RuSSIR
Russian Summer School
in Information Retrieval
2008

Natural Language Processing for Information Access

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Overview of the course

- NLP technology and tools (Day 1 & 2)
- Question Answering (Day 3 & 4)
- Text Summarization (Day 4 & 5)

Outline

- NLP for Information Access
- Information Retrieval
- Information Extraction
- Text Summarization
- Question Answering
- Cubreporter: a case study
- Other applications
- GATE tools for NLP
- Components
  - tokenisation
  - sentence splitting
  - part of speech tagging
  - named entity recognition
  - morphological analysis
  - parsing
- Demonstrations

Information Retrieval (Salton'88)

- Given a document collection and a user information need
- Produces lists of documents matching the information need
- Information needs can be expressed as sets of keywords
- Documents are pre-processed in order to produce term indexes which contain information about where each term occurs in the collection - decisions have to be taken with regards to the definition of term

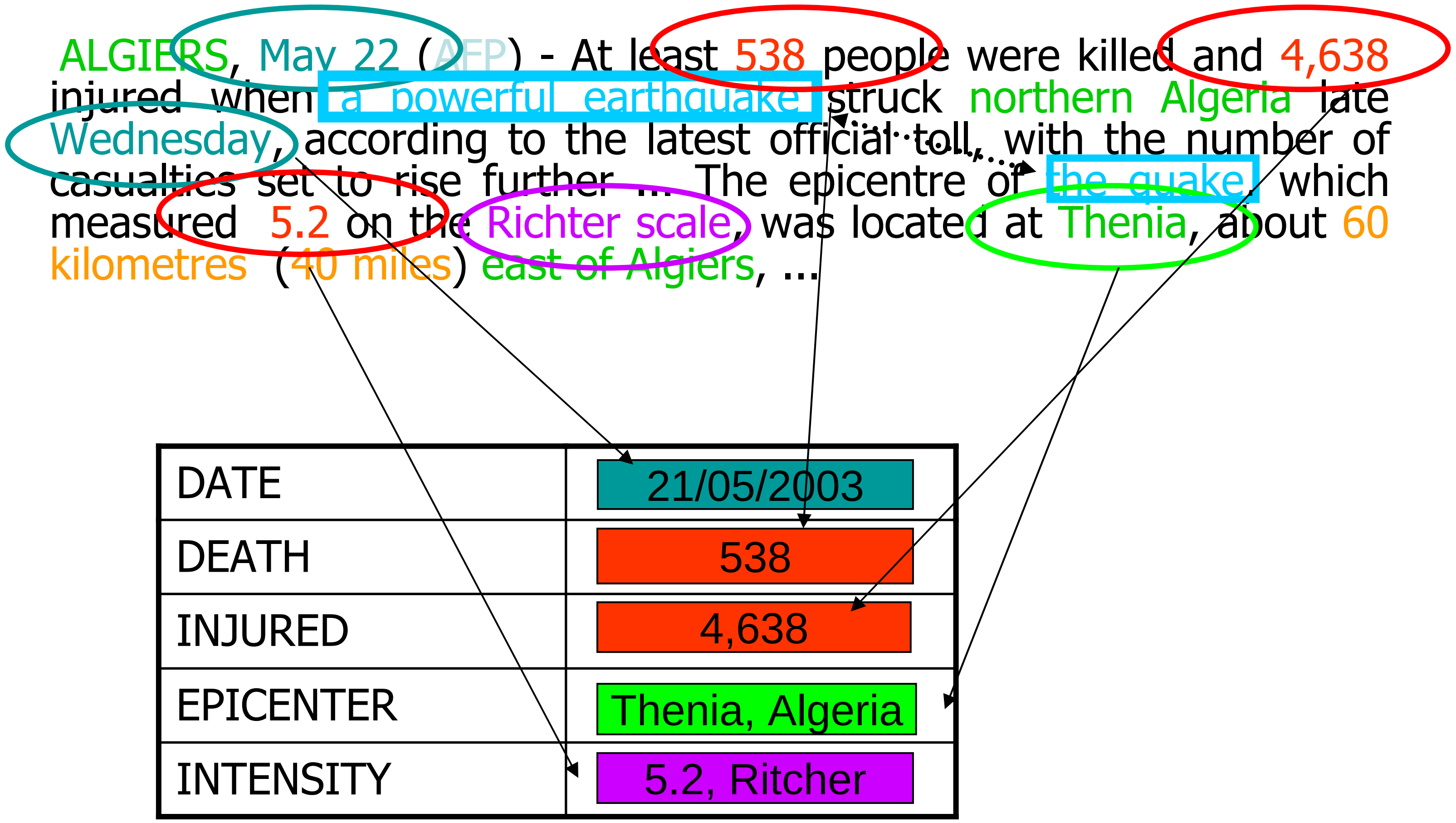
Information Retrieval

- Needs a method to measure the similarity between documents and queries
- The user has to read the documents in order to find the desired information
- IR can be applied to any domain
- Text Retrieval Conferences (since 1992) contributed to system development and evaluation (http://trec.nist.gov)

Information Extraction (Grishman'97)

- Pulls facts from the document collection
- Based on the idea of scenario template
  - some domains can be represented in the form of one or more templates
  - templates contain slots representing semantic information
  - IE instantiates the slots with values
- IE is domain dependent – a template has to be defined
- Message Understanding Conferences 1987-1997 fuelled the IE field and made possible advances in techniques such as Named Entity Recognition
- From 2000 the Automatic Content Extraction (ACE) Programme

Information Extraction



ALGIERS, May 22 (AFP) - At least 538 people were killed and 4,638 injured when a powerful earthquake struck northern Algeria late Wednesday, according to the latest official toll, with the number of casualties set to rise further ... The epicentre of the quake, which measured 5.2 on the Richter scale, was located at Thenia, about 60 kilometres (40 miles) east of Algiers, ...

DATE	21/05/2003
DEATH	538
INJURED	4,638
EPICENTER	Thenia, Algeria
INTENSITY	5.2, Ritcher

Information Extraction

- Template can be used to populate a data base
- Template can be used to generate a short summary of the input text

  A 5.3 intensity earthquake in Algeria killed more than 500 people.
- Data base can be used to perform reasoning
  - What Algerian earthquake killed more people?

Information Extraction Tasks

- Named Entity recognition (NE)
  - Finds and classifies names in text
- Coreference Resolution (CO)
  - Identifies identity relations between entities in texts
- Template Element construction (TE)
  - Adds descriptive information to NE results
- Scenario Template production (ST)
  - Instantiate scenarios using TEs

Examples

- NE:
  - Thenia (Location), Algiers (Location), May 22 (Date), Wednesday (Date), etc.
- CO:
  - *a powerful earthquake* and *the quake*
  - *ALGIERS* and *Algiers*
- *TE:*
  - entity descriptions: Thenia is in Algeria, Algiers is capital of Algeria
- ST
  - combine entities in one scenario (as shown in the example)

Question Answering (Hirschman&Gaizauskas’01)

- Given a document collection (can be the Web) and a natural language question
- Extract the answer from the document collection
  - answer can in principle be any expression but in many cases questions ask for specific types of information such as person names, location, dates, etc.
- Open domain in general
- Text Retrieval Conferences Question Answering Track responsible for advances in the field of system development and evaluation (since 1999)
- From 2008 the Text Analysis Conference

QA Task (Voorhees'99)

- In the Text Retrieval Conferences (TREC) Question Answering evaluation, 3 types of questions are identified
- <u>Factoid</u> questions such as:
  - "Who is Tom Cruise married to?"
- <u>List</u> questions such as:
  - "What countries have atomic bombs?"
- <u>Definition</u> questions such as:
  - "Who is Aaron Copland?" or "What is aspirin?"

(Changed name to "other" question type)

Text Summarization (Mani'01)

- Given a document or set of documents
- Extract the most important content from it and present a condensed version of it
  - extracts vs abstracts
- Useful for decision making: read or not read; saves time; can be used to create surrogates; etc.
- Open domain, however domain knowledge proves important (e.g., scientific domain)
- Document Understanding Conferences (since 2000) contributed with much development in the field
- From 2008 the Text Analysis Conference

Integration of technologies for background gathering (Gaizauskas&al07)

- *Cubreporter Project*
  - *IR, QA, TS, IE*
- *Background gathering*: the task of collecting information from the news wire and other archives to contextualise and support a breaking news story
- Backgrounder components
  - similar events in the past; role players' profiles; factual information on the event
- Collaboration with Press Association
  - 11 year archive with more than 8 million stories

Background Examples

- Breaking News

  "Powerful earthquake shook Turkey today"

- Past Similar Events

  "Last year an earthquake measuring 6.3-magnitude hit southern Turkey killing 144 people."

- Extremes

  "Europe's biggest quake hit Lisbon, Portugal, on November 1, 1755, when 60,000 people died as the city was devastated and giant waves 10 metres high swept through the harbour and on to the shore."

- Definitions

  "Quakes occur when the Earth's crust fractures, a process that can be caused by volcanic activity, landslides or subterranean collapse. The resulting plates grind together causing the tremors.

Text Analysis Resources

- General Architecture for Text Engineering
  - (http://gate.ac.uk)
  - Tokenisation, Sentence Identification, POS tagging, NE recognition, etc.
- SUPPLE Parser
  - (http://nlp.shef.ac.uk/research/supple)
  - syntactic parsing and creation of logical forms
- Summarization Toolkit
  - (http://www.dcs.shef.ac.uk/~saggion)
  - Single and multi document summarization
- Lucene
  - (http://lucene.apache.org)
  - Text indexing and retrieval

Summarization System

- Scores sentences based on numeric features in both single and multi-document cases
  - position of sentence, similarity to headline, similarity to cluster centroid, etc.
  - values are combined to obtain the sentence score
  - single-document summaries and summaries for “related” stories
- Press Association profiles are automatically identified
- Other profiles created using QA/summarization techniques

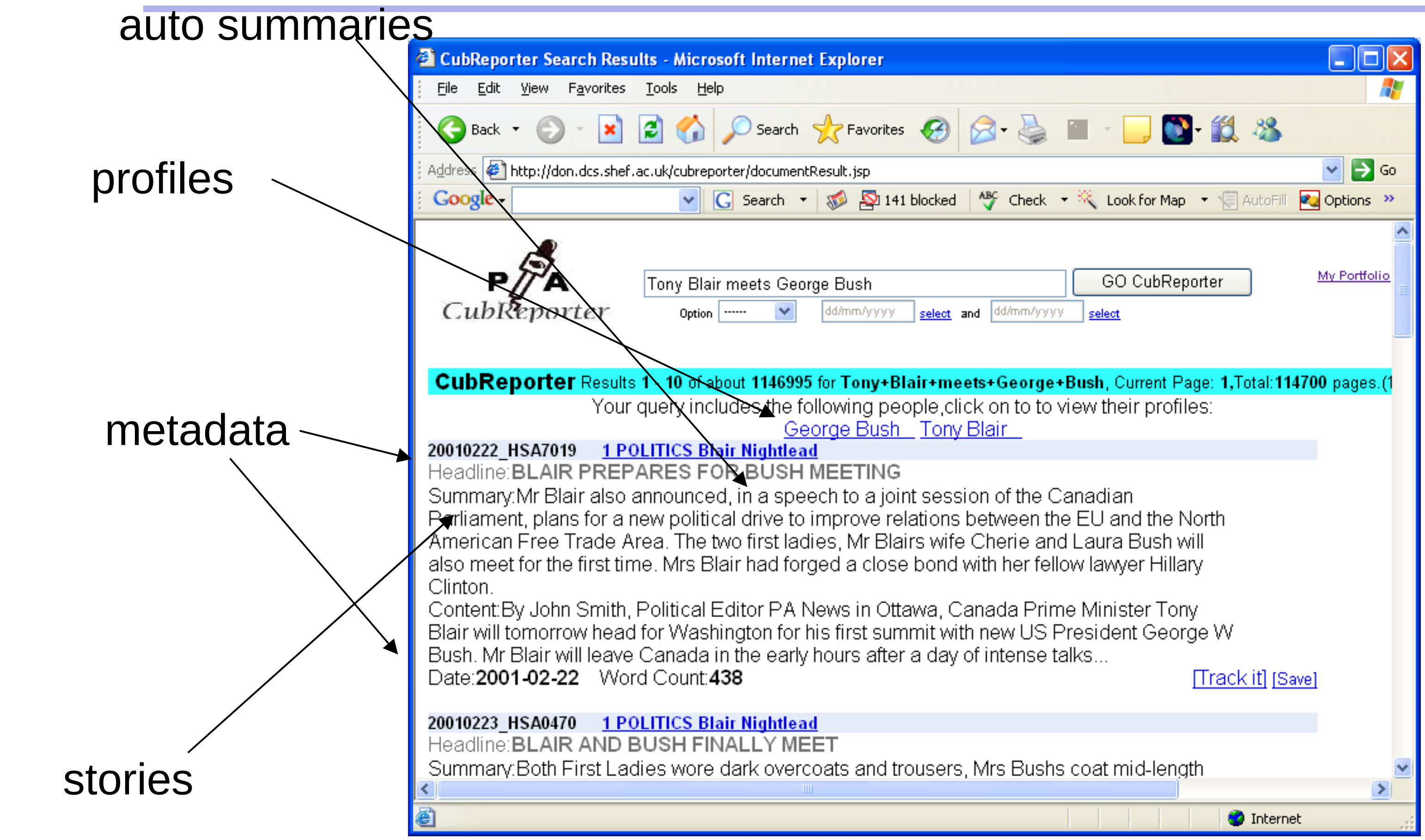
Question Answering

- Passage (i.e., paragraph) retrieval using question
- Question and passage analysis using a parser (SUPPLE)
  - semantic representation
  - identification of expected answer type (EAT)
  - each “entity” in a sentence is considered a <u>candidate</u> answer
- Answer candidates in passages scored using
  - sentence score (overlap with question)
  - “similarity” of <u>candidate</u> answer to EAT
  - count relations between candidate and “question entities”
  - merge scores across passages and select candidate with highest score

Semantic Representations

- To search for "similar events"
- Leading paragraphs are parsed using SUPPLE and semantic representations created
  - *"The head of Australia's biggest bank resigned today"*
  - *head(e2), name(e4,'Australia'), country(e4), of(e3,e4), bank(e3), adj(e3,biggest), of(e2,e3), resign(e1), lsubj(e1,e2)*
- Database records are created and used to support similar event search
- We can search for "resignation" events
  - "resign" -> leave job = quit, renounce, leave office
  - "head" -> person in charge = chief

Finding Stories



Tony Blair meets George Bush

dd/mm/yyyy

CubReporter Results 1 - 10 of about 1146995 for **Tony+Blair+meets+George+Bush**, Current Page: **1**,Total:**114700** pages.(1

Your query includes the following people,click on to to view their profiles:
George Bush Tony Blair

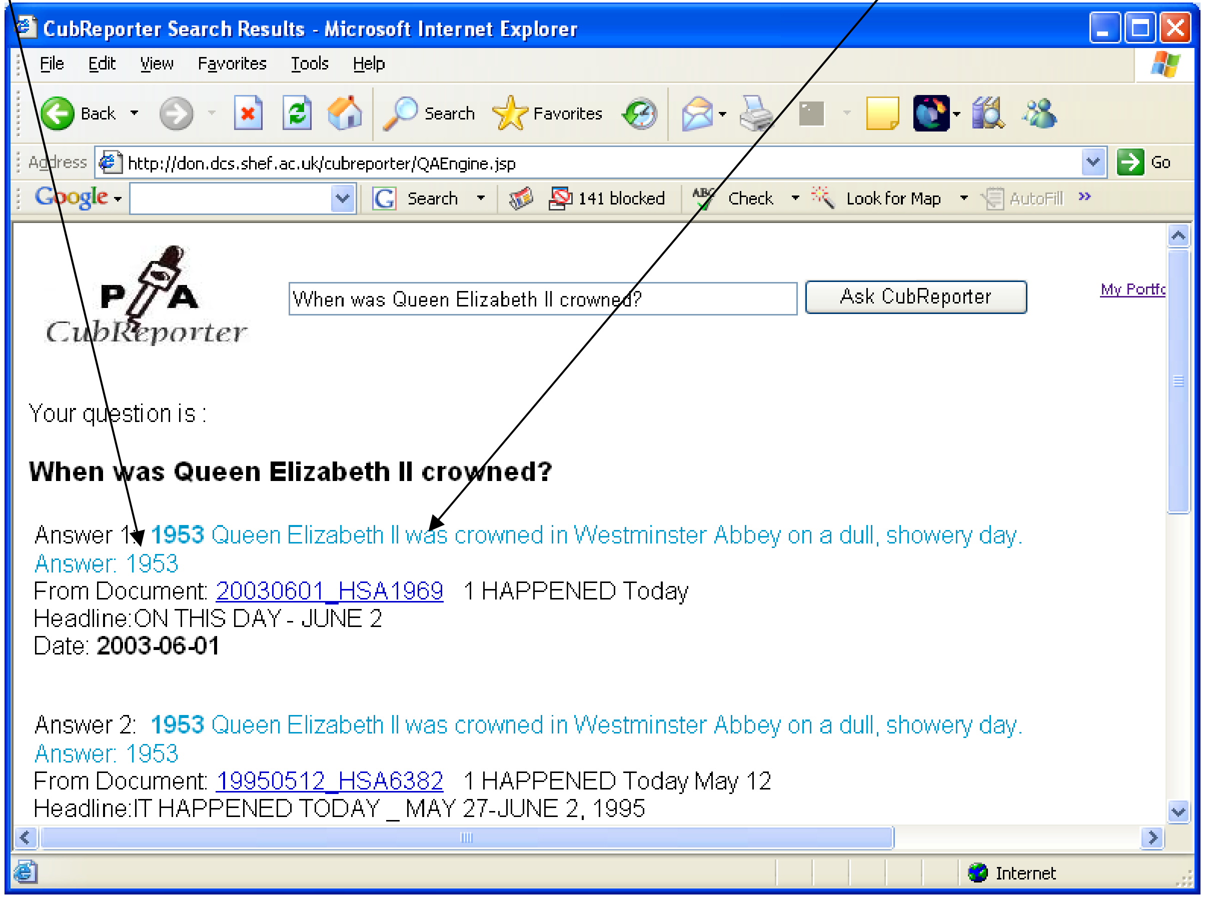
20010222_HSA7019 1 POLITICS Blair Nightlead
Headline:**BLAIR PREPARES FOR BUSH MEETING**
Summary:Mr Blair also announced, in a speech to a joint session of the Canadian Parliament, plans for a new political drive to improve relations between the EU and the North American Free Trade Area. The two first ladies, Mr Blairs wife Cherie and Laura Bush will also meet for the first time. Mrs Blair had forged a close bond with her fellow lawyer Hillary Clinton.
Content:By John Smith, Political Editor PA News in Ottawa, Canada Prime Minister Tony Blair will tomorrow head for Washington for his first summit with new US President George W Bush. Mr Blair will leave Canada in the early hours after a day of intense talks...
Date:**2001-02-22** Word Count:**438** [Track it] [Save]

20010223_HSA0470 1 POLITICS Blair Nightlead
Headline:**BLAIR AND BUSH FINALLY MEET**
Summary:Both First Ladies wore dark overcoats and trousers, Mrs Bushs coat mid-length

Getting Answers

answers

context


CubReporter Search Results - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back
Search
Favorites
Address
http://don.dcs.shef.ac.uk/cubreporter/QAEngine.jsp
Go
Google
Search
141 blocked
Check
Look for Map
AutoFill
PA CubReporter
Ask CubReporter
My Portfo
Internet

When was Queen Elizabeth II crowned?

Your question is :

When was Queen Elizabeth II crowned?

Answer 1: **1953** Queen Elizabeth II was crowned in Westminster Abbey on a dull, showery day.
Answer: 1953
From Document: 20030601_HSA1969 1 HAPPENED Today
Headline:ON THIS DAY - JUNE 2
Date: **2003-06-01**

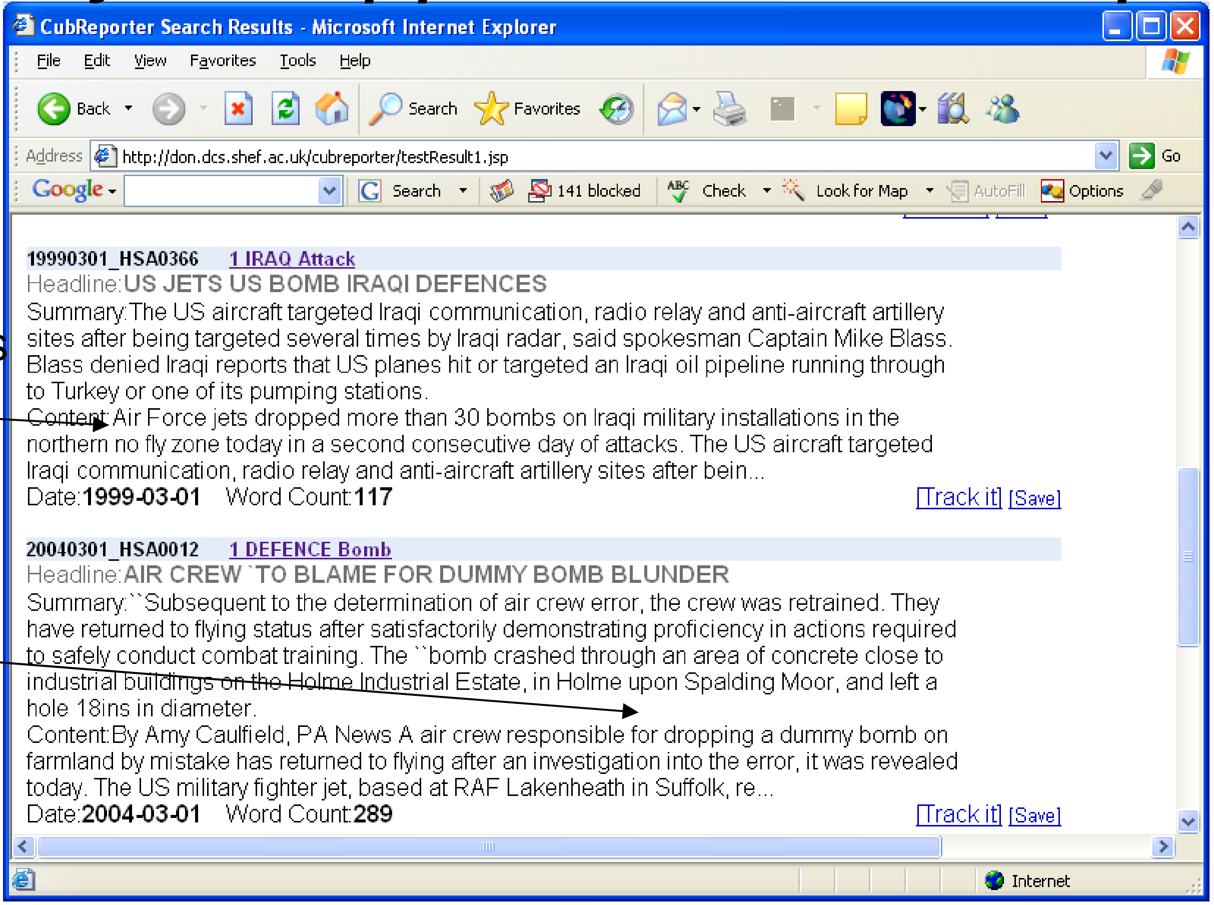
Answer 2: **1953** Queen Elizabeth II was crowned in Westminster Abbey on a dull, showery day.
Answer: 1953
From Document: 19950512_HSA6382 1 HAPPENED Today May 12
Headline:IT HAPPENED TODAY _ MAY 27-JUNE 2, 1995

Getting Similar Events

"jet dropped bomb in Iraq"

jets drop bombs

bombs dropped


CubReporter Search Results - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://don.dcs.shef.ac.uk/cubreporter/testResult1.jsp Go
Google Search 141 blocked Check Look for Map AutoFill Options
Internet

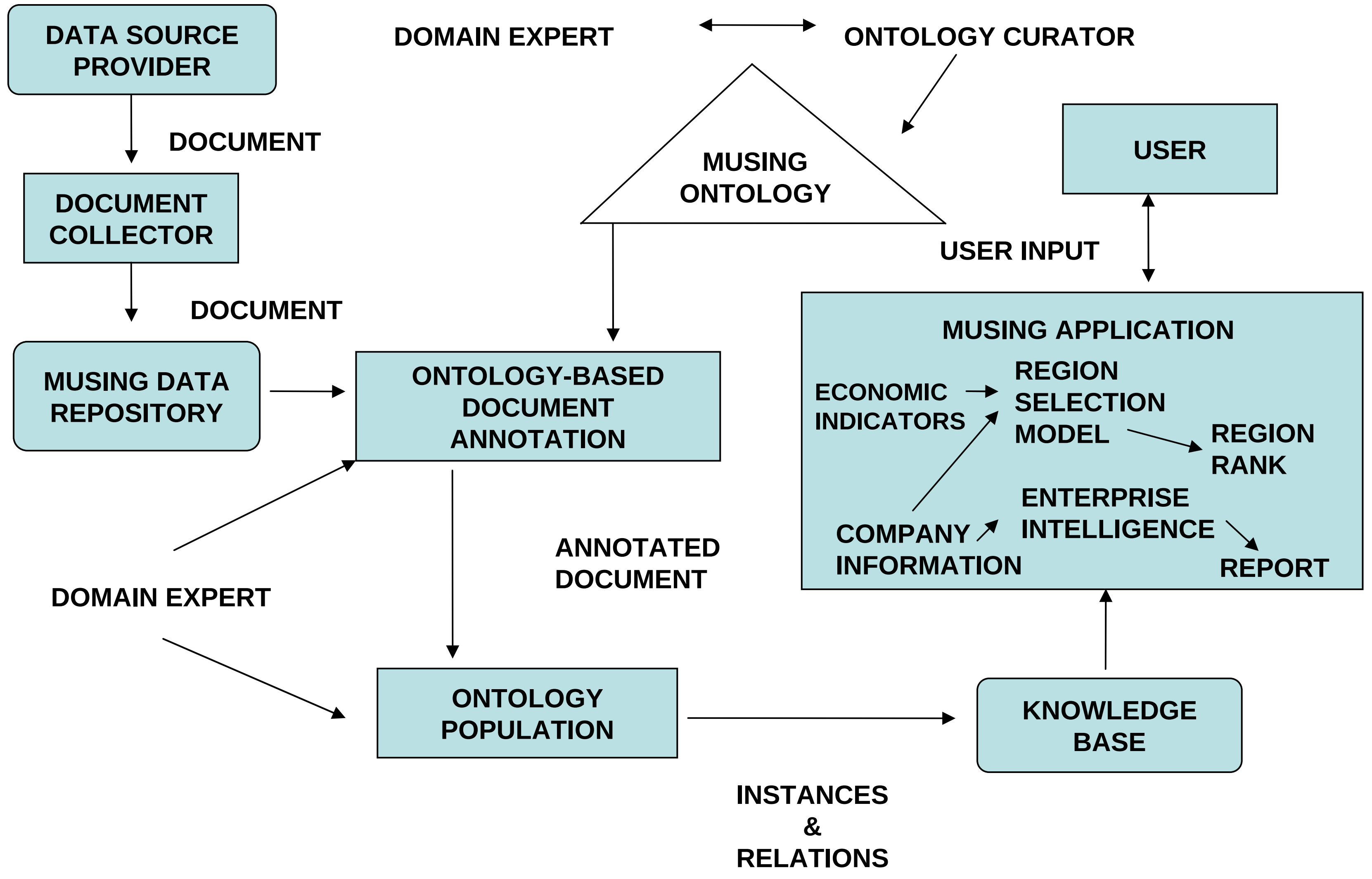
19990301_HSA0366 1 IRAQ Attack
Headline: US JETS US BOMB IRAQI DEFENCES
Summary: The US aircraft targeted Iraqi communication, radio relay and anti-aircraft artillery sites after being targeted several times by Iraqi radar, said spokesman Captain Mike Blass. Blass denied Iraqi reports that US planes hit or targeted an Iraqi oil pipeline running through to Turkey or one of its pumping stations.
Content: Air Force jets dropped more than 30 bombs on Iraqi military installations in the northern no fly zone today in a second consecutive day of attacks. The US aircraft targeted Iraqi communication, radio relay and anti-aircraft artillery sites after bein...
Date: 1999-03-01 Word Count: 117 [Track it] [Save]

20040301_HSA0012 1 DEFENCE Bomb
Headline: AIR CREW `TO BLAME FOR DUMMY BOMB BLUNDER
Summary: ``Subsequent to the determination of air crew error, the crew was retrained. They have returned to flying status after satisfactorily demonstrating proficiency in actions required to safely conduct combat training. The ``bomb crashed through an area of concrete close to industrial buildings on the Holme Industrial Estate, in Holme upon Spalding Moor, and left a hole 18ins in diameter.
Content: By Amy Caulfield, PA News A air crew responsible for dropping a dummy bomb on farmland by mistake has returned to flying after an investigation into the error, it was revealed today. The US military fighter jet, based at RAF Lakenheath in Suffolk, re...
Date: 2004-03-01 Word Count: 289 [Track it] [Save]

Extracting information for business intelligence applications

- MUSING Project – 6FP European Commission (ICT)
  - integration of natural language processing and ontologies for business intelligence applications
  - extraction of <u>company information</u>
  - extraction of <u>country/region information</u>
  - identification of <u>opinions</u> in text for company reputation

Ontology-based IE in MUSING

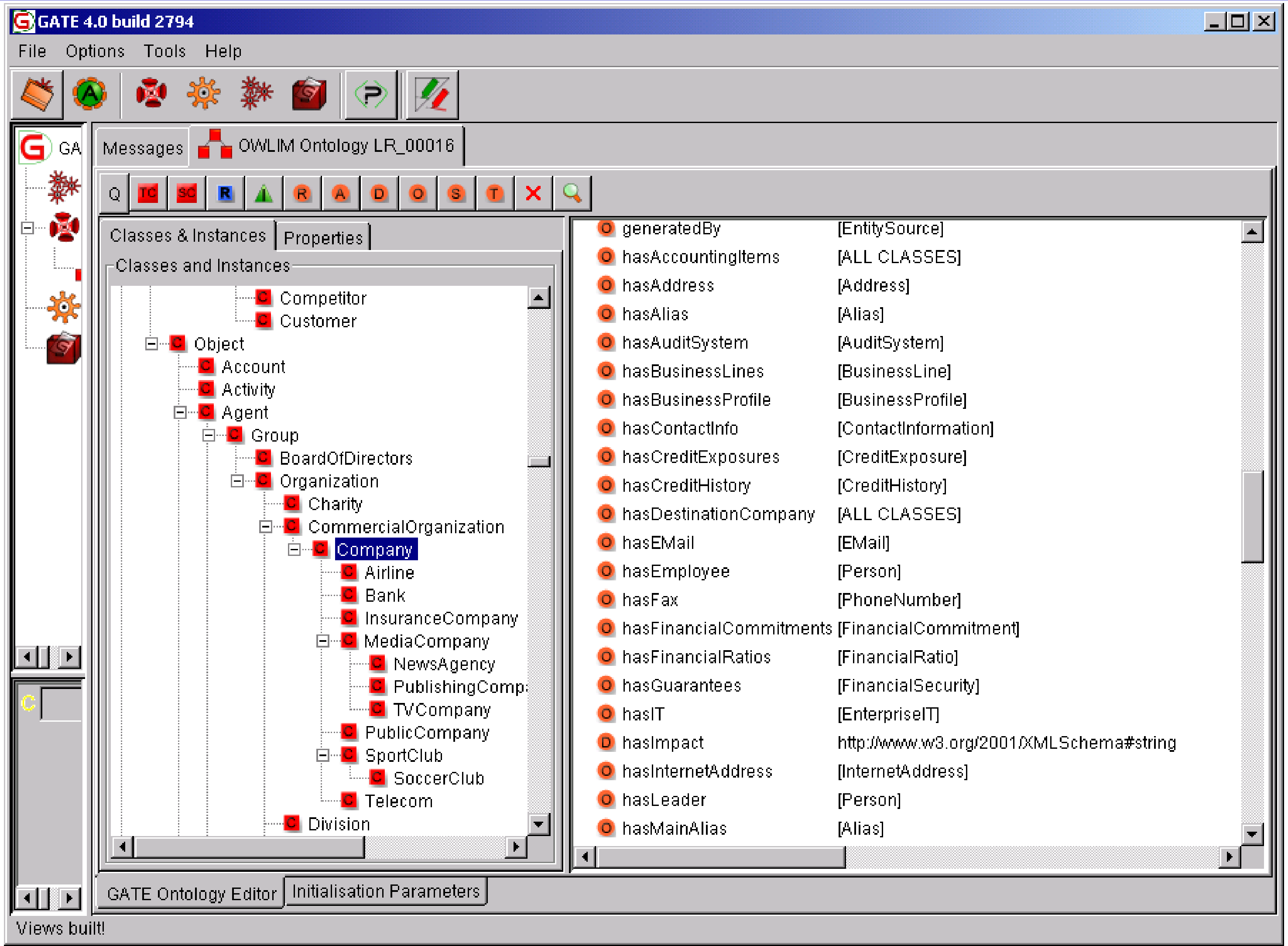


Data Sources in MUSING

- Data sources include balance sheets, company profiles, press data, web data, etc. (some private data)
  - News papers from Italian financial news provider
  - Companies' web pages (main, "about us", "contact us", etc.)
  - Wikipedia, CIA Fact Book, etc.

- Ontology is manually developed through interaction with domain experts and ontology curators
  - It extends the PROTON ontology and covers the financial, international, and IT operational risk domain

Company Information in MUSING

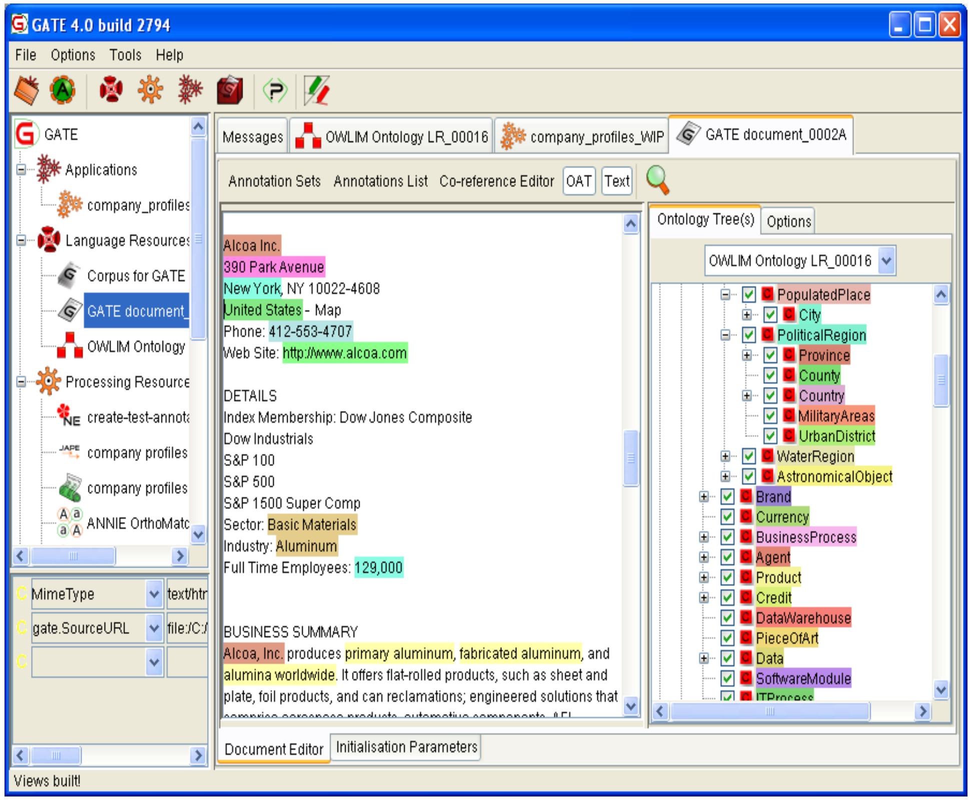


```
Competitor
Customer
Object
  Account
  Activity
  Agent
    Group
      BoardOfDirectors
      Organization
        Charity
        CommercialOrganization
          Company
            Airline
            Bank
            InsuranceCompany
            MediaCompany
              NewsAgency
              PublishingComp
              TVCompany
            PublicCompany
            SportClub
              SoccerClub
            Telecom
        Division
```

```
generatedBy              [EntitySource]
hasAccountingItems       [ALL CLASSES]
hasAddress               [Address]
hasAlias                 [Alias]
hasAuditSystem           [AuditSystem]
hasBusinessLines         [BusinessLine]
hasBusinessProfile       [BusinessProfile]
hasContactInfo           [ContactInformation]
hasCreditExposures       [CreditExposure]
hasCreditHistory         [CreditHistory]
hasDestinationCompany    [ALL CLASSES]
hasEMail                 [EMail]
hasEmployee              [Person]
hasFax                   [PhoneNumber]
hasFinancialCommitments  [FinancialCommitment]
hasFinancialRatios       [FinancialRatio]
hasGuarantees            [FinancialSecurity]
hasIT                    [EnterpriseIT]
hasImpact                http://www.w3.org/2001/XMLSchema#string
hasInternetAddress       [InternetAddress]
hasLeader                [Person]
hasMainAlias             [Alias]
```

Extracting Company Information

- Extracting information about a company requires for example identify the Company Name; Company Address; Parent Organization; Shareholders; etc.
- These associated pieces of information should be asserted as properties values of the company instance
- Statements for populating the ontology need to be created (“Alcoa Inc” hasAlias “Alcoa”; “Alcoa Inc” hasWebPage “http://www.alcoa.com”, etc.)



MimeType text/htm
gate.SourceURL file:/C:/

Alcoa Inc.
390 Park Avenue
New York, NY 10022-4608
United States - Map
Phone: 412-553-4707
Web Site: http://www.alcoa.com

DETAILS
Index Membership: Dow Jones Composite
Dow Industrials
S&P 100
S&P 500
S&P 1500 Super Comp
Sector: Basic Materials
Industry: Aluminum
Full Time Employees: 129,000

BUSINESS SUMMARY
Alcoa, Inc. produces primary aluminum, fabricated aluminum, and alumina worldwide. It offers flat-rolled products, such as sheet and plate, foil products, and can reclamations; engineered solutions that

General Architecture for Text Engineering – GATE (Cunningham&al'02)

- Framework for development and deployment of natural language processing applications
  - http://gate.ac.uk
- A graphical user interface allows users (computational linguists) access, composition and visualisation of different components and experimentation
- A Java library (gate.jar) for programmers to implement and pack applications

Component Model

- Language Resources (LR)
  - data
- Processing Resources (PR)
  - algorithms
- Visualisation Resources (VR)
  - graphical user interfaces (GUI)

- Components are extendable and user-customisable
  - for example adaptation of an information extraction application to a new domain
  - to a new language where the change involves adaptation of a module for word recognition and sentence recognition

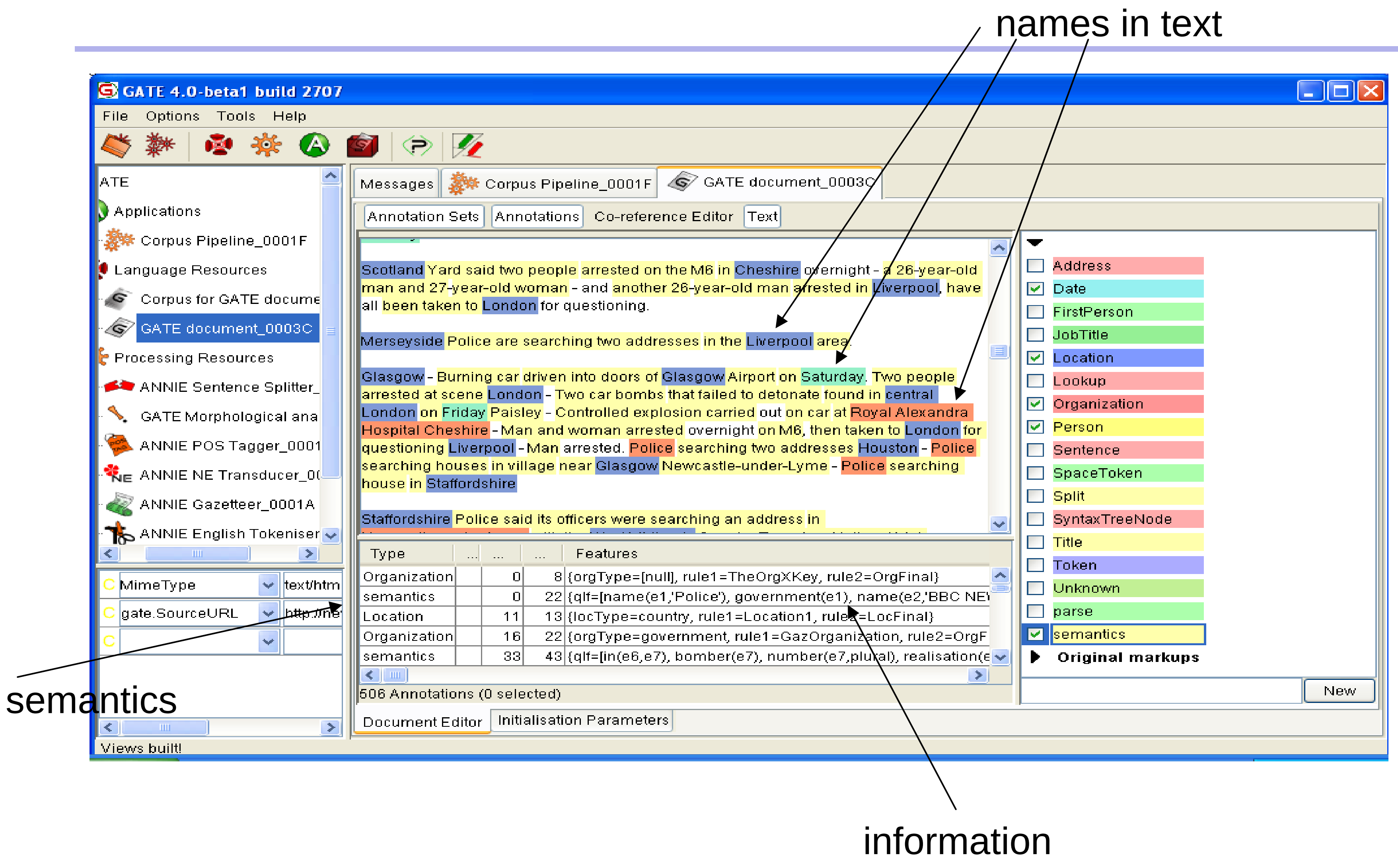
Documents in GATE

- A document is created from a file located somewhere in your disk or in a remote place or from a string
- A GATE document contains the “text” of your file and sets of annotations
- When the document is created and if a format analyser for your type is available “parsing” (format) will be applied and annotations will be created
  - xml, sgml, html, etc.
- Documents also store features, useful for representing metadata about the document
  - some features are created by GATE
- GATE documents and annotations are LRs

Documents in GATE

- Annotations have
  - types (e.g. Token)
  - belong to particular annotation sets
  - start and end offsets – where in the document
  - features and values which are used to store orthographic, grammatical, semantic information, etc.
- Documents can be grouped in a Corpus
- Corpus is other language resource in GATE which implements a set of documents

Documents in GATE


names in text
semantics
information
GATE 4.0-beta1 build 2707
File Options Tools Help
Messages | Corpus Pipeline_0001F | GATE document_0003C
Annotation Sets | Annotations | Co-reference Editor | Text
Document Editor | Initialisation Parameters
New

ATE
- Applications
  - Corpus Pipeline_0001F
- Language Resources
  - Corpus for GATE docume
  - GATE document_0003C
- Processing Resources
  - ANNIE Sentence Splitter_
  - GATE Morphological ana
  - ANNIE POS Tagger_0001
  - ANNIE NE Transducer_00
  - ANNIE Gazetteer_0001A
  - ANNIE English Tokeniser

MimeType	text/htm
gate.SourceURL	http://ne

Views built!

Scotland Yard said two people arrested on the M6 in Cheshire overnight - a 26-year-old man and 27-year-old woman - and another 26-year-old man arrested in Liverpool, have all been taken to London for questioning.

Merseyside Police are searching two addresses in the Liverpool area.

Glasgow - Burning car driven into doors of Glasgow Airport on Saturday. Two people arrested at scene London - Two car bombs that failed to detonate found in central London on Friday Paisley - Controlled explosion carried out on car at Royal Alexandra Hospital Cheshire - Man and woman arrested overnight on M6, then taken to London for questioning Liverpool - Man arrested. Police searching two addresses Houston - Police searching houses in village near Glasgow Newcastle-under-Lyme - Police searching house in Staffordshire

Staffordshire Police said its officers were searching an address in

Type	...	...	...	Features
Organization		0	8	{orgType=[null], rule1=TheOrgXKey, rule2=OrgFinal}
semantics		0	22	{qlf=[name(e1,'Police'), government(e1), name(e2,'BBC NEW
Location		11	13	{locType=country, rule1=Location1, rule2=LocFinal}
Organization		16	22	{orgType=government, rule1=GazOrganization, rule2=OrgF
semantics		33	43	{qlf=[in(e6,e7), bomber(e7), number(e7,plural), realisation(e

506 Annotations (0 selected)

- ☐ Address
- ☑ Date
- ☐ FirstPerson
- ☐ JobTitle
- ☑ Location
- ☐ Lookup
- ☑ Organization
- ☑ Person
- ☐ Sentence
- ☐ SpaceToken
- ☐ Split
- ☐ SyntaxTreeNode
- ☐ Title
- ☐ Token
- ☐ Unknown
- ☐ parse
- ☑ semantics

Original markups

Annotation Guidelines

- People need clear definition of what to annotate in the documents, with examples
- Typically written as a guidelines document
- Piloted first with few annotators, improved, then "real" annotation starts, when all annotators are trained
- Annotation tools require the definition of a formal DTD (e.g. XML schema)
    - What annotation types are allowed
    - What are their attributes/features and their values
    - Optional vs obligatory; default values

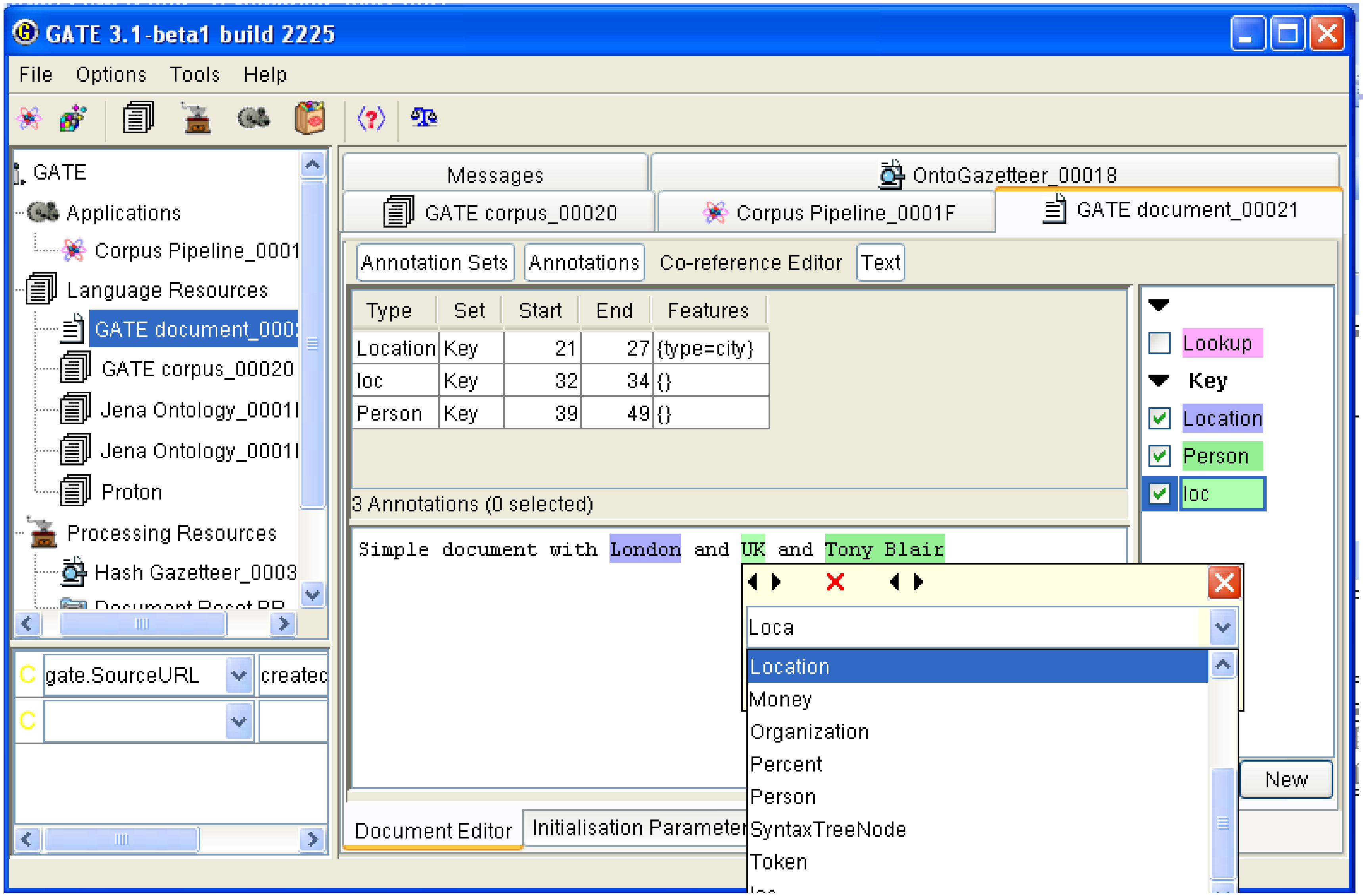
Annotation Schemas

```
<?xml version="1.0"?>
<schema
   xmlns="http://www.w3.org/2000/10/XMLSchema">
   <!-- XSchema definition for email-->
   <element name="Email"  />
</schema>
```

Annotation Schemas

```
<?xml version="1.0"?>
<schema xmlns="http://www.w3.org/2000/10/XMLSchema">
    <!-- XSchema definition for token-->
    <element name="Address">
      <complexType>
        <attribute name="kind"  use="optional">
       <simpleType>
         <restriction base="string">
             <enumeration value="email"/>
             <enumeration value="url"/>
             <enumeration value="phone"/>
             <enumeration value="ip"/>
             <enumeration value="street"/>
             <enumeration value="postcode"/>
             <enumeration value="country"/>
             <enumeration value="complete"/>
                  </restriction> …
```

Manual Annotation in GATE GUI



Type	Set	Start	End	Features
Location	Key	21	27	{type=city}
loc	Key	32	34	{}
Person	Key	39	49	{}

3 Annotations (0 selected)

```
Simple document with London and UK and Tony Blair
```

Loca

- Location
- Money
- Organization
- Percent
- Person
- SyntaxTreeNode
- Token

gate.SourceURL | createc

Annotation in GATE GUI

The following tasks can be carried out manually in the GATE GUI:

- Adding annotation sets
- Adding annotations
- Resizing them (changing boundaries)
- Deleting
- Changing highlighting colour
- Setting features and their values

Preserving and exporting results

- Annotations can be stored as stand-off markup or in-line annotations
- The default method is standoff markup, where the annotations are stored separately from the text, so that the original text is not modified
- A corpus can also be saved as a regular or searchable (indexed) datastore

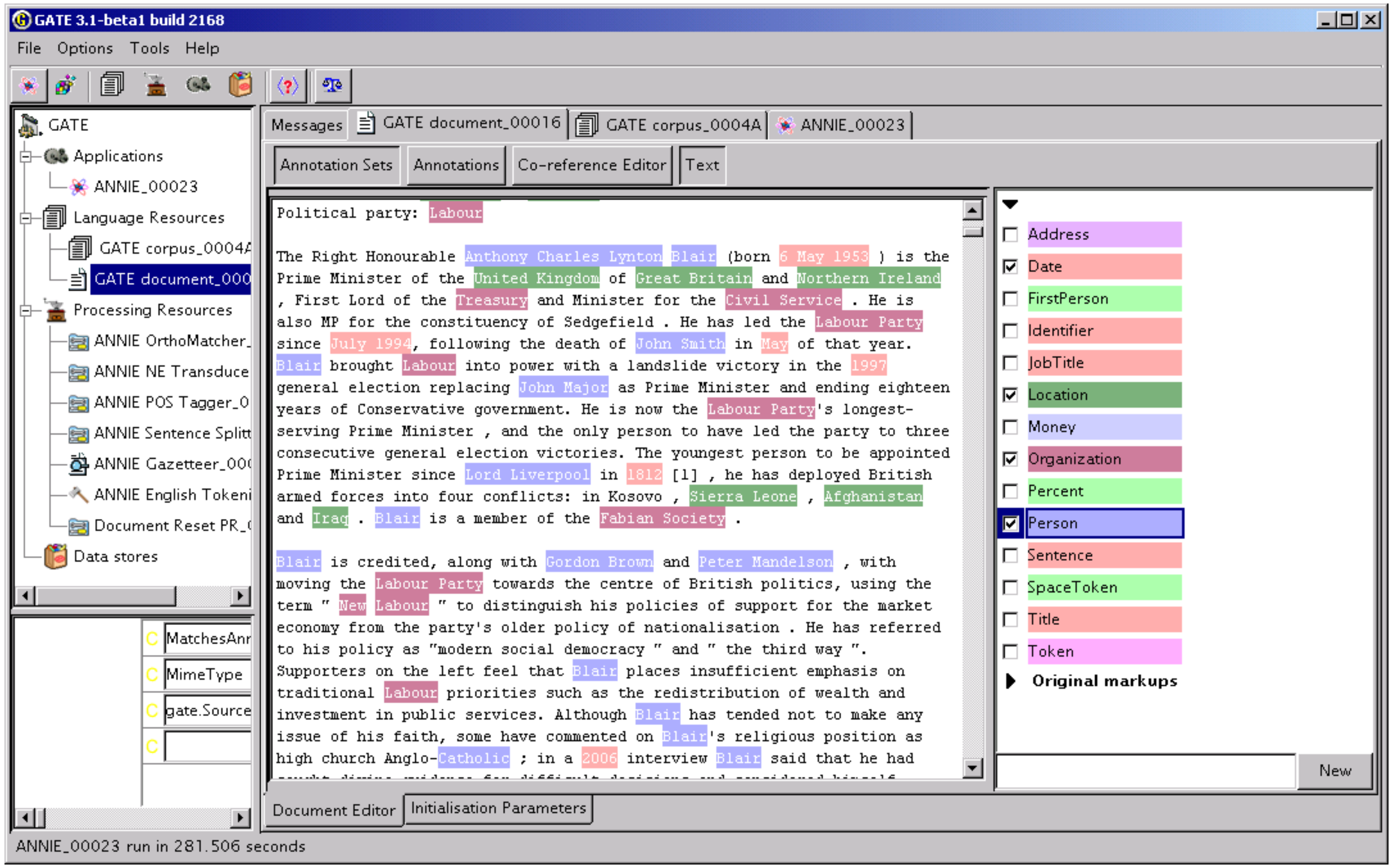
Corpora and System Development

- "Gold standard" data created by manual annotation
- Corpora are divided typically into a training, sometimes testing, and unseen evaluation portion
- Rules and/or ML algorithms developed on the training part
- Tuned on the testing portion in order to optimise
  - Rule priorities, rules effectiveness, etc.
  - Parameters of the learning algorithm and the features used
- Evaluation set – the best system configuration is run on this data and the system performance is obtained
- No further tuning once evaluation set is used!

Applications in GATE

- Applications are created by sequencing processing resources
- Applications can be run over a Corpus of documents – <u>corpus pipeline</u>
  - so each component is applied to each document in the corpus in sequence
- Applications may not have a corpus as input, but different parameters – <u>pipeline</u>

Name Entity Recognition



Political party: Labour

The Right Honourable Anthony Charles Lynton Blair (born 6 May 1953) is the Prime Minister of the United Kingdom of Great Britain and Northern Ireland , First Lord of the Treasury and Minister for the Civil Service . He is also MP for the constituency of Sedgefield . He has led the Labour Party since July 1994, following the death of John Smith in May of that year. Blair brought Labour into power with a landslide victory in the 1997 general election replacing John Major as Prime Minister and ending eighteen years of Conservative government. He is now the Labour Party's longest-serving Prime Minister , and the only person to have led the party to three consecutive general election victories. The youngest person to be appointed Prime Minister since Lord Liverpool in 1812 [1] , he has deployed British armed forces into four conflicts: in Kosovo , Sierra Leone , Afghanistan and Iraq . Blair is a member of the Fabian Society .

Blair is credited, along with Gordon Brown and Peter Mandelson , with moving the Labour Party towards the centre of British politics, using the term " New Labour " to distinguish his policies of support for the market economy from the party's older policy of nationalisation . He has referred to his policy as "modern social democracy " and " the third way ". Supporters on the left feel that Blair places insufficient emphasis on traditional Labour priorities such as the redistribution of wealth and investment in public services. Although Blair has tended not to make any issue of his faith, some have commented on Blair's religious position as high church Anglo-Catholic ; in a 2006 interview Blair said that he had

- ☐ Address
- ☑ Date
- ☐ FirstPerson
- ☐ Identifier
- ☐ JobTitle
- ☑ Location
- ☐ Money
- ☑ Organization
- ☐ Percent
- ☑ Person
- ☐ Sentence
- ☐ SpaceToken
- ☐ Title
- ☐ Token
- Original markups

ANNIE_00023 run in 281.506 seconds

Text Processing Tools

- Document Structure Analysis
  - different document parsers take care of the structure of your document (xml, html, etc.)
- Tokenisation
- Sentence Identification
- Parts of speech tagging
- Morphological analysis

- All these resources have as runtime parameter a GATE document, and they will produce annotations over it
- Most resources have initialisation parameters

Creole

- a Collection of REusable Objects for Language Engineering ~ Language Resources + Processing Resources
- creole.xml provides details about available components, the java class that implements the resource, and jar file where it is found

Example of resource

```
<RESOURCE>
                                        <NAME>ANNIE English Tokeniser</NAME>
                                        <CLASS>gate.creole.tokeniser.DefaultTokeniser</CLASS>
                                        <COMMENT>
                                                    A customisable English tokeniser
                                                    (http://gate.ac.uk/sale/tao/#sec:en-tokeniser).
                                        </COMMENT>
                                        <PARAMETER NAME="document"
                                                    COMMENT="The document to be tokenised" RUNTIME="true">
                                                    gate.Document
                                        </PARAMETER>
                                        <PARAMETER NAME="annotationSetName" RUNTIME="true"
                                                    COMMENT="The annotation set to be used for the generated annotations"
                                                    OPTIONAL="true">
                                                    java.lang.String
                                        </PARAMETER>
                                        <PARAMETER NAME="tokeniserRulesURL"
                                                    DEFAULT="resources/tokeniser/DefaultTokeniser.rules"
                                                    COMMENT="The URL for the rules file" SUFFIXES="rules">
                                                    java.net.URL
                                        </PARAMETER>
                                        <PARAMETER NAME="transducerGrammarURL"
                                                    DEFAULT="resources/tokeniser/postprocess.jape"
                                                    COMMENT="The URL for the postprocessing transducer"
                                                    SUFFIXES="jape">
                                                    java.net.URL
                                        </PARAMETER>
                                        <PARAMETER NAME="encoding"
                                                    COMMENT="The encoding used for reading the definitions"
                                                    DEFAULT="UTF-8">
                                                    java.lang.String
                                        </PARAMETER>
                                        <ICON>tokeniser</ICON>
</RESOURCE>
```

Tokenisation

- Identify different words in text: numbers, symbols, words, etc.
  - not only sequences between spaces or separators (in English)
  - 2,000 is not “2” “,” “000”
  - I’ve is “I” and “’ve”
  - $20 is “$” and “20”

Tokenisation in GATE

- Rule-based LHS > RHS
  - LHS is a regular expression over character classes
  - RHS specifies annotation to be created and features to be asserted for the created annotation
    - "DECIMAL_DIGIT_NUMBER"+ >Token;kind=number;
    - (SPACE_SEPARATOR) >SpaceToken;kind=space;
    - (CONTROL) >SpaceToken;kind=control;
    - "UPPERCASE_LETTER" (LOWERCASE_LETTER (LOWERCASE_LETTER|DASH_PUNCTUATION|FORMAT)*)* > Token;orth=upperInitial;kind=word;
- Tokeniser produces a <u>Token</u> type of annotation

Tokenisation in GATE

- Features produced by the tokeniser
  - string: the actual string of the token
  - orth: orthographic information
  - length: the length of the string
  - kind: the type of token (word, symbol, punctuation, number)
- SpaceToken is another annotation produced
  - features: kind (control or space), length, string

Sentence Splitter

end of sentence

not end of sentence

- Decide where a sentence ends
  - “The court ruled that Dr. Smith was innocent.”
- A rule based mechanism
  - uses a list of known abbreviations to help identify end of sentence uses (e.g. Dr)
  - a period is a sentence break if it is preceded by a non-abbreviation and followed by an uppercase common word
- The Splitter in GATE produces a Sentence type of annotation

Parts of Speech Tagging (Hepple'00)

- Associate a part of speech tag to each word
  - tags from the Penn Treebank including punctuation
- Based on Brill's tagger but a different learning approach used for rule acquisition – no need for re-annotating the corpus at each iteration during learning
- Two steps during tagging
  - initial guess based on lexicon (contain most likely tag)
  - correction based on a list of rules (contextual)

POS tags used

CC - coordinating conjunction: ”and”, ”but”, ”nor”, ”or”, ”yet”, plus, minus, less, times (multiplication), over (division). Also ”for” (because) and ”so” (i.e., ”so that”).
CD - cardinal number
DT - determiner: Articles including ”a”, ”an”, ”every”, ”no”, ”the”, ”another”, ”any”, ”some”, ”those”.
EX - existential there: Unstressed ”there” that triggers inversion of the inflected verb and the logical subject; ”There was a party in progress”.
FW - foreign word
IN - preposition or subordinating conjunction
JJ - adjective: Hyphenated compounds that are used as modifiers; happy-go-lucky.
JJR - adjective - comparative: Adjectives with the comparative ending ”-er” and a comparative meaning. Sometimes ”more” and ”less”.
JJS - adjective - superlative: Adjectives with the superlative ending ”-est” (and ”worst”). Sometimes ”most”and ”least”.
JJSS - -unknown-, but probably a variant of JJS
-LRB- - -unknown-
LS - list item marker: Numbers and letters used as identifiers of items in a list.
MD - modal: All verbs that don’t take an ”-s” ending in the third person singular present: ”can”, ”could”, ”dare”, ”may”, ”might”, ”must”, ”ought”, ”shall”, ”should”, ”will”, ”would”.
NN - noun - singular or mass
NNP - proper noun - singular: All words in names usually are capitalized but titles might not be.
NNPS - proper noun - plural: All words in names usually are capitalized but titles might not be.
NNS - noun - plural
PDT - predeterminer: Determinerlike elements preceding an article or possessive pronoun; ”all/PDT his marbles”, ”quite/PDT a mess”.
POS - possesive ending: Nouns ending in ”’s” or ”’”.
PP - personal pronoun
PRPR$ - unknown-, but probably possessive pronoun
PRP - unknown-, but probably possessive pronoun
PRP$ - unknown, but probably possessive pronoun,such as ”my”, ”your”, ”his”, ”his”, ”its”, ”one’s”, ”our”, and ”their”.
RB - adverb: most words ending in ”-ly”. Also ”quite”, ”too”, ”very”, ”enough”, ”indeed”, ”not”, ”-n’t”, and ”never”.
RBR - adverb - comparative: adverbs ending with ”-er” with a comparative meaning.
RBS - adverb - superlative
RP - particle: Mostly monosyllabic words that also double as directional adverbs.
STAART - start state marker (used internally)
SYM - symbol: technical symbols or expressions that aren’t English words.
TO - literal to
UH - interjection: Such as ”my”, ”oh”, ”please”, ”uh”, ”well”, ”yes”.
VBD - verb - past tense: includes conditional form of the verb ”to be”; ”If I were/VBD rich...”.
VBG - verb - gerund or present participle
VBN - verb - past participle
VBP - verb - non-3rd person singular present
VB - verb - base form: subsumes imperatives, infinitives and subjunctives.
VBZ - verb - 3rd person singular present
WDT - wh-determiner
WP$ - possesive wh-pronoun: includes ”whose”
WP - wh-pronoun: includes ”what”, ”who”, and ”whom”.
WRB - wh-adverb: includes ”how”, ”where”, ”why”. Includes ”when” when used in a temporal sense.

Parts of Speech Tagging

- Two resources
  - lexicon collected from corpus with <word, list of valid tags>
    - employs VBZ
    - empty JJ VB VBP
  - some heuristics for unknown words
  - rules for correcting tagging mistakes
    - NN VBG PREVWD before
  - rules instantiate patterns such as:
    - Change tag A to tag B if Condition
- The GATE tagger produces a feature <u>category</u> for each token in the document, the value of the feature is the name of the POS tag

Morphological Analysis in GATE

- For each noun and verb in the document identifies lemma and affix which are stored in the Token annotation (‘root’, ‘affix’)
- A set of rules for regular cases is used
- A set of irregular cases which explicitly indicate how to decompose the word is also used

Stemming in GATE

- Removing prefixes and suffixed of a word
  - produces a feature 'stem' in the Token annotation
  - John -> stem=john
  - tells -> stem=tell
  - considered -> stem=consid (root=consider)
  - leaving -> stem=leav (root=leave)
  - had -> stem=had (root=have)
- Available for English and other languages (e.g. Spanish)

Named Entity Recognition

- It is the cornerstone of many NLP applications – in particular of IE
- Identification of named entities in text
- Classification of the found strings in categories or types
- General types are Person Names, Organizations, Locations
- Others are Dates, Numbers, e-mails, Addresses, etc.
- Domains may have specific NEs: film names, drug names, programming languages, names of proteins, etc.

NER problems

- There are problems even with well known categories
- "Ambrose Chapel" it's not a name it is a place!!!!
- Ambiguity is one problem
    - "Paris" can be a city or a person
        - Paris (for Paris Hilton, the Person); Paris Hilton hotel (the place)
    - London can be a place or an organization (the government)

Approaches to NER

- Two approaches: (1) Knowledge-based based on humans defining rules; (2) Machine learning approach, possibly using an annotated corpus
- Knowledge-based approach
  - Word level information is useful in recognising entities:
    - capitalization, type of word (number, symbol)
  - Specialized lexicons (Gazetteer lists) usually created by hand; although methods exist to compile them from corpora
    - List of known continents, countries, cities, person first names
    - On-line resources are available to pull out that information

Approaches to NER

- Knowledge-based approach
  - rules are used to combine different evidences
  - a known first name followed by a sequence of words with upper initial may indicate a person name
  - a upper initial word followed by a company designator (e.g., Co., Ltd.) may indicate a company name
  - a cascade approach is generally used where some basic names are first identified and are latter combined into more complex names

Approaches to NER

- In GATE Gazetteers lists entries may contain some useful semantic information
  - for example one may associate some features and values to entry names
  - features can be used in grammars or can be used to enrich system output
  - gazetteer lists are organized in index files

Gazetteers in GATE

- Lists store keywords (one keyword per line)
  - list of male names (person_male.lst)

    Aaron

    Abraham

    ….
- Set of lists compiled and a finite state machine is created which operates on the strings
- The machine produces annotations of type Lookup when the keyword is found in text
- 60k entries in 80 types:
  - organization; artifact; location; amount_unit; manufacturer;

Gazetteer in GATE

- Sets of lists are organized in a main lists file
- Each list specifies attributes <u>majorType</u> and <u>minorType</u> and <u>language</u>, having major and minor types gives some flexibility to grammar rules

  government.lst:organization:government
  department.lst:organization:department
  person_male.lst:person_first:male
  person_female.lst:person_first:female

  (look into gate/plugins/ANNIE/gazetteers for examples)
- Attributes are used to help identification of more complex entities (for example discriminating when possible between a male or female name)
- List entries may be entities or parts of entities, or they may contain contextual information (e.g. job titles often indicate people)

Named Entity Grammar in GATE

- Implemented in the JAPE language (part of GATE)
  - Regular expressions over annotations
  - Provide access and manipulation of annotations produced by other modules
- Rules are stored in grammar files
- Grammar files are compiled into Finite State Machines
- A main grammar files specifies how different grammars should be executed (phases)
  - constitute a cascade of FSTs over annotations

NER in GATE

- Rules are <u>hand-coded</u>, so some linguistic expertise is needed here
- uses annotations from tokeniser, POS tagger, and gazetteer modules
- use of contextual information
- rule priority based on pattern length, rule status and rule ordering
- Common entities: persons, locations, organisations, dates, addresses.

JAPE Language

- A JAPE grammar rule consists of a left hand side (LHS) and a right hand side (RHS)
  - LHS= what to match (the pattern)
  - RHS = how to annotate the found sequence
  - LHS - - > RHS
- A JAPE grammar is a sequence of grammar rules
- Grammars are compiled into finite state machines
- Rules have priority (number)
- There is a way to control how to match
  - options parameter in the grammar files

LHS of JAPE rules

- The LHS of the rule contains patterns to be matched, in the form of annotations (and optionally their attributes).
- Annotation types to be recognized must be declared at the beginning of the phase
- Annotations may be combined using traditional operators [| * + ?]

Referring to annotation in JAPE

- Token; Token.string == "…"; Lookup; Lookup.majorType == "…"; Person; etc.
- {Token.kind == word, Token.length == 2}
- ({Token.kind == word} | {Token.length == 2})
- {Token.kind == word} {Token.kind == word}
- ({Token.orth == upperInitial})+ {Lookup.majorType == location}

LHS of JAPE rules

- There is no negative operator
- More than one pattern can be matched in a single rule
- Left and right context (not to be annotated) can be matched
- LHS has labels to be referred to in RHS

Examples of LHS patterns

- //identify a token with upper initial
  ```
  ({Token.orth == upperInitial}):upper
  ```
- //recognise a sequence of one upper initial word followed by a location designator (e.g. Ennerdale Lake)
  ```
  ({Token.orth == upperInitial}
  {Lookup.majorType == loc_designator})  :location
  ```
- //same but with upper initial or all capitals
  ```
  (({Token.orth == upperInitial}|{Token.orth == allCaps})
  {Lookup.majorType == loc_designator})  :location
  ```

Example of RHS

```
({Token.orth == upperInitial}
      {Lookup.majorType ==
  lake_designator}) :location
→
  :location.Location = { type = “lake” }
```

- Indicates annotation type to be produced ‘Location’ and features and values for that annotation type

Macros in JAPE grammars

```
Macro: ONE_DIGIT
({Token.kind == number, Token.length == "1"})

Macro: TWO_DIGIT
({Token.kind == number, Token.length == "2"})

Macro: FOUR_DIGIT
({Token.kind == number, Token.length == "4"})

Macro: DAY_MONTH_NUM
(ONE_DIGIT | TWO_DIGIT)
```

In the LHS of the rule one can use the macro name:

```
    (DAY_MONTH_NUM):annotate -> :annotate.DAY = {}
```

Example of RHS (context)

```
Rule: Date

({Token.string == "Date"} {Token.string == ":"}):context
(({Token.kind == "number", Token.length == "2"})
 ({Token})
({Token.kind == "number", Token.length == "2"})
 ({Token})
({Token.kind == "number", Token.length == "2"})):annotate
-->
:annotate.Date = { type = "dd/mm/yy format" }
```

JAPE Grammar

- In a file with name something.jape we write a Jape grammar (phase)

```
Phase: example1
Input: Token Lookup
Options: control = appelt

Rule: PersonMale
Priority: 10
(
{Lookup.majorType == first_name, Lookup.minorType == male}
({Token.orth == upperInitial})*
):annotate
-->
:annotate.Person = { gender = male }

….(more rules here)
```

Main JAPE grammar

- Combines a number of single JAPE files in general named “main.jape”

```
MultiPhase: CascadeOfGrammars
Phases:
grammar1
grammar2
grammar3
```

Further processing in RHS

- Java code can be included in the RHS of the rule
- It is a powerful mechanism which can help add semantic information to the annotations
    - for example extracting information from the context

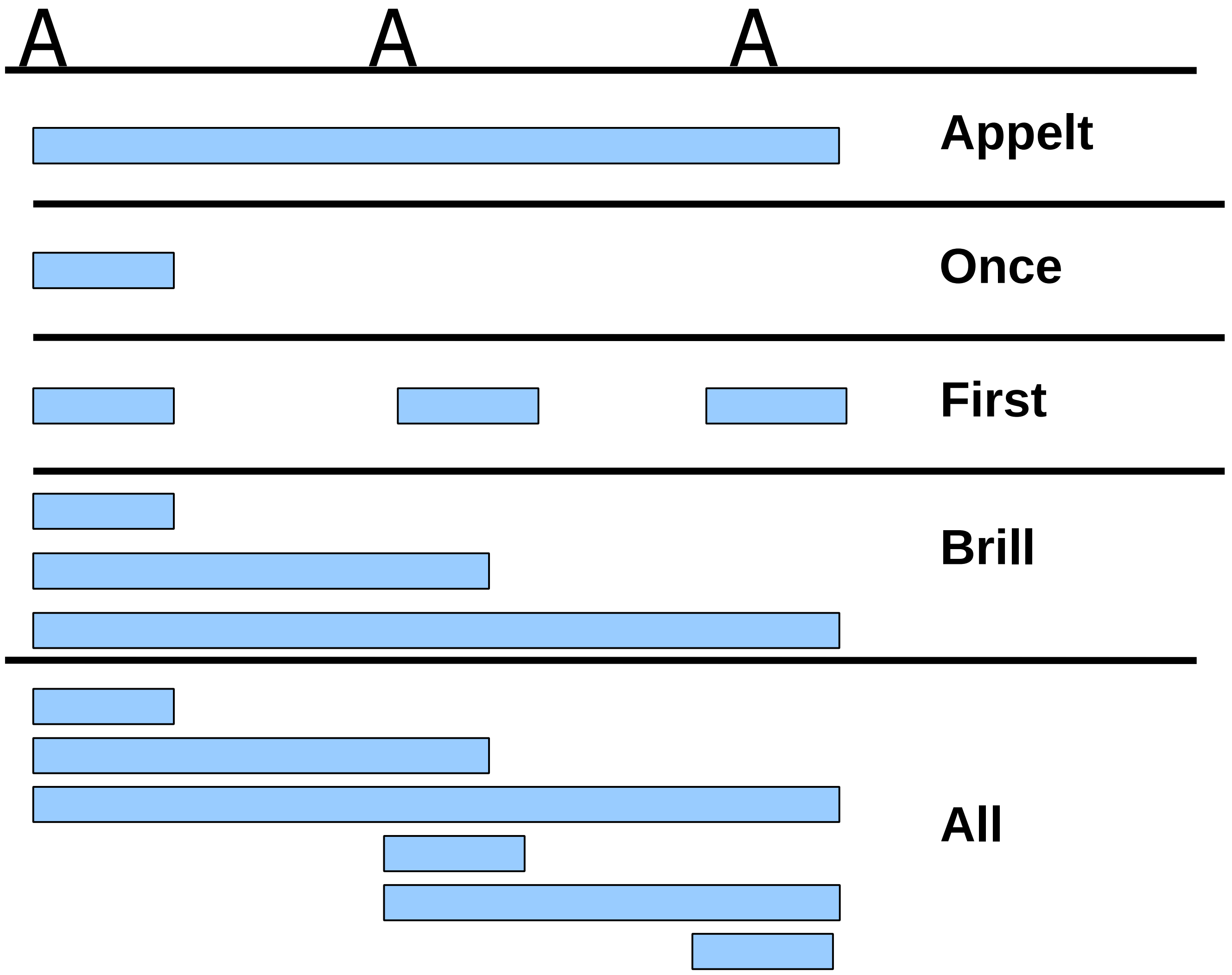
Available Java objects

- bindings: labels used in LHS are available
- doc: the GATE document which is being process
- annotations: all GATE document annotations produced until that stage
- inputAS, outputAS: phase input and output annotations

JAPE Application modes

- Matching control for rules
  - Brill (fires all matches)
  - First (shortest match fires)
  - Once (Phase exits after first match)
  - All (as for Brill, but matching continues from offset following the current one, not from the end of the last match)
  - Appelt (priority ordering: longest match fires, then explicit rule priority, then first defined rule fires)

JAPE Application Modes



- {A}+

Using phases

- Grammars usually consist of several phases, run sequentially
- A definition phase (conventionally called *main.jape*) lists the phases to be used, in order
- Only the definition phase needs to be loaded
- Temporary annotations may be created in early phases and used as input for later phases
- Annotations from earlier phases may need to be combined or modified

Coreference Resolution

- Name coreference
  - matches *similar* names in text, e.g. "Dr. Jacob Smith" and "Smith"
  - creates a 'matches' annotation which allows you to extract a chain of 'equivalent' names
- Pronominal coreference
  - solves references to named entities of pronouns in English (tokens marked with POS category PRP or PRP$)

Coreference Resolution

- Orthographic co-reference can improve NE results by assigning entity type to previously unclassified names, based on relations with classified NEs
- May not reclassify already classified entities
- Classification of unknown entities very useful for surnames which match a full name, or abbreviations, e.g. "Bonfield" will match "Sir Peter Bonfield"

ANNIE System

- A Nearly New Information Extraction System
  - recognizes named entities in text
  - "packed" application combining/sequencing the following components: document reset, tokeniser, splitter, tagger, gazetteer lookup, NE grammars, name coreference
  - can be used as starting point to develop a new named recogniser

Performance Evaluation

- Evaluation metric – mathematically defines how to measure the system’s performance against a human-annotated, gold standard
- Scoring program – implements the metric and provides performance measures
  - For each document and over the entire corpus
  - For each type of NE

The Evaluation Metric

- Precision = correct answers/answers produced
- Recall = correct answers/total possible correct answers
- Trade-off between precision and recall
- F-Measure = $(\beta^2 + 1)PR / \beta^2 R + P$ [van Rijsbergen 75]
- β reflects the weighting between precision and recall, typically $\beta=1$

Document Indexing

- Indexing with Lucene
  - Populate a corpus
  - Create a Data Store (java serialisation)
  - Save corpus to DS
    - the corpus become “indexable” by Lucene
  - Index the corpus using document content
  - To search use the Information Retrieval plug-in
    - SearchPR processing resource (put it in a “pipeline”)
    - Specify parameters of search (corpus, query, etc.) and run
    - double clicking on SearchPR displays the results

Annotations in Context (ANNIC)

- Create a linguistic/semantic index
  - Create a Lucene Searchable DS
  - Populate a corpus
  - Apply ANNIE to the corpus
  - Save corpus to DS
  - Search in Context in the DS GUI

Machine Learning Approach

- Given a corpus annotated with named entities we want to create a classifier which decides if a string of text is a NE or not
  - …<person>Mr. John Smith</person>…
  - …<date>16th May 2005</date>
- The problem of recognising NEs can be seen as a classification problem

Machine Learning Approach

- Each named entity instance is transformed for the learning problem
  - …<person>Mr. John Smith</person>…
  - Mr. is the beginning of the NE person
  - Smith is the end of the NE person
- The problem is transformed in a binary classification problem
  - is token begin of NE person?
  - is token end of NE person?
- Context is used as features for the classifier

Parsing with SUPPLE (Gaizauskas&al'05)

- Sheffield University Prolog Parser for Language Engineering
- A bottom-up parser for English which produces syntactic and semantic sentence respresentations
- An attribute-value context-free grammar of English is used to derive syntactic representations (it includes a question grammar for QA applications)
  - categories in the grammar have attributes and values which can be instantiated during parsing

Parsing with SUPPLE

- The grammar covers the following constituents
  - prepositional phrases; noun phrases; core verbs; verb phrases; relative clauses; sentences; questions
- The input to the parsing process is a ‘chart’ where both lexical items and multiword expressions (named entities) are allowed
- The output is the best possible ‘parse’ of the sentence, this can be partial

Parsing with SUPPLE

- Semantics is constructed compositionally as the sentence is parsed
- nouns and verbs are represented as normalised unary predicates (cat, eat, etc.)
- Identifiers (ei) are used to refer to an entity or an event and are produced for each noun and verb
  - cat(e1), eat(e2)
- binary predicates represent relations or attribute values of the entities or events; they are a fixed inventory used to represent grammatical and semantic relations
  - lsubj(X,Y), lobj(X,Z), of(X,Y), name(X,Z),…

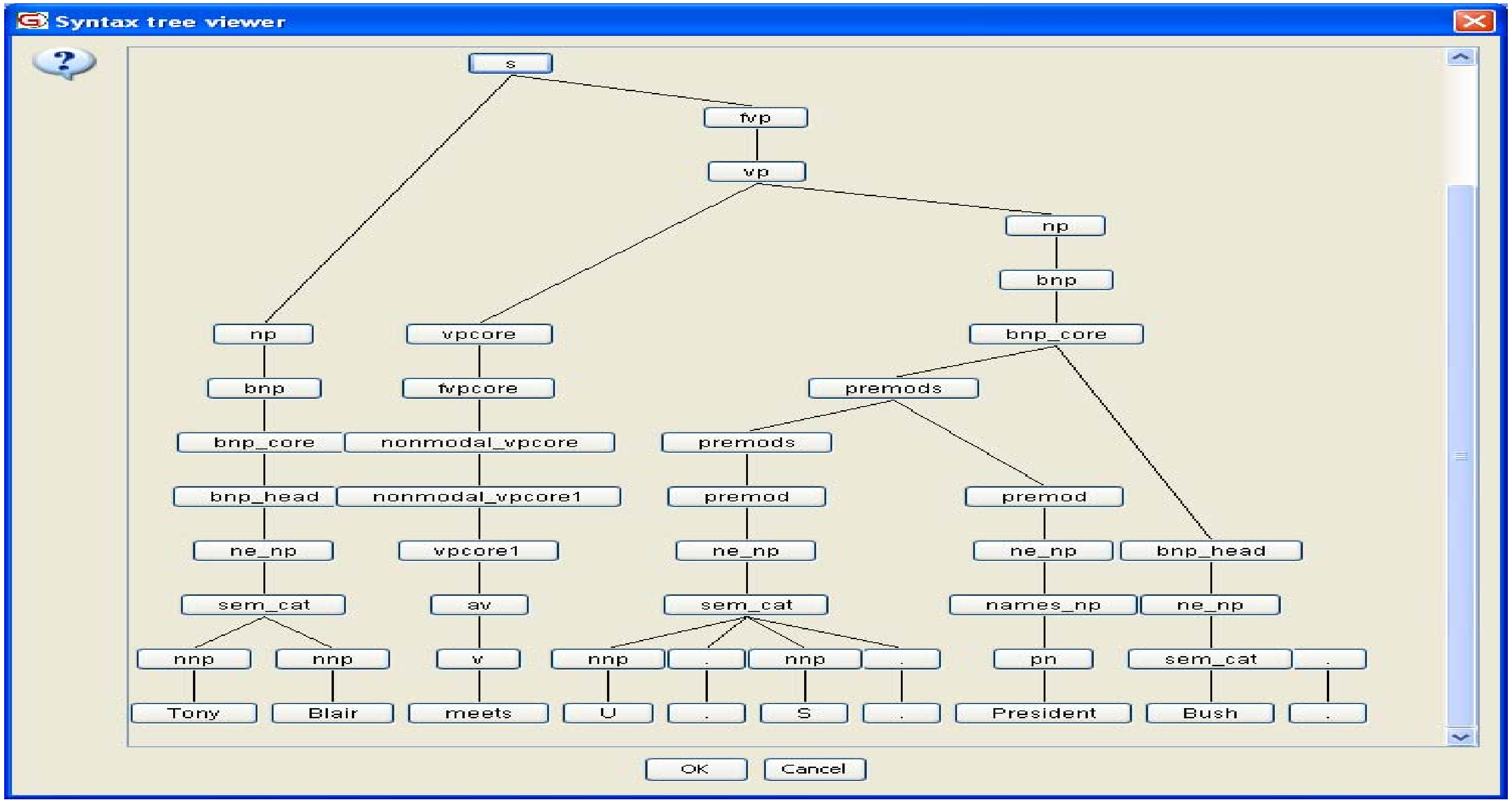
Parsing with SUPPLE

- Example
  - Tony Blair meets U.S. President Bush.
    - identifies Tony Blair and Bush as Person type and U.S. is a Location type
    - wraps those constituents so that SUPPLE does not have to analyse them
    - rest of elements in the sentence are passed as words with POS, roots, number, gender, etc.

Parsing with SUPPLE

- Syntactic Annotation (string)
  best_parse=(s (np (bnp (bnp_core (bnp_head (ne_np (sem_cat "Tony Blair")))))) (fvp (vp (vpcore (fvpcore (nonmodal_vpcore (nonmodal_vpcore1 (vpcore1 (av (v "meets"))))))) (np (bnp (bnp_core (premods (premods (premod (ne_np (sem_cat "U.S.")))) (premod (ne_np (names_np (pn "President"))))) (bnp_head (ne_np (sem_cat "Bush"))))))))))

Parsing with SUPPLE



Parsing with SUPPLE

- Semantic Annotation (array of strings)

```
qlf=[name(e2,'Tony Blair'), person(e2),
realisation(e2,offsets(0,10)), meet(e1),
time(e1,present), aspect(e1,simple),
voice(e1,active), lobj(e1,e3), name(e3,'Bush'),
person(e3), name(e4,'U.S.'), location(e4),
country(e4), realisation(e4,offsets(17,21)),
qual(e3,e4), ne_tag(e5,offsets(22,31)),
name(e5,'President'),
realisation(e5,offsets(22,31)), qual(e3,e5),
realisation(e3,offsets(17,36)),
realisation(e1,offsets(11,36)), lsubj(e1,e2)]
```

Parsing with SUPPLE

- A wrapper is provided in GATE
  - given a text which has been POS-tagged and Morphologically analysed, maps the tokens in each sentence to the input expected by SUPPLE
  - read the syntactic and semantic information from files and stores the information into the GATE documents as
    - parse, semantics, syntax tree nodes
- Can be run with SICStus prolog, SWI prolog, and PrologCafe (Java implementation)

Summary of first part

- Examples of Information Access Applications: Cubreporter & Musing
- General Architecture for Text Engineering (GATE)
  - Components: LR & PR
  - Demonstration: GUI and Java programs
  - Applications for text processing and named entity recognition