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Lars Baacke
University of St. Gallen, lars.baacke@unisg.ch

Tobias Mettler
University of St. Gallen, tobias.mettler@unisg.ch

Peter Rohner
University of St. Gallen, peter.rohner@unisg.ch

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Baacke, Lars, University of St. Gallen, Mueller-Friedberg-Strasse 8, CH-9000 St. Gallen, Switzerland, lars.baacke@unisg.ch

Mettler, Tobias, University of St. Gallen, Mueller-Friedberg-Strasse 8, CH-9000 St. Gallen, Switzerland, tobias.mettler@unisg.ch

Rohner, Peter, University of St. Gallen, Mueller-Friedberg-Strasse 8, CH-9000 St. Gallen, Switzerland, peter.rohner@unisg.ch

Abstract

Structural changes and increasing market dynamics in the health care sector intensify the hospitals' need for cost-savings and process optimization. A first step is the documentation of processes in order to clarify the actual needs. As in health care processes are rather complex and often different players with divergent demands are involved, a disciplined approach to effectively and efficiently model processes is required. For this purpose, in this contribution a component-based modelling approach is presented and applied.

Keywords: Business Process Management, Design Research, Health care, Workflow.

1 INTRODUCTION

The health care sector is confronted with unsatisfactory performance in costs (i.e. health expenditure) and quality (i.e. effectiveness of service delivery and medical malpractices) for years (Porter & Olmsted Teisberg, 2004). Affected organisations counteract these deficiencies by various changes on strategic, procedural, technological, and cultural level. Horizontal mergers, outsourcing and shared services, public-private-partnerships, managed competition, integrated and preventive care, new medical procedures and information systems, clinical information interfaces, and digital imaging are only few examples for the dynamic environment and related challenges of health care organisations (Denis et al., 2000; Ginter et al., 2002; Ham, 2003). However, transformation projects often fail or at least do not meet raised expectations due to unexpected influences and obstacles (Berg, 2001; Lorenzi & Riley, 2004). These are in most cases the result from the high *complexity* of change projects. Complexity is related to the number of elements of a whole system as well as their interrelations (Schneberger & McLean, 2003). Looking at an enterprise or hospital from an intra-organisational perspective, this understanding covers organisational and procedural structures as well as the information processing landscape and the target systems of employees (Mettler et al., 2008). From an inter-organisational perspective, involved stakeholders (e.g. patients, health care service providers, suppliers, administrations, competitors, insurance providers), regulatory conditions, requirements of the market (e.g. collaborative service production), etc. have to be considered (Denis et al., 2000). These circumstances point out the complexity of health care organisations (Anderson & McDaniel, 2000) and respective changes, and clarify the need for transparency, in order to identify potential areas of modernisation as well as to derive concrete actions for a successful transformation.

Prerequisite for transparency is the comprehensive understanding of relevant structures and influences basing on respective documentations. However, looking at current change projects (regardless whether technically, organisationally or strategically motivated), required information is costly gathered primarily within those projects by internally responsible persons or expensive external consultants. Resulting documentations are closely aligned to the goals of the respective project and their quality, to large extents, depends on knowledge and experiences of the modeller. Thus, they are often not reusable for other purposes and integrable to existing documentations. A model-based representation of knowledge provide the foundation for documenting organisational architectures in a standardised, comprehensible, and interoperable way which is the basis for a cross-organisational identification of deficiencies and the design of a targeted state, for communication with involved stakeholders as well as for derivation of the transformation process itself.

Although models are well known and accepted for abstracting real life systems in medical research, they are not yet broadly diffused for documenting *business-related* knowledge in health care organisations. In contrast to medical or biological models which are widely accepted (e.g. Rector et al., 1997; National Library of Medicine, 2005), business-related models are applied to homogeneous groups of organisations, single organisations or even specific units. While re-use is limited, effort for creating new business-related models is unequally high. In addition, business process models typically involve several people with different perspectives and comprehension (Vassilacopoulos & Paraskevopoulou, 1997). However, there are much more influencing factors that constrict broad diffusion of process modelling, such as the confusing variety of modelling notations for similar purposes, the incompatibility of different tools and the integrability of respective models, the dependency on modellers' knowledge and experiences, the diverging levels of detail and abstraction, the inconsistent use and poor definitions of organisational terminologies, or the lack of maintenance and up-to-dateness which are limiting re-usability (Chen et al., 2008; Curtis et al., 1992; Christov et al., 2007).

This contribution addresses this heterogeneity and uncertainties by proposing a component-based modelling approach. The composition of predefined *Generic Activities* (GAs) establishes a common terminology and understanding of what a process is. It aligns the levels of detail and abstraction, and finally enables compatibility of independently created model parts as well as their combination to complete processes. For that purpose, a proven concept for development of GAs is being adopted from public sector research, and its applicability in the health care domain is discussed.

After the description of the research method in the subsequent section, the conceptual foundations and the procedural model for identifying the demanded model components are presented in section 3. Then, the identified model components and practical aspects of applying GAs for modelling processes of the health care domain are discussed in section 4 by exemplifying a concrete model instance. The main findings and topics for further research are summarised in the last section.

2 RESEARCH METHOD

As the documentation of organisational knowledge is a rather pertinent and practical issue, engaged research is needed in order to provide rigorous solutions for this relevant problem. A theoretical basis that serves both relevancy and rigour of research and requires engaged research is that of design science research (Hevner et al., 2004; March & Smith, 1995; Venable, 2006). While natural sciences try to explain and predict behavioural aspects of the reality by developing and verifying theories, design-oriented research aims to build and evaluate innovative artefacts, in order to extend existing capability limitations. Artefacts represent the actual results of a design process. They can be characterised as "constructs, models, methods, and implementations" (March & Smith, 1995). The model components presented in this contribution can be categorised as constructs since they are used as essential building blocks within process models.

In order to ensure the quality of a new artefact, the design-oriented approaches inherently consist of two iterative steps: *build* (i.e. construction of the artefact in a transparent and traceable way) and *evaluate* (i.e. activities to prove innovativeness and ability to solve the addressed problem). In order to demonstrate the functional capability, effectiveness and efficiency of the developed problem solution, analytical (e.g. architecture analysis), descriptive (e.g. scenarios), experimental (e.g. simulation), or observational (e.g. case study) evaluation methods can be applied (Hevner et al., 2004). As it was our aim to test the GAs (which are considered the artefacts of this research) in a 'real world' setting and it is difficult to 'simulate' a health care environment, we chose the case study method to evaluate our findings (Kitchenham et al., 1995; Smith, 1990). In doing so, a project with five hospitals was started aiming at the depiction of the logistic processes using the identified GAs. An extract of the findings is presented in the subsequent sections. For illustration purpose, the Business Process Modeling Notation (BPMN) is used. However, other modelling notations such as Event-Driven Process Chains, Object Process Methodology, or flow charts can be applied since the proposed findings are notation independent to a large extent.

3 IDENTIFICATION OF GENERIC ACTIVITIES

3.1 Configurative and Compositional Mechanisms of Reference Modelling

For purposes of reducing heterogeneity of process descriptions by means of standardisation and improving syntactic, semantic as well as pragmatic model quality (Lindland et al., 1994), the concept of reference modelling provides generic mechanisms for reuse and adaptation based on predefined models or model components (Thomas, 2005). Mechanisms of adaptation can be categorized into configurative (Gottschalk et al., 2007) and compositional concepts (vom Brocke, 2007). Examples are the configuration of business processes within standard software applications (Dreiling et al., 2005) or the composition of independent software services to complete business workflows (Szyperski et al., 2002). The configurative top-down mechanism requires extensive knowledge about feasible variants potentially occurring within the process and the respective conditions for those variants which have to be formalised to configuration parameters. Although the adaptation effort is considered low, the construction effort – especially in complex domains – is comparatively high (vom Brocke, 2007). As allowed variants have to be known in the development phase of the reference model, flexibility in creating new (innovative) process solutions during adaptation phase is as limited as the applicability of the predefined models for differing situations which are not supported by the reference model and its configuration parameters. Thus, the configurative mechanism is suitable for highly standardised and well structured processes.

In order to model processes in a more complex, distributed environment, compositional mechanisms of adaptation are considered more suitable (Reichert & Dadam, 1998; Baacke et al., 2007). Especially in information processing domains, process structures are very heterogeneous but basic activities (i.e. model components) recur regularly. Bottom-up composition of modular activities promises moderate effort for adaptation. Although composition supports restricting mechanisms (e.g. by using combination rules) to ensure model consistency and plausibility, the potential for process innovation and flexibility to depict both the individual as-is and the potential to-be situation are high. As a consequence, composition of standardised GAs is considered an appropriate adaptation mechanism for distributed modelling of cooperative processes.

3.2 Applicability of Public Sector Modelling in the Health Care Domain

As the component-based approach used for this contribution originates from the public sector (PICTURE Consortium, 2006), the question arose if it is applicable for business process modelling in the health care domain as well. Although processes in health care organisations are considered rather complex and correct outcome is crucial, there are many similarities in the service production of public and health care services. Example characteristics are

- Division of labour through specialisation and function-oriented organisation
- Cooperative service production involving several specialists and resulting in a number of organisational interfaces
- High autonomy of cooperating units
- Decision-intensive processes (and variable results) cause structural complexity
- Occurrence of similar activities in different processes
- Little experience in process modelling and heterogeneity of existing documentations.

At least for workflows of information exchange and processing as well as for administrative processes the appropriateness of compositional (compared to configurative) process modelling can be derived. Due to the specificity of medical treatment and extensive analogies to administrational processes, this contribution excludes processes of diagnostics and therapy and, instead, focuses on modelling more administrative processes of enterprise management, patient management, care administration, communication, supporting services and business support (Helfert et al., 2005) which predominantly focus on information management as well as procurement and provision of medical commodities for actual treatments. Such surrounding processes (internal and external) in general aim at providing a required quantity of information or products (in the required conditions and in time) for appropriate cost to the right customer (Plowman, 1964).

3.3 Decomposition of Modelling Constructs

As already mentioned, the component-oriented modelling approach is based on standardised GAs. Depending on the used notation and the understanding of the modeller, tasks are not only represented by activities or functions but also by organisational units, documents, events, etc. In order to standardise process models and to ensure compatibility to other process models and other model types, a precise differentiation of *Generic Activity* and respective *Processed Object* (PO) is demanded (Baacke et al., 2007). This differentiation is visualised in Figure 1.

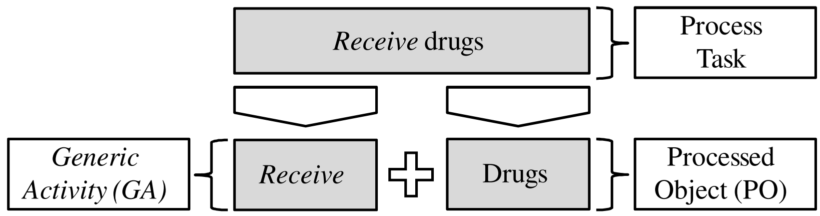

Figure 1. Differentiation of process tasks into GAs and POs.

Although for this contribution medical treatment processes and their specific activities have not been analysed, the conceptual differentiation between GAs and POs supports consistent access and processing of information also for medical purposes (cp. Figure 2).

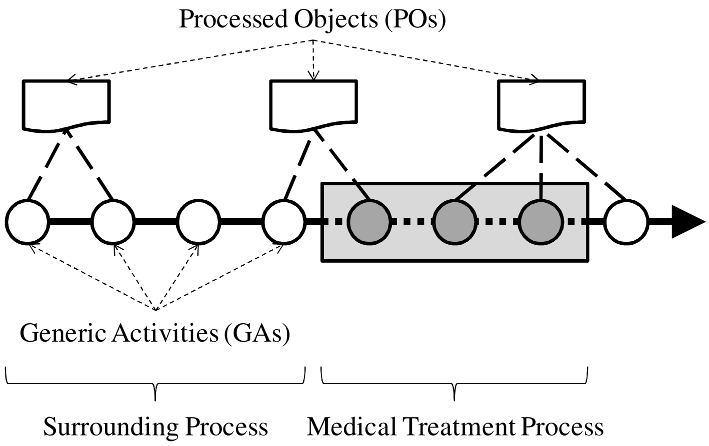

Figure 2. Surrounding vs. medical treatment processes.

Depending on the notation used for modelling, further entity types can be connected, e.g. responsible organisational units or supporting information systems (Baacke et al., 2008).

3.4 Procedure for Identification of Generic Activities

The procedure for identification of GAs conforms to the iterative build and evaluate phases of design research (cp. Section 2). The main steps as well as expected results are specified in Table 1.

Design activities	Phases of design research	Expected results
(1) Identification of GAs	Build	Initial GA catalogue
(2) Initial evaluation	Evaluate	User feedback Example process models
(3) Revision	Build	Evaluated GA catalogue
(4) Final evaluation	Evaluate	User feedback Example process models Detailed GA documentation

Table 1. Design activities and expected results of the methodology.

Due to the similar characteristics of processes in public administrations and support processes in health care organisations, not all GAs had to be newly identified. Instead, already developed GAs (Baacke et al., 2008) have been reused to some extent. However, the procedure for identification has been applied without modifications (cp. Figure 3).

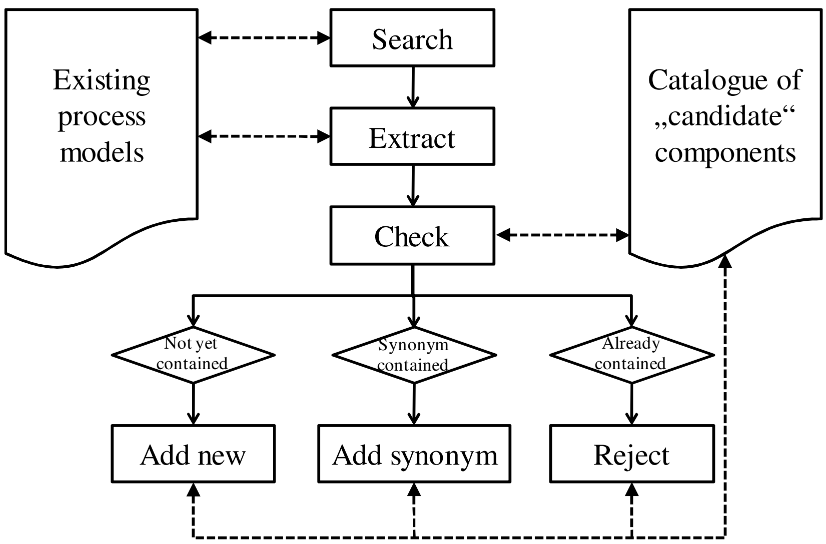

Figure 3. Procedure for identification of GAs.

Analysing existing process models, an activity, function, task, or corresponding element was selected in the first step in order to identify a new GA candidate. In doing so, the core activity had to be extracted (generalisation). As not all selectable components necessarily need to be activities (cp. discussion of heterogeneity of models in Section 3.1), they had to be (re-) phrased as a verb (e.g. “receive” instead of “reception”). This activity then became a potential GA candidate. In the third step, the catalogue of existing GA candidates – which due to the reused GAs was not empty – has been checked whether the new candidate or a synonym was already contained. If a synonym was contained, the new GA candidate has been added as an alternative. Subsequently, the procedure iterated until no new activities were identified respectively the GA catalogue was considered to be complete. As the

GA catalogue was not empty at the beginning, the case of synonym occurrence has frequently been experienced.

3.5 Resulting List of Generic Activities

Result of these design activities is the catalogue of GA candidates (including synonyms) which had to be evaluated. Evaluation was especially important as existing GAs from the public sector domain had been adopted without further reflections. Evaluation should identify those GAs and synonyms which are considered inappropriate or irrelevant for health care processes. In total, the catalogue consists of 19 GAs which are listed and categorised in Table 2. Thereby, 17 GAs from the public sector could have been reused with minor modifications (esp. regarding synonyms). Only two GAs had to be newly added to the catalogue which confirms the theoretically derived similarities of service delivery processes in public administrations and non-medical processes in health care organisation (cp. Section 3.2).

Categories	**Generic Activities (GAs)**
Transfer/Communicate	Send/Hand over/Deliver, Receive/Accept, Demand/Follow up
Analysis	Retrieve/Enquire, Check/Verify, Examine/Analyse
Production	Produce/Create, Change/Update/Complete
Transformation	Capture/Enter/Fill in, Print, Scan, Copy
Administration	Archive, Dispose/Delete, Start/Open
Miscellaneous	Pay, Sign, Prepare/Setting up, Store/Relocate

Table 2. Categories and related GAs.

Such categorisation does not only support users in quickly finding and selecting appropriate GAs but also enables implementation of mechanisms to ensure consistency and plausibility of the resulting models by double-checking syntactic and semantic rules (e.g. whether the GA “send” is connected with a corresponding “receive” or not). In addition, each GA is further specified defining its meaning, category, evaluation status, etc.

Although it was not in the focus of this investigation, typical POs have also been identified using the same, slightly modified procedure. Instead of extracting activities and re-phasing as a verb, components have been analysed with regards to contained objects such as documents, information or materials (e.g. medical products). Respective objects have been extracted and added to a PO catalogue. Some examples of the identified POs are drugs, internal requisitions and external purchase orders, invoices, and delivery notes.

4 CASE STUDY

In order to exemplify and evaluate the theoretical results presented above, and to practically prove the applicability of the concept in the health care domain, a case is presented in this section. Thereby, special emphasis is given to the illustration of the expressive power of the identified components. However, to validate our proposal not only the semantic, syntactic and pragmatic aspects are important (Lindland et al., 1994) but also the domain appropriateness since the model components are intended to capture the knowledge of the problem domain for the purpose of communication and understanding among the stakeholders (Siau & Rossi, 1998; Mylopoulos, 1992). Thus, Krogstie et al. (Krogstie et al., 1995) propose to subsume this as explicit evaluation criterion called ‘knowledge quality’.

4.1 What is the Case?

Hospital pharmacy is an interesting arena to bring many functions and relationships together for study. On the one hand, the hospital pharmacy acts as an interface between the many external stakeholders involved in supply of drugs and the particular hospital. The process documentation therefore has to comply with many, sometimes divergent, needs. On the other hand, it serves as a focal point for many internal departments (medical and non-medical). For example, the pharmacy is not only responsible for drugs supply but also offers consultancy services to clinics, prepares medical devices for the laboratory, provides additional information for the patient administration and financial department etc. Having this gatekeeper role, the hospital pharmacy is supposed to be an important opinion leader when logistic processes have to be re-engineered.

For the case study expert interviews represent the essential sources of information, and are the primary means for evaluating the utility of our approach. Semi-structured interviews were conducted with three hospital pharmacists and two purchasing managers who have at least 10 years practical knowledge in medical as well as in administrative needs. Main characteristics of the involved hospitals are provided in Table 3.

Characteristics	**Units of Analysis**				
	Hospital A	Hospital B	Hospital C	Hospital D	Hospital E
# Beds	400	350	300	200	550
# Inpatients/year	9,500	8,000	7,000	7,800	21,100
# Outpatients/year	46,000	40,000	24,000	39,000	315,150
Automation level	low	low	moderate	low	moderate

Table 3. Characteristics of the surveyed hospitals.

It is important to note that we did not involve explicit control or manipulation of any variables of the subject under study. However, to gain that deeper understanding we acknowledge our own subjectivity as part of research.

4.2 Application of the Components in the Context of a Hospital Pharmacy

Hospital pharmacies have a permanent obligation for service delivery, not only under usual circumstances, but also in case of a crisis. Therefore only a marginal fault tolerance in the procurement processes is admissible. Sophisticated mechanisms to manage the entire supply chain are needed. However, in health care this is more aspiration than reality (Burns, 2002). To understand the current drawbacks it is crucial to have an overview of the present situation. A key process is the general order routine for purchasing regular drugs (cp. Figure 4). We used this process to evaluate our proposal against the ‘knowledge quality’ criterion (cp. introduction of Section 4).

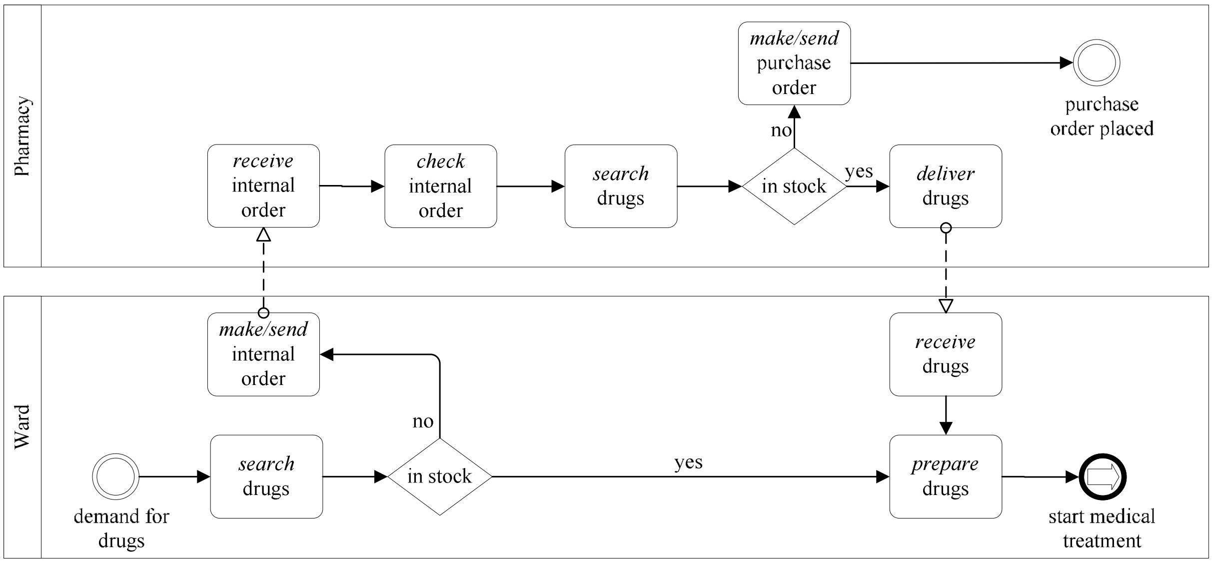

Figure 4. *Example of GA application to picture a logistic process.*

As described in Section 3.3, essential components for modelling processes are GAs and POs. When using BPMN as standard modelling language, the GAs can be used to determine the activity (italic text in rounded-corner rectangle) to be done within a task. The POs (plain text in rounded-corner rectangle) define the object an activity is operating on. However, other BPMN standard elements such as organisational responsibilities (swim lanes), events (circles) and gateways (diamond shapes) can be used as well. For instance, the presented process model starts with an event called ‘demand for drugs’. This event triggers a task within the ward containing the GA ‘search’ and PO ‘drugs’ which on its part causes a decision. The interface to the medical treatment process is represented by a black circle labelled ‘start medical treatment’.

4.3 Lessons Learned

Although not accustomed to think ‘in boxes and arrows’, the hospital pharmacists were able to understand and interpret the process descriptions. Furthermore, with a brief training they were able to model even complex processes by their own (simplicity of modelling). After a short period of learning how to model with predefined GAs, the time to depict a process or sub-process was significantly reduced even for inexperienced partners. In addition, comparability of processes has been improved: Same processes were modelled for different hospital pharmacies. Although there were considerable differences in the realisation of the processes, the flow of activities was still comparable since a standardised terminology was used. The terminological standardisation based on predefined GAs not only improves comparability of process models but provides an important foundation

- to diffuse modelling in health care organisations by adressing also inexperienced users,
- to harmonise decentralised modelling activities,
- to enhance the efficiency of modelling and
- to enable extensive, model-spanning analyses.

Although the case study with hospital pharmacists could not evaluate all of these potentials, as a first step the applicability of the GA-based modelling concept by inexperienced users has been proven successfully. However, the suggested standardisation of modelling terminology still leaves room for misinterpretation. In order to further support the modeller, a system of rules should to be incorporated which limit reasonable GA combinations or even suggests frequently used GAs (e.g. based on GA patterns). Such mechanisms will improve model quality by extending consistency and plausibility checks.

5 CONCLUSION AND FURTHER RESEARCH

In this contribution, an approach of component-based modelling developed for public sector organisations was introduced and adopted in the health care domain. Summarising, this adoption is considered quite successful by hospital pharmacists as modelling with GAs considerably improved standardisation and comprehensibility of process models. After brief introductions even inexperienced case study partners were able to conceptualise their process knowledge re-using predefined GAs. In addition, the link-up from GAs to POs supports consistency and model-spanning analyses.

However, some limitations became visible. Although only few GAs had to be newly introduced, the list of GAs is not yet representative as it bases on a limited number of processes used for identification. Thus, further evaluation needs to be conducted in order to complete the specification. Furthermore, the occurrence of specific GA combinations should be analysed in order to identify typical process patterns. Such rules and patterns will significantly improve effectiveness, efficiency and quality of process modelling. In addition, more POs should be identified and categorised in order to further standardise modelling. As competition is not that intensive and externalisation of internal knowledge is not considered that crucial, it is furthermore planned to record and provide process description (best practices) in a common repository.

In order to address divergent processes perceptions of involved people (e.g. medical specialists or administrative staff) and to harmonise their model-based conceptualisation, the composition of GAs should provide alternative terminologies (e.g. synonyms), a set of individual rules to restrict combinations of GAs for plausibility and consistency purposes as well as transformations into user-oriented model views. Those semantic features extend classical syntactical checks significantly. They can be implemented by means of ontologies (Uschold & Jasper, 2001). If GAs and POs are depicted in an ontology they can be re-used (instantiation and composition) by mapping the ontology concepts and properties to the meta model elements of a suitable notation, such as UML Class Diagram or BPMN (Saeki & Kaiya, 2006). The ontology-based standardisation of model content not only improves transparency and model quality but especially provides the foundation for other powerful mechanisms such as semantic analyses, e.g. regarding concrete weakness patterns (Baacke et al., 2008). Weakness patterns are combinations of model components that represent a deficiency, such as a media break or an inefficient communication channel. On that basis, analyses can be automated to some extent. As automated analyses are not limited to single processes, they can easily be applied to the whole process landscape. Hence, further research will aim at the development of standardised analysis patterns specialised on issues of the health care domain.

In order to realise and prove these potentials, the component-oriented and ontology-based modelling approach is currently being implemented in a software tool which will be used for extensive evaluations and further developments (PICTURE Consortium, 2006). As the case study presented in this paper just prove applicability in the context of hospital pharmacies, further – more extensive – evaluations have to address syntactic and semantic interoperability, comparability, processability and quality of resulting models as well as efficiency of process modelling. Last, it has to be investigated if this approach can be adopted to other industries, such as finance or insurance, as well.

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