Open Access Journal of Information Systems (OAJIS)

Available at http://is.its.ac.id/pubs/oajis/index.php

The Third Information Systems International Conference

A Framework to Enhance Rural Healthcare Services Utilizing Cloud Computing and Videoconferencing

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Abstract

Lack of medical workers and poor medical services causes difficulty to detect contagious diseases for people living in remote areas. Early treatment which cannot be attained causes the mortality rate to increase in Malaysia from years to years especially in rural areas. A framework is proposed to control and monitor the infectious diseases and illnesses in rural areas. The main objective of this research paper is to overcome the physical barrier between patients in rural area and medical expert in urban area. Secondly, to help patients identify the possibility of getting infectious diseases and enhance medical quality in rural area by using videoconferencing technology, knowledge-based approach and cloud computing. In this framework, video conferencing, SMS, and voice call will be applied to exchange patient information. Knowledge-based approach is applied to pre- diagnose patients. For noncritical illness, the pre-diagnosis function can avoid the patient from travelling to save time and cost to meet a doctor. Patient's Electronic Medical Record (EMR) is stored in the cloud database which improves the management of patient record and analysis of diseases can be done in the future. The expected outcomes are to minimize the number of death caused by infectious diseases and serious illnesses and to improve medical services in remote area. The most suitable EMR system and videoconferencing software will be chosen for the framework. A prototype based on the framework will be developed and evaluation on prototype will be done at the end of this research.

Keywords: Rural Healthcare, Electronic Medical Records, Videoconferencing, Cloud Computing, Automated Pre-Diagnosis;

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1. Introduction

Communicable diseases and illnesses in rural area is a global health problem. Statistics show that approximately 2000 people were infected by cholera in year 2011 and the mortality rate reached 0.04% of 100,000 populations. 18.32% people suffer from Malaria and mortality rate is 0.06% of the population. Another serious infectious disease is Tuberculosis, which about 71.35% out of 100,000 populations suffer from Tuberculosis and the mortality rate is 5.68% of 100,000 populations [1]. People who live in urban area have much easier facilities to seek help compared to those who are staying in the rural area. Majority of populations who live in remote areas face difficulties to access basic and quality healthcare services.

There are several problems encountered by people in the rural area. Due to lack of medical experts and increasing number of patients in rural area, only a small number of patients can be treated directly by these medical experts in hospitals or clinics. Patients from rural area waste half their time in long distance travel just to reach the medical centre which only ends up in delay treatment and deaths. Moreover, increases in medical cost are not affordable by the poor family in rural area. Besides that, most clinics in rural area are still using paper based form to store patient's record which is not effective and efficient. To resolve all this problems we have designed a framework to enhance the rural services utilizing current technology. The framework is intended to overcome the physical barrier for patients in rural area to get diagnosis from medical expert in urban area. With this framework, it is hoped to reduce number of deaths that is caused by the delay of treatment of certain disease. The framework will also improve the quality and reduce cost of medical services delivery in rural areas. Another reason is to enhance the storage, retrieval and analysis of patient medical record.

The rest of this paper is organised as the following sequence: Section 2 discusses technologies related to the proposed system. Section 3 is the proposed framework and followed by Section 4 the system prototype. The evaluation will be covered in Section 5. Section 6 concludes the paper and identifies the future work.

2. Literature Review

2.1. Cloud Computing

Cloud computing can be defined as a computing environment where it provides a large flexibility and scalability with least physical structure. Cloud computing provides three service models i.e. Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) [2]. The cloud computing is important as it provides flexibility and it also increases collaboration by allowing all among the people involved in the environment, this in case, it allows the medical experts and the patients from rural area to work in the same environment. Cloud database is beneficial in healthcare fields as physicians can store more patients' EMR on the cloud. Three commonly used cloud databases are Amazon RDS [3], Google Cloud SQL [4]and Oracle Database Cloud Service [5]. In summary, Oracle Database Cloud Service is chosen for the proposed framework. Most of the EMR' databases are compatible with Oracle platform, hence, Oracle Database Cloud Service is much easier to integrate with most EMR system, capable for future extension and it is free to use. Amazon RDS is powerful, however it provides less ability to access and modify system data while Google Cloud SQL provides insufficient storage space.

2.2. Electronic Medical Record

An electronic medical record (EMR) is a digital version of a paper chart that contains all of a patient's medical history. An EMR is mostly used by providers such as doctors, nurses, and medical experts for diagnosis and treatment. EMR data can be created, managed, and consulted by authorized providers and staffs across more than one healthcare organization. EMR includes information of patients such as a

patient's contact information, prescriptions, allergies, past medical history, and billing information [6]. It provides a better storage, analysis and data management on patients' medical record. EMR is also known as electronic health record (EHR). Three selected existing commercial and open source EMR software that will be reviewed are GNUmed [7], OpenEMR [8], and MediTouch [9]. In short, GNUmed is too complicated in GUI and hard to use while MediTouch is commercial EMR and only can run in limited platform. Hence, OpenEMR is the most suitable software as it is open source, easy to adapt, learn and use as well as providing necessary features that fulfil medical needs.

2.3. Teleconferencing

A teleconference is a generic term for linking people between two or more locations by technology. The advantage of video conferencing is the capability to display moving images in which the participants can see motion images of each other without the restriction of geographical location. Hence, the consultation can be carried out with face to face interaction among doctor from the city and patient in rural area. It is very cost effective too especially for rural area which lack of medical facilities [10]. Three selected teleconference software's for review are Skype [11], Google Hangouts [12] and AnyMeeting [13].

Based on the review, it can be concluded that Skype is the most suitable software for teleconferencing services. It provides all the features required for a physician to carry out-face-to-face diagnosis. Google Hangouts is good too, however, it requires the user to register Gmail account, hence reduces the flexibility. AnyMeeting on the other hand is more suitable for business purpose.

3. Proposed Framework

The proposed framework will provide a telemedicine system that enable physicians to carry out diagnosis through teleconferencing and save patients information as EMR on the Cloud. The use of Cloud increases flexibility on data transferring, whereby physicians can directly obtain and update patients' EMR instead of requesting from the patient and other physicians. Figure 1 shows proposed framework which includes three main components i.e. cloud database, pre-screening and communication.

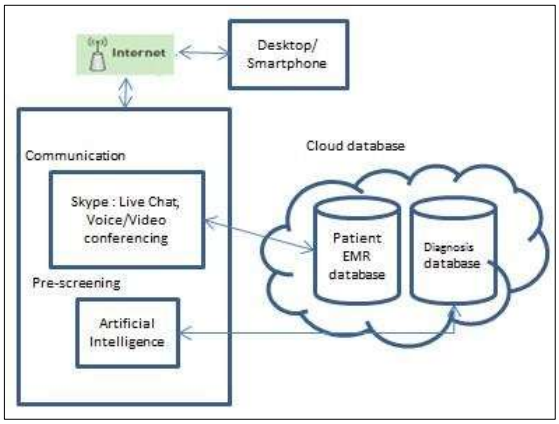

Figure 1: Overview of Proposed Framework

For cloud database component, Oracle Database Cloud Service is incorporated in the proposed framework. In current market, most of the database systems are managed by Oracle, whereby implementing Oracle Cloud allows it to act like an extended platform for the user. In other words, a user's

current work can be maintained and be transferred to cloud without complex steps. Oracle also offers rapid application development and instant deployment, which allows developers and users to work together in real time to create optimal solutions. Inside the Cloud database, there are two database, patient EMR database and diagnosis database.

For the patient EMR database, OpenEMR is integrated the in framework to present the medical record of patient due to being simpler and easier to learn and use. OpenEMR provides essential functions which are needed for a physician to record the patient's data such as entering results of diagnosis, make appointments, and scheduling. For the diagnosis database, it stores the content which is used for pre-screening mechanism. The content includes the symptom of sickness and the name of disease. In the pre-screening component, knowledge-based approach is applied to pre-diagnose the patient with the use of relevant content in diagnosis database.

For communication component, Skype is included in the framework due to its learnability and functionality. Skype can provide teleconference for direct consultation among doctors and patients in rural areas. Besides, Skype has high flexibility as it also provides extended features if users pay some additional charges.

4. System Prototype

Based on the proposed framework, RuralCare, a web based application has been developed as shown in Figure 2. RuralCare supports teleconference and is able to store patient medical records with the integration of Skype and OpenEMR into RuralCare. Oracle Database cloud service has been applied on OpenEMR, where the patients' medical data are stored. Figure 3 shows that Skype as the videoconference tool and integration of OpenEMR into RuralCare. Besides that, a dengue fever pre-screening form is also being included in the RuralCare prototype that is shown in Figure 4 and 5. This form applies rule-based reasoning that is able to detect suspected dengue patients based on the symptoms that are shown by the user.

Figure 2: The main page of RuralCare prototype

Figure 3: Skype is integrated in RuralCare prototype as the videoconference tool

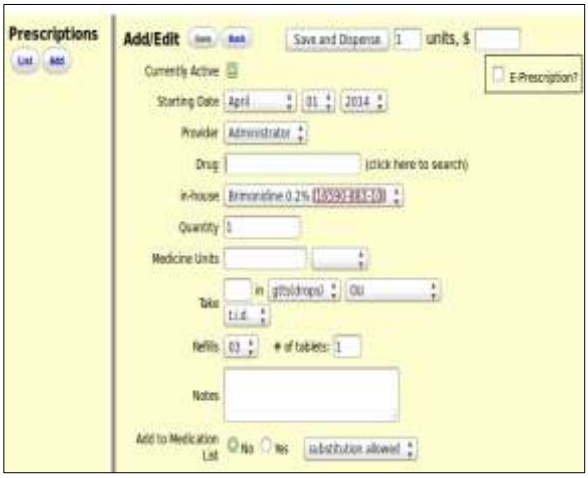

Figure 4: Pre-screening form to detect dengue cases prototype

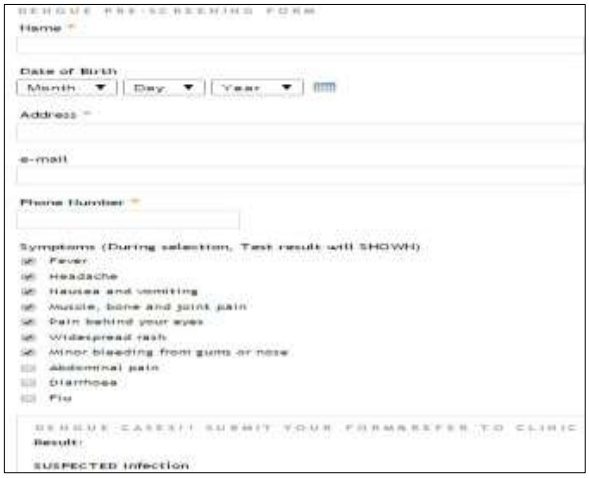

Figure 5: Applying OpenEMR in the RuralCare

5. Evaluation

Evaluation of the prototype has been carried out by 5 physicians and 5 medical staffs. The evaluation results are shown in Figure 6. The evaluation value is scalable from '1' (Strongly Dissatisfy) to '5' (Strongly Satisfy). The evaluation is done based on 5 criteria i.e. ease of use, functionality, response time performance, acceptability, and security and availability. Ease of use examines the usability of the prototype to check whether it is easy to learn and use by the users. Functionality is evaluated based on the functional requirement of the prototype to check whether the features are performing well and whether the functions fulfil users' expectation and requirements.

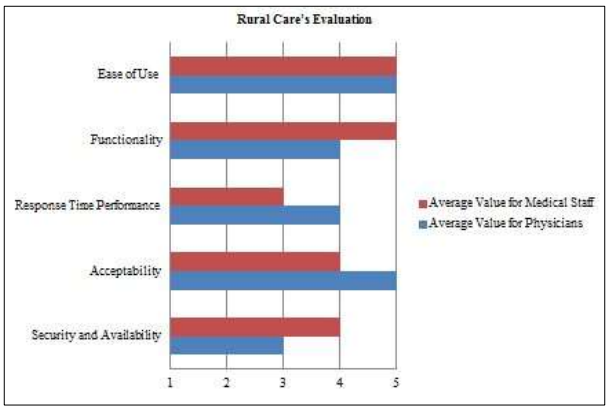

Figure 6: RuralCare's Users Evaluation Graph

The prototype scores an average value of '5' from both physicians and medical staffs in ease of use and functionality criteria. Response time performance examines the performance of the prototype by determining time for retrieving patient's data and page loading time. In this criterion, medical staffs are neutral to it while physicians are satisfied. Next, acceptability examines the acceptance of the framework

or prototype in the view of users. Both evaluation party expressed high satisfaction towards the acceptance of the prototype. Lastly, concerning the security and availability issues, medical staffs' gave a value 4 to show their satisfaction while physicians are neutral towards the issues. Security issue is important in protecting patients' medical history while availability makes sure a system or resources are available for the users in timely manner.

6. Conclusion

The research on electronic healthcare service in order to enhance quality of healthcare in rural area is an interesting research topic nowadays. Many of the current research in this area aim to improve the quality of healthcare in rural area. This research aims to ease the doctor to overcome the physical barrier in solving the infectious diseases and illnesses in rural areas. The proposed framework used video conferencing to exchange patient information or get direct diagnosis from medical specialist. In the prototype, dengue pre-screening function is designed to filter potential dengue suspected patient from non-dengue suspected patient in an efficient way. All patients' medical record will be stored in cloud database which can improve the management of patient record.

RuralCare has received positive feedback due to its functionalities and user friendly interface that able to increase the medical service quality in rural area. RuralCare will be completed and launched in future. Advanced analysis of diseases functionality can be added into EMR in the future by using the patient data as the input in order to analyze the certain diseases trend, location and source. The pre-screening form can be enhanced by focusing on varieties of diseases to increase the effectiveness in treating a patient without any delay.

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