LINKED DATA

Potenzial und Nutzen

Dr. Steffen Lohmann

11. November 2016
Stuttgart
Evolution of the Web

Web of Documents  ➔  Web of Data

Hyperlinks  ➔  Typed Links

"Documents"  ➔  "Things"

https://www.futurelearn.com/courses/linked-data/0/steps/16079
Web of Documents

Stuttgart


https://de.wikipedia.org/wiki/Stuttgart
Web of Data

About: Stuttgart

An Entity of Type: Siedlung, from Named Graph: http://dbpedia.org, within Data Space: dbpedia.org

Stuttgart (ˈʃtʊtɡaʁt; German pronunciation: [ʃtʊtgaʁt], Swabian: Schduagert, pronounced [ʃ杕ʊəɡɛɾt]) is the capital and largest city of the state of Baden-Württemberg in southwest Germany. The eighth largest city in Germany, Stuttgart has a population of 600,068 (October 2014) while the greater Stuttgart Metropolitan Region has a population of 5.3 million (2006), being the fourth-biggest in Germany after the Rhine-Ruhr area, Berlin/Brandenburg and Frankfurt/Rhine-Main.

Property Value

- dbo:leaderName dbr:Fritz_Kuhn
- dbo:leaderTitle Oberbürgermeister (en)
- dbo:populationTotal 604297 (xsd:integer)
- dbo:postalCode 70173–70619
- is dbo:birthPlace of dbr:Eberhard_Weber
  dbr:Ferdinand_Alexander_
  dbr:Klaus_Schedl
  dbr:Bernard_Tomic
  dbr:Fritz_Leonhardt
  dbr:Hans_Wilhelm_König
  dbr:Alexander_Tuschinski
  dbr:Frederick_Leyboldt
  dbr:Gottlob_Christian_Sto
  dbr:Gustav_Friedrich_Het
  dbr:Hermann_Plocher
  dbr:Nadine_Hildebrand
  dbr:Patrick_Auracher

http://dbpedia.org/page/Stuttgart

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S. Lohmann: Linked Data - Potenzial und Nutzen
Based on RDF Statements

Stuttgart

Mayor

Fritz_Kuhn

Subject

Predicate

Object

Stuttgart

Mayor

Fritz_Kuhn;

Ferdinand_Porsche

Birthplace

Stuttgart;

Fritz_Kuhn

Mayor

Ferdinand_Porsche

Birthplace

Stuttgart
DHL

---

DHL International GmbH

---

Logistics

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Logistik

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Post Tower

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Bonn

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DHL International GmbH

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DHL
Potential: Relationship Discovery

Ferdinand Porsche was an Austrian-German automotive engineer and honorary Doctor of Engineering. He is best known for creating the first hybrid vehicle (gasoline–electric), the Volkswagen Beetle, and the Mercedes-Benz SSK, as well as the first of many Porsche automobiles. Porsche designed the 1923 Benz Tropfenwagen, which was the first race car with mid-engine, rear-wheel drive layout. Known in business circles as the "great engineer", he made a number of contributions to advanced German tank design: Tiger I, Tiger II, and the Ferdinand as well as the super-heavy Panzer VIII Maus tank, which was never put into production. He also made contributions in aircraft design, including the Junkers Ju 88, and the...
Knowledge Representation with RDF

Alice

is a friend of

Person

is born on

14 July 1990

BOB

is interested in

The Mona Lisa

was created by

Leonardo Da Vinci

is about

La Joconde à Washington
Knowledge Representation with RDF

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

Alice
http://example.org/alice#me

Bob
http://example.org/bob#me

Leonardo Da Vinci
http://dbpedia.org/resource/Leonardo_da_Vinci

The Mona Lisa
http://www.wikidata.org/entity/Q12418

La Joconde à Washington
http://data.europeana.eu/item/04802/243FA8618938F4117025F17A8B813C5F9AA4D619

https://www.w3.org/TR/2014/NOTE-rdf11-primer-20140624/
Knowledge Representation with RDF

```xml
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/>

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

wd:Q12418
  dcterms:title "Mona Lisa" ;
```
XML Serialization of RDF

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix dbp: <http://dbpedia.org/property/> .
@prefix dbr: <http://dbpedia.org/resource/> .

XML Serialization of RDF

```xml
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix dbp: <http://dbpedia.org/property/> .
@prefix dbr: <http://dbpedia.org/resource/> .


<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:dbp="http://dbpedia.org/property/">
  <rdf:Description rdf:about="http://dbpedia.org/resource/Stuttgart">
    <dbp:mayor rdf:resource="http://dbpedia.org/resource/Fritz_Kuhn"/>
  </rdf:Description>
  <rdf:Description rdf:about="http://dbpedia.org/resource/Ferdinand_Porsche">
  </rdf:Description>
</rdf:RDF>
```
Semantic Web “Layer Cake” 2000

https://www.w3.org/2000/Talks/1206-xml2k-tbl/slide10-0.html
Semantic Web “Layer Cake” 2015

- RDF
- RDF/XML
- JSON
- XML
- Unicode
- SPARQL
- RDF Data Shapes
- RDF Schema
- Vocabularies
- SKOS Thesauri
- Ontologies
- SWRL Rules
- Logic

(Access control), Signature, Encryption (HTTPS/CERT/DANE)

IRIs

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Vocabularies (Ontologies)

```
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/>

<bob#me>
    a foaf:Person ;
    foaf:knows <alice#me> ;
    schema:birthDate "1990-07-04"^^xsd:date ;
    foaf:topic_interest wd:Q12418 .

wd:Q12418
    dcterms:title "Mona Lisa" ;
```
Vocabularies: RelFinder

Ferdinand Porsche (3 September 1875 – 30 January 1951) was an Austrian-German automotive engineer and honorary Doctor of Engineering. He was best known for creating the first hybrid vehicle (gasoline-electric), the Volkswagen Beetle, and the Mercedes-Benz SSK/SSK1 as well as the first of many Porsche automobiles. Porsche designed the 1923 Benz Typ Tropfenwagen, which was the first race car with mid-engine, rear-wheel drive layout. Known in business circles as the "great engineer", he made a number of contributions to advanced German tank designs: Tiger I, Tiger II, and the Elefant as well as the super-heavy Panzer VIII Maus tank, which was never put into production. He also made contributions in aircraft design, including the Junkers Ju 88, and the...
Vocabularies (Ontologies)

FOAF vocabulary visualized with VOWL
Linked Open Vocabularies (LOV)

https://lov.okfn.org/dataset/lov/
Querying Linked Data
SPARQL Queries

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dbpp: <http://dbpedia.org/property/>
PREFIX dbpr: <http://dbpedia.org/resource/>
PREFIX dbpo: <http://dbpedia.org/ontology/>

SELECT ?Node1
WHERE {
  ?Node1 a foaf:Person .
  ?Node2 a dbpo:University .
  { ?Node1 ?Link5 dbpr:Barack_Obama . }
  UNION { dbpr:Barack_Obama ?Link5 ?Node1 . }
  ?Node3 a dbpo:PoliticalParty .
}
```
SPARQL Queries

PREFIX dbpedia-owl: <http://dbpedia.org/ontology/>
PREFIX dbpprop: <http://dbpedia.org/property/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>

SELECT DISTINCT (COUNT(DISTINCT ?a) AS ?f)
WHERE {
  ?a a dbpedia-owl:Island.
  ?a dbpprop:population ?b.
  FILTER(?b >= 10000).
  {?a dbpprop:location/rdfs:label ?c.
   ?a dbpprop:areaKm ?d.
   FILTER(contains(ucase(?c), ucase("Asia"))
     && ?d >= 1000).
   UNION 
   {?a dbpprop:location/rdfs:label ?e.
   FILTER(contains(ucase(?e), ucase("Europe")))
   }.
  }
}
Linking Open Data (LOD) Cloud

http://lod-cloud.net
Linking Open Data (LOD) Cloud
Linked Data Principles

1. Use URIs to identify the “things” in your data

2. Use HTTP URIs so people (and machines) can look them up on the web

3. When a URI is looked up, return a description of the thing (in RDF format)

4. Include links to related things
Vocabulary Development (VoCol)

- Authoring
- Validation
- Issue tracking
- Documentation
- Publishing
- Visualization
- Modeling
- Vocabulary
- Queries
- Data
- Testing
- Population

VoCol

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Example: Linked Machine Data
Example: Linked Machine Data
## Example: Linked Machine Data

### Properties of Machine

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PrefLabel</td>
<td>Maschine@de; Machine@en;</td>
</tr>
<tr>
<td>Definition</td>
<td>A generic Machine class for grouping all machine together.@en</td>
</tr>
<tr>
<td>SeeAlso</td>
<td><a href="http://dbpedia.org/page/Machine">http://dbpedia.org/page/Machine</a></td>
</tr>
</tbody>
</table>

### Properties of Machine

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>hasInstallationDate</td>
<td>date</td>
<td>Date when the Machine installation was completed.</td>
</tr>
<tr>
<td>hasMachineStatus</td>
<td>string</td>
<td>Points to a specific status of the machine.</td>
</tr>
<tr>
<td>hasNote</td>
<td>string</td>
<td>Points to a note of the machine.</td>
</tr>
<tr>
<td>hasOperator</td>
<td>MachineOperator</td>
<td>Person(s) who operates the Machine.</td>
</tr>
<tr>
<td>hasPlannedEndTime</td>
<td>date</td>
<td>Points to the date in which the machine is planned to end a certain order.</td>
</tr>
<tr>
<td>hasPlannedStartTime</td>
<td>dateTime</td>
<td>Points to the date in which the machine is planned to start a certain order.</td>
</tr>
<tr>
<td>hasRealEndTime</td>
<td>date</td>
<td>Points to the date in which the machine actually ended a certain order.</td>
</tr>
<tr>
<td>hasRealStartTime</td>
<td>date</td>
<td>Points to the date in which the machine actually started a certain order.</td>
</tr>
<tr>
<td>hasVersionDescription</td>
<td>string</td>
<td>Describes the version of the machine.</td>
</tr>
<tr>
<td>inInPlant</td>
<td>Plant</td>
<td>Points to the location of a machine.</td>
</tr>
<tr>
<td>isDevelopedBy</td>
<td>string</td>
<td>Points to the original manufacturer of the machine.</td>
</tr>
</tbody>
</table>
Example: Linked Machine Data
Example: Querying Machine Data
Example: Querying Machine Data

<table>
<thead>
<tr>
<th>Werk</th>
<th>Bezeichnung</th>
<th>APL</th>
<th>Aktueller FAUF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0072</td>
<td>Deckel Maho Gildemeister DMC 80 FD</td>
<td>12118554</td>
<td>1773564</td>
</tr>
</tbody>
</table>

> Open work orders

<table>
<thead>
<tr>
<th>Auftragsnummer</th>
<th>AVO</th>
<th>APO-Text</th>
<th>Status</th>
<th>Arbeitsplatz</th>
<th>Mat.-Nr.</th>
<th>Materialtext</th>
<th>Sollmenge</th>
<th>Ist-Menge</th>
<th>Gutmenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1773564</td>
<td>0060</td>
<td>BO.U GR KPL</td>
<td>80</td>
<td>85076863</td>
<td>0618346530000</td>
<td>IR_RTC260-0011</td>
<td>23 St.</td>
<td>5 St.</td>
<td>5 St.</td>
</tr>
<tr>
<td>1773178</td>
<td>0050</td>
<td>BO U GR 1.SEITE KOMPL. 2.SEITE GR V.HAND</td>
<td>45</td>
<td>85076863</td>
<td>0729496190000</td>
<td>AU.ZKLD325-0311</td>
<td>23 St.</td>
<td>0 St.</td>
<td>0 St.</td>
</tr>
<tr>
<td>1827634</td>
<td>0030</td>
<td>DREH u Bohren kpl Z-0013</td>
<td>45</td>
<td>85076863</td>
<td>0588227200000</td>
<td>F-227870.01-0011.EXR.DML3E</td>
<td>220 St.</td>
<td>0 St.</td>
<td>0 St.</td>
</tr>
</tbody>
</table>

Query work orders
Example: Querying Temperature

Analytics

Graph Type: BarChart
SPARQL endpoint: http://localhost:2020/sparql

Query: Maximum Value from Sensor Data

PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX om: <http://www.wurvoc.org/vocabularies/om-1.8/>
PREFIX rami: <http://w3id.org/i40/rami/>

SELECT ?time ?value WHERE {
    ?measurement rami:recordedTime ?time ;
    om:Temperature ?value .
    FILTER (xsd:dateTime(?time) >= "2015-01-29T10:00:00Z"^^xsd:dateTime)
    FILTER (xsd:dateTime(?time) <= "2015-01-29T11:00:00Z"^^xsd:dateTime)
}
ORDER BY DESC(?value) LIMIT 20
Example: Querying Temperature

Analytics

Graph Type: BarChart
Query: Maximum Value from Sensor Data
SPARQL endpoint: http://localhost:2020/sparql

![Bar Chart Example]

Value

Year
Example: Energy Consumption
Example: Linked Machine Data
Industrial Data Space
Data Integration
Data Analysis
Data Visualization
Linked Data

Vocabulary Development
Semantic Technologies
Industry 4.0
Internet of Things

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Enterprise Information Systems (University of Bonn)