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Specification of a Reference Model for the Domain Layer of a Hospital Information System

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Abstract

Objectives: One of the tasks of information management is systematic planning of a Hospital Information System (HIS). However, the description and the analysis of the current state of a HIS typically create high costs and are not well supported. The aim of this paper is therefore to report about the specification of a reference model for the domain layer of a Hospital Information System. Methods: We developed a reference model for the domain layer of a Hospital Information System based on the requirements index for information processing in hospitals for describing the enterprise functions, and based on the object types from the Health Level 7 Reference Information Model (HL7-RIM) for describing the entity types. Result: The developed reference model is a comprehensive hierarchic model of the enterprise functions of hospital information systems. The central enterprise function "patient treatment" for example is described with 35 enterprise functions and 38 entity types on a three-level hierarchy. Discussion: Reference models provide a kind of modelling patterns that can easily be used and adapted to a respective Information System. The availability of reference models should therefore provide a highly valuable contribution to keep the costs for modelling Hospital Information Systems low. We will start to evaluate the reference model by using it in the description of the information systems of a University Clinic of the Tiroler Landeskrankenanstalten GmbH (TILAK), Austria. If this pre-test is positive, it is planned to extend the use of the reference model to the overall Hospital Information System of the TILAK.

Keywords:
Reference models, Hospital Information Systems, Information Management

1. Introduction

Information Systems, especially Hospital Information Systems (HIS), have the task to support patient care, hospital administration and economic business management within hospitals. As a result of the increasing importance of efficient information processing, systematic information management is typically seen as a central management task. The complex processes in health care, which are highly informative and communicative, have to be analysed, controlled and continuously adapted [1]. Hospital Information Systems play a

significant role in providing quality health care services [2]. In such a dynamic environment, information and communication technologies (ICT) are taking a leading role and are currently significantly impacting the practice of health care at all levels. The catalyst for change in the health care sector, based on the use of ICT, is the improved quality of health care services and the containment of related costs, as reported in [3].

A HIS is defined in [4] as a sociotechnical subsystem of a hospital, which comprises all information processing as well as the associated human or technical actors in their respective information processing roles. In [5], the central importance of socio-technical and organizational issues for information systems are further discussed. The main objective of information management is described in [6] as the systematic continuous development of the information system as well as the reliable and high-quality operation of the information system. The main tasks of strategic information management in a hospital are "planning", "directing" and "monitoring" of the HIS. The strategic information management is responsible for the overall planning of the whole information system and for the initiation of corresponding projects. A strategic information management plan plays an important role in guiding the deployment of applications and technologies for management service organizations. The IT strategy provides the framework, or "road map", for the chief information officer (CIO) making critical decisions about the deployment of ICT [7].

Before any planning can begin, the HIS's current state must be thoroughly described. This description and the assessment of the current state is the basis for identifying those functions of the hospital that are well supported, and those functions that are not (yet) well supported. Thus application components as well as existing information and communication technology have to be described, including how they contribute to the support of the hospital's functions [4]. However, describing and modelling the Information System from scratch is often found rather labour costly [8-10]. Reference models for a HIS may be very useful here, as they can be used as model patterns. One further advantage of reference models is that they help to standardise HIS terminology between various institutions. This problem of using different terminologies may also be avoided [11].

There are various reference models for hospital information systems as the common basic specification of the British National Health Services (NHS), which is a functional reference model. The framework of the European "Réseau d'Information et de Communication Hospitalier Européen (RICHE) [12] is a process reference model for the activities in hospitals. There exist a lot of reference models for typical processes of a hospital, but functional reference models are hardly available.

The aim of this paper is:

- to report about the development of a reference model for the domain layer of Hospital Information Systems.
- to investigate, based on case studies whether this reference model is in fact useful for the information management of a hospital

2. Materials and Methods

Reference Model of the Domain Layer of a HIS

Reference models can be defined as models that present a kind of pattern for a certain class of aspects. On the one hand these model patterns can help to derive more specific models through modifications, limitations, or add-ons (generic reference models). On the other hand, these model patterns can be used to directly compare models concerning their completeness

(nongeneric reference models) [4]. Reference models evolve inductive from consolidation of know how of existing models, documentation of applications, concepts of experts etc., or deductive from theoretical findings [13].

For planning the reference model we used the process model based on Rosemann and Schütte [14], which consists of five phases:

- phase 1: Definition of the problem
- phase 2: Construction of a framework for the reference model
- phase 3: Construction of the structure of the reference model
- phase 4: Completion of the reference model
- phase 5: Application of the reference model

Phase 1:

The basic problem is the great amount of effort needed when modelling hospital information systems. This is both supported by the literature as well as by own experiences in various HIS analysis and modelling projects. The definition of enterprise functions and related entity types especially takes a lot of time. Therefore, we decided to develop a reference model of the domain layer of a HIS.

Phase 2:

We decided to use the three-level graph-based meta-model ($3LGM^2$) for modelling the reference model because it has been approved in some projects in the University Hospital of Innsbruck and in the University Hospital of Leipzig for the static view of a HIS [15, 16]. This meta-model can be used to model HIS on three layers, thus offering more than one point of view on the information model. The domain layer of this meta-model describes the hospital enterprise functions (e.g. patient administration) and the entity types. The entity types present the information on physical or virtual objects in the hospital (e.g. patient, clinical finding). There are two different instances of association between the enterprise functions and the entity types. Enterprise functions either *use* or *create* information about entities of a given entity type.

Phase 3 and phase 4:

We use the $3LGM^2$-meta-model and the respective tool for describing a reference model of the domain layer of a HIS.

Enterprise functions: We decided to take the Heidelberg requirements index for information processing in hospitals [6] as a basis for describing the enterprise functions. The requirement index is separated into two main parts, the “functional requirements” and the “function-independent requirements”. The advantage to other comparable work is that these requirements are formulated independent of information processing tools or of information system architectures.

The major enterprise functions are: Treatment of patient, handling of patient records, scheduling and resource allocation, hospital management and research and education. Each major enterprise function consists of several sub-functions, for example, the sub-functions of patient treatment are: patient admission, planning and organisation of patient treatment, order entry, execution of diagnostic or therapeutic procedures, administrative documentation, billing, clinical documentation, discharge and referral to other institutions.

Entity Types: We settle for describing the entity types based on the object types as defined in the Health Level 7 Reference Information Model (HL7-RIM) Version 2.04 [17]. The RIM is the cornerstone of the HL7 version 3 development processes. The HL7 RIM is an object

model created as a part of the HL7 version 3 methodology. The RIM intends to provide a coherent shared information model that contains all data content relevant to HL7 messages.

The elements of the domain layer of the reference model of a HIS were also adjusted with other resources like HISA [18] and the German Frame architecture for Telematics in Health Care [19].

To check completeness and comprehensibility of the reference model, we organised workshops with employees of the strategic information management of hospitals, with care professionals, with employees of business consultancy for health care institutions and also with medical informaticians.

Phase 5:

For the continuous development of the reference model it is important to consider the whole cycle from the construction to the application of the model. We will start to evaluate the reference model by using it in the description of the information systems of the University Clinic of Radiodiagnostics - Radiology II in Innsbruck, Austria. After the first practical application, an adaptation of the reference is necessary which we will add to the reference model. If this pre-test is positive, it is planned to extend the use of the reference model to the overall Hospital Information System of the Tiroler Landeskrankenanstalten GmbH (TILAK).

3. Results

Our resulting reference model of Hospital Information Systems is hierarchically structured and consists in its actual state of one primary model with the central enterprise function “patient treatment” and the four cross-sectional enterprise functions “handling of patient records”, “scheduling and resource allocation”, “hospital management” and “research and education”. This primary model is then subdivided into 21 submodels that describe the sub-functions according to their refinements. For example, the enterprise function “patient treatment” is subdivided into 8 sub-functions. Four of these sub-functions are associated with further sub-functions.

Figure 1 shows for example a section of the submodels of the enterprise function “patient treatment”. According to the 3LGM² tool rectangles denote an instance of the class “enterprise function”. Ovals denote an instance of class “entity type”. Arrows from rectangles to ovals describe if the enterprise functions use or create information about entities of that entity type.

The hierarchical structure enables a modeller to create a model of the HIS in that degree of refinement that he finds necessary. The modeller can decide, depending on his or her analysis question, to take over the whole or a part of the reference model. He will then only have to adapt and/or refine the elements to his respective information system. Of course; it is also possible to add elements to the model if necessary. The hierarchical structure of the reference model also helps to keep an overview of HIS, and to only show those details that are found necessary in a given situation.

This reference model is available for the modeller in the 3LGM2-Tool.

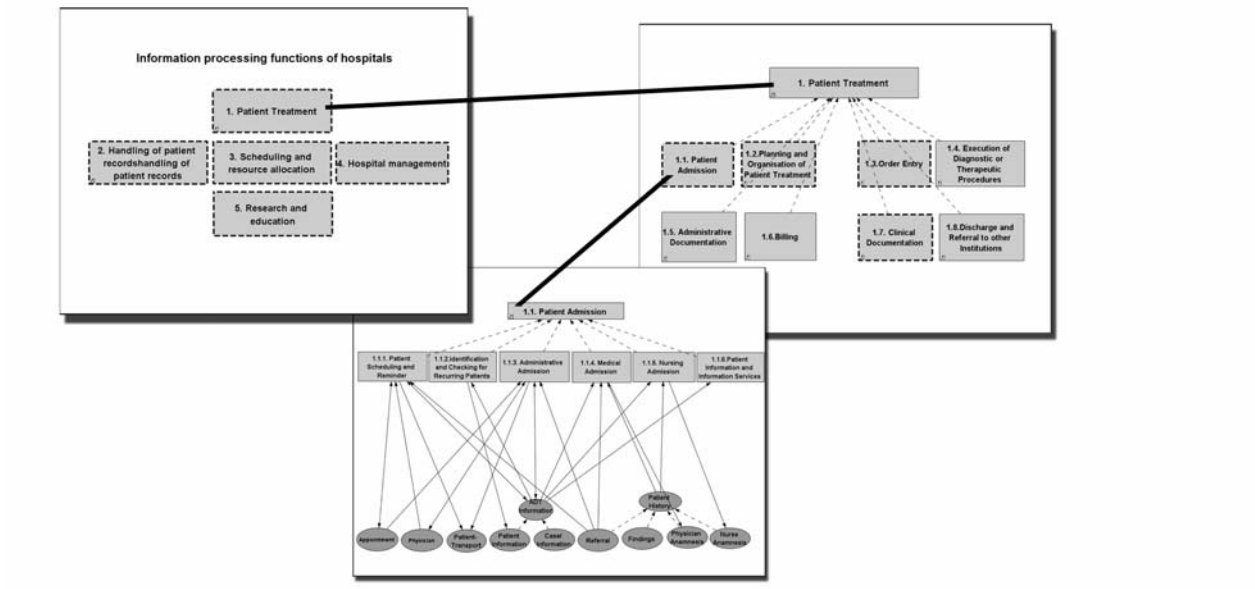

Figure 1 - Section of the submodels of the central enterprise function "patient treatment"

4. Discussion and Conclusion

We developed a reference model for the domain layer of a HIS. We expect that the availability of a reference model will provide a highly valuable contribution to keep the costs for the creation of HIS models low - the modeller can decide, depending on his or her analysis question, to take over the whole or a part of the reference model. He will then only have to adapt the elements to the respective information system.

While creating the reference model, we incorporated available experiences and know how from different domains and from existing models such as HL7-RIM, and we included future users in the development process. This procedure is recommended by [14]; it advises validation through a potential user. We also want to adjust our reference model for the domain layer of a HIS with other approaches like the Reference Model of Open Distributed Processing (RM-ODP) [20].

Using the reference model should not only make modelling easier, but it will also present a kind of central repository of terms of hospital information systems, i.e. a standardised HIS terminology, at least on the domain level (not yet on the tool levels). This standardised terminology will help to make HIS models more comparable.

In the next weeks we will start to evaluate the reference model by using it in the description of the HIS of the University Clinic of Radiodiagnostics - Radiology II in Innsbruck, Austria. If this pre-test is positive, it is planned to extend the use of the reference model to the overall Hospital Information System of the Tiroler Landeskrankenanstalten GmbH (TILAK). The TILAK is a publicly owned holding company established in Tyrol, Austria. The TILAK manages six hospitals, with a total of approximately 2,300 beds, with more than 6,000 staff members, including more than 1,000 physicians [21]. So we have the opportunity to evaluate the reference model by modelling both a whole hospital information system as well as a departmental information system.

We will report on first results during MIE 2005 in Geneva.

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