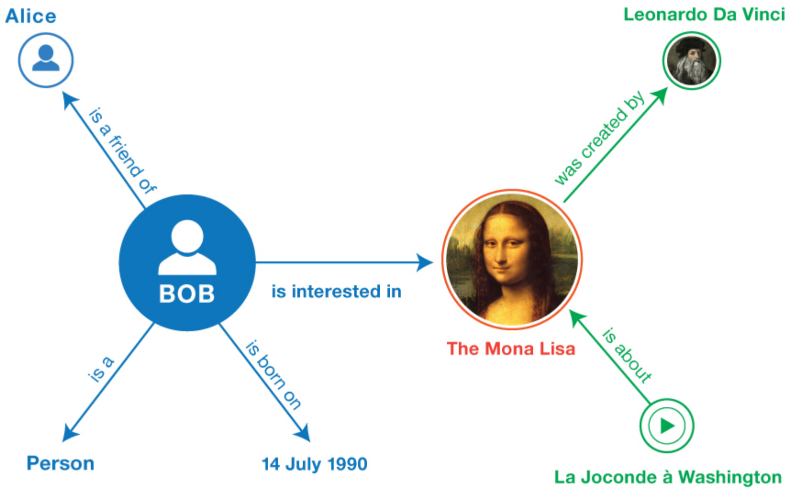
Resource Description Framework (RDF)

VL Semantic Technologies

Bernd Neumayr
(with contributions from Dieter Steiner)

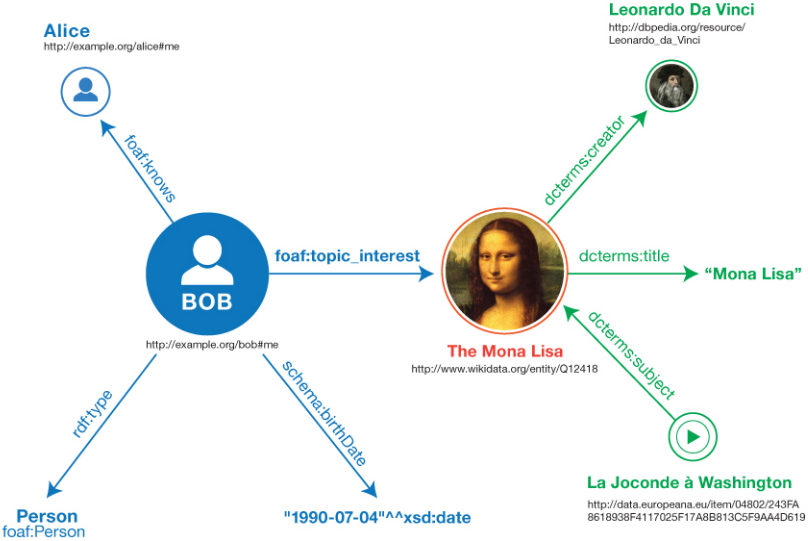
Department for Business Informatics – Data & Knowledge Engineering

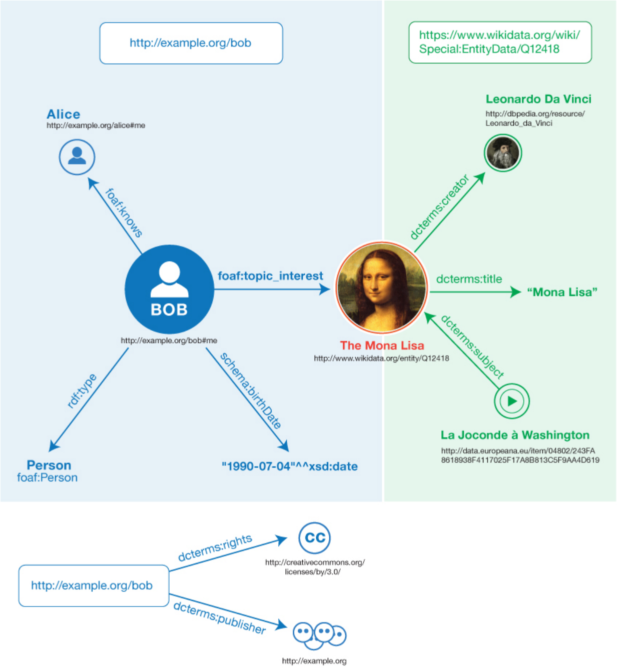
Informal Representation of an RDF Graph



Source: `http://www.w3.org/TR/rdf11-primer/`

RDF Graph


Alice
http://example.org/alice#me
foaf:knows
Leonardo Da Vinci
http://dbpedia.org/resource/
Leonardo_da_Vinci
dcterms:creator
BOB
http://example.org/bob#me
foaf:topic_interest
dcterms:title
"Mona Lisa"
The Mona Lisa
http://www.wikidata.org/entity/Q12418
dcterms:subject
rdf:type
schema:birthDate
La Joconde à Washington
http://data.europeana.eu/item/04802/243FA
8618938F4117025F17A8B813C5F9AA4D619
Person
foaf:Person
"1990-07-04"^^xsd:date


http://example.org/bob
https://www.wikidata.org/wiki/Special:EntityData/Q12418
Alice
http://example.org/alice#me
foaf:knows
Leonardo Da Vinci
http://dbpedia.org/resource/Leonardo_da_Vinci
dcterms:creator
BOB
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dcterms:title
"Mona Lisa"
dcterms:subject
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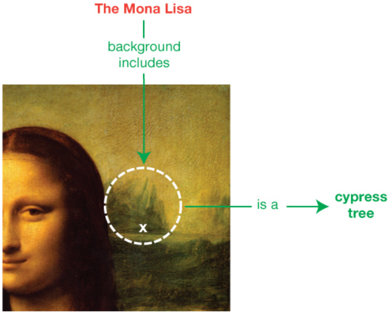
Person
foaf:Person
"1990-07-04"^^xsd:date
dcterms:rights
cc
http://creativecommons.org/licenses/by/3.0/
http://example.org/bob
dcterms:publisher
http://example.org

Source: `http://www.w3.org/TR/rdf11-primer/`

Blank Nodes



Quelle: `http://www.w3.org/TR/rdf11-primer/`

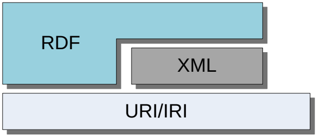
Resource Description Framework

Data Model for the Web of Data

1. URI/IRI – Uniform / Internationalized Resource Identifiers
2. Resource Description Framework (RDF)
3. Linked Data – Web of Data
4. RDF Schema

Overview

RDF within the Semantic Web Stack



enabling technologies for the Semantic Web

- Identification mechanism
- Data model
- Data format

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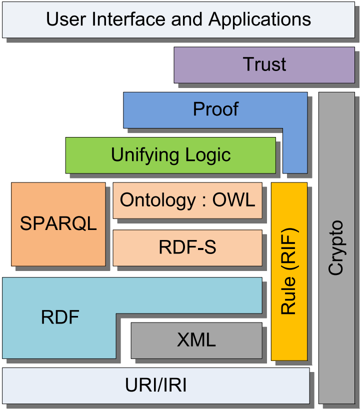

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URI/IRI – Uniform / Internationalized Resource Identifiers

Resources and their global identification

Everything is a Resource

- Files: documents, multimedia files, ontologies
- Things: objects, persons, products, abstract things such as countries, time periods, . . .
- Concepts: classes, relations
- Services
    - Services, in the sense of SOA, independent of a concrete implementation
    - Web Services, concrete implementations of services
    - . . .

Information vs. Non-Information Resource

Non-Information Resource

- Thing, Real-World-Entity
- e.g., the person ‘Bob’ is identified by `http://example.org/bob#me`

Information Resource

- Document, file on the Web; description, picture, or representation of a Non-Information Resource
- e.g., the RDF file that describes ‘Bob’ is identified by `http://example.org/bob`

- Information- and Non-Information Resources are disjoint
- ‘Ceci n’est pas une pipe’ `http://collections.lacma.org/node/239578`

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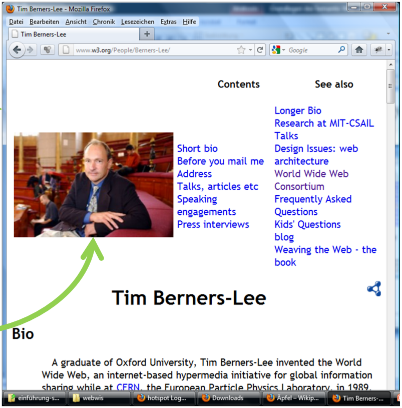
Information Resources

http://www.w3.org/People/Berners-Lee/index.html

http://www.w3.org/Press/Stock/Berners-Lee/2001-europaeum-eighth.jpg


Tim Berners-Lee - Mozilla Firefox
Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Hilfe
Tim Berners-Lee
www.w3.org/People/Berners-Lee/
Google
einführung-s...
webwis
hotspot Log...
Downloads
Apfel – Wikip...
Tim Berners-...

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Short bio
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Talks, articles etc
Speaking engagements
Press interviews

Longer Bio
Research at MIT-CSAIL
Talks
Design Issues: web architecture
World Wide Web Consortium
Frequently Asked Questions
Kids' Questions
blog
Weaving the Web - the book

Tim Berners-Lee

Bio

A graduate of Oxford University, Tim Berners-Lee invented the World Wide Web, an internet-based hypermedia initiative for global information sharing while at CERN, the European Particle Physics Laboratory, in 1989.

Information vs. Non-Information Resources

http://www.w3.org/People/Berners-Lee/card#i

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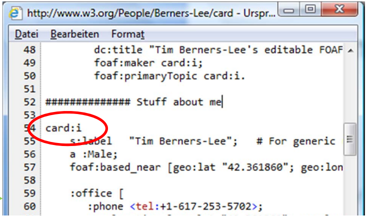

```
        dc:title "Tim Berners-Lee's editable FOAF
        foaf:maker card:i;
        foaf:primaryTopic card:i.

############### Stuff about me

card:i
    s:label   "Tim Berners-Lee";   # For generic
    a :Male;
    foaf:based_near [geo:lat "42.361860"; geo:lon

    :office [
       :phone <tel:+1-617-253-5702>;
```

No Unique Name Assumption

in databases: Unique Name Assumption

- Each tuple/object is identified by exactly one ID/OID
- Different objects in the database represent different things
- Or alternatively: There are only names and no objects. (Herbrand-Universe, Datalog)

in the Web: No Unique Name Assumption

- A single resource can be identified by multiple different IRIs.
- Every IRI identifies exactly one resource.

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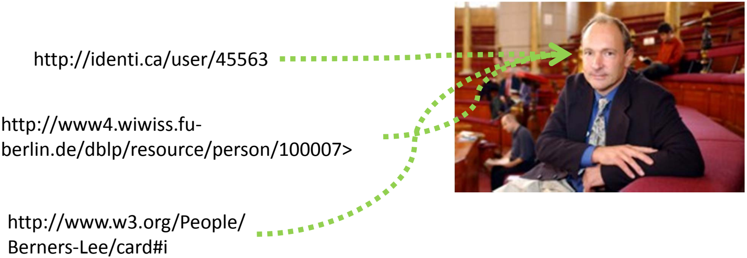

http://identi.ca/user/45563

http://www4.wiwiss.fu-berlin.de/dblp/resource/person/100007>

http://www.w3.org/People/Berners-Lee/card#i

Structure of HTTP-URIs

`http://www.foo.com/data/persons?family=black#john`

- Scheme
  `http`
- Authority
  `www.foo.com`
- Path
  `/data/persons`
- Query (optional)
  `?family=black`
- Fragment (optional, not part of an HTTP-Request)
  `john`

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Abbreviations of IRIs: Namespace Prefixes

without Namespace Prefixes

```
<http://www.dbpedia.org/resource/Linz>
<http://example.org/famblack.rdf#Jim>
```

with Namespace Prefixes

```
@prefix dbpedia: <http://www.dbpedia.org/resource/>.
@prefix f: <http://example.org/famblack.rdf#>.

dbpedia:Linz
f:Jim
```

Types of IRIs, Standards

Uniform Resource Locator (URL)

identification through access mechanism permits dereferencing, e.g., using HTTP or FTP

Uniform Resource Name (URN)

no dereferencing possible, e.g., urn:ISBN

Internationalized Resource Identifier (IRI)

Internationalized URI; allows Unicode characters

Types of IRIs, Standards

JKU

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IRI/URI – Summary

- ‘Everything’ is a resource
- Non-Information Resource vs. Information Resource
- Every IRI identifies exactly one resource
- No Unique Name Assumption: Multiple IRIs can identify the same resource

additional information:

- `http://www.w3.org/TR/webarch/#id-resources`
- `http://www.ietf.org/rfc/rfc3986`

Resource Description Framework (RDF)

A Data Model for the Web of Data

- Overview
- Data Model
- Serialization
- RDF Dataset, Named Graphs
- Summary

RDF

RDF is a data model for a

- **linked** (RDF Statement = Link),
- **decentralized** (distributed and without central control mechanism),
- **machine interpretable** (uniform and easily interpretable data model: a subject is described by a predicate and an object),
- **conceptual** (close to the mental conceptions of humans: direct representation of entities and their relations and properties)

description of resources.

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Related Technologies

- Frames
- Conceptual Graphs
- Topic Maps
- Metadata Frameworks
- RSS (Really Simple Syndication)
- . . .

RDF Statement (Triple)

subject

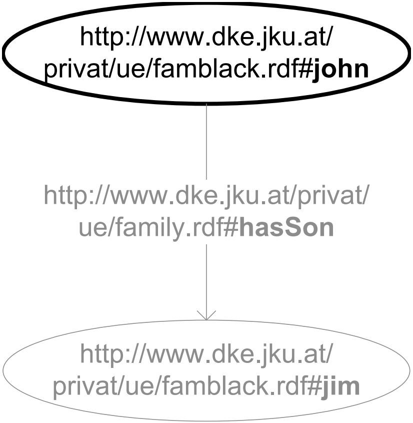
- IRI (Resource) or
- Blank Node

predicate

- IRI (Property)

object

- IRI (Resource),
- Blank Node or
- Literal


http://www.dke.jku.at/privat/ue/famblack.rdf#**john**
http://www.dke.jku.at/privat/ue/family.rdf#**hasSon**
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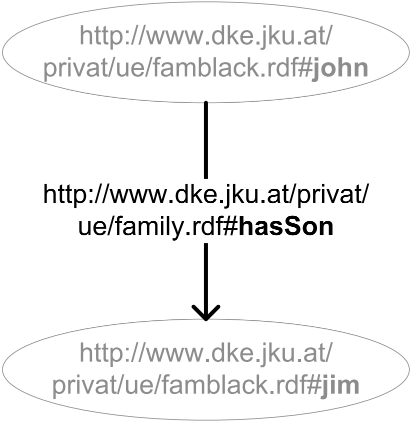

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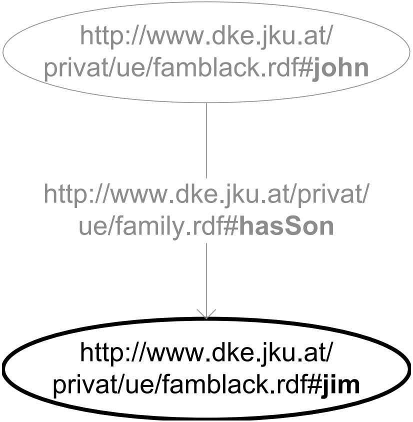
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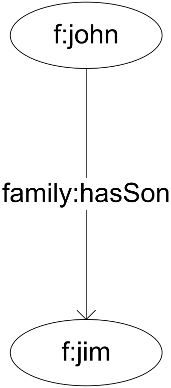
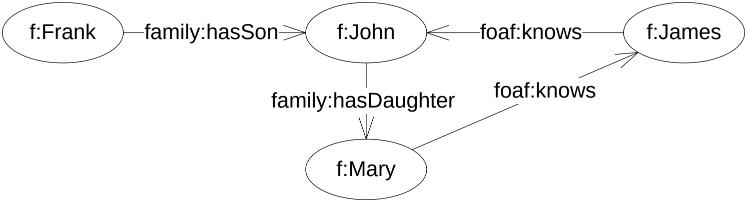


RDF Graph = Set of Statements

An RDF graph is a directed, labelled graph.



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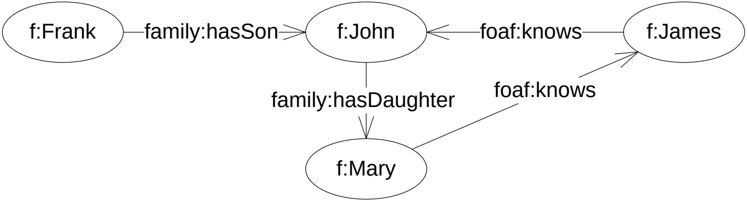
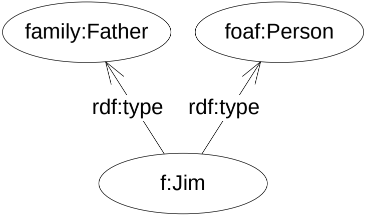


corresponds to a ternary relation (set of triples):

```
subject   predicate           object
---------------------------------------
f:Frank   family:hasSon       f:John
f:James   foaf:knows          f:John
f:John    family:hasDaughter  f:Mary
f:Mary    foaf:knows          f:James
```

Classification

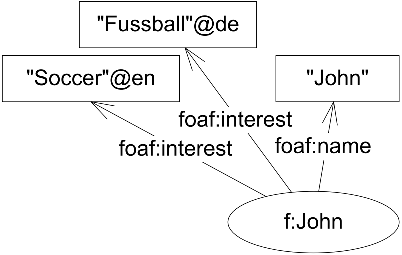
- `rdf:type`
- Multiple classifications possible
- No distinction between classes and individuals



Literals

Plain Literal

- Character string with optional language definition
- Represents itself
- in RDF 1.1, every literal has a type



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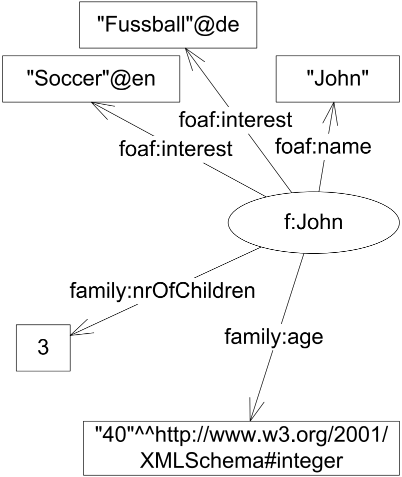
Typed Literal

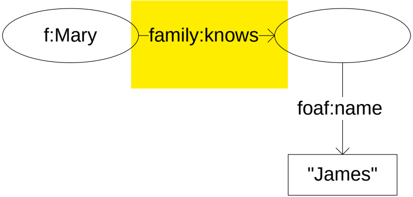
- Character string and data type URI
- Represents element from the data type's value space



Blank Nodes – Unnamed Nodes

- Auxiliary nodes
- Specification of IRI not necessary

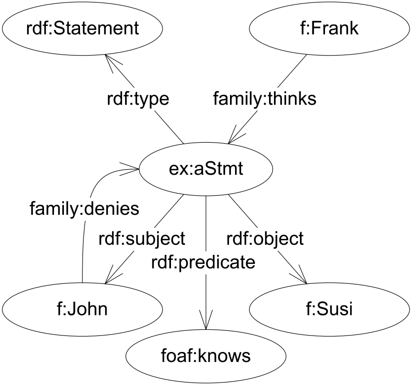
Mary knows someone who is called James.



Reification: Statements about Statements

- Statements as resources
- Particular vocabulary:
  - `rdf:subject`
  - `rdf:predicate`
  - `rdf:object`
  - `rdf:Statement`

Frank thinks that “John knows Susi”, John denies this.



Container and Collections

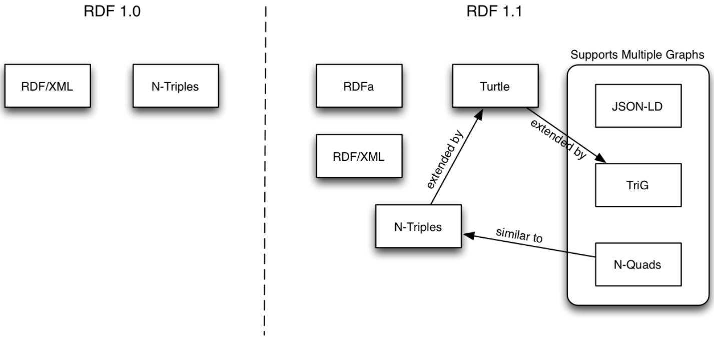
Container

- Adding additional elements is possible.
- `rdf:Bag`, `rdf:Seq`, `rdf:Alt`

Collection (Finalized List)

- No additional elements can be added.
- `rdf:List`, `rdf:first`, `rdf:rest`, `rdf:nil`

Serialization of RDF



Source: `http://www.w3.org/TR/rdf11-new/`

Serialization of RDF

Turtle family

Turtle and TriG offer a convenient, abbreviated notation for N-Triples and N-Quads.

RDF/XML

widespread; good tool support

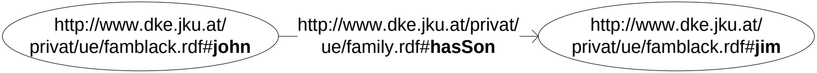
JSON-LD

JSON for Linked Data

RDFa

Embedding of RDF in HTML, Google Rich Snippets; alternative: Microdata (schema.org), Microformats

Turtle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<http://example.org/famblack.rdf#John>
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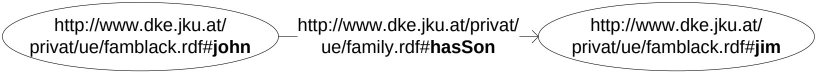
```

abbreviated notation using prefixes:

Turtle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@prefix f: <http://example.org/famblack.rdf#>.
```

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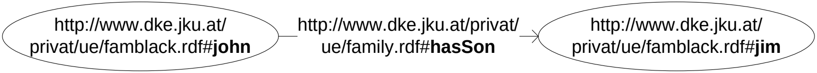

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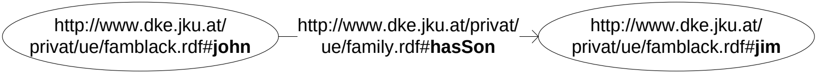
```

RDF/XML



http://www.dke.jku.at/privat/ue/famblack.rdf#**john**

http://www.dke.jku.at/privat/ue/family.rdf#**hasSon**

http://www.dke.jku.at/privat/ue/famblack.rdf#**jim**

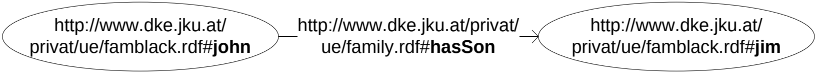
```
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:f="http://example.org/famblack.rdf#"
  xmlns:family="http://example.org/family.rdf#">






</rdf:RDF>
```

RDF/XML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http://www.dke.jku.at/privat/
ue/family.rdf#**hasSon**
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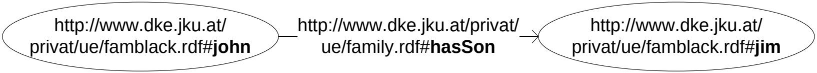
```
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:f="http://example.org/famblack.rdf#"
  xmlns:family="http://example.org/family.rdf#">
  <rdf:Description rdf:about=
        "http://example.org/famblack.rdf#John">


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

RDF/XML



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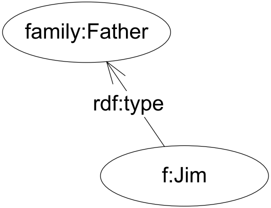
  xmlns:f="http://example.org/famblack.rdf#"
  xmlns:family="http://example.org/family.rdf#">
  <rdf:Description rdf:about=
        "http://example.org/famblack.rdf#John">
    <family:hasSon rdf:resource=
          "http://example.org/famblack.rdf#Jim"/>
  </rdf:Description>
</rdf:RDF>
```

Classification



Turtle:

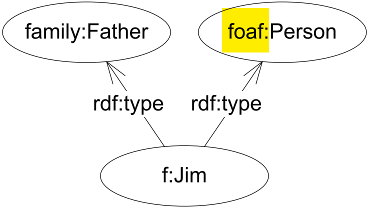
```
f:Jim a                    family:Father.
```

RDF/XML:

```
<family:Father rdf:about=
  "http://example.org/famblack.rdf#Jim">


</family:Father>
```

Classification



Turtle:

```
f:Jim a foaf:Person, family:Father.
```

RDF/XML:

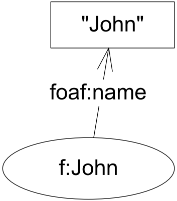
```
<family:Father rdf:about=
  "http://example.org/famblack.rdf#Jim">
  <rdf:type rdf:resource=
      "http://xmlns.com/foaf/0.1/Person"/>
</family:Father>
```

Literals (Turtle)

```
@prefix xsd: <http://www.w3.org/2001/XMLSchema#>.
```

.

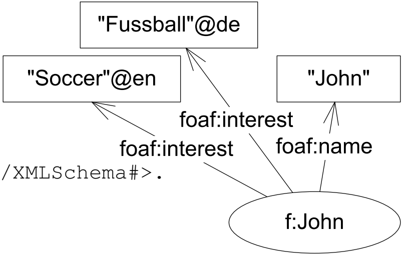
Literals (Turtle)



```
@prefix xsd: <http://www.w3.org/2001/XMLSchema#>.

f:John
    foaf:name "John";
                          .
```

Literals (Turtle)



```
@prefix xsd: <http://www.w3.org/2001/XMLSchema#>.

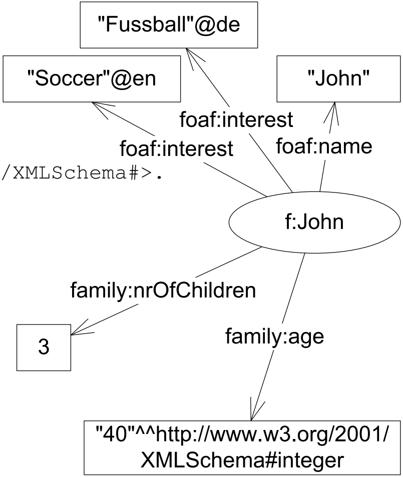
f:John
    foaf:name "John";
    foaf:interest "Soccer"@en,
                  "Fussball"@de;

                        .
```

Literals (Turtle)

```
@prefix xsd: <http://www.w3.org/2001/XMLSchema#>.

f:John
    foaf:name "John";
    foaf:interest "Soccer"@en,
                  "Fussball"@de;
    family:age "40"^^xsd:integer;
    family:nrOfChildren 3.
```



Literals (RDF/XML)

```
<rdf:Description rdf:about=
      "http://example.org/famblack.rdf#John">
   <foaf:name>John<foaf:name>








 </foaf:Person>
```

Literals (RDF/XML)

```
<rdf:Description rdf:about=
      "http://example.org/famblack.rdf#John">
   <foaf:name>John<foaf:name>
   <foaf:interest xml:lang="de">
       Fussball
   </foaf:interest>
   <foaf:interest xml:lang="en">
       Soccer
   </foaf:interest>









 </foaf:Person>
```

Literals (RDF/XML)

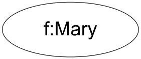
```
<rdf:Description rdf:about=
      "http://example.org/famblack.rdf#John">
   <foaf:name>John<foaf:name>
   <foaf:interest xml:lang="de">
       Fussball
   </foaf:interest>
   <foaf:interest xml:lang="en">
       Soccer
   </foaf:interest>
   <family:nrOfChildren rdf:datatype=
     "http://www.w3.org/2001/XMLSchema#integer">
       3
   </family:nrOfChildren>
   <family:age rdf:datatype=
      "http://www.w3.org/2001/XMLSchema#integer">
       40
   </family:age>
 </foaf:Person>
```

Blank Nodes

Turtle:

```
f:Mary

        .
```



RDF/XML:

```
<rdf:Description rdf:about=
  "http://example.org/famblack.rdf#Mary">



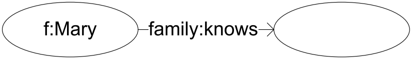
</rdf:Description>
```

Blank Nodes

Turtle:

```
f:Mary family:knows [

       ].
```



RDF/XML:

```
<rdf:Description rdf:about=
  "http://example.org/famblack.rdf#Mary">



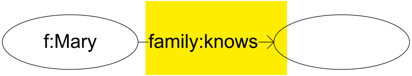
</rdf:Description>
```

Blank Nodes

Turtle:

```
f:Mary family:knows [

       ].
```



RDF/XML:

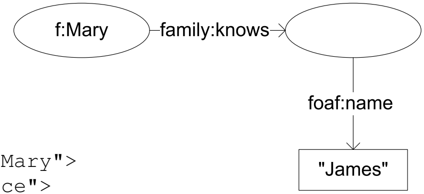
```
<rdf:Description rdf:about=
  "http://example.org/famblack.rdf#Mary">
  <foaf:knows rdf:parseType="Resource">

  </foaf:knows>
</rdf:Description>
```

Blank Nodes

Turtle:

```
f:Mary family:knows [
           foaf:name "James"
       ].
```



RDF/XML:

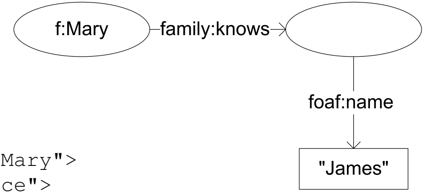
```
<rdf:Description rdf:about=
  "http://example.org/famblack.rdf#Mary">
  <foaf:knows rdf:parseType="Resource">

  </foaf:knows>
</rdf:Description>
```

Blank Nodes

Turtle:

```
f:Mary family:knows [
            foaf:name "James"
        ].
```



RDF/XML:

```
<rdf:Description rdf:about=
  "http://example.org/famblack.rdf#Mary">
  <foaf:knows rdf:parseType="Resource">
    <foaf:name>James</foaf:name>
  </foaf:knows>
</rdf:Description>
```

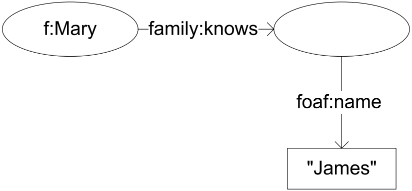
Blank Nodes - Alternative Turtle Notation

Turtle:

```
f:Mary family:knows [
    foaf:name "James"].
```

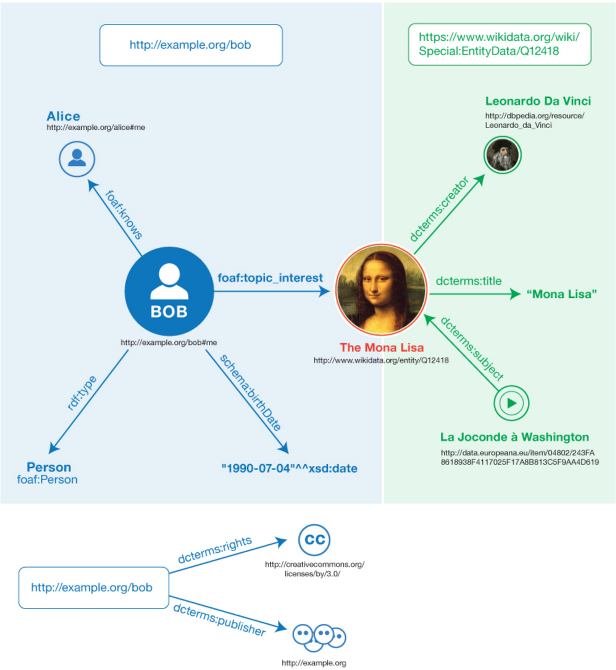
alternative Turtle notation:

```
f:Mary family:knows _:1.
_:1 foaf:name "James".
```



RDF Dataset, Named Graphs

- An RDF dataset consists of one or more RDF graphs.
  - one unnamed Default Graph
  - any number of Named Graphs
- Named Graphs are identified by an IRI or a Blank Node.
- Graphs can be linked.
- Statements can be made about graphs.
- A dataset can be serialized using N-Quads, TriG, or JSON-LD.



Quelle: `http://www.w3.org/TR/rdf11-primer/`

Serialization of an RDF Dataset using TriG

```
BASE   <http://example.org/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX schema: <http://schema.org/>
PREFIX dcterms: <http://purl.org/dc/terms/>
PREFIX wd: <http://www.wikidata.org/entity/>

GRAPH <http://example.org/bob>
  {
    <bob#me>
        a foaf:Person ;
        foaf:knows <alice#me> ;
        schema:birthDate "1990-07-04"^^xsd:date ;
        foaf:topic_interest wd:Q12418 .
  }

GRAPH <https://www.wikidata.org/wiki/Special:EntityData/Q12418>
  {
    wd:Q12418
        dcterms:title "Mona Lisa" ;
        dcterms:creator <http://dbpedia.org/resource/Leonardo_da_Vinci> .

    <http://data.europeana.eu/item/04802/243FA8618938F4117025F17A8B813C5F9AA4D619>
       dcterms:subject wd:Q12418 .
  }

<http://example.org/bob>
    dcterms:publisher <http://example.org> ;
    dcterms:rights <http://creativecommons.org/licenses/by/3.0/> .
```

Source: http://www.w3.org/TR/rdf11-primer/

RDF – Summary

- RDF is a data model for the linked, decentralized, machine interpretable, conceptual description of resources.
- Every statement is a triple in the form of a subject-predicate-object expression.
- Sets of RDF statements form a graph.
- There are multiple formats for serializing RDF, e.g., Turtle, RDF/XML.
- To be continued ...

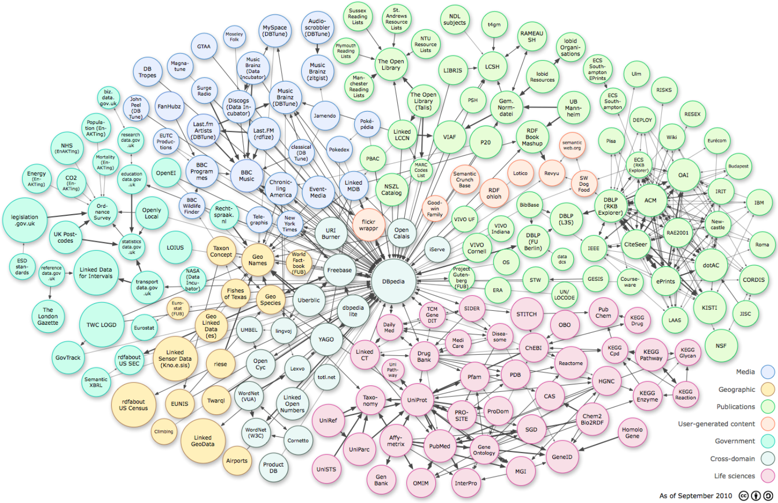
Further Information

- RDF 1.1 Primer
  `http://www.w3.org/TR/rdf11-primer/`
- Current Recommendations: RDF 1.1
  `http://www.w3.org/standards/techs/rdf`
- List of tools for working with RDF
  `http://www.w3.org/RDF/`

Linked Data – Web of Data

The Web as *Decentralized* Database

Linked Data Cloud



Linking Open Data cloud diagram, by Richard Cyganiak and Anja Jentzsch. `http://lod-cloud.net/`

Linked Data – Data Sources

- DBPedia `http://dbpedia.org`
- Wikidata `http://www.wikidata.org/`
- Google Knowledge Graph Search API `https://developers.google.com/knowledge-graph/`
- GeoNames `http://www.geonames.org/`
- data.gov.uk `http://data.gov.uk/data/search?res_format=RDF`
- datahub `http://datahub.io/dataset`
- Freebase; foundation for Google Knowledge Graph `http://www.freebase.com`, `https://developers.google.com/freebase/`

Web of Documents → Web of Data

- Starting point: Vast amount of unstructured data and knowledge in the Web represented as hypertext
- Problem: Knowledge and data extraction is difficult and only partially supported by machines. Document Retrieval (search engines), Browsing, reading
- Goal: Query (analogous to database)

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JKU

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Databases → Web of Data

- Starting point: Vast amount of structured data in databases
- Problem: Data integration
  - heterogeneous data models
  - heterogeneous conceptualizations
  - heterogeneous database schemas
  - instance level: duplicates, referencing
- Goal: simple, inter-organizational integration of databases
- First steps (Web of Data):
  - RDF as data model for integration (DB→RDF Mappings)
  - Ontologies, Ontology Mappings
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  - IRIs as global IDs, linking, sameAs

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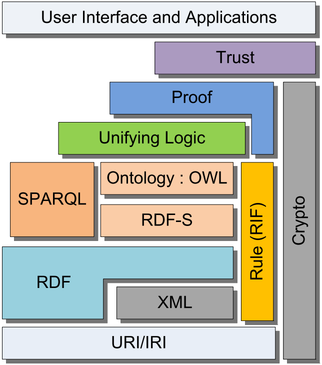
Semantic Web Stack



Semantic Web is more difficult than initially thought.
Technologies are in part still

- **not mature**:
  Unifying Logic, Proof, Trust
- **too complex** for efficient computation:
  Reasoning, . . .
- **too difficult** in their application:
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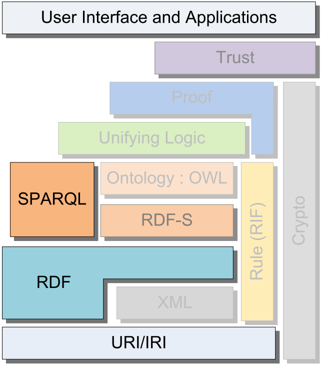

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Keep it Simple!

Related Approaches and Technologies

- Mashups (ad-hoc, not generic)
- Semantic Search (automatic identification of entities and relationships in hypertext; very complex)
- Web Data Extraction, Lixto
- Database integration
- Distributed databases
- . . .

Linked Data on the Web

- Distributed and linked RDF data
- Non-local IRIs in RDF documents as links to other documents
- RDF Statements as typed links

Four rules:

- Use IRIs as names for things.
- Use HTTP IRIs so that people can look up those names.
- When someone looks up a IRI, provide useful information.
- Include links to other IRIs. so that they can discover more things.

(Berners-Lee, `http://www.w3.org/DesignIssues/LinkedData.html`)

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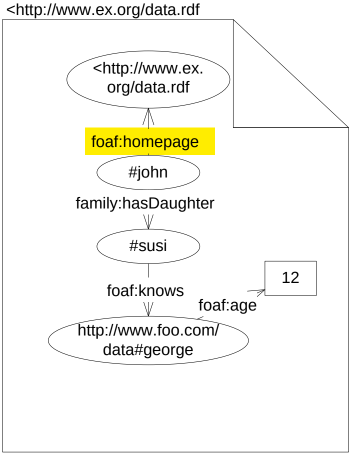
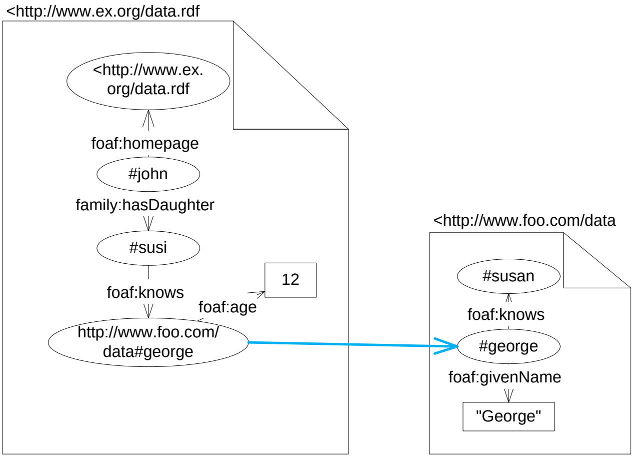
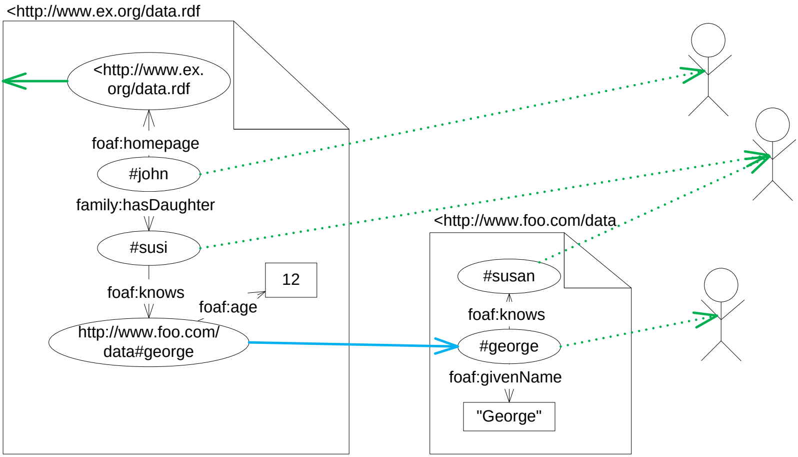
Distributed RDF



Distributed RDF



Distributed RDF



URIs for Non-Information Resources

- How to name things and concepts and how to access their description?
- Variant 1: Hash-URIs
- Variant 2: 303 Response

URIs for Non-Information Resources

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Variant 1: Hash-URIs

- Tim Berners-Lee
  `http://www.w3.org/People/Berners-Lee/card#i`
- Description of Tim-Berners-Lee
  `http://www.w3.org/People/Berners-Lee/card`

Variant 1: Hash-URIs

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Dereferencing of
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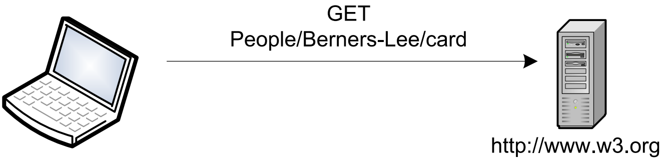

GET
People/Berners-Lee/card

http://www.w3.org

Variant 1: Hash-URIs

- Tim Berners-Lee
  `http://www.w3.org/People/Berners-Lee/card#i`
- Description of Tim-Berners-Lee
  `http://www.w3.org/People/Berners-Lee/card`

Dereferencing of
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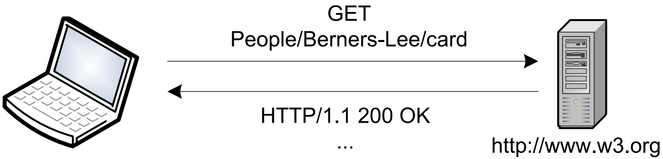

Variant 2: 303 Response

- Linz
  `http://de.dbpedia.org/resource/Linz`
- Description of Linz
  `http://de.dbpedia.org/data/Linz`

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- Linz

  `http://de.dbpedia.org/resource/Linz`
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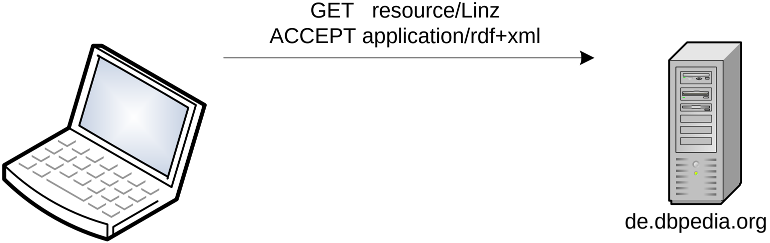

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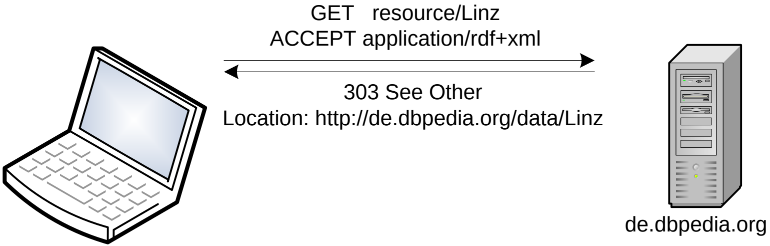
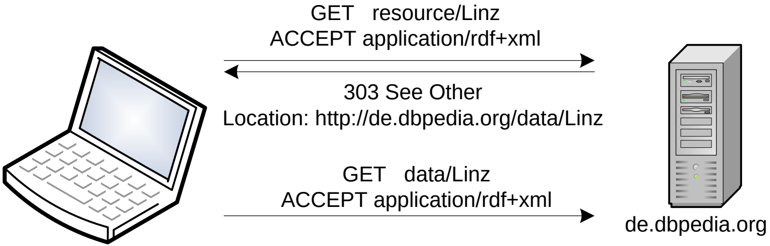

GET resource/Linz
ACCEPT application/rdf+xml
303 See Other
Location: http://de.dbpedia.org/data/Linz
de.dbpedia.org

Variant 2: 303 Response

- Linz
  `http://de.dbpedia.org/resource/Linz`
- Description of Linz
  `http://de.dbpedia.org/data/Linz`

Dereferencing of
`http://de.dbpedia.org/resource/Linz`?



GET resource/Linz
ACCEPT application/rdf+xml

303 See Other
Location: http://de.dbpedia.org/data/Linz

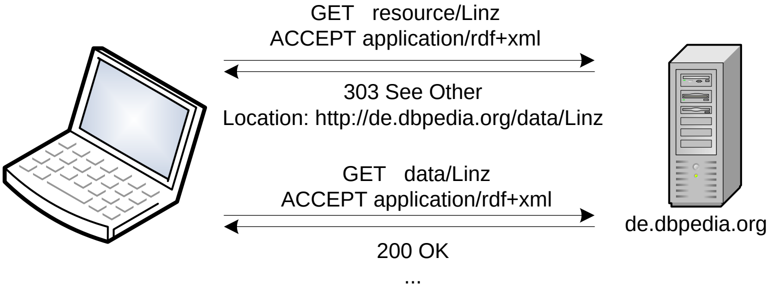
GET data/Linz
ACCEPT application/rdf+xml

de.dbpedia.org

Variant 2: 303 Response

- Linz
  `http://de.dbpedia.org/resource/Linz`
- Description of Linz
  `http://de.dbpedia.org/data/Linz`

Dereferencing of
`http://de.dbpedia.org/resource/Linz`?



GET resource/Linz
ACCEPT application/rdf+xml

303 See Other
Location: http://de.dbpedia.org/data/Linz

GET data/Linz
ACCEPT application/rdf+xml

200 OK
...

rdfs:seeAlso

`rdfs:seeAlso` is used to indicate that additional information can be found at the referenced location.

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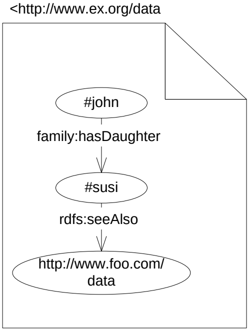

rdfs:seeAlso

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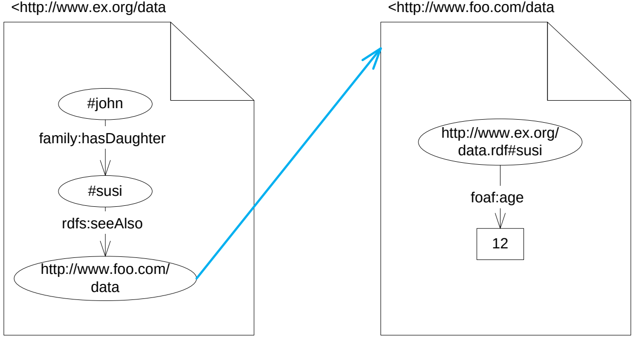

owl:sameAs

`owl:sameAs` is used to indicate that two IRIs identify the same Resource.

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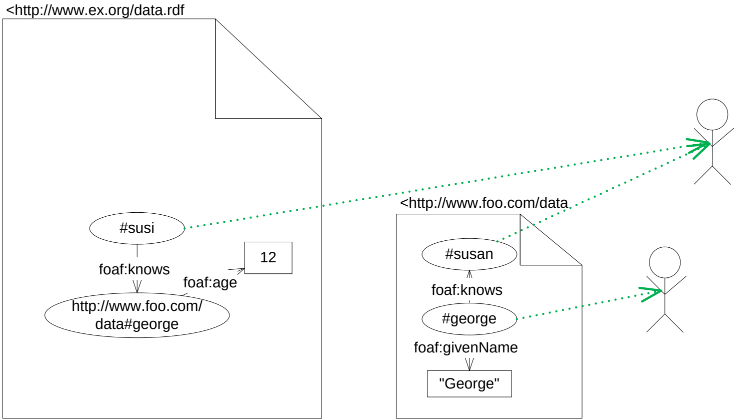

owl:sameAs

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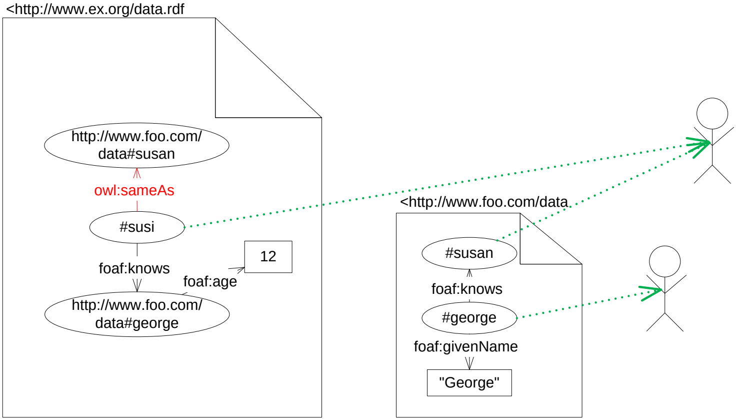


Summary

Linked Data on the Web

- Linked data are distributed, linked RDF data.
- HTTP-URLs are used as identifiers and locators of Information and Non-Information Resources.

Further Reading

- How to Publish Linked Data on the Web
  `http://wifo5-03.informatik.uni-mannheim.de/bizer/pub/LinkedDataTutorial/`
- Christian Bizer, Tom Heath, Tim Berners-Lee: Linked Data - The Story So Far. Int. J. Semantic Web Inf. Syst. 5(3): 1-22 (2009)
- Nigel Shadbolt, Kieron O'Hara, Tim Berners-Lee, Nicholas Gibbins, Hugh Glaser, Wendy Hall, m. c. schraefel: Linked Open Government Data: Lessons from Data.gov.uk. IEEE Intelligent Systems 27(3): 16-24 (2012)

RDF Schema

RDF Vocabulary Description Language

- Selected Language Elements
- RDFS Examples

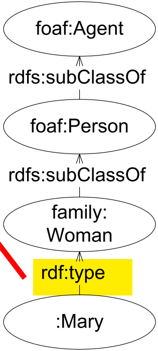
Class Hierarchies

"a" und "rdf:type" können beide dafür verwendet werden

Given:

```
:Mary a family:Woman.
family:Woman rdfs:subClassOf
                   foaf:Person.
foaf:Person rdfs:subClassOf
                   foaf:Agent.
```

Deduced:



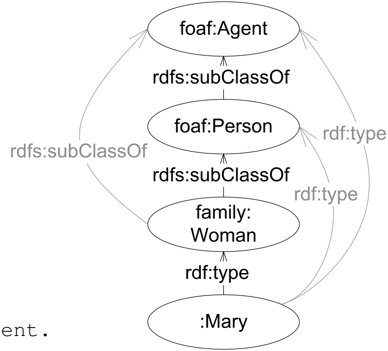
Class Hierarchies

Given:

```
:Mary a family:Woman.
family:Woman rdfs:subClassOf
                   foaf:Person.
foaf:Person rdfs:subClassOf
                   foaf:Agent.
```

Deduced:

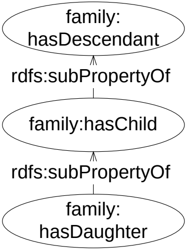
```
:Mary a foaf:Person.
:Mary a foaf:Agent.
family:Woman rdfs:subClassOf foaf:Agent.
```



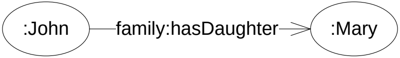
Property Hierarchies

Given:

```
family:hasDaughter
   rdfs:subPropertyOf
        family:hasChild.
family:hasChild
   rdfs:subPropertyOf
     family:hasDescendant.
:John family:hasDaughter :Mary.
```



Deduced:



Property Hierarchies

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family:hasChild
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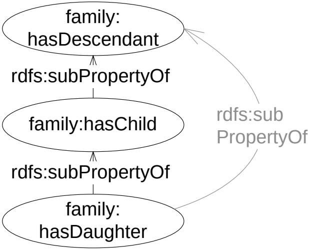
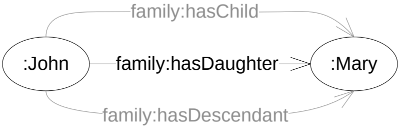


Deduced:

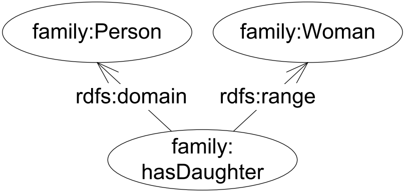
```
family:hasDaughter
   rdfs:subPropertyOf
        family:hasDescendant.
:John family:hasChild :Mary.
:John family:hasDescendant :Mary.
```



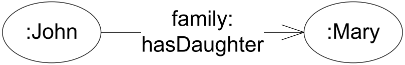
Domain and Range of Properties

Given:

```
family:hasDaughter
  rdfs:domain family:Person;
  rdfs:range family:Woman.
:John family:hasDaughter :Mary.
```



Deduced:



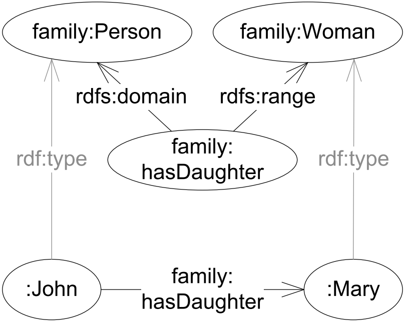
Domain and Range of Properties

Given:

```
family:hasDaughter
  rdfs:domain family:Person;
  rdfs:range family:Woman.
:John family:hasDaughter :Mary.
```

Deduced:

```
:John a family:Person.
:Mary a family:Woman.
```

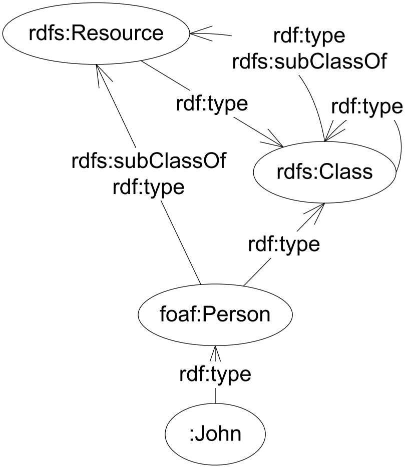


Metamodeling

No separation between model levels:

- Individuals, such as `:John`
- Classes, such as `family:Person`
- Metaclasses, such as `rdfs:Class`

A class can be a member of itself. Attention, this is not compatible with OWL DL!



RDF Schema – Summary

- RDF Schema is a semantic extension of RDF
- It is used to define simple vocabularies (Concepts/Classes and Properties)
- Further Reading:
  `http://www.w3.org/TR/rdf-schema/`

RDFS Examples

RDF Schema (1)

The following sample document is given:

```
...
:hasYoungDaughter rdfs:subPropertyOf :hasDaughter.
:hasDaughter rdfs:range :Women.
:hasChild rdfs:range :Person;
          rdfs:domain :Person.
:Women rdfs:subClassOf :Person.
:Maria :hasYoungDaughter :Susi.
```

Can the following statements be deduced?

- `:Maria a :Person`
- `:Maria :hasChild :Susi`
- `:Susi a :Women`
- `:Susi a :Person`
- `:Maria :hasDaughter :Susi`

RDF Schema (1)

The following sample document is given:

```
...
:hasYoungDaughter rdfs:subPropertyOf :hasDaughter.
:hasDaughter rdfs:range :Women.
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          rdfs:domain :Person.
:Women rdfs:subClassOf :Person.
:Maria :hasYoungDaughter :Susi.
```

Can the following statements be deduced?

- `:Maria a :Person` no
- `:Maria :hasChild :Susi`
- `:Susi a :Women`
- `:Susi a :Person`
- `:Maria :hasDaughter :Susi`

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Can the following statements be deduced?

- `:Maria a :Person` no
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- `:Susi a :Women`
- `:Susi a :Person`
- `:Maria :hasDaughter :Susi`

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- `:Susi a :Person`
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- `:Susi a :Women` yes
- `:Susi a :Person` yes
- `:Maria :hasDaughter :Susi`

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:Maria :hasYoungDaughter :Susi.
```

Can the following statements be deduced?

- `:Maria a :Person` no
- `:Maria :hasChild :Susi` no
- `:Susi a :Women` yes
- `:Susi a :Person` yes
- `:Maria :hasDaughter :Susi` yes

RDF Schema (2)

Can the following information be modeled using RDF(S)? If so, provide a solution:

- Each person knows its children.
- Each car is a vehicle.
- Only persons can own things; everyone who owns something is a person.
- Every father has at least one child.

RDF Schema (2)

Can the following information be modeled using RDF(S)? If so, provide a solution:

- Each person knows its children.

```
:hasChild rdfs:subPropertyOf foaf:knows.
```

- Each car is a vehicle.
- Only persons can own things; everyone who owns something is a person.
- Every father has at least one child.

RDF Schema (2)

Can the following information be modeled using RDF(S)? If so, provide a solution:

- Each person knows its children.

```
    :hasChild rdfs:subPropertyOf foaf:knows.
```

- Each car is a vehicle.

```
    :Car rdfs:subClassOf :Vehicle.
```

- Only persons can own things; everyone who owns something is a person.

- Every father has at least one child.

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Can the following information be modeled using RDF(S)? If so, provide a solution:

- Each person knows its children.

```
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```

- Each car is a vehicle.

```
:Car rdfs:subClassOf :Vehicle.
```

- Only persons can own things; everyone who owns something is a person.

```
:owns rdfs:domain :Person.
```

- Every father has at least one child.

beispiele:

RDF Schema (2)

Can the following information be modeled using RDF(S)? If so, provide a solution:

- Each person knows its children.

```
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```

- Each car is a vehicle.

```
:Car rdfs:subClassOf :Vehicle.
```

- Only persons can own things; everyone who owns something is a person.

```
:owns rdfs:domain :Person.
```

- Every father has at least one child.

```
no solution
```

extra hint:
für typenbeschreibung funktioniert Bsp "Mary is a Person"
:Mary a :Person . ODER   :Mary rdf:type :Person .

extra hint 2:
für Integer funktioniert Bsp "Mary ist 27 Jahre alt"
:Mary foaf :age 27 . ODER   :Mary foaf:age "27"^^xsd:integer .