IN3060/4060 – Semantic Technologies – Spring 2021

Lecture 15: Publishing RDF Data on the Web

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Today's Plan

1. Relevant highlights from RDF lecture
2. Linked (Open) Data
3. Conclusion

Outline

1. Relevant highlights from RDF lecture
2. Linked (Open) Data
3. Conclusion

RDF

- Why URIs?
  - URIs naturally have a “global” scope, unique throughout the web.
  - URLs are also addresses.
  - *“A web of data.”*
- Why triples?
  - Any information format can be transformed to triples.
  - Relationships are made explicit and are elements in their own right
  - Again, *“A web of data”*.

RDF on the web: Where is it?

- In files:
  - In some serialisation format: XML/RDF, Turtle, . . .
  - Typically small RDF graphs, i.e., max. a few 100 triples, e.g.,
    - Vocabularies: `http://xmlns.com/foaf/spec/index.rdf`.
    - Tiny datasets: `http://folk.uio.no/martingi/foaf.rdf`.
- "Behind" *SPARQL endpoints*:
  - Data kept in a *triple store*, i.e., a database.
  - RDF is served from endpoint as results of *SPARQL queries*.
  - Exposes data (in different formats)
    - with endpoint frontends, e.g., `http://dbpedia.org/resource/Norway`, or
    - by direct SPARQL query: `http://dbpedia.org/sparql`.

Publishing RDF on the web

- If URIs of resources are dereferencable. . .
- . . . clients can use URIs to request a description of the resource.
- Make data available in different formats. Typically:
  - HTML for humans,
  - RDF for computers.
- This is called *content negotiation*.
- Endpoint frontends will do all of this for you.
- In this lecture, we look at some of the technicalities.

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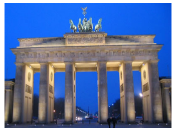
URIs

- URIs in RDF can have many different forms:
  - `http://www.google.com/` – a web page
  - `mailto:jsmith@example.com` – a mailbox
  - `http://dbpedia.org/resource/Oslo` – a town
  - `http://folk.uio.no/martingi/foaf#me` – a person
  - `tel:+47-22855050` – a telephone line
  - `urn:isbn:0-395-36341-1` – a book
- Two basic types
  - "information resources": downloadable documents.
  - "non-information resources": other entities.

The Problem and Two Solutions

- The problem:
  - Need to locate information *about* a resource.
  - The same URI cannot denote a *downloadable* resource.
- Example: Need to differentiate between:
  - A web page or RDF file about Berlin.
  - The city of Berlin.

 ≠

- Two W3C-recommended solutions:
  - The hash-namespace solution.
  - The slash-namespace solution (aka HTTP 303 redirects).
- To fully understand them, we need to have a look at HTTP.

HTTP

- HTTP Server listens to "requests" (usually on TCP/IP port 80).
- An HTTP client sends requests to the server and obtains responses.
- A typical request: `http://folk.uio.no/martingi/`.
  - Connect to port 80 on `folk.uio.no`.
  - Send:

    ```
    GET /martingi/ HTTP/1.1
    User-Agent: Mozilla/5.0 (X11; U; Linux i686; ...
    Accept: text/html,application/xhtml+xml,...
    Accept-Language: no, en
    Host: folk.uio.no
    ...
    ```

    followed by a blank line.
- Other "methods": `HEAD`, `POST`, `PUT`,...

HTTP (cont.)

- A typical response to the GET request:

  ```
  HTTP/1.1 200 OK
  Date: Wed, 05 May 2010 14:15:24 GMT
  Server: Apache/2.2.14 (Unix) ...
  Content-Length: 14348
  Content-Type: text/html

  <!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01//EN"
      "http://www.w3.org/TR/html4/strict.dtd">
  <html> ...  </html>
  ```

- Result may vary depending on the `Accept:` choices in request.
- `200 OK` is not the only possible response ("status code"):
  - `404 Not Found`
  - `401 Unauthorized`
  - `303 See Other`

Fragment identifiers

- A *fragment identifier* is the part after # in a URI:

  ```
  http://en.wikipedia.org/wiki/Fragment_identifier#Examples
  http://www.w3.org/1999/02/22-rdf-syntax-ns#type
  ```

- HTTP specifies that fragment identifiers are processed client-side:
  - GET request is sent without the fragment identifiers:

    ```
    GET /wiki/Fragment_identifier HTTP/1.1
    ```

  - fragment identifier is processed by client.
- For HTML or XHTML:
  - Elements (sections titles, paragraphs, etc.) can have *id* attributes:

    ```
    <h2 id="Examples">Examples</h2>
    ```

  - Browser will jump to element identified by fragment identifier.

Hash namespaces

- For RDF served over HTTP: fragment identifiers identify resources:
  - `http://bla.bla/bla#resource` is a resource
  - `http://bla.bla/bla` is a document describing the resource
- e.g., FOAF files:
  - `http://folk.uio.no/martingi/foaf.rdf#me` - a person
  - `http://folk.uio.no/martingi/foaf.rdf` - an RDF/XML file
- *By convention* the RDF file contains some triples involving resources identified by its fragments.
- Can use the part of the URI until # as namespace

```
@prefix myfoaf:  <http://.../martingi/foaf.rdf#>
myfoaf:martin foaf:givenname "Martin" .
```

- This is known as a “hash namespace”.

Hash namespaces – pros and cons

- Hash namespaces solve our problem:
  - Resources are separate from documents about them.
  - It is possible to find a document given a resource URI.
- Moreover:
  - Fetching the right document is done automatically by HTTP.
  - It is enough to publish the RDF file on an HTTP server.
  - Very low tech and fool proof, in other words.
- However:
  - All data published this way about all entities in a hash namespace needs to be stored in the same RDF file

    ```
    http://brreg.no/bedrifter.rdf#974760673
    ```
  - Too tight coupling of URI schema (name design) and physical storage (file name).

HTTP Redirection

- Reminder: HTTP responses start with a “status code”:
  - Usually “200 OK”, if the document was found and can be served.
  - “404 Not Found”, if the document does not exist.
- One of the possible status codes is “303 See Other”.
- Always comes with a `Location:` field in the response.
- Tells the client to submit a “GET” request to that location.
- Also known as “303 redirection”.
- Followed by all modern HTTP clients.
- Often used when URIs have changed.

Example of 303 Redirection

- User requests `http://www.dnvgl.com/`.
- Client sends request to `www.dnvgl.com`:

  ```
  GET / HTTP/1.1
  Host:  www.dnvgl.com
  ```
- DNV GL changed name to DNV . . . Server responds:

  ```
  HTTP/1.1 303 See Other
  Location:  http://www.dnv.com/
  ```
- Client sends new request to `www.dnv.com`:

  ```
  GET / HTTP/1.1
  Host:  www.dnv.com
  ```
- Server at `www.dnv.com` responds:

  ```
  HTTP/1.1 200 OK
  Content-Type:  text/html
  ...
  ```

303 Redirection for RDF

- Find information about `http://dbpedia.org/resource/Oslo`.
- Send “GET” request to server `dbpedia.org`:
  ```
  GET /resource/Oslo HTTP/1.1
  Accept:  application/rdf+xml
  ```
- Server `dbpedia.org` recognizes this as a non-information resource.
- Redirects to a file with data about the city of Oslo:
  ```
  HTTP/1.1 303 See Other
  Location:  http://dbpedia.org/data/Oslo.xml
  ```
- Browser can now send a new request for that location:
  ```
  GET /data/Oslo.xml HTTP/1.1
  Accept:  application/rdf+xml
  ```
- This time the server responds with the requested document:
  ```
  HTTP/1.1 200 OK
  Content-Type:  application/rdf+xml
  ...
  ```

Slash Namespaces

- Common to use URIs with a slash (/) as last non-identifier character:

  `http://dbpedia.org/resource/Oslo`
- Can use URI up to last slash as namespace:
  ```
  @prefix dbpedia:  <http://dbpedia.org/resource/>
  dbpedia:Oslo dbprop:maySnowCm "0" .
  ```
- Known as a “slash namespace”.
- Advantages over hash namespaces:
  - Whole URI is sent to server, so. . .
  - Possible to redirect different resources to different documents.
  - Possible to change redirection without changing URIs.
- Requires some more server configuration.
- See recipes at `http://www.w3.org/TR/swbp-vocab-pub/`.
- See also `http://linkeddatabook.com/`.

Serving Vocabularies

- What about classes and properties?
- Identified by URIs:
  ```
  http://xmlns.com/foaf/0.1/Person
  http://xmlns.com/foaf/0.1/knows
  http://www.w3.org/1999/02/22-rdf-syntax-ns#Statement
  http://www.w3.org/1999/02/22-rdf-syntax-ns#type
  ```
- What should be served in response to these?
  - A description of the “vocabulary” defining the term.
  - Often an RDF file with RDFS or OWL/RDF content.
  - Sometimes (FOAF) just an HTML page with documentation.
- Mechanisms are the same as for “ordinary” RDF data.
- A single RDF file (hash namespace) is usually OK.
- Should also serve the vocabulary description for the “vocabulary URI”:
  ```
  http://xmlns.com/foaf/0.1/
  http://www.w3.org/1999/02/22-rdf-syntax-ns#
  ```

HTTP Content Type Negotiation

- In HTTP, data formats are identified by “internet media types”.
  - Previously known as MIME types.
  - `text/html, image/jpeg, application/pdf,...`
- RDF media types:
  - RDF/XML: `application/rdf+xml`.
  - Turtle: `text/turtle`.
  - N3: `text/n3`.
- Client sends accepted media types in `Accept:` header:
  - `Accept:  text/html, text/plain`
- Server chooses sent media type:
  - Picks the preferred one among available types.
  - Sends the media type of the response in the header.
  - `Content-Type:  text/html`

Content Type Negotiation for RDF

- Given the URI of a non-information resource. . .
  - A semantic web applications wants RDF data, as discussed.
  - A regular WWW browser wants HTML, human readable.
- This can be achieved using HTTP content type negotiation.
- Semantic web client:
  - Requests RDF, e.g., `Accept: application/rdf+xml, text/turtle`.
  - Server uses e.g., 303 redirection to an RDF file.
- HTML web client:
  - Requests text, e.g., `Accept: text/html, text/plain`.
  - Server uses e.g., 303 redirection to an HTML file.
- Also possible with hash namespaces, see `http://www.w3.org/TR/swbp-vocab-pub/`.

Example: dbpedia.org

- Requesting the URI `http://dbpedia.org/resource/Oslo`
- From an HTML web browser:
  - Sends `Accept: text/html` in request
  - Server returns:

```
HTTP/1.1 303 See Other
Location: http://dbpedia.org/page/Oslo
```

  - Client requests `http://dbpedia.org/page/Oslo`
  - Server sends HTML document:

```
HTTP/1.1 200 OK
Content-Type: text/html
```

Example: dbpedia.org (cont.)

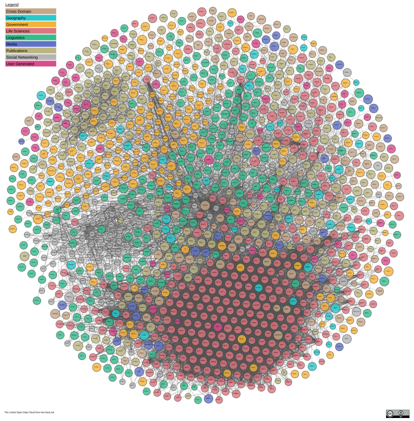
- Requesting the URI `http://dbpedia.org/resource/Oslo`
- From a semantic web browser:
  - Sends `Accept: application/rdf+xml` in request
  - Server returns:

```
HTTP/1.1 303 See Other
Location: http://dbpedia.org/data/Oslo.xml
```

  - Client requests `http://dbpedia.org/data/Oslo.xml`
  - Server sends RDF/XML document:

```
HTTP/1.1 200 OK
Content-Type: application/rdf+xml
```

The Linked Open Data Cloud



`http://lod-cloud.net/`

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Topics Covered

- RDF, principles, Turtle syntax
- The Jena API for RDF
- The SPARQL Query Language
- Basics of the RDFS and OWL ontology languages
- Basics of model semantics and reasoning
- Linked Open Data
- Constraints, SHACL
- OTTR Templates

Topics *Not* Covered

- Rule Languages (SWRL, RIF, Jena rules, etc.)
- SW application structures
- Semantic Web Services
- Details of RDF/RDFS model semantics
- Some details of OWL
- Details of OWL 2 profiles
- Logical theory: Soundness, Completeness,. . .
  - (You ain't seen nothing yet :-)
- And many more!

Help! I Can't Get Enough!

- For more information on theory:
  - Book on Foundations of SW Technologies
  - Take a course in logic or automated reasoning
- For more information on practical questions:
  - Book on Semantic Web Programming
  - Standards texts on W3C Web pages
  - Google
- Still not enough?
  - Contact us for possible MSc topics!

That's all Folks!