Investigating the Collaborative Process of Process Modeling

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Abstract. Research on quality issues of business process models has recently begun to explore the process of creating process models. With growing complexity, the creation of business process models requires the presence of several, potentially spatially distributed stakeholders. As a consequence, the question arises how this affects the process of process modeling. This paper describes a thesis working on this question. More precisely, an infrastructure for recording and analyzing the collaborative process of process modeling is introduced and further used for investigating this process using empirical research methods.

1 Introduction

"*Business process modeling is the task of creating an explicit, graphical model of a business process from internalized knowledge on that process*" [1]. The resulting business process models play an important role for the management of business processes [2], depicting how "*various tasks are coordinated to achieve specific organizational goals*" [3]. Such process models are used to build a consensus among stakeholders involved within the business process [3], help to obtain a common understanding of a company's business processes [4], serve as drivers for the implementation and enactment of business processes, and enable the discovery of improvement opportunities [5]. Therefore, the quality of business process models is essential [6] as it constitutes a measure of the fulfillment of its purpose (e.g., to serve as a basis for a system development project) [7]. However, industrial process model collections suffer from a range of quality problems. Understandability of process models suffers from poor quality which subsequently hampers the models' maintainability [8, 9]. Examples for typical quality problems are non-intention-revealing or inconsistent naming [10], redundant process fragments [11] or overly large and unnecessarily complex models [12].

To address these quality problems significant research has been conducted in recent years on factors that impact process model understandability and maintainability [8, 9, 6]. Focus of these works is on the *outcome of the modeling process* [13, 14], i.e., the resulting process model. In turn, relatively little emphasis has been put on the fact that model quality presumably depends upon the modeling process that was followed to create it, i.e., the *process of process modeling* (PPM) [15]. For example, [16] aims at a better understanding of the PPM, i.e., the formalization of a process model from an informal requirements specification. Thereby, [16] assumes a modeling setting where a single model engineer is creating a process model and where the communication between model engineers and domain experts is mediated via an informal requirements specification [15]. However, when looking at the complexity of real life projects it is often not possible to have only a single model engineer creating the corresponding business process model, since knowledge of the business process might be distributed over a number of domain experts [17]. Similarly, the corresponding knowledge to create the process model has to be distributed among model engineers. As a consequence, various domain experts and model engineers are involved in the development cycle, who collaboratively create a process model [18]. By this close collaboration the border between requirements elicitation and formalization becomes blurred. In fact, the distinction between those two phases disappears and is replaced by an iterative process performing them repeatedly.

2 Problem Identification

Even though collaborative process modeling settings are increasingly found in practice [19, 20] and results in software engineering have shown that collaboration can increase quality and efficiency significantly [21], the way how process models are collaboratively created is hardly understood [19]. Therefore, we want to extend existing work on the PPM [15], which focuses on single model engineer settings, toward a collaborative setting where multiple stakeholders (e.g., domain experts and model engineers) collaboratively create process models. Our work is closely related to research on collaborative process modeling and the PPM as detailed in the following. First, we will give an overview of research on collaborative process modeling, specifically focusing on factors influencing its outcome (cf. Sect. 2.1) and introduce various environments fostering collaborative modeling (cf. Sect. 2.2). Afterwards, we introduce research on the PPM (cf. Sect. 2.3) and subsequently on the collaborative PPM (cf. Sect. 4.2).

2.1 Research on Factors Influencing the Outcome of Collaborative Process Modeling

There has already been some research in the area of collaborative process modeling investigating the influence of various factors on the outcome of collaborative modeling [22, 23]. [22] investigates the impact of end-user involvement and team composition on perceived model quality and perceived consensus among the users. Most recently, [23] analyzed how technology capabilities (i.e., ease of collaboration, ease of modeling, and ease of validation) foster process gains and subsequently affect the collaboration outcome (i.e., perceived semantic quality, perceived usefulness, and satisfaction).

2.2 Research on Collaborative Modeling Environments

In addition to research on factors influencing the outcome of collaborative process modeling, considerable work on collaborative modeling environments fostering collaboration between stakeholders exists [24–27]. One example of such an environment is Collaborative Modeling Architecture [24]. The COMA Tool provides process model collaboration by means of negotiation on proposed models by the participants. In this collaboration methodology participants are working asynchronously together. In addition, there exists a collaboration methodology where participants are working synchronously together on the same model. The advantage of this approach is the fact that participants are able to track model changes immediately. Examples are the Signavio Process Editor[1] and the Software AG's ARIS[2] collaborative tool where it is possible to work simultaneously together on one model using a web browser. As another example [25] introduces a 3D BPMN modeling environment which is integrated into a second life environment. There, participants are collaboratively modeling using an avatar. An environment (CoMoMod) for collaborative business process modeling within virtual organizations is introduced in [26]. CoMoMod allows simultaneously working on one process model using a variety of different modeling languages. Finally, [27] introduces an infrastructure (CEPE) supporting the building of knowledge about deployed processes. Therefore, CEPE can be used for process reengineering of existing processes within organizations.

These tools and their corresponding research works (cf. Sect. 2.1) focus on the output of the modeling process rather than the modeling process itself. However, there exists another stream of research focusing on the creation process itself (cf. Sect. 2.3).

2.3 Research on the Process of Process Modeling

The importance of the modeling process itself in addition to the actual outcome is stated in [17] and has led to an emerging stream of research on the PPM [15, 16, 28]. Research on the PPM focuses on the modeler's interactions with the modeling environment [15], i.e., the *formalization* of a process model as described in [17]. During the PPM, modelers are facing the task of creating a syntactically correct process model reflecting the description of the real world's domain by interacting with the modeling environment [17]. The PPM can be described as a flexible, iterative process consisting of the three phases of comprehension, modeling and reconciliation [15, 28].

Comprehension. According to [29] a problem solver formulates a mental representation of the problem as a first step. When creating a process model, the limitations of working memory prevent modelers from creating a complete representation in a single step [28, 15]. Rather, the problem is broken down into small chunks which are addressed sequentially [28, 15].

Modeling. After formulating a mental representation of the problem, the modeler utilizes the constructs of the modeling language for creating a formal process model [28, 15]. For this purpose, the modeler interacts with the modeling environment by adding or removing activities, gateways and edges.

Reconciliation. Modelers may reorganize a process model (e.g., renaming of activities) and utilize its *secondary notation* (e.g., notation of layout, typographic cues) to enhance understandability [30].

[1] http://www.signavio.com/

[2] http://www.softwareag.com/

Research on the PPM focuses on modeling settings where a single model engineer creates the process model. However, in order to deal with the complexity of real life projects various domain experts and model engineers are collaboratively creating these process models.

2.4 Research on the Collaborative Process of Process Modeling

While we have some insights into the individual processes [15, 28] within the PPM, we still lack of detailed insights into the processes additionally involved when multiple stakeholders are collaboratively creating process models (i.e., the *collaborative process of process modeling* (cPPM)). When process models are created collaboratively, the individual processes (i.e., *comprehension*, *modeling*, and *reconciliation*) are only one aspect of the problem. In addition, team processes take place during which teams exchange information, create solution options, exchange knowledge, evaluate and negotiate alternatives, and assess their own processes [31]. As a result, the team is building further knowledge and a shared understanding of the process model [31, 22]. On first sight these team processes seem to be more complex than the individual processes and up to now there has only been little research on those processes. [32] investigates collaborative modeling settings concentrating on the negotiation phase of this process. Investigating a closely guided, wizard like conceptualization support is in the focus of [33, 34]. The team-building processes when creating a model collaboratively using a proposal based tool (COMA) and allowing face to face communication are researched in [35] and evaluated using various measures (e.g., number of proposals per participant, comments per proposal). The practices employed within a collaborative modeling environment (i.e., ProcessWave[3]) are observed in [36]. Here, effectiveness and efficiency are measured using the notation of breakdowns.

As opposed to [32] we want to investigate the team processes involved within the cPPM on a micro-cognitive level. Moreover, we want to analyze an unguided model creation process in contrast to [33, 34]. In contrast to [35] our participants are able to synchronously work on the same process model. Unlike [36], we are not only interested in observing the difficulties participants are facing during the modeling process, but also the team processes taking place.

3 Research Question

The central research question of this thesis is *how process models are collaboratively created*. In order to answer this question two sub questions are relevant and require consideration. *RQ*1 addresses the question: "*How can we collect and analyze data of the collaborative creation process of process models?*" To address this question an infrastructure capable of collecting and analyzing this data has to be developed which can subsequently be used to investigate and ultimately understand the cPPM. *RQ*2, in turn, is concerned with the analysis of cPPM using the developed infrastructure and can be stated as follows: "*What are the phases occurring within the cPPM and how do they interact with the individual ones (i.e., comprehension, modeling, and reconciliation)?*" In order to address

[3] http://www.processwave.org/

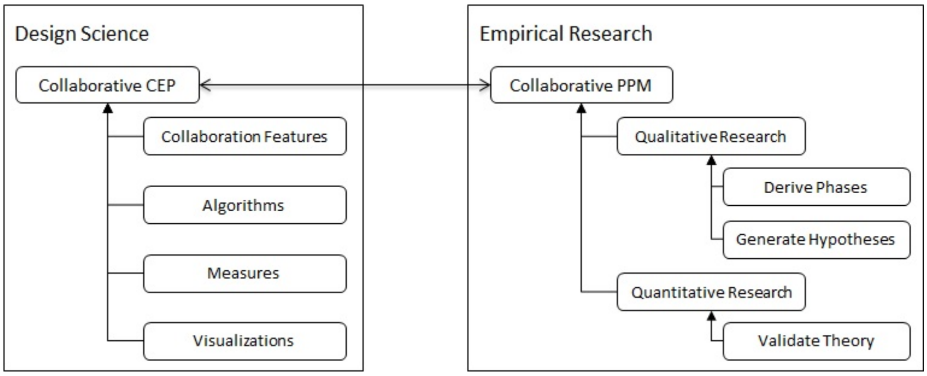

Fig. 1. The Research Method.

this question it has to be investigated *how* teams exchange information, create solution options, exchange knowledge, evaluate and negotiate alternatives, assess their own processes [31], and divide workload. In addition, the roles involved within the cPPM and which actions they perform during the cPPM have to be analyzed. Moreover, it has to be investigated whether these roles are statically assigned to the participants during modeling sessions or if these assignments are subject to change and if yes under which circumstances they occur.

4 Research Method

To address the previously stated research questions we follow a mixed method approach combining design science principles [37] with empirical research (cf. Fig. 1). On the one hand, to build an infrastructure capable of recording, measuring and visualizing the cPPM we employ design science principles. The infrastructure is then used in a subsequent step to conduct modeling sessions and to investigate the cPPM. For this, exploratory modeling sessions for hypotheses generation are conducted, which are then tested in confirmatory modeling sessions. In addition, the platform is iteratively extended and refined based on findings from these modeling sessions. In the following we explain the research methods that are planned to be used to address $RQ1$ (cf. Sect 4.1) and $RQ2$ (cf. Sect 4.2).

4.1 Collaborative CEP

We follow the design science approach [37] for building and evaluating our infrastructure in order to meet our identified business needs [38] (i.e., recording and analyzing the cPPM). Basically, design science methods are guidelines for building and evaluating novel and innovative artefacts (e.g., tools) during a research process [38]. In the upcoming section we will introduce our infrastructure.

Collaborative Cheetah Experimental Platform (cCEP)—an infrastructure for investigating the cPPM—builds upon Cheetah Experimental Platform (CEP) for single modeler settings [39]. For this purpose, cCEP provides features supporting collaboratively creating process models [40]. Beside capturing the cPPM, investigating the cPPM in a structured manner is essential. Therefore, cCEP provides visualizations for analyzing the cPPM (e.g., heat maps, active modeler diagrams) [40]. It is not in our interest to have a fully fledged modeling environment but an environment to investigate the cPPM. An initial version of cCEP is already in place and can be applied in modeling sessions. Using feedback and findings during future modeling sessions we will iteratively refine and extend cCEP.

Collaboration Features. Extensions to the modeling editor of CEP are necessary to enable users to collaboratively and concurrently edit a business process model. Therefore, cCEP provides a modeling editor that distributes the modeling commands to all clients. Meaning, spatially separated participants are able to see changes made to the process model immediately. Additionally, spatially distributed participants need a way communicating with each other. Therefore, we integrate a communication window into cCEP. Using this communication window participants are able to exchange messages for evaluating and negotiating alternatives, exchanging knowledge, and assessing their own processes [31]. After the modeling session ends this window can further be used for conversation protocol analysis (e.g., using Grounded Theory [41]) by researchers.

Algorithms. A semiautomatic algorithm for linking messages with the corresponding model elements is under development, supporting the subsequent coding of conversation protocols (e.g., using the negotiation patterns [32]). After linking messages to model elements researchers are able to see by *whom*, *when* and even *why* elements were created.

Measures. In [40], we introduced measures for evaluating the cPPM (e.g., number of changes per node and number of nodes created per participant). The measure *number of changes per node* might indicate model elements that cause difficulties or controversy during the modeling process and *number of nodes created per participant* might indicate the participants providing the most domain knowledge.

Visualizations. Additionally, cCEP utilizes heat maps illustrating those measures. Using the heat map illustrating the measure *number of changes per node* it is possible to identify the most controversial elements right within the model.

Active modeler diagrams are another type of visualizing the cPPM [42]. These diagrams display changes to the model or messages sent for each participant. For this, we filter interactions for creating model elements, sending messages, and laying out model elements and plot them on a time-line using different colors for each participant.

Beside those visualization techniques, cCEP provides the ability of replaying the creation process after the modeling process ended. Using this feature researchers are able to step back and forth within the cPPM.

4.2 Collaborative PPM

After developing cCEP according to design science principles [37] we are using cCEP and its analysis techniques (cf. Sect 4.1) for investigating the cPPM. In order to address $RQ2$ we apply empirical research methods. More precisely, we use qualitative research methods followed by quantitative methods.

During qualitative research we perform exploratory modeling sessions using cCEP for collecting data. Subsequently, we analyze this data using grounded theory [41] and derive phases and generate hypotheses describing the cPPM resulting in an in-depth understanding of the cPPM. More precisely, we want to investigate *how* teams exchange information, create solution options, exchange knowledge, evaluate and negotiate alternatives, assess their own processes [31], and divide workload. In addition, we want to analyze which roles are involved within the cPPM, which actions they perform, and under which circumstances the assignments of these roles are subject to change. Ultimately, we develop a theory describing the cPPM. This theory will then be tested using quantitative research methods. In particular, we plan to perform lab experiments for validating our theory.

Preliminary results suggest that the cPPM comprises several team knowledge building phases [31] during which participants try to understand the requirements to be modeled as well as the model that has been created so far. Moreover, modelers try to understand the solutions of their companions and try to convince them of their own ones [32]. After such team knowledge building phases a modeling and reconciliation phase takes place during which one participant extends the model (i.e., the driver) and the other one performs layout changes (i.e., the navigator). Additionally, role changing phases occur during which the participants switch their roles. Preliminary results give a first hint, why these role changing phases occur. When the navigator finds a mistake or wants additional information being integrated into the model he takes over the driver role and performs this changes himself. Meanwhile, the participant normally being the driver becomes the navigator. After an additional negotiation phase the roles change back into their initial constellation. It is important to mention that these preliminary results were gained from two modeling sessions where in each case two modelers were collaboratively creating a process model.

5 Summary and Outlook

In this paper a thesis investigating the cPPM is described. Specifically, the question *how process models are collaboratively created* will be answered during this thesis. Therefore, an infrastructure for recording and analyzing the cPPM will be developed and subsequently be used to investigate the cPPM. Contribution of this thesis will be a better understanding of the cPPM.

So far, an infrastructure for recording and analyzing the cPPM has been developed. As a next step, exploratory modeling sessions for collecting data will be conducted. This data will then be analyzed using grounded theory [41]. In particularly, phases will be derived and hypotheses will be generated ending up in a theory describing the cPPM. Additionally, cCEP will be iteratively extended and refined based on the feedback and findings during these modeling session. As a last step, the theory will be validated using further experiments.

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