

Welcome to INFO216: Advanced Modelling

Theme, spring 2017:
**Modelling and Programming
the Web of Data**

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Lecture 5

- Themes:
 - *what is Linked (Open) Data?*
 - open data, linked data
 - *what are web APIs (web services)?*
 - service-oriented architecture (SOA)
 - JavaScript Object Notation (JSON)
 - *semantic web APIs (web services)*
 - JSON-LD
 - programming JSON-LD in Java



Readings

- Sources:
 - json.org
 - json-ld.org
 - in particular the videos on top of the page
 - seksjon 2 i JSON-LD 1.0 Processing Algorithms and API (<https://www.w3.org/TR/json-ld-api/#features>)



Linked Open Data



Linked Open Data (LOD)

- 3-4 basic principles (Berners-Lee 2006):
 1. IRIs (Internationalized Resource Identifier) *identify resources*
 - [http://dbpedia.org/resource/Hovden_\(Setesdal\)](http://dbpedia.org/resource/Hovden_(Setesdal))
 2. IRIs *answer to HTTP requests* (dereferencing)
 - Hypertext Transfer Protocol
 - maybe also to *RDF-queries* (SPARQL)
 3. Returns *information about the resource* on standard format
 - Hypertext Markup Language (HTML)
 - eXtensible MarkupLanguage (XML)
 - Resource Description Framework (RDF)
 - JavaScript Object Notation (JSON)
 4. The information contains IRI-s that *identify related resources*



Benefits

- Immediate:
 - *Anyone Anything Any topic (AAA)* for semantic data
 - quicker, easier to exchange and combine data
 - quicker, easier to deploy new applications
 - data sets can be used and combined independently of origin
 - new uses of existing data sets and services
- Longer term:
 - increasingly autonomous agents
 - towards an artificially intelligent web



Web APIs (RESTful web services)



Web APIs

- *When we make programs, what if we could call other programs over the web (almost) as easy as we can call methods (or sub-routines, procedures, functions) we have written ourselves?*
- Web APIs let us do this!
- A Web API offers several operations or functions that
 - take inputs in a well-defined format
 - perform a well-defined operation on the inputs
 - return outputs in a well-defined format
- Examples of functions:
 - registering **student12345** to course **info216** at **uib**
 - listing all students in the course
 - unregistering the student from the course



Example calls

- We call a Web API by requesting an IRL
- Examples:
 - registering student12345 to course info216 at uib:
GET [http://onewebapi.example.no/register?](http://onewebapi.example.no/register?university=uib&course=info216&student=student12345)
university=uib&course=info216&student=student12345
 - listing all info216 students:
GET [http://onewebapi.example.no/listStudents?](http://onewebapi.example.no/listStudents?university=uib&course=info216)
university=uib&course=info216
 - unregistering from the course:
GET [http://onewebapi.example.no/unregister?](http://onewebapi.example.no/unregister?university=uib&course=info216&student=student12345)
university=uib&course=info216&student=student12345
- Of course, our program can change the values uib, student12345 and info216 between each call



Example calls (different style)

- We can design Web APIs with different IRL style
- Examples:
 - registering student12345 to course info216 at uib:
POST <http://onewebapi.example.no/registrations/ui/info216/student12345>
 - listing all info216 students:
GET <http://onewebapi.example.no/registrations/ui/info216>
 - unregistering from the course:
DELETE <http://onewebapi.example.no/registrations/ui/info216/student12345>
- The HTTP operations (PUT, GET, POST, DELETE, and also PATCH) are used for creation, retrieval, update and deletion



Service-oriented architecture (SOA)

- Building applications by combining operations from different Web APIs
 - company internal over intranets
 - public over the internet
 - “service orchestration” and “choreography”
 - the applications can offer new operations in turn
 - operations are ideally small and stateless
- Everything is based on established proven standards:
 - HTTP, IRL, JSON (...TCP/IP, Unicode...)



Using Web APIs from Java

- Similar to making a HTTP request:
 - often a GET to a resource at a particular IRL
 - sometimes a POST, PUT or delete
 - lots of libraries for this
 - built-in Java SE, cURL, Apache Commons...
 - some of them also have JSON support
- We will keep things as simple as we can
 - use built-in Java SE APIs
 - registration can complicate things
 - login / HTTPS can also complicate
 - no asynchronous behaviour!



Using Web APIs from Java

```
static Object getJsonBody(URL serverAddress) {
    Object jsonObject = null;
    HttpURLConnection connection = null;
    try {
        connection = null;
        connection = (HttpURLConnection) serverAddress.openConnection();
        connection.setRequestMethod("GET");
        connection.setReadTimeout(10000);
        connection.connect();
        jsonObject = JsonUtils.fromInputStream(connection.getInputStream());
    } catch (Exception e) {
        e.printStackTrace();
    } finally {
        connection.disconnect();
        connection = null;
    }
    return jsonObject;
}
```



Using Web APIs from Java

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    } catch (Exception e) {  
        e.printStackTrace();  
    } finally {  
        connection.disconnect();  
        connection = null;  
    }  
    return jsonObject;  
}
```



Providing Web APIs (with Java)

- A bit more complicated
 - you need a web server (Apache, Nginx...)
 - the web server must allow executing programs
 - translate resource requests into program calls
- The program itself is simple:
 - takes input parameters on command line (GET)
 - may also take longer input in JSON (POST)
 - outputs results in JSON
 - which the web server returns to the client



Providing Web APIs (with Java)

- How to translate resource requests into program calls?
- Example:
 - we have written this program:
`/home/programs/student-list <univ-code> <course-code>`
 - we receive this request:
`GET /listStudents?university=uib&course=info216`
`Host: onewebapi.example.no`
 - we need a rewrite rule like this (example from Apache, based on *regular expressions*):
`RewriteRule`
`^/listStudents?university=([a-z]+)&course=([a-z0-9]+)$`
`/home/programs/student-list $1 $2`



Providing Web APIs (with Java)

- How to translate resource requests into program calls?
- Example:

- we have written this program:

- `/home/programs/student-list <univ-code> <course-code>`

- we receive this request:

- `GET /listStudents?university=uib&course=info216`

- `Host: onewebapi.example.no`

- we need a rewrite rule like this (example from Apache, based on *regular expressions*):

- RewriteRule

- `^/listStudents?university=([a-z]+)&course=([a-z0-9]+)$`

- `/home/programs/student-list $1 $2`



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Providing Web APIs (with Java)

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- Example:
 - we have written this program:
`/home/programs/student-list <univ-code> <course-code>`
 - we receive this request:
`GET /listStudents?university=uib&course=info216`
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 - we need a rewrite rule like this (example from Apache, based on *regular expressions*):
`RewriteRule`
`^/listStudents?university=([a-z]+)&course=([a-z0-9]+)$`
`/home/programs/student-list uib info216`



JSON



JSON

```
{  
  "homepage": "http://me.markus-lanthaler.com",  
  "name": "Markus Lanthaler",  
  "workplaceHomepage": "http://www.tugraz.at/"  
}
```

← Name-Value pair

Object Name Value (String, Number, Boolean, null or Array)

JavaScript Object Notation (JSON)
www.json.org



JSON

```
{  
  "homepage": "http://me.markus-lanthaler.com",  
  "name": "Markus Lanthaler",  
  "workplaceHomepage": "http://www.tugraz.at/"  
}
```

← Name-Value pair

Object Name Value (String, Number, Boolean, null or Array)

```
{  
  "homepage": "http://me.markus-lanthaler.com",  
  "name":  
    {  
      "firstname": "Markus",  
      "lastname": "Lanthaler"  
    },  
  "workplaceHomepages": [ "http://www.tugraz.at/", "http://www.uib.no" ]  
}
```

Array

Element (String, Number, Boolean, null or Object)

Java Lists

- A built-in Java SE class
- Java Lists contain many similar objects
 - elements can be added to the list
 - elements can be removed from the lists
 - you can also iterate over lists etc.
- Are used to store JSON Arrays!



Java Maps

- A built-in Java SE class
- Java Maps contain key-value pairs
 - key-value pairs can be added
 - the value for a key can be removed
 - the value for a key can be changed
 - you can get lists of all the keys or all the values etc.
- Are used to store JSON Objects!



JSON objects

- JSON objects are declared as Java Objects
 - they contain either a Map or a List
 - Lists can contain Maps
 - Maps can have List values
- JSON objects can be created by parsing Strings
`jsonObject = JsonUtils.fromInputStream(jsonStream);`
- JSON objects can be converted to formatted Strings
`jsonString = JsonUtils.toPrettyString(jsonObject)`



JSON-LD



JSON

```
{  
  "homepage": "http://me.markus-lanthaler.com",  
  "name": "Markus Lanthaler",  
  "workplaceHomepage": "http://www.tugraz.at/"  
}
```

This is the person's id!

<http://xmlns.com/foaf/0.1/name>

<http://xmlns.com/foaf/0.1/workplaceHomepage>

<http://xmlns.com/foaf/0.1/Person>

How to represent semantic data in JSON?



JSON-LD

```
{  
  "homepage": "http://me.markus-lanthaler.com",  
  "name": "Markus Lanthaler",  
  "workplaceHomepage": "http://www.tugraz.at/"  
}
```

This is the person's id!

<http://xmlns.com/foaf/0.1/name>

<http://xmlns.com/foaf/0.1/workplaceHomepage>

<http://xmlns.com/foaf/0.1/Person>

```
{  
  "@type" : "http://xmlns.com/foaf/0.1/Person",  
  "@id": "http://me.markus-lanthaler.com",  
  "http://xmlns.com/foaf/0.1/name": "Markus Lanthaler",  
  "http://xmlns.com/foaf/0.1/workplaceHomepage":  
    { "@id" : "http://www.tugraz.at/" }  
}
```

JSON Linked Data (JSON-LD)
json-ld.org



JSON-LD to Turtle

```
{  
  "@type" : "http://xmlns.com/foaf/0.1/Person",  
  "@id": "http://me.markus-lanthaler.com",  
  "http://xmlns.com/foaf/0.1/name": "Markus Lanthaler",  
  "http://xmlns.com/foaf/0.1/workplaceHomepage":  
    { "@id" : "http://www.tugraz.at/" }  
}
```

JSON Linked Data (JSON-LD)
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JSON-LD to Turtle

<<http://me.markus-lanthaler.com>>

```
{  
  "@type" : "http://xmlns.com/foaf/0.1/Person",  
  "@id" : "http://me.markus-lanthaler.com",  
  "http://xmlns.com/foaf/0.1/name" : "Markus Lanthaler",  
  "http://xmlns.com/foaf/0.1/workplaceHomepage" :  
    { "@id" : "http://www.tugraz.at/" }  
}
```

JSON Linked Data (JSON-LD)
json-ld.org



JSON-LD to Turtle

```
<http://me.markus-lanthaler.com>  
  a      http://xmlns.com/foaf/0.1/Person”;
```

```
{  
  “@type” : “http://xmlns.com/foaf/0.1/Person”,  
  “@id”: “http://me.markus-lanthaler.com”,  
  “http://xmlns.com/foaf/0.1/name”: “Markus Lanthaler”,  
  “http://xmlns.com/foaf/0.1/workplaceHomepage”:  
    { “@id” : “http://www.tugraz.at/” }  
}
```

JSON Linked Data (JSON-LD)
json-ld.org



JSON-LD to Turtle

```
<http://me.markus-lanthaler.com>  
  a      http://xmlns.com/foaf/0.1/Person";  
  <http://xmlns.com/foaf/0.1/name>  
    "Markus Lanthaler";
```

```
{  
  "@type" : "http://xmlns.com/foaf/0.1/Person",  
  "@id" : "http://me.markus-lanthaler.com",  
  "http://xmlns.com/foaf/0.1/name" : "Markus Lanthaler",  
  "http://xmlns.com/foaf/0.1/workplaceHomepage" :  
    { "@id" : "http://www.tugraz.at/" }  
}
```

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JSON-LD to Turtle

```
<http://me.markus-lanthaler.com>  
  a      http://xmlns.com/foaf/0.1/Person";  
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    "Markus Lanthaler";  
  <http://xmlns.com/foaf/0.1/workplaceHomepage>  
    <http://www.tugraz.at/"> .
```

```
{  
  "@type" : "http://xmlns.com/foaf/0.1/Person",  
  "@id" : "http://me.markus-lanthaler.com",  
  "http://xmlns.com/foaf/0.1/name" : "Markus Lanthaler",  
  "http://xmlns.com/foaf/0.1/workplaceHomepage":  
    { "@id" : "http://www.tugraz.at/" }  
}
```

JSON Linked Data (JSON-LD)
json-ld.org



Some reserved keys in JSON-LD

- **@type**: signifies that the JSON object with the @type key has a particular RDF type (or several types)
- **@id**: signifies that the JSON object with the @id key is identified by a particular IRI
- **@value**: signifies that a value is a literal
- **@context**: signifies a JSON object that contains the context (or semantic mapping) for the other objects in the same JSON array
- **@base**, **@graph**, **@language**, **@vocab**, ...



JSON-LD context

```
{
  "@context": {
    "name": "http://xmlns.com/foaf/0.1/name",
    "homepage": {
      "@id": "http://xmlns.com/foaf/0.1/homepage",
      "@type": "@id"
    }
  },
  "@id": "http://me.markus-lanthaler.com/",
  "name": "Markus Lanthaler",
  "homepage": "http://www.markus-lanthaler.com/"
}
```



Another JSON-LD context

```
{
  "@context": {
    "website": "http://xmlns.com/foaf/0.1/homepage"
  },
  "@id": "http://me.markus-lanthaler.com/",
  "http://xmlns.com/foaf/0.1/name": "Markus Lanthaler",
  "website": { "@id": "http://www.markus-lanthaler.com/" }
}
```



JSON-LD forms

- The same graph can be expressed in several different ways:
 - expanded form: *expansion* removes context by pushing semantics out into the objects
 - compact form: *compaction* simplifies the objects by pulling semantics back into the context
 - *flattened* form: normalised form for easier parsing by computer – has both expanded and compact variant
- ...all these forms are easier to program than “free” JSON-LD, because they are more regular



Programming JSON-LD



Expansion

- Goals:
 - removing the contextual information object
 - pushing it out into the other objects
 - ensuring all values are in a regular form
- Steps:
 - expanding all properties to absolute IRIs
 - expressing all values in arrays in expanded form
- The most verbose and regular way of writing JSON-LD:
 - all contextual information is stored locally with each value



Expansion (before)

```
{
  "@context": {
    "name": "http://xmlns.com/foaf/0.1/name",
    "homepage": {
      "@id": "http://xmlns.com/foaf/0.1/homepage",
      "@type": "@id"
    }
  },
  "@id": "http://me.markus-lanthaler.com/",
  "name": "Markus Lanthaler",
  "homepage": "http://www.markus-lanthaler.com/"
}
```



Expansion (after)

```
[
  {
    "@id": "http://me.markus-lanthaler.com/",
    "http://xmlns.com/foaf/0.1/name": [
      { "@value": "Markus Lanthaler" }
    ],
    "http://xmlns.com/foaf/0.1/homepage": [
      { "@id": "http://www.markus-lanthaler.com/" }
    ]
  }
]
```



Compaction

- The opposite of extraction
 - based on a user-supplied context object
- Goals:
 - condensing contextual information into an object
 - pulling it out of the other objects
 - expressing data in application specific terms
 - making data easier to read for humans
 - make data easy to program against
- Steps:
 - condenses properties with IRIs
 - adds a @context to the array



Compaction (before)

```
[{  
  "@id": "http://me.markus-lanthaler.com/",  
  "http://xmlns.com/foaf/0.1/name": [  
    { "@value": "Markus Lanthaler" }  
  ],  
  "http://xmlns.com/foaf/0.1/homepage": [  
    { "@id": "http://www.markus-lanthaler.com/" }  
  ]  
}]
```

+

```
{ "@context": {  
  "name": "http://xmlns.com/foaf/0.1/name",  
  "homepage": {  
    "@id": "http://xmlns.com/foaf/0.1/homepage",  
    "@type": "@id"  
  }  
}}
```



Compaction (after)

```
{
  "@context": {
    "name": "http://xmlns.com/foaf/0.1/name",
    "homepage": {
      "@id": "http://xmlns.com/foaf/0.1/homepage",
      "@type": "@id"
    }
  },
  "@id": "http://me.markus-lanthaler.com/",
  "name": "Markus Lanthaler",
  "homepage": "http://www.markus-lanthaler.com/"
}
```



Flattening

- Expansion:
 - ensures that a document is in a uniform structure
- Flattening:
 - also ensures that the shape of the data is deterministic
- Steps:
 - all properties of a node are collected in a single JSON object
 - all blank nodes are labeled with a blank node identifier
- Flattening makes it easier to process JSON-LD data



Flattening (before)

```
{
  "@context": {
    "name": "http://xmlns.com/foaf/0.1/name",
    "knows": "http://xmlns.com/foaf/0.1/knows"
  },
  "@id": "http://me.markus-lanthaler.com/",
  "name": "Markus Lanthaler",
  "knows": [
    {
      "name": "Dave Longley"
    }
  ]
}
```



Flattening (after – expanded form)

```
[ {
  "@id": "_:t0",
  "http://xmlns.com/foaf/0.1/name": [
    { "@value": "Dave Longley" }
  ]
},
{
  "@id": "http://me.markus-lanthaler.com/",
  "http://xmlns.com/foaf/0.1/name": [
    { "@value": "Markus Lanthaler" }
  ],
  "http://xmlns.com/foaf/0.1/knows": [
    { "@id": "_:t0" }
  ]
}] }
```



Flattening (after – compacted form)

```
{
  "@context": {
    "name": "http://xmlns.com/foaf/0.1/name",
    "knows": "http://xmlns.com/foaf/0.1/knows"
  },
  "@graph": [
    {
      "@id": "_:t0",
      "name": "Dave Longley"
    },
    {
      "@id": "http://me.markus-lanthaler.com/",
      "name": "Markus Lanthaler",
      "knows": { "@id": "_:t0" }
    }
  ]
}
```

