Process Model Engineering Lifecycle: Holistic Concept Proposal and Systematic Literature Review

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***Abstract*—Organizations establish process models for different purposes and goals. However, they have in common issues concerning quality assurance and successful project management. Process models can be applied on different levels in process engineering, depending on whether processes are to be executed, defined or improved. Various individual methods and tools have been developed to help process engineers and members who are engineering and performing processes. These methods however do not support continuous integration into a process engineering lifecycle that consists of creating, defining, executing and improving processes. Therefore, we propose a holistic view of artifacts and activities in the process engineering lifecycle in an effort to create a consensus on what constitutes a process engineering lifecycle and take a look at recent research results covering the issues mentioned. We have identified approaches on process descriptions, on meta-models and on support in executing processes in the last years.**

Key words: process engineering, continuous process engineering lifecycle

I. Introduction

Organizations introduce process models to benefit from their advantages. They ensure process and product quality and provide transparency. Process models document the capability and maturity [1] of an organization to improve. There are different process models on the market, each one having different aims, tools and process-engineering methods. Depending on the organizational environment, one organization might not use all tools and methods provided by a process model to fit its needs. Sometimes some of them might be applied in a different way from the way they purport to do. Therefore, methods, tools, workflows and so on are tailored and adapted to fulfill an intended organizational goal.

In the domain of process engineering, numerous fields have been addressed by practitioners and scholars: process modeling and tailoring (create & update), process meta-model adaption, process actuation, process evaluation and improvement, and model-based process execution. However, these approaches lack a holistic concept to unify both the creation and use of process models. Thus, to achieve a continuous concept of a process engineering lifecycle, disparities between the existing concepts have to be eliminated.

In this paper we provide a holistic view of the entire domain and identify specific roles, structural elements, and activities as central assets of process model engineering with the view to integrating and combining related approaches into a single process engineering lifecycle. We have therefore performed a systematic literature review, in order to identify the related approaches from which parts of our holistic concept can be retrieved.

II. Process Model Engineering—Definitions

We propose a holistic view on process model engineering by collecting specific fields and activities in process model engineering. For this purpose we have identified various levels of modeling and executing processes, artifacts to be considered and activities to transform those artifacts in order to reach a consensus on our proposed process engineering lifecycle.

A. Structural dependencies in Process Model Engineering

A view of the structural dependencies in process model engineering can be depicted in Fig. 1. Here we have defined the four different levels: *Process Meta-model Level*, *Process Description Level*, *Process Execution Level* and *Inter- and cross-level Improvement*. Each level contains a type of structural element outlining its disciplines and artifacts. We distinguish two relationships between the structural elements: content source and structure definition. The first relationship describes the reuse of process models or parts of them to update process (meta-) models or to establish them for the purpose of further application. The latter relationship characterizes the relation between models and instances.

The *Process Description Meta-Model (PDMM)* is considered to be a framework defining the attributes and relations of roles, work products etc. on the type level. It constitutes a structural frame for process descriptions, e.g. the Software Process Engineering Metamodel (SPEM) [2] or V-Model XT Meta-model [3].

A *Process Description (PD)* contains concrete roles, work products etc. on the type level (e.g. meeting protocol). A PD can be derived by creating it using the 'defines structure' relation, by reuse, adaptation or applying improvement information of existing PDs ('content source' relation).

The *Process Embodiment (PEmb)* represents both the implementation of a process description in a current project and the execution of described processes of the PD. Hence, whereas a PD contains descriptions of roles and work products to produce, in PEmb there are specific roles and work products etc. based on instance level.

Process Improvement Information (PII) is a collection consisting of improvement information relating to process descriptions and process embodiments in use or in evaluation. It is the basis for improving decisions concerning process descriptions and process description meta-models. Improvement information can be observations of differences of

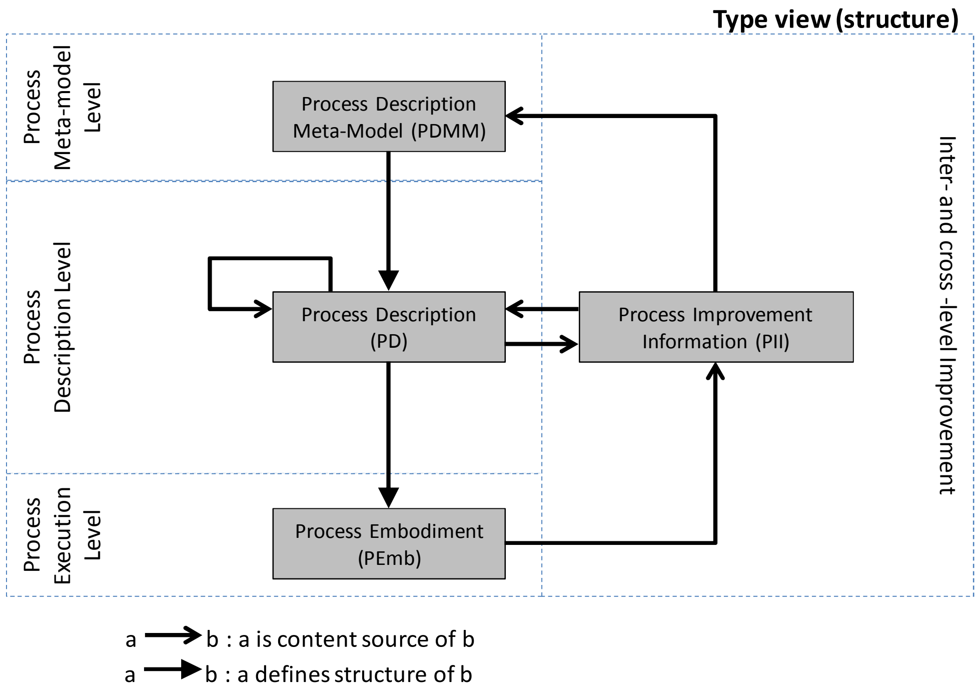

Fig. 1. Structural View.

defined and lived processes. More generally PII has the ability to store any information about measurable features—e.g. processes used, manpower and other ressources—which can help to enhance process descriptions, meta-models and embodiments.

B. Activities in Process Model Engineering

Activities describe concepts, methods and tools that can be applied to the structural elements mentioned, to derive and adapt new structural elements. Here, activities are not meant to be subprocesses, but rather actions between structural elements. Nevertheless, there are roles responsible for each activity, and these are described in the following subsections.

1) *Roles*: We identified the two roles of process engineer (PE) and process member (PMem) to reasonably fulfill the task of executing activities, see Fig. 2. The PE is in charge every

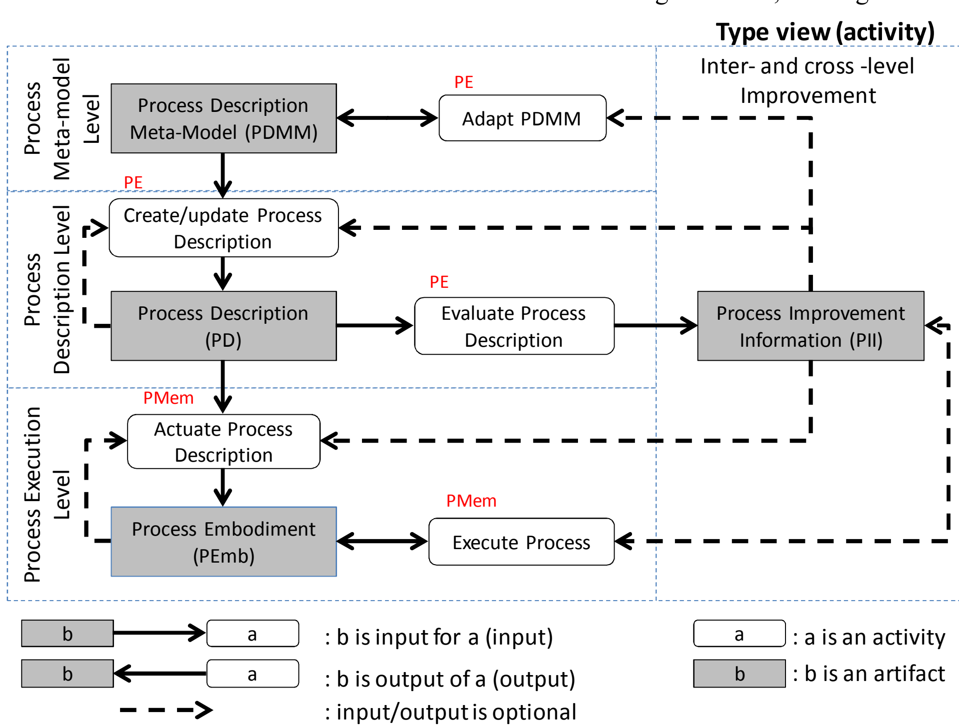

Fig. 2. Activity View.

time a process description or its meta-model has to be created or modified. *A* PMem, on the other hand, is in contact with processes to be performed, e.g. starting a defined process, modifying products or measuring process's performance.

2) Activities: Activities shown in Fig. 2 describe how artifacts of structured elements can be modified to gain more refined artifacts of structural elements. The arrows between activities and artifacts show which activity follows which (input) artifact, and correspondingly which (output) artifact follows which activity. The following paragraphs explain the general understanding of the activities between the artifacts.

Create/update Process Description is the action of deriving a PD initially out of a PDMM or another PD. In the case of changes in a PDMM, there are concepts needed to update a PD due to an altered meta-model description, e.g. using variability operations instead of a "copy and change" semantic.

The activity *Evaluate Process Description* takes a PD for an evaluation to provide improvement information. The gathering of concepts and tools and the measuring of the features of process descriptions support this evaluation and contribute to extracting useful improvement information. A process engineer can use this information to perform an update on the process description, as described earlier.

Actuate Process Description concentrates on methods that bring the defined processes of a PD to execution. An important aspect of actuation is the creation of representants of assets defined in the PD. During execution, changes may occur in the process embodiment that result in new processes that have to be actuated.

Execute Process takes a process embodiment to support process members continuously. Generally spoken, 'execution' is the conceptual representation of the actual work in a project. The activity encapsulates procedures for project members, which can be applied to a process. It may also interact with the PII artifact to either provide useful information for further process executions by measuring process performance or to use improvement information for enhanced process execution. The execution can be done either by a real running project or by simulation, for instance testing the performance of a defined process.

Process description meta-models continuously evolve in order to stay up to date. Thus, there are various methods by which a process engineer can *adapt a PDMM*. He might use a reference meta-model description, or improve information from the PII artifact.

III. Reviewing Methods, Tools and Workflows

Today, there are many tools, methods and workflows that have been developed to support process engineers and members. We are considering those of the years 2009 - 2013 and reviewing them for the purpose of checking the compliance of our continuous process engineering lifecycle.

A. *Structured Review*

First of all, we created a systematic literature review protocol, in order to specifiy the methods that will be used to undertake to extract relevant literature and to reduce the possibility of researcher bias according to [4], [5] and [6]. Because of shortage of space, we cannot assume on the protocol in detail. We have included publications on methods, tools and workflows in the context of process engineering, primarily from the International Conference on Software and Systems Process (ICSSP) and the Euromicro Conference series on Software Engineering and Advanced Applications (SEAA), as well as the Journal of Software Engineering and Applications (JSEA). We consider these three literature sources to be appropriate because of their high level of acceptance. Publications are chosen if they match selected key words or any of their synonyms. Then the results are filtered for whether they meet our continuous process engineering lifecycle approach. Finally, the remaining publications are mapped to the proposed structural elements and activities of Fig. 1 and 2. Publications may be assigned to at least one structural element or activity if their content addresses our description criteria of the element types and activites mentioned above.

B. *Results*

Of the 125 publications that matched to one or more of the chosen key words, 46 have been rejected in the review process. I.e. about 63% are accepted as falling within the scope of our approach. Table I. shows an overview of the number of studies that consider at least one structural element or activity in process engineering. Mostly the studies do not focus on one topic at a time, so multiple nominations of structural elements or activities are approved.

1) Common Findings: Considering structural elements, TABLE I. reveals that most studies focus on process improvement information [7], [8], [9], [10]. Note that, in JSEA there are comparatively more papers on improvement than on other topics. In our review we identified two general adressed topics in process improvement: process evaluation [7], [11], [12] and process simulation [13], [14]. The next largest group consists of studies that cover process descriptions, the basis on which methods and tools can operate on [15], [16], [8], [17]. These studies either use existing process descriptions or implement their own or an adapted process description for the

TABLE I. Overview of Studies grouped by Conference/Journal

	No. of Studies			#studies / 79 [%]
	SEAA	*ICSSP*	*JSEA*	
PDMM	3	11	2	20.25
PD	9	29	2	50.63
PEmb	2	4	0	7.59
PII	16	34	6	70.89
Adapt PDMM	0	1	0	1.27
Create/Update PD	5	17	0	27.85
Evaluate PD	7	19	0	32.91
Actuate PD	1	5	1	8.86
Execute PD	4	10	0	17.72

purpose of satisfying goals such as improving tailoring [18], [19], [20], enhancing execution [21], [22], [23] or enabling their evaluation [24], [25], [26], [27]. When activities are considered, most studies concentrate on evaluating process descriptions and modifying them through creation or updating. Thus, most studies on process improvement propose a method for process evaluation that is used to update an existing process description [7], [28], [29], [30]. Besides updating process descriptions through information on improvement, some studies [32], [18], [20], [6], [33], [34] focus on tailoring and composing variants of process descriptions. Some studies [28], [23], [30], [31] are related to many of the structural elements and activities in our approach, but there is no study that proposes a holistic view on a continous process life cycle.

IV. SUMMARY

We have proposed a holistic view on a continuous process engineering lifecycle. This view highlights structural elements, roles and activities that we assumed to be common elements in the domain of process model engineering. Moreover, we have performed a survey regarding their occurrence in 79 process model related conference and journal publications. As there are no standardized semantics of these terms, we mapped the described concepts to our terms. The result of this survey shows that most publications cover the area of process improvement information (70,89%) and process descriptions (50,63%). Other areas identified in our holistic view were described with a reasonable frequency, too. There are some aspects identified that were seldomly described: the occurrence of a process embodiment (7,59%), actuation of process description (8.86%), and the adaptation of process description meta-models (1 publication). Since we found occurrences for all identified elements, we are confident that the proposed continuous process engineering lifecycle adequately covers the area of process model engineering.

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