Business Process Lines to develop Service-Oriented Architectures through the Software Product Lines paradigm

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Abstract

Lately many researchers are focused on differences and similarities between Software Product Lines (SPL) and Service-Oriented Architectures (SOA). An interesting research topic is how to apply the SPL good practices to the SOA building. So the authors introduce the concept of Business Process Line (BPL) in order to transfer the SPL peculiarities first to the business processes and then to the SOA systems implementing them. A BPL realizes processes able to adapt themselves to different customers or market segments needs. Each process of a BPL can be composed and then transformed in the corresponding SOA system. In this way, all the resultant SOA systems will be suitable to different customer needs as the underlying processes, so that advantages from SPL good practices are gained from SOA architectures. In this paper the authors propose a methodology based on decision tables to represent a BPL and sketch an ongoing case study.

1. Introduction

Software Product Lines (SPL) [1] and Service-Oriented Architectures (SOA) [2] are two emerging approaches to the software development that are currently receiving great attention both in research and in practice [3, 4]. They aim to achieve different goals through two common perspectives: software reuse and flexibility [5]. In fact, both approaches enable the enterprises to implement new software systems reusing software resources in legacy systems rather than developing the same software capabilities again. Thus enterprises gain in productivity, software quality and time to market. Another characteristic of these approaches is flexibility allowing to adapt the systems to the different customers of a whole market segment. Nevertheless, whereas SPL focuses on the analysis and the management of commonality and variability to build a set of software products [6], SOA allows to compose, orchestrate and maintain solutions based on services, implementing business processes [7, 8]. Earlier research works, concerning the comparison between the two approaches to the software development, are just appearing in the software engineering research community [9]. In this context, our work suggests an approach to build a SOA systems line suitable to customers or market segments needs in a specific application domain. For this purpose, we propose transferring advantages from SPL to SOA operating on the business processes. We start from a deep analysis of the business processes identifying in them commonality and variability typical of the SPL paradigm. That’s why we introduce the concept of Business Process Line (BPL). A BPL realizes processes able to adapt themselves to different customer needs. Each process of a BPL can be then transformed into the corresponding SOA system as described in [10]. This transformation can be automated as much as possible considering the non deterministic decision points that can be resolved only through human interventions [11]. The resulting SOA system automates the underlying business processes; so, if we adapt the business processes to the customer needs and then we generate from it a corresponding SOA system, it will result in its turn suitable to the specific customer requirements. The commonality and the variability of the resulting SOA systems line will correspond to the translation of the underlying BPL commonality and variability.

A business process of a BPL is obtained (as a software product of a SPL) composing commonality and variability through a decision model. The innovation here proposed suggests structuring and organizing a BPL through two decision models:
- Configuration Decision Model able to select, according to the requested business capabilities, suitable process elements that have to be added to
a basic process in order to obtain the target business process.

- **Specialization Decision Model** able to specialize each process element of the target business process according to specific customer requirements. In particular through this decision model we can specify the software services that have to be orchestrated in order to implement the business capabilities of the target business process.

In order to guarantee the effectiveness of our approach we use tools supporting the decision models management and automating the transformation of a process model into a service-based system. In the following sections we discuss the proposed methodology in details: in section 2 we explain how to apply the SPL good practices to the business process modeling context, in section 3 we present the decision models supporting a BPL, in section 4 we describe a case study currently developing; in the last section some conclusions are drawn.

2. From SPL to BPL

In this section we explain the BPL concept that allows to manage business processes according to the SPL logic. For this purpose, first we will give an overview on the peculiarities of the SPL approach, after we adapt these characteristics to the business processes context.

2.1 SPL: Overview

A software product line is a set of software-intensive systems sharing a common set of features that satisfy the specific needs of a particular market segment and that are developed from a common set of core assets in a prescribed way [12].

In general, the SPL paradigm is characterized by two kinds of activities:

- Management of the “Core Asset”, that is collection, organization and systematic refinement of the assets, invariant or variant, representing respectively the SPL commonality and variability.

- Automatic building of the products based on the systematic reuse of the “Core Assets”. Each asset is a software component having fixed specifications allowing to:
  - **Configure** the products through asset integration procedures
  - **Specialize** the assets through the specification of their parametric parts

2.2 Towards a Business Process Line

The above mentioned SPL peculiarities can be used in the business processes context. For this purpose we can adapt the SPL asset concept referring it to the business processes and therefore we can borrow also the typical operations of configuration and specialization. In the business processes context we can consider as asset activities or work definitions [13] representing specific business capabilities. So, there is an analogy between the SPL product configuration and the business processes one. In fact, the above defined assets (activities and work definitions) can be added to a basic business process in order to configure the target business process. In particular, a configuration procedure is associated to each asset in order to add the asset itself to the basic business process. Moreover, there is also an analogy as regards the specialization task. In fact either the process elements or the software components can be general and parametric and then they can be specialized. In particular each specific business capability of the target business process can be specialized through attributes indicating specific architectural characteristics to implement them. For example the same business capability can be implemented through one service or through the orchestration of several services. Moreover the services implementing a business capability can be in their turn parametric. So the specialization task provides also the specification of this kind of parameters.

All this makes possible introducing the concept of Business Process Line working like a SPL based on a Core Asset and structured in commonality and variability and generating process models similar each other but each with a specific business objective. In order to formalize the decision model underlying the processes configuration and the specialization in a BPL, in the next section we propose using the decision tables formalism.

3. BPL Decision Models

In this section we put forward a hypothesis about organizing and structuring the decision model underlying a BPL. For this purpose it’s necessary to represent the relations between the business capabilities characterizing the customer needs and the suitable processes elements that have to be integrated in the target business process. Moreover we need to represent the relations between the customer
requirements and the specific peculiarities of the processes elements previously integrated in the target process. The authors propose representing these relations through the decision tables formalism. A decision table is a tabular representation of the decision-making task, where the state of a set of conditions implies the execution of a set of actions [14, 15, 16, 17]. In general, a decision table has four quadrants: conditions (Cond), conditional states (S), actions (Act) and rules (x) as shown in figure 1. The table is defined so that each combination of conditions and conditional states corresponds to a set of actions to carry out. The conditional-oriented approach of a decision table allows to express knowledge related to the examined problem.

**Figure 1. An Example of Decision-Table.**

The decision tables formalism assures a compact overview of a large number of information, modular knowledge organization, effective evaluation of consistency, completeness and redundancy. According to the business processes configuration and specialization provided in a BPL, two different kinds of decision tables are proposed: the configuring tables and the specializing tables.

For each BPL a set of invariant assets is associated and a configuring table is built. A configuring table allows to select the suitable variant assets characteristic of the requested business capabilities. They have to be composed with the invariant assets (integrated into a basic process) in order to generate the target business process. That’s why this kind of decision table is structured as follows (figure 2):

- the CONDITION quadrant contains a set of business capabilities, BCi i=1,…n leading the variant assets selection
- the CONDITIONAL STATE quadrant contains the possible values of each business capability [BC]=BC1, BC2, …, BCIq
- the ACTION quadrant contains all the possible variant assets {va1, va2, …, vaI} that can be added to the process commonality
- the RULE quadrant identifies the relations between each capabilities profile and the corresponding variant assets to be added.

**Figure 2. An Example of Configuring Table.**

For each asset, variant or invariant, a specializing table is defined. It supports the assets specification. This kind of decision table is structured as follows (figure 3):

- the CONDITION quadrant contains a set of customer requirements, CRj j=1,…m, to specialize the parametric part of the asset
- the CONDITIONAL STATE quadrant contains the possible values of each requirement: [CRj]=CRj1, CRj2, …, CRjT
- the ACTION quadrant contains the parameters {p1, p2, …, ps} and their values allowing to specialize the parametric part of the asset according to the specified customer requirements
- the RULE quadrant identifies the relations between each customer requirements values set and the corresponding specializing parameters.

**Figure 3. An Example of Specializing Table.**

In short, after having specified the business capabilities in the configuring table, it’s possible to extract the suitable variant assets that have to be integrated with the invariant part of the process. Afterwards, the assets will be specified through the related specializing level tables. As a result the target process is generated. The presented decision model is organized separating the configuration task by the specialization one so as to
be understandable and manageable also in a not automatic way. This is necessary because we can’t exclude human activities during the composition process. For example the systems validation activity based on semantic controls requires necessarily the human intervention.

4. Case Study

In this section we introduce a case study in order to explain our methodology. At the moment, the proposed approach is being investigated in an industrial case during the research project “DAMA” concerning the automation of business processes about the “Data Archiving Management and Acquisition”. The enterprise collaborating to the realization of this experimentation is a stable ICT company, whose core business concerns document management solutions for public and private financial institutions. Every day the enterprise receives packets of documents from its clients. These documents are primarily banking files containing pure text, images, diagrams, charts. Because of the large number of documents that have to be stored, the enterprise needs the implementation of automated processes to scan every document in the packets, recognize errors in words, distinguish images from pure text and store everything according to proper category. Here, for space reasons, only a part of the case study is presented.

The figure 4 shows the invariant part of the Recognizing process (the used formalism is described in [13]). This process contains an OCR (Optical Character Recognition) activity requiring a scanned Document Image as input and produces a recognized Text Document as output.

![Figure 4. Invariant Parts of Recognizing Process.](image)

The enterprise needs besides to elaborate and archive structured and typewriting documents, containing images and without signature. For this purpose we have to compose the basic process with the suitable variant assets through a configuring table (figure 5). In particular the table provides the following business capabilities: Signature Extraction, Layout Analysis and Image Extraction.

<table>
<thead>
<tr>
<th>Signed Documents</th>
<th>Digital</th>
<th>Adographic</th>
<th>Without Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Structured</td>
<td>Unstructured</td>
<td>Structured</td>
</tr>
<tr>
<td>Documents with Images</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Layout Analysis</td>
<td>X</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Image Extraction</td>
<td>X</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Adographic Sign Extraction</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Digital Sign Extraction</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

![Figure 5. Configuring Decision Table.](image)

For each set of required business capabilities a set of suitable variant assets can be selected and added to the basic process. In figure 6 is shown the process configured according to the requested business capabilities.

![Figure 6. Configured Process.](image)

After the business process configuration we have to specialize the assets included in the target business process. In particular we can specify the services that have to be orchestrated in order to automate it. Afterwards we can implement the modeled business process through a SOA architecture. For this purpose we can transform the target business process into an executable workflow orchestrating the services specified during the process specialization.

5. Conclusions

This work represents a contribution to apply the good practices of SPL to SOA. In particular the authors propose to perform a deep analysis about the business
processes in order to identify commonality and variability in them. For this purpose they introduce the BPL concept to adapt the business processes to the customer requirements. The business processes specified in this way are automated through a SOA system so that it results suitable for the requested customer needs. The proposed approach and the results obtained encourage further investigations. Nevertheless these results cannot be generalized to other applicative domains, so more empirical evidence is needed.

In order to support the application of the approach here presented, the authors are developing two tools: the former aims to automate the decision tables management (design and consulting), the latter is able to transform business process models in executable workflows for SOA systems.

References