Aspect-Oriented Business Process Management (Extended Abstract)

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Abstract. Separation of concerns has long been considered an effective and efficient strategy to deal with complexity in information systems. One sort of concern crosses over other concerns, which makes their management difficult. Aspect Orientation is a paradigm in information systems which aims to encapsulate cross-cutting concerns to overcome this problem.
In the Business Process Management (BPM) area, Aspect Oriented Business Process Modeling aims to specify how this technique can support encapsulating cross-cutting concerns in process models. However, it is not clear how these models should be supported in the whole BPM lifecycle.
Therefore, this thesis investigates how aspect orientation can be supported over the whole BPM lifecycle. This thesis has been carried out following the design science framework, and the result is presented as a set of artifacts (in the form of constructs, models, methods, and instantiations) and empirical findings.
The artifacts support modeling, analysis, implementation/configuration, enactment, monitoring, adjustment, and mining cross-cutting concerns while supporting business processes using Business Process Management Systems. The use of these artifacts and their application shows that they can reduce the complexity of process models by separating different concerns.

Keywords: Separation of Concerns, Cross-Cutting Concerns, Business Process Management, Aspect-Oriented

1 Introduction

Business Process Management (BPM) is an important area of research which aims to support the design, administration, configuration, enactment, and analysis of business processes through sets of concepts, methods, and techniques [5]. Each business process has a boundary indicating the set of activities, data and the organizational settings which are required to enact the process. There are usually many concerns involved when designing and enacting business processes, and some of these concerns are not limited to the boundary of one business process, e.g. security, privacy, etc. Indeed, these concerns cross over the boundaries of many processes, so they should be considered when supporting these processes.

The cross-cutting nature of some concerns not only increases the complexity of process models but also makes their management difficult. These concerns are realized in different process models as sub-set of activities, data, and the organizational settings. The realization of these concerns in process models introduces two problems, called *scattering* and *tangling*.

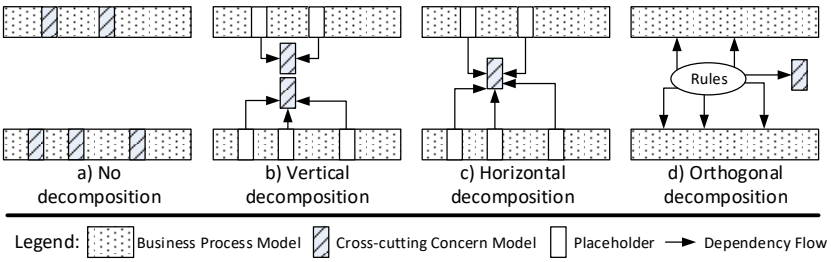

Fig. 1. The modularization techniques in the BPM area

The *scattering problem* in modeling cross-cutting concerns refers to the repetition of the sub-models that capture these concern in different process models. For example, this problem occurs when we ignore to encapsulate the specification of these concerns or encapsulate the specification of these concerns using vertical decomposition like sub-processes, shown at an abstract level in Fig. 1(a&b).

The *tangling problem* in modeling cross-cutting concerns refers to the problem of scattered placeholders that capture the relations between these concerns and business processes. For example, if we use a horizontal modularization technique, we need placeholders that specify when the encapsulated concern should be applied in the model, so many placeholders need to be scattered in the definition of process models to indicate this relation (see Fig. 1(c)). Thus, if the relation is changed, it will be difficult to manage the concerns.

Aspect-Oriented modularization is a sort of orthogonal decomposition that aims to solve the scattering and tangling problems in information system development. In orthogonal decomposition, we encapsulate core- and cross-cutting concerns and their relations in separate modules (shown in Fig. 1(d)).

Fig. 2 shows an abstract view of the aspect oriented approach can support modeling cross-cutting concerns. In the left-side of the figure, we see different business processes (visualized as horizontal lines), and there are several cross-cutting concerns (visualized as vertical lines) that should be considered in these processes. A concern should be considered in a process model if it crosses over the process in this figure. In the right-side of the figure, we show different elements of an aspect-oriented business process model. These models contain encapsulations of core-concerns, cross-cutting concerns, and rules. Core- and cross-cutting concerns capture the functionality of core business processes and the cross-cutting concerns respectively. Rules capture the relation between Core- and cross-cutting concerns.

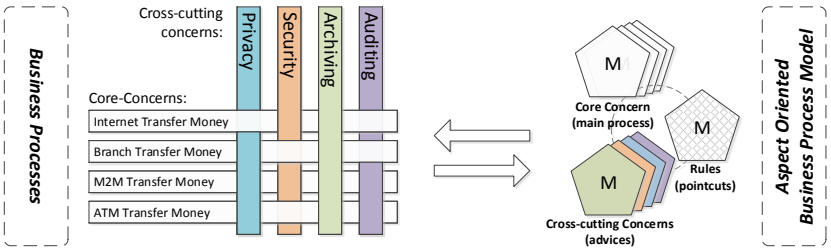

Fig. 2. Aspect-Oriented Business Process Modeling Approaches in general

There are few attempts that propose how aspect-oriented business process modeling should be supported, yet no formal definition of syntax and semantics has been defined to support this modeling technique. This gap also results in the lack of support for managing cross-cutting concerns in the whole BPM lifecycle.

Therefore, this thesis aims to address this gap by developing concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of aspect-oriented business process models. Thus, this thesis aims to answer the following research question:

– *How should the separation of cross-cutting concerns be supported by means of aspect-oriented business process management?*

The design phase in BPM lifecycle is usually considered as a starting point for managing business processes, and there are three approaches to specify business processes, named *imperative*, *declarative* and *hybrid*. *Imperative models* aim to describe a process by specifying all possible scenarios, so a scenario is possible if it is specified in these models. *Declarative models* aim to describe a process using constraint which should not be violated, so all scenarios are possible except violating the specified constraints. Imperative and declarative models are known to be suitable for rigid and flexible processes respectively. *Hybrid models* are a combination of these two approaches that aim to describe processes which are rigid in some parts yet flexible in some other parts.

Therefore, this thesis specifies how cross-cutting concerns should be supported by means of imperative, declarative and hybrid aspect-oriented business process modeling. In addition, it develops concepts, methods, and techniques to support the administration, configuration, enactment, and analysis of imperative aspect-oriented business process models to proof the feasibility of supporting the management of cross-cutting concerns through the whole BPM lifecycle.

Section 2 explains the methodology behind the thesis. Section 3 lists a summary of results, and Section 4 concludes this paper.

2 Methodology

Considering that the tool support is vital for supporting aspect-oriented modularization, this sort of research cannot be solved solely by an empirical study. Indeed, we need the development of tools that enable us to manage cross-cutting concerns in the BPM area. Using these tools, it is then possible to conduct some empirical studies to investigate different aspects of using this technique in different contexts. Thus, the core contribution of this thesis is about developing and demonstrating artifacts to support aspect-oriented modularization in the BPM area. Design science ... [in the area of information systems and IT] aims to create novel artifacts in the form of models, methods, and systems that support people in developing, using, and maintaining IT solutions [4]. Therefore, this thesis falls into the area of design science [2].

According to Hevner and Chatterjee, “Design science research is a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence” [2]. Different frameworks are proposed to enable development of artifacts and knowledge around it; this thesis follows the Design Science Research Framework.

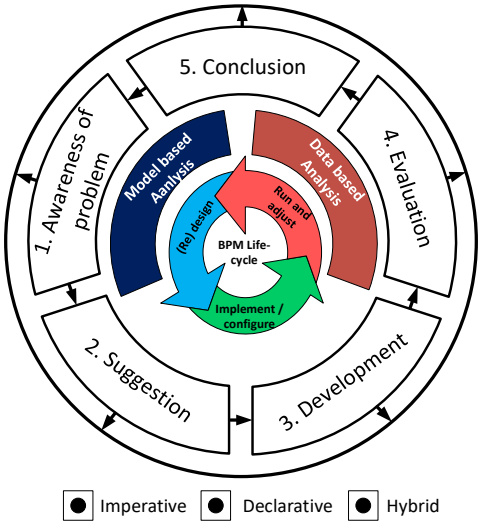

Fig. 3. The employed research framework

Fig. 3 shows the application of the design science research framework which is used in this thesis. It contains five phases which are illustrated in a cycle, and the arrows show the possibilities for moving from one phase to another. It starts with awareness of problem based on which a researcher can suggest a solution. Then, the artifact can be developed, and it can be evaluated. Finally, the conclusion can be made. Note that the process is cyclical and a researcher can come back to earlier phase to refine the result. In the middle of this figure, we show the BPM lifecycle proposed by van der AAlst [1]. At the bottom, we can see three possible modeling paradigm, i.e. imperative, declarative and hybrid.

We developed different artifacts for different purposes in this thesis. All artifacts are developed based on the framework illustrated in Fig. 3. The details about the choice of method for each phase and configuration of this framework for each work can be found in more detail in [3].

3 Result

The result of this thesis is a set of artifacts and knowledge around them that support separation of cross-cutting concerns in the BPM area. A summary of the result is described bellow.

In *design phase*, the separation of cross-cutting concerns is supported by development of artifacts which support imperative, declarative and hybrid aspect-oriented business process modeling. The imperative modeling is supported by extending and formalizing BPMN and Petri nets notations. We also defined and formalized a general aspect-oriented business process modeling notation. We developed artifacts in the form of instantiation to support designing aspect-oriented Petri nets and YAWL models. The declarative modeling is supported by extending the declare notation. The hybrid modeling is supported by proposing a new modeling technique as a combination of Petri nets and declare notations.

In *model based-analysis phase*, the separation of cross-cutting concerns is supported development of a method that specifies how aspect-oriented business process models should be merged into traditional models. The approach is formalized based on aspect-oriented Petri nets, and an algorithm is defined to describe the merging method. The approach is implemented as an artifact to support analyzing aspect-oriented Petri nets models.

In *configuration/implementation phase*, the separation of cross-cutting concerns is supported by development of artifacts which defines how aspect-oriented business process models should be configured/enacted. To configure/enact these models, the business process management system should be aware of the semantics of these models. Thus, we defined the operational semantics in Coloured Petri Nets, which is implemented in CPN Tools. The implemented artifact is verified using state-space analysis technique.

In *run/adjustment phase*, the separation of cross-cutting concerns is supported by the development of artifacts which support running/adjustment of aspect-oriented business process models. The CPN model is used in this stage as a blueprint to extend the functionality of YAWL. The new functionality is implemented as a service in YAWL, and it is used in a banking case study to evaluate the support of these models through the whole BPM lifecycle.

In *data-based analysis phase*, a new method (called aspect mining) is defined to support discovering aspect-oriented business process models from event logs.

As mentioned earlier, a different setting of the research framework is used in the development of each artifact. For example, some artifacts are evaluated through case study while some others are demonstrated through other methods. The details about all choices of methods and details about each artifact can be found in more detail in [3].

4 Conclusion

This thesis has investigated how aspect orientation can be supported in business process management using information technology. The thesis has used the framework of design science, and it defined the support of separation of cross-cutting concerns for different phases of the BPM lifecycle. The result has been presented as a set of artifacts and their empirical findings about how separation of cross-cutting concerns can be supported in the Business Process Management (BPM) area. The result enables management of cross-cutting concerns in the BPM area, and it can help practitioners to develop systems further to support the effective and efficient management of these concerns.

References

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