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# Knowledge Graph-based System for Technical Document Retrieval

## A deductive reasoning-focused exploration

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September 5, 2024

# RESPONDING THESIS

Knowledge Graph-based System for Technical Document Retrieval
A deductive reasoning-focused exploration

- Research objective: Leveraging domain knowledge to enhance Information Retrieval in a technical context.
- CIFRE contract (financed by ANRT) between the Litis lab and the company Traceparts
- Began on March 15th 2021.

From a keyword-based search to a concept-based one.

# Traceparts

One of the world's leading CAD-content platforms for Engineering, Industrial Equipment and Machine Design. The CAD-content platform traceparts.com provides access to over 1.8 thousand supplier-certified product catalogues with 2D drawings, 3D CAD models and product datasheets.

- Technical content aimed at an engineering audience from multiple industries
- Content available in 25 languages
- Users can search using :
  - A full text search
  - A list of catalogues
  - Different classifications

traceparts

Product Content Everywhere™

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# Information Retrieval

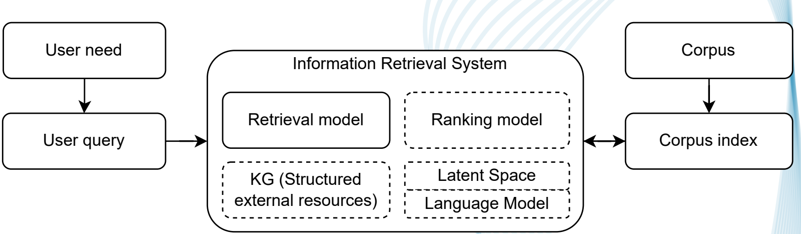


Figure: Information Retrieval System overview

Traditional approaches leverage statistics about the text corpus. Recent methods implement deep learning models and combines multiple approaches.

# BM25

BM25 (and its many variants) is:

- based on the Term Frequencies and Inverse Document Frequencies (TF-IDF)
- still widely used in practice
- computes many statistics offline

Traceparts search system is largely based on a BM25 implementation.

# Knowledge Graph and ontology

Knowledge Graph (Hogan et. al. 2021): *a knowledge graph is a graph of data intended to accumulate and convey knowledge of the real world, whose nodes represent entities of interest and whose edges represent relations between these entities.*

Ontology (Hogan et. al. 2021): *In the context of computing, an ontology is then a concrete, formal representation of what terms mean within the scope in which they are used (e.g., a given domain).*

In our work, we consider an ontology a particular component of a Knowledge Graph

# Knowledge Acquisition

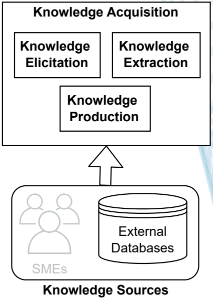


Figure: KGBS: Knowledge acquisition

# Knowledge modeling

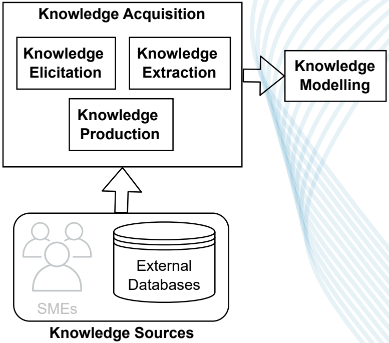


Figure: KGBS: Knowledge modeling

# Knowledge Graph

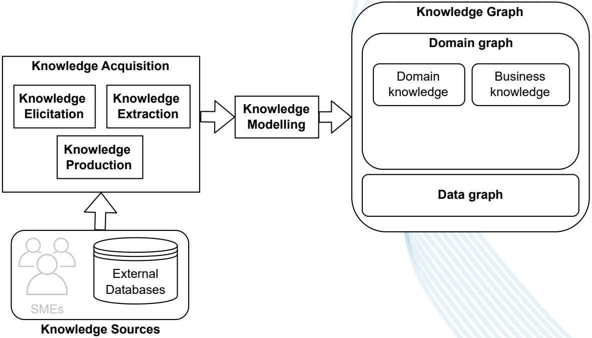


Figure: KGBS: Knowledge Graph

# Knowledge consumption

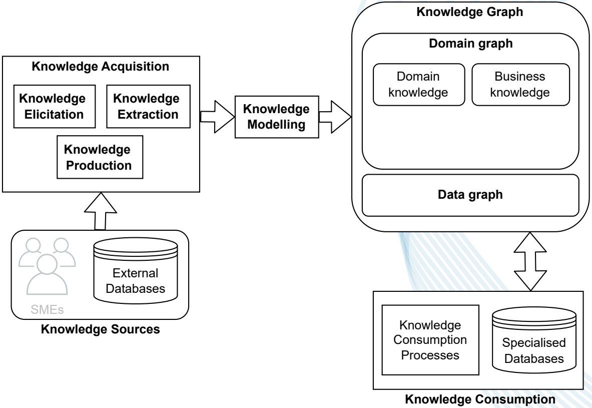


Figure: KGBS: knowledge consumption

# Knowledge Graph-Based System architecture

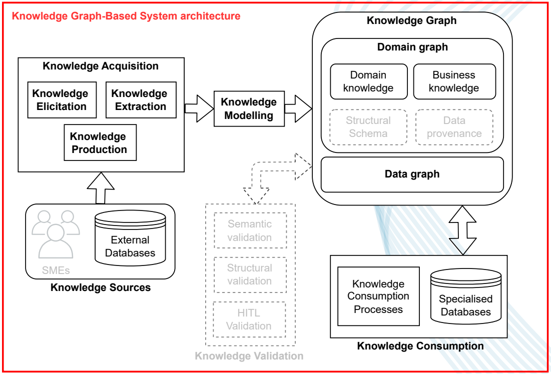


Figure: KGBS architecture

# Ontology Learning Applied Framework (OLAF)

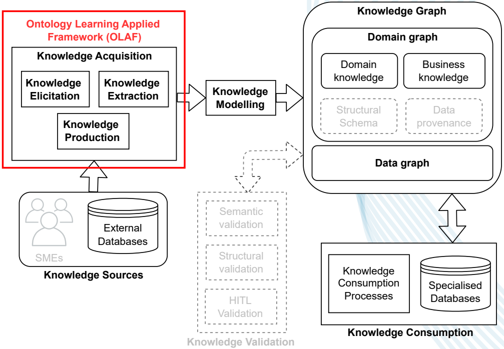


Figure: KGBS architecture: OLAF

# Information Retrieval ontology

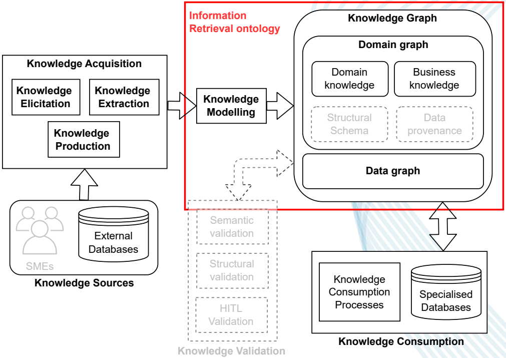


Figure: KGBS architecture: IR ontology

# Industrial experiments

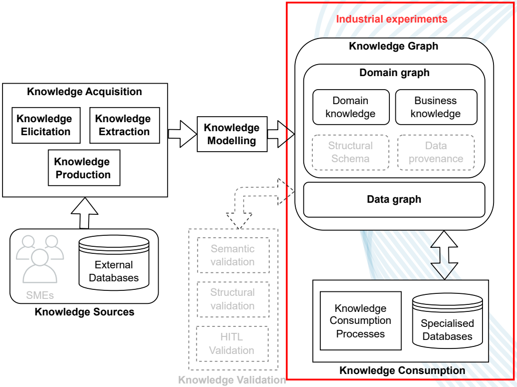


Figure: KGBS architecture: Industrial experiments

# In this presentation

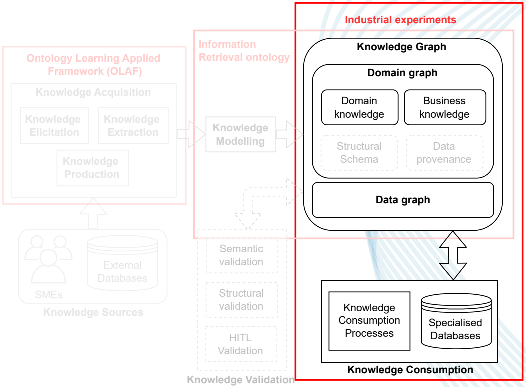


Figure: This presentation KGBS architecture components focus

## Corpus

- Over 1.1 million document families
- Over 127.8 millions individual documents
- 25 languages
- Documents' texts contain average 50 characters and 7 words
- Over 210 thousand tags, amongst which:
  - Over 2.5 thousand suppliers and manufacturers
  - Over 1.9 thousand catalogues
  - Over 208 thousand categories

Some text content examples are:

- *DIN 912*
- *The P01 to P08 pumps are designed to pump lubricating fluids (oil, diesel oil, etc.). Their flow rate is from 1 to 24 L / min; maximum working pressure 10 bar.*

# User searches

User text searches:

- are composed of domain-specific keywords, notations, identifiers, and acronyms.
- contain on average 13 characters separated into 2 words.
- can come in any languages

Some common search examples are:

*motor*, *din 912*, and *ball valve*.

# Traceparts search system challenges

Traceparts search challenges come from:

- Short multilingual texts
- Technical texts with many synonyms, acronyms, homonyms, and notations
- A large and heterogeneous corpus
- Multiple engineering domains coverage
- High recall but low precision

# Experiments objective

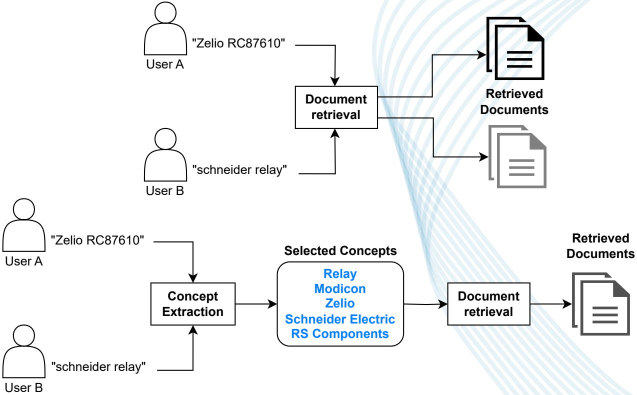
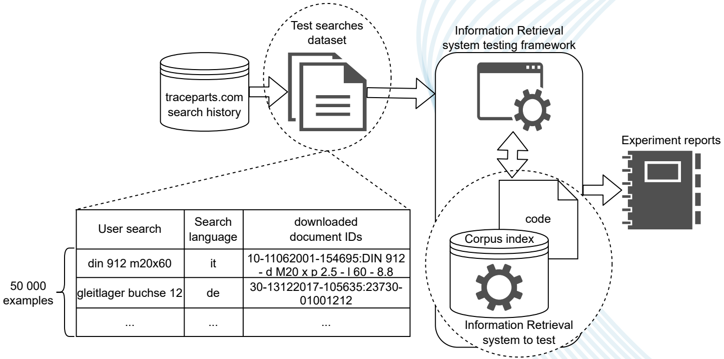


Figure: Text-based vs concept-based search.

# Evaluation metrics

- Mean Average Precision at k (MAP@k):
  - A sliding (or growing) precision window, averaged over a set of query examples.
  - Ranges from 0 to 1 (1 is the best value).
  - Gives information about the amount and positions of positive results in the k first ones.
- Binary Mean at k (BM@k):
  - Binary average over a set of query examples.
  - Ranges from 0 to 1 (1 is the best value).
  - Provides information about the amount of queries with a positive result in the k first ones.
  - Does not give any detail on the positive result position.

# Experiments protocol



| User search | Search language | downloaded document IDs |
|---|---|---|
| din 912 m20x60 | it | 10-11062001-154695:DIN 912 - d M20 x p 2.5 - l 60 - 8.8 |
| gleitlager buchse 12 | de | 30-13122017-105635:23730-01001212 |
| ... | ... | ... |

Figure: Experiments Protocol.

# Experiments

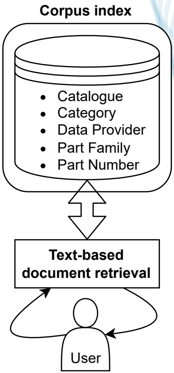
6 distinct systems built iteratively:

- *Text-based system (baseline)*
- Concept-based system
- **Knowledge Graph-based system with implicit knowledge**

Systems implementations:

- User search concept matching problem as an information retrieval task.
- Leverage user search history as implicit knowledge.
- Query concept enrichment as a graph traversal task.

# Text-based system (baseline)

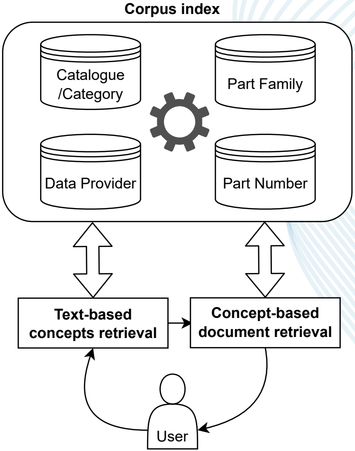


# Text-based system (baseline) results

|  | Text-based system (baseline) |  |
|---|---|---|
| **@k ↓** | **MAP@k** | **BM@k** |
| **@5** | 0.061 | 0.114 |
| **@25** | 0.064 | 0.148 |
| **@50** | 0.064 | 0.157 |
| **@100** | 0.064 | 0.161 |
| **@350** | 0.064 | 0.164 |

Table: Text-based system (baseline) results for different k values.

# Concept-based system

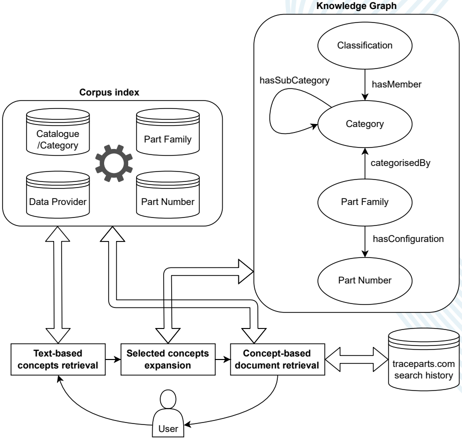


# Concept-based system results

| | Text-based system (baseline) | | Concept-based system | |
|---|---|---|---|---|
| **@k ↓** | **MAP@k** | **BM@k** | **MAP@k** | **BM@k** |
| **@5** | 0.061 | 0.114 | 0.152 | 0.243 |
| **@25** | 0.064 | 0.148 | 0.159 | 0.334 |
| **@50** | 0.064 | 0.157 | 0.160 | 0.371 |
| **@100** | 0.064 | 0.161 | 0.161 | 0.403 |
| **@350** | 0.064 | 0.164 | 0.161 | 0.429 |

Table: Text and concept-based systems results for different k values.

# Knowledge Graph-based system with implicit knowledge



# Knowledge Graph-based system with implicit knowledge results

| | Text-based system (baseline) | | Concept-based system | | KG-based system with search history | |
|---|---|---|---|---|---|---|
| **@k ↓** | **MAP@k** | **BM@k** | **MAP@k** | **BM@k** | **MAP@k** | **BM@k** |
| **@5** | 0.061 | 0.114 | 0.152 | 0.243 | 0.115 | **0.291** |
| **@25** | 0.064 | 0.148 | 0.159 | 0.334 | 0.122 | **0.471** |
| **@50** | 0.064 | 0.157 | 0.160 | 0.371 | 0.123 | **0.552** |
| **@100** | 0.064 | 0.161 | 0.161 | 0.403 | 0.123 | **0.624** |
| **@350** | 0.064 | 0.164 | 0.161 | 0.429 | 0.124 | **0.715** |

Table: Text, concept, and KG-based systems results for different k values.

## Quantitative results

| | **No results** | **Less than 400 results (non empty)** |
|---|---|---|
| **Text-based system (baseline)** | 64.48% | 35.44% |
| **Concept-based system** | 11.43% | **88.36%** |
| **KG-based system with search history** | **8.10%** | 51.59% |

Table: Comparing all search systems results set corpus.

# Conclusion

We have:

- Explored a Knowledge Graph-Based System (KGBS) architecture
- Detailed each KGBS containers and activities
- Explored a real-world use case moving from a text-based to a KG-based Information Retrieval (IR) System.
- Introduce and compared 3 IR systems:
  - A text-based IR system
  - A concept-based IR system
  - A KG-based IR system

KG-based systems for IR on a multi corpus of technical documents show promising results overcoming the text-based approaches limitations.

# Future works

- KGBS architecture:
  - Implement an end-to-end Knowledge Graph-Based System architecture use case.
  - Further explore the modularity of the architecture
  -
- Knowledge Graph-based Information Retrieval system:
  - Expand the Knowledge Graph
  - Enhance the concept matching task
  - Expand the approach to other domains

# Perspectives: Knowledge Graph

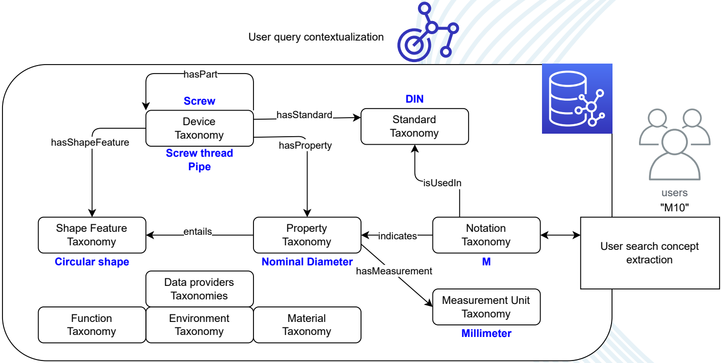


Figure: Extended semantic search example.

# Contributions

A top-down approach from a system perspective down to solution implementations.

Contributions:

- A unifying definition of Knowledge Graph
- An architecture for Knowledge Graph-Based Systems
- A framework for Ontology Learning
- An OWL Information Retrieval ontology
- A study of a text-based compared to a Knowledge Graph-based Information Retrieval system

# Scientific productions

Peer-reviewed international conference papers:

- An operational architecture for knowledge graph-based systems. Proceedings of the 26th International Conference KES2022.
- (with Marion Schaeffer) Olaf: An ontology learning applied framework. Proceedings of the 27th International Conference KES2023.

Open-source software library (with Marion Schaeffer):

- Ontology Learning Applied Framework Python library implementation: https://wikit-ai.github.io/olaf/

# Thank you!

Thank you for your time and attention.

I am now ready to answer to any questions.