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Health Information Sharing in Chronic Disease Self Management: A Hybrid Cloud Approach

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Abstract: Health information sharing improves the performance of patient self-management when dealing with chronic diseases such as diabetes and other cardiovascular diseases. Most of the healthcare Organizations are now adopting cloud computing resources with the objective of delivering better healthcare services and preserving the privacy of patients' information at lower cost. As a result, the healthcare providers must become more efficient in managing, analyzing, and sharing patient data globally. Since, diseases are becoming more complex, new advancements in research and technology have facilitated the emergence of new and more effective diagnoses and treatment techniques. The proposed study can achieve patient recorded health information sharing via hybrid cloud, to prove the feasibility. Cloud services provided by Amazon, Google or other enterprises, and open source cloud platform such as Open stack, Eucalyptus, could be used to support the development of the proposed prototype.

Keywords: Health information Sharing, hybrid cloud, self-management and chronic disease.

I. INTRODUCTION

Most of the chronic diseases such as diabetes and cardiovascular diseases have become a main challenge for healthcare sectors worldwide. According to the recent information available [1], almost 1 in 10 adults have diabetes in the world and are continuing to increase. The patients suffering from chronic disease have to be checked and monitored from time to time resulting in high cost and time consuming for patients. This challenge needs a new e-health approach. Therefore, it is very necessary to adopt an effective approach to trace and monitor patients' physical condition via healthcare services.

The feasibility of home based e-health system has been highly raised [2] where, patients can record various health parameters by themselves at home and share it with a certain healthcare provider. The home based e-health can thus improve the quality of life of individual by giving them timely treatment during medical emergencies. Additionally, this process of long term monitoring will generate huge samples of patient self-recording health data. Most of the patients share their health data to third party applications such as health service provider for analysis and to have a clear understanding of their state of health. This will benefit in research of many chronic diseases and provide better treatment for patients as well.

Due to the high demand of workload in uploading and sharing the patient's medical details, most of the healthcare organizations are now adopting cloud computing resources such as servers, storage and other services, which are on-demand, scalable, flexible and available at a low cost. However, there are few issues for sharing health records through cloud. The patient health information is very sensitive since it includes his personal details such as medical history, treatment and associated diseases. Hence, securing the privacy and security of patients' personal details is challenging in cloud computing environment. Moreover, the threats to privacy and security are not only brought from using cloud, but also by the involvement of third party institution results in more complicated problems. Another issue is the selection of cloud deployment model. Cloud systems can be divided into four categories from the view of deployment model: public cloud, private cloud, community cloud and hybrid cloud [3]. Each deployment model has different organizational structure and different provisioning location. It results in different utilization style, security level and other characteristics offered by these four deployment models. There are many crucial requirements on sharing health information among groups of different credibility, such as privacy, accessibility and utility. Adopting an inappropriate cloud deployment model will bring problems.

II. RELATED WORK

There have been many researches related to this area. M. Hussain et al. proposed a Smart Clinical Decision Support System (Smart CDSS) [4]. It gathers data from diverse modalities, such as sensors, patient profile information, social media, clinical knowledge bases and medical expertise, with cloud architecture to generate standards-based recommendations to patients. But this CDSS lacks of some important health data from patient daily life when adopting it to chronic disease patient, such as physiological measurements, diet or daily activities.
For exchange health data between eHealth applications and health information systems, A. S. Radwan et al. [5]

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proposed a cloud based solution which emphasizes standardizing a data exchange mechanism and interoperability between health information systems and eHealth applications. In addition, this system allows patient to create and store PHR, and allows healthcare professionals to access to PHR. In this system, Information Systems (HIS) and third party eHealth applications were combined in the same environment, it will probably bring potential problems.

To meet the increasing requirements of enabling chronic disease patients to manage and improve their healthcare delivery, a distributed service application on supporting chronic disease self-management was proposed by Ali Sunyaev et al. [6]. The proposed application will keep tracking blood glucose and other related health measurements, allow reviewing history records by displaying graphs over a period or comparing several periods. To enhance the usability and interoperability, this system is able to integrate with the Microsoft HealthVault and the closed Google Health. But this application lacks of information sharing, it is just for personal using, therefore it has no concern on security and privacy. For collecting patients' vital data, C. O. Rolim et al. proposed a cloud based solution in [7], which automates the collecting process by using wireless sensor networks. It makes the data collection real-time, and enables the data to be processed by expert systems or medical staff in the cloud. L. Fan et al. [8] identified the concerns on service integration, large scale deployment, and security, integrity and confidentiality of sensitive medical data. For addressing these challenges, they proposed the cloud based solution Data Capture and Auto Identification Reference (DACAR). But in this solution, there is no concern on what actually be shared and what is the role of hospital.

III. PROPOSED PROTOTYPE

The study aims to identify a suitable form of health information sharing for chronic disease self-management, figuring out the problems of using cloud computing to achieve health data sharing among multi-groups, and find out a suitable solution to address these problems. The solution should enable patient to share the health information what and where they want to share, and improve the quality and expandability of chronic disease self-management. To prove the feasibility and practicality of the notion, the research will start with the self-management of type 2 diabetes, and then a prototype will be implemented and evaluated.

In this study, a prototype, which can achieve patient recorded health information sharing via hybrid cloud, is implemented to prove the feasibility. Cloud services provided by Amazon, Google or other enterprises, and open source cloud platform such as Open stack, Eucalyptus, could be used to support the development of prototype.

IV. CHRONIC DISEASE SELF-MANAGEMENT

1.4.1. Challenges in Chronic Diseases

The chronic diseases have become the main threats to health all over the world. According to World Health Organization, chronic diseases such as diabetes, heart diseases and hypertension have resulted in 63% of the deaths around the world so far [9].The patients suffering from chronic diseases needs to traced and monitored from time to time which is expensive and time consuming and inconvenience for most of patients specially the aged people. Thus the challenge is even more complex due to the limited healthcare resources [1].

1.4.2 Self-Management and Health Information Sharing

Most of the chronic diseases usually do not need immediate medical diagnosis and treatment. For the patients with cardiopathy or hypertension, it is adequate to trace and control the patients' conditions via the healthcare services such as physiological signals monitoring and recording [2]. Moreover, lifestyles, diet and metabolism are the main factors of causing most common chronic diseases. Most conditions of chronic diseases therefore might be avoided by changing behaviours, such as quitting smoking, keeping healthy diets, or increasing physical activities [10]. For instance, diabetes is a disease that patients need to be monitored continuously for a number of parameters, such as blood sugar level, blood pressure and so on. Simultaneously, the effect of environmental factors such as nutrition, stress and exercise should also be taken into account when managing this disease [11]. It would be beneficial and efficient if these various aspects of parameters could be recorded by the patients themselves at homes.

The treatment process for chronic diseases involves long-term monitoring and recording of various health parameters. Synchronizing these patient data to a trusted Healthcare provider is an obvious benefit. They can receive useful feedback, to help them in having a clear understanding of their health status and get some useful medical recommendations.

V. CONCEPTUAL SYSTEM MODEL

The figure below depicts a conceptual scenario that a patient self-manages himself at home, records and shares his health information to a hospital and third party healthcare service providers or research institution for the purposes of monitoring, receiving healthcare services, improving treatment and contributing to researches.

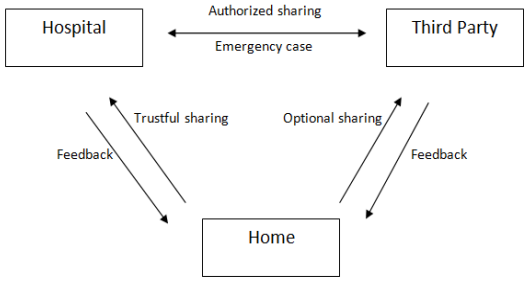

Fig 1: Conceptual Scenario of Sharing Health Information

Share to Hospital: Sharing the information to hospital involves detail health information of a patient including

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patients' personal data. But the process of treatment probably involve nurses or other medical personnel, they do not need to get the whole information about the patient. Except emergency cases, it's better to make the health information with fine-grained data access control mechanism to provide patient-centric privacy control over their health information.

Share to Third Parties: Sharing of personal health information to third parties is quiet inappropriate, since privacy and security are the major patients' concerns. Since there is no need to share the whole health information to third parties, it is adequate to just share the health information that meets the requirement of a specific purpose. There are different patient consent models that are appropriate for sharing the information:

- **Opt-out:** health information is included by default, patients are able to opt health information out completely.
- **Opt-out with exceptions:** health information is included by default, patients are able to opt health information out completely or only allow selected information to be included.
- **Opt-in:** patients must actively express consent to choose health information to be included, once if they opted in, then their health information will be all included.
- **Opt-in with restrictions:** no patient health information is included in default, but patients are able to allow selected data to be included.

In short, patient should be given the right to choose what information to share and whom to share. The opt-in with restrictions therefore is the appropriate consent model in the conceptual health information scenario.

Share between Hospital and Third Parties: When the information is shared to other organization, it is necessary to inform the patient with reasons. The patient should authorize the sharing before it is transferred to other organization. Every time when a health record is shared in emergency case, it needs to be recorded for verification.

VI. PROPOSED SCHEME

In the Proposed Scheme, the Hybrid Cloud is designed and depicted for the expected purpose. A pure Public Cloud is inappropriate for security and privacy concerns and a pure Private Cloud may not be a high cost effective choice either. Besides the cost, the reason of restricting benefits from third party organizations makes a pure private cloud inappropriate. By combing private cloud with public cloud, hybrid cloud seems to be the most appropriate cloud deployment model for the objective of sharing patient-generated health data to hospital and third parties at the same time.

PROPOSED SYSTEM MODEL

The Proposed System Model consists of following modules:

- **Roles:** The system here, involves different roles such as patient, Hospital, Third party research institutions and eHealth service Providers. Each role has different degree of credibility. The role of a patient act as a vital component in the system. The role of hospitals are located in private cloud by being considered as trustful. The role of third party research institutions and eHealth service providers locates in a public cloud by being considered as non-fully trustful.
- **Objects:** An object refers to a person or an entity that acts in this system. A patient is an object of the patients' role, who record and share his health data at home. A directly authorized hospital personnel object is the doctor who responsible for the patient. In addition, each service entity either in private cloud or public cloud is regarded as an object.
- **Health Records:** A patient's health record includes personal information and various health parameters recorded by the patient. The health record is shared among different organizations, for different purposes under the authorization of patient since the patient has the right to choose what to share in his health record.
- **Procedures:** Due to the different credibility degree of each role, there are different health record transferring procedures. The hospital is considered as trustful, so the health record sharing between a patient's home and a private cloud of hospital is a trustful sharing procedure. A public cloud of third parties is considered as non-fully trustful, and some services just require a part of health record, so this sharing procedure should be treated differently. Therefore the optional sharing procedure enables patients to share what and where they are willing to. Because of the relatively low cost and high capability offered by public cloud, it will be efficient that the hospital private cloud utilize the public cloud in non-critical applications. The non-critical utilization procedure expands the capability of a private cloud without involving sensitive personal information. In addition, there has to be an emergency case procedure, which can track to the certain patient in case of emergency cases.

The following Figure shows the Proposed System Model

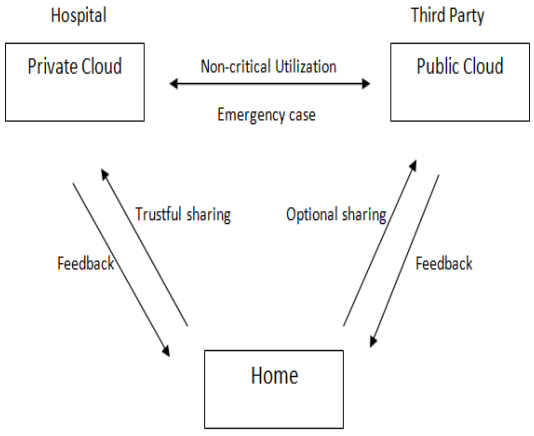

Fig 2: Proposed System Model

VII. SYSTEM DESIGN

- *Conceptual Structure of Private Cloud Platform*

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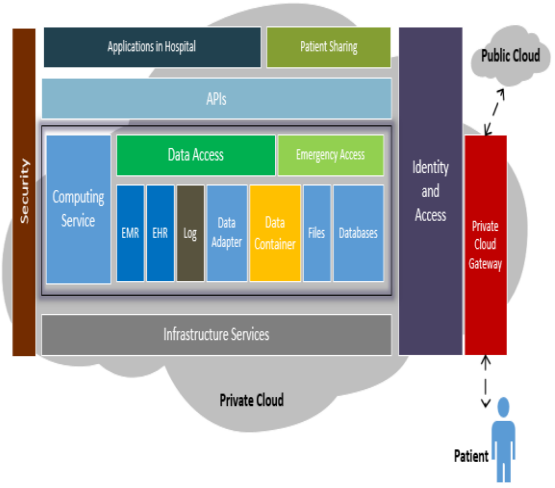
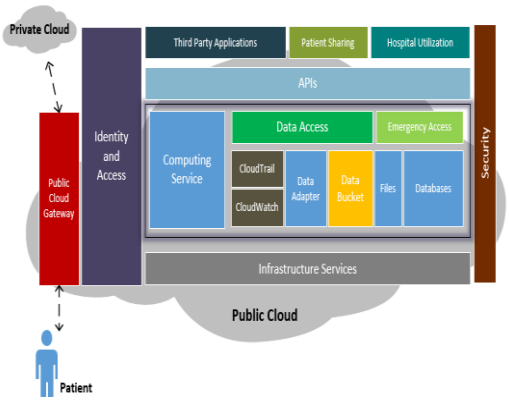


The above private cloud platform is based on OpenStack Cloud System. By utilizing private cloud infrastructure services, the health records shared by patients will be stored in assigned data containers of OpenStack Swift. The concerned doctor can get the access to the shared health records in data containers after being authorized by the owners of these data. Other cooperative doctor or nurse can get access to part of or the whole health record through authorizing by the in-relation doctor under the permission of patient. Role-Based Access Control (RBAC) [12] and Attribute-Based Encryption (ABE) [13] are probably able to support this kind of fine-grained access control requirement. An EHR system can be hosted in this private cloud, therefore the shared health records will be integrated into EHRs. The data or images of previous medical examinations can be integrated into EMR and EHR, or sent to patients by requests as well. The computing service of the private cloud provides capability to operate healthcare applications such as clinical decision support system by utilizing patient's health information. When receiving emergency request, the emergency access component can get access to health records by tracking a unique tracking ID and then send back the required data. All the accesses to data and computing will be monitored and recorded by the log component. It can detect insecurity operations and analyze usage of resources [14].

- *Conceptual Structure of Public Cloud Platform*

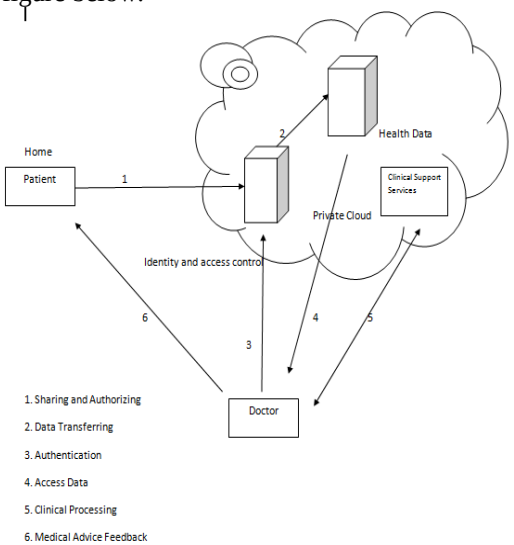


The above public platform is based on Amazon Web Services. By utilizing public cloud infrastructure services, the health records shared by patients will be stored in specific data buckets of Amazon S3. The conceptual structure of public cloud platform gives the possibility to provide IaaS, PaaS or both to third party research institutions and eHealth service providers, which should be certificated as trusted organizations [14]. As they developed based on this platform, they can provide SaaS to patients for better healthcare, or gathering data for research.

The third party applications, either research programs or eHealth services, can get the access to the shared health records in different data buckets only when being authorized by the owners of these data. The access control can be achieved by AWS IAM and further modifications. For higher demand of access control, XACML-based mechanism [12] is a good choice. The computing service of public cloud provides high performance computing resources to these third party applications. The private cloud of hospital can expand or migrating non-critical computing tasks and insensitive data to this public cloud platform. The emergency access component can access to health records, send alarm to data owner and hospital by tracking the unique tracking ID once in emergency situation. The AWS CloudWatch service and CloudTrail service can be used to detect insecurity operations and analyze [15] by monitoring and recording all the resources usage and API calls.

- *Working Scenario of Private Cloud Communication*

The scenario of the private cloud communication is shown in the figure below.



A patient suffering from one or more chronic diseases self-manages and records health information at home. After inputting all the data into the health record, the patient chooses the target doctor in the hospital and shares to the private cloud. Then the health record will be transferred and stored in his container in Swift storage. When the doctor wants to get the access to the health record, he has to be authenticated that he has the right to access. When the doctor received the health record, he can send medical advice back to patient immediately or after the analyzing with clinical support services.

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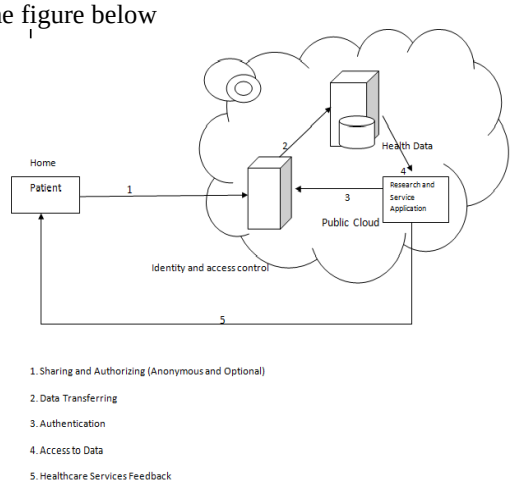
- *Working Scenario of Public Cloud Communication*

The scenario of the public cloud communication is shown in the figure below



After inputting all the data into the health record, the patient chooses a target application or research institution in the cloud platform, and then chooses which parts of data to share. When the sharing procedure is performed, the anonymous health record fragment will be transferred and stored in a particular bucket in AWS S3 storage. Any registered research or service application in the cloud platform want to get access to the health records, it has to be authenticated that it has the access right, which has been authorized when the patient was sharing. When the application received the health record, it can send certain results back to the patient. And research programs, such as clinical data mining, can utilize the authorized health data to perform researches.

VIII. CONCLUSION AND FUTURE WORK

Self management is becoming more and more important method for patients suffering from chronic diseases. Therefore patient-recorded health information sharing is the key process to promote the treatment of chronic diseases, either sharing to hospital or other healthcare related organizations. One problem here is that, among the plenty of data generated in patient's daily life, what data is valuable to record and share, and what data is suitable to share to the non-fully trustful organizations. Analyzing these problems, the proposed scheme introduces a hybrid cloud solution, with the functions for recording health information, sharing to the private cloud and optional sharing to the public cloud. Therefore the proposed hybrid cloud solution achieved the objective of sharing patient recorded health information in the application scenario of chronic disease self-management.

Although the prototype achieved the main functions of recording health information, sharing to private cloud and optional sharing to public cloud, there are still works remained to achieve an actual usable hybrid cloud based health information sharing solution. Integration of automatic health devices and personal mobile devices is a vital task of health information sharing and chronic disease self-management. The automatic way of health data collection is not only to facilitate patients to record massive data, but also to reduce errors due to lacking of medical knowledge. And the support of mobile devices not just releases patients from a restricted place, it also brings a flexible way of collecting data, or even a new variety of health data.

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