Conceptual Database Design for Smart Medical Clinical System

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***Abstract*—Hospitals are known for having separate information systems across various departments, which are usually heterogeneous in nature. Medical experts could benefit greatly from the integration of these islands, but the heterogeneity of the sources/databases often impedes this. Most cardiothoracic units use isolated heterogeneous systems to keep patients records as well as to support the experts when deciding for cardiothoracic surgery. These include patient's information system, lab results for x-ray, angiography, echocardiogram, blood etc. All these information are stored in heterogeneous systems and as such, a user would have to log-in and log-out from one system to another, to monitor/trace a patient's medical record. As the solution, we proposed a clinical database system in which the system incorporates the overall patient's management, from ward admission through Operation Theatre, Coronary Intensive Care Unit (CICU), recovery and discharge in which is divided into several modules. The purpose of this paper is to presents the conceptual database design for the Smart Medical Clinical System which include features that could alert the healthcare personnel regarding any abnormal trend in the data, so that medical experts need not have to repeat the same investigations.**

Keywords-clinical database; smart medical system; ERD

I. INTRODUCTION

Information technology has increasingly played an important role in the management of hospitals. It has generally shown benefits in patient registration, keeping track of treatments/consultations, previous history, laboratory test orders, inventory monitoring of medications etc. [1]. The study suggested that future research on information technology in health care providers must move on to evaluate as a whole the main outcomes for patients, practices, and the health service.

In Malaysia, cardiovascular disease remains the number one killer and the National Health and Morbidity survey showed that 61% of the patients had one risk factor or more [2]. There are several public and private hospitals in the country that specializes on this disease and they provide treatment for heart patients. Most of these health care providers have computerized systems, state-of-the-art and sophisticated equipments as well as very specialized team of medical experts such as doctors, surgeons, anaesthetists, and perfussionists. In spite of all these blessings, timely and accurate data for monitoring or assessing the trends in cardiovascular patients are unavailable. This information is vital in the decision making for determining the preventive measures that could be taken to improve the health quality of the nation. One good reason for this setback is that a patient's information are scattered in different systems across the hospital.

Since existing systems are isolated, most of the time the hardcopy of reports from the various systems are printed and compiled as one huge patient's file. Should a patient be moved from one unit to another, the hardcopy file would also be transferred/moved. The tendency for this file to be lost or misplaced is really high. Therefore, by introducing integration of heterogeneous medical databases, it could assist medical experts either before or after cardiothoracic surgery, be it of data collection, and/or decision support system. Databases could be accessed and updated in one place and at the same time and there would not have to be repeatition of the same data entry into separate systems. Thus minimizing errors and risks, saves cost, better and improve patients' management, faster decision-making are among the benefits to be favored by medical experts when implementing integrated heterogeneous medical databases.

II. RESEARCH BACKGROUND

Hospitals are known for having separate information systems across various departments, which are usually heterogeneous in nature. Medical experts could benefit greatly from the integration of these islands, but heterogeneity of the source/databases often impedes these [3]. Many efforts have been made to overcome this difficulty such as ontology-based system [4], agent-based system [5], hybrid technique [6].

One such effort is the data-translation strategy that involves the development of physically separate database that aggregates data from the various departmental systems and makes them available in a "clinical data repository" for online access, decision support, and reporting. However, it has historically required hospitals to laboriously construct and painstakingly maintain custom interfaces for each departmental system [7]. The limitation is that data are not available in the global repository until they are physically updated from the departmental systems.

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Integrated medical databases system could overcome this by having all of them in one 'space', which is convenient enough for managing all of data into an integrated database. Nevertheless, schema management is one of the problems in data integration systems [8]. Schema integration conceptually integrates heterogeneous databases into a single schema. Schema heterogeneity can be classified into three broad categories, namely, platform and system heterogeneity, syntactic and structural heterogeneity, and semantic heterogeneity [8]. Platform and system heterogeneity refers to the differences in operating systems, hardware, and DBMS. Syntactic and structural heterogeneity refers to the differences between data model, schema abstraction, domain, entity definition, and data value incompatibility. Semantic heterogeneity includes naming conflicts and abstraction level conflicts.

III. RESEARCH PROBLEM

Most cardiothoracic units use isolated heterogeneous systems to keep patients records as well as to support the experts when deciding for cardiothoracic surgery. These include patient's information system, lab results for x-ray, angiography, echocardiogram, blood, etc. All these information are stored in heterogeneous systems and as such, a user would have to log-in and log-out from one system to another, to monitor/trace a patient's medical record. Since existing systems are isolated, most of the time the hardcopy of reports from the various systems are printed and compiled as one huge patient's file. Should a patient be moved from one unit to another, the hardcopy file would also be transferred/moved following the patients' where about. The tendency for this file to be lost or misplaced is really high.

Therefore, alternatively an integrated system to combine the existing heterogeneous systems is required. By introducing integration of heterogeneous medical databases, it could assist medical experts either before or after cardiothoracic surgery, be it of data collection, and/or decision support system. Databases could be accessed and updated in one place and at the same time there would not have to repeat the same data entry into separate systems. Thus minimizing errors and risks, saving cost, improving patients' management, faster decisions making are among the benefits to be favored by medical experts when implementing integrated heterogeneous medical databases. However, due to technical constraints such as different system ownership/rights, incompatible database designs, etc. have hindered the process of system/database integration.

In data integration, schema matching and mapping are fundamental components used to express the relationship between the local and global schema. Traditionally, the matching and mapping tasks were performed manually by a database designer who has a good knowledge on the semantics of the schemas. However, this task is laborious, time-consuming and error-prone due to the complexity and large size of the available schemas, as well as their complicated semantics.

This project will investigate the common practices and the existing systems, such as Critical Care Info System, Queue Managament System, Laboratory, Radiology, Cardiology, and etc. Then the assessment of the heterogeneous databases designs need to be carried out in order to determine the global schema required for a global integrated system. In addition, this work will also explore various techniques used in schema matching and mapping tasks. Eventually, our designed scheme matching and mapping for the cardiothoracic surgical data will be evaluated and the capability of data integration for the cardiothoracic surgical system will be analyse. Finally based on the findings we shall implement our integration model for the heterogeneous cardiothoracic surgical databases in real scenario. As a pilot project, the Cardiothoracic Intensive Care Unit, Pusat Perubatan Universiti Kebangsaan Malaysia conceptual database design for smart medical clinical system.

IV. METHODOLOGY

The system incorporates the overall patient's management, from ward admission through Operation Theatre, Coronary Intensive Care Unit (CICU), recovery and discharge in which is divided into several modules. The components include medical records, CICU monitoring system, blood investigation, x-rays, electrocardiogram (ECG), angiograms, echocardiography and lung function tests. Each component is responsible to collect significant data from its integrated functions and if possible, to provide support for decision making to be made by physicians. Databases would alert the healthcare personnel regarding all the abnormalities, have the ability to store, access and update, so that medical experts need not have to repeat the same investigations. By introducing integration, databases could be stored, accessed and updated simultaneously – eliminating data duplication, which is beneficial to medical experts.

The developed prototype can contribute the following benefits: (1) Prevention from late decision; (2) Improve patient care; (3) Avoid unnecessary decision in surgery; (4) Reduce mortality rate; and (5) Reduce cost operation.

In order to overcome the problem and to come out with good conceptual design, we have steps as stated below to be used in this research. The steps are:

i. Review designs of existing databases and system
   - Analyze existing databases and system design
   - Identify the accurate and clear database and system design without data duplication

ii. Design integration and system model
   - Come out with conceptual design of global database
   - The conceptual design is use to define schema for integration purposes

- Design model of the prototype of peri-operative medical laboratory investigation system.

V. Conceptual Database Design of Smart Medical Clinical System

Based on problem stated, this section will present the conceptual design by using the Entity Relationship Diagram (ERD). ERD is a conceptual database design which is a graphical representation used to depict efficient database design. The ERD for the Smart Medical Clinical Database System is a result of analysis from user requirements which covers the cardiothoracic patient transfer within the Cardiothoracic Surgery Unit in Pusat Perubatan Universiti Kebangsaan Malaysia is as shown in Figure 1.

Initially a patient which is admitted in the ward will be monitored before the scheduled surgery. During the surgery, in the operation theatre, some monitoring are done and the crucial data are captured especially which involves the anaesthetist, perfusionist, and surgeon. Once the operation has completed, patients will be transferred to CICU for further monitoring. Once the patient is stable, he will be transferred back to the ward for monitoring. Throughout these processes many crucial data are being captured which are useful for pattern analysis. The study of all the above processes enabled us to design the database for storing the data efficiently.

The idea of this conceptual database design is to ensure the easily extended design when added with new requirements gathered or raise during development of the smart medical clinical system later. The ERD also has been designed to fulfill the function of peri-operative process in the proposed smart medical clinical system.

VI. Conclusion and Future Works

The conceptual database design of the Smart Medical Clinical System has been presented in this paper. The design takes into consideration the data from heterogeneous islands of sub-systems which forms the essential requirement for the development of a complete and independent system for use in the cardiothoracic surgery unit.

Currently, the design has been used in the development of some modules of the Smart Medical Clinical Database system prototype. In future, we shall expand the scope of the cardiothoracic surgery monitoring process to include the prior diagnostic process.

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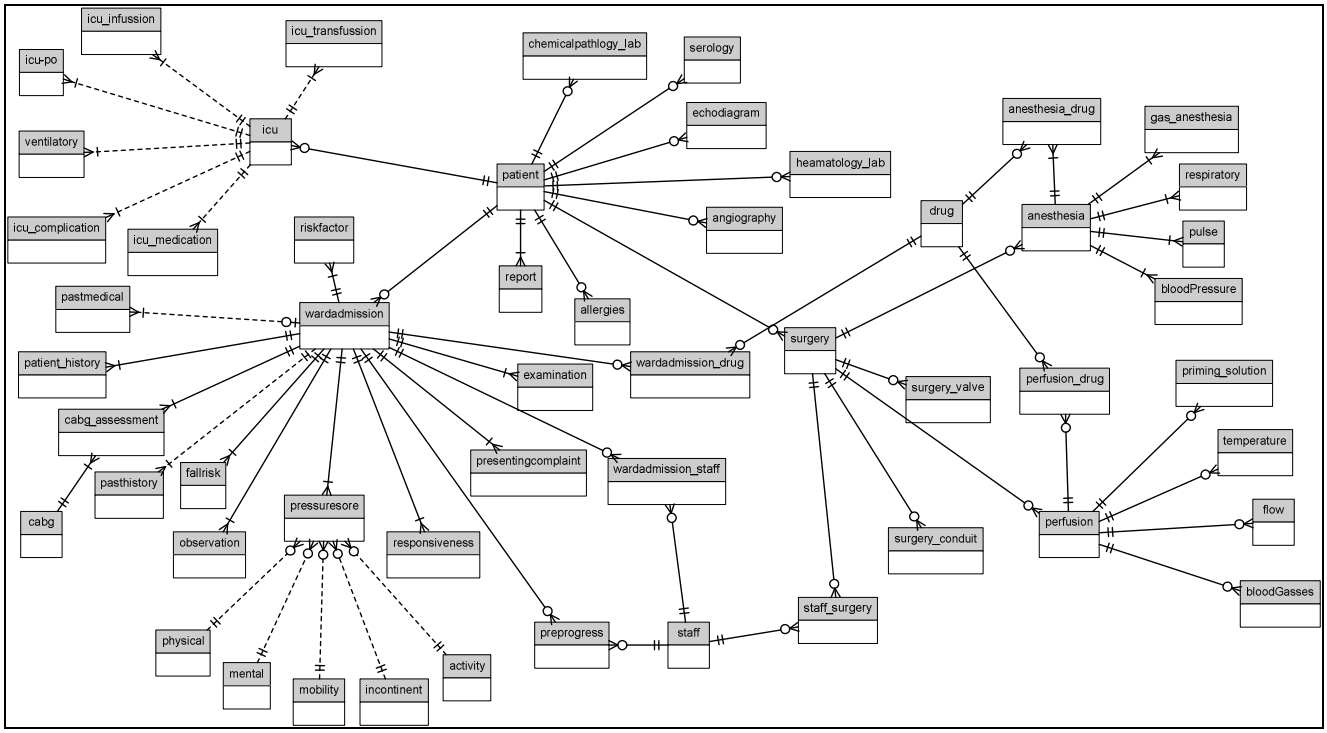

Figure 1. The Entity Relationship Diagram for Smart Medical Clinical System ©2010