How Scenario Building supports Conceptual Modelling

Anna Sumereder[1], Damiano Falcioni[1] and Robert Woitsch[1]

[1] *BOC Group, Operngasse 20b, 1040, Vienna, Austria*

Abstract
A trend on digitization, digitalization, and digital transformation associated with several challenges and complexity can be observed. In this context, the usage of conceptual modelling, particularly business process modelling, is a widely established approach to structure complex activities. However, innovative approaches are required to tackle its liaison with digital technologies. In this paper, after an analysis of the state of the art for business process management approaches and related digital technology aspects, an interactive process model-based approach – the so called "Scenario Scanner" – is proposed and applied in the context of the EU project Change2Twin. Finally, insights on future research consider conceptual modelling in an era of digital transformation.

Keywords
Interactive model-based Approach, OMiLAB Experiment, Scenario Scanner, Business Process Management, Change2Twin.

1. Introduction and Motivation

Digital transformation encompasses a broad spectrum of initiatives ranging from IT modernization considering legacy systems, over streamlining processes through digital optimization to adopting innovative business models. To develop a business strategy for digital transformation, aligning information and operational technology can be supported by using various methods to discover, model, analyze, measure, improve, and optimize business processes – known as *business process management* (BPM). Based on Gartner's definitions [2], the liaison among business processes and digital technologies seems natural.

Starting with, a targeted set of exact search terms was elected to provide an indication on research trends in a BPM context. The results (see Table 1) deem from a selection of international renowned databases and illustrate that a plethora of literature on BPM exists (till October 2023), while the numbers significantly decrease regarding digital technologies, innovative approaches, or digital transformation. Although digital twins (DTs) are already widely researched, DTs of processes are barely established and cannot found before 2018. Nevertheless, the well-established discipline BPM can be considered as a driver of organizational efficiency. However, contemporary ecosystems are marked by agility and uncertainty resulting in disruption and business model innovation. Hence, traditional BPM

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anna.sumereder@boc-group.com (A. Sumereder); damiano.falcioni@boc-group.com (D. Falcioni); robert.woitsch@boc-group.com (R. Woitsch)
0000-0001-6209-9593 (A. Sumereder); 0000-0001-7955-0272 (D. Falcioni); 0000-0002-4783-4999 (R. Woitsch)

requires transformation towards more flexibility, modularity and context-sensitivity [4]. For the evolution of BPM, emerging digital technologies pose several challenges ranging from technological to organizational aspects requiring sophisticated management approaches – in this paper building upon conceptual modelling.

Table 1
BPM research trends in an era of digital transformation, from selected international renowned databases (ACM Digital Library, IEEE Xplore, ScienceDirect, Springer Link).

Search Term (found in any part of the publications)	**ACM Digital Library**	**IEEE Xplore**	**Science Direct**	**Spring Link**	Total
("Business Process Management")	3903	1482	3925	17342	26652
("BPM-based Approach" OR "Business Process Management-based Approach")	0	2	7	14	23
(("Business Process Management") AND ("Digital Transformation" OR "Digital Technologies" OR "Digital Technology"))	112	30	375	2312	2829
(("Digital Twin of a Process" OR "Digital Twin of Processes") AND ("Business Process" OR "BPMN"))	0	0	28	12	40

With respect to digital technologies, the European H2020 project Change2Twin [20] aims at supporting small and medium-sized manufacturing enterprises in their digital twinning efforts. The project includes the provisioning of appropriate DT solutions, which is far from being trivial. This paper attempts to bridge conceptual modelling – particularly in form of (business) process models – and the establishment of DTs. Specifically, scenario building is used to elaborate on the connection between the digital models and the real world. The paint production pilot case of Change2Twin is used to demonstrate DT challenges related to the production process.

Concluding the introduction, the overlying question for this work is how conceptual modelling (starting with BPM) must transform to a more agile, interactive, and innovative approach, allowing to gain benefits from digital technologies, while keeping the human in the loop. The following chapters present a selection of related work that is followed by the proposed model-based approach referred to as Scenario Scanner. The next chapter illustrates the experimental prototyping for the Change2Twin pilot case. The work is concluded with brief insights on further research.

2. Related Work

A deeper look into selected publications on BPM-based approaches revealed diverse application domains – ranging from adaptive processes for learning purposes to the management and monitoring of IoT devices – underpinned with related industrial tools. Contemporary, BPM is considered as a key success factor for digitization initiatives harmonizing business and IT perspectives [10] building upon process optimization considering context and dependencies of process-related models influencing process architectures and their evaluation. Going beyond digitization, the implementation of a multi-sensor approach [11] for monitoring hand-operated process parts revealed that a combination of sensors, context and process data is needed to digitally monitor manual business processes. However, there is still a gap in more integrative and cyber-physical BPM approaches. The plethora of existing modelling and formalization approaches can serve to tackle this gap, where an essential aspect is the readability of the models influencing the validation by human experts [12]. Here, business process modelling can support process analysis for instance by applying process automation and mining techniques facilitating the translation of sensor measurements and logs into human actions. Especially in hybrid and heterogeneous environments across industries, model-driven workflow automation – e.g. using the BPMN 2.0 standard – facilitates human system interaction for both automated and manual subprocesses [3]. However, often there is a lack of process specification and understanding. Therefore, BPM is used to restructure the interpretation and management of processes, such as academic processes [7]. Here, key performance indicators (KPIs) are used to quantify the positive impact of applying business process models. Going one step further, BPM can be an approach to tackle quality management – particularly process quality – for instance in the electrical motor industry [6]. A more comprehensive approach for process modelling with the goal of transforming and improving business performance is enterprise business process analysis [24]. Decision making is supported by considering several functional aspects as well as perspectives such as strategy, architecture or automation. The top five customer-rated products are Visio (Microsoft), ADONIS (BOC Group), ARIS (Software AG), SAP Signavio Process Manager (SAP), and Process360 Live (iGrafx). The products are rated based on capabilities, deployment options, integration competences, evaluation strength and contracting flexibility, as well as on service and support. Among the top capability features are support for distributed teams, decision making, discovery and harvesting process and business knowledge, architecture alignment as well as access to data. Based on the industrial tools, it can be observed that process management goes beyond modelling by offering advanced analysis and collaboration mechanisms. Concluding the above, BPM's relevance is unchallenged in several industries when it comes to formalization and structuredness.

With regard to technologies, a strive for the integration of conceptual models with digital technologies and related services makes sense in the long run to foster transparency and understandability in complex heterogeneous and agile environments. Starting from a business perspective, the OMiLAB Community of Practice [21] offers such an innovation environment that looks into business ideas and drills them down to the level of feasibility experiments. Here, conceptual modelling serves as an intermediary between business and cyber-physical experimentation. Digital twinning is an underlying concept of the OMiLAB environment, establishing conceptual representations bridging business and technological perspectives. In [22] the integration of DTs into organizational structures and business models is proposed. Technology-wise there has been a lot of research on DT development, whereas the connection to business aspects is deficient. Hence, the authors suggest extending the DT design towards capability driven development such as developing DT management dashboards based on capability design and context models including KPIs and historical data about components' performances. [23] points out that targeted DTs of organizations come across challenges such as interdependencies requiring innovative ways, like more comprehensive vocabulary, compared to current business process models.

3. The Scenario Scanner – An interactive model-based Approach

The Scenario Scanner builds upon the OMiLAB Innovation Environment [16] aiming at facilitating the tackling of digitalization challenges. OMiLAB's architecture is structured in three main layers, which are business, conceptual modelling, and proof-of-concept layer. Those layers are considered being in line with the building blocks of the Scenario Scanner. A set of (modelling) tools and approaches accompany the laboratory ecosystem such as the meta modelling platform ADOxx [1] and the OMiLAB modelling ecosystem [5] that enable domain specific modelling, the OLIVE microservice framework [19] supporting data- and service-related questions as well as the digital design thinking environment Scene2Model [9] transforming haptic scenarios to digital models. In particular, the Scenario Scanner aims at paving the way for developing a methodology supporting the establishment of DTs of processes by bridging conceptual models (including digital model) and digital technologies (often building upon physical devices in the real world).

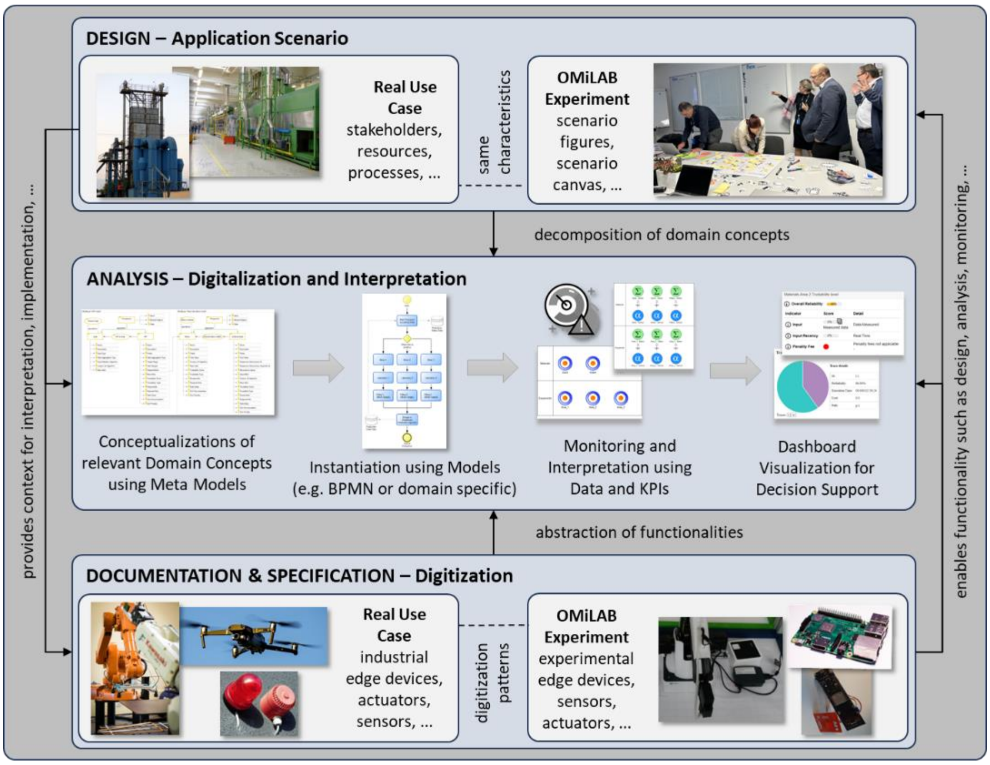

Figure 1: Scenario Scanner building blocks

Figure 1 shows an overview of the Scenario Scanner building blocks that are described in the following. On top, the *application scenario is designed* – such as introducing a DT in manufacturing to monitor the production and related processes. The real use case is considered to have the same characteristics as the related lab experiment. In the middle, complex domain concepts are decomposed, and the usage of conceptual modelling allows for formalization enabling advanced *analysis*, while at the same time being understandable for humans. On the bottom, there is a *specification of appropriate digitization hardware* for collecting the relevant data to feed the scenario. The parts of the Scenario Scanner that are supported by the physical OMiLAB environment are referred to as experiments.

The scenario building starts from a business perspective drilled down to experimental prototypes of DTs. An innovative design thinking approach is followed to create physical scenes describing business processes in a co-creative way. This can be done either following a pen and paper-based approach or in a technology supported way based on the Scene2Model [8] modelling method. In order to co-creatively design application scenarios, domain experts are collaboratively asked to reason over a targeted use case and represent a scene with available elements in form of paper figures or post-its – the scene is stepwise updated as it is supposed to evolve over time. The domain experts will use several domain scenario elements depicting the application scenarios' aspects of interest. Application scenario elements can be classified in elements on impact (e.g. cases, events), processes (e.g. tasks, procedures), organizational aspects (e.g. personnel, skills, relationships) and resources (e.g. material, infrastructure, devices). The proposed classes are in line with the perspectives that can be used for structuring goals and KPIs relevant for analysis purposes and more generic for managing knowledge to improve performance [17].

Identifying the right balance between top-down and bottom-up approach is not trivial. On the one hand, disruptive business models must be supported to deal with the contemporary agile ecosystems, potentially resulting in additional hardware (sensors or actuators) needs. On the other hand, existing hardware should be exploited to limit infrastructure costs and risks. The Scenario Scanner is intended to support in this balancing act by establishing experiments – where possible considering underlying processes and BPM efforts that are already in place in application scenarios – focusing on relevant aspects of digital transformation and managing the transition from the domain concepts to physical devices and vice versa via a model-based approach. Digitization patterns [15] are applied – on both, the experiment, and the real application case – in order to facilitate the selection of proper measures and technologies for implementing the scenario characteristics. However, the reader should bear in mind that the scenario building will evolve with further experiments towards a more holistic method (e.g. applying patterns or providing recommendations) supporting conceptual modelling and exploiting contemporary digital technologies.

4. Experimental Prototype of the Paint Production Pilot in Change2Twin

Change2Twin perceives DTs as "a digital replica of an artefact, process or service that is so accurate that it can be the basis for decisions. The digital replica and physical world are often connected by streams of data". This experiment illustrates the paint production pilot revealing the potential of DTs and related technologies in manufacturing. Originally, the paint producer strongly relied on paper-based documentation, where an error-proneness of the manual activities could be observed. Therefore, the company intended the installation of a real-time inventory, leveraging the paper-based documentation. Starting with the *design* building block of the Scenario Scanner, a series of process modelling workshops with representatives of the paint producer and digital technology providers was conducted. Based on the process map of the production plant a focus was set on the raw material flow, the production process itself, and the labelling process. Detailed *digital process models* were designed (involving the middle building block of the Scenario Scanner) in guided workshops to depict the activities of the production and the labelling as well as their execution sequence. Means of abstraction were applied onto the defined processes to reduce the complexity and focus on the digitization relevant aspects. The *digitization* (involving the bottom building block of the Scenario Scanner) was tackled building upon the digital models (considered as an early stage of a DT). Referring to the digitization building block of the Scenario Scanner, (process) modelling served as a foundation for the technology specification and documentation following an event-based approach. Ideas on digitizing a production use case were presented in [13], a focus on integration considering models, data and products was set in [18] and the usage of physical experiments to reduce the use case complexity were researched in [14].

Summarizing, three digitization challenges were extracted: the digitization of (a) the production process, (b) the raw material warehouse, and (c) the product information. Starting from completely analogous machines was particularly challenging for the development of a DT. Hence, the DT experiment in the OMiLAB mirroring the production process was used to transparently discuss the digitization challenges among the heterogeneous stakeholders such as technical or business experts. The experiment (see Figure 2) used a simplified, familiar association – the making of tea – covering the major pilot characteristics to identify appropriate infrastructure. RFID technology – one digitization option – was used to digitize production orders, material slots and production process steps. Going through the process, the captured information enables monitoring in real-time paving the way for further analysis such as process simulations and predictions. Haptic process simulations were used to collect event data in form of timestamps allowing conclusions on stock levels or maintenance plans. After the finalization and evaluation of the paint production experiment, the pilot company decided to equip the production stages and the warehouses with RFID technology (similar to the one used in the experiment) allowing for a continuous collection of data throughout the process highly leveraging the manual documentation towards a real time DT approach.

Figure 2: Paint production experiment for the Change2Twin project

5. Conclusion and Outlook

In line with traditional BPM approaches, the Scenario Scanner is intended to support the establishment of DTs of processes. So far, the automation of currently manual steps was researched by implementing promising digital technologies and services. Showcased in the Change2Twin project pilot, digital twinning was facilitated by scenario building in the manufacturing domain. The usage of physical experimentation is considered promising to leverage conceptual modelling towards more interactivity and innovation. However, in future a more comprehensive methodology on how to apply the Scenario Scanner by conducting application scenario experimentation in heterogeneous domains is expected to contribute to conceptual modelling in general and to targeted concepts for innovative BPM.

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