Process Weakness Patterns for the Identification of Digitalization Potentials in Business Processes

Florian Rittmeier[1], Gregor Engels[1], and Alexander Teetz[2]

[1] Paderborn University, si-lab, Fürstenallee 11, 33102 Paderborn, Germany
{florianr,engels}@uni-paderborn.de
[2] Paderborn University, Dept. of Computer Science, Fürstenallee 11, 33102 Paderborn, Germany
alexander.teetz@uni-paderborn.de

Abstract. An important element of digital transformation is the digitalization of processes within enterprises. A major challenge is the systematic identification of digitalization potentials in business processes. Existing approaches require process analysts who identify these potentials by using the time-consuming method of pattern catalogs or by relying on their professional experiences. In this paper, we classify potentials of digitalization and derive corresponding patterns for a future pattern-based analysis procedure. This shall enable the automated identification of digitalization potentials in BPMN diagrams. Those patterns were derived from our work with five companies from different sectors. In comparison to existing approaches, our proposed method could support a more efficient and effective identification of digitalization potentials by process analysts.

Keywords: digitalization potentials · process weakness patterns · BPI · digital transformation · information flow modeling · requirements engineering

1 Motivation

Digitalization is on everyone's mind as it changes many areas of life. Digitalization also changes the general conditions for companies, for example when competitors make existing products and services more attractive for customers by exploiting digitalization potentials. Those digitalization potentials for processes arise, for example, if existing processes can be improved through the use of new assistance systems or digital interfaces. Correspondingly, companies have to adapt by identifying and exploiting digitalization potentials in their own company and market in order to remain competitive.

When discussing digitalization potentials, it is important to emphasize what is meant by digitalization. The differences between digitization, digitalization and digital transformation are explained using an example from Fischer et al. (2017). If the business process of an industrial picking scenario is performed using a "Paper-based Clipboard" and this is replaced by a "Digital checklist on

Rittmeier F., Engels G., Teetz A. (2019) Process Weakness Patterns for the Identification of Digitalization Potentials in Business Processes. In: Daniel F., Sheng Q., Motahari H. (eds) Business Process Management Workshops. BPM 2018. Lecture Notes in Business Information Processing, vol 342. Springer, Cham

The final authenticated version is available online at https://doi.org/10.1007/978-3-030-11641-5_42

a tablet" this change represents the change by doing digitization, i.e. replacing paper by bits and bytes. The "Digital checklist on a tablet ordered dynamically based on a big data analysis" is an example of the change in the process through the use of digital technology, which we call digitalization. Thus, digitization is a more basic and technical transformation, which forms the foundation for more complex transformations in which digitalization enables news types of processes. While we will mostly talk about digitalization, this usually also includes digitization. The digital transformation is an even broader term and includes the transformation of business process, competencies, activities and models.

It is a challenge for companies to systematically identify the digitalization potentials of their processes. Figure 1 illustrates how process analysts identify digitalization potentials today. As a common methodical basis, practitioners and scholars recommend modeling a business process to document the current business processes using a language for describing business processes (Process discovery). Process analysts then identify process weaknesses by analyzing the business processes (Process analysis) and provide digitalization recommendations, which then are discussed with the process stakeholders and lead to improved business processes (Process redesign). Thus digitalization potentials are exploited.

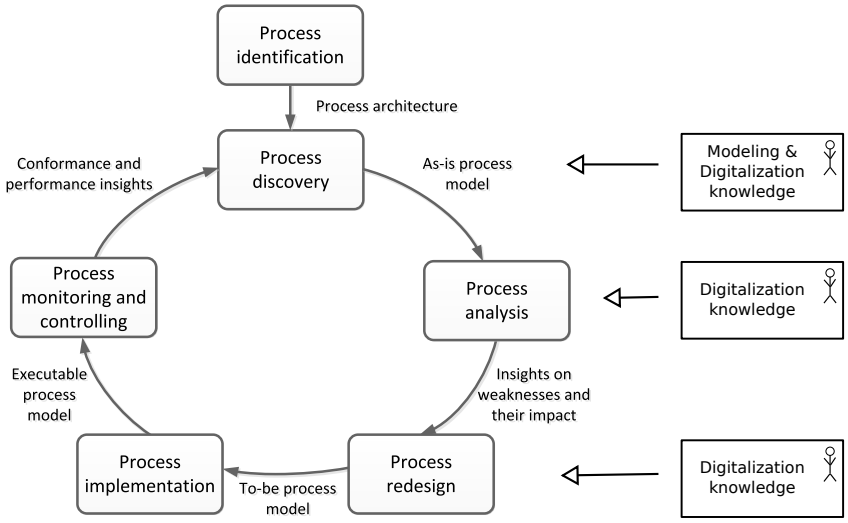


Fig. 1: Work of process analysts today related to BPM Lifecycle (Dumas et al. 2013)

Accordingly, process analysts and their knowledge of modeling and digitization play an important role today. Such process analysts are in demand and their use entails considerable costs for small and medium-sized enterprises (SMEs). Therefore, the question arises as to how the number of process analysts who

deliver high-quality results can be increased and support from them can become more cost-effective for SMEs.

Other approaches address these challenges by describing process weaknesses, such as digitalization potentials, using so-called process weakness patterns. These allow process analysts to discuss the characteristics of weaknesses and also to identify weaknesses based on these patterns. This is how the quality of the results of the process analysts is decoupled from the knowledge they have gathered in practice. Unfortunately, the systematic application of these patterns in existing approaches is very time-consuming. Others are more efficient, but focus on digitalization potentials for the public sector instead on those for SMEs.

We propose using an assistance system that supports process analysts by automatically identifying digitalization potentials in business process models using process weakness patterns for digitalization. In addition, we provide guiding questions that support process analysts in capturing relevant digitalization aspects and describe a relevant language extension for BPMN 2.0 in order to be able to model these digitalization aspects.

The patterns, guiding questions and insights of our approach are based on our work in the project "Business 4.0 – New business models and value chains with ICT"[3]. The aim of the project is to support small and medium-sized companies in developing digitalization strategies. Within the scope of this project, workshops were conducted with five companies in order to identify digitalization potentials in processes relevant for SMEs. The companies came from different industries and acted as research subjects.

The rest of the paper is structured as follows: We first discuss the related work (section 2). Afterwards, our solution approach is explained (section 3) and examples for digitalization potentials are given (section 3.1). In addition, the guiding questions are presented (section 4) followed by the introduction of the information carrier type (section 5). Based on this language extension, the process weakness patterns for digitalization are described (section 6). The article is concluded with a summary and outlook (section 7).

2 Related work

The result of the analyses of process analysts is highly dependent on the experience and interpretation of the process analyst (Phalp and Shepperd 2000). Less experienced process analysts produce less effective results. Vergidis et al. (2008) emphasize that for analyses of business process models, which should not be primarily based on experience of the process analyst, support from the business process modeling language is necessary. This enables implicit knowledge to be documented explicitly.

Language support would make it possible to identify digitalization potentials using process weakness patterns. Such a pattern is a formalized description of a process weakness. As a rule, such a description refers to a part of a process

[3] `http://owl-morgen.de/projekte/business-40/`

model that can be described on the basis of concrete structural properties. Based on such a pattern, comparable constellations in other process models can be identified on the basis of this pattern.

Existing approaches such as Falk (2017) already work with patterns, but the process analyst must check manually whether a pattern is applicable. For many patterns this check is very time-consuming (Falk 2017). Our approach focuses on the use of an assistance system which is intended to identify applicable patterns and thereby not only make the work of the process analyst more effective, but at the same time make it as efficient as possible.

Other approaches like Höhenberger and Delfmann (2015) use automated matching of process weakness patterns to analyze existing process models from the public sector. Most of the SMEs we had contact with do not have existing process models. Therefore, modeling the business process usually is the starting point. This allows to use guiding questions when modeling to take relevant information required for the later analysis into account and also to model digitalization aspects in more detail if the process modeling language allows for that. Therefore, our approach is tailor-made for digitalization and, to the best of our knowledge, more holistic.

3 Solution approach

The resulting question is how digitalization potentials in business process models can be identified on the basis of language elements. We employ the business process modeling language BPMN 2.0 (Object Management Group 2011), since it is widely used in practice (Dumas et al. 2013) and comes with a precise definition of syntax and execution semantics. Therefore, the following research questions should be noted:

1. How can process analysts be supported in modeling all aspects of a given process that are relevant to the detection of process weaknesses in a digitalization context?
2. Can digitalization potentials be identified by using language elements of BPMN 2.0?
3. Which process weakness patterns describe digitalization potentials and which recommendations can be given on the basis of these potentials?

From the previous remarks it follows that it is necessary to identify digitalization potentials and patterns for these. Furthermore, it is necessary to describe the patterns in machine-readable form so that an algorithm can then check whether an application of a corresponding pattern in an (extended) BPMN diagram exists. With regard to such an algorithm, approaches such as Förster et al. (2007) can be used. Based on this, individual patterns can then also be assigned to recommendations that exploit the digitization potential. In a first step, these recommendations can be formulated in textual descriptions. In the future, these recommendations should be made directly applicable through suitable model transformations.

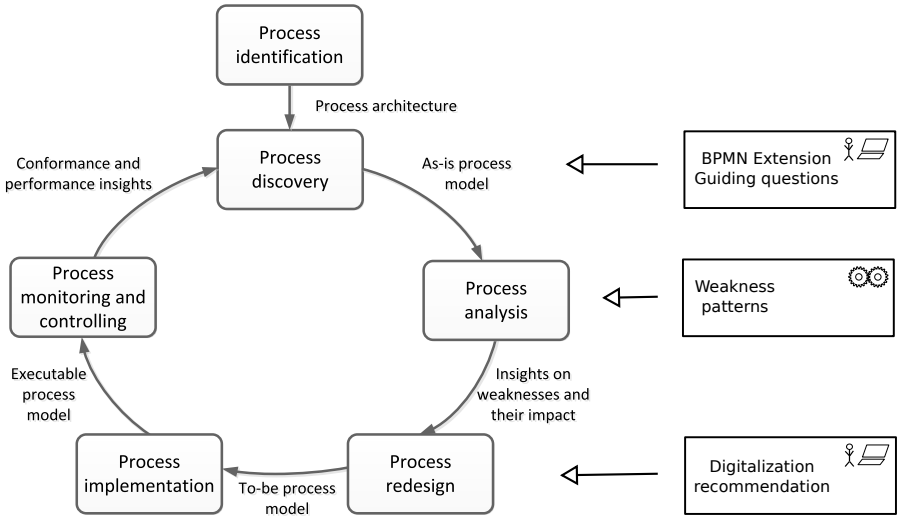


Fig. 2: Solution approach related to BPM Lifecycle (Dumas et al. 2013)

Putting our solution approach in the context of the BPM Lifecycle described by Dumas et al. (2013), we address the phases *Process discovery*, *Process analysis* and *Process redesign*. Guiding questions support the process analyst in capturing as many relevant aspects as possible in the course of the *Process discovery*. This supports the *Process analysis* using process weakness patterns for digitalization, as these can only be found automatically by the assistance system if the quality of the model reaches an appropriate level. As those patterns have digitalization recommendations associated they also provide relevant input for the *Process redesign*. Figure 2 illustrates the relationship between our solution approach and the BPM Lifecycle.

3.1 Digitalization potentials

In the Business 4.0 project, we identified digitalization potentials in workshops on the digitalization of processes. These digitalization potentials relate to situations in which

- only nondigital information carriers are used in a process step,
- a nondigital information carrier is linked to the copy of the information in an IT system and this link is not simple[4] or not efficient[5],
- information between process steps is not transferred through digital information carriers,

[4] It is not considered simple if the digital twin has to be searched for, for example because no primary key exists or it cannot be used for selection.

[5] It is not efficient to type in a primary key, e.g. a customer or order number. Scanning the primary key with a reader would be considered efficient here.

- work steps could be supported by the use of a digital assistance system,
- unstructured data can be structured in such a way that it can be further processed.

4 Guiding questions

The guiding questions shall support the process analyst in modelling the process to cover all aspects relevant for identifying process weaknesses in a digitalization context. Therefore, the structure used in Turban and Schmitz-Lenders (2017) is followed. Although they derive software requirements from the process model on the basis of guiding questions, the structuring on the basis of the model elements seems to be a promising procedure, since it easily allows a systematic check-up by the process analyst. We have identified the following guiding questions, which we have grouped according to model elements. This first set of guiding questions should be asked by a process analyst during modeling per model element to improve the quality of the model with respect to aspects of digitalization.

Process

- Are all decisions explicitly modeled?

Task

- Are all data inputs for the tasks covered? On which data does the task work?
- Did you specify whether a human user (manual task), a human user using an application (user task), or a service (service task) is performing the task?
- If a human user is using an application, when performing the task, did you model the application as data store, if the application has data store characteristics, or as artefact, if it does not have data store characteristics?

Decision (data driven)

- Is there a task in front of the decision node which prepares the descision?
- Does the task preparing the decision makes this based on data? Is this data modelled?

Data (input and output)

- Did you capture the type of information carrier?

Data input

- Is the source of the data modeled? Is it another task or a data store?

Data store

– Did you capture the type of information carrier?

When analyzing how a process analyst can use these guiding questions to model a business process, we faced the problem, that there is no existing good way in modeling the type of information carrier. The sole existing option is to model this aspect by writing it into labels of the relevant model elements. But this leads to ambiguity. We therefore choose to extend BPMN 2.0 to model this aspect as it is described in the next section.

5 Modeling the information carrier type

In BPMN 2.0 you can only describe textually what kind of information carrier provides the information. The extension mechanism of BPMN 2.0 has to be used to add an attribute that formally describes the type of information carrier. Alternatively, you can insert new types of data objects that represent the values of the attribute. It would be good to visualize the additional information content as this supports process stakeholders during the discussion with the process analyst. Depending on the tool support, you can define a separate display for either one or the other.

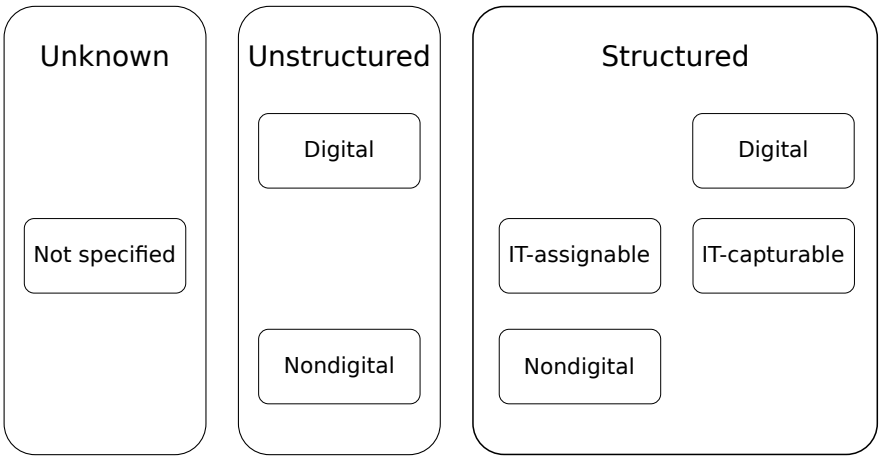


Fig. 3: Taxonomy of information carrier type

Our approach formulates the following possible values for the attribute with which we describe the information carrier formally. These values build a taxonomy illustrated in figure 3:

Not specified This is the default value. Software systems/tools should encourage the modeler to set one of the other values.

Nondigital Unstructured This classifies the data as unstructured data such as notes and original sounds that require interpretation.

Nondigital Structured Although this data has a nondigital information carrier, the data is structured in such a way that it can be easily mapped in an IT system for further processing, e.g. a form.

IT-assignable Information carriers that have the properties of *Nondigital Structured* and where the same data exists in an IT system and can be found there with little effort using a key, e.g. using an order number.

IT-capturable For such information carriers, the data in the corresponding IT system can not only be found with little effort, but the key on the nondigital information carrier can be machine-recorded, e.g. with a barcode.

Digital Unstructured It is a digital information carrier but the data has no or no useful meta-model, e.g. a PDF file.

Digital Structured It is a digital information carrier and the data has a useful meta-model, e.g. a Excel file.

The assistance system can support the process analyst in choosing the right type by providing hints and examples.

6 Process weakness patterns for digitalization

In order to identify the patterns, we have clarified which model elements and properties of these were used by process analysts to identify the digitalization potentials in the five SMEs analysed in the project Business 4.0. The first four patterns have been identified as follows. The headings Intent, Motivation, etc. are standard structures for patterns.

6.1 Pattern 1: Information on nondigital information carrier

Intent Enforce the processing of information using *Digital Structured* information carriers.

Motivation This pattern identifies situations in which information is required for a task and that information is available on an information carrier that is not the best choice in terms of digitalization and processing of information by IT systems.

Applicability This pattern can be applied if information from order forms, goods without barcode and scanned documents is used. The use of PDF files whose contents must be typed for further processing is also an application case.

Structure This pattern is illustrated in figure 4a. A task *T1* has an assigned data input *DI1*. *DI1* is provided by an information carrier that is not *Digital Structured*. There is no information in the model on how *DI1* is generated, i.e. *DI1* is not assigned to any other model element as data output.

Recommendation(s) Taking into account the type of information carrier of the found *DI1*, there are different potentials at occurrences of this pattern, depending on the type of information carrier encountered in each case.

If the data is *Nondigital Unstructured* it would be recommended to first examine the data to structure or formalize it. This is to be understood as a preparatory step for a later digitalization. If it is already *Nondigital Structured* it would be recommended to select a digital data store in which this data will be stored and managed digitally in the future. The corresponding data store would have to be added to the diagram if this potential were to be realized. If the data is already *IT-assignable*, it is recommended to make the key capturable. Examples of different common solutions to make the key capturable, such as the use of barcodes, QR codes or RFID tags, can be given here. If the data is already *IT-capturable*, the recommendation would be to check whether the data cannot be obtained via a digital interface, because a digital data store must already exist by definition. In the case the data is *Digital Unstructured*, it should be checked whether it can also be provided or being automatically transformed in a structured format.

(a) Pattern 1. (b) Pattern 2.

Fig. 4: Patterns of digitalization potentials

6.2 Pattern 2: Information transmission via nondigital information carriers

Intent Enforce the transfer of information using digital structured information carriers.

Motivation The second pattern describes the transfer of information from one task to another using a nondigital information carrier.

Applicability This is the case, for example, when a clerk transfers information from one application to another by typing.

Structure This pattern is illustrated in figure 4b. Data *D2* is data output of task *T2* and data input for task *T3*. *D2* is provided by an information carrier that is not *Digital Structured*.

Recommendation(s) The recommendations are similar to those of pattern 1, but are formulated in relation to the transfer from *T2* to *T3*. They are therefore somewhat more specific in terms of their wording than in application of pattern 1 in these cases.

6.3 Pattern 3: nondigital information transmission between digital data stores

Intent Enforce the use of digital interfaces between digital data stores.

Motivation The third pattern describes the transmission between two tasks, each supported by a digital data store. Transmission takes place using a nondigital information carrier or digital unstructured information carrier. Those transmissions should be done using a digital structured information carrier as this simplifies data processing.

Applicability This is the case, for example, when information is typed from one application to another or information is printed from one application so that a colleague can enter this information from the printout into another business application.

Structure This pattern is illustrated in figure 5a. A task *T4* has a data store *DS1* as data input. *T4* has data *D3* as data output, which is also data input for *T5*. Task *T5* has a data store *DS2* as data output. *T4* and *T5* have no other data inputs or data outputs. The information carrier type of *D3* is not *Digital Structured*. The information carrier type of *DS1* and *DS2* is *Digital Structured*.

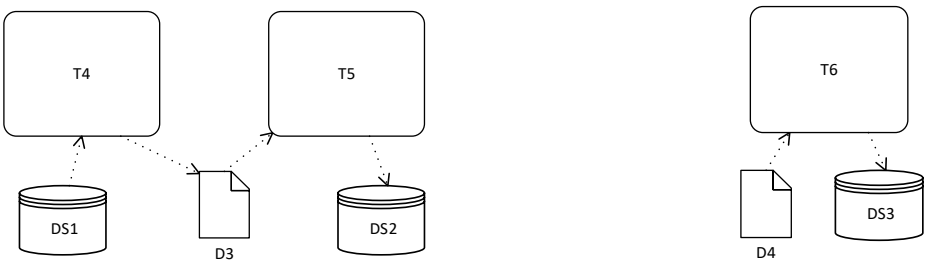
Recommendation(s) The recommendation is to switch the information carrier for the transfer from *T4* to *T5* to a *Digital Structured* information carrier, which usually is done by establishing a digital interface between *DS1* and *DS2*.

6.4 Pattern 4: Storage of digital information in nondigital data store

Intent Enforce the use of digital data stores.

Motivation This pattern describes storing digital information in a nondigital information store.

Applicability This may indicate, for example, that information is printed out to be archived in a file folder.



(a) Pattern 3. (b) Pattern 4.

Fig. 5: More patterns of digitalization potentials

Structure This pattern is illustrated in figure 5b. There is a task *T6*, which has data *D4* as data input. Furthermore, *T6* has data store *DS3* as data output. *D4* is *Digital Structured* and *DS3* is *Nondigital Unstructured* or *Nondigital Structured*.

Recommendation(s) Substitute *DS3* by a data store, which is *Digital Structured*.

7 Conclusion and Outlook

A number of digitalization potentials were classified and it was shown that BPMN 2.0 has to be extended if digitalization potentials are to be automatically identified via process weakness patterns in BPMN diagrams. The information that has to be expressed in BPMN has been described for this purpose. Appropriate patterns and associated recommendations were also explained as examples.

Further guiding questions and patterns are to be developed in the future, particularly as patterns have not been identified for all the digitalization potentials presented. For example, when it comes to identifying tasks that need to be supported by assistance systems. It can be assumed that some of these patterns require additional extensions of BPMN. It is also necessary to investigate how patterns can be made even more precise in order to identify recommendations that are even more specific to the respective process context.

Also, the procedure for identifying the pattern matches shall be explained in detail. The efficiency and effectiveness of the approach will also be evaluated.

Acknowledgements

This article was written in the context of the project Business 4.0 (`http://owl-morgen.de/projekte/business-40/`), which is part of the integrated action concept “OWL 4.0 - Industry, Labour, Society”. The project is supported by the European Regional Development Fund (ERDF).

References

[1] Marlon Dumas et al. *Fundamentals of Business Process Management*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2013. https://doi.org/10.1007/978-3-642-33143-5.

[2] Thomas Falk. "Evaluation of a Pattern-Based Approach for Business Process Improvement". In: *Proceedings der 13. Internationalen Tagung Wirtschaftsinformatik (WI 2017)*. Ed. by Jan Marco Leimeister and Walter Brenner. 2017, pp. 241–255.

[3] Holger Fischer, Michael Engler, and Stefan Sauer. "A Human-Centered Perspective on Software Quality: Acceptance Criteria for Work 4.0". In: *Design, User Experience, and Usability: Theory, Methodology, and Management - 6th International Conference, DUXU 2017, Held as Part of HCI International 2017, Vancouver, BC, Canada, July 9-14, 2017, Proceedings, Part I*. Ed. by Aaron Marcus and Wentao Wang. Vol. 10288. Lecture Notes in Computer Science. Springer, 2017, pp. 570–583. https://doi.org/10.1007/978-3-319-58634-2_42.

[4] Alexander Förster et al. "Verification of Business Process Quality Constraints Based on Visual Process Patterns". In: *First Joint IEEE/IFIP Symposium on Theoretical Aspects of Software Engineering (TASE '07)*. IEEE, 2007, pp. 197–208. https://doi.org/10.1109/TASE.2007.56.

[5] Steffen Höhenberger and Patrick Delfmann. "Supporting Business Process Improvement through Business Process Weakness Pattern Collections". In: *Smart Enterprise Engineering: 12. Internationale Tagung Wirtschaftsinformatik, WI 2015, Osnabrück, Germany, March 4-6, 2015*. Ed. by Oliver Thomas and Frank Teuteberg. 2015, pp. 378–392.

[6] Object Management Group. *Business Process Model and Notation (BPMN), Version 2.0*. 2011.

[7] Keith Phalp and Martin Shepperd. "Quantitative analysis of static models of processes". In: *Journal of Systems and Software* 52.2-3 (2000), pp. 105–112. https://doi.org/10.1016/S0164-1212(99)00136-3.

[8] Bernhard M. Turban and Johannes Schmitz-Lenders. "A Pattern-Based Question Checklist for Deriving Requirements from BPMN Models". In: *Business Process Management Workshops - BPM 2017 International Workshops, Barcelona, Spain, September 10-11, 2017, Revised Papers*. Ed. by Ernest Teniente and Matthias Weidlich. Vol. 308. Lecture notes in business information processing. Springer, 2017, pp. 630–641. https://doi.org/10.1007/978-3-319-74030-0_50.

[9] K. Vergidis, A. Tiwari, and B. Majeed. "Business Process Analysis and Optimization: Beyond Reengineering". In: *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)* 38.1 (2008), pp. 69–82. https://doi.org/10.1109/TSMCC.2007.905812.