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# Four-level Process Modeling in Healthcare SOA Analysis and Design

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**Abstract.** Process and activity modeling are widely used in healthcare work and systems development projects. There are various approaches and abstractions available for process modeling. This study describes a four-level approach to activity and process modeling which has been used in modeling healthcare activities in relation to the specification of service-oriented information systems solutions. Based on the material and experience from these efforts: 1) overview level descriptions are well capable of illustrating the domain of the development, 2) many current notations and techniques on process level fail to describe diverse practices in healthcare, 3) descriptions on activity level should be generalized and combined in novel ways to achieve reuse and to support complex domains, 4) very accurate and detailed action-level modeling should be used cautiously to reduce unnecessary workload and to focus on the essential features of the solutions.

**Keywords**: health information systems, process modeling, activity modeling, software design, service-oriented architecture

## 1. Introduction

Process modeling is used widely in various types of healthcare projects to increase shared understanding of activities or workflows, and to identify improvement needs [1]. Furthermore, process models are utilized in process automation, monitoring and simulation. In healthcare, at least partially automated, human-assisted processes [2] are used increasingly. This, however, requires bridging the gap between human and organizational behavior and automatic information processing. The processes and tasks need to be described using deterministic techniques to support development work or automation. In traditional Business Process Management, production effectiveness is emphasized, and process flow is typically described using task- and goal-oriented view through different activities and units [3]. In healthcare, however, processes are modeled from various viewpoints, including patient, employee, management or data flow, each of which may perceive totally different aspects of a single process. This has produced difficulties in supporting healthcare processes systematically or efficiently using established process modeling methods [4, 5].

In SerAPI R&D project in Finland, one of the focuses in 2006-2007 was models to support the identification and realization of processes on selected healthcare domains. The goal was to improve the production of process models to support the development of service-oriented architectures (SOAs) and their constituent software services for health information systems [6]. This paper documents some main results and conclusions of these activities, based on the experience gained and models used.

## 2. Methods: process modeling levels and modeling domains

In the SerAPI project, the notations and process modelling methods were related to four levels of abstraction based on previous research [7] which can be used in general to classify different consideration levels or approaches of modelling methods:

1. *overview level*: environment of the activities, holistic view of the activity system,
2. *process level*: description of one specified process,
3. *activity level*: more specific description of one process phase or activity,
4. *actions and tools level*: accurate descriptions, details of user or system interfaces.

At overview level, descriptions focus on activity networks, organizational units, identified processes and their connections. At process level, phases and progress of high-level workflow or process between various participants is generally described. On activity level, the descriptions are focused on the rather constant activities of given actors or units which also often contain consecutive tasks or phases. Actions and tools level provides detailed information on the actions and tool requirements which can be used in detailed design of applications or IT solutions such as software services.

At overview level, the used description methods included process maps and graphical descriptions of the activity networks [5]. On process level, various process modeling notations, including BPMN (Business Process Modeling Notation) and Activity Diagrams of UML (Unified Modeling Language) were used. On activity level, more accurate process diagrams, workflow diagrams and textual scenarios or storyboards were used. At actions and tools level, scenario and use case descriptions and detailed information, functionality and service specifications were produced. In addition, on levels 2-4 we used tabular descriptions of processes, activities and use cases, and all levels included narrative descriptions in addition to graphical diagrams.

The process and service specification work in the project produced models for two domains: endoscopy examination domain (as an example of central supportive process in various healthcare institutions) and for maternity care domain (as an example of diverse network of different services). The selection of different types of domains was deliberate, to provide opportunities for evaluating methods and notations in different situations. The produced models were mainly based on readily available material and joint work with the participants from companies and hospitals in several workshops.

Endoscopy modeling produced on overview level a process map, on process level process descriptions tables and high level as well as detailed level process diagrams. On activity level, 18 activity description tables were produced, and 25 use case descriptions and 12 software service descriptions were also produced and connected to the descriptions of the processes. Figure 1 portrays activities and use cases of the first main phase of the described process.

In maternity domain, a high-level illustration of the entire domain was produced. More focused descriptions were produced for specialized care, maternity clinic and delivery activities. These domains were supported with example models using various methods and notations down to the activity level, for example 16 activity description tables and detailed use case descriptions of delivery activities. Software services were not identified from the models, however, but the descriptions were focused on the activities and actions from user and professional viewpoints instead of applications.

Similar notations and modeling methods were used in several interface-oriented work items in the SerAPI project, such as Scheduling services, Clinical Decision Support, Patient list and Patient grouping interfaces. These modeling efforts did not consider as strict a separation between the modeling levels, however.

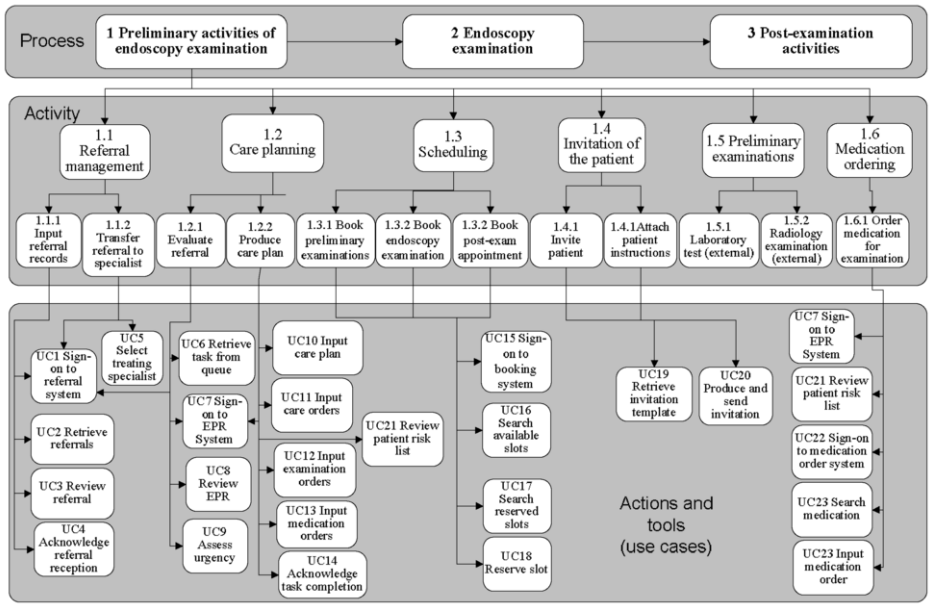


*Figure 1. Subjects of modeling of endoscopy example on process, activity and action levels.*

## 3. Results: experience and applicability of process modeling approaches

For maternity and endoscopy, 23 different process and activity modeling notations or methods were used or developed. Five of them were used on several modeling levels. In conjunction, a method for producing process and activity models was developed. This section contains central observations related to the process modeling cases.

The production of process descriptions on several levels and from the viewpoints of several actors was found useful. Some notations can be used on several modeling levels and different viewpoints of processes. For example, UML activity diagrams were used both for patient process model related to ultrasound screening examination and to illustrate the workflows of a typical workday of ultrasound midwife / nurse. Modeling work requires initial learning efforts, but becomes significantly faster, as the modeling conventions and tools (such as modeling levels, template tables, modeling activities, tool software) become familiar to the modelers. We successfully used modeling level specific tabular templates to give coherent structure for the modeling and to guarantee the systematic inclusion of most necessary elements or questions.

In endoscopy modeling, the actions and tools -level modeling of activities was laborious, but it produced detailed information which is useful if the design and implementation of solutions requires accurate and comprehensive information. Traceability between different modeling levels is well preserved, and it is possible to smoothly move from overview-level descriptions down to the actions and tools -level models [5]. The most technical results of endoscopy modeling included tabular descriptions of identified software services, but these services were not further technically specified, implemented or harvested from existing systems.

The maternity modeling revealed the necessity of constraining the domain to avoid unmanageable workload: there are crucial choices on what to model on a detailed level, what on generic level - and what is left outside modeling efforts. The maternity models included an overview and phases and tasks of the selected processes on rather detailed level, but the identification of software services (which was one of the goals of the modeling) was not performed adequately. This was mainly due to the fact that despite readily available material, the modeling of various parts of this wide domain consumed most of the time and resources. It was also found evident that literature or generic knowledge of the domain cannot replace the use of domain experts in modeling. Arrangements are needed to guarantee the availability of experts who work in the modeled domain to support the modelers, or tools and methods which are usable by the domain experts themselves [8]. In addition, strict separation of current state from target state descriptions is necessary especially if the modeling is based on available material.
The use of nested modeling levels was found practically inevitable on both domains. Most of the detailed use case descriptions could be part of several different processes for the identification of reusable software services in SOA. In contrast, some high-level activity descriptions include details which are very domain-specific.
Generalization of process descriptions was not performed to the maximum extent for the two domains. More generalized activities or sub-processes would promote reuse and identification of core services and processes of SOA. Scenario-based modeling produces accurate descriptions but fails to cover variations. In practice, most of the healthcare processes were found too dynamic to enable accurate modeling of nothing but the most common workflows and a few alternative ones. This is also supported by observations such as identification of more than 1200 different care pathways of coronary disease patients in one hospital district, while ten most common pathways cover two thirds of the patients [9]. Furthermore, the modeling levels and parallel diagrams on most accurate level promote understandability; the diagrams would be unreadable if details of actions and tools level use cases were included in one diagram.
Exact descriptions of clinical actions and tasks are non-optimal material for specifying software services or interfaces. Detailed action-level descriptions produce information which is abstracted out of generalized process models which form the basis for SOA. Detailed models require more maintenance, but reveal several requirements related to the exact definition of information contents and usability requirements which are crucial to ensure the successful implementation and user acceptance. Thus it is evident that mere identification of process phases or functionality of software services is not enough for acceptable solutions. Likewise, if only use cases had been used, most of the now explicitly documented knowledge would have remained tacit. In addition to the process aspects, special attention must be paid to the modeling of information which of the processes, tasks and actions. In addition to horizontal process models which cross several actors, vertical models related to the activities of one actor may reveal significant bottlenecks for the process improvement. Even though many modeling activities do not directly serve the identification of SOA services, there are always other goals of modeling which should be identified and supported as well.
Descriptions and scenarios written by nurses and doctors are often focused on clinical or nursing details of the workflows. This gives IT design opportunities to identify new ways to support care (e.g. rules and guidelines in software) and a thorough overview of the activities and tasks. However, these descriptions often omit necessary aspects for information and functionality of IT solutions and need generalization to promote the reusable design. Tabular modeling templates alleviate this to some extent.

## 4. Discussion and conclusions

The modeling results in our two domains cannot be directly generalized for healthcare in general. The validation of models was not performed as much as originally desired. However, the models produced in more technical work of the project support the observations of this study, in addition to the observations from the storyboards of HL7 version 3 standards and IHE (Integrating Healthcare Enterprise) integration profiles.

The identification and documentation of essential needs and requirements and improvements in domain knowledge are benefits of process and domain modeling in healthcare. According to this study, main risks include getting stuck in numerous detailed models or details which do not have direct impact on the goals, and on the other hand, the omission of necessary information from the models. The modeling must be goal-driven: the models for medical expert system are very different from the models for specifying reusable service interfaces in the same domain. Adequate overview is often needed for focusing the modeling efforts.

Comprehensive modeling or automation is practically impossible in most healthcare processes. Non-deterministic variations make it impossible to reach both accuracy and coverage especially on the process level. Generalization on the boundaries of activities, and identification of activities without specifying all their sequences and relationships in diagrams seem promising approaches to overcome some of these problems. This, however, requires more flexible infrastructure and dynamic development model than current approaches [3, 4] and support for local adaptability.

Accurate modeling of healthcare domains is laborious and time-consuming, and models do not automatically bridge the gap between healthcare work and IT development. The models aggregate knowledge of which only part is in the heart of IT design. For this complex environment, the four-level approach eases the selection of complementary modeling notations and methods and helps focusing the modeling work.

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