

CLOUD COMPUTING MODEL FOR SECURE HEALTHCARE SERVICES

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Abstract: Cloud computing is changing our daily lives manifold at a quick pace. The new technological innovation of cloud computing in the healthcare is biggest potential change. The benefits of storing records of patients in clouds have increased productivity of patient care and made easy usage and accessibility of records. The paper surveys the integration of cloud computing with existing healthcare management system and discusses the benefits and challenges of this new technology. A new innovative model is proposed showing how Personal Health Record can be stored in multiclouds. Homomorphic Encryption is suggested to be used for enhancing the security of PHR. The document also discusses the work done on integration of cloud computing with healthcare system.

Key Words: EHR, PHR, Cloud Computing, Healthcare services, Homomorphic encryption, Multiclouds

I. INTRODUCTION

Electronic Health Record (EHR) is a Performa describing systematic health information about an individual or population in an electronic form and is usually stored in a digital form. Personal Health Record (PHR) has evolved as a patient centric form of health information exchange. The patients could share their sensitive Personal Health Information (PHI) on a semitrusted third party. These days, EHR's are shifted to clouds for quick and quality treatments provided by various healthcare facilities and clinical practioners.

Cloud computing is considered to be the future of internet and is an emerging technology these days. It provides services to the user on pay per use basis and is highly cost efficient and flexible. It provides a distributed computing environment in which large numbers of computers are connected via internet. Cloud computing can be defined to use the concept of distributed computing wherein web services are delivered to the users through internet. The customers pay for the services and resources they actually use. Example: Youtube is used to upload video files. Grid computing is a form of distributed system which is based on the concept of power grids and used to solve large scale processing tasks. A cloud uses a grid but a grid may not be part of cloud. Cloud computing has subsequent crucial Characteristics, Service models and Deployment models as shown in figure 1.

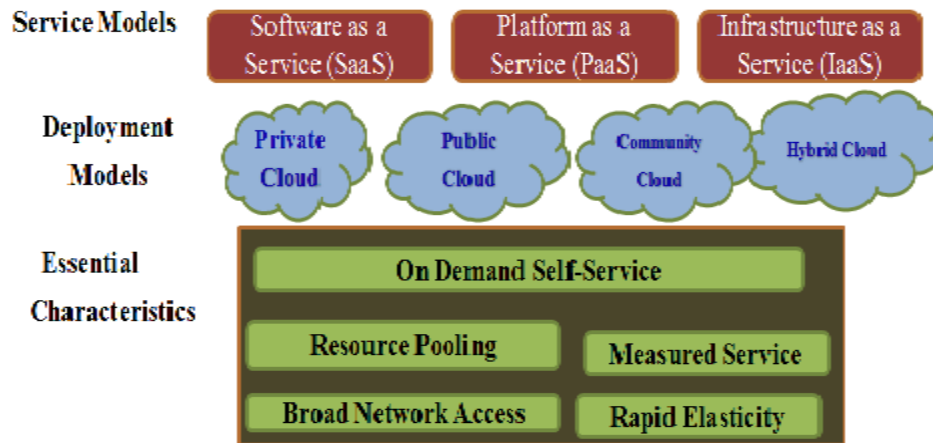


Figure 1: Cloud Computing paradigm

Cloud computing is the biggest potential change to the healthcare industry to focus their research on clinically relevant services and better patient outcomes and diminish infrastructure management burden. Manual collection of data by medical staff as shown in figure 2 is slow, time consuming and manpower demanding which requires to be replaced by an automated process where information can be made collected, processed and delivered at any time.

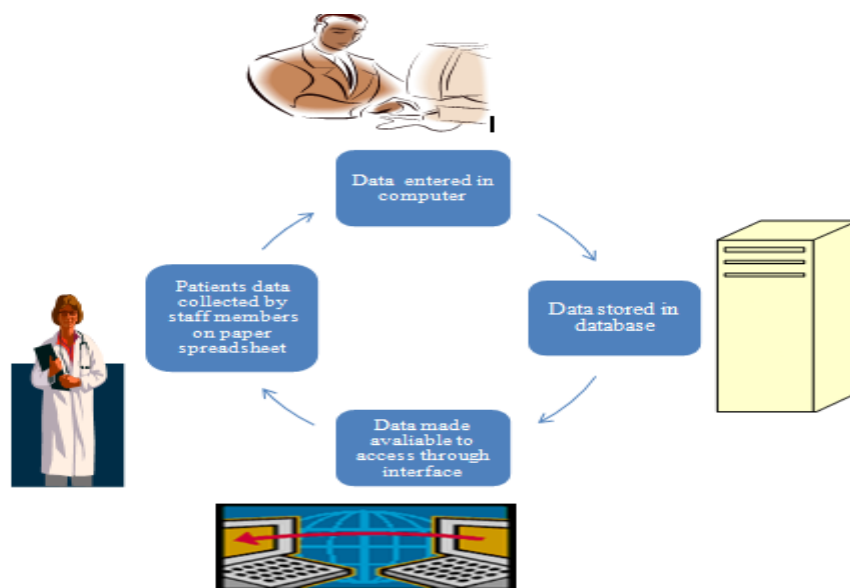


Figure 2: Procedure of manual data entry [1]

The paper is organized as follows. Next section mentions why cloud computing is motivated to be adopted in cloud computing. Section III describes the current state and needs for adoption of Cloud computing in healthcare. Section IV and Section V describes the challenges and benefits in adoption of cloud computing in healthcare respectively. Section VI gives summary of related work. Section VII gives an overview of the proposed model. Section VIII including summary and future work forms the last part of the paper.

II. WHY CLOUD COMPUTING IN HEALTHCARE

The environment in healthcare industry is changing gradually demanding for most effective medical services at low cost increasing competition level between different healthcare providers. Cloud computing aims to decipher clinical troubles faced nowadays and resolve business deeds that have plagued current healthcare providers. Big data has been better managed due to cloud as it provides more computation power and storage. Patients will be most benefited by this technology as they can search for preferred treatment addressing their state of health and drive down cost and improve efficiencies. Cloud computing can be proved as a boon for healthcare actors like doctors, nurses, physicians, patients etc. as cloud computing has several benefits like:

- 1) Improved access to data
- 2) Dynamic administration of infrastructure
- 3) Improved services to patients

III. CURRENT STATE AND REQUIREMENTS FOR ADOPTION OF CLOUD COMPUTING IN HEALTHCARE

Though cloud computing has entered various applications but it is not so much used in practice in healthcare industry where it is still underutilized. Healthcare industry still relies on paper work which is not portable. The hour of the need is that Health Information Technology (HIT) requires to be mandatorily reformed. The type of application under healthcare can be either clinical or nonclinical. The former consists of electronic health record, physician order entry, imaging software and utilizes private or hybrid cloud and the latter includes billing system ,payroll management, increased income etc and uses public clouds.

Certain requirements that must be fulfilled by healthcare industry are:

- 1) The system must be flexible to various departmental needs and organizational sizes.
- 2) Open sharing of information and data sources must be encouraged.
- 3) Capital expense (CAPEX) to operational expense (OPEX) cost must be overseen in case of this migration from client server system to cloud model.
- 4) Portability is required to easily access remote data.
- 5) Security and privacy of data need to maintain.

IV. CHALLENGES IN ADOPTION OF CLOUD COMPUTING IN HEALTHCARE

Some of the significant barriers of cloud computing responsible for its slow adoption in healthcare are:

- 1) Privacy and Security challenges: data stored in a cloud may contain personal, private and confidential information which requires to be protected from disclosure or misuse. A service level agreement among cloud service provider and covered entities including institutions, organizations or persons transmitting every health information electronically needs to be established under HIPAA regulations. Whenever PHI data flows over open networks, it must be encrypted. The

HIPAA compliance requires recognition and authentication of users along with a complete authorized privilege and role based admittance control like passwords to validate the uniqueness of

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users seeking permissions to access the PHI information.

- 2) Workflow challenges: From paper work and data entry system to cloud model, new training and new skill sets need to be planned. Electronic medical record (EMR) should be emphasized.
- 3) Reliability and performance: Disaster recovery being a component of service reliability is difficult to develop as most SLA doesn't provide satisfactory guarantees in case of a service outage due to a calamity. Another factor is performance which is affected by mismatch in types of internet connections which vary in different speeds.
- 4) Integration and interoperability: The Standard Development Organization (SDO) develops specification and principles to sustain healthcare information, exchange of information and systems integration which is difficult to maintain.
- 5) Data portability and mobility of records: The movement of data between healthcare organization and cloud vendors requires no disruption to data. The migration to a new cloud service provider (CSP) in case if any CSP goes out of service becomes a serious issue.
- 6) Speed: By using cloud computing, faster and accurate access to all information for healthcare service can be made.

V. BENEFITS OF CLOUD COMPUTING FOR HEALTHCARE

- 1) Clinical Research: The research and drug development has increased manifold with the adoption of cloud computing which were previously unattended. Patients don't need to travel long distances for tests to be performed as experts can access patient information remotely and on request through internet.
- 2) Electronic Medical Record (EMR): burdensome task is gradually offloading from hospital IT department by putting data online.
- 3) Telemedicine: Teleconsultation and Telesurgeries have increased manifold because of health record exchange, web conferencing and home monitoring through mobile technologies and intelligent medical devices.
- 4) Health Information Exchange (HIE): It allows sharing of data contained in EHR systems. The delay in treatment of patients by storing data in records has reduced significantly.
- 5) Big data: Cost of storing data has reduced as the cloud can store large data sets for EHRs, images related to radiology and genomic records for clinical drug trials.
- 6) Type of Cloud: The type of cloud public, private, hybrid which meets the needs of healthcare industry in a better way is still a question of debate.

VI. RELATED WORK

One of the most difficult aims in cloud computing for healthcare industry is to enhance the quality of medicinal assistance delivery. A high degree of patient privacy is required along with easy and quick access to information stored in cloud. This section presents an outline of existing review articles allied to cloud computing in table 1.

Table 1. Summary of related work

| Author name | Purpose | Technology used | Advantage | Disadvantage |
|-------------|--------------|-----------------|--------------------|--------------|
| Carlos[1] | Sensor nodes | Used Cloud | Always on for data | Communicatio |

| | | | | |
|------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
|] | used to gather and broadcast data through wireless medium | Computing and Wireless sensor networks | collection, eliminated manual collection of data No cabling or physical setup required | n overhead caused by XML usage. |
| Sundarar aman[9] | Solution proposed to examine cardiovascular disease | Used personal digital assistant and grid computing | Used in SaaS | Not able to collect information about secure data |
| Xiao [10] | Mobile devices used to parse components of web page | Wireless web access used | Addressed the technical and clinical issues of wireless web access | Solution not suitable for large scale integration |
| Ming Li [2] | Secure sharing of PHR in clouds | ABE and multiauthority used to encrypt and enhance data security. | Key management complexity decreased Increased privacy level Efficient and scalable solution proposed | Overhead incurred due to XML usage |
| M.T. Nkosi [3] | Existing mobile health monitoring systems functioning improved and burden reduced | NGN/IMS system used Multimedia sensor signal processing used | Improved utilization of mobile device for health service delivery to rural communities | More research on IMS client need to be done |
| Li M[16] | Framework provided to realize patient centric privacy for PHR clouds | Utilized multi-authority ABE to encrypt PHR data | Key management complexity reduced | Data required to be decrypted before performing operations Doesn't support owner defined access policies |
| Vidya [7] | Discussed patient centric mode and cloud computing in PHR system | Used trusted third party, Homomorphic encryption with data auditing to verify, store and process PHR. | TPA allowed to evaluate risk and improve cloud based service policy | Not fully trustworthy system as sensitive data an be addressed by members |
| Soubhag | Addressed | Homomorphic | Access privilege | Key |

| | | | | |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| ya B [6] | security and privacy issues of cloud based PHR systems | encryption integrated with PHR system | assigned to patients to protect valuable information | management and policy were complex |
| Benaloh [13] | Provides strong authentication to users for sharing access rights | Encryption scheme used to propose patient controlled encryption(PC B) for secure and private storage of patients medical records | System prevented unauthorized access to patients medical data | Not efficient in terms of key management and key escrow not supported problem in emergency |
| Huda M.D.N[15] | Privacy management architecture called P3HR proposed for PHR | Strong authentication with smart IC cards used | Authentication mechanism provided | Only username and password based authentication provided which was not efficient |
| Aderonke [4] | PHR accessed through web portal by multiple users. Secure EHealth system called SECHA proposed and composed of five basic components | HE used along with Bilayer Access control to provide security and full access rights to user | Supports large number of patients to be attended in limited time and accessed anywhere in the world with ensured security | Emergency rule access to system still a question to be addressed |
| Chandrani [5] | Surveyed different cloud based healthcare system | Discussed integration of healthcare system and social media with public cloud, private cloud with different examples | Healthcare management system combined with cloud computing and social media | Paper doesn't provide any details of implementation |
| Doukas [12] | Collected and stored motion and heartbeat data on an open cloud infrastructure for monitoring and processing | SOAP message and HTTP/HTTPS used for data exchange. Google chart used for data visualization. | Health alert issued to patients. Patients monitored by doctors easily | Bluetooth used in system can be easily manipulated. Privacy of data not considered |

| | | | | |
|-------------|-----------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------|
| | purpose | Cloud developed using Java. Rest web service used on Android smartphone | | |
| Deng. M [8] | Proposed a homehealthcare system for patients | Apache and MySQL, SOAP interface used as IaaS. User access provided through web | Improved drug therapies management. monitored physical activity of patients | Doesn't consider of privacy of patients |

VII. PROPOSED CLOUD MODEL

Security and privacy violation in clouds has been the primary factor restricting its widespread use. So, encrypted data is required to be stored in clouds. An automated process of collecting patient's vital information and delivering this information to be stored, processed and distributed over cloud is proposed. In this segment, we are going to analyze our projected system model, which will allow information to be stored on multiple clouds transparently to the user. The system will consist of four major components:

- Patient
- Cloud
- Data users
- Trusted Third Party

In the proposed system Architecture, the patients are the entites whose personal health record will be uploaded in the Cloud. The information is stored in Personal Health record. Trusted Authority (TA) is responsible for user registration and authentication and stores user information on cloud data store. After login authentication when user wants to upload any file he requests to cloud to upload a specified file .The Cloud performs key generation and distributes the keys to the Owners. The datasets are arbitrarily partitioned using horizontal and vertical partitioning. Then the partitioned dataset is encrypted using the homomorphic encryption algorithm. Encrypted file and generated key are stored in the database. Homomorphic encryption is suggested to be used which is the conversion of plain data into ciphertext without requiring decryption of data before usage. A key is sent to the user as an acknowledgement which is further used for downloading a file. When user wants to download his file, again he needs to specify a file name and key which is obtained in response while uploading a file. The cloud again decrypts the desired file with the help of key and sends back a decrypted file i.e. original file. Multiclouds are proposed to be used so as to increase the security level and avoid vendor lock-in problem that exists in single cloud. Figure 3 below shows the overall concept of the framework.

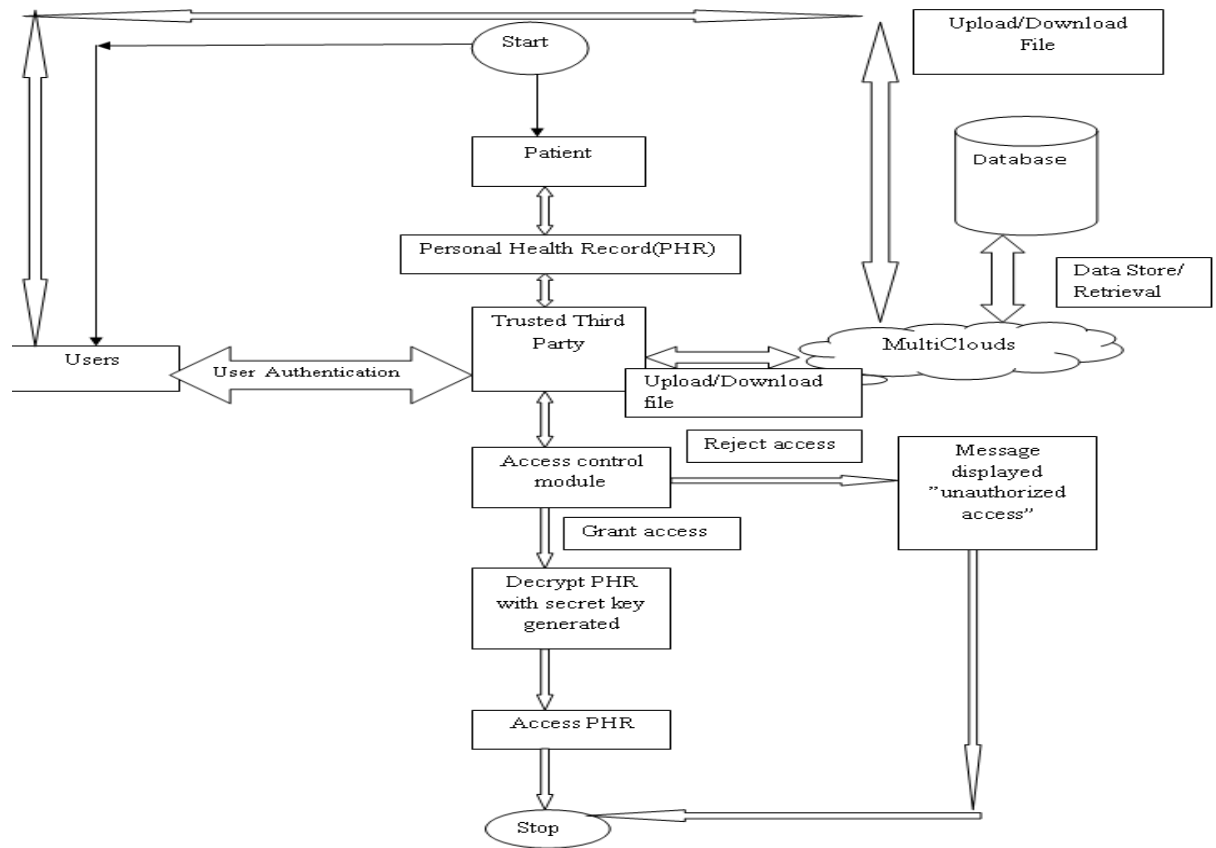


Figure 3: Architecture of Proposed model

Domains using PHR can be categorized as

- public domain including healthcare domain (institutions,hospital,doctors,nurses) and Insurance domain.
- Private domain: including PHR owner,friend etc.

Personal Health record can have following attributes personal health information,medical history,Examination, Emergency contact and Insurance information as shown in figure 4.

| Personal Health Record (PHR) | | | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Personal information patient id patient name Date of Birth Age Height(cm) Gender Weight(kg) Blood Group Phone number State of origin Address | Examination • Lab Test • Physical Scan | Medical History • Hospital name • Record Date • Department/Role • Allergies • Medical Prescription • Complaint /Symptoms • Doctor's remark | Insurance Information • Company name • Patient Name • Health Insurance • Address • Phone number | Emergency contact • Patient name • Phone number • Relationship |

Figure 4: Attributes of PHR

VIII. SUMMARY AND FUTURE WORK

Cloud computing is emerging as an innovative technology to be deployed in healthcare industry which may have its impact over next several years. Cloud computing will be the foundation of healthcare modernization. Government incentives for EHR, digitization and decreased cost will require that cloud computing become more mainstream. In the innovative representation, a multicloud based privacy system has been presented storing the PHR and accessed by multiple owners and users. For future use, through implementation and simulation in java programming language, we aim to show that our approach provides always-on and real time data and system is scalable and proficient.

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