Towards a Living Software Development Process based on Process Patterns [1]

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Abstract. A Software Development Process for a certain enterprise and/or a certain project will usually integrate elements from a variety of existing process models, comprising generic standards as well as specific development methods. Besides that, change and evolution of business and technology imply change and evolution of development processes. In this paper we propose a Process Framework, which is modularly structured, and define the concept of process patterns. This framework allows us to describe development processes in such a way that integration, change and evolution of processes are facilitated. An example illustrates our approach.

1 Introduction

Nowadays, many different process models exist. These models range from generic ones, like the waterfall model [21] or the spiral model [6], to detailed models defining not only major activities and their order of execution but also proposing specific notations and techniques of application. Examples of the latter kind are the Objectory Process [13], the Unified Software Development Process [15], the Catalysis Approach [11], the V-Modell 97 [12], or eXtrem Programming [4] – just to name some of them.

All these process models have their individual assets and drawbacks. Hence, one would wish to take all the different assets and benefits of the various process models as a basic construction kit for an integrated development process tailored to the specific needs of the individual team, project, company, and customer. Jacobson, for example, talks about the unified process as a “strawman” serving only for explanatory purposes and probably never applied exactly as proposed [14].

To assemble a specific development process from existing models we have to identify and characterize explicitly the building blocks and their relations of a process

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model in general. Therefore we need a set of basic notions and definitions common for all process models – the Process Framework. This Process Framework must allow us to integrate the various existing process models. The Process Framework can serve as a common basis for the definition of a development process that incorporates the assets and benefits of the different existing process models and that can be flexibly adapted to different kinds of project requirements and situations.

Once you have defined your standardized development process in terms of the Process Framework, you still have to adapt this development process to different projects and project situations. This is often referred to as static tailoring. But, our business is changing almost every day: the requirements of our customers change, new technology has to be adopted, and finally the way we work together evolves. To be successful in a changing environment we not only need static adaptation but also a more flexible way of adaptation - the dynamic adaptation.

Tom DeMarco even mentioned about the nature of process models and methodologies in [10]: „It doesn't reside in a fat book, but rather inside the heads of people carrying out the work." Thus, our Process Framework must additionally offer the ability to incorporate the process knowledge of the whole company. It must provide a platform for a learning organization recording the evolution steps of a living software development process.

Therefore the Process Framework must be open for the integration of new process elements, for the extension and adaptation to new technologies and fields of application. Besides static adaptation – support of different kinds of projects and project situations – there is a need of dynamic adaptation.

In this paper we propose a Process Framework that is sufficiently powerful to fulfill these requirements. First, in Section 2 we give an overview over different modeling levels of development processes. We present the requirements on and user views of a living process model. In the next section, Section 3, we define our Process Framework. In Section 4 we discuss the work product related parts of our framework in more detail, and in Section 5 we present the concept of process patterns, providing guidelines about the organization of the actual development process. A conclusion is given at the end of the paper in Section 6.

2 Basic Concepts of the Living Software Development Process

Various people and groups get into touch with process models and metamodels. In the next section, we discuss the different levels of a software development process. Then, in the following two sections, we present the two main views on process models - the project view and the method view. We will discuss their specific way of interaction with the living software development process we are going to propose in this work. Thus, we can show the needs and benefits of the two different user groups mentioned above.

2.1 Process Models and Metamodels: From a Bird's Eye View

Developing and maintaining software has become one of the most challenging tasks a company can do. Following some kind of process model, such as the Rational Unified Process [17] or the V-Modell 97 [12], promises to provide guidance facilitating the development task. Usually there are different people involved with different views on the development process itself.

Developers and project leaders are concerned about the development process of their individual projects. They concentrate on concrete tasks and results of their actual project, like the development of an analysis model of the system under consideration applying UML use-case diagrams. Accordingly to [28, 29] we can divide the software development process into the *production process*, that is the process in charge of developing and maintaining the products to be delivered, and the *meta process*, that is the process in charge of maintaining and evolving the whole software process. Using this terminology, we see the focus of developers on the production process.

Another group of people being concerned with development processes – especially in large organizations – might be a methodology group which is concerned with the meta process (cf. [28, 29]). Companies, which are on Capability Maturity Model (CMM) level 3 or higher, have a standardized process model [20]. This standard process model provides guidelines and support for organization's projects in general.

If a company is on CMM level 5 a continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies [20]. The organization as a whole and the projects themselves must address continuous realization of measurable software process improvement, like for instance defect prevention, technology change management, and process change management. Thus, the companies' methodology group must be able to improve and evolve the standard software process. Therefore this group needs a common Process Framework capturing the basic concepts of software development process models. Figure 1 illustrates three levels of an overall model for software development processes where all the different aforementioned views can be mapped on.

The Instance Level captures those elements that belong to a certain project, such as an analysis document of a concrete project.

The Model Level describes a certain software development process. This process definition contains an outline of an analysis document or a description and guidelines of how to organize and hold a workshop with customers to elicit the requirements. This level offers the guideline and information for project managers as well as team members. A specific *Process Model*, as defined in [28], expressed in a suitable process modeling language, would be an element in our Model Level.

The Metamodel Level provides the basic framework to establish a living process model. It offers clear definitions for terms like „Work Product" or „Activity". The Metamodel Level represents the common conceptual base of a companie's methodology group to improve and evolve the underlying standard software development proc-

ess of the company[2]. It is on this level where (the concepts of) process modeling languages, such as EPOS SPELL and SOCCA (cf. [9, 28]) are to be found.

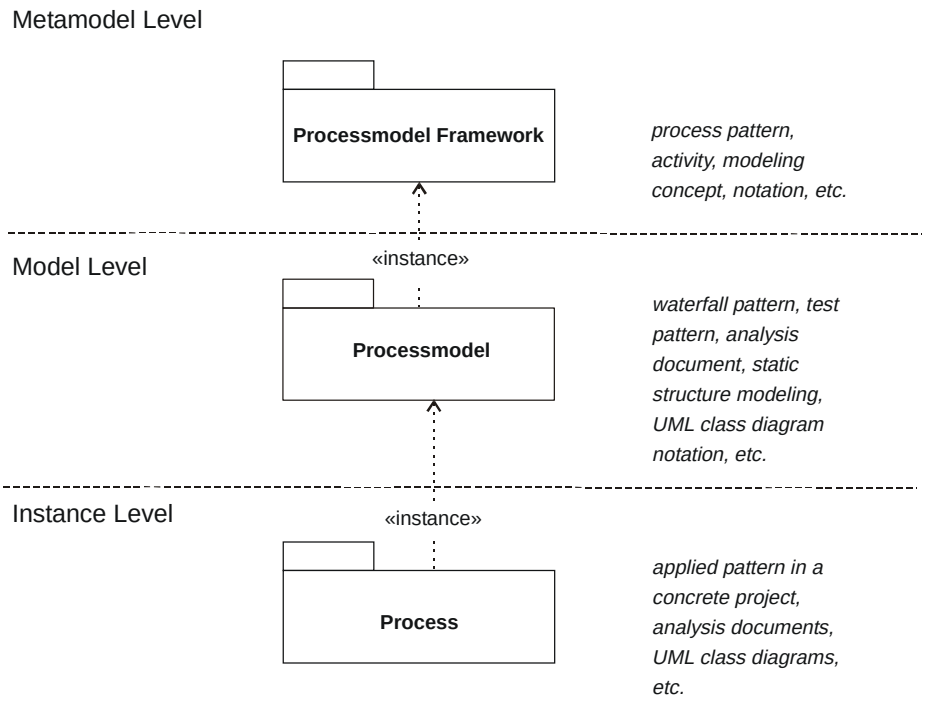

Fig. 1. The Layers of an Overall Process Model

2.2 The Project View of the Living Software Development Process

Project managers and project team members follow the concepts, guidelines, and help that is provided by a specific software development process defined on the Model Level in Figure 1. While performing their daily tasks they are creating instances on the Instance Level in Figure 1. This project view is shown in Figure 2.

Managing a concrete project implies selection of a suitable process from a set of existing, possibly standardized alternatives. Then the chosen process has to be tailored accordingly to the project's characteristics. This tailored process represents the guidelines, which are to be followed in the project. In terms of our Process Framework, given in section 3, the tailored process defines which work products are to be pro-

[2] Note, this metamodel structure follows the guidelines provided by the Meta Object Facility (MOF) specification of the Object Management Group (OMG) [19].

duced, and which modeling concepts, notations, and patterns may be applied in the project.

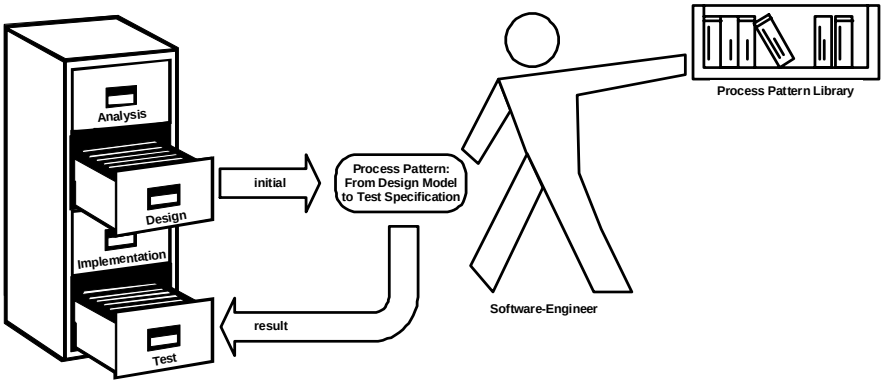

Fig. 2. The Living Software Development Process from the Project View

2.3 The Method View of the Living Software Development Process

Process improvement, as required on CMM level 5 [20] for example, means the evolution of process models, i.e. of elements on the Model Level in Figure 1.

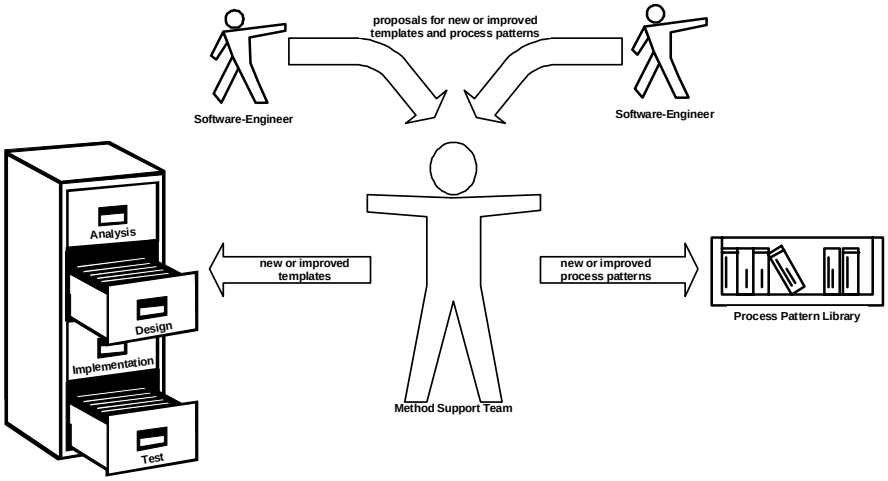

Fig. 3. The Living Software Development Process from the Method View

The formulation of process models on the basis of a well-defined ontology facilitates comprehension and hence changes of development processes. The elements of the

Metamodel Level in Figure 1 are supposed to play the role of such an ontology defining terms like “Activity”, “Process Pattern”, “Work Product” and their inter-relations. In [9, 28] a set of process modeling languages is discussed, and a basic ontology common for these languages is given.

An ontology for development processes provides both, developers and the methodology group, with a common vocabulary. On the one hand a methodology group can use such an ontology for the definition of standardized processes. On the other hand developers can use this vocabulary for the description of proposals for changes or additional process elements, which reflect their experience made with former process elements. On the basis of these proposals redefinitions by the methodology group can be done. Figure 3 shows this method view on a living software development process.

In our ontology, which we call the Process Framework, given in section 3, we follow the principle of separation of concerns so that changes are facilitated because of having minimal and localized effects.

3 Framework of a Living Software Development Process

In the previous section we have shown how developers and methodology group may interact for elaborating and improving the standard software development process establishing a living software development process. The basic ontology is defined in the Process Framework, which is the Metamodel Level in Figure 1.

The Process Framework must provide the ability to define and maintain a process model, which integrates elements of all the various existing process models, like for instance the Rational Unified Process [17] or the V-Modell 97 [12]. Thus, the framework must enable the methodology group to state clearly the correlations between the elements of the different process models. Additionally, the Process Framework must support static as well as dynamic adaptation of the process model with respect to the evolution and learning of a living organization (c.f. Section 1).

To come up with the model of our Process Framework, we can either develop a brand new model or we can take one of the existing models that is almost well suited for our needs and enhance it. The new, upcoming concept of process patterns seems to be an approach which basically follows our ideas and which may fulfill our requirements. Process patterns are a very general approach allowing us to integrate existing process models without having to develop a brand new model [7], [8], [2], [3]. For example in [1] we have already shown the integration of the V-Modell in the process pattern approach.

The basic idea of the concept of process patterns is to enable us to describe and document process knowledge in a structured, well defined, and modular way. Conform with most authors, patterns in our approach consist mainly of an initial context, a result context, a problem description and a solution. The initial context is an overall situation giving rise to a certain recurring problem that may be solved by a general and proven solution. The solution leads to the result context [5].

We show how the process pattern approach from [7], [8] can be re-used and enhanced to model a sophisticated Process Framework which is powerful enough to

integrate different process models, and which is dynamically adaptable. The new, enhanced model is based on a clear separation of concerns between the overall result structure, the consistency criteria, and the process patterns themselves.

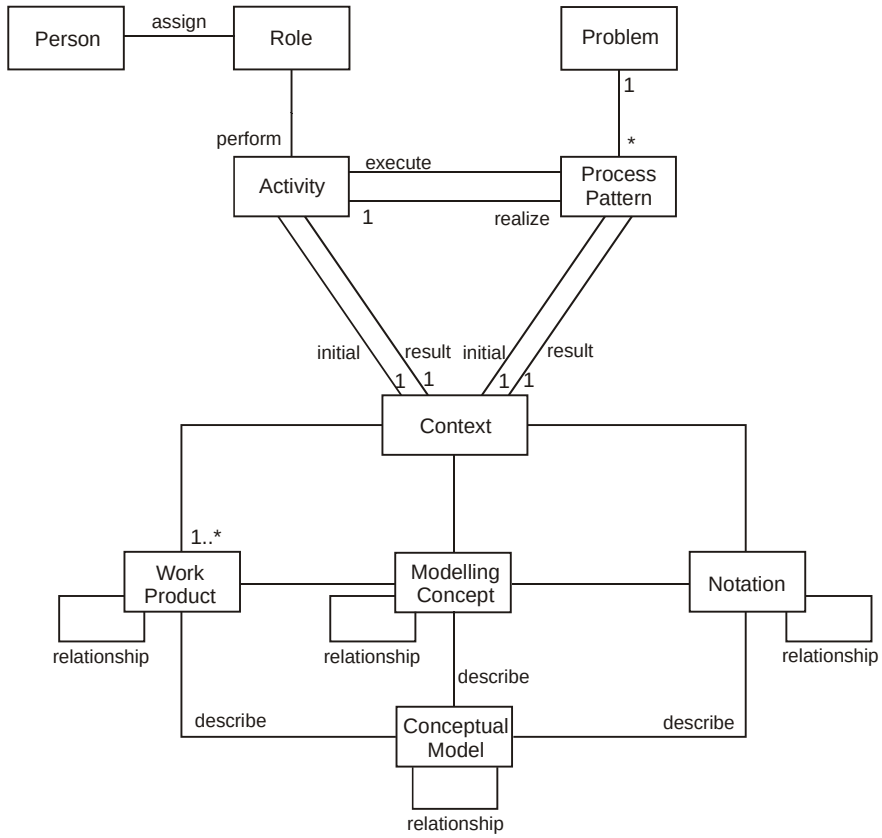

Fig. 4. The Process Framework

Figure 4 illustrates the basic concepts of the proposed Process Framework. It is based on the process pattern approach in [7], [8], and integrates it with an enhanced variant of a widely accepted process model framework (cf. [9]).

A Process Pattern defines a general solution to a certain recurring problem. The problem mentions a concrete situation that may arise during the system development. It mentions internal and external forces, namely influences of customers, competitors, component vendors, time and money constraints and requirements. A process pattern suggests an execution of a possibly temporally ordered set of activities. Activities themselves may be carried out following the guidelines of other, subordinated process patterns realizing the activity in question. Therefore process patterns and activities in our framework may be structured hierarchically, but iterative activities like the appli-

cation of the spiral model [6] may also result in more complex structures that contain loops.

Process Patterns in our framework represent strategies to solve certain problems. Activities represent development steps and are executed by process patterns. An activity does only describe what is to be done but not how it is to be done. In contrast to that a process pattern provides a solution for realizing an activity. Hence generally one activity might be realized by different process patterns. Activities are performed by definite roles. In turn roles are assigned to corresponding persons.

Each process pattern as well as each activity needs an initial context to produce a result context. The initial context describes the required project situation to perform an activity or pattern, respectively. The result context describes the situation we reach when performing an activity or pattern, respectively. The context captures the internal state of the development project and can be characterized by constraints over the set of work products. Simple constraints are that certain work products have to exist.

A process model assigns certain process patterns, as for instance the pattern “Planning the Project”, to certain work products, as for example the “Project Schedule”. These work products are described by means of modeling concepts, as for instance “Time Flow Modeling”. The modeling concepts are represented by certain notations, such as “UML Sequence Diagrams”.

The initial and result context of a process pattern may not only require the existence of certain work products, but also that certain modeling concepts and notations are to be applied for these work products. This is important when a pattern proposes the application of notation specific techniques. For instance in [18] methodical guidelines for the refinement of specifications are introduced. These refinement techniques require the modeling concept “Interaction Modeling” based on the notation “Message Sequence Charts”.

Note that the initial and result context of an activity have to be consistent with the initial and result context of a realizing process pattern. Whereas the activity may apply to a set of work products a process pattern realizing the activity must refer to the same set of work products but might furthermore fix notations and modeling concepts for these work products.

Initial and result contexts allow us also to identify activities, which use the same work products. This helps us to identify potentially conflicting activities that cannot be executed simultaneously. However a discussion about work product sharing of concurrent activities is not within the scope of this paper.

The precise definition of the meaning of and context conditions between work products can be achieved by the use of a so-called conceptual model. Work products that are based on sound description techniques have not only a well-defined notation, but also a possibly even formal semantics in form of a mapping from the set of work products into the set of systems (cf. [16, 23, 25]). The conceptual model characterizes, for instance, the set of all systems that might ever exist. This integrated semantics provides the basis for the specification of a semantic preserving translation from specification work products to program code. This can serve as a basis for correct and comprehensive code generation.

The circular relationship associations assigned to various elements, such as work product and conceptual model, in Figure 4 cover the general idea of structuring these elements, for example hierarchically.

4 Model of Work Products

In this section we take a closer look at the work product related part of our Process Framework. First of all, in section 4.1 we discuss the role of work products as part of a process model. For the representation of the information covered by work products we apply modeling concepts and according notations. In section 4.2 we discuss how these framework elements are related.

4.1 Work Product Part of the Process Framework

When we intend to set up a concrete process model (located in the Model Level of Figure 1) one of the first and most important steps is the definition of work products and their relationships. This step has to be taken before the definition of activities, because activities refer to initial and result contexts consisting of work products. Samples for instances of work products are business process model, project contract, or Java class file. Note that these instances are located on the Model Level in Figure 1.

Concerning work product associations of the Process Framework in Figure 4 we modeled a general Relationship association between work products. For setting up a concrete process model we need a more detailed framework where we refine this general relationship between work products to more specific ones, such as

- cartesian product and union to build composite work products, and
- refinement to relate work products representing information on different levels of detail.

Work products and their relations define a structure like a filing cabinet that has to be filled during a development project.

Figure 5 shows an instance diagram illustrating the composition structure of the work product instances Initial Customer Specification and Business Process Model together with the associations Refinement and Simple Binary Undirected Relationship between some of its sub-work products.

An Initial Customer Specification is a work product, which expresses roughly what the customer expects the system to do. It consists of three different parts. Firstly there is a short statement about the goals of the project, the System Vision. Secondly it contains short descriptions of entities the system must handle, the Business Entities. Thirdly there is a set of informally described Business Scenarios, which represent an exemplary specification of business processes.

A Business Process Model provides a more complete and precise representation of the business processes of an organization than the one documented in the Initial Customer Specification. A Task Chain defines the business activities a business process consists of. Moreover it describes the transitions between the activities. A Task De-

scription is a complete definition of all the elements of a business process. In addition to the information covered in a Task Chain, a Task Description contains the effects of the task and information about its performers. The Organizational Structure documents an organization's different departments and the roles, which may perform tasks.

Since a business process model is supposed to consist of task chains, task descriptions, and a documentation of organizational structures (cf. [24]) we composed the business process model by means of according Cartesian Product relations. The fact that a task description is a more detailed specification of a business process than a task chain is reflected by the Refinement relationship between the two work product instances.

The work product instance Business Scenario, which is part of the work product Initial Customer Specification, is also related to the Task Description. Generally a business scenario is an exemplary description of a business process that may be described in full detail in a task description. In order to cover the information about which task description and business scenarios are related we use a Simple Binary Undirected Relationship being an refinement of the general Relationship association in the Process Framework. We refer from this relationship to an additional consistency criterion. This criterion requires a business scenario to denote one of all the possible variants of a business process described in the related task description.

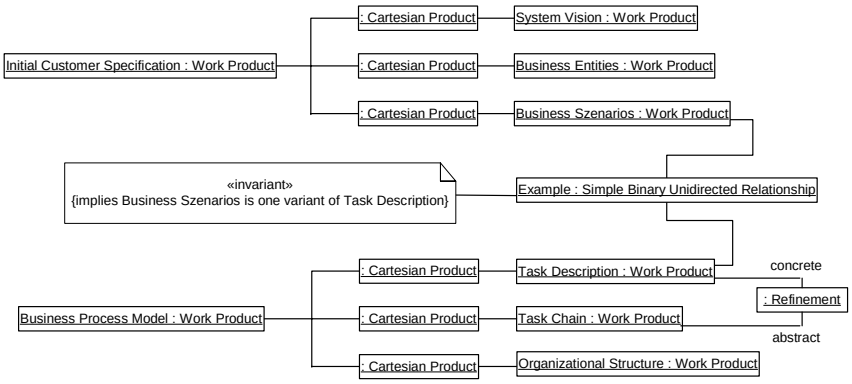

Fig. 5. Instance Diagram of the Work Product 'Business Process Model'

In our process model framework in Figure 4 we proposed a Conceptual Model, which is supposed to play the role of a "semantic" model that helps us express the purpose or meaning of work products in terms of an explicit and precise model resp. ontology. The model given in [27] for business processes would be a suitable conceptual model for the work product instances discussed in this section. However, the Conceptual Model and the mapping of work products to this model is not a topic of this paper. More information about this subject can be found in [25].

4.2 From Work Products to Notations

Most traditional process models (cf. e.g. [9]) do not distinguish between work products, modelling concepts, and notations. However, in our view this distinction is important. In general there are complex relations between these elements of a process model. Thus, following the principle of separation of concerns, we have to make a clear distinction between these concepts and model relationships explicitly. For instance, we can use different Modeling Concepts to describe the contents of Work Products. Besides that, we can represent a given Modeling Concept by different Notations, and vice versa.

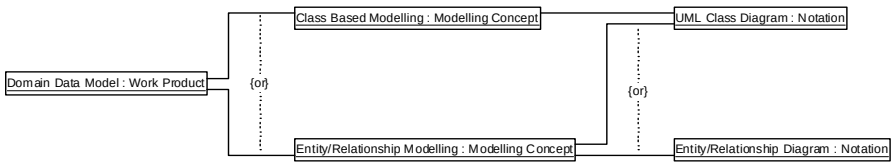

Fig. 6. Instance Diagram of a Work Product, applied Modeling Concepts and Notations.

In Figure 6 we show an instance diagram representing a part of the process model located Model Level of Figure 1. As shown, the representation of the work product Domain Data Model can use either Class Based or Entity/Relationship Modeling concepts. Moreover, the process model offers different representations for certain modeling concepts. In this example a system analyst can decide, whether he wants to use UML Class Diagrams to represent concepts of class based modeling, or in case of entity/relationship modeling he can chose either entity/relationship diagrams or UML class diagrams.

5 Process Patterns

A process pattern enables us to describe and document process knowledge in a structured and well-defined way. As already discussed in Section 3 and illustrated in Figure 4 process patterns consist mainly of a problem solved by a proven solution applied through certain activities, and an initial as well as a result context. The activities play important roles in process patterns, because they reflect the tasks, which have to be carried out as described by the solution.

Process patterns, as well as all kinds of patterns, must be presented in an appropriate form to make them easy to understand and discussable. In this section, we first present a uniform pattern description template for process patterns. As already mentioned above, activities are rather important in the context of patterns. For this reason, we present a template for activities, too. Then we provide a sample process pattern to illustrate the basic concepts of process patterns. Once you start filling your pattern

library with those patterns you will sooner or later have a huge number of process patterns. For that reason you need some kind of index or guideline to select the patterns concerning your context and problem in your specific project situation.

5.1 Pattern Description Template

A good description helps us grasp the essence of a pattern immediately – what is the problem the pattern addresses, and what is the proposed solution. A good description also provides us with all the details necessary to apply the pattern and to consider the consequences of its application. Moreover a uniform, standardized description template for process patterns is needed. This helps us compare one pattern with another, especially when we are looking for alternative solutions. Furthermore, we are interested in details of the activities, which represent the tasks to be done, by using the solution of a pattern. For these activities we need a uniform, standardized pattern, too.

The basic structure of process pattern, problem, solution, activity and context, we already have mentioned, provides us with a good starting point for a description that meets our requirements. However, a pattern must be named, we want to use diagrams and scenarios to illustrate the solution, and we want to include guidelines for the application of the pattern. Hence, we have to refine the basic structure.

Table 1 shows the enhanced process pattern description template.

Table 1. Process Pattern Description Template

Entry	Process Pattern Description
Name	The name of the pattern.
Author	The name of the creator of the pattern.
Version	The current version number of the pattern. Important during evolution of a pattern.
Also Known As	Other possible names of the pattern, if any available.
Keywords	Some important words describing the context and the intent of the pattern.
Intent	A concise summary of the pattern's rationale and intent. It mentions the particular development issue or problem that is addressed by the pattern.
Problem	The problem the pattern addresses, including a discussion of the specific development task, i.e. the realized activity, and its associated forces. Moreover the problem description may contain information with respect to consumers, competitors, and the market situation.
Solution	A solution may suggest certain activities to be applied to solve a certain problem. Possibly an order may be given in which to perform these activities, or alternatives may be proposed. Besides that the solution comprises methodical guidelines and concrete recommendations. A solution shows a possible answer to balance the various forces that drove the project into the current

	situation. The solution includes a list of activities for execution. In contrast to these activities, the activity realized by the process pattern is referenced below. Moreover the solution depicts the relationships of the initial and result contexts of the executed activities and shows how the activities are combined.
Realized Activity	The name of the activity for which the pattern provides a strategy of how to execute it. Every process pattern realizes one activity.
Initial Context	The internal state of the development project, i.e. the state of the corresponding work products, that allows the application of this process pattern.
Result Context	The expected situation after the process pattern has been applied, i.e. the resulting state of the work products.
Pros and Cons	A short discussion of the results, consequences, and trade-offs associated with the pattern. It supports an evaluation of the pattern's usefulness in a concrete project situation. The problem description together with the pros and cons of a pattern helps us in choosing from alternatives, that is static and dynamic tailoring. Thereby these two pattern elements have a purpose similar to selection guidelines in [22].
Example	Known uses of the pattern in practical development projects. These application examples illustrate the acceptance and usefulness of the pattern, but also mention counter-examples and failures.
Related Patterns	A list of related patterns that are either alternatives or useful in conjunction with the described pattern.

Moreover, we need a description template for activities. For a named activity we want to know the belonging development issue and both contexts, the initial and the result. The contexts are summed up in the realized process pattern as described above. Table 2 shows the activity description template.

Table 2. Activity Description Template

Entry	Activity Description
Name	The name of the activity.
Role	A list and description of the roles that may have to perform the activity.
Development Issue	It mentions the particular development issue that is addressed by the activity.
Initial Context	The situation in which the activity may be applied, i.e. the required internal state of the development project. The internal state is particularly given by the state and consistency of the work products the activity needs as input.

Result Context	The expected situation after the activity has been applied. This is the state and consistency of the work products affected by the application of the activity.

5.2 A Process Pattern – From Initial Customer Specification to Business Model

In this section a sample Activity and a corresponding Process Pattern are given to illustrate the basic concepts of process patterns. A detailed discussion of a wider range of process patterns is not in the scope of this paper and can be found in [7], [8]. Please note, that the sample Process Pattern of this section resides in the Instance Level of the Overall Process Model shown in Figure 1.

We show how a certain activity and a certain process pattern realizing this activity can be described in detail following the description template from the previous section. We chose the activity Business Process Modeling and a process pattern called Business Process Modeling Task Analysis with Activity Diagrams. This process pattern provides project team members with a strategy for developing a Business Process Model from an Initial Customer Specification.

Table 3 gives the description of the Business Process Modeling Activity:

Table 3. Activity Description: Business Process Modeling

Entry	Activity Description
Name	Business Process Modeling (BPM)
Role	Business Expert, Software Architect
Development Issue	The goal of performing this activity is to develop a (complete) business process model, which covers all the business scenarios and business entities described by example in the Initial Customer Specification serving as input. Thereby the project goals, system vision, and constraints specified in the initial customer specification are to be taken into account.
Initial Context	Initial Customer Specification[3]
Result Context	Initial Customer Specification, Business Process Model

Table 4 gives the description of the pattern BPM Task Analysis with Activity Diagrams, which realizes the Business Process Modeling activity:

Table 4. Process Pattern Description: BPM Task Analysis with Activity Diagrams

Entry	Process Pattern Description
Name	BPM Task Analysis with Activity Diagrams
Keywords	Business Process Modeling, Task Analysis, UML Activity Diagrams, Stepwise Refinement, Iterated Modeling with Reviews

[3] The related work products have already been introduced in section 4.

Intent	Development of – a precise and unambiguous documentation of a BPM – documentation of BPM on different levels of abstraction cover not only all details but also provide an overview of relevant business processes. – documentation of BPM such that it can be understood by business experts as well as software developers – ensured adequacy of BPM (validated model)
Problem	Business experts are available but a precise documentation of as-is and to-be business processes being relevant for the system to be developed does not exist. High complexity of business processes. The system vision of the initial customer specification hints at a strong relationship between the system to be developed and the business processes (e.g. support of large parts of business processes by the intended software system).
Solution	In order to achieve a precise and unambiguous documentation of business processes use UML activity diagrams [26] with its formal syntax to describe business processes. In order to achieve a documentation of different layers of abstraction apply the principle of stepwise refinement (cf. pattern's activity diagram). Start with the definition of major tasks and refine them iteratively. Ensure adequacy of the business process model by reviewing each iteration of the model with (third party) experts. Involve business and software architecture experts being fluent with activity diagrams. The pattern's workflow is illustrated in Figure 7[4]. After having identified major tasks and user classes assign user classes as actors to tasks. Refine task characteristics of major tasks, and define a first version of the tasks' task chains by decomposing it into sub-tasks, and defining their causal dependencies. Consider alternative chains. Review this first model involving persons representing the identified user classes in the review. Perform the refinement steps of tasks iteratively and review each iteration (apply pattern Refinement of Activity Diagrams).
Realized Activity	Business Process Modeling
Initial Context	Initial Customer Specification with arbitrary modeling concepts and notations

[4] Please note, that this decomposition in activities serves as an illustration of the concept and therefore is not complete. There is also no detailed description of these executed activities provided in this paper.

Result Context	Business Process Model with UML activity diagrams as notation for task chains and a pre- and post-condition style specification of tasks.
Pros and Cons	Pros: – UML Activity Diagrams provide a standardized, concise and unambiguous notation to document business processes (Task Chains). The applied modeling concepts are widely used by business experts (e.g. similarity with Event Driven Process Chains) [24] as well as software developers (e.g. similarity with Petri nets). – This precise way of description supports detailed and precise review. – Iterative modeling and review increases understanding and quality of the business model. Cons: – Usage of specific notations, namely UML activity diagrams, may require training of involved persons. A common understanding of the notation must be ensured. – Stepwise refinement is a pure top down approach so that consideration of existing parts may be difficult.
Related Patterns	See also: BPM Informal Task Analysis

Figure 7 shows the temporal ordering of the activities, which are executed by the BPM Task Analysis with Activity Diagrams Process Pattern. Additionally the input and output work products of the executed activities are given.

Except from BPM Task Analysis with Activity Diagrams, as mentioned in Table 4, the activity Business Process Modeling might be performed in a different way. For example the process pattern BPM Informal Task Analysis represents an alternative strategy for business modeling proposing an informal documentation of business processes. This might be suitable when business processes are simple and the software system does not play a major role in these processes. The pattern map given in Figure 8 shows these two alternative performance strategies for the business modeling activity.

How we perform activities proposed in a process pattern might again be described by further patterns. For example a pattern providing a strategy for the activity Review Business Model might be called Check Coverage of Business Scenarios.

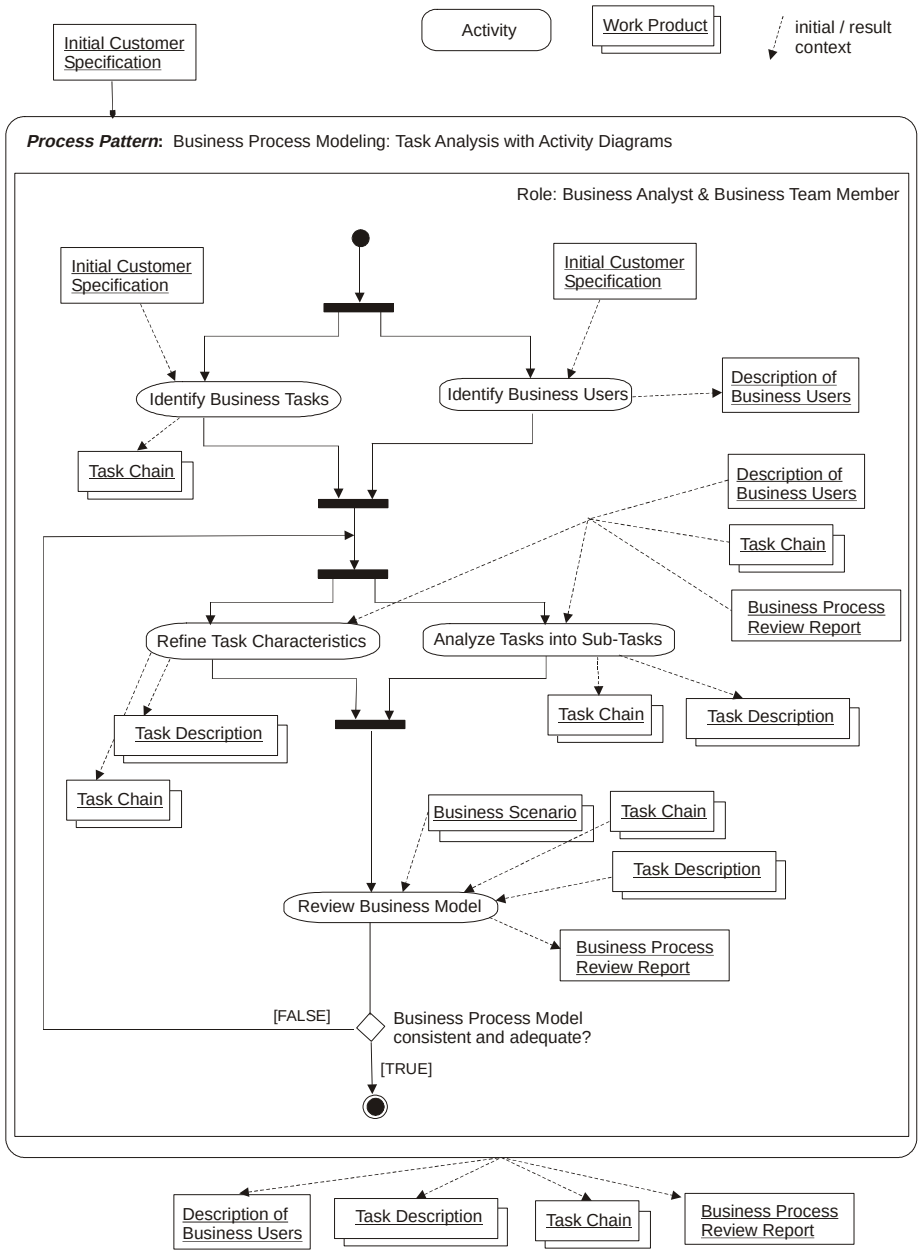

Fig. 7. UML Activity Diagram of the BPM Task Analysis Pattern

5.3 Managing the Process Lifecycle – Process Pattern Maps

As already mentioned process patterns will exist on several levels of detail. Like in other pattern-based approaches, the single patterns may also be combined with each other, forming a multi-level system of patterns. The combination of those patterns forms the lifecycle of a development process. This lifecycle will not be fixed, but will vary from project to project and from situation to situation, according to the specific problems of the projects.

The selection of a process pattern may be outlined as follows: Based on the project's current situation, as partly represented by the state and consistency of work products, the project leader tries to identify the next activities he wants to be executed. This information leads to the selection of one or more alternative process patterns with initial contexts and problem descriptions matching the current situation. After a careful consideration of the alternatives' pros and cons and their problem descriptions one pattern is chosen. This pattern recommends a number of development activities and their temporal order. For each of its activities the solution may require or propose the application of certain process patterns.

By choosing process patterns the project manager forms the process lifecycle. Usually a process pattern library will contain a large number of patterns. We introduce two kinds of pattern maps providing an overview over a set of patterns by structuring them from different points of view.

One possibility is to structure process patterns accordingly to the activities they realize. We call this activity process pattern map. Activity process pattern maps are directed graphs. These graphs have two kinds of nodes, namely activities and process patterns. A process pattern node has edges to all the activities that have to be performed by applying the pattern and exactly one edge to the activity it realizes. Each activity may be performed following the solution provided by a process pattern. Hence each activity node has edges to process pattern nodes that provide guidelines to perform the activity. Figure 8 illustrates such an activity process pattern map that builds a tree. However, as already mentioned there may also exist patterns and activities that deal with refinement and iteration, that introduce loops in the graph.

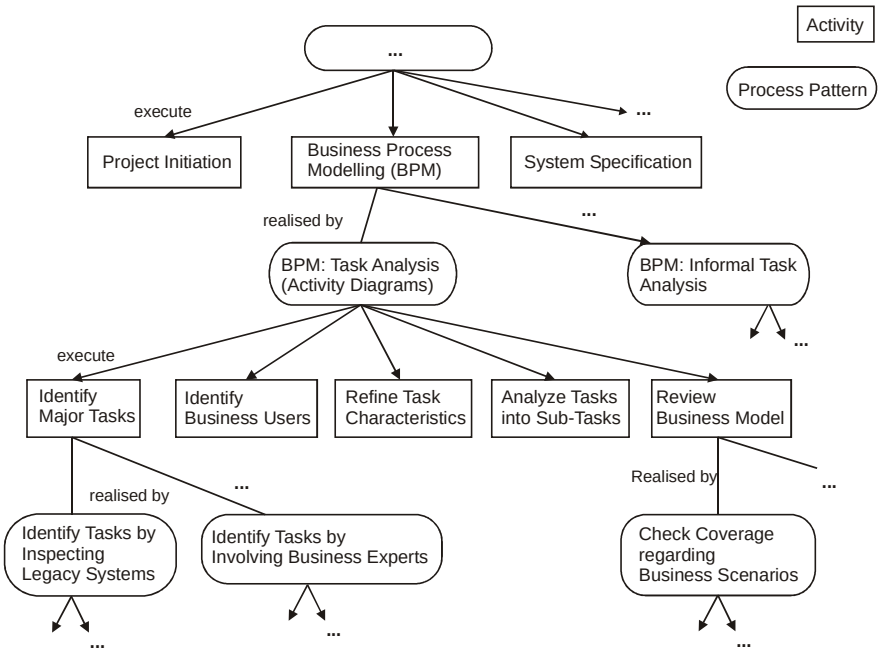

Fig. 8. An Activity Process Pattern Map

A second viewpoint on a set of pattern maps is the so-called context process pattern map. This kind of map is a directed graph with contexts as nodes and patterns as arcs. This way we can easily see alternative ways, i.e. process patterns, from one context to another. These maps are similar to the maps presented in [22].

6 Conclusion and Further Work

In this paper we introduced a process pattern based approach, which allows software developers to implement a very flexible and tailored development process. According to the best of breed idea a company can combine the most appropriate solutions from different established methods and best practices to form a perfectly tailored process for this company and for all types of projects within the company. Therefore we introduced a Process Framework that facilitates integration, tailoring, and evolution of process models. Further questions concerning the application of a pattern based development process, like the concurrent use of work products through different activities, do not belong to the scope of this work.

We enhanced existing Process Frameworks comprising elements, such as work product, activity, and role, by introducing the notion of process pattern as a modular way for the documentation of development knowledge. Similar to approaches, such as [22], by stating the tackled problem as well as discussing pros and cons, patterns sup-

port selection of adequate strategies during process enactment that is problem-driven dynamic process tailoring.

A further difference to existing approaches is the explicit modeling of relationships between work products, modeling concepts, and notations, allowing us to describe and integrate generic processes, referring to work products only in general, with specific development processes providing concrete modeling concepts and notations.

To realize a process pattern approach within a company software developers need some guidance to find their way through the vast number of process patterns that may have been developed at their company. A possible way to store and manage process patterns is a book or folder, where patterns are written down in accordance with a fixed scheme as presented in section 5. However searching for the right pattern for a certain situation within a given context in a book is not very comfortable. Further process patterns evolve and establish dynamically, so it doesn't seem a good idea to document the living process in the form of an unalterable book. Thus a tool to store, present and manage process patterns and work product definitions within an organization dynamically would be very desirable. Due to the continuous evolution and change of a living development process, we work on a tool supporting process model maintenance. Moreover by realizing the presented pattern maps this tool is supposed to provide guidance for software developers in finding their way through the jungle of process patterns.

To sum up the application of a process pattern approach seems to be very promising, as it provides a flexible way to define a tailored development process that can be easily adapted to new requirements. Combined with a reasonable tool support for the management and development of process patterns this approach may help organizations to create and evolve their custom development process.

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