Towards a Process Meta-Model

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Abstract

Process modelling has a long and established research tradition, in the context of formally capturing sequences of activities, as well as the involved parties and the exchanged data. It will, without a doubt, continue to play a major role in the context of supporting the development of added-value services industry 4.0. In the medical domain, clinical pathways are a specific form of process modelling. They are an evidence-based response to particular problems and care needs in clinics. Current developers and latest technologies, improve and refine, among others, also the expressivity of clinical pathways. As a result, advanced pathways modelling optimises the treatment procedures in clinics (i.e. by reducing the stay of a patient or the mortality rates). However, as a side-effect of this trend, clinical pathways become increasingly complex and it becomes harder to keep up to date with the latest published processes. In oder to address the challenge of analysing clinical pathways, we provide an approach to capture information about activities and annotate the modelled pathways with references to external data sources. We demonstrate the practical applicability of our approach by using our system to model an actual clinical pathway, and enrich it with meta-information and references to external data sources, such as PubMed. We show the use and expressivity of our data model by querying the captured data.

Keywords: Medical Services, Process Modeling, Business Process Model and Notation, Clinical Pathways, Semantic Media Wiki

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1. Introduction

Clinical Pathways are guidelines used in clinics to support physicians by providing recommendations of the sequence and timing of actions necessary to achieve an efficient treatment of patients Panella et al. (2003); Kinsman et al. (2010). They are evidence-based and use insights of former treatments of patients. However, due to the increasing volumes of data and developments in the medical domain, the clinical pathways become more complex. Each clinic has its own pathway based on its evidence and experience. Therefore, there are multiple pathways available that target different problems and care needs Zand (2002); Kris Vanhaecht et al. (2006); Hindle and Yazbeck (2005). They can be distinguished in their degree of complexity, in execution, and can be grouped according to the specific problems and care needs that they target. In order to capture meta-information about clinical pathways and activities, to compare, analyse and group them, we present a system that allows to capture meta-information about the activities. This information can be used to provide healthcare services i.e. planning resources and improve the outcome of clinical pathways.

We demonstrate the applicability of our solution by modelling a concrete perioperative pathway. The used methods and an overview of the system are described in Section 2. Overall, we address the following research questions:

1. How can we capture meta-information in clinical pathways?

2. How can we implement the infrastructure necessary for storing, accessing, and processing the meta-information?

We show that our approach is easy to use and extensible to capture further meta-information (Section 2). Furthermore, we show that our approach is sufficient to query and process the captured information (Section 3). A short discussion and lessons learned are given in Section 5.

2. Material and Methods

Our approach to capture meta-information is hierarchical (Figure 1 illustrates our hierarchical model). The hierarchy has at least two levels. The highest level (Level 1) represents an abstract element of a modelling language. The elements in the following levels inherit from elements located in the previous level. Therefore, each attribute modelled in the superclass, is available in the subclass. The relationship between the superclass and its subclasses is $1 : n$. Hence, a subclass does not inherit from multiple superclasses, but a superclass can be used as a generalisation for multiple subclasses.
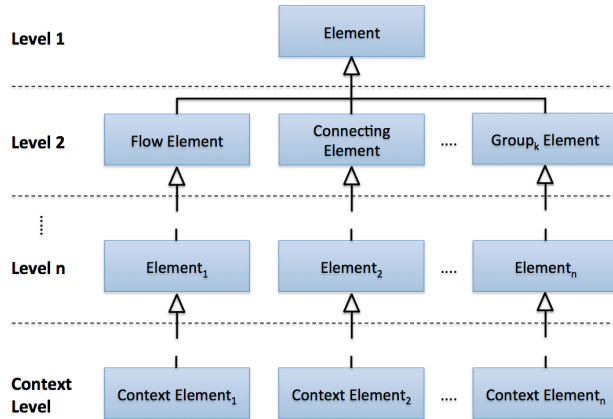
Figure 1: Hierarchical model to capture meta-information.

The elements in the second level (Level 2) inherit from the abstract element. Therefore, each attribute modelled in the superclass is available in the subclass. Usually modelling languages consists of nodes (Flow Elements) and edges (Connecting Element) between the nodes. These two kind of elements are arranged in the second level (Level 2) of our meta-model. Some modelling languages (i.e. BPMN) distinguish between more elements than Flow Objects and Connecting Objects. These additional objects can be arranged in Level 2. Following, more levels can be append and enriched with elements that inherit from elements located in the previous level. The specific inheritance depends on the chosen modelling language. I.e. BPMN distinguish between three flow elements: events, activities, and gateways. These elements are arranged in a following layer (Level 3) in the hierarchical meta-model. However, a Petri net distinguish only between places and transitions.

The last level (Context Level) is an optional level that allows to create use case-specific distinctions of each element from the last layer. For instance tasks in clinics can be divided into preoperative and surgical tasks.

3. Evaluation

For validation of our approach, we applied the hierarchical model to capture meta-information about a perioperative pathway. Figure 2 shows the perioperative process modelled in BPMN.
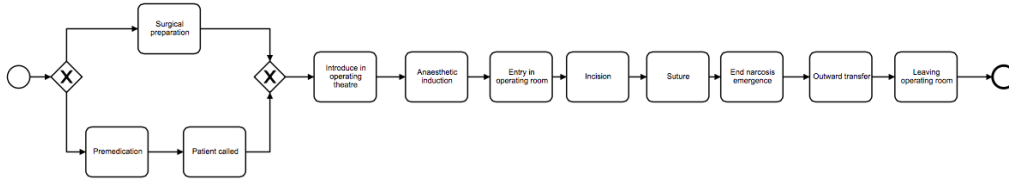
Figure 2: Perioperative process, modelled in BPMN.

We use a Semantic Media Wiki[1] to capture the activities, workflow and the meta-information. SMW is an open-source collaborative knowledge management system to store and query data. We used Semantic Forms[2] to provide forms in order to facilitate the input of meta-information.
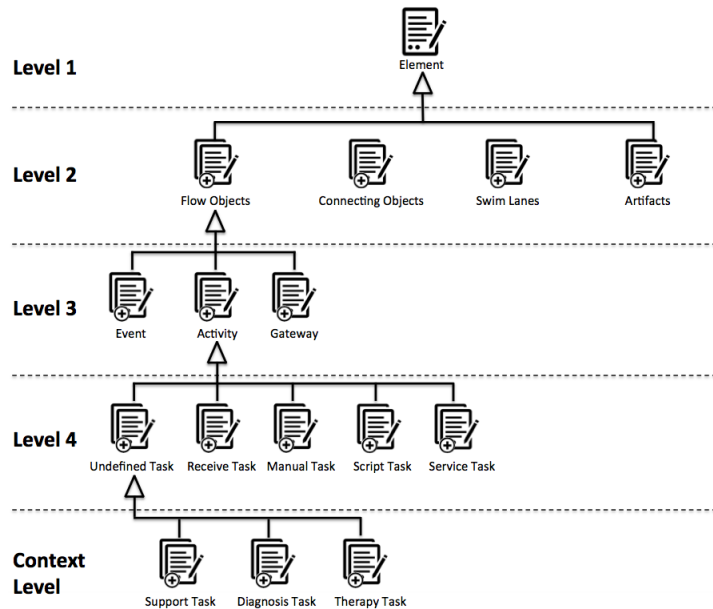

Figure 3: Extract of the implemented hierarchical meta-model.

Figure 3 illustrates the links and inheritances of the semantic forms. Forms from successive levels inherit from their superclass and consist of the form of the superclass enriched with attributes, captured on this hierarchical level.

On the top level (Element) we introduced the attributes *Label,Comment* and *Reference.* Forms in the lower level inherit from this form and enrich it with further attributes. Thus in the form Flow Objects we introduced the attributes *Responsible Person, Goal, Condition* and *Guideline.* Some attributes can be mandatory, allow only specific values or have multiple manifestations. For instance we choose *Responsible Person* as a mandatory attribute. Thereby, each flow object is connected to a responsible person, so that in case of doubt one has a contact person.

On the lowest level there are twelve attributes. We use an existing classification Braun et al. (2014) to classify different medical tasks in more detail on the context level. They slightly differ in their attributes. Thus, the Therapy Task has an attribute *Planned Therapy*, and the Diagnosis Task has an attribute *Supposed Disease.*

We enrich the BPMN elements with meta-information according to the provided forms. As a results, we can query for the following information:
1) Total runtime of the complete process; 2) Number of Elements contained in the process; 3) Responsible person, for specific tasks and processes; 4) Number of decisions within a process. The structured data in the SMW is stored in Resource Description Framework (RDF). Elements in RDF are represented by HTTP URIs We can use SPARQL[3] in order to retrieve queries on the data. SPARQL is a semantic query language for RDF. A concrete SPARQL query to request the total runtime of the perioperative process is given in the following.

```
PREFIX aifb: <http://aifb−ls3−vm2.aifb.kit.edu>

SELECT sum(?runtime) WHERE {
aifb:BPMNProcess_Perioperative
aifb:Property−3AHas_element ?Element .
?Element aifb:Property−3AHas_Runtime ?runtime .}
```

4. Related Work

The Dublin Core Schema[4] consists of a set of metadata terms that can be used to describe resources. However, it does not stipulate the model that must be used.

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[3]http://www.w3.org/TR/rdf-sparql-query/
[4]http://dublincore.org

The Learning Object Metadata (LOM) is an open standard, published by the Institute of Electrical and Electronics Engineers (IEEE), to describe learning objects. Learning objects are the smallest contents in which learning sources can be resolved. The LOM stipulates the attributes and their connection. The structure of LOM consists of nine categories but they are not arranged in a hierarchy.

The Computational Independent Metamodel (CIM) Yang et al. (2009); Kutsche et al. (2008) describes scenario requirements. It abstracts from the business process and data flow model. Platform specific metamodels (PSMM) describe technical aspects of systems including the structure, behaviour and communication of the interfaces. PSMM supports information like interface semantics, remote addresses, signatures and communication properties Yang et al. (2009); Kutsche et al. (2008). In contrast, Platform Independent Metamodels (PIMM) Yang et al. (2009); Kutsche et al. (2008) abstract from platform-specific properties and interface descriptions.

A semantic meta-model by Yang et al. (2009) represents the information in a graph, similar to RDF. Subjects and objects are modelled as classes and linked via predicates. The meta-model contains predefined predicates, but can be extended with specific predicates.

5. Conclusions

The long-term goal of our work is to develop a system that analyses processes, while making use of all available knowledge. To this end, we introduced a new concept for modelling, processing, and accessing meta-information. The used approach abstracts away from a specific modelling language. Moreover, it is adaptable to different use case scenarios.

We actively use the presented infrastructure for data collection and processing. SMW provides a suitable environment to model, store and access meta-information about processes and allows references to external data sources. In order to investigate the benefit of our approach, we will focus on capturing further processes in the medical domain, as well as in other domains.

Future work includes the analysis of processes with respect to uncertainty. Clinical pathways have already been analysed in previous works, i.e. Yang et al. (2012), however we will not focus on clinical pathways in particular but on processes in general.

In conclusion, we introduced a hierarchical meta-model to capture meta-information in processes.

References

Braun, R., Schlieter, H., Burwitz, M., and Esswein, W. (2014). Bpmn4cp: Design and implementation of a bpmn extension for clinical pathways. In *Bioinformatics and Biomedicine (BIBM), 2014 IEEE International Conference on*, pages 9–16.

Hindle, D. and Yazbeck, A. (2005). Clinical pathways in 17 european union countries: a purposive survey. *Australian Health Review*, 29(1):94–104.

Kinsman, L., Rotter, T., James, E., Snow, P., and Willis, J. (2010). What is a clinical pathway? development of a definition to inform the debate. *BMC Medicine*, 8(31).

Kris Vanhaecht, K., Bollmann, M., Bower, K., Gallagher, C., Gardini, A., Guezo, J., Jansen, U., Massoud, R., Moody, K., Sermeus, W., Zelm, R., Whittle, C., Yazbeck, A. M., Zander, K., and Panella, M. (2006). Prevalence and use of clinical pathways in 23 countries — an international survey by the european pathway association. *International Journal of Care Coordination*, 10(1):28–34.

Kutsche, R., Milanovic, N., Bauhoff, G., Baum, T., Cartsburg, M., Kumpe, D., and Widiker, J. (2008). Bizycle: Model-based interoperability platform for software and data integration. In *Proceedings of the MDTPI at ECMDA*.

Panella, M., Marchisio, S., and Di Stanislao, F. (2003). Reducing clinical variations with clinical pathways: do pathways work? *International Journal for Quality in Health Care*, 15(6):509–521.

Yang, J., Ginige, A., Mayr, H., and Kutsche, R.-D., editors (2009). *Metamodeling Foundation for Software and Data Integration*, volume 20 of *Lecture Notes in Business Information Processing*. Springer Berlin Heidelberg.

Yang, X., Han, R., Guo, Y., Bradley, J., Cox, B., Dickinson, R., and Kitney, R. (2012). Modelling and performance analysis of clinical pathways using the stochastic process algebra pepa. *BMC Bioinformatics*, 13(14):S4–S4.

Zand, e. K. (2002). Integrated care pathways: eleven international trends. *International Journal of Care Coordination*, 6(3):101–107.