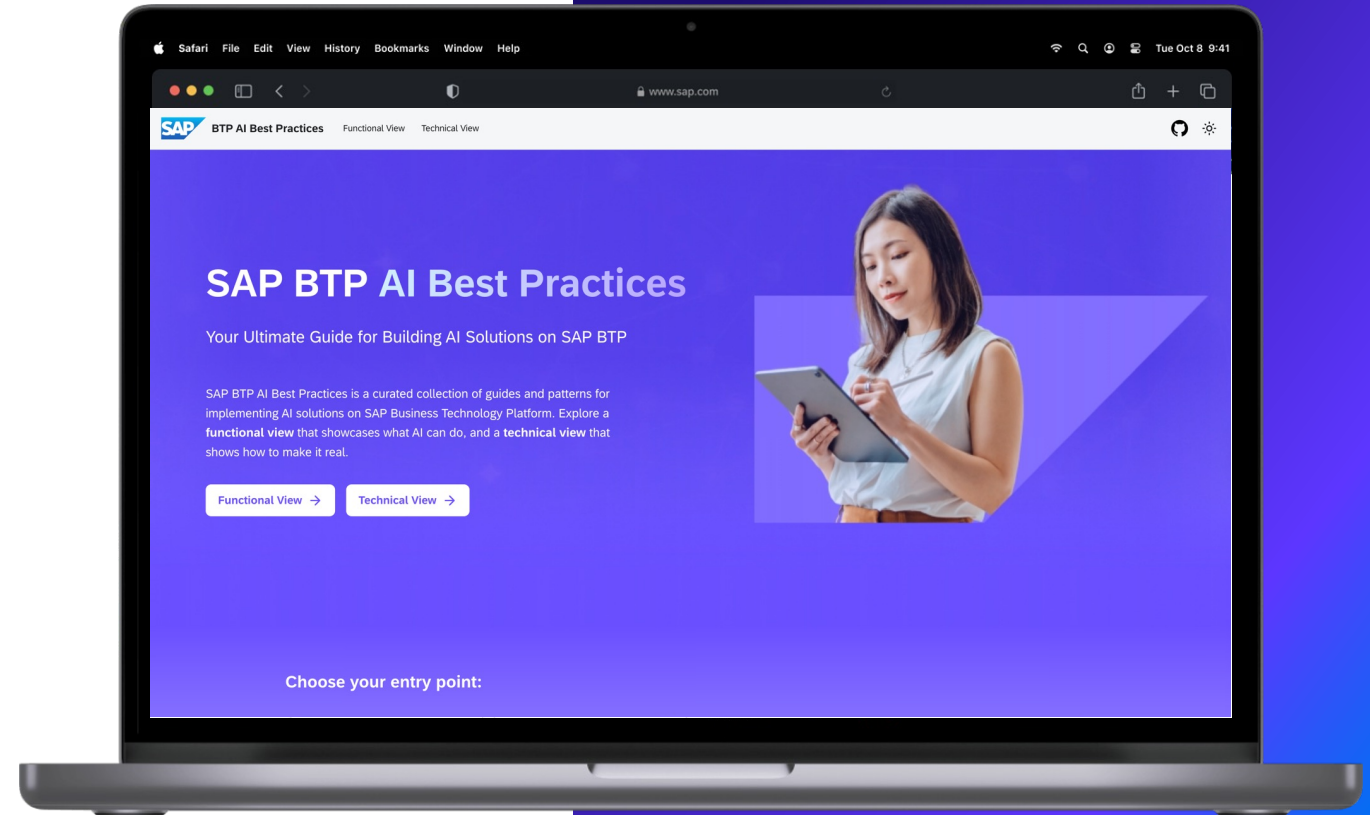


SAP BTP AI Best Practices

Knowledge Graph RAG - Query Pipeline

Graph-based Retrieval-Augmented Generation (RAG)
with Knowledge Graphs in SAP HANA Cloud



BTP AI Services Center of Excellence

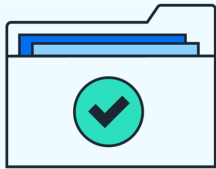
06.08.25

Steps

- 1 Overview**
- 2 Pre-requisites**
- 3 Illustration of the Process Through an Example**
- 4 Expand Your Knowledge**

Why is Knowledge Graph suitable for a query pipeline?

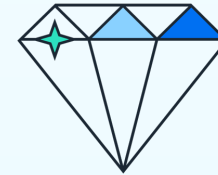
Overcoming limitations of traditional retrieval methods



**Retrieve: Structured
and semantic access**



**Augment: Contextual grounding
from RDF triples**



**Generate: Explainable
and traceable outputs**

Expected Outcome

Accurate, explainable responses grounded in structured business knowledge
Improved LLM performance through semantic augmentation and precise fact retrieval
Scalable GenAI with traceability, reduced hallucination, and faster decision support

Key Concepts

What is Graph RAG?

Pipeline Integration: The process of connecting your KG to other AI components (like LLMs) so you can use facts from the graph as part of a bigger workflow. For example, the KG gives expected object properties to the LLM before extraction.

Prompt Templating: Building a structured prompt that includes terms or properties from your KG. This lets you control what the LLM looks for when reading documents.

Business Traceability: The ability to show where every answer comes from, by linking LLM outputs back to facts in your KG. This is important for audits and trust.

Pre-requisites

Commercial

- SAP AI Core with the “Extended” tier on SAP BTP
- SAP HANA Cloud on SAP BTP
- SAP AI Launchpad

Technical

- Setup SAP Business Technology Platform (SAP BTP) subaccount ([Setup Guide](#))
- Create an instance of SAP HANA Cloud ([Setup Guide](#))
- Create an instance of SAP AI Core ([Setup Guide](#))
- Subscribe to SAP AI Launchpad ([Setup Guide](#))
- Enable ‘Triple Store’ on the SAP HANA Cloud Central tool during instance provisioning

SAP Business Technology Platform (SAP BTP)

- SAP Business Technology Platform (BTP) is an integrated suite of cloud services, databases, AI, and development tools that enable businesses to build, extend, and integrate SAP and non-SAP applications efficiently.

SAP AI Core

- SAP AI Core is a managed AI runtime that enables scalable execution of AI models and pipelines, integrating seamlessly with SAP applications and data on SAP BTP that supports full lifecycle management of AI scenarios.

SAP AI Launchpad

- SAP AI Launchpad is a multitenant SaaS application in SAP BTP. Customers can use SAP AI Launchpad to manage AI use cases (scenarios) across multiple instances of AI runtimes.

SAP HANA Cloud with Knowledge Graph Engine

- SAP HANA Cloud is a database as a service that powers mission-critical applications and real-time analytics with one solution at petabyte scale. Use relational, property graph, spatial, vector, and semi-structured data along with embedded machine learning to power intelligent data applications.
- SAP HANA Database Knowledge Graph Engine is a built-in capability that lets you model, store, and query enterprise knowledge as interconnected facts, giving your applications instant access to rich context and relationships without leaving the HANA environment.

High-level reference architecture

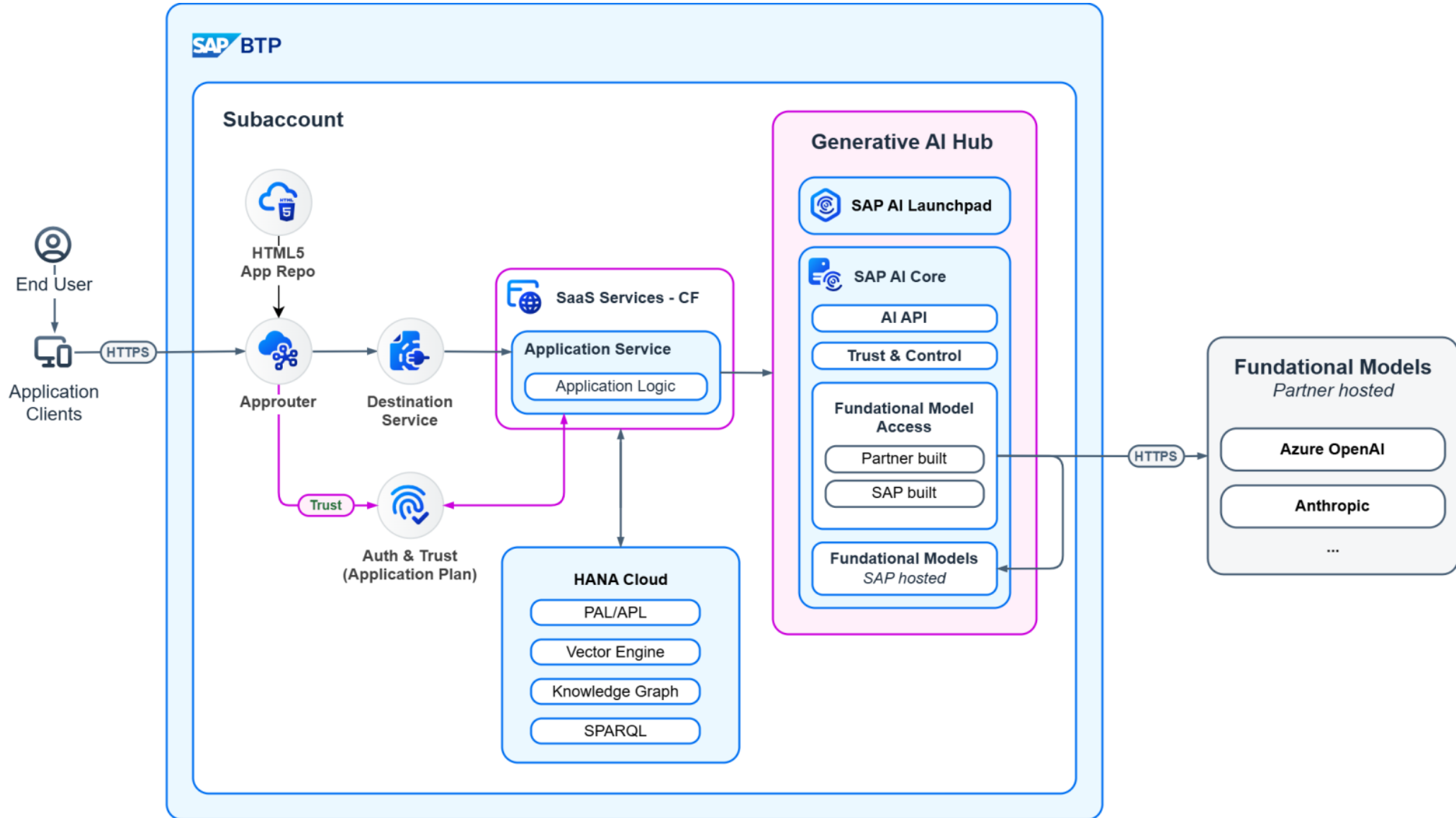


Illustration of the Process Through an Example

From Knowledge Graph to usable answers

Functions that make the pipeline reusable and repeatable:

`extract_and_store_kg_from_pdf`: Extracts facts from a PDF and stores them in HANA KG

`get_unique_relations`: Lists all property/relation types in the KG

`filter_relations_by_business_question`: Uses an LLM to choose only relevant relations

`get_triples_by_relations`: Retrieves matching triples for filtered relations

`ask_llm_sample`: Sends triples + question to LLM for human-like output

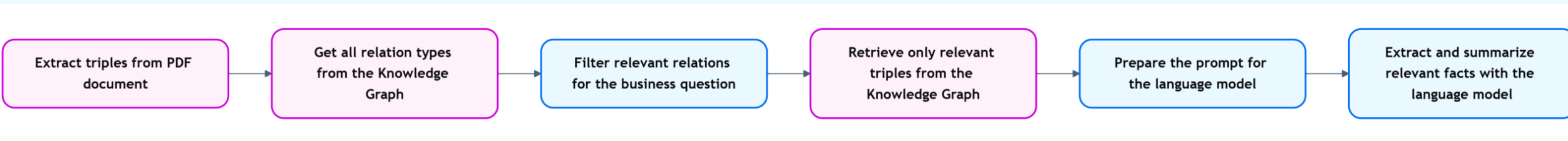
`clear_kg_graph`: Clears the KG after demo

`connect_hana` / `close_hana`: Manage DB connection

Case #1

Use a KG pipeline to answer business questions from documents

Pipeline Overview



Steps

1. Extract triples from PDF document
2. Get all relation types from the Knowledge Graph
3. Filter relevant relations for the business question
4. Retrieve only relevant triples from the Knowledge Graph
5. Prepare the prompt for the language model
6. Extract and summarize relevant facts with the language model

Case #1

Use a KG pipeline to answer business questions from documents

- A complete example showing how the Knowledge Graph pipeline works for a single document.
- We demonstrate the workflow from extraction to business-ready summary, so you can easily adapt it to your own scenarios.

```
1 business_question = "Summarize the energy efficiency of this motor."
2 pdf_filename = "A700000008070326.pdf"          # your PDF file with equipment spec
3 GRAPH_NAME = "KG_pdf_demo_01"
4
5 # 1. Extract triples from the PDF and store them in SAP HANA KG
6 triples = extract_and_store_kg_from_pdf(
7     pdf_filename=pdf_filename,
8     GRAPH_NAME=GRAPH_NAME,
9     KNOWLEDGE_TRIPLE_EXTRACTION_PROMPT=KNOWLEDGE_TRIPLE_EXTRACTION_PROMPT,
10    chat_llm=chat_llm,
11    dbapi=dbapi,
12    to_iri=to_iri,
13    to_literal=to_literal,
14    hana_env=hana_env
15 )
16
17 # 2. Get all property/relation names present in the new KG
18 relations = get_unique_relations(GRAPH_NAME, dbapi, hana_env)
19 print("All relations found in KG:", relations)
20
21 # 3. Use the LLM to filter only those relations that are relevant for the business question
22 relevant_relations = filter_relations_by_relations(GRAPH_NAME, relations, business_question, ask_llm_simple)
23 print("Relevant relations for the question:", relevant_relations)
24
25 # 4. Retrieve only the triples that match the relevant relations
26 triples_for_summary = get_triples_by_relations(GRAPH_NAME, relevant_relations, dbapi, hana_env)
27 print("Triples selected for summary:", triples_for_summary)
28
29 # 5. Build a summary with the LLM using only the relevant triples
30 if triples_for_summary:
31     # Create a prompt with the selected triples
32     summary_prompt = (
33         f"You are an equipment expert. Given the following technical facts:\n"
34         f"{triples_for_summary}\n"
35         f"Please provide a concise summary that answers this question: {business_question}\n"
36     )
37     summary = ask_llm_simple(summary_prompt)
38     print("=" * 60)
39     print("Summary:\n", summary)
40     print("=" * 60)
41 else:
42     print("No relevant facts found for this question in the current knowledge graph.")
43
44 # 6. (Optional) Clean up graph after demo
45 clear_kg_graph(GRAPH_NAME, dbapi, hana_env)
```

Case #1

Prompt with triples extracted from knowledge graph

Business question: Summarize the energy efficiency of this motor.

```
summary_prompt = (  
    f"You are an equipment expert. Given the following technical facts:\n"  
    f"{triples_for_summary}\n"  
    f>Please provide a concise summary that answers this question: {business_question}\n"  
)  
summary = ask_llm_simple(summary_prompt)
```

Conclusion:

The energy efficiency of the 1AV3112B SIMOTICS GP 112 M IM B5 4p motor varies depending on the voltage and frequency. At 400V and 50Hz, the motor has efficiency ratings of 88.6%, 89.2%, and other values. At 460V and 60Hz, efficiency ratings range from 87.7% to 90.0%. At 690V and 50Hz, efficiency ratings are 88.6% and 89.2%. These variations show how the motor's efficiency changes with different electrical conditions.

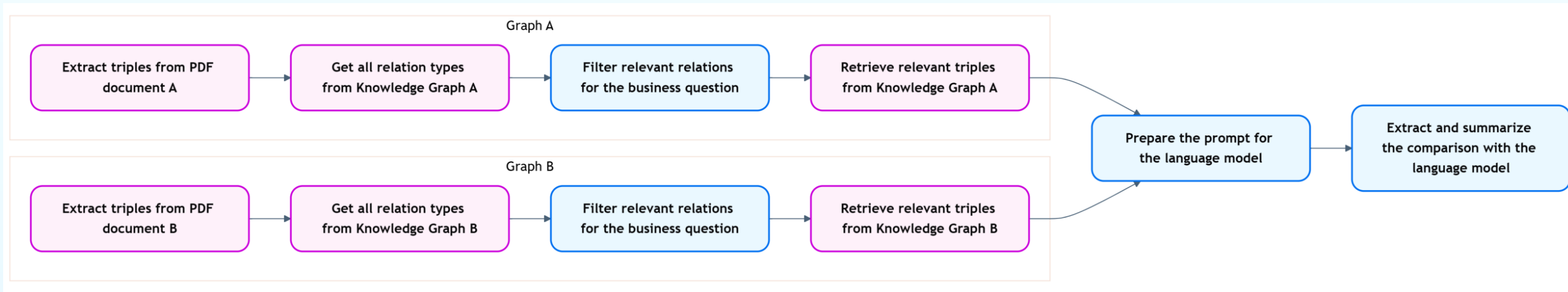
Triples selected for summary:

```
[('http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p', 'http://example.com/property/88.6%25%20at%20400V%20%394%2050Hz', 'has efficiency rating'),  
( 'http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p', 'http://example.com/property/90.0%25%20at%20460V%20%394%2060Hz', 'has efficiency rating'),  
( 'http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p', 'http://example.com/property/89.2%25%20at%20400V%20%394%2050Hz', 'has efficiency rating'),  
( 'http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p', 'http://example.com/property/89.5%25%20at%20460V%20%394%2060Hz', 'has efficiency rating'),  
( 'http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p', 'http://example.com/property/89.4%25%20at%20460V%20%394%2060Hz', 'has efficiency rating'),  
( 'http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p', 'http://example.com/property/89.3%25%20at%20460V%20%394%2060Hz', 'has efficiency rating'),  
( 'http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p', 'http://example.com/property/89.2%25%20at%20690V%20Y%2050Hz', 'has efficiency rating'),  
( 'http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p', 'http://example.com/property/87.7%25%20at%20460V%20%394%2060Hz', 'has efficiency rating'),  
( 'http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p', 'http://example.com/property/88.6%25%20at%20690V%20Y%2050Hz', 'has efficiency rating')]
```

Case #2

Compare Two Equipment Specifications for Substitution

Pipeline Overview



Steps

1. Extract triples from PDF document A and Extract triples from PDF document B
2. Get all relation types from Knowledge Graph A and Knowledge Graph B
3. Filter relevant relations from KG's for the business question
4. Retrieve relevant triples from both Knowledge Graphs
5. Prepare the prompt for the language model
6. Extract and summarize the comparison with the language model

Case #2

Compare Two Equipment Specifications for Substitution

- A complete example showing how the Knowledge Graph pipeline works for a dual-document comparison scenario.
- We demonstrate the end-to-end workflow to answer a substitution question using both documents.

```

1 pdf_filename_A = "A700000000070326.pdf" # Motor A
2 pdf_filename_B = "A7000000006779737.pdf" # Motor B
3 GRAPH_NAME_A = "KG_motor_A"
4 GRAPH_NAME_B = "KG_motor_B"
5 business_question = (
6     "Can Motor B replace Motor A in our setup? "
7     "Please focus on power rating and any other important technical attributes."
8 )
9
10 # 1. Extract triples and store in separate KGs
11 triples_A = extract_and_store_kg_from_pdf(
12     pdf_filename=pdf_filename_A,
13     GRAPH_NAME=GRAPH_NAME_A,
14     KNOWLEDGE_TRIPLE_EXTRACTION_PROMPT=KNOWLEDGE_TRIPLE_EXTRACTION_PROMPT,
15     chat_llm=chat_llm,
16     dbapi=dbapi,
17     to_iri=to_iri,
18     to_literal=to_literal,
19     hana_env=hana_env
20 )
21 triples_B = extract_and_store_kg_from_pdf(
22     pdf_filename=pdf_filename_B,
23     GRAPH_NAME=GRAPH_NAME_B,
24     KNOWLEDGE_TRIPLE_EXTRACTION_PROMPT=KNOWLEDGE_TRIPLE_EXTRACTION_PROMPT,
25     chat_llm=chat_llm,
26     dbapi=dbapi,
27     to_iri=to_iri,
28     to_literal=to_literal,
29     hana_env=hana_env
30 )

```

```

31
32 # 2. Get all relations from both KGs
33 relations_A = get_unique_relations(GRAPH_NAME_A, dbapi, hana_env)
34 relations_B = get_unique_relations(GRAPH_NAME_B, dbapi, hana_env)
35 all_relations = list(set(relations_A) | set(relations_B))
36 print("All relations in both KGs:", all_relations)
37
38 # 3. Use the LLM to filter only those relations relevant for the replacement question
39 relevant_relations = filter_relations_by_business_question(all_relations, business_question, ask_llm_simple)
40 print("Relevant relations for replacement decision:", relevant_relations)
41
42 # 4. Retrieve the relevant triples from each graph
43 triples_A_relevant = get_triples_by_relations(GRAPH_NAME_A, relevant_relations, dbapi, hana_env)
44 triples_B_relevant = get_triples_by_relations(GRAPH_NAME_B, relevant_relations, dbapi, hana_env)
45
46 print("Motor A relevant triples:", triples_A_relevant)
47 print("Motor B relevant triples:", triples_B_relevant)
48
49 # 5. Pass both sets of triples to the LLM for a side-by-side comparison
50 comparison_prompt = (
51     f"You are a technical expert. Here are the relevant technical facts for Motor A:\n"
52     f"{triples_A_relevant}\n"
53     f"And here are the relevant facts for Motor B:\n"
54     f"{triples_B_relevant}\n"
55     f"Based on these, answer the following business question: {business_question}\n"
56     f"Give a clear, practical comparison, and say whether Motor B can reasonably replace Motor A."
57 )
58 comparison = ask_llm_simple(comparison_prompt)
59 print("=" * 60)
60 print("Replacement comparison summary:\n", comparison)
61 print("=" * 60)
62
63 # 6. (Optional) Clean up graphs after demo
64 clear_kg_graph(GRAPH_NAME_A, dbapi, hana_env)
65 clear_kg_graph(GRAPH_NAME_B, dbapi, hana_env)

```

Case #2

Prompt with triples extracted from knowledge graph

Business question: Can Motor B replace Motor A in our setup?

```
comparison_prompt = (  
    f"You are a technical expert. Here are the relevant technical facts for Motor A:\n"  
    f"{triples_A_relevant}\n"  
    f"And here are the relevant facts for Motor B:\n"  
    f"{triples_B_relevant}\n"  
    f"Based on these, answer the following business question: {business_question}\n"  
    f"Give a clear, practical comparison, and say whether Motor B can reasonably replace Motor A."  
)  
comparison = ask_llm_simple(comparison_prompt)
```

Motor A relevant triples:

```
[('http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p',  
'http://example.com/property/sound%20level%2070.0%20dB%28A%29%20at%2060Hz', 'has load characteristic'),  
(('http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p',  
'http://example.com/property/sound%20level%2062.0%20dB%28A%29%20at%2050Hz', 'has load characteristic'),  
(('http://example.com/resource/1AV3112B%20SIMOTICS%20GP%20%2D%20112%20M%20%2D%20IM%20B5%20%2D%204p',  
'http://example.com/property/sound%20level%2074.0%20dB%28A%29%20at%2060Hz', 'has load characteristic'), .....]
```

Motor B relevant triples:

```
[('http://example.com/resource/RS%20PRO%203%20Phase%20AC%20motor', 'http://example.com/property/breakdown%20torque%203.15', 'has load characteristic'),  
(('http://example.com/resource/RS%20PRO%203%20Phase%20AC%20motor', 'http://example.com/property/rated%20torque%202.48%20Nm', 'has load characteristic'),  
(('http://example.com/resource/RS%20PRO%203%20Phase%20AC%20motor', 'http://example.com/property/no%2Dload%20current%201.05A', 'has load characteristic')....]
```

Conclusion:

****Motor B**** cannot reasonably replace ****Motor A**** in your setup for the following reasons:

- **Power Rating****: Motor A has a significantly higher power rating ranging from 3.70 kW to 4.55 kW depending on the voltage and frequency, whereas Motor B only has a power rating of 0.75 kW. This indicates that Motor B is underpowered compared to Motor A.
- **Efficiency****: Even though Motor B has an IE3 efficiency classification, its specific load efficiency percentages are lower than Motor A's efficiency ratings. Higher efficiency is critical for reducing operational costs and energy consumption
- **Speed Rating****: Motor A and Motor B have vastly different speed ratings. The setup may require a specific speed range that Motor B's single speed rating of 2885 RPM may not meet.....

Expand your Knowledge

Tutorials and Learning Journeys

Strategic Applications of Knowledge Graphs in AI

- [Knowledge graphs for LLM grounding and avoiding hallucination](#) Leverage our unique structured and unstructured knowledge assets (business data models, business process metadata and documentation) for generative AI scenarios
- [Leveraging Generative AI Advancements for Linked Business Data](#) Dives into various aspects of SAP's approach to generative AI, and its technical underpinnings
- [SAP launches collaborative AI agents, adds Knowledge Graph](#) SAP promises that its AI copilot, Joule, will support 80% of its most-used business tasks by year end

Practical Use and Tutorials

- [Explicit knowledge representation and reasoning with Knowledge Graphs: introduction & use case](#) Explore how SAP HANA Cloud is further increasing its multi-model capabilities by supporting also RDF-based Knowledge Graphs and SPARQL querying and we will see a real-world business application of this
- [Gain hands-on experience with SAP HANA Graph - YouTube](#) Deep dive into SAP HANA Graph capabilities, explaining numerous use cases and specific benefits

Expand your Knowledge

Additional Materials

Other articles

- [Combining Knowledge Graphs and Large Language Models](#) This research has systematically reviewed 28 papers on combining KGs and LLMs to highlight key methods, trends, and challenges for building more trustworthy AI solutions.
- [HybridRAG: Integrating Knowledge Graphs and Vector Retrieval Augmented Generation for Efficient Information Extraction](#) The HybridRAG method combines knowledge graph-based search and vector search in the HybridRAG approach, improving both search and answer accuracy, outperforming traditional RAG methods in financial Q&A problems and offering broader applicability to other domains.
- [Using LLMs for the Extraction and Normalization of Product Attribute Values](#) This paper investigates how LLM's can be used to extract and normalize attribute-value pairs from product titles and descriptions on e-commerce websites, enabling accurate product filtering and recommendations.

Reference Code

- [SAP BTP AI Best Practices - Sample Code](#)

Contributors



Rzhaksynskyi, Andrii



Marques, Luis



CIGAINA, MARCO

Thank you