

3LGM²-Modelling to Support Management of Health Information Systems

Alfred Winter^a, Birgit Brigl^a, Gert Funkat^a, Anke Häber^b, Oliver Heller^a, Thomas Wendt^a

^a Leipzig University, Department for Medical Informatics, Statistics and Epidemiology, Leipzig, Germany
^b University of Applied Science Zwickau, Department of Informatics, Zwickau, Germany

Abstract

Both regional health information systems and hospital information systems need systematic information management. Due to their complexity information management needs a thorough description or model of the managed HIS. The three layer graph based meta model (3LGM²) and the 3LGM² tool provide means for effectively modeling HIS. The 3LGM² tool has been used to build a model of the health information system of the German federal state Saxony. The model is not only used to support the further development of the Saxonian health information system but also for supporting strategic information management planning in the medical center of Leipzig University. Acceptance of the method depends strictly on its integration in management structures on the institutional, regional, national or even European level.

Keywords:

Hospital Information Systems, Health Information Systems, Information Management, Systems Integration, Organizational Models, 3LGM², Information Systems Modeling

1. Introduction

The driving force for health care has recently been the trend towards a better coordination of care. The focus has been changed from isolated procedures in a single health care institution (e.g. a hospital or a general practice) to the patient-oriented care process spreading over institutional boundaries. Health care providers and health care professionals in a region - and in many cases even worldwide – have to cooperate in order to achieve health for the patient. [1]

The hospital's system for communicating and processing information, i.e. the hospital information system (HIS), is that socio-technical subsystem of a hospital which presents information at the right time, in the right place to the right people [2, 3]. Consequently the heterogeneity of a hospital is reflected by its information system. It has to be actively designed and constructed like a (complex of) building(s) out of different and usually heterogeneous bricks and components.

Widening the scope to the health care region and the necessity for regional cooperation of health care professionals and institutions, we have to claim for the respective cooperation of institutional information systems, e.g. hospital information systems or information systems of practitioners. They shall form again an integrated information system, i.e. the regional health information system (rHIS). Since the complexity of an rHIS is something like the

product of the complexity of the information systems included, there is an even stronger demand for systematic information management in the region [1].

Like an architect each hospital's information manager needs a blueprint or model for the information system architecture respectively the enterprise architecture [4-6]. Obviously this holds, a fortiori, for the manager of an rHIS.

The aim of the paper is to illustrate, how models for (r)HIS can be constructed and used for information management tasks. We therefore will shortly introduce the meta-model 3LGM² and the 3LGM² tool for modeling information systems, present a 3LGM² model of parts of the rHIS of the German federal state Saxony, and illustrate some benefits of the model for further development of digital image communication in Saxony and for strategic information management planning in the Leipzig University Medical Center.

2. Method: The Three Layer Graph Based Meta-Model 3LGM² and the 3LGM² tool

In [7] we proposed the three layer graph-based meta model (3LGM²) as a meta model for modeling HIS. 3LGM² has been designed to support the hospital information management in its enterprise architecture planning (EAP) (see e.g. [6, 8]) activities. Accordingly, it distinguishes three layers of information systems, which especially provide a framework for describing both information processes at the domain layer and communication paths between application components and their interdependencies. 3LGM² is defined using the Unified Modeling Language (UML).

The *domain layer* of 3LGM² describes a hospital independently of its implementation by its enterprise functions. Enterprise functions 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. *Component interfaces* ensure the communication among application components. The *physical tool layer* consists of physical data processing components (like personal computers, servers, switches, routers, etc), which are physically connected via data transmission connections (e.g. data wires). They carry the application components.

The meta model has been supplemented by the 3LGM² tool [9]. Using 3LGM² as the ontological basis this tool enables information managers to graphically design even complex HIS (Figure 1). It assists information managers similarly to computer aided design tools (CAD) supporting architects. The tool provides means for analyzing an (r)HIS model and thus for assessing the (r)HIS's quality. On the modeling canvas, which dominates the main window of the tool, an information system can be modeled and displayed on three layers as explained before. The three different layers can be viewed and edited separately but also in a multi-layer view. Models especially of rHIS tend to be rather complex. Depending on the complexity and the required level of detail the model diagram may easily get unclear and confusing. The 3LGM² tool includes functionality to extract subsets of models into sub-models. It provides a set of predefined analysis functions, which are designed to answer specific questions arising in information management business.

3. Results

3.1 A 3LGM² model of the rHIS of the German federal state of Saxony

Applying the 3LGM² tool we constructed a 3LGM² model comprising a detailed description of the current state of the Leipzig University Medical Center's HIS (UKL-KIS) ("KIS

Universitätsklinikum Leipzig”) and important elements of the rHIS of Saxony. The rHIS of Saxony has been further developed by the SAXTELEMED project, funded by the Saxonian ministry of social affairs [10]. The project focused mainly on the exchange of radiological images and intended to improve integration of ambulatory and inpatient care.

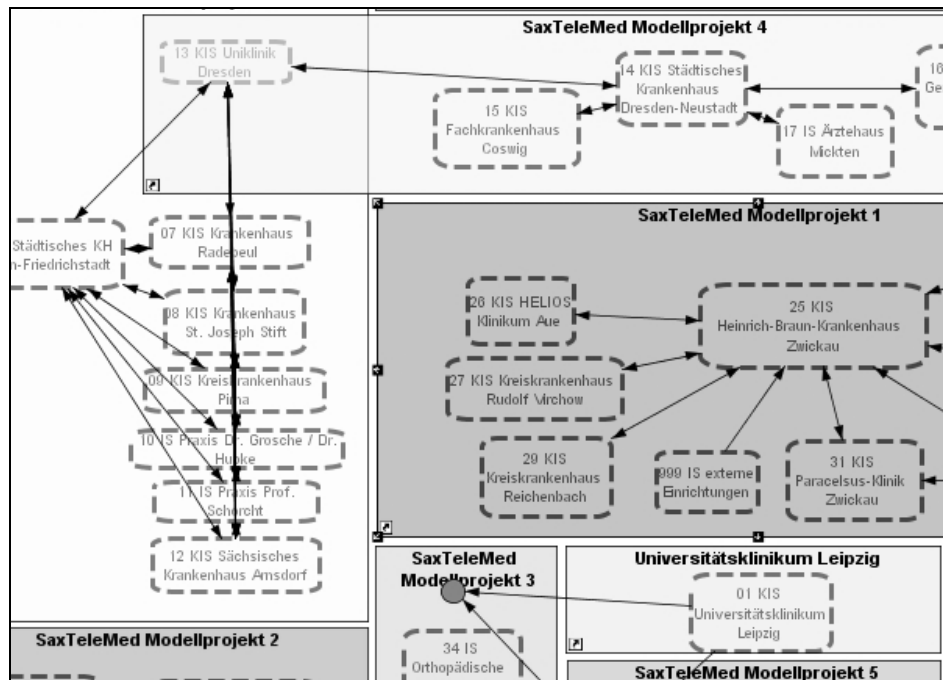


Figure 1 – 3LGM² model of the Saxonian rHIS: Cutout of the overview at the logical tool layer (Names in German since figure is taken from the original model)

Figure 1 gives an overview of the model (SAX-rHIS 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. Frames and respective headers (in German, e.g. “SaxTeleMed Modellprojekt 4”) indicate sub projects of SAXTELEMED. Sub projects had been defined at seven medical centers to realize an infrastructure for exchanging radiological images between these centers and healthcare institutions in the neighborhood. Now the ministry’s focus is on connecting these ‘islands’. One of the frames contains the UKL-KIS. Each frame is linked to the related, more detailed submodel of the respective information system and their components. The 3LGM² tool thereby provides comfortable means for switching between different levels of granularity.

3.2 Supporting further development of the Saxonian rHIS

Investments in Saxonian hospitals – especially those for information technology – are funded by the ministry of social affairs. Respective proposals are reviewed by experts in this field.

The SAX-rHIS model is the only central repository for information concerning the rHIS infrastructure in Saxony. Using this model and the analysis tools provided by the 3LGM² tool, officers in the ministry, reviewers, and applicants among others gain the following advantages:

- If e.g. application components at different sites support the same enterprise function (e.g. report writing), they are linked to the same model element representing the function. In general same real world entities (e.g. communication standards, message types, software products and brands etc.) are represented by the same modelling concepts and elements. So the different information systems’ architectures are described in a coher-

ent way, which overcomes the very individual methods usually used in different proposals. Thus the model supports the stakeholders mentioned above in understanding

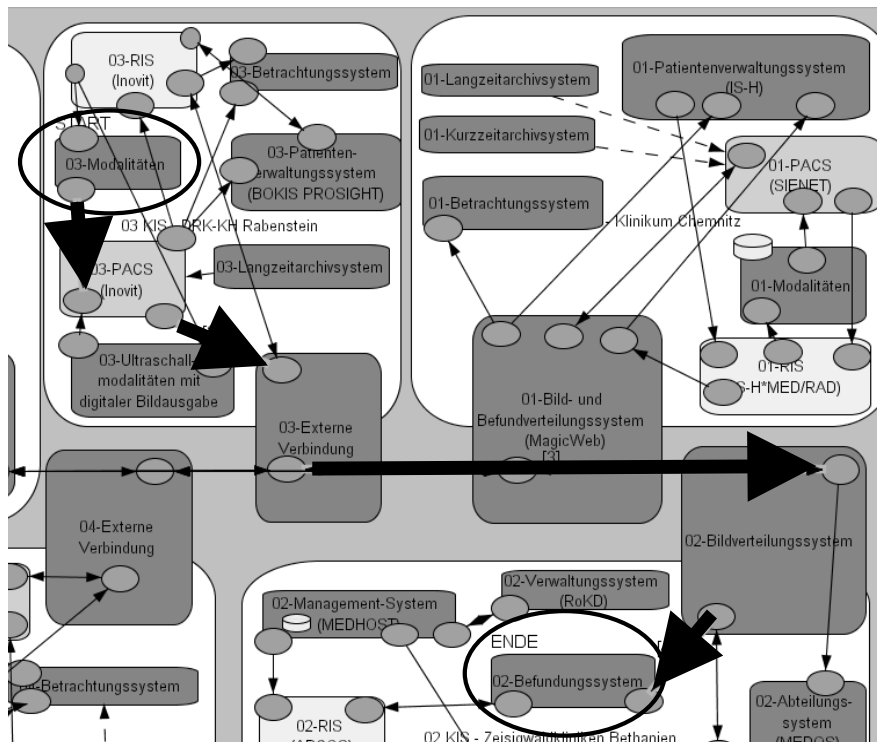


Figure 2 – calculated communication path in the Saxonian rHIS: Images can be sent from the application component “03-Modalitäten” (a modality in the hospital of Rabenstein City) to the component “02-Befundungssystem” (component for supporting writing of radiological findings in the hospital of Bethanien City). (Names in German since figure is taken from the original model)

and comparing different solutions.

- Given, hospital A wants to introduce an application component for radiological imaging, i.e. a radiological modality. In order to avoid unnecessary investments it should be questioned, whether there is already a similar modality in another hospital B and whether it would be possible to transport images from hospital B to A. Appropriate modalities can be found by selecting the function “radiological imaging” at the domain layer; the analysis tool will then highlight the components used for imaging at their different sites. Communication paths on which images could be transported can be found by using a shortest path algorithm implemented in the 3LGM² tool [11]. Figure 2 shows a calculated communication path, if for B the hospital of Rabenstein City and for A the hospital of Bethanien City is taken. The algorithm finds, that images from the modalities in Rabenstein can be sent to the diagnosing system in Bethanien.

3.3 Preparing a strategic information management plan (SIM plan) for the Leipzig University Medical Center

We are now completing the third issue of the SIM-plan for the Leipzig University Medical Center which is valid for 2005 – 2007. Its structure is close to the recommendations in [3]. So, description and analysis of the current state of the UKL-KIS form an important part of the plan.

The sub model of the UKL-KIS in the SAX-rHIS model can be seen as the central repository

for information about the UKL-KIS. For example it delivers detailed information concerning interfaces between application systems and the communication server as well as descriptions about redundant storage and communication of patient data. Similar as illustrated in figure 2 it can be derived, what communication links might be used to transport pathological findings to the application systems used at the ward.

For preparing the strategic plan rather simple features of the 3LGM² turned out to be very helpful. Besides features for exporting graphical illustrations like figure 2 we used the reporting facilities of the 3LGM² tool to generate tables describing what application systems are used for particular enterprise functions in different organizational units. As an example figure 3 shows, that for admission of outpatients four different software products are used and that one product (MCS IKA) has been installed as two different and separated application systems. Additionally it can be seen, that in department STRA1 (Radiation Therapy and Radiation Oncology) two different application systems are in duty for the same function. So the table clearly shows a heterogeneity, which is worth to be discussed very seriously.

Even those things, which can not be found in the model turned out to be of mayor

enterprise function	organizational unit	application system (software product)
...	...	...
Admission (outpatient)	KCHA1, GYNA4, IN4A4, HUG, IN1A2, IN1A3, HNOA1, GYNA8, IN1A5, GYNA5, CHZA, AUG, NCHA1, ...	Patient management system (SAP IS-H)
	NET	Outpatient management system NET (MediTec)
	PSYA1	Outpatient management system PSY (MCS IKA)
	RADA1	RIS Radiology information system RAD (MEDOS)
	STRA1	Patient management system (SAP IS-H)
		Outpatient management system STR (MCS IKA)

Figure 3 - Excerpt from the table of enterprise functions, organizational units and application components, generated automatically by the 3LGM² tool

importance for the strategic plan: The lack of powerful interfaces to other health care institutions in the region lead to the clear statement, to concentrate on better integration into the rHIS of Saxony within the next three years.

4. Discussion

Information management in health care regions should be and can be supported by dedicated modeling methods and tools coming from hospital information management. The 3LGM² tool with its means for analysing information processes and related communication paths is suitable to support documentation and planning an (r)HIS and to illustrate its capabilities.

Experiences in Saxony show, that the application of our approach only makes sense, if there is an institution in the region, which feels responsible for information management from a regional perspective. This institution could be a ministry for health, another health care body or even a health care enterprise. Without such an institution a systematic planning and development of an rHIS is impossible – and our approach is not needed.

Experiences at the Leipzig University Medical Center additionally show, that the model can be maintained if (and only if) tactical and strategic information management [12] are closely connected. As a consequence the model has been implemented as the central documentation device for information systems components in the Leipzig University Medical Center. Project managers are obliged to document the information system components created or updated during their projects in the 3LGM² model.

As a conclusion we found, that a systematic organization of information management in health care institutions and regions is the prerequisite for 3LGM² modeling; but modeling and thorough documenting (r)HIS, e.g. using 3LGM², is the basis for systematic information management in health care (regions). This also holds for a nationwide or European perspective.

6. Acknowledgments

This work is part of the research project 'Integrative modeling of structures and processes in hospital information systems' supported by the Deutsche Forschungsgemeinschaft (DFG), grant no. WI 1605/2-1.

7. References

- [1] Winter A. Health Information Systems. In: Yearbook of Medical Informatics. Stuttgart: Schattauer; 2004. p. 359-8.
- [2] Berg M. Medical Work and the Computer-Based Patient Record: A Sociological Perspective. *Methods of Information in Medicine* 1998; 37 294-301.
- [3] Brigl B, Ammenwerth E, Dujat C, Gräber S, Große A, Häber A, Jostes C, and Winter A. Preparing strategic information management plans for hospitals: a practical guideline. *International Journal of Medical Informatics* 2005; 74 (1) 51-65.
- [4] Chief Information Officer Council. A Practical Guide to Federal Enterprise Architecture. Boston: Chief Information Officer Council c/o Rob C. Thomas, U.S. Customs Service 7681 Boston Boulevard Springfield, VA 22153; 2001 February 2001. Report No.: <http://www.cio.gov>.
- [5] Martin J. Information Engineering, Book II: Planning & Analysis. Englewood Cliffs: Prentice Hall; 1990.
- [6] Spewak SH, and Hill SC. Enterprise Architecture Planning: Developing a blueprint for Data, Applications and Technology. New York: John Wiley & Sons; 1992.
- [7] Winter A, Brigl B, and Wendt T. Modeling Hospital Information Systems (Part 1): The Revised Three-Layer Graph-Based Meta Model 3LGM2. *Methods Inf Med* 2003; 43 544-51.
- [8] Zachman JA. A framework for information systems architecture. *IBM Systems Journal* 1987; 26 (3).
- [9] Wendt T, Häber A, Brigl B, and Winter A. Modeling Hospital Information Systems (Part 2): Hospital Information Systems (Part 2): Using the 3LGM2 Tool for Modeling Patient Record Management. *Methods Inf Med* 2004; 43 (3) 256-67.
- [10] Saxonian Ministry for Social Affairs. Saxtelemed [Website]. www.saxtelemed.de; 2003
- [11] Brigl B, Wendt T, and Winter A. Modeling interdependencies between information processes and communication paths in hospitals. *Methods of Information in Medicine* 2005; in press.
- [12] Winter AF, Ammenwerth E, Bott OJ, Brigl B, Buchauer A, Gräber S, Grant A, Häber A, Hasselbring W, Haux R, Heinrich A, Janssen H, Kock I, Penger O-S, Prokosch H-U, Terstappen A, and Winter A. Strategic Information Management Plans: The Basis for systematic Information Management in Hospitals. In: Yearbook of Medical Informatics. Stuttgart: Schattauer; 2003. p. 431-441.
- [13] Gunasekaran S, and Garets DE. Business value of IT: the strategic planning process. *J Healthc Inf Manag* 2003; 17 (1) 31-6.
- [14] Thomas M, and Vaughan G. Preparing for the Joint Commission Survey: The Information Systems Perspective. *HIMSS Proceedings* 1998; 3 369-382.
- [15] Gartner Group. Three Documents for Healthcare IT Planning. Gartner Group's Healthcare Executive and Management Strategies Research Note; 1998. Report No.: KA-03-5074.
- [16] Ward J, and Griffiths P. Strategic Planning for Information Systems. Chichester: John Wiley & Sons; 1996.

Address for correspondence

Prof. Dr. Alfred Winter, Department for Medical Informatics, Statistics, and Epidemiology, Leipzig University, Haertelstr. 16-18, D-04107 Leipzig, Germany, alfred.winter@imise.uni-leipzig.de, www.3lgm2.de