ARPN Journal of Engineering and Applied Sciences

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IMPLEMENTATION OF HYBRID SOFTWARE ARCHITECTURE FRAMEWORK IN CLINICAL INFORMATION SYSTEM: A CASE STUDY OF A MALAYSIAN CLINIC

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ABSTRACT

This paper proposes an evaluation of HybridCIS, a hybrid based clinical information system in a clinic in Universiti Teknikal Malaysia Melaka. Data gathering involved repeated group discussions for a period of ten months with key clinical staff. Implementation of HybridCIS was executed in the clinic and tested by clinical staff using real time patient data. Results show that HybridCIS provides a better solution of software architecture framework compared to existing approaches during network availability and unavailability. The result of the implementation dramatically improves the performance of the system in terms of response time.

Keywords: clinical information system, hybrid framework, Malaysian clinic.

INTRODUCTION

Health Care Information System nowadays is far more advanced from what we are twenty years ago. Adding to that, Health Care Information System is moving towards computerization, simplification, and informative era (Kamal-Nasir & Dominic, 2011). However most the health care information system nowadays lack of many things such as; non-integrated clinical information, slow performance of system's response time, and threat on integrity of the electronic medical records (Liu & Park, 2012). Doctor-patient consultation plays a very important role in diagnosis of many clinical findings. Conventional ways of capturing clinical findings using paper's note, note book, manually entered digital records, and so on are still being used in the Malaysian healthcare system (Raja Ikram & Abd Ghani, 2015a, 2015b)(Raja Ikram, Abd Ghani, & Abdullah, 2013; Raja Ikram, Ghani, & Abdullah, 2015). Patients are usually required to go to hospitals for consultation due to unavailability of informatics applications (Abd Ghani, Bali, Naguib & Marshall, 2008; Nguyen *et al.*, 2008). Plus, patients who lived in rural area will suffer a lot from travelling frequently especially to have repeating consultation compare to those in urban area although those in urban area affected by other factor like traffic jam that caused the travel period became long (Ou *et al.*, 2013). This research will provide a better way to fasten and enhance the process of doctor-patient consultation using this proposed hybrid software architecture framework. This paper is based on a case study in a clinic in Universiti Teknikal Malaysia Melaka (UTeM). This research will provide a seamlessly solution for a hybrid based clinical information system in any condition of network downtime.

MOTIVATION

The current clinical information system used in UTeM utilizes high end bandwidth and depends solely on network communication. Inadequate or unstable bandwidth will slow down the consultation process. This produces low respond time for the doctor to capture patient's health records. Unstable network bandwidth interrupts the consultation process and the data will be lost and need to be entered repeatedly. Non-standard clinical coding terminology used by the doctors also cause difficulty in generating Electronic Medical Records (EMR) during and after the doctor-patient consultation process.

METHODOLOGY

Repeated routine group discussions were conducted with key clinic staff of Universiti Teknikal Malaysia Melaka from September 2013 to November 2014 to understand the current system and document requirements for a hybrid software architecture implementation. A total of twelve people were involved in the discussion together with two doctors, five medical assistants, two pharmacists and three nurses. The main issues discussed revolve around three main questions:

- What is the process flow of the current procedure if there is no access to internet or network downtime?
- What are the limitations and technical constraints of the current system or process?
- What are the major problems encountered that require the proposed system to solve?

A Hybrid Clinical Information System was then developed to meet the requirements as per the discussions with UTeM clinic staff. This Clinical Information System was then implemented in the clinic and performance was measured based on system response time. The results were documented and compared with the current framework for validity.

CURRENT FRAMEWORK

This current framework can be categorized into a few categories, process flow during network downtime and technical constraints.

Process flow during network downtime or no network

The UTeM clinic has 15 staff with 10 numbers of desktops, which are all interconnected with a server in the same building. Daily activities include registration, doctor patient consultation, medical certificate issuance, nursing procedures, dispensing of medicine, referral from medical assistants to doctors and billing. Patients constitute of university staff, local and international students. The following Figure-1 describes the process flow during network downtime. The explanation of arrow line in Figure-1 and Figure-3 are describes in Table-1.

Table-1. Explanation of arrow line usage in Figure-1 and Figure-3.

Arrow Type	Description
——→	The data is transfer and achive using digital and external devices or manual paper.
- - - - -→	The data is transfer and achive using external devices or manual paper.
No line	No data can be transferred using digital nor external devices or manual paper.

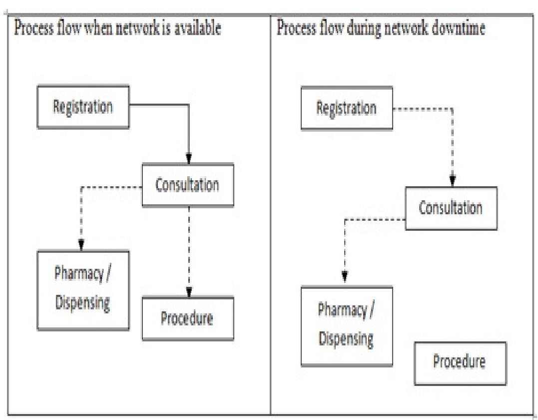

Figure-1. Process flow during availability and non-availability of network in UTeM clinic.

While process flow in network availability, the process start with registration at the registration counter. The staff will key in all patient demographic info into the queue system. That data will be shown at the doctor's screen for consultation process. After the consultation process with the patient, the doctor will prescribe the medications for that patient in a piece of clinical note and pass it to the pharmacy for the dispensing process. This process is also repeated for the procedural processes.

During process flow in non-network availability, the process begins with registration at the registration counter. The staff notes all basic demographic patient info for doctor's references in a piece of clinical note. That note will be pass to the available doctor for the consultation process. After the consultation process with the patient, the doctor will prescribe the medications for that patient in the same clinical note and pass it to the pharmacy for the dispensing process. Procedural process is excluded from this process.

The big difference between these two processes flows is the usage of physical clinical notes for capturing patient's medical records.

Technical constraint of implementation

The major technical constraint of implementing the clinical information system on this clinic is the type of network telecommunication. The landline network telecommunication used at this clinic is using broadband (Streamyx package) with 1 Megabytes per seconds (Mbps).

PROPOSED FRAMEWORK

Based on the findings of the current framework, this paper shall propose a hybrid software architecture, HybridCIS as shown in Figure 2 to solve the problems faced from the implementation of the previous framework.

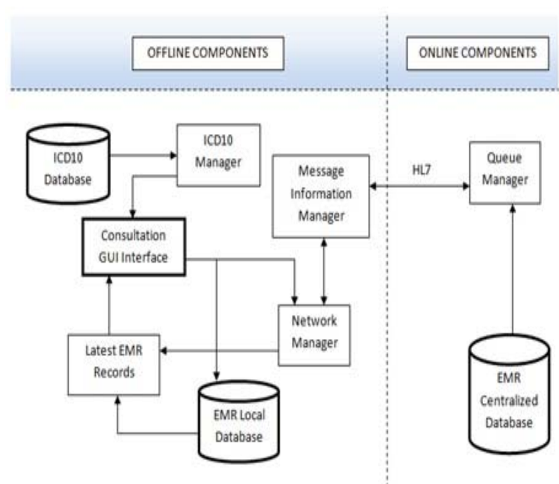

Figure-2. Proposed HybridCIS framework.

Figure-2 shows the proposed HybridCIS Framework. There are two modes in this system – the offline and online mode. The offline mode consists of ICD10 Database, ICD10 Manager, and Consultation GUI Interface. ICD10 Database component contains all databases for storing static databases of International Classification of Diseases version 10 (ICD10). It is clinical diseases terms that need to be used by other components in the framework.

ICD10 Manager is a controller to control the searching process by the other component that are required to access the ICD10 database. It also has SEO (Search Engine Optimization) algorithm to optimize the search result for the other component.

VOL. 10, NO. 20, NOVEMBER 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

The Consultation GUI Interface provides Graphical User Interface (GUI) for doctor to capture patient's clinical findings during doctor-patient consultation. This component uses data search from ICD10 database. This interface also provides options for doctor to store the clinical records in either local storage, online storage, or other external storage.

Electronic Medical Record (EMR) Local Database is used as a local storage for storing patient's clinical information while both offline and online mode.

Network Manager acts as a controller to provide a signal for the framework system during the condition of availability of online network with the server. This manager also acts as a bridge to pass through the online data to any local components.

The functionality of Latest EMR Records is to provide the latest clinical information from episodes of a particular patient. This controller reduces and fastens the consultation process's response time while a doctor viewing their patient's EMR. The number of latest episodes of the particular patient is set by the doctor during the consultation process.

Message Information Manager is the main controller for transit and receives the clinical records in Health Level 7 (HL7) format through the online network. This controller reduces the capacity of data that been sent or received through the network by using set of rules for encoding documents in a format which is both human-readable and machine-readable. The design goals of this format emphasizes simplicity, generality, and usability across the all components in the framework. It is a textual data format that only can be interpreted by this controller.

EMR Centralized Database used as an online storage for storing patient's clinical information while online mode only.

Queue Manager is a controller that provides a queue management system for online transaction. Whenever the data had been sent to the MR Centralized Database, this controller will accept it as raw data. Subsequently, this controller will automatically allocate the raw data into every particular table.

HybridCIS framework process flow

Figure-3 shall present the process flow of HybridCIS during availability and downtime of network:

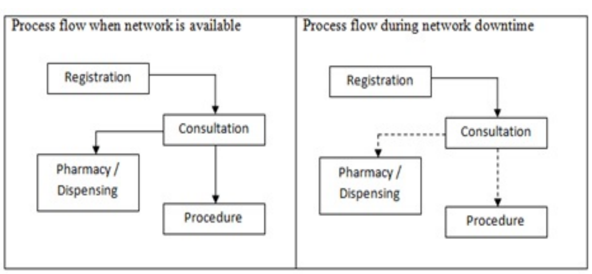

Figure-3. HybridCIS process flow during availability and non-availability of network in UTeM clinic.

During process flow in network availability, the process begins with registration at the registration counter. The staff will key in or search the particular patient demographic info in HybridCIS and register the patient into the queue system. That data will be shown at the doctor's screen for consultation process. After the consultation process with the patient, the doctor will prescribe the medications for that patient in the system and the system will submit the information to the pharmacy for the dispensing process. This process is also repeated for the procedural processes.

During process flow in non-network availability, the process begins with registration at the registration counter. However, if network is offline, the registration process can be held at the doctor's desk that has been allocated by the staff. The doctor will then key in or search the particular patient demographic info into the queue system. The doctor can conduct the consultation process and still can type down the patient's clinical information into the system. After the consultation process with the patient, the doctor can prescribe the medications for that patient in the system, in case of this offline mode the doctor will need to print it into a piece of paper, and pass it to the pharmacy for ordering and dispensing process. This process is also repeated for the procedural processes.

Between those two processes flows, the process from registration until the end will still running with less interruption.

IMPLEMENTATION

HybridCIS was implemented in UTeM clinic in December 2014 and system response time was obtained. The HybridCIS user interface screen is showed in Figure-4.

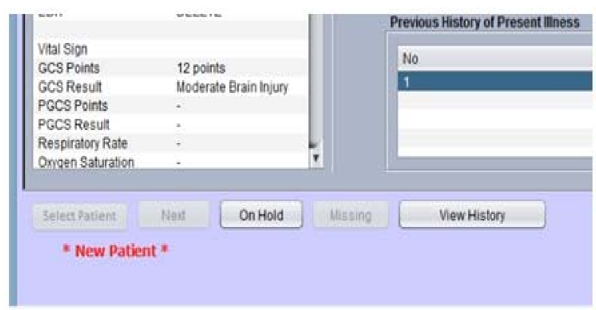

Figure-4. The interface of consultation process that use HybridCIS framework.

The response time was captured through function that has been embedded in each button, trigger, and process. That function will measure the time differences between start time and end time while executing that button, trigger, or process. Then the differences of time will be stored in the local database for analysis.

Figure-5 depicted the example of codes been triggered by the Next button in the interface of consultation process that been mentioned in Figure 4. Codes that in the green box represent the measurement function that measure the differences of time (response time process) of codes in the blue box. For example, the codes that in the blue box is the core function process of that Next button.

Figure-5. Example of response-time measurement function in next button.

The response time was divided into several process and sub-process categories. The response time was measure in the measurement unit of second, and was captured during the whole process mentioned in Figure 1 and Figure 3.

A: Current Framework with network (seconds)
B: HybridSys with network (seconds)
C: Percentage of improvement with network (%)
C = ((A – B) / A) * 100)
D: Current Framework without network (seconds)
E: HybridSys without network (seconds)
F: Percentage of improvement without network (%)
F = ((D – E) / D) * 100)
W: Registration
X: Consultation
Y: Pharmacy
Z: Procedure

Table-2. The comparison of response time between current framework and HybridCIS framework.

Process	Sub-process	A	B	C	D	E	F
W	Search patient.	3	2	33.33	20	5	75.00
	Register patient into system.	2	1	50.00	8	1	87.50
	Register patient into queue.	2	1	50.00	8	1	87.50
	Update patient demographic information.	1	1	0.00	3	2	33.33
X	Select new patient from the queue.	1	1	0.00	3	2	33.33
	View patient's past medical record.	3	1	66.67	8	1	87.50
	Search diseases.	2	1	50.00	6	1	83.33
	Ordering and prescribe medications.	2	4	-100.0	10	2	80.00
	Ordering procedures.	1	1	0.00	9	1	88.89
	Discharge patient.	1	1	0.00	2	2	0.00
Y	Order and prescribe medication.	5	2	60.00	5	2	60.00
	Select order from the ordering queue.	2	1	50.00	2	2	0.00
	Dispense medication.	3	1	66.67	4	1	75.00
Z	Order procedure.	3	2	33.33	3	2	33.33
	Select order from the ordering queue.	2	1	50.00	2	2	0.00
	Submit the completed procedure.	2	1	50.00	2	1	50.00

Based on data from Table-2, it is shown that twenty four processes have shown an improvement, seven processes showed no improvement, and one process showed negative improvement. There were no improvement in the seven processes because the procedure involved was straightforward and not complex to be executed. Thus the response time is similar. The negative improvement is due to delay during transition of medication ordering after the consultation process. Most of the searching and ordering process during consultation uses static data from local database. This increase the searching process and create and update records. HybridCIS framework also retrieve medications information from local database and this is an advantage compared to previous approach that rely on network availability. It was noted from the case study that the proposed HybridCIS improve overall response time of clinical information system especially during doctor-patient consultation. Thus, improve healthcare services by lessen information retrieving and patient waiting.

CONCLUSIONS

This paper has been presented the case study of proposed HybridCIS implemented in UTeM clinic. The framework reduce and enhance the system's response time in clinical information system. The analysis of the result conclude the response time for HybridCIS framework is better than the current framework. HybridCIS shall be extended to include other features such as data mining for diseases and drug pattern.

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