Integrating EHR and PHR in Cloud - A Paradigm

Bobby Sathyaseelan, Anju Mathew Cherian, John Velloreuzhathil Chacko

Gulf College, Sultanate of Oman

Abstract - Healthcare providers usually use the information of a particular patient only during the time the patient arrives the hospital. But once he/she leaves the hospital the data is not available for the doctors. In the current scenario it becomes the responsibility of the patient. Today in the era of life style diseases patients are expected to know more about their health, and to engage actively in their own care. This paper proposes a paradigm in which the doctor and the patients can check their past records and routines whenever required. Out paradigm focuses on creating a profile controlled by four actors i.e. Document Source, Document Recipient, Document Consumer and Document Responder. Finally the paper deals with the hurdles in the implementation by analyzing the technology and infrastructure available.

Keywords – Personal Health Records (PHR), Electronic Health Records (EHR), Cloud, Database as a Service.

I. INTRODUCTION

Now a day's organisations are growing along with the rapid booming of technology. The chunk of every organisation is its data or we can tell that the backbone of the organisation is its data. Data are of different types. Depending on the size and the work the organisations are associated with, data may vary from a single page to thousands of pages. Data are either in quantitative nature or in qualitative nature or a mix of these. The organised or structured collection of inter related data for one or more use is termed as database. Databases are stored in computers mainly in servers and are processed using database management system (DBMS). Majority of the organisations follows traditional way to store these databases. For the same, the databases are installed in the on-site server, and the data is stored, maintained, processed, accessed using a database management system directly or through a local area network (LAN) system to facilitate the service. The stored information should be arranged in such a way to retrieve easily and relational database is the answer for the same where information is arranged in tables with rows and columns. In this case, relational database management system (RDBMS) performs the tasks such as storage, maintain and retrieval.

Managing the databases in on-site server (local database) and accessing through LAN in traditional way requires lot of infrastructure and at most care must initiate for security, maintenance and license management. These problems can be simply eliminated by opting a cloud computing system.

The cloud computing provides hassle free management of the system. It provides number of advantages both to end users and the organisations where size of the organisation doesn't matter. We can leave the concern on huge investment and support for infrastructure, knowledge necessary for developing, installing and maintaining the infrastructure, development environment or application to the service providers. Cloud computing helps the organisations to cut its cost significantly and also help the users to focus more on their core business area rather than struggling with the often arise IT issues. Self-service provision to access all the IT resources, elasticity to broaden or cut down the usage of resources to meet the demand and availability of pay per use (metered service) are some other benefits in using cloud computing.

In traditional system, data and programs are stored in on-site computer hard drives whereas cloud computing serves as a platform for providing various computing resources from applications to data centres through online by means of a paid subscription. These data and programs are resided on off-site across remote servers or machines in different geographical locations. Once you have subscribed; with an online connection, cloud computing can be done anytime, anywhere using multiple device which means no time restriction or geographical barrier at all.

II. BACKGROUND STUDY

2.1 Cloud Database

Database is a key component in most computing infrastructures[1]. In its simplest definition, a database is a computerised system which helps us to manage information by means of store, select, search, segregate and process. Database allows users to store data in an organised manner and provide efficient retrieval of data easily[1]. Factors such as tremendous growth in the increase of data transfer through online and social media, change in data storage requirements, broadband facilities for better and faster services and Cloud computing led to the emergence of cloud databases [2]. Several definitions were derived for cloud database. Many of the researchers widely quoted and referred Gordon's definition on cloud database. According to Gordon, it's a database which usually runs on a cloud computing platform. Some of the cloud computing platforms available in the market are Amazon EC2, GoGrid, Rackspace and delivered to users on demand via the Internet[3]. Most of these cloud databases are designed in such a way to run on a cluster of thousands or more of the nodes. They are capable of handling data ranges from hundreds of terabytes to petabytes[4].

Different implementation models are available to manage Personal Health Record (PHR). It may be one of the simplest PHR models which use paper forms to record the patient details or it may be a portable device such as USB storage device which is compatible with any computer[5]. To retrieve the encrypted data a password must be provided to decrypt. Other model which helps the user to enter and access own health data by creating their own PHR with use of any commercially available applications which include a stand-alone system to a web-based application [6].

For the exchange of health information, PHR service is an emerging model. This enables patients to create, manage and update their personal medical information and share these details with other health care service provides for a second opinion on their medical issues or for a prior approval from the insurance company for detailed tests [7][6]. On the advancement of the technology, cloud computing PHR has experienced considerable changes. Health care providers and vendors working with healthcare information technology initially started the PHR services just as a storage service and later with the emergence of cloud computing, it turns to provide service for patients by allowing them to share health information with others [8].

The next question is how to run a database in a cloud. There are three different models to deploy a database. They are

1. Virtual Machine Image
2. Database as a service
3. Managed Hosting

For the first deployment method that is for Virtual Machine Image, users' needs to be purchased the instances for virtual machines for a limited period of time through the cloud platform. Users have the provision to upload either their own machine image with database installed on it or can use ready-made machine images that already include an optimised installation of Oracle Database 11g Enterprise Edition on Amazon EC2[3].

Some of the cloud platforms offer options of using Database as a service (DBaaS); the second deployment model. In this model, it is not required to physically launch virtual machine instance for the database. It is the responsibility of the database service provider for the installation and maintenance of the database and the application owners pay based on their usage [3].

In the third deployment model, the cloud provider installs, maintains and manages the entire database implementation which is suitable for small organisations with the benefit of providing database without the administrative responsibilities and IT overhead typically required of DBMS usage.

For the implementation of PHR, we chose the deployment model Database as a Service (DBaaS).

2.2 Database as a Service (DBaaS)

DBaaS can be simply defined as a paradigm for data management in which a third party service provider hosts a database and provides the associated software and hardware support. Companies using this model outsource all database management operations, from installation to backups, to the provider, and focus on developing applications. They can access their databases instances on-demand, using querying interfaces or programming tools[9].

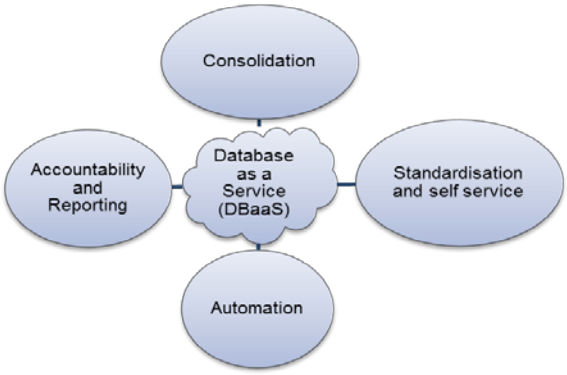

Fig 1: DBaaS Components Diagram

There are different companies offering database as a service. Each service provider is different from the other depending upon the quality and sort of services being provided [10]. While selecting DBaaS, not only depends on the services being provided by the company, but also try to match it with the requirements of the company as well. Data sizing, portability, transaction capabilities, configurability, data accessibility, data integrity, security and storage privacy are some of the parameters which help to choose the best DBaaS.

III. MOTIVATION

Healthcare providers usually use the information available to them during the diagnosis of a particular patient. But once your patients leave hospital, they become responsible for staying healthy each day. Today in the era of life style diseases patients are expected to know more about their health, and to engage actively in their own care. Often, family members and friends are also involved in the caretaking process. Most patients receive care from many health care providers, and consequently their health data are dispersed over many facilities' paper and EHR-based record systems [8]. A fragmented system of storing and retrieving essential patient data delays optimal care. In the current status the information is available with a particular hospital, the insurance provider, the patient and some close

relatives and friends. If the patient is travelling from one place to another or if shifting to another country they usually don't have all their records with them. Let us consider the following cases

1. Where a particular person met with an accident and if their relatives or friends are not near to explain the history.
2. A patient suffering from dementia or Alzheimer's disease
3. A patient in a new country or a new place where he is new and come across a medical emergency

The above mentioned are the very critical situations where every seconds matter for the life of a matters. Eventually in any cases even the hospital infrastructure is not sufficient to provide the patients with a lifelong health records for the patients. The situation is more critical when the integration is required between two hospitals or two countries. This poor integration results in poor communication even with in national networks. Personal Health Records will help to build a solution for this vital situation.

IV. SYSTEM MODEL

Personal health records (PHR) are protected electronic application files through which individuals can access, manage and share their health information.

A PHR can include data and information entered by the Individuals themselves, or data or information inputs from other sources such as health care professionals, hospital applications, laboratory or other diagnostic systems. These will contain data which are more than the information available in the health provider's electronic health record (EHR) [5].

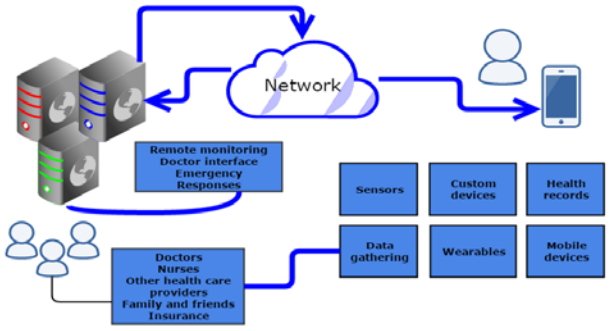

Fig 2: PHR as a service prototype.

In our proposed model of PHR the patients will be allowed to enter and view their own health records by integrating the healthcare providers EHR with the PHR. This will help the patients to collect their fragmented medical records in one place. This prototype will even help the providers and physicians to value the patients' day to day activities and home monitoring. A particular patients data can be collected from the patient himself, the general or primary physician, the other specialists, EHR form each hospital he/she visits and from the insurance claims [11]. The above is a diagram (Fig 2) which shows the different types of information/entities that has be collected from different sources.

PHR-S as Document Source within XDS

Our approach is to put the PHR directly into an existing domain as another document Source, so that the patient can also provide and register documents into the document Repository and document registry. In this way it will serve as a patient-maintained document but will have all the information's available in the healthcare provider's information system (e.g. Hospital Information and management System). PHR uses an RESTful interface to an XDS environment based on the mobile access to health documents profile. It is a standardized interface to health documents to be used by the mobile devices and desktop devices so that deployment of applications is more steady and reusable. [5] The intention is to use state-of-the-art web technologies like REST (Representational State Transfer) web services to serve modern web applications and native mobile apps which support these web standards out-of-the-box. The profile will have four actors i.e. Document Source – Document Recipient, Document Consumer – Document Responder). The document source and document consumers are designed so that they can be implemented on a mobile device, and yet have sufficient functionality to support a wide range of applications. The document recipient and document responder are expected to be implemented in a service environment that does not have the constraints of a mobile device.

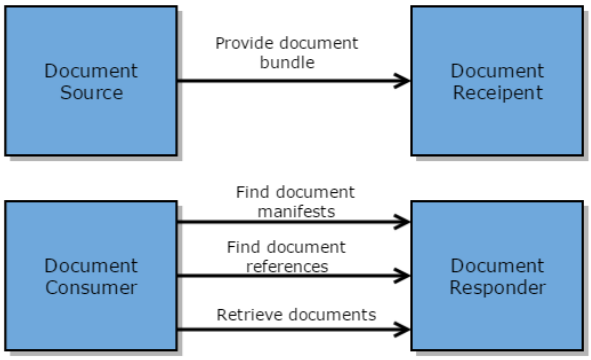

Fig 3: PHR service protocol.

The transactions in the MHD Profile correspond to the following equivalent transactions used in XDS.

Our main design goal is to help the PHR owner achieve fine-grained access control on files stored in Cloud Servers. Specifically, we want to enable the data owner to enforce a unique access structure on each user, which precisely designates the set of files that the user is allowed to access. Our paradigm will help the users to have a control on their PHR data.

This paradigm will help the healthcare industry to shift towards an information-centric care delivery model, enabled in part by open standards that support cooperation, collaborative workflows and information sharing. Cloud computing provides an infrastructure that allows hospitals, medical practitioners, insurance companies, and ubiquitous devices merge and work together.

• Enables on-demand access to computing and large storage facilities which are not provided in traditional IT environments.

• Supports big data sets for electronic health records (EHR),

• Facilitates the sharing of EHRs among authorized physicians and hospitals in various geographic areas, providing more timely access to life-saving information and reducing the need for duplicate testing.

• Improves the ability to analyze and track information (with the proper information governance) so that data on treatments, costs, performance, and effectiveness studies can be analyzed and acted upon.

Our paradigm will reduce the cost of data exchange and medical examination retake, the costs related to the implementation and maintenance of patient-owned records which are maintained on cloud has to be taken into account. Moreover, we argue that our paradigm can become a success only by exploiting its complementarity to existing PHR and EHR systems.

V. ISSUES AND CHALLENGES IN CLOUD PHR

The cloud data base in PHR shall be the most suitable option for the patients in spite of certain challenges in its implementation and successful execution. One of the major challenges will be to convince the consumers who are severely concerned about the privacy of their health information and who attribute to major portion of adult consumers. However, chronic patients who are totally dependent of the health care services are least worried about privacy but are low in numbers. Hence the implementation rate of PHR shall be nominal. This research aims at illustrating the key issues that hinder PHR implementation.

5.1 Integrity of the information is the key element that is to be catered professionally for the successful implementation of cloud data base with 4G LTE in PHR. The technology should abide by the security policy and ascertain the data integrity without unauthorized deletion, manipulation or fabrication. Organizations and firms can attain confidence in data and system security only by preventing unauthorized access. It should ensure the highest degree of data protection to the end users and give the service providers the utmost benefit over the contemporary fixed and mobile networks. Such technologies enable profuse transparency in determining the source that has altered or breached the data or system information, phenomenally affecting their accountability. Authorization determines the level of accessibility a specific authorized user can access the secured information which is controlled by the system. Due to enormous inflow of entities and access points in a cloud environment, authorization is key element to ensure the safe data access by only authorized entities. A cloud computing provider needs to maintain the integrity, sovereignty and accuracy of the consumer's data. However, cloud model poses serious threats such as sophisticated insider attacks or intentional or unintentional deletion of the data. Hence software integrity becomes a mandatory factor for such applications. For instance, an annoyed employee tends to forge with the data in certain circumstances.

Set of software interfaces are required to be implemented for smooth interaction and with cloud services. Another major challenge posed by the providers is the security of these interfaces from unauthorized users. Hence the software administrator is accountable for the integrity of the software.

Lastly the cloud provider is posed by the challenge of protecting the hardware and network integrity from theft or deletion or modification.

5.2 Multi-Tenancy

There may be a database and a workload that needs to be handled, but the main thing to ponder over is that what is the best way to get the maximum perform from the given machine. In this regard, it is important that the number of machines should be lesser and the efficiency should not decrease. The system should be able to understand the number of hardware resources that are required for each of the workload. The workloads may be located on the same machines and which mechanism is used when they need to be joined. The best solution for this is to make virtual machines for each database and many virtual machines for a number of databases built on the same machine .There are more machines are required let's say 2 to 3 machines that will be required to share the same workload. This eventually reduces the performance and the speed 6 to 10 times. The reason behind this lower performance is that each of the virtual machine has its own operating system and its own database. When these two major components are separate for each virtual machine, each virtual machine has its own buffer loop. The better idea is to use the same database server on different machines that will increase the performance as well.

5.3 Seamless and robust IP mobility is one of the key features of 4G networks. These networks enable combine

multi-vendor, multi-technologies networks covering a specific area apart from wireless LAN and cellular network integration. Each and every network including GSM, GPRS, UMTS, DCS have their own set of compliances and standards which lead to overlapping of cells. These cells vary in transmission characteristics such as bandwidth, connection set-up time, terminal density per cell, call tear-down probability apart from physical or logical diameters. Unstable handover situations and coverage issues are the major hassles especially in systems with 60GHz.

Personal Health Record storage options are in abundant ranging from a USB-stick to a cloud server which are not known to the users. These different options have their own advantages and disadvantages. For instance, USB does not enable to update the records. However, storage on web-based devices or cloud server enables updating records though poses security threats. Such hassles on the storage of PHR are hindering the adoption of PHR. There is a need for appropriate awareness on various options and threats of PHR storage solutions among the users.

Initially, barrier portals were adopted as extensions of EHRs which furnished the users with their medical history. However, these portals have limitations as the users cannot update or modify their records. The users often get confused with the terms PHR and portal even after switching over to user-oriented portals. Another issue is the usage of numerous usernames and passwords by the consumers which can be wearisome. These issues can be resolved by having an integration layer which integrates all the portals providing single access interface to the user. It also enables the export of data from their HER to their PHR. A slight modification in the PHR technology can also resolve certain barriers automatically. There should be clarity in the separation of data uploaded by the user and the information from HER in order to safeguard the liability. Once there is a defined precision on the privacy and protection, the use of PHR shall become user friendly resolving the major hurdles.

VI. CONCLUSION

Cloud PHR (Public Health Records) shall be a pioneer in the current health care system catering the needs of the consumer with easy access to the health care data. Data getting updated automatically is the key element of this application. Ministry of health, Oman should think upon adopting 4G LTE in PHR which paves way to development and financial growth. As for the financial aspect, not only the government but also the hospitals as well as the users should contribute for successful implementation of this application. This multiple paying participation makes it economical although the commercial companies will have a major share in the development expenses.

Secondly, the user should have the access to update information as well as upload relevant information from the EHR to the PHR by a portal. However, there should be a clear separation between the user fed data and the EHR fed data in order to facilitate the physicians for better diagnosis. User should have the upper hand to permit the physician to view his PHR through portal. However, the implementation of this application shall be a boon medical industry by enhancing the interface between various service providers and the accessibility and reliability of the health data.

REFERENCES

[1] F. Gagliardi and S. Muscella, “Cloud Computing,” *Cloud Comput. Princ. Syst. Appl.*, pp. 257–270, 2009.

[2] I. Arora and A. Gupta, “Cloud Databases: A Paradigm Shift in Databases,” *Int. J. Comput. Sci.*, vol. 9, no. 4, pp. 77–83, 2012.

[3] R. Bhoyar and N. Chopde, “Cloud Computing : Service models , Types , Database and ssues,” *Ijarcsse*, vol. 3, no. 3, pp. 695–701, 2013.

[4] Y. E. Gelogo and S. Lee, “Database Management System as a Cloud Service,” *Int. J. Futur. Gener. Commun. Netw.*, vol. 5, no. 2, pp. 71–76, 2012.

[5] W. Crawford, “Personally controlled health records: The US landscape and the indivo project,” *CEUR Workshop Proc.*, vol. 219, 2006.

[6] J. Piggot, “Personal Health Records : Solving barriers to enhance adoption Personal Health Records : Solving barriers to enhance adoption,” no. October, 2015.

[7] A. Kaletsch and A. Sunyaev, “Privacy Engineering: Personal Health Records in Cloud Computing Environments,” *Icis-Rp*, pp. 1–11, 2011.

[8] B. R. Kumar and S. Satyanarayana, “Secure Sharing of Personal Health Records in Cloud Computing,” *Int. J. Sci. Eng. Res.*, vol. 1, no. 1–3, pp. 323–325, 2013.

[9] M. Abourezq and A. Idrissi, “Database-as-a-Service for Big Data : An Overview,” vol. 7, no. 1, pp. 157–177, 2016.

[10] W. Al Shehri, “Cloud Database - Database As a Service,” *Int. J. Database Manag. Syst.*, vol. 5, no. 2, pp. 1–12, 2013.

[11] C. W. Kraan, F. Van Der Vegt, and L. Wisse, “Personal Health Records : Solving barriers to enhance adoption,” no. July, 2015.

AUTHOR'S PROFILE

Bobby Sathyaseelan has received her master’s degree in computer application from School of Technology and Applied Sciences. At present she is working as a lecturer in Gulf College Sultanate of Oman. Her areas of interests are cloud computing, distributed computing, computer security and IoTs.

Anju Mathew Cherian has received her master's degree in computer application. At present she is working as a lecturer in Gulf College Sultanate of Oman. Her areas of interests are distributed computing, cloud computing and database security.

John Velloreuzhathil Chacko has received his master's degree in both Computer Applications and Business Administration with specialisation in Information Systems. He has a passion of teaching the programming languages and his research interests are in the areas of data mining, big data and cloud computing.