INDEXING AND SEARCHING RDF DATASETS

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

Mike Hugo
Entagen, LLC

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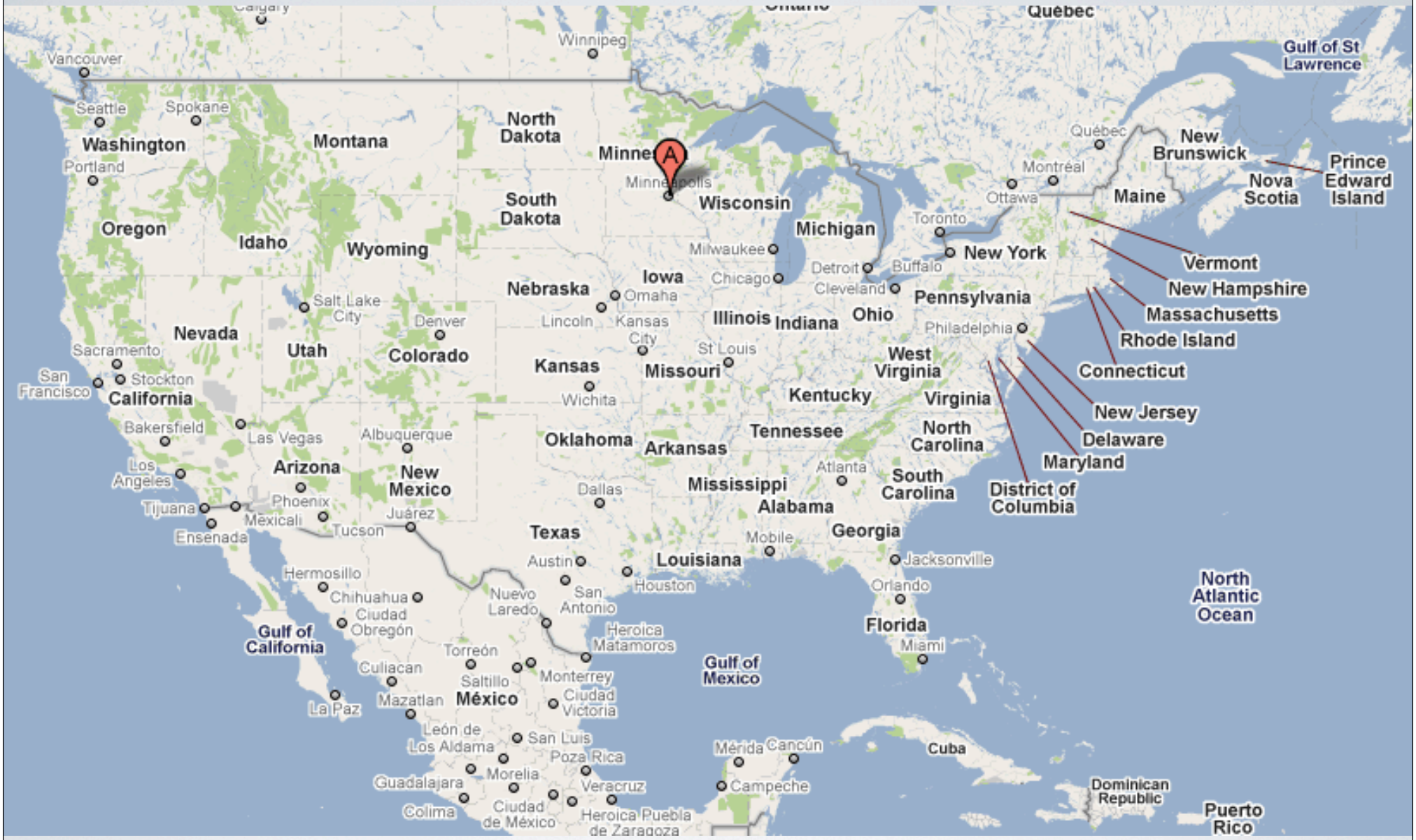
slides and sample code can be found at

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



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Groovy
HIBERNATE
JBoss™
GRAILS
Java
Sun Microsystems
ORACLE
Apache
Solr
MySQL®
Lucene
Spring
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ENTAGEN OVERVIEW

- Founded in May 2008
- 17 Team Members located in two onshore offices: Boston & Minneapolis
- Life sciences & biomedical expertise, extensive network and focused technical specialization in enterprise class search, integration and analysis systems
- Custom Software Development
- Proprietary Software Applications: TripleMap, BrightScan, ExaSeq
- Professional Services/Strategic Consulting

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SELECT ENTAGEN CLIENTS

MERCK

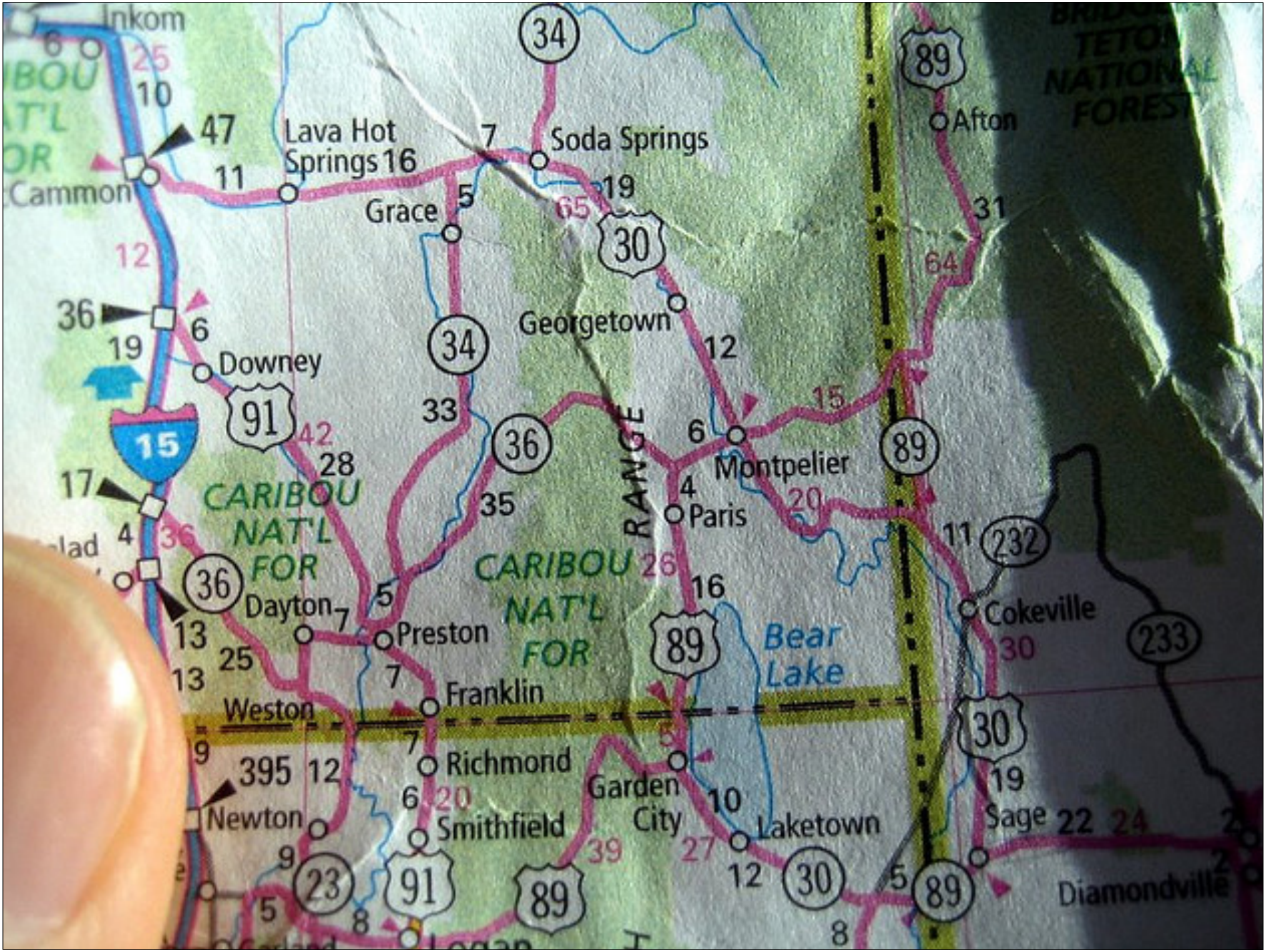
NOVARTIS

Boehringer Ingelheim

MILLIPORE

DANA-FARBER
CANCER INSTITUTE

AGENDA


Inkom
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Lava Hot Springs
Soda Springs
Afton
Grace
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Georgetown
Downey
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CARIBOU NAT'L FOR
RANGE
Montpelier
Paris
89
232
Dayton
Preston
CARIBOU NAT'L FOR
Bear Lake
Cokeville
233
Weston
Franklin
Richmond
Garden City
Laketown
Sage
Newton
Smithfield
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30
Diamondville


SPARQL
LUCENE
SIREN
TripleMap.com
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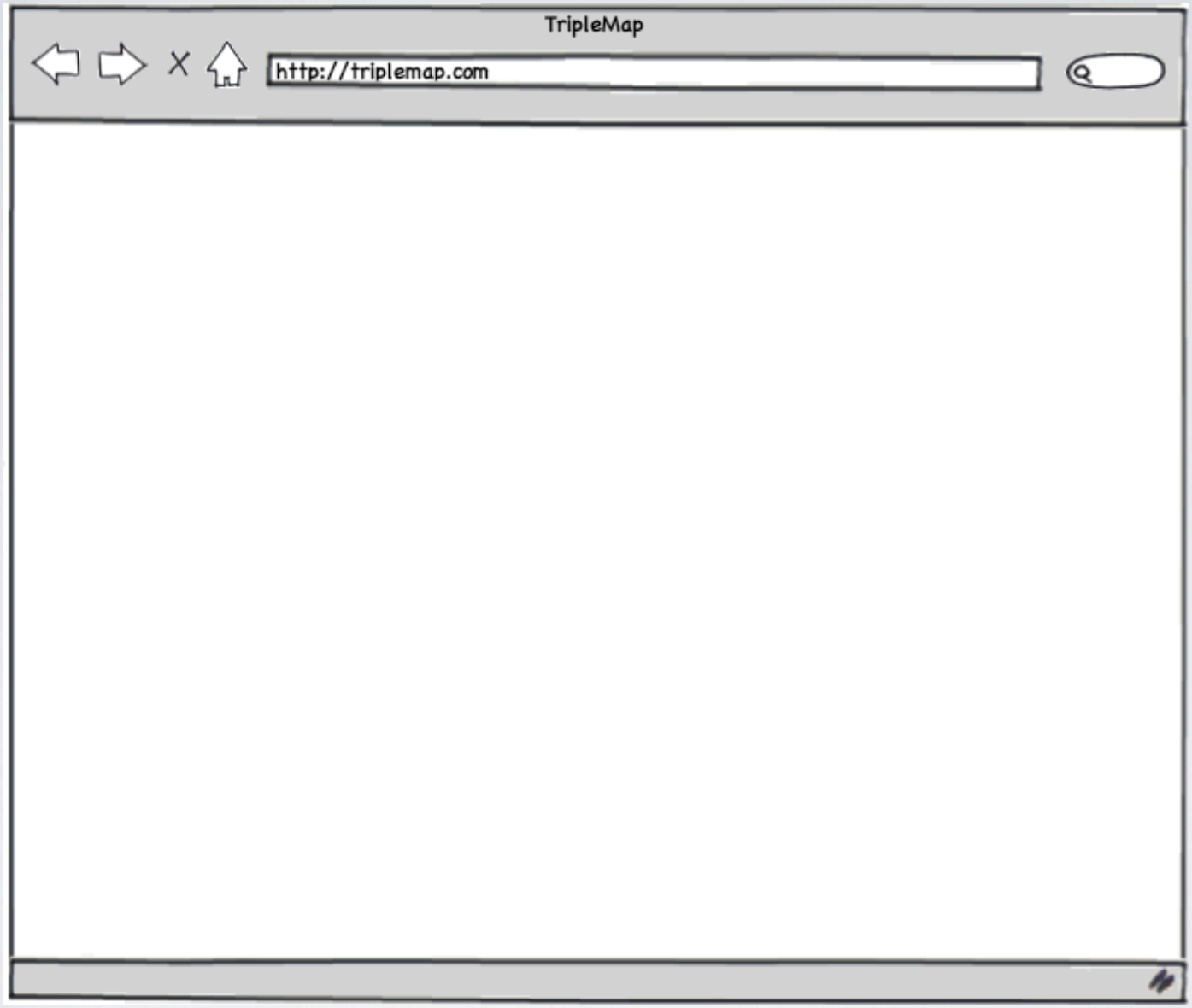

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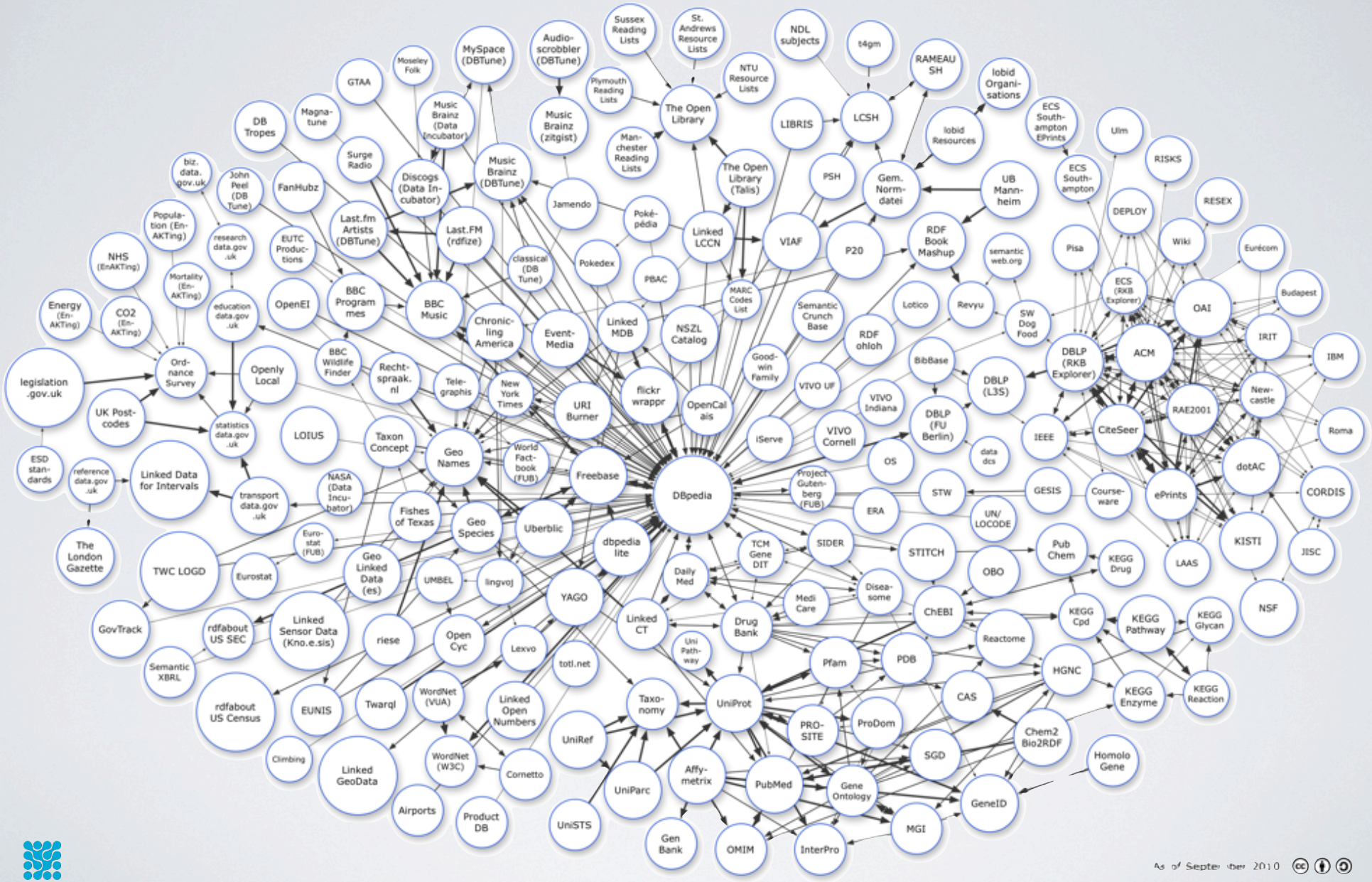
LINKING OPEN DATA



As of September 2010

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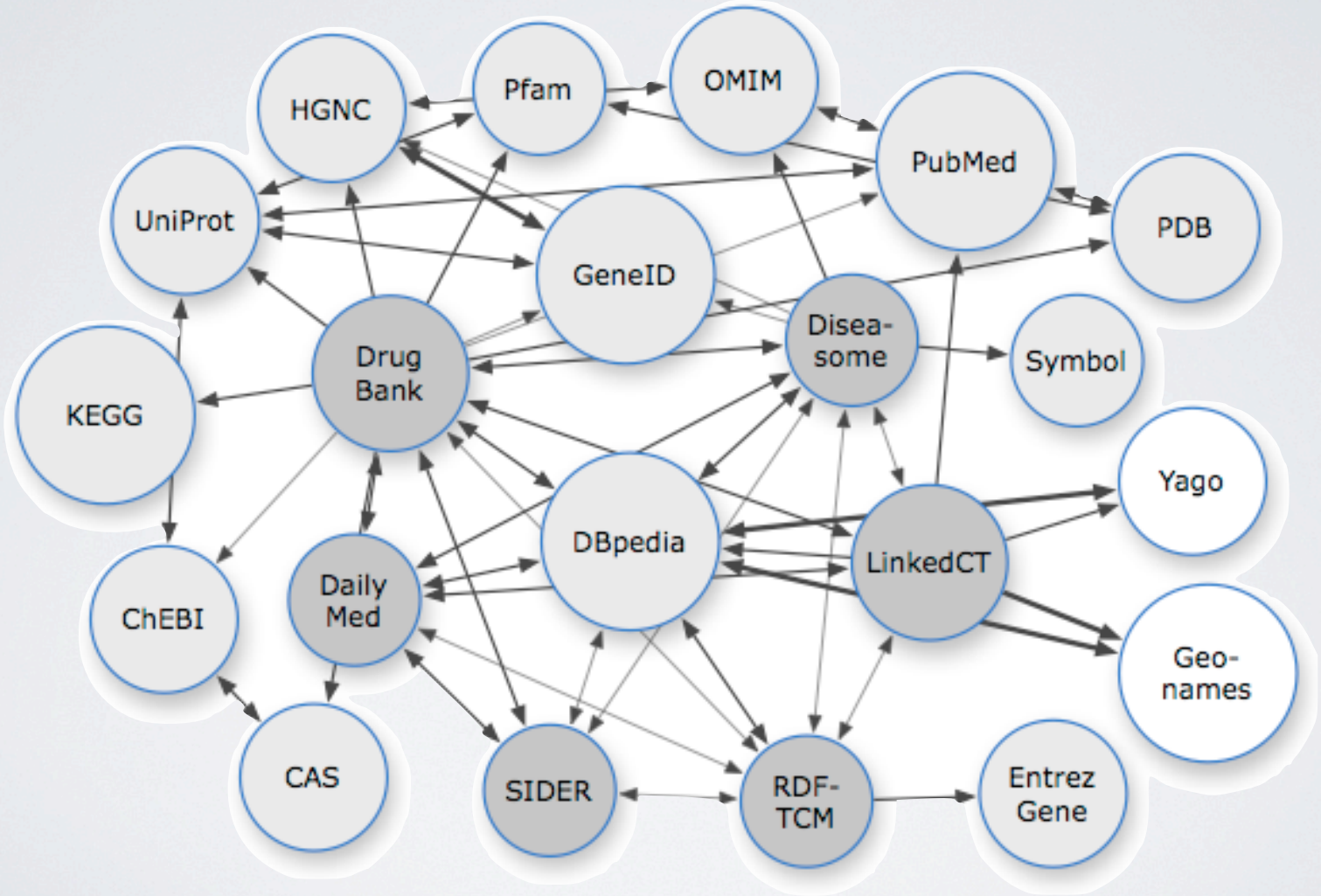
LINKING OPEN **DRUG** DATA

http://esw.w3.org/HCLSIG/LODD



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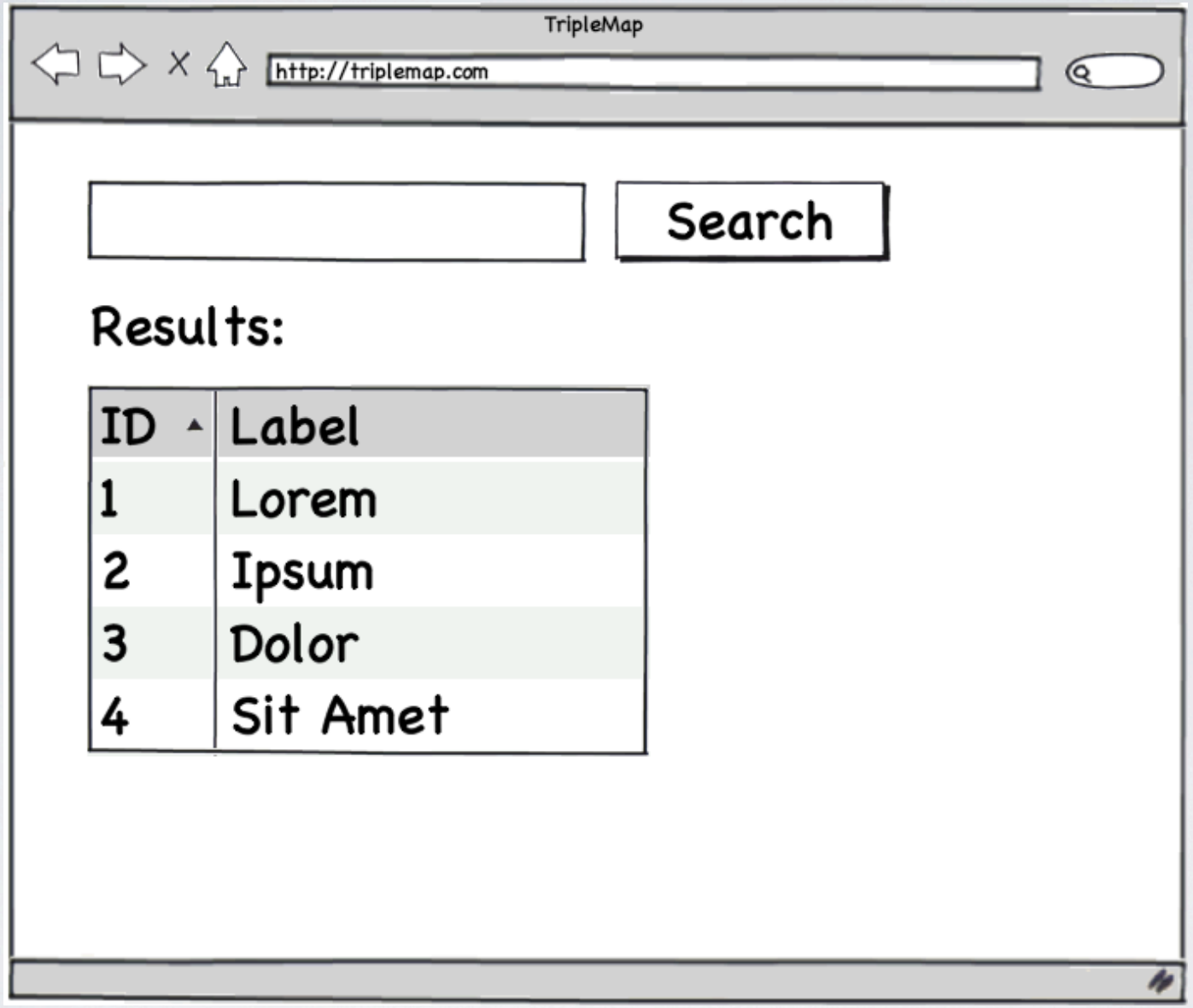

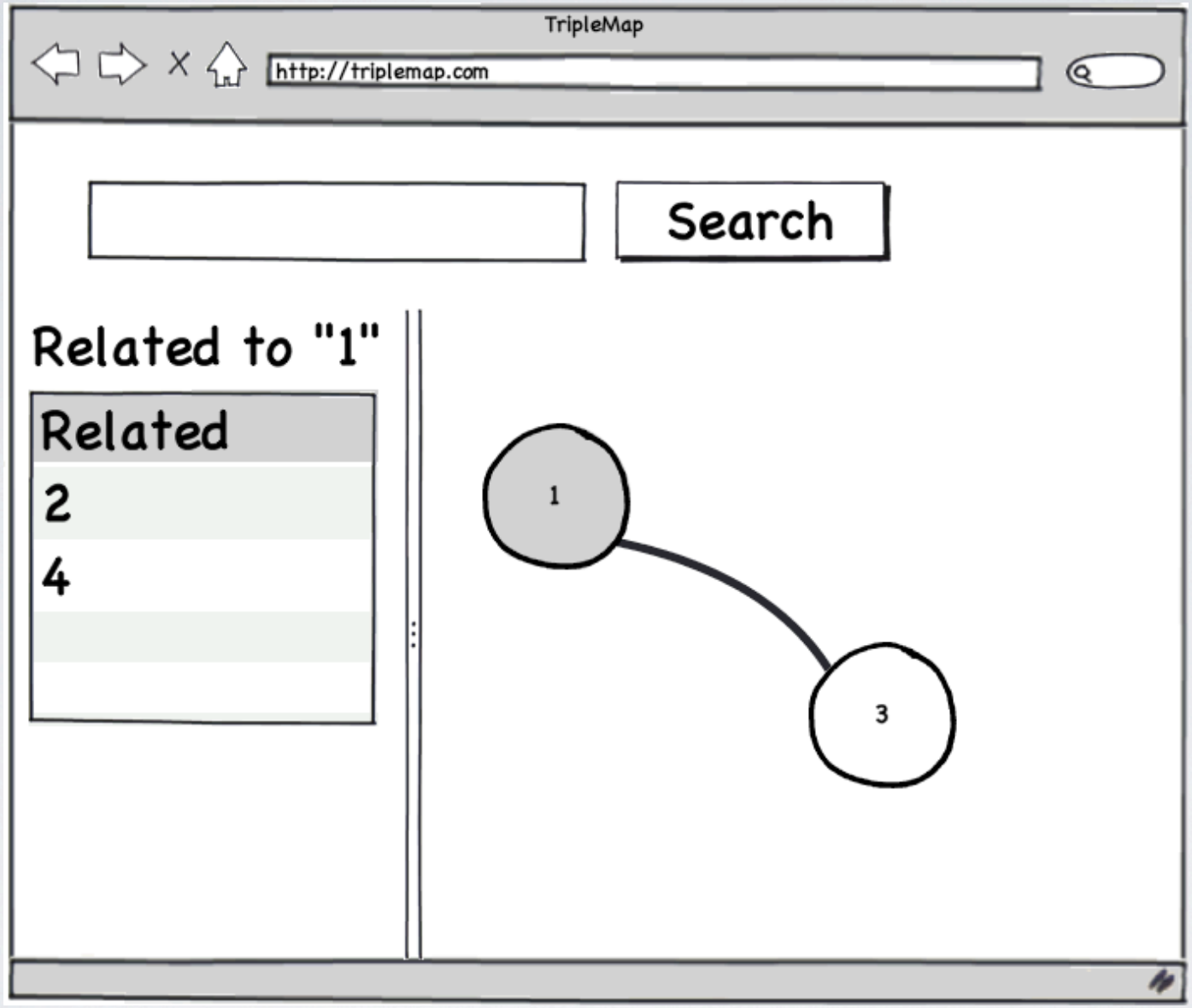

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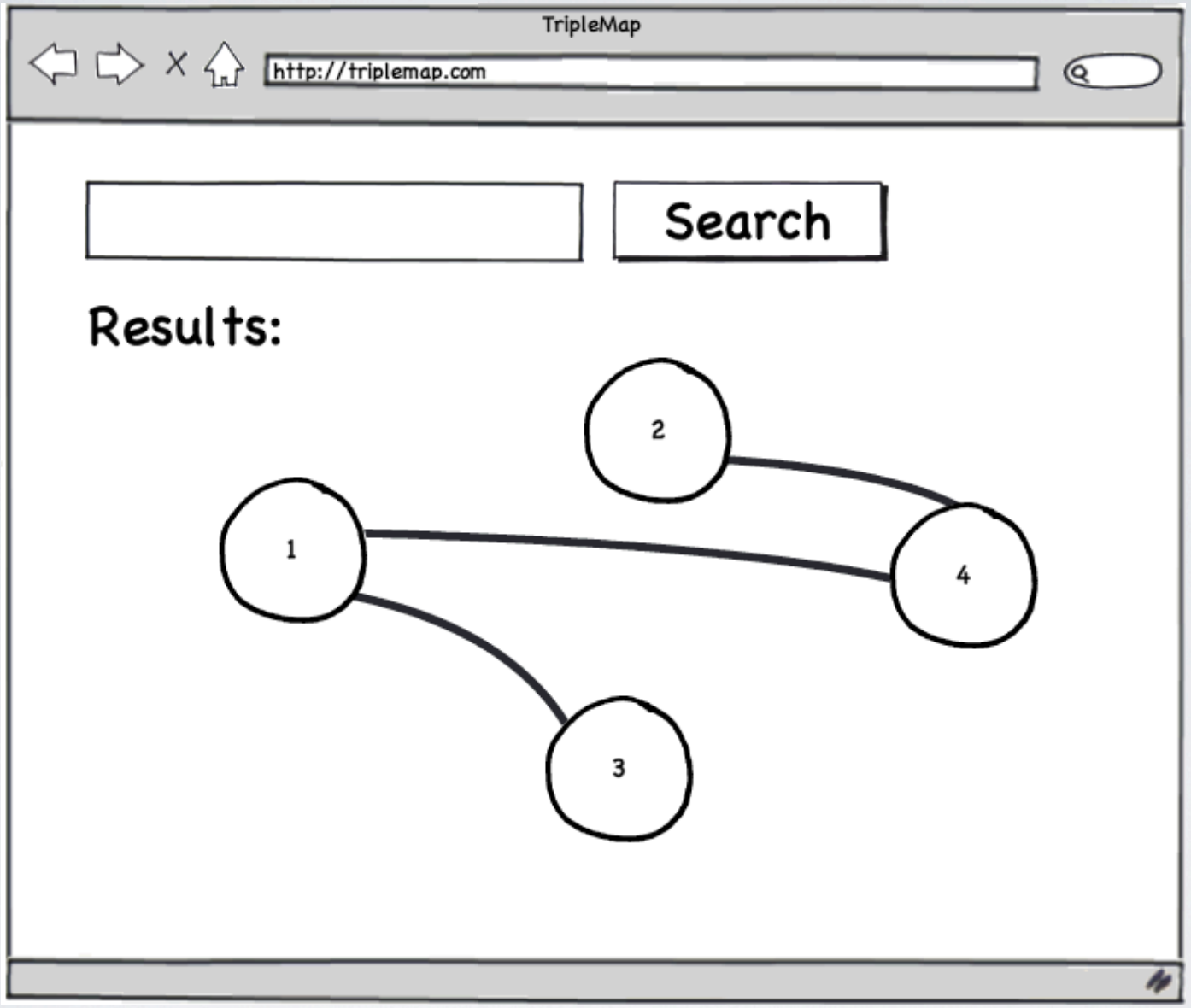

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Ready, GO!

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

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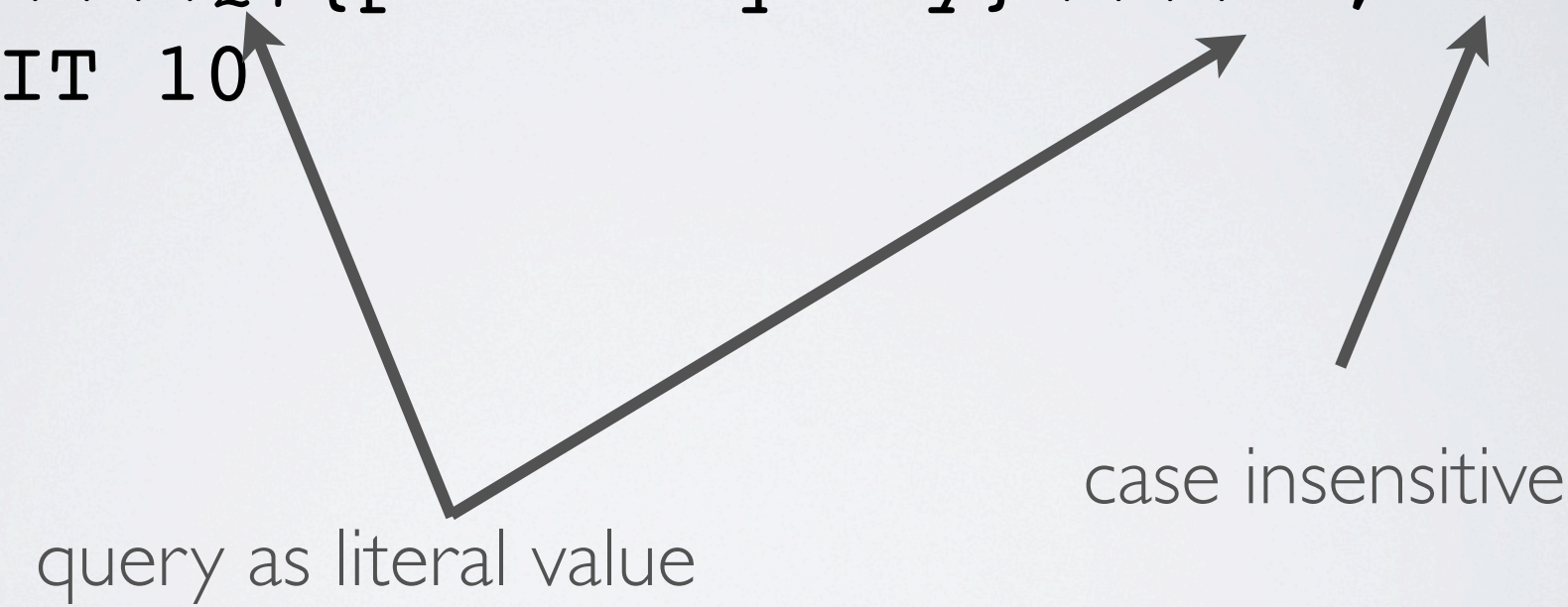
```
select id, label
from targets
where label
 ilike '%${queryValue}%'
```

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

```
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
```



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DEMO

Baseline SPARQL Query Performance

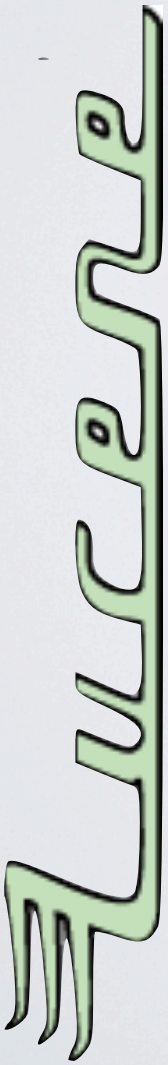
FASTER!

Java API

Indexing and Searching Text

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

indexing



storage

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Document

Document

field	value
ID	2
name	"Mike Hugo"
company	"Entagen"
bio	"lorem ipsum dolor sum etc..."

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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**

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Query: **name: mike**

Matching Documents:

field	value
id	2

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field	value
id	2

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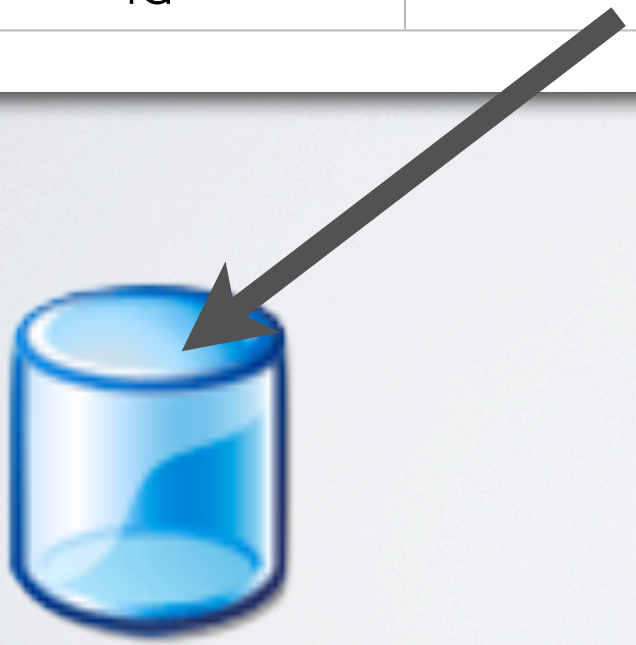
field	value
id	2



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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

Lucene index of rdfs:label

Build the Index

```
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
```

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

    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.Ind

    writer.addDocument(doc)
```

Execute the SPARQL query

```
liqlQueryService.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.YES,
         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,
     value label,
            Field.Store.NO,
            Field.Index.ANALYZED));


 writer.addDocument

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

key

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

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

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

Add the document to the Index

Query the Index

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

def s                                    ime
List                                     teQuery(query)
def e                                    ime

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

query this field

for this value

Create a Lucene Query from user input

```
IndexSearcher searcher = luceneSearche
ScoreDoc[] scoreDocs =
    searcher.search(query, 10).scoreDo
List results = []
def connection = r                    ctior
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.connectior
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.connectior
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.connectior
scoreDocs.each {
  Document doc                                .doc)
  String uri =                                IELD]
  Map labelAnd
   sparqlQueryService.
     getLabelAndType(uri, connection)
  results.add([
        uri: uri,
        type: labelAndType.type,
        label: labelAndType.label])
}
connection.close()
return results
```

return results containing Subject URI, Type, and Label

DEMO

Lucene Index of Searchable Labels

WHAT ABOUT ENTITY RELATIONSHIPS?

WHAT ABOUT OTHER PROPERTIES?

SIREn

{ Semantic Information Retrieval Engine }

Lucene Extension

Indexing and Searching Semi-Structured Data

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SIREn

{ Semantic Information Retrieval Engine }

Document

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SIREn

{ Semantic Information Retrieval Engine }

Document

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

Build the Index

```
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

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

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

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

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

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```
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

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```
        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

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```
            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

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```
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

```
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(predica
        SirenTupl                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

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```
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(predica
        SirenTupl                    T)
query.add(object,
        SirenTupleClause.Occur.MUST)

List results = executeQuery(query)
```

matching the user input

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```
                params.query.toLowerCase())
object.constraint = OBJECT_CELL
```

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

```
List results = exe
```

Build query of with both pieces - predicate and object

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

Query: **“imatinib”**

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

Query:

triples field

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

Query:

predicate = rdfs:label

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field	value
URI	<DB00619>
triples	<DB00619> rdfs:label "Imatinib" . <DB00619> rdf:type <drugbank:drugs> . <DB00619> drugbank:brandName "Gleevec" . <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,
            label: labelAndType.label
```

Search the index (limit 10) for matching documents

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```
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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```
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

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SIREn Index of RDF Entities

FLEXIBILITY

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

Query:

predicate = rdfs:label

object = “imatinib”

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

Query:

object = “imatinib”

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

Query:

object = “imatinib”

OR

object = “gleevec”

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MORE THAN LITERALS

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

Query:

predicate = brandName

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

Query:

predicate = target

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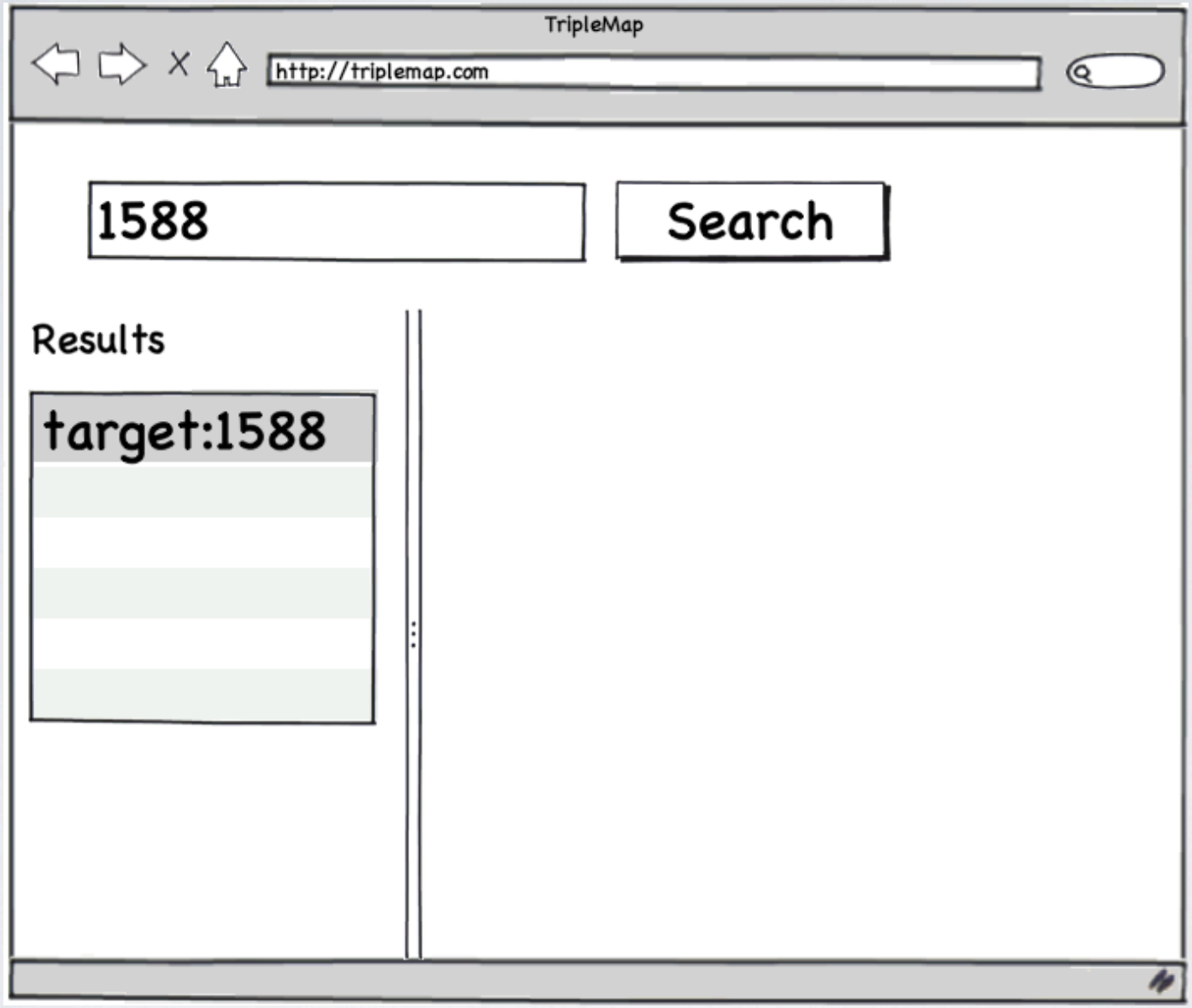
RELATIONSHIPS



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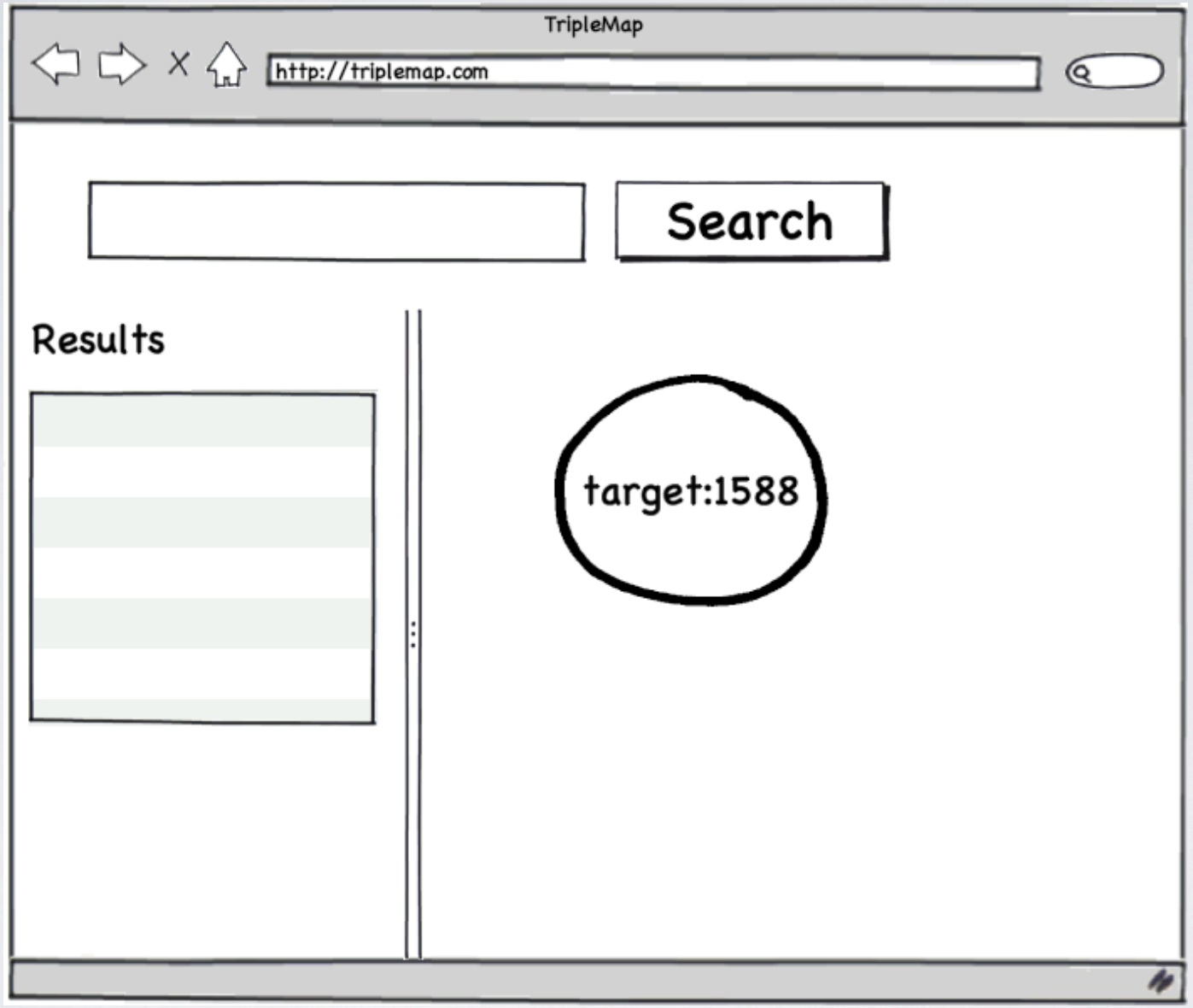
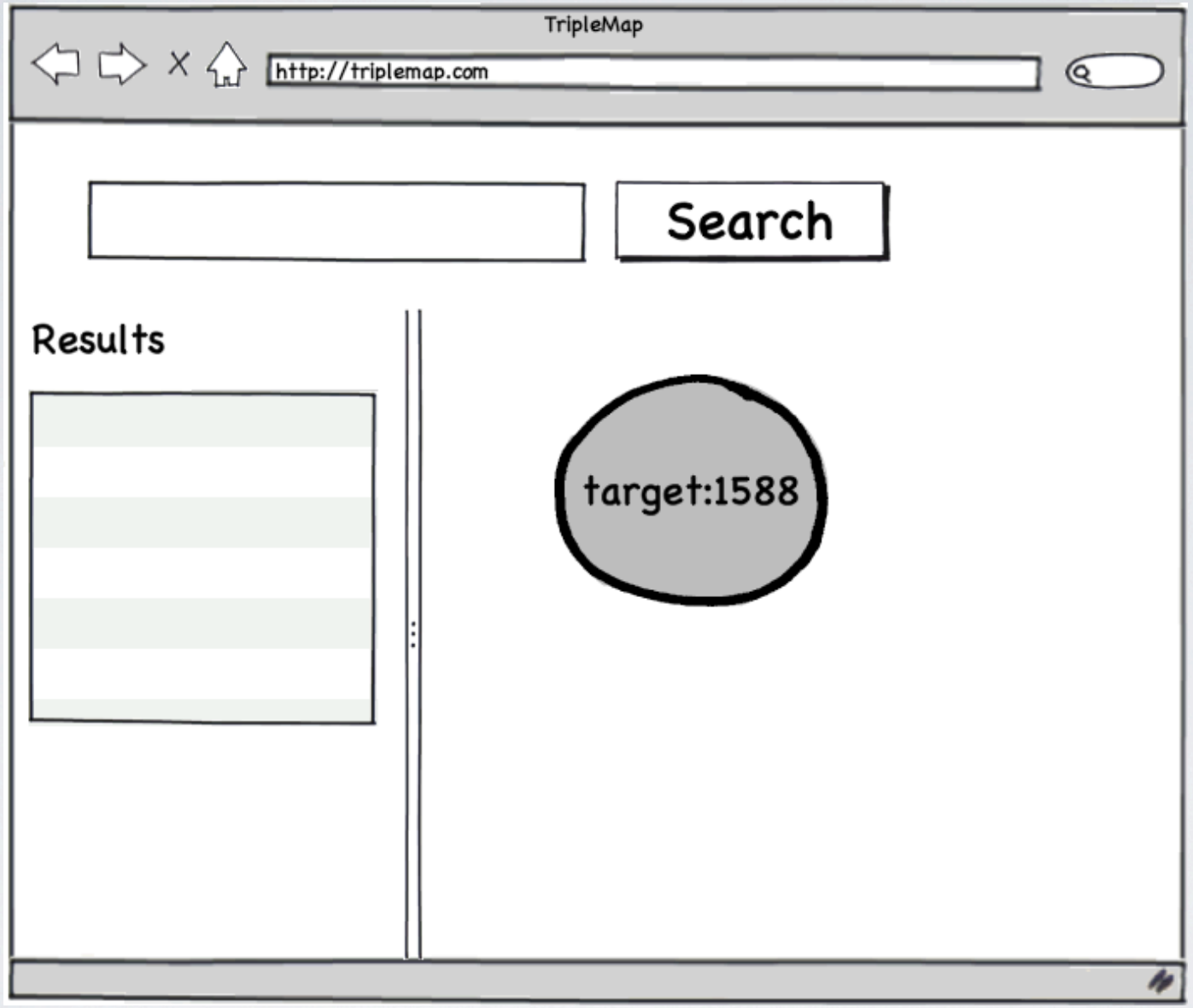


ENTAGEN
ACCELERATING INSIGHT



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

Query:

object = <targets/1588>

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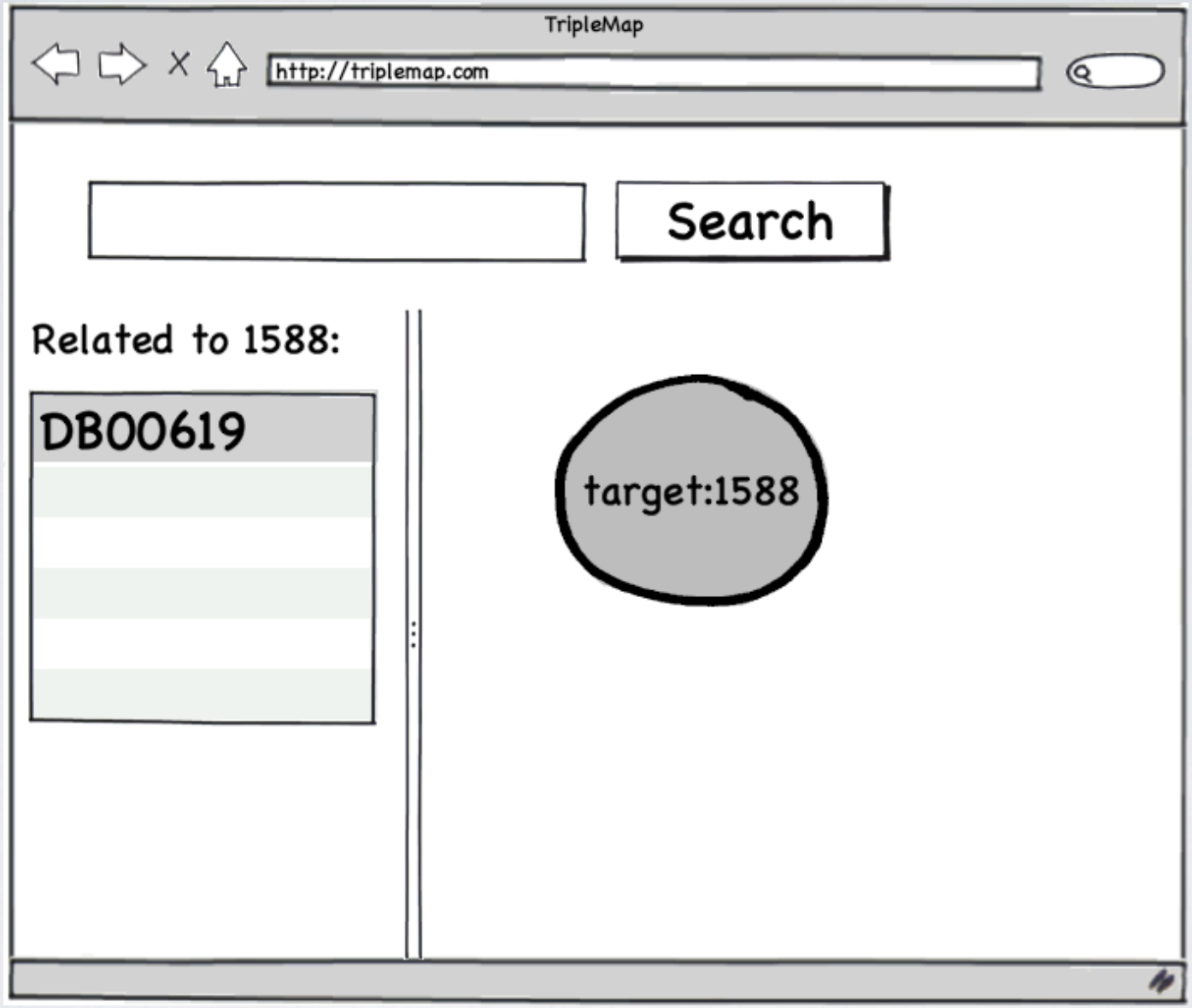

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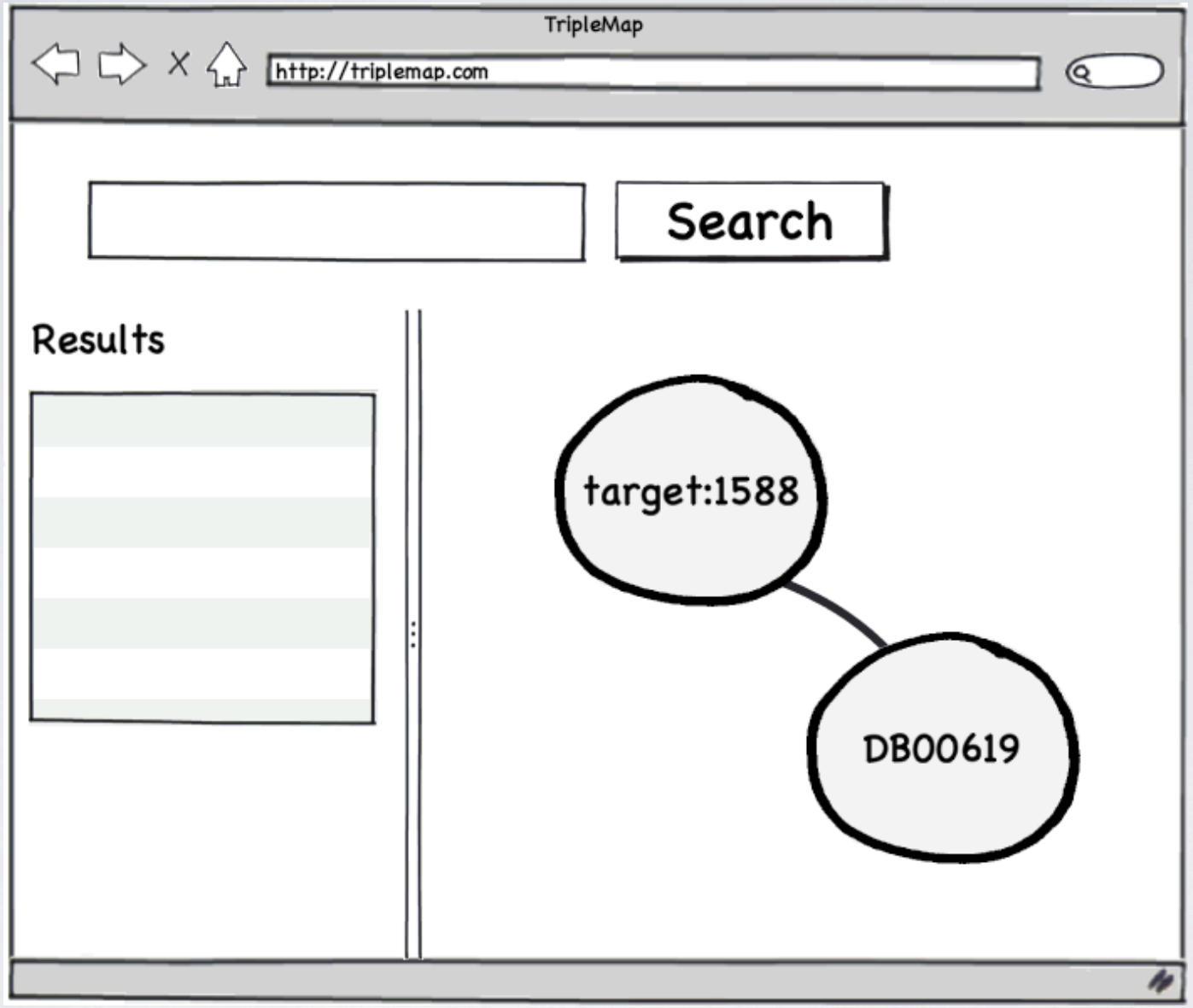

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DEMO

Searching SIREn Index for Relationships

SIREn

{ Semantic Information Retrieval Engine }

Distributed
Indexing and Searching Semi-Structured Data

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scale

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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)

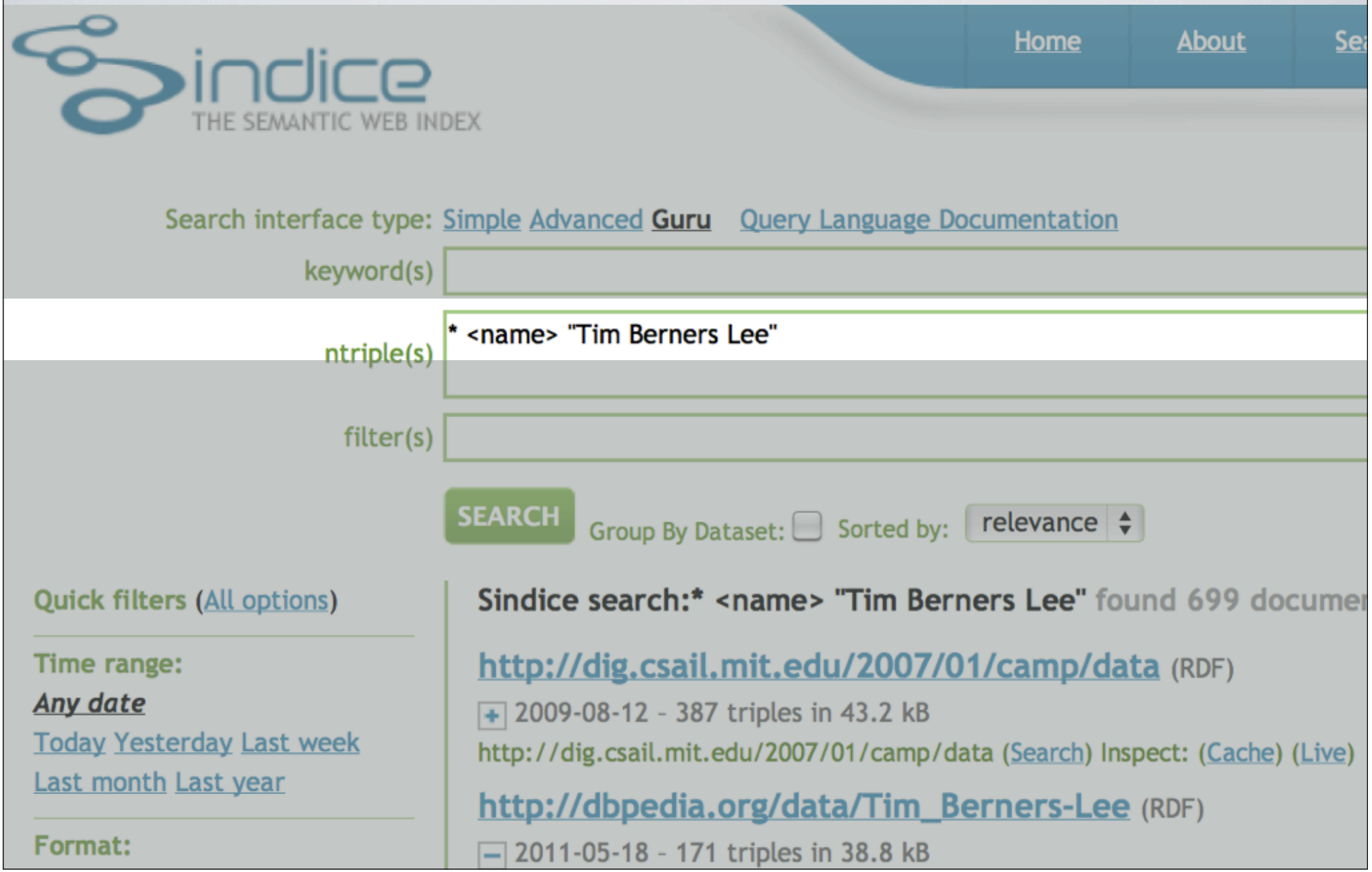
http://dbpedia.org/data/Tim_Berners-Lee (RDF)

2011-05-18 - 171 triples in 38.8 kB

SIGMA FULL CONTENT GRAPH TRIPLES(890)

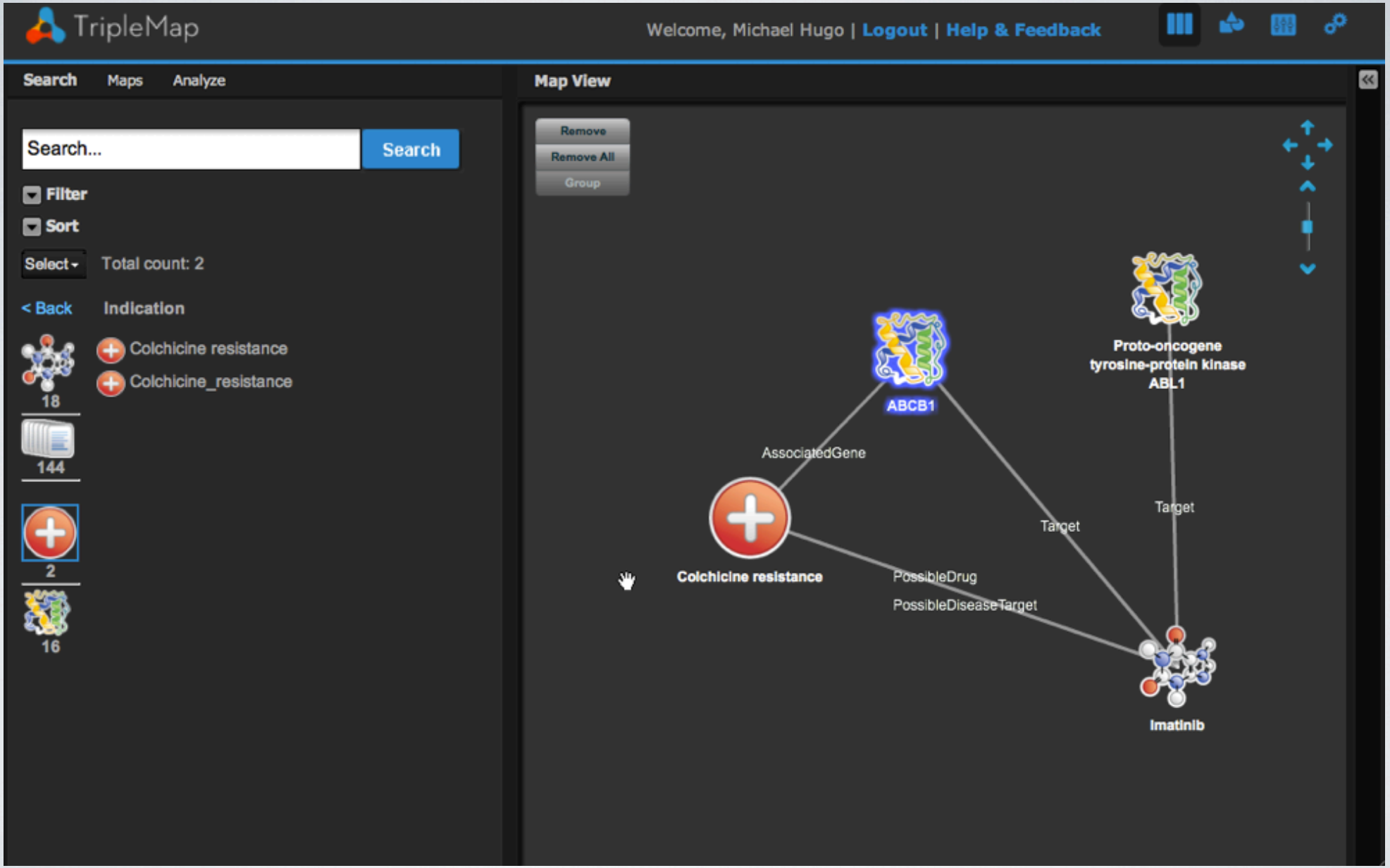
See all we know about "Tim Ber

Query Parser



DEMO

SIREn in action on TripleMap.com



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SIREN
TripleMap.com
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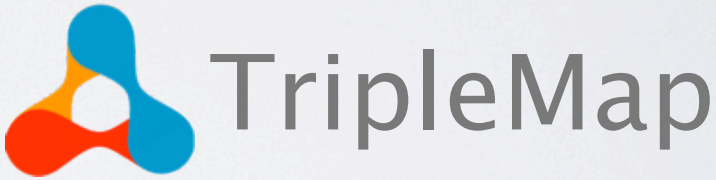
QUESTIONS?

mike@entagen.com / twitter: @piragua

http://www.entagen.com



http://www.triplemap.com