Process Risk Management Using Configurable Process Models

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Abstract. Almost no construction project performs totally as planned as dynamic changes are frequently needed. These changes can be ascribed to the high uncertainty, which is evaluated as potential causes of risks and risks is in turn are evaluated as potential causes of plan changes. Several concepts from the Business Process Modeling domain are adopted to build an explicit process-oriented knowledge documentation of the construction processes.
A standardized process description is suggested that offers flexibility in its content to be usable in different contexts. Configurable fragments in the course of the process models express the uncertain parts of the process. A general structure of a Configurable Reference Process Model (CRPM) is developed as an ontology model to document the construction processes in a Process-oriented Knowledge base. By using this knowledge base a considerable planning effort will be saved. Moreover, the quality of the process schedules, since they will be derived from the reference process models, will be enhanced and the expenditure of time will be reduced.

Keywords: Uncertainty, Risk, Change, Configuration, Business Process Modeling, Reference Process Model.

1 Introduction

The construction industry is a project-based business sector. Each project can be considered as a temporary alliance among diverse partners that will execute, in a private or in a cooperative way, several processes. This results in achieving the planned project objectives.

In this industry, the experience showed that mostly no construction project goes totally as planned because of the needed dynamic changes to different management plans. These changes can be ascribed to the relatively high uncertainty in the planning phase of a construction project. Several factors play a role to increase the total project uncertainty, such as the lack of experience with a certain type of construction processes or the changeable environment that surrounds and affects a construction process. In view of that, the risk of changing the already planned course of work as a need to adjust to current situation is really high. Such adjustments could be carried out, as a proactive or reactive risk treatment, even several times within the execution phase of the targeted process, if different risks in different points in time will arise.

The process knowledge collected from different resources is valuable for the effective process management, as it can reduce the uncertainty and, consequently, the error rate in the process planning will be lower. Hence, this knowledge should be documented in an explicit way to enable all the interested people to share and use their experiences properly. In a view of that, the standardization of construction processes that will include the best process practice can be a possible solution to reduce the accompanied uncertainty. Nevertheless, it is mostly impossible to apply the exact construction process as explicit work route in different projects. Accordingly, a degree of individuality is required within each process use. For that reason, a standardized process description should offer a certain degree of flexibility in its content to be usable in different project contexts.

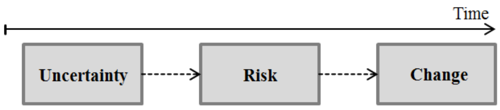
In other business sectors, like insurance, banking and government, different Business Process Modeling techniques were successfully used to standardize and optimize business process knowledge. Moreover, they were used to communicate process contents between different disciplines or else to automate, partially or completely, process execution. Instead of that, for the modeling of construction processes, the traditional critical path method is still widely used. However, this method has no ICT support in its background.

The paper introduces a novel, process-centered view on process standardization that focuses on the risk management using some configuration aspects from the Business Process Modeling domain. Accordingly, a structure of a configurable reference process model (CRPM) that includes configurable fragments is suggested. These configurable fragments are based on the configuration templates mentioned in chapter 3. For a better management of the CRPMs, a knowledge base is introduced in chapter 5 that reflects the structure of the CRPM and enables the maintenance of the process-oriented knowledge.

2 Dependencies Between Uncertainty, Risk, and Change Terms

Generally, the uncertainty in construction is a result of the lack of needed reliable information, which can be attributed to different environmental, organizational, or technical factors. The role and importance of each factor differs from project to project according to the specific project characteristics and to its surrounding environment. This uncertain nature may lead to a big variance between the results of deterministic methods used for project management planning and real practice. Usually, the deviation of the project management baselines can be reduced when the degree of uncertainty in the project can be decreased. This can be done as soon as a comprehensive knowledge about the project is available. As the practice in construction is project-based, better knowledge can be acquired from lessons learned and experiences gained from the past projects. This knowledge will help to make better planning decisions as well as to reduce mistakes on past projects to be repeated. When the project progresses, the accuracy of the made decisions becomes more clear and the ambiguity disappears gradually. However, it is generally impossible to acquire a comprehensive knowledge about the project in advance. Therefore, a systematic risk analysis should be undertaken to evaluate the project's risks and opportunities and, consequently, to reduce the negative effect of uncertainty on the project objectives.

Nevertheless, changes in construction projects are likely to occur at any stage and can affect different project management plans. In the literature on change management [1], [2], [3] it is emphasized that changes are inevitable in construction projects even if comprehensive studies have been made. The uncertainty in the project should be evaluated as potential causes of risks in the project [4]. In turn, in this work it is assumed that risks should be evaluated as potential causes of changes in the project management plan (Fig. 1). Based on this, a risk as an uncertain event may invoke one or more changes in the one or more project plans.



Consequences	Unpredictable	Predictable	Mostly known
Occurrence probability	Unpredictable	predictable	Known (1 or 0)
Timing	Unknown	Unknown	Known

Fig. 1. The possible causality between uncertainty, risk and later change.

3. Configuration Templates

A main hypothesis of this work is that all possible ways of changes in the structure of process models, as a treatment to probable or even actual risks, can be standardized by generalized templates. For this purpose, several templates are suggested as types of configurable fragments within process models [5]. Those are assumed to cover all kinds of process model related structure changes and consequently they will offer the needed flexibility in the process model. These templates are based on the concepts suggested by [6] as an extension to the event-driven process chains (EPC) elements. In view of that, a configuration template can be defined as a basic type of configurable fragments in the process model that describes one possible way of model structure change as a response to a certain event. As a result, a configured and specified template can be used to represent the structural change in a process model caused by the treatment of a specific risk event. Nevertheless, more than one configuration template may be used to represent a complex effect of one risk when it will cause changes in more than one location in the process model. In this sense, dealing with complex issues does not require complex templates as the basic suggested templates can be used together to cover a complex change case.

Building upon the classifications of risks and changes in the literature of construction management two major aspects were considered important from the process-oriented perspective. These aspects are (1) the timing of response to the risk (proactive or reactive response) and (2) the effect of the risk on the progress of the process, i.e. will it cause progress interruption or not. In view of that, the templates are classified into three main groups. These groups are:

- General Templates; these templates can be implemented in either proactive or reactive treatment cases. The general templates group contains the Insertion, Substitution, Cancelation, and Parallelism templates.
- Interruptive Templates; used to describe a disturbance risk that affects and stops a process during its execution. The interruptive templates group contains the Stop and Action templates.
- Reactive Templates; used only as response to events which have affected tasks or products considered to be completed. The reactive templates group contains the Repetition and Demolition templates.

4. Using Configurable Fragments in Process Models

A configurable fragment is an implemented instance of one of the configuration templates in a process model. In this work, a configurable process model is defined as a process model that contains one or more configurable fragments. Fig. 2 shows a configurable process model that contains three configurable fragments, namely (I) insertion of T(r) after T(i), (II) T(y) parallelism to T(k) as well as (III) T(m) and T(n) substitution by T(s). The configuration requirement R(1) links the configurable fragments (I) and (II) together. So according to the Risk 1 status (ON, OFF) these two configurable fragments will be configured. The link of configurable fragments (I) and (II) through the requirement R(1) builds a way to reflect the case when a risk may cause changes in different positions in the process model.

The configurable fragment (III) in Fig. 2 is configured according to the (ON, OFF) status of Risk 2. Accordingly four Configured Cases (CCs) can be derived from the configurable process model in Fig. 2.

5. Knowledge-Base for the Specification of Configurable Reference Process Models

The configuration templates offer an approach to represent the flexibility, needed in construction processes, in the shape of configurable fragments within the process models. The configurable fragments represent risk treatments that may be adopted or skipped according to the risk status. Generally, a process model that contains, amongst others, all the exceptional cases, in the shape of configurable fragments, of the process is a candidate to be a CRPM for this particular process. Nevertheless, if the process may have several interrelated exceptional cases the corresponding model can be complex and, consequently, difficult to illustrate graphically, use or to update. Therefore, a knowledge-base (KB) is suggested to manage these reference models. The KB structure is designed as an ontology model that consists of several process-oriented concepts related to each other via proper properties [7]. The configuration templates represent a fundamental part of the KB structure, see Table 1. In view of that, every risk treatment fragment within the CRPM should be associated to a suitable configuration template that describes how to integrate it later within the process model.

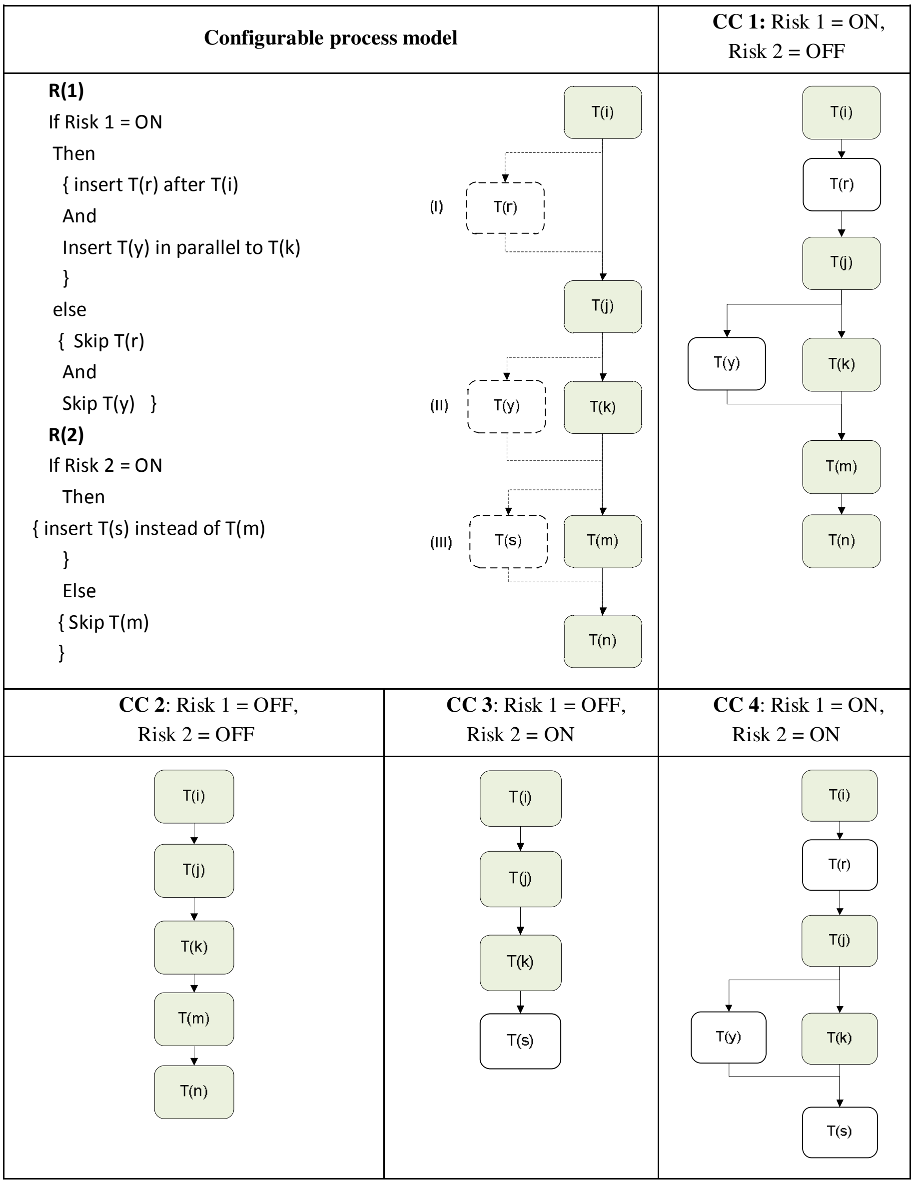


Fig.2. A configurable process model and the four possible configured process models derived from it.

Using such a KB within a construction company will enable the description of its process knowledge in a project neutral context. As a result, this could support decision-making and increase the intelligence of the construction processes. Consequently, the expenditure of time and money in the process design will be reduced. Also, A clearly defined semantics for the process models can be achieved by instantiating the elements of a CRPM from the concepts of an ontological KB. Accordingly, the ambiguity and the shortage in formality in process models can be avoided. Moreover, storing the construction CRPMs in an ontological KB will enable making advanced queries when retrieving information. These queries may even infer facts that were not explicitly created by the modeler of the CRPM. As a KB is passive data source, it is here considered as a commodity to develop a process management software tool. Therefore, it is needed to improve the access to the knowledge included in the CRPMs by developing methods, which can support the choice, the configuration, and the composition of the relevant CRPMs.

Table 1. The properties relate the configuration fragments to the Task concept through the Configuration Template concept in the ontology model.

<table>
<tr><th>Concept</th><th>Property ⟺</th><th>Concept (Abstract)</th><th>Property ⟺</th><th>C-template groups</th><th>Property ⟺</th><th>C-template</th><th>Property ⟺</th><th>Concept</th></tr>
<tr><td rowspan="8">One Action Risk Treatment</td><td rowspan="8">Integrates/ integrated according to</td><td rowspan="8">Configuration Template</td><td rowspan="8">Is a</td><td rowspan="4">General Template</td><td rowspan="4">is a</td><td>Insertion</td><td>Before/ after/ between</td><td rowspan="8">Task</td></tr>
<tr><td>Parallelism</td><td>Start - End</td></tr>
<tr><td>Substitution</td><td>Start - End</td></tr>
<tr><td>Cancelation</td><td>Target</td></tr>
<tr><td rowspan="2">Reactive Template</td><td rowspan="2">is a</td><td>Demolition</td><td>Target</td></tr>
<tr><td>Repetition</td><td>Target</td></tr>
<tr><td rowspan="2">Interruptive Template</td><td rowspan="2">is a</td><td>Action</td><td>Target</td></tr>
<tr><td>Stop</td><td>Target</td></tr>
</table>

6. Software Architecture for CRPM-based Process Management

The architecture of the suggested software tool consists of three tiers (Data, Application, and Graphical User Interface (GUI)). The data tier includes the Process-DB and the CRPM-KB. Within this tier, different types of information, CRPMs and versions of instantiated process models (IPMs), can be stored and retrieved. The retrieved information will be then passed through to the application tier for processing, and then, eventually, to the user. The data tier keeps the comprised information neutral and independent from the application tier, which improves the scalability and performance of the intended software tool. The Application tier moves the process data between the two surrounding layers. Moreover, it performs the needed procedures, e.g., configuration tasks, and makes the required procedures on the retrieved process data. Amongst others, the Application tier has to do the following:

- Query the CRPM-KB to get the relevant CRPMs.
- Configure the selected CRPM according to the preferences of the user.
- Instantiate the configured CRPM and to store it after that to the Process-DB.
- Establish a new CRPM.
- Compare different versions of the same IPM.

The GUI tier displays the processed and original information related to the process and, accordingly, allows the users to interact with the software application.

An example of the software implementation is shown in Fig. 3. During the implementation time of an IPM an exceptional event, i.e. risk, may arise and, accordingly, changes will be needed in the already planned IPM. The KB can be queried in order to find out if there is any relevant solution for the new condition. In the case that a solution is chosen from the KB, it needs to be configured, instantiated and integrated in the already planned IPM. Otherwise, an external solution will be sought after. An external solution can be used for the specific IPM and can be as well integrated in the CRPM to enhance the process knowledge included in the KB.

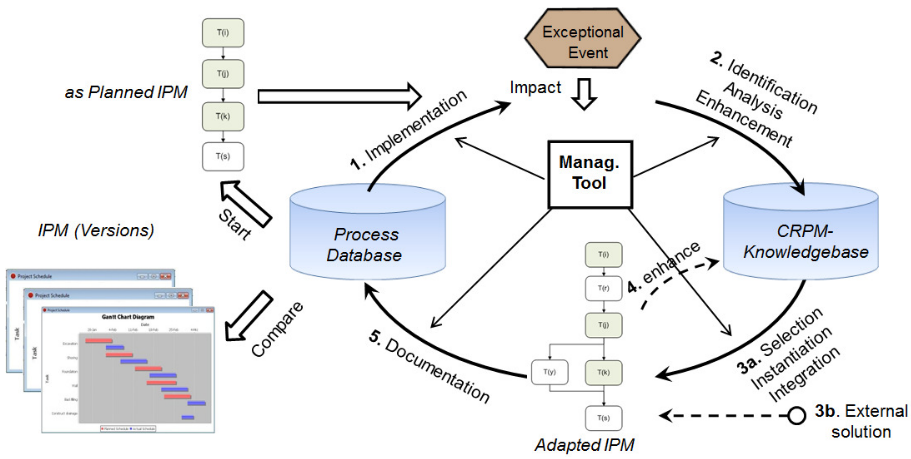


Fig.3. The iterative adaptation cycle of an IPM

4. Conclusion

The presented approach can be used in the planning phase as well as in the execution phase of the project. In the planning phase this can help to speed up the planning and to ensure getting more reliable process schedule plans. In the execution phase it can help to accelerate the adaptability of the changed schedule plans by offering ready integrable solutions for recurring problems.

The exceptional events included in each CRPM can be used, in the planning phase of the project as a part of the checklist for risk management. Accordingly, risks can be identified based on the project relevant CRPMs and, subsequently, risk assessment can be carried out. Hence, the risks with probability/impact values above the agreed thresholds should be considered in the planning phase of the project in a proactive way. This means that the configurable fragments, which represents the risk treatment, should be adopted (included) as a part of the configured CRPM. Anyway, to realize these CRPMs in the construction practice it is still required from the construction companies to structure their knowledge in a process-oriented way and to classify the process model parts to essential and configurable fragments. Subsequently, the configurable fragments will be connected to their potential trigger-risks using the configuration templates. For this purpose, only qualified personnel should carry out the modeling of the needed CRPMs. Qualification means here that the modelers should possess enough knowledge concerning the construction process technical issues and the process modeling issues.

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