

GRAPH DATABASES AND ROBOTIC PROCESS AUTOMATION: ACHIEVING IMPROVEMENT IN PROJECT KNOWLEDGE MANAGEMENT

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Abstract A key component for project success, particularly for complex and risky projects, is adequate knowledge management. The results of our feasibility study reveal the need for a dedicated analytical instance to better support virtual knowledge processes. We suggest combining robotic process automation (RPA) with a knowledge-focused graph database (GDB). Therefore, we present a prototypic approach for integrating this concept into project management routines.

Keywords:

GDB,
graph
databases,
RPA,
robotic
process
automation,
project
knowledge
management.

1 Introduction

Due to the current economic trends of globalization and digitization, today's companies are faced with sometimes radical changes in their corporate environment (Astor et al. 2016, Friedrich 2016; Welter et al. 2014). In order to remain competitive and innovative in this volatile environment, companies have to adapt fast to changing markets and requirements (Ludwig et al. 2016, Schulz & Riedel 2016). Therefore, project-based work forms play a crucial role in the work organization of today's companies because project work makes it possible to react fast and flexible on changing demands (Keegan & Den Hartog 2019; Turner & Miterev 2019).

The ability to recognize and use the relevant knowledge resources is central in project-based forms of work (Handzic & Durmic, 2014). Furthermore, it has been proven in numerous studies that inadequate knowledge management is a main cause of project failure (e.g. Desouza & Evaristo, 2004).

However, because of digitization and virtualization, the conditions and challenges of project knowledge management have changed. Particularly, higher amounts of information and knowledge available and increasing knowledge interfaces inside and outside of projects requires new technological solutions, in order to control critical knowledge flows as well as to keep transparency of available knowledge.

The current paper addresses this problem and suggests an integrative technological approach, which may support project knowledge management in virtual environments.

In a first step, the authors present a novel RPA-based framework for supporting controlling and integration of critical knowledge flows in projects. In a second step, the authors introduce a practical graph-based approach for knowledge mapping in projects. For this purpose, ontology-based knowledge maps are suggested to appropriately capture and organize project knowledge.

2 Challenges of Project Knowledge Management

A central base for the success of project management is effective information and knowledge management (Davidson & Rowe 2009; Gasik 2011; Handzic & Durmic 2014). In fact, one main reason for using project-based work-forms is the prospect of pooling and transforming specialized and dispersed knowledge to generate synergies and innovative services and products (Handzic & Durmic, 2014).

But, particularly due to the current economic trends of digitization and globalization, the conditions and opportunities of project-based work are changing radically (Turner & Miterev 2019). Examples are increasing virtualization of project work environments, new sources of information and knowledge, and knowledge intensification of processes. As a consequence, there are several upcoming challenges and tasks for project-based knowledge management, e.g., management of large amounts of data and information, controlling of virtually distributed knowledge flows, and the appropriation of novel technological tools and solutions.

Results of a current study on challenges and success factors of processual knowledge management in IT-projects confirm a variety of conditions that need to be considered when managing knowledge processes in project teams (Kneisel, Tietz & Werner 2020).

The mentioned study based on 27 in-depth interviews with members and leaders of 20 project teams, stemming from six German companies in the IT sector. Interviewees were invited to describe situations, which they perceived as success-critical for effective project knowledge management, in as concrete and comprehensive as possible.

Study results show that specific characteristics of project environments can inhibit effective knowledge processes. Particularly, heterogeneous information and knowledge channels, information overload, high amount of knowledge interfaces inside and outside of projects as well as spatial separation hinder sharing and integrating of project-based knowledge. Furthermore, localization and visualization of relevant sources of knowledge are challenging. Different networks make it

difficult to keep track of existing knowledge. As a result, existing knowledge resources – and relations are underutilized.

In sum, current results indicate two central requirements for successful project knowledge management. *First*, project knowledge management requires a central controlling function for coordinating flow and storage of dispersed knowledge. Knowledge flow must be controlled in a structured and targeted manner in order to successfully implement specialized and heterogeneous knowledge and expertise in project teams. Probably due to the lack of time and implicit control mechanisms, there is a high need for supporting explicit management of knowledge processes, e.g. by a central technical integrator and controller. At best, such a central controlling instance has a high level of meta knowledge about individual expertise, relevant team processes as well as rules and norms within the team, which helps to localize and coordinate relevant knowledge within the team. *Second*, there is a high need for capturing and visualizing relevant knowledge available, e.g., through knowledge maps. Knowledge maps may support identifying, organizing, and visualizing kind, ownership, and connectedness of critical knowledge in and outside the project. As a result, they help to find the most relevant knowledge for project management to make proper decisions and solutions.

Based on the outlined challenges of project knowledge management, in the following a promising technology-based approach is presented, which combines a RPA-based framework for knowledge controlling with a graph-based solution for knowledge mapping.

3 Robotic Process Automation for Project Knowledge Management

3.1 Robotic Process Automation

Robotic Process Automation (RPA) is understood as the automation of well-structured and rule-compliant processes which have been performed by human agents so far by means of software robots (Willcocks et al. 2005, pp. 5–6, Mendling et al. 2018, pp. 300–302, Allweyer 2016, pp. 1–3, IEEE 2017, p. 11). For that the software robot (or bot) imitates the behavior of the human agents, i.e. it enters data into or reads data from control elements of programs (e.g. entry masks), changes data, moves data between programs or starts programs (Allweyer 2016, p. 2, Czarnecki & Auth 2018, pp. 116–117).

The objective of RPA is the elimination or at least minimization of human interaction within a business process. Bots can handle processes much faster, in higher quantity and without changes in quality. With bots taking care of the repetitive and tedious tasks, humans are free to concentrate on the tasks that involve decision making or are of immediate use for the customer (Hofmann et al. 2019, p. 3, Mendling et al. 2018, p. 302, Smeets et al. 2019, p. 22, Willcocks et al. 2015, p. 6).

Bots are not bound to single systems; they can emulate users across different systems. By mimicking human behavior bots do not (necessarily) need application programming interfaces for system access. Thus, the existing systems remain unchanged. RPA simply creates a supplementary layer of technology above the existing IT landscape without any program or data integration (van der Aalst et al. 2018).

This aspect is the reason for the high expectations of a robotic process automation (Bingler 2019, Czarnecki & Auth 2018, p. 117): With only minimal changes to the existing IT landscape processes can be optimized and automated much faster than with the introduction of new software or the revision of existing systems and the time-consuming integration of all systems on a technical level. There is recognizable potential for process automation and for significant cost reduction (Smeets et al. 2019, pp. 22–23, Lacity et al. 2015).

The initial stage of RPA adoption comprises the automation of well-defined processes (Agostinelli et al. 2019). The next stage will see the combination of RPA with techniques of artificial intelligence (AI) to an “Intelligent (Process) Automation” (Berruti et al. 2017, Huang & Vasarhelyi 2019, p. 9, Bingler 2019, Bremmer 2019, Safar 2019). RPA bots are supposed to take over more unstructured processes and decision-making tasks and learn from human users and previous process executions (Mendling et al. 2018, p. 301, Czarnecki et al. 2019, pp. 799–801, Bremmer 2019).

3.2 Graph Database and Bot-based Solution for Project Knowledge Management

3.2.1 Parameterizable Bot Structures

Project teams that operate virtual and across organizational boundaries are subject to the need to work with a wide variety of application systems and to exchange data between them. Due to security-related and legal framework conditions, this can rarely be achieved via technical interfaces. As solutions available on the market show heterogeneity in terms of technology, functionality and usability and the short innovation cycles in the field of teamwork-relevant software, a desired solution for project management must necessarily be highly flexible and be able to interact with any software. This is not in the nature of API-based system communication but can be solved using the RPA approach.

In contrast to classic use cases of RPA or Workflow Management, in which the processes can be implemented in a stable and thus fixed manner, a useful application of RPA in the context of virtual teams is only effective through highly parameterizable bot structures that are based on a knowledge database.

In a bot-based approach, a team bot supports or replaces the previous human integrator, who was necessary for the control of team processes and who had the relevant, sometimes implicit, process knowledge. The latter is explicated in the bot-based approach and persisted in a corresponding database (specifically a graph database, GDB; see chapter 4).

The current survey (Kneisel, Werner & Tietz 2020) initially revealed the need to store information about team members, their roles, relevant information objects, their storage locations as well as distribution scenarios for information objects. Furthermore, the flexible storage of team rules, i.e. of explicit process knowledge, is needed. These requirements can be met using the bot-based solution described below (see figure 1).

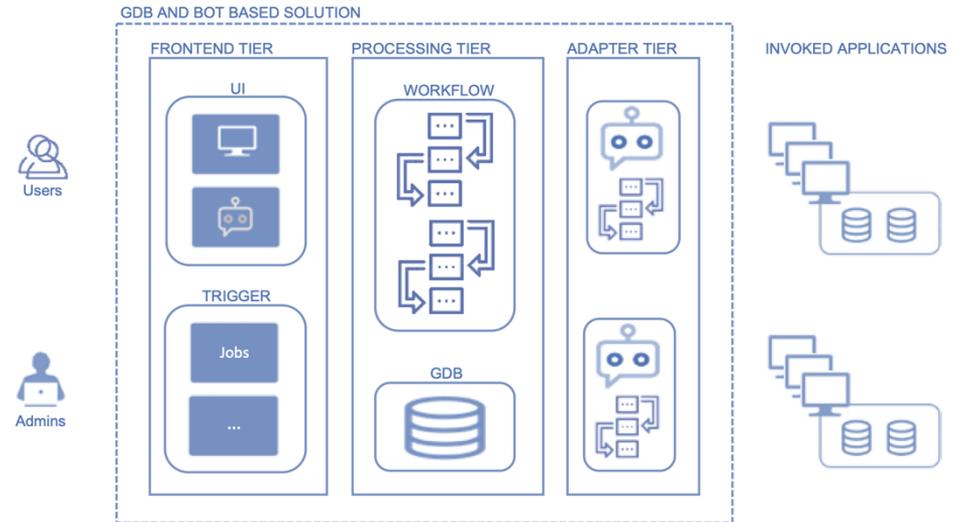


Figure 1: GDB and bot-based solution for project knowledge management.
Source: Authors

The core idea here is not to persist process-related information in a proprietary way within RPA systems, but rather to store it in a widely accessible knowledge database based on a graph database. The rules stored there can be directly linked to existing data objects in the database, and, at the same time, RPA systems from different suppliers can execute the process knowledge.

3.2.2 Frontend tier

End users communicate with the system via classic applications (personal information management software, messaging clients, VoIP software, etc.) or, for example, via chatbots. Events arising from this trigger the corresponding control workflow. Such events can also be raised by periodic jobs.

In this area there will be lots of add-ons using AI to optimize the work which has to be done in the front-end tier. A recent study depicts many areas for the application of AI to RPA (see Koch & Wildner 2020).

3.2.3 Process tier

On the process tier a central control workflow runs to select the correct response (i.e. a procedure with a collection of tasks) to a specific trigger. The control workflow executes the procedure tasks linked to the trigger based on information stored in a graph database.

However, the workflow is not a complete implementation of the process at design time, rather the relevant process information is obtained from a graph database.

The process tier has to handle aspects of system stability, integrity and scalability. The workflow and its information container are intended to be completely information agnostic to work in its intended generic implementation. Specific knowledge (as to how people of a team interact, etc.) is stored exclusively in the graph database.

3.2.4 Adapter tier

The control workflow as well as the actual interaction with target systems is realized via software bots using RPA technology. This ensures that changes to the IT landscapes in which the bot-based solution is applied are reduced to a minimum. However, if there is a continuous, simple and secure way to address an API, the usage of this kind of connectivity should be preferred. If not available RPA will be the technology of choice.

Here, a target-system-specific implementation takes place at design time and the relevant execution parameters are transferred, which are obtained from the knowledge database through the control workflow, at runtime. At this point there has to be also deep knowledge about the information gathered in the workflow container.

Actually, the adapter tier looks quite similar to normal RPA projects, only without the flexible structures we discuss in the paper. But the reusability of the elements will be much higher, if the concept proposed here is followed consistently.

4 Persistence Layer using Graph Database Technology

4.1 Graph Databases

The persistence of process knowledge must be implemented in such a way that, on the one hand, a flexible expansion of the data structures is possible, for example the arbitrary addition of entities, and on the other hand there must be the possibility of using e.g. AI, data mining or process mining technologies on this data. In this context, implementation is based on a graph database (GDB).

Graph databases are used primarily when connections between data objects are more important than the data itself. Compared to relational databases, a particular advantage is the improved representation and investigation of complex systems. The many different relations are represented in the form of graphs. Thus, they can also be visualized much more efficiently. The use of these databases has become particularly prevalent over the last decade. In principle, they complement other concepts, such as hierarchical or relational databases (Angles & Gutierrez, 2008).

Many graph databases provide tools for a graphical representation of the data. It enables visualizations that make it easier for people to recognize connections visually. In combination with process models, such as the robotic process automation, this opens up new possibilities for gaining knowledge.

With process models, it depends first of all on how much time is spent on individual stages. In addition, people play a role in robotics, since these tasks are designed for robots. Graph databases, in combination with semantic tools or artificial intelligence in general, allow to model knowledge in these approaches. In content-rich processes it is particularly important that documents and roles are semantically processed. In fact, the content rarely depends on quantitative values like in a normal database, but on the connections. Thus, we apply graph databases. Hereby, so-called edges and nodes play an important role (Jouili & Vansteenbergh, 2013).

If we now look at our processes, that we intend to automate using RPA, it is not primarily the absolute values that matter, but the connectivity. This enables us to answer questions such as the following: What is the shortest route that can be taken

when a user submits an error to the help desk, for example? If there are similar problems, we can identify these, by looking for specific clusters in corresponding visualizations. However, the images are not essentially required since graph database often come with a specific query language such as Ciper for Neo4J (Wood, 2012).

4.2 Design of the persistence layer

The meta model of the persistence layer differentiates master data – even transaction data if needed and not usefully stored in backend systems – as well as rules, e.g. approval limits and the actual process information. In the interests of greater reusability, standard tasks are first encapsulated and then reused in procedures. (see figure 2).

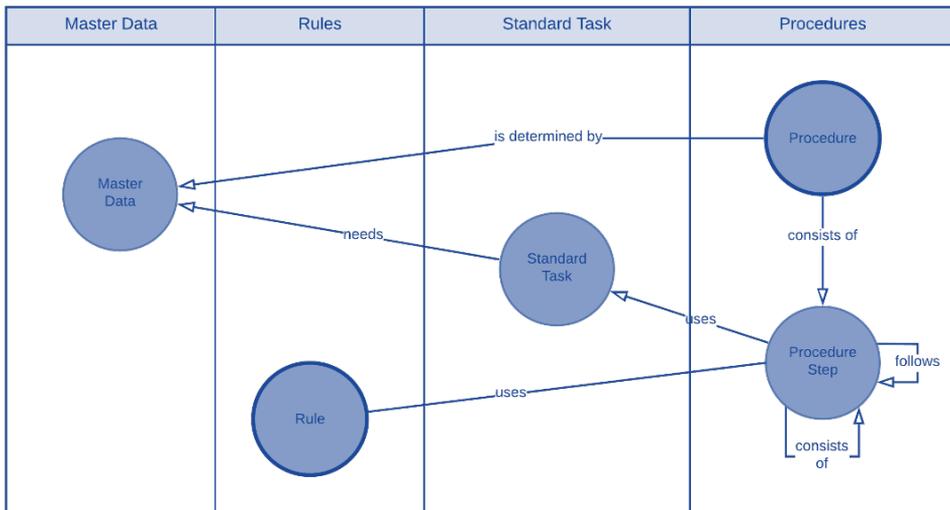


Figure 2: Data meta model

Source: Authors

The graph database contains data objects in the classical sense as well as process-related information, represented here by procedure steps and standard tasks. A procedure is then executed step by step by the Workflow Engine of the RPA system. Encapsulated in standard tasks, the relevant data objects are obtained for each

procedure step. It is also possible to access rules directly from Business Rules Frameworks. Figure 3 illustrates an example of such a persistence solution.

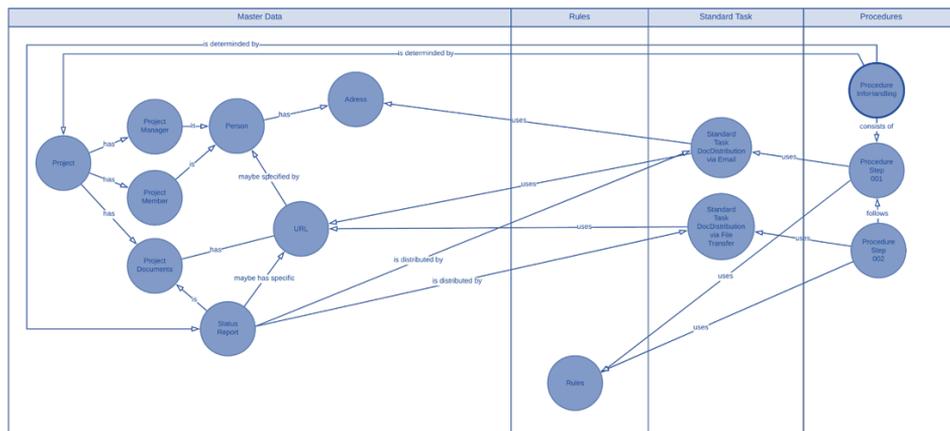


Figure 3: Modelling of master data, rules and procedures (example).

Source: Authors

5 Conclusion

This paper suggests an integrative approach to optimize knowledge management tasks in project management using modern technologies such as GDB and RPA. Where a high degree of flexibility and reusability can be recognized, it is provided by the separation of tiers and especially the persistence layer.

The explication of project knowledge can be supported in this way and, above all, methods of AI can be applied to the data and process information.

Further research in the project described here will first investigate the mapping process of the content in the graph database and link it to data objects. Furthermore, we plan to “find” optimum process paths by elucidating content relations machine learning. For this purpose, we plan to investigate a standardized process with and without graph databases/AI. Exemplary and specific processes from the project management environment, especially elements of the executing process group according to PMI (PMI, 2017), will be used to validate the procedure in practice.

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