HOSPITAL INFORMATION SYSTEM MODELING

HAMID REZA KAGHAZCHI

UNIVERSITI TEKNOLOGI MALAYSIA

ABSTRACT

A hospital consists of different organizational units with specified activities. Conduction of an effective communication throughout this heterogeneous organization is very intensive. Developing a comprehensive model is essential for information managers to ensure about the quality of information systems and understanding the communication within the hospital. So far, many various models have been developed to support the information managers but each one of them present only one aspect of hospital information system. This study is set out to consider the different suggested models for hospital information system and then to look at their advantages and disadvantages in comparison with other models. Pusat Kesihatan UTM has been chosen as a particular small-medium hospital to explore the problems in the heterogeneity of hospital information and to experiment the selected hospital information system model. This is where this project comes in; to study the current information system architecture and the quality of information system at UTM Clinic and to propose a comprehensive hospital information system model to support information system managers who are involved within the clinic. Qualitative method is used to get needed information and study the current situation of information system at the clinic. Internal interview was carried out with the director and information manager of Pusat Kesihatan UTM to understand the weaknesses of the current system within the clinic and also to recognize the expectations of top managers of the clinic. Certain common standards such as reference models were used to identify the existing gaps within the current system and suggest an efficient strategy towards implementation. Through the analysis of different models, this study came up with a meta model called 3LGM which present three aspects of hospital information system that include enterprise functions, logical tools, and physical tools and the relation between each layer with other layers. It is hoped that this project can provide benefits to the Pusat Kesihatan UTM.

ABSTRAK

Sesebuah hospital mempunyai pelbagai unit organisasidengan aktiviti yang tertertu. Kelancaran komunikasi yang efektif menerusi organisasi heterogeneous adalah sangat intensif. Membangunkan model yang lengkap adalah penting kepada pengurusan maklumat untuk memastikan kualiti system maklumat dan pemahaman berkomunikasi antara hospital. Setakat ini, pelbagai model telah dibangunkan untuk membantu menguruskan maklumat namun setiap satu daripadanya hanya membicarakan satu aspek dalam sistem maklumat hospital sahaja. Kajian ini dibuat untuk mempertimbangkan perbezaan model. Model yang disarankan untuk sistem maklumat hospital dan seterusnya memerhatikan kebaikan dan keburukan dalam perbezaan model. Model yang dimaksudkan iaitu Pusat Kesihatan UTM telah dipilih sebagai hospital medium kecil untuk mencari permasalahan *heterogeneity* dalam maklumat hospital dan untuk mengkaji model sistemmaklumat hospital.. Projek ini menengahkan kajian terhadap sistem maklumat arkitek masa kini dan kualiti dalam sistem maklumat di klinik UTM dan untuk menawarkan model sistem maklumat hospital yang lengkap untuk menyokong sesiapa yang menguruskan sistem maklumat antara klinik. Kaedah kualitatif yang digunakan untuk mendapatkan maklumat yang diperlukan dan mengkaji situasi sistem maklumat di klinik pada masa sekarang. Interaksi dalaman telah diadakan bersama pengarah dan pengurus maklumat Pusat Kesihatan UTM untuk memahami kelemahan sistem sekarang antara klinik dan juga mengenalpasti tanggapan dalam pengurusan yang tertinggi di klinik. Sesetengah model seperti model rujukan digunakan untuk mengekal pasti jurang yang wujud dalam sistem sekarang dan mencari strategi yang cekap untuk menghasilkan sesuata yang lengkap. Menerusi kajian dalam perbezaan model meta yang dipanggil 3LGM yang menerangkan 3 aspek sistem maklumat hospital yang mengandungi aktiviti berfungsi, peralatan logik peralatan fizikal dan hubungan antara

satu lapisan dengan satu lapisan yang lain. Ini menjadi harapan bahawa projek ini dapat memberi faedah kepada Pusat Kesihatan UTM.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	TITLE	**i**
	DECLARATION	**ii**
	DEDICATION	**iii**
	ACKNOWLEDGEMENTS	**iv**
	ABSTRACT	**v**
	ABSTRAK	**vi**
	TABLE OF CONTENTS	**viii**
	LIST OF TABLES	**xiv**
	LIST OF FIGURES	**xv**
	LIST OF ABBRIVATIONS	**xviii**
	LIST OF APPENDICES	**xix**
1	**PROJECT OVERVIEW**	**1**
	1.1 Introduction	1
	1.2 The Background of the Problem	2
	1.3 Problem Statement	3
	1.4 Objective of the Project	4
	1.5 Scope of the Project	4
	1.6 Importance of Project	4
	1.7 Chapter Summary	5
2	**LITERATURE REVIEW**	**6**

2.1 Introduction 6
2.2 Health Information system (HIS) 8
2.2.1 Definition 8
2.2.2 How to have an effective HIS 9
2.2.3 Hospital Functionalities 11
2.3 Information System Architecture 12
2.3.1 Definition 12
2.3.2 Methods for Modeling Information System Architecture 13
2.4 Models and Meta Models for HIS 14
2.4.1 Definition 14
2.4.2 Functional Modeling 15
2.4.3 Technical Modeling 16
2.4.4 Organizational Modeling 18
2.4.5 Data Modeling 19
2.4.6 Business Process Modeling 20
2.4.7 Enterprise Modeling 22
2.4.8 Reference Models for HIS 23
2.4.9 Three-Layer Graph-Based Meta Model (3LGM) 27
2.5 Case Study 32
2.5.1 A Reference Model for Domain Layer of HIS 32
2.5.2 Leipzig University Hospital (UKL) 33
2.5.2.1 Challenges 37
2.5.2.2 Discussion 38
2.6 Closing Remarks 38
2.6.1 Lakes of Other Approaches 40
2.6.2 Lakes of 3LGM 41
2.7 Chapter Summary 42

3	**METHODOLOGY**		**43**
	3.1	Introduction	43
	3.2	Research purpose	43
		3.2.1 Exploratory Studies	44
		3.2.2 Descriptive Studies	44
		3.2.3 Explanatory Studies	45
	3.3	Research Approach	45
		3.3.1 Quantitative Approach	46
		3.3.2 Qualitative Research	47
	3.4	Research Strategy	49
		3.4.1 The Case Study Approach	50
		3.4.1.1 Single Case Study	52
	3.5	Project Methodology	54
		3.5.1 Planning Phase	55
		3.5.2 Analysis Phase	56
		3.5.3 Design and Development Phase	56
	3.6	Project Schedule	57
	3.7	Chapter Summary	57
4	**FINDINGS**		**59**
	4.1	Introduction	59
	4.2	Current System	60
		4.2.1 Organizational Analysis	60
		4.2.2 Pusat Kesihatan UTM Mission	61
		4.2.3 Pusat Kesihatan UTM Objectives	61
		4.2.4 Pusat Kesihatan UTM Services	61
		4.2.5 Pusat Kesihatan UTM Organizational Structure	62
		4.2.6 Patient Core Process in Pusat Kesihatan UTM	65
		4.2.7 ICT in Pusat Kesihatan UTM (TISMA)	69

4.2.8 Workflow in Pusat Kesihatan UTM 69
4.2.8.1 Work Flowchart for Registration Process 71
4.2.8.2 Work Flowchart for Treatment Process 72
4.2.8.3 Work Flowchart for Giving Medicine Process 73
4.2.8.4 Work Flowchart for X-Ray Process 74
4.2.9 Data Flow Diagram (DFD) 75
4.2.10 Use Cases 78
4.2.10.1 Use Case Description 80
4.2.11 Sequence Diagram 81
4.2.11.1 Login 82
4.2.11.2 Check Patient Records 83
4.2.11.3 Create new patient 84
4.2.11.4 Order lab test 85
4.2.11.5 Order x-ray 86
4.2.11.6 Order medication 87
4.2.11.7 Check patient's history 88
4.2.11.8 Request report 89
4.2.12 Activity Diagram 90
4.2.13 Activities Description for Treatment Process 91
4.3 Functions involved in Treatment Process according to different Roles 93
4.4 Comparing the Three layers of 3LGM for Pusat Kesihatan UTM with Heidelberg Reference Model 94
4.5 Function Description and involved Tasks 95
4.6 Development the Three Layer Graph-based Meta Model (3LGM) for Treatment Process of Pusat Kesihatan UTM 105

	4.6.1	Domain Layer: Enterprise Functions	105
	4.6.2	Logical Tool Layer: Application Components	107
	4.6.3	Linking Application Components to Enterprise Functions	110
	4.6.4	Physical Tool Layer: Physical Data Processing Components	111
	4.6.5	Linking Physical Data Processing Components to Application Components	112
	4.7	Chapter Summary	115
5	**RESULT AND IMPROVED MODEL DEVELOPMENT**		**116**
	5.1	Introduction	116
	5.2	Weaknesses of the Current System and System Improvement	117
	5.3	Domain Layer Improvement	121
	5.4	Logical Tool Layer Improvement	122
	5.5	Physical Tool Layer Improvement	124
	5.6	Chapter Summary	127
6	**ORGANIZATIONAL STRATEGY**		**128**
	6.1	Introduction	128
	6.2	Development the Proposed System	129
	6.3	Implementing the 3LGM	131
	6.4	Chapter Summary	132
7	**DISCUSSIONS AND CONCLUSION**		**133**
	7.1	Introduction	133
	7.2	Achievement	134
	7.3	Constraints and Challenges	134
	7.4	Aspirations	135
	7.5	Future Enhancement for the System	136

7.6 Chapter Summary 137

REFERENCES **138**

Appendices A-E 140-159

CHAPTER 1

PROJECT OVERVIEW

1.1 Introduction

Information handling is extensive and critical in the work of most organizations. Hospitals are also one of these organizations in which information systems have especial importance. It has been estimated that as much as two thirds of the work of health professionals within the hospital involves information handling. Sufficient information is essential to the health care process, to the management of health care organizations, and to the advancement of the field through research and teaching. Almost all healthcare professionals need a large amount of information. It is an essence for the quality of patient care and for the quality of hospital management to fulfill these information needs. Currently healthcare relies heavily on the ability of health information system (HIS) to assist in the diagnosis, management, education, and to health services provider.

Due to the importance of information processing as a quality and cost factor, a hospital has to invest systematically in hospital information system. The amount of clinical data is increasing concerning to the advances in medical information technology. Otherwise hospital information systems are going to shift to distributed

systems in stead of isolated systems. Because of these reasons, hospitals are encouraged to have an adequate system to manage hospital information system.

First of all, this thesis considers various models for hospital information systems and comparing them with 3LGM.

In next step, current information system architecture of UTM Clinic is defined by using Unified Modeling Language (UML).

Going step further, it determines the quality of information system in UTM Clinic by developing 3LGM respective current HIS. At the end, it proposes a new 3LGM for UTM Clinic according to the HIS requirements and information needs. Suggestion about implementing the improved system strategy is the following step in this study.

1.2 The Background of the Problem

Heterogeneity is inherent to hospitals. A hospital consists of various organizational units with differing tasks for various types of healthcare professionals. Since integrated care should be the aim, a high degree of interoperability has to be reached. This requires intensive internal communication among organizational units and healthcare professionals as well as external communication (Winter, Brigl, Wendt, 2003).

The hospital is itself a system, precisely a socio technical system, in which human beings and machines carry out specific actions following established rules. In this context, it is not surprising, that constructing and managing communication and interoperation needs a socio technical approach (A.Winter, and R. Haux, 1995, A. Winter, B. Brigl, and T. Wendt, 2003).

Managing clinical information is a challenge with unique requirements, and so far, no system has been able to address the complexity of the entire hospital

environment. Some medical information systems such as Hospital Information System (HIS), Picture Archiving and Communication System (PACS), Radiology Information System (RIS) and Laboratory Information System (LIS) are used in hospitals now, but they are usually heterogeneous and isolated. Data is incomplete, workflow is discontinuous, and management is not uniform (Xudong Lu et al. 2005).

Hospital involves a multitude of patient-hospital interactions, and these interactions require a complex network of communications and information systems. There is a lack of information to support the primary processes. The respondents suggest data management and files to be patient oriented in stead of specialist or departmental orientation.

As an attempt to explore the problems in the heterogeneity of hospital information, this research shall focus on a particular small-medium hospital i.e. UTM Clinic.

In this thesis, Three-Layer Graph-based Meta-model (3LGM) has been used and developed to support management of information systems at the Health Center in University Technology Malaysia. This model effectively describes and models HIS by hospital functions, application systems and physical data processing components. It serves to uncover weaknesses such as unintended redundancies, bottlenecks and etc.

1.3. Problem Statement

1. How to support strategic information management in hospital informtion system (HIS)?
2. How to understand the hospital's enterprise functions and the way they can be adequately supported by information and communication technology?
3. Which model is able to provide a terminology or ontology for designating HIS and their components which will serve as a blueprint to information system managers?

4. Which model is able to represent different aspects of HIS (functions, logical tools, physical tools) and also the relationship between them?

1.4. Project Objective

The objectives of this project include:

i. to study the current UTM clinic information system architecture
ii. to determine the quality of information system at UTM Clinic by using 3LGM, Heidelberg reference model, and Requirements Index for Information Processing in Hospitals, Version 1.0b.
iii. to propose a hospital information system (HIS) model for UTM clinic
iv. to propose an implementation strategy towards implementation

1.5. Scope of the Project

These are the identified scopes which define the boundary of the project:

1. This research will look at the hospital enterprise functions recognized in UTM Clinic and their existing path with application components and physical data processing components.
2. This research will focus on analyzing current status of information system architecture UTM Clinic.

1.6. Importance of Project

The heterogeneity of a hospital is reflected by its HIS. Like an architect the information manager needs a blueprint or model not only for planning the

LIST OF REFERENCES

Ammenwerth E., Buchauer A, and Haux R (2002). A Requirements Index for Information Processing in Hospitals. *Methods of Information in Medicine*. 41 (4), 282-8. The requirements index is available at: http://www.umit.at/reqhis.

Azizul Rusmadi Bin Abdul Rahman (2006). *Sistem Pengesanan Dan Diagnosa Tahap Kesihatan Pusat Kesihatan Universiti, UTM.* . Master Science, University Technology Malaysia, Skudai.

Engelbrecht Rolf, Geissbuhler A., Lovis C (2005). *Connecting Medical Informatics and Bio-informatics: Proceedings of MIE2005: the XIXth International Congress of the European Federation for Medical Informatics.* IOS Press.

Haux R., Ammenwerth E, and Buchauer A. (Ed) (2001*). The Requirements Index for Information Processing in Hospitals.* Version 1.0b.Germany: Inattitut für Medizinische Biometrie und Informatik (imGi). Supported by the Deutschungsgemeinschaft (DFG), Adopted by the DFG's Computing Facilities Committee. Editorial department: Department of Medical Informatics, Institute for Medical, Biometry and Informatics, University of Heidelberg.

Haux R., Michaelis J (1997). *Investitionsschema zur Inforamtionsverarbeitung in Krank enhausern (investment scheme for information processing in hospitals)*. Das Krankenhaus. 7, 425-26.

Haux Reinhold, Winter Alfred, Brigl Birgit (2004). *Strategic Information Management in Hospitals: An Introduction to Hospital Information Systems*. Springer. 63-73.

Hubner-Bloder Gudrun, Ammenwerth Elske, Brigl Birgit, and Winter Alfred (2005). Specification of a Reference Model for the Domain Layer of a Hospital Information System. In: Engelbert Rolf, Geissbuhler A., and Lovis C. Connecting *Medical Informatics and Bio-informatics*. IOS Press. 497-502.

Mohd Rosman Bin HJ ABD Rahman (2006). *Sistem Pengurusan Maklumat Dan Rawatan Pergigian Pusat Kesihatan UTM*. Master Science, University Technology Malaysia, Skudai.

Public Health Informatics Institute (2004). *Advancing public health practitioners' ability to strategically apply and manage information systems*. Decatur, GA. www.phii.org

Roussel Linda, Swansburg Russell C, Swanburg Richard J (2005). *Management and Leadership for Nurse Administrators*. Contributor Russell C. Swansburg, Richard J Swansburg. Jones & Bartlett Publisher.

Wendt T., Haber A., Brigl B., and Winter A (2004). Modeling Hospital Information Systems (Part 2): Using the 3LGM² Tool for Modeling Patient Record Management. *Methods Inf Med.* (43), 256-267.

Winter A. and Haux R (1995). A Three-Level Graph Based Model for the Management of Hospital Information Systems. *Methods of Information in Medcine*. 34 (4), 378-96.

Winter A., Brigl B., and Wendt T. (2003). Modeling Hospital Information Systems (Part 1): The Revised Three-layer Graph-based. *Methods Inf Med*. (5), 544-551.

Winter Alfred, Brigl Birgit , Funkat Gert , Ha¨ber Anke , Heller Oliver, Wendt Thomas. (2007). 3LGM²-Modeling to support management of health information systems. *International journal of medical informatics.* (76), 145–150.

Web site, http://dssresources.com/glossary/116.php, August, 2008.

Web site, www.Wikipedia.org, August, 2008.