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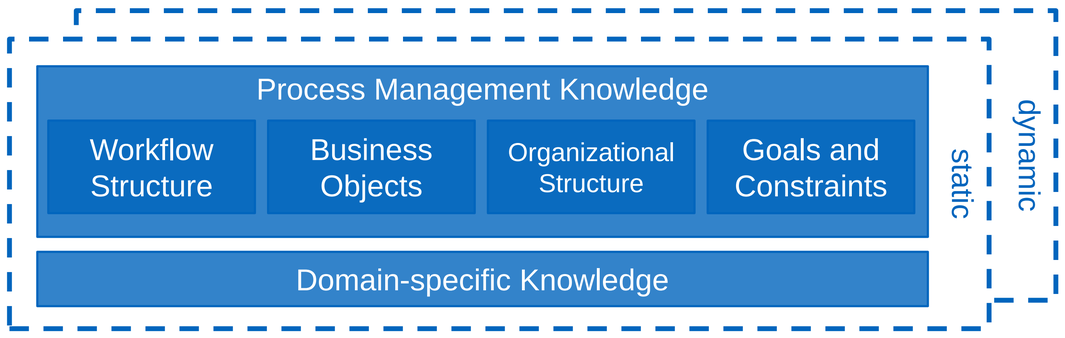
Knowledge Graph Reasoning for Intelligent and Explainable Business Process Technologies

Knowledge in Business Processes

The management and execution of business processes involve a large and diverse set of knowledge.



The Business Process Management (BPM) field commonly reasons about the following dimensions of knowledge:

- **Workflow Structure**, i.e., which activities exist and how they relate
- **Business Objects** that are created and required by activities
- **Organization Structure**, i.e., which (human) resources exist, how do they relate to each other, which activities can they perform
- **Goals and Constraints** for activities, processes, or the organization as a whole

Further, knowledge about **domain-specific entities**, such as symptoms and treatments in medicine or loan goals and risk classes in finance, is relevant for business processes.

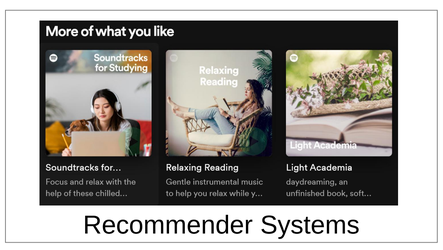
However, these knowledge dimensions are usually not holistically considered in Business Process Management Systems.

Knowledge Graph Reasoning

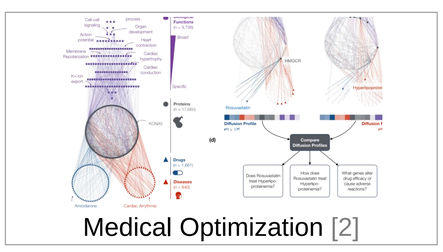
Knowledge graphs (KGs) are graphs of data which
- represent real-world entities of interest and their relations
- are enhanced with context in the form of, e.g., schema, annotations, identity, ontologies, or rules [1]

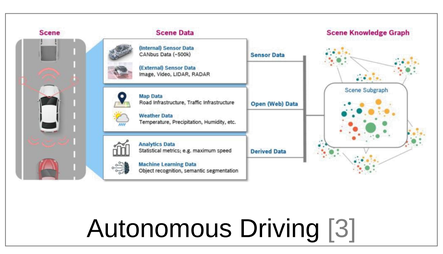
Knowledge graphs allow to integrate a broad width of knowledge on which reasoning and knowledge retrieval can be performed. They are used, i.a., for:

Knowledge Retrieval



Recommender Systems


Medical Optimization [2]



Autonomous Driving [3]

Knowledge graph reasoning (KGR) approaches combine symbolic techniques such as graph analytics and rules with subsymbolic techniques, such as embeddings and graph neural nets, placing them as neuro-symbolic AI, often providing explainability.

How can we use this in BPM?

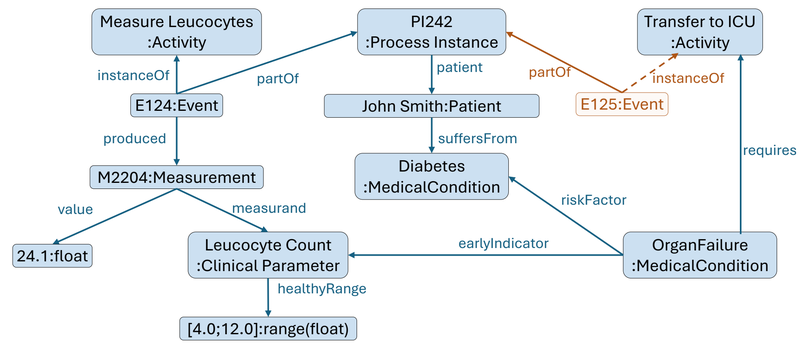
Bein, L., Pufahl, L.: *Knowledge Graphs: A Key Technology for Explainable Knowledge-Aware Process Automation?* BPM Workshops 2024

Integrated Process Knowledge

Problem: Relevant process knowledge is diverse and split over different systems and abstractions, making unified reasoning difficult.

How KGs can help: Combining all process knowledge into one *process knowledge graph* allows unified modeling on, retrieval of, and reasoning on the whole width of process knowledge.

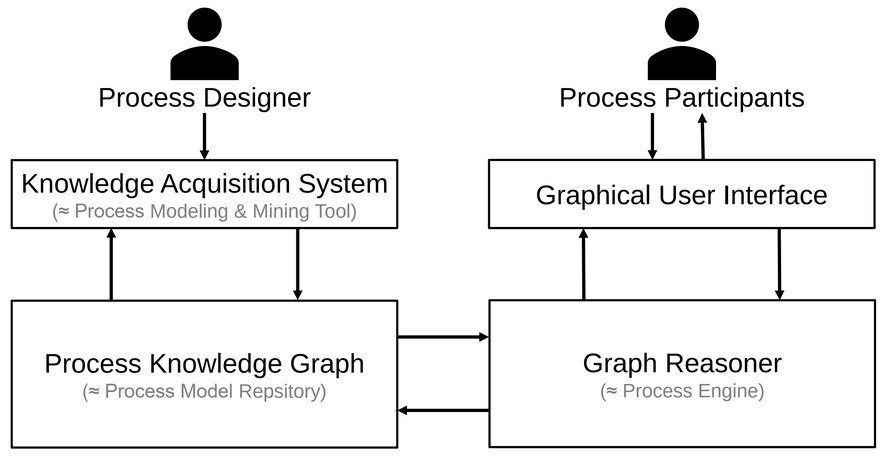
For example, in the following graph, medical concepts live together in one data structure with measurement artifacts as resulting from instances of process activities:



Explainable Knowledge-aware Automation

Problem: Existing intelligent process automation approaches reason only on subsets of process knowledge, fail to provide adequate explanations for their outputs, and are unstable on changing knowledge.

How KGR can help: With a process knowledge graph as centerpiece, intelligent Business Process Management Systems can be constructed that utilize graph reasoning to support process execution, e.g., by recommending or deciding what activities to perform next or which resources to assign, or by predicting the occurrence of events such as process outcome and proactively initiating their handling or prevention.



Notably, such systems promise:
- Considering the full width of process knowledge
- Determining process continuation within a loosely modeled framing
- Providing comprehensive reasoning for decisions made

We research the design and impact of such systems!

Knowledge Graph Background References:
[1] A. Hogan et al.: Knowledge Graphs. ACM Computing Surveys 54(4), 1–37 (2022)
[2] C. Ruiz, M. Zitnik, J. Leskovec: Identification of disease treatment mechanisms through the multiscale interactome, Nature Communications (2021)
[3] C. Henson, S. Schmid, T. Tran, A. Karatzoglou: Using a Knowledge Graph of Scenes to Enable Search of Autonomous Driving Data, ISWC (satellites) (2019)

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Check out our website!

Check out our tools on GitHub!