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Reference Modelling in Health Care

State of the Art and Proposal for the Construction of a Reference Model

The quality of medical services gains increasing importance in the consumer perception. Up to 2003, the outpatient physicians had sole responsibility for the implementation of a quality management system. To standardise the utilisation of such systems, the legislature decided on the mandatory implementation of a quality management system (QMS) by 2009. However, the introduction was slow due to very time consuming and costly processes. Knowledge about the own processes is an essential part of QMS. Process models are the common tool to document them, as well as being effective instruments to manage organisational structures. To make the design process of such models more effective, reference models are built to foster the reuse of common and best practice solutions in similar cases. This paper aims to apply the theoretical knowledge of reference modelling in the context of the ambulatory sector. It presents the empirically based construction of a reference model. Therefore structured interviews were carried out with physicians of various disciplines.

1 Quality Management in Outpatient Health Care

Health services become increasingly comparable because they are widely discussed in public media and the internet. This leads to an increase in quality-based selection of physicians by the patients. In the competitive market environment, quality management (QM) becomes to an important task in the health care sector. Its application promises a high level of care and a cost-effective use of resources. Quality management can be motivated internally (e.g., physicians want to improve their care) or externally (e.g., legal changes or rules of health insurance providers).

In case of the German health care system, in 1999 the 72nd Conference of Health Ministers defined goals for a unified quality strategy. Systematic quality management was specified for the ambulatory sector (Kunhardt et al. 2005). Based on the experience of the stationary sector, the law of modernisation of public health insurance (Deutscher Bundestag 2003) specified obligations to participate in cross-sectoral QM activities and to implement or to advance a praxis‘ internal quality management (Diel and Gibis 2004). It also defines the basic requirements of QMS against the organisational structure and against process organisation.

A QMS is defined as the part of the management system ‘to direct and control an organisation with regard to quality’ (DIN 2008). QMS aim to make the organisations capable to improve the quality of their products or services according to their goals.

The schedule of the directive plans that all practices have to implement a QMS by December 2009. Currently, 20 percent of the practices have not implemented a QMS yet (Burgdorf et al. 2009; Stiftung Gesundheit 2009). This is due to the lack of incentives and sanctions. The implementation of QMS is a complicated task requiring additional resources of practices. However, these resources rarely exist in the small size practices.

A study of the German ‘Stiftung Gesundheit’ shows that the acceptance of medical professions

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is divided. Still, many medical professionals see in the implementation of a QMS rather an additional overhead than an opportunity to improve transparency, quality and process control (Stiftung Gesundheit 2009). The most used QMS in the ambulatory sector are based on the standard family of DIN EN ISO 9000-family (24.1 %) (Deutsches Institut für Normung e.V.; Europäische Normen; International Organisation for Standardisation) and the system called 'Qualität und Entwicklung in der Praxis' (QEP, 26.4 %).

The QEP is a specific QMS for the ambulatory sector developed by the 'Kassenärztliche Vereinigung'. According to Stiftung Gesundheit (2009), about 40 further systems exist besides the five most used QMS. They are mainly derivatives or in-house developments. A core component of QMS is the documentation of the most important organisational processes and responsibilities in order to gain the awareness for processes. This helps to define objectives, to initiate measurements and assess their achievement. The necessary process documentation varies depending on the QMS and the associated goals.

The domain-unspecific standard family of the DIN EN ISO 9000 (referred to hereinafter as DIN9000) gives the users quite a few liberties in the design. Users are not limited to the amount of processes and to the form in which the processes have to be documented. Only the QM processes have to be described.

Other QMS define a minimum number of processes which have to be documented. Table 1 summarises a process oriented comparison of the most commonly used QMS.

The benefit in terms of a real QMS is doubtful for dictating specific processes, a fixed number of processes to be collected, or completely filled quality management manuals; however, it demonstrates the goal to minimise the costs of implementation by the reuse of predefined components. Thus, the aim is to support the physicians or contracted service provider as much as possible but give them enough free space for the necessary creativity to implement an optimal solution. The objective of any solutions in this field should be to support a low-cost, time-efficient and functioning implementation of a QMS.

The conceptual modelling provides an approach to describe complex information systems in an understandable diagrammatic form. Process models nowadays provide a multi-used tool to analyse, manage, and improve business processes.

However, the construction of process models is a very time-consuming and costly activity. Furthermore, the model construction is highly related to the subject in the constructivism understanding. Thus models depend strongly on the experience and abilities of the modeller. Based on this, the reuse of conceptual models is discussed (Hammel 1999).

Reference modelling is an approach for reusing conceptual models (Schütte 1998). Reference models are models which are reused to construct another specific model in a similar but not necessarily identical situation (Brocke and Buddendick 2004). Reference models are built on the basis of common-practice or best-practice solutions. The minimisation of design and the increase of the user acceptance are expected with the use of reference models (Esswein et al. 2010).

The objective of the study is to demonstrate the process of constructing an adaptive reference model for the ambulatory sector based on empirical-grounded surveys. The reference model should accelerate the process of implementation. Furthermore, it should improve the quality of implementing a certifiable QMS. The users could be utilise the reference model as guideline on the one hand but on the other hand not be restricted by it. The research analyses existing development procedures for reference models and evaluates one of them in a case.

At the beginning the paper introduces the situation of QM and QMS in German practices. A

Table 1: Comparison of five most used QMS in the ambulatory sector

Name of QMS	QEP®	KPQM 2006	KTQ ®	EPA	DIN EN ISO 9000 ff.
Requirements for process documentation	yes	yes	yes	yes	yes
Further requirements for process documentation	Processes as well as general conditions of all praxis areas	Documentation of procedurals instructions of at least 10 processes of all practice aspects as flow charts	Practice processes and general conditions	Practice processes and general conditions	Processes according to the DIN-framework
Assessment tools	Quality-goal manual	/	Assessment manual	Assessment forms, Benchmarking database	/
User support for process documentation	QEP manual with sample documents, e.g., checklists, process templates for management processes, internal agreements	KPQM 2006 Information folder & Manual for flow chart development	KTQ-Manual with checklists, questionnaires, templates	Manual with checklists and process templates, software support	Framework of the DIN-standard

comparison will show that the process documentation is a necessary part of QMS in the outpatient sector. After the introduction, the theoretical foundations of reference modelling and especially the reference model construction are discussed. The chapter lays the foundation for the development process to be discussed in Sect. 3 by consolidating process models for reference model construction and modelling languages for reference modelling. The paper finishes with a discussion of research implications and with opportunities for further research.

2 Theoretical Foundations

2.1 Reference Modelling

Reference models are designed and intended for reuse. Considering this, reference models are a type of generic model. Their design emphasises the adaptability to different scenarios (Schütte 1998).

According to the literature review of Matook and Indulska (2009), 'the general aspect of model reuse dates back to the 1930s (Thomas 2006b) but was revitalised in the early 1990s by Scheer (1994), Österle (1995), and Hammel (1999) for the process modelling domain'. Up to the current date, a uniform understanding of the term *reference model* does not exist in the information science. A lot of literature is published in various German IS-research. Depending on the assumed understanding of the concept model, either mapping-driven model definition or construction-oriented model definition (Schütte 1998), different definitions for reference modelling that are reused frequently exist.

In the last twenty years, there has been a great deal of discussion about the characteristics of a reference model. In the early nineties (in mapping-driven model understanding), the reference models were understood as models which can be consulted for development of other models. Hars (1994) characterises them by universality, adaptability, and applicability. With the shift in model-understanding in the later nineties, these characteristics have been increasingly questioned and discarded as constituent attributes.

Brocke (2003) for example mentioned an area of conflict between the declaration and the adaptation of reference models. He argues that the degree of recommendations depends on a subjective perception. Similarly, the universality

depends on the actual use of the reference model. As the most important characteristic of reference models, he highlights the content-related support of the modeller through the construction process by a reference model. Hence, the relation between the reference model and the derived specific model is the only constitutive characteristic. Nevertheless, universality and recommendation character can be assigned as intentional attributes of a reference model.

According to this use-based definition, each model which is used for the construction of a specific model is a reference model. Thomas (2006b) takes up the discussion and points to the following scenarios:

- A reference model is developed and declared as such, but not used in practice.
- A model is used to develop a specific model but it is not explicitly developed or declared as a reference model.
- A reference model is developed and declared as such and also used to create a specific model.

According to the types of relationships between reference model and the derived model, the problem is posed that a reference model which is created and declared as such, but not used in practice, is not a reference model. Consequently, the reference model is characterised only by reuse. This strict positioning leads to the problem that models designed for reuse must wait for their reuse. We do not want to follow this strict position. In research, it is necessary to anticipate the use of solutions such as reference models. Their evaluation in practice remains and their recognition in the research community is needed. We attend to distance ourself from this strict viewpoint and argue that if a reference model is built for reuse and the research links to this design process or the design results in any findings, then one can call it a reference model, too. Also reference models as scientific artefacts have to be developed, discussed and possibly modified before they can see the practical application. In addition, the reference model is different from the specific model as soon as construction techniques are applied. Therefore, the declaration always precedes the application. In context of construction, reference models and specific models are different (Brocke 2003; Brocke and Buddendick 2004). According to the opinion of the authors, a reference model is also a model designed particularly for re-use, which must still apply. In particular when the reference model is based on an empirical analysis of detail models. In summary, reference models are blueprints of recommended practice to design a specific model (Fettke and Loos 2004; Schütte 1998). For further terminological discussion, we recommend the work of Brocke (2003), Thomas (2006b), and Delfmann (2006).

2.2 Design Principles of Reference Modelling

Design principles are special language artefacts which extend the regular modelling language (Brocke 2007). Synonymously, they are also called reference modelling techniques or design techniques. Design principles which define the rules of a reference model can be adapted to a specific model (Brocke 2003; Brocke and Buddendick 2004).

From the perspective of the reference model creator, the design techniques foster the adaptation according to his intentions. Those techniques reduce the fuzziness between creator and user of a reference model. Such reference models are also called adaptive reference models (Delfmann 2006). Scientific literature provides two general classes of such adaptation supporting techniques: formative techniques and rule-based techniques (Braun 2009).

The technique of configuration is part of the rule-based class. All model variations are pre-defined by the reference model creator. The user of the reference model is not involved in the modelling process (Becker et al. 2004). Moreover, he decides, by setting the values of configuration parameters, which views, presentations or model elements would be part of the specific model. In

this adaptation process the users of the reference model are always restricted to the parameters and the value range the creator defined.

A second class includes the formative techniques. These are the instantiation, specialisation (or free modification (Delfmann 2006)), aggregation and analogy construction. For a deeper insight, we want to refer to the related work of Becker et al. (2004), Braun (2009), Brocke (2007), and Delfmann (2006). In practice, hybrid forms (mixed forms) are often implemented to combine the most useful design principles with regard to possible application context. Hybrid forms promise a better cost-benefit ratio than the utilisation of only one design technique. Strict recommendations may be implemented using the technique of configuration. For model elements that can be optionally adapted, for example, the techniques of the specialisation modification or the analogy construction can be selected. Depending on the way the reference model constructor wants to guide the adaptation. These different design techniques can be applied in the reference model. In addition to these conceptual considerations, the flexible application of different design techniques in a reference model is also limited by modelling tools (Delfmann and Knackstedt 2007).

2.3 Development of Reference Models

Reference models have a major influence on the design of business processes. They include decision making components, such as business rules or policies. Hence a high quality specification of the reference model is important to ensure the optimal compliance with needs of the organisation. So far there are only a few studies focussing on how a reference model can be made of good quality (e.g., complete, accurate, and easily configurable) and how their quality can be measured (Matook and Indulska 2009).

For the reference model construction two questions arise: which reference modelling language should be used, and how to proceed?

To date, no modelling language exists which is specifically designed for reference modelling and no extension for common modelling language is enforced as a standard (Brocke 2003, Thomas 2006b). In context of the 'Architecture of Integrated Information Systems' (ARIS), Event-driven Process Chains (EPC) are often used for process modelling and the Entity Relationship Model (ERM) for modelling structural aspects (Becker and Schütte 2004, Delfmann 2006). In contrast, the Unified Modelling Language (UML) is used in object-oriented reference models.

The most important publications in the field of process models for the reference model construction are the investigations of Schütte (1998), Becker et al. (2001), Brocke (2003), Schwegmann (1999), Schlagheck (2000), Delfmann (2006). The phase model of Schütte (1998) describes the steps: problem definition, construction of a reference model framework, construction of reference model structure, and completion. These phases are formulated abstractly but serve as a basis for various following works, such as like the study of distributed reference modelling by Brocke (2003), the study of management of reference models by Thomas (2006a), and the study on adaptive reference modelling by Delfmann (2006).

It also forms the basis for the approach of Schwegmann (1999) and Schlagheck (2000) on object-oriented reference modelling. The research of Schütte is extended by Becker et al. (2002), who developed a project framework for construction of reference model . This work was summarised by Delfmann (2006) to a detailed procedure for construction and application of adaptive reference models.

The shortcomings of these approaches are that they are very focused on the participants of the reference modelling process and the abstract development steps as well as the necessary roles and modelling languages. However, there are no statements pertaining to how a survey has to designed to obtain information for the reference model, which documents can be considered

and how the surveyed information can be aggregated in a reference model. According to this deficit, Ahlemann and Gastl (2007) published an empirically grounded process model for reference modelling. It details the phases of reference model construction (construction of a reference model framework, construction of reference model structure) by the steps of inquiry (preparation and execution).

Thus, the process model of Delfmann (2006) and Ahlemann and Gastl (2007) are combined to the following main steps:

1. Definition of project objectives
2. Definition of reference modelling techniques
3. Preparation of inquiry
4. Execution of inquiry
5. Implementation of design techniques
6. Reference model construction and refinement
7. Evaluate the reference model
8. (Publish reference model)

3 Construction of the Reference Model

As a guideline for the development of the reference model, the previously described steps are used. If the aims of the project differ significantly compared to the process model for reference model construction, we adjust the sub-steps but retain the main phases of the development process.

3.1 Definition of Project Objectives

In the first step, the utilisation of the results has to be described and the profile of the adaptation parameter have to be defined. The project goal is to support the implementation of a quality management system in the ambulatory sector. The market model depends on the way of utilisation of the reference model. Currently, the reference model is a scientific artefact (Fettke and Loos 2004). For it a set of requirements can be derived from the project goal. These are strongly connected to the theoretical aims of reference modelling in general (see Sect. 2.1).

Req. 1 Reusability for similar problem situations

Req. 2 Useful adaptation support

Req. 3 Acceleration of adaptation

Req. 4 Recommendation character

The adaptation parameter we identified were the practice type (specialist or general practice), main subject of physician, the way of data processing (full, half, or non IT-supported) and the type of appointment system.

3.2 Definition of Design Techniques

According to the future users and the defined requirements (esp. Req. 2, Req. 3), the definition of the design techniques is guided by two principles. The techniques have to be understandable and simple because physicians are not modelling experts and the reference model should be clear without extensive consultation (Req. 1).

Nevertheless, design techniques are essential to guide the user through adaptation. Thus, they are very important for the success of the reference model. As argued in Sect. 3.4.1 and due to the non-existent standard reference modelling language, we chose the UML activity model as basis of the reference modelling language.

Design techniques are often implemented by special language constructs, which have to be implemented additionally. The UML provides several options to customise its languages. According to OMG (2010), there are profiles to extend the 'existing meta model with constructs that are specific to a particular domain, platform or method'. Furthermore, first-class extensions can be used to change directly the UML-meta model. For the customisation (specification) of the language we use the profile-mechanism of UML. This lightweight extension mechanism supports the specialisation of the basic UML meta-types and adds additional constraints to them.

For this purpose, we basically added the *RM-Region* as a specialisation of the regular region

element and the *RM-Annotation* as a specialisation of the annotation element. Regions are applied to group model elements within a diagram (e.g., to add a termination event for that group). In the reference model it is used similarly. However, we want to group elements for which similar design techniques exist. The advice about the handling of these regions through adaptation can be specified directly in the head of the *RM-Region* or by a *RM-Annotation*. They can be linked to a model element or to a group of elements collected in a *RM-Region*. The specification of design techniques is in accordance with the five construction techniques: configuration, instantiation, specialisation, aggregation, and the analogy construction (see Sect. 2.2).

The annotations are defined in the following syntax. It begins with the stereotype «RM-Annotation». It is followed by the declaration of the design techniques. Depending on the type of chosen technique, further structured advices are specified after a colon. To highlight the adaptation advices in the reference model, we change the background for the representation (the so-called concrete syntax) of the reference model elements. Independent of the formal specifications of adaptation advices, further explanation or notification can be added in plain text to the design techniques at the end of the annotation. The terms that define the design techniques have a great non-formal proportion due to the better understandability for non-modelling expert; however, they are formal enough to interpret it in order to computerise analysation of design technique, affected model elements, and the conditions for adaptation in case of configuration.

In case of specialisation, for example, the *RM-Annotation* can look like: '«RM-Annotation» specialisation [-]: may be omitted depending on the type of ECG unit'. This example is shown in the bottom part of Fig. 3. A group of elements selected by *RM-Region* is shown.

The linked *RM-Annotation* stated that at this point the reference model user can eliminate some activities, depending on the specifics of the ECG unit. For example, in the case of a system with an automated standby, the activity 'Switch-off ECG' can be eliminated. Although this is a relatively simple example, it shows how those recommendations support the adaptation process effectivily.

Beside the two essential elements of *RM-Annotation* and *RM-Region*, some further elements are introduced to the reference modelling grammar which are implemented to use the design principle of instantiation (see legend of Fig. 3).

3.3 Implementing the Design Techniques

In the phase of reference model implementation a suitable modelling tool has to be selected. Delfmann and Knackstedt (2007) have evaluated different modelling tools with respect to the ability to describe design techniques. None of the seven tested tools were able to support all generative mechanisms. However, they found that with scripting language or macro declaration support, the design techniques can be implemented in some modelling tools. This is the common way that generic modelling tools can be used.

For our research we decided to use a meta-CASE tool (Computer-aided software engineering) which is called Cubetto Toolset® (Cubetto Toolset). The toolset is a generic tool, which functions on the basis of the meta modelling language E^3 to construct, expand or apply different modelling languages (Greiffenberg 2004). A graphic editor as well as an API allows the introduction of new concepts into modelling languages and new functions into the toolset.

To define the necessary elements for the reference model we built a UML profile. Within the profile, new objects are defined by stereotypes which refine the existing UML elements. These stereotypes are depicted in the legend of Fig. 3.

Using the graphic editor of the tool set and the meta model editor, we implemented the tailored representation as well as the new language concepts.

3.4 Process Analysis

3.4.1 The Survey Procedure

The empirical inquiry is carried out to capture the domain experts' knowledge. Therefore the interview partners need to be selected and the interview guide has to be created.

Different strategies exist which are able to select interview partners for the empirical inquiry (Ahlemann and Gastl 2007). We decide to make a *chain sampling*, which means that we use an existing network to identify the experts. With this method, the cost of finding and explaining, as well as inclusion are less. A broader sampling can be carried out in the phase of reference model validation. Overall, we interviewed six physicians of four different practices. All participants are interviewed twice.

The process analysis was executed in two stages. At first, a pre-interview was made to build the interview guide. In this phase, usual organisational characteristics were questioned (e.g., number of employees, proportion of unannounced visits, and main services). It was also asked about existing documentation or other helpful documents (e.g., standard operation procedures, guidelines, disinfection policies), which were incorporated into the survey process. The results of the pre-interview are depicted in Table 2.

With the pre-interviews in the early phase, two main methods of questioning have emerged as practicable to overcome the issue that the participants tend to fall into small-talk. If practices have a very strict appointment system and only few unannounced visits, we asked for the main and common diagnosis. The diagnoses were then assigned typical therapy processes.

The second method was to document the service catalogue of practices directly. This procedure was performed if a lot of different diagnosis were treated with a small services portfolio. Both methods are top down procedures that have a service landscape as a result.

Afterwards the business services are refined successively. All processes were discussed and documented with annotated flow charts because they are good to use in discussion with non-modelling experts e.g., physicians. The concepts of flow charts are very intuitive comprehensible and easy to migrate into other modelling languages.

Therefore, we are guided by typical process characteristics (Becker and Kahn 2008):

1. What are clinical (so-called medical outcome) and economical process goals?
2. What is the order of the activities?
3. Who is responsible for the activities?
4. What are the process inputs (resources, documents)?
5. What are the process outputs (clinical results, documents)?

Using the example of ECG process, the procedure will now be illustrated. In the first step, the ECG-service was identified as a main service in the general practice. The goal of the process is the guideline-conform diagnosis and patient satisfaction. The physician and the doctor's assistant are responsible for the process. Necessary resources are, besides the common practice infrastructure (e.g., room, treatment seat), the ECG unit. Further process inputs are the current health record of the patient, which informs about medical history and possible contraindications. The process was documented in detail considering the existing flow charts. It was discussed and annotated in case of uncertainties. The process analysis ends with the specification of the output, which is the ECG curve in digital as well as in analogue form.

After the two interviews per practice, the annotated flow charts were migrated to activity charts of the UML (Gehlert 2007). We decided to use the acitivity chart as the goal modelling language for the reference model (OMG 2010) because it is widely accepted in the research community and it is flexibly extendible. Doing the migration, we used intensively the annotation of activity

Table 2: Overview of practice profiles

Practice profile	Specialist in neurology & psychiatry	General practitioner	Specialist in cardiology & specialist in neurologist & psychiatry	Dentist
Number of physicians/ Number of employees	1/2	2/4	2/8	1/4
Number of interviews	2	4	4	2
Proportion of unannounced visits	< 5 %	> 95 %	< 5 %	< 3 %
Main services	Electromyography, electron neurography, electroencephalography	Rapid test, electrocardiogram, pulmonary test, 24h haemodynamometry	Rapid test, resting ECG, pulmonary test, long-term haemodynamometry, wound care	Prophylaxis, ceramic restoration, bleaching, teeth cleaning, x-ray examination

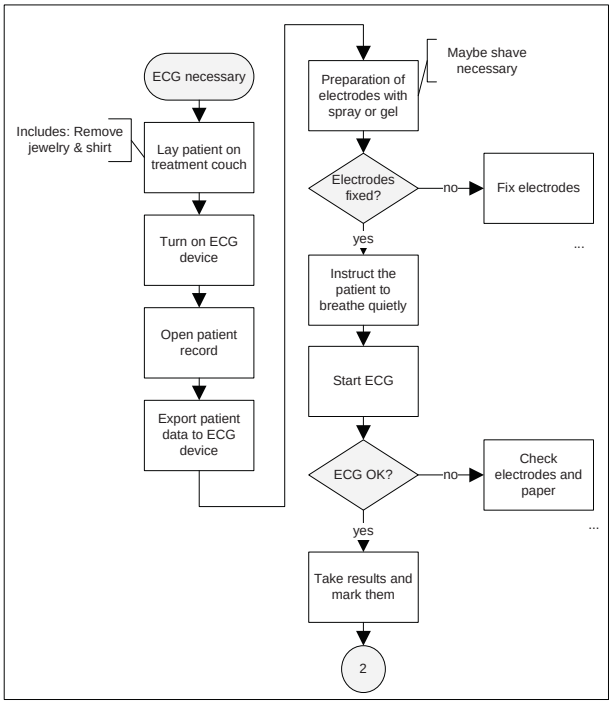

Figure 1: Flow chart of ECG process

diagrams to document process pre-conditions as well as further information, which are later used to make the model more generic. For example, they guide the decision on the use of design principles.

3.4.2 Results of the Process Analysis

Through the analysis process, two results for the reference model are achieved. At first, it helped to finalise the reference model framework. This framework comprises the main process categories in the outpatient sector. The framework is based on the typical process dimensions: supporting processes, operational processes and management processes. Operational process categories are, e.g., diagnosis processes, therapy processes, anamnesis processes as well as consulting processes. The framework is depicted in Fig. 2. The reference model framework systematises the single diagrams of the reference model, which supports the identification of single models, and the completeness of the reference model (Schlagheck 2000).

The second main result of the analysis is the identification of standard processes (e.g., admission of patients, communication process with health insurance and the 'Kassenärztliche Vereinigung', emergency treatment of patient, patient data management) and the detailed proc-

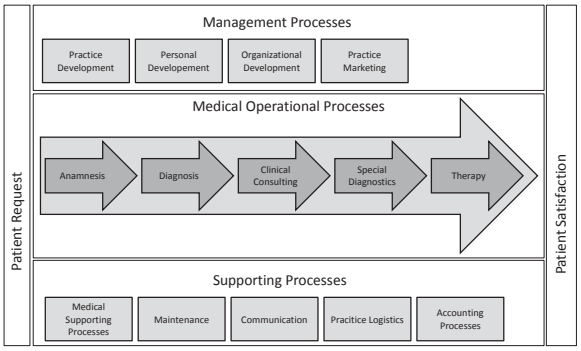

Figure 2: Framework of Practice Processes

ess charts. The investigation of standard processes was even hard due to the differences in the sample (see Table 2).

3.5 Construction of the Reference Model

The reference model construction starts with the development of the reference model framework. It is used to systematise the process models. A reference model framework provides uniform access to the reference models and structures the process models (Delfmann 2006). It reflects the multi-perspective view on the information system of the practices.

The construction of each part of the reference model is based on the results of the process analysis. The structured and unstructured data of the process analysis are consolidated in an iterative procedure to the process models. This process differs from traditional modelling construction because the modellers have to think ahead to the application of the model.

The modellers have to support the reuse by implementing generic model elements. However, they should not specify the model element too abstract because the reference model would lose too much recommendation character. This situation is one of the great dilemmas of reference modelling. We encounter this problem in a paradigmatic way, due to Delfmann (2006) giving no advises to solve this issues.

Table 3: Decision matrix for selection of design techniques

Possibility of parametrisation	Pre-defined parameter range	Strictness	Design technique(s)
yes	yes	high	Configuration
yes	no	high	Configuration, instantiation
yes	no	middle	Aggregation
no	no	middle & high	Specialisation
no	no	low	Analogy construction

After the process modelling, we annotated the model element with information on reuse terms like the parametrisation, influencing parameters, and the strictness of the recommendation. This step supports the selection of adequate construction techniques in the next iteration. Table 3 shows the decision matrix for that selection. Finally the parametrisation and the formal description of the implemented techniques were carried out.

The result is a hybrid adaptive reference model. It combines non-generic and generic construction techniques. Thus, the model is neither a monolithic construct nor a component library (Delfmann 2006). Moreover, the resulting reference model includes the definition of adaptation rules and the preconceived model components.

Figure 3 shows a section of the final reference model, which depicts the ECG-diagnosis process. It is classified into the category of 'special diagnostics' (cf. Fig. 2). It shows how the adaptation is guided by the configuration. The corresponding configuration parameter is the deepness of IT-support.

In this example, two design techniques are implemented. On the one hand the configuration is used. The elements for configuration are marked by three RM-Regions with the configuration parameter 'IT-system support'. This parameter can have one of the following values: full IT-integration, a partly IT-support, or no IT-support (e.g., in case of a paper-driven processes). These configuration alternatives are specified by the term:

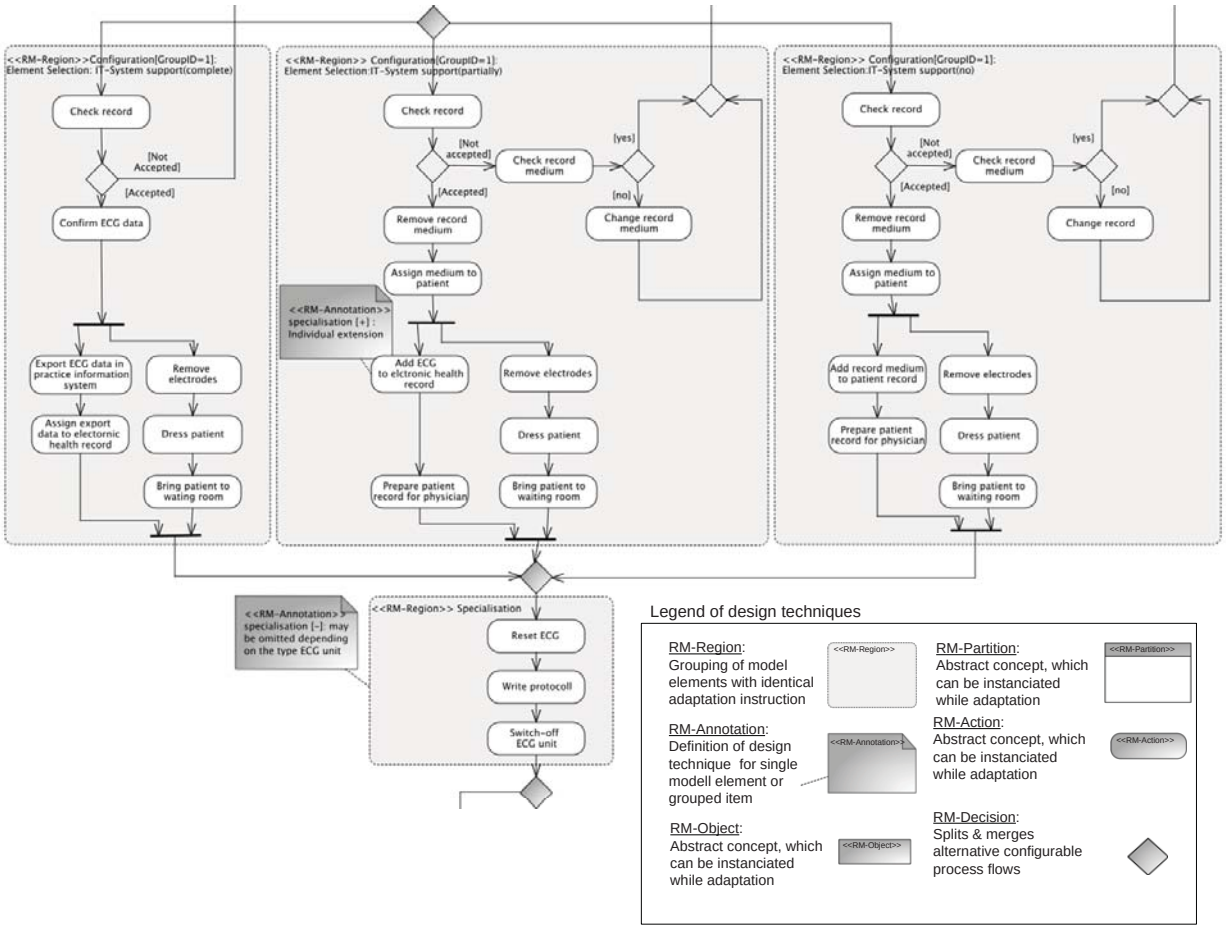

Figure 3: Section of adaptive reference model - ECG process

«RM-Region» Configuration[GroupID=1]: Element Selection: IT-system support(*value*) (see Sect. 3.5). The stereotype «RM-Region» introduces the design technique. It is followed by the specific technique, which includes the definition of a GroupID and the type of configuration. The GroupID helps to identify related model parts, which are effected by the configuration. The formal part of the term ends up with the configuration parameter[s] and its [their] instantiations. Depending on the IT-infrastructure, the user can decide between three variants of ECG process having GroupID one.

On the other hand a specialisation advise is annotated in the region of the partial IT-support (middle). The activity 'Add ECG to electronic health record' is annotated with a *RM-Annotation* that recommends to extend the activity individually depending on the specific process steps of practice.

3.6 Validation

After the reference model was constructed, the result was presented the former interview partner. Although, this evaluation is very subjective but it deliver a first response whether the reference model would be fit to their process context or not. Four of the six interviewed physicians agree that it would be easier to implement a QMS with the reference model. One of the asked physicians announced to use the reference model directly for his upcoming QMS implementation and certification. In further research we will carry out a greater empirical analysis of acceptance for

proposed the reference model as like the influence on effectiveness of adaptation process.

4 Conclusions and Further Research

In this article we represent the results of our current research on reference modelling in the ambulant sector, which show that a reference model supported adoption of a QMS is practicable in the ambulant sector. Furthermore, we have clarified how reference models can be designed for a certain domain grounded on an empirically basis. The process of a reference model construction shows also a high complexity of reference modelling. This highlights the argumentation of Brocke (2007), who estimates the complexity of reference modelling as very high and sees a trade-off by a reduction of costs that can be realised through a reference model. This requires, inevitably, many use cases.

Furthermore, in our survey we could identify two problems: different medical fields and low standardisation in the processes, so that the reference model is relatively abstract. Through the heterogeneity of medical fields the reference model tends to a framework with partially prepared solutions. To counter this tendency we refrain in our future research from designing of such a comprehensive reference model. Reference models for specific medical fields should be rather designed, even if the generality of a reference model would partially be neglected. Hence the following advantage arises, medical processes can be more easier integrated in a reference model, for example the content of Clinical Practice Guidelines provided by medical professional associations.

The number of interviewed persons has to be increased so that general statements could be proved. For reaching the required validity the results of our work have to be passed through an empiric evaluation in the further research. Before the results can be verified in a case study an evaluation of the reference model and of its processes has to be carried out with the help of interviews with potential users.

Furthermore, the suitability of modelling language in context with our research has to be evaluated. Particularly the following subjects have to be studied: tool support for design techniques as well as language adequacy of models for the medical domain. It is necessary to investigate, wether classical modelling concepts fit in order to describe clinical processes or not. The explication of the adaptation method is the next step of our work. It should also be investigated how reference modelling techniques can be designed as independent as possible from a regular modelling language. This would improve the reusability of the design techniques in another context.

Additionally, a concept has to be developed which increases the acceptance of reference models, and which makes the reference models available. In this context the work of the Open Model Initiative (OMI) may be mentioned (Frank 2007). OMIs intention is to research what barriers exist in the use of reference models, e.g., the influence of modelling language and problems of model migration. For selecting a suitable reference model the requirements on meta-information have to be defined. Only then is the development of suitable tools for design, replacement, increasing use, and application of reference models possible.

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