria.fr/fabien.gandon#me", "@type": "foaf:Person",
      "foaf:age": 40,
      "foaf:birthday": { "@type": "xsd:MonthDay", "@value": "--07-31" },
      "foaf:family_name": { "@value": "Gandon", "@language": "fr" },
      "foaf:givenname": { "@value": "Fabien", "@language": "fr" },
      "foaf:homepage": { "@id": "http://fabien.info" },
      "foaf:knows": [ { "@type": "foaf:Person", "foaf:name": "Olivier Corby" },
        { "@type": "foaf:Person", "foaf:name": "Catherine Faron" }
      ]
    }
  ]
}
```

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JSON-LD with Context (Types)

```
{ "@context": {
  "foaf": "http://xmlns.com/foaf/0.1/",
  "xsd": "http://www.w3.org/2001/XMLSchema#"
},
"@graph": [
  {
    "@id": "http://ns.inria.fr/fabien.gandon#me",
    "foaf:age": 40,
    "foaf:birthday": { "@type": "xsd:MonthDay", "@value": "--07-31" },
    "foaf:family_name": { "@value": "Gandon", "@language": "fr" },
    "foaf:givenname": { "@value": "Fabien", "@language": "fr" },
    "foaf:homepage": { "@id": "http://fabien.info" },
    "foaf:knows": [ { "@type": "foaf:Person", "foaf:name": "Olivier Corby" },
    { "@type": "foaf:Person", "foaf:name": "Catherine Faron" }
  ]
}
]
```

168

JSON-LD with Context (Language)

```
{ "@context": {
  "foaf": "http://xmlns.com/foaf/0.1/",
  "xsd": "http://www.w3.org/2001/XMLSchema#"
},
"@graph": [
  {
    "@id": "http://ns.inria.fr/fabien.gandon#me",
    "foaf:age": 40,
    "foaf:birthday": { "@type": "xsd:MonthDay", "@value": "--07-31" },
    "foaf:family_name": { "@value": "Gandon", "@language": "fr" },
    "foaf:givenname": { "@value": "Fabien", "@language": "fr" },
    "foaf:homepage": { "@id": "http://fabien.info" },
    "foaf:knows": [ { "@type": "foaf:Person", "foaf:name": "Olivier Corby" },
    { "@type": "foaf:Person", "foaf:name": "Catherine Faron" }
  ]
}
]
```

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JSON-LD with Context (Blank Nodes)

```
{ "@context": {
  "foaf": "http://xmlns.com/foaf/0.1/",
  "xsd": "http://www.w3.org/2001/XMLSchema#"
},
"@graph": [
  {
    "@id": "http://ns.inria.fr/fabien.gandon#me",
    "foaf:age": 40,
    "foaf:birthday": { "@type": "xsd:MonthDay", "@value": "--07-31" },
    "foaf:family_name": { "@value": "Gandon", "@language": "fr" },
    "foaf:givenname": { "@value": "Fabien", "@language": "fr" },
    "foaf:homepage": { "@id": "http://fabien.info" },
    "foaf:knows": [ { "@type": "foaf:Person", "foaf:name": "Olivier Corby" },
    { "@type": "foaf:Person", "foaf:name": "Catherine Faron" }
  ]
}
]
```

170

Compact / Expand = Add / Remove Context

COMPACT →

```
{ "@context": {
  "foaf": "http://xmlns.com/foaf/0.1/",
  "xsd": "http://www.w3.org/2001/XMLSchema#"
},
"@graph": [
  {
    "@id": "http://ns.inria.fr/fabien.gandon#me",
    "foaf:age": 40,
    "foaf:birthday": { "@type": "xsd:MonthDay", "@value": "--07-31" },
    "foaf:family_name": "Gandon",
    "foaf:givenname": "Fabien",
    "foaf:homepage": { "@id": "http://fabien.info" },
    "foaf:knows": [
      { "@type": "foaf:Person", "foaf:name": "Catherine Faron" },
      { "@type": "foaf:Person", "foaf:name": "Olivier Corby" }
    ]
  ]
]
```

→ **EXPAND**

```
{
  "@id": "http://ns.inria.fr/fabien.gandon#me",
  "@type": {
    "http://xmlns.com/foaf/0.1/Person": 1,
    "http://xmlns.com/foaf/0.1/age": {
      "@value": 40
    },
    "http://xmlns.com/foaf/0.1/birthday": {
      "@value": "--07-31"
    },
    "http://xmlns.com/foaf/0.1/family_name": {
      "@value": "Gandon"
    },
    "http://xmlns.com/foaf/0.1/givenname": {
      "@value": "Fabien"
    },
    "http://xmlns.com/foaf/0.1/homepage": {
      "@id": "http://fabien.info"
    },
    "http://xmlns.com/foaf/0.1/knows": [
      { "@type": "foaf:Person" },
      { "@type": "foaf:Person" }
    ],
    "http://xmlns.com/foaf/0.1/name": {
      "@value": "Catherine Faron"
    },
    "http://xmlns.com/foaf/0.1/name": {
      "@value": "Olivier Corby"
    }
  ]
}
```

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Contextualizing JSON from APIs e.g. "LinkedIn"



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E.g. LinkedIn in JSON

```
{
  "firstName": "Fabien",
  "headline": "Research Director at Inria",
  "id": "Pg-fjkekzI",
  "lastName": "Gandon",
  "siteStandardProfileRequest": {
    "uri": "https://www.linkedin.com/profile/view?id=AAAAA"
  }
}
```

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E.g. LinkedIn in JSON (with Context)

```
{
  "@context": {
    "@vocab": "http://schema.org/",
    "@base": "http://data.org/",
    "id": "@id",
    "firstName": "givenName",
    "lastName": "familyName",
    "headline": { "@id": "jobTitle", "@language": "en" },
    "siteStandardProfileRequest": null },
  "firstName": "Fabien",
  "headline": "Research Director at Inria",
  "id": "Fg-fjekzI",
  "lastName": "Gandon",
  "siteStandardProfileRequest": {
    "url": "https://www.linkedin.com/profile/view?id=AAAAAA"
  }
}
```

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E.g. LinkedIn in JSON (Voc & Base)

```
{
  "@context": {
    "@vocab": "http://schema.org/",
    "@base": "http://data.org/",
    "id": "@id",
    "firstName": "givenName",
    "lastName": "familyName",
    "headline": { "@id": "jobTitle", "@language": "en" },
    "siteStandardProfileRequest": null },
  "firstName": "Fabien",
  "headline": "Research Director at Inria",
  "id": "Fg-fjekzI",
  "lastName": "Gandon",
  "siteStandardProfileRequest": {
    "url": "https://www.linkedin.com/profile/view?id=AAAAAA"
  }
}
```

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E.g. LinkedIn in JSON (Map Properties)

```
{
  "@context": {
    "@vocab": "http://schema.org/",
    "@base": "http://data.org/",
    "id": "@id",
    "firstName": "givenName",
    "lastName": "familyName",
    "headline": { "@id": "jobTitle", "@language": "en" },
    "siteStandardProfileRequest": null },
  "firstName": "Fabien",
  "headline": "Research Director at Inria",
  "id": "Fg-fjekzI",
  "lastName": "Gandon",
  "siteStandardProfileRequest": {
    "url": "https://www.linkedin.com/profile/view?id=AAAAAA"
  }
}
```

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E.g. LinkedIn in JSON (Specify the Language)

```
{
  "@context": {
    "@vocab": "http://schema.org/",
    "@base": "http://data.org/",
    "id": "@id",
    "firstName": "givenName",
    "lastName": "familyName",
    "headline": { "@id": "jobTitle", "@language": "en" },
    "siteStandardProfileRequest": null },
  "firstName": "Fabien",
  "headline": "Research Director at Inria",
  "id": "Fg-fjekzI",
  "lastName": "Gandon",
  "siteStandardProfileRequest": {
    "url": "https://www.linkedin.com/profile/view?id=AAAAAA"
  }
}
```

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E.g. LinkedIn in JSON (Ignore)

```
{
  "@context": {
    "@vocab": "http://schema.org/",
    "@base": "http://data.org/",
    "id": "@id",
    "firstName": "givenName",
    "lastName": "familyName",
    "headline": { "@id": "jobTitle", "@language": "en" },
    "siteStandardProfileRequest": null },
  "firstName": "Fabien",
  "headline": "Research Director at Inria",
  "id": "Fg-fjekzI",
  "lastName": "Gandon",
  "siteStandardProfileRequest": {
    "url": "https://www.linkedin.com/profile/view?id=AAAAAA"
  }
}
```

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E.g. LinkedIn in JSON to RDF

```
{
  "@context": {
    "@vocab": "http://schema.org/",
    "@base": "http://data.org/",
    "id": "@id",
    "firstName": "givenName",
    "lastName": "familyName",
    "headline": { "@id": "jobTitle", "@language": "en" },
    "siteStandardProfileRequest": null },
  "firstName": "Fabien",
  "headline": "Research Director at Inria",
  "id": "Fg-fjekzI",
  "lastName": "Gandon",
  "siteStandardProfileRequest": {
    "url": "https://www.linkedin.com/profile/view?id=AAAAAA"
  }
}
```

@prefix : <http://schema.org/> .
<http://data.org/Fg-fjekzI> :familyName "Gandon" ;
:givenName "Fabien" ;
:jobTitle "Research Director at Inria"@en .



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E.g. Google Knowledge Graph Search API

```
{ "context": {
  "vocab": "http://schema.org/",
  "goog": "http://schema.googleapis.com/",
  "resultScore": "goog:resultScore",
  "detailedDescription": "goog:detailedDescription",
  "EntitySearchResult": "goog:EntitySearchResult",
  "kg": "http://g.co/kg"
},
"type": "Result",
"resultScore": {
  "type": "EntitySearchResult",
  "result": { "id": "kg:/m/0114t", "name": "Taylor Swift",
    "description": "Singer-songwriter",
    "image": {
      "url": "https://en.wikipedia.org/wiki/File:Taylor_Swift.jpg",
      "license": "http://creativecommons.org/licenses/by-sa/4.0/"
    },
    "detailedDescription": {
      "articleBody": "Taylor Alison Swift is an American singer-songwriter and actress. Based in Wyoming, Pennsylvania, she moved to Nashville, Tennessee, at the age of 18 to pursue a career in country music.",
      "url": "https://en.wikipedia.org/wiki/Taylor_Swift",
      "license": "https://en.wikipedia.org/wiki/Wikipedia:Text_of_Creative_Commons_Attribution-ShareAlike_3.0_Unported_License"
    }
  },
  "url": "http://taylorswift.com/"
},
"resultScore": 894.574599
}
```

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Linked Data in HTML

- <http://rdfa.info/play/>



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JSON for Linking Data

- <https://json-ld.org/playground/>



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Google Knowledge Graph Search API

<https://developers.google.com/knowledge-graph/>

"The Knowledge Graph Search API lets you find entities in the Google Knowledge Graph. The API uses standard schema.org types and is compliant with the [JSON-LD](https://json-ld.org) specification."

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Integration With Other Data Formats and Sources

1. RDFa: a RDF syntax inside HTML
2. GRDDL: extract RDF from X(HT)ML
3. JSON-LD: JSON syntax for RDF
4. Tabular data and metadata (CSV)
5. R2RML: integration with databases
6. LDP: a REST API to linked data

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