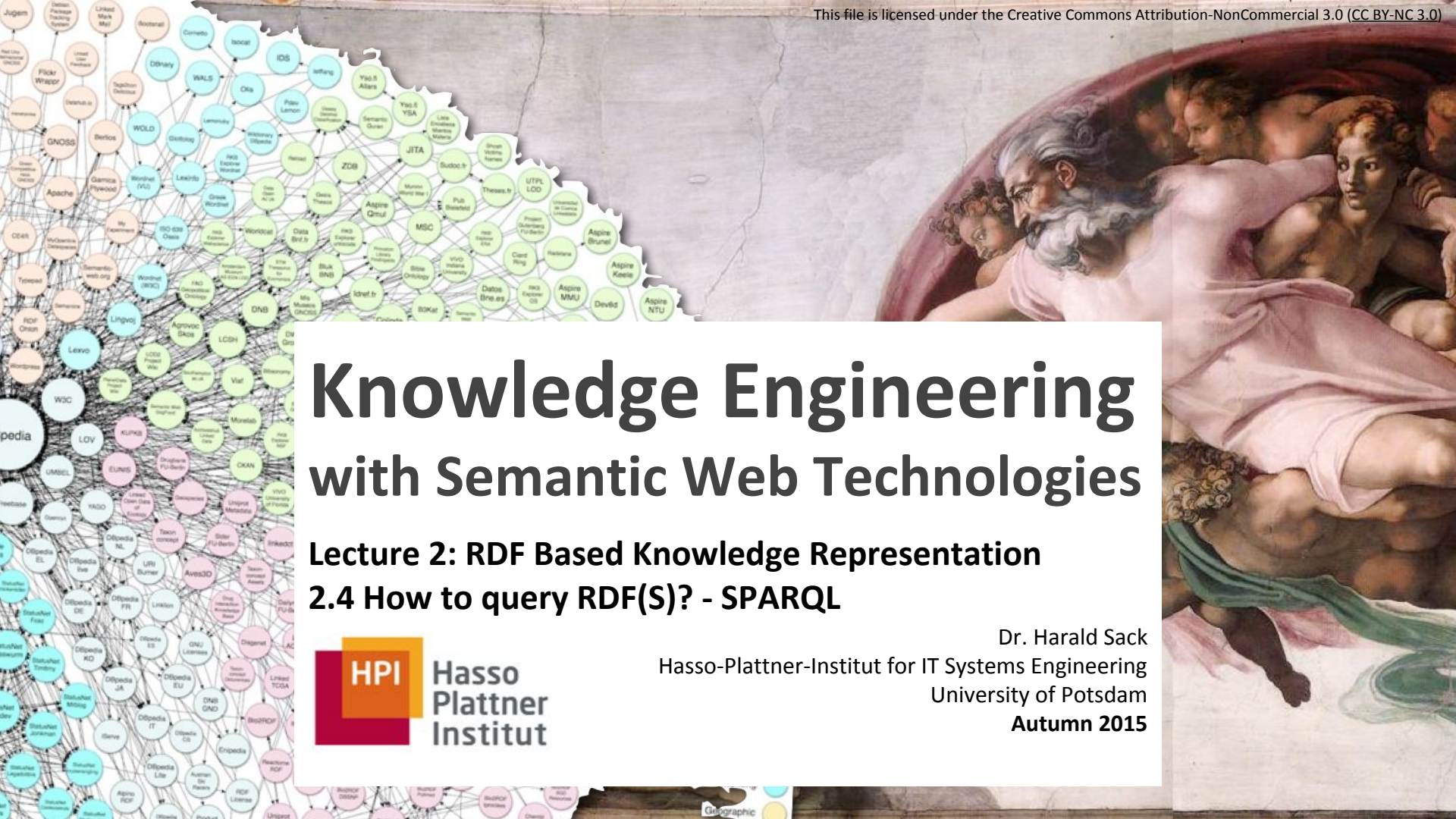

Knowledge Engineering
with Semantic Web Technologies

Lecture 2: RDF Based Knowledge Representation
2.4 How to query RDF(S)? - SPARQL

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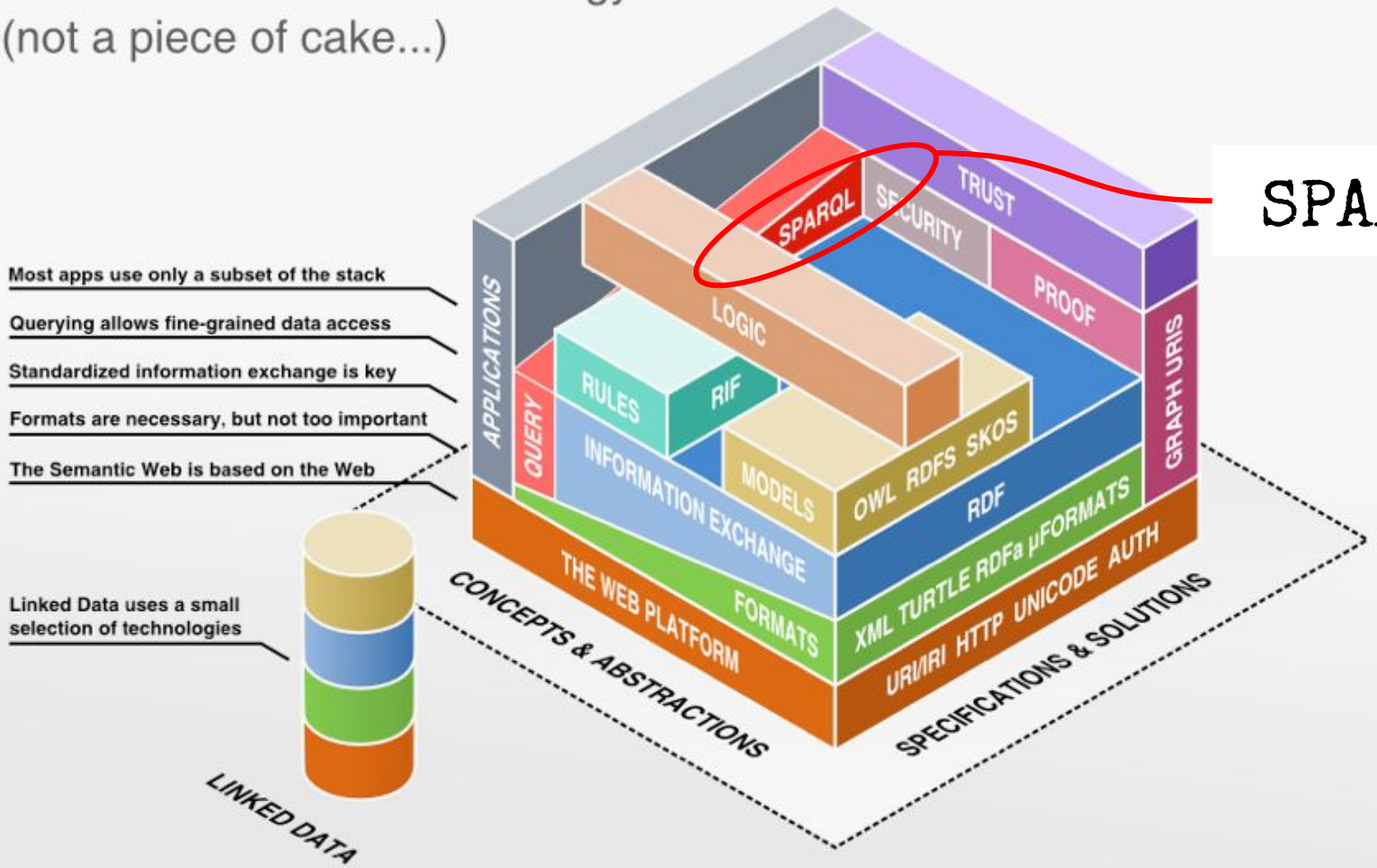
Autumn 2015

The Semantic Web Technology Stack
(not a piece of cake...)



Most apps use only a subset of the stack

Querying allows fine-grained data access

Standardized information exchange is key

Formats are necessary, but not too important

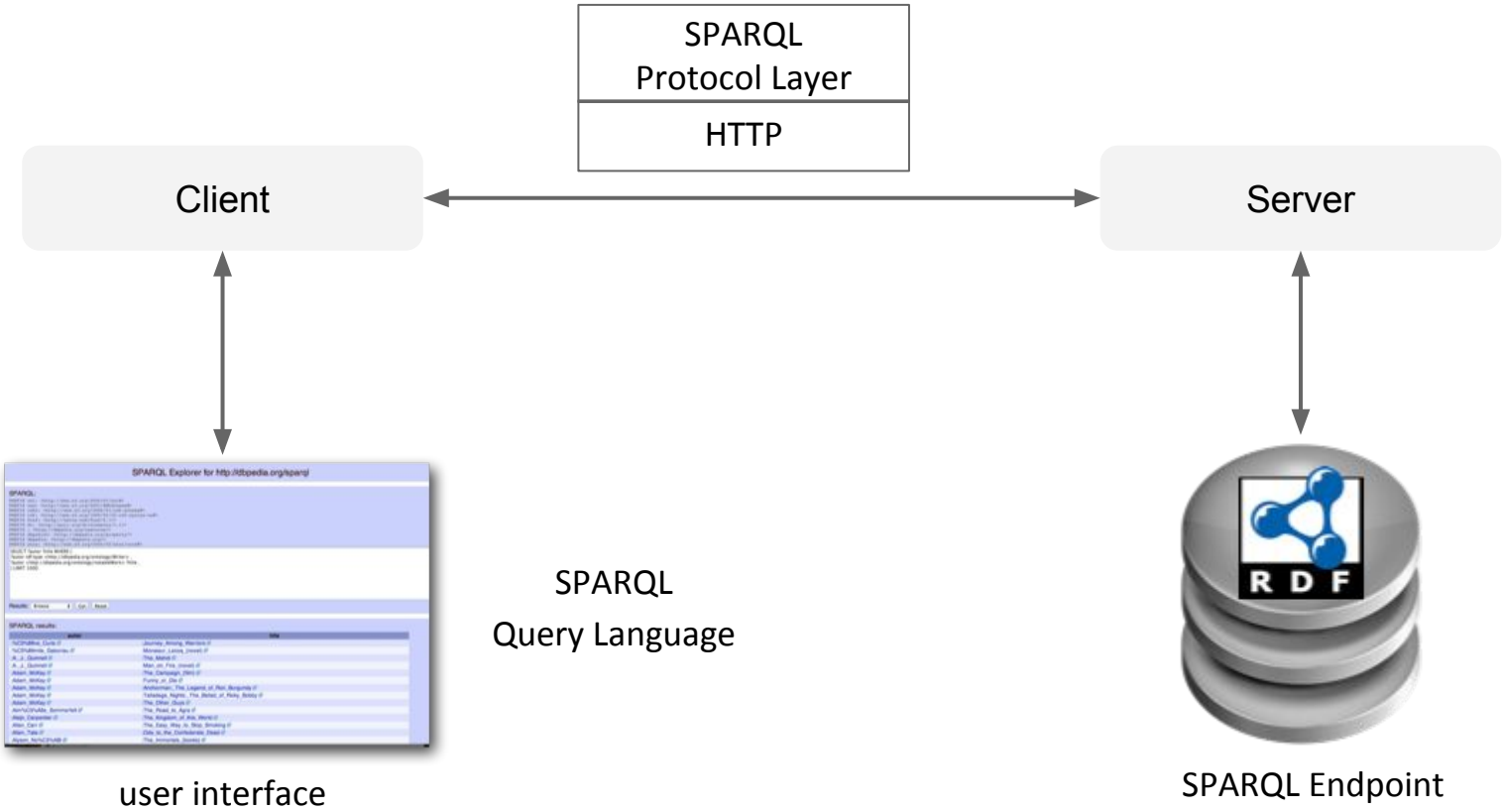
The Semantic Web is based on the Web

Linked Data uses a small selection of technologies

SPARQL

HPI Hasso Plattner Institut

SPARQL - A Query Language for RDF



SPARQL - A Query Language for RDF

- **SPARQL P**rotocol **a**nd **R**DF **Q**uery **L**anguage is
  - a **Query Language** for RDF graph traversal (*SPARQL Query Language Specification*)
  - a **Protocol Layer**, to use SPARQL via http (*SPARQL Protocol for RDF Specification*)
  - an **XML Output Format Specification** for SPARQL queries (*SPARQL Query XML Results Format*)
  - W3C Standard (SPARQL 1.1, Mar 2013)
  - inspired by SQL

SPARQL - A Query Language for RDF

- **SPARQL Features:**
  - **Extraction** of Data as
    - RDF Subgraphs, URIs, Blank Nodes, typed and untyped Literals
    - with aggregate functions, subqueries, complex joins, property paths
  - **Exploration** of Data via Query for unknown relations
  - **Transformation** of RDF Data from one vocabulary into another
  - **Construction** of new RDF Graphs based on RDF Query Graphs
  - **Updates of RDF Graphs** as full data manipulation language
  - **Logical Entailment** for RDF, RDFS, OWL, and RIF Core entailment.
  - **Federated Queries** distributed over different SPARQL endpoints

For Queries we need Variables

- SPARQL **Variables** are bound to RDF terms
  - e.g. **?title, ?author, ?address**
- In the same way as in SQL,
  a **Query for variables** is performed via **SELECT statement**
  - e.g. **SELECT ?title ?author ?published**

SPARQL Query

- A SELECT statement returns Query Results as a **table**

?title	?author	?published
1984	George Orwell	1948
Brave New World	Aldous Huxley	1932
Fahrenheid 451	Ray Bradbury	1953

SPARQL Result

SPARQL - Graph Pattern Matching

- SPARQL is based on **RDF Turtle serialization** and **basic graph pattern matching**.
- A **Graph Pattern** (**Triple Pattern**) is a RDF Triple that contains variables at any arbitrary place (Subject, Property, Object).

  (Graph) Triple Pattern = Turtle + Variables

- Example:
  Look for countries and their capitals:

```
?country dbo:capital ?capital .
```

- A **Basic Graph Pattern** (**BGP**) is a set of Triple Pattern

SPARQL - Graph Pattern Matching

Triple Pattern

```
?country dbo:capital ?capital .
```

RDF Graph

```
dbpedia:Venezuela rdf:type dbo:Country .
dbpedia:Venezuela dbo:capital dbpedia:Caracas .
dbpedia:Venezuela dbprop:language "Spanish" .
dbpedia:Germany rdf:type dbo:Country .
dbpedia:Germany dbo:capital "Berlin" .
dbpedia:Germany dbp:language "German" .
...
```

SPARQL - Complex Query Patterns

- SPARQL Graph Pattern can be combined to form **complex (conjunctive) queries** for RDF graph traversal

- *Find countries, their capitals, and their population count:*

```
?country dbo:capital ?capital .
?country dbo:population ?population .
```

- *Given a FOAF URI, find the name of a person and her friends:*

```
<http://hpi-web.de/id#haraldsack> foaf:name  ?surname ;
                                  foaf:knows  ?friend .
?friend foaf:name ?friend_surname .
```

SPARQL - General Query Format

- *search all authors and the titles of their notable works:*

```
PREFIX :     <http://dbpedia.org/resource/>
PREFIX rdf:  <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dbo:  <http://dbpedia.org/ontology/>

SELECT ?author_name ?title

FROM <http://dbpedia.org/>

WHERE {
     ?author rdf:type dbo:Writer .
     ?author rdfs:label ?author_name .
     ?author dbo:notableWork ?work .
     ?work rdfs:label ?title .
}
```

specifies namespaces

specifies output variables

specifies graph to be queried

specifies graph pattern to be matched

SPARQL - General Query Format

- *search all authors and the titles of their notable works **ordered by** authors in ascending order and **limit** the results to the first 100 results starting the list at **offset** 10 position:*

```
PREFIX :     <http://dbpedia.org/resource/>
PREFIX rdf:  <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dbo:  <http://dbpedia.org/ontology/>

SELECT ?author_name ?title

FROM <http://dbpedia.org/>

WHERE {
      ?author rdf:type dbo:Writer .
      ?author rdfs:label ?author_name .
      ?author dbo:notableWork ?work .
      ?work rdfs:label ?title .
}
ORDER BY ASC (?author_name)
LIMIT 100
OFFSET 10
```

solution sequence modifiers

query SPARQL endpoint

SPARQL - Blank Nodes

- In SPARQL Blank Nodes can be used as
  - **subject** or **object** of a triple pattern
  - “non selectable” **variables**

```
PREFIX :     <http://dbpedia.org/resource/>
PREFIX dbp:  <http://dbpedia.org/property/>
PREFIX dbo:  <http://dbpedia.org/ontology/>

SELECT ?author_name ?title
FROM <http://dbpedia.org/>
WHERE {
      _:x rdf:type  dbo:Writer ;
          dbp:award [ dbp:awardName ?name;
                      dbp:awardDate ?date ] .
}
```

SPARQL - Filter Constraints

```
PREFIX : <http://dbpedia.org/resource/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dbo: <http://dbpedia.org/ontology/>
SELECT ?author_name ?title ?pages
FROM <http://dbpedia.org/>
WHERE {
       ?author rdf:type dbo:Writer .
       ?author rdfs:label ?author_name .
       ?author dbo:notableWork ?work .
       ?work dbo:numberOfPages ?pages
       FILTER (?pages > 500) .
       ?work rdfs:label ?title .
} LIMIT 100
```

specifies constraints for the result

- `FILTER` expressions contain operators and functions
- `FILTER` can NOT assign/create new values

query SPARQL endpoint

SPARQL - Unary Operator Constraints

Operator	Type(A)	Result Type
`!A`	xsd:boolean	xsd:boolean
`+A`	numeric	numeric
`-A`	numeric	numeric
`BOUND(A)`	variable	xsd:boolean
`isURI(A)`	RDF term	xsd:boolean
`isBLANK(A)`	RDF term	xsd:boolean
`isLITERAL(A)`	RDF Term	xsd:boolean
`STR(A)`	literal/URL	simple literal
`LANG(A)`	literal	simple literal
`DATATYPE(A)`	literal	URI

SPARQL - Filter Constraints

- Example: Filter results only for English labels

```
PREFIX : <http://dbpedia.org/resource/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dbo: <http://dbpedia.org/ontology/>
SELECT ?author_name ?title ?pages
FROM <http://dbpedia.org/>
WHERE {
       ?author rdf:type dbo:Writer .
       ?author rdfs:label ?author_name
       FILTER (LANG(?author_name)="en").
       ?author dbo:notableWork ?work .
       ?work dbo:numberOfPages ?pages
       FILTER (?pages > 500) .
       ?work rdfs:label ?title .
       FILTER (LANG(?title)="en").
} LIMIT 100
```


query SPARQL endpoint

SPARQL - First Hands On

- From Wikipedia to DBpedia
  e.g. from http://en.wikipedia.org/wiki/George_Orwell to
  http://dbpedia.org/page/George_Orwell
- Browsing DBpedia
  e.g. using http://dbpedia.org/page/George_Orwell as a starting point to learn more about DBpedia structure and DBpedia ontologies
- Using DBpedia Sparql Endpoint with
  http://dbpedia.org/sparql
  and query DBpedia via SPARQL

Next: 05 - SPARQL is more than a Query Language

OpenHPI - Course Knowledge Engineering with Semantic Web Technologies

Lecture 2: RDF Based Knowledge Representation