ISWC 2017 Tutorial:
Semantic Data Management in Practice

Part 4: Searching

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image source: https://pixabay.com/en/browse-search-subjects-website-42931/

Goal

- Query a dataset by using keywords
  - Full-text search

- Typical use cases are related to datasets that contain literals with (large) texts

image source: https://www.flickr.com/photos/projectart69/6704263029

Options

- Use a full-text search engine
  (as a separate component in the software stack)
- Use full-text search features built into triple stores
  - Native full-text search functionality
  - Integration of external search engines

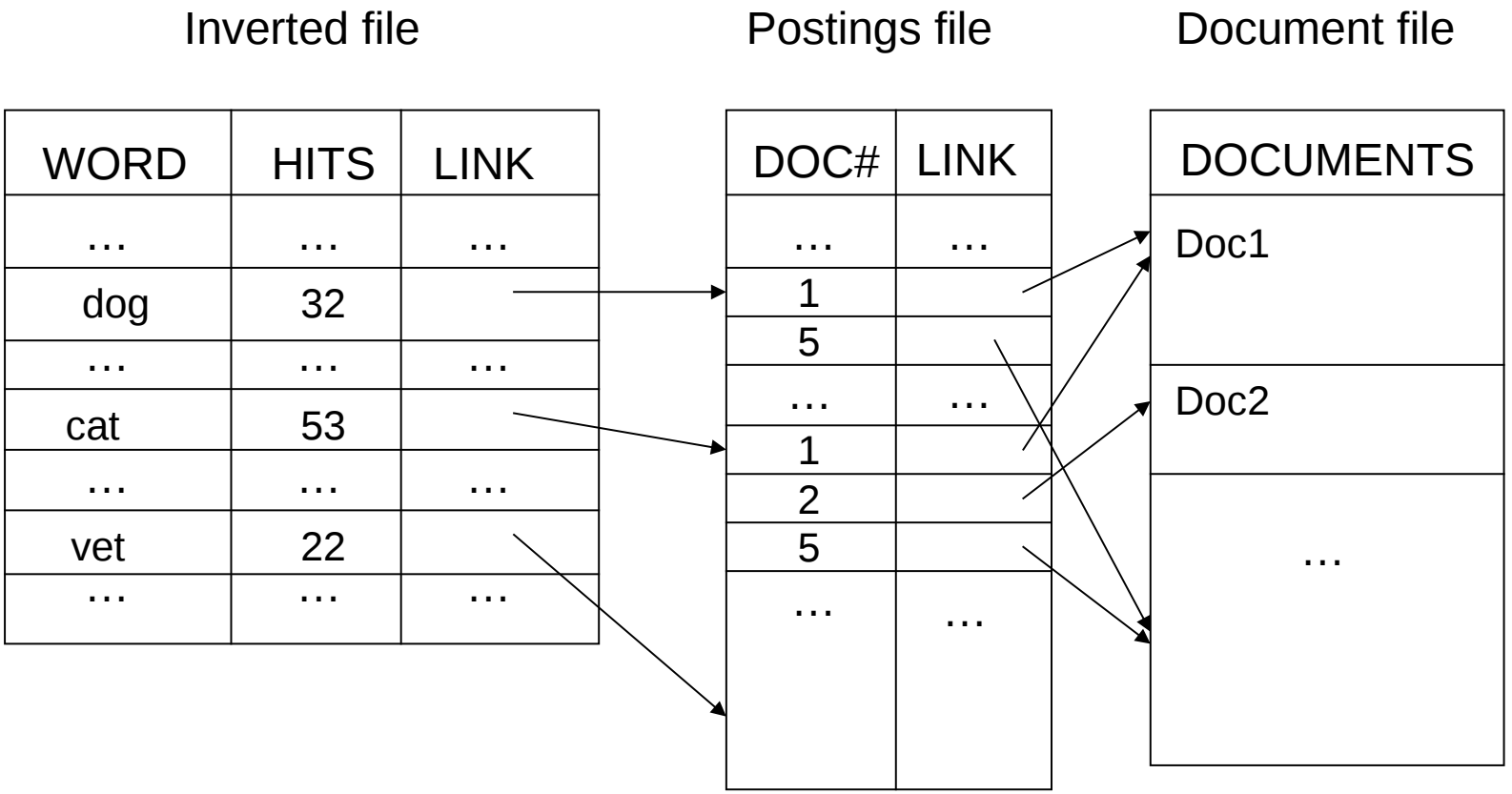
What is Full-Text Search?

- Retrieve text documents out of a large collection
- Query is an unordered set of tokens (seq. of chars)
- Result is a set of documents relevant to the query
- Relevance may be *boolean*
  - i.e., document contains all tokens or not

  or

  degree-based
  - relevance of a document usually measured by taking into account the frequency of tokens in it, normalized by frequency in all documents
  - in this case, result set is ordered

Indexes to Support Full-Text Search



- Note that such an index must be maintained

Popular Full-Text Search Engines

- Apache Lucene is a Java-based full-text indexing and search library with a lot of features

- ElasticSearch is a distributed full-text search engine built on Lucene

- Apache Solr is another distributed full-text search engine, also built on Lucene

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Built-In Full-Text Search in Triple Stores

Triple store	Integrated	external
MarkLogic	x	
Virtuoso	x	
Allegrograph	x	Solr (1.5.2)
Stardog	x	
GraphDB SE	x	Lucene Solr, ElasticSearch (Enterprise)
BlazeGraph	x	SolR
Oracle 12c	x	

Native Full-Text Search in Blazegraph

- Built-in full-text search feature is custom-built
- Enabled by default in the configuration file
  `com.bigdata.rdf.store.AbstractTripleStore.textIndex=true`
- B+Tree over tokens extracted from each RDF literal added to the database
  - Fast exact match on tokens
  - Fast prefix match
  - Fast match on multiple tokens
  - No performance gains for arbitrary regular expressions

Native Full-Text Search in Blazegraph

- Integration into SPARQL via the **`bds:search`** predicate

```
prefix bds: <http://www.bigdata.com/rdf/search#>
SELECT ?s ?p ?o WHERE {
  ?o bds:search "dog" .
  ?s ?p ?o .
}
```

Native Full-Text Search in Blazegraph

- Integration into SPARQL via the **`bds:search`** predicate and other related predicates

```
prefix bds: <http://www.bigdata.com/rdf/search#>
SELECT ?s ?p ?o ?score ?rank WHERE {
   ?o bds:search "dog cat" .
   ?o bds:matchAllTerms "true" .
   ?o bds:minRelevance "0.25" .
   ?o bds:relevance ?score .
   ?o bds:maxRank "1000" .
   ?o bds:rank ?rank .
   ?s ?p ?o .
}
```

Only literals that contain all of the specified search terms are to be considered

Using External Solr Services in Blazegraph

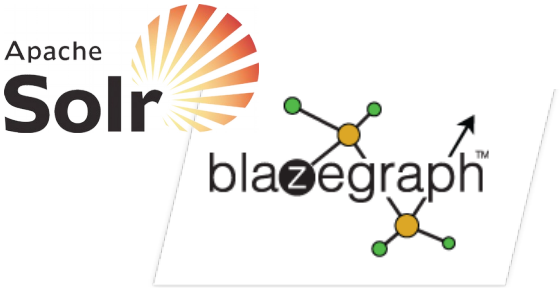
- Access to an external Solr service from within a SPARQL query is supported out of the box

```
prefix fts: <http://www.bigdata.com/rdf/fts#>
SELECT ?person ?kwDoc ?snippet WHERE {
  ?person rdf:type ex:Artist .
  ?person rdfs:label ?label .
  SERVICE <http://www.bigdata.com/rdf/fts#search> {
   ?kwDoc fts:search ?label .
   ?kwDoc fts:endpoint "http://my.solr.server/solr/select" .
   ?kwDoc fts:params "fl=id,score,snippet" .
   ?kwDoc fts:scoreField "score" .
   ?kwDoc fts:score ?score .
   ?kwDoc fts:snippetField "snippet" .
   ?kwDoc fts:snippet ?snippet .  }
} ORDER BY ?person ?score
```

Using External Solr Services in Blazegraph

- Use BIND to construct more complex search query

```
...
?person rdfs:label ?label .
BIND(CONCAT("\"", ?label,
            "\" AND -\"expressionism\"") AS ?search)
SERVICE <http://www.bigdata.com/rdf/fts#search> {
 ?kwDoc fts:search ?search .
 ...
```



Native Full-Text Search in Virtuoso

- Objects of RDF triples with a given predicate or in a given graph can get indexed for full-text search
- Full-text index is in batch mode by default
  - Changes in triples are reflected in the index periodically (i.e., no strict synchronization)
  - Configuration option to enforce synchronization
- Powerful grammar for full-text queries – examples:

```
"dogs AND cats"
vet AND (dog OR cat)
dog AND NOT (dog NEAR cat)
"dog h*"
```

Native Full-Text Search in Virtuoso

- RDF triples whose object has been indexed can be found in SPARQL using the predicate **`bif:contains`**
  - ```
    SELECT * WHERE {
       ?s foaf:name ?name .
       ?name bif:contains "rich*".
    }
    ```
  - ```
    SELECT * WHERE {
       ?s ?p ?o .
       ?o bif:contains "New AND York"
       OPTION (score ?sc) .
    }
    ORDER BY DESC (?sc)
    LIMIT 10
    ```

Native Full-Text Search in AllegroGraph

- Full-text search via API and in SPARQL queries
- Syntax of full-text search queries:
  - Wildcards: `?` (single char.), `*` (multiple chars)
  - Boolean operators: `and`, and `or`
  - Double quotes around an exact phrase to match
- Multiple full-text indexes possible
- Each index works with one or more predicates, including an option to index all predicates
- Each index can be configured to include:
  - All literals, no literals, or specific types of literals
  - Full URI, just the local part, or ignore URIs entirely
  - Any combination of the four parts of a triple (incl. G)

AllegroGraph
Franz Inc.

Solr Integration in AllegroGraph

- External full-text search by using Apache Solr
  - Solr server must be installed and started separately
  - Inserts, updates, and deletes in the Solr database must be done in the application logic
- Solr features that the native solution does not have:
  - Faceted search
  - Finding words close together
  - Relevancy ranking and word boosting
  - Text clustering
  - Hit highlighting

AllegroGraph
Franz Inc.

Apache Solr

Solr Integration in AllegroGraph (cont'd)

- Storage strategy for an RDF triple such as:

```
ex:someSubj ex:somePred "text to index"
```

  - Tell Solr to associate `"text to index"` with a new `id`
  - Then, add a new triple into AllegroGraph:

```
ex:someSubj <http://www.franz.com/solrDocId> id
```

- Now, you may write a SPARQL query such as:

```
PREFIX solr: <http://www.franz.com/ns/allegrograph/4.5/solr/>
PREFIX franz: <http://franz.com/ns/allegrograph/4.5/>
SELECT * WHERE {
  ?s solr:match 'medicate disastrous' .
  ?s franz:text ?text .
  ?s otherProperty ?other . }
```

- Solr can also be used from the API and the CLI

Native Full-Text Search in Stardog

- Based on Lucene
- Creation of a “search document” per RDF literal
- Disabled by default, must be enabled:

```
stardog-admin db create -o
                    search.enabled=true -n myDb
```

- Three modes for rebuilding indexes, configured by setting **`search.reindex.mode`** to:
  - *sync* (synchronous rebuild with a transacted write, dflt.)
  - *async* (asynchronous rebuild “as soon as possible”), or
  - *scheduled* (cron expression specifies when to rebuild)

Native Full-Text Search in Stardog (cont'd)

- Search syntax as in Lucene:
  - e.g., wildcards `?` and `*`, fuzzy with similarity `~0.5`
- Use it on the command line:

```
stardog query search -q "html" -l 10 myDb
```

- Use it in SPARQL:

```
SELECT DISTINCT ?s ?score WHERE {
?s ?p ?l.
(?l ?score) <tag:stardog:api:property:textMatch>
                                        "html"}

SELECT DISTINCT ?s ?score WHERE {
?s ?p ?l.
(?l ?score) <tag:stardog:api:property:textMatch>
                                ("html" 0.5 10)}
```

Native Full-Text Search in GraphDB

- Based on Lucene
- For each RDF node, text document that is made up of other nodes reachable from the node (“molecule”)

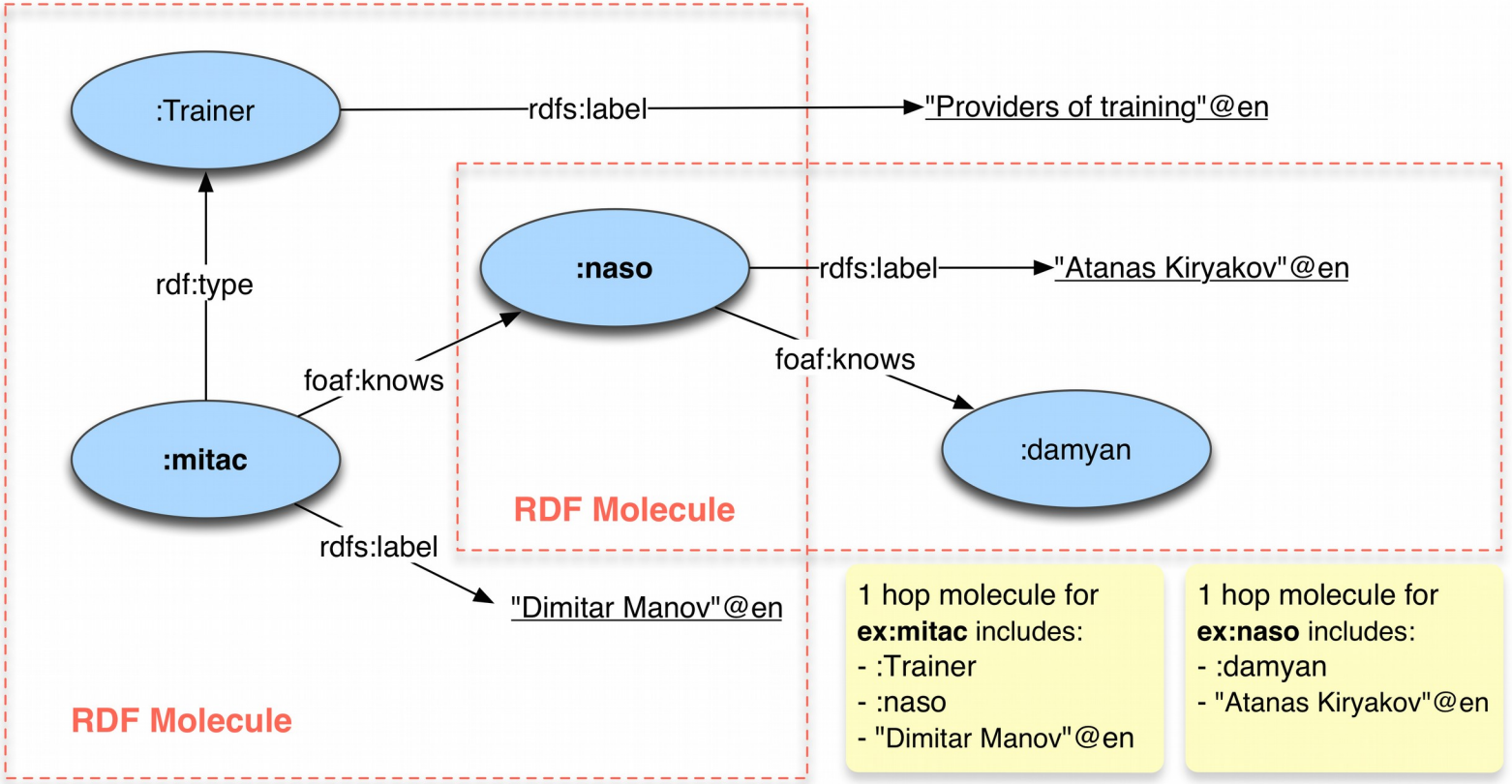


Image source: http://graphdb.ontotext.com/documentation/free/full-text-search.html

Native Full-Text Search in GraphDB

- Based on Lucene
- For each RDF node, text document that is made up of other nodes reachable from the node (“molecule”)
- Indexes can be parameterized
  - what kinds of nodes are indexed (URIs / literals)
  - literals with specific language tags only
  - what is included in the notion of “molecule”
  - size of the “molecule” to index
  - relevance of nodes boosted by RDF Rank values
  - alternative analyzers
  - alternative scorers
- Multiple, differently configured full-text indexes possible

Native Full-Text Search in GraphDB (cont'd)

- Setting up an (example) configuration for full-text indexes:

```
PREFIX luc: <http://www.ontotext.com/owlim/lucene#>
INSERT DATA {
  luc:index          luc:setParam  "uris" .
  luc:include        luc:setParam  "literals" .
  luc:moleculeSize   luc:setParam  "1" .
  luc:includePredicates  luc:setParam
     "http://www.w3.org/2000/01/rdf-schema#label" .
}
```

- Creating a new index (uses the previous configuration):

```
PREFIX luc: <http://www.ontotext.com/owlim/lucene#>
INSERT DATA {
  luc:myTestIndex luc:createIndex "true" .
}
```

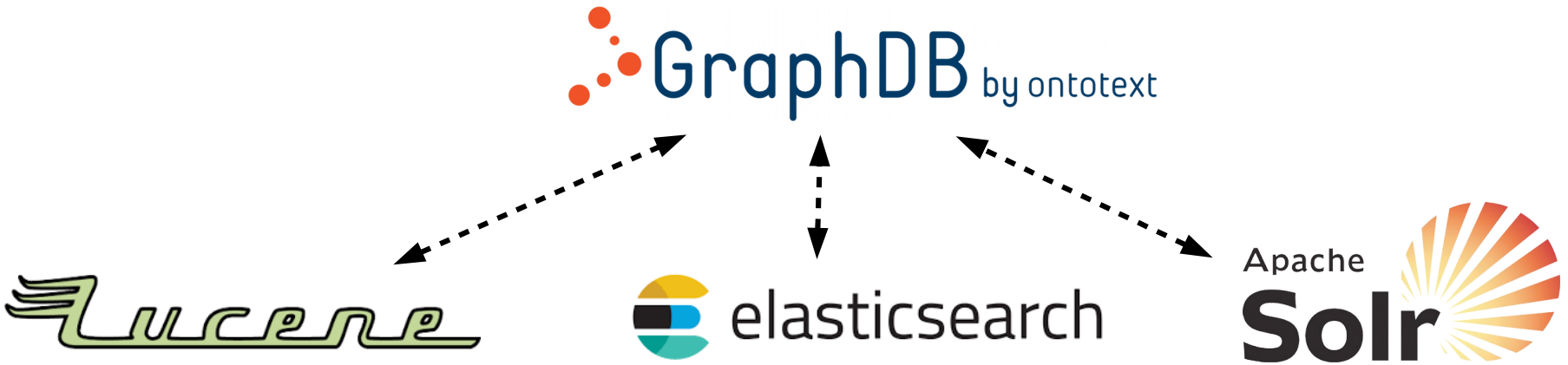
Native Full-Text Search in GraphDB (cont'd)

- Use the index in a query
  - ```
    PREFIX luc: <http://www.ontotext.com/owlim/lucene#>
    SELECT * { ?id luc:myTestIndex "ast*" }
    ```
  - ```
    PREFIX luc: <http://www.ontotext.com/owlim/lucene#>
    SELECT * {
      ?id luc:myTestIndex "lucene query string" .
      ?node luc:score ?score .
    } ORDER BY ( ?score )
    ```
- Incremental update

```
PREFIX luc: <http://www.ontotext.com/owlim/lucene#>
INSERT DATA {
  luc:myTestIndex luc:addToIndex ex:newURI .
}
```

Connecting External Search to GraphDB

- Connectors for Lucene, Solr, and Elasticsearch (the latter two only in the enterprise edition of GraphDB)
- Similar to how Blazegraph supports access to an external Solr service from within a SPARQL query



Native Full-Text Search in MarkLogic

- Built-in full-text search feature is custom-built
- Full-text indexes created when loading a document
- Powerful grammar for string queries
  - Examples:

```
(cat OR dog) NEAR vet
dog NEAR/30 vet
cat -dog
"cats and dogs"
dog NOT_IN "dog house"
dog BOOST cat
```

Built-In Full-Text Search in Triple Stores

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GraphDB SE	x	Lucene Solr, ElasticSearch (Enterprise)
BlazeGraph	x	SolR
Oracle 12c	x	