



Ontological-Semantic Analysis: Processes, Knowledge Resources, Tools, Applications

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November 24, 2006*



" Duma Putin meeting "

Information
Retrieval

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Latest news for Duma Putin meeting:

- [Putin crackdown to limit the power of foreign-funded NGOs](#) - Times Online - 16 hours ago

Duma Heads Prepare for Putin Meeting
Ahead of a Wednesday meeting with President Vladimir Putin, State Duma Speaker Boris Gryzlov gathered the heads of the Duma factions in his office to ...
[Visited 3 minutes ago] <http://www.moscowtimes.ru/stories/2005/05/18/014.html> - 34k Cached [\[88k info\]](#)

Russian Military Reform: Putin & Duma - CDI RW #257
The Duma ratified the Strategic Offensive Reductions Treaty (SORT) yesterday, on which Vladimir Putin had insisted at a meeting with faction leaders Monday ...
[New] <http://www.cdi.org/russia/257-9.cfm> - 14k Cached [\[58k info\]](#)

Russia, Putin Meeting, David Johnson - JRL 9-13-04
David Johnson's Informal Notes on the Meeting with President Putin on September 6 Warning: All that follows is based on my incomplete information and not ...
[New] <http://www.cdi.org/russia/johnson/8363-1.cfm> - 47k Cached [\[88k info\]](#)

Bush and Putin, meeting in Asia, try to show unity among differences
US officials' concerns have grown with the introduction of legislation last week in Russia's State Duma by members of Putin's party that would keep foreign ...
<http://www.abcactionnews.com/stories/2005/11/051118bush.shtml> [\[88k info\]](#)

Pravda.RU "BRIGADE GENERAL" CAPTURED AT NIGHT IN URUS-MARTAN...
President Putin Declares For Elaborating Common Approaches To Combating ... The first plenary meeting of the autumn session of Russia's State Duma (the ...
[New] <http://english.pravda.ru/politics/2001/09/19/> - 62k Cached [\[88k info\]](#)

Pravda.RU Putin's Meeting With Russian Businessmen
Russian President Vladimir Putin is holding a Kremlin meeting with Russia's ... Taking part in the meeting were State Duma Chairman Gennady Seleznyov and US ...
[New] <http://english.pravda.ru/diplomatic/2001/05/31/6468.html> - 56k Cached [\[88k info\]](#)



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РОССИЙСКАЯ НАЦИОНАЛЬНАЯ ВЫСТАВКА

ТАДЖИКИСТАН, г. ДУШАНБЕ

29 ноября - 2 декабря 2005 года

Wednesday, May 18, 2005. Page 4.

Duma Heads Prepare for Putin Meeting

By Francesca Mereu
Staff Writer

Ahead of a Wednesday meeting with President Vladimir Putin, State Duma Speaker Boris Gryzlov gathered the heads of the Duma factions in his office to discuss reforms mentioned by Putin in his recent state of the nation address.

Faction leaders said the two-hour talks Tuesday focused on two Putin proposals: to allow political parties that win regional legislative elections to nominate governors and to give opposition factions a greater voice in the Duma.

[...]

[Help Jews Escape](#)

from Russia, Argentina, Ethiopia Arab Lands to Israel

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Find political parties here. We offer local search in your state

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This is only an excerpt from the full story.

The entire article is approximately **242 words** in length.

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- [Federal Forces Say No. 2 Rebel Killed](#) (The Associated Press)
- [Putin, Nazarbayev Meet](#) (The Associated Press)
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- [Council of Europe Tackles Rivalry](#) (The Associated Press)

LATEST WIRES

- [Russia to tighten Amur River water control](#) (RIAN)
- [CNN plans to open bureau, new channel in Ukraine](#) (RIAN)
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- [Russia to launch 3 GLONASS satellites December 25](#) (RIAN)



" Duma Putin meeting "

Information
Retrieval

Information
Extraction



| <i>Meeting property name</i> | <i>Meeting property value</i> |
|------------------------------|-------------------------------|
| who | President Vladimir Putin |
| time | Wednesday |
| reported by | Moscow News |

| <i>Gather property name</i> | <i>Gather property value</i> |
|-----------------------------|----------------------------------|
| who | State Duma Speaker Boris Gryzlov |
| what | Heads of the Duma factions |
| time | before May 18, 2005 |
| reported by | Moscow News |

Ahead of a Wednesday meeting with President Vladimir Putin, State Duma Speaker Boris Gryzlov gathered the heads of the Duma factions in his office to discuss reforms mentioned by Putin in his recent state of the nation address.

Little or no help with:

ambiguity resolution
reference resolution

- events
- named entities

data **accuracy**

- confidence / trust
- timeline



" Duma Putin meeting "

Information
Retrieval



Enhanced IE performs ambiguity and reference resolution;
reasons about trust issues and timelines

Enhanced
Information
Extraction

MEETING-23
AGENT
AGENT
TIME
ABSOLUTE-TIME

INFO-SOURCE
textpointer

; Putin/Gryzlov meeting
SPOKESPERSON-1
PRESIDENT-47
> MEETING-24.TIME
(YEAR 2005) (MONTH MAY)
(DAY WEDNESDAY) (DAY 18)
NEWSPAPER-FR80
meeting

SPOKESPERSON-1
RELATION
HAS-FIRST-NAME
HAS-LAST-NAME
AGENT-OF
AGENT-OF
EFFECT
textpointer

LEGISLATIVE-ENTITY-3
Boris
Gryzlov
MEETING-23
MEETING-24
MEETING-24 ; 'makes happen'
Speaker Boris Gryzlov

LEGISLATIVE-ENTITY-3
RELATION
COREFER
textpointer

SPOKESPERSON-1
LEGISLATIVE-ENTITY-FR64
State Duma

PRESIDENT-47
AGENT-OF
HAS-FIRST-NAME
HAS-LAST-NAME
COREFER
textpointer

MEETING-23
Vladimir
Putin
PRESIDENT-48, HUMAN-FR-2223
President Vladimir Putin

MEETING-24
AGENT
AGENT
CAUSED-BY
TIME
ABSOLUTE-TIME

LOCATION
PURPOSE
INFO-SOURCE
textpointer

; Gryzlov/Duma factions meeting
SPOKESPERSON-1
SOCIAL-ROLE-79
SPOKESPERSON-1
< MEETING-23.TIME
< ((YEAR 2005) (MONTH MAY)
(DAY WEDNESDAY) (DAY 18))
OFFICE-1
DISCUSSION-4
NEWSPAPER-FR80
gathered ; gather + HUMANS =
cause a MEETING

SOCIAL-ROLE-79
CARDINALITY
HEAD-OF
textpointer
> 1
SET-13
heads

SET-13
MEMBER-TYPE
CARDINALITY
RELATION
textpointer
HUMAN
> 1
LEGISLATIVE-ENTITY-4
factions

LEGISLATIVE-ENTITY-4
RELATION
textpointer
SET-13
Duma

OFFICE-1
RELATION
LOCATION-OF
textpointer
SPOKESPERSON-1 ; 'his'
MEETING-24
office

DISCUSSION-4
THEME
PURPOSE-OF
INFO-SOURCE
textpointer
REFORM-1
MEETING-24
NEWSPAPER-FR80
discuss

REFORM-1
THEME-OF
THEME-OF
INFO-SOURCE
textpointer

ASSERTIVE-ACT-30
THEME
AGENT
TIME
INFO-SOURCE
textpointer

PRESIDENT-48
AGENT-OF
HAS-LAST-NAME
COREFER
textpointer

DISCUSSION-4
ASSERTIVE-ACT-30
NEWSPAPER-FR80
reforms

REFORM-1
PRESIDENT-48
INFORM-22.TIME
NEWSPAPER-FR80
mentioned

INFORM-22
ABOUT-AS-TOPIC
TIME-OF
TIME

AGENT
INFO-SOURCE
textpointer

PRESIDENT-48
ASSERTIVE-ACT-30
Putin
PRESIDENT-47, HUMAN-FR-2223
Putin

STATE-OF-AFFAIRS (DOMAIN NATION-FR12)
ASSERTIVE-ACT-30
.2 BEFORE
(ABSOLUTE-TIME (YEAR 2005) (MONTH MAY)
(DAY WEDNESDAY) (DAY 18))
ASSERTIVE-ACT-30.AGENT
NEWSPAPER-FR80
state of the nation address

NEWSPAPER-FR80
INFO-SOURCE-OF

; Moscow Times, metadata
MEETING-23, MEETING-24, DISCUSSION-4,
REFORM-1, ASSERTIVE-ACT-30, INFORM-22



" Duma Putin meeting "

**Information
Retrieval**



**Information
Extraction**



Archive of
IE Results
(with keyword
search)



" Duma Putin meeting "

**Information
Retrieval**



**Enhanced
Information
Extraction**

**Ontology-Based
Fact Repository
Encoded in KRL**



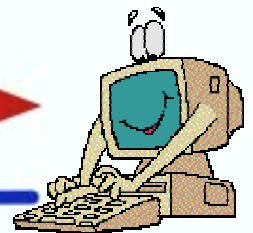
" Duma Putin meeting "

**Information
Retrieval**

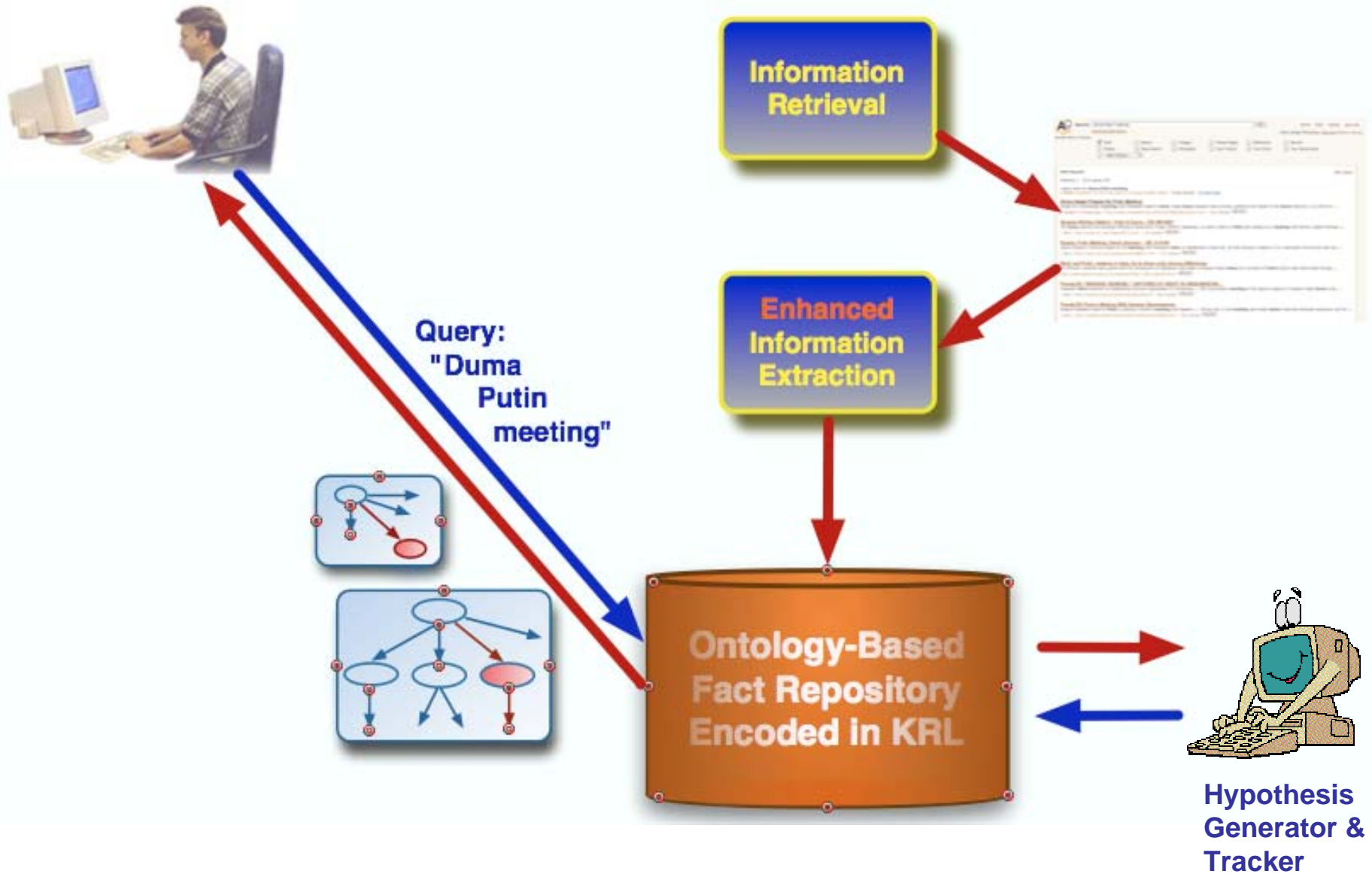


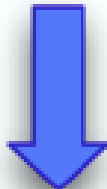
**Enhanced
Information
Extraction**

**Ontology-Based
Fact Repository
Encoded in KRL**



**Multipurpose reasoning
system**





Continuous Autonomous Fact Extraction

(driven by standing
queries and scripts
chosen or created
by analyst)

**Information
Retrieval**

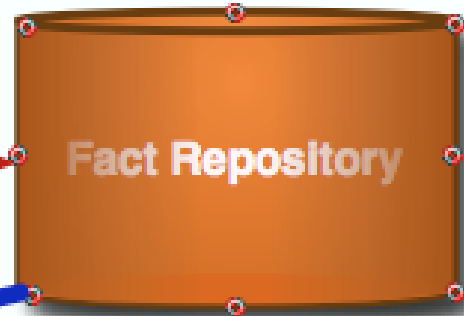
**Enhanced
Information
Extraction**

Fact Repository

Queries

**Reports
and
alerts**

Directed Follow-Up Queries
(driven by need for completeness
and high confidence level of facts)



The fact repository provides knowledge for a variety of needs:

- ambiguity resolution (all kinds) in text and in knowledge
- hypothesis generation and tracking
- understanding user queries
- generation of reports and alerts

The fact repository must be continuously updated.

This requires a natural language processing component capable of extracting, representing and manipulating **meaning**.

A major objective of our work in **ontological semantics** is automatic extraction of structured, unambiguous, ontologically interpreted knowledge from unstructured text.

It is such knowledge that we encode in the fact repository.

When search, comparison and clustering algorithms rely on knowledge structures instead of textual strings, the quality of information extraction, report generation, question answering, knowledge merging and other advanced applications is enhanced.

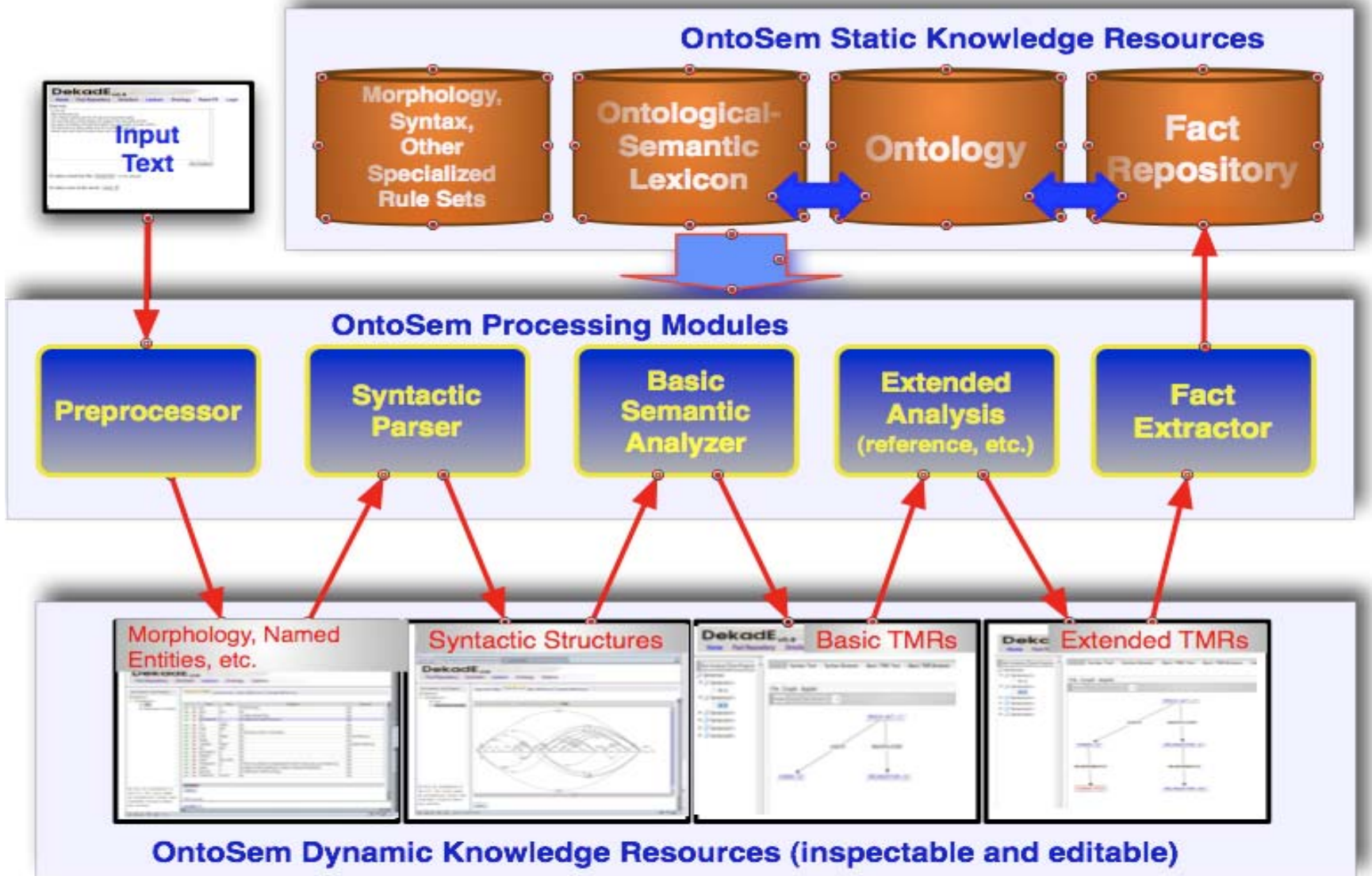
Knowledge structures are much more useful for automatic reasoning than textual strings

Knowledge Structures

- unambiguous
- interconnected through multiple formally defined ontological relations
- allow use of prior knowledge in solving current problems

Textual Strings

- ambiguous (including referential ambiguity)
- interconnected only by ambiguous names and through co-occurrence in text
- not readily amenable for reference to prior knowledge



- POS tagged
- morphology analyzed
- named entity recognized
- acronyms resolved
- numbers, dates processed

- phrase boundaries and heads established
- syntactic dependency established

- basic TMR produced
- word sense ambiguity resolved
- basic semantic dependency established

- extended TMR produced
- referential ambiguity resolved
- dependency ambiguity finalized
- partial temporal ordering derived
- trust data collected

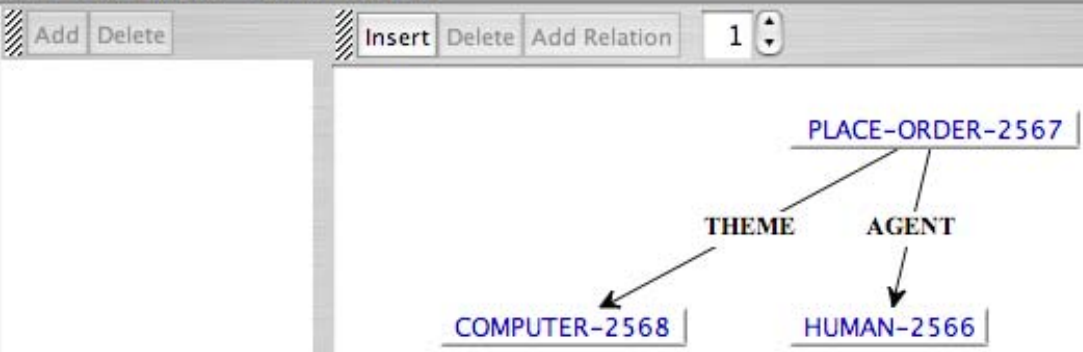
The crucial problem in creating structured knowledge from text is
ambiguity resolution

- **word sense** ambiguity resolution
- **semantic dependency** (compositional) ambiguity resolution
- **referential** ambiguity resolution (“entity resolution”)

In the OntoSem system, we develop algorithms and environments for all three kinds of ambiguity resolution.



File Attributes Graph Applet



He ordered a computer.



HUMAN-3132

textpointer

HE

word-num

0

AGENT-OF

PLACE-ORDER-3133

TRIGGER-REFERENCE

((PERSON THIRD) (GENDER MALE))

PLACE-ORDER-3133

textpointer

ORDER

word-num

1

THEME

COMPUTER-3134

AGENT

HUMAN-3132

COMPUTER-3134

textpointer

COMPUTER

word-num

3

THEME-OF

PLACE-ORDER-3133



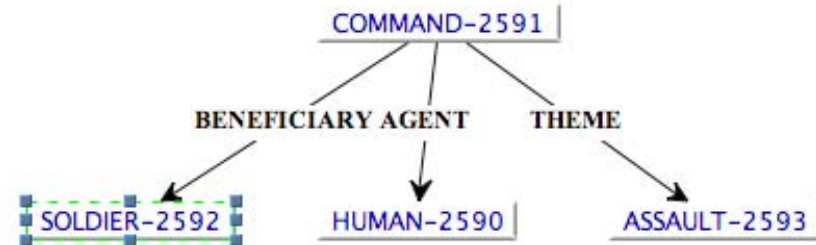
File Attributes Graph Applet

Add Delete

Insert Delete Add Relation

1

Name SOLDIER-...
Type object
textpointer SOLDIER
word-num 3



He ordered the soldiers to attack.



HUMAN-2590

| | |
|-------------------|--------------------------------|
| textpointer | HE |
| word-num | 0 |
| AGENT-OF | COMMAND-2591 |
| TRIGGER-REFERENCE | ((PERSON THIRD) (GENDER MALE)) |

COMMAND-2591

| | |
|-------------|--------------|
| textpointer | ORDER |
| word-num | 1 |
| THEME | ASSAULT-2593 |
| BENEFICIARY | SOLDIER-2592 |
| AGENT | HUMAN-2590 |

SOLDIER-2592

| | |
|----------------|--------------|
| textpointer | SOLDIER |
| word-num | 3 |
| BENEFICIARY-OF | COMMAND-2591 |

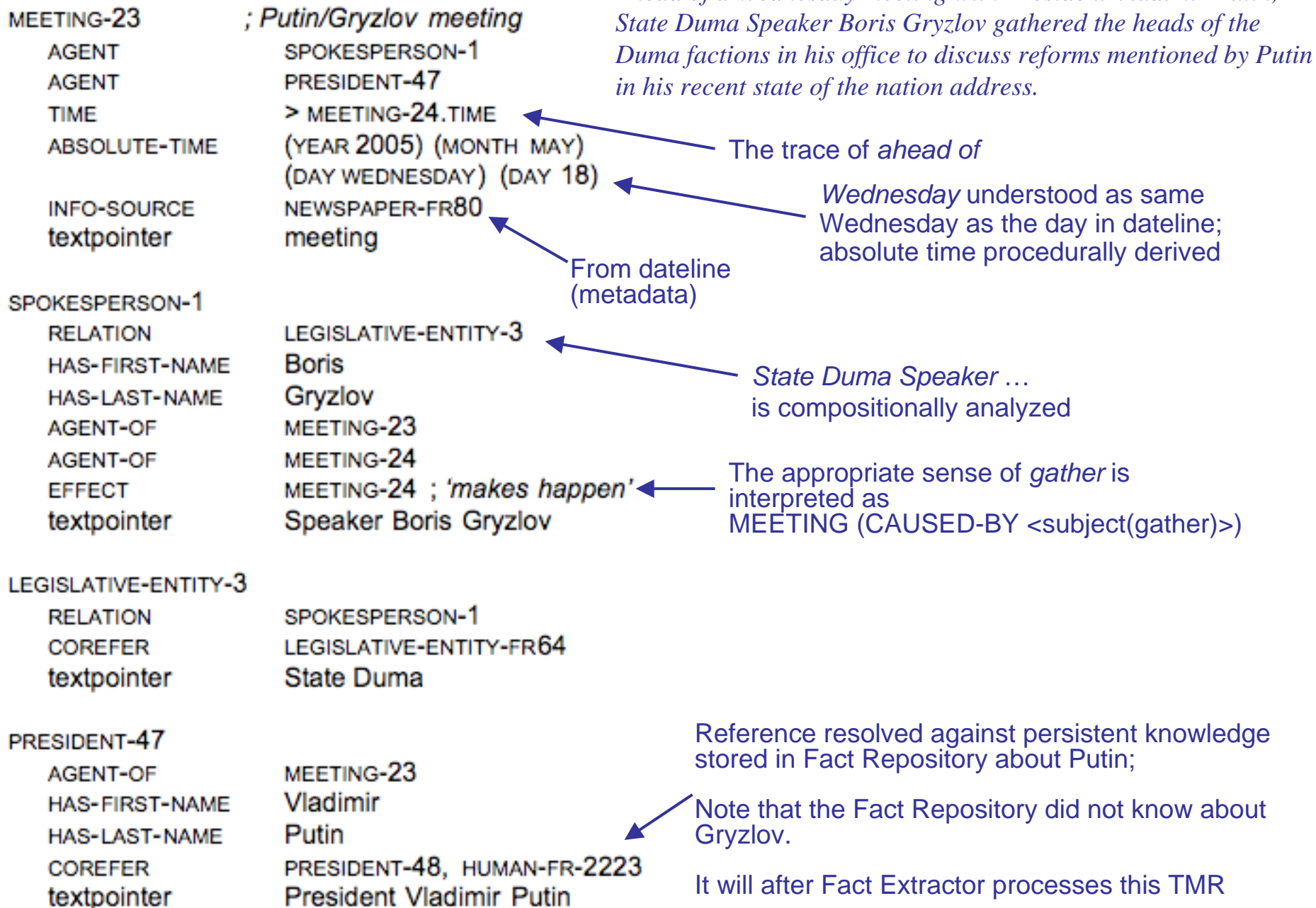
ASSAULT-2593

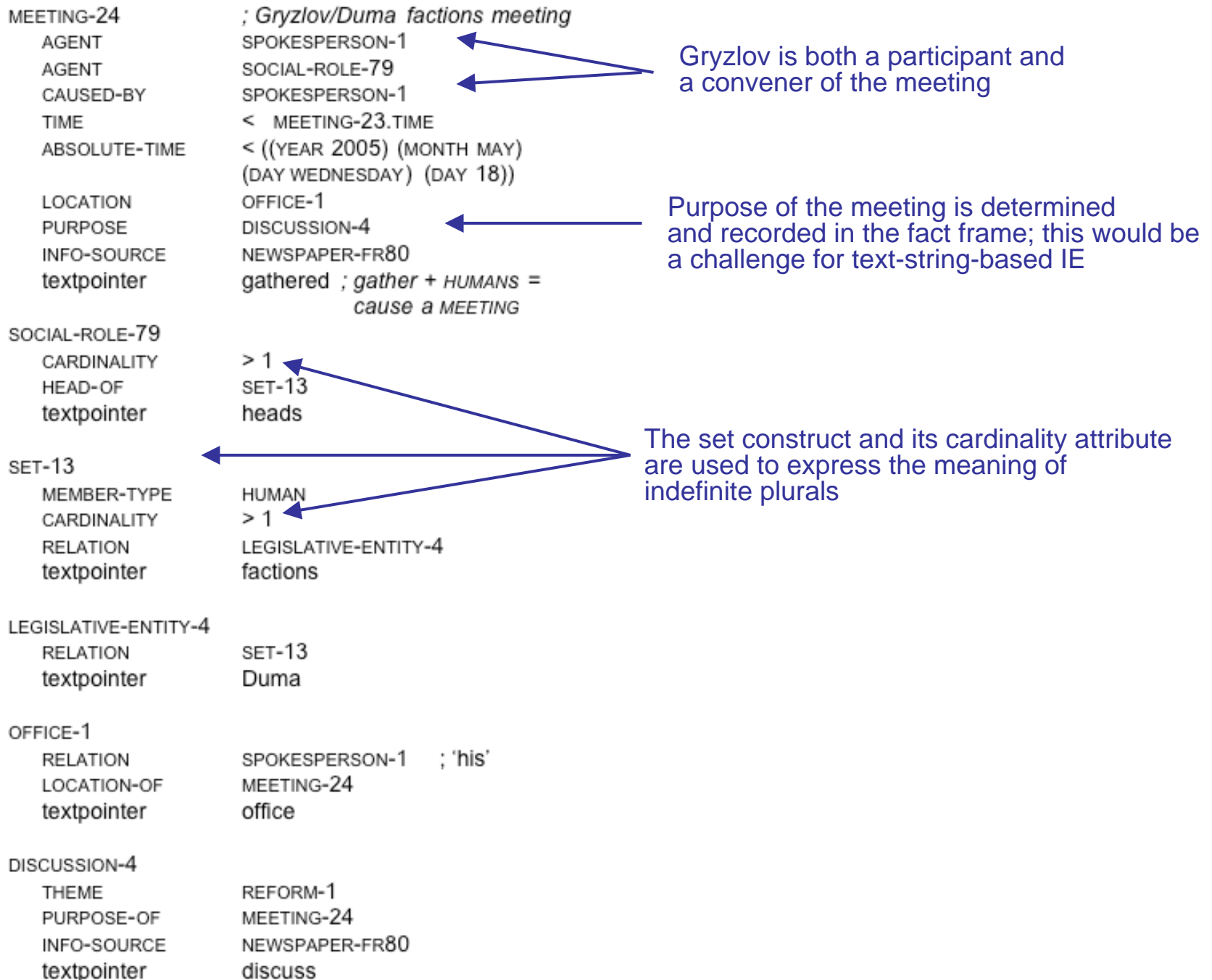
| | |
|-------------|--------------|
| textpointer | ATTACK |
| word-num | 5 |
| THEME-OF | COMMAND-2591 |

```

(order
  (order-n1 (cat n) (anno (ex "a request to supply goods or services")))
  (syn-struct ((root $var0) (cat n))) (sem-struct (commercial-order)))
  (order-v1 (cat v)
    (anno (ex "he ordered them to put down their weapons")))
    (syn-struct
      ((root $var0) (cat v) (subject ((root $var1) (cat np)))
        (indirectobject ((root $var2) (cat np)))
        (xcomp ((root $var3) (cat v)))))
      (sem-struct
        (command (agent (value ^$var1)) (beneficiary (value ^$var2))
          (theme (value ^$var3)))))
  (order-n2 (sublanguages) (cat n)
    (anno (ex "an order from the general to stop operations")))
    (syn-struct
      ((root $var0) (cat n)
        (pp ((root from) (cat prep) (root $var4) (opt +)
          (obj ((root $var2) (cat np)))))
        (pp ((root to) (cat prep) (root $var5) (opt +)
          (obj ((root $var6) (cat n)))))
        (xcomp ((root $var3) (opt +) (cat v)))))
      (sem-struct
        (command (agent (value ^$var2)) (theme (value ^$var3))
          (beneficiary (value ^$var6))
          (^$var4 (null-sem +)) (^$var5 (null-sem +)))))
  (order-v2 (cat v)
    (anno (def "to place an order for some good")
      (ex "they ordered new curtains")))
    (syn-struct
      ((root $var0) (cat v) (subject ((root $var1) (cat np)))
        (directobject ((root $var2) (cat np)))))
      (sem-struct
        (place-order (agent (value ^$var1)) (theme (value ^$var2)))))

```





REFORM-1

THEME-OF
THEME-OF
INFO-SOURCE
textpointer

DISCUSSION-4
ASSERTIVE-ACT-30
NEWSPAPER-FR80
reforms

ASSERTIVE-ACT-30

THEME
AGENT
TIME
INFO-SOURCE
textpointer

REFORM-1
PRESIDENT-48
INFORM-22.TIME
NEWSPAPER-FR80
mentioned

PRESIDENT-48

AGENT-OF
HAS-LAST-NAME
COREFER
textpointer

ASSERTIVE-ACT-30
Putin
PRESIDENT-47, HUMAN-FR-2223
Putin

SPECIFY-APPROXIMATION meaning procedure
will determine the estimate for the time of the address

INFORM-22

ABOUT-AS-TOPIC
TIME-OF
TIME

STATE-OF-AFFAIRS (DOMAIN NATION-FR12)
ASSERTIVE-ACT-30
.2 BEFORE
(ABSOLUTE-TIME (YEAR 2005) (MONTH MAY)
(DAY WEDNESDAY) (DAY 18))

AGENT
INFO-SOURCE
textpointer

ASSERTIVE-ACT-30.AGENT
NEWSPAPER-FR80
state of the nation address

This information facilitates reasoning about
attribution and trust

NEWSPAPER-FR80

INFO-SOURCE-OF

; *Moscow Times*, metadata
MEETING-23, MEETING-24, DISCUSSION-4,
REFORM-1, ASSERTIVE-ACT-30, INFORM-22

Results expected from IE based on string comparison

| <i>Meeting property name</i> | <i>Meeting property value</i> |
|------------------------------|-------------------------------|
| who | President Vladimir Putin |
| time | Wednesday |
| reported by | Moscow News |

| <i>Gather property name</i> | <i>Gather property value</i> |
|-----------------------------|----------------------------------|
| who | State Duma Speaker Boris Gryzlov |
| what | Heads of the Duma factions |
| time | before May 18, 2005 |
| reported by | Moscow News |

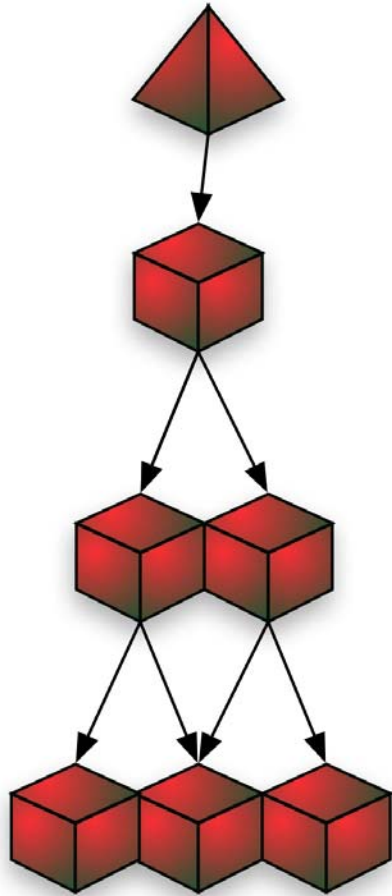
Results expected from IE based on OntoSem analysis

| <i>Meeting property name</i> | <i>Meeting property value</i> |
|------------------------------|--|
| participants | President Vladimir Putin State Duma Speaker Boris Gryzlov |
| time | May 18, 2005 |
| status | potential |
| reported by | Moscow News |

| <i>Meeting property name</i> | <i>Meeting property value</i> |
|------------------------------|--|
| participants | State Duma Speaker Boris Gryzlov Heads of Duma factions |
| time | before May 18, 2005 |
| Purpose | Discuss reforms mentioned by Putin in his recent state of the nation address |
| status | actual |
| reported by | Moscow News |

Ahead of a Wednesday meeting with President Vladimir Putin, State Duma Speaker Boris Gryzlov gathered the heads of the Duma factions in his office to discuss reforms mentioned by Putin in his recent state of the nation address.

Ontology

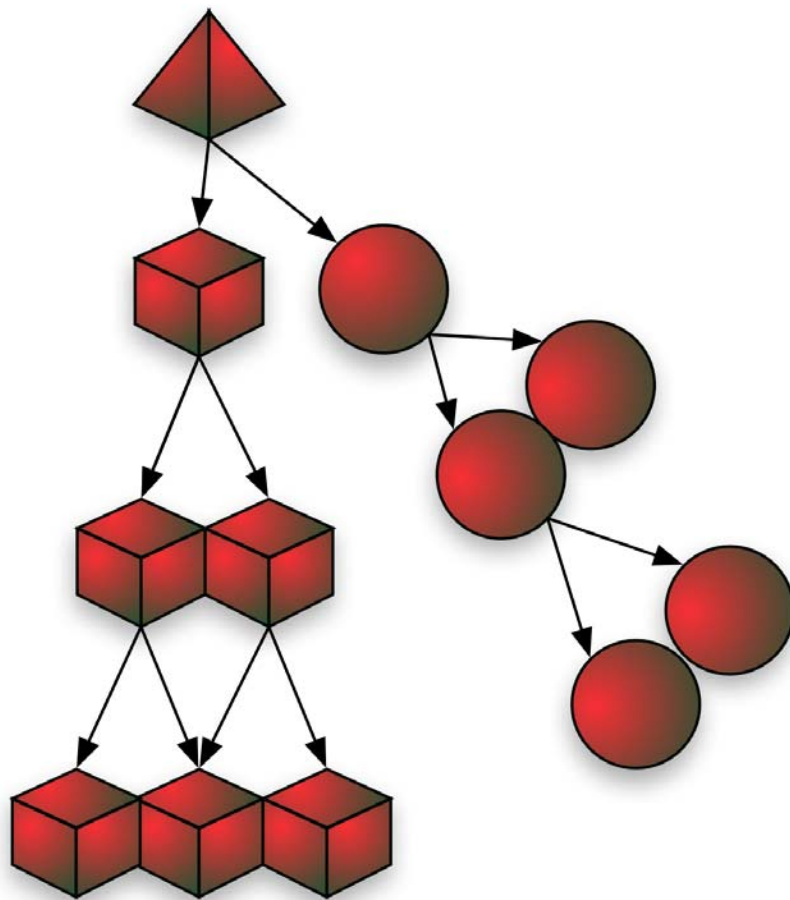


Legend



Object
(NATION,
AIRCRAFT)

Ontology



Legend



Object
(NATION,
AIRCRAFT)

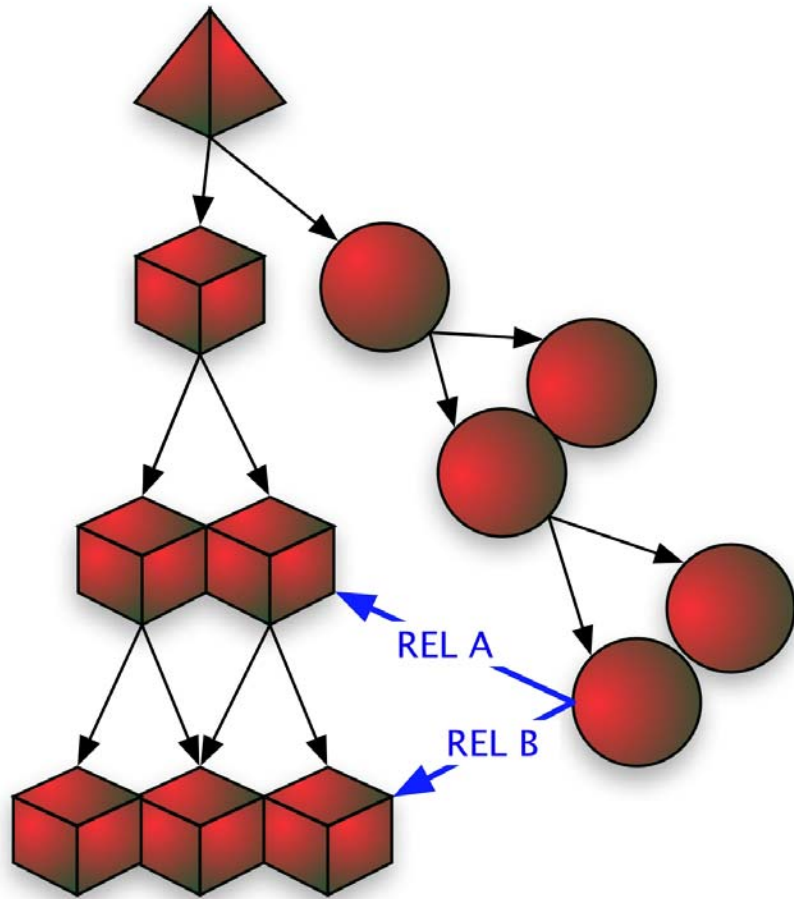


Event
(WAR,
TRAVEL)



Subsumption
relation

Ontology



Legend



Object
(NATION,
AIRCRAFT)



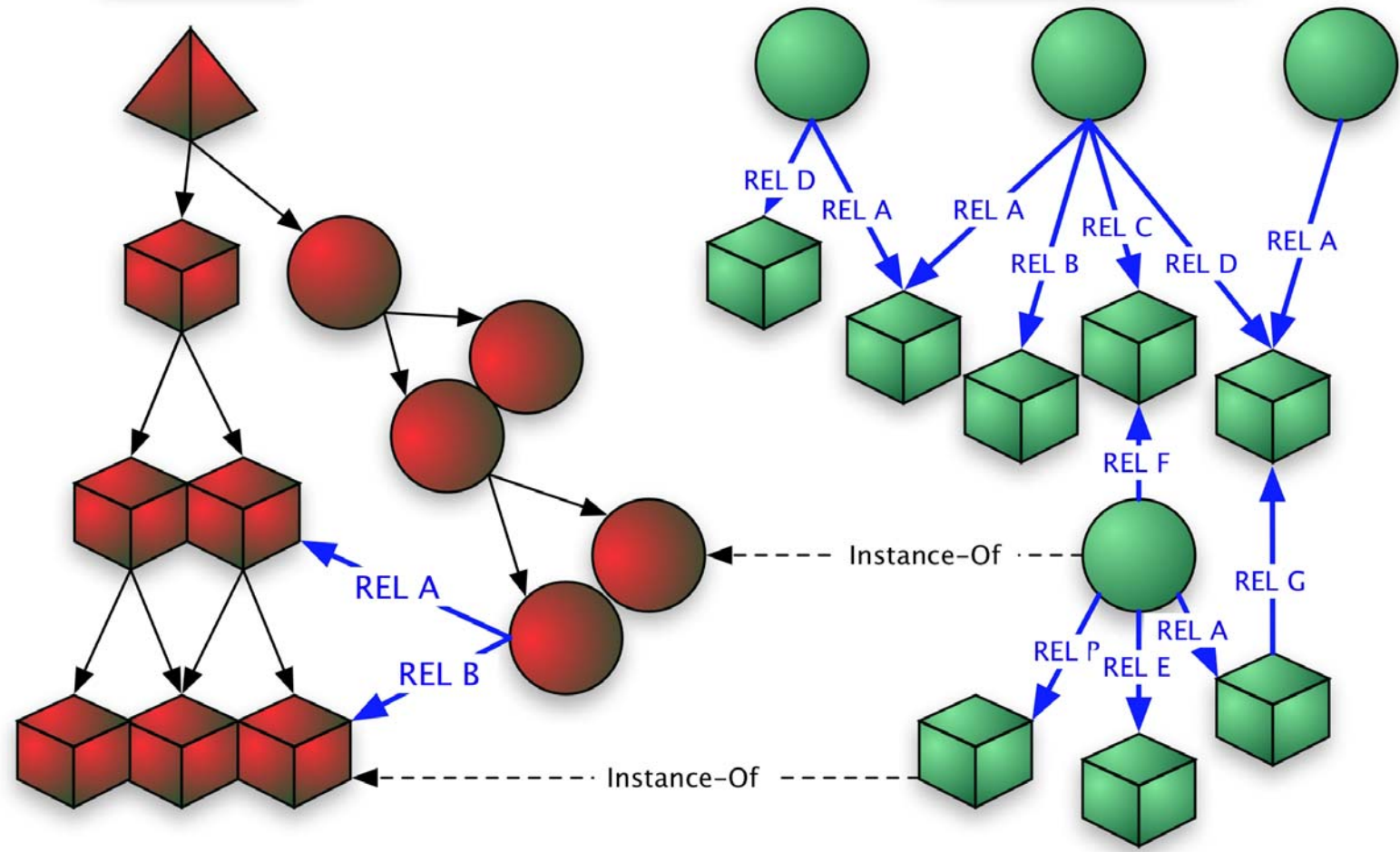
Event
(WAR,
TRAVEL)



Subsumption
relation

Ontology

Fact Repository



Legend



Object
(NATION,
AIRCRAFT)



Event
(WAR,
TRAVEL)



Object
instance
("Sweden",
boat-FR311)

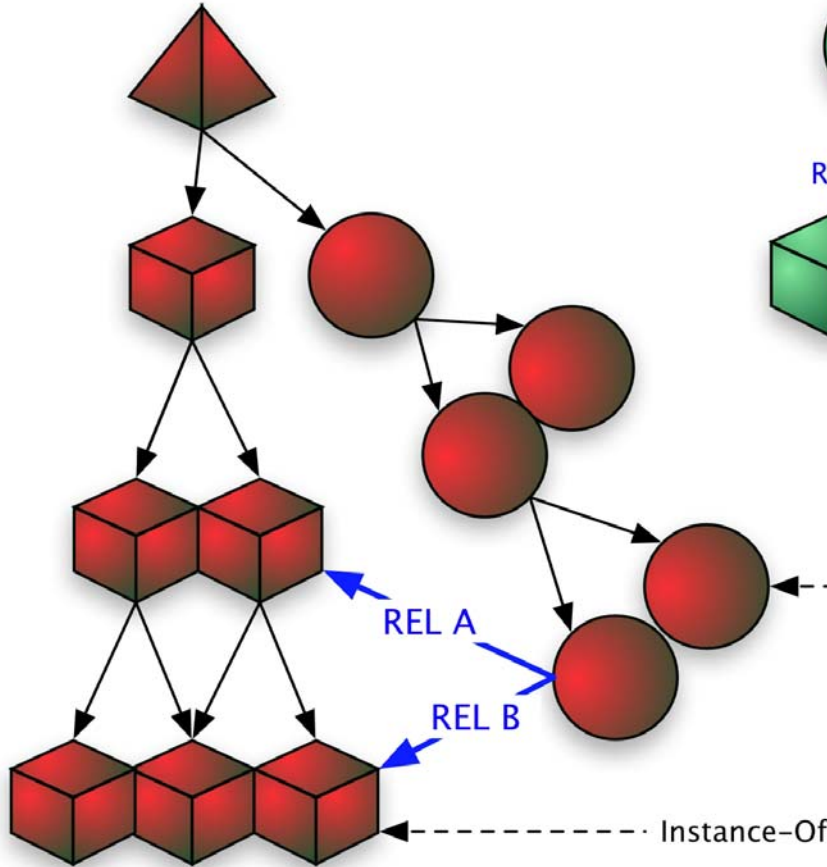


Event
instance
(*travel-FR97*)

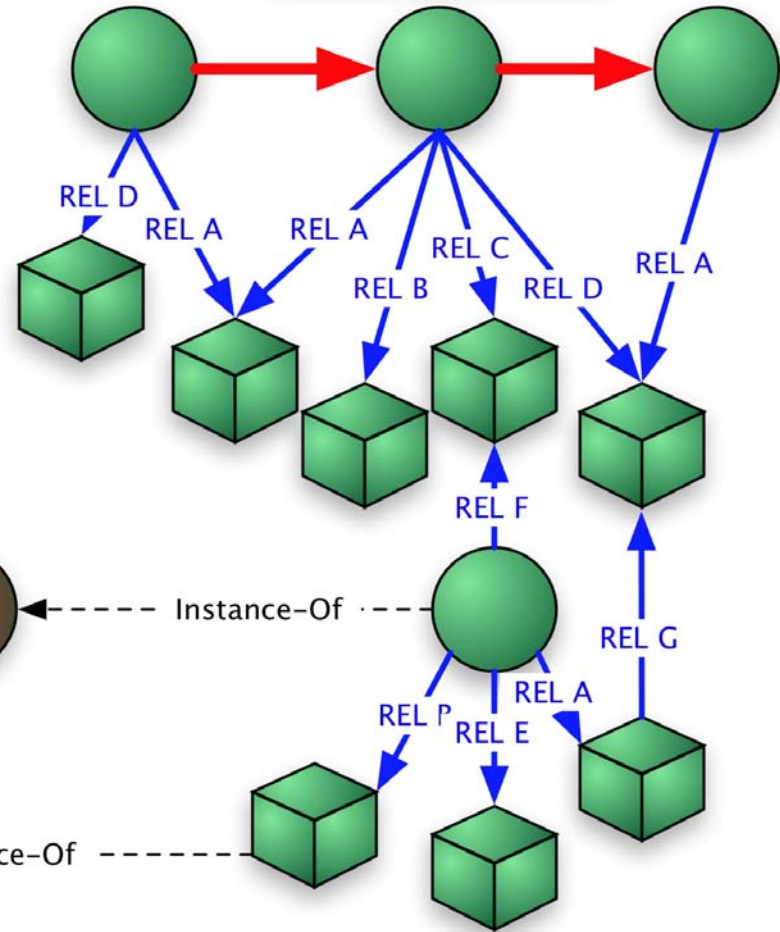


Subsumption
relation

Ontology



Fact Repository



Legend



Object
(NATION,
AIRCRAFT)



Event
(WAR,
TRAVEL)



Object
instance
("Sweden",
boat-FR311)



Event
instance
(*travel-FR97*)



Subsumption
relation



Causality
and temporal
relations

A few details about OntoSem

- NLP-oriented **ontology** of about 8,200 concepts (~105,000 RDF triples)
- Semantic **lexicons** (~25,000 entries for English)
- **Lexical rules** for lexicon expansion
- **Fact repository** of about 20,000 facts (largest of several)
- Tokenization knowledge (including large onomasticons)
- Morphological and syntactic grammars for several languages
- Assorted rule sets for **microtheories** of modality, reference, rhetorical relations, etc.
- Word sense and semantic dependency disambiguation; reference resolution.
- Static semantic constraints are **multivalued**: the values of selectional restrictions are arranged in three defeasible layers to facilitate flexible interpretation
- Dynamic, context-induced constraints are encoded using meaning **procedures** in lexicon entries that use information from the nascent TMR for a text and from fact repository.

Sample applications of OntoSem

- machine translation (KBMT-89, Pangloss and Mikrokosmos projects)
- question answering (the AQUAINT MOQA project)
- cognitive modeling and simulation: the Maryland Virtual Patient (MVP) project
- lifelong learning of lexicon and ontology (knowledge acquisition)
- Information extraction on the semantic web (the SemNews project)
- generating jokes (Raskin and Hemplemann)
- information security (Attala and Raskin)
- Mixed human-bot multi-agent systems with natural language-enabled agents (proposed)

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DekadeE v0.99

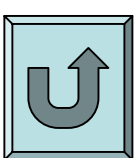
[Fact Repository](#) [OntoSem](#) [Lexicon](#) [Ontology](#) [Options](#)

[Run Analyzer](#) [Save Progress](#)

Sentences

[Sentence1++](#)

- As Is
- Preprocessor Corrected



will be extradited to
 U.S. for trial under
 extradition treaty that
 resident Virgilia Barco
 revived.

[Preprocessor Editor](#) [Syntax Browser](#) [Basic TMR Browser](#) [Extended TMR Browser](#)

| + | - | Root | Pos | Features | Senses |
|----|----|--------------|---------|--|-----------------|
| W+ | W- | HE | N | ((TYPE PRO)) | NIL |
| W+ | W- | WILL | AUX | NIL | NIL |
| W+ | W- | BE | V | ((FORM INFINITIVE)) | NIL |
| W+ | W- | EXTRADITE | V | ((FORM PAST-PARTICIPLE)) | NIL |
| W+ | W- | TO | PREP | NIL | NIL |
| W+ | W- | THE | ART | NIL | NIL |
| W+ | W- | U.S. | N | ((TYPE PN) (TYPE COUNTRY)) | NIL |
| W+ | W- | FOR | PREP | NIL | ((FOR-PREP2)) |
| W+ | W- | TRIAL | N | NIL | NIL |
| W+ | W- | UNDER | PREP | NIL | ((UNDER-PREP3)) |
| W+ | W- | AN | ART | NIL | NIL |
| W+ | W- | EXTRADITI... | N | NIL | NIL |
| W+ | W- | TREATY | N | NIL | NIL |
| W+ | W- | THAT | REL-PRO | NIL | NIL |
| W+ | W- | *PERSON* | N | ((TYPE PN) (PREFIX PRESIDENT) (FIRST VIRGILIA) (LAST BARCO)) | NIL |
| W+ | W- | HAVE | V | ((FORM ACTIVE) (PERSON THIRD) (TENSE PRESENT)) | NIL |
| W+ | W- | REVIVE | V | ((FORM PAST-PARTICIPLE)) | NIL |
| W+ | W- | *PERIOD* | PUNCT | NIL | NIL |

EXTRADITE

[Save](#)

[View as text.](#)

[extradite-v1](#)

Dekade v0.99

Fact Repository OntoSem Lexicon Ontology Options

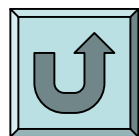
Run Analyzer Save Progress

Sentences

● Sentence1++

● As Is

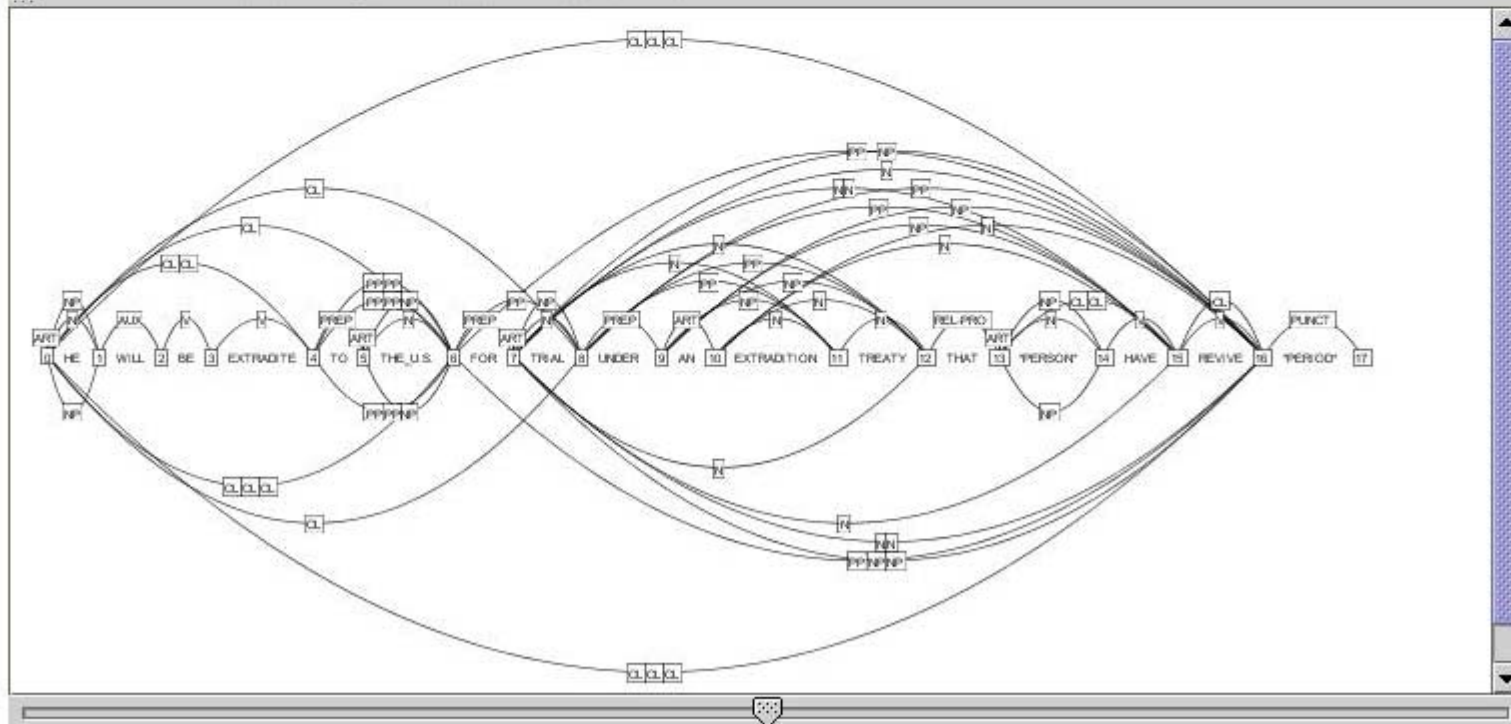
● Preprocessor Corrected



will be extradited to
the U.S. for trial under
extradition treaty that
President Virgilia Barco
revived.

Preprocessor Editor Syntax Browser Basic TMR Browser Extended TMR Browser

Undo Redo Delete Arc + Orphans Delete Arc(s) Alone Save



Save

Dekade v0.8

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Sentences

▼ Sentence1+

As Is

▼ Sentence2+

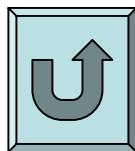
As Is

▶ Sentence3+

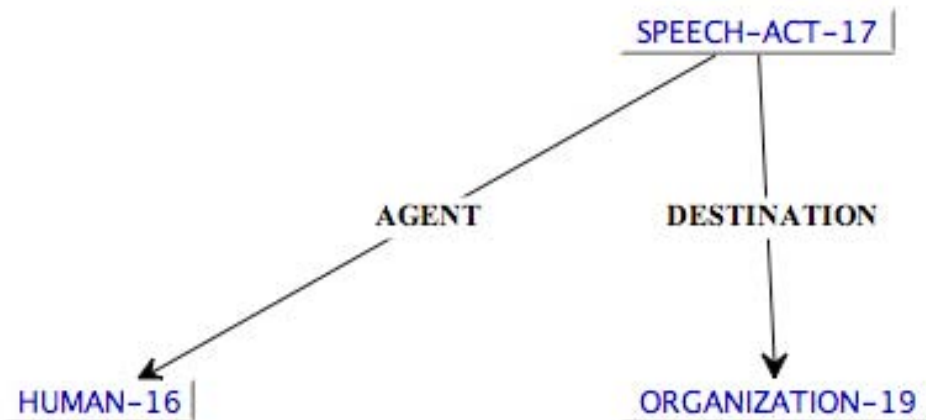
▶ Sentence4+

▶ Sentence5+

▶ Sentence6+

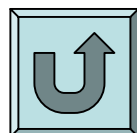
[Syntax Text](#)[Syntax Browser](#)[Basic TMR Text](#)[Basic TMR Browser](#)

File Graph Applet

[Insert](#)[Delete](#)[Add Relation](#)

[Run Analyzer](#) [Save Progress](#)[Syntax Text](#)[Syntax Browser](#)[Basic TMR Text](#)[Basic TMR Browser](#)[Ext](#)

- Sentences
 - ▼ Sentence1+
 - As Is
 - ▼ Sentence2+
 - As Is
 - ▶ Sentence3+
 - ▶ Sentence4+
 - ▶ Sentence5+
 - ▶ Sentence6+



File Graph Applet

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1

