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# A SURVEY ON PRIVACY PRESERVING HEALTHCARE DATA USING CLOUD COMPUTING

**M. Rajakumar* & Dr. S. Thavamani****

* Research Scholar, Department of Computer Science & Applications, Sri Ramakrishna College of Arts and Science, Coimbatore, Tamilnadu

** Associate Professor, Department of Computer Science & Applications, Sri Ramakrishna College of Arts and Science, Coimbatore, Tamilnadu

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**Abstract:**

Cloud Computing is a new way of delivering computing resources and services. It is a model for on-demand network access to a shared pool of configurable computing resources like, networks, servers, storage, applications, and services that can be provided with minimal management effort or service provider interaction. Healthcare is faster growing way to adopt cloud computing. It is very important for every individual and essential for every country in the Globe. Electronic healthcare systems in the world are moving towards a more accessible, collaborative and more proactive way in reaching out to the public. The delivering of public health solutions can lead to increased efficiencies in health related data. Many nations across the globe have launched aggressive stimulus programs aimed at solving public healthcare problems in efficient way. This review article mainly focus on different ICT based infrastructure facilities available in various hospitals in India, abroad with cost effective manner using cloud computing technologies, services and this will be a best solutions for healthcare systems in rural areas. And also in this paper presented about various cloud service providers, investment in healthcare, IT adoption in Indian Healthcare sector, Major benefits of Cloud-based Patient Management System [PMS], about SADA systems, Top ten cloud storage companies in healthcare and Pros and Cons of EHR systems, comparison of Indian healthcare systems with US system, and various Cloud Simulators.

**Key Words:** Electronic Healthcare Systems, ICT Based Infrastructure, EHR systems, Indian Healthcare Sector & Cloud Simulators.

## 1. Introduction:

Cloud Computing refers to the set of networks of remote servers which are hosted over the internet. These servers help businesses in storing, managing, and processing data. Organizations back upon these servers or the cloud in total, thus its security remain a main concern. It is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be provided with minimal management effort or service provider interaction.

Cloud Computing Security refers to the set of policies and technologies that help us govern and protect our data on the cloud. Cloud security is a sub-domain of computer and network security. It also comprises of information security.

Cloud Computing Essential Characteristics: There are five essential characteristics: On-demand self-service, broad network access, resource pooling, rapid elasticity, measured service.

Overview of Healthcare: Healthcare organizations are under tremendous pressure to make sweeping changes to their existing landscape due to increased regulatory compliance and Healthcare reform mandates. Public healthcare sector organizations are developing and delivering the best public health services, and at all level, the governments modernized processes and systems are improving citizens' communications and overall service levels. To meet the responsibilities of their citizens, governments must focus on improving service delivery, operations, availability of data [11], medical education and improved access to healthcare. Many nations across the globe have launched aggressive stimulus programs aimed at solving public healthcare problems and moving their public sector to move forward.

Cloud Computing in Hospitals: Cloud computing makes healthcare efficient. Storing healthcare data in one central location an online location can be more efficient for healthcare providers. When patient data are stored in the cloud, healthcare providers can access that data anytime and anywhere through a secure online portal.

Cloud Computing for Healthcare: Traditional healthcare IT departments are set up with an IT director and staff, a network infrastructure, and local data centers. For many years, the healthcare industry has been exchanging information, such as medical images and more recently electronic medical records, through a local network. [12, 13] Healthcare organizations use ventilators, heart monitors, ultrasound wands, and countless other portable medical devices.

Traditionally, these devices are plugged into a hard-wired Internet connection, and the data is downloaded onto a local PC connected to a network. The data are downloaded at specified intervals, such as each night, or once

per week. Many times the data are never used, or perhaps a physician will refer to the data after a problem has occurred.

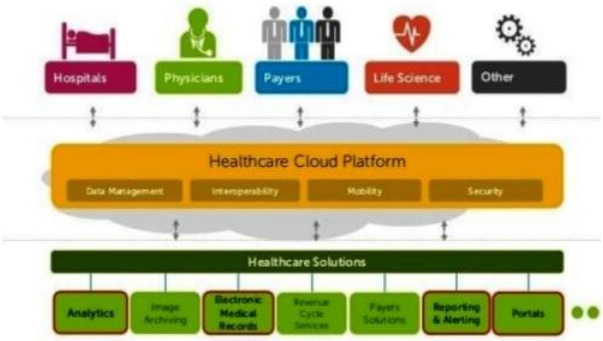


Figure 1: Impact on Healthcare

| | Patients | Providers | Payers |
|---|---|---|---|
| EMR | Easier to read and understand | Easy storage and retrieval; improved efficiency and productivity | |
| EHR | Better diagnosis and treatment | Coordination and informed decision-making | Faster reimbursements |
| Personal Health Records | Personal wellness management | Consistency of information | Links to healthcare plans and lower claims |
| Remote Diagnostics | Reduces duplicated tests and referrals | Easy access | Lower cost |
| Remote Monitoring | Patient-centric integrated care | Reduce emergency and re-admissions | Lower cost |
| Telecare | Access to specialist care | Improves productivity and reduces burden of healthcare resources | Lower cost |
| mHealth applications | Greater patient engagement and saves time | Proactive and targeted care | |
| Big Data/Analytics | Accurate diagnosis, better treatment | Improves diagnostics and accuracy of treatment | Lower cost |

Figure 2: Summary of benefits of digitizing healthcare for patients, providers and payers

**2. Literature Review:**

Dharampuriya (2016): have explained the 6 ways how Internet of Things is transformational", 200 more hospitals by the end of this year that is our goal, so it will be close to 300. Since the start of 2016, e Clinical Works is focusing on the Indian healthcare market. With a majority of its current 75 client base in India consisting of large size hospitals and clinics from Mumbai, Delhi, Bangalore, Ahmedabad and other urban cities, e Clinical Works aim to tap the more business opportunities in the urban areas.

March 27, 2017 - As health IT infrastructure becomes more advanced, organizations are adopting big data analytics incentives, mobile and Internet of Things (IoT) devices collecting information that needs to be stored. Cloud storage solutions in healthcare allow facilities to expand and scale their IT infrastructures to meet the demands set by advanced analytics and connected medical devices to decrease overall costs and save on space needed to house physical servers. Based on market reports from Global Industry Analysts, Markets and Markets, and Report buyer, HITInfrastructure.com presents the following list of top healthcare cloud storage companies and how they meet specific healthcare needs.

India Cloud services compared with US: "A lot of that (money) will go into the R&D, where we realized that Indian healthcare market is different from the US. And so that's one area where we got to understand what the market needs and continue to enhance our products to make it more convenient and easy," Dharampuriya explained.

Improving Cloud Health IT Infrastructure for Smart Hospitals: December 11, 2017 - Many organizations are enhancing their health IT infrastructure with the intention of becoming smart hospitals by embracing digital transformation. Smart hospitals rely on interconnected advanced technology and automation to improve patient care, clinician workflow, and overall efficiency. Smart hospitals utilize health IT infrastructure technology such as mobile devices, data analytics solutions, and cloud computing, according to a recent Frost and Sullivan report. The report also predicted that the market opportunity for smart hospitals will reach revenues of $5.9 billion in 2018.

Cloud Computing is coming to Indian Healthcare: [14] As health organizations transform how they serve their patients and partners, cloud computing provides a way to reduce costs, simplify management, and improve services in a safe and secure manner [3]. The company studied the health care IT cloud market for the period 2012-2017. In the health care cloud market, no cloud provider holds more than a 5% share, according to the report. Healthcare cloud vendors include Agfa Healthcare, Care Cloud, Dell, GE Healthcare and Merge Healthcare. Information and Communications Technology (ICT) goals: Online health and wellness tools, application development, data and image storage and sharing, and PC management and security.

Indian healthcare to make major investments in health IT deployment in 2017: Initiatives within organization in 2016, technology planning for 2017 and the tech investments trends across the Indian healthcare sector. In an interview with ETCIO, Arvind Sivarama Krishnan, CIO – Apollo Health Enterprise Ltd (AHEL) [6] talks about technologies that impacted overall operations and functions in 2016, new technology led initiatives for 2017 and his perspective on Indian healthcare sector and technology adoption in the next year. Sivaramakrishnan is responsible for the IT strategy and implementation for the entire group and its companies. As a CIO he also oversees change management and business process reengineering for enterprise wide healthcare IT adoption and driving efficiency, quality and excellence across clinical, financial, operational and service sectors of the organization. [8].

Most solutions are certified and compliant to healthcare regulatory bodies including National Accreditation Board for Hospitals & Healthcare (NABH) in India and Joint Commission International (JCI) globally. Today, company has over 4500 staff with three offices in India. Besides, it has six offices in the US and one in the UK, while it has an overall presence across 30 different countries. Last year e Clinical Works' revenue cross $400 million and it expects to grow revenue to $500 million by 2016 end.

| Sl. No. | Author Name | Paper Title | Journal Name | Methodology / Algorithm used | Advantages | Limitations |
|---|---|---|---|---|---|---|
| 1. | Pengliang Liu, JianfengWan, Hua Ma, HaixinNie | Efficient Verifiable Public Key Encryption with Keyword Search Based on KP-ABE [15] | 9th International Conference on Broadband and Wireless Computing, Communication and Applications. | Key Policy Attribute Based Encryption (KP-ABE) | It increases the data confidentiality. | It is not scalable to high dimensional data |
| 2. | V.Ramya, S.Thavamani | A Study on Security Mechanism Employed on the Electronic Health Records in the Cloud [12] | International Journal of Contemporary Research in Computer Science and Technology (IJCRCST) **ISSN: 2395-5325** Volume 3, Special Issue 3, Sep-2017. | 1. Efficient Verifiable Public Key Encryption with Keyword Search Based on KP-ABE, 2. Public key encryption with keyword search, 3. Time-based proxy re-encryption, 4. Searchable Attribute-Based Mechanism with Efficient Data Sharing, 5. Hybrid Cryptographic Access Control. | 1. Satisfy the data owner's access control policy. 2. To search encrypted index structure for encrypted data files. 3. Automatically update the access time. 4. Data owner to efficiently share his data to a specified group. 5. Scalable, secure, and reliable for accessing and managing EHR data. | PEKS secure against keyword guessing attack is only secure under the random oracle model, which does not reflect its security in the real-world. |
| 3. | Ming Li, Shucheng Yu, Yao Zheng, Kui and Wenjing Lou | Scalable and Secure Sharing of Personal Health Records in Cloud Computing using Attribute Based Encryption [16] | IEEE Transactions on Parallel and Distributed Systems, Vol:24, No:1, Year 2013. | Attribute Based Encryption (ABE) | Increased security, scalability and efficiency | For increased data transfer time duration will be increased |
| 4. | Ning Cao, Cong Wang, Ming Li, Kui Ren, Wenjing Lou | Privacy-Preserving Multi-keyword Ranked Search over Encrypted Cloud Data [17] | IEEE Transactions on Parallel and Distributed Systems, Vol:25 No:1, Year 2014. | Multi-keyword ranked search | Improved privacy and efficiency, Lowest overhead on computation & communication. | Not supporting other multi-keyword semantics over encrypted data and integrity |
| 5. | Dhanamma Jagli, Seema Purohit, Subhash Chandra | Knowledge Acquisition for Electronic Health Records on cloud [18] | International Conference on Knowledge Based and Intelligent Information and Engineering Systems, KES2017, 6-8 September 2017, Marseille, France. | Linear Regression method, K-means Clustering algorithm | Finding relationship and for grouping the data records for EHR SaaS dataset | It does not produce any further changes over the objects, To do the clustering groups according to the features of each individual EHR SaaS . |

Table 1: Analysis of Healthcare data in Cloud

**3. Materials and Methods:**

Major Benefits of Cloud-Based Patient Management System [8]: In today's technological world this, not a time to overlook healthcare industry at any cost. A cloud-based patient management system is an essential requirement of time, as industrial growth is dependent on such developments. No wonder such improvement is essentially required by healthcare industry because record maintenance and management is one of most critical

requirement. There are different healthcare portals or modules available but cloud-based systems are preferred due to different reasons. There are two types of healthcare software are available in the market: Cloud-based and Client-Server based. The cloud-based patient management system is selected because it is more beneficent than other traditional software solutions.

Advantages of Cloud-Based Patient Management System (CBPMS) [8]: Data Security, Cost Effectiveness, Easy System Access, IT Requirements and Scalability. The PMS is a single module of the healthcare system. Undoubtedly initially it seems costly to purchase and implementation of a cloud-based system. In a hospital or clinic, there is no specific time to access important data related to patient care and others. Therefore cloud-based patient improves the accessibility. So, a cloud-based system is easily accessible without discrimination of location, PC, and tablet. CBPMS reduces the business cost associated with an IT infrastructure.

Different hardware that usually used in software installation, update, data backup and transfer are no more required. A comprehensive cloud-based system makes it easier to add, manage, and modify the data, locations and patient record. It is flexible enough to add new locations, patients, staff, and doctors.

SADA Systems [9] is a Microsoft Cloud Solutions Provider with Gold Competencies, a Google Cloud Premier Partner, and a Workplace by Facebook Service Partner focused on delivering innovative cloud technologies and tools, combined with expert consultation and exceptional customer experience.

A new survey demonstrates just how prevalent cloud technology is in health care right now.

The survey, conducted by cloud tech provider SADA Systems, asked hundreds of healthcare IT pros about whether their organizations were taking advantage of cloud technology and, if so, in what capacity.

Advantages to Cloud Apps [9]: The vast majority of those surveyed (89%) are currently using cloud-based apps in their hospitals, and the apps have boosted performance at their facilities. Out of all IT professionals working with cloud apps, 56% said the apps are improving patient satisfaction and 55% said they led to better treatment. In addition, 64% noticed improvement in productivity and efficiency in their organizations (for both patients and staff) due to the apps, while 54% believed cloud apps and tools are helping their facilities deliver faster care.

Over one-third of those surveyed (35%) said cloud technology helps them better support hospital patients and staff, and 23% said it gives them greater control over the organization's use of software and hardware. Also, about half (51%) indicated that cloud apps help them be more innovative, and 17% said cloud tools help them deliver products and services faster. The types of apps used by healthcare IT pros vary. Respondents use cloud apps most often for email access (68%), followed by apps designed for patient care (64%) and file sharing (55%). Most are using between six and 10 different cloud apps on a regular basis.

Top Cloud data storage companies offer service to healthcare organizations [5]: March 27, 2017 - As health IT infrastructure becomes more advanced, organizations are adopting big data analytics incentives, mobile and Internet of Things (IoT) devices collecting information that needs to be stored. Cloud storage solutions in healthcare allow facilities to expand and scale their IT infrastructures to meet the demands set by advanced analytics and connected medical devices to decrease overall costs and save on space needed to house physical servers. Based on market reports from global industry analysts, and markets, and Report buyer, hitinfrastructure.com presents the following list of top healthcare cloud storage companies and how they meet specific healthcare needs.

Amazon Web Services (AWS) focuses on helping healthcare providers deliver efficient, quality care to patients through reducing the time needed to run existing workloads and providing access to useful analytics capabilities. AWS also prioritizes meeting all security and privacy requirements. The cloud storage vendor gives providers access to archiving solutions and allows hospitals to store backup servers in the cloud to save space

Microsoft Azure is one of the most widely used healthcare cloud providers. The collection of integrated cloud services offers healthcare organizations solutions ranging from the Internet of Things (IoT) to big data and analytics. Microsoft Azure equips providers with the necessary tools to engage patients, empower care teams, and optimize clinical and operational effectiveness.

Dell EMC Secure Healthcare Cloud offers HIPAA-compliant security and disaster recovery. The cloud provider hosts applications, and assists users in building a private cloud or integrating Dell's solutions into their existing infrastructure.

Google Cloud Platform offers evolving infrastructure with big data and analytics capabilities through a focus on developing code over configuring servers. Google Cloud Platform strives to meet stringent security, and compliance controls, including HIPAA, so healthcare organizations can trust their infrastructure meets all relevant regulations. The cloud provider offers a variety of products including cloud storage and databases, cloud virtual networks, and a cloud machine learning engine.

IBM supplies healthcare organizations with the necessary tools and technology to deliver quality patient care using a cloud service with apps and services integrated with cognitive and analytics capabilities for valuable insights. IBM offers a variety of secure, scalable, private cloud options available in more than 45 data centers worldwide. The cloud platform integrates DevOps tools to accelerate the development and delivery of web and mobile services.

Clear DATA prioritizes healthcare security and managing sensitive healthcare data through compliance and security safeguards, healthcare expertise, and DevOps automation. Clear DATA equips healthcare providers with the tools to deal with the large volume of data and analysis involved in population health management.

Intel specializes in facilitating workflows and customized treatments in clinical and distributed care settings using data analytics and clinical decision support. Intel also provides resources for mobile healthcare teams for consolidating patient data and transferring patient information wirelessly before the patient arrives onsite.

Iron Mountain, Iron Mountain's information management solutions specialize in records management, information destruction, and data backup and recovery. Iron Mountain's scalable portfolio of health IT management solutions focus on accelerating user EHR transitions and reduce their hybrid period. The cloud provider helps manage clinical and business solutions for over 2,000 hospitals.

SAP provides software for healthcare providers to aid with patient care delivery, care collaboration, healthcare analytics and research, and platform and technology. SAP's analytics and real-time health IT platform helps healthcare providers with integrated patient access to information and health data exchange. SAP solutions specialize in enabling information exchange, managing risk and compliance, and personalizing healthcare and patient engagement.

Cloud Simulators [4]: The need for a cloud computing simulator arises in order to witness an implementation scenario in real-time. Cloud simulators play a crucial role in reducing the complexity of the infrastructure, in executing new algorithms, analyzing security threats and measuring the overall quality and performance of the infrastructure. Some of the top free and open source cloud computing simulators available today are: Cloud Sim, Cloud Analyst, Green Cloud, iCan Cloud and EMUSIM.

Improving Cloud Health IT Infrastructure for Smart Hospitals: Cloud health IT infrastructure supports more advanced tools as organizations are looking to advance as smart hospitals. December 11, 2017 - Many organizations are enhancing their health IT infrastructure with the intention of becoming smart hospitals by embracing digital transformation. Smart hospitals rely on interconnected advanced technology and automation to improve patient care, clinician workflow, and overall efficiency. Smart hospitals utilize health IT infrastructure technology such as mobile devices, data analytics solutions, and cloud computing, according to a recent Frost and Sullivan report. The report also predicted that the market opportunity for smart hospitals will reach revenues of $5.9 billion in 2018.

Pros and Cons of EHR systems, according to doctors [7]: A new survey has some details on what clinicians see as the pros and cons of Electronic Health Records (EHRs). Not a whole lot of doctors are thrilled about working with EHR systems, according to a recent report from IDC. Among the 212 ambulatory practices surveyed, 58% were dissatisfied or neutral about EHR software.

While there are still a lot of issues to iron out, providers still hope to get a number of benefits from EHR systems. The top goals for adopting a system, according to respondents:

- Improved regulatory compliance (cited by 56% of providers).
- Improved care quality (43%).
- Higher efficiency and productivity (30%), and
- Better communication and collaboration (22%).

From the above study, Healthcare organizations need to be doing more to help doctors and others use EHR software more effectively. That includes choosing systems that meet doctors' needs, as well as offering enough training and other support to help doctors with new technology.

Security and privacy of healthcare data with cloud computing [2], [10]: In order to maintain the security and privacy of healthcare data, both cloud service providers and healthcare organizations should take extreme measures to secure a safe handling of patient's data. Proper authentication systems added to the role-based system supports more secure environment to store and manage patients' data. In the process of migrating healthcare data to a cloud system, there are security precautions to be taken which include data encryption. While data encryption seems be the most secure method for handling patients data, however not all EHR systems are compatible with standard encryption methods. This is due to the multiple users who each have a role-based access. This needs to develop more advanced encryption methods that are suitable for the EHR. An

example is using a Symmetric-Key Encryption (SKE). It is an advanced encryption technique which is considered efficient; however it still introduces complexity in EHR systems. This is due to the encryption technique that requires all healthcare providers to use one key for encryption and decryption.

Also it utilizes user roles for accessing and handling secure data. It provides reasonable performance and consumes small storage area; therefore it can be used as a replacement to standard encryption mechanisms in cloud-based EHR systems.

**4. Conclusion and Future Work:**

This review article describes in detail about the importance of Electronic healthcare systems using Cloud computing and other ICT Technologies. And also discuss about various cloud service providers, comparison of Indian healthcare systems with US system, investment in healthcare, IT adoption in Indian Healthcare Sector, Major benefits of CBPMS, about SADA systems, Top ten cloud storage companies in healthcare and Pros and Cons of EHR systems and various Cloud Simulators. Future work, this type of Cloud and ICT based technologies can used for even rural healthcare organizations for providing more security, efficiency, faster processing and accuracy for which a detailed study can be done about some of the rural places and suitable suggestions to be given for their development.

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