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Representing Business Process Flexibility using Concept Maps

Asma Mejri[a*], Sonia Ayachi Ghannouchi[a,b], Ricardo Martinho[c,d]

[a]*Laboratory RIADI-GDL, ENSI, Mannouba 2010, Tunisia*
[b]*High Institute on Management of Sousse, Tunisia*
[c] *School of Technology and Management, Polytechnic Institute of Leiria, Portugal*
[d]*Center for Health Technology and Services Research (CINTESIS), Portugal*

Abstract

Business process flexibility has been a relevant research topic within Business Process Management (BPM) for the past 20 years. Several taxonomies were proposed along this time, emphasizing certain aspects of flexibility or change within business processes, taking into account the various dimensions of business processes. Although these taxonomies have been most useful in contributing to research advances on flexibility, they contain distinct concept names for the same meaning and vice-versa. Additionally, they are often textual and heavily descriptive, and do not provide a simplified representation of their concepts and relationships. In this paper we propose the use of the Concept Maps (CMaps) approach to achieve this simplified representation of business process flexibility. The main output is concept maps covering the wide and diverse spectrum of business process flexibility concepts and relationships. In this way, researchers can benefit from a simpler and yet understandable representation, which also takes into account the most established business process flexibility definitions found in prominent research literature.

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* Corresponding author. Tel.: +21623844689; fax: +21623844689.
E-mail address: mejri.assma@gmail.com

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1. Introduction

To carry out their missions, organizations manage complex business processes and need to react to changes. It is desirable to have business processes (BPs) that allow for flexibility [1]. In particular, flexible processes promise to cope with increasing demand of variety and uncertainty [2]. The topic of process flexibility has become thus a center of attention from both commercial and research institutions as understanding of requirements for business processes capable to adapt their behavior to changes [3].

For the past 20 years, several taxonomies, ontologies and frameworks have been proposed to define and correlate the properties of flexibility, changeability and variability with the Business Process Management (BPM) discipline. Consequently, different research approaches, explanations, contexts and focuses were proposed, taking into account the particular objectives of each research. In fact, all these descriptions and conceptualizations have greatly contributed to the advances on business process flexibility and Business Process Management in general, both from academia and industry points of view.

Nevertheless, we can observe that quite often BP flexibility taxonomies and frameworks are based on heavily descriptive textual definitions, without a simple and clarified representation of their relationships. Moreover, they can also be dispersed and cover distinct aspects of business processes, regarding the research focus being pursued. This makes it difficult for BP flexibility researchers (especially newcomers) and practitioners to have a basic starting point on BP flexibility. In fact, researchers may view this concept partially or subjectively, and practitioners perceive it according only to their (often limited) organizations' environment and culture.

Research using Concept Maps (CMaps) has enabled advances in several fields, been applied in a variety of subjects and for a variety of purposes [4]. It enclosures a visual and diagram-based approach that represents a conceptual framework of a complex topic. In this paper, we propose an alternative representation of BP flexibility using this CMaps approach, in order to capture the most relevant concepts and relationships associated. The main output is concept maps that visually represent BP flexibility in a structured way, and therefore benefit from a well-proven approach for building solid conceptual references for researchers and practitioners.

The remainder of this paper is structured as follows: in the next section, we highlight the background of this research. We discuss therefore the main concepts of BP flexibility and give an overview on concept maps. Then, we explain the methodology that we have followed in order to construct the proposed concept maps. On this basis, we present our concept maps of BP flexibility. In the last section, we present the conclusions. We provide then implications for theory and practice and we suggest future avenues of research which are necessary to continue to understand more deeply the BP flexibility.

2. Background

In this section, we provide a synthesized literature about BP flexibility (specifically definitions and taxonomies). Our focus in the third sub-section was to give an overview on concept mapping.

2.1. BP flexibility definitions

Research related to process flexibility in literature has grown intensively over the past couple of decades. Most of the early works that began to examine this topic focused precisely on defining process flexibility. A definition of BP flexibility was given in [5]: the fast reaction to internal and external changes that affects the enterprise and the easiness to modify business processes schemes and to set up the new enterprise activity.

In [6], authors describe BP flexibility as the amount of change that a process can accept in the presence of different perturbations. It is the ability to give way to change without disappearing, i.e. without losing identity. Another definition proposed in [7] stated it as the capability to implement changes in the business process type and instances by changing only those parts that need to be changed and keeping other parts stable.

In [8], authors propose that BP flexibility can be seen as the ability to change or deviate from the business process and plays an important role in the extent to which such systems can support dynamic processes.

According to [9], flexibility of BP is associated with their ability to deal with both foreseen and unforeseen changes in the context or environment in which they operate. In addition to the ability to deal with change, authors in [9] also

cited that flexibility is “the quality of a process” that reflects its ability to adapt to changing business circumstances. They consider that flexibility is a balance between change and stability that ensures that the identification of the process is retained.

In order to enhance flexibility, many paradigms have been proposed in literature. Each of the paradigms has its specific characteristics which are adjusted to specific organization’s needs. The case handling paradigm supports flexible and knowledge intensive BPs [10]. The rule based paradigm allows the BP to be modelled in a declarative way, by means of business rules [11]. The constraint based paradigm provides possibilities to execute both optional and allowed scenarios in BPs [12]. Finally, the adaptive paradigm was designed to cope with adaptive response requirements [13].

2.2. BP flexibility taxonomies

Presenting BP flexibility taxonomies has been an important topic of interest to researchers in the area of BPM.

In [14], authors presented a taxonomy of process flexibility. This taxonomy identifies four main flexibility types: flexibility by definition, flexibility by deviation, flexibility by under-specification, and flexibility by change.

Reichert et al. [15] also defined a taxonomy of BP flexibility. According to them, business processes can be characterized by four major flexibility needs, namely support for variability, looseness, adaptation, and evolution .

A taxonomy of process flexibility is also presented in [16]. This taxonomy of Nurcan focused on studying the nature of flexibility. Thus two major flexibility types were defined: 1) flexibility by selection (*a priori*) and; 2) flexibility by adaptation (*a posteriori*).

Regev et al. presented in [7] a taxonomy of flexibility in business processes. It includes three orthogonal and combinable dimensions: abstraction level of change, subjects of change and properties of change.

These taxonomies were selected because of their frequent usage in the BPM research field. For instance, taking into account the Google Scholar search engine, and as of May 2016, the taxonomy in [7] (Regev et al.) was cited 107 times, the taxonomy in [15] (Reichert et al.) 271, the taxonomy in [16] (Nurcan) 102 and the taxonomy in [14] (Schonenberg et al.) 225.

There are many similar concepts across these most prominent BP flexibility taxonomies, with also a few different ones. Table 1 presents them across the above-mentioned taxonomies. Alternative names for the same concepts are also presented, as well as a short description for each concept, according to the taxonomy it belongs.

Table 1.Concepts in the most prominent taxonomies.

Concepts	Alternative names	Derived taxonomy	Description
Process variant	Versioning	[15](Reichert et al.)	Process variability requires processes to be handled differently resulting in different *process variants*
		[16](Nurcan)	The *versioning* defines if it is possible to handle several versions of the same process definition. It offers a means to anticipate the future transformations.
Process model	- Process type - Process definition - Entry-time	[16](Nurcan)	Flexibility by adaptation (*a priori*) allows adapting the *process definition*.
		[14](Schonenberg et al.)	The *process definition* can be changed by extending or by reducing the activities in the definition, or by relinking the activities. Regarding entry time, changes can be performed only at the moment the process instance is created.
		[7](Regev et al.)	The standard way of working, as defined in the *process type*, could be changed.
Process instance	On the fly	[16](Nurcan)	Flexibility by adaptation (*a posteriori*) allows adapting the process *instances* during their execution.
		[14](Schonenberg et al.)	Changes can be performed at any time during process execution, customizing a given process instance.
		[7](Regev et al.)	Changing process instances means that a deviation from the standard way of working is created for one or more instances.
Drivers (internal or external)	- External or	[15](Reichert et al.)	Flexibility is often driven by several *drivers*. In addition to *external* triggers, changes implemented in the process might become necessary due to developments inside the process organization (*internal*).

	environmental change - triggers	[16](Nurcan)	Flexibility can offer the capacity to deal with the *environmental change.*
Momentary change		[14](Schonenberg et al.)	A momentary change is a change that affects the execution of one or more selected process instances.
Evolutionary change		[15](Reichert et al.)	Evolutionary change affects all newly created process instances as well as all ongoing process instances.
		[14](Schonenberg et al.)	Evolutionary change is a change caused by modification of the process definition, potentially affecting all new process instances
		[16](Nurcan)	In evolutionary change, transformation is required due to the redesign or reconfiguration of the BP. The old process definition is then considered as inappropriate with regard the new management objectives.
Incremental change		[7](Regev et al.)	*Incremental* changes start from an existing process type and only introduce changes to the already existing process type.
		[15](Reichert et al.)	*Incremental* changes require small changes of the implemented process as for continuous process improvements.
Revolutionary change		[7](Regev et al.)	*Revolutionary* changes abolish the existing process type and creates a completely new one.
		[15](Reichert et al.)	*Revolutionary* changes require radical changes.
Deferred change		[7](Regev et al.)	*Deferred* changes are only applied to new instances of the process. The already running instances remain unchanged.
		[15](Reichert et al.)	The change is *deferred* when it only affects newly created process instances.
Immediate change		[7](Regev et al.)	*Immediate* means that the change is applied to all instance of the process, also the running ones.
		[15](Reichert et al.)	*Immediate* evolution is mostly relevant for long-running process instances.
Temporary change		[7] (Regev et al.)	A *temporary* change is valid only for a limited period of time and reset afterwards.
		[15](Reichert et al.)	*Temporary* changes are only valid for a certain period of time.
Permanent change		[7](Regev et al.)	*Permanent* changes are valid until the next permanent change, they are not reset.
		[15](Reichert et al.)	Permanent changes are valid from the time they are introduced
Planned change	Anticipated Prepared	[7](Regev et al.)	Planned changes are often part of a process redesign
		[15](Reichert et al.)	Process change can only be planned if both the context of its occurrence and measures to handle it are known.
Ad-hoc change	Unplanned change	[15](Reichert et al.)	*Unplanned* changes are hardly possible to be foreseen. Exceptions may occur in the context of a particular process.
		[16](Nurcan)	The *ad-hoc* change is a non-predefined action on instances or definition. It is created during the execution to modify the behavior of the BP.
		[7](Regev et al.)	*Ad-hoc* changes are often made to cope with exceptional situations
Corrective change		[16](Nurcan)	The transformation aims to correct a design error on the process definition or to react to an exception which happens during the execution of an instance.

Table 1 shows that 13 concepts are similar across at least 2 taxonomies, considering their alternative names and definitions, while 2 concepts are specific to only 1 taxonomy. From the 13 similar concepts, 7 present alternative names (with a sum of 16 different names). The BP flexibility definitions and taxonomies referred above are often presented within a mix of textual descriptions and graphical representations, and we could not perceive the use of any structured way of representing their concepts and relationships.

2.3. Concept maps

Concept Maps were first proposed in [17] to represent knowledge as a network consisting of nodes as *concepts* and links as the relations between them. Concept maps are defined in [18], as "*a type of knowledge visualization for representing the knowledge of an individual by means of nodes, displaying concepts and labeled links between the nodes, representing the relations between the concepts*". In [19], a definition of a concept map as "*as a perceived regularity in events or objects, or records of events or objects, designated by a label*" was given. Concept maps consist thus of pairs of concepts joined by link lines with descriptive labels (e.g. has a, is a, leads to, etc.) that indicate the relationship between pairs of concepts [20].

A concept map is also characterized by the inclusion of cross-links which are relationships or links between concepts in different segments or domains of the concept map [19].

The aim of concept mapping is not to generate spontaneous associative elements but to outline relationships between ideas. Thus, concept mapping is a relational device [21].

Our starting point is therefore to construct a concept map that contains the most relevant concepts related to BP flexibility.

3. Representing BP flexibility using Concept Maps

In order to construct our BP flexibility Concept Map, we adopted the method described in [22] and [19], namely.

1. Definition of the area of knowledge: this is done by preparing an appropriate focus question, or a question that will be answered by the knowledge that is mapped. In this paper, our focus question is: *"How can a business process be flexible?"*
2. Identification of the key concepts (usually 15 to 25 concepts will suffice): taking into account the concepts analyzed in section 2 (both from most prominent definitions and taxonomies studied) ; we list in Table 2 the concepts that we will be using to construct our Concept Map;
3. Construction of the preliminary concept map: for this purpose, we used the software tool CmapTools [23].
4. Revision of the concept map: we added these concepts: goal, system data, application data, process data, rigid and flexible. We also have deleted some concepts like business process. Besides, we have edited some relationships such as the relationship between change and property which is changed from "has" to "has a set of".

We begin by illustrating in Figure 1 the main concept map for our purpose, and present apart in Figures 2 and 3 specializations of some of these concepts, for the sake of readability.

Starting from Figure 1, a *Flexible business process* could be defined as a collection of inter-related *elements* that collectively lead to a business *goal*. A flexible process *element* can be distinguished by associating it with a process perspective. The functional perspective describes activities to perform during process execution. A process performs *activities*. Activities are logical units of work [24]. In the behavioural process perspective, an activity can have pre-conditions and post-conditions.

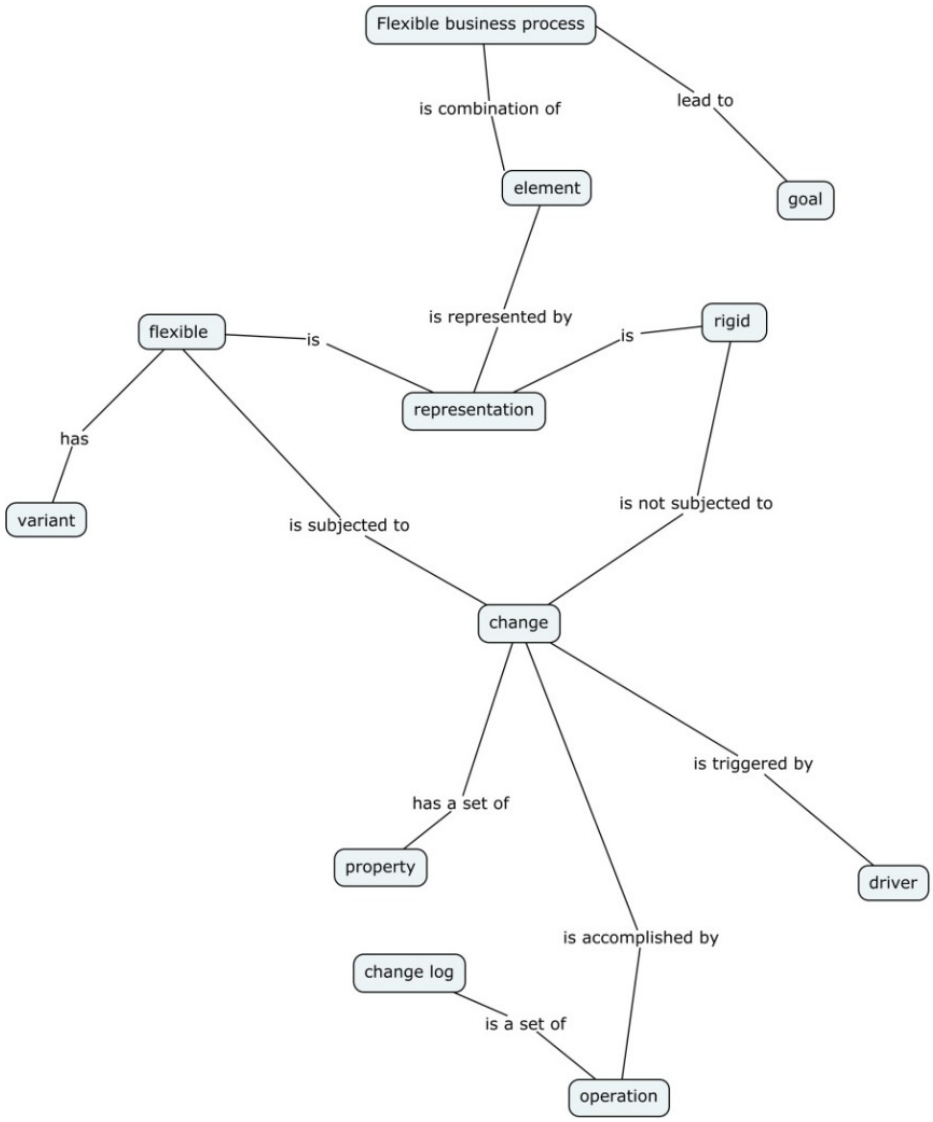

Fig. 1.Concept map on BP flexibility.

The coordination between activities (control-flow) is then specified by *control connectors*. The operational perspective defines elementary *operations* performed into the atomic activities. Activities can execute one or several operations. The informational perspective deals with production and use of information. An activity consumes and/or produces *informational resources*. An informational resource could be a *system data*, an *application data*, or a *process data*. The organizational perspective describes relationships between *roles* and *actors* giving them authorizations to perform atomic activities. An atomic activity is performed by a role, which is played by several actors.

On the basis of these perspectives, a flexible business process encompasses a number of *elements* which are activities, operations, informational resources, roles, control connectors and actors. In order to best take into account the flexibility in BP, we added concepts related to the business process modelling paradigms (such as the constraint-based, the rule-based, the adaptive process management...) dealing with flexibility in BPM.

The constraint-based paradigm supports flexibility by being able to keep track of multiple *constraints* in multiple business processes and preventing users from violating these constraints. In addition, it is also possible to distinguish between the *mandatory* constraints (i.e., that must be followed) and *optional* constraints (i.e., that should be followed) [25]. On the other hand, rule-based approaches have been proposed to deal with the flexibility requirement in a proper way by modelling the logic of a process with a set of *rules* [26]. Business rules are defined as [27]:"the set of policies for regulating the whole business within and outside an organization". Thus business processes can be modelled as a set of business rules. The rule based approaches are flexible because they are able to express the temporal requirements. They take also advantage from adaptation to ad hoc modification at runtime and exceptions [28].

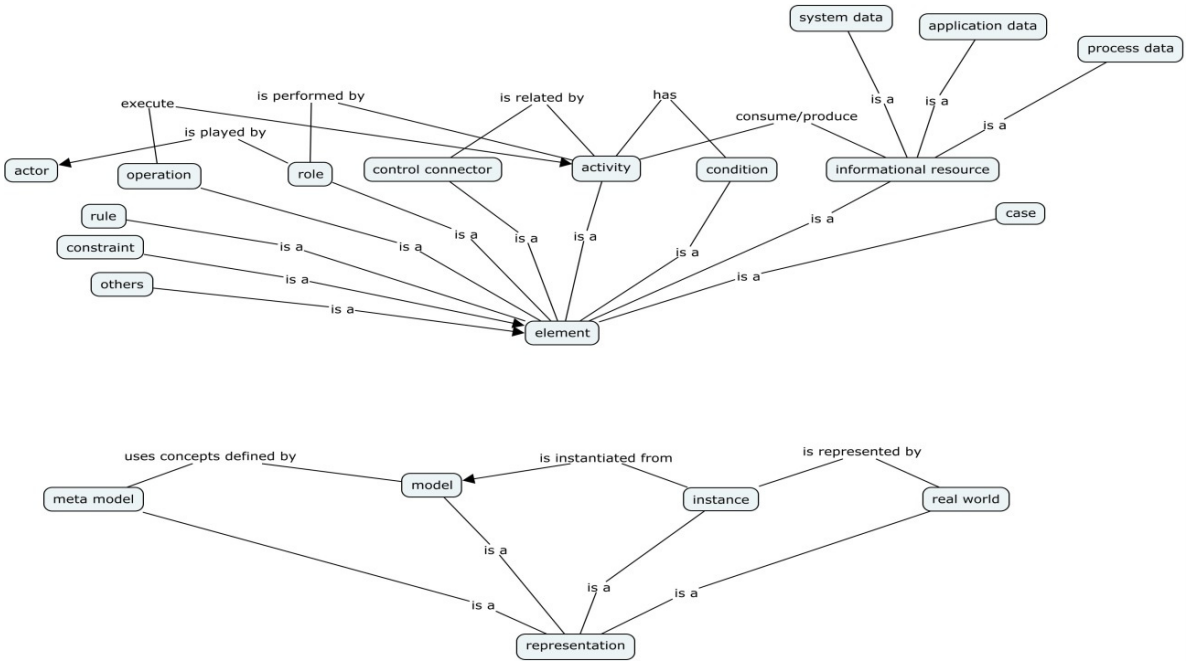

Fig. 2.Generalization relationships for the concepts of *element and representation*

The case handling paradigm focuses mainly on the *case* itself [29]. The central concept for case handling is the case and not the activities. The case is the "product" which is manufactured, and at any time workers should be aware of that [24]. The case should be considered as a 'product' with structure and a current state [24]. Each case is linked to one process but one process can be linked to many cases [24]. All these different process elements and relationships are depicted in the concept map of Figure 2.

Back to Figure 1, the *business process model* represents this set of elements and is the centre for conducting business or improving how the business is operated. It also helps process engineers to focus on their thinking, as working with process models increases their understanding of the business and, hopefully, also their awareness of new opportunities for improving business [30]. The process model aims to capture the different ways in which a *process instance* can be handled [31]. A *business process instance* represents a (digital form) of a concrete, *real-world* case in the operational business of a company, consisting of process model element instances such as activities, data objects or role assignment instances [32]. In turn, a process *meta-model* defines the set of element types and association rules that can be used by a model to represent a certain business process. Therefore, a flexible process *element* can have 4 distinct *representations* (abstraction levels): *meta-model*, *model*, *instance* and *real-world*.

According to the definitions presented in section 2.1, BP flexibility denotes the ability to balance, within the set of elements in a process, those element *representations* that can be subjected to change (*flexible*) and those that cannot (*rigid*). Therefore, process *change* is accomplished by applying a sequence of *change operations* to a given *flexible representation* of a process element. Such *change operations* structurally modify the initial process representation.

Thus, each application of a change operation results in a new process *variant* [33]. Though the depicted change operations in Figure 3 were discussed in relation to the ADEPT change framework, they are generic in the sense that they can also be applied in connection with other process meta-models [34].

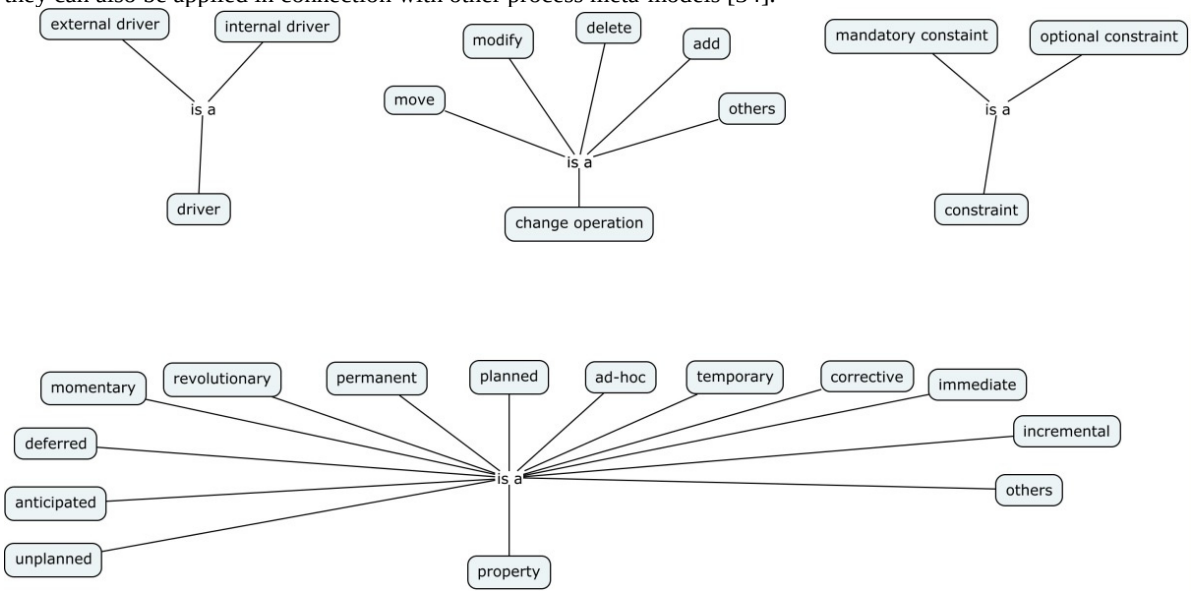

Fig. 3.Generalization relationships for the concepts: driver, property, constraint and change operation

While *insert*, *delete*, *move* and *modify* operations are important for changing the set of elements in a process representation, other change operations are also possible. Additionally, a change can also have a set of properties that reflect its extent (*incremental* or *revolutionary*), duration (*momentary*, *temporary* or *permanent*), swiftness (*immediate* or *deferred*) and anticipation (*planned* or *ad-hoc*).

4. Conclusion and future work

Because of the dynamic environment business processes are involved in, defining a flexible business process in a detailed and comprehensive way is a complex task. This paper proposes the use of the Concept Maps approach to depict BP flexibility as a set of diagrams where concepts are laid out along with their relationships. We started by studying most prominent definitions and taxonomies on this subject, and found out that there are some concepts with different meanings and different concept names for the same meaning around the BP flexibility domain.

We then constructed our concept maps following the approach identified in [22, 19], and pictured in Figures 1, 2 and 3 the concepts and relationships that we could derive from our study in section 2. Figure 1 presents the overall, generic concept map, while Figures 2 and 3 are focused on specializations of concepts identified in Figure 1, as well as their relationships.

In our ongoing research, we aim to develop a new concept map which focuses on the following focus question “How can a process engineer be guided to choose the BPMS that best fits his organization's needs in terms of flexibility in business processes?”.

References

1. Adriansyah A, van Dongen BF, van der Aalst WM. Towards robust conformance checking. In: Business Process Management Workshops. Springer; 2010. p. 122-133.
2. Afferbach P, Kastner G, Krause F, Roglinger M. The Business Value of Process Flexibility. Business & Information Systems Engineering. 2014;6(4):203-214.
3. Mulyar N, van der Aalst WM, Russell N. Process flexibility patterns. Technische Universiteit Eindhoven. 2008.

4. Van Bon-Martens M, van de Goor L, Holsappel J, Kuunders T, Jacobs-van der Bruggen M, Te Brake J, et al. Concept mapping as a promising method to bringpractice into science. Public health. 2014;128(6):504-514.
5. Daoudi F, Nurcan S. A framework to evaluate methods' capacity to design flexible business processes. In: 6th International Workshop on Business Process Modeling. vol. 12; 2005. p. 1-8.
6. Regev G, Wegmann A. A regulation-based view on business process and supporting system flexibility. In: Proceedings of the CAiSE. vol. 5; 2005. p. 91-98.
7. Regev G, Soffer P, Schmidt R. Taxonomy of Flexibility in Business Processes. In: BPMDS; 2006.
8. Pesic M, Van der Aalst WM. A declarative approach for flexible business processes management. In: Business Process Management Workshops. Springer; 2006. p. 169-180.
9. Schonenberg H, Mans R, Russell N, Mulyar N, van der Aalst WM. Towards a Taxonomy of Process Flexibility. In: CAiSE forum. vol. 344; 2008. p. 81-84.
10. Van der Aalst WM, Weske M, Gr unbauer D. Case handling: a new paradigm for business process support. Data & Knowledge Engineering. 2005;53(2):129-162.
11. Sun X, Liu XZ, Jiao WP, Huang G, Mei H. A Rule-Based Approach to Supporting Adaptable Web Service Composition. CHINESE JOURNAL OF COMPUTERSCHINESE EDITION-. 2006;29(7):1084.
12. Pesic M. Constraint-based workflow management systems: shifting control to users. Technische Universiteit Eindhoven; 2008.
13. Buhler PA, Vidal JM. Towards adaptive workflow enactment using multiagent systems. Information technology and management. 2005;6(1):61-87.
14. Schonenberg H, Mans R, Russell N, Mulyar N, van der Aalst W. Process flexibility:A survey of contemporary approaches. In: Advances in Enterprise Engineering I.Springer; 2008. p. 16-30.
15. Reichert M, Weber B. Enabling flexibility in process-aware information systems:challenges, methods, technologies. Springer Science & Business Media; 2012.
16. Nurcan S. A survey on the flexibility requirements related to business processesand modeling artifacts. In: Hawaii International Conference on System Sciences,Proceedings of the 41st Annual. IEEE; 2008. p. 378-378.
17. Novak JD, Gowin DB. Learning how to learn. Cambridge University Press; 1984.
18. Engelmann T, Hesse FW. How digital concept maps about the collaborators knowledge and information influence computer-supported collaborative problem solving. International Journal of Computer-Supported Collaborative Learning. 2010;5(3):299-319.
19. Novak JD, Canas AJ. The Theory Underlying Concept Maps and How to Construct and Use Them. Florida Institute for Human and Machine Cognition; 2008.
20. Clariana RB, Engelmann T, Yu W. Using centrality of concept maps as a measure of problem space states in computer-supported collaborative problem solving. Educational Technology Research and Development. 2013;61(3):423-442.
21. Davies M. Concept mapping, mind mapping and argument mapping: what are the differences and do they matter? Higher education. 2011;62(3):279-301.
22. Novak JD, Canas AJ. Theoretical origins of concept maps, how to construct them, and uses in education. Reflecting Education. 2007;3(1):29-42.
23. Canas AJ, Hill G, Car R, Suri N, Lott J, Eskridge T, et al. CmapTools: A knowledge modeling and sharing environment. In: Concept maps: Theory, methodology, technology. Proceedings of the first international conference on concept mapping. vol. 1; 2004. p. 125-133.
24. Van der Aalst WM. Business process management: A comprehensive survey. ISRN Software Engineering. 2013;2013.
25. Van Der Aalst WM, Pesic M, Schonenberg H. Declarative workflows: Balancing between flexibility and support. Computer Science-Research and Development. 2009;23(2):99-113.
26. Boukhebouze M, Amghar Y, Benharkat AN, Maamar Z. A rule-based approach to model and verify flexible business processes. International Journal of Business Process Integration and Management. 2011;5(4):287-307.
27. Hay D, Healy KA, Hall J, et al. Defining business rules-what are they really. Final Report. 2000.
28. Bekki K, Belbachir H. A Flexible Integration of Security Concern in Rule Based Business Process Modeling. In: ICWIT. Citeseer; 2012. p. 222-231.
29. Wohed P, Russell N, ter Hofstede AHM, Andersson B, van der Aalst WMP. Patterns based evaluation of open source BPM systems: The cases of jBPM, Open-WFE, and Enhydra Shark. Information and Software Technology. 2009;51(8):1187-1216.
30. Eriksson HE, Penker M. Business modeling with UML. Business Patterns at Work, John Wiley & Sons, New York, USA. 2000.
31. Van der Aalst WM, Berens P. Beyond workflow management: product-driven case handling. In: Proceedings of the 2001 International ACM SIGGROUP Conferenc eon Supporting Group Work. ACM; 2001. p. 42-51.
32. Weske M. Business process management: concepts, languages, architectures. Springer Science & Business Media; 2012.
33. Li C, Reichert M, Wombacher A. A heuristic approach for discovering reference models by mining process model variants. 2009.
34. Li C. Mining process model variants: Challenges, techniques, examples. University of Twente; 2010.