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Modeling flexible configurable processes applied to the enrollment process in higher education institutions

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Abstract

Modern information systems need to be able to deal with uncertainty and variability, as well as to support the evolution of business processes. In this work, we apply two flexible and configurable modeling approaches to model the process of the student enrollment at a higher education institution. A model based on the configuration of the reference model requires a comprehensive reference model, while the model based on the model structure adaptation contains a minimal reference model. Both modeling approaches proved to be applicable to modeling the process of the student enrollment at a higher education institution.

Keywords: reference process model, business process, flexible business process, adaptive business process

Introduction

In recent years, there is a constant need to effectively support business processes at an operational level. Process aware information systems need to be able to deal not only with exceptions, change the execution of single business cases on the fly and efficiently deal with uncertainty and variability, but also to support the evolution of business processes (Reichert & Weber, 2012).

The concept of flexibility is often viewed as the ability of a model to adapt to the business and technology changes in an organization (Snowdon R.A. at all, 2007). The main feature of configurable processes is explicit presentation of point variation and variations of process models (Carlsen S., 1997; Daoudi F 2007).

The models can use configurable connectors to represent design decisions taken by the analyst in the process of practical adjustment of the process as required by the organizations (Becker, 2003; Dumas, 2005; Heinl, 1999).

Two modelling approaches, that are configurable at a high level of abstraction by applying a set of well-defined change operations to a reference process models are proposed in (Hallerbach, Bauer & Reichert, 2010). The first modeling approach contains an overall presentation of the model that uses configurable connectors to exclude processes that are not currently required, which enables the customization and flexibility in the model. The second approach is based on the simplest model of the process and configurable nodes that allow the model to adapt to changes in the business process at given points. The two proposed models have been used for modelling the processes of admitting and treating patients at a medical institution (Reichert & Weber, 2012).

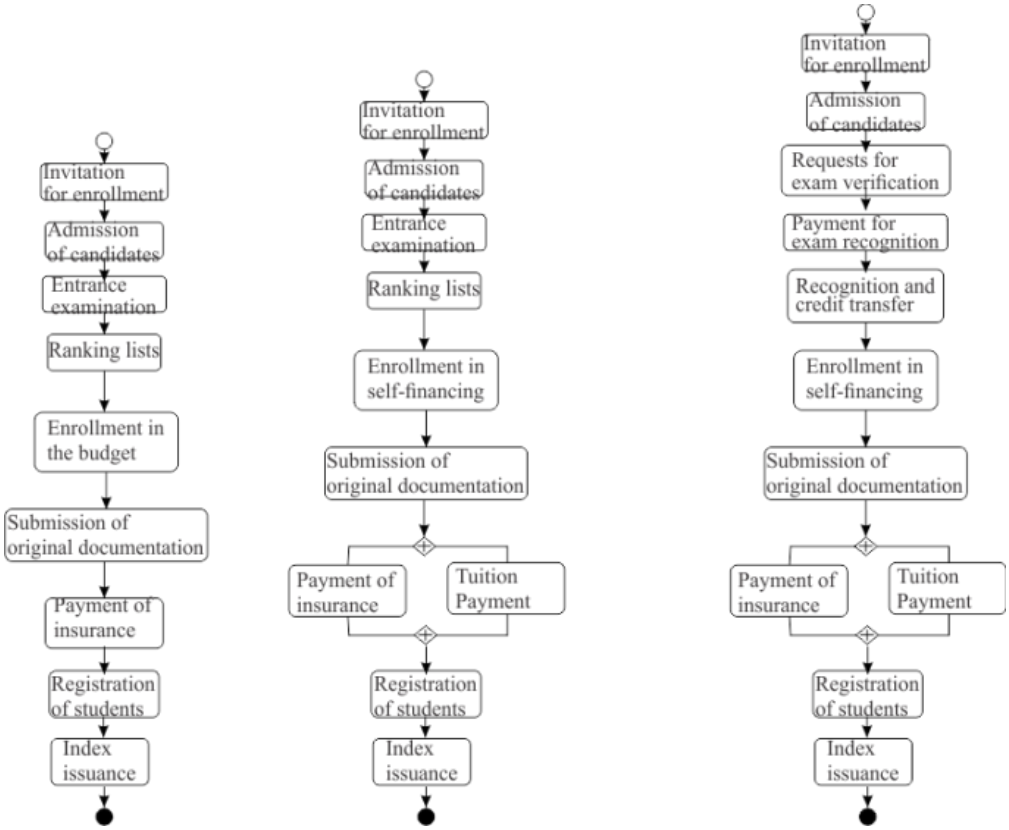
Information systems that support the evolution of business processes have been used in various domains, such as e-commerce (Gordijn & Akkermans, 2003), transportation (Bassil, 2005), and

healthcare (Lenz & Reichert, 2007). To the best of our knowledge, they have not yet been widely used in the domain of education. The goal of this work is to apply flexible and configurable modeling to the process of enrollment in higher education institutions. We compare the two models and analyze their features.

The rest of the paper is organized as follows. We first model the process of the student enrollment at a higher education institution based on the two approaches. The limitations of the model using configurable nodes are then discussed. We then give the comparison of the two modeling approaches, and finally draw the conclusions.

The modeling approach based on the configuration of the reference model

By analyzing the enrollment process, we found that there are several families of processes for candidate's enrollment in the first year of study. To illustrate the flexible modeling based on the two modeling approaches, we use a family of processes regarding the candidate enrollment. We model three variants of the candidate enrollment process, which differ in the candidate financial support: the candidates financed from the government budget, self-financing candidates, and candidates transferring from another higher education institution, as shown in Figure 1.



a)Budget *b) Self-financing* *c) Transfer*

Figure 1. Model variants of the process of the candidate's enrollment for studies

Considering the three variants of the process model shown in Figure 1, their joint activities and the activities in which they differ, we extracted the reference process model, as shown in Figure 2. The reference process model of the candidate enrollment comprises the budget, self-financing and transferring process variants.

In the reference process model shown in Figure 2, we define four rules R1, R2, R3, and R4 that should be applied when modeling the configurable process. The rules are given as follows:

R1: $XOR_1 = \text{`}SEQ_{1a}\text{`} \vee XOR_1 = \text{`}SEQ_{1b}\text{`}$

R2: $XOR_1 = \text{`}SEQ_{1b}\text{`} \Rightarrow OR_3 = \text{`}SEQ_{3b}\text{`}$

R3: ($XOR_1 = \text{`}SEQ_{1a}\text{`} \wedge$ Ranking List = „B“) $\Rightarrow OR_3 = \text{`}SEQ_{3a}\text{`}$

($XOR_1 = \text{`}SEQ_{1a}\text{`} \wedge$ Ranking List = „S“) $\Rightarrow OR_3 = \text{`}SEQ_{3b}\text{`}$

R4: $OR_3 = \text{`}SEQ_{3a}\text{`} \Rightarrow OR_5 = \text{`}SEQ_{5a}\text{`}$

$OR_3 = \text{`}SEQ_{3b}\text{`} \Rightarrow OR_5 = \text{`AND`}$

The activities that are common for all three variants are shown in gray fields in Figure 2. For example, *Submission of original documentation* is included in all variants of the process model.

On the other hand, the variability of the three process variants are caused by the factors such as the value of *editing and publishing ranking lists, type of payment*, or whether there was a *the recognition of exams*.

After finishing common activities at the start of the reference process model, the rule R1 determines the first variability. The conditions in R1 determine the selection of group activities for the entrance examination (SEQ1a) or transferring from other institutions (SEQ1b).

If the candidate is transferring from another institution (SEQ1b), he/she enrolls as self-financing, which is given by the rule R2. Otherwise, the variability between the budget enrollment and the self-financing enrollment depends on the ranking list, as described by the rule R3. If the candidate is undertaking entrance examination (SEQ1a) and can be financed from the budget according to the ranking list (Ranking List = „B“), the candidate enrolls as financed from the budget (SEQ_{3a}). On the other hand, if the value of the ranking list activity is "S", the candidate enrolls as self-financing (SEQ_{3b}).

The rule R4 refers to the type of payment. If the candidate is financed from the budget, he/she pays the insurance only (SEQ_{5a}). If the candidate is self-financing, the connector OR_5 becomes `AND`, implying he/she has to pay both insurance and tuition.

The variation points can be characterized in several ways. As we can see on the reference model in Figure 2, they depend on the configurable connectors OR1, OR3 and OR5, as well as the activities of *Ranking Lists*.

A configurable process model depends on many variable points, which is implemented as a configurable node in the model. Each node refers to a decision that must be made during the design of the process.

Once all decisions are made, the process is individualized, since the variants that are no longer relevant are eliminated. As a result, we obtain an individualized process model. This process model can still be used in the analysis, for simulation, or to perform a specification for a given set of requirements.

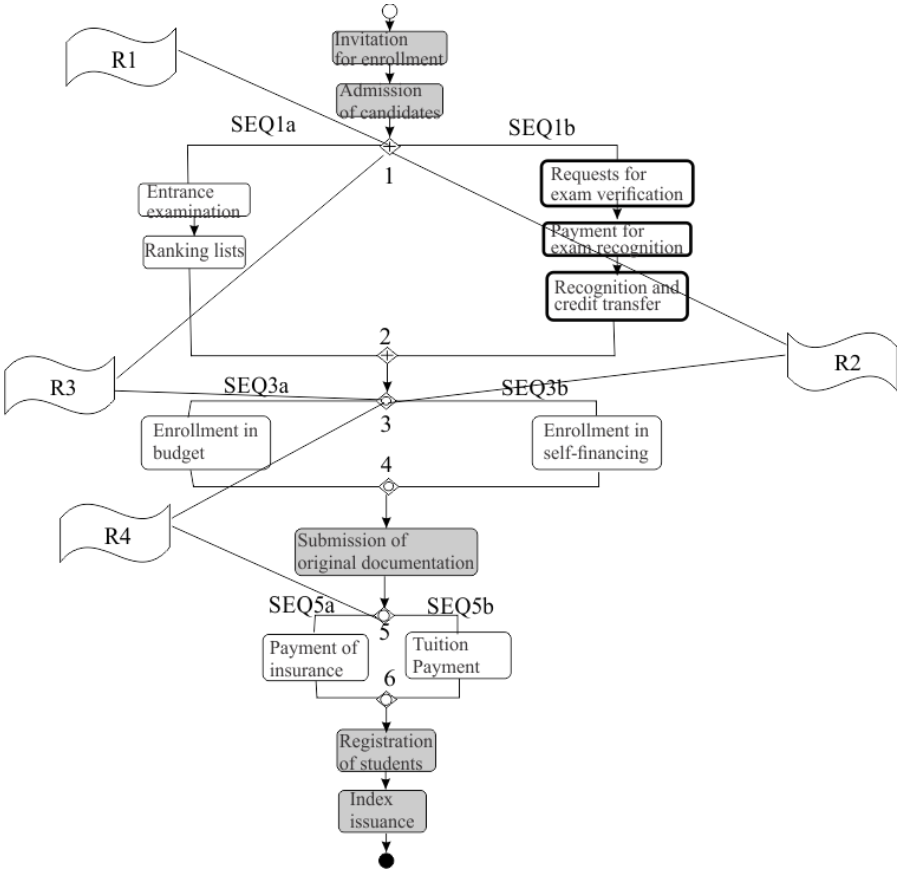


Figure 2. Reference model process of candidate's enrollment for studies

The modeling approach based on the model structure adaptation

In this section, we provide the model of the previously described example of the student enrollment process using the approach based on the model structure adaptation, where the activities can be added, moved, or deleted. The adaptation of the configuration structure offers high flexibility and adaptability in relation to the selection of the basic process model and the specified models of changes (La Rosa M., 2009).

The model is designed based on five rules for defining and executing the reference model (Subić N.,2013; Hallerbach F., 2013).

The reference model is designed based on the process that happens most frequently during the enrollment, which is the variant where financing is from the budget (Figure 1a).

Based on the rule 3, stating that the reference model should be minimal, either the activity *Enrollment from the budget*, or the activity *Enrollment as self-financing*, will be present in the configurable model. The activity *Submission of original documentation* is a part of the reference model, as it is required in all process variants.

Option 1 in Figure 3 determines whether the candidate transfers from other higher education institutions. If the type of study is *transfer* then the activities *Entrance examination* and *Ranking list* will be deleted from the reference model.

Option 2 in Figure 3 allows to choose the activity *Enrollment in the budget* or *Enrollment in self-financing*. The choice depends on the value of the activity *Ranking list*.

Option 3 in Figure 3 enables to perform checks of submitted original documents. If the value of activity *Submission of original documentation* is "NO", the activity is deleted from the basic model and will not exist in the executive model.

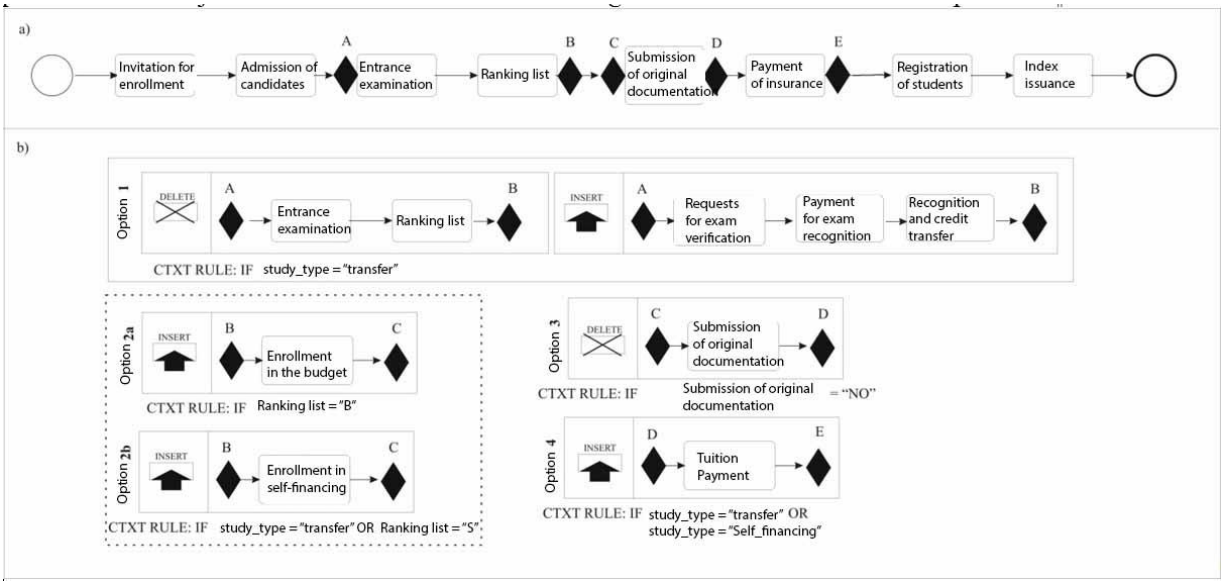


Figure 3. The example of configurable basic process model and relevant options changes

Option 4 in Figure 3 determines whether it is necessary to pay tuition. The activity *Tuition Payment* will exist in the executive model only if the type of enrollment is *self-financing* or *transfer*.

Limitations in the design of option changes

Step 1 - Selecting relevant option changes

To ensure the structural accuracy as well as the precision, option changes are limited by Context rules (CTXT). Variants of the process model will be included in the executive model only if they comply with the rules in the environment to which configurable process model is being adapted. This requires an appropriate context model (Table 1).

Table 1. Context model of the enrollment process family

Contextual variable	Range of values
Study type	budget, self-financing, the transfer
Submission of original documentation	No, Yes
Ranking list	B, S

Table 1 shows the variables on which the design of the executive model depends upon. For example, if the value of the contextual variables *Ranking list* is "B" the candidate enrolls as financed from the budget, while it is "S", the candidate enrolls as self-financed.

Step 2 - Ensuring the limitation of option changes

Another limitation when designing executable process model variants is in the permitted combinations of options. To ensure semantic and syntactic accuracy these limitations must be defined (Figure 4).

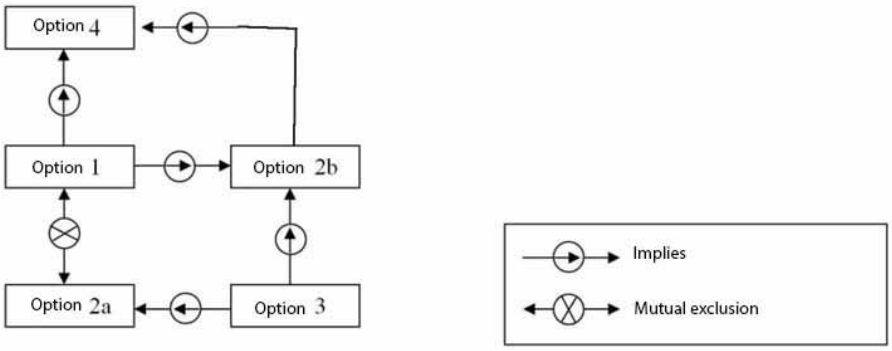


Figure 4. Allowed limitations of option changes combinations

Combining limitations shows mutual exclusion between *Options 1* and *2a*, i.e. if *the transfer* option is selected, it is not possible to enroll *from the budget*. Also, *Option* 1 implies *enrollment in self-financing* and *payment of tuition*. Only if original documents are submitted it is possible to enroll studies either from the budget or as self-financing, which is limited by implying *Option 3* toward *Option 2a* and *Option 2b.*

Step 3 - Defining the order

The schedule of assigning options follows the given order to configure the basic model of the process. If the order is not complied with, it may result in inconsistent or undesirable variations of the process model. When determining the schedule it is also necessary to monitor limitations that are specified in step 2.

In the example of the candidate enrollment, we can extract the following sequences:

1. Regular enrollment
    a. If the value of the activity *Ranking list* is equal to „B"

    Option 2a → Option 3

    b. If the value of the activity *Ranking list* is equal to „S"

    Option 2b → Option 4 → Option 3

2. Transfer from other higher education institution

Option 1 → Option 2b → Option 4 → Option 3

Option 3 occurs in all variants and depends on the value of the action *Submission of original documents* – if the value is "NO" the option is deleted, otherwise the option is executed.

Step 4 - Configuration of the process model variant

By applying the defined series of operation changes to the basic process model, a specific variant of the process model is selected, and the process is individualized.

We explain in more detail the adaptation of the basic model of the process in case of candidate's enrollment when transferring from the other institutions of higher education.

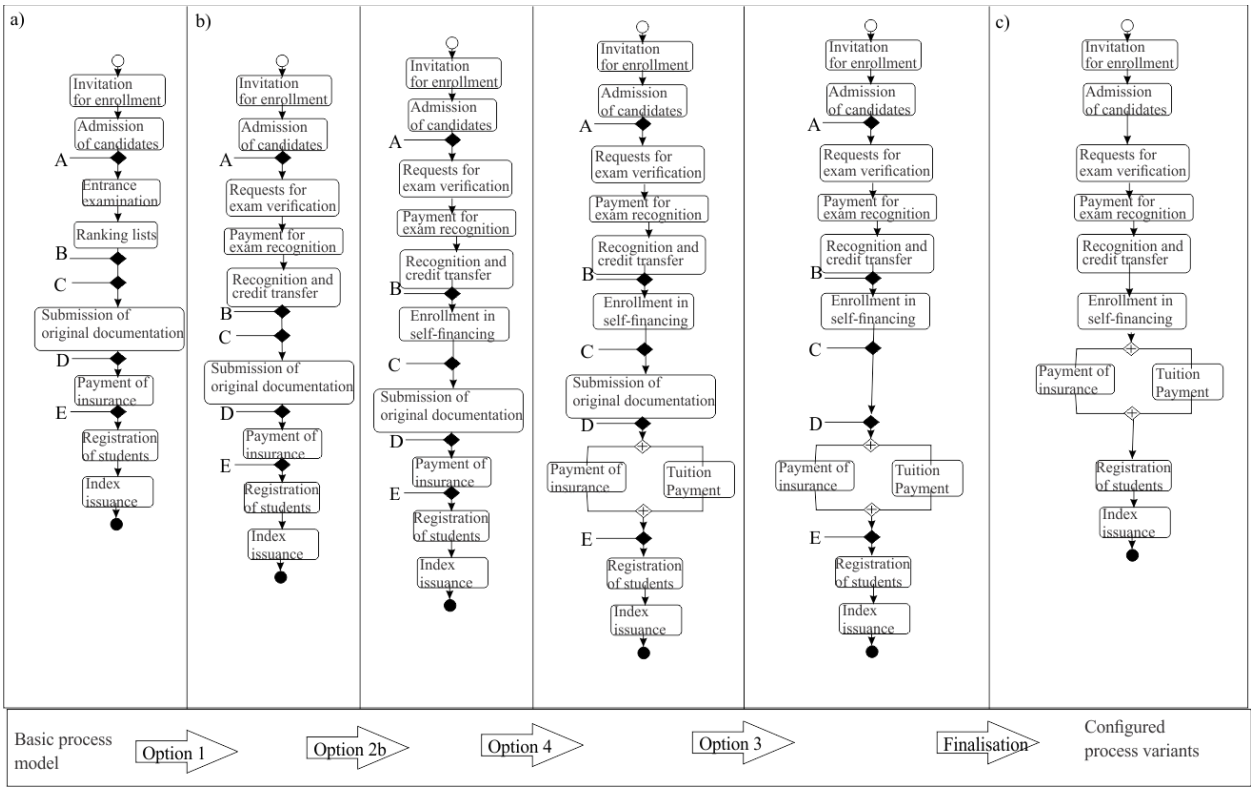


Figure 5. Configuration of the basic process model through structural adaptation

According to the options changes shown in Figure 5, we can configure the desired variant of the process model. Points of adaptation of the basic model of the process, shown in the Figure 5a, represent stable connections for option changes and the corresponding operation changes. Activities *Entrance exam* and *Ranking list* are replaced by the activities *Applying for recognition of the exams*, *Payment for exam recognition* and *Recognition and credit transfer*.

Option 2b between points of adaptation B and C changes the structure of the basic model of the process by inserting activity *Enrolment in self-financing*. *Option* 1 implies the *Option* 2b, as stated in the Step 2.

Every time the structure is adapted by changes in adaptation points A and B, with the execution of operation changes defined by *Option* 1, the model structure is changed in adaptation points D and E. When the changes implied by the *Option* 1 cause insertion of the activity *Tuition Payment*, the *Payment of insurance* activity will also be executed according to *Option* 4.

According to *Option* 3 the activity *Submission of original documentation* is deleted if its value is "NO", which can happen only if the candidate has submitted original documents during the activity *Admission of candidates*.

After applying four options selected in the previously explained steps points of adaptation are removed, as shown in Figure 5b. As a result, the variant of the process model is configured, as shown in Figure 5c.

The result of using this modeling approach is the configurable reference model, which is flexible and adaptive. By applying well-defined options in adaptation points, the variant of the process model is configured, tailored to the specific process in the organization. It is important to respect the option changes, limitations and adaptation points. If this were not observed while configuring the model, it would result in inadequate configured model variants.

Comparison of the two flexible modeling approaches

We have identified the basic features of flexible models and outlined whether the two applied modeling approaches complies with them, as shown in Table 2.

Table 2. Comparison of the flexible modeling approaches

Feature	model configuration	model structure adaptation
Flexibility	Yes	Yes
Adaptation	Yes	Yes
The reference model	Yes (comprehensive)	Yes (minimal)
The configuration variant	Yes	Yes
Individualization	Yes	Yes

Both modeling approaches provide flexibility and adaptation of the business processes. Both modeling approaches allow changing the structure of the process model to adapt to the specific requirements of the organization.

In the modeling approach based on the configuration of the reference model, there is one universal model, which enables customization and flexibility using configurable connectors. Configurable alternatives can be configurable OR, configurable XOR or configurable AND.

The modeling approach based on the model structure adaptation is based on the reference model, which may not be comprehensive, and is formed with consideration to the well-defined rules. By applying the defined options of change, adaptability and flexibility are enabled. The options of change include the operations INSERT, DELETE and MOVE, which enable the adaptation of the structure in strictly defined points of adjustment.

The main difference of these two approaches is in the reference model. The first approach provides a comprehensive baseline model that should predict all possible situations. The other

approach sets a minimum structure and allows adding new processes that can easily be implemented in the structure of the rules and options.

The decision on the selection of available alternatives in both approaches is essential. This is a key part of the flexibility and adaptability of business process models, and requires the involvement of human experts. The selection of further alternative is mostly reduced to manual selection which increases the possibility of errors. In the second approach, the order of option changes is well defined, which ensures greater accuracy and consistency in the selection of alternatives.

Conclusion

Modern information systems used in various business domains need to be able to deal with uncertainty and variability, as well as to support the evolution of business processes. In this paper, we have applied two flexible and configurable modeling approaches to model the process of the student enrollment at a higher education institution.

The two modeling approaches are very similar as they both provide flexibility, adaptation and individualization based on the configuration variants. While they both contain a reference model, in the modeling approach based on the model structure adaptation it is comprehensive, while in the modeling approach based on the model structure adaptation the reference model is minimal.

When applying the modeling approach based on the configuration of the reference model, it is essential to capture all processes at the beginning of the modeling, which may be a difficult task. Further, the selection of a particular model at the stage of individualization is then straightforward.

The modeling approach based on the model structure adaptation is somewhat more flexible in the way that the modeling can be done in stages, as new options and rules can be added at a later stage of modeling.

The paper demonstrates the usage of both flexible modeling approaches to modeling the process of the student enrollment at a higher education institution. Both approaches proved to be applicable in this domain.

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