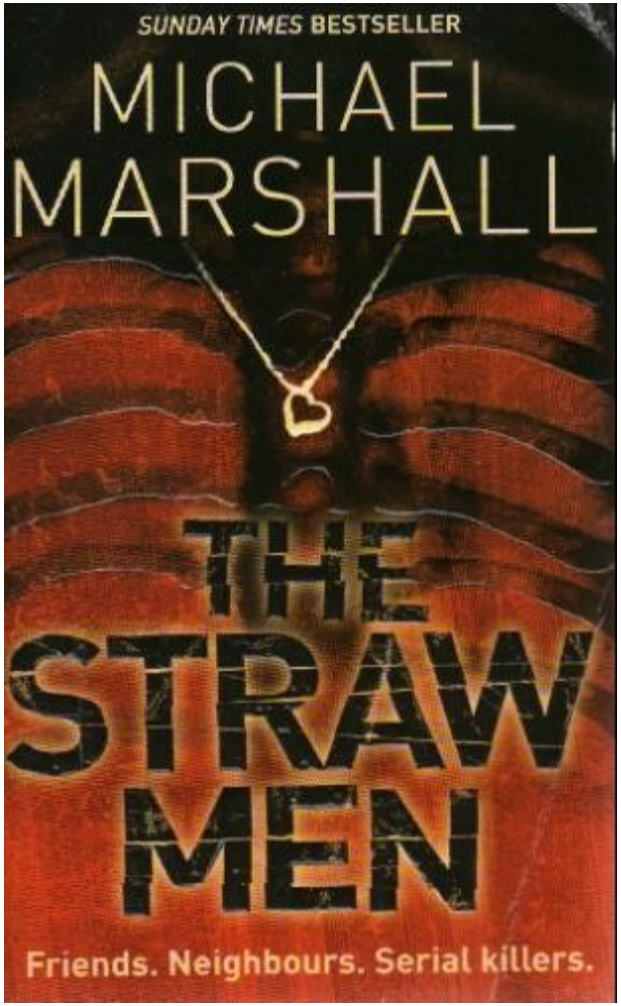
Ontologies and Semantic Annotation

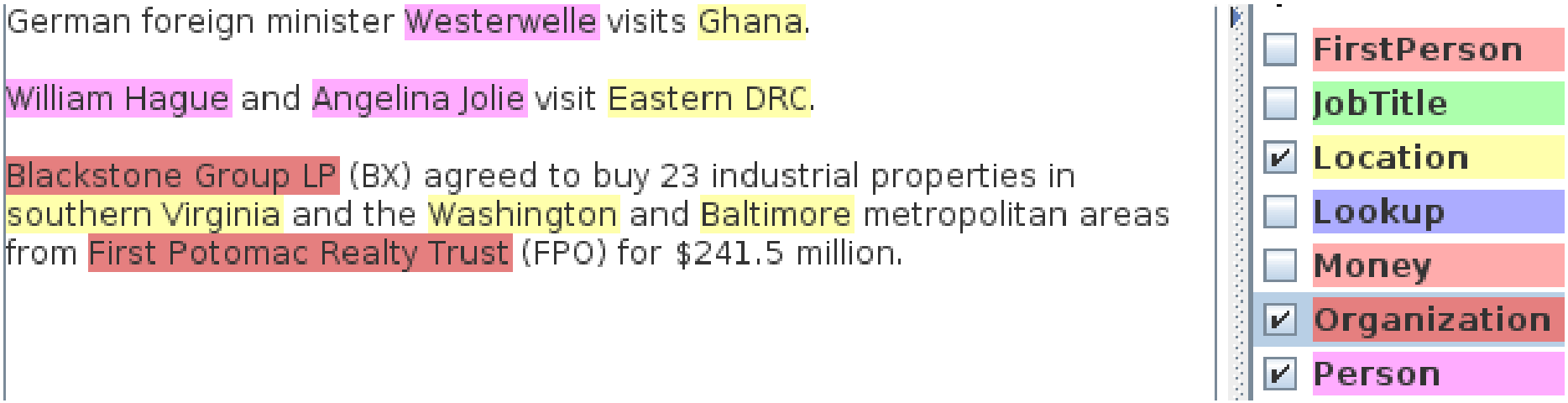
Text Search isn't Enough



“I like the Internet. Really, I do. Any time I need a piece of shareware or I want to find out the weather in Bogota... I'm the first guy to get the modem humming. But as a source of information, it sucks. You got a billion pieces of data, struggling to be heard and seen and downloaded, and anything I want to know seems to get trampled underfoot in the crowd."

Michael Marshall, The Straw Men. HarperCollins Publishers, 2002.

ANNIE Annotations



- We know the type of named entity but nothing more
- What kind of organization is Blackstone Group LP?
- What is the job of William Hague?
- Where is Eastern DRC, what does DRC stand for?

=> only semantics: choice of annotation type name

=> some knowledge hidden deep in JAPE & Code

Need More Semantics:

- To co-reference DRC with “Democratic Republic of Congo”
- To avoid scattered knowledge in JAPE/Java?
  Cities are locations, cities have zip codes, ...
- To disambiguate: which “Washington” (state / city)?
- To use extracted information to allow for queries like:
  - European politicians who visited an African country?
  - Politicians and actors travelling together?
- To use extracted information to add information to our own Database/Knowledge base:
  - Add information about the buying-agreement to our data about Blackstone Group and First Potomac Realty Trust
  - Connect with trading information or other data we have

Semantic Queries in Google

Paris convention and visitors office - Official website - **Paris** tourism
en.**paris**info.com/
Paris convention and visitors office diffuses all information to organise your stay or your trip in **Paris**: hotels and loadings, museums, monuments, going out, **...**
Our welcome centres - Paris Map - Transports and ... - Getting around - Book online

Paris - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/**Paris**
Coordinates: 48°51'24"N 2°21'03"E / 48.8567°N 2.3508°E / 48.8567; 2.3508. **Paris** is the capital and largest city of France. It is situated on the river **...**
List of tourist attractions in Paris - History of Paris - Demographics of Paris - Portal

Paris.com - **Paris** Travel Guide and hotel accommodation
www.**paris**.com/
Paris.com : **Paris**, France tourist services offering hotel accommodation, holiday apartments. We guide you to the best **Paris** city tours and things to do!

News for **paris**

Paris women finally allowed to wear trousers
BBC News - 21 minutes ago
The French government overturns a 200-year-old ban on women wearing trousers in the capital, **Paris**, dating from November 1800.

Skirts rule lifted: Centuries-old ban on women wearing trousers in **Paris** is finally axed
Mirror.co.uk - 3 hours ago
Women in **Paris** finally allowed to wear trousers
Telegraph.co.uk - 1 day ago

Paris | Travel | The Guardian
www.guardian.co.uk/travel/**paris**
Latest news and comment on **Paris** from guardian.co.uk.

.co.uk/search?hl=en&tbo=d&biw=1081&bih=623&q=paris+weather

Paris

Paris is the capital and largest city of France. It is situated on the river Seine, in northern France, at the heart of the Île-de-France region. The city of Paris, within its administrative limits, has a population of about 2,230,000. Wikipedia

Population: 2,234,105 (2009)

Area: 105.4 km²

Weather: 8°C, Wind SW at 10 mph (16 km/h), 71% Humidity

Local time: Monday 23:12

Points of interest

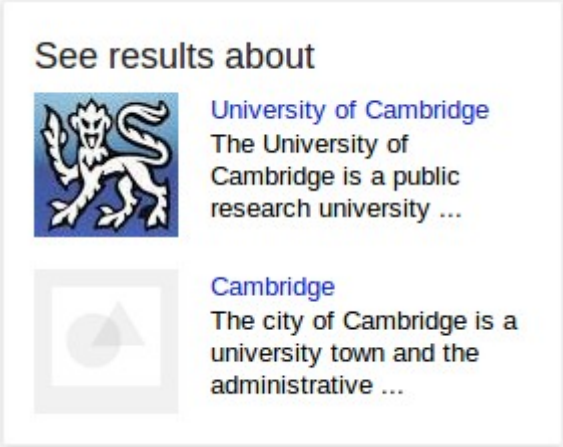

Eiffel Tower


Louvre


Disneyland Resort Paris

Searching for Things, Not Strings

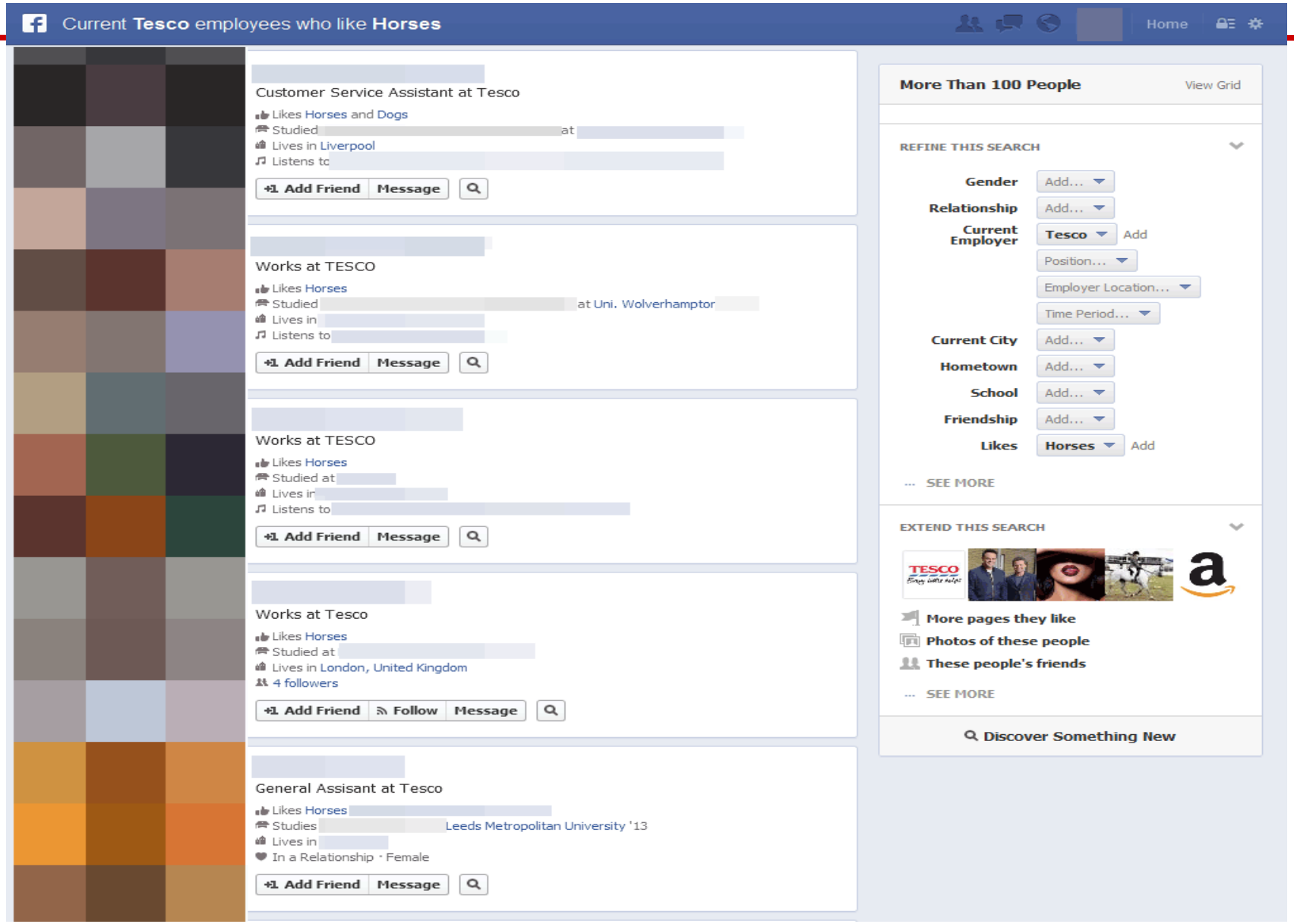
- 500 million entities that Google "knows" about
- Used to provide more accurate search results



- Summaries of information about the entity being searched

http://googleblog.blogspot.it/2012/05/introducing-knc

Facebook Graph Search



Semantic Enrichment

- Textual mentions aren't actually that useful in isolation
  - knowing that something is a “Person" isn't very helpful
  - knowing which Person the mention refers to can be very useful
- Disambiguating mentions against an ontology provides extra context
- This is where **semantic enrichment** comes in
- The end product is a set of textual mentions linked to an ontology, otherwise known as **semantic annotations**
- Annotations on their own can be useful but they can also
  - be used to generate corpus level statistlcs
  - be used for further ontology population
  - form the basis of summaries
  - be indexed to provide semantic search

Automatic Semantic Enrichment

- Use Text Mining, e.g.
  - Information Extraction – recognise names of people, organisations, locations, dates, references, etc.
  - Term recognition – identify domain-specific terms
- Automatically extend article metadata to improve search quality
- Example: using a customised GATE text mining pipeline to enrich metadata in the Envia environmental science repository

  http://www.bl.uk/reshelp/experthelp/science/eventsandprojects/enviatbl/index.html

Semantic Enrichment in Envia

BRITISH LIBRARY

envia

Environmental Information Discovery and Access

BETA

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Search... Whole words only Go

Show Advanced Filters

Preliminary flood risk assessment : prepared to meet the Vale of Glamorgan Council's duties to manage local flood risk under the Flood Risk Regulations (2009)

URL

Citation

"2011. Preliminary flood risk assessment : prepared to meet the Vale of Glamorgan Council's duties to manage local flood risk under the Flood Risk Regulations (2009). Barry : Vale of Glamorgan."

View/Open

http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/flho1111bvet-e-e.pdf

Description

Title from PDF cover (viewed on June 27, 2012).

Includes bibliographical references (p. 29-30).

Date

2011

Content Type

Report

Pagination

1 online resource (31 p.)

Author(s)

Vale of Glamorgan (Wales). Council

Subject

Floods, Risk assessment, Wales, Vale of Glamorgan, Maps, Flood forecasting, Flood control, Planning

Publisher

Barry : Vale of Glamorgan

Subject

- England (296)
- Great Britain (276)
- Flood control (258)
- Floods (157)
- Risk assessment (135)
- ... View More

Type

- Report (1615)
- Thesis (690)
- Dataset (120)
- atlas (13)
- conference proceedings (3)
- ... View More

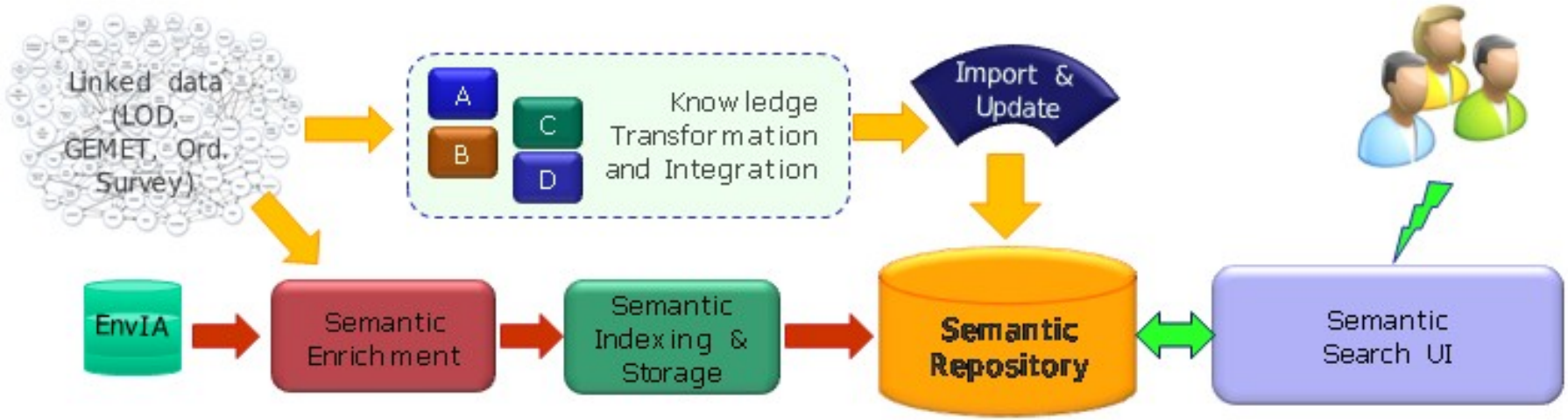
Publisher

- Bristol : Environment Agency (355)
- Luxembourg : Publications Office of the European Union (354)
- London : Department for Communities and Local Government (51)

Why ontologies for semantic search?

- **Semantic annotation**: rather than just annotating the word “Cambridge” as a location, link it to an ontology instance
  - Differentiate between *Cambridge, UK* and *Cambridge, Mass*.
- **Semantic search via reasoning**
  - So we can infer that this document mentions a city in Europe.
  - Ontologies tell us that this particular Cambridge is part of the country called the UK, which is part of the continent Europe.
- **Knowledge source**
  - If I want to annotate *strikes* in baseball reports, the ontology will tell me that a *strike* involves a *batter* who is a *person*
  - In the text “BA went on strike”, using the knowledge that BA is a company and not a person, the IE system can conclude that this is not the kind of strike it is interested in

Example Semantic Search Architecture



GATE MÍMIR OWLIM

What is Semantic Annotation?

Annotation:

*The process of adding **metadata** to [parts of] a document.*

Semantic Annotation:

Annotation process where [parts of] the annotation schema (annotation types, annotation features) are ontological objects.

Semantic Annotation: Basic Idea

- Link annotations to concepts in a knowledge base.
- The annotated text is a “Mention” of a concept in the KB
- We can use the knowledge associated with Mentions in our IE pipeline
  - e.g. Persons have JobTitles, Cities have zip codes
- We can use the knowledge associated with Mentions for “Semantic Search”
- We can use semantically annotated documents to add new facts to our knowledge base

=> We need some way to represent knowledge

Knowledge Base

Would want to represent knowledge for this domain:

- Westerwelle:
  has job Foreign minister of Germany → a politician
  Germany → a country, in Europe
  Member of the Free Democratic Party
  Free Democratic Party → a political party
  Political party → an organization
  …
- Blackstone Group L.P. → a private equity company
  has NYSE symbol: BX
  based in: New York City
  New York City → a city
  located in: New York State which is located in USA
  ...

Ontology

A formal way to represent knowledge as:

- Concepts of a domain or a set of domains
  “Agelina Jolie”, “Ghana”
- Relationships between concepts
  “New York City is located in New York State”
- Hierarchies of Concepts and Relationships
  “New York City is a City which is a Location”
- Associated Data
  “Blackstone Group has NYSE symbol BX”
- => most widely used formalism is RDF/OWL

What is an Ontology?

- Set of concepts (instances and classes)
- Relationships between them (is-a, part-of, located-in)
- Multiple inheritance
  - Classes can have more than one parent
  - Instances can have more than one class
- Ontologies are graphs, not trees

OWL Ontologies

- OWL: Web Ontology Language
- Classes/Concepts and Individuals/Instances
- Properties:
  DatatypeProperty: individual → literal
  ObjectProperty: individual → individual
  AnnotationProperty: resource → literal, but no inference
- Inference/Reasoning:
  - Inheritance/Subsumption (classes and properties)
  - “Restrictions”: domain, range, allValuesFrom, hasValue …infer class membership, property values
    Open World Assumption: what isn’t asserted, we don’t know
    Non Unique Name Assumption: different names may be used for same entity
- Classes can have more than one parent, Individuals can belong to more than one class → OWL Ontologies are graphs, not trees

DBpedia

- Machine readable knowledge on various entities and topics, including:
  - 410,000 places/locations,
  - 310,000 persons
  - 140,000 organisations
- For each entity we have:
  - entity name variants (e.g. IBM, Int. Business Machines)
  - a textual abstract
  - reference(s) to corresponding Wikipedia page(s)
  - entity-specific properties (e.g. latitude and longitude for places)

Example from DBpedia

D About: Thames Barrier

dbpedia.org/page/Thames_Barrier

dbpedia Thames B

About: Thames Barrier

An Entity of Type : _Feature, from Named Graph : http://dbpedia.org, within Data Space : dbpedia.org

The Thames Barrier is the world's second-largest movable flood barrier and is located downstream of central London, United Kingdom. Its purpose is to prevent London from being flooded by exceptionally high tides and storm surges moving up from the sea. It needs to be raised (closed) only during high tide; at ebb tide it can be lowered to release the water that backs up behind it.

...

owl:sameAs	▪ http://cs.dbpedia.org/resource/Bariéry_na_Temži ▪ http://de.dbpedia.org/resource/Thames_Barrier ▪ http://fr.dbpedia.org/resource/Barrière_de_la_Tamise ▪ http://it.dbpedia.org/resource/Thames_Barrier ▪ http://sws.geonames.org/2636058/ ▪ freebase:Thames Barrier
geo:geometry	▪ POINT(0.0367 51.4977)
geo:lat	▪ 51.497700 (xsd:float)
geo:long	▪ 0.036700 (xsd:float)

Links to GeoNames And Freebase

Latitude & Longitude

GeoNames

- 2.8 million populated places
  - 5.5 million alternate names
- Knowledge about NUTS country sub-divisions
  - use for enrichment of recognised locations with the implied higher-level country sub-divisions
- However, the sheer size of GeoNames creates a lot of ambiguity during semantic enrichment
- We use it as an additional knowledge source, but not as a primary source (DBpedia)

Ontologies in GATE

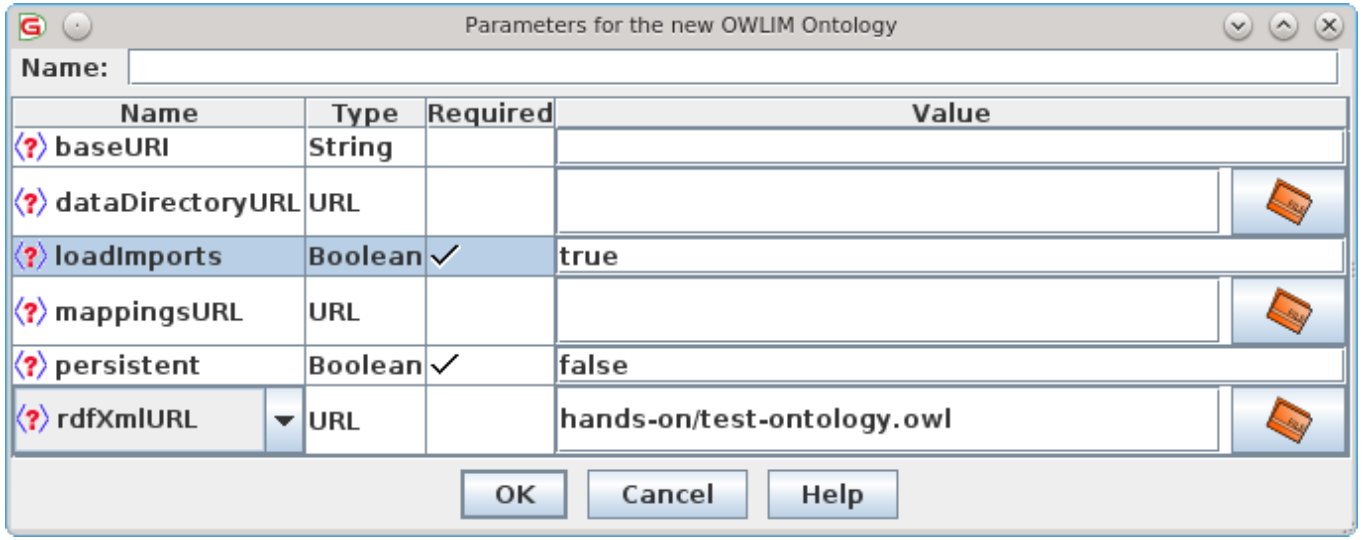
- Can use OWL-Lite ontologies as language resources (→ Plugin Ontology)
- Ontology Editor, Ontology Annotation Tool, Relation Annotation Tool (→ Plugin Ontology_Tools)
- Ontology-enabled JAPE, JAPE Plus
- LKB Gazetteer (→ Plugin Gazetteer_LKB)
  OntoRoot Gazetteer (→ Plugin Gazetteer_Ontology_Based)
- Ontology-based evaluation (→ Plugin Ontology_BDM_Computation)
- Java API for ontology manipulation, triple manipulation, SPARQL queries

GATE Ontology Implementation

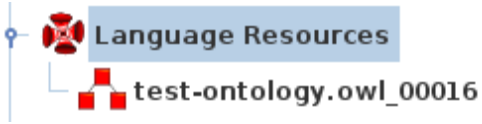
- Based on Sesame and the OWLIM-Lite SAIL (Storage and Inference Layer) implementation from Ontotext
- Fast in memory repository, scales to millions of statements (depending on RAM)
- In addition to local file ontology, can connect to server:
  - OWLIM Lite
  - OWLIM SE/Enterprise: commercial product, persistent and scalable implementation for huge (billion triples) ontologies
- Java API represents OWL concepts (ontology, property, literal) as Java objects
- Also provides support for SPARQL and manipulating Triples directly

Load Ontology

- Need plugin Ontology
- For Editor, also need plugin Ontology_Tools
- Language Resource → New → OWLIM Ontology



- Loaded:



Ontology Viewer/Editor

- Basic viewing of ontologies
- Some edit functionalities:
  - create new concepts and instances
  - define new properties and property values
  - deletion
- Some limitations of what's supported, basically chosen from practical needs for semantic annotation
- Not a Protégé replacement

Ontology Editor

File Options Tools Help

GATE
- Applications
- Language Resources
  - protonust-populated
  - test-ontology
- Processing Resources
- Datastores

Messages | test-ontology | protonust-popul...

Classes & Instances | Properties

Classes and Instances
- Canyon
- WaterBank
- Waterfalls
- South
- NonGeographicLocation
- PoliticalRegion
- Country
  - Algeria
  - Amer
  - Arge
  - Austr
  - Belgium
  - Brazil
  - Britain
  - Canada
  - Denmark
  - England
  - France
  - Germany
  - India
  - Iran
  - Ireland
  - Italy
  - Japan
  - Netherlands
  - Nigeria
  - Northern Ireland
  - Qatar
  - Russia
  - South Africa
  - South Korea
  - Spain
  - Sweden

Properties
Same As Instance
Delete

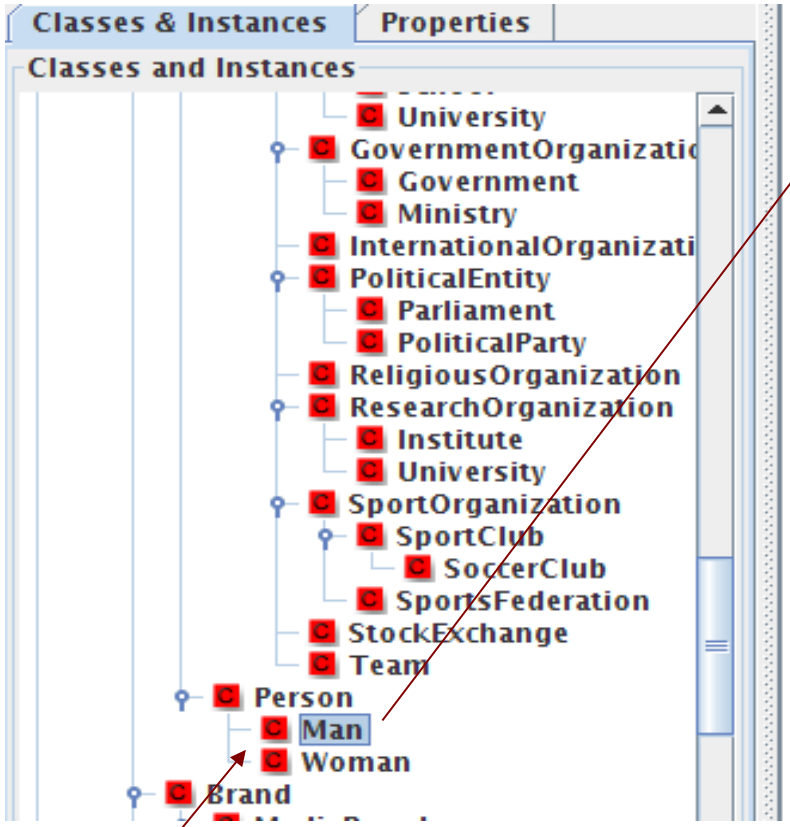
hasSon
hasSpouse
label
hasEMail
hasAddress
informationResourceIdentifier
hasCapital
hasContactInfo
isDefinedBy
partOf
hasCurrency
More >

Resource Information	
Algeria	Algeria
URI	http://gate.ac.uk/owlim#Algeria
TYPE	Ontology Instance
Direct Types	
Country	Country
All Types	
Location	Location
Country	Country
	PoliticalRegion
	[Man]
	[ALL CLASSES]
	[PhoneNumber]
	[ALL RESOURCES]
	[ALL CLASSES]
	[EMail]
	[Address]
	[InternetAddress]
	[Man]
	[PhoneNumber]
transitiveOver	[ALL RESOURCES]
hasEmployee	[ALL CLASSES]
hasDate	http://www.w3.org/2001/XMLSche
informationResourceIdentifier	http://www.w3.org/2001/XMLSche
hasCapital	[Capital]
comment	[ALL RESOURCES]
hasDaughter	[Woman]
hasMember	[ALL CLASSES]

GATE Ontology Editor | Initialisation Parameters

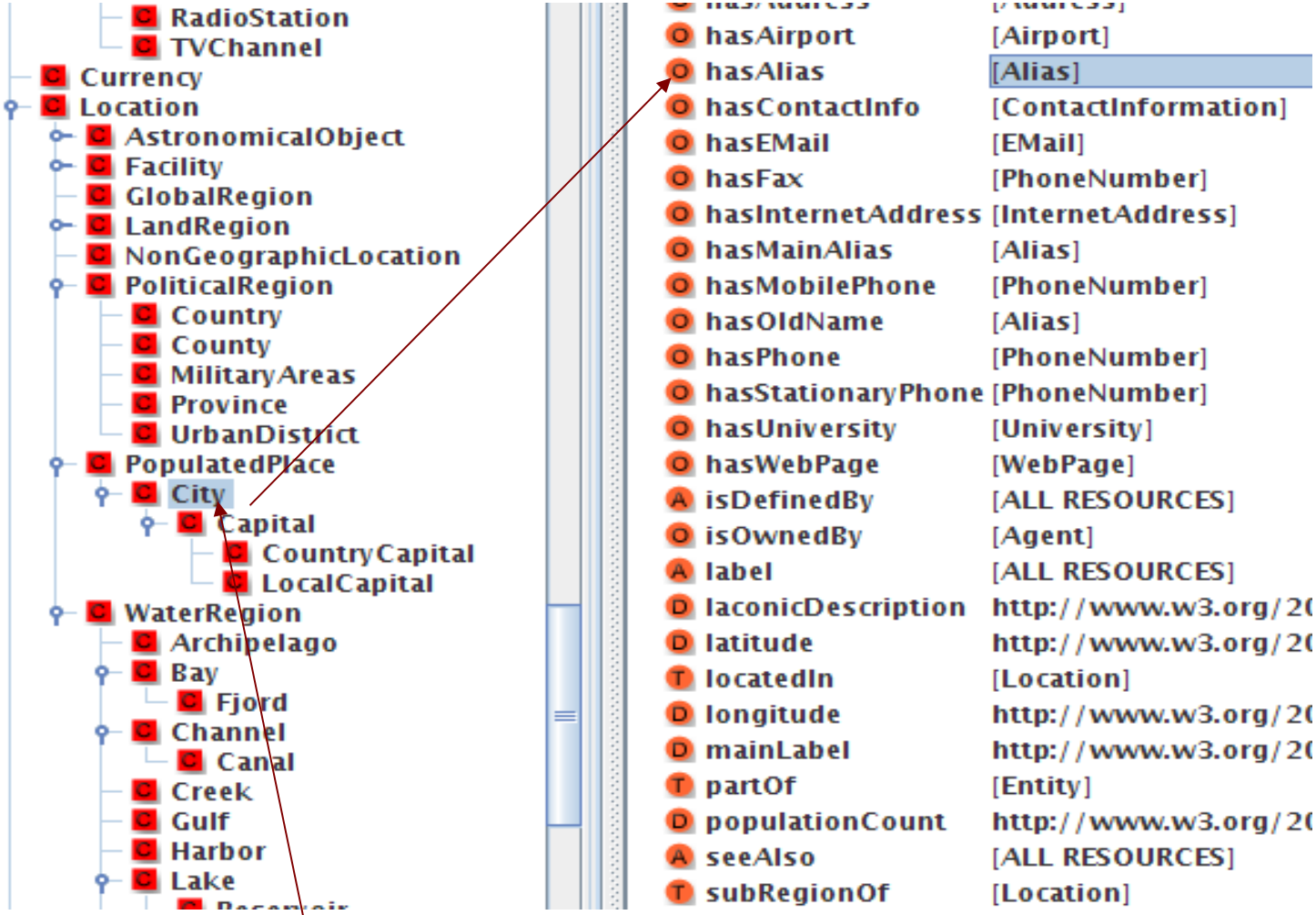
Views built!

Ontology-based IE



John lives in London. He works there for Polar Bear Design.

Ontology-based IE (2)

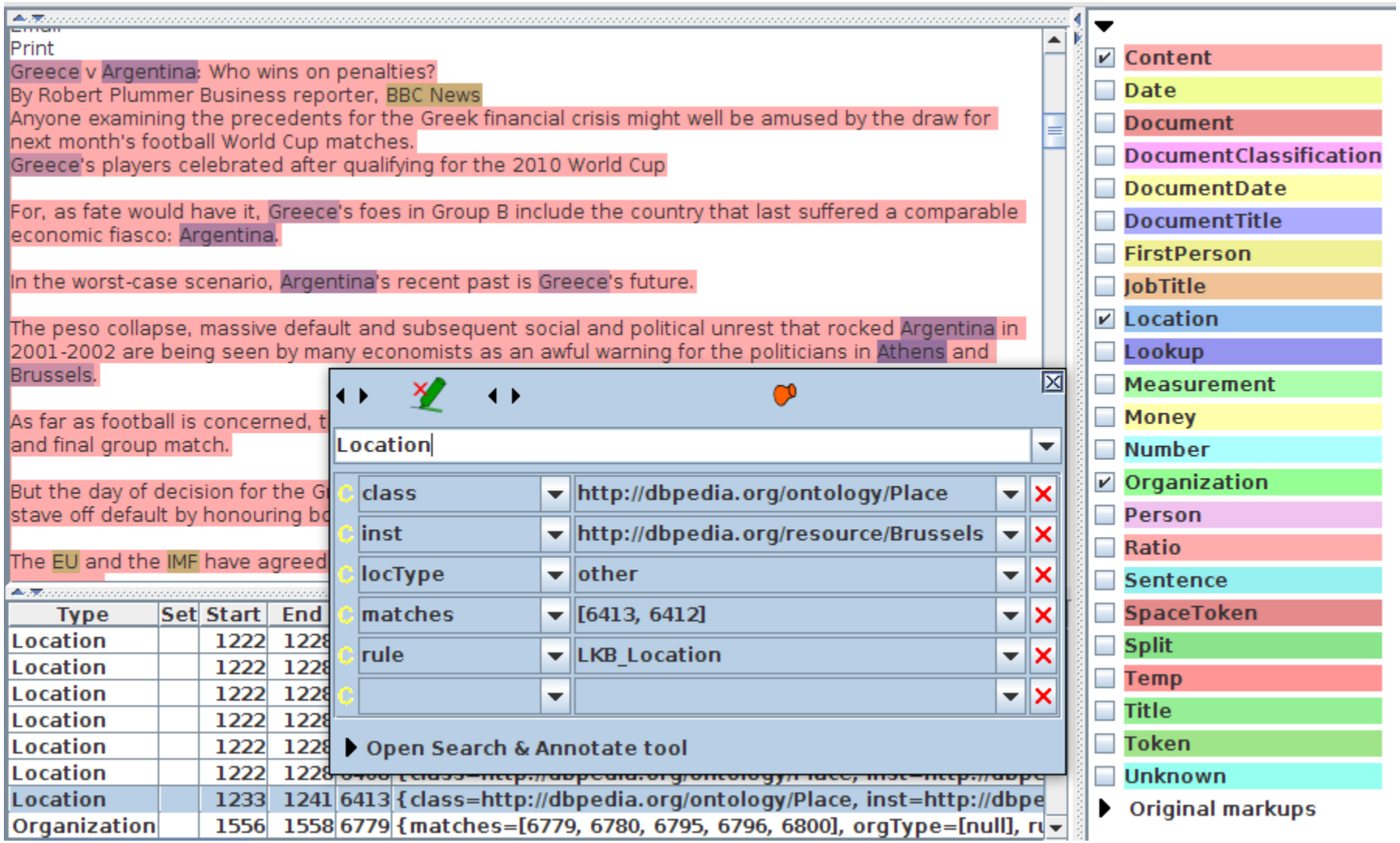


John lives in London. He works there for Polar Bear Design.

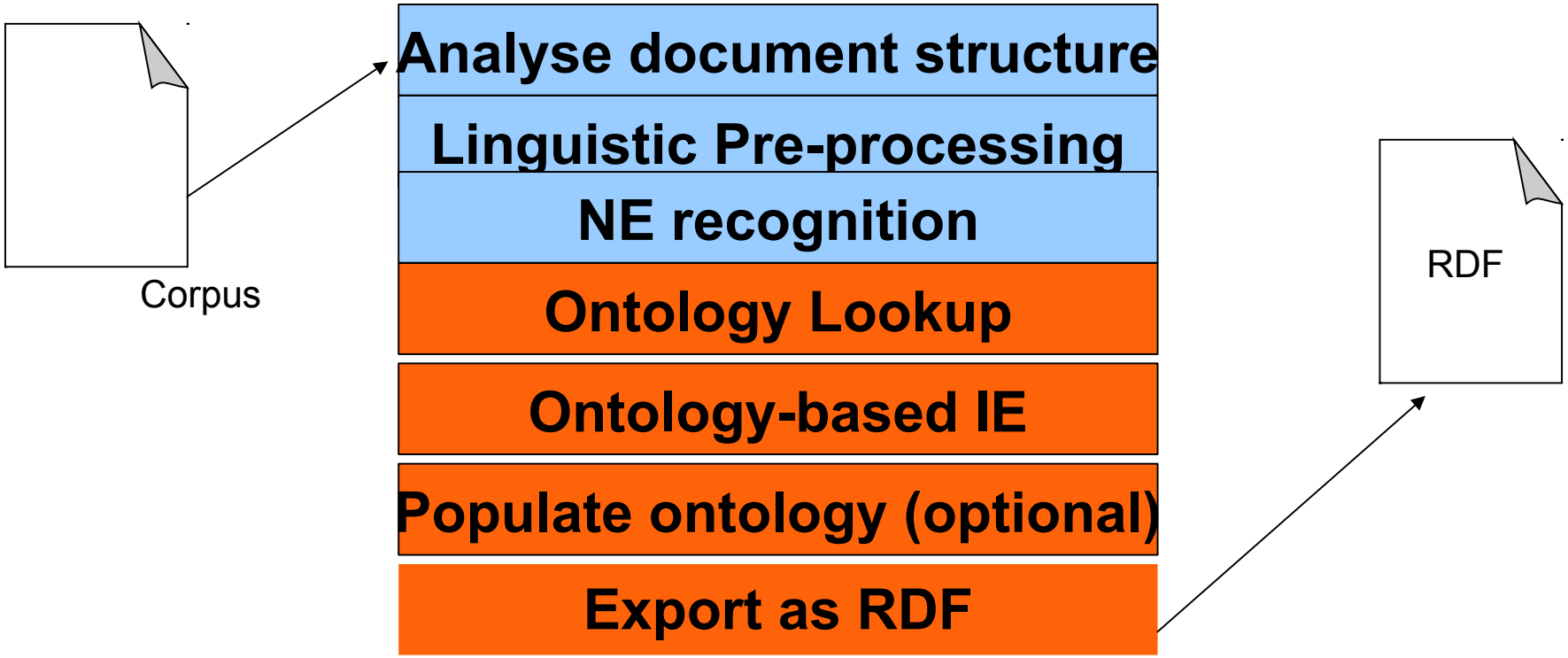
Hands-on: loading an ontology

- Load plugin Ontology (for basic ontology support)
- Load plugin Ontology_Tools (for a simple ontology editor)
- Language Resource → New → OWLIM Ontology
- Fill in the parameter “rdfXmlURL” by navigating through the hands on material to pubmed-hands-on/FastVacOntology_Nov2013v3.owl
- Double-click the ontology to view it
- Scroll through the ontology
- Search for something (e.g. Yersinia Pestis)
- Look at its ancestors and descendants
- Look at its properties, including “label”

Semantic Annotation



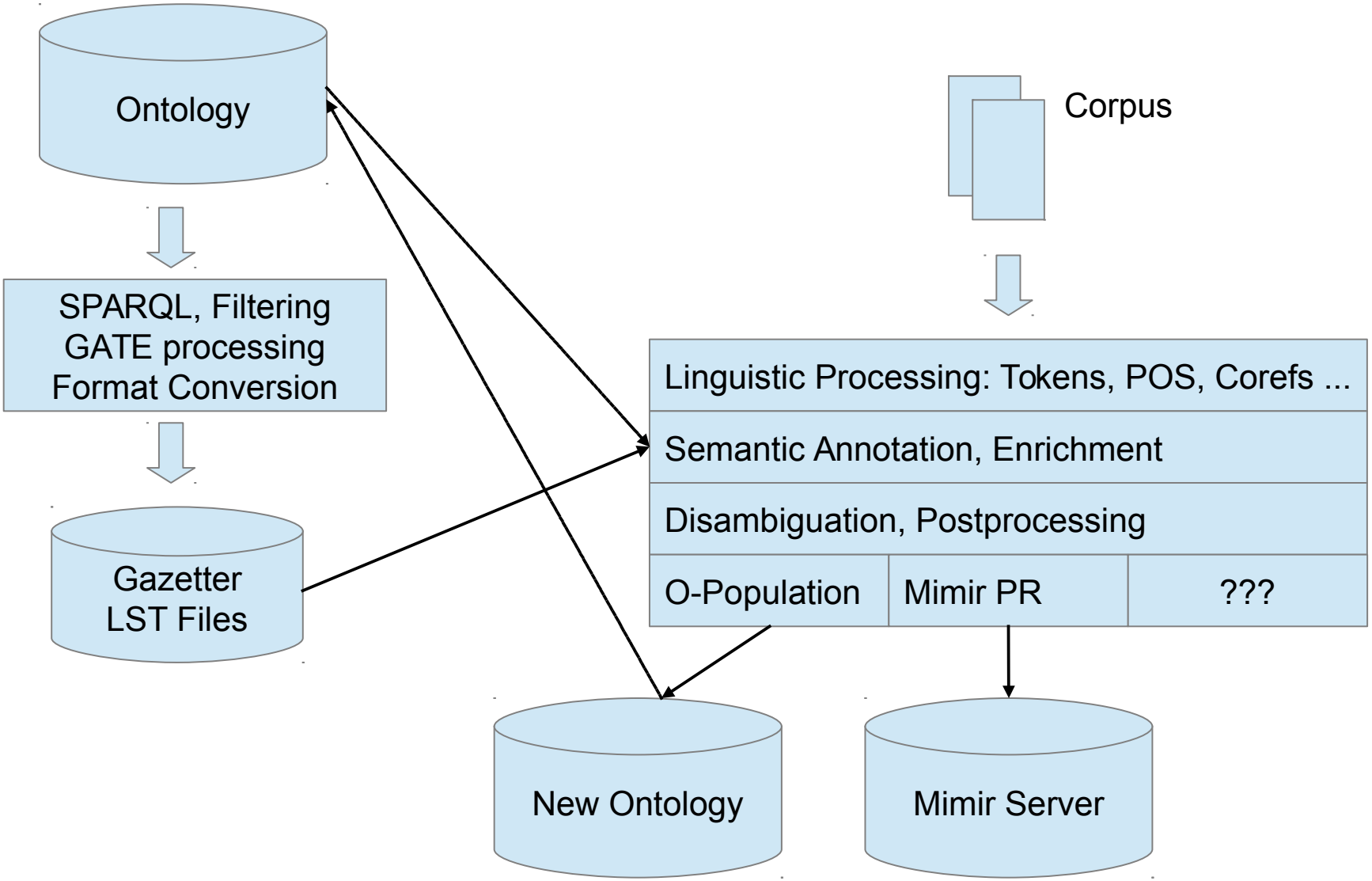
Typical Semantic Annotation pipeline



Semantic Annotation: How

- Manually
  GATE: ontology based annotation using OAT/RAT or through crowdsourcing
- Automatically
  - Gazetteer/rule/pattern based
  - Classifier (ML) based
  - Combination of the two

Semantic Annotation: The Big Picture



GATE: Automatic Semantic Annotation

- Ontology aware Gazetteers:
  - OntoRoot Gazetteer
  - LKB Gazetteer
  - Other gazetteers, using inst/class features
- Ontology aware JAPE
- Semantic Enrichment: LKB Gazetteer, JAPE

Ontology Lookup: OntoRoot Gazetteer

- Finds mentions in the text matching classes, instances, data property values and labels in the ontology
- Matching can be done between any morphological or typographical variant (e.g. upper/lower case, CamelCase)
- Converts CamelCase names, hyphens, underscores
- Morphological analysis is performed on both text and ontology, then matching is done between the two at the root level.
- Text is annotated with features containing the root and original string(s)
- Creates a gazetteer PR that can be used with the FlexibleGazetteerPR

OntoRoot Gazetteer

- Lives in the Gazetteer_Ontology_Based plugin
- Generates candidate gazetteer list from ontology
- Runs the Tokeniser, POS tagger, Morphological Analyser to create lemmas from the labels and the fragment identifiers of all classes and instances and then creates lists to match against the text
  - Gordon_Brown, GordonBrown → Gordon Brown
- Note that the gazetteer produced is stored in memory only and cannot be edited
  → limited size!
- Must use tokeniser, sentence splitter, POS tagger and morphological analyser first: so we get “root” (lemma) feature!

Init-time OntoRoot params

Parameters for the new Onto Root Gazetteer

Name:

Name	Type	Required	Value
caseSensitive	Boolean	✓	false
considerHeuristicRules	Boolean	✓	false
considerProperties	Boolean	✓	true
morpher	Morph	✓	<none>
ontology	Ontology	✓	<none>
posTagger	POSTagger	✓	<none>
propertiesToExclude	String		
propertiesToInclude	String		
separateCamelCasedWords	Boolean	✓	true
tokeniser	DefaultTokeniser	✓	<none>
typesToConsider	Set		[]
useResourceUri	Boolean	✓	true

OK Cancel Help

One or more of “class”,”instance”,”property”

Ontology LR

POS Tagger

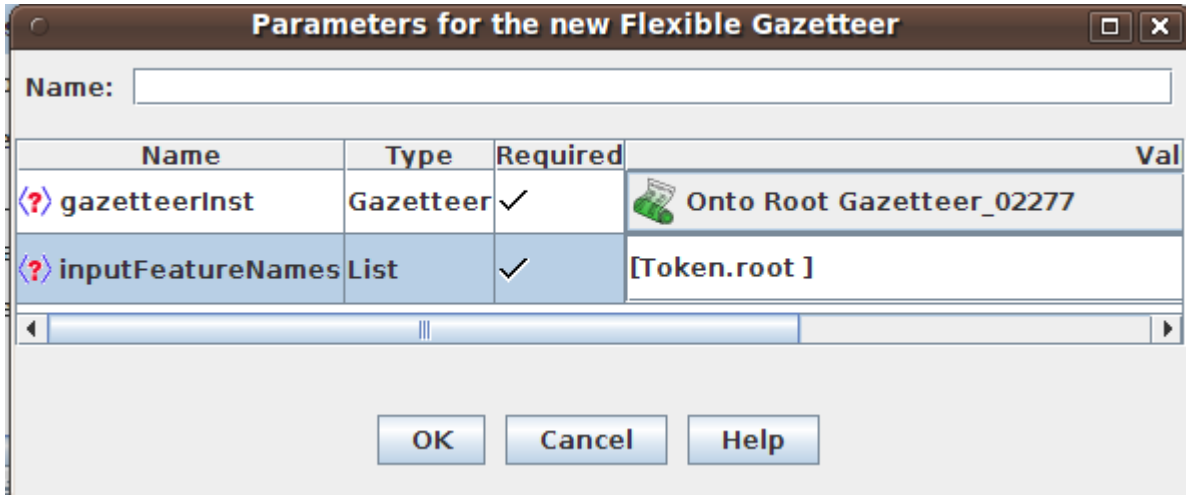
Tokeniser

Running the OntoRoot gazetter

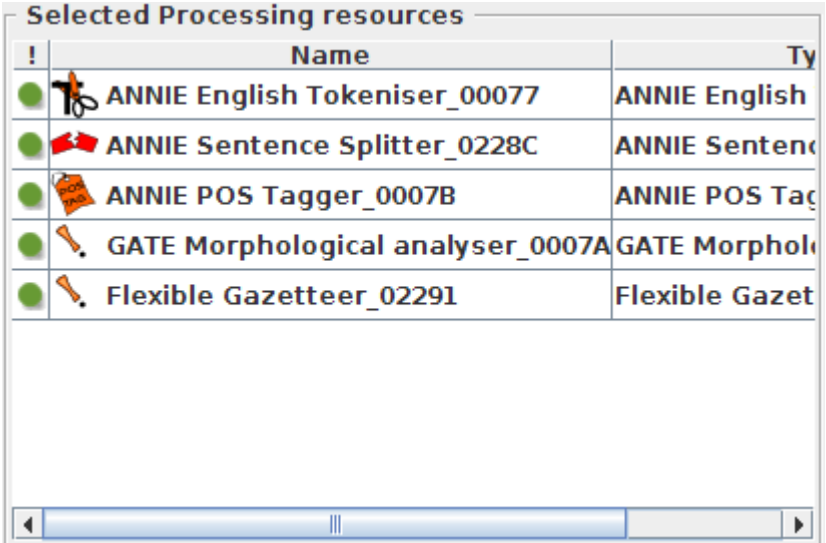
- If mostly matching proper names, then add to your application and run like the ANNIE gazetteer
- It will match against the document text as it is, which is not ideal if matching against terms (“leaders” should match “leader”: need lemma/root)
- To find root we need: Tokeniser, Sentence Splitter, POS tagger, and Morphological Analyser
- To match the root and not the text, use Flexible Gazetteer PR with OntoRoot as the embedded gazetteer
- Flexible Gazetteer delegates to OntoRoot Gazetteer: Flexible Gazetteer is the one that needs to be added to the application!
  → If Flexible Gazetteer is used, no need to add OntoRoot Gazetteer to application.

OntoRoot Application in GATE

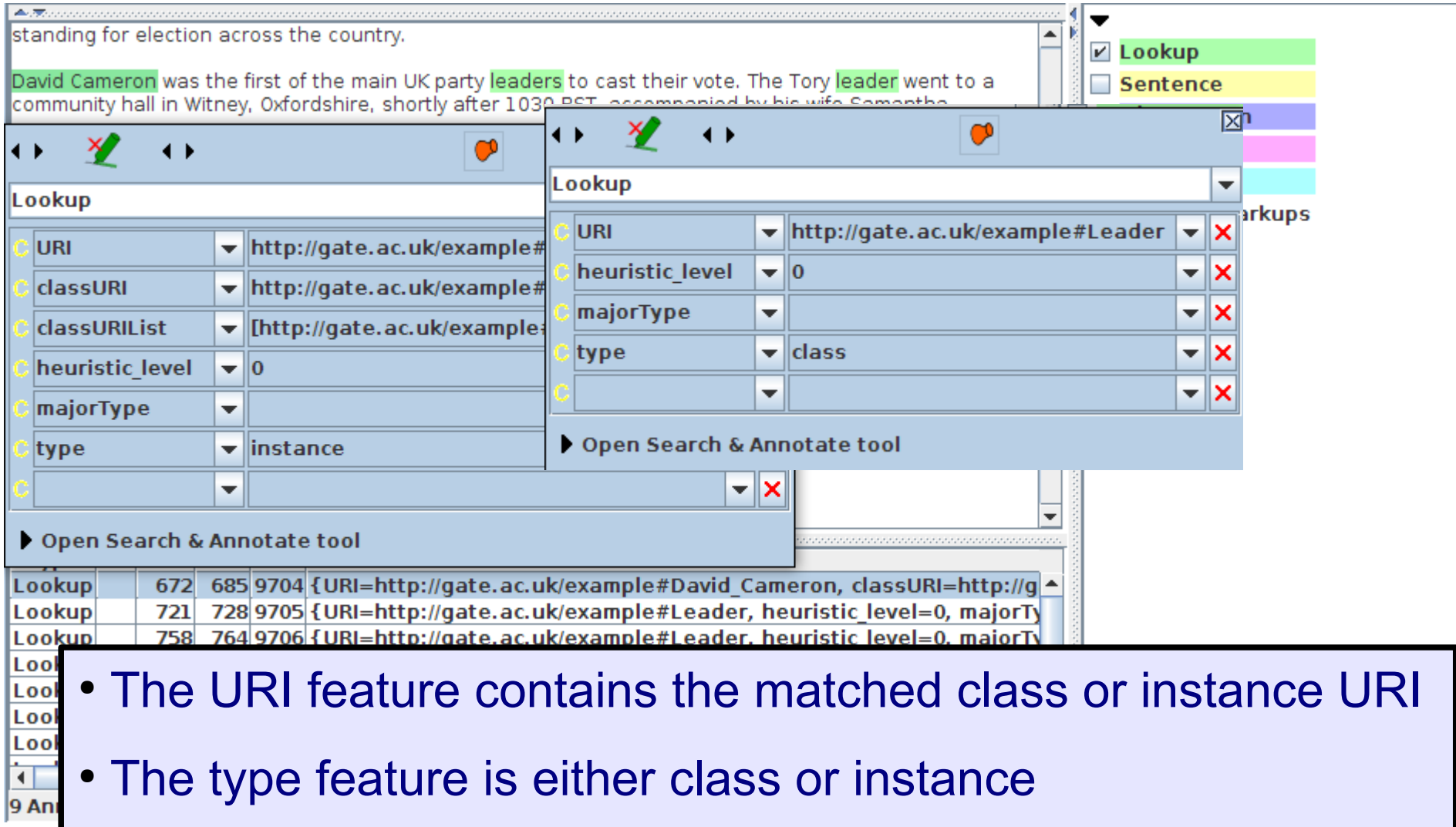
Create a Flexible Gazetteer with an OntoRoot inside it



Build a GATE application with the PRs shown



Output Example



- The URI feature contains the matched class or instance URI
- The type feature is either class or instance
- Instances have also features classURI and classURIList

Hands-on: OntoRootGazetteer

- Load Gazetteer_Ontology_Based plugin, Format_PubMed, ANNIE and Tools plugins
- Create Document Reset, Tokeniser, Sentence Splitter, POS Tagger, and Morphological Analyser (all with defaults)
- Create a new corpus pipeline called “text”, and add the above PRs to it in that order
- Create another new corpus pipeline called “ontology” and add the Tokeniser, POS Tagger, and Morphological Analyser in that order
- Create an OntoRootGazetteer, configuring these parameters:
  - ontology – the FastVac ontology
  - RootFinderApplication – the “ontology” pipeline
  - propertiesToInclude:
    - http://www.w3.org/2000/01/rdf-schema#label,http://fera.gsi.gov.uk/gate#Latin_name
  - separateCamelCaseWords – false
  - useResourceUri - false

Hands-on: OntoRoot (contd.)

- Create a FlexibleGazetteer PR:
  - add Token.root to inputFeatureNames
  - choose the OntoRoot gazetteer as gazetteerInst
- Add Flexible Gazetteer to the “text” pipeline
- In a text editor, examine a document from the corpus in the hands on material, pubmed-hands-on/corpus
- They are in native PubMed format
- Create a corpus and populate it from this corpus, setting encoding to UTF-8
- Examine a document in GATE. Look at the original markup annotations, and the document features
- Run the “text” pipeline over the corpus and inspect the resulting Lookup annotations

Conventions in GATE

- We use “Mention” annotations to reflect the fact that the text mentions a particular instance or a class
- The Mention annotations have two special features:
  - *class* = class URI from the ontology
  - *inst* = instance URI from the ontology (if available)

    e.g. Mention {class=Leader, inst=Gordon_Brown}
- It's important **not** to use *class* and *inst* as features unless you're dealing with ontologies, as these are predefined names in several tools
- OntoRoot Gazetteer does not follow the conventions

Compatibility with OntoRootGazetteer

- The OntoRootGazetteer always puts the matching resource (class or individual) URI in a feature called “URI” and the kind of match in a feature called “type”. For individuals it also creates the features “classURI” and “classURIList”
- But GATE/JAPE requires these features to be called **class** and **inst**
- So we need a JAPE grammar to first change the names of these features

JAPE grammar to change feature names

```
Phase: LookupRename
Input: Lookup
Options: control = appelt

Rule: RenameLookup
(
  {Lookup.type == instance}

):match
-->
:match{
  for (Annotation lookup : matchAnnots) {
    FeatureMap theFeatures = lookup.getFeatures();
    theFeatures.put(
       "class", theFeatures.get("classURI"));
    theFeatures.put("inst", theFeatures.get("URI"));
  }
}
```

finds all Lookups which OntoRoot gazetteer created from ontology instances

add a new feature **class** with the value of the original classURI feature

do the same for inst

Ontology Aware JAPE

- JAPE transducers have a run-time parameter which is an ontology
- [Note that the ANNIE NE Transducer] does not have this parameter, so you cannot use it for ontology-aware JAPE]
- By default it is left blank, so not used during LHS matching
- When an ontology is provided, the **class** feature can be used on the LHS of a JAPE rule
- When matching the **class** value, the ontology is checked for subsumption: any subclass on the left side of “==” matches
- e.g. {Lookup.class == Person} will match a Lookup annotation with **class** feature, whose value is either Person or any subclass of it

Ontology-aware JAPE example

```
Phase: OntoMatching
Input: Lookup
Options: control = appelt

Rule: PersonLookup
(
  {Lookup.class == Person}

):person
-->
:person.Mention =
   {class = :person.Lookup.class,
    inst = :person.Lookup.inst}
```

Matches the class Person or any of its subclasses

Adds class and instance information as features on the Mention annotation

Ontology-aware JAPE example

```
{Lookup.class == “http://example.com/stuff#Person”}
```

Matches this class or any subclass in the ontology

```
{Lookup.class == “Person”}
```

If the string is not a full URI, JAPE adds the default namespace from the ontology, looks up that class in the ontology, and matches it or any subclasses. Be very careful if your ontology uses more than one namespace!

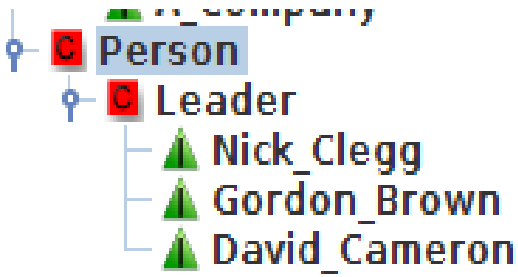
Templates to simplify namespaces

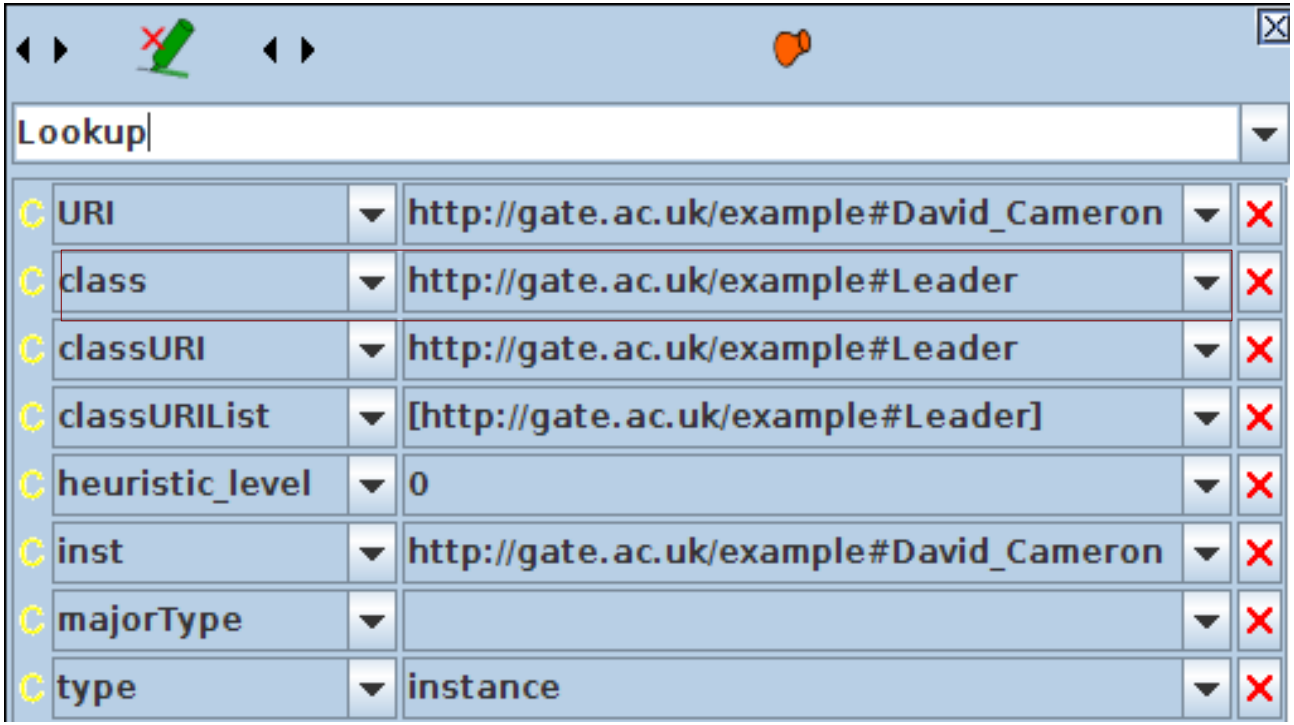
```
Template: protont =
  “http://proton.semanticweb.org/2005/04/protont#${n}”
...
{Lookup.class == [protont n=Person]}
...
{Lookup.class == [protont n=Location]}
```

```
Template: protont =
  “http://proton.semanticweb.org/2006/05/protont#${n}”
...
```

Matching subclasses

David Cameron was the first of the main UK party leaders...





The rule matches because Leader is a subclass of Person

Hands-on: ontology-aware JAPE

- Load the JAPE transducer *rename-lookup-features.jape* and add to the end of your “text” pipeline
- Run the modified pipeline to see how the Lookup annotations for Lookups now have class features
- Examine the JAPE file *pathogen-onto-matching.jape*
- Load the JAPE transducer *pathogen-onto-matching.jape* and add it to the end of the “text” pipeline as before.
- In the pipeline, select the FastVac ontology as the ontology run-time parameter of the transducer
- Run the modified pipeline to see how it creates new *Pathogen* annotations

Semantic Annotation with other tools: OpenCalais

http://viewer.opencalais.com/

Paste text of http://www.membranes.com/

Since its founding in 1975, **Hydranautics** has been committed to the highest standards of **technology research**, produc
utics entered the reverse osmosis (RO) water treatment field in 1970, and is now one of the most respected and experie
y. **Hydranautics** became part of the **Nitto Denko Corporation** when it was acquired in 1987. **Hydranautics** corporate
California in a 160,000 ft2 (14,684 m2) **manufacturing facility residing** on 14 acres, all owned by **Hydranautics**.

Hydranautics' continuing commitment to research and **technology results** in the ongoing development of a **range of s**
s' products are currently in use on seven continents throughout the world for **such diverse applications** as potable wat
astewater treatment, surface water treatment, seawater desalination, electronic rinse water, agricultural irrigation and

Comprehensive customer service and support are available virtually around the clock and around the world. **Hydranauti**
rk of worldwide sales offices throughout the **United States**, **Latin America**, **Europe** and **Asia**.

Entities:

- **City**
  - Oceanside,California,United
- **Company**
  - Hydranautics Inc
  - NITTO DENKO CORPORATION
- **Continent**
  - Asia
  - Europe
- **Country**
  - United States
- **Industry Term**
- **Province Or State**
  - California,United States
- **Region**
- **Technology**
  - wastewater treatment

Events & Facts:

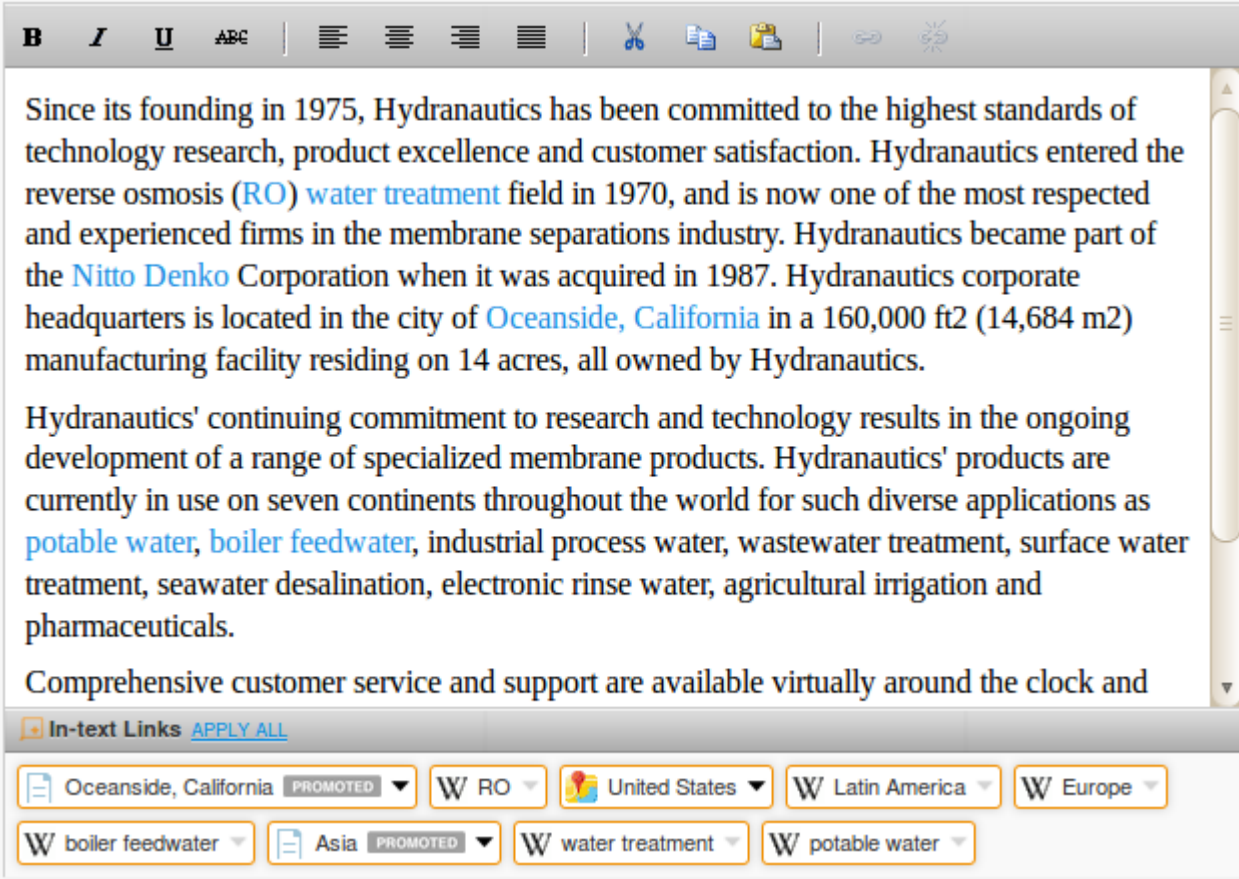
- **Acquisition**
  - NITTO DENKO CORPORATION, 1987-00-00, in
- **Company Founded**
  - Hydranautics Inc, 1975
- **Generic Relations**
  - Hydranautics Inc, be
  - Hydranautics Inc, part of the Nitto Denko
  - Hydranautics Inc, commit
  - a network of worldwide sales offices,
  - Hydranautics Inc, the reverse osmosis, enter

Not easily customised/extended

Domain-specific coverage varies

Zemanta

- Paste text from www.membranes.com
- The main entity of interest “Hydranautics” is missed
- Common problem with general purpose, open-domain semantic annotation tools
- Best results require bespoke customisation



QUESTIONS?