Toward Model-driven Planning Support for Construction Processes

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Abstract

Construction sites are shaped by knowledge-intensive, multi-instance, and item-dependent processes. The knowledge workers in such domains need to model the construction processes and construction elements and plan the future process execution collaboratively with all involved parties. However, it is challenging to model these processes comprehensively and accessibly for domain experts, while the planning of the future execution can not be fully supported yet. This position paper proposes the means toward developing suitable process modeling approaches, providing the opportunity to model process goals, and combining both to derive useful execution plans from analyzing the process model's state space in regard to the goal model.

Keywords

Knowledge-intensive Processes, Construction Processes, Process Modeling, Goal Modeling, Planning Support

1. Introduction

In recent years, construction sites are becoming more and more digitized; from mobile devices to 4D-Models of construction sites, and drones for supervising the construction progress [1].

The business process management community also started to investigate the use case of construction sites [2, 3]. In general, processes on construction sites can be considered knowledge-intensive [2] as they have the following characteristics[4], which are imposed by the volatile execution context of the processes. Knowledge-intensive processes are executed by knowledge workers such as construction workers and construction managers. Furthermore, knowledge-intensive processes are unpredictable and unrepeatable. They emerge as knowledge workers make decisions based on their domain knowledge. Planning is an important part of knowledge work. It means aligning the future execution of tasks toward a process goal. As weather conditions change, faults occur, and delays postpone future progress, plans have to be adapted and the knowledge workers need to re-plan.

More challenging, processes on construction sites can be considered multi-instance processes and item-dependent [3]. A house has multiple process instances running for each of its flats, which in turn influence each other's process execution. Also, all instances are item-dependent as the performed activities like painting jobs depend on existent material such as the paint and

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a plastered wall.

Traditional modeling techniques like BPMN are not well suited to depict the complexity of such domains. Even the existing modeling approaches for construction processes [2, 3, 5] do not fulfill certain requirements of knowledge-intensive processes fully. For instance, late goal modeling and planning are an important part of knowledge work [4]. Planning is the alignment of actions according to a goal. With changing goals and execution contexts, execution plans on construction sites need to be re-planned frequently. If construction workers become sick, the delivery of the paint postpones, or simply the weather permits painting the house's facade, the painting activities have to be rescheduled. This might influence the overall progress and the schedule of the whole construction site needs to be replanned.

To tackle the problem of providing planning support for complex domains such as construction sites, we provide a research agenda that combines the analysis of the use case and the applicability of different process modeling approaches to it. We also need to allow the modeling and re-modeling of goals during design- and run-time. With the process model and the goal models at hand, the behavior of the process model can be analyzed in regard to the goals. The results can be used to generate execution plans for the future execution of the current case.

In the following Section 2, we outline the existing work related to our research endeavor. Section 3 discusses our approach and the planned contribution before Section 4 concludes the paper.

2. Related Work

Work related to our research agenda includes knowledge-intensive processes, modeling approaches toward construction processes, the modeling of knowledge-intensive processes, and planning support.

Knowledge workers face tasks of identifying and solving problems with a low level of standardization in knowledge-intensive processes [6]. Their execution context is vast and fast-changing [7]. Di Ciccio et al. provide an overview of the characteristics of knowledge-intensive processes and the requirements to support them [4]. However, it is challenging to model them comprehensively and they are often under-specified [7]. Additionally, to being knowledge-intensive, construction processes can be considered multi-instance and item-dependent [3] making modeling even more challenging.

Different approaches aim to model construction processes. First, van der Aalst et al. introduced case handling as a means to support the processes of a dutch construction company [2]. By now, new case management approaches have emerged and might also be applicable. Marengo et al. proposed the construction process modeling language CoPModL [3]. It combines the declarative modeling of activities and items on which these activities can be executed.

In the context of Lean Construction Management, different Tools have been developed to model and monitor the processes on construction sites [8].

Different modeling approaches aim to depict knowledge-intensive processes and might, therefore, be suitable to model construction processes. Hybrid modeling techniques combining the concepts of declarative and data-centric process modeling approaches are promising for the construction domain. Contemporary approaches are OCBC [9], RESEDA [10], and

ReGraDa [11]. Other approaches aim to implement case management [7] to support knowledge-intensive processes. Case Management and Model and Notation [12] and fragment-based Case Management [13, 14] were proposed.

Though late goal modeling is crucial for knowledge-intensive processes, it is only limitedly supported in most process modeling approaches [4]. In previous work, the means toward the modeling of goals for knowledge-intensive processes were provided [15, 16].

Another important aspect of knowledge work is planning. It is the alignment of actions to reach a goal. Different approaches aim at providing planning support. SmartPM [17] can be used for exception handling. Sprovieri and Vogler [18] compose process models from partly structured models. Other approaches by Wynn et al. [19] and Rozinat et al. [20] allow to simulate process models to provide decision support. Different predictive process monitoring approaches predict the next actions in running instances based on machine learning [21, 22]. Still, the contemporary approaches do not fully map the characteristics and requirements for knowledge-intensive processes. The first steps toward model-driven planning support by providing recommendations for the next best actions according to a goal were made in previous contributions [23, 16].

3. Planned Contribution

We endeavor to provide suitable planning support for knowledge-intensive, multi-instance, and item-dependent processes like construction processes. To pursue this goal, the general idea is to combine the process model with a goal model for the current process execution. The model's state space can then be analyzed to find possible execution sequences that satisfy the goals of the knowledge workers [16]. Analyzing goal-satisfying paths may result in knowledge about what next actions are suitable to reach the goal. This knowledge can be used to provide decision support [23]. In the future, comprehensive execution plans could be generated as well.

First, a suitable behavioral modeling technique to define the processes on construction sites is needed. Second, goals need to be modeled in that context. The state space analysis with both models needs to provide meaningful planning support in form of execution plans. This results in our following research questions.

RQ1 What is a suitable modeling language to depict construction processes comprehensively?
RQ2 How can goals be modeled in the context of construction processes?
RQ3 How can execution plans for construction sites be automatically generated from process models and goal models?

To answer **RQ1**, we plan to analyze the requirements for modeling knowledge-intensive, multi-variant, and item-dependent processes. We will investigate and compare contemporary approaches for modeling construction processes and knowledge-intensive processes. As a result, existing approaches can then be extended or new approaches can be developed to map these requirements. In our first informal analysis, case management [7], especially fragment-based case management [24] seemed promising. The concepts allow a notion of multi-instance processes while being able to depict the depending items. Yet, different adaptations have to be made to utilize these approaches fully.

Also part of the prior analysis is identifying the means to model goals, answering **RQ2**. Techniques to model goals can then be combined with the result of RQ1. A general approach toward the modeling of goals for knowledge-intensive processes was already provided [15, 16]. A constraints the state of the involved data and available actions in future execution states. However, the involved knowledge workers profit from more domain specific means to model goals. Such approaches could include the utilization of buiding information models (BIM), which provide 3D-models of buildings to be built. They are already well established in the domain and can depict the construction items in different execution states.

To address **RQ3**, the state space of the construction process models can be analyzed. Several challenges have to be overcome. State spaces of process models grow exponentially and can become infinitely large. However, the large state spaces also yields the possibility to find many suitable process executions that can be utilized to derive execution plans. However, it should be reduced as much as possible and suitable algorithms need to be developed that cope with their size and return suitable plans. The retrieved suitable execution plans can then be evaluated how resilient they are to changing execution context. In that context, machine learning techniques can be utilized to incorporate domain knowledge into the plans. These plans then need to be displayed comprehensibly. A usual way to display plans on construction sites are schedules with Gantt-charts. The resulting planning recommendations should balance the complexity of all possible execution sequences and comprehensibility.

All three research questions long for tooling support. We aim to develop prototypical implementations for construction process modeling, construction goal modeling, and the computation of planning recommendations out of the previous two. The suitability of the presented approach should be evaluated in the field by conducting case studies.

4. Conclusion

Construction processes are knowledge-intensive, multi-instance, and item-dependent. Planning is an important task of the involved knowledge workers, but only limitedly supported. This position paper proposes an approach to provide planning support for processes on construction sites and similar domains. The approach starts by analyzing the requirements for comprehensive construction process models. Such a modeling approach can then be developed and combined with suitable goal modeling for construction sites. Both process model and goal model can then be utilized to analyze the model's possible behavior in order to find execution plans that satisfy the goal. The result of this endeavor is model-driven planning support for construction sites and similar domains.

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