Flexibility in Business Process Modeling to Deal with Context-Awareness in Business Process Reengineering Projects

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Abstract. Current research on Business Process Management (BPM) outlines the importance of Business Process Reengineering (BPR) operations for business improvements' goals. One of the main issues when conducting this kind of project is basically related to the modeling of current (as-is) and future (to-be) processes in the enterprise. In fact, traditional business process modeling techniques (BPMT) are being difficult to adopt for BPR projects which are being more and more context-aware, especially for two root causes: (i) BPR projects are conducted in a changing environment and (i) Business Process (BP) requirements are constantly evolving especially within permanent customers' changing needs. Thereby, the contexts in which BPR projects are conducted, are different; they may have various purposes, may cover different perspectives of the organization, etc. That's why business process modelling techniques supporting flexibility could be more suitable to deal with these changing atmosphere. In this paper, we propose the use of an approach for flexible business process modeling BPVM [1] for BPR projects.

Keywords: Business process reengineering
Business process modeling techniques · Flexibility · Context-awareness

1 Introduction

Many researches on Business Process Management (BPM) highlight the importance of Business Process Reengineering (BPR) operations for business improvements' goals allowing them to better support current business requirements.

In the current complex and dynamic environments, Business Processes (BP) have to be flexible and adaptable to changes in theses environments. Flexibility in business process modeling has been the focus of many researches [24, 25, 30, 31]. There are many definitions of the flexibility in literature. It is defined in [32] as "the ability to

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yield to change without disappearing". We define flexibility as the capacity of making a compromise between, first, satisfying, rapidly and easily, the business requirements in terms of adaptability when organizational, functional and/or operational changes occur; and, second, keeping effectiveness. Among techniques used for dealing with flexibility we mention (i) *variability* which iss defined as "the ability of deriving different variants from the same BP" [31], (ii) *adaptability* that can be defined as the ability to temporarily deviate the flow during the execution of a BP [31], and (iii) *context-awareness* which is the ability to use contextual information to adapt the process [12]. A lot of approaches dealing with techniques implementing flexibility were proposed. While some of them focus on context-awareness and adaptation [12, 19, 26], others propose reuse and variability mechanisms [1, 2, 8, 21, 27–29].

Moreover, the needs of approaches to deal with context-awareness in BPR projects are significant. Many researches in business process management stress the importance of context-awareness issues in different aspects related to BPR. In fact, BPR projects are often context dependent; not only the environment in which BPR projects are lead is changing, but also, business requirements are evolving. More precisely BPR projects can have different purposes and may cover different modeling perspectives in the organization.

Furthermore, one of the main phases when conducting BPR projects is related to the modeling of current (as-is) and future (to-be) processes in the organization. These tasks need the use of business process modeling techniques (BPMT).

Adopting a non-flexible BPMT in a BPR project, which being context-aware, may makes difficult the realization of these projects.

That is why, we argue that business process modelling techniques supporting flexibility could be more suitable to deal with these changing atmosphere.

In this paper, we propose the use of an approach for flexible business process modeling BPVM [1] to model as-is and to-be business processes in BPR projects. We focus on the BP design and redesign.

The rest of this paper is organized as follows: Sect. 2 presents an overview of BPR and introduce a set of research issues for dealing with context-awareness in this field, and particularly in the phases related to design steps in BPR life cycle. Section 3, presents a flexible business process modeling approach for the formalization of existing business processes to redesign (as-is), for the identification of the changes, and for the modeling of future business processes (to-be) in the organization with a flexible way. This approach is called BPVM (Business Process Variability Model).

2 BPR (Business Process Reengineering) and Context-Awareness

According to Hammer et al., BP renginering is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance such as cost, quality, service and speed [5]. Also, BPR has been used by organizations as an approach to implement and manage changes [9]. A key issue in BPR is the 'how' question. BPR requires some methodology guidelines [3, 4].

The Business process reengineering (BPR) is one of the most adopted methods to introduce change in enterprises. In fact organizations often have to change their processes at higher or lower frequencies, in order to improve and make them more efficient. To reach this goal a BP modelling task is to be fulfilled during the analysis, diagnose and redesign BPR phases.

Modeling business processes is very helpful for the success of BPR projects according to the several advantages it offers, such:

- understanding the existing BPs, identifying their weakness and problems,
- identifying areas of potential improvement and areas with a gap between existing BPs and the BPR objectives,
- representing new BPs in order to evaluate their performance
- increasing the speed and the quality of the implementation of BPR improvements
- being used for end-user training: all documents such as work instructions, user instructions, ISO documents, etc. are stored in the model that constitutes a single information source
- being used as "the best practices models", BPs models can be used as start point in similar companies initiating BPR projects.

The modeling task is not easy to be put into practice in BPR projects due to the huge number of emerging business process modeling techniques, notations and languages (e.g. Event-driven Process Chains (EPC), UML Activity Diagrams, Business Process Modeling Notation (BPMN) [11], Business Process Execution Language (BPEL), etc.) [3]. A lot of researches dealing with this problem were performed [10, 15, 16, 20].

Some research labors are based on the track of context awareness in BPR to solve this difficulty. Among research works dealing with context aware BPR we mention [3, 4, 7].

The authors of [4] introduce a Context-aware Business Process Evaluation and Redesign approach which consists in two principle steps: first, it identifies the BP context; second, it enhances the original BP model by using process chunks appropriate for this context. The proposed approach use the workflow patterns [6] as an extension mechanism in the phase of redesign. To each pattern is associated a relevance degree in a particular context of use.

In [3, 7] authors propose a metamodel for BPR vocations which encompasses knowledges and concepts related to (i) modeling BPs in the context of the enterprise and (ii) BPs reengineering. In fact a guidance approach is performed for selecting adequate BP models to be used for as-is or to-be BPs during BPR projects. This approach is based on a classification framework for about 30 traditional BP modelling techniques (e.g. EPC, Petri nets, UML class diagrams, UML activity diagrams, IDEF 0, State/transition diagrams, BPMN, Role Activity diagrams, etc.). The framework is built on four dimensions: (i) Type of business processes, (ii) Degree of change, (iii) Modeling purpose, and (iv) Modeling view.

(i) Type of business processes: which reflects the three ISO classification of the enterprise BPs: Core, Management and Support BPs [33].

  - Core (operational) processes: are the operational processes of the business which result in the production of the outputs that are required by external customers,

- Support processes: are those that enable the core processes to exist. They concentrate on satisfying internal customers,
- Management Processes: concern themselves with managing the core processes or the support processes, or they concern themselves with planning at the business level.

(ii) Degree of change (level of change): which reflects the degree (or the scale) of BPR radicalness. In fact, a BPR project might consider one or many BP at one time and, according to fixed objectives. For each BP a level of change is then defined. In fact a BPMT might be more appropriate than others to reach a fixed change level. Levels of radicalness are: radical and incremental (Fig. 1). So if the level is radical then the BPMT should allow the redesign of the BP, i.e. it is necessary to remodel the process in order to have radical changes. In contrast, if the level is incremental then the BPMT should allow modelers to interact with the obtained BP model in order to bring continuously and incrementally the desired changes [3, 7].

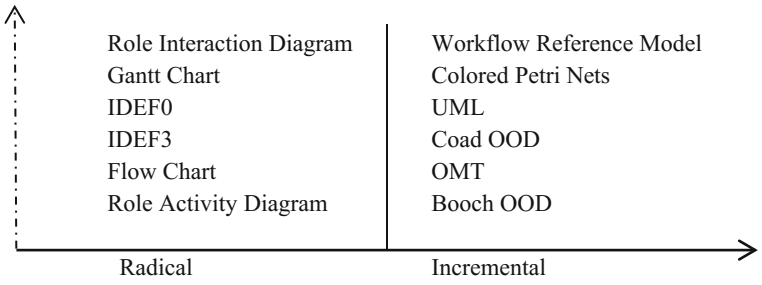

Fig. 1. Classification of BPMTs based on change degree.

(iii) Modeling purpose: which reflects objectives reached from the processes modeling. In fact in BPR actions it is a question of defining new BPs or redesign existing ones. Theses actions require BPMT for different objectives which might be: analysis, decision, decision execution and information technology solutions support [3, 7]. Figure 2 presents a classification of some traditional BPMTs according to modeling purposes.

(iv) Modeling view (modelling perspective): a BP model should be capable of providing the necessary BP information elements, such as: what are the activities composing the process, who is performing these activities, what elements they provide, where and how, etc. So a BPMT supports many modeling views (Fig. 3), such as: functional (what), behavioral (when and how), informational (entities produced by or manipulated by a process) and organizational (where and by which role).

Even if the introduced framework was proposed to help analyzing and evaluating business process modeling techniques, it can also be used for the definition of new

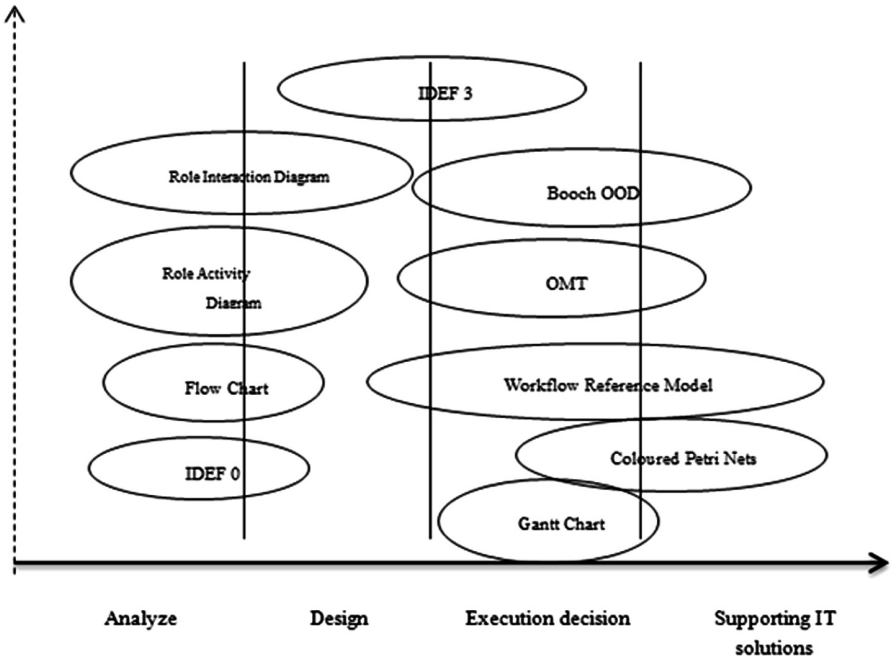

Fig. 2. Classification of BPMTs based on modeling purposes [3, 7]

ones. That is why, is Sect. 3, we will introduce BPVM as a modeling technique, supporting flexibility, for BPR projects.

3 BPVM (Business Process Variability Model) for Context-Aware BPR Projects

We introduce in this section the business process modeling approach for the representation of flexible business processes BPVM [17] and we demonstrate its adequacy as a modeling technique in BPR projects. We start by presenting an overview and the meta-model of BPVM in Sect. 3.1; then, in Sect. 3.2, we describe briefly the main concepts of this approach while situating it with reference to the multidimensional classification structure proposed in [3, 7]. We demonstrate the manner it embodies the capability to take into consideration flexibility requirements and support most of the dimensions introduced in the framework introduced in Sect. 2.

3.1 Overview of BPVM

BPVM is a multi-perspectives business process modeling approach integrating variability. It allows to represent business processes in a way to give them their capacity to be adaptable, on the one hand, and to identify and to formalize the factors whose variations require changes at run-time (i.e. context, and quality requirements), on the

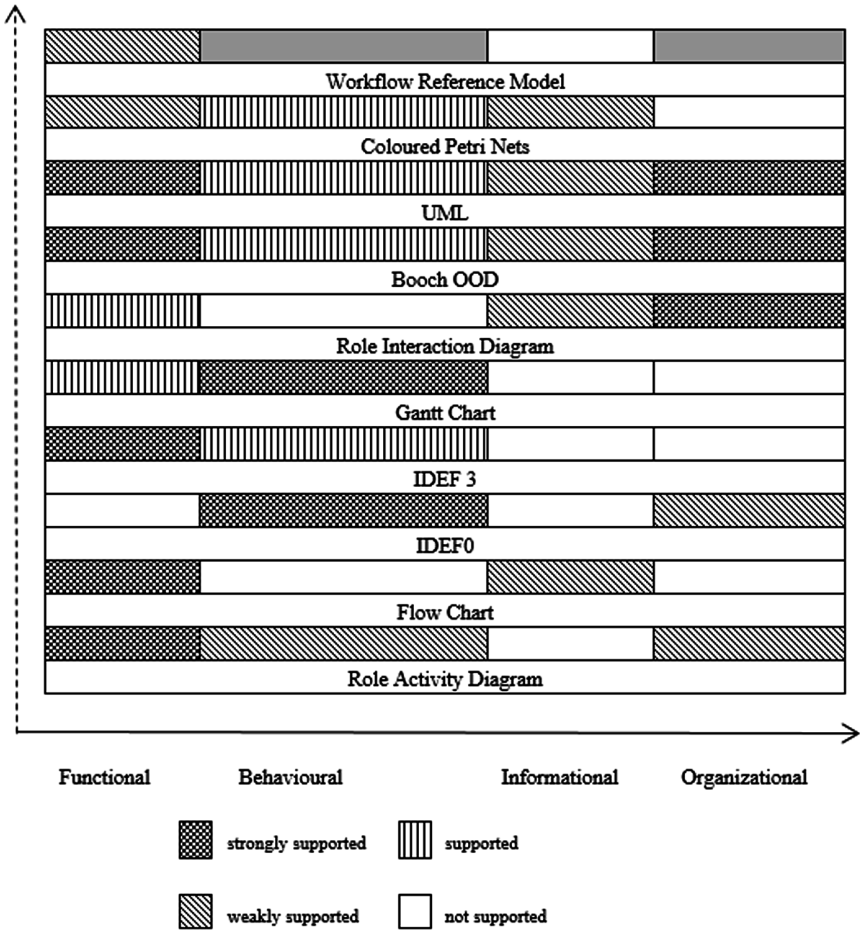

Fig. 3. Classification of BPMTs based on modeling perspectives [3, 7]

second hand. The proposed approach allows to build several possible representations of a business process and to capture change requirements that affect the process execution.

Figure 4 shows the meta-model BPVM using the notation of UML class diagram. The proposed meta-model includes five parts that cover the following perspectives: the intentional perspective, the functional perspective, the organizational perspective, the non-functional perspective and the non-organizational resource perspective. As shown in Fig. 4, the core concept in BPVM is that of business process fragment (BPF). The perspectives of the meta-model are interconnected through this concept.

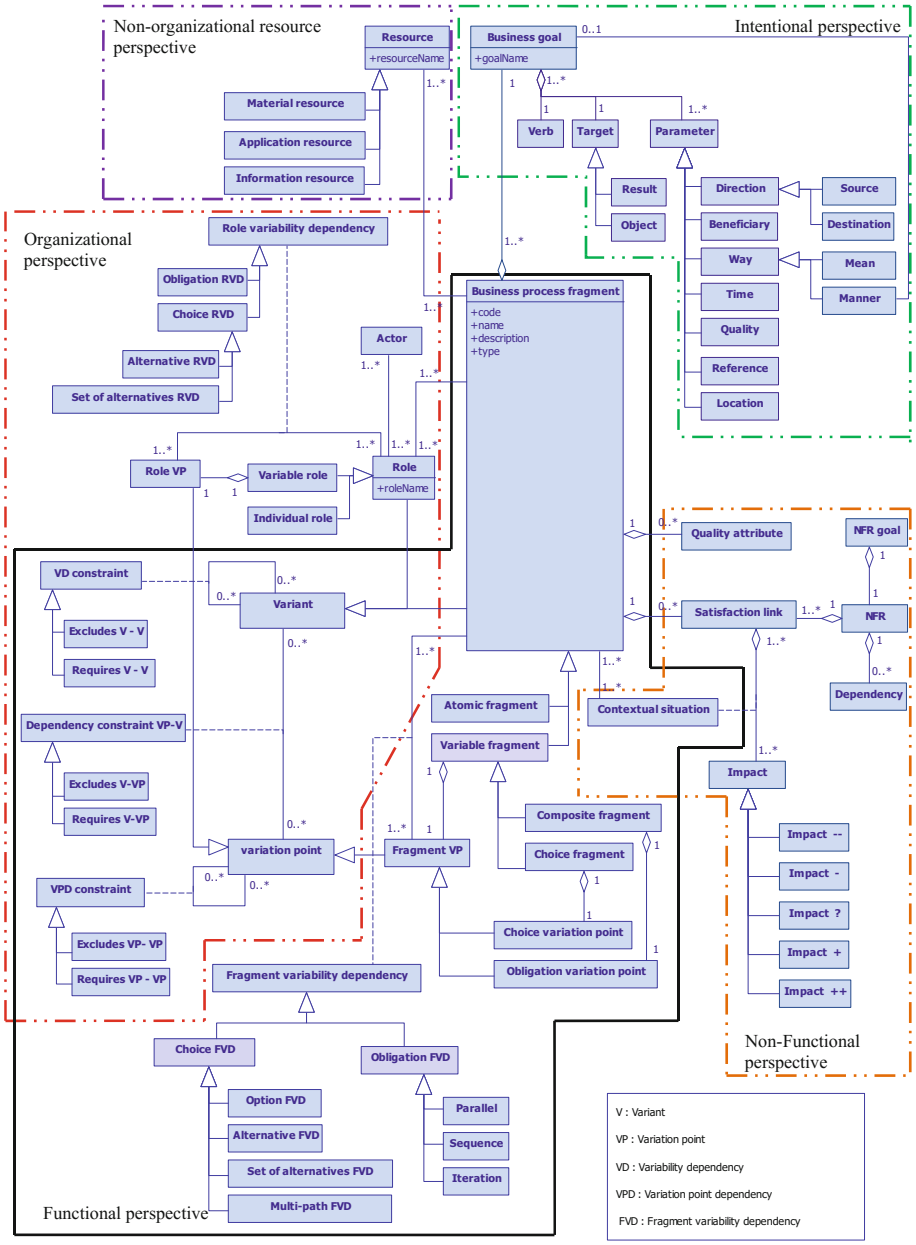

Fig. 4. BPVM Meta-model [17]

3.2 Analysis of BPVM with Reference to the Modeling Techniques Classification Framework

In this section, we demonstrate the adequacy of BPVM for modeling BP in context-aware BPR by analyzing it with reference to the dimensions of the classification framework introduced in Sect. 2.

a. **Dimension 1: Modeling view**

To represent flexible processes, a modeling solution has to provide a minimum set of perspectives to represent the enterprise elements that are potentially impacted by changes [24].

Regarding the dimension *Modeling view*, BPVM is a multi-perspectives business process modeling approach which allows business processes to be represented according to five perspectives: *intentional perspective*, *functional perspective*, *non-functional perspective*, *organizational perspective* and *non-organizational resources* perspective.

The functional view. The functional view represents the BPFs by specifying their functional composition of units of finer granularity. This composition follows a hierarchical structure whose leaves fragments represent atomic processes. This perspective represents a business process model in terms of BPFs which have to be achieved as well as their structures, the composition links and the variability dependencies between them, and the conditions and the constraints governing their achievements.

A BPF is defined as a part of a business process model that (i) creates value for the organization, (ii) can be reused in several process models, (iii) can be placed under the responsibility of one or more roles (iv) and whose implementation allows to satisfy a business goal. This concept aims to define multiple levels of abstraction. It is similar to the concept of sub-process defined by the WfMC [10] and the OMG [11].

The Organizational View. This view allows to express the organizational resources which are required for the business process realization. These resources are the actors and the roles they play. The core concept in this perspective is that of role. A role is defined as an organizational entity which is responsible for the achievement of a BPF and that can be assigned to one or more actors; it can represent a skill, a competency or qualification or a responsibility. It can also represent a group of individuals. The concept of role is also considered as a means allowing to assign the actors to the BPFs instances. This concept is similar to the concepts of business role and business entity defined in BPMN(Business Process Modelling Notation), to the concept of organizational unit defined in EPC, and to the concept of organizational role defined by the WfMC [13]. An actor is defined as a resource that is involved in the execution of a process instance fragment since it is assigned to a role responsible for the achievement of this fragment. An actor is assigned to one or more roles based on their qualifications and skills. An actor may be responsible for the achievement of one or more instances of BPFs according to the roles they can play. This concept is similar to that of participant defined by the WfMC.

The Behavioral View. BPFs define the structure of a process and they can cover the following modeling situations: atomicity, composition, sequence, parallelism, optionality and choice (alternative or multiple).

A fragment variation point is a representation of one or more places to which an obligation of selection or a choice decision is attached. The choice decision is made based on the intention of the actor, the context, the responsible role and the desired quality properties. Each variable BPF is associated to a fragment variation point.

The association of a BPF to a variation point is expressed using the relationship *Fragment variability dependency* (FVD). Figure 4 shows two types of FVD: *obligation* and *choice*. An obligation FVD can be of three kinds: *parallel*, *sequence* or *iteration*. A choice FVD can be of four types: option, alternative, set of alternatives or path.

The Non-functional View. This view formalizes the non-functional requirements that a business process have to meet and the qualitative goals of the organization which allow improving the quality of the business processes [18, 22]. As shown in Fig. 4, BPVM expresses the quality requirements related to business processes as well as the satisfaction links between the goals and the BPFs, and the impact values according to a given context. "Accuracy" and "Safety" are examples of quality requirements. The information about the impact of a non-functional requirement (NFR) on every fragment is considered as a quality attribute for this fragment. Thus, the quality of the business process is expressed through the quality of its components, i.e. the BPFs. As shown in Fig. 4, the quality of a BPF is formalized by the use of the links between the classes "Business process fragment" and respectively the classes "Quality attribute" and "Satisfaction link".

The Informational View. The informational view is supported by the non-organizational resources perspective in BPVM. Non organizational resources are the resources used - or produced - by process fragments: data, business objects, and so on. Resources can be of different natures. As shown in Fig. 4, three subclasses of resources are distinguished: information resources, application resources, and hardware resources. A resource can be used by a process fragment. It can also be "consumed" (for some hardware resources), or produced during the execution of the process.

The Intentional View. The intentional perspective allows expressing the goals that business processes have to meet. It is represented, in the meta-model by the fact that a BPF (Business Process Fragment) achieves a goal. The relationship between BPFs and goals which can be achieved by these BPFs is formalized by the link between the classes *Business process fragment* and *Business goal*. In BPVM, a business goal specifies an objective that we have to achieve without detailing how to achieve it. It identifies the needs and the expectations attached to a business process. A business goal is defined as an objective of the organization in carrying out its activities which is satisfied through the realization of one or several BPFs. Business goals are formalized using a linguistic approach that is based on the formalism proposed in [23]. This formalism provides a support for the business processes engineering based on goals [5]. The linguistic template of a goal includes a verb, a target and a set of parameters that play specific roles related to the verb. The list of parameters is as follows: *Source* and *Destination* (which are generalized by the parameter *Direction*), *Means* and *Manner*

(which are generalized by the parameter *Way*), *Beneficiary*, *Time*, *Quality*, *Reference* and *Location*. The verb and the target are mandatory, whereas the parameters are optional. The target designates the entity affected by the goal. It can be of two kinds: *object* or *result*. The parameters are defined in details in [17].

The Contextual View. The contextualization of a business process model (obtained by the instantiation of BPVM) consists in informing all its conditions of applicability of the BPFs. This is done by representing the context characteristics and the contextual conditions. Two kinds of contextualization are proposed: the functional contextualization and the non-functional contextualization.

The first kind of contextualization consists in expressing the contextual conditions related to BPFs and to the roles and in representing the impact of the context on the way of executing these BPFs and of choosing the appropriate BPFs and roles at run-time. A contextual condition is associated to every BPF allowing to specify the conditions under which the execution of the BPF is possible.

The non-functional contextualization consists in adding the contextual conditions to the quality attributes. In fact, in some situations, the context has an impact on the contribution value of the variants in the satisfaction of a quality goal, i.e. according to the context, and according to the desired quality purposes, it is better to select an alternative rather than another one.

b. **Dimension 2: Modeling purpose**

In BP reengineering projects, BPVM can be used not only for defining new BPs, but also for or redesigning existing ones. Moreover, it is adequate to use for many modeling purposes which might be: analysis, design, and decision execution. Firstly, BPVM can define business processes at the intentional level as well as et the operational level; secondly, regardless of the abstraction level, using the concept of BP fragment different levels of abstraction can be expressed. In fact, BPVM allows to represent high-level orientation views of business processes, aiming to understand business environment, defining business decisions, strategies and goals.; also more detailed views of the business activities can be expressed, as well, the diffrent aspects related to business activities (i.e. the behaviour, resources, etc…).

c. **Dimension 3: Types of processes**

BPVM can be used for the representation of (i) core processes which represent the essential activities the organization whose achievement allows to satisfy organizations goals and objectives, (ii) management processes that are designed to plan, to monitor and to control business activities, and (iii) support processes which assist the value-delivering core processes by providing the resources and infrastructure required by them.

d. **Dimension 4: Degree of change**

BPVM can be used for radical change and incremental change. It deals with the needs related to the reuse and the modularity. The concept of BPF that we propose allows to define modular and reusable components which are linked to goals to satisfy. BPVM supports variability in the organizational and the functional perspectives.

Functional Variability. Using BPVM, a business process model can be represented by a set of BPFs which can be achieved in different contexts and by different actors that can have various preferences on the manner in which their intentions are achieved. Thus, a BPF can be achieved in different ways and different alternatives for the accomplishment of a business process model can be defined.

In order to deal with variability, BPVM introduces key concepts related to variability: *variation point* and *variant* which are based on OVM (Orthogonal Variability Model) [14]. In BPVM, BPFs and roles are considered as variability units. BPVM extends OVM by the concepts of *role* and *BPF*. These two concepts refer to the concept of variant in OVM. Figure 4 shows the meta-model of OVM extended by the concepts of BPF and role (which specializes the concept of variant in the original model) as well as the concepts of *variation point role* and *variation point fragment*. According to the meta-model, a variation point is a point in the business process where a change occurs indicating the existence of various realization alternatives. A variant is a possible alternative related to a variation point. The variants and the variation points are connected by *variability dependencies*. The variability dependencies can be of two types: *choice* and *obligation*. As shown in Fig. 4, a set of dependency constraints between the variants, between the variation points, and between the variants and the variation points, are defined. The dependency constraints represent the rules that have to be followed to ensure the consistency of the business process instances. BPVM distinguish two types of dependency constraints similar to those defined by FODA (Feature Oriented Domain Analysis): the *Requires* and the *Excludes* constraints.

Organizational Variability. The organizational perspective expresses the variability dependencies between the roles. Like the dependencies of variability between process fragments, the dependencies between the roles are based on the variability model OVM. As shown in Fig. 4, two kinds of roles are defined: individual role and variable role.

A BPF can be achieved under the responsibility of several actors playing different roles. The concept of variable role is used. Roles and variability dependencies between them constitute a role hierarchy whose leaves represent individual roles. The purpose of this representation is to provide a mechanism for flexible assignment of the BPFs to the actors playing various roles. Thus, the same BPF can be achieved by different roles in different situations.

An individual role is a role that does not include other roles. Director is an example of individual role. A variable role is an entity that expresses an organizational variability by grouping a set of roles. We identify three kinds of variables roles: (i) composite role which consists of two or more roles, (ii) alternative role which includes mutually exclusive roles and (iii) set of alternatives-roles which includes a set of roles from which at least one role is selected at run-time. A variation point is associated to each variable role.

Thus, we can resume our BPVM, according to the multidimensional classification structure for BPM techniques presented in Sect. 2, with extending the mentioned framework with the intentional view, by defining the different dimensions and charecteristics proposed, as illustrated in Table 1. We note that we have extended the classification framework by three views in the dimension modeling view. These views are the contextual view, the intentional view and the non-functional view.

Table 1. Analysis of the BPVM according to a set of dimensions from the extended modeling techniques selection framework

Dimension	Value	Support
Modeling view	Informational view	*Yes*
	Functional view	*Yes*
	Organizational view	*Yes*
	Behavioral view	*Yes*
	Intentional view	*Yes*
	Non-functional view	*Yes*
	Contextual view	*Yes*
Modeling purpose	Analysis	*Yes*
	Design	*Yes*
	IT solution support	*Yes*
Type of process	Management processes	*Yes*
	Core (operational) processes	*Yes*
	Support processes	*Yes*
Degree of change	Radical	*Yes*
	Incremental	*Yes*

4 Conclusion

In this paper, we discussed the use of a business process modeling approach (BPVM) which supports flexibility, for modeling the "as-is" and the "to-be" business processes in context-aware BP reengineering projects. This approach allows to represent a business process model according to many modeling perspectives. Also, it can be used to model different types of business processes. What's more, it can be used for analysis or design purposes. And finally, it allows to take into consideration both radical and incremental change; it fact it supports variability in both the functional and the organizational perspectives hence variations are defined with respect to the way of achievement of business process fragments and to the actors' roles.

The work presented in this paper in founded on a multidimensional classification framework of many used traditional BPMT which presented the goal of helping analyzing and evaluating business process modeling techniques and consequently the definition of new ones.

In the future, we will continue our efforts to evaluate the use of BPVM in BPR projects on a large BPs panoply. It will be interesting to work on software development processes which funded on COTS (Commercial off-the-shelf) software components as they are in a close relationship with the context in which they are chosen, applied, tested and maintained by software developers.

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