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Research Article

The 3LGM²-tool to support information management in health care

Der 3LGM²-Baukasten zur Unterstützung des Informationsmanagements im Gesundheitswesen

Abstract

Hospital information systems (HIS) as well as transinstitutional health information systems (tHIS) are constructed like a (complex of) building(s) out of different and probably heterogeneous bricks and components. Like an architect the information manager needs a description or model for the information system's architecture respectively the enterprise architecture. 3LGM² as a meta model has been designed to describe information systems (IS) by concepts on three layers. The meta model has been supplemented by the 3LGM² tool. It enables information managers to graphically design even complex IS and provides means for analyzing information system's quality and thus supports strategic, tactical and operational information management.

Keywords: 3LGM², hospital information systems, transinstitutional health information systems, information management

Zusammenfassung

Sowohl Krankenhausinformationssysteme als auch transinstitutionelle Informationssysteme sind ähnlich wie Gebäude(komplexe) aus meist heterogenen Bausteinen und Komponenten zusammengesetzt. Ähnlich wie ein Architekt, benötigt ein Informationsmanager eine Beschreibung, d.h. ein Modell der Informationssystem-Architektur. Mit dem Metamodell 3LGM² können solche Architekturen beschrieben bzw. modelliert werden. Hierzu werden Konzepte auf drei Ebenen verwendet. Passend zu 3LGM² ist eine Modellierungssoftware verfügbar, die mit ihren Analysemethoden das strategische, taktische und operative Informationsmanagement unterstützen kann.

Schlüsselwörter: 3LGM², Krankenhausinformationssysteme, transinstitutionelle Informationssysteme des Gesundheitswesens, Informationsmanagement

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1 Introduction

A mayor driving force for healthcare is still the trend towards a better continuity of care [1]. Health care professionals in different departments of a hospital but moreover in a region – and in many cases even worldwide – have to cooperate in order to achieve health for the patient [2].

Cooperation needs an adequate system for communicating and processing of information, i.e. an information system, which is that socio-technical subsystem of a (set of) health care institution(s), which presents information at the right time, in the right place to the right people [3], [4].

Hospital information systems (HIS) as well as transinstitutional health information systems (tHIS) [5] (consisting of different institutional information systems) are constructed like a (complex of) building(s) out of different and probably heterogeneous bricks and components. Thus cooperation depends especially on the availability of adequate communication links between the institutional information systems and their components. Besides technical problems of communication links there are a lot of complex problems of connecting heterogeneous software components of different vendors and with different database schemata to be solved. Like an architect the information manager needs a blueprint or model for the information system's architecture respectively the enterprise architecture [6], [7].

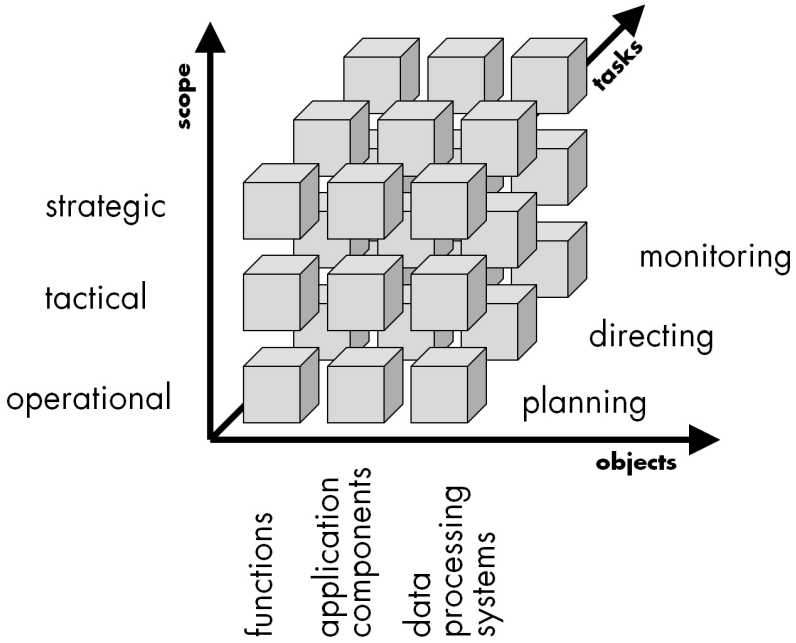

Figure 1: Three-dimensional classification of information management activities

The paper deals with the question of how the three layer graph based meta model (3LGM²) [8] and the 3LGM² tool [9] can be used for describing and modeling HIS and tHIS and how 3LGM² can support information managers in their planning, directing and monitoring activities. Therefore our concept of information management will be explained first. The second section will introduce the main features of 3LGM² and the 3LGM² tool. Finally the tool's analyzing features to support information management will be illustrated.

2 Information management

According to [3] information management in hospitals is the sum of all management activities in a hospital that transpose the potential contribution of information processing to fulfill the strategic hospital goals into hospital's success.

Therefore, it manages the maintenance and operation of the hospital information system.

The question of information management focuses on the issue, whether the performance of the information system can be enhanced, for example by using adequate computer-supported information processing tools. Accordingly, information management engages in the following objects [7]: enterprise functions and entity types, i.e. types of information, used by these functions, application components, data processing systems like computer-supported and non-computer-supported information and communication tools.

The general tasks of management are planning, directing, and monitoring. For information management in hospitals this means *planning* the hospital information system, respectively its architecture, *directing* its establishment and its operation, and *monitoring* its development and operation with respect to the planned objectives.

Information management in hospitals is a complex task. In order to reduce complexity, we distinguish strategic, tactical, and operational information management. This is essential, because each of these information management levels views hospital information systems from different perspectives, and therefore uses other methods and tools.

In summary, activities of information management can be classified by a three dimensional classification as depicted in Figure 1.

3 3LGM²

3.1 The Meta Model 3LGM²

The three layer graph based meta model (3LGM²) has been designed to describe information systems by concepts on three layers [8].

The domain layer of 3LGM² describes a hospital independently of its implementation by its enterprise functions. Enterprise functions describe what has to be done in the institution. They need information of a certain type about physical or virtual things of the hospital. These types of information are represented as entity types. The access of an enterprise function to an entity type can be in a using or an updating manner.

The *logical tool layer* concentrates on *application components* supporting enterprise functions. Application components are responsible for the processing, storage and transportation of data representing entity types. Application components may have a local *database* to store data. *Component interfaces* ensure the communication among application components. A component interface can receive or send messages of a certain message type. A message type transports (a) certain entity type(s). For

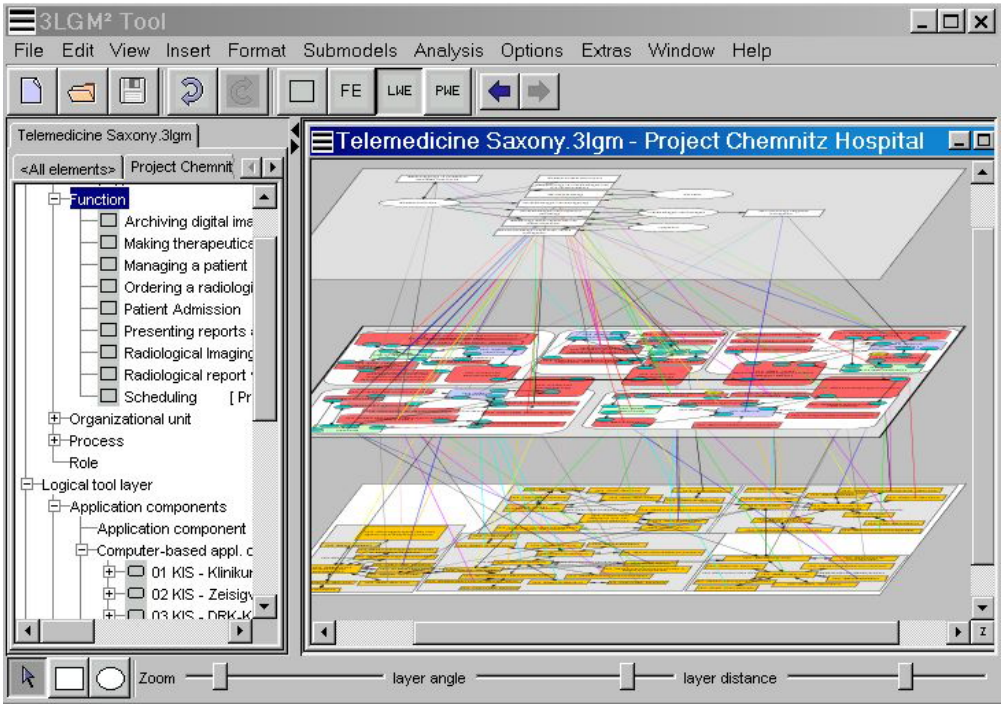

Figure 2: The 3LGM² tool: modeling canvas offering typical operations for graphical display and modeling (right), a model browser for hierarchical browsing through the model structure (left), a menu bar and tool bars for accessing common operations (top) (for more details please refer to [9] and http://www.3lgm2.de/).

the communication among application components *communication links* can be defined as relations between two communication interfaces, one being the sender of a message, the other one being the receiver.

The *physical tool layer* consists of physical data processing systems (like personal computers, servers, switches, routers, etc), which are physically connected via data transmission connections (e.g. data wires).

Between concepts of the different layers there exist so-called interlayer relationships, which enable to describe the dependencies between model elements belonging to different layers. In this paper, the following interlayer relationships are of special interest:

- An enterprise function is supported by a set of application components.
- An Entity type can logically be represented by a dataset type or a message type to describe how it is stored and communicated. Dataset types describe what information is stored in a database; message types describe what information is transported by a communication link between two application components.

3.2 The 3LGM² tool

The meta model has been supplemented by the 3LGM² tool [9]. It enables information managers to graphically design even complex HIS and assists information managers similarly to computer aided design tools (CAD) supporting architects. The tool provides means for analyzing a HIS or a tHIS model and thus for assessing tHIS's quality.

The 3LGM² tool is a software product designed to create information system models on the basis of 3LGM² (Figure 2). On the modeling canvas, which dominates the main window of the tool, an information system can be modeled and displayed on three layers. A model diagram is a graph; i.e. consists of nodes and edges. There are different node types corresponding to the element classes defined in the 3LGM² as mentioned before.

- On the top layer – the *domain layer* – the hospital's enterprise functions and entity types used by these functions are displayed.
- The middle layer – the *logical tool layer* – contains application components, database systems, document collections, component interfaces and communication links between them. Application components support functions and store data about entity types in database systems. These relations are modeled explicitly by linking elements from the logical tool layer to elements of the domain layer and can be displayed as interlayer relationships like in Figure 2.
- The bottom layer – the *physical tool layer* – contains the physical tools: record shelves, computers, network components and even personnel, i.e. 'touchable' components of the information systems. Physical data processing systems are the basis for application components. Similar to the relations between the domain layer and the logical tool layer, relations between the latter and the physical tool layer are modeled explicitly by linking model elements.

Each of the element classes function, entity type, application component, database system, document collection, component interface, and physical data processing

component is visualized in the model diagram and has a default geometric shape and a default background color.
The three different layers can be viewed and edited separately but can also be combined in a multi-layer view as shown in Figure 2. A lot of analysis functions are provided. Thus users can find e.g. those enterprise functions which are supported by a selected server. Additionally quality indicators like data redundancy are calculated.

4 The 3LGM² for information management

4.1 The 3LGM² for strategic information management

Strategic information management deals with the hospital's information processing as a whole. It depends strictly on the hospital's business strategy and strategic goals and has to translate these into a well fitting information system.
The result of strategic information management *planning* activities is a strategic information management plan [10]. The plan describes the direction and strategy of information management and gives directives for the construction and development of the hospital information system by describing its intended architecture. It includes a description of the current state of the information system and a description of its planned state.
Using the 3LGM² tool continuously can provide information management with a documentation of the managed information system as a whole which might be up-to-date. The tool's means for generating reports as well as graphical illustrations can easily be used for describing the current state of the information system within a strategic plan. Modifying the model according to the "directives for the construction and development of the hospital information system" (as said before) will help to describe the intended architecture. Reportedly 3LGM² has been used in this context in some German academic medical centers [11], [12], [13] and especially in Leipzig [14].
The 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. However, describing and modeling the information system from scratch is often found rather labor costly. 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 standardize HIS terminology between various institutions [15]. A reference model for the domain layer of a Hospital Information System for describing the enterprise functions and entity types has been presented in [16].
Especially in the setting of a transinstitutional health information system (tHIS) a proper and comparable description of the institutional information systems being part of the tHIS and their relationships is essential for strategic planning. We applied the 3LGM² tool to construct a 3LGM² model of the tHIS of Saxony, which is federal state of Germany [17]. The tHIS of Saxony has been further developed by the SAXTELEMED project, funded by the Saxonian ministry of social affairs [18]. The project focused mainly on the exchange of radiological images and intended to improve integration of ambulatory and inpatient care.
Figure 3 gives an overview of the model (SAX-tHIS model) at the logical tool layer. At a low level of granularity it shows the hospital information systems and the information systems of practitioners involved as application components. The 3LGM² tool provides comfortable means for switching between different levels of granularity.
To strategically *monitor* an information system means to continuously audit its quality. An important part is the quality assessment of the information system's architecture. Therefore, quantitative architectural quality criteria are helpful. On the basis of relevant architectural components of a HIS, as defined by 3LGM², the following quality criteria have been defined: functional redundancy [19], data redundancy, data availability [20], functional undersaturation, functional correspondence, informational redundancy, degree of heterogeneity and degree of computer-support. These quality criteria were implemented as part of the 3LGM² tool. Moreover the before mentioned reference-model supports systematically comparing information systems of different institutions [21].

4.2 The 3LGM² for tactical information management

Tactical information management deals with certain hospital functions. It aims to construct or to maintain components of the information system. Related activities are usually executed as projects.
Tactical projects usually start with a systems analysis of the organizational unit in which a new component shall be introduced. Again a continuously maintained 3LGM² model will provide easily with the current state of the IT-infrastructure in the unit and the institution as a whole. An analysis of the domain layer can identify those hospital functions and tasks of employees, which should be supported better in the future. Thus the domain layer will help structuring a document for the specification of new Soft- and Hardware to be selected at the market place.
Introducing a new information system's component in a health care institution needs considerations on how to integrate it with the already existing components of the institution's information system as well as with the components of the related tHIS.
Especially communication interfaces and links have to be planned and specified. Using a 3LGM² model of the current state of the HIS or tHIS and the 3LGM² tool the planned communication interfaces and links and the entire information system's architecture can be constructed and planned similarly like using a computer aided

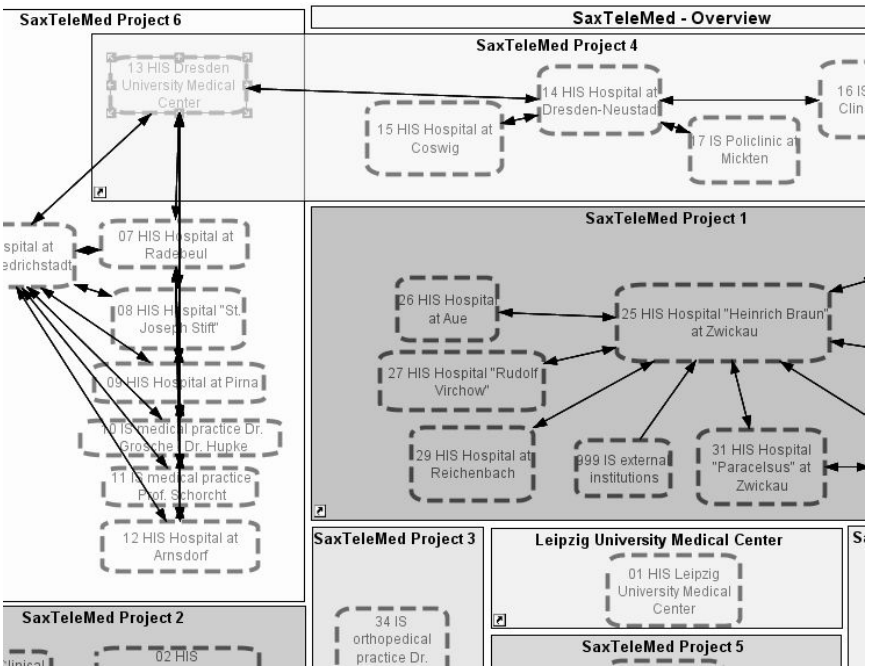

Figure 3: 3LGM² model of the Saxonian tHIS: Cutout of the overview at the logical tool layer

design (CAD) tool for engineering. To support this task the 3LGM² tool provides e.g. reference models as templates for modeling HL7 messages and integration by means of communication servers.

Many projects will deal with problems, which are not unique for a particular institution. For example problems of archiving patient records digitally are common for hospitals on the way to an electronic patient record [22]. In [9] we reported on how to model archiving of patient records in hospitals by means of 3LGM². Moreover we prepared a reference model for integrating medical record archiving systems [23] into a hospital information system based on a guideline [24]. Another reference model provides with a modelling template for transinstitutional communication standards, interfaces and links [25].

4.3 The 3LGM² for operational information management

Operational information management is responsible for maintaining the installed hospital information system and its components and will provide an adequate IT service [26]. For this service a configuration management database is essential [27]. The 3LGM² model of HIS or tHIS can serve as configuration management database. Using the 3LGM² tool and its analyzing functions employees at the service desk can easily find out, what physical data processing components may be the reason if a user reports problems concerning a particular application component e.g. the laboratory information system. Conversely, if a certain server breaks down, those hospital functions can be determined which may be affected.

5 Conclusion

In the previous sections 3LGM² and the corresponding 3LGM² tool for modeling information systems was shortly introduced and possible opportunities for information management in a HIS as well as tHIS were illustrated. There are methods and tools comparable to our approach as has been discussed earlier in [8] and [9]. Newer approaches dealing with a thorough support of information systems' management can be found in the field of application portfolio management [28], [29], [30]. Future work has to carefully look for an integration of 3LGM² and those methods and tools.

There are some organizational prerequisites for a useful application of 3LGM² in regional and even national settings. Especially for a tHIS, there must be a super-ordinate institution responsible for information management from a regional perspective. This might become an important challenge because healthcare regions, at least in Germany, are not necessarily institutional bodies with their own administration, but a rather loose coupling of autonomous institutions [31]. Nevertheless, the super-ordinate institution could be a ministry for health, another health care body or even a health care enterprise.

So we finally can conclude that 3LGM² as modeling instrument for information systems can support information management in every setting where an information management authority is installed.

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Notes

Competing interests

The author declares that he has no competing interests.

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