# INDEXING AND SEARCHING RDF DATASETS

## Improving Performance of Semantic Web Applications with Lucene, SIREn and RDF

Mike Hugo
Entagen, LLC

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slides and sample code can be found at

https://github.com/mjhugo/rdf-lucene-siren-presentation

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Groovy


HIBERNATE


Java
Sun Microsystems


JBoss™


ORACLE®


GRAILS


MySQL®


Apache
Solr


Lucene


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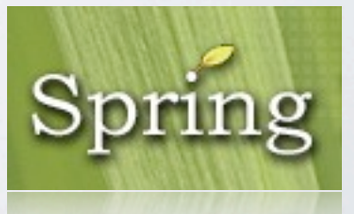
S




Spring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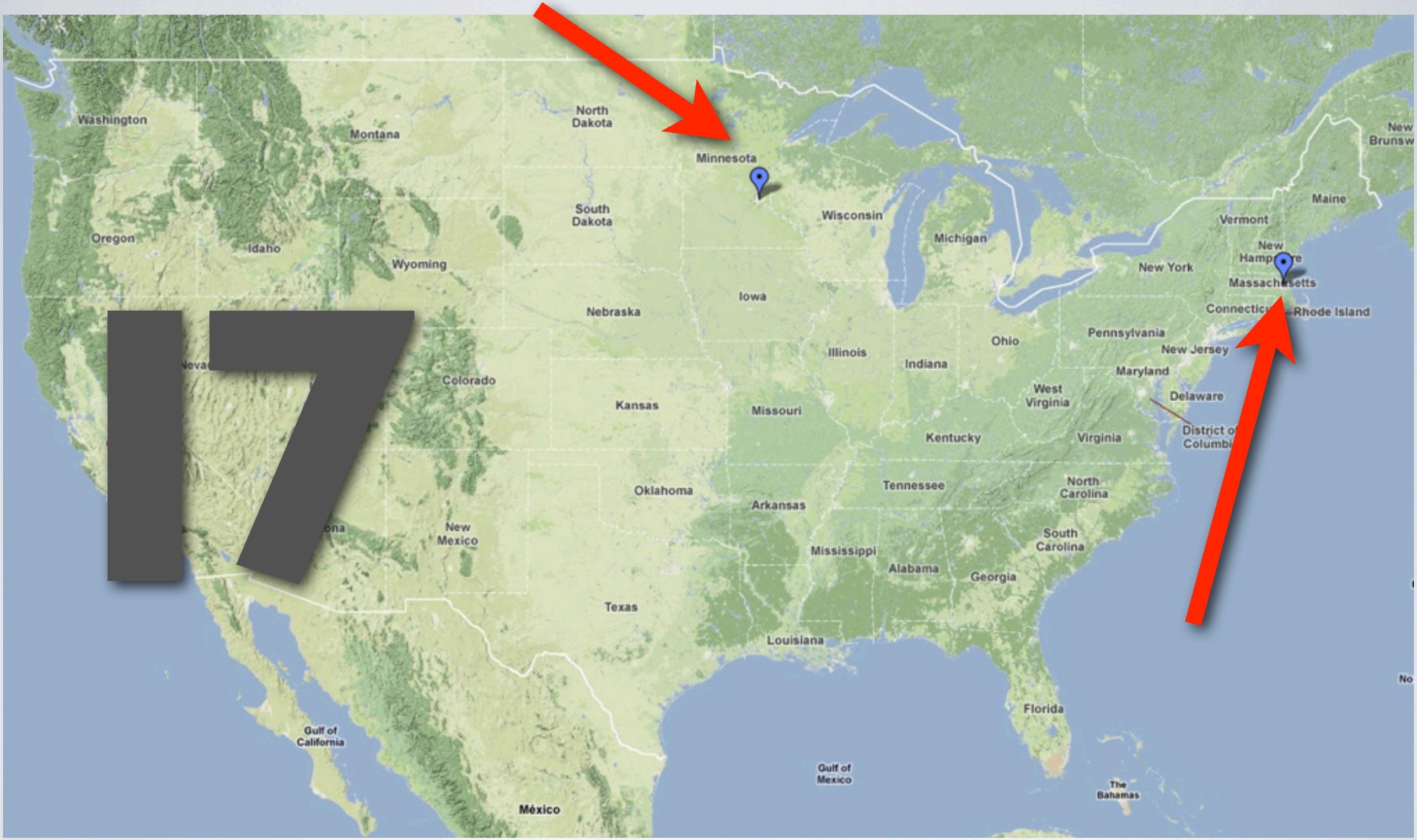


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MERCK

VULCAN

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quality of mind

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# TripleMap

Connections Matter

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# AGENDA

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Inkom
25
10
47
Lava Hot Springs
16
11
7
Soda Springs
19
Cammon
Grace
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Afton
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8

# SPARQL


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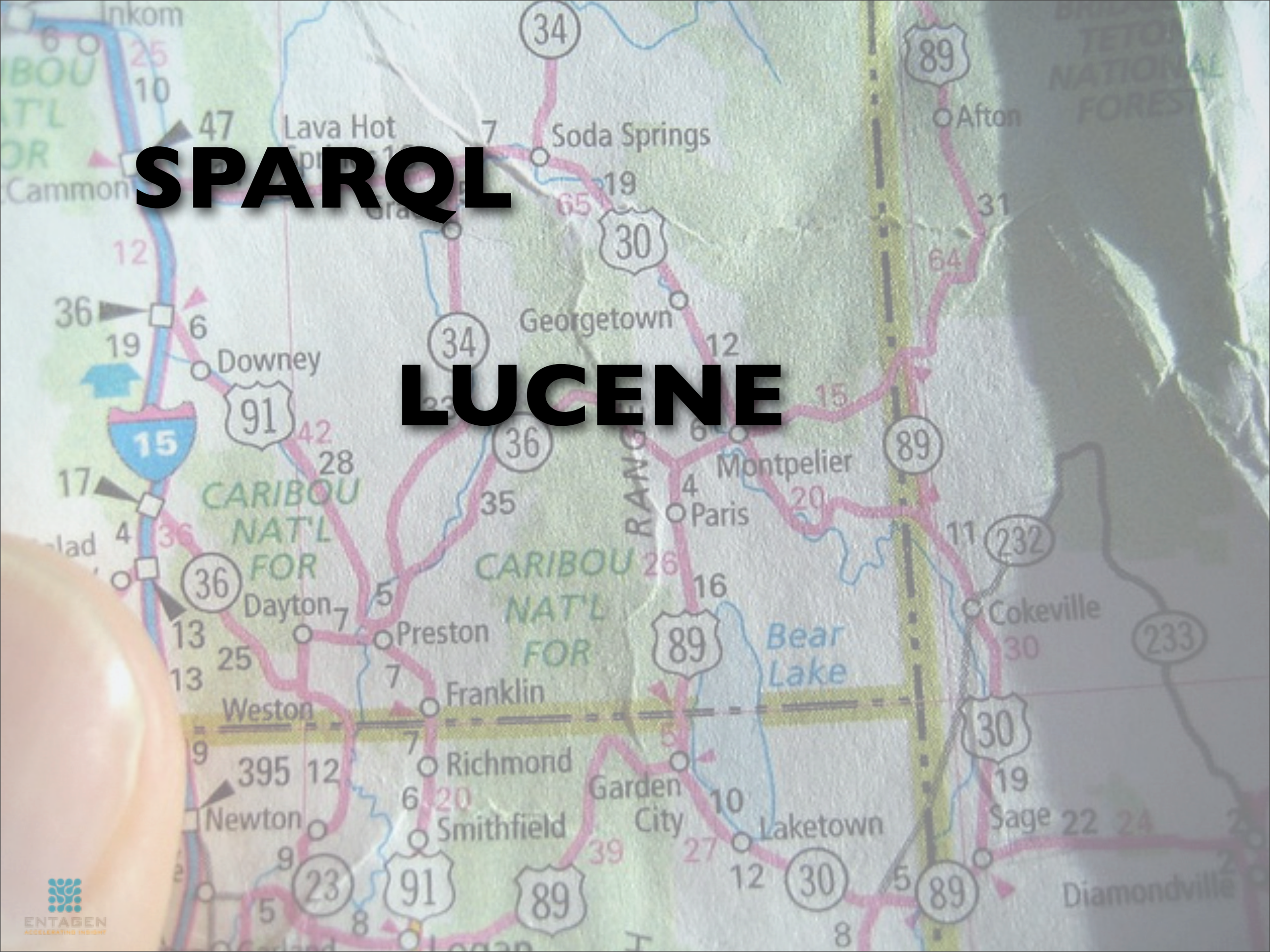
# SPARQL

# LUCENE

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Soda Springs
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# SPARQL

# LUCENE

# SIREN

# TripleMap.com

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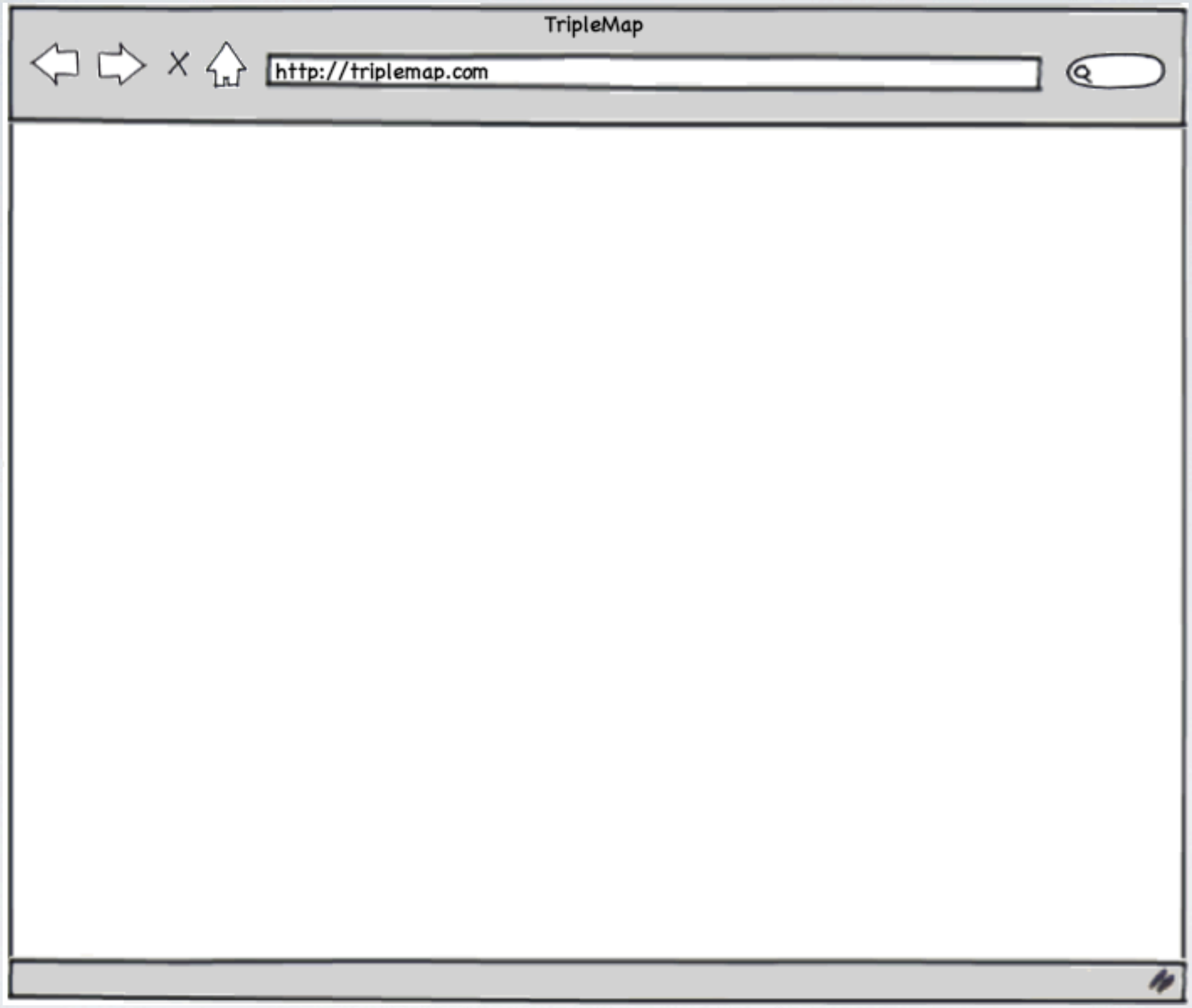


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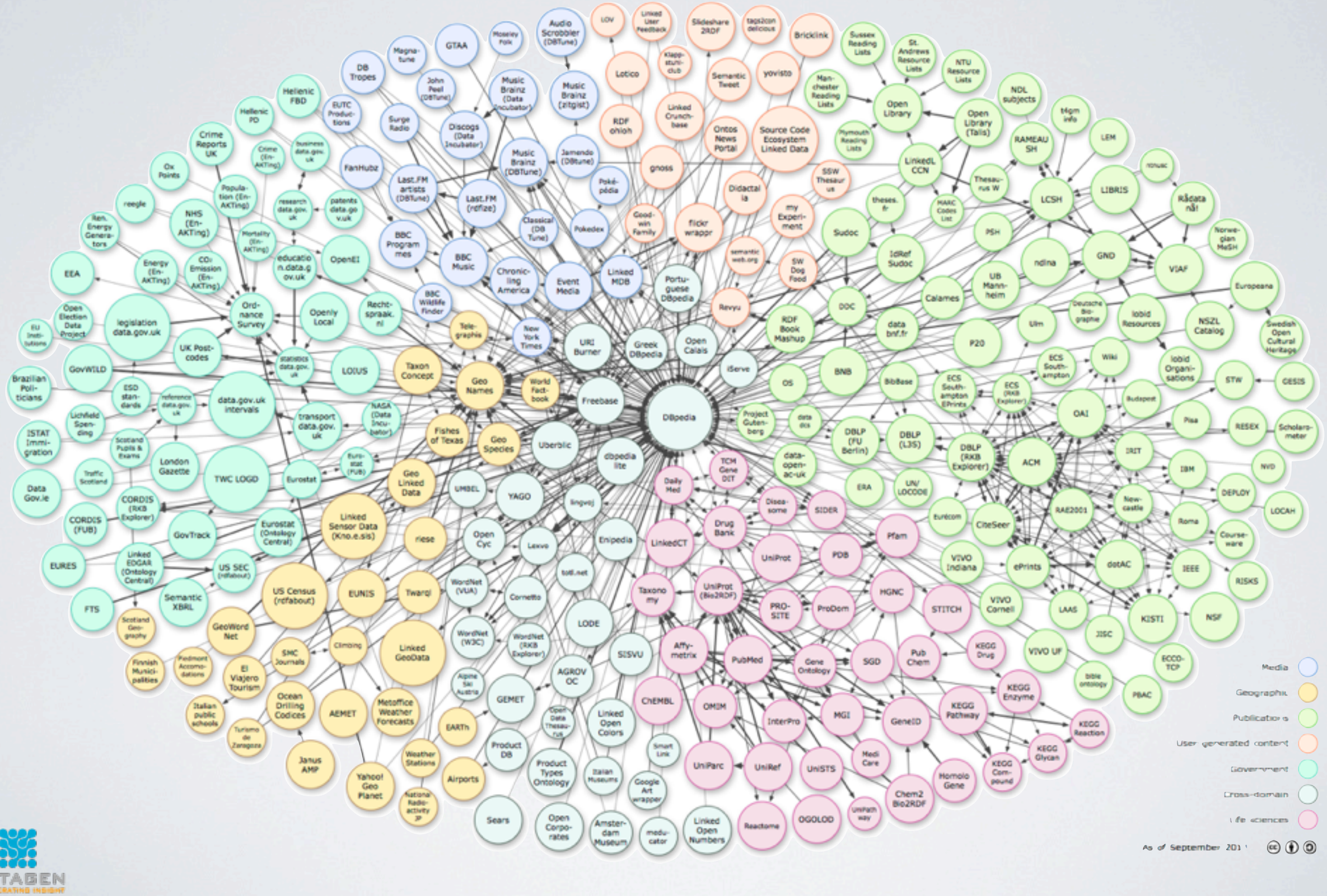
# LINKING OPEN DATA

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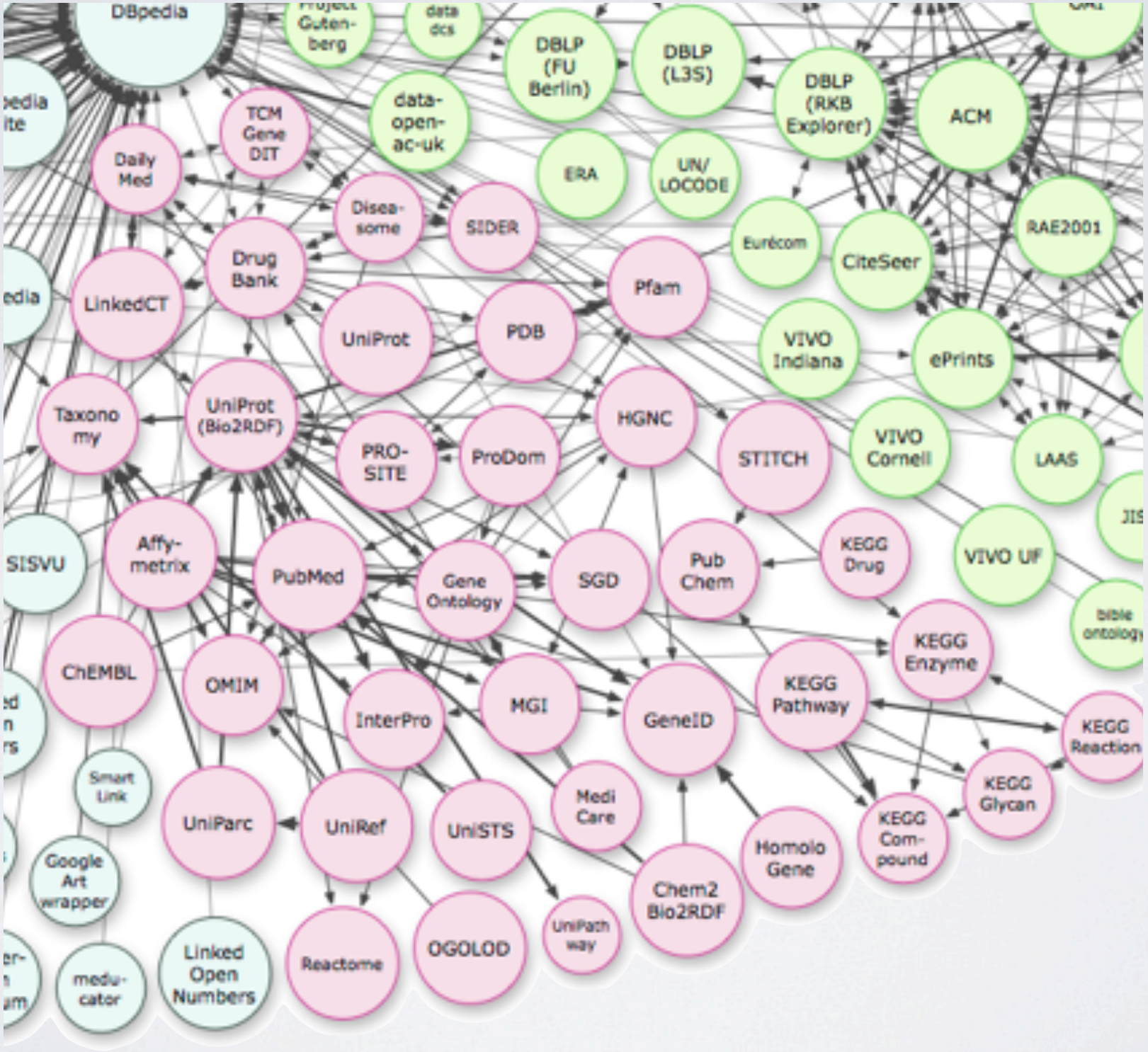
# **LIFE SCIENCE** LINKED DATA

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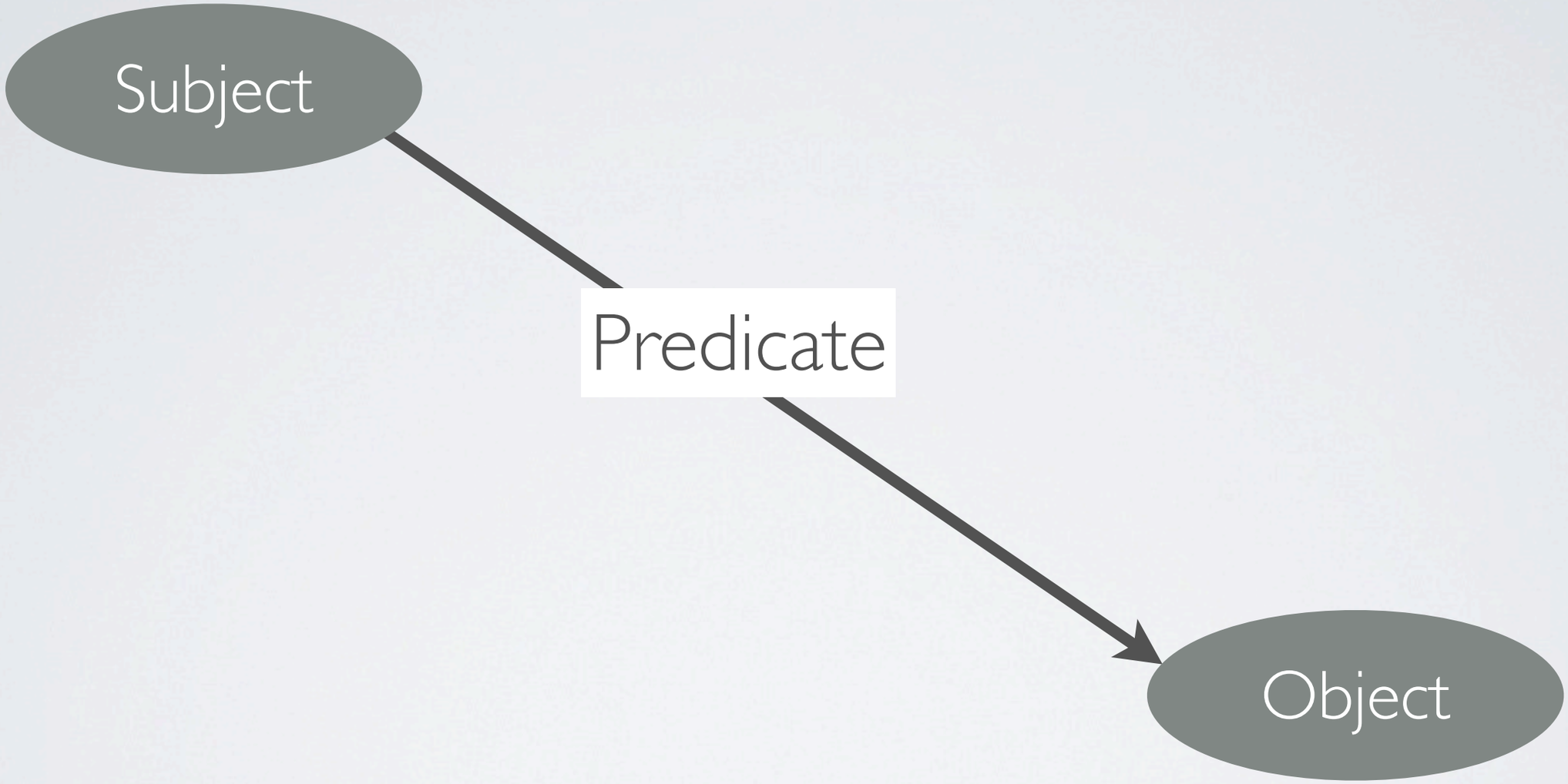
# WHAT'S A TRIPLE?

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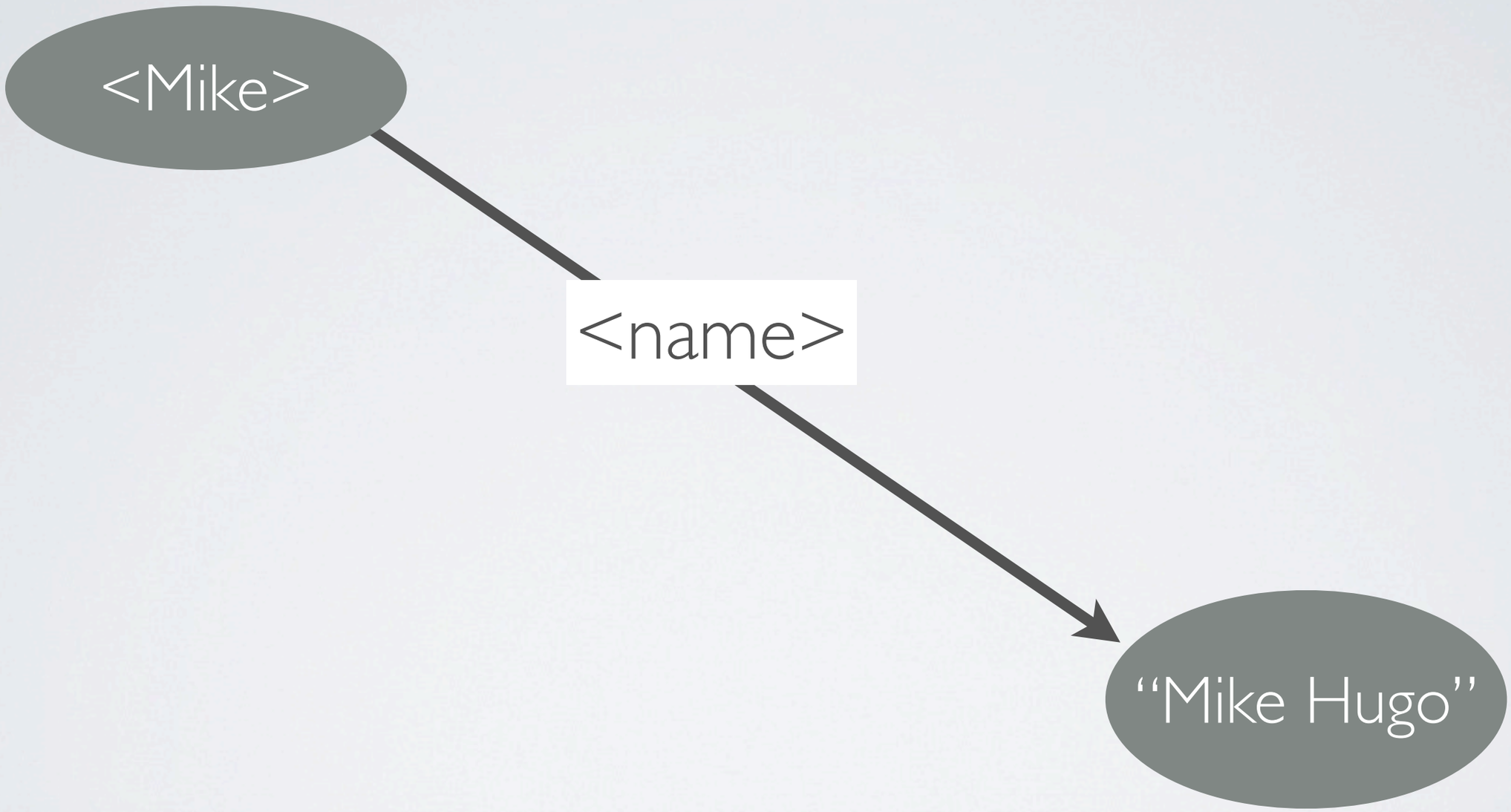
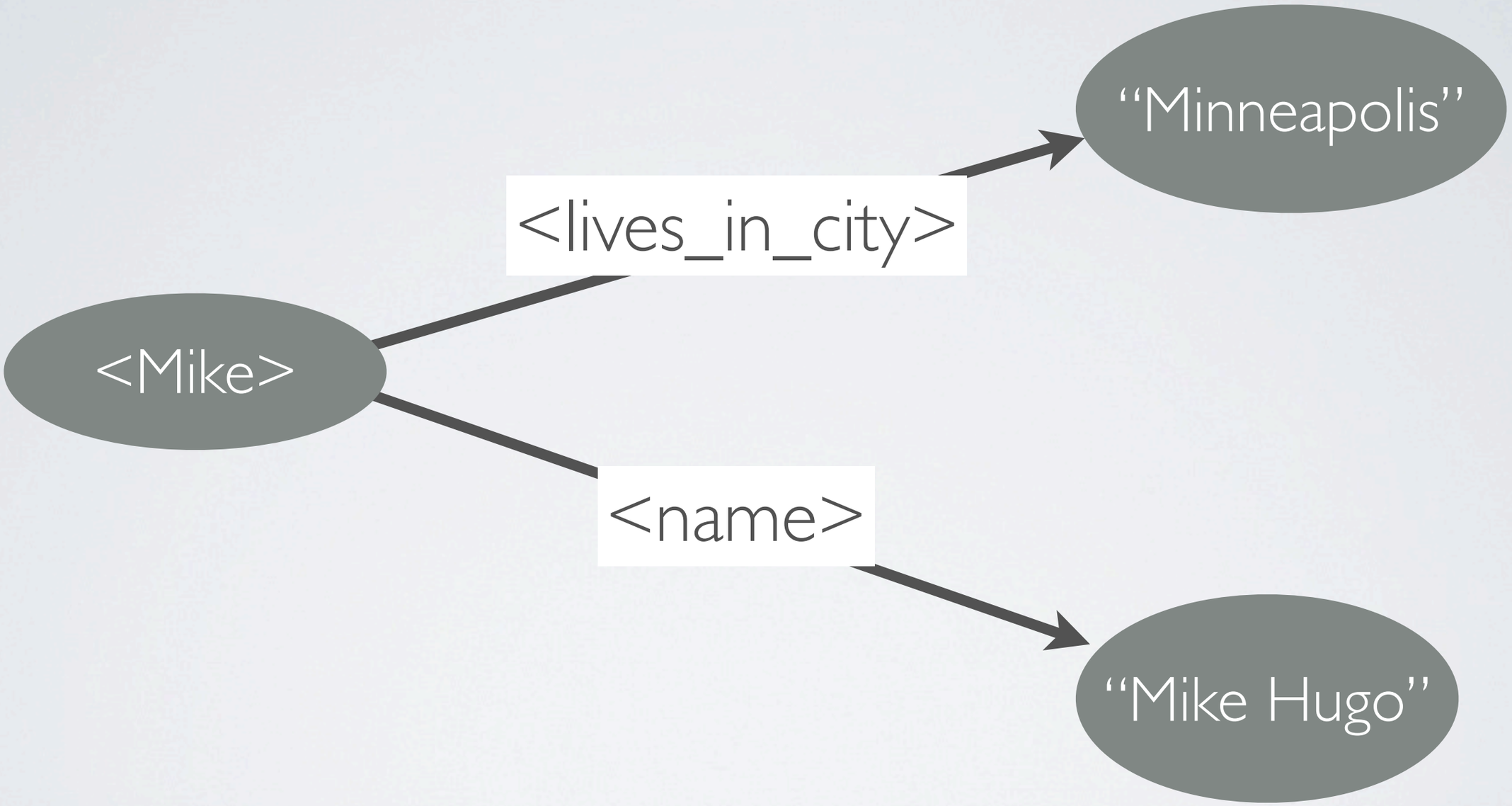
# WHAT'S A TRIPLE?



# WHAT'S A TRIPLE?

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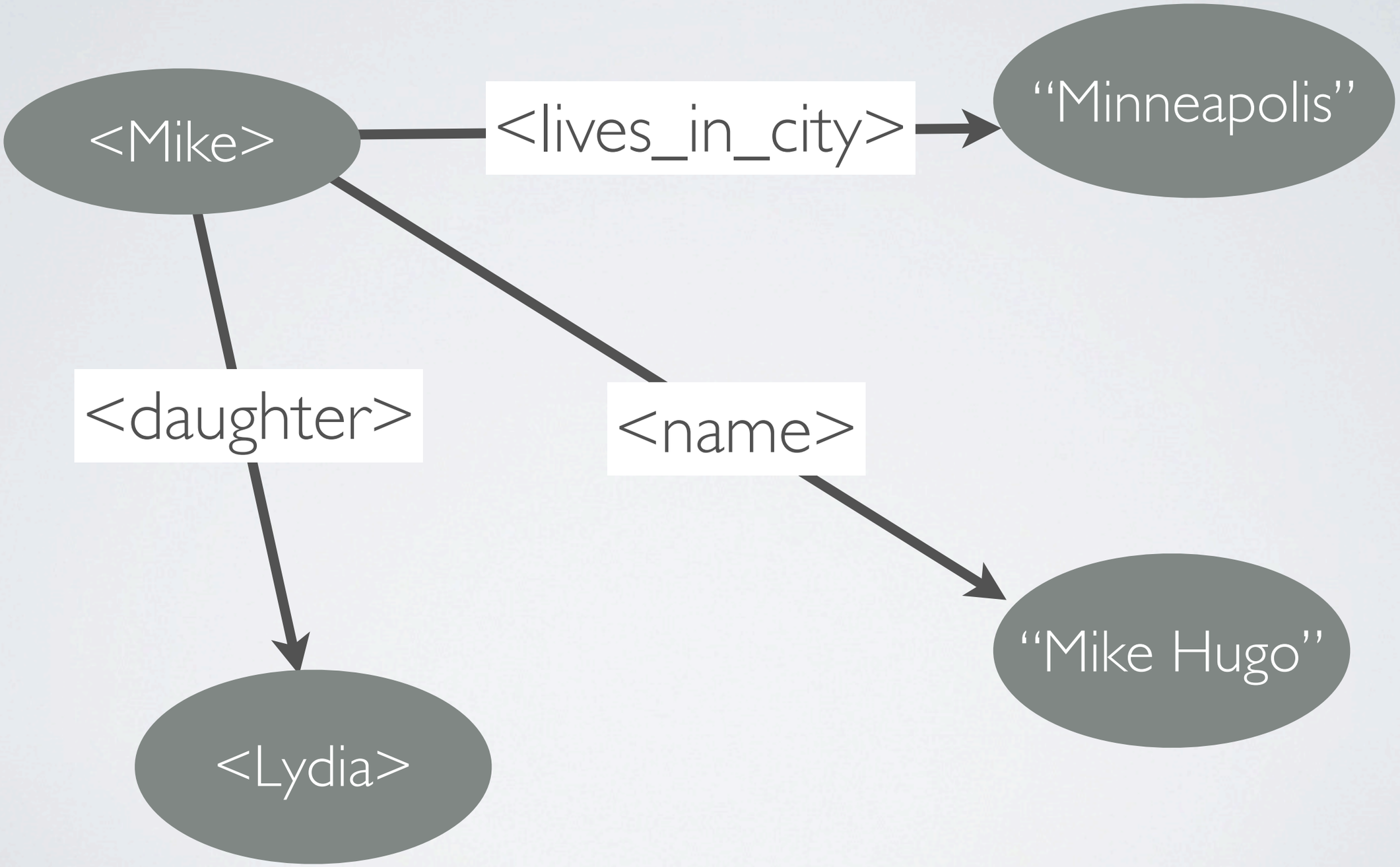
# WHAT'S A TRIPLE?

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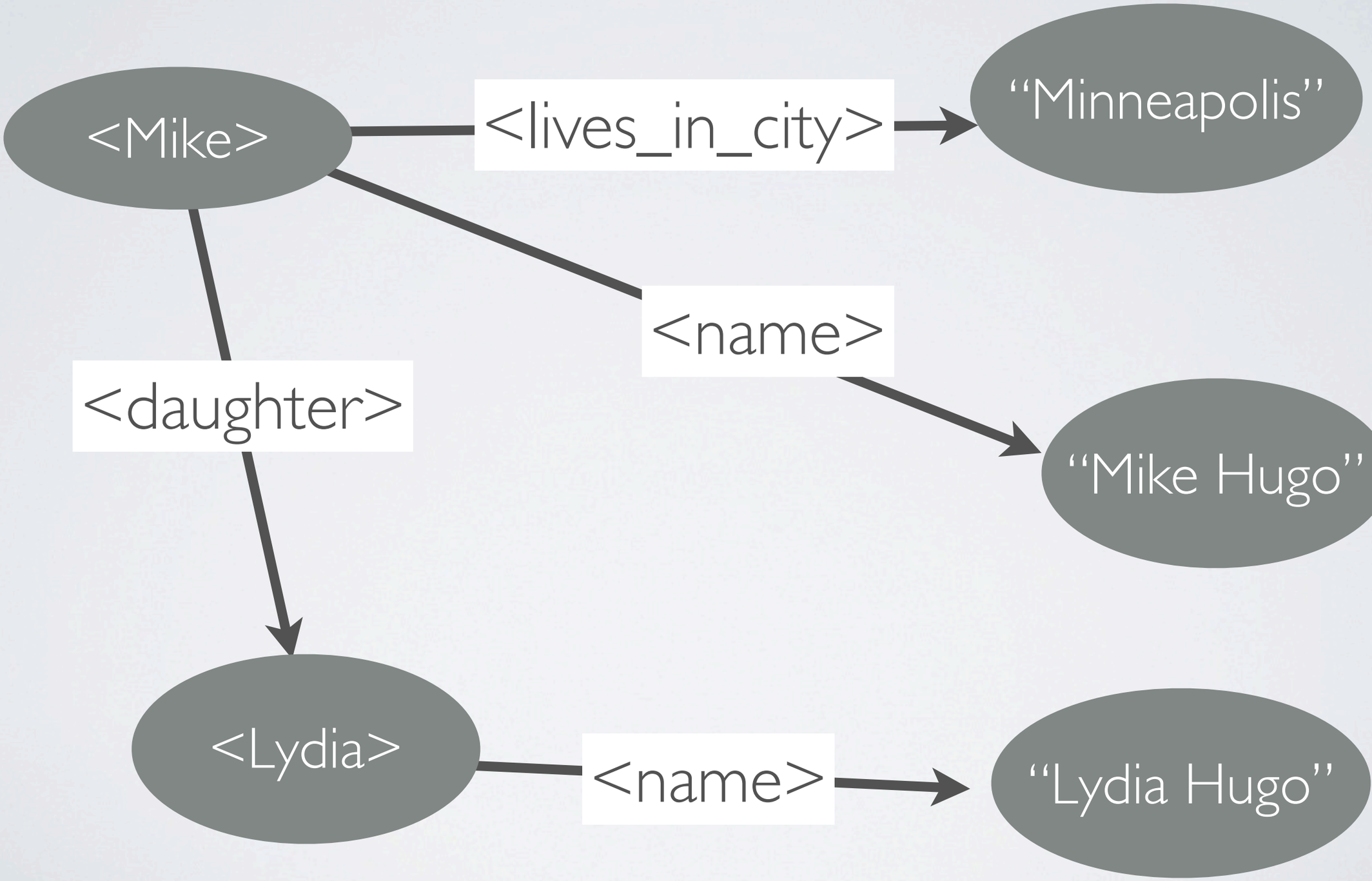
# WHAT'S A TRIPLE?

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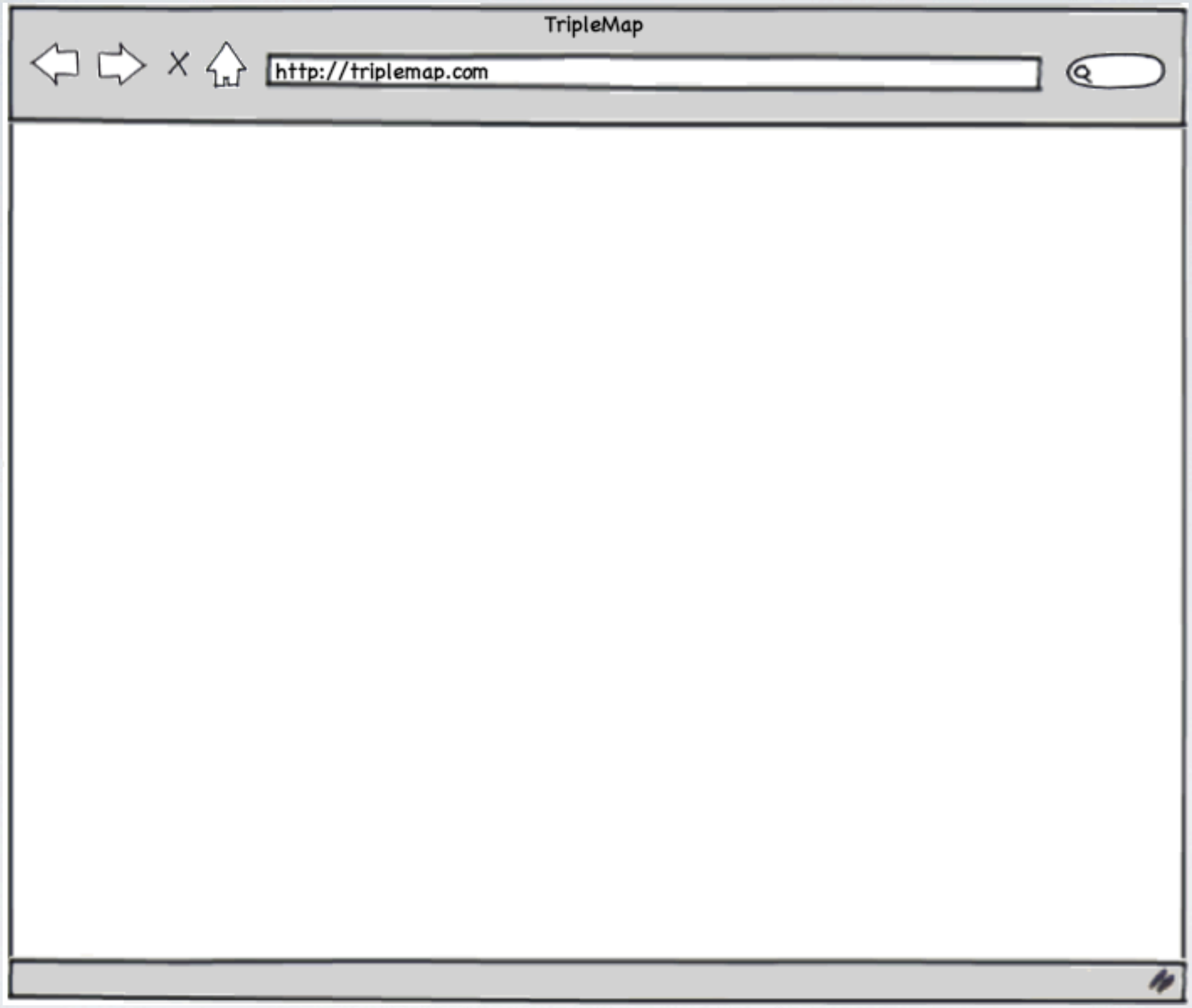


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TripleMap

http://triplemap.com

Search

Results:

| ID | Label |
|---|---|
| 1 | Lorem |
| 2 | Ipsum |
| 3 | Dolor |
| 4 | Sit Amet |

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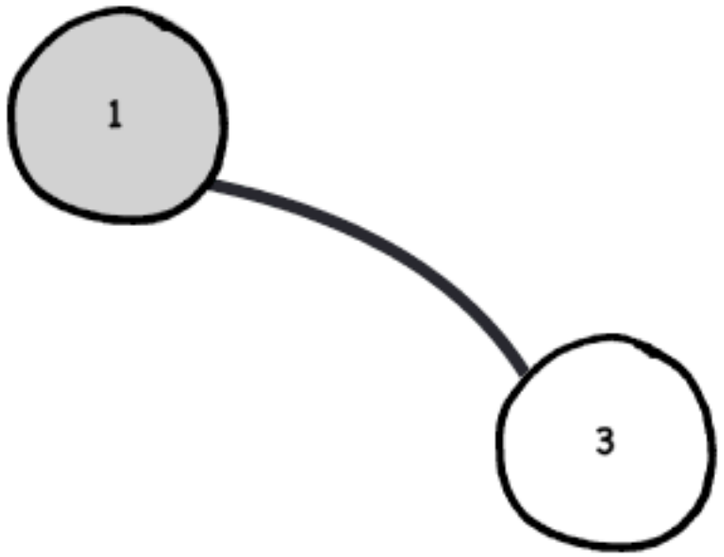
TripleMap

http://triplemap.com

Search

Related to "1"

| Related |
| --- |
| 2 |
| 4 |
| |
| |

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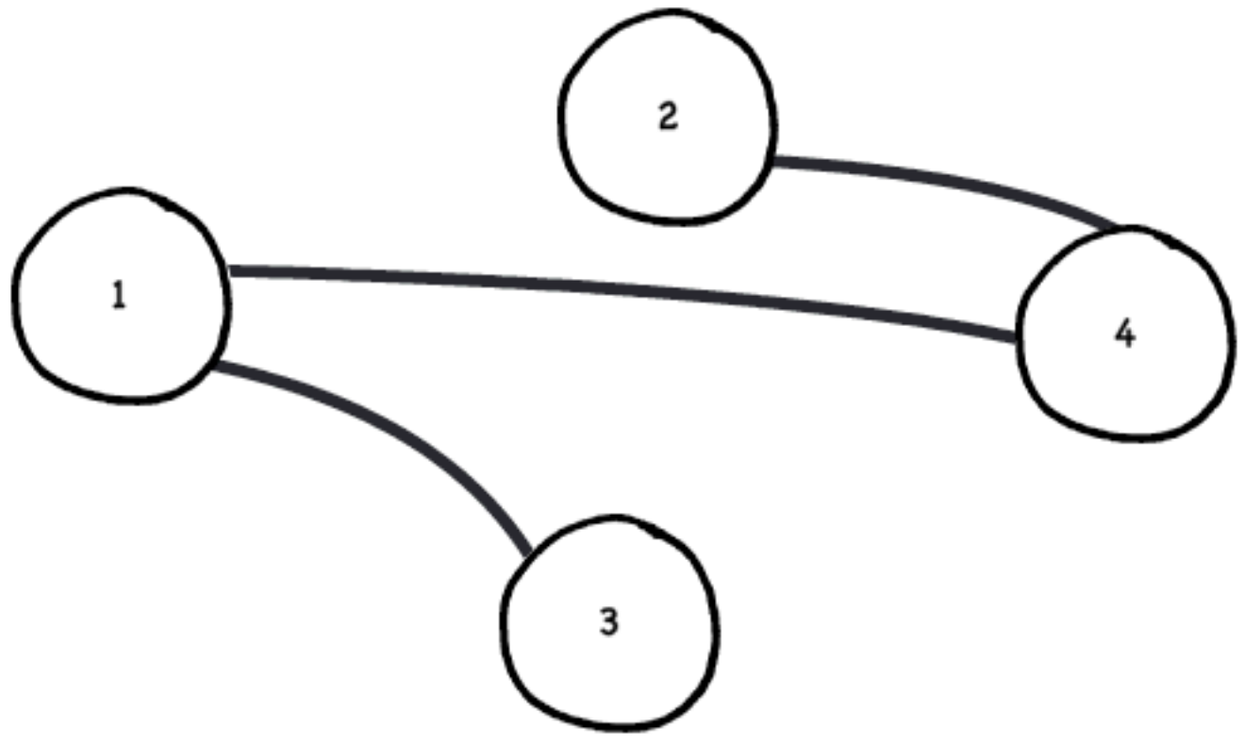
TripleMap

http://triplemap.com

Search

Results:

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# Ready, GO!

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```
select id, label
from targets
where label = '${queryValue}'
```

```
select id, label
from targets
where label
 ilike '%${queryValue}%'
```

```
SELECT ?uri ?type ?label WHERE {
   ?uri rdfs:label ?label .
   ?uri rdf:type ?type .
   FILTER (?label = '${params.query}')
} LIMIT 10
```

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```
SELECT ?uri ?type ?label WHERE {
  ?uri rdfs:label ?label .
  ?uri rdf:type ?type .
  FILTER regex(?label,
    '\\\\Q${params.query}\\\\E', 'i')
} LIMIT 10
```

```
SELECT ?uri ?type ?label WHERE {
   ?uri rdfs:label ?label .
   ?uri rdf:type ?type .
   FILTER regex(?label,
      '\\\\Q${params.query}\\\\E', 'i')
} LIMIT 10
```

query as literal value

case insensitive

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# DEMO

Baseline SPARQL Query Performance

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# FASTER!

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# Lucene


# Java API

# Indexing and Searching Text

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lucid IMAGINATION

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comcast®

ATLASSIAN

http://wiki.apache.org/lucene-java/PoweredBy

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# indexing


# storage

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Lucene

# Document


# Document

| field | value |
|---|---|
| ID | 2 |
| name | “Mike Hugo” |
| company | “Entagen” |
| bio | “lorem ipsum dolor sum etc...” |

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Lucene

# Index

| field | value |
|---|---|
| id | 2 |
| name | “Mike Hugo” |
| company | “Entagen” |
| bio | “lorem ipsum dolor sum etc.. |

**Indexed not Stored**

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Query: **name: mike**

Lucene

Query: **name: mike**

Matching Documents:

| field | value |
|---|---|
| id | 2 |

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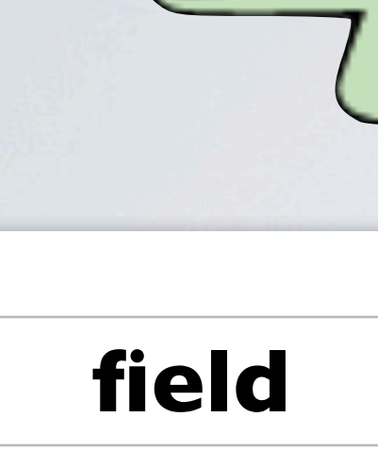
| field | value |
|---|---|
| id | 2 |

Lucene

| field | value |
| --- | --- |
| id | 2 |

Lucene

| field | value |
|---|---|
| id | 2 |



| field | value |
|---|---|
| ID | 2 |
| name | “Mike Hugo” |
| company | “Entagen” |
| bio | “lorem ipsum dolor sum etc...” |

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# Simplest Solution

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# Lucene index of rdfs:label

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# Build the Index

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```
String queryLabels = """
    SELECT ?uri ?label
    WHERE {
        ?uri rdfs:label ?label .
    }
"""
```

**Build a SPARQL query to find all the rdfs:label properties**

```
sparqlQueryService.executeForEach(repo
    def doc = new Document()
    String uri = it.uri.stringValue()
    String label = it.label.stringValu

    doc.add(new Field(SUBJECT_URI_FIE
            Field.Store.YES, Field.Ind
```

```
sparqlQueryService.executeForEach
  (repository, queryLabels) {
    String uri = it.uri.stringValue()
    String label = it.label.stringValu
```

**Execute the SPARQL query**

```
    new Document()

    doc.add(new Field(SUBJECT_URI_FIE
            Field.Store.YES, Field.In
    doc.add(new Field(LABEL_FIELD, la
            Field.Store.NO, Field.Inde

    writer.addDocument(doc)

}
```

```
iqiQueryService.executeForEach(reposito
 String uri = it.uri.stringValue()
 String label = it.label.stringValue()

 Document doc = new Document()
 doc.add(new Field(SUBJECT_URI_FIELD,
           uri,
           Field.Store.Y
           Field.Index.ANALYZED))
doc.add(new Field(LABEL_FIELD,
           label,
           Field.Store.NO,
           Field.Index.ANALYZED))

writer.addDocument(doc)
```

**Instantiate a new Lucene Document**

```
Document doc = new Document()
doc.add(new Field(SUBJECT_URI_FIELD,
        uri,
        Field.Store.YES,
        Field.Index.ANALYZED))
doc.add(new Field(LABEL_FIELD,
        label,
        Field.Store.NO
        Field.Index.AN

 writer.addDocument(doc)

ly {
```

key

value

**Add the Subject URI to the Document**

```
            Field.Store.YES,
            Field.Index.ANALYZED));
doc.add(new Field(LABEL_FIELD,
    label,
            Field.Store.NO,
            Field.Index.ANALYZED));


 writer.addDocument

ly {
ter.close()  // Close index
```

key

value

**Add the Label field to the document (but don't store it)**

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```
                Field.Store.NO,
                Field.Index.ANALYZED))

    writer.addDocument(doc)
}
inally {
 writer.close()   //
```

**Add the document to the Index**

# Query the Index

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```
query = {
Query query = new QueryParser(
    Version.LUCENE_CURRENT,
    LABEL_FIELD,
    new StandardAnalyzer())
            .parse(params.query);
```

query this field

for this value

```
def s                                    ime
List                                     teQuery(query)
def e                                    ime

render(view: 'index', model: [results:
```

**Create a Lucene Query from user input**

```
IndexSearcher searcher = luceneSearche
ScoreDoc[] scoreDocs =
    searcher.search(query, 10).scoreDo
List results = []
def connection = r                    ction
scoreDocs.each {
    Document doc =                    t.doc
    String uri = doc[SUBJECT_URI_FIELD
    Map labelAndType = sparqlQueryServ
    results << [uri: uri, type: labelA
}
connection.close()
return results
```

**Search the index (limit 10) for matching documents**

```
List results = []
def connection = repository.connection
scoreDocs.each {
  Document doc = searcher.doc(it.doc)
  String uri = doc[SUBJECT_URI_FIELD]
  Map labelAndType =
    spa
      g                                    i, connection)
  resu
                uri: uri,
                type: labelAndType.type,
                label: labelAndType.label])
}
connection.close()
return results
```

**For each matching document, get the doc and extract the Subject URI**

```
List results = []
def connection = repository.connection
scoreDocs.each {
  Document doc = searcher.doc(it.doc)
  String uri = doc[SUBJECT_URI_FIELD]
  Map labelAndType =
   sparqlQueryService.
     getLabelAndType(uri, connection)
  results.add([
        uri: uri
        type: la
        label: l                    ])
}
connection.close()
return results
```

**Using the Subject URI, load properties from the triplestore**

```
List results = []
def connection = repository.connection
scoreDocs.each {
  Document doc
  String uri =
  Map labelAnd
   sparqlQueryService.
     getLabelAndType(uri, connection)
  results.add([
        uri: uri,
        type: labelAndType.type,
        label: labelAndType.label])
}
connection.close()
return results
```

.doc)

IELD]

**return results containing Subject URI, Type, and Label**

# DEMO

Lucene Index of Searchable Labels

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# WHAT ABOUT ENTITY RELATIONSHIPS?

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# WHAT ABOUT OTHER PROPERTIES?

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**SIREn**

*{ Semantic Information Retrieval Engine }*

# Lucene Extension

# Indexing and Searching Semi-Structured Data

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**SIREn**

*{ Semantic Information Retrieval Engine }*

# Document

**SIREn**

*{ Semantic Information Retrieval Engine }*

# Document

| field | value |
|---|---|
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib" .<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec" .<br><DB00619> drugbank:target <targets/1588> . |

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# Build the Index

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```
Connection connection = repository.conn
y {
  String subjectUris = """
     SELECT distinct ?uri
     WHERE {
          ?uri ?p ?o .
     }
  """

  sparqlQueryService.executeForEach(rep
       def doc = ne

       String subje                    ring
       doc.add(new Field(SUBJECT_URI_FIE
                 subjectUri,
                 Field.Store.YES
```

**Select all Subject URIs from the triplestore**

```
"""
sparqlQueryService.executeForEach(
  repository, subjectUris) {
    def doc = new Document()

    String subjectUri = it.uri.stringV
    doc.add(new Field(SUBJECT_URI_FIEL
            subjectUri,
            Field.Store.YES,

    StringWr                    er =
    NTriplesWriter nTriplesWriter =
        new NTriplesWriter(triplesStri
    connection.exportStatements(
```

**Execute the Sparql Query**
**For each URI, create a new Document**

```
def doc = new Document()

String subjectUri = it.uri.stringValue
doc.add(new Field(SUBJECT_URI_FIELD,
          subjectUri,
          Field.Store.YES,
          Field.Index.ANALYZED))

StringWriter triplesStringWriter = new
NTriplesWriter nT
    new NTriplesW                    ngWr
connection.exportStatements(
          new URIImpl(subjectUri),
          null, null, false,
```

**Add the Subject URI to the Document**

```
        Field.Index.ANALYZED))

StringWriter triplesStringWriter = new
NTriplesWriter nTriplesWriter =
    new NTriplesWriter(triplesStringWr
connection.exportStatements(
        new URIImpl(subjectUri),
        null, null, false,
        nTriplesWriter)

doc.add(new Field(T
        triplesStri                    ())
        Field.Store
        Field.Index.ANALYZED))
```

**Get an NTriples string from the triplestore**

```
            new URIImpl(subjectUri),
            null, null, false,
            nTriplesWriter)


doc.add(new Field(TRIPLES_FIELD,
            triplesStringWriter.toString(),
            Field.Store.NO,
            Field.Index.ANALYZED))

writer.addDocumen
```

**Add the NTriples string to the document**

```
                                    );

doc.add(new Field(TRIPLES_FIELD,
                  triplesStringWriter.toString(
                  Field.Store.NO,
                  Field.Index.ANALYZED))

writer.addDocument(doc)
```

**Add the document to the index**

# Query the Index

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```
SirenCellQuery predicate =
  new SirenCellQuery(
    new SirenTermQuery(
      new Term(TRIPLES_FIELD,
      RDFS.LABEL.stringValue())));
predicate.constraint = PREDICATE_CELL

SirenCellQuery object =
  new SirenCellQue
    new SirenTermQu
      new Term(TRIPLES_FIELD,
      params.query.toLowerCase()))
object.constraint = OBJECT_CELL
```

**query the Triples field**

```
SirenCellQuery predicate =
  new SirenCellQuery(
    new SirenTermQuery(
        new Term(TRIPLES_FIELD,
        RDFS.LABEL.stringValue())));
predicate.constraint = PREDICATE_CELL
```

```
SirenCellQuery object =
  new SirenCellQue
    new SirenTermQuery(
        new Term(TRIPLES_FIELD,
        params.query.toLowerCase()))
object.constraint = OBJECT_CELL
```

**for a predicate**

```
SirenCellQuery predicate =
  new SirenCellQuery(
    new SirenTermQuery(
        new Term(TRIPLES_FIELD,
        RDFS.LABEL.stringValue())));
predicate.constraint = PREDICATE_CELL

SirenCellQuery object
  new SirenCellQuery(
    new SirenTermQuery(
        new Term(TRIPLES_FIELD,
                                Case()))
object.constraint = OBJECT_CELL
```

**of rdfs:label ***

*** note: could be any predicate!**

```
SirenCellQuery object =
   new SirenCellQuery(
    new SirenTermQuery(
                new Term(TRIPLES_FIELD,
                         params.query.toLowerCase()))
object.constraint = OBJECT_CELL

Query query = new SirenTupleQuery()
query.add(predicat
          SirenTuple                    T)
query.add(object,
          SirenTupleClause.Occur.MUST)
```

**query the Triples field**

```
SirenCellQuery object =
   new SirenCellQuery(
    new SirenTermQuery(
            new Term(TRIPLES_FIELD,
            params.query.toLowerCase()))
object.constraint = OBJECT_CELL
```

```
Query query = new SirenTupleQuery()
query.add(predicate
        SirenTupleClause.Occur.MUST)
query.add(object,
        SirenTupleClause.Occur.MUST)
```

**for an object**



```
List results = executeQuery(query)
```

```
SirenCellQuery object =
   new SirenCellQuery(
    new SirenTermQuery(
                new Term(TRIPLES_FIELD,
                  params.query.toLowerCase()))
object.constraint = OBJECT_CELL
```

```
Query query = new SirenTupleQuery()
query.add(predicat
        SirenTuple                    T)
query.add(object,
        SirenTupleClause.Occur.MUST)
```

**matching the user input**


```
List results = executeQuery(query)
```

| field | value |
|---|---|
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib" .<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec" .<br><DB00619> drugbank:target <targets/1588> . |

Query: **“imatinib”**

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| field | value |
| --- | --- |
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib" .<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec" .<br><DB00619> drugbank:target <targets/1588> . |

Query:

**triples field**

| field | value |
|---|---|
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib" .<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec" .<br><DB00619> drugbank:target <targets/1588> . |

Query:

**predicate = rdfs:label**

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ACCELERATING INSIGHT

| field | value |
| --- | --- |
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib".<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec" .<br><DB00619> drugbank:target <targets/1588> . |

Query:

**predicate = rdfs:label**

**object = “imatinib”**

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```
List executeQuery(Query query) {
IndexSearcher searcher = sirenSearcherM
ScoreDoc[] scoreDocs =
  searcher.search(query, 10).scoreDocs
List results = []
def connection = repos                    n
scoreDocs.each {
    Document doc = sea                    c
    String uri = doc[S                    D
    Map labelAndType = sparqlQueryServi
        getLabelAndType(uri, connectio
    results.add([
            uri: uri,
            type: labelAndType.type,
```

**Search the index (limit 10) for matching documents**

```
List results = []
def connection = repository.connection
scoreDocs.each {
    Document doc = searcher.doc(it.doc)
    String uri = doc[SUBJECT_URI_FIELD]
    Map labelAndType = sparqlQueryServic
            get                    connectio
    results.
                                   pe.type,
                label: labelAndType.label])
}

connection.close()
return results
```

**For each matching document, get the doc and extract the Subject URI**

```
 connection = repository.connection
reDocs.each {
 Document doc = searcher.doc(it.doc)
 String uri = doc[SUBJECT_URI_FIELD]
 Map labelAndType = sparqlQueryService.
       getLabelAndType(uri, connection)
 results.add([
              uri: uri,
              type: lab
              label: la
nection.close()
urn results
```

**Using the Subject URI, load properties from the triplestore**

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ACCELERATING INSIGHT

```
String uri = doc[SUBJECT_URI_FIELD]
Map labelAndType = sparqlQueryService.
      getLabelAndType(uri, connection)
results.add([
        uri: uri,
        type: labelAndType.type,
        label: labelAndType.label])
```

```
nection.close()
urn results
```

**return results containing Subject URI, Type, and Label**

# DEMO

SIREn Index of RDF Entities

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# FLEXIBILITY

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| field | value |
| --- | --- |
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib".<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec" .<br><DB00619> drugbank:target <targets/1588> . |

Query:

**predicate = rdfs:label**

**object = “imatinib”**

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| field | value |
|---|---|
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib".<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec" .<br><DB00619> drugbank:target <targets/1588> . |

Query:

**object = “imatinib”**

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| field | value |
| --- | --- |
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib".<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec"<br><DB00619> drugbank:target <targets/1588> . |

Query:

**object = “imatinib”**

**OR**

**object = “gleevec”**

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# MORE THAN LITERALS

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| field | value |
|---|---|
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib" .<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec" .<br><DB00619> drugbank:target <targets/1588> . |

Query:

**predicate = brandName**

| field | value |
| --- | --- |
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib" .<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec" .<br><DB00619> drugbank:target <targets/1588> . |

Query:

**predicate = target**

# RELATIONSHIPS

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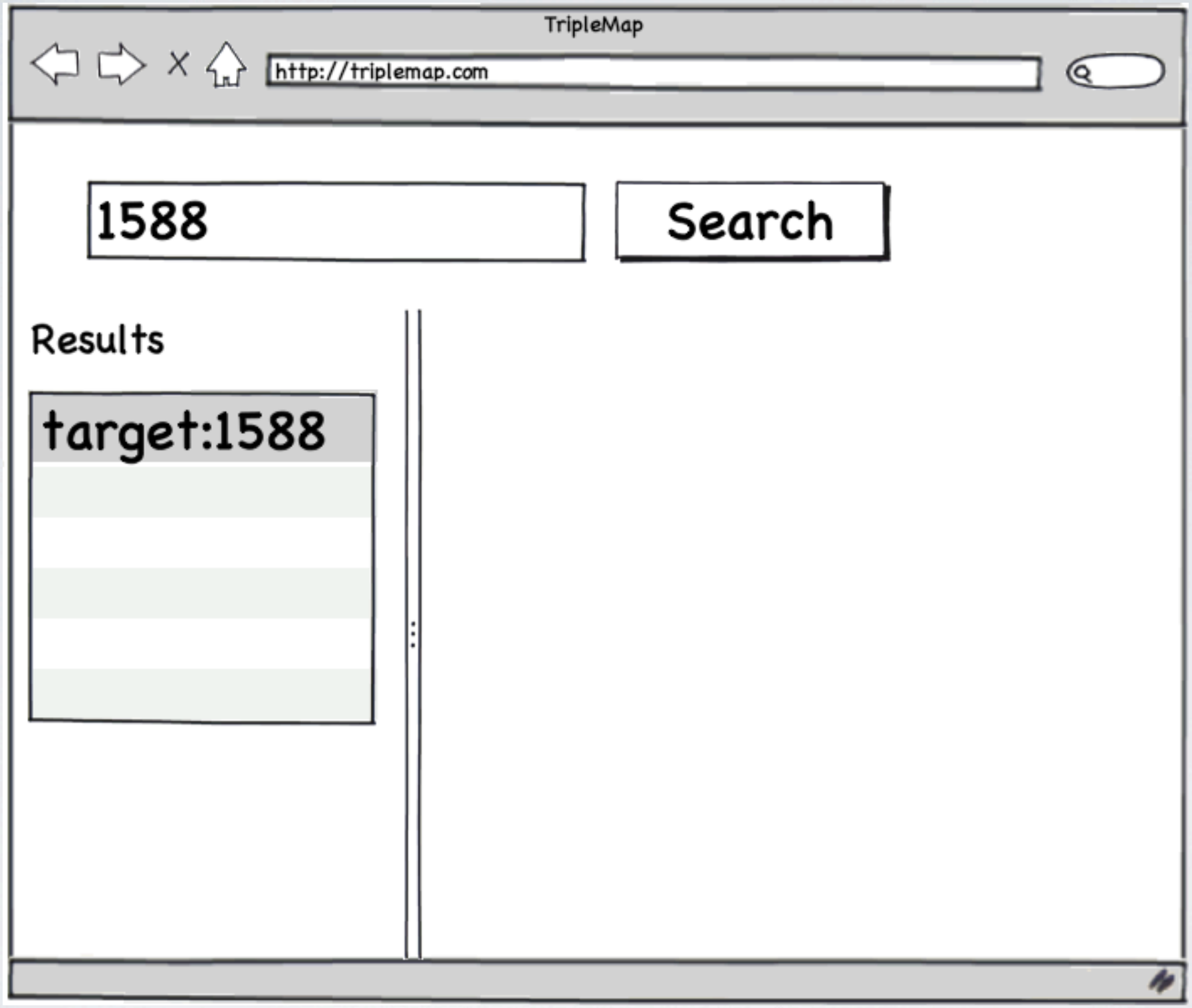
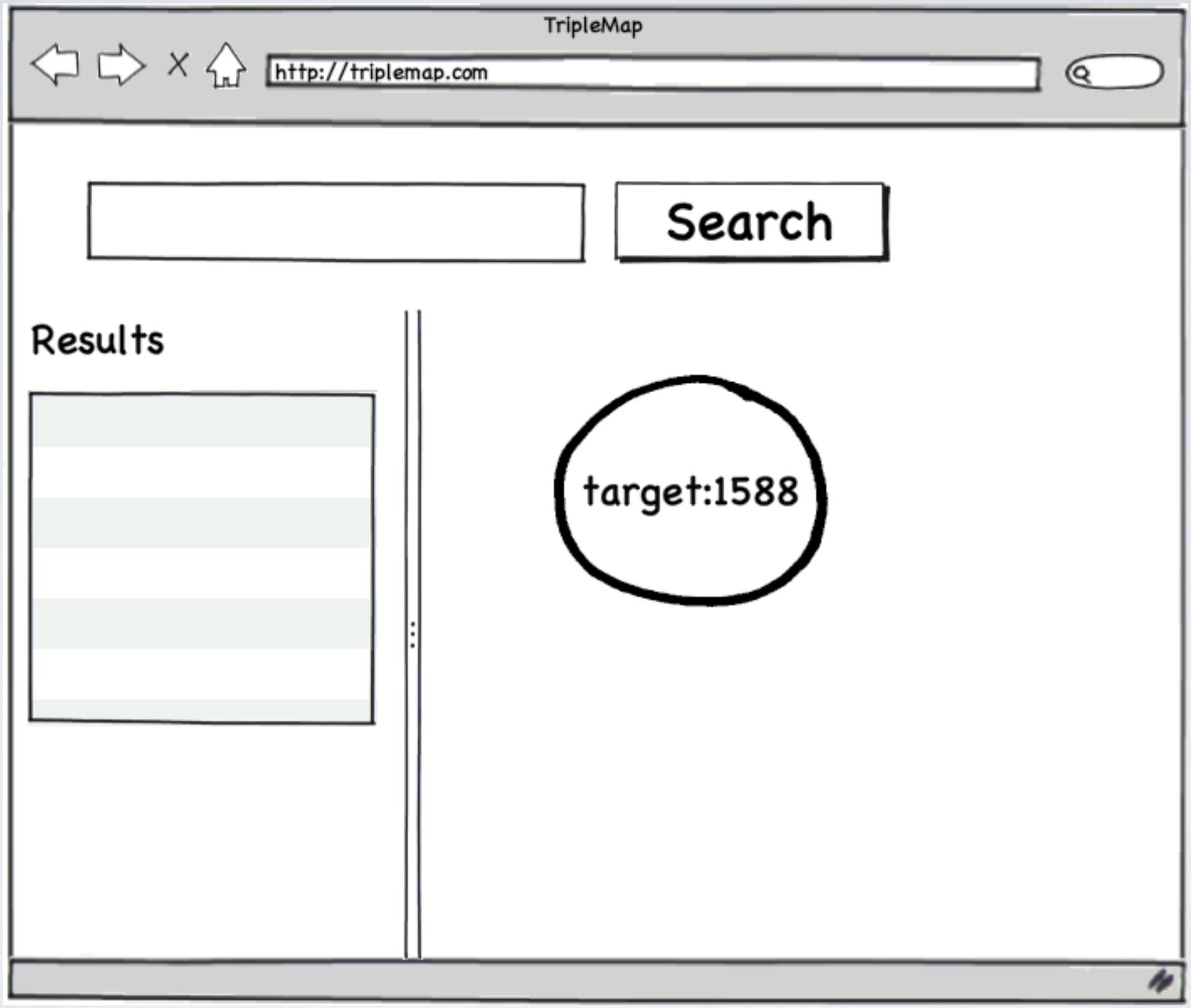

TripleMap
http://triplemap.com
1588
Search
Results
target:1588

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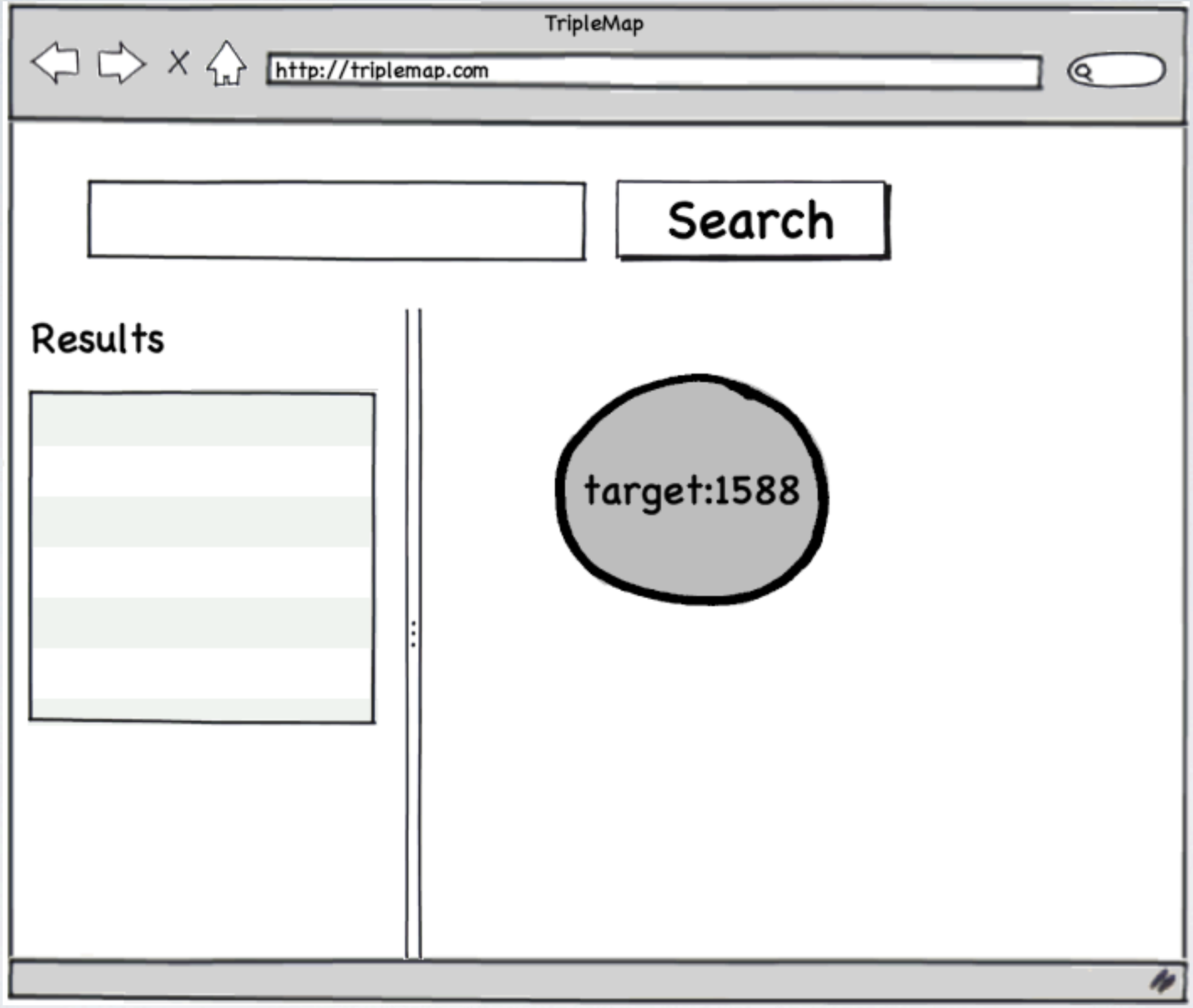


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TripleMap

http://triplemap.com

Search

Related to 1588:

| DB00619 |
| --- |
| |
| |
| |
| |
| |


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| field | value |
| --- | --- |
| URI | <DB00619> |
| triples | <DB00619> rdfs:label "Imatinib" .<br><DB00619> rdf:type <drugbank:drugs> .<br><DB00619> drugbank:brandName "Gleevec" .<br><DB00619> drugbank:target <targets/1588> . |

Query:

**object = <targets/1588>**

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# DEMO

Searching SIREn Index for Relationships

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# SIREn

*{ Semantic Information Retrieval Engine }*

Apache Solr

# Distributed
# Indexing and Searching Semi-Structured Data

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Apache Solr

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Apache Solr

Apache Solr

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indice
THE SEMANTIC WEB INDEX

Home About Se

Search interface type: Simple Advanced **Guru** Query Language Documentation

keyword(s)

ntriple(s) * <name> "Tim Berners Lee"

filter(s)

SEARCH Group By Dataset: Sorted by: relevance

Quick filters (All options)

Time range:

***Any date***

Today Yesterday Last week

Last month Last year

Format:

***Any format***

RDF RDFA MICROFORMAT XFN

HCARD HCALENDAR HLISTING

HRESUME LICENSE GEO ADR

**Sindice search:* <name> "Tim Berners Lee"** found 699 documer

http://dig.csail.mit.edu/2007/01/camp/data (RDF)

+ 2009-08-12 - 387 triples in 43.2 kB

http://dig.csail.mit.edu/2007/01/camp/data (Search) Inspect: (Cache) (Live)

http://dbpedia.org/data/Tim_Berners-Lee (RDF)

− 2011-05-18 - 171 triples in 38.8 kB

SIGMA FULL CONTENT GRAPH TRIPLES(890)

See all we know about "Tim Ber

indice
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Home About Se

Search interface type: Simple Advanced **Guru** Query Language Documentation

keyword(s)

ntriple(s) * <name> "Tim Berners Lee"

# 400 Million Documents
# > 12 Billion Triples

SEARCH Group By Dataset: Sorted by: relevance

Quick filters (All options) Sindice search: <name> "Tim Berners Lee" found 699 documen

**Time range:**

***Any date***

Today Yesterday Last week

Last month Last year

**Format:**

***Any format***

RDF RDFA MICROFORMAT XFN

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# Query Parser

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Search interface type: Simple Advanced **Guru** Query Language Documentation

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filter(s)

SEARCH Group By Dataset: Sorted by: relevance

Quick filters (All options)

Time range:

***Any date***

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nterface type: Simple Advanced **Guru** Query Language Documentation

keyword(s)

ntriple(s) * <name> "Tim Berners Lee"

filter(s)

SEARCH Group By Dataset: Sorted by: relevance

**subject** **predicate** **object**

tions)

Sindice search:* <name> "Tim Berners Lee" foun

http://dig.csail.mit.edu/2007/01/camp/data

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http://dig.csail.mit.edu/2007/01/camp/data (Search) Inspe

st week

ar

# DEMO

SIREn in action on TripleMap.com

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TripleMap

Welcome, Michael Hugo | **Logout** | **Help & Feedback**

**Search** Maps Analyze

Search... Search

Filter

Sort

Select Total count: 2

< Back **Indication**

Colchicine resistance

Colchicine_resistance

18

144

2

16

**Map View**

Remove

Remove All

Group

ABCB1

Proto-oncogene tyrosine-protein kinase ABL1

AssociatedGene

Target

Target

Colchicine resistance

PossibleDrug

PossibleDiseaseTarget

Imatinib

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# SPARQL

# LUCENE

# SIREN

# TripleMap.com

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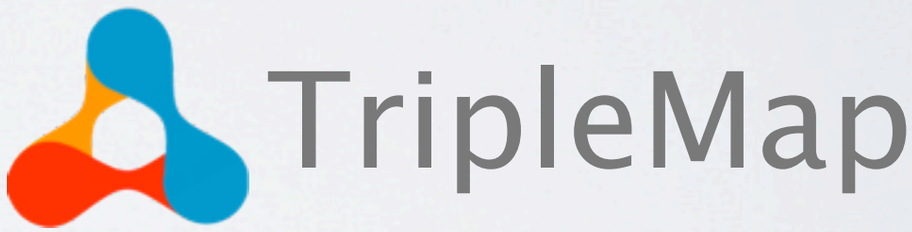
# QUESTIONS?

mike@entagen.com / twitter: @piragua


http://www.entagen.com




http://www.triplemap.com