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Aspect-oriented business process modeling: analyzing open issues

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Abstract

Purpose – The aspect-oriented paradigm provides mechanisms to modularize crosscutting concerns. Applying aspect-oriented concepts in business process modeling raises the possibilities of modularization, but brings out several concerns related both to process and to product. This paper aims to provide an overview of the aspect-oriented business process modeling area, point out the open issues and analyze possible solutions to such issues.

Design/methodology/approach – This paper is based on a research project, where real business process models from a large oil and gas organization were analyzed, re-modeled and re-analyzed to put the AO-BPM approach in practice.

Findings – The paper indicates the need for more research on aspect-orientation applied to business process models, backed by open issues that are faced in this research. The authors categorized the open issues as: aspects identification, elements used in the models, levels used to modularize business process models, assignment of aspects to organizational actors, and ways that an aspectized model can be generated or visualized. The authors listed initial thoughts on possible solutions that they foresee based on previous work in software engineering.

Originality/value – This paper is the first one in analyzing research questions facing AO-BPM. By now there have just been papers focusing on presenting its understanding on how to apply the aspect-orientation approach to solve business process models modularity issues as can be seen in the related works section. The paper's main contribution is making explicit the roadblocks that are faced and opening up new avenues of research on BPM modularization, in particular with respect to AO-BPM.

Keywords Business process models, Modularization, Crosscutting concerns, Aspects, Process management, Oil industry

Paper type General review

1. Introduction

This paper stands on the shoulders of previous results (Cappelli *et al.*, 2010), which improved business process modularity by the use of the aspect-oriented perspective. Our main goal is to expose open issues in business process modeling (BPM), in special within the use of the aspect-oriented modularity. Our experience on using aspect-oriented business process modeling (AO-BPM) in real processes have shown that there is still problems that need further research, a fact confirmed by a review of the literature. Our contribution is the analysis of those problems and their clustering in a list of six major

open issues, as well as a vision of possible solutions. Some of these possible solutions are based on solutions widely accepted by the software engineering area (Sommerville, 2004).

Our contribution is anchored on the discussion and clarification of important problems facing modularization of business processes. Some of the issues are related to method, how to do it; others are related to the representation language, how to write it, and there are also questions related to management, how to use it.

Business process management, in general, has been using a perspective[1] highly focused on processes, whereas others perspectives are also available (Sanz, 2011). Even in ARIS (Scheer, 2000), where there is an attempt to balance different perspectives, the process (event process chain) is still the focal point. Business process modeling notation (BPMN) (OMG, 2011) is also process centered. As such, business process management is a discipline with a dominant perspective, despite other possibilities, as pointed by Sanz (2011). Our work is contextualized within the dominant perspective that is: we are addressing issues related to business process modularity.

The use of aspect-oriented modularization for BPM is yet at early research stages and few have been working on this topic, as pointed out at Section 4. We understand that two different but complementary threads are being pursued: one at the execution level (Charfi, 2007) and another at the business level (Cappelli *et al.*, 2010). Our initial work (Cappelli *et al.*, 2009) has been addressing the business level, that is the use of aspect-oriented modularization on the definition and modeling of business processes using BPMN-like notations. The aspect-oriented modularization aims to factor out repeated content and content understood as a supporting feature from the core business processes and activities. As such the approach stresses the process essence and factor out other content as aspects. Moreover, those aspects know the places in the models where they must act.

This paper reports on open issues found in our research project, however some of them are more general than AO-BPM. It is mister to say that we have been experimenting on the use of AO-BPM modularization on a large base of process models in use for a major oil and gas company. This company, like many large corporations, uses the ARIS platform provided by Software A.G. As such the examples we will use are described in the ARIS language (Scheer and Nüttgens, 2000; Scheer, 2000).

The paper is structured as follows: Section 2 provides an introduction to BPM modularity. Section 3 shows how AO-BPM improves BPM modularity by means of examples. Section 4 briefly describes some related work. These related works are further described in Section 5 along with our main contribution: explanation and categorization of the issues found in AO-BPM modularization. Section 6 highlights some possible strategies to handle the issues presented in Section 5. We conclude stressing the importance of more research on the topic, describing some possibilities of future work including the need for experimental validation.

2. BPM modularity

Modularization of business processes descriptions is a topic which has been attracting the attention of different researchers. Recker *et al.* (2009) argue that the process modeling techniques do not provide adequate support for process decomposition. Reijers and Mendling (2008) point out that although the use of sub-processes is an important practice to handle complexity, there is a lack of precise guidelines for applying modularity. According to Scheer (2000) hierarchy diagrams are used to break down functions but this kind of top-down approach makes consistency between

functions at certain level difficult to control, as classification rules must be used. Cappelli *et al.* (2010) indicate:

> We concluded that modularity is concentrated basically on levels of abstraction within process models, and, for lower granularity levels, definition of its atomic elements, which can be reused along the diverse diagrams. Crosscutting concerns which may occur among those diverse levels have not been addressed properly.

This means one can use Scheer's (2000) approach to establish the hierarchic of complex and elementary functions but crosscutting functionality may appear repeated at different levels of the hierarchy.

In order to handle complexity, the ARIS architecture uses VAC, EPC, and function allocation diagram (FAD) to represent the organizational functions in a modular manner. The VAC diagram is used to represent high level functions, one VAC element can be further detailed using EPC diagrams. EPCs represent organizational business processes. Each EPC element can be detailed using FAD diagrams where the activities can be fully detailed including data consumed and produced, indicators, software support, and technical terms. Figure 1 shows, graphically, the modularity provided by ARIS.

Modularity as it is in ARIS or BPMN, in general, does not handle crosscutting processes, and this brings out modularity problems. The modularity problems refer to a concern repeated in the same process or in different processes. This makes reuse and maintainability more difficult and masks concern understanding as a whole, since, in each process, it is operationalized in a different way.

In Figure 2 is demonstrated that the modularity problem when using conventional business process modeling languages (BPMN). In the change management process there are three activities to represent the same element Send change request, four activities to represent the same element Get change request form, five elements to represent Request data, and two elements to represent Request form standard.

3. How AO-BPM improves BPM modularity

The result of using AO-BPM to enhance modularity is a model that is smaller and less complex. In the case of change management process (Figure 2), the resultant aspect-oriented model is shown in Figure 3. The repeated elements were removed from the model so it is possible to see the core elements of the process.

In Figure 4 is depicted a real world business process from an oil and gas organization named "close monthly production of organizational unit A". In this process the production of the month must be consolidated with the correct data. In this business process the pre-division is fired in every first working day of the month and after daily closing has been performed. If data is incorrect, the OP area must be informed about the problems and corrects the data. If data is correct, the monthly division must be fired, the monthly gas totals must be closed, the petroleum chain must be informed and finally four activities must be executed: elaborate the report of the production execution, elaborate the report of the forecast control, elaborate the commitment term panel, and elaborate the operational production forecast.

In Figure 5 is depicted the aspect-oriented version of the close monthly production of organizational unit A. A comparison between Figures 4 and 5 also shows a reduction of complexity and size similar to the reduction between Figures 2 and 3, but here in a large oil and gas corporation. In the business process model shown in Figure 4 without
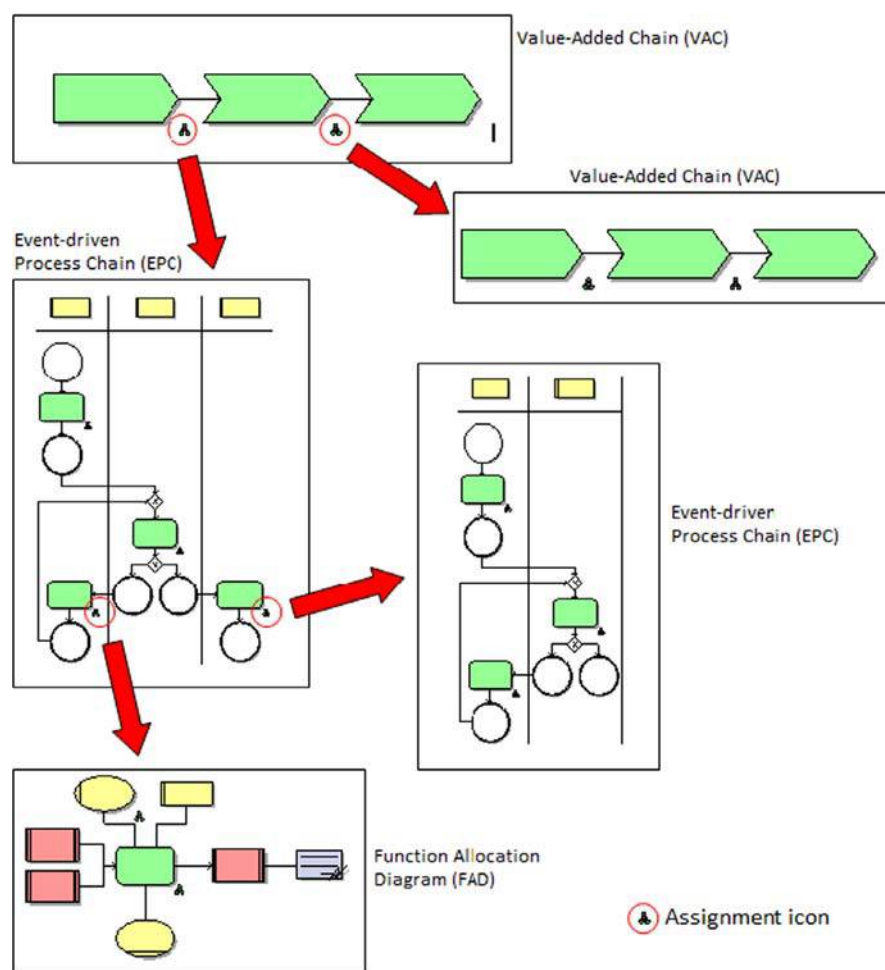
Figure 1.
VAC, EPC, and FAD
diagrams (DDD)

aspect-oriented programming (AOP) there are 21 nodes. In the model shown in Figure 5 using AO-BPM there are 16 nodes, so the reduction in the number of nodes is about 30 percent. This improves comprehension of the processes overall.

In the same oil and gas organization there is a similar business process to close monthly production of another organizational unit named B. In this process the activities and the flow is slightly different with 34 nodes. When using AOP ideas in this process there is a reduction to 22 nodes. In this case, the decrease is also 30 percent.

The existing modularization of BPM is insufficient to modularize the concerns repeated in several parts of the same process or in several different activities and in overlapped processes, the so-called crosscutting concerns (Filman *et al.*, 2005; Kiczales *et al.*, 1997). Such concerns are interlaced with other basic concepts of a process and are scattered in various parts of the process model and cannot be effectively modularized using the given BPM abstractions. Based on the aspect-oriented paradigm (Kiczales *et al.*, 1997),

968

Figure 2.
Change management process
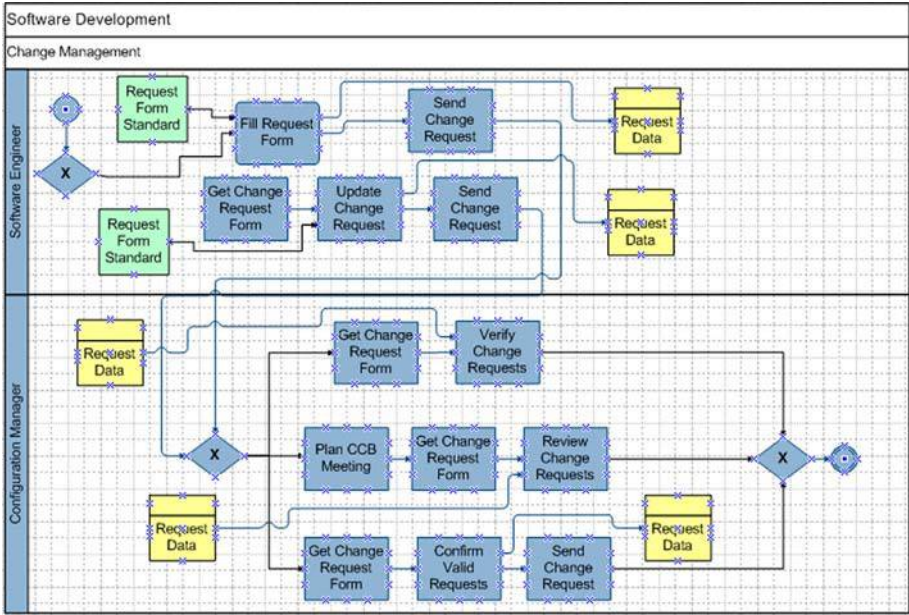
Source: Cappelli *et al.* (2010)

that proposes the modularization of crosscutting concerns, AO-BPM approach (Cappelli *et al.*, 2010) improves modularity. AO-BPM separates the business process into:

- the basic business process (core process) which contains the essence of the business process; and
- the aspect process which captures the crosscutting information cutting across the core process.

Aspect-oriented software development (AOSD) proposes the following abstractions (see Kiczales *et al.* (1997) for those definitions). Aspects are the elements designed to encapsulate crosscutting concerns and take them out of the core elements in a given specification or implementation. For instance, activities representing the logging concept can be modularized as an aspect. In order to specify the composition of an aspect with the core process flow, an aspect contains pointcuts and advices. Pointcuts are sets of join points. Join points are the core description elements which an aspect intercepts: thus, join points facilitate aspect composition. For instance, in the logging aspect, join points are core process flow elements where the aspect is applied. A pointcut defines an expression with quantification mechanisms to select one or more join points to be advised by an aspect. A pointcut language defines patterns to write pointcut expressions. Advices define the action which must be taken when a join point is reached. They act on a pointcut and can be configured to act before (before advice), after (after advice), or around (around advice) the join point. In the logging aspect case, the advice is the set of activities to log the core process.
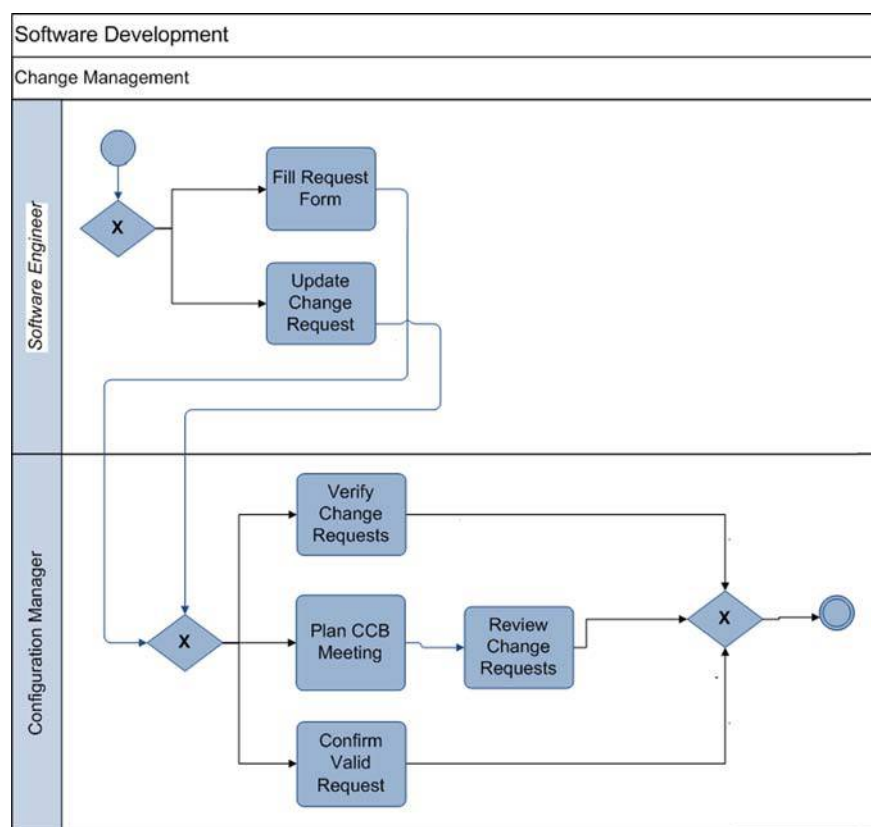
Figure 3.
Aspect-oriented change management process – core view

A process model is typically composed of: processes, sub-processes, activities, rules, events, data, actors, and connectors (sequence flow, message flow, and association). We argue in Cappelli *et al.* (2010) that all those elements of a process model may be identified and represented as a crosscutting concern. In addition, crosscutting concerns can be identified in the context of the same process (intra-process) or among different processes (inter-process). Therefore, in Cappelli *et al.* (2010) we suggest heuristics for aspect identification. They are as follows:

(i) if the concept is repeated several times in different places, (ii) if the concept is used by different other concepts, (iii) if the concept reflects an integration of semantically distinct situations, (iv) if the concept represents a decision situation from which different options may be taken, (v) if the concept's absence does not interfere with the global goals of the whole, (vi) if the concept can be reused in other domains, and (vii) if the concept is very much independent of other concepts.

These heuristics were inherited from software engineering, mostly from the work of Silva (2006). They are supposed to be used by people playing the role of modelers, which, of course, should be familiar with the representation language (AO-BPM) and the business process being modeled. This role is usually played by information
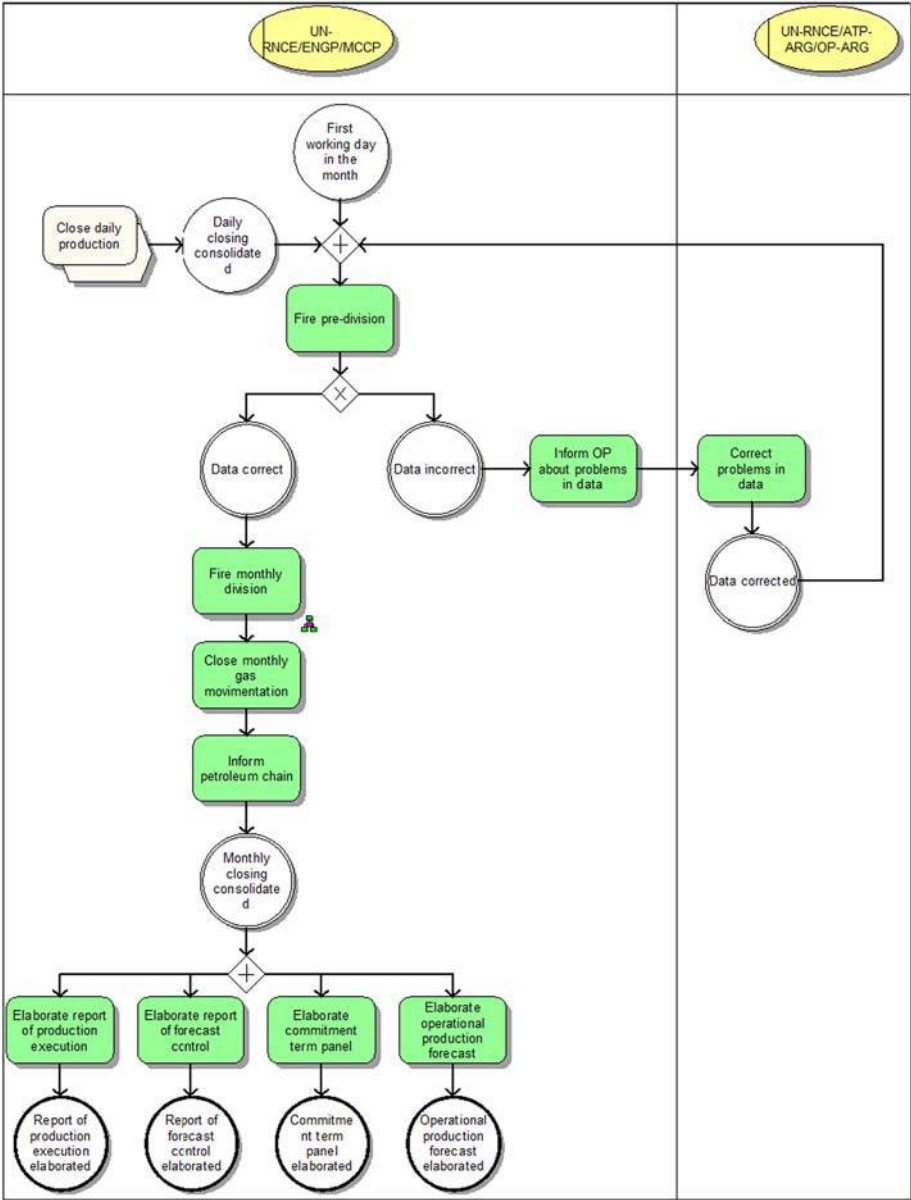
Figure 4.
Close monthly production
of organizational unit A

engineers (a.k.a Business Analyst). These heuristics are general, and their refinement is found in Cappelli *et al.* (2010) and Santos *et al.* (2011b). Different works in software engineering have tackled the issue of aspect identification (Silva, 2006; Antonelli *et al.*, 2010; Sampaio *et al.*, 2005; Moreira *et al.*, 2005). On the other hand, identification of business processes aspects has been addressed as well (Wang *et al.*, 2007).
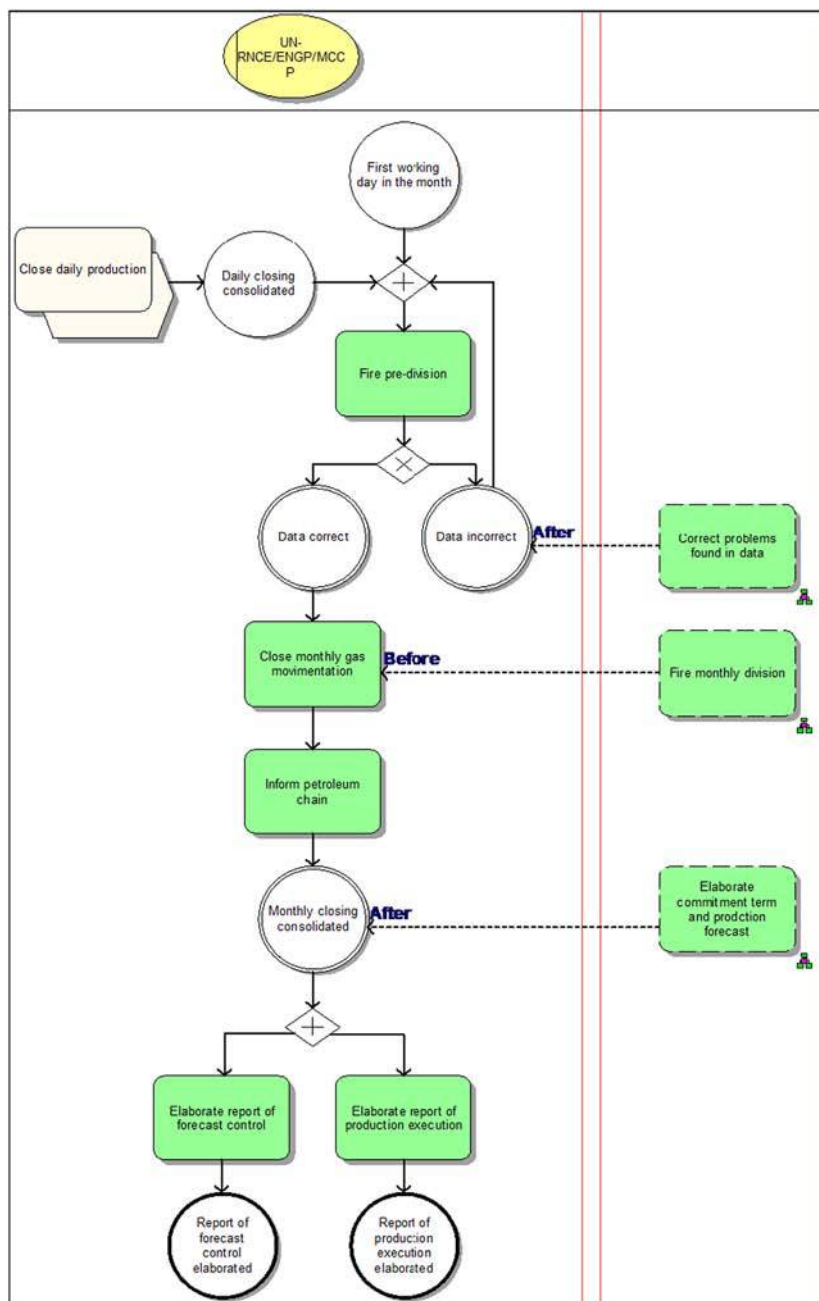
Figure 5.
Aspect-oriented close
monthly production of
organizational unit A

In terms of representation, Cappelli *et al.* (2010) proposed to characterize the crosscutting concern in a specific swimlane to highlight that a crosscutting concern is orthogonal to the core elements as well as to make the representation of the crosscutting relationships comprehensible. Figure 2 shows the proposal representation described in detail in Cappelli *et al.* (2010). As can be seen, the decision was to use a symmetric strategy to represent aspects using the same concepts as the base description language. In addition, the graphical representation of the join points is a ground element which locates near the core process element, allowing the source of the crosscutting relationships to be the crosscutting element and the target to be the ground element representing the join point.

A new connector object called crosscutting relationship was defined to represent how a crosscutting element (the source) affects another element (the target). The crosscutting relationship also represents the interaction among a crosscutting concern and the core process elements. Moreover, in order to detail the crosscutting relationship, a quantification mechanism is used. It helps to make the several references to each join point explicit in a single statement.

A pointcut language was also specified in this context (Cappelli *et al.*, 2010). It allows stating the different types of join points which appear in a process model, the points where the aspect acts, and the moment this is being applied (before, after or around) at the core description, in a textual format. Basically, it expresses the inclusion of crosscutting concerns in a process. In our case the include primitive is the main clause of the pointcut language, used in the advice part to specify the insertion of a crosscutting concern in a core process.

Crosscutting leads to a set of BPM elements representing a concern, being scattered and tangled all over the business process specification. This results in reduced understandability and reuse capability of those models and also in increased maintenance overhead. Using AO-BPM the complexity of the models is now reduced and the crosscutting concerns are properly treated as they can be represented without redundancy. Even with these advantages some issues and problem remain.

4. Related work

As pointed out in Section 2, modularization of business process descriptions still demands more research. We have found four relevant contributions when searching for related work in the use of aspects for improving modularization of business processes. Most of them propose different approaches, but do not ponder about the impacts caused by their solution.

Charfi *et al.* (2010) propose AO4/BPMN as means to modularize business process crosscutting concerns, exemplified by compliance, monitoring, and separation of duties. This work centers on BPEL, so regarding process execution level. Shankardass (2009) proposes AOBPMN, another approach similar to Charfi *et al.* (2010), where the author aims to use aspect-oriented ideas also on model and execution level.

In a short paper, Wang *et al.* (2007) proposes a more in-depth approach including a method. As the first two ones, Francescomarino and Tonella (2008) propose an extension to BPMN named BPMN visual query language (VQL) as a mechanism to support crosscutting concern mining at model level.

These works will help us in describing the problems we have faced in our experience with AO-BPM, and, as such, they will be referred throughout the next section.

5. Open issues on AO-BPM

Although a lot of concepts can be represented in aspect-oriented approaches for BPM, our continuing experimentation with this new approach has found some issues that need attention. These issues are related to:

(1) process of aspects identification;

(2) elements used in the models;

(3) levels used to modularize business process models;

(4) assignment of aspects to organizational actors;

(5) ways an aspectized model can be generated, as the ones shown in Figures 3 and 5 or visualized; and

(6) issues related to adoption.

Some of these issues are related to method (1, 3, 4), to model (2-5), and to management (1, 4, 5, 6).

5.1 Issues related to aspect identification process

Most of our AO-BPM models built so far were based on heuristic (i) presented in Section 3. Recently, the idea of (v) was explored (Santos *et al.*, 2011b) where the global goal of the process is used to identify crosscutting concerns. As proposed in Santos *et al.* (2011b), after the identification of the whole process goal, the goal of each activity composing the model is identified and an analysis of all activities goals regarding the whole process goal is performed. If the activity is not indispensable to the whole process to reach its goal, then it is a candidate aspect, else it is part of the core process.

The elements repetition or its support to the process goal indicates a crosscutting concern, but crosscutting concerns are generic concepts, which can be applied in different business processes. This conclusion helps to discover which characteristics a process must have to be considered an aspect. The heuristics (i) and (v) have been used to identify candidate aspects from already modeled processes, but it is still an open issue which other heuristics could provide guidance on aspects identification and the order in which the heuristics should be applied.

We are confident that heuristics (i) and (v) will also be useful for modeling aspect-oriented business process models from scratch. However, which other heuristics will be necessary for identifying aspects early on is still an open question. Despite general heuristics, we also need to know how organizational guidelines and the domain will influence aspect identification.

Charfi *et al.* (2010) do not indicate how to find crosscutting concerns; they just point the problems of the lack of modularity in the business process models when such concerns must be considered. Shankardass (2009) also does not mention any aspect identification process or any kind of open issues. These authors just provide examples.

Wang *et al.* (2007) state that conventional business process composition and decomposition is not enough to address crosscutting concerns complexity and propose concern oriented business process modeling (COBPM) where the concept of aspectual process is introduced to BPM. Their approach aims to allow business people to use AOP ideas on BPM. They present a tool to support their approach and introduce a method covering concern definition, identification, extracting, assembling, and weaving with the core process. For the authors, a concern is anything someone may be interested in.

COBPM method is composed of: concern definition, concern identification, concern extraction, concern assembling, concern weaving, concern creation, and concern modification. In the concern definition step, the business people specify a concrete and specific concern, for example, all tasks performed by a specific role. In the concern identification step, all elements related to the concern must be identified, this task can be done by automatic selection using any query engine or manual user selection. In the aspectual process extraction step, the concerns identified in the previous step are separated from the original model. The aspectual process assembling step is used to add aspectual process to another aspectual process or processes. It is done by linking corresponding interaction point pairs (control nodes in the aspectual process and in the process represented the integration of aspectual processes). In the concerns weaving step, the assembled business process shows the concerns as separated aspectual processes so, it is not yet a general business process and the weaving algorithm will be used to merge them together into one conventional business process model. Even with a method, specifically a step for aspect identification, it does not provide any guide to help modelers identify the crosscutting concerns.

An important difference between COBPM and our AO-BPM is related to the concept of crosscutting concern. In our approach it is any concern spread all over a business process or more than one business process, the same holds for Charfi *et al.* (2010), Shankardass (2009) and Francescomarino and Tonella (2008).

BPMN VQL (Francescomarino and Tonella, 2008) do not provide any means to identify the crosscutting concerns. They just provide as example of crosscutting concerns the customer preferences, data management, and communication regarding the activities of an on-line shop. It is possible to mine the concerns using queries. For documentation purposes, it is required that the query be stored as one more design artifact. Regarding the concern evolution, due to modification on technology or customer requests, the authors state that the query artifact stored can also provide support, as it indicates all places a concern is realized.

5.2 Issues related to business process language

As pointed in Section 3, business process model elements are process, sub-process, activities, rules, events, data, actors, and connectors. Theoretically, all of them can be considered a candidate aspect (Cappelli *et al.*, 2010) but the definition of which elements can be considered an aspect is still an open issue.

Considering business process model elements, isolated events should not be considered aspects, due to the following considerations: events are consequence of the activities, to occur an event some activity must be performed generating the event occurrence; there is a distinction between single happening and type of happening, this means that different activities may generate the same type of event but events are still related to the activities and are unique. In the case of starting events, they are not consequence of activities, they are responsible for starting a process flow (Owen and Raj, 2003) (i.e. monthly, every Monday). This kind of event should not be considered an aspect since they are too generic, even possibly repeated in many processes.

Some BPMN components (White, 2004) including the types of artifacts used in BPMN named Data Object are used to represent data required or produced by the activity being connected to it. This kind of object may represent crosscutting concerns with adequate level of generality, as such they may be considered candidate aspects. An example is

shown in Figure 3 where form (Request Form Standard) and data (Request Data) are placed in the aspectual columns. These elements are connected through the crosscutting relationship with the activities in which they are consumed or generated. It is important to point out that the essence of data and form elements is crosscutting, as they may be consumed or used by many activities in the business process models and its repetition (i) in all processes they are consumed is an indicator of a candidate crosscutting concern. In our opinion the repetition is not enough to affirm a concern is an aspect. In order to do so it is required to apply one or more other heuristics (i.e. (v)) to conclude that data elements are aspects. This issue is related to the process used to identify the aspects (Section 5.1).

Another issue is related to the actor representation. We depart from the idea that crosscutting concerns are related to "what has to be done", as such the actor in a business process model has not been considered an aspect. In the models, actors are responsible for performing the activities and they are represented in the corresponding swimlanes. When aspectizing a process element, which actor will name the swimlane in the case of more than one actor performing the same aspectual element? Are swimlanes appropriate to host the aspects as we did in the examples so far?

Charfi et al. (2010) proposes AO4BPMN as an extension of BPMN realized through a group of BPMN elements called artifacts. These elements allow the introduction of new elements in the language. The authors present two syntaxes: heavy-weight and light-weight. In the former, new graphical constructs are proposed to represent crosscutting concerns, as such it requires tool support, also presented by the authors. In the latter, conventional tools supporting BPMN can be used as it uses conventional BPMN elements.

The possible join points in AO4BPMN are flow objects, activities, and events. The pointcuts are represented as a new artifact that optionally has a query attribute. In the light-weight syntax, the pointcuts are data objects associated with an annotation which contains the text pointcut. In the heavy-weight syntax, pointcuts are represented by an oval object. There are three alternatives for the pointcut language: explicit association of pointcut with join points, pointcut language based on query, and pointcuts annotation.

The advices are sub-processes implementing the crosscutting logic and can include a special activity named proceed. It allows the integration of join point in the middle of the advice and the indication of the advice order in relation to join points. It avoids the need of indicating the grounding type (before, after, or around). The Aspects are elements used to modularize crosscutting concerns and are composed of pointcuts and advices. In the light-weight syntax, they are represented as a pool with an annotation that contains the text Aspect. In the heavy-weight syntax, they are represented as pools with rounded edges.

Another approach to represent aspects in business process models is presented by Shankardass (2009). The aim of this work is to develop an integrated approach to handle crosscutting concerns at modeling level, transformation of model to code, and execution of the code deployed on a platform which allows dynamic aspects weaving. To do so, the author proposes an extension of BPMN with a characteristic deemed important by him: it integrates the aspects into the main process without weaving it. According to the author, it allows strong decoupling of the aspects thought the entire software development lifecycle. The extension was necessary because BPMN notation defines few modularized elements (process and activities) and they are not enough to support

crosscutting concerns modularization. In this approach, an aspect is a segment of main business process which crosscuts the entire system during main business process execution.

AOBPMN introduces three new notations in the BPMN meta-model: aspect dot, aspect flow, and aspect wrapper. The aspect dot is a dot with a vertical line attached to it on the right or left side. It determines the location of the aspect for execution purposes. It can be inserted before or after any activity, its sequence determines the sequence of the advice execution. It represents the point in the model where the aspect (activity) will be executed (join point). The aspect flow is a dotted line with an arrow that links the aspects with the main process. It connects the aspect with the aspect dot and it can be of two types: single (before and after each activity), and forked (around the activity). The aspect wrapper is a swimlane with bold borders. It is named with the aspect name and contains one or many pools. It also provides a unique identity to the aspect. These notations allow the representation of the relationships between the aspect and main process models. It allows generation of code without user interaction. An example provided by the author is a logging aspect in a credit application approval process. This logging aspect is used to record the time and date of activities in the main process.

In a way similar to our approach, Shankardass (2009) also represents the aspect and the points where it must act in an integrated form. However, this approach requires the insertion of new elements in the core model. Thus, it is an asymmetric approach that is different from our symmetric solution. Besides, this approach considers an aspect to be represented as another process as the pool indicates, but in some cases, the aspect can be a single activity. In addition, this approach does not consider this simple case or the case of a crosscutting element as a form or data according to our discussion in this section.

In Wang *et al.* (2007) proposal the representation of an aspectual process includes a boundary box with the name of the aspectual process used to encapsulate all elements that compose the aspectual process. It also allows the representation of interaction points that act like interfaces between the aspectual process and other processes or other aspectual processes. Their representation includes losing/gaining control nodes used during their method to weave the business and the aspectual process.

COBPM (Wang *et al.*, 2007) provides a conceptual extension of the generic aspect concept from AOP. In their approach, its name is aspectual process and their concept of concern does not follow the AOSD principles of quantification and obliviousness. The aspectual process is a representation of part of a business process, a group of business process parts, or a complete business process regarding a specific perspective. According to the authors, "an aspectual process is considered as a self-contained meaningful process".

5.3 Issues related to abstraction level
In ARIS (Scheer, 2000), the FAD allows the representation of concepts such as clusters, data, and indicators to provide more details regarding an activity. If these elements of an FAD were considered aspects, they will go unnoticed since ARIS do not explicit its repetition. Using AO-BPM, when an activity is considered an aspect and aspectized in a specific swimlane, all the diagrams used to provide more detail are also aspectized (Figure 6) but even in this way it is not possible to know the details of the element without the FAD (Figure 7). The levels of details provided by ARIS are graphically shown in Figure 1.
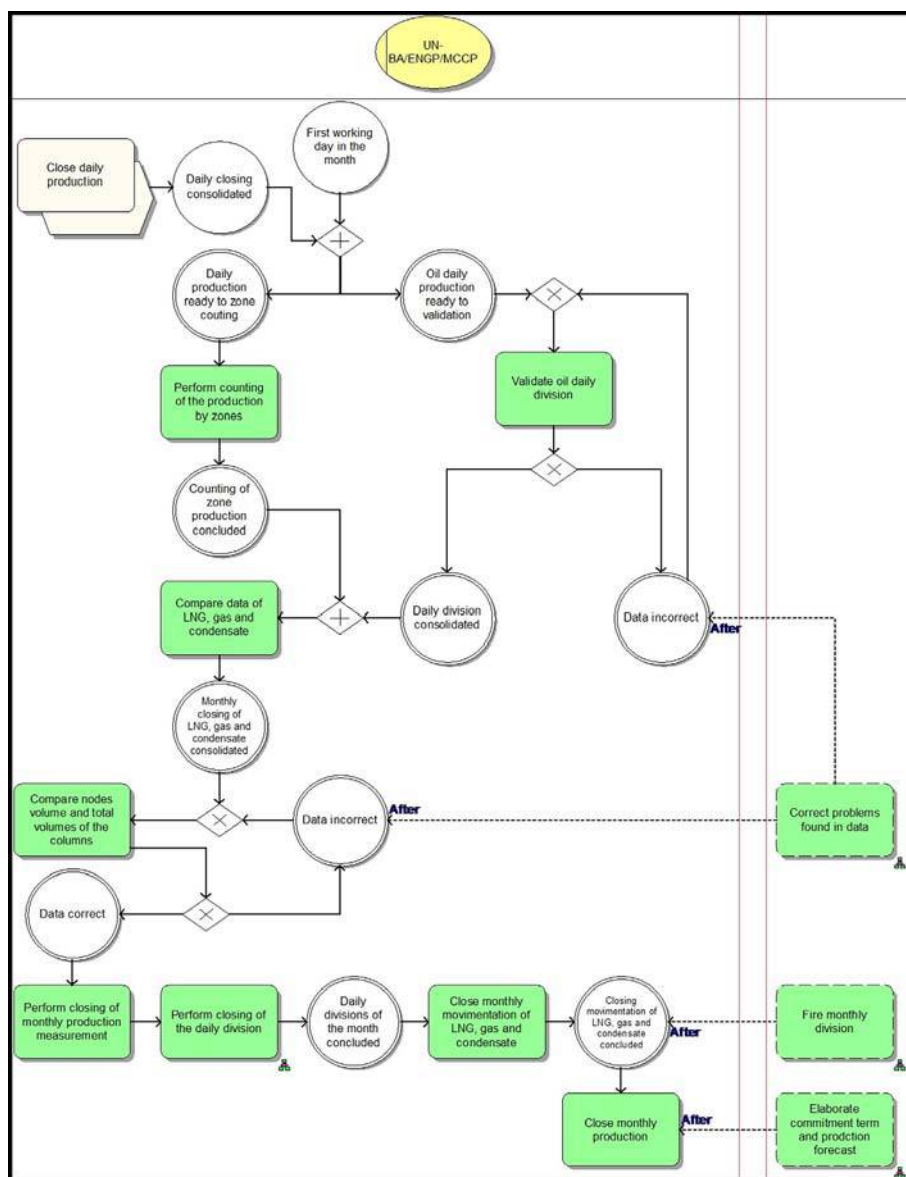
Figure 6.
Close monthly production
of organizational unit A
aspect-oriented

In AO-BPM, crosscutting concerns can be of two types: atomic or group elements. Considering elementary crosscutting concerns, the elements should be aspectized alone. However, considering groups of elements, the elements that compose the group should be aspectized completely (for example, the aspectual element "Correct Problems Found in Data") using the ARIS assignment concept or sub-process concept in BPMN. In Figure 7, the aspectual elements "Correct Problems Found in Data",

Figure 7.
Detail of aspectual group
of elements correct
problems found in data

"Fire Monthly Division" and "Elaborate Commitment Term and Production Forecast" use the assignment concept to represent the elements.

It is important to stress that the use of the assignment for clustering group elements as we are using is a workaround, since we are reusing the decomposition operator (assignment) for something other than its intended functionality.

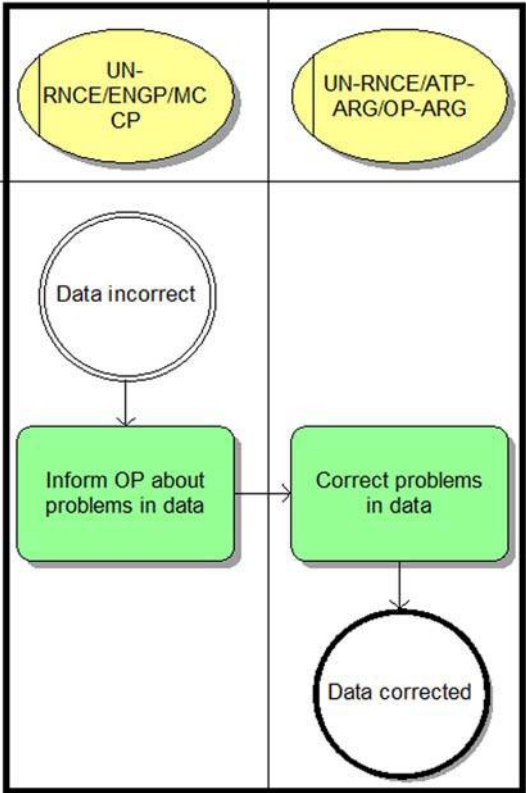Charfi *et al.* (2010), Shankardass (2009) and Wang *et al.* (2007) do not mention how their approach treats conventional modularity already used to generate business process models as their examples are simple without sub-processes or any other conventional modularity.

BPMN VQL (Francescomarino and Tonella, 2008) supports browsing and exploring the crosscutting concerns relevant in a business domain. This query language is able to quantify the business process model elements, identify, localize, and present the crosscutting concerns to the users, highlighting them in the models. It is possible using semantic annotations in the business process elements from the business domain. The representation of the semantic annotations is the standard BPMN element annotation, its content is the symbol @ plus the semantic concept. The semantic concept is supposed to be specified based on domain ontology. These annotations allow the categorization of business process elements by means of unifying the different names

that the same concept may have. This is related to the issue regarding activities name level of detail presented in Section 5.6.

Francescomarino and Tonella (2008) does not discuss abstraction level but affirm their approach is helpful regarding crosscutting concerns as they might be represented in isolated parts of the design as the case of elements represented as or in sub-processes and their approach is able to find a concern in any levels used to describe the model. So this approach might be useful in solving the issue presented in this section but a pre-condition is to know what the crosscutting concerns are.

5.4 Assignment of aspects to organizational actors

When aspectizing groups of elements, we have noticed that several issues related to organizational actors may occur. Below we list situations that we have identified:

(1) A group of elements may be performed by two or more distinct actors. In this case when the group of elements is removed from the core process, there must be a way to represent a new group of actors composed by the actors involved in performing the group of elements. Figure 8 shows a part of a real business process model. In this case there is a repetition of two activities (receive cargo documentation and free transportation ship) for three distinct actors
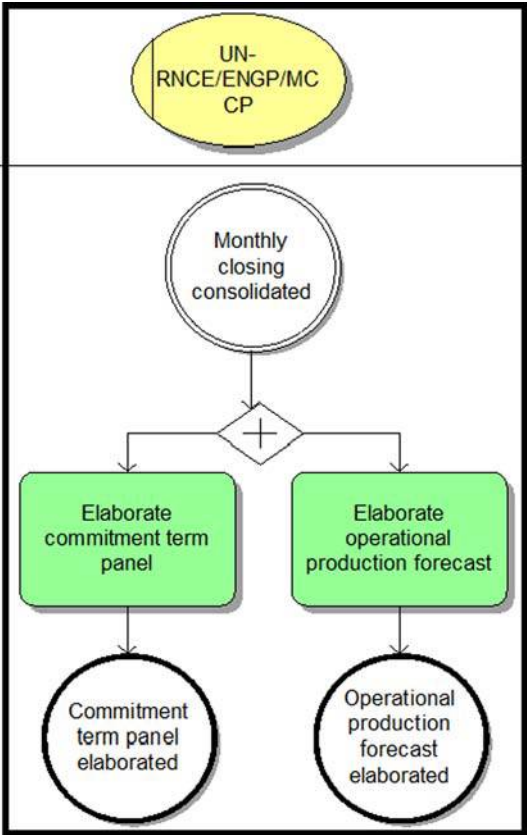

Figure 8.
Detail of aspectual group of elements elaborate commitment term and production forecast

980

(maintenance technician, operator – crane and operator – process). If we use the AO-BPM when generating an aspect-oriented model, a new role must be created to represent all actors that are able to perform this group of activities.

(2) The group of elements may be removed entirely from the core process, causing the absence of any element in the swimlane of the actor responsible for performing the group of elements. This situation is also shown in Figure 8 where the removal of the group of repeated elements leaves the actor's swimlane empty and there is no way to indicate in the resultant model where each specific actor must act. In this case, the crosscutting relationship should be connected to the element preceding the removed elements located in a swimlane that is not the swimlane of any actors responsible for the aspectual elements. Even if the aspect indicates the actors responsible for performing them, it is still not possible to know, in each occurrence, which actor is the executor. This issue is related to letter (a). This case also happens in Figure 4.

(3) In some cases, when the element or group of elements must be removed from the core process there is a need to connect two events, if we follow the existing guidelines. However, this is in opposition with process idea, as events results from activities. Thus, the model must be analyzed to become adequate when this case happens.

(4) When only one activity must be aspectized, this activity will be moved to the aspectual swimlane, and the swimlane of the actor responsible for performing the activity becomes empty or it has just activities that are not related to the flow in which the aspectized activity must occur. This scenario can be seen in Figure 9 when aspectizing the Approve Authorization Document activity. The swimlane of the coordinator actor will be left without a place to anchor the pointcut of the factored aspect. In Figure 4 the same happens.

(5) In the case of aspectizing a group of elements with two possibilities of continuation (events Move Authorized and Forecast Informed in Figure 10), there is no way to graphically discover which one of the options is predecessor of a core process element. The unique way is to analyze the meaning of the activity but in some cases it might require domain knowledge. It can be exemplified considering the group of elements in the swimlane of the actors maintenance technician and operator – crane.

(6) In some cases, the group of elements is repeated for two or more actors and one is a sequence of the other. In this case, shown in Figure 11, there is no way to represent the sequence without repetition.

None of the approaches in the related works, found during our research, make any consideration about maintenance of model integrity when removing aspectual elements from the core business processes. None of them analyzes the new model after the application of their approach and the models are so simple with activities and other elements belonging to only one actor. Thus, this issue is not elaborated by any author.

5.5 Issues related to model generation
We proposed a customization of the ARIS tool to allow aspects representation. This approach was used in Section 3 to generate the aspect-oriented business process
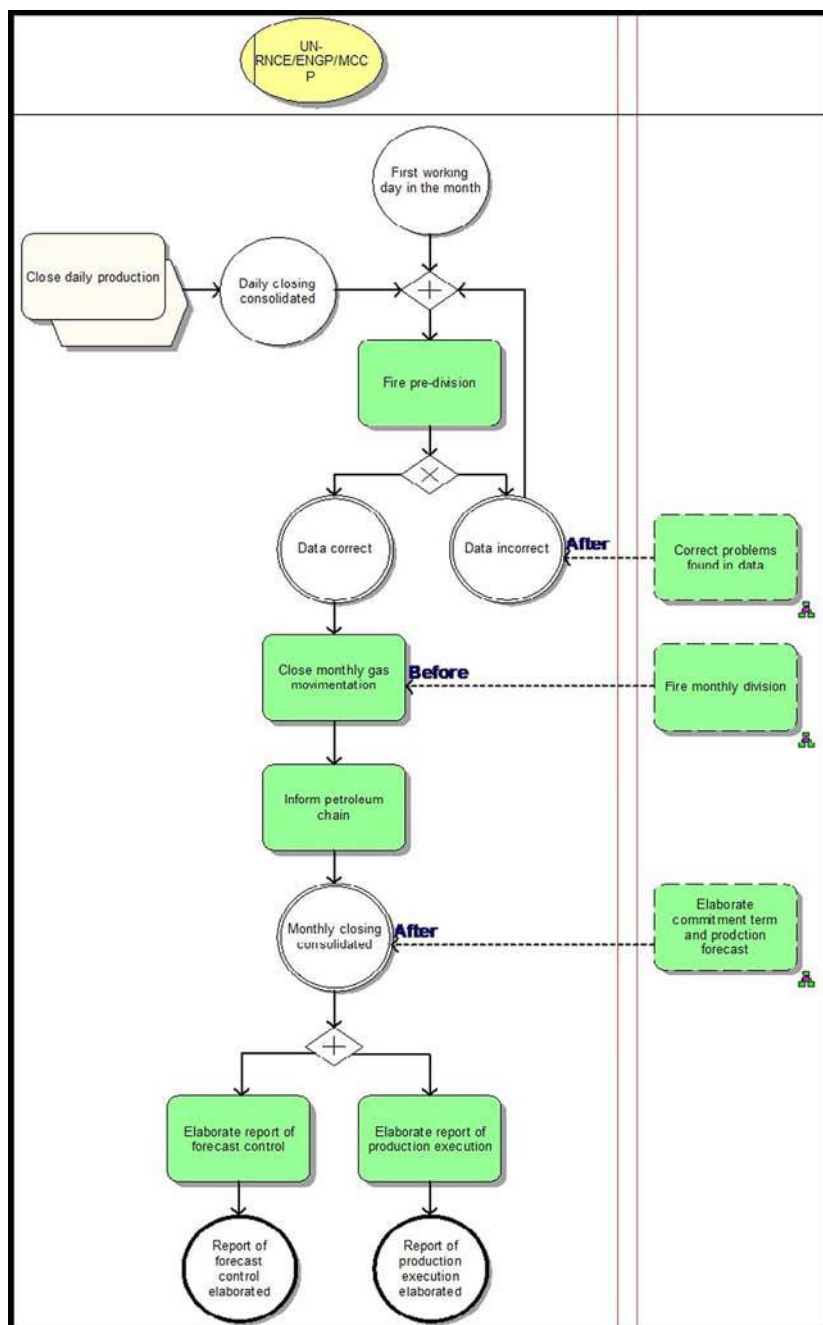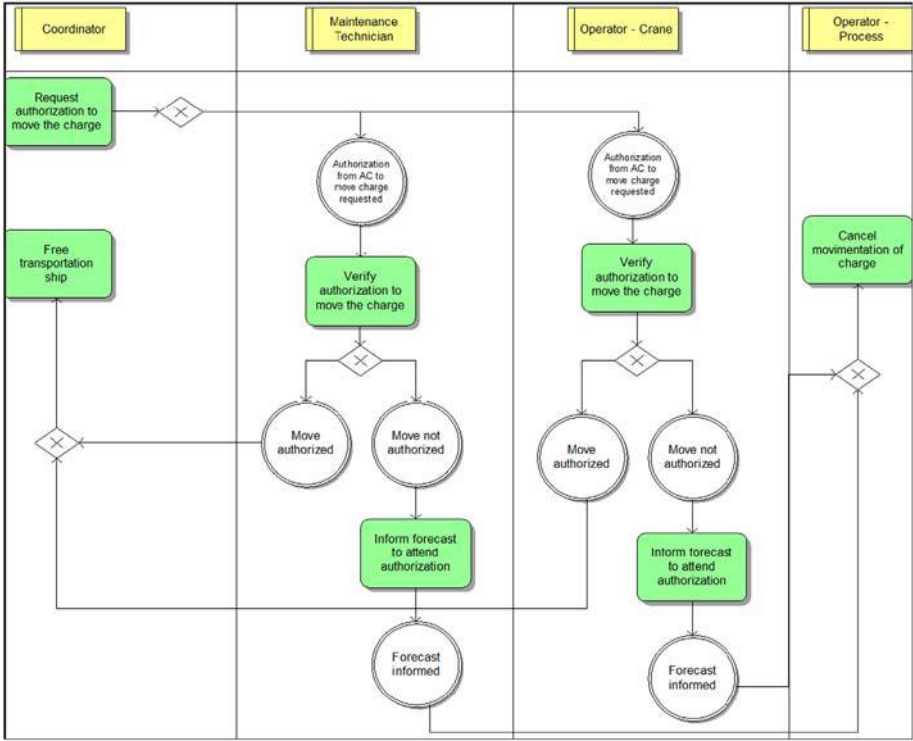
Figure 9.
Close monthly production
of organizational unit B
aspect-oriented

Figure 10.
Group of elements to be
aspectized present in the
swimlanes of actors
maintenance technician
and operator – crane

model (Figure 5). In this customization, the attribute type in ARIS is used to identify
and naming a given aspect, together with a new dotted border appearance for the
aspectual elements.

One of the benefits of AO-BPM is the possibility to generate different views of a model.
These views help stakeholders to focus on their specific interests as security, information,
auditing, etc. The views allow us to focus on the presentation of the model with the
elements of a certain context emphasizing, for instance, just one crosscutting concern.

To create models regarding specific views, the model must have been created using
AO-BPM and the aspectual elements must indicate the kind of aspect they belong to.
After that, the user must choose the kinds of aspects that will compose the desired
view. At this moment, a view selection mechanism:

- selects all elements that belong to the kind of aspect selected;
- removes all elements that do not belong to the kind selected;
- carries out graphic simplification rules; and
- applies a method to decide the new coordinates x and y of every element.

It is possible to create such view selection mechanism using ARIS scripts, which are a
restrict language to manipulate ARIS models. It is also possible to export ARIS models
and perform the view selection using a combination of third parties software, like the
Graphviz open source tool (Graphviz – Graph Visualization Software, 1999). It allows
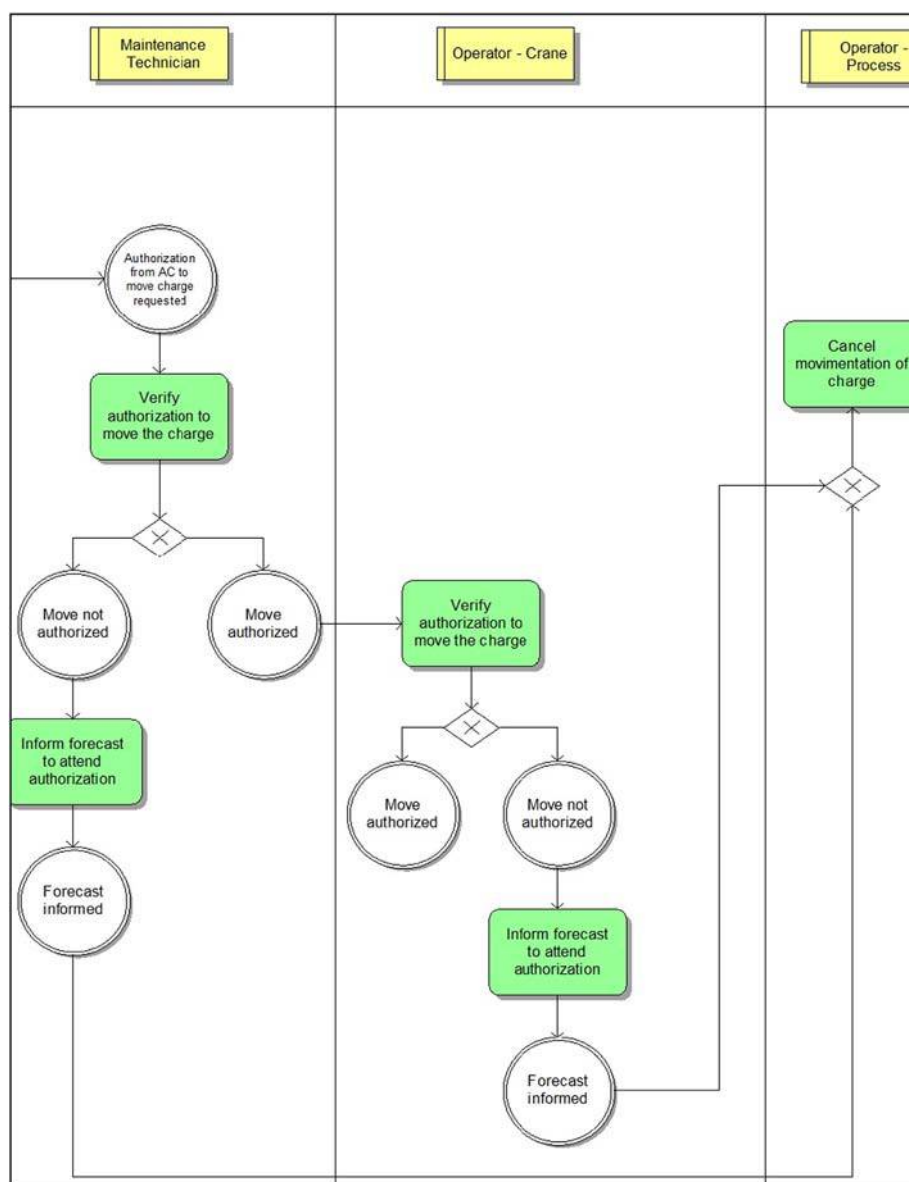
Figure 11.
Sequence of repeated
group of elements

the visualization of graphs, including business process models. This tool redesigns the
model using its own algorithm. It is possible to integrate ARIS and Graphviz to create
the views of the models but Graphviz requires, as input models, the DOT format, while
ARIS provides output models in ARIS Markup Language (AML) format. In order to
use Graphviz there must have a transformation from AML to DOT due to Graphviz
lack of knowledge about the AML structure. This transformation is not trivial and

requires detailed knowledge regarding the involved languages. To assist in this transformation, EPC Markup Language (EPML) (Mendling and Nüttgens, 2002) could be used as an intermediary language. It represents EPCs in a generic and neutral way.

Some issues were found in our attempts to generate the models regarding some aspectual view using ARIS scripts, they are:

- In EPCs with a huge number of elements in the same level (elements in the same linear position) and less linear at all, the relationship between the elements is unclear with lines from some elements overlapping. Thus, it is difficult to know the relation source/target between the elements and in some cases the lines pass over the elements.

- In ARIS there is a limit for the max number of levels, for instance, 80 for EPC. It is a serious limitation in the cases of a very large source EPC, so it is not possible to generate a complete model if it will have more than 80 levels.

- The flows in the model sometimes are hard to understand so the elements from the source model usually are in a different position in the new model.

In AOBPMN (Charfi *et al.*, 2010), aspects and business processes are modeled in separate models. The authors indicate as a future work the development of a weaver to compose both models. In their approach, the process model has no indication of aspects existence; different from our approach where it is possible to visualize the aspects and the process model and the exact place where the aspect must act in the core process model. However, in AO4BPMN, once a weaver is available, the resultant model contains both the core and aspectual elements mixed. The authors present as example the business process Quote Flight of a tour operator. In this example, start Timer and stop Timer are activities presented in grey representing the crosscutting concern monitoring.

COBPM also does not provide means to see the aspectual processes in relation to the core processes where it must act. This approach also includes new constructs to the model (control nodes) used in the process of weaving. In COBPM crosscutting concerns are like a point of view. In AO-BPM, views are used to focus either on weaved or aspectized or just showing parts of the model.

AOBPMN (Shankardass, 2009) represents where the aspects act in a business process and the elements that compose the aspect but the connection between aspect and business process is from the aspect and there is no way to discover where each element must act, instead in the case of an aspect composed of just one single element. Thus, this approach does not mention the generation of view from their representation.

Francescomarino and Tonella (2008) also do not mention view generation, but their approach can provide support for this task as it shows as the result of a query, the elements that meet a specified condition.

5.6 Issues related to AO-adoption

Some organizations already have modeled their business process models and others will certainly follow suit. In the case of generating new models using AO-BPM, if a process is well defined, the organization may build their models with explicit crosscutting concerns profiting from modularization advantages. However, early adopters of business modeling must review the models to aspectize them, so the conventional model will be analyzed and a new aspectized model will be generated, but in which cases the lack of modularity will suggest the use of AO-BPM?

To help answer this question, the level of generality required by the organization must be considered. During business process analysis, we perceived similar business process models became different regarding the level of details. In one model there are activities and events more generic and in other cases activities and events were highly detailed. For example, in one process the activity name was Perform Maintenance and its resultant event was Maintenance Performed. In other process the activity name was Perform Electric Maintenance and its resultant event was Electric Maintenance Performed. In this case, regarding repetition, the elements are different, but their essence is the same, so the level of detail required in one model may impact aspect-orientation tasks. The important consideration is related to the level of detail present in every business process model.

As proposed in many business process management approaches, there must have good practice guide to help people responsible for generating business process models, especially in the case of using AO-BPM to support the analysis of elements.

These guidelines are dependent on the organizational objectives in aspect-oriented adoption. One organization may consider a beginning with few types of elements when starts using this new modularization approach and later expand it to every type of elements. Thus, a method and techniques to define these guidelines are required.

AO4BPMN (Charfi et al., 2010), AOBPMN (Shankardass, 2009), and COBPM (Wang et al., 2007) do not mention how to maintain the aspect-oriented models regarding organizational adoption. The authors also do not describe how their approach will handle the scenarios described in this section as an organization already with business process modeled and the ones who will adopt BPM.

Francescomarino and Tonella (2008) approach seems to help on issue 5.6, so the annotation based on domain ontology could be integrated to our AO-BPM approach, since we also present means to encapsulate the crosscutting concerns which are spread over many business processes. This domain ontology can be used as a base to name the business process model elements. Doing so we believe the level of generality of the elements will be properly addressed.

6. Aligning possible solutions

As we reported in the previous section, several issues did arise from our experience, which are also present on other researchers work, although not clearly identified or dealt with. Using a software engineering approach to the problem, we could say that we have problems related both to the product and to the process. As such these problems demand methods, techniques and tools that will help dealing with modularity on business processes and in special with the addition of aspect-oriented (AO) modularity to the usual hierarchical modularity (process/sub-process) used in BPM.

One possibility in solving these issues is to align some of the possible research directions using the ideas of process, products, methods, techniques, and tools. As from Section 5, we could say that two issues are related to th1e process perspective, two issues are related to product perspective and one issue is shared by both. The process issues are:

(1) model generation;

(2) aspect identification process; and

(3) abstraction level.

986

The product issues are:

(1) organizational actors;

(2) abstraction level; and

(3) business processes language.

Some of these difficulties are inherited from the way we have been conducting our research. The insight of applying AOP concepts to business processes came as Cappelli *et al.* (2007) were conducting research on process transparency (Cappelli *et al.*, 2007). It was noticed (Cappelli *et al.*, 2007) that, for better describing models with included transparency, a new modularity would be necessary. The use of existing business process models continue as we had access to the oil and gas company large library of ARIS processes. Also, as we moved to examine existing processes, we had focused our attention on finding aspects already presented in the models. In performing this type of work, we first centered our attention on atomic elements of the language, basically activities, and latter we exploited the possibility of aspectizing groups of elements. As such, we were more centered on the language issue, a technique and supporting tools. We have developed extensions for existing tools: Oryx and ARIS in a prototyping approach.

Cappelli's approach (Cappelli *et al.*, 2007) proposed, influenced by the work of Silva (2006), a symmetric approach to BPMN, where no new element was created on the language. The approach was to define a modularity operator, the crosscutting relationship, which is non intrusive. The join points were described without having to change the grammar of the base language. With this approach, any element of the existing language could be aspectized and the join point could be included anywhere in the process.

However, for process consideration, it was found that it would be interesting to limit the elements that may receive join points as well as elements that could be aspectized. We believe that the approach to address this problem has to be based on experimentation; that is, from the models that were re-modularized using AO-BPM, what is the frequency that certain elements were found candidates to be aspectized, or where usually join points occur. As such, we believe that product issue (c) has to be anchored on experimentation.

With respect to the product issue (a), that is how an aspect which is to be performed by two different actors are to be represented in AO-BPM, we have a catch 22 type of problem: that is, as we aspectize part of the process we would have to repeat the aspect for each actor influenced by it. This problem is a characteristic of BPM languages, which bring a ternary relationship with respect to modularization: we will have to add a join point to both the process as well as the actor (swimlane). Although this is not a problem for the grand representation schema (Silva, 2006), it is a problem when the presentation is concerned, that is, how to present the modularized process with the usual matrix presentation (actor x process)? One way, as described above, is to group actors, but that seems a little artificial, this is something that we need to investigate a little more.

The issues related to product refereed in the previous paragraph will require specific techniques dealing with the separation and the weaving of the aspects impacting the tools that are necessary to support them.

With regard to process, we understand that we can take advantage of already available guidelines proposed by the requirements engineering community (Antonelli *et al.*, 2010; Moreira *et al.*, 2005; Sampaio *et al.*, 2005), mainly with respect

to aspect identification; process issue (b). However, we need to do better; that is we need to start coding the processes that we have been using for modeling AO-BPM and monitor their use by newcomers as such we will be addressing issue (c) as well. As the literature has pointed out (Recker *et al.*, 2009): "[...] the lack of precise guidelines turns out to be a major impediment for applying modularity [...]".

With respect to process issue (c), abstraction level, we consider that this issue is very much related to the context at hand. In some contexts, an activity may be found to be atomic, and in others the same type of activity may need further decomposition. On the other hand, we also believe that addressing the non-functional characteristics of business process will be positive for helping process engineers to deal with the complex issue of introducing quality characteristics into BPM (Kueng and Kawalek, 1997; Soffer and Wand, 2005).

7. Conclusion
Although aspect-oriented ideas in business process models brings out better modularization, our continuing experimentation with this approach brought out some issues that need more attention. This paper lists and explains these issues. These issues were identified through examples of a real world company. Some of these issues have already been mentioned in the literature. Others even not been mentioned yet are, at first, analogous to software engineering issues regarding software modularity.

We identified basically five issues, which are related to:

(1) aspects identification process;

(2) elements used in the models;

(3) assignment of aspect to organizational actors;

(4) levels used to modularize business process models; and

(5) modularization process with AO-BPM.

As described in Sections 4 and 5, there are some few works on BPM regarding crosscutting concerns and all of them consider different ways to provide modularity to business processes. It is clear that all of them treat the basic issues, as defining what kinds of elements can be considered an aspect or how to represent an aspect, but none of them deals explicitly with other issues listed in Section 5 nor do they propose to work on these issues or how to solve them. As such, our paper helps the field in pointing out important areas that need more research as well as providing an initial vision of possible solutions.

Some of the issues are related to method, how to do it (process issues), and others are related to the technique, the representation language (product issues). We believe that future work, which we plan to pursue, is very much based on experimentation both on process and on product. Having access to a large base of modeled processes of our industrial partner is certainly an advantage. However, we have also to exploit the creation of AO-BPM from scratch. We plan to evaluate the AO-BPM with an experimental approach (Kitchenham *et al.*, 2005) in order to strength our understanding about BPM modularization.

Regarding the aspect identification we plan to perform a deep analysis of heuristics presented in Section 2. As we concluded, repetition is not enough to point out that a concern is an aspect. One possibility is to use a combination of the already mentioned

heuristics or to discover new ones via experimentations. It is also important to analyze business processes from more than one domain, so we will be able to confirm if the aspects can be present in any kind of organization or if they are domain dependent. This issue is also related to the ways that an aspectized model can be generated, as the aspect identification is required to generate an aspectized model.

Another required research initiative is the operationalization of heuristics used to identify crosscutting concerns. We believe that an automatic mechanism could be build to discover candidate aspects from business process models. With an automatic mechanism, organizations will be more easily convinced to try this new modularization approach. So this initiative brings aspect-oriented ideas to the reality of organizations.

We also have to establish means to group similar aspectual elements maybe through the use of catalogs and propose an aspectual life cycle. To be able to do that, a case study on a real organization must be done so will be possible to analyze the aspects evolution. It also would allow us to study how this new modularization approach impacts on the organizational structure and management. Almost all of the issues are related to each other, so that the results for one of them can benefit another. For instance, the plans to explore aspects identification on a real organization can help the resolution of issues related to adoption and aspectized model generation. As a consequence, we will have more information to confirm that each element really have aspectual characteristics and also exploit the level to modularize the models.

It is also important the establishment of metrics in aspect-oriented business process models. This initiative can depart from works regarding metrics using aspect-oriented ideas in software engineering and metrics in business process design. The former can be exemplified by Sant'Anna (2004) who proposes a framework to evaluate maintainability and reusability of aspect-oriented software. His framework is composed of metrics and a model of quality including coupling and coherence. An example of the latter is Vanderfeesten *et al.* (2007). The authors confirm quality metrics brings several benefits in software code and design and indicate the relation between them and business process design. More than that, they elaborate on BPM metrics importance through the presentation of a classification of current business process metrics and an example of implementation of these metrics using a free analysis tool.

Note

1. "A perspective is a set of facts observed and modeled according to a particular modeling aspect of reality and a viewpoint. An example of such modeling aspect is what is known as 'data modeling'" (Leite and Freeman, 1991).

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