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Data Extraction using NLP techniques and its Transformation to Linked Data

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Mexico, Tuxtla Gutiérrez

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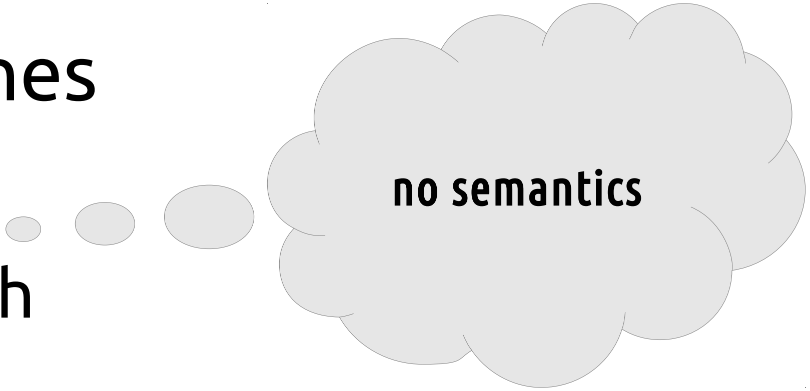
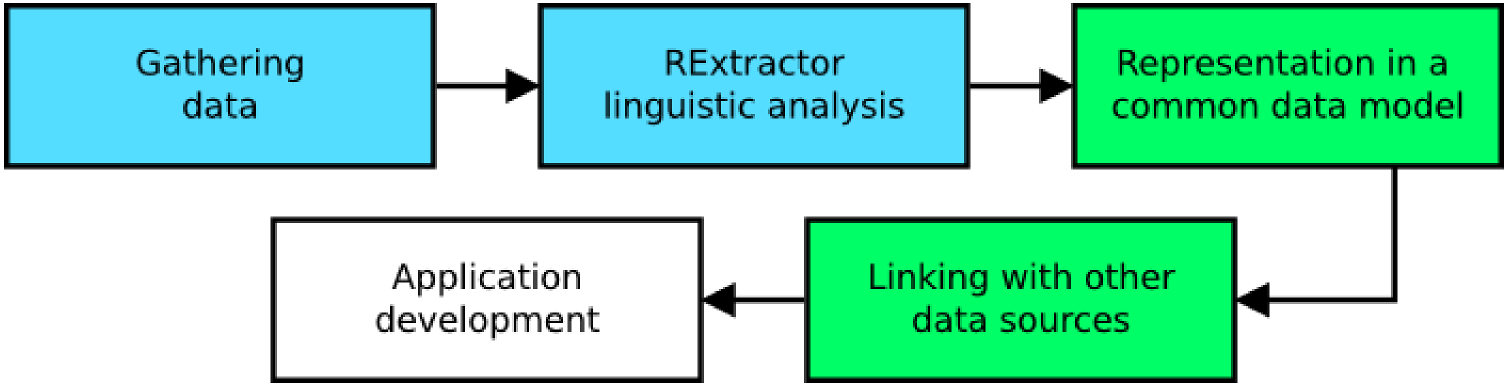
Motivation

- large collections of documents
- efficient browsing & querying
- typical approaches
  - full-text search
  - metadata search


no semantics

- semantic interpretation of documents → suitable DB & query language → user-friendly browsing & querying

Scenario


Gathering data
RExtractor linguistic analysis
Representation in a common data model
Linking with other data sources
Application development

- **Cooperation between**
  - 🟦 Information Extraction
  - 🟩 Semantic Web

Scenario

- **Extracting knowledge base** 🟦
  - set of entities and relations between them
  - linguistic analysis (RExtractor)
- **Knowledge base representation** 🟩
  - Linked Data Principles
  - Resource Description Framework (RDF)

Scenario

- **Extracting knowledge base** 🟦
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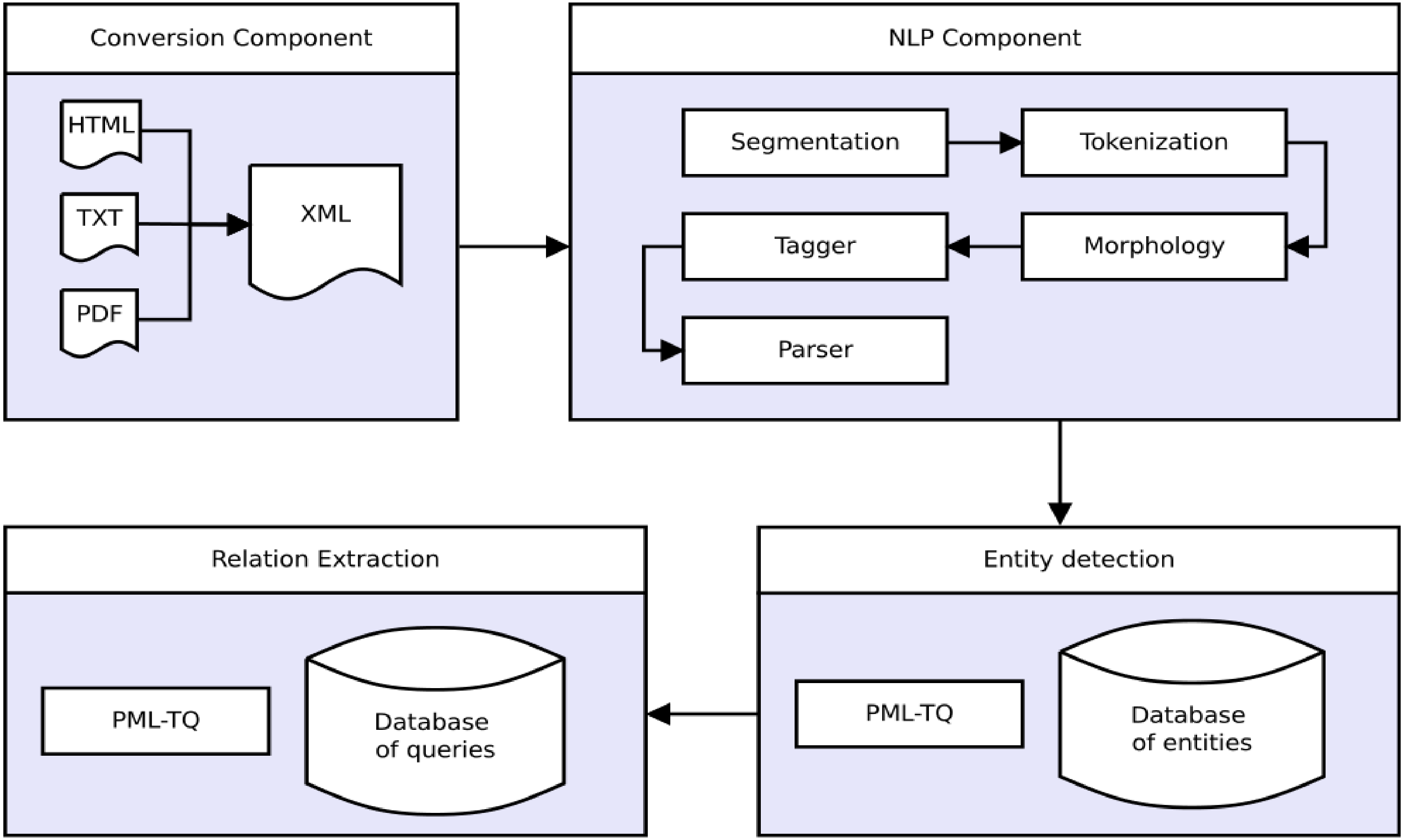
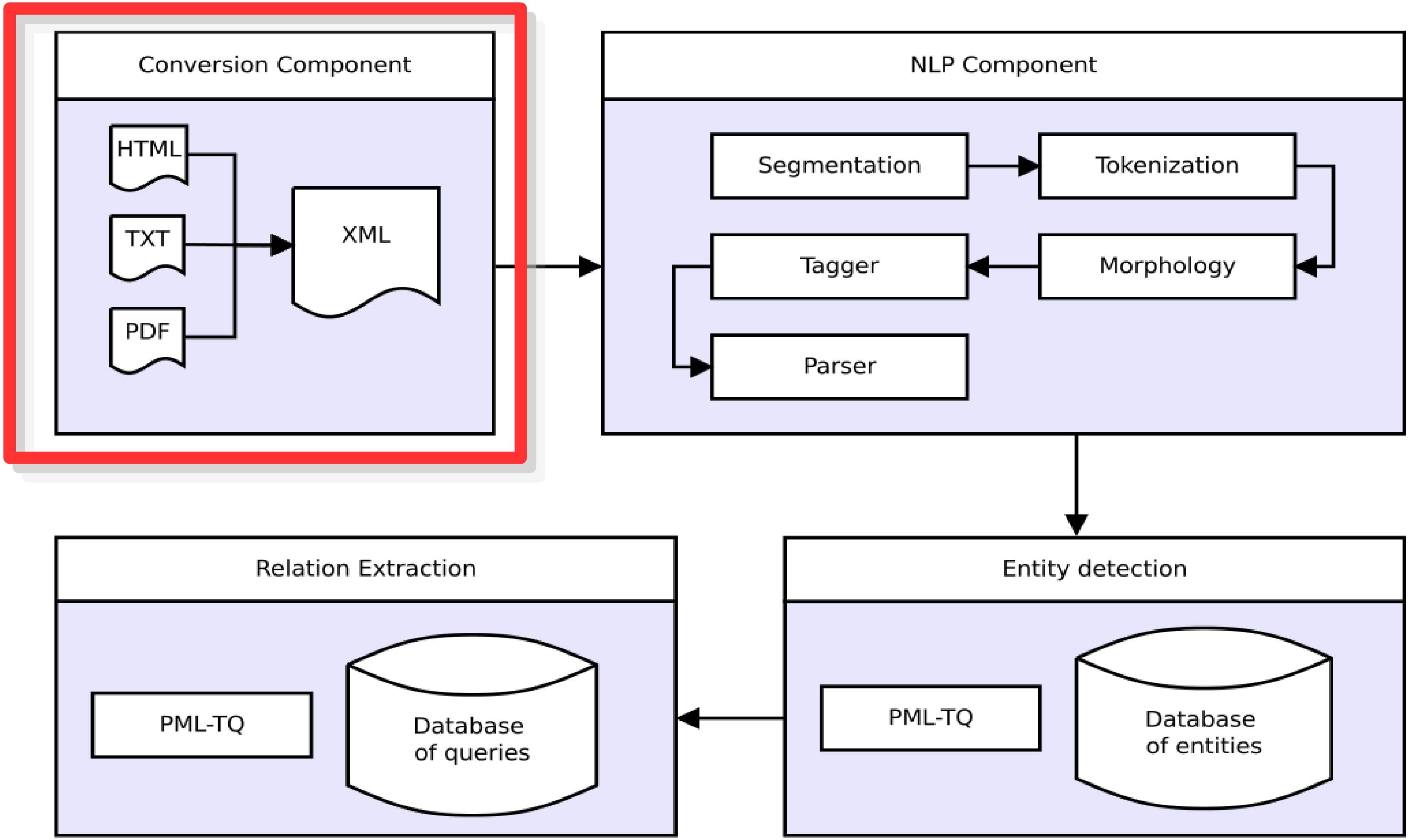
RExtractor Architecture

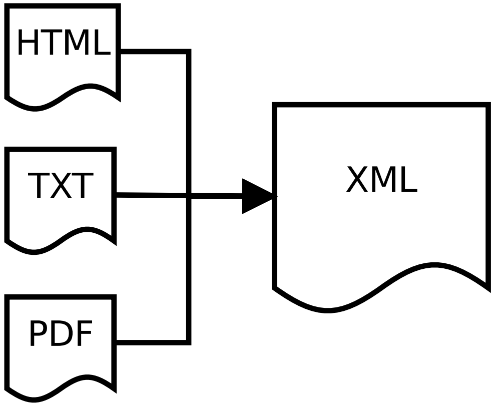


RExtractor Architecture

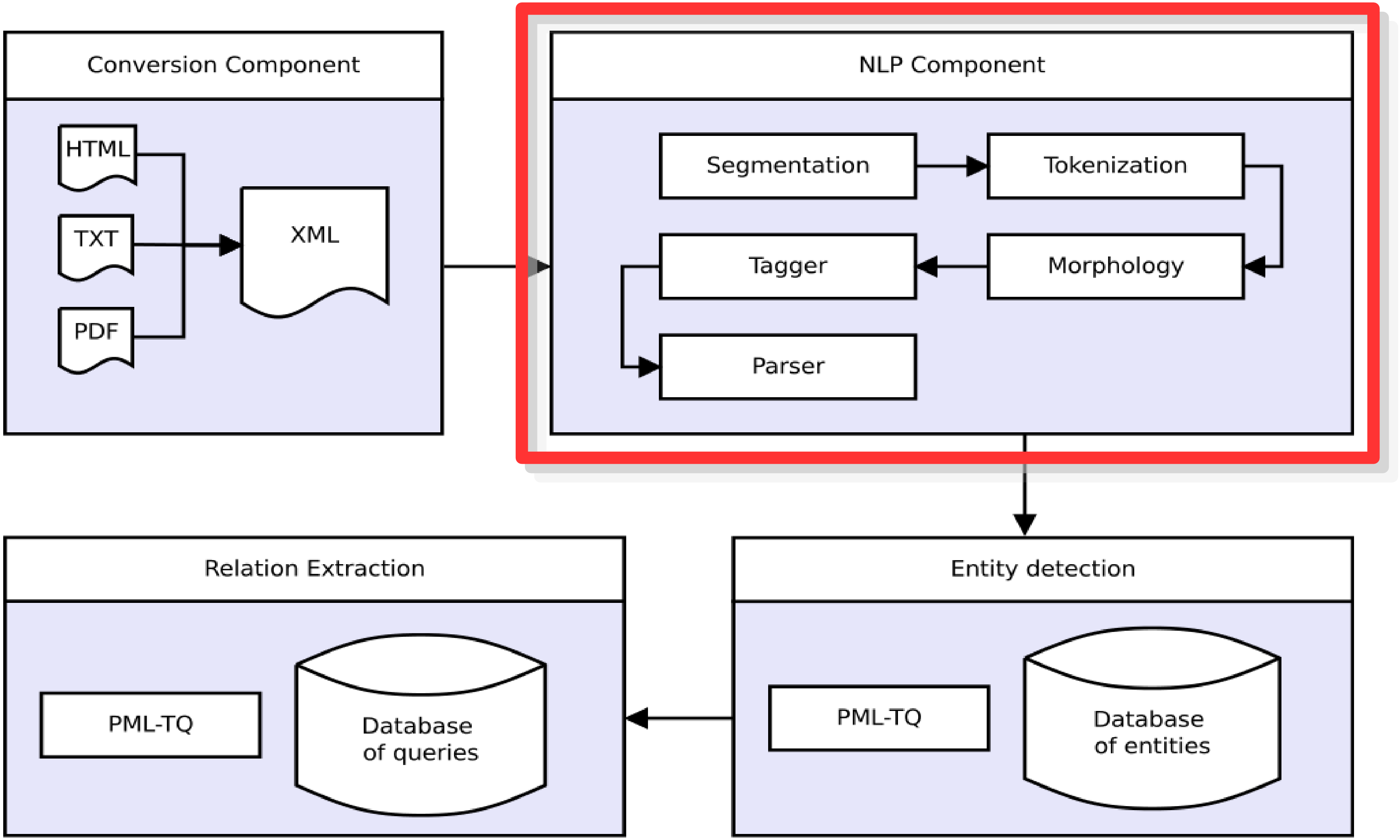


Conversion Component

- converts various input formats into a unified representation (XML)



RExtractor Architecture

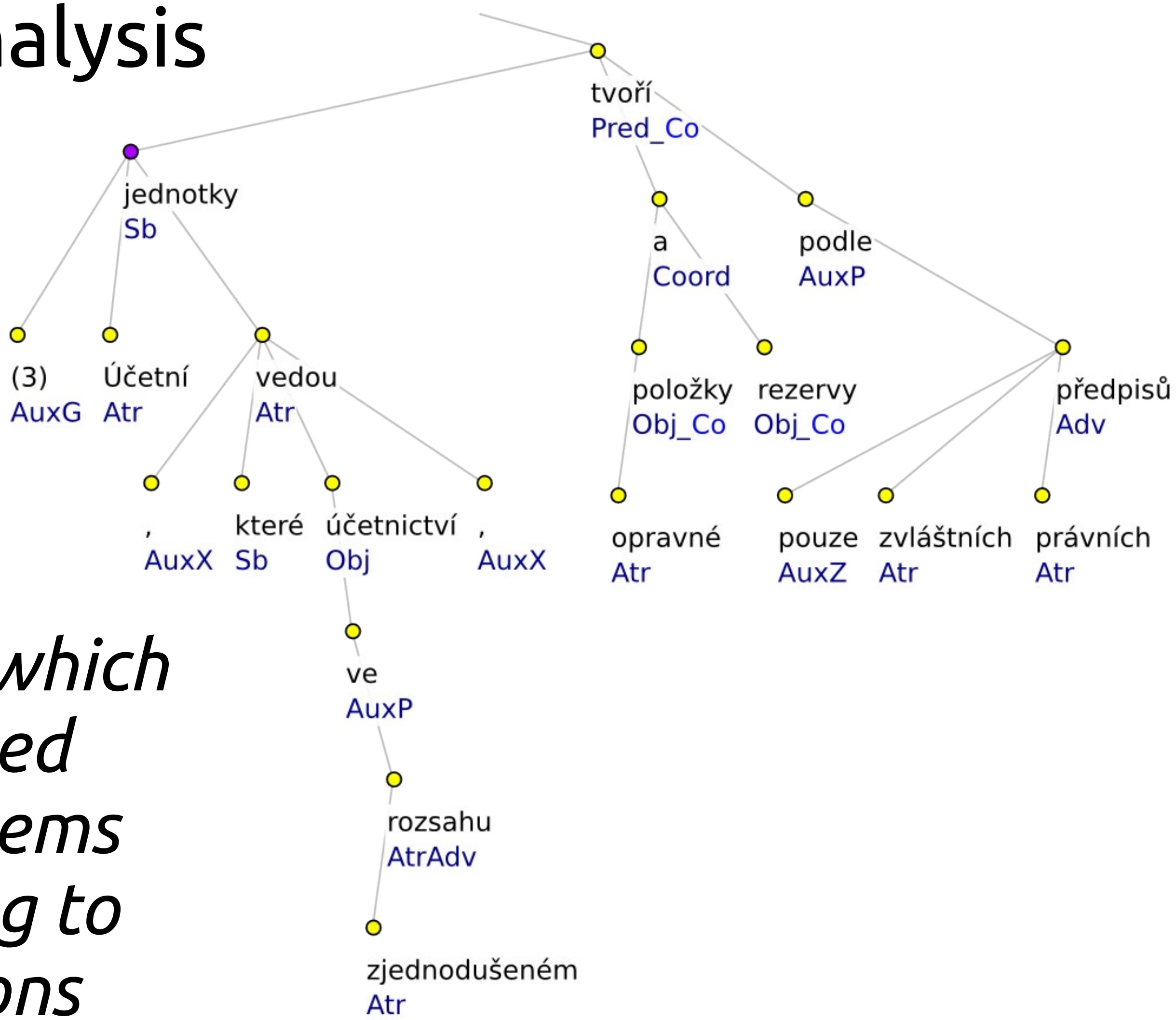


NLP Component

- **Prague Dependency Treebank** framework
  - http://ufal.mff.cuni.cz/pdt3.0
- **Tools**
  - segmentation & tokenization
  - lemmatization & morphology
  - syntactic parsing
  - Treex (http://ufal.mff.cuni.cz/treex)

NLP Component

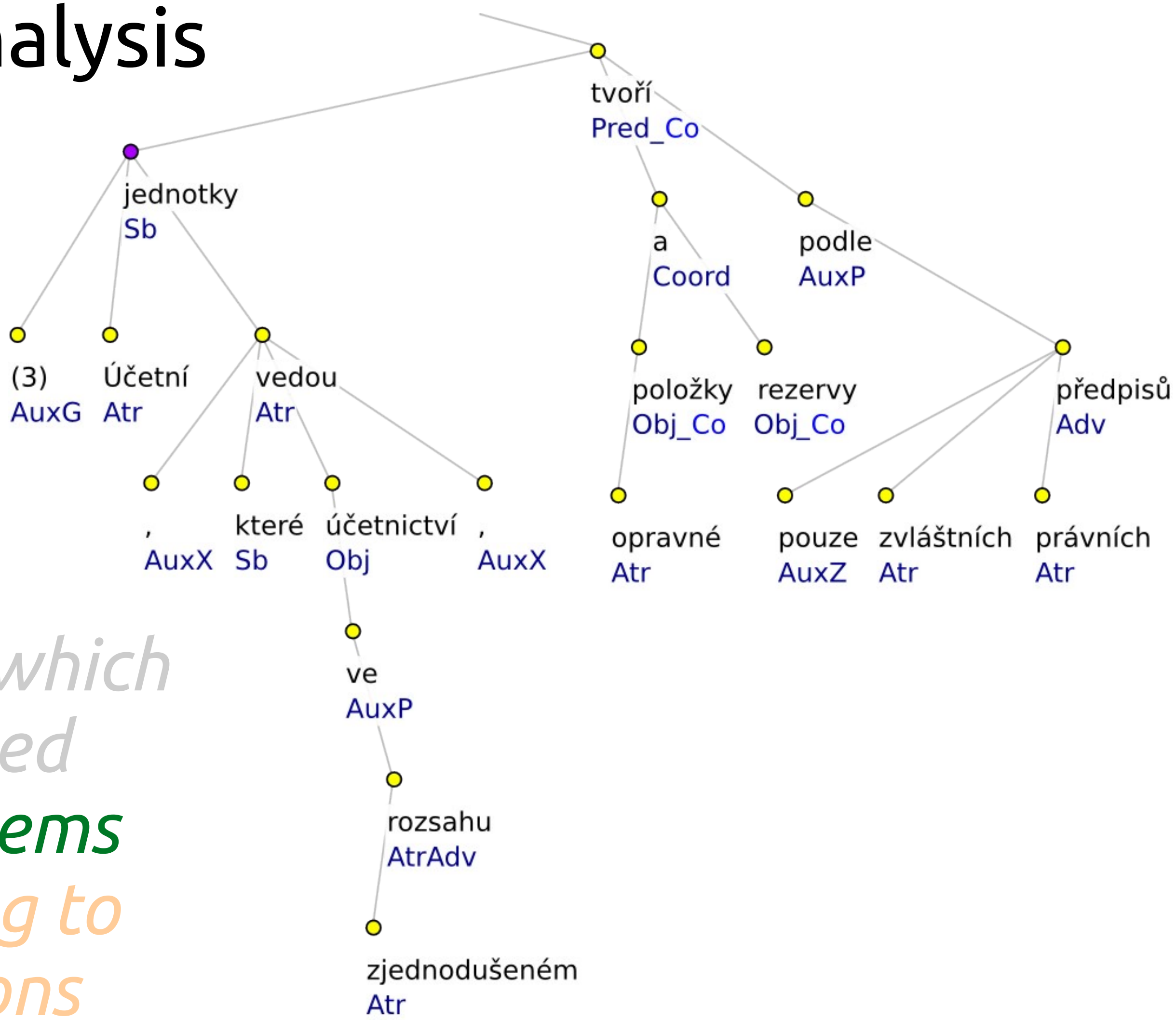
- Output of the analysis



(3) Accounting units, which keep books in simplified extent, create fixed items and reserves according to special legal regulations

NLP Component

- Output of the analysis



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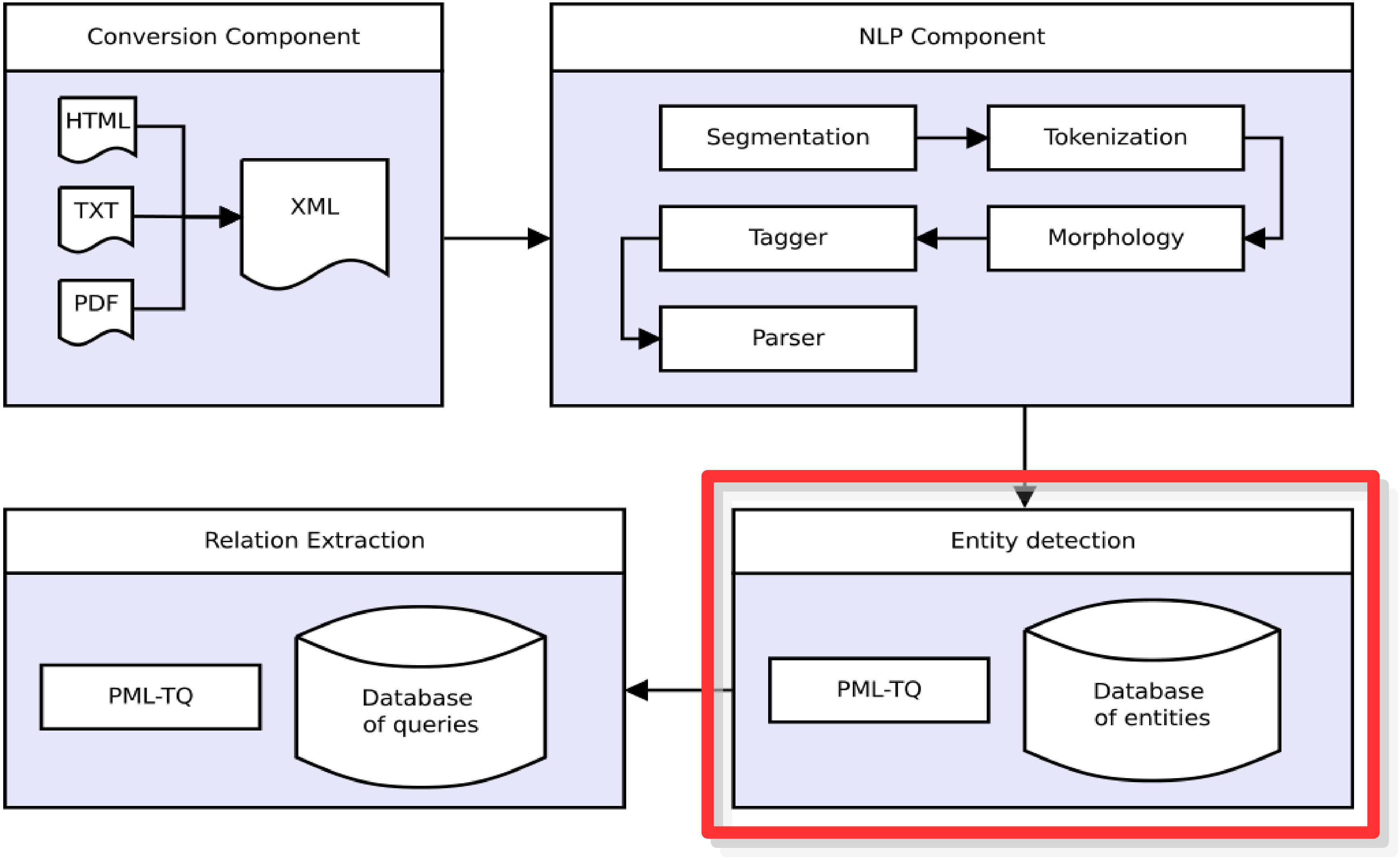
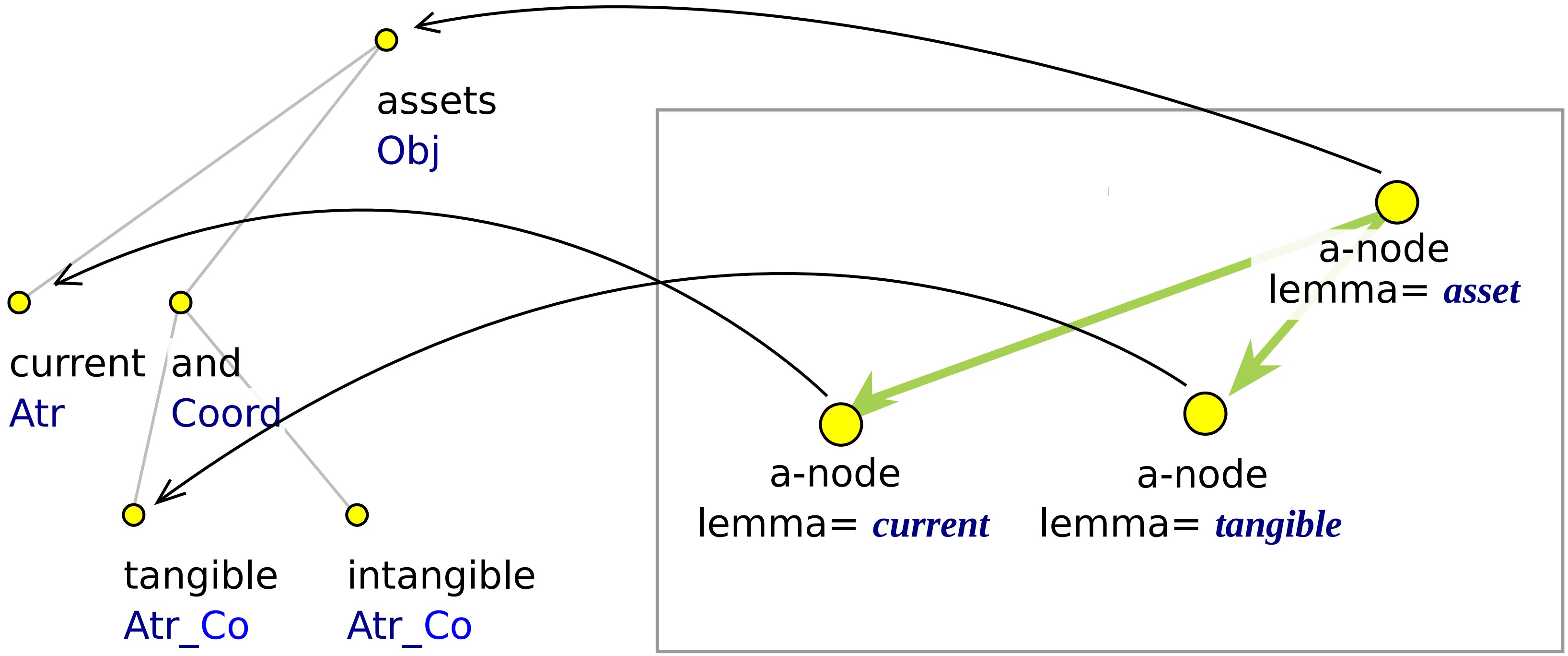


Entity Detection Component

- **Database of Entities**
  - entities specified by domain experts
- **PML-TQ** (http://ufal.mff.cuni.cz/pmltq)
  - tree queries better than regular expressions
    - coordination
    - several word forms in inflective languages
  - find the entity *current tangible assets* in the text *current tangible and intangible assets*

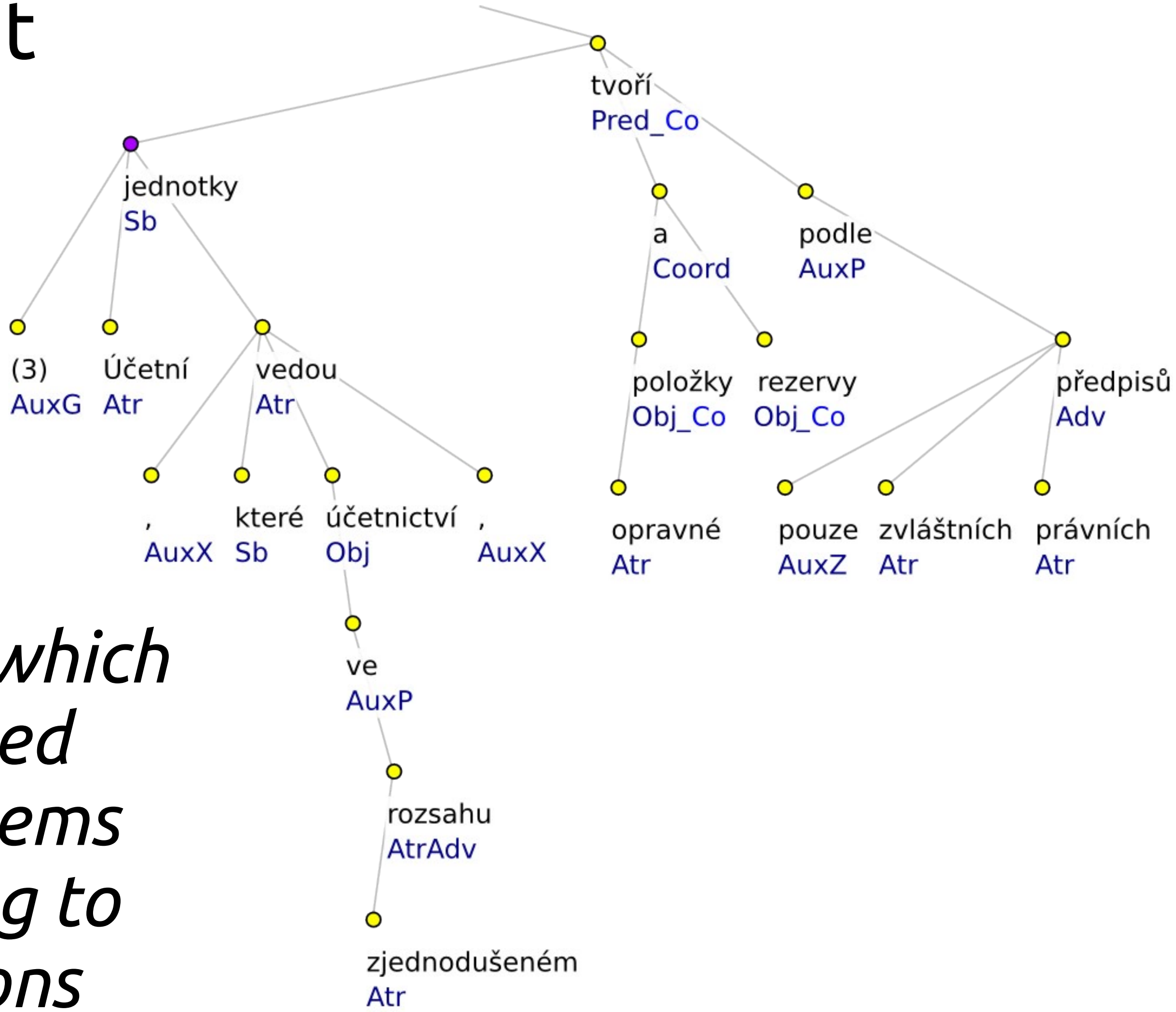
Entity Detection Component

- find the entity *current tangible assets* in the text *current tangible and intangible assets*



Entity Detection Component

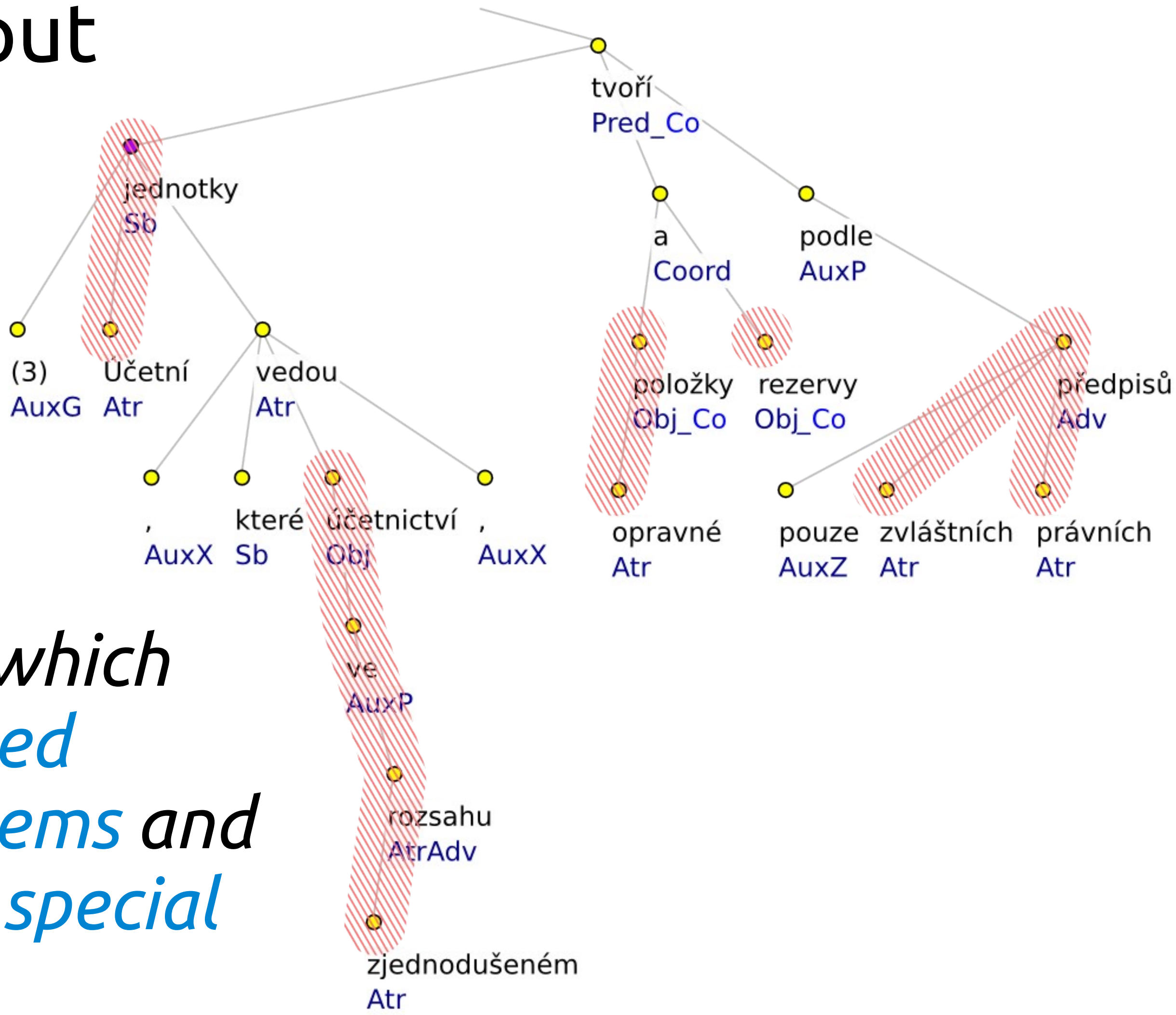
- Component input



(3) Accounting units, which keep books in simplified extent, create fixed items and reserves according to special legal regulations

Entity Detection Component

- Component output



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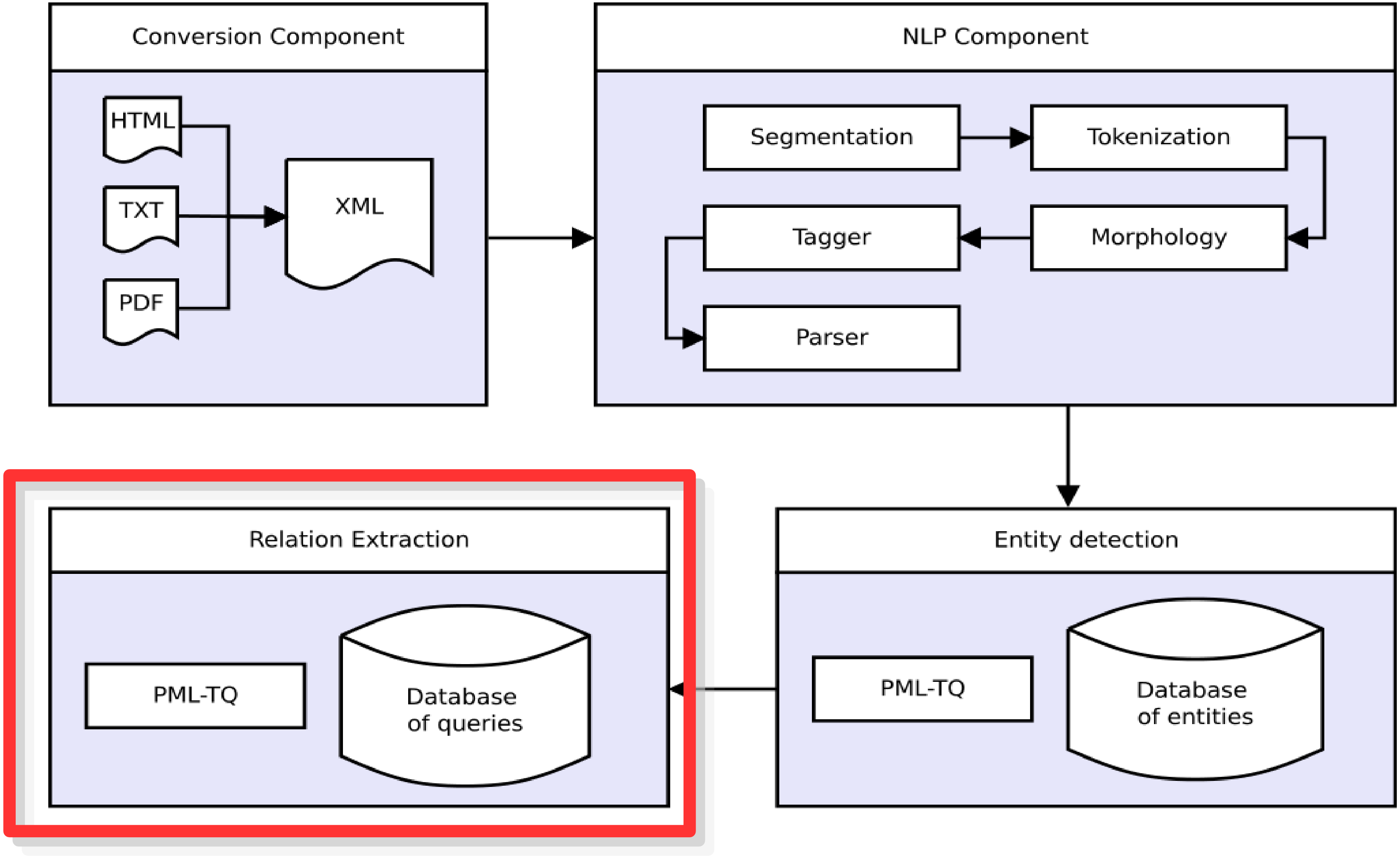
RExtractor Architecture

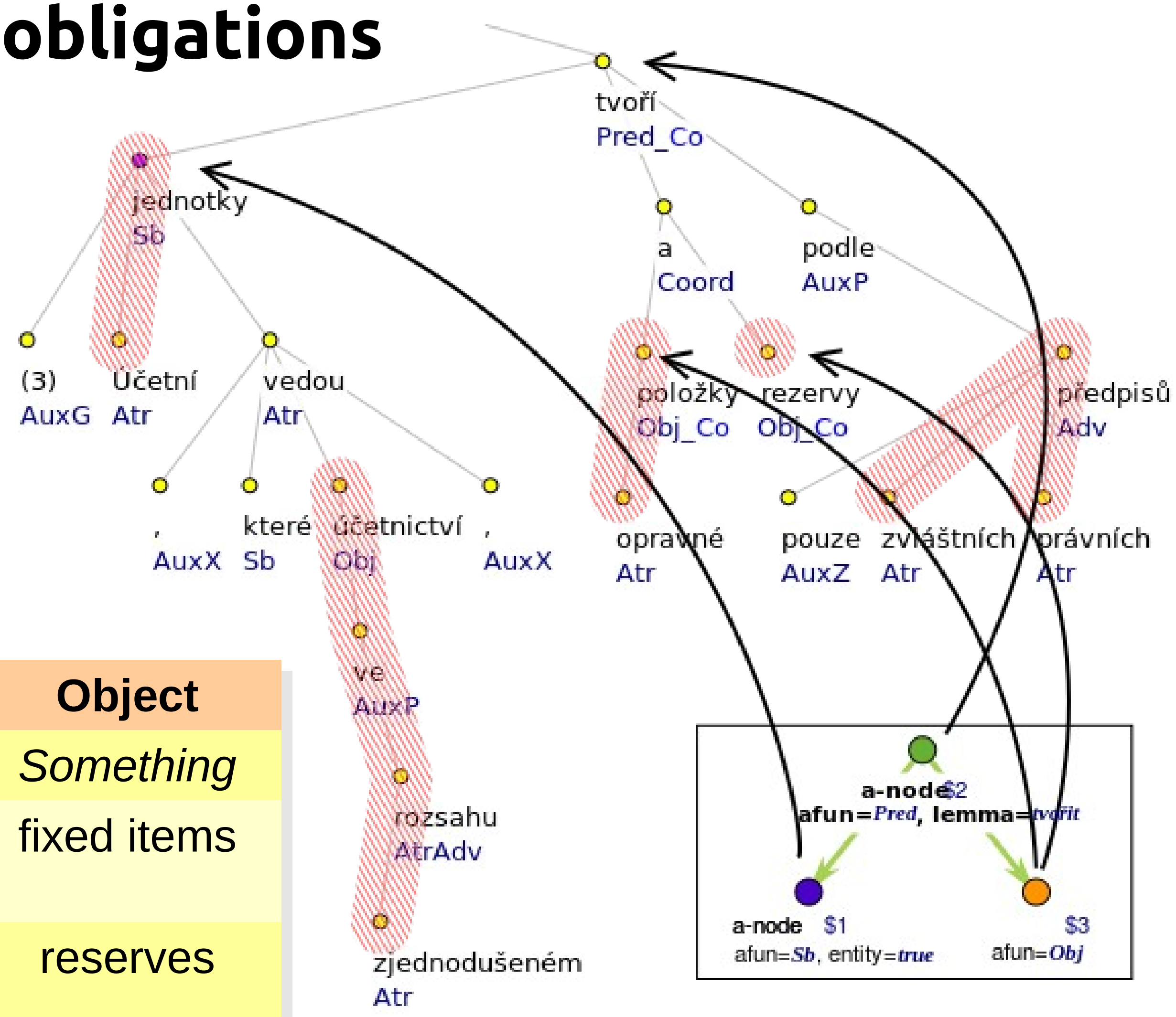


Relation Extraction Component

- **Database of Queries**
  - queries formulated by domain experts
  - their formulation in the form of PML-TQ queries on dependency trees
- **RDF ready output**
  - triples (*subject, predicate, object*)
  - each position
    - is annotated in a text (*text chunk)*
    - has a specific **ontological concept** *(RDF Class)*

Relation Extraction Component

- **Accounting units' obligations**



Subject	Predicate	Object
Entity	*hasToCreate*	*Something*
Accounting units	create	fixed items
Accounting units	create	reserves

Case study on legislative domain

Legal texts

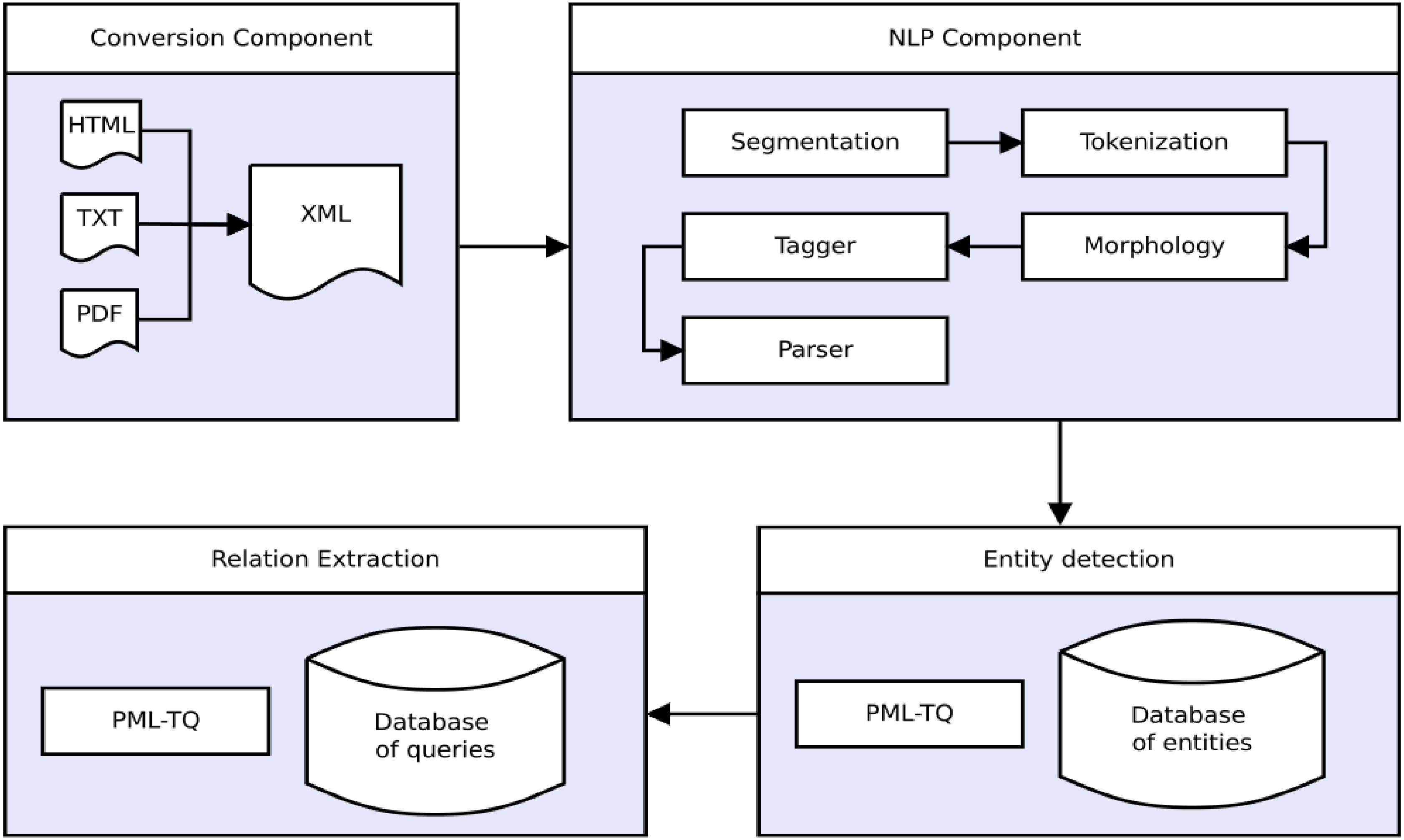
- specialized texts operating in legal settings
- they should transmit legal norms to their recipients
- they need to be clear, explicit and precise

Sentences

- simple sentences are very rare
- usually long and very complex

Legal texts are “generally considered very difficult to read and understand”. (Tiersma, 2010)

RExtractor Architecture



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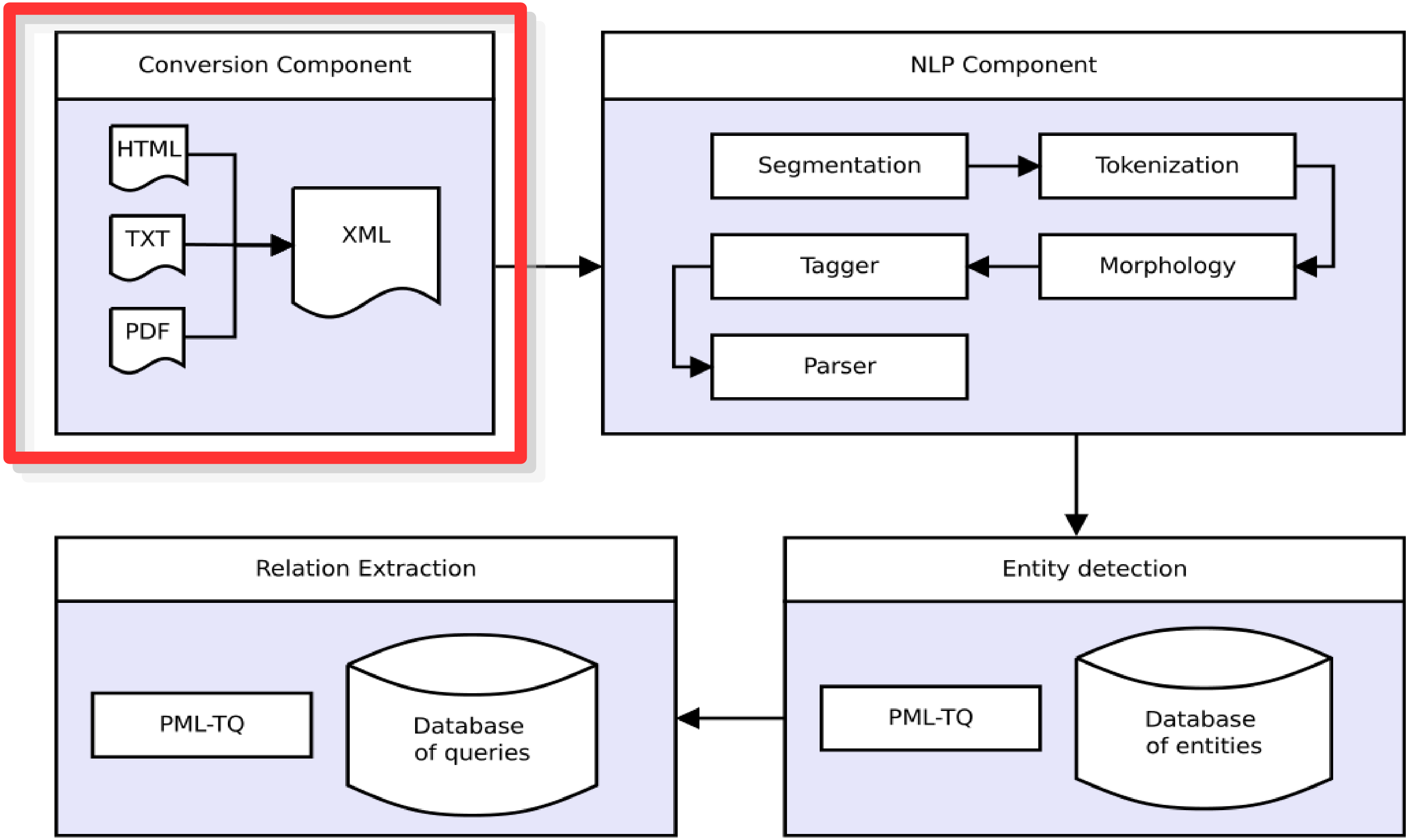

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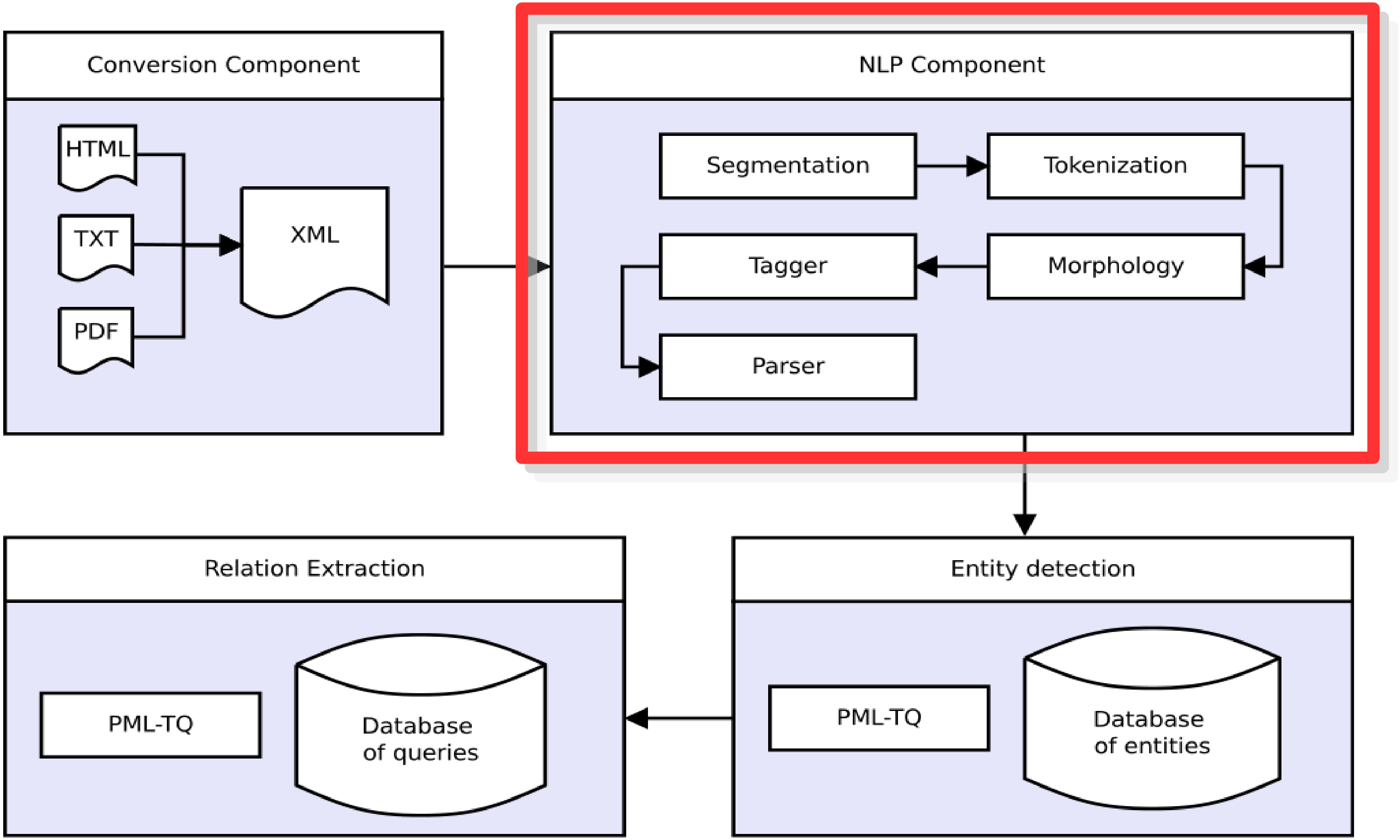


NLP Component

Automatic parsers for Czech

- trained on **newspaper texts**
- verification whether we can use the parser trained on newspaper texts or some modifications are needed
- **MST parser**
  - Ryan McDonald, Fernando Pereira, Kiril Ribarov, Jan Hajič (2005): Non-projective Dependency Parsing using Spanning Tree Algorithms. In: Proceedings of HLT/EMNLP, Vancouver, British Columbia.

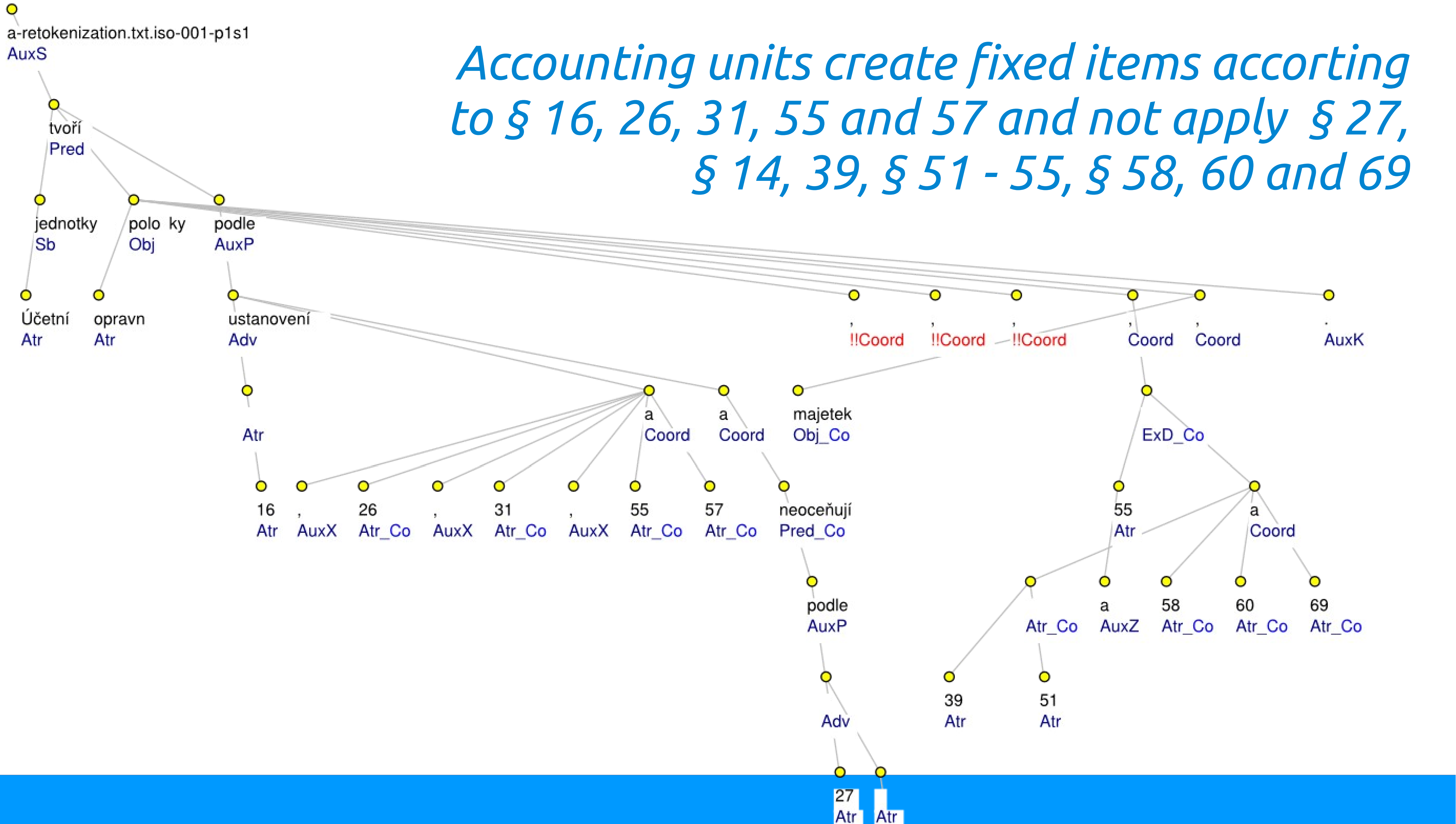
NLP Component

Corpus of Czech legal texts (CCLT)

- Accounting Act (563/1991 Coll.)
- Decree on Double-entry Accounting for undertakers (500/2002 Coll.)
- automatically parsed, then manually checked
  - 1,133 manually annotated dependency trees
  - 35,085 tokens

NLP Component

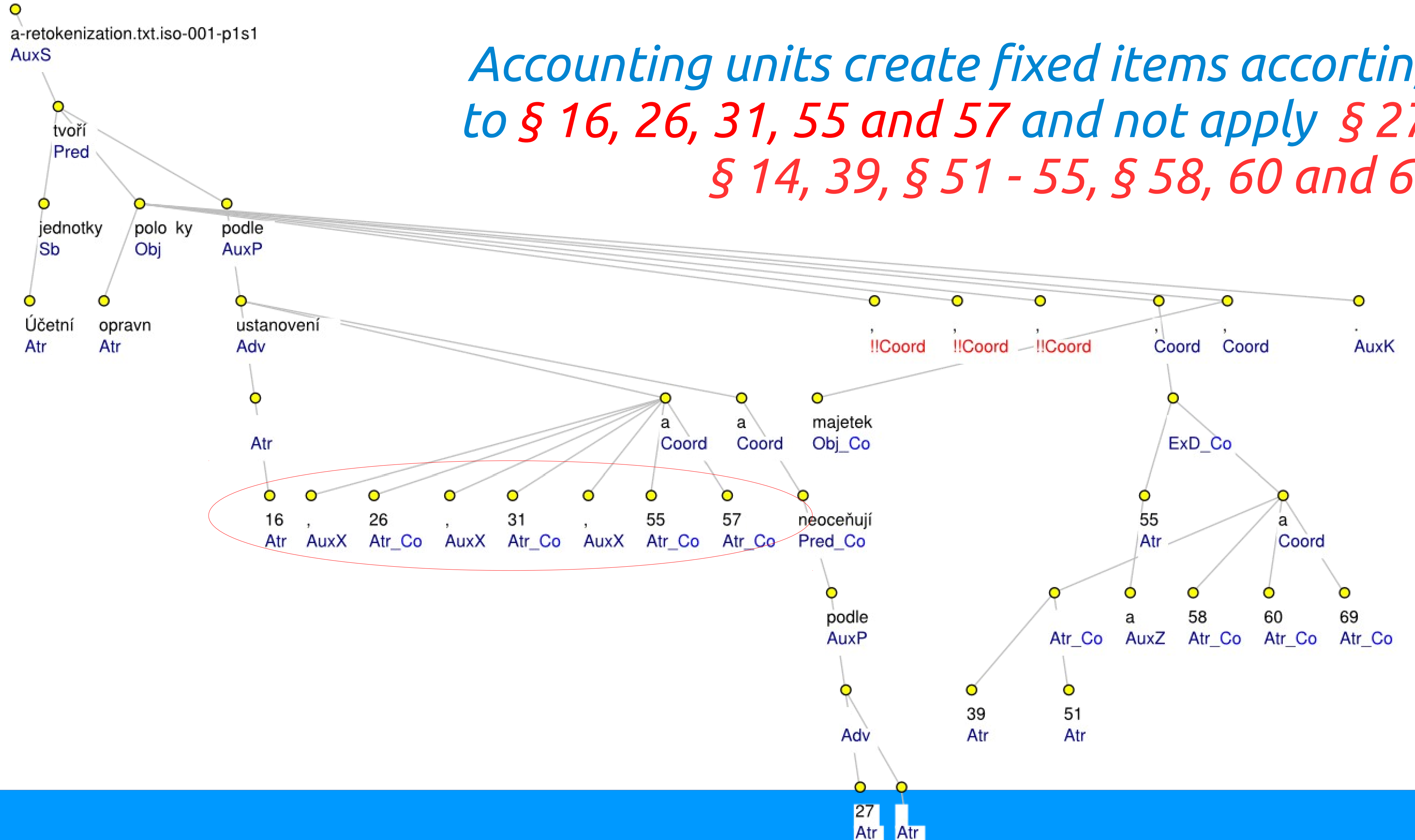
Re-tokenization



Accounting units create fixed items accorting to § 16, 26, 31, 55 and 57 and not apply § 27, § 14, 39, § 51 - 55, § 58, 60 and 69

NLP Component

Re-tokenization



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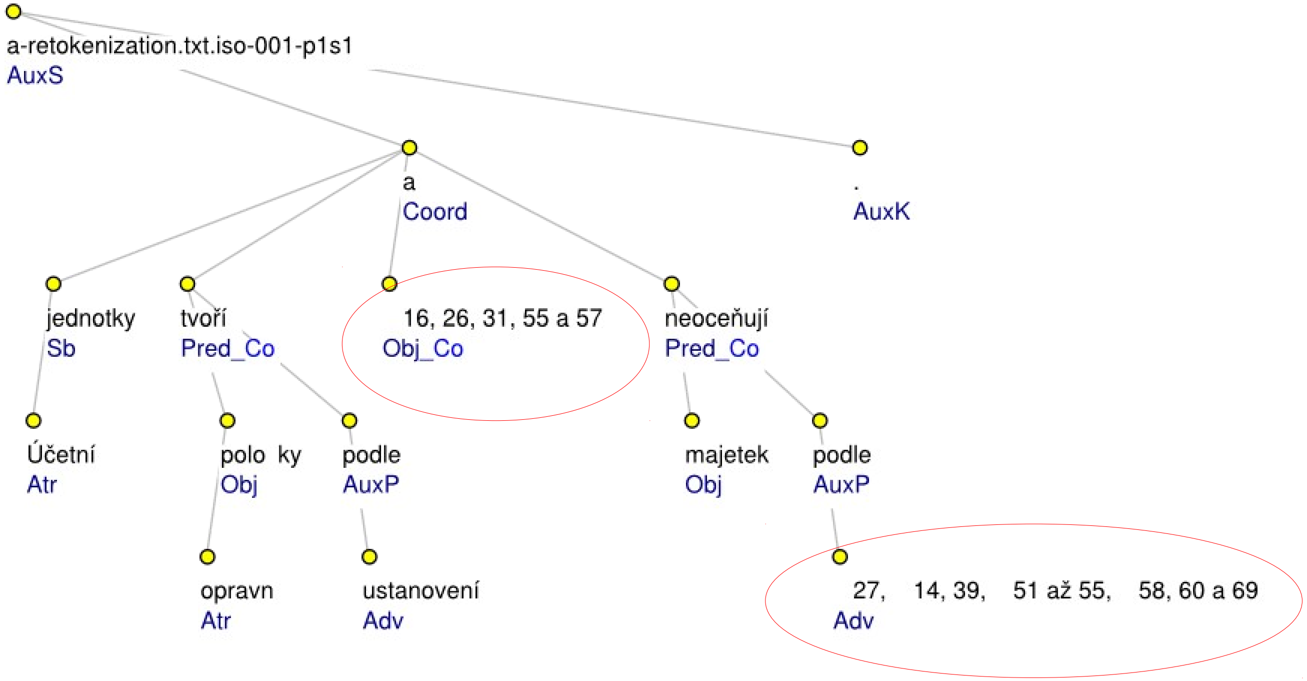

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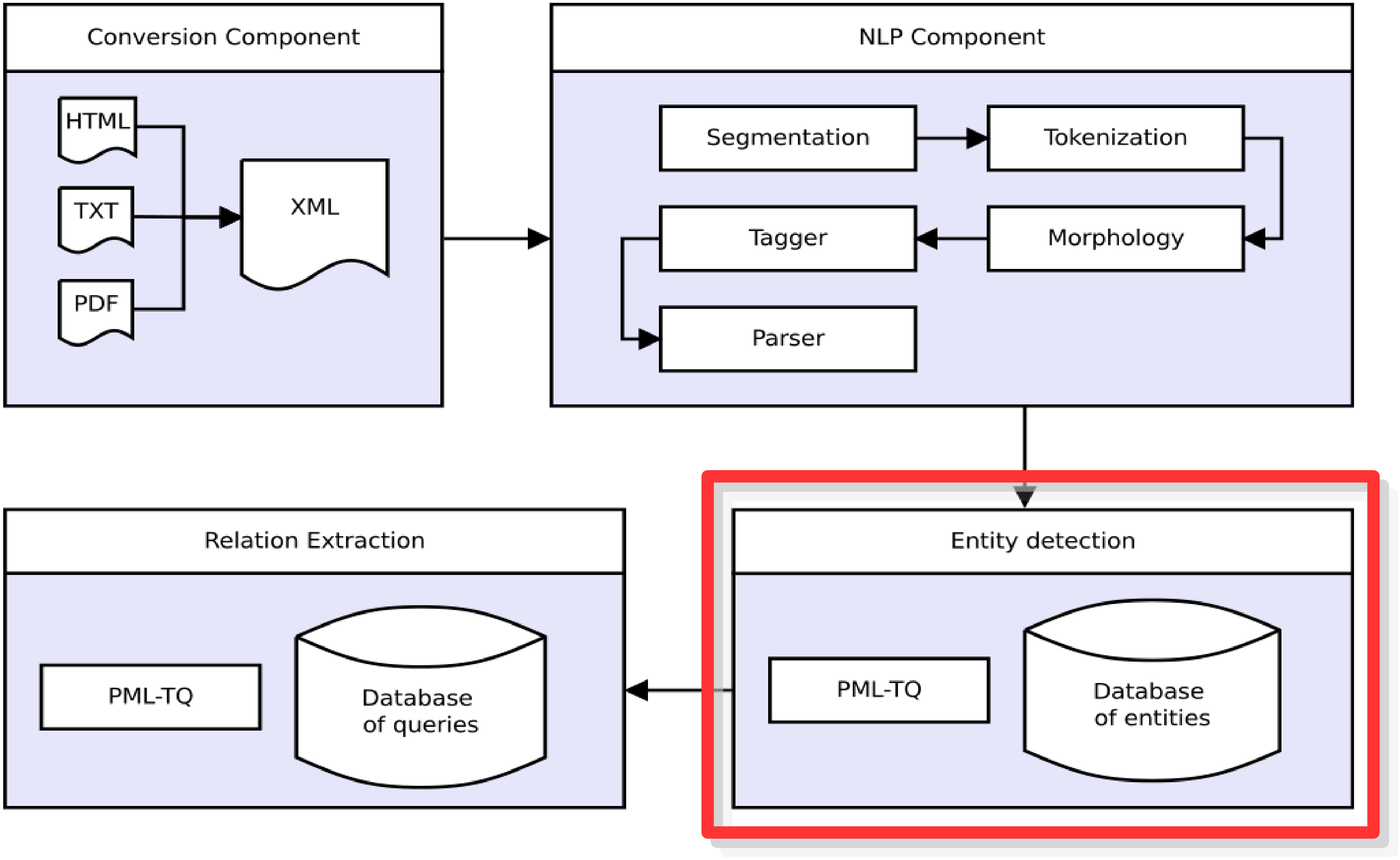
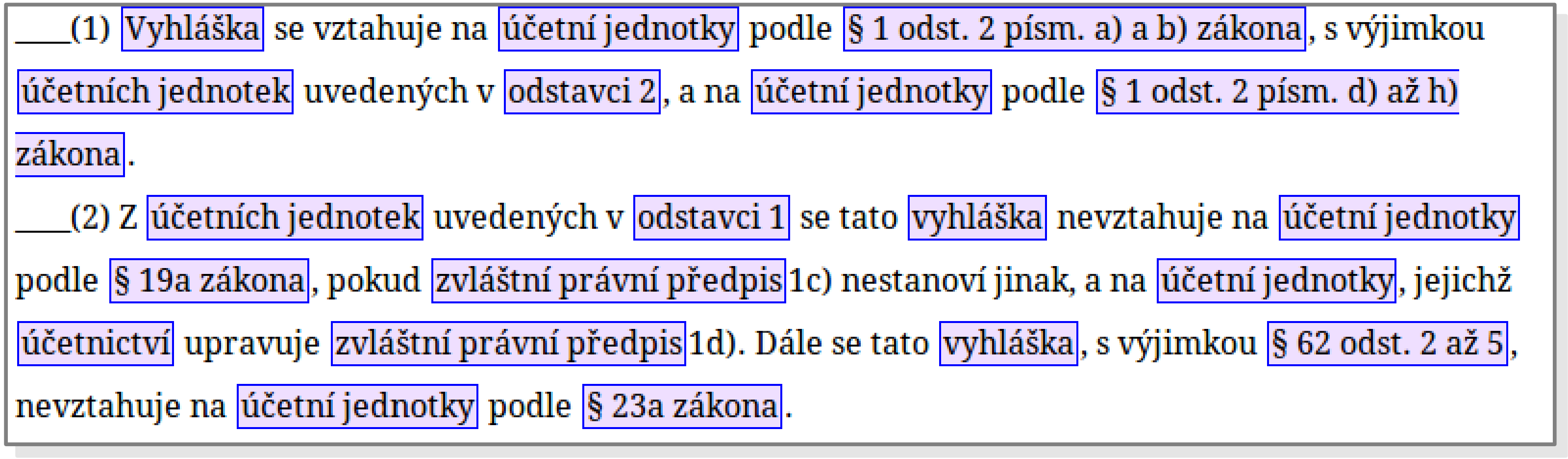


Entity Detection Component

Entities in CCLT

- Accounting subdomain
- Entities manually annotated by domain experts
  - Decree on Double-entry Accounting for undertakers (500/2002 Coll.)

Sample



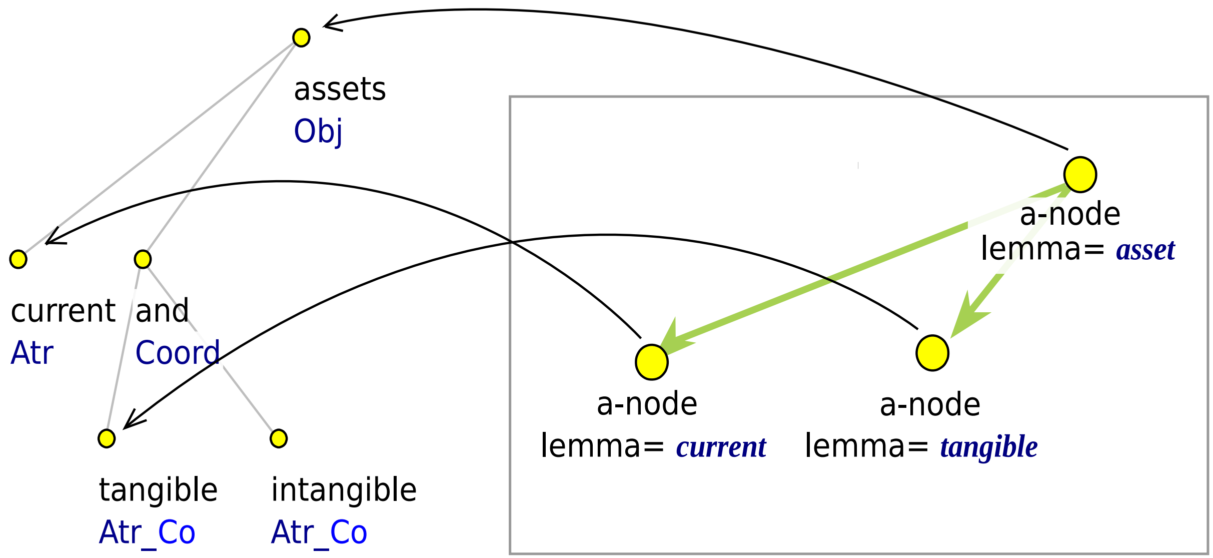
___(1) Vyhláška se vztahuje na účetní jednotky podle § 1 odst. 2 písm. a) a b) zákona, s výjimkou účetních jednotek uvedených v odstavci 2, a na účetní jednotky podle § 1 odst. 2 písm. d) až h) zákona.

___(2) Z účetních jednotek uvedených v odstavci 1 se tato vyhláška nevztahuje na účetní jednotky podle § 19a zákona, pokud zvláštní právní předpis1c) nestanoví jinak, a na účetní jednotky, jejichž účetnictví upravuje zvláštní právní předpis1d). Dále se tato vyhláška, s výjimkou § 62 odst. 2 až 5, nevztahuje na účetní jednotky podle § 23a zákona.

Entity Detection Component

Initializing DBE with entities from CCLT

- Each (unique) entity parsed automatically by MST
- Automatic procedure takes an entity dependency tree and creates a PML-TQ query



Entity Detection Component

Experiment

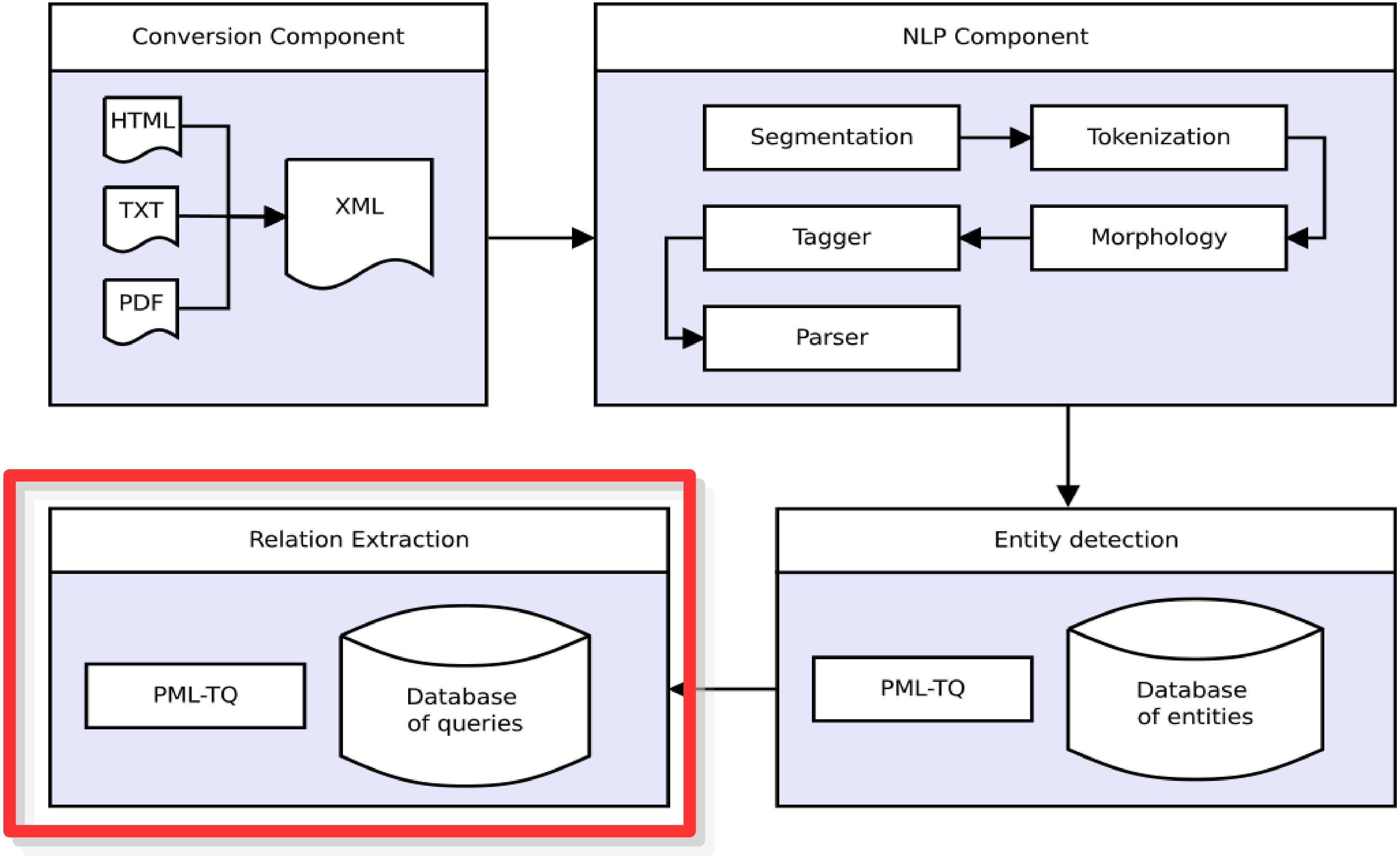
- identify entities in the gold standard trees in CCLT
  - with re-tokenized tokens and *(very) long* sentences
- identify entities in the trees created by MST
  - with re-tokenized tokens and split sentences

Parsing method	Extracted	TP	FP	FN	Precision	Recall
Manual	16428	9549	6879	628	58.1	93.8
Automatic	16160	9278	6882	838	57.4	91.7

Results

- high False positives
- automatic parser has low influence on detection

RExtractor Architecture



Relation Extraction Component

Manual design of queries

- Strategy: cover maximum of relations with minimum of queries
- tree query expert
  - observes typical constructions for a given relation type
  - designs a query for the most frequent construction
  - goes through matches and redesigns the query if needed

Relation Extraction Component

Types of relations

- **Definitions** **D**
  - entities are defined or explained
- **Obligations** **O**
  - an entity is obligated to do something
- **Rights** **R**
  - an entity has right to do something

Relation Extraction Component

Query design & evaluation on CCLT

- Query design
  - on *Accounting Act (563/1991 Coll.)*
  - 5 queries for **Definitions**
  - 4 queries for **Rights**
  - 2 queries for **Obligations**
- Evaluation
  - on *Decree on Double-entry Accounting for undertakers (500/2002 Coll.)*

Relation Extraction Component

Results

	D	R	O	Total
# of queries	5	4	2	11
Goldstandard	97	308	62	467
Extracted	70	255	41	366
True positive	53	206	36	295
False negative	44	102	26	172
False positive	17	49	5	71
Precision (%)	**75.7**	**80.8**	**87.8**	**80.6**
Recall (%)	**54.6**	**66.9**	**58.1**	**63.2**

Relation Extraction Component

Error analysis

Error	# of errors	Ratio
Parser	145	59.7%
Query	93	38.3%
Entity	5	2.1%

Results

- errors in automatic parsing
- query design

Scenario

- **Extracting knowledge base** 🟦
  - set of entities and relations between them
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Legal ontologies

- **Document structure**
  - Act » Expression » Section
- **Document semantic**
  - Legal Concepts Ontology (`lexc:`)
    - represents entities & relations
    - Concept » Concept Version
    - Property » hasDefinition, hasRight, hasObligation, …
  - Linguistic Ontology (`lingv:`)
    - links entities with their appearance in texts

Conclusion

- general pipeline for **extraction** and **representation** of information that is presented in raw texts
  - processes input texts by linguistically-aware tools
  - extracts entities and relations from sentence syntactic representation
  - Linked Data principles
- **Legal documents** as a pilot domain