A Method for Integrated Modeling of KiPs and Contextual Goals

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Abstract. Knowledge-intensive processes (KiPs) progress in a flexible way towards the achievement of process goals. Contextual factors like location and regulations affect how these goals are achieved in KiPs. Conventionally, a context is considered to be either static or dynamic. For some KiPs part of the context can be dynamic, meaning that the context can change during the execution of the KiP as a result of the decisions and interpretations of the knowledge-worker based on the information gained throughout the process. A holistic approach linking dynamic context, goals and processes is vital for modeling such KiPs. This paper presents a method, based on enterprise models, for integrated modeling of KiPs with contextual goals under dynamic contexts. With our method, we guide business analysts in modeling complex, flexible KiPs under dynamic contexts.

Keywords: Knowledge-intensive process · Enterprise modeling · Goal modeling · Process modeling · Context

1 Introduction

Knowledge-intensive processes (KiPs) are executed in a flexible way by knowledge workers to achieve goals. Flexible process models support knowledge-workers in executing the KiPs [5]. However, goals are implicit in process models. The relation between the processes and goals is even more evident for KiPs than traditional activity-centered business processes, since KiPs are by definition goal-oriented [5]. It is crucial that the goals and the KiP models are aligned well to make sure the goals are satisfied properly throughout the process execution.

The context of a business process covers any information that affects the design and execution of a business process and how the process goals are achieved [19]. Values taken by a combination of one or more contextual factors e.g., weather or location, define the business process context, e.g., rainy weather or location as city center. A process context is typically assumed to be either static or dynamic. In a single execution of a process, static context is fixed and predefined, e.g., the season for an airline booking process. The context can also be

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dynamic, so change during the process execution, e.g., the weather for an airline booking process.

The dynamism of the context of a business process usually originates from the changes in the environment. But in a KiP, context can also dynamically change based on the interpretations and decisions made by the knowledge workers throughout the process execution. For example, in a medical diagnosis process, the process goal is to come up with a diagnosis by doing some tests. Depending on which diseases are suspected, the clinician should perform different tests to decide upon the final diagnosis and achieve the process goal. Therefore, the set of suspected diseases defines the context of the diagnosis process. But the results of a test may be such that the clinician decides to investigate a new disease, so the clinician can dynamically change the context of the diagnosis process.

Conventionally, context-awareness in business processes deals with adapting processes to unexpected or uncontrolled changes in the context due to a change in the environment. However, like in a medical diagnosis process, the change in the context can be an inherent part of the business logic rather than being unexpected or uncontrolled. For such KiPs, knowledge workers need to cater for changing goals as a result of controllable changes in dynamic context during the process execution. Failing to do so results in KiPs where goals are not satisfied properly. Therefore, integrated modeling of goals, the dynamic context, and the processes is essential to support knowledge workers in executing these process.

Several related works focus on the link between goals, processes, and context. However, they either focus on procedural process models that are not suitable for KiPs [6,9,13,21], consistency analysis rather than process modeling [7,8] or they do not cover all of these three aspects (i.e., goals, processes, and context) in an integrated and holistic manner [10–12,15,16,19].

To fill this gap, we present *a method based on process and goal models for integrated modeling of contextual goals and KiPs*, when the context is dynamic and controllable.

The method enables the representation of the contextual goals on KiP models and supports the alignment of KiP models with goals in dynamic contexts. We have followed the design science research (DSR) methodology [18] to develop our method and investigated its use in a real-life case study. The results indicate that the method can be used to build a link between a KiP and its contextual goals and support effective execution of KiPs under dynamic contexts.

The paper is organized as follows. Section 2 presents the design of our method. Section 3 briefly discusses the evaluation. Lastly, Sect. 4 concludes our paper.

2 Method for Integrated Modeling of KiPs with Contextual Goals

In this section, we describe our method on a running example on Abdominal pain treatment process inspired from [14] (See appendix[1] for background knowledge).

[1] https://sites.google.com/view/methodintegratedkipmodeling/home.

The Abdominal pain treatment process is a KiP where the clinicians, as experts, have the discretion over how the process is executed to achieve the goals of the process. The clinician first aims to determine the disease causing the abdominal pain (Final diagnosis determined), and then to treat the patient (Treatment finalized). Final diagnosis determination requires an iterative process of information gathering. First, based on the information provided by the patient and physical examination, the clinician determines a working diagnosis (Working diagnosis identified), i.e., a potential diagnosis explaining the patient's symptoms. Usually, clinicians come up with a list of working diagnoses and refine this list as more information is gathered, through tests done throughout the differential diagnosis process. Each suspected disease requires different tests to be confirmed as the final diagnosis. The clinician performs these tests to achieve the Differential diagnosis examined goal in Fig. 1. Therefore, each suspected disease is a contextual factor defining the context for the Abdominal pain treatment process. That context is dynamic since throughout the process, the suspected disease that is investigated by the clinician can change until the final diagnosis is made.

Our method takes a contextual goal model as input. Contextual goal models are introduced in requirements engineering literature [1]. Existing approaches can be used to derive the input contextual goal model [1,17]. First, the goals that will be modeled in the process model are selected. Then, in the second step, goals are modeled as milestones in the process model. Next, milestone sentries are specified. At this point, a draft process model is obtained that does not yet consider the effect of context. Simultaneously in the fourth step, taking the contextual goal model as input, different goal model variants for different dynamic contexts are derived. Using the goal model variants and the draft process model as input, the milestones in the process model are contextualized and a final draft process model with contextual goals is obtained. Table 2 in the appendix (see footnote 1) summarizes the steps and their inputs and outputs. Each step in our method is further elaborated in the following subsections.

2.1 Selecting Goals

Our method starts with the selection of goals that will be modeled in the process model from the goal model. This selection is done based on different goal types proposed in [4]. Our method assumes that the goals in our input goal model are already classified using this taxonomy and proposes a selection strategy. Figure 1 is the goal model of our example on healthcare services. For this goal model, we focus on the goals of the Abdominal pain treatment process, as explained in the following paragraphs.

First, fundamental, means-ends, process, and activity goals are investigated. Fundamental goals do not have a direct link to the process but are related to the process by their means-ends goals [4]. Next, the lowest level means-ends goals are investigated and the processes they relate to are identified. For instance, in our example, we select the means-ends goal Patient with abdominal pain treated as the goal of the Abdominal pain treatment process. From this point on, our scope is this means-ends goal and its sub-goals. Means-ends goals can have more

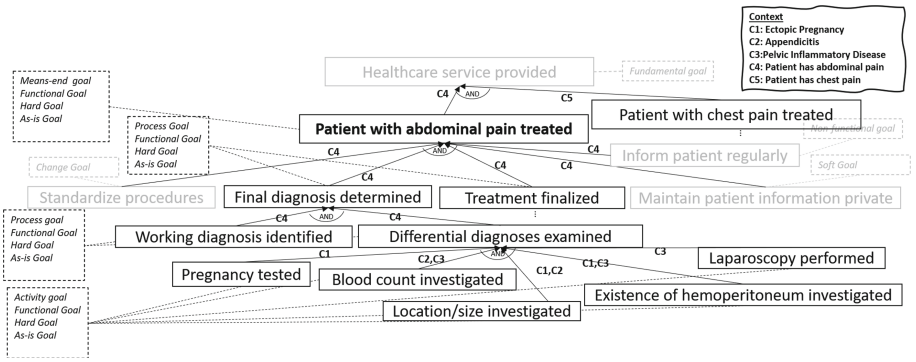

Fig. 1. Contextual Goal Model for Healthcare Services (Goals to be modeled in the process model in bold

refined goals like process and activity goals. Next, process or activity goals are also selected to be modeled in the process model.

Opposed to [4], we believe both functional and non-functional goals can be related to processes. For instance, the goal Inform patient weekly is a non-functional goal, yet can be selected and modeled in Abdominal Pain Treatment process, if required. Therefore, a business analyst can decide to select both functional and non-functional goals.

Next, hard goals and soft goals are investigated. While modeling goals as milestones in a CMMN model, the expressions stating when such a goal is achieved should be modeled in a clear-cut manner. This is very challenging for soft goals as they are subjective. Although soft goals can be related to a business process or activity [4], modeling them as achievable targets within a process model is not feasible. Therefore, soft goals are not selected to be modeled in the process model in our method.

The goals are also classified with respect to their temporal aspect, as goals of the current process (as-is goal), motivations for change (change goal), or a future goal to be aimed in an improved business process (to-be goal) [4]. Our aim is to model the current goals in a process model such that the achievement of goals through process activities can be depicted and traced. Therefore, change and to-be goals are not selected.

Lastly, for the process goals, restricted scope or broad scope goals are investigated. Restricted scope goals are achieved within a single execution of one business process, whereas a broad scope goal requires multiple executions of one or more business processes to be achieved. Our aim is to model the goals in a process model such that we can trace them throughout a single execution. Therefore, we leave out broad scope goals.

2.2 Modeling Goals and Associated Tasks in KiP Models

Next, we turn our attention to modeling the selected goals in the KiP model. Since milestones represent achievable targets in a CMMN model [2], there is a natural correspondence between goals and milestones. Hence, in our method, goals are modeled as milestones in the CMMN model. For this step, we consider regular goal models. In Sect. 2.5, we discuss how to model contextual goals, building upon the models we derive in this section.

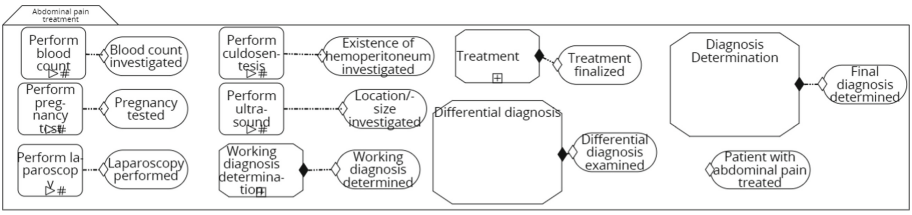

Fig. 2. Activity, process and means-ends goals modeled as milestones, abdominal pain treatment process (See Fig. 1 in the appendix (see footnote 1) for a bigger picture.)

Figure 3 depicts the draft process model obtained as output of this step. First, milestones corresponding to the goals selected in the previous step are created. Activity goals are modeled as milestones. Related activities are modeled as tasks and linked to these milestones. Process goals are modeled as milestones and related processes are modeled as stages attached to these milestones, as process goals refer to goals achieved by a set of activities. For instance, we modeled the activity goal Blood count investigated and the process goal Working diagnosis determined as milestones and we next identified the task Perform blood count and the stage Working diagnosis determination, respectively, and linked them to these milestones.

If the process goal is decomposed into more refined goals, its milestone is attached to an expanded stage, e.g., the milestone Differential diagnosis examined. If the process goal is not decomposed into sub-goals, it is attached to a collapsed stage, indicating that the goal model does not provide further information for modeling this goal in the process model, e.g., the milestone Treatment finalized. The milestone corresponding to the selected means-ends goal is modeled as a separate milestone, e.g., the milestone Patient with abdominal pain treated. Figure 2 show the draft process model of our running example at this point.

Next, the following patterns are applied to the milestones in the process model to represent the goal relations in the goal model. Note that, M1 is the milestone representing goal G1, M2 is the milestone representing goal G2 etc.

Pattern-1: If a process goal, G1, is decomposed into more refined (sub)process goals, G2, or activity goals, G3, then its corresponding milestone, M1, is attached to a stage containing a sub-stage, an activity and their milestones M2 and M3. If G1 is AND(OR)-decomposed into G2 and G3, then M2 and M3 are linked to M1 on the same (different) sentry.

Pattern-2: If multiple process goals, G1 and G4, are decomposed into more refined (sub)process goals and share some of their sub-goals, G2 and/or G3, then M2 and M3 are either contained in the stage that owns M1 or M4. Then the milestone of the stage that contains M2 and M3 is linked to the other milestone that requires M2 and M3.

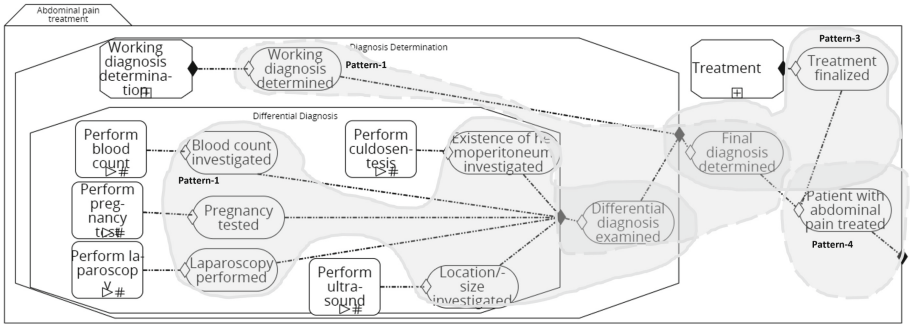

Fig. 3. Draft process model, abdominal pain treatment process

Pattern-3: If G1 and G2 are activity or process goals AND(OR)-decomposed from the same means-ends goal, G3, M1 and M2 are linked to M3 on the same (different) sentry.

Pattern-4: When the milestone corresponding to the selected top-level means-ends goal is achieved, the case is completed. Therefore, this milestone is linked to the case exit sentry.

Figure 3 shows the draft process model we get at this point with patterns 1, 3, and 4 applied.

2.3 Modeling Sentries

Depending on the goal modeling notation used, the goal models may be specified in different levels of detail regarding the achievement of goals e.g., goal outcomes in Archimate [20] or plans in TROPOS [3]. Our method assumes that the detailed information regarding the achievement of goals do not exist on the goal model and should be derived manually. In this step, the draft process model is extended with sentry expressions of each milestone, as depicted in Table 1.

When modeling the goals as milestones, tasks and processes were already linked to related milestones (activity or process goals). This shows that the milestone requires completion of the activity/process attached to it to be achieved; the ON-part of the sentries can be derived based on such relations. The IF-part of the sentries should be manually derived by the business analyst.

Lastly, milestones are also linked to each other to represent the hierarchy on the goal model. A sentry on a milestone that is linked to other milestones checks the occurrence of other milestones linked to it. Therefore, this is also included in the ON-part of the related sentry.

2.4 Deriving Goal Model Variants

Up to this point, a draft CMMN model is derived using a goal model as input. In this subsection, we introduce the notion of contextual goals in a CMMN model.

Table 1. Milestones and sentry expressions, abdominal pain treatment process (See Table 3 in the appendix (see footnote 1) for the full table.)

Milestone	Sentry Expression
Working diagnosis determined	ON Working diagnosis determination is complete IF Working diagnosis is found
...	...

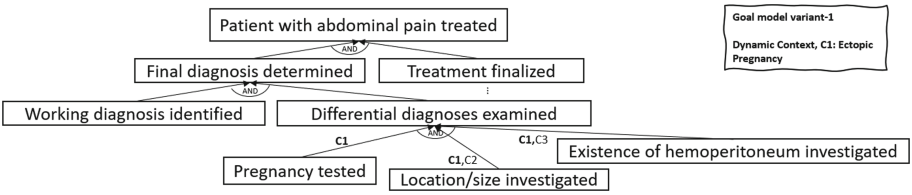

Fig. 4. Goal model variants, abdominal pain treatment process

First, goal model variants are derived from the input contextual goal model. Since context identifies the goals that should be achieved by the business process, different contexts refer to different goal models, which we refer to as goal model variants [1]. Goal model variants are derived from the contextual goal model by choosing the relevant context. We differentiate between static and dynamic context. In a single execution of a process, static context is fixed and can be predefined. In our goal model in Fig. 1, C4 and C5 are static contexts. The current static context is C4, patient with abdominal pain. This is a fixed context, which can be determined before the diagnosis process starts and does not change during the diagnosis process.

By setting the static context, the contextual goal model is reduced to a smaller goal model that contains only dynamic context annotations. Our aim is to cover the effect of dynamic contexts in a process model.

In our example, the suspected diseases define the context since each disease requires different tests to be confirmed as the final diagnosis. At the beginning, the clinician might suspect multiple diseases, but the final diagnosis, or the final context, is determined by looking at the results of the tests obtained throughout the diagnosis process. Therefore the context is not fixed and changes throughout the process as the suspected diseases investigated by the clinician change.

Then, for each mutually exclusive dynamic context, a goal model variant is derived. In our example, we have three mutually exclusive dynamic contexts;

C1,C2 and C3. Therefore we have three goal model variants. Figure 1 shows the goal model variant for the context C1 (See Fig. 2 in the appendix (see footnote 1) for other goal model variants). Note that, in this example we assume that the patient suffers from only a single disease causing the abdominal pain.

Table 2. Sentry expressions for contextual milestones, abdominal pain treatment process (See Table 4 in the apppendix for the full table.)

Milestone-Context	Sentry Expression
Differential diagnosis examined-Context-1	ON Perform pregnancy test is complete ∧ Perform culdosentesis is complete ∧ Perform ultrasound is complete
...	...

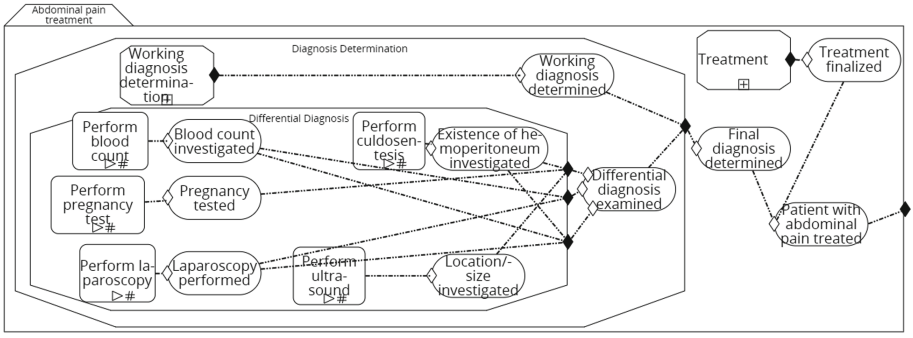

Fig. 5. Draft process model with contextual goals, abdominal pain treatment process

2.5 Contextualizing the Milestones

In this subsection, we explain how the goal model variants are expressed in a single CMMN model by contextualizing the milestones. On the goal model variants, the parent goals (means-ends goal decomposed into more refined process or activity goals OR process goals decomposed into sub-process/ activity goals) are investigated. Sentries are added to the corresponding milestone of the parent goal, such that there is a separate sentry for each goal model variant where this parent goal has a different set of sub-goals.

In our example, the goal Differential diagnosis examined has a different set of sub-goals in each goal model variant. Therefore, it has three different sentries representing three different ways of its achievement under different dynamic contexts. Then, we update Table 1, adding the expressions for the new sentries in Table 2.

Lastly, the links between tasks/stages and milestones in the draft process model are updated based on the expressions of the newly added sentries. The

final draft of the process model of our example is shown in Fig. 5. Note that this draft process model should be further refined by the business analyst to derive a complete process model as part of the standard process analysis activities.

3 Evaluation

We evaluated our method through demonstration (See Sect. 3 in the appendix (see footnote 1)) on a case study about medicinal product development process in the iPSpine project. We presented our method and the models to domain experts consisting of six senior biomedical scientists and two regulatory experts in a meeting. The experts inspected models and we performed semi-structured interviews on usefulness. The experts indicated that they are positive about the usefulness of the process and goal models and our method for integrated modeling of processes and contextual goals in practice. Next, we implemented the models in a prototype platform[2] for the EU project iPSpine, based on the Flowable BPM Platform. The platform was used by three junior, three senior scientists and two regulatory experts. Then, we performed semi-structured interviews on usefulness and understandability.

The users mentioned that they can use these models to justify what they have done (process) and identify what they need to do to better comply with the chosen regulatory framework (goals). Also, they mentioned that the models and the platform are easy to use and understand with the user guide we have provided. They mentioned that the idea of linking the different contexts, the process model and the goal model is definitely useful when the scientific development is at the stage where different regulatory frameworks are investigated. We received minor improvements to increase the understandability of the models, e.g., adding additional explanations to the platform. Currently, we continue improving our models and the method based on the feedback we get from users, and we are evaluating with other domain experts.

4 Conclusion

In this paper, we have presented a method for the modeling KiPs with contextual goals under dynamic contexts. The contribution of this paper is the structured guideline that supports business analysts in modeling the contextual goals in a CMMN model.

The demonstration of the method on a real-life complex KiP and evaluation with the stakeholders confirm the usefulness of the models. The users commented that the explicit modeling of goals and the link to the process in goal models is useful for their job. Furthermore, introducing the effect of context to the models helps them investigate the effect of context on the process efficiently. One limitation of our method is that the evaluation is carried out by model inspection rather than method application by users. However, the evaluation on

[2] https://sites.google.com/view/ipspinepmp/ipspine-process-management-platform.

the models provided positive insights on the usefullness of the models generated by our method. As a next step, we plan to extend our evaluation such that the method is applied by users and apply our method to model different KiPs.

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