A Taxonomy and Catalog of Business Process Model Patterns

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While a large number of business process model patterns have been suggested in the literature, it is currently difficult to find patterns that might be useful in a given context. The reason is that the relevant publications are spread in various journals and other types of publications, and there is no guidance for locating a pattern that can be useful for solving a given problem. In our article, we present the results of a literature survey that has been conducted with the aim to get an exhaustive overview on existing publications on business process modeling patterns. The results of the survey allowed us to propose a taxonomy of existing patterns as a first step towards a pattern language of business process model patterns. Furthermore, we created an online catalog that allows finding publications on business process model patterns based on various search criteria. It is intended to be useful both for business process modeling practitioners as for researchers in need of sound literature references. Currently, this catalog includes links to 89 publications (usually containing more than one pattern). It is our aim to populate the catalog with patterns published in the future.

Additional Key Words and Phrases: business process modeling, patterns, workflow patterns, pattern catalog, pattern repository, taxonomy

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1. BUSINESS PROCESS MODELS AND BUSINESS PROCESS MODEL PATTERNS

The ISO standard 19439 [ISO 2006] defines the term "business process" as a "partially ordered set of enterprise activities that can be executed to achieve some desired end-result in pursuit of a given objective of an enterprise or a part of an enterprise".

In our paper, we will build on the established term "business process", but use it in a slightly broader sense such that it includes processes in all kinds of profit-oriented and non-profit organizations. In fact, the patterns discussed in this paper are not specific for any kind of organization.

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A business process model is the abstract description of such a business process. Our work deals with models that have been constructed using a graphical modeling language. The ISO standard 19439 also names different views that can be contained in business process models: The model can include information about the processing steps and the relations between them, about the data used and exchanged when executing a process, about the human and non-human resources that are needed to perform a process and about the structure of an organization including the organizational chart and the decision-making responsibilities.

A process model representing a process such as “process customer order” contains several tasks and their logical order (the so-called sequence flow). Fig. 1 shows a business process model depicting three tasks. Tasks represent what is done in the process, e.g., “Receive Order”, “Ship Goods”, “Create Invoice”. In the most simple case, the completion of the previous task triggers some succeeding task(s). The model has been drawn using the language defined by *Business Process Model and Notation* (BPMN) [OMG 2011] standard - at present the most prominent business process modeling language.

Fig. 1. Simple Business Process Model in the Language BPMN

In the context of our catalog, we define a business process model pattern as a description of a proven solution to a recurring problem that is related to the creation or modification of business process models in a specific context. In addition, to consider such a description as a business process model pattern, a standardized description (usually using a pattern template) is required. Typical parts of this structure are the pattern name, a problem description, a solution, known uses and a discussion, which enables the reader to understand under which circumstances the proposed solution will be useful.

It should be noted that in the existing literature, the term *business process model(ing) pattern* is not used in a consistent way. For example, [Kavanagh 2004] or [Jung and Sprenger 2006] used this term exclusively for describing patterns on how to develop or improve business processes. In this case, the patterns refer to the actual process (not to the process model). An example for such a pattern would be: *Avoid manual tasks that can be done by a computer system.* Our definition includes such patterns, and is much broader.

The aim of business process model patterns can be:

to support the creation of good business process models,
to support the improvement of the modeled business processes,
to support working with them.

Although a considerable number of papers about business process model patterns have been published, it is rather difficult for a process modeler or a researcher to find out which published patterns could be helpful in a given situation. There are two reasons for this:

First, relevant publications can be found in a great variety of proceedings, journals and web sites. For certain types of patterns, compilations of the patterns and related work can be found on the web. The most remarkable web site is www.workflowpatterns.com, which is a great resource for getting familiar with a certain kind of business process model patterns. However, this site is restricted to “low-level” patterns that describe the basic building blocks that a workflow engine or process modeling language should support. There exists no single resource that provides an entry point for searching the full spectrum of pattern papers.

And second, patterns dealing with the same topic are not named in a unified way. For example, patterns dealing with adaption and change between model variants are called *change patterns* [Uronkarn and Senivongse 2015], *adaption patterns* [Döhring et al. 2010], *variability design patterns* [Yousfi et al. 2016], *high-level change operations* [Li et al. 2008] or just *differences* [Dijkman 2007] by different authors.

Our work deals with both problems: By providing a pattern catalog www.bpmpatterns.org, we want to establish a starting point for the search for business process model patterns that can be used by practitioners and researchers. And by providing a first taxonomy that categorizes the types of publications on such patterns, we hope to broaden the knowledge on which types of patterns exist.

Our work builds on previous work by [Becker and Klingner 2014] who provide a first overview on business process model patterns based on criteria such as type of publication, accessibility, notation used for describing the patterns, etc. A categorization according to the type of patterns, which will be presented in this paper, was not taken into account in [Becker and Klingner 2014]. Another related work is [Haddar et al. 2014]. This survey on reuse in the business process management field includes a discussion of certain patterns in this area.

2. LITERATURE SURVEY

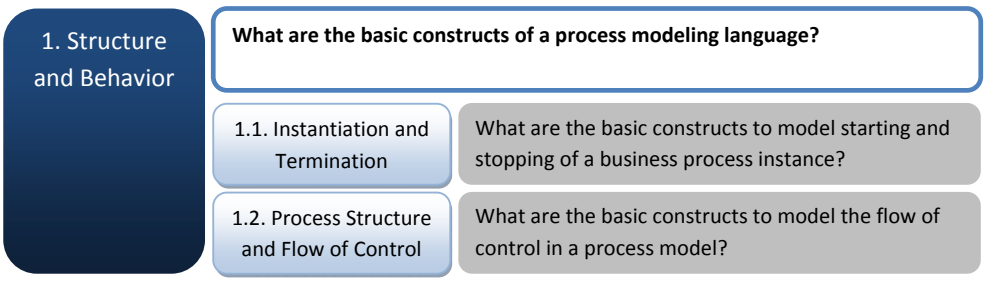
In December 2015, we conducted a literature search to get an overview on published business process model patterns. First, we searched the ACM, ISI Web of Knowledge, IEEE, Ebsco Host and Springer research databases according to the recommendations by [Webster and Watson 2002]. We applied a full-text search with several key words such as “business process”, “workflow”, “pattern”, “template”, etc. Additionally, we used Google Scholar to find appropriate literature. In addition, we conducted a backward search to find more appropriate publications cited in papers of the first search round.

Fig. 2. Business Process Model Pattern Taxonomy

With the structured literature search, we identified 275 relevant publications. We cross-checked the references in [Becker and Klingner 2014; Haddar et al. 2014] with our set of 275 papers. We identified four additional papers and added them to our initial result list. In addition, we included six more papers, which had not been found in the literature search but were known by the authors. In the end, we identified 285 publications. After filtering out duplicates or papers, which actually do not present patterns, we identified 89 publications in English and German language. A typical reason for filtering out papers was when a publication did not present new patterns but uses patterns published elsewhere as its research base as it is the case for several papers, which discuss the expressiveness of modeling languages based on previously published patterns. These 89 publications (usually containing more than one pattern) were included into our catalog. In addition, we categorized the problems discussed in the patterns in order to find common types of patterns. This resulted in a taxonomy of business process model patterns that will be described in the following section.

3. TAXONOMY

Following the process described in [Nickerson et al. 2013], we developed a taxonomy for the publications. Our taxonomy uses a two-level categorization schema. Fig. 2 gives a first overview about the main categories.

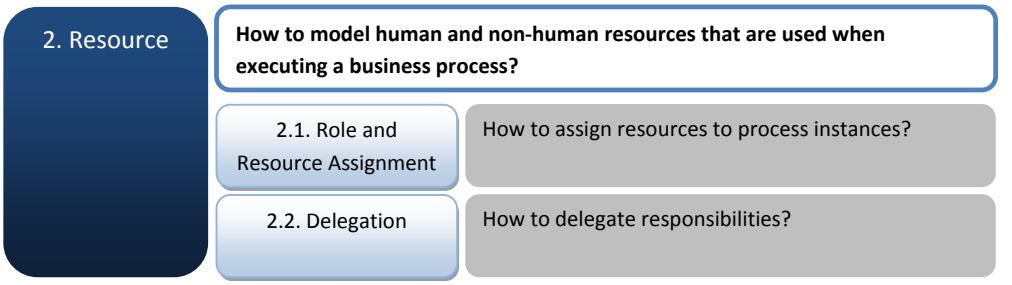


1. Structure and Behavior Patterns. Structure and behavior patterns contain patterns relating to the constructs of process modeling languages and how to use them. They are helpful for selecting a workflow system and for evaluating the expressiveness of modeling languages [van der Aalst and ter Hofstede 2012]. In the seminal publication called "Workflow Patterns" [van der Aalst et al. 2003], the term "workflow patterns" has been used to denote the patterns of this category. However, later the term "workflow patterns" was used in a broader sense, including also the data and resource perspective (which we categorize in other categories).

The subcategory 1.1 INSTANTIATION AND TERMINATION deals with starting and stopping instances of a business process. In contrast to a process model, which represents all possible process executions, a *process instance* represents a concrete case of a process. For instance, in a business process model that describes an order process in a general way (see Fig. 1), an instance could be to receive a specific order from a concrete customer with unique customer ID.

Subcategory 1.2 PROCESS STRUCTURE AND FLOW includes the "classic" workflow patterns [van der Aalst et al. 2003; Russell et al. 2006]. Those patterns describe basic constructs of a workflow system in a language-independent manner. In addition to constructs that can be found in all common workflow systems, this subcategory also covers specific patterns such as control-flow patterns that consider location-dependency. Furthermore, this subcategory includes patterns for exception handling

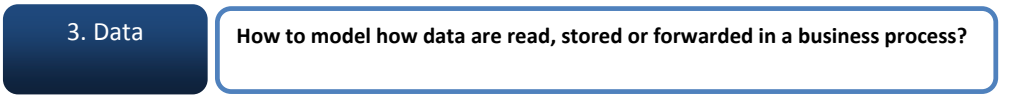
covering the reaction to foreseen and unforeseen exceptions that can occur when actually executing a business process.



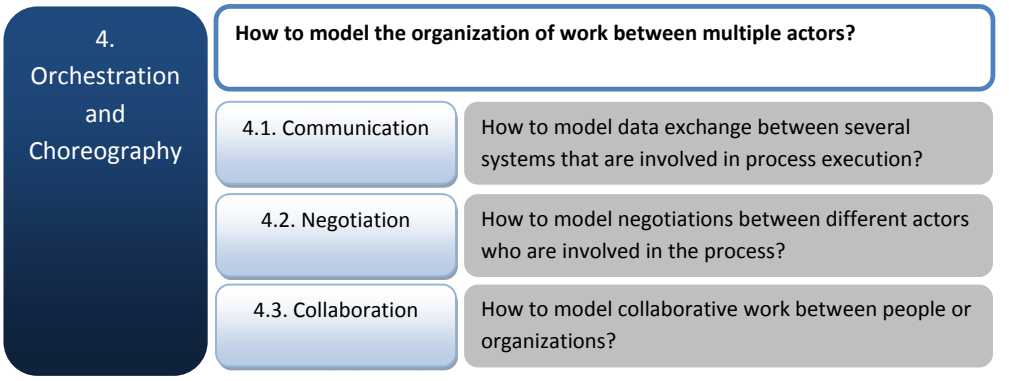
2. Resource Patterns. This category contains patterns that are related to resources that are needed for executing a business process.

Subcategory 2.1 ROLE AND RESOURCE ASSIGNMENT deals with associating human and non-human resources to process instances. In case of human resources, this includes patterns that consider roles, rights and responsibilities.

Subcategory 2.2 DELEGATION deals with cases where a delegation of responsibilities is necessary.



3. Data Patterns. This category deals with data that can be read, stored or forwarded in a process.



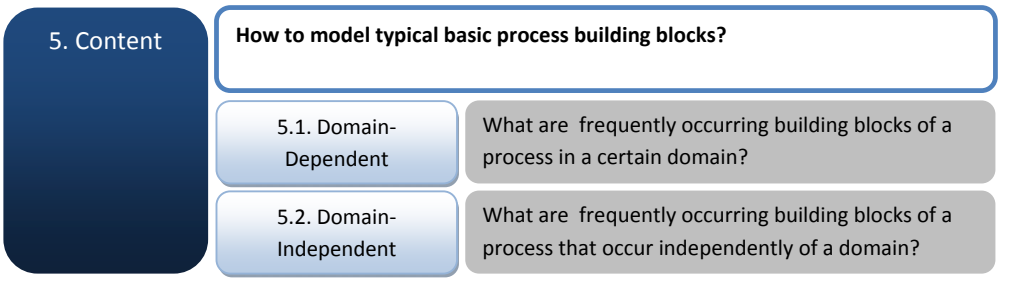
4. Orchestration and Choreography Patterns. This category contains patterns for organizing process work that is jointly executed by multiple actors (humans or machines involved into the execution of the process). Orchestration emphasizes the coordination of actors executing a process, while choreography focuses on the interplay between the actors participating in a process.

This category includes three subcategories:

4.1 COMMUNICATION covers data exchange between actors that contribute to a business process. In the context of service-oriented architectures, those patterns are known as service interaction patterns.

Subcategory 4.2 NEGOTIATION deals with the process of establishing a contract between the actors on how to execute a process.

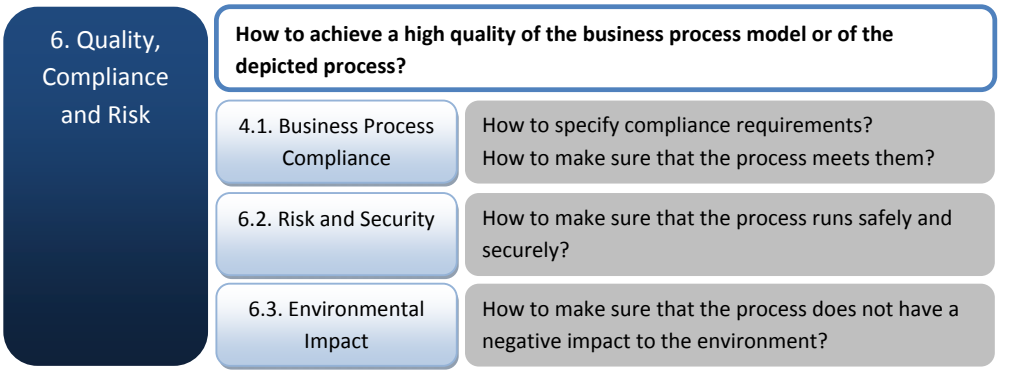
Subcategory 4.3 COLLABORATION includes patterns for organizing collaborative work of groups of people. This includes, but is not restricted to patterns involving social media platforms.



5. Content Patterns. Content patterns are patterns addressing the semantic meaning of process model building blocks. This means that business goals and sub-goals can be considered. A basic distinction is made between domain-dependent and domain-independent patterns:

The subcategory 5.1 DOMAIN-DEPENDENT includes content patterns that are specific to a certain domain. We found patterns for two such domains: health-care (to be used in clinical workflows) and software engineering (software processes).

In contrast, subcategory 5.2 DOMAIN-INDEPENDENT includes patterns that are not specific to a certain industry. Those patterns cover rather fundamental situations that can be found in various domains. Examples are *approval* or *review*.



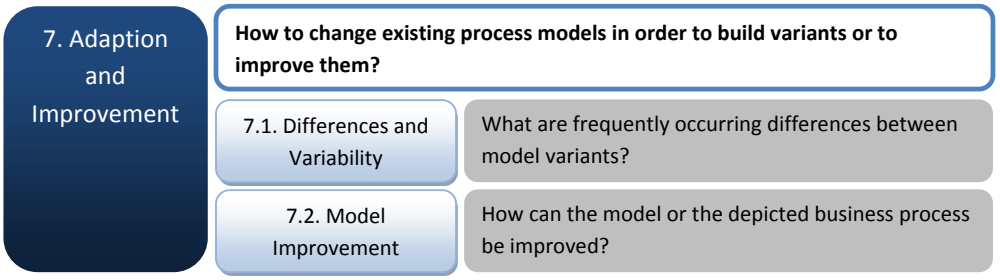
6. Quality, Compliance and Risk Patterns. This category contains patterns aiming to ensure that processes have a high quality and adhere to regulations.

Subcategory 6.1 BUSINESS PROCESS COMPLIANCE deals with patterns concerning the adherence to general legal regulations, but also to (company-specific) standards or guidelines. This subcategory includes patterns for common requirements, e.g., about the order between process tasks, the time restrictions between them, or the association of resources to tasks. Included are both patterns for the specification of such requirements and for monitoring whether the requirements are fulfilled at runtime. They can be considered as a special case of property specification patterns [Dwyer et al. 1998]

or time-related specification patterns [Gruhn and Laue 2006]. Those patterns have been developed to support the specification of the required behavior of a system (or a business process in our case).

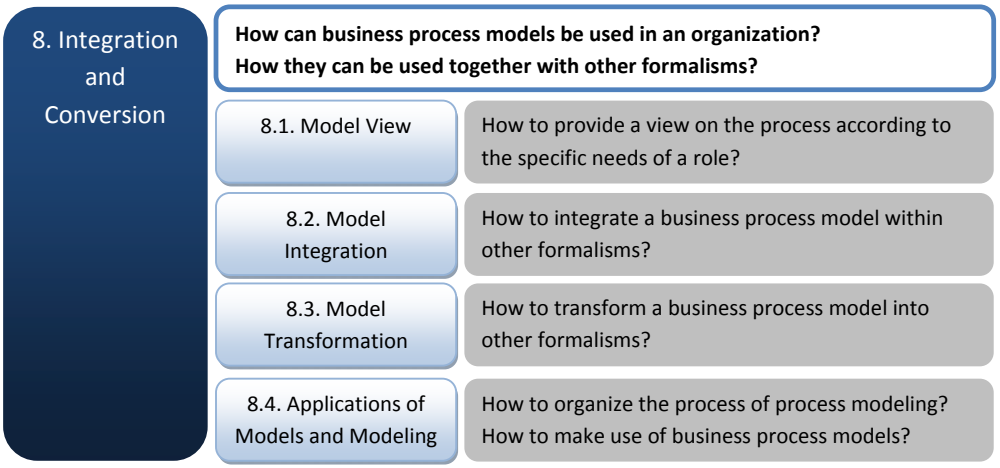
Subcategory 6.2 RISK AND SECURITY includes patterns that deal with risks, safety and security. These patterns aim to support the development of secure business processes.

Subcategory 6.3 ENVIRONMENTAL IMPACT includes patterns that discuss the ecological perspective of business process executions.



7. Adaption and Improvement Patterns. This category contains patterns for changes and enhancements of existing processes. In regard to changes, patterns may relate to adaptation mechanisms such as process configuration. Such patterns are useful for defining processes that have commonalities but also differ in certain aspects (process families), for adapting processes at runtime, and for understanding the differences between process models. Those patterns are included in subcategory 7.1 DIFFERENCES AND VARIABILITY.

Subcategory 7.2. MODEL IMPROVEMENT deals with patterns for changes that lead to an improved process model. This improvement can either aim to the process model (e.g., to improve its readability or to reduce its complexity) or to the process itself. In the latter case, the patterns describe how a current business process can be improved with respect to a certain goal. Typical goals are to improve certain performance indicators such as quality, cost or throughput. This category of patterns is also called *optimization patterns* by some authors.



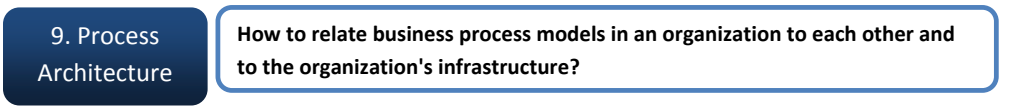
8. Integration and Conversion Patterns. Process models can depict a business process from various perspectives. The patterns in this category deal with working with those perspectives.

Subcategory 8.1. MODEL VIEW contains patterns for providing views of a process that are adjusted in order to answer the questions related to a certain perspective. This subcategory also includes patterns for changing the granularity of the view.

Subcategory 8.2 MODEL INTEGRATION deals with solutions for integrating various viewpoints such as a strategy model and a business process model. While those models are usually expressed in different modeling languages, both viewpoints have to be integrated in order to get a consolidated overview of an organization. This means that these patterns can deal with enterprise modeling in a broader sense, where business process modeling is just one aspect among others.

Subcategory 8.3 MODEL TRANSFORMATION includes patterns for transforming business process models from one language to another one. This includes patterns for transformations between process descriptions in natural language and models in a business process modeling language, but also transformations between different formal languages. An example for the latter case is a formalism that describes how certain patterns in a BPMN model can be transformed into a formal language that can be understood by a simulation tool or a model checker.

Other than the patterns described so far, the subject of the patterns in subcategory 8.4 APPLICATION OF MODELS AND MODELING are neither processes nor process models. Instead, the patterns in this category address the persons working with business process models and the tools and processes they use for this purpose. The patterns in this category deal with the organization of modeling projects and the collaboration between modelers.



9. Process Architecture Patterns. This category deals with process architecture patterns, the so-called process landscapes of an organization. Patterns of this category consider relationships between the components of an enterprise architecture and describe the relationships within a process (model) architecture.

4. PATTERN CATALOG

Based on the taxonomy described in the previous section, we compiled an online catalog of papers on business process model patterns. It is available at www.bpmpatterns.org. The catalog provides access to the pattern papers and adds metadata that allow filtering for several criteria.

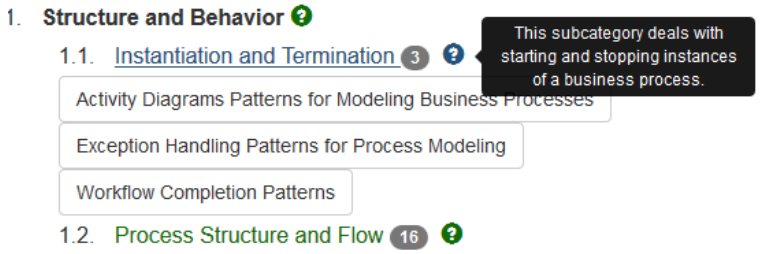


Fig. 3. Screenshot from www.bpmpatterns.org

As can be seen in Fig. 3, the catalog is organized by topics using the two-level taxonomy described in Sect. 3. Whenever possible, we linked to the original work such that the majority of resources can be accessed directly.

In addition, it is also possible to search the catalog according to various aspects. For example, it is possible to search for patterns that are relevant to a given modeling language only (see Fig. 4).

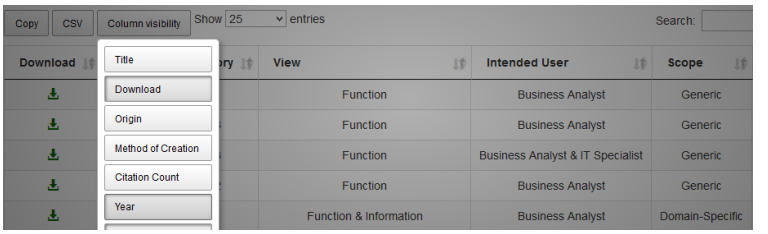


Fig. 4. Detailed Search at www.bpmpatterns.org

It is our aim to keep our pattern catalog up-to-date by adding further pattern collections to it. As a first step, we would like to include business process modeling anti-patterns that are not yet part of the catalog.

Furthermore, we will be grateful for being informed about any relevant work in this area. We will be glad to add any relevant work that will be published in the future. We hope that www.bpmpatterns.org will become a starting point for everyone who is interested in learning about business process model patterns.

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