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INFORMATION INTEGRATION IN ELECTRONIC HEALTH INFORMATION SYSTEMS USING SERVICE ORIENTED ARCHITECTURE APPROACH

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ABSTRACT

Health Information System (HIS) integration constitutes one of the main challenges to the developers. Although current integration technologies are up to now quite mature, we confront several problems and challenges regarding the complexity of functions and database of the HIS. The efficiency and performance are the issues for the HIS implementation that related to information integration problems. This research proposed an approach using Service Oriented Architecture (SOA) through Web Services (WS) to integrate the information used by the HIS. This study explored the problems and issues of information integration in HIS and uses the WS and SOA to improve the performance of HIS. The performance of data integration is measured to evaluate the proposed approach. Moreover, benchmark with the current approach is carried out in order to describe the efficiency of the proposed solution.

Keywords: service oriented architecture, data and information integration, health information system.

INTRODUCTION

Information integration has become one of the important challenges faced in today system development process. It is very crucial to ensure that the data integration needs are in line with organization's information technology (IT) development (Inmon, 2008). The challenge for managing the huge and complex big data has initiated new approaches in data integration solution (Smith, 2013). Moreover, when there is a change in the system, the process of data collection, development, integration and transformation on different platforms as well as a separate system becomes tedious and difficult. Data integration becomes important due to data being distributed across entities, platforms and data repositories. Generally, the cost of data integration for any software system accounted for up to 40% of data processing budgets (Brodie, 2010).

With the advancement of technology and the demanding needs within health industry, health information system (HIS) is becoming more complicated. Health management operation is struggling to coupe with the evolution of information management (Lucas et al., 2013, Ajami et al., 2013 and Le, 2013). One of the factors that lead to lack of efficiency in HIS implementation can be largely caused by uncoordinated approach to the design and implementation of smart interactions. This inefficiency will create barriers to accessibility and integration, which will burden healthcare providers with administrative and information overload (Kuziemsky, Peyton, Weber, Topalogou, and Keshavjee, 2011). Therefore, causing problem for health related organizations to deliver efficient service delivery (Bloomrosen et al., 2011).

This research is motivated by the data and information integration problems of HIS in Universiti Utara Malaysia (UUM). The problem has caused the inefficiency of service delivery by the Health Management Center (HMC) to the patients. HIS need to be integrated for maintaining the smoothness of health management operation. The current HIS application contains several modules, which some of the modules were not properly integrated. The modules are Registration, Treatment, Inventory, X-Ray and Laboratory. Nevertheless, HIS needs to access and integrate data from other University information systems such as Personnel System (PERSIS), Academic Student Information System (ASIS), Graduate Academic Information System (GAIS) and Integrate Financial and Accounting System (IFAS), which requires access across various operating systems, applications, system software, and application infrastructure. However, data integration approaches were not well implemented due to some system with less automated elements in data integration method.

The efficiency and performance are the main issues in the HIS implementation and requires a proper data integration method in order to solve the problems. Current approaches were adopted from various technologies provided by industries. However, less attention were givrn to identify the best practice methods for integrating the data during the implementation of other university's information systems with HIS. The advancement of web services (WS) within the Service Oriented System (SOA) framework is suitable and practical for integrating the data and application in an enterprise environment. Therefore, this research aims to explore the integration solution using the SOA and WS for HIS, which is lacking in solution for HIS and will improve the implementation of University HIS in the future.

RELATED WORKS

Data integration refers to the creation of an integrated view over seemingly incompatible data that are normally collected from different sources (Waddington, 2008). Wang *et al.* (2013) identified challenges of data

integration is real-time performance and Zhang *et al*. (2013) have conducted an experimental study on the performance of data integration. Health workers often need real time or near real time access to large and complex sections of the data. Complex data environment of the new information is often highly complex in structure and the data sources are heterogeneous with no common structure formats (Ovaska *et al*., 2010). Consequently, planning is difficult due to the future structure of the healthcare industry is unclear. The role of most individual new technologies in a long-term structure of the different healthcare processes is uncertain (Oberlander *et al*., 2010). Moreover, the tool for data integration is expensive, but no promises are being realized in practice (Benkner *et al*., 2010). Many data integration projects failed, even the well-known, widely used tools in the industries.

Information is shared by using various data integration approaches. Normally, these approaches cover the level of information and application in an enterprise environment and can be classified in three ways: data federation, data consolidation, and data propagation. The bulk of the data integration researches use queries (views) as its mechanism for describing mappings: views can relate disparate relational structures, and can also impose restrictions on data values. There are two standard ways of using views for specifying mappings in this context: data sources can be described as views over the mediated schema (this is referred to as local-as-view or LAV), or the mediated schema can be defined as a set of views over the data sources or global-as-view (GAV).

It is important to note that in general, using a view in the reverse direction is not equivalent to writing an inverse mapping (Halevy et al., 2003). In particular, the important property of LAV is that it enables describing the data sources that organize their data differently from the mediated schema. Various tools can be used to integrate systems and data. The introduction of these tools brought the promised of benefits, but no promises are being realized in practices. Most criticisms on data integration tools and vendors are that data integration solution is expensive, difficult and have no means (Benkner et al., 2010). Several solutions are made too simple to perform the tasks, butothers are made too complex. Moreover, the costs of building and maintaining solutions have rocketed, not to mention the nearly impossible tasks of integration in different systems together. It seems that reaching the right level of simplicity is more like a dream than reality.

According to Imhoff (2005), three types of technologies used to implement the integration, namely: Enterprise Application Integration (EAI), Enterprise Information Integration (EII), and Extract, Transform and Load (ETL). Summary of the research works on data integration in HIS is shown in Table-1.

Table-1. The *Research Works for Data Integration* on HIS.

Author	Research Focus	Method / Framework
Kart *et al*., (2008)	Use WS to integrate data from mobile devices	Web Services Framework
Yang *et al*. (2010)	Design RIM-Based computer for CIS	Propriety method of CIS, RIM-Based concept and clinical database.
Chute *et a*l. (2010)	Enterprise data warehouse for biomedical data	Enterprise Information Management (EIM)
Zapletal *et al*. (2010)	Integration for clinical data warehouse	Component-bases approach and 12B2 framework
Bouras *et al*. (2010)	Integrate with healthcare system	Semantic-based SOA
Gong and Chen (2010)	HMS integration and shared platform based on SOA	Service Oriented Architecture

Based on the Table-1, very few researches focused on using WS and SOA to resolve the problem in data integration for HIS. Therefore, this research is focused on schema level of data integration, which is very important for efficient implementation of HIS, especially in the University environment.

HEALTH INFORMATION SYSTEM

Management of Health Information gives focus to communication and accurate record keeping. Currently, an important portion of the HIS contains various stand-alone applications that have been integrated and delivered in a more unified manner. The performance, effectiveness and other factors of these applications can alter the performance of the HIS. The HIS also provides user interfaces for patients, physicians or doctors, nurses and pharmacists. Increasingly, the HIS is being constructed from sets of preexisting sub-systems, which are developed and owned by the independent unit or department (Tyson *et al*., 2011).

HIS was broadly used and has many different names and definitions. These include Electronic Health

Record (EHR), Electronic Medical Record (EMR), Electronic Patient Record (EPR), Computerized Patient Record or Computer-based Patient Record (CPR), Electronic Health Care Record (EHCR), Virtual HER, Personal Health Record (PHR), Digital Medical Record (DMR), Clinic Information System (CIS) and Hospital Information System (HIS). Most of the commercial HIS was developed according to the Health Level Seven (HL7) standardization. The HL7 contains six profiles in health management functions: Clinical Research, Behavioral Health, Long Term Care, Child Health and Records Management and Evidentiary Support and Pharmacy.

University HIS comprises of one or several software components with specialty-specific extensions, as well as of a large variety of sub-systems in medical specialties. Components of University HIS consist of the following modules: Clinical Information System (CIS), Financial Information System (FIS), Laboratory Information System (LIS), Nursing Procedures (NP), Pharmacy Information System (PIS), Picture Archiving Communication System (PACS) and Radiology Information System (RIS). Figure-1 showed the modules of University HIS.

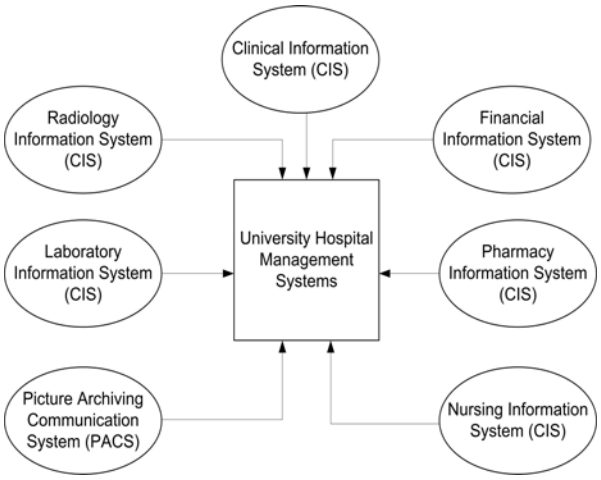

Figure-1. Database environment for university HIS.

WS AND SOA-BASED INTEGRATION

University HIS has several modules such as Queuing, Patient Registration, Treatment and Pharmacy. The patients' data need to be integrated from several applications such as ASIS, GAIS and PERSIS. Based on observation and interview with the users, the efficiency and performance of the HIS are the main issues. This was related to the poor performance of the data integration tasks. The initial database structure was comprised of data sources and data destination, which were integrated in different settings (e.g., DBMS, platform) as shown in Figure-2.

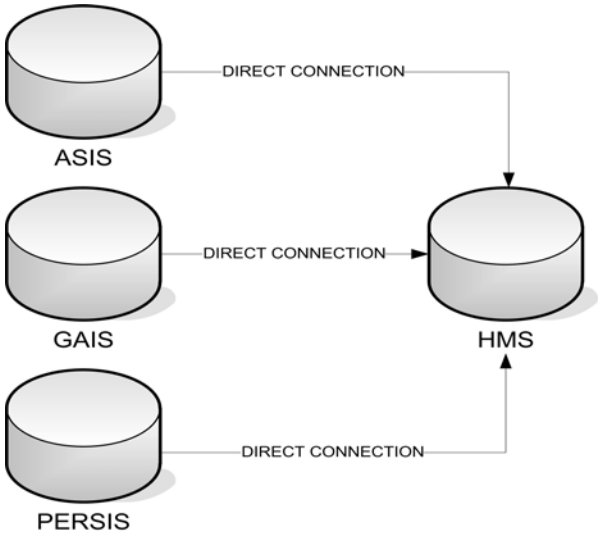

Figure-2. Database integration setting for university HIS.

The model in Figure-2 was chosen because it is easy to implement and gives faster access to the database sources that are separated in different platforms. Moreover, several HIS modules purchased from the vendors were supplied in different platforms because plenty of technology existed with competitive capabilities and prices. This has created the island of servers and caused continuous problems for data integration. Indeed, this has lead to the inefficient and performance problems of the HIS.

SOA

SOA goal is to achieve loose coupling among interacting software agents. A service is a unit of work done by a service provider to achieve desired end results for a service consumer. Both provider and consumer are roles played by software agents on behalf of their owners (Nadkarni and Miller, 2007). This method is used to integrate distributed system infrastructure as raising the quality of health management at low cost (Benkner et al., 2010). It will enable loose coupling of components across heterogeneous platforms, ease of maintenance and integration, easier discovery, use and aggregation of services and components (Nadkarni and Miller, 2007, Bouras et al., 2010).This means the SOA can perform the communication services to integrate service and data into other web resources.

WS

WS is used to expose applications directly over the internet or within an organization for particular purposes. The technology allowed exchanging the information across the heterogeneous networks, platforms and systems. WS and SOA have been explored to produce a solution for integrating patients' data in HIS.

Integration Approach

This research considered the data integration problem in two main modules of University HIS that are Treatment and Pharmacy. Both modules need to share some data, such as drug code, drug stock, patient registration and treatment. These modules were implemented on different platforms, which is Pharmacy run on the Microsoft SQL Server and NET Framework. The Treatment module implemented in Sybase and Power Builder platforms. The proposed data integration model is shown in Figure-3.

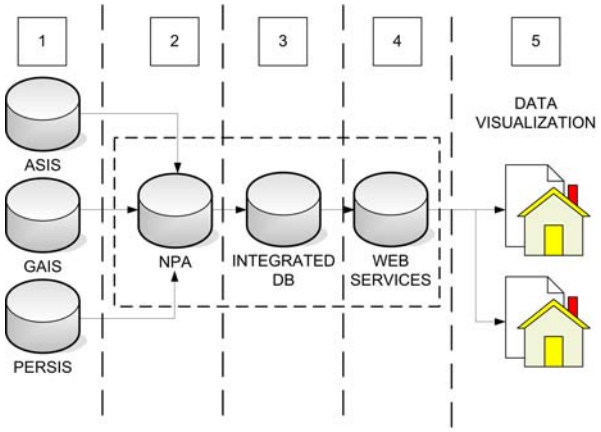

Figure-3. Data integration model for university HIS.

Based on Figure-3, the data integration model defined the Treatment database as one of the database sources and the Pharmacy database is the destination database. To perform the data integration process, the integrated database is created in order to store and manipulate data from the database sources. The integrated database is used to provide the data for operating the functions of the system. The implementation of data integration was performed by the WS functionality and is comprised of five components: data source, negotiate proxy agent (NPA), integrated database, web services (WS), data visualization, and data sources.

Data sources

Data sources for University HIS consist of ASIS, GAIS, PERSIS and IFAS. In order to provide the unified view of patient's data, the combination of data source from ASIS, GAIS and PERSIS are needed. For example, the data regarding the payment are available from IFAS, whereas the information about patient profile is provided by the ASIS, GAIS and PERSIS. These four systems were integrated with the patient information. Moreover, some database schemas were designed in different structures, even used for the same purpose.

Negotiate Proxy Agent (NPA)

The NPA is a mechanism or agent to perform a negotiation between two agents (Chhetri et al., 2007). A Service provider can expose their negotiation capabilities either as an agent-based system or as WS, which can be registered in and retrieved from a service registry. In this research, NPA takes place between each database provider for database sources and the database for Pharmacy. The flow for implementing NPA is shown in Figure-4.

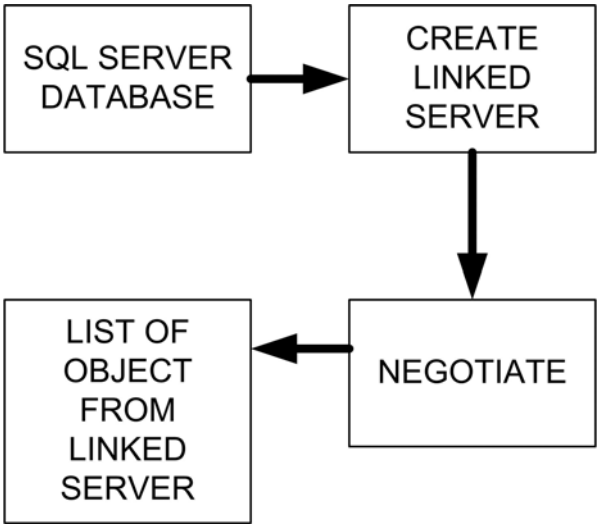

Figure-4. Negotiation between SQL server and linked server.

The NPA used Linked Server function in the Microsoft SQL Server (in another database, e.g. Sybase is using Remote Server). This function established the connection, authenticated the user and displayed the object from different servers and different types of database. This made the object from a local table containing metadata used to access a table on a remote database server as if, it was a local table. The example scripts for creating NPA using the Linked Server is shown in Figure-5. The scripts were executed in Microsoft SQL Server as a local server, and instantly establishes the NPA to facilitate the interaction between local to remote servers.

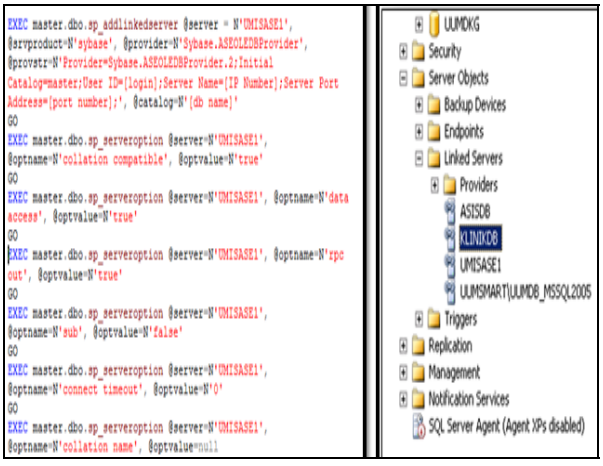

Figure-5. The example scripts for creating NPA.

Integrated database

The integrated database function is to perform data cleaning and consolidate all proxy tables to be used by the University HIS. The proxy tables were derived from the various data sources, which maintained the connection to the original data sources. Two methods were used to perform these tasks:

a) The data is read from the proxy table as a data source. The proxy table is maintained as online transactions that required real time data access.
b) The data is a copy of the proxy table in the integrated database.

The process flow is to maintain the integrated database is shown in Figure-6.

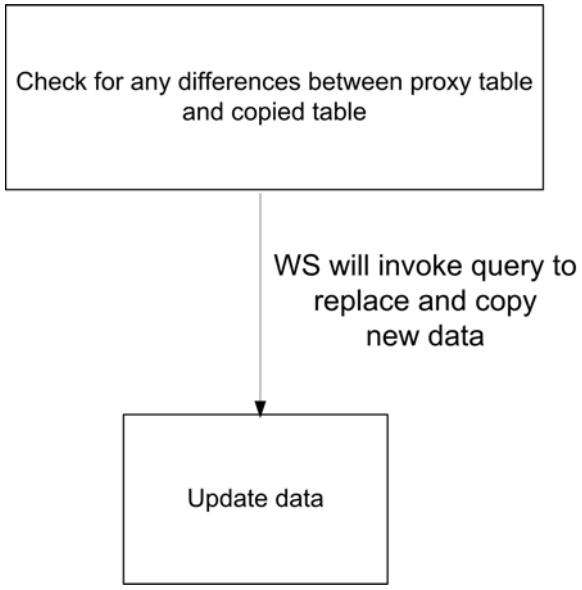

Figure-6. Process flow to maintain integrated database.

Web services (WS)

WS is a main component used in SOA. In this research, a dynamic WS were created to execute queries for an assortment of functions from various database platforms. The example of the WS page scripts (i.e., VBScripts) is shown in Figure-7.

```
Public Class _default1
    Inherits System.Web.UI.Page

    Protected Sub Page_Load(ByVal sender As Object, ByVal e As System.EventArgs)
Handles Me.Load
        Dim ws As New SQLWS.SQLWS

        Dim db As New ParamWS
        Dim ds2 As New DataSet
        ds2 = ws.GetData(db.ds, "dbo.sp_datetime_process", 1)
        GridView1.DataSource = ds2
        GridView1.DataBind()
    End Sub

End Class
```

Figure-7. The WS page scripts for invoking query.

Data visualization

The results of the query and transaction of this system are displayed as an output to the users. Users can evaluate the effectiveness or performance of the system and benchmark with the current system for evaluating the implementation of the HIS. This study was not focusing on this section. However, the prototypes of integration functionalities were developed to be used for evaluation purposes.

EVALUATION AND FINDINGS

The performance of data integration was evaluated to identify the improvement of the proposed data integration model compared to the current approach. The data transfer rate was captured in two types of measurements:

a) Data for patient - the data accessed from the student records (i.e., ASIS and GAIS) and staff records (i.e., PERSIS). The data sources must constantly be up to date.
b) Data for dispense - the transaction data need to be accessed in real time by pharmacists to dispense the medication for the patient based on doctor's prescription.

The latency rate for transferring patient data

Latency is defined as time period taken for processing the task of data integration. To measure the latency of the transfer rate, the data was captured in a second interval time. The list of stored procedures executed for data integration by WS is shown in Table-2.

Table-2. Stored procedures for data transferring.

Description	Date time process	Query / Stored procedure name
Student Data	5/23/2013 12:59:00 AM	IntegrateSybase.dbo.trn_t210student_scd
Staff Data	5/23/2013 3:07:45 AM	IntegrateSybase.dbo.trn_t630t631_scd

Partly of the data transferring process is shown in Table-3. This process was performed from 29 April 2013 to 22 May 2013 during the peak time period, which is student course registration and payroll disbursement process. The average of the transfer rate is 8.06 seconds as shown in Figure-8.

Table-3. Data transferring process.

No.	Date	Time	Delay (Sec)
1	29/4/2013	16:24:05	1
2	30/4/2013	1:00:31	8
3	30/4/2013	4:09:05	3
4	1/5/2013	0:59:46	17
5	1/5/2013	4:08:15	1
6	2/5/2013	1:00:39	10
7	2/5/2013	4:09:12	9
8	7/5/2013	9:20:56	5
9	7/5/2013	9:23:02	6
10	7/5/2013	9:25:06	4

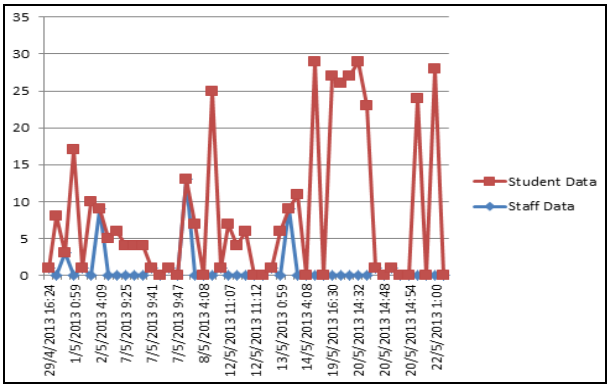

Figure-8. The average of the data transfer rate.

Current data transfer using data pipeline method to perform the data integration process. Data pipeline is a function provided by the Sybase tool, which facilitates the direct transferring of data within the Sybase or to other platforms. Based on the experiment transferring 118,732 student records took 1.17 minutes, and to update student record took 37 seconds. This task is performed in every semester during the student registration. Unfortunately, this process is performed manually due to no automatic mechanism provided.

Based on the comparison between data pipeline and SOA method for transferring student data, the maximum transfer rate for SOA is 29 seconds and using the data pipeline is 1.17 minutes. Since the transfer rate for SOA is less than pipeline method, the differences in transfer rate are calculated as follows:

Transferring Rate Differences
= Pipeline Transfer Rate – SOA Tranfer Rate
= 77 seconds – 29 seconds
= 48 Seconds

This has shown that the SOA and WS method was performed the data integration process faster than a proprietary method (i.e., Pipeline) by 48 seconds. Indeed, the higher number of data transferred, the significantly reduced number of transferred rate can be recorded.

CONCLUSIONS

This research explored the need for data integration solutions based on current technology to facilitate the process of data integration for University HIS. The research proposed the model of data integration by using SOA and WS approach. Several researchers have proposed solutions by using SOA. However, less effort in conducting the research for HIS implemented in the University environment, particularly in best practices solution for data integration problems. The proposed model was designed in SOA and WS to perform the process of data integration. To validate the model, the experiments of data transferring was conducted by integrating a set of programming tools that supports SOA, WS and .NET. Microsoft SQL Server was used as a local database server to demonstrate the implementation data integration. The data integration solution will help to improve the performance of HIS in the future, especially in University environment.

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