Integration of Heterogeneous Databases for Medical Experts

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***Abstract*—This paper presents an initial work on the conceptual architecture of medical databases integration. The problem with current medical institutions are that most of them have variety of systems across various departments where most of the systems have existing and incompatible database management system that are tied together in a network. All these systems stored patients' information in an isolated and stand-alone environment and as such, a user who wish to use the system would have to log-in and log-out from one system to another in order to monitor or trace a patient's medical record. To overcome the problem above, we proposed an integration of heterogeneous medical databases that can eliminate data duplication and save cost, and at the same time can assist medical experts either before or after a surgery.**

Keywords-heterogeneous database; patients information system; medical database; cardiothoracic surgery; database integration.

I. INTRODUCTION

Medical institutions usually have variety of computers across various departments where most of the systems have existing and incompatible database management system that are tied in a network. This scenario has fostered incompatible databases that prevented the sharing of common data among applications. In any medical heart institutes, 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, and 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 in order to monitor or trace a patient's medical record. 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 can be accessed and updated in one place and at the same time the experts would not have to repeat the same data entry into separate systems [1]. With fully accessible and integrated electronic patient records, and with instant access to up-to-date medical knowledge, faulty decision making resulting from a lack of information can be significantly reduced [2].

In addition they can minimize errors and risks, save cost, enhance and improve patients' management, and faster decision making are among the benefits to be favored by medical experts when using the integrated heterogeneous medical databases**.**

This paper presents the conceptual architecture of heterogeneous databases integration for one of the medical institutions in Malaysia. The remainder of this paper is organized as follows. In the next section, the related work of the study is reviewed. Section 3 presents the architectural design and finally, section 4 concludes the paper.

II. RELATED WORK

Ash et al. (2003) discussed two main categories that occur in an information system. The first category discussed errors in the process of entering and retrieving information in or from the system, while the second category discussed errors in the communication and coordination processes that the Patient Care Information System (PCIS) is supposed to support. As been discussed in their paper, such failures are the result of mistaken assumptions about health care work that are built into PCIS applications, creating dysfunctional interactions with users and, sometimes, leading to actual errors in the delivery of health care.

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Increasingly, the entry and retrieval of information into and from a PCIS are a core activity in health care work. Given the characteristics of this work, these PCIS applications have to fulfill specific demands. Many of these are well known; PCIS applications have to have fast response times, have negligible downtime, be easily accessible, and have interfaces that are easy to understand and navigate [2, 7]. Also, the software and hardware have to be designed to optimally fit the ecology of the work practice: mobile when necessary, robust, small but ergonomically suitable [8, 9]. Although such requirements are widely known and accepted, they are often not met. Moreover, they mentioned that many system interfaces are still so impractical that using the systems takes a great deal of costly time on the part of busy professionals.

In the second category, the authors discussed on how computers can undermine communication and coordination of events and activities. These have lead to poor workflow, which can cause late delivery of services in the health care environment.

The scenarios mentioned above are similar to what the existing systems in the medical institution are facing. The next section described the conceptual architectural design of the medical database integration.

III. ARCHITECTURAL DESIGN

Many technologies are currently available to manage patient's medical record and support the experts when deciding for cardiothoracic surgery, but most related systems are heterogeneous and are difficult to support the medical workflow which includes clinical and research tasks. Although the development of stand-alone applications has been easy but it has created incompatible databases that prevent the sharing of common data among various applications. By introducing integration, databases could be stored, accessed and updated simultaneously, thus, eliminating data duplication.

The proposed architecture can contribute the following benefits:

(1) prevention from late decision
(2) improve life style
(3) avoid unnecessary decision in surgery
(4) reduce mortality rate, and
(5) reduce cost operation.

In order to overcome the problem above, we performed the necessary steps below to help us come out with a good and effective architectural design.

i. Review designs of existing databases and system
   - Analyze existing databases and system design
   - Identify an accurate database and system design with no data duplication

   The requirements for the activities above are obtained through interview with the medical doctors and medical users operating the health systems and devices, interview with the Information Technology officers whom are responsible for the current Hospital Information System, and visiting the relevant existing systems in their respective departments.

ii. Design integration and system model
   - Implement a conceptual design of the global database
   - The conceptual design is then used to define schema for integration purposes in the next phase

   The conceptual design is shown to the medical experts to gain feedback or comments before proceeding to the next level of discussion.

The next subsections below show the proposed conceptual architecture of the medical databases integration starting with an introduction to the existing system.

A. Existing System

The existing systems are used by medical experts in a medical institution relating to cardiothoracic surgery. The systems incorporate the overall patient's management that covers:

- ward admission
- Operation Theatre (OT)
- Intensive Care Unit (ICU),
- recovery and discharge

These components include medical records, Cardiac Intensive Care Unit (CICU) monitoring system, blood investigation, x-rays, Electrocardiogram (ECG), angiograms, echocardiography, and lung function tests. Each component collects significant data from its integrated functions and pushes the information to this existing system (refer to Figure 1). Most of the systems (as shown in Figure 1) that push information into this existing system are independent and are not able to communicate directly with one another. Currently, the information pushed into the existing system are basic patients' record and there are no extensive clinical or detail medical historical data stored in it. The difficulty arises when medical experts wish to access the patients' historical medical records and will have to deal with different systems at different time. Moreover, these records are important for research purposes by the medical experts. Therefore, by having a fully accessible and integrated electronic patient records together with a complete medical history, and with instant access to up-to-date medical knowledge, faulty decision making resulting from a lack of information can be significantly reduced.

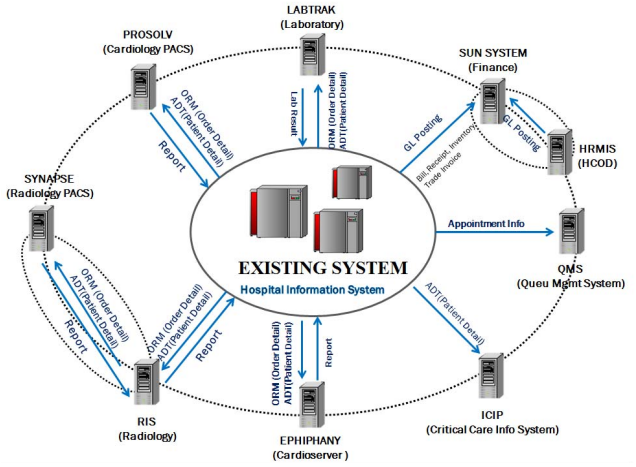

Figure 1. Existing system

B. *Proposed System*

To overcome the current limitations of the existing systems and the current Hospital Information System, we have designed a new database system known as CASDClinical, which communicates with the existing systems and the newly four proposed components.

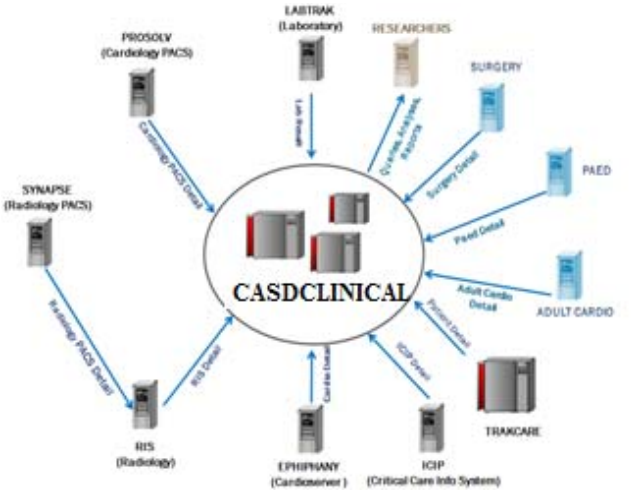

Figure 2. Proposed CASDClinical

This new proposed database system will incorporate the current Hospital Information System with other existing systems and the new four proposed components known as Surgery, Pediatric and Adult Cardiac together with a proposed Researchers component to fulfill the needs of medical experts (as shown in Figure 2). The CASDClinical will store information pertaining to not only the patients' management record but also the detail medical records. The Researchers component is to allow medical experts to retrieve or extract any relevant data for future research purposes. Thus, the new CASDClinical system together with the four proposed components will have the ability to store, access and update, so that medical experts need not have to repeat the same investigations. Moreover, databases can be accessed and updated simultaneously, thus, eliminating data duplication which is beneficial to medical experts. The next section shows how the proposed database is developed conceptually that shows a link between enterprise level and data storage level. The existing systems in the medical institution together with CASDClinical communicate with a data warehouse to facilitate the manipulation and exchange of data.

C. *Proposed Data Warehouse*

A data warehouse is a database specially designed to facilitate business analysis and decision support as well as to analyze what has occurred within the business across time in order to obtain a competitive edge in the marketplace [5]. According to Bill Inmon [3], "A Data Warehouse is a repository where data is kept in a subject oriented, integrated, time variant and non volatile manner to facilitate decision support".

Data from the existing operational enterprise system and proposed CASDClinical are extracted, cleaned, and loaded into data warehouse. The proposed configuration conceptual design of data warehouse depicted in Figure 3 can be used at the enterprise level and serve the needs of the whole organization which can be integrated with the Electronic Medical Record (EMR) System soon to be implemented by the Ministry of Health, Malaysia [6].

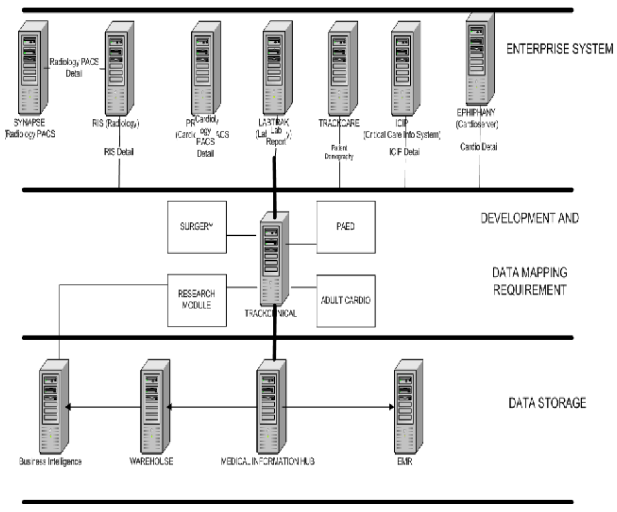

Figure 3. Proposed configuration conceptual design integration and application of CASDClinical data warehouse

In addition, the proposed configuration is also to facilitate operational efficiency and informed administrative decision making. The aim is to provide users with direct access or interaction with the data to produce detail, flexible, and rapid retrospective views of clinical, administrative, management, financial, patient data including research and education.

IV. CONCLUSION AND FUTURE WORK

Medical error reduction is an international issue as reported by the Institute of Medicine where it cause up to 98,000 deaths in hospitals and cost approximately US$38 billion per year in the US [10]. The results of the study revealed that among all the types of medical errors reported by surgeons, the types that occur most often are misdiagnosis and delayed diagnosis [1, 4].

This paper has presented a design of integration medical databases to allow communication between various systems with multiple platforms and languages in a medical institution. Databases can be accessed and updated in one place and at the same time the experts would not have to repeat the same data entry into separate systems. Thus, the new integrated heterogeneous medical databases can minimize errors and risks, saves cost, enhance and improve patients' management, and produce faster decision making. Our next step is to refine the architecture and implement the proposed CASDClinical database system with the four proposed components based on the conceptual design agreed by the medical experts.

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