Information Extraction using PDT Tools and Inductive Logic Programming

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Outline

Information Extraction Task

- The Task of Information Extraction
  - Automatically find the information you're looking for.
  - Pick out the most useful bits.
  - Present it in preferred manner, at the right level of detail.

"Axis" of Information Extraction

- Information depth
  - "Document labeling"

    ```
    The event started at  half pas six.
                          ↖time_expression
    ```

  - Uniform representation ("Semantic interpretation")

    ```
    The event started at  half pas six.
                          ↖time_expression=18:30
    ```

- Task complexity
  - Entity recognition

    ```
    J. Dědek  is a PhD student at the  Charles Univ.
    ↖Person                            ↖Organization
    ```

  - Relation extraction

    ```
    J. Dědek  is a PhD student at the  Charles Univ.
    ↖Person     ⟶has_affiliation⟶      ↖Organization
    ```

Example of the web-page with a report of a fire department

HZS Jihomoravského kraje

Zubatého 1, 614 00 Brno, telefon 950 630 111,
http://www.firebrno.cz
Zpravodajství v roce 2006

15.05.2007

V trabantu zemřeli dva lidé

K tragické nehodě dnes odpoledne hasiči vyjížděli na silnici z obce Česká do Kuřimi na Brněnsku.

Nehoda byla operačnímu středisku HZS ohlášena ve 13.13 hodin a na místě zasahovala jednotka profesionálních hasičů ze stanice v Tišnově. Jednalo se o čelní srážku autobusu Karosa s vozidlem Trabant 601. Podle dostupných informací trabant jedoucí ve z Brna do Kuřimi zřejmě vyjel do protisměru, kde narazil do linkového autobusu dopravní společnosti ze Žďáru nad Sázavou. Ve zdemolovaném trabantu na místě zemřeli dva muži – 82letý senior a další muž, jehož totožnost zjišťují policisté.

Hasiči udělali na vozidle protipožární opatření a po vyšetření a zadokumentování nehody dopravní policií vrak trabantu zaklesnutý pod autobusem pomocí lana odtrhli. Po odstranění střechy trabantu pak z kabiny vyprostili těla obou mužů. Obě vozidla – trabant i autobus, pak postupně odstranili na kraj vozovky a uvolnili tak jeden jízdní pruh. Únik provozních kapalin nebyl zjištěn. Po 16. hodině pomohli vrak trabantu naložit k odtahu a asistovali při odtažení autobusu. Po úklidu vozovky krátce před 16.30 hod. místo nehody předali policistům a ukončili zásah.

Odkazy

skryj menu

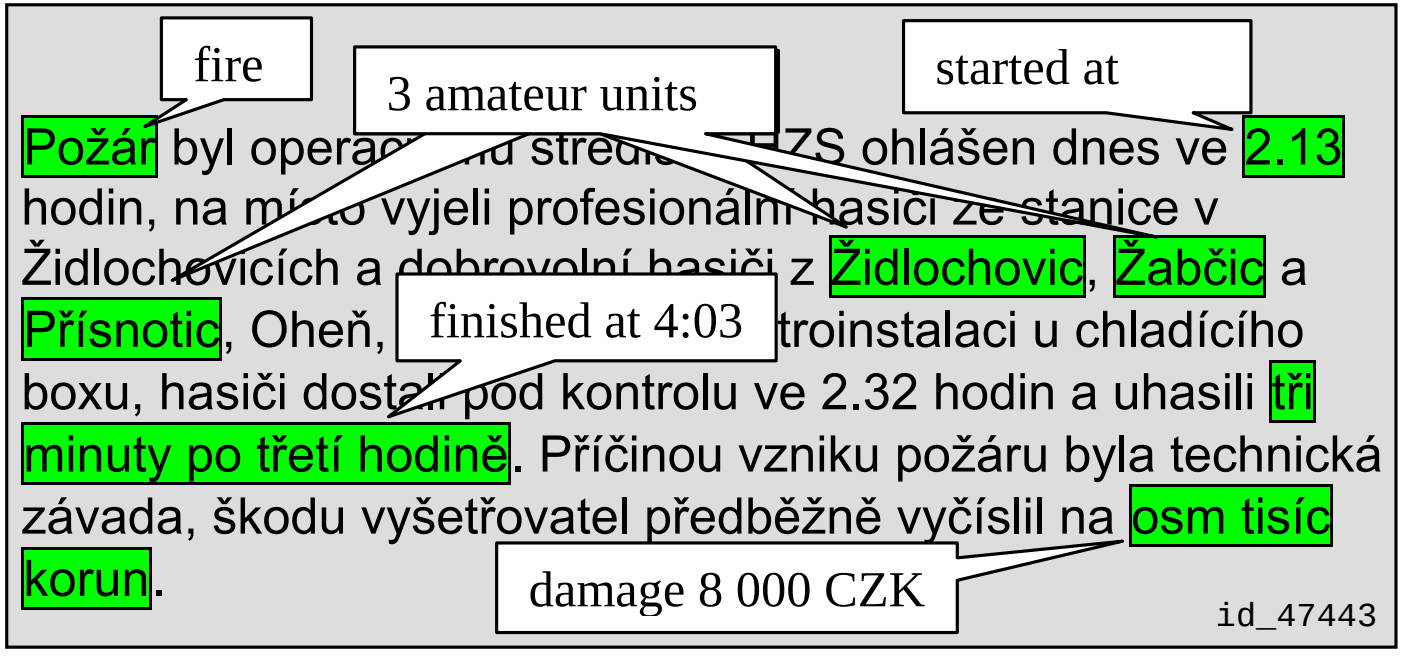
Hasiči
- Generální ředitelství
- hl. m. Praha
- Jihočeský kraj
- Jihomoravský kraj
- Karlovarský kraj
- Královéhradecký kraj
- Liberecký kraj
- Moravskoslezský kraj
- Olomoucký kraj
- Pardubický kraj
- Plzeňský kraj
- Středočeský kraj
- Ústecký kraj
- kraj Vysočina
- Zlínský kraj

Euroskop.cz

V této rubrice Zpravodajství
- Aktualizace stránek
- Archiv zpravodajství
- Bleskové zpravodajství RSS
- Boj proti korupci
- Digitální televize
- Hasiči
- Hlavní zprávy
- Ministerstvo
- Od dopisovatelů (neoficiální)
- Policie
- Regiony
- Servis nejen pro novináře
- Schengenská spolupráce
- WebEditorial

Na našem serveru v jiných rubrikách
- Aktuality Národního archivu

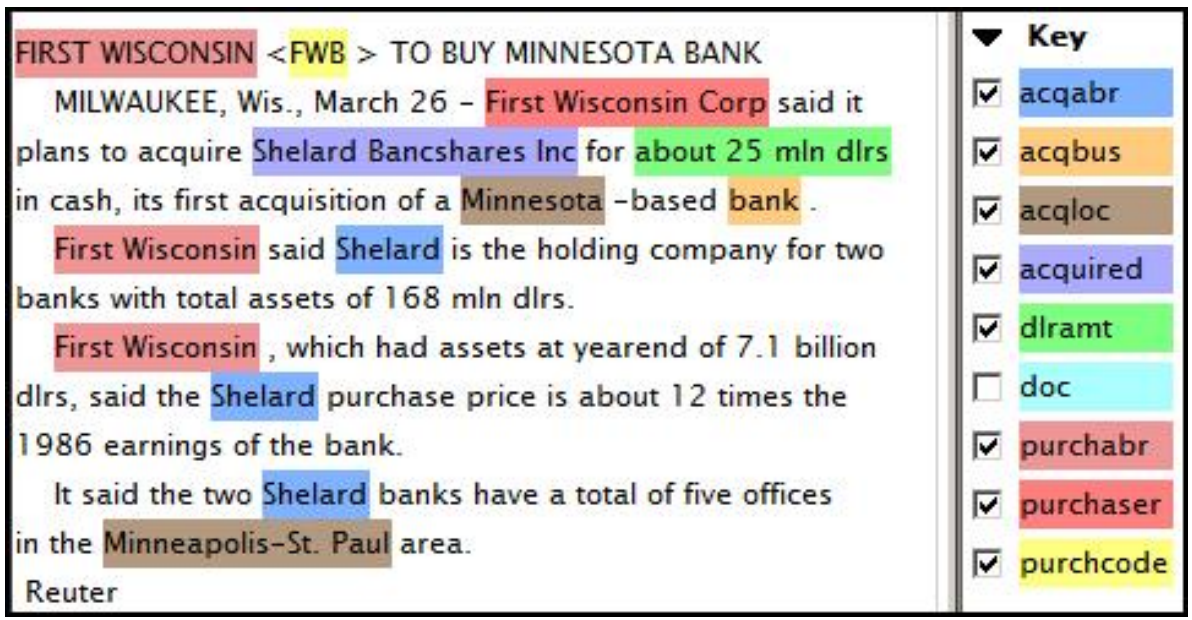
Text of an Accident Report and Contained Information



- Information to be extracted is decorated.

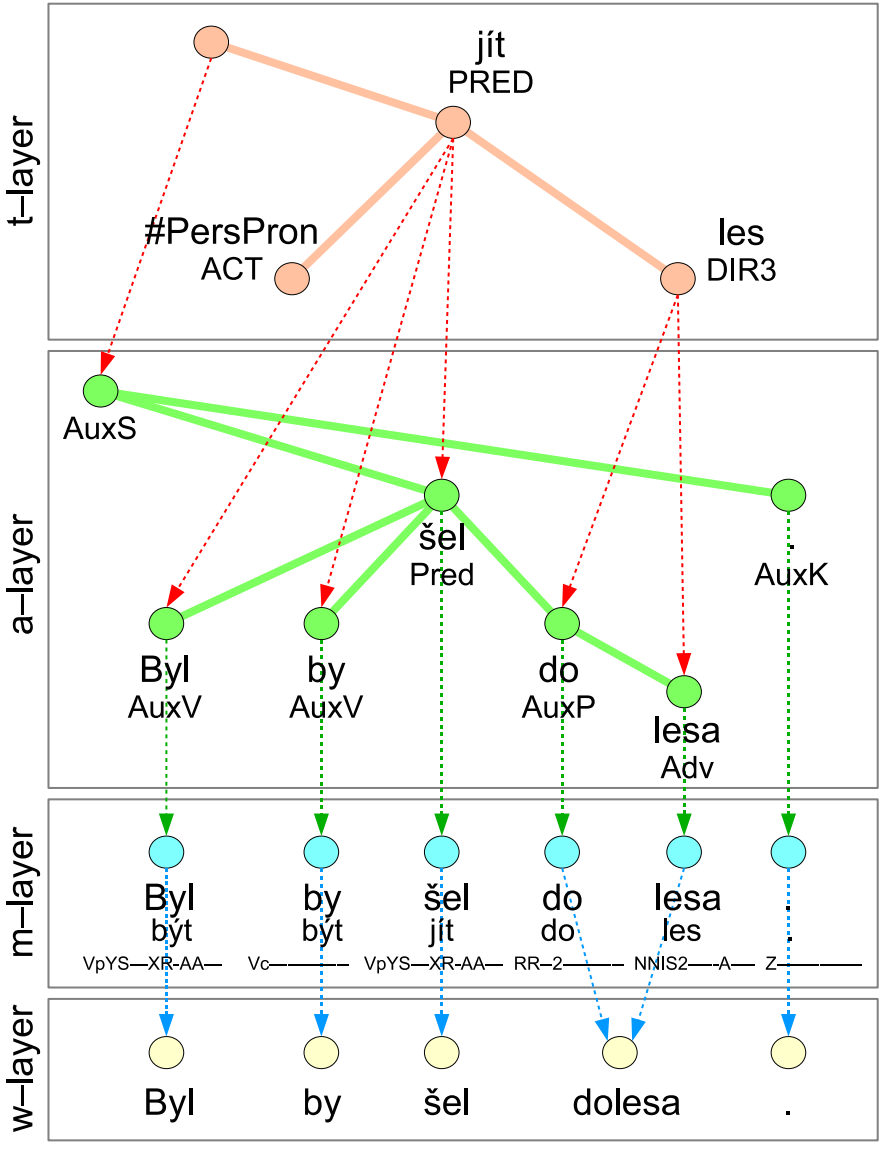
Acquisitions Corpus

- Corporate Acquisition Events
- Acquisitions v1.1 version[1]



[1] from the Dot.kom project's resources:
`http://nlp.shef.ac.uk/dot.kom/resources.html`

Layers of linguistic annotation in PDT



- Tectogrammatical layer
- Analytical layer
- Morphological layer
- PDT 2.0 on-line:

`http://ufal.mff.cuni.cz/pdt2.0/`

Sentence:

Byl by šel dolesa.
He-was would went toforest.

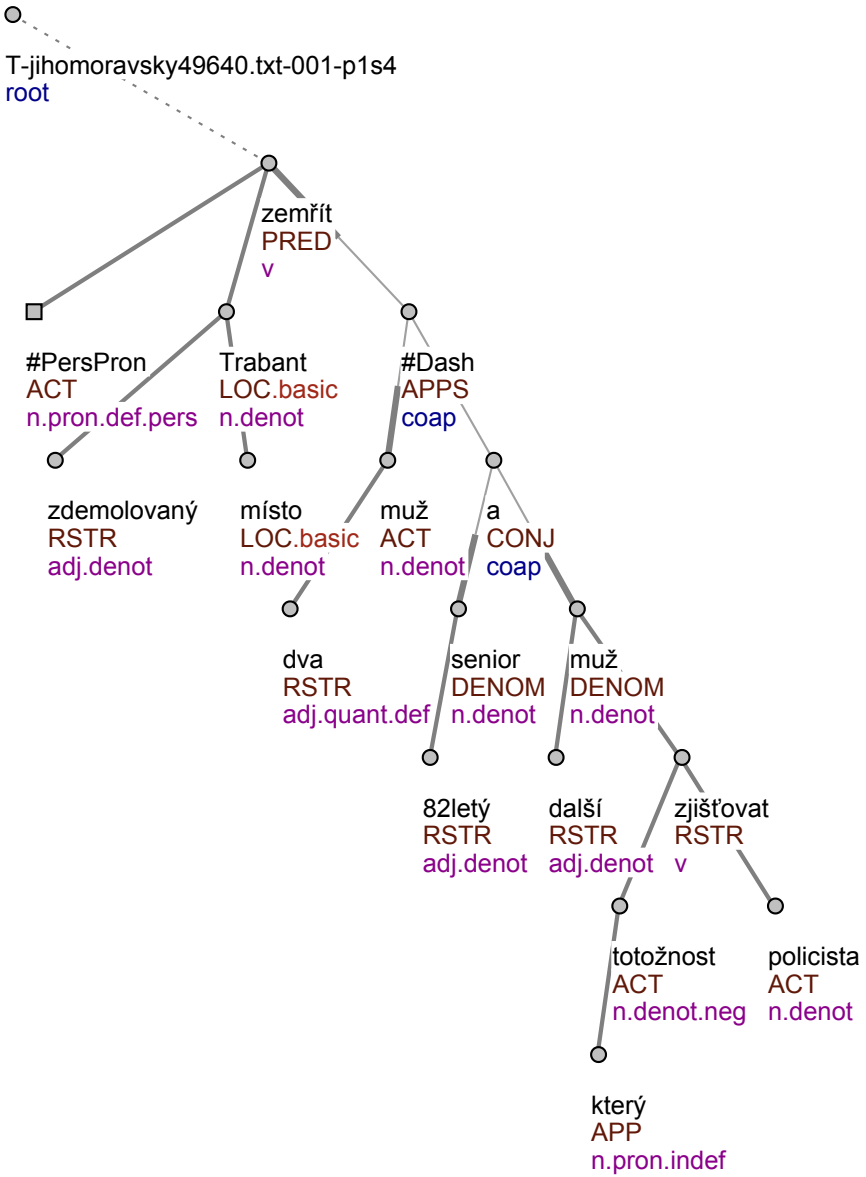
Tools for machine linguistic annotation

1. Segmentation and tokenization
2. Morphological analysis
3. Morphological tagging
4. McDonnald's Maximum Spanning Tree parser
   – Czech adaptation
5. Analytical function assignment
6. Tectogrammatical analysis
   – Developed by Václav Klimeš

- Available within the TectoMT[2] project

[2] http://ufal.mff.cuni.cz/tectomt/

Example of an output tectogrammatical tree



- Lemmas
- Functors
- Semantic parts of speech

Sentence:

Ve zdemolovaném trabantu na místě zemřeli dva muži – 82letý senior a další muž, jehož totožnost zjišťují policisté.

Two men died on the spot in demolished trabant – . . .

Netgraph

- http://quest.ms.mff.cuni.cz/netgraph/

- PML Tree Query
- Query Engine and Query Language for TreeBanks
- http://ufal.mff.cuni.cz/~pajas/pmltq/

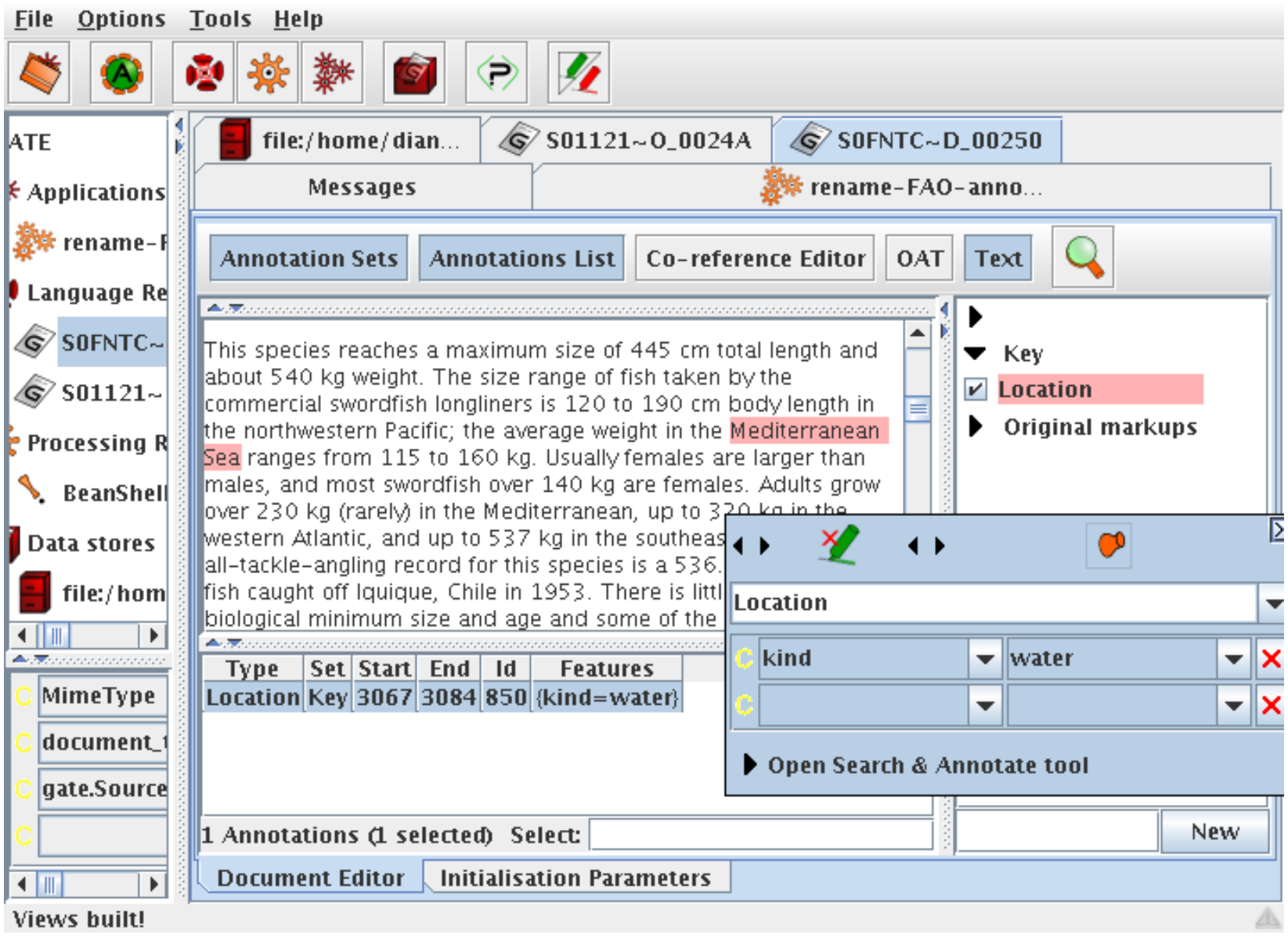
GATE info

- General Architecture for Text Engineering
- University of Sheffield, UK
- Natural Language Processing (NLP)
- Information Extraction (IE)
- Text Annotation
- Developed in Java
- `http://gate.ac.uk/`

GATE features

- Document and annotation management
- Language and processing utility resources
  - Taggers, Parsers, Coreference-processors, Named entity recognizers, Alignment tools, WordNet, Yahoo search, etc
- JAPE grammar rules
- Performance evaluation tools
- Machine learning facilities
- Ontology support

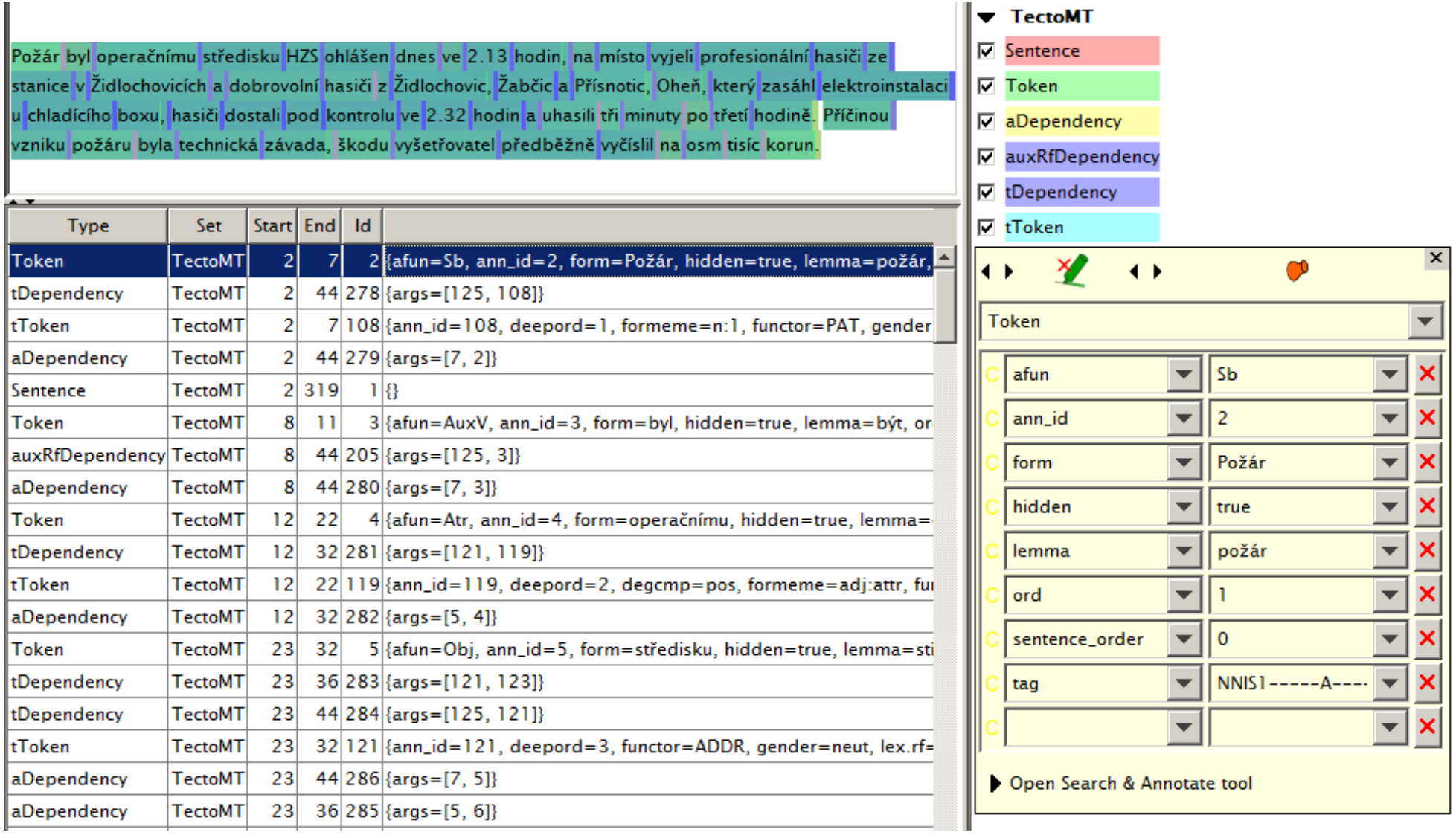
GATE screen shot



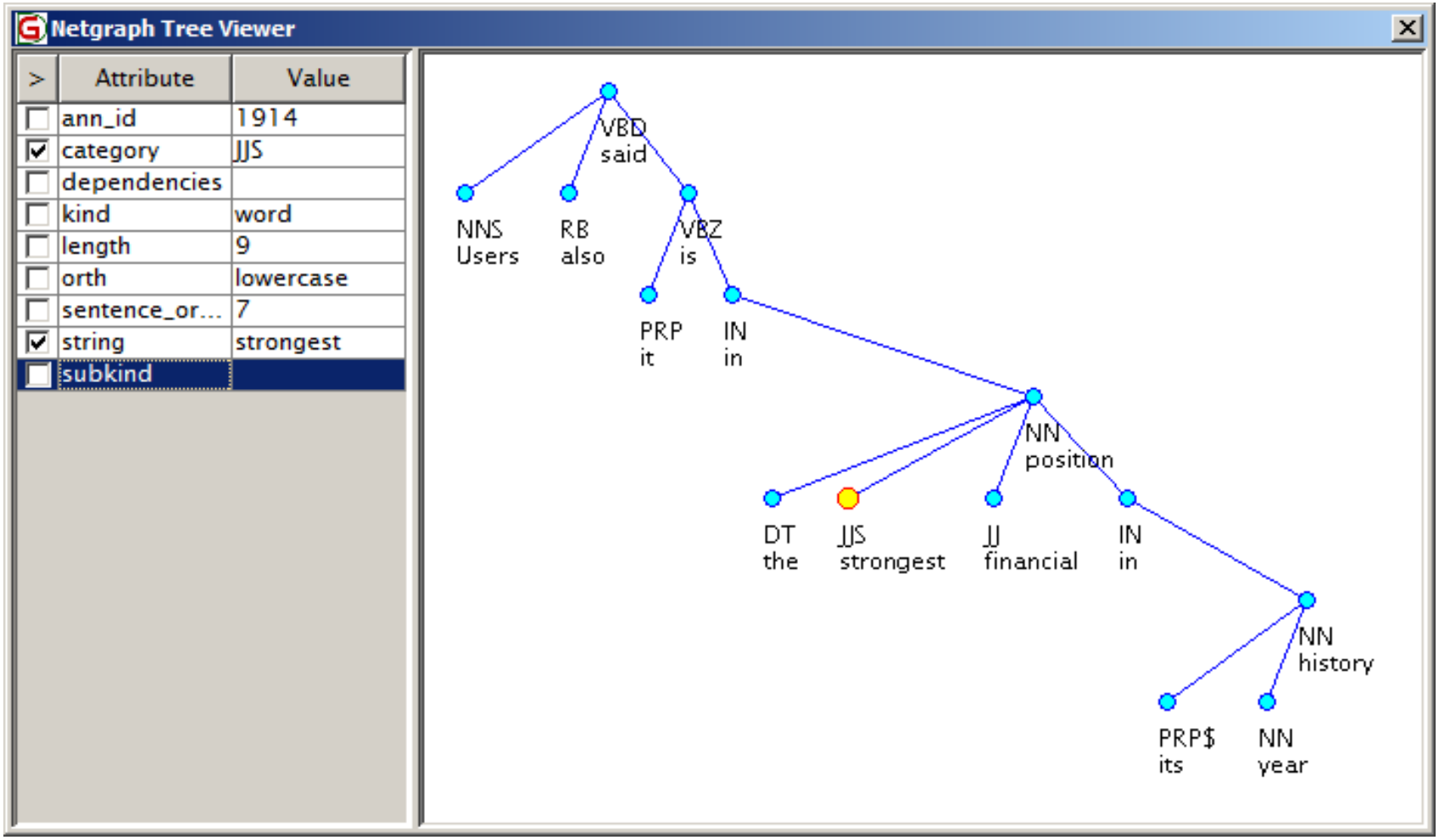
Integration of PDT in GATE

- Implemented Batch TectoMT Language Analyzer
  - Transformation of PDT annotations to GATE
- Netgraph used as a tree viewer
  - Works also for Standford Depndencies
- `http://czsem.berlios.de/`

PDT in GATE

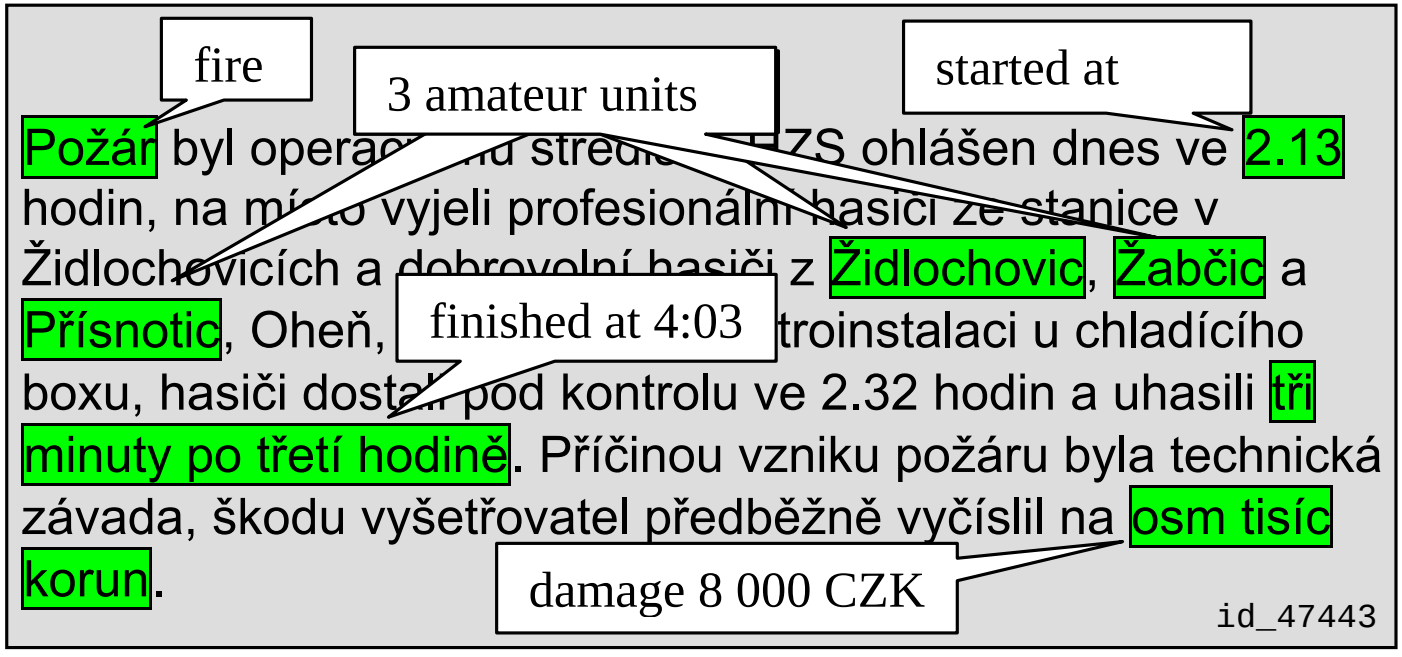

Požár byl operačnímu středisku HZS ohlášen dnes ve 2.13 hodin, na místo vyjeli profesionální hasiči ze stanice v Židlochovicích a dobrovolní hasiči z Židlochovic, Žabčic a Přísnotic, Oheň, který zasáhl elektroinstalaci u chladícího boxu, hasiči dostali pod kontrolu ve 2.32 hodin a uhasili tři minuty po třetí hodině. Příčinou vzniku požáru byla technická závada, škodu vyšetřovatel předběžně vyčíslil na osm tisíc korun.
Type Set Start End Id
Token TectoMT 2 7 2 {afun=Sb, ann_id=2, form=Požár, hidden=true, lemma=požár,
tDependency TectoMT 2 44 278 {args=[125, 108]}
tToken TectoMT 2 7 108 {ann_id=108, deepord=1, formeme=n:1, functor=PAT, gender
aDependency TectoMT 2 44 279 {args=[7, 2]}
Sentence TectoMT 2 319 1 {}
Token TectoMT 8 11 3 {afun=AuxV, ann_id=3, form=byl, hidden=true, lemma=být, or
auxRfDependency TectoMT 8 44 205 {args=[125, 3]}
aDependency TectoMT 8 44 280 {args=[7, 3]}
Token TectoMT 12 22 4 {afun=Atr, ann_id=4, form=operačnímu, hidden=true, lemma=
tDependency TectoMT 12 32 281 {args=[121, 119]}
tToken TectoMT 12 22 119 {ann_id=119, deepord=2, degcmp=pos, formeme=adj:attr, fu
aDependency TectoMT 12 32 282 {args=[5, 4]}
Token TectoMT 23 32 5 {afun=Obj, ann_id=5, form=středisku, hidden=true, lemma=sti
tDependency TectoMT 23 36 283 {args=[121, 123]}
tDependency TectoMT 23 44 284 {args=[125, 121]}
tToken TectoMT 23 32 121 {ann_id=121, deepord=3, functor=ADDR, gender=neut, lex.rf=
aDependency TectoMT 23 44 286 {args=[7, 5]}
aDependency TectoMT 23 36 285 {args=[5, 6]}
TectoMT
Sentence
Token
aDependency
auxRfDependency
tDependency
tToken
Token
afun Sb
ann_id 2
form Požár
hidden true
lemma požár
ord 1
sentence_order 0
tag NNIS1-----A----
Open Search & Annotate tool

Netgraph Tree Viewer in GATE (for Stanford Dependencies)



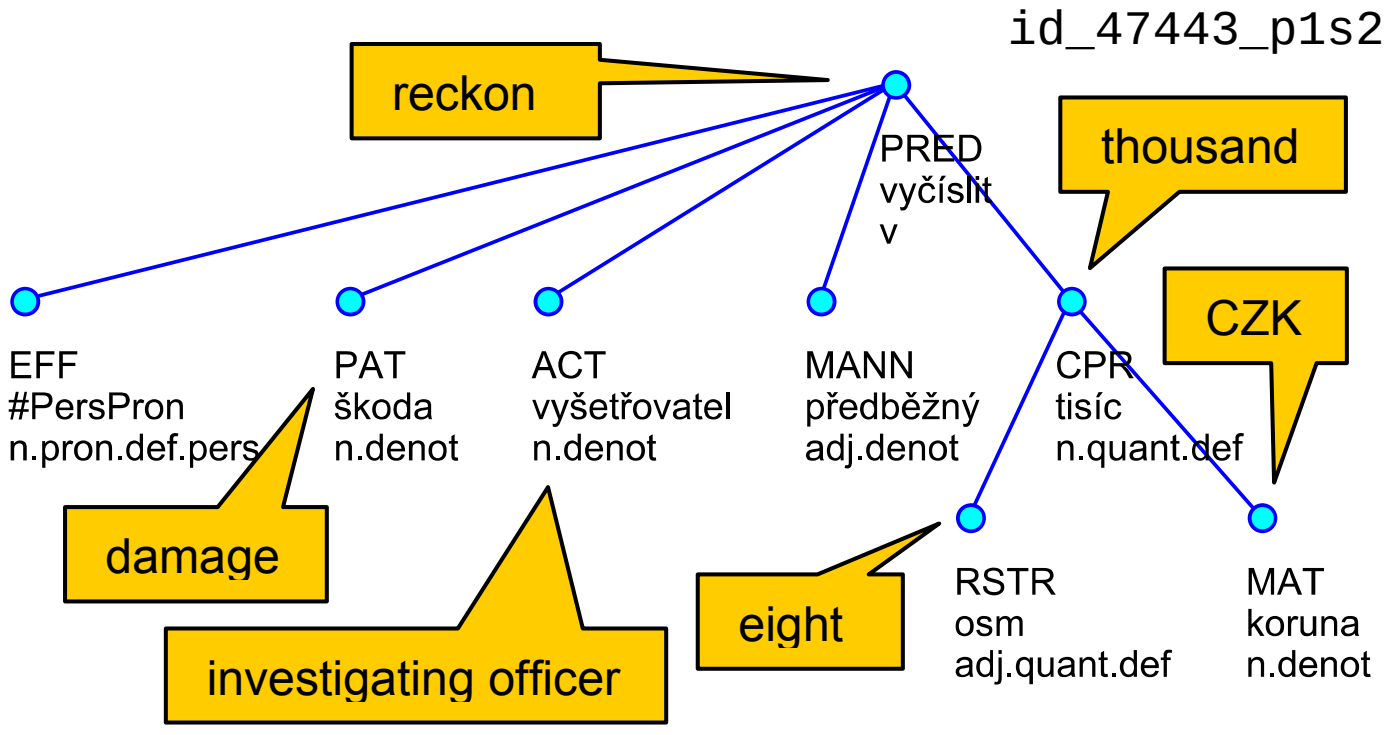
Sentence: Users also said it is in the strongest financial position in its 24-year history.

How to extract the information about the damage of the accident?



- How to extract the information about the damage of the accident?
- See the last sentence on the next slide.

Corresponding linguistic tree



…, škodu vyšetřovatel předběžně vyčíslil na osm tisíc korun.

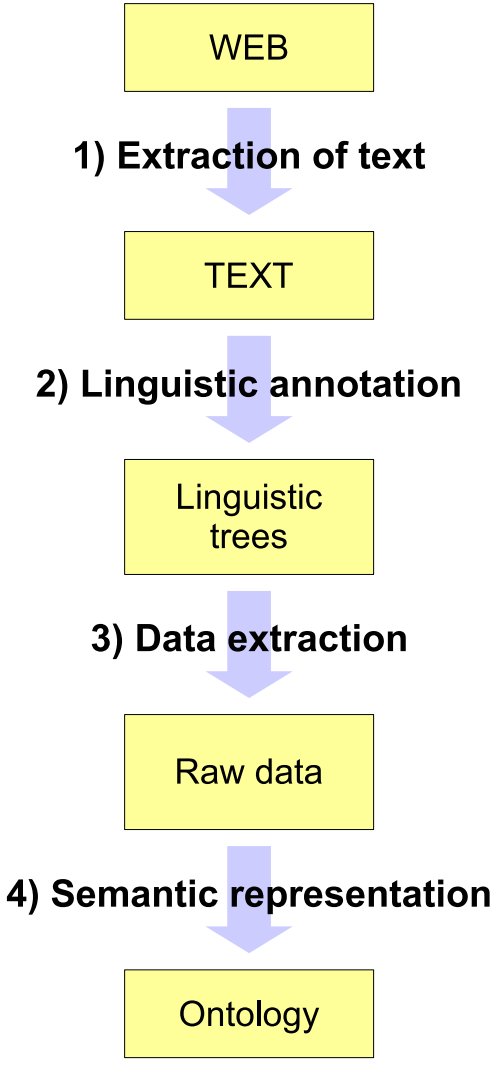
…, investigating officer preliminarily reckoned the damage to be 8 000 CZK.

- Basic Idea: use tree queries (tree patterns) to extract the information.

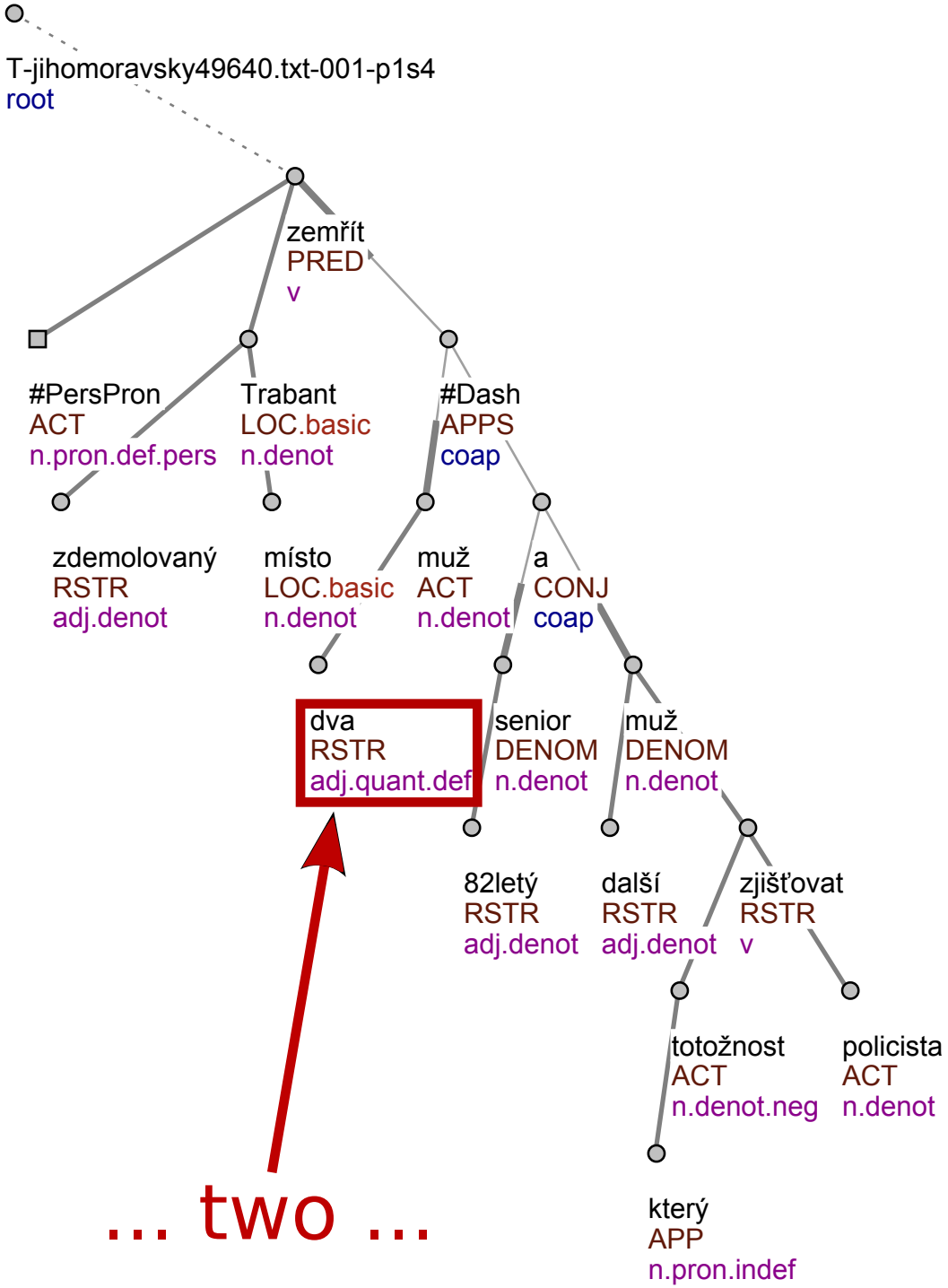
Introduction of Our Solution

- Extraction of semantic information from texts.
- Exploiting of linguistic tools.
  - Mainly “from” the Prague Dependency Treebank project.
    - Related tools – language analyzers (TectoMT), Netgraph, etc.
  - Experiments with the Czech WordNet.
- Rule based extraction method.
  - Extraction rules $\approx$ tree queries
  - ILP learning of extraction rules

Schema of the extraction process

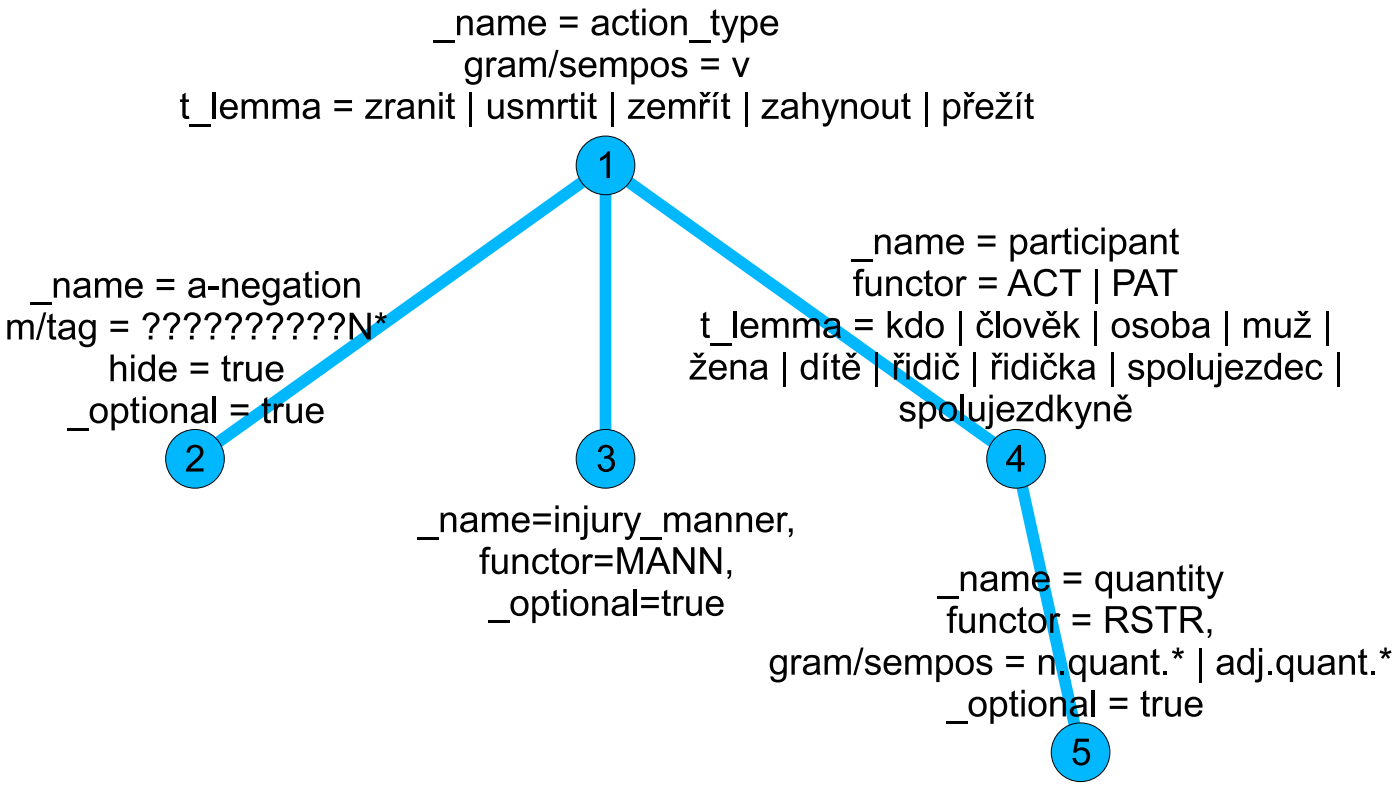


1. Extraction of text
   - Using RSS feed to download pages.
   - Regular expression to extract text.
2. Linguistic annotation
   - Using chain of 6 linguistic tools (see on next slides).
3. Data extraction
   - Exploitation of linguistic trees.
   - Using extraction rules.
4. Semantic representation of data
   - Ontology needed.
   - Semantic interpretation of rules.
   - Far from finished in current state.



- How to extract the information about two dead people?

Extraction rules – Netgraph queries



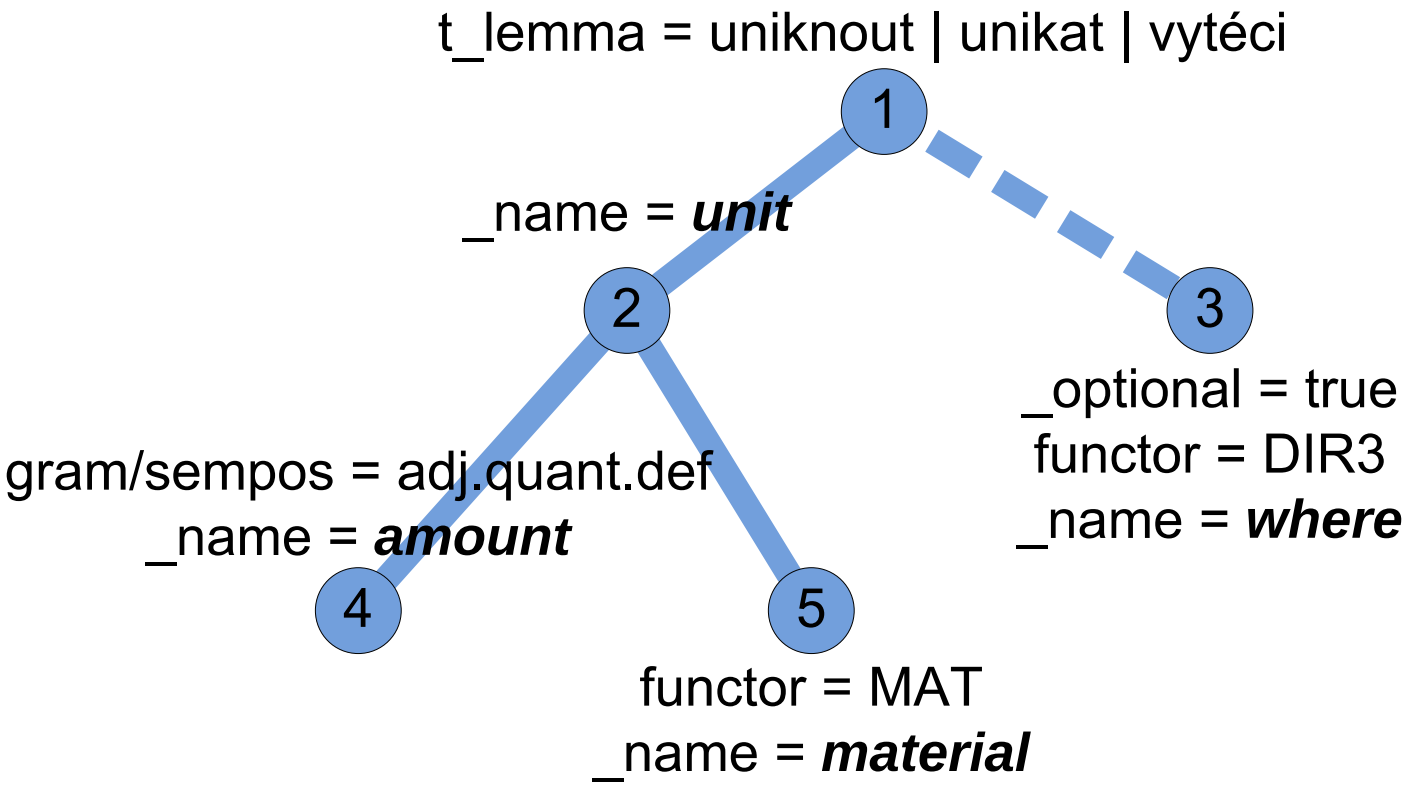
- Tree patterns on shape and nodes (on node attributes).
- Evaluation gives actual matches of particular nodes.
- Names of nodes allow use of references.

Raw data extraction output

```
<QueryMatches>
  <Match root_id="T-vysocina63466.txt-001-p1s4" match_string="2:0,7:3,8:4,11:2">
    <Sentence>
      Při požáru byla jedna osoba lehce zraněna - jednalo se
      o majitele domu, který si vykloubil rameno.
    </Sentence>
    <Data>
      <Value variable_name="action_type" attribute_name="t_lemma">zranit</Value>
      <Value variable_name="injury_manner" attribute_name="t_lemma">lehký</Value>
      <Value variable_name="participant" attribute_name="t_lemma">osoba</Value>
      <Value variable_name="quantity" attribute_name="t_lemma">jeden</Value>
    </Data>
  </Match>
  <Match root_id="T-jihomoravsky49640.txt-001-p1s4" match_string="1:0,13:3,14:4">
    <Sentence>
      Ve zdemolovaném trabantu na místě zemřeli dva muži - 82letý senior
      a další muž, jehož totožnost zjišťují policisté.
    </Sentence>
    <Data>
      <Value variable_name="action_type" attribute_name="t_lemma">zemřít</Value>
      <Value variable_name="participant" attribute_name="t_lemma">muž</Value>
      <Value variable_name="quantity" attribute_name="t_lemma">dva</Value>
    </Data>
  </Match>
  <Match root_id="T-jihomoravsky49736.txt-001-p4s3" match_string="1:0,3:3,7:1">
    <Sentence>Čtyřiatřicetiletý řidič nebyl zraněn.</Sentence>
    <Data>
      <Value variable_name="action_type" attribute_name="t_lemma">zranit</Value>
      <Value variable_name="a-negation" attribute_name="m/tag">VpYS---XR-N A---
      </Value>
      <Value variable_name="participant" attribute_name="t_lemma">řidič</Value>
    </Data>
  </Match>
</QueryMatches>
```

SELECT action_type.t_lemma, a-negation.mtag, injury_manner.t_lemma, participant.t_lemma, quantity.t_lemma **FROM** ****extraction rule****

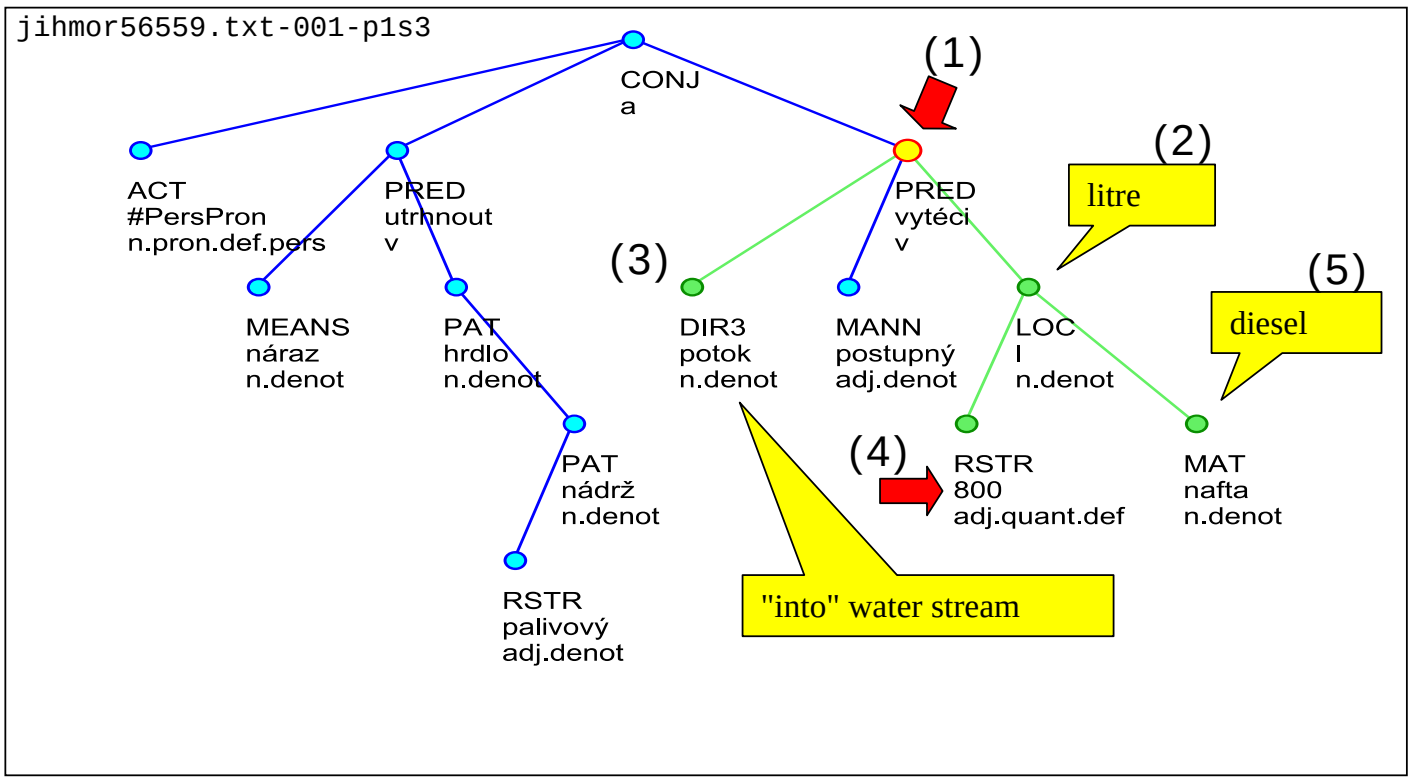
Extraction rules – Environment Protection Use Case



Matching Tree

"Due to the clash the throat of fuel tank tore off and 800 litres of oil (diesel) has run out to a stream."

"Nárazem se utrhl hrdlo palivové nádrže a do potoka postupně vyteklo na 800 litrů nafty."



Raw data extraction output

```
<QueryMatches>
  <Match root_id="jihmor56559.txt-001-p1s3" match_string="15:0,16:4,22:1,23:2,27:3">
    <Sentence>Nárazem se utrhl hrdlo palivové nádrže a do potoka postupně vyteklo na
800 litrů nafty.</Sentence>
    <Data>
      <Value variable_name="amount" attribute_name="t_lemma">800</Value>
      <Value variable_name="unit" attribute_name="t_lemma">1</Value>
      <Value variable_name="material" attribute_name="t_lemma">nafta</Value>
      <Value variable_name="where" attribute_name="t_lemma">potok</Value>
    </Data>
  </Match>
  <Match root_id="jihmor68220.txt-001-p1s3" match_string="3:0,12:4,21:1,22:2,27:3">
    <Sentence>Z palivové nádrže vozidla uniklo do půdy v příkopu vedle silnice zhruba
350 litrů nafty, a proto byli o události informováni také pracovníci odboru životního
prostředí Městského úřadu ve Vyškově a České inspekce životního prostředí.</Sentence>
    <Data>
      <Value variable_name="amount" attribute_name="t_lemma">350</Value>
      <Value variable_name="unit" attribute_name="t_lemma">1</Value>
      <Value variable_name="material" attribute_name="t_lemma">nafta</Value>
      <Value variable_name="where" attribute_name="t_lemma">půda</Value>
    </Data>
  </Match>
...
```

litre

water stream

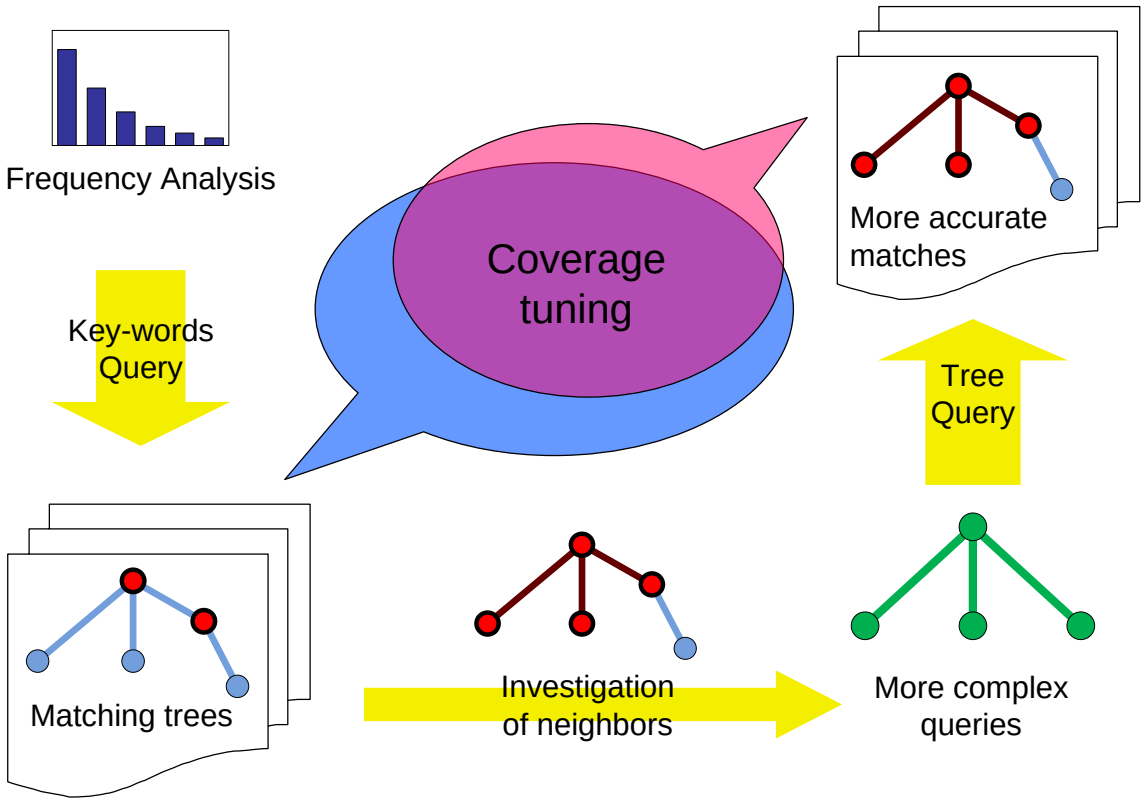
diesel

soil

SELECT amount.t_lemma, unit.t_lemma, material.t_lemma, where.t_lemma

FROM ****extraction rule****

Design of extraction rules – iterative process



1. Frequency analysis → representative key-words.
2. Investigating of matching trees → tuning of tree query.
3. Complexity of the query ≅ complexity of extracted data.

Corpus of Fire-department articles

- Fire-department articles
- Published by The Ministry of Interior of the Czech Republic[3]
- Processed more than 800 articles from different regions of Czech Republic
- 1.2 MB of textual data
- Linguistic tools produced 10 MB of annotations, run time 3.5 hours
- Extracting information about injured and killed people
- 470 matches of the extraction rule, 200 numeric values of quantity (described later)

[3] http://www.mvcr.cz/rss/regionhzs.html

Inductive Logic Programming

- Inductive Logic Programming (ILP)
  - is a Machine Learning procedure for multirelational learning
  - Heuristic and iterative method, learning is usually slow
  - It is capable to deal with graph or tree structures naturally
  - Learns form positive and negative examples
    - Positive and negative tree nodes
    - It is necessary to label tree nodes from corresponding labeled text (not trivial problem)
  - Learned rules are strict (no weights, probabilities, etc.)
    - Easier human understanding, modification
    - Possibility of sharing of rules amongst different tools
    - Lower performance (precision, recall)

ILP principles

- Learning examples $E = P \cup N$ (Positive and Negative)
- Background knowledge B
- ILP task – to find hypothesis H such that:

$$(\forall e \in P)(B \cup H \models e) \ \ \& \ \ (\forall n \in N)(B \cup H \not\models n).$$

ILP Example

Types of ground variables

```
animal(dog). animal(dolphin) ... animal(penguin).
class(mammal). class(fish). class(reptile). class(bird).
covering(hair). covering(none). covering(scales).
habitat(land). habitat(water). habitat(air).
```

Background knowledge

```
has_covering(dog, hair). has_covering(crocodile, scales).
has_legs(dog,4). ... has_legs(penguin, 2). etc.
has_milk(dog). ... has_milk(platypus). etc.
homeothermic(dog). ... homeothermic(penguin). etc.
habitat(dog, land). ... habitat(penguin, water). etc.
has_eggs(platypus). ... has_eggs(eagle). etc.
has_gills(trout). ... has_gills(eel). etc.
```

ILP Example

Positive examples

```
class(lizard, reptile).
class(trout, fish).
class(bat, mammal).
```

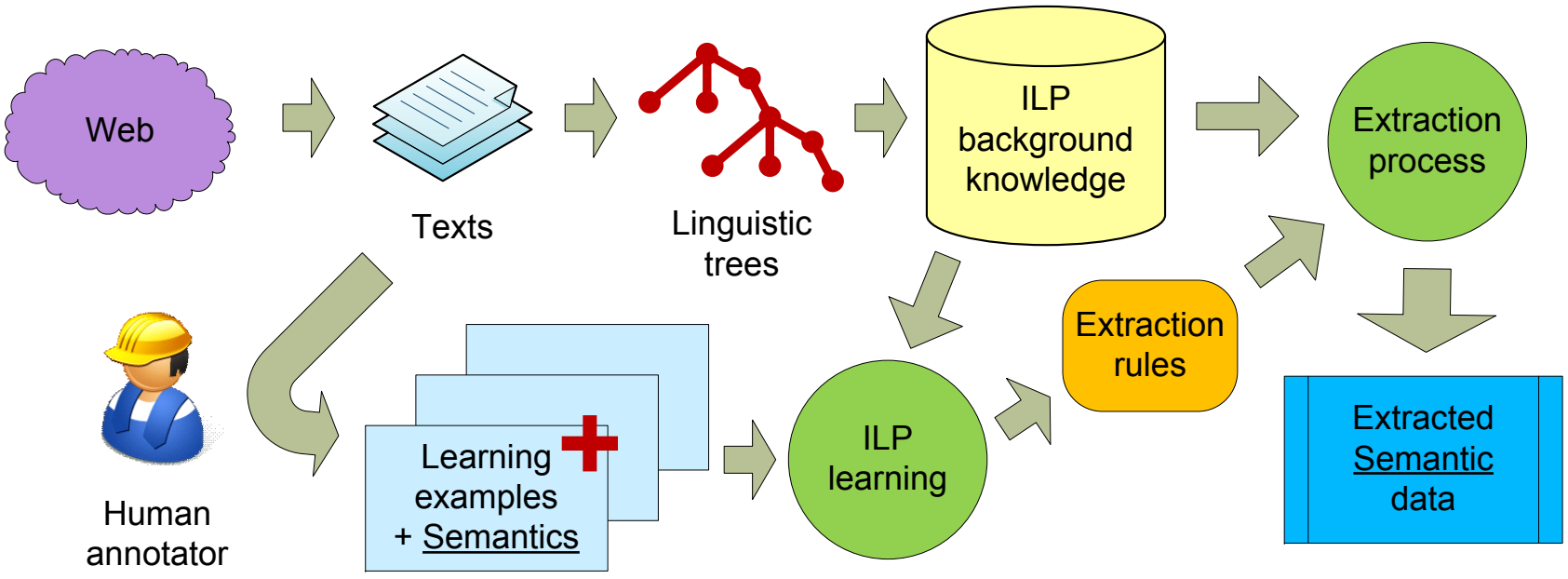
Negative examples

```
class(trout, mammal).
class(herring, mammal).
class(platypus, reptile).
```

Induced rules

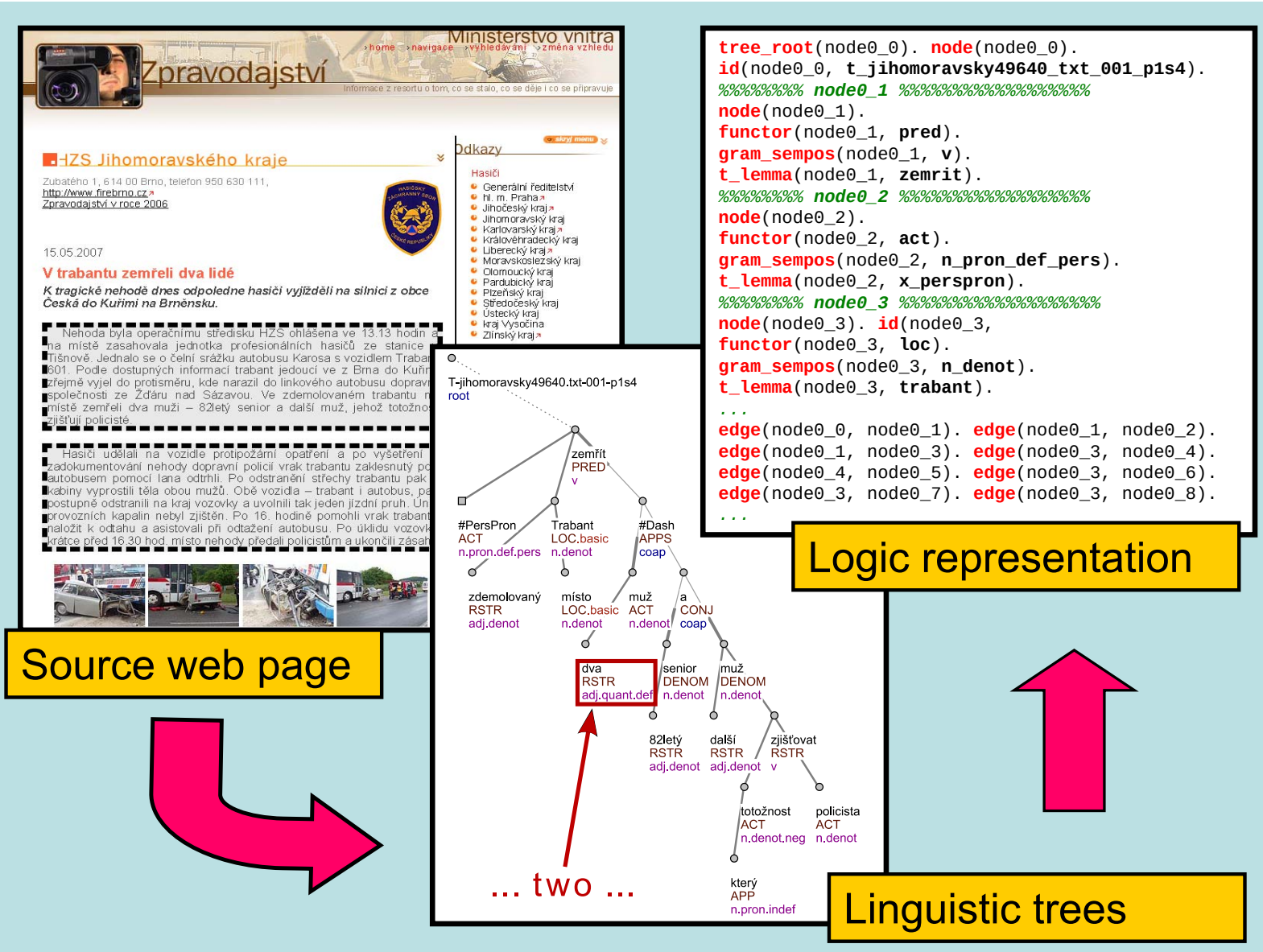
```
class(A,reptile) :- has_covering(A,scales),
                    has_legs(A,4).
class(A,mammal) :- homeothermic(A), has_milk(A).
class(A,fish) :- has_legs(A,0), has_eggs(A).
class(A,reptile) :- has_covering(A,scales),
                    habitat(A,land).
class(A,bird) :- has_covering(A,feathers).
```

Integration of ILP in our extraction process

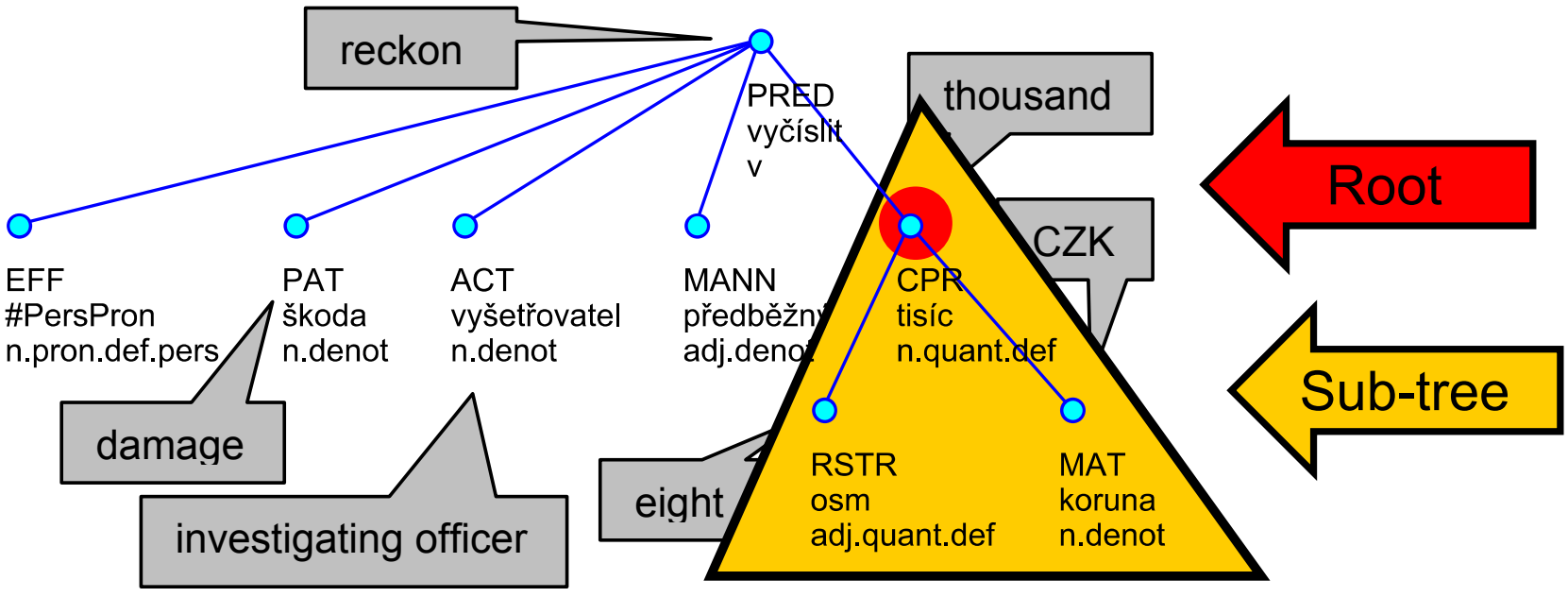


- Main point: transformation of trees to logic representation.
- Human annotator does not need to be a linguistic expert.

Logic representation of linguistic trees



Root/Subtree Preprocessing/Postprocessing (Chunk learning)



…, škodu vyšetřovatel předběžně vyčíslil na osm tisíc korun.

…, investigating officer preliminarily reckoned the damage to be eight thousand Crowns (CZK).

Examples of learned rules, Czech words are translated.

Example

[Rule 1] [Pos cover = 14 Neg cover = 0]

```
damage_root(A) :- lex_rf(B,A), has_sempos(B,'n.quant.def'),
   tDependency(C,B), tDependency(C,D),
   has_t_lemma(D,'investigator').
```

[Rule 2] [Pos cover = 13 Neg cover = 0]

```
damage_root(A) :- lex_rf(B,A), has_functor(B,'TOWH'),
   tDependency(C,B), tDependency(C,D), has_t_lemma(D,'damage').
```

[Rule 1] [Pos cover = 7 Neg cover = 0]

```
injuries(A) :- lex_rf(B,A), has_functor(B,'PAT'),
   has_gender(B,anim), tDependency(B,C), has_t_lemma(C,'injured').
```

[Rule 8] [Pos cover = 6 Neg cover = 0]

```
injuries(A) :- lex_rf(B,A), has_gender(B,anim), tDependency(C,B),
   has_t_lemma(C,'injure'), has_negation(C,neg0).
```

Evaluation results

task/method	matching	missing	excess	overlap	prec.%	recall%	F1.0%
damage/ILP	14	0	7	6	51.85	70.00	59.57
damage/ILP – lenient measures					74.07	100.00	85.11
dam./ILP-roots	16	4	2	0	88.89	80.00	84.21
damage/Paum	20	0	6	0	76.92	100.00	86.96
injuries/ILP	15	18	11	0	57.69	45.45	50.85
injuries/Paum	25	8	54	0	31.65	75.76	44.64
inj./Paum-afun	24	9	38	0	38.71	72.73	50.53

- 10-fold cross validation
- Two tasks: ‘damage’ and ‘injuries’
- Root/subtree preprocessing/postprocessing used for ‘damage’ task

Summary

- Implemented a system for extraction of semantic information
- Based on third party linguistic tools (TectoMT[4])
- Extraction rules adopted from Netgraph[5] application.
- ILP used for learning rules.
- All methods integrated inside GATE[6].

- Main advantages:
  - Automated selection of learning features
  - “Language independent”
  - Rule based

[4] http://ufal.mff.cuni.cz/tectomt/
[5] http://quest.ms.mff.cuni.cz/netgraph/
[6] http://gate.ac.uk/

Future work

- Use some Knowledge Base (e.g. WordNet).
- Adaptation of this method on other languages.
- Evaluation of the method on other datasets.
- Be able to provide more semantics.
  - e.g. sophisticated semantic interpretation of extracted data

Semantic Web Introduction

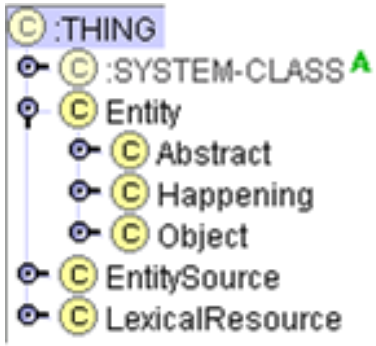
We use semantic web ontologies to express the semantics.

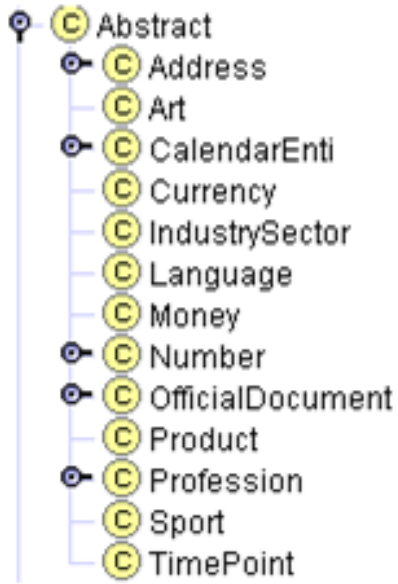
- RDF, OWL languages
- Motivated by description logics

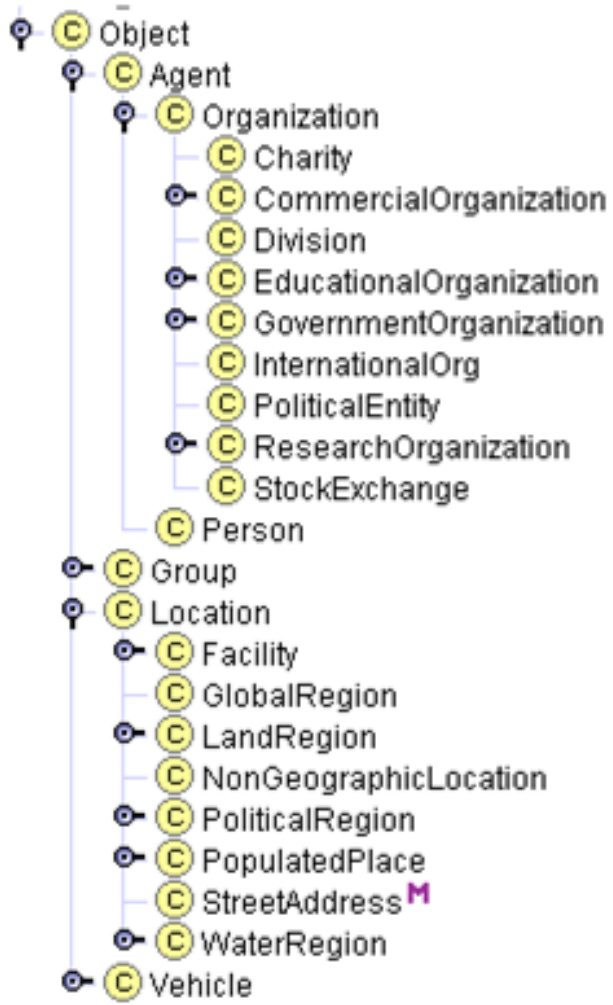
- Concepts or Classes
- Predicates or Relations
- Individuals or Instances

- RDF triples: <Subject> <Predicate> <Object>
- RDF triples form a named oriented graph
  - Basic data structure of the Semantic Web

Ontology (example)

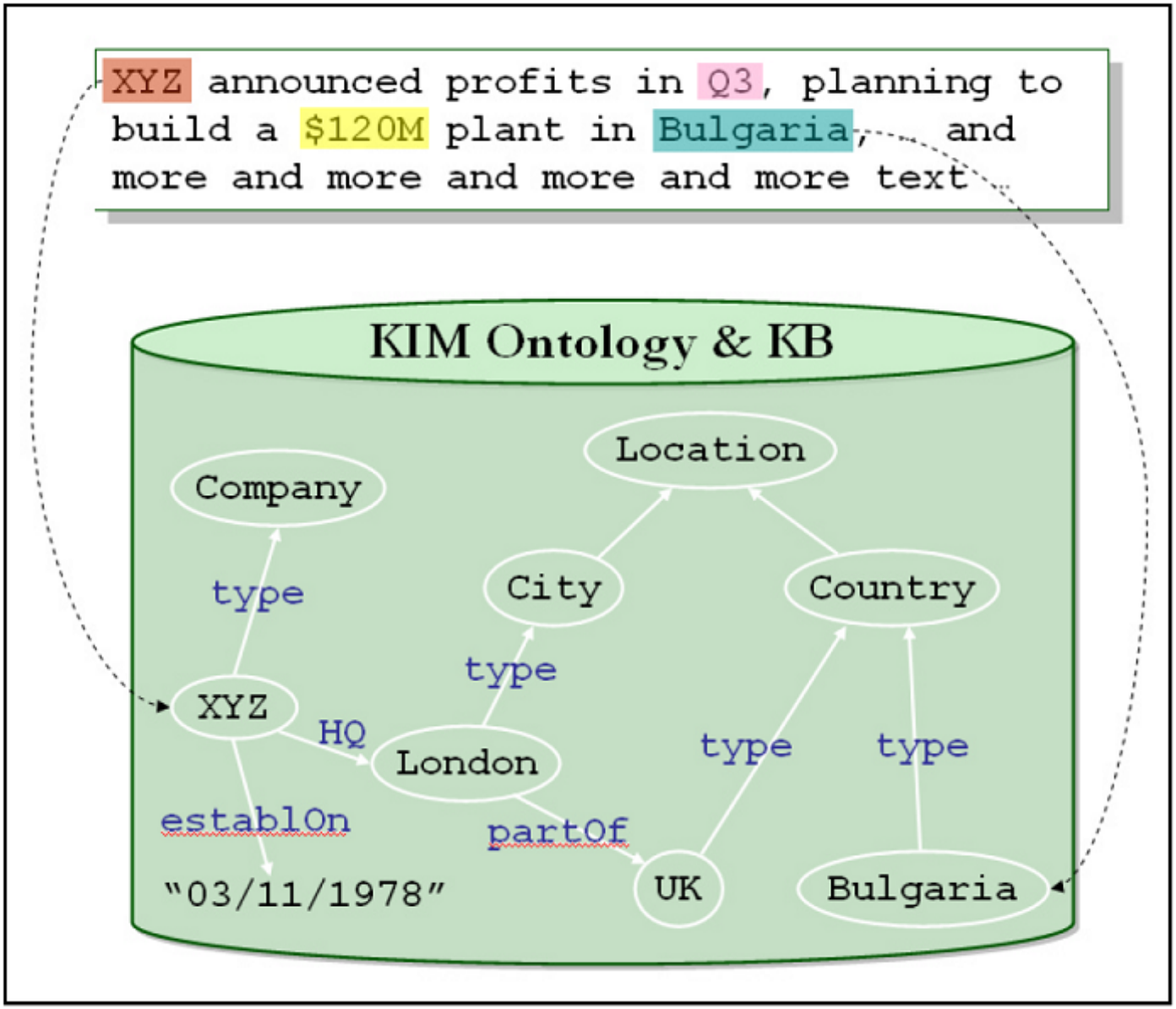




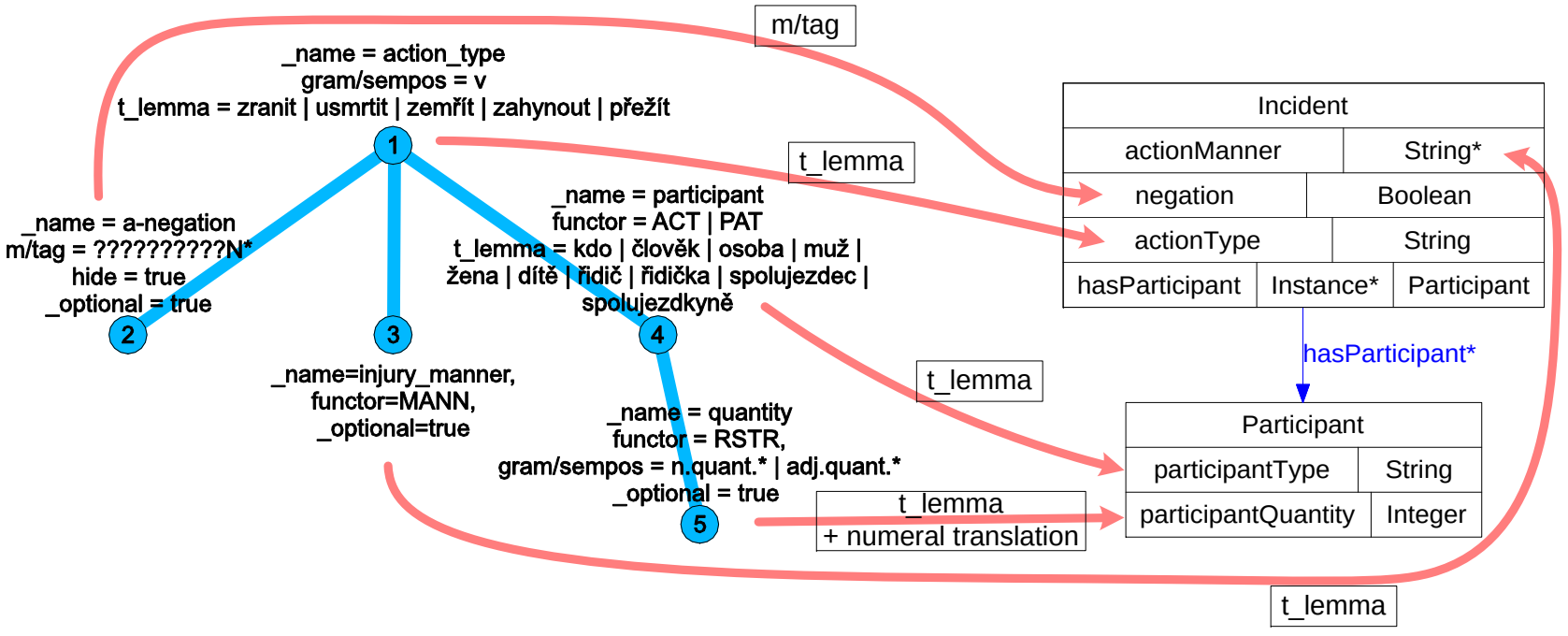


- PROTON (PROTo ONtology)
  `http://proton.semanticweb.org/`

Semantic Annotation (http://www.ontotext.com/kim/)

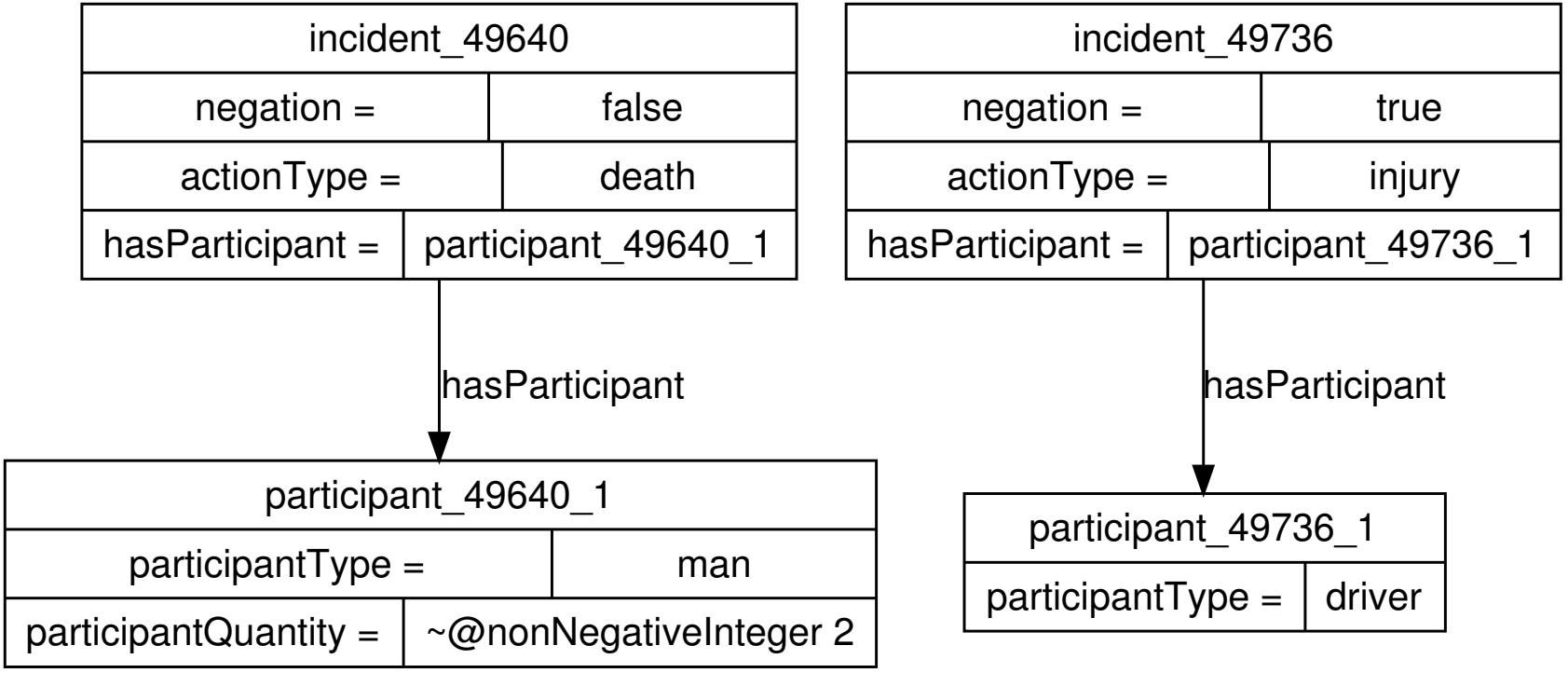


Semantic interpretation of extraction rules



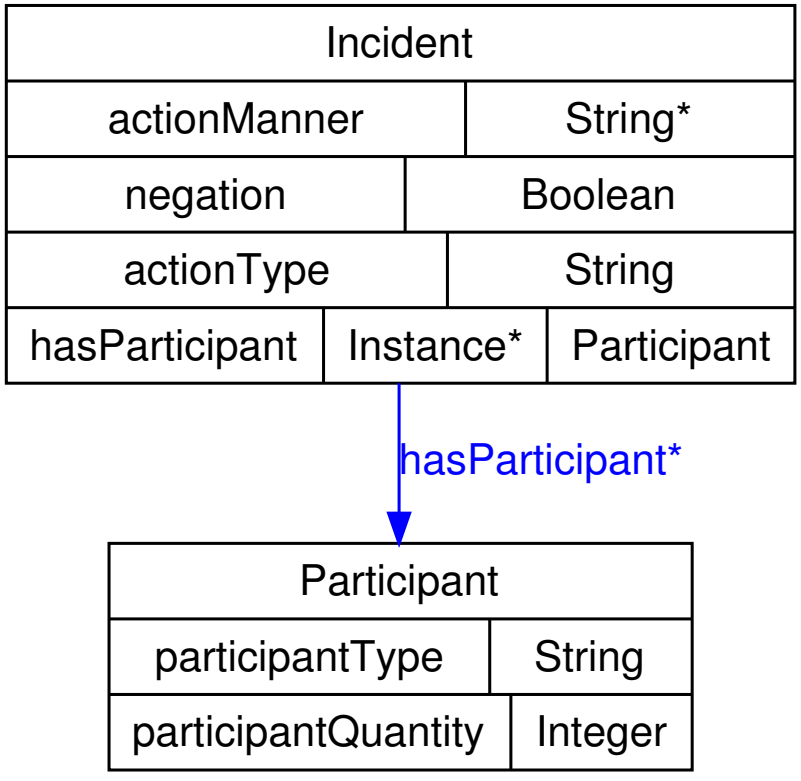
- Determines how particular values of attributes are used.
- Gives semantics to extraction rule.
- Gives semantics to extracted data.

Semantic data output



- Two instances of two ontology classes.

The experimental ontology

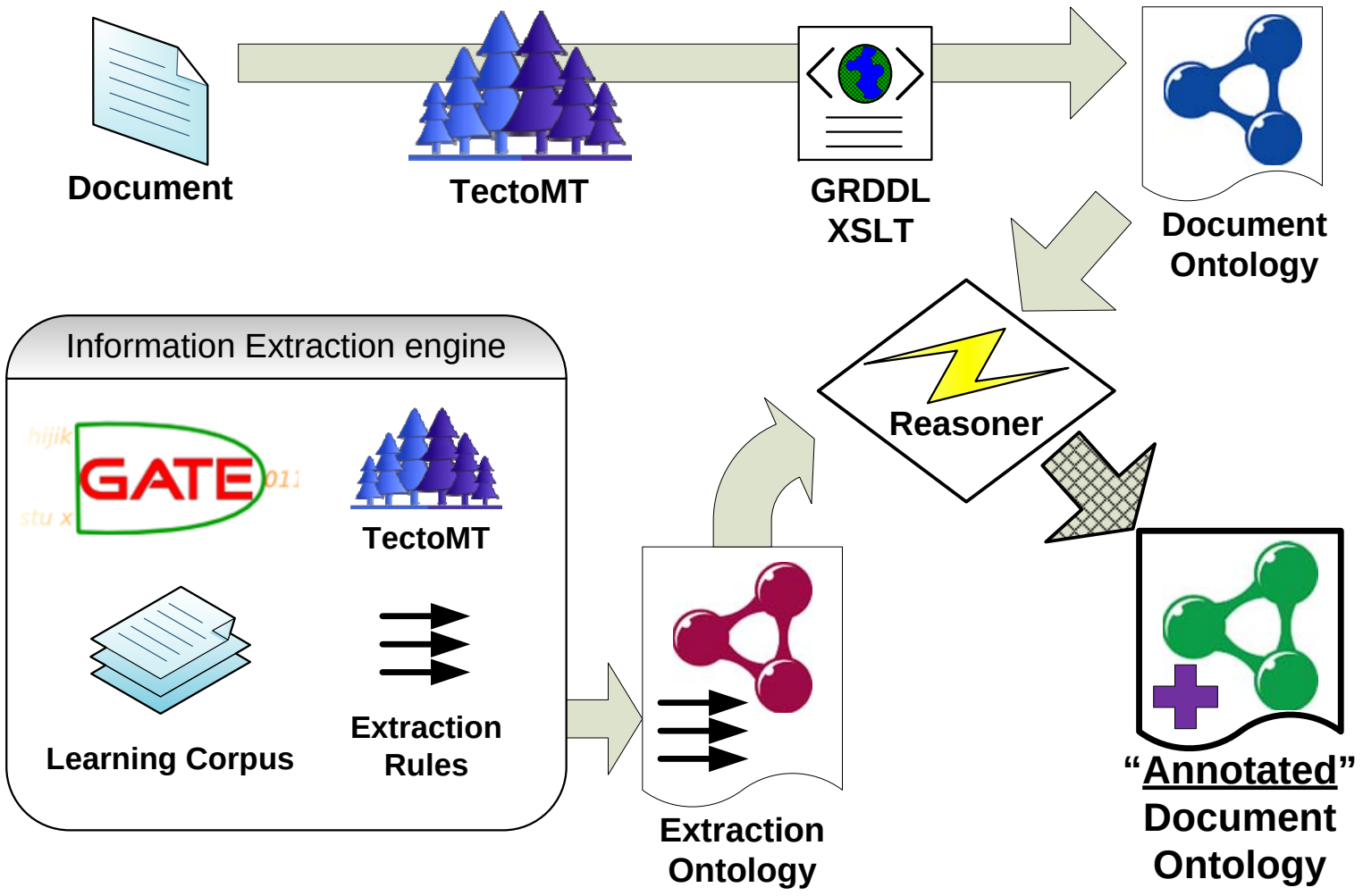


- Two classes
  - Incident and Participant
- One object property relation
  - hasParticipant
- Five datatype property relations
  - actionManner (light or heavy injury)
  - negation
  - actionType (injury or death)
  - participantType (man, woman, driver, etc.)
  - participantQuantity

Transformation of PML to RDF

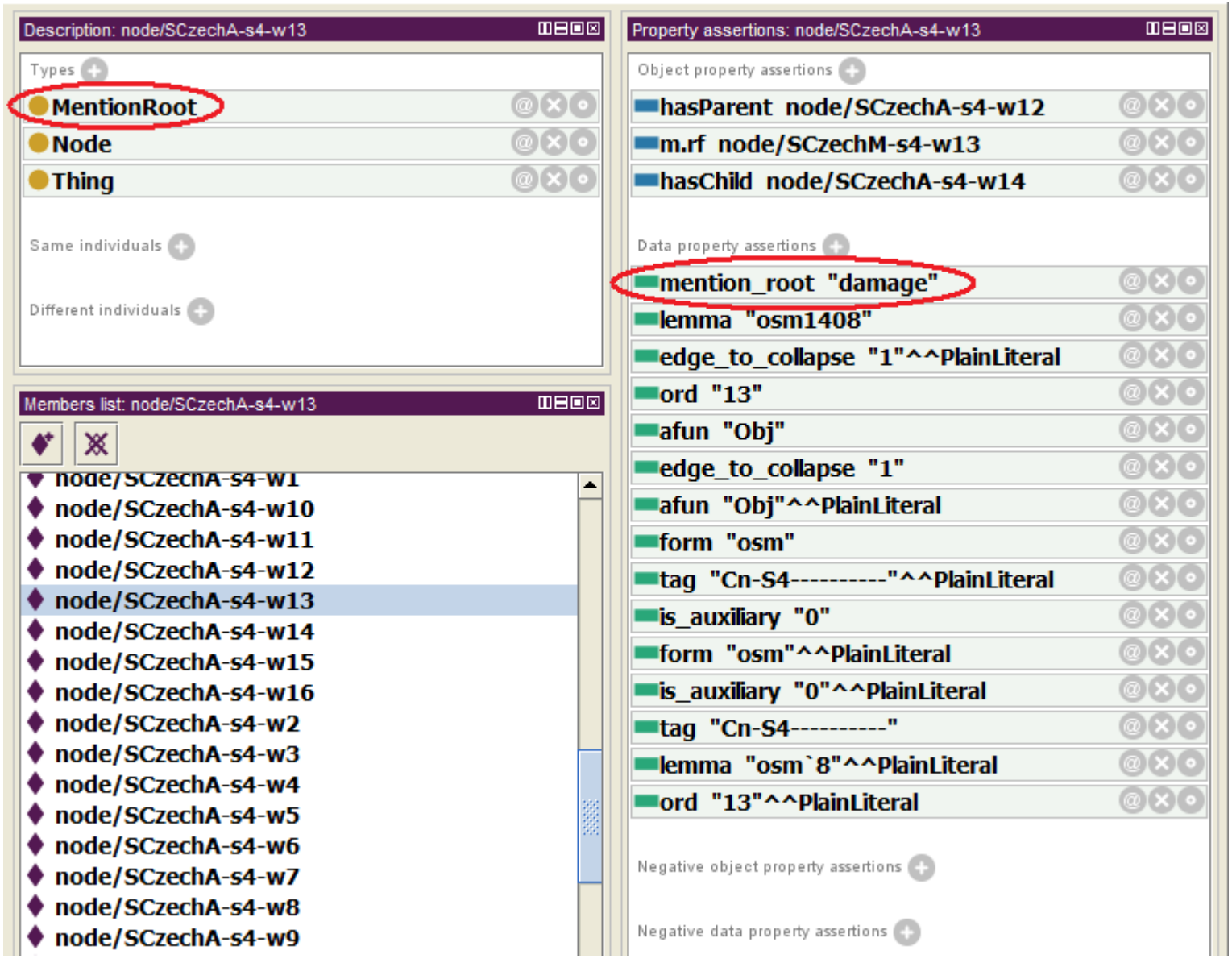
- Quite simple XSLT transformation
- Allows working with PDT annotations inside Semantic Web tools
  - Ontology Editors
  - Reasoners
  - Query tools (graph queries)
  - ?Visualization and navigation tools?
- In our case interpretation of extraction rules by a OWL reasoner

Extraction Rules Interpreted by OWL Reasoner



- Tool independent extraction ontologies

PDT in The Protégé Ontology Editor



Examples of extraction rules in the native Prolog format.

[Rule 1] [Pos cover = 23 Neg cover = 6]

```
mention_root(acquired,A) :-
   'lex.rf'(B,A), t_lemma(B,'Inc'), tDependency(C,B),
    tDependency(C,D), formeme(D,'n:in+X'), tDependency(E,C).
```

[Rule 11] [Pos cover = 25 Neg cover = 6]

```
mention_root(acquired,A) :-
   'lex.rf'(B,A), t_lemma(B,'Inc'), tDependency(C,B),
    formeme(C,'n:obj'), tDependency(C,D), functor(D,'APP').
```

[Rule 75] [Pos cover = 14 Neg cover = 1]

```
mention_root(acquired,A) :-
   'lex.rf'(B,A), t_lemma(B,'Inc'), functor(B,'APP'),
    tDependency(C,B), number(C,pl).
```

Examples of extraction rules in Protégé 4 – Rules View's format

[Rule 1]

```
lex.rf(?b, ?a), t_lemma(?b, "Inc"), tDependency(?c, ?b),
tDependency(?c, ?d), formeme(?d, "n:in+X"),
tDependency(?c, ?e)
      -> mention_root(?a, "acquired")
```

[Rule 11]

```
lex.rf(?b, ?a), t_lemma(?b, "Inc"), tDependency(?c, ?b),
formeme(?c, "n:obj"), tDependency(?c, ?d), functor(?d, "APP")
      -> mention_root(?a, "acquired")
```

[Rule 75]

```
lex.rf(?b, ?a), t_lemma(?b, "Inc"), functor(?b, "APP"),
tDependency(?c, ?b), number(?c, "pl")
      -> mention_root(?a, "acquired")
```