Systematic Review of Cloud Computing in Healthcare Domain

By

Anurag Dadheech

Dissertation submitted for the partial fulfillment of the

MBA Hospital and Health Management

Academic year, 2015-2017

The IIHMR University, Jaipur

1, Prabhu Dayal Marg, Sanganer, Airport
Jaipur 302029, Rajasthan
Ph: 0141 3924700, Fax: 3924738
Website: **www.iihmr.edu.in**

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1, Prabhu Dayal Marg, Sanganer, Airport
Jaipur 302029, Rajasthan
Ph: 0141 3924700, Fax: 3924738
Website: www.iihmr.edu.in

INSTITUTE OF HEALTH
MANAGEMENT RESEARCH
(WHO Collaborating Centre for District Health System Based on Primary Health Care)

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This is to certify that **Dr. Anurag Dadheech** student of MBA Hospital and Health Management from The IIHMR University, Jaipur has undergone internship training at **NTT Data Services, Bangalore** from 6th February 2017to 5th May, 2017

The Candidate has successfully carried out the study designated to his during internship training and his approach to the study has been sincere, scientific and analytical.
The Internship is in fulfillment of the course requirements.

I wish him all success in all his future endeavors.

Dr. (Col) Ashok Kaushik
Dean, Academics and Student Affairs
The IIHMR University, Jaipur

Dr. (Col) Ashok Kaushik
Dean, Academics and Student Affairs
The IIHMR University, Jaipur

1, Prabhu Dayal Marg, Near Sanganer Airport, Jaipur- 302029, Rajasthan, India.
Ph.: 0141- 3924700, 2791431- 32, Fax: 0141 3924738, E-mail: iihmr@iihmr.edu.in, Web.: www.iihmr.edu.in

NTT DATA Information Processing Services Private Limited
(Formerly known as Dell Business Process Solutions India Private Limited)
Plot 123, EPIP Phase II, Whitefield Industrial Area
Bengaluru, Karnataka 560 066, India

NTT DATA
Global IT Innovator

To whomsoever it may concern

This is to certify that **Dr. Anurag Dadheech** of **The IIHMR University, Jaipur** has been working with NTT DATA Services for his summer project.

Project Details:

Project Name : A systematic review of cloud computing in Healthcare domain
Duration : 90 days
Location : Bangalore
Guide Name : Dr. Kuljeet Singh & Shibor Hinge
Sponsor Name : Ajay Aiyar

He has successfully completed his project and his performance during the tenure of the internship has been found to be satisfactory.

His findings in course of the project has been found to be practical and relevant and some of the recommendations will be incorporated on the floor on approval from the business.

Thanking You,

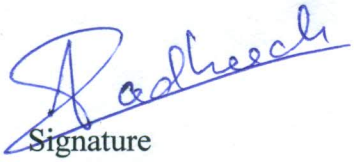
Regards,

Dilipkumar Santhanam
Business Partner Director, Services HRBP Team
NTT DATA Services

THE IIHMR UNIVERSITY, JAIPUR

CERTIFICATE BY SCHOLAR

This is to certify that the dissertation titled "**A Systematic Review of Cloud Computing in Healthcare Domain**" and submitted by **Dr. Anurag Dadheech** Enrollment No. **IIHMR-U/01/2015-17/0257** under the supervision of **Col. (Dr) Ashok Kaushik** for award of Postgraduate Diploma in Hospital and Health Management of the University carried out during the period from 6th February 2017 to 5th May 2017 embodies my original work and has not formed the basis for the award of any degree, diploma associate ship, fellowship, titles in this or any other Institute or other similar institution of higher learning.



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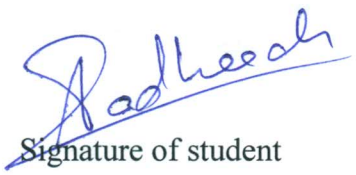
This is to certify that all ethical issues have been considered while collecting data for my dissertation titled "**A Systematic Review of Cloud Computing in Healthcare Domain**"



Signature of student

Acknowledgement

I started off my training with a vision in my mind so as to be able to learn about the practical aspects of Healthcare Information Systems in a detailed manner. I would like to express my deep gratitude to **Dr. S.D. Gupta** (Chairman, IIHMR University) and **Col. (Dr.) Ashok Kaushik** (Dean Academics, Institute of Health Management Research, Jaipur) for placing me in such an esteemed organization to undertake my dissertation and internship. I am grateful to **Col. Dr. Ashok Kaushik** for his constant feedbacks and valuable advises without which this dissertation would be far from completion.

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Dr. Anurag Dadheech

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List of Abbreviations:

NIST	National Institutes of Standards and Technology.
ICT	Information and Communication Technology.
IoT	Internet of Things.
HIT	Health Information Technology.
PGHD	Patient Generated Health Data.
EMR	Electronic Medical Record.
EHR	Electronic Health Record.
PHR	Personal Health Record.
HIPAA	Health Insurance Portability and Accountability Act.
DICOM	Digital Imaging and Communication in Medicine.
PACS	Picture Archiving and Communication Systems.
DACAR	Data Capture and Auto-Identification Reference.
SLA	Service Level Agreement.
HITECH	Health Information Technology for Economic and Clinical Health Act.
ARRA	American Recovery and Reinvestment Act.
CMS	Centers for Medicare and Medicaid Services.
CAH	Critical Access Hospitals.
CIS	Clinical Information System.
NCIS	Non-Clinical Information System.
CPOE	Computerized Provider Order Entry.
HIE	Healthcare Information Exchanges.
ICD	International Classification of Disease.
HMIS	Hospital Management Information System.

Chapter 1 Introduction

Dawn of cloud computing along with the business models had major impact, not only on the computer industry but had its effects on other industries as well. It is expected that 81% of businesses currently will be move to cloud by 2020. The word cloud computing is defined by the National Institutes of Standards and Technology (NIST), "as a model for enabling ubiquitous, convenient, on demand access to a shared pool of configurable computing resources" [1]. Mell P, Grance T (2011), application of information technology in the health provider segment is significantly less used, mainly in areas of operational proficiency. Acc. To Hitachi Data Systems (2012), most health providers and organizations up till date rely on paper based medical records, hence restraining coordination and collaboration between physicians and patients. The current scenario is aiming to access information from anywhere at any time, that could be attained by shifting healthcare information on cloud services. On-demand access, omnipresent to infinite assets in blend with a pay-per-use model allows innovative ways of delivering, use of service and developing. Daily, there are noteworthy generations of healthcare statistics. The statistics is vital and important for delivering the best care and decision making in patient welfare.

Cloud computing, a cost effective method enabling simultaneous data storage, data collection and exchange between healthcare organizations. Cloud computing is a system that measures service which has the facility of control with analyzing assets use with respect of type of service delivered example processing & storage. Healthcare industries can be benefited from solutions of cloud computing and fetch many profits like aid to increase quality of care and decrease healthcare expenses for the patient. cloud computing, was influenced by cloud representation which is well used to denote internet inside diagrams and flow charts.

Cloud computing is enabled by virtual technology since 1967, but was accessible on mainframe systems for many years. Cloud computing is made innovative and distinguished from "grid computing" by virtualization. Cloud computing not like grid computing powers virtualization of capitalizes on computing authority. Virtualization solves few issues faced by grid computing by means of separating logical from physical. While grid computing attains an extraordinary use over the sharing multiple servers into a single job and task, the

virtualization of server in cloud computing realizes great use in permitting server to compute numerous jobs parallel.

Cloud computing denotes an innovative way in many cases of a cost efficient method, for providing enterprise IT. It is not only altering the technique IT infrastructure is supplied, consumed and the business models also the fundamental architecture of how we deploy, develop, deliver and run applications. It's extensively accepted that cloud computing expose standards are important keystones to reorganize healthcare from monitoring of patients, maintaining health records, managing diseases or collaboration with peers and exploration of data. Enabling the access to data of healthcare at a global level will help us advance healthcare as the data will be accessible from anywhere at every time, and it helps breaking down the costs noticeably. An essential footstep for accomplishment of healthcare tapping in the cloud is in deep understanding and actual implementation of privacy and security. It is rapidly getting revolutionary movement to our work and individual life, and offers small industries an unmatched opportunity to utilize informative technology to strive effectively.

Chapter 2 Objectives & Methodology

Objectives:

1) To understand the current scenario & trends of cloud computing in healthcare.
2) To identify the challenges and opportunities in cloud computing in healthcare.
3) To compare cloud computing in healthcare among various locations.
4) To analyze various healthcare IT products that utilize cloud computing.

Methodology:

A systematic review was carried out which comprised the four stages:

1) Collecting publications and articles through searching in web based database.
2) Relevant screening of data to screen out results.
3) Proper evaluation of filtered data.
4) Summarize the contents.

Study Design:

A descriptive study design have been applied in this study.

Sample size:

The sample size contained 50-70 relevant articles, journals, e-books, projects and papers published on the topic.

Exclusion Criteria:

Published articles on cloud in non-computing sense along with cloud computing in a non-healthcare related topics were excluded.

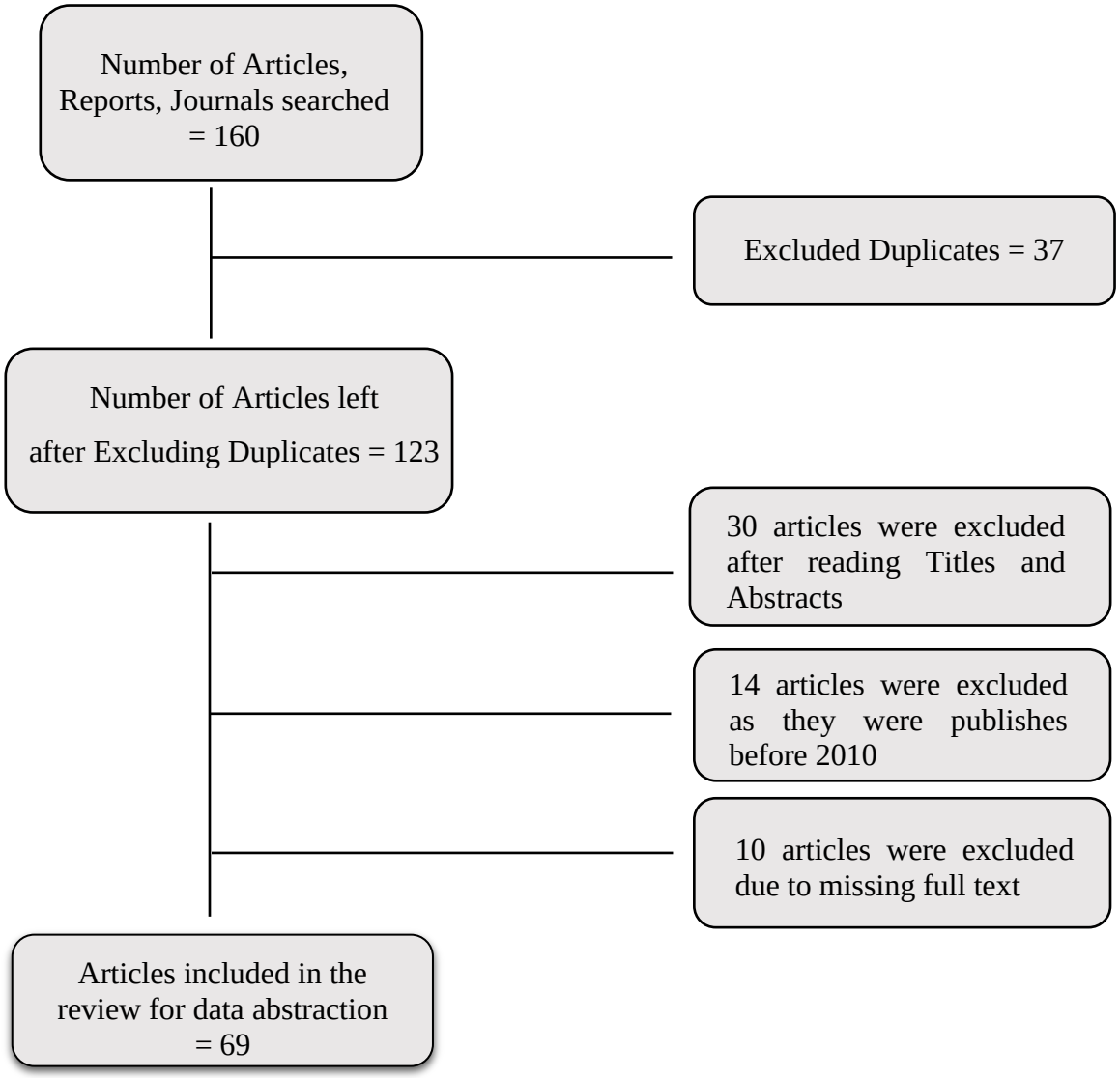
Inclusion Criteria:

- Papers, e-books, articles, journals and projects published on the topic after 2010.

Keywords:

Healthcare, e-health, cloud computing, opportunities and challenges in healthcare.

- The time period for this review would be 3 months i.e. form 6th February 2017 to 5th May 2017.



Flow Chart for Systematic Review of Articles, Journals, Papers.

Chapter 3 Review of Literature

The word "cloud computing" is described by the National Institutes of Standards and Technology (NIST), as "a model for enabling ubiquitous, convenient, on demand access to a shared pool of configurable computing resources" [1]. The business value of cloud computing is growing rapidly cutting down costs and driving up flexibility and convenience. Also the ability to locate, compute and store resources anywhere makes best sense for cheaper power, or even lower cost of maintenance. Cloud services require high bandwidth connections at local, national and international levels and will become a prevailing stimulus to increase bandwidth at every layer. IT penetration and understanding of aids of IT in various walks of life in India may be economic or social can be enriched by cloud computing, specifically when combined with health, mobile, applications for educations, employment, finance and pervasive networks.

When cloud computing begun, it was whispered that it may not succeed for extensive period. But contrary to all the prophecies by IT pundits, it revolved to be a huge triumph and kept aiding various segments that is continued up till date. Cloud computing is center of interest for organizations with diverse backgrounds from healthcare outfits, medical researches and pharmaceuticals where organizations are distinctly engage in discovering cure and treatment for chronic diseases. Sophisticated Information and Communication Technology (ICT) is costly for middle size industries like hospitals, with small budgets that can obstruct the reshaping of newest ICT. Alternatively, a cloud computing and smart item is easily adaptable and moderately cost effective.

Acc. To Lena Griebel, Hans-Ulrich Prokosch (Et. Al), 2015 cloud computing delivered several openings for industries by posing customers variety of services. The current "pay-as-you-go" model has become a resourceful substitute in managing and preserving private data cores for clients with batch processing and web applications. However, cloud computing becomes a concern for sensitive applications, that wants nodes in the locality to attain their daily necessities.

Practice of cloud in healthcare is a favorable trend, mainly in use of smart items. Affordability, access and quality to healthcare, a huge task in society. Through the deployment of smart sensors opportunities to improve healthcare and their services wherever needed. The healthcare industry has underutilized technology habitually, as a

mean of refining the delivery of patient care. Sharing of patient data among departments, clinicians, and patients is rare and complex. Today also healthcare industries still rely on handwritten notes and paper medical records to inform and make decisions.

Acc. To Haiying Ren (2012) [2], the service models available are:

1. **Infrastructure as a Service (IaaS) –**

   The customer is provided with the ability to networks, provision processing, storage and other fundamental computing resources allowing them to run and deploy arbitrary software, which may cover operating systems and applications. The consumer has control on operating systems, deployed applications, storage and some control of select networking components.

2. **Platform as a Service (PaaS) –**

   The consumer is provided with the capability to deploy onto the consumer created, cloud infrastructure, or acquired applications, produced using tools and programming languages supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including servers, network, operating systems, or storage, but has control over the deployed applications and some application hosting environment configurations.

3. **Software as a Service (SaaS) –**

   The consumer is provided with the capability to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices, through a thin client interface, such as a web browser. The consumer does not control or manage the underlying cloud infrastructure, including network, storage, operating systems, servers, or even individual application capabilities, with the exception of limited user specific application configuration settings.

4. **IT-as-a-Service (ITaaS) –**

   Also known as Business Process as a Service (BPaaS).

   This service type combines the application elements of cloud computing with a human aspect. The main difference from traditional IT outsourcing is the fact that the human resources providing the ITaaS service are pooled as well between different clients.

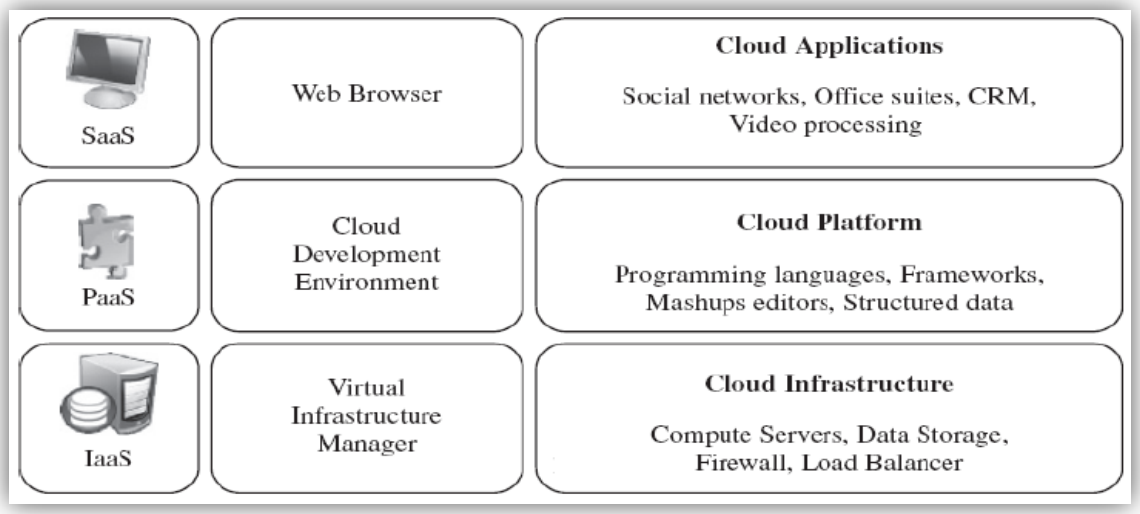


Figure 3.1: Service models in cloud computing

Source: Imran Ashrafa, http://ijmcr.com July/August 2014 IssueVol. 2

The principle of cloud computing exists to decouple the conveyance of computing services from underlying technology. Cloud computing, an evolving approach to shared infrastructure in which large groups of systems are associated together in public/private network to offer IT services. It represents the next phase in logical advancement in delivery of IT services, built on previous innovations which include utility, grid and on demand computing. It provides an environment that empowers organizations to position their companies to more competitive in cost effective way and to leverage developing technology that addresses growing business challenges.

Different kinds of models are recognized for solutions based on architecture of cloud mainly these are 4 deployment models [2]:

- **Private cloud-**

  Infrastructure mainly functioned for private body. It could be directed by the company or could be done by a 3rd party. The servers can exist on the premises of the company or away from premises i.e. on a different geographical location.

- **Community cloud-**

  Infrastructure is shared by many groups or companies and provisions a particular society which is dominated by communal worries like security requests, mission, compliance, policy concerns. The servers can be present on site of the company or away from site i.e. on different geographical location.

- **Public cloud-**

  Infrastructure can be available to public as well as to an industry cluster but is possessed by a party selling the services of the cloud. Usually, servers are off site.

- **Hybrid cloud-**

  Infrastructure has been alignment of dual or more clouds (community, public/private) which remains an exclusive entity however are destined together by proprietary technology and standardized, which supports application and data portability.

Chapter 3.1 To understand the current scenario & trends of cloud computing in healthcare

Current Scenario of Cloud Computing In Healthcare:

Current trends is targeting towards retrieving data anytime, everywhere that can be accomplished when moving data to the cloud. The fresh delivery model can help in making healthcare far more effective at a lesser rate to budget. In situations characterized by growing aging populations, decreasing resources, rising costs there is a rising interest in the conveniences provided by cloud computing for expansion of a patient-centered healthcare process and e-Health. Smart items existing in the sector can be used in scenarios like stationary care. With the increased price, hospitals or other patient care facilities likes intensive care units are having issues like lack financial funds. Wireless networks provide speedy access to the patient information delivered by the servers. Cloud computing based smart stationary objects and healthcare solutions can play an important part in refining the healthcare services. Smart healthcare objects benefits are both profiting patients along with healthcare providers. In a stationary setting, lessening cost of labor becomes a acute criterion for the application of smart objects infrastructure. The devices are connected to each other executing their responsibilities effortlessly via network.

Health information Technology (HIT) "is a set of technologies that are used to convey and manage health information for use by all the groups which have concern in health as well as in health care". A study lead by the European Commission, a great majority of 81% hospitals within the European Union are linked to internet wherein around 2/3rd i.e. 66% of all measured hospitals have their own wireless infrastructure, a potential rise of 12% points within two years [17]. Competent IT staff is mostly available as most of these hospitals had IT services which were managed by them. The understanding and exhibiting healthcare processes for technical application is an unescapable job to develop practice based solutions with goal of providing high quality smart healthcare services.

By combination of cloud services and smart healthcare answers support the medics and other care staff in giving improved yield with value of care and taking informed decision. Wireless channels amongst gateways, instruments allows nonstop data transmission to

cloud and creating its availability for medics, patient and care staff to retrieve the health status and sustaining the records regularly.

It is valuable for a healthcare providers, as:

- It shrinks the amount of work by replacing human based monitoring, dropping the gamble of human blunder.
- Wearable instruments are proficient of detecting small fluctuations in vital signs and record them impossible for human to detect, such as blood oxygen level, pulse etc.
- Lives can be saved by real time measurement while the collected health data deposited can provision in decision making if desired.
- Doctors can be enabled by cherished assistance from the "electronic physician".

A healthcare receiver is aided as they acquire quality of healthcare treatment at doorstep, an environment making them feel more comfortable and having their family members close to them which results in reduces mental stress. Other factors like convenience and dignity are greatly supported and the patient gets treated at his doorstep.

The basic framework for smart performance is provided in most of the hospitals. The current challenge is combing medical experts and IT professionals to recognize smart solutions that aid in supporting healthcare services in an accurate way.

UPCOMING TRENDS:

i. Fog Computing:

The fog ranges the cloud to be nearer to the device which acts on & produces IoT data. These are known as fog nodes these can be installed anyplace with a wireless network connection like alongside railway track, on factory floor, on oil rig or in any vehicle. Device with storage, network connectivity & computing could be a fog node. Fog computing provides cloud, aid to handle the Exabyte of data produced daily from IoT. Processing the data closer from where it's generated and needed resolves the challenges of blowing up data volume, velocity and variety [3].

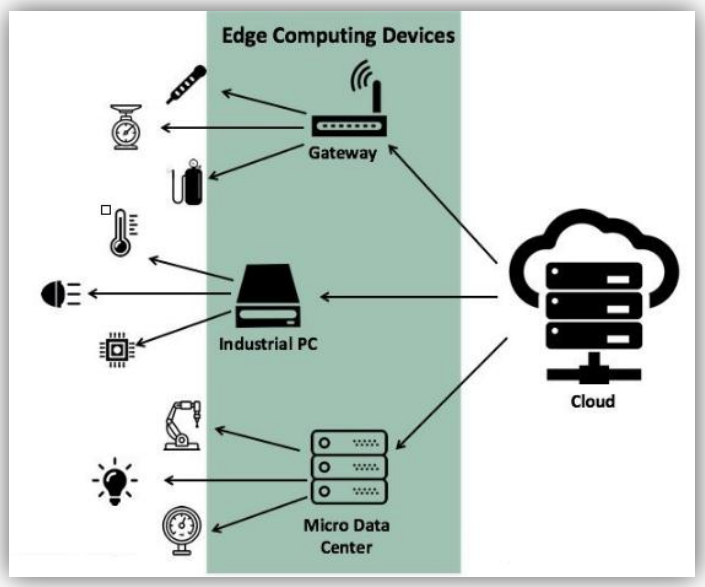


Figure 3.2: Edge Computing Devices

Fog computing outspreads the paradigm to the verge of network. While both cloud and Fog use same resources (storage, networking, and compute) and share various same traits (multi-tenancy, virtualization) and mechanisms, the extension is a non-trivial one in which there occur few fundamental modifications that stem from the Fog raison d'etre. Fog vision was considered to address services and applications that do not fit well with the paradigm of the cloud like applications that necessitate very low but predictable latency, large scale distributed control systems like gaming [4].

According to (Wager, Lee, & Glaser, 2009), primarily two categories of healthcare information are: clinical information and administrative information. Concentrating on them, HIT systems are similarly positioned on clinical systems and administrative systems.

The major progresses in information technology as well as noteworthy government initiation had major effect on the advancement of healthcare information system. Both the changes in healthcare environment and information technology development are essential in determining future of Health state along with the current state.

Recently, there has been an increase in demand from both the government and the healthcare community for easy and more advanced to routine Healthcare Information Technology (HIT) systems to sustain the rules and regulations formulated.

Role of fog computing:

The role fog computing in day to day life are as follows:

i. Geographical distribution
ii. Smart Grid
iii. Wireless Sensor and Actuator Networks

Uses of Fog Computing in Healthcare:

1. It act and analyze the data in milliseconds.

2. Data collection at the edge: Hospitals, Homes and other examples like railways, roads etc.

3. Billions or trillions of things either wearable body sensors or planted across the globe will generate vast healthcare data in our daily living activities.

4. With the use of services based on the cloud and technologies it ensures accurate & faster entree to complete vital information for the healthcare services.

5. It includes protection of backup data and encrypting of information which comprises health information of an individual then validating whether the information can be regained and lastly security can be improved by use of secured & permission based database.

6. To enable "real-time analytics," healthcare organizations frequently use cloud solutions as a storage layer between insight and device. Data is uploaded to the cloud and the relevant elements are identified, pulled back down into an analytics engine before it is shuttled to visualization in the user interface [6].

ii. Dew Computing:

Dew computing, novel paradigm which got recognized after cloud computing got accepted. Acc. to Flavio Bonomi, Jiang Zhu, Rodolfo Milito, Sateesh Addepalli (2015) it has two key features first, local devices like tablets, laptops, desktops and smart phones to provide rich micro services free of cloud services. Second, these micro services collaborate with cloud services [6]. Dew computing, concerned with distribution of workloads between local computers and cloud servers. Its emphasis is the software organization of local device. The objective of dew computing is to identify the capabilities of cloud services and local computers. Dew computing can be differentiated from cloud computing and fog computing although these can work together as a hierarchy.

Dew computing is a computer software/hardware available on-premise of organization in the computing environment in which the computer supplies functionality which is autonomous of services but is collaborative with services. Objective is to comprehend the capabilities of cloud services and on-premises computers completely.

Two important characters of dew computing are shown in the definition these are:

- **Independence-**

The on-premises computer provides functionality without internet connection and cloud services, which means the application is not completely cloud serviced or online application [8].

- **Collaboration-**

The automatic exchange of information in the application during its operation with cloud. This type of collaboration includes correlation, synchronization, or other kinds of interoperation [8].

Dew computing insurances extensive range of technologies like mobile data acquisition, wireless network of sensor, supportive applications on distributed processing environments and peer-to-peer ad hoc networking. They spread to autonomic data intensive, self-healing networks and increased reality of applications which open daily,

general purpose use for living and working environments and simple purpose gear and micro services. The main advantage is in its extreme scalability.

Dew computing in the future drive focus on the three points:

- Metadata and raw data processing.
- Re-configurability /programmability of user requests.
- Complexities of daily human information using high efficiency.

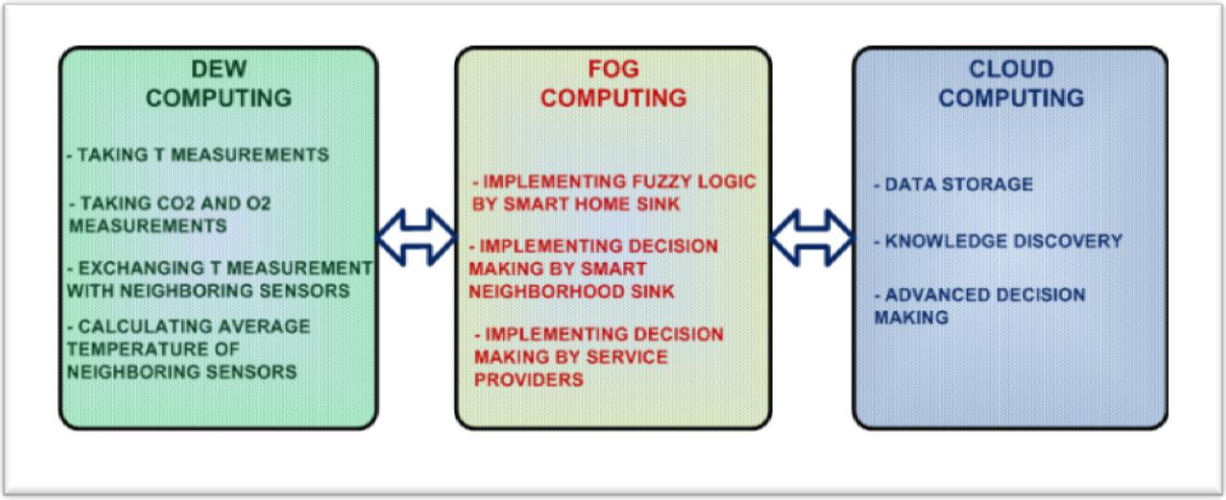


Figure 3.3: Relationship between Dew, Fog and Cloud Computing

Uses of Dew Computing in Healthcare:

1. It performs an important part in wide-ranging healthcare applications. From preventing disease at one end to managing chronic diseases to at the other.
2. It aids in clinical care to patients whose physiological status need a close monitoring using non-invasive monitoring in a hospital.
3. With low access to effective health monitoring, people may suffer health related problems. With use of powerful wireless solutions connected that are small, are now making it likely for monitoring such patients.
4. Active and healthy people can also be benefited by monitoring of their well-being and daily activities. For example, a senior citizen who lives alone, may need a monitoring

equipment that could spot a collapse, any disruption of day to day activity and direct a message to family members, emergency respondents etc.

5. Patient-generated health data (PGHD), created by blood glucose monitors, wearable devices, tele-health tools, home scales, mHealth apps, and any other device, is a stone in health information management, EHR workflow designers and data integrity experts.
6. An increasing population with chronic diseases and old age along with the rise in medical costs has shaped a demand to extend the healthcare services from hospital to home with a focus on competently managing disease and overall welfare of patients.

iii. BlockChain:

Blockchain is "a peer-to-peer (P2P) distributed ledger technology for a new generation of transactional applications that establishes transparency and trust". Block chain is the primary material for Bitcoin, designed pattern which consists of 3 major components: shared ledger, distributed network and the digital transactions [9].

It is decentralized P2P architecture. Each member keeps a matching copy of the pooled ledger and deviations to the shared ledger are reflected in all. Possibility of no change is present if an entry is entered into blockchain database. Bitcoin was the most well-known and first application of blockchain technology in digital currency. All the transactions on the network are used by Bitcoin which uses blockchain [10]."

Any block chain for healthcare will require being public and will also need to embrace technological solutions for the key elements i.e. access security, scalability and data privacy. Tracking personalized data in real-time, formation of a single storage site for the data, and security to set data access agreements at granular level will serve investigation as well as tailored medicine.

Blockchain in healthcare will increase the attainment of health information to comprise data from populations of people who are underserved by community or does who do not contribute in research. The shared data environment delivered by Block chain makes it at ease to involve tough to reach populations and cultivate results more illustrative of the public. "Blockchain is a distributed, encryption-based, decentralized public ledger backed by peer-to-peer (P2P) protocols" [11]. The technology that supports the digital currency bitcoin is characterized by high availability, decentralization of control and strong data integrity through end-to-end encryption [11]. It enables all the certified entities in network to access verified information with the use of a private or universal key or code. It also generates a precise track of transactions which in the context of healthcare could relate to medical histories and bill payments.

Uses of BlockChain in Healthcare:

Blockchain can be an effective medium for transforming the healthcare industry. It qualifies to reduce the cost of audits and compliance, lower compliance risk by ensuring

greater transparency in claims activities, create tamper-proof audit trails, and improve patient data security. Blockchain can be used in the following fields:

1. Population health management.
2. Patient generated data.
3. Clinical studies.
4. Payments and payer contracts.

”We are witnessing a shift from legacy IT services to cloud-based services. Cloud services are growing due to organizations pursuing a digital business strategy" says Sid Nag who is research director, Gartner [12]. Cloud computing is an internet based technology that serves integrated data to remote devices linked via intranet or internet. It is network where a program or application runs on a server and can be shared through numerous devices such as smartphones, laptops and personal computers. The market size for cloud computing is expected to witness major growth from 2016 to 2023 [13]. Greater scalability combined with faster access to infrastructure are predicted to surge the demand growth . With a prediction of over $9.48 Billion by the year of 2020, cloud computing will open space for the re-evolution in healthcare industry, from physically bound network of enterprises into on the cloud neighborhoods [13]. Large industries makes use of private clouds to ensure security and reliability, whereas smaller industries uses public cloud services as they are cheap and cost efficient in nature.

”The global healthcare cloud computing market to grow at a CAGR of 21.24% during the period 2017-2021.” A strong outlook on the healthcare cloud computing market size, likely to exceed USD 13 billion by 2023 [14]. Around 58% of industry share was accounted by Hybrid cloud in 2014 and over 30% for public cloud and about 5% for private cloud in the same year. Market share for SaaS cloud computing accounted for over 49% revenue in 2014, around 28% for IaaS and over 18% for PaaS [13]. SaaS is operated for the circulation of software for the consumers who can access over the Internet. A user contacts it with the help of any standard web browser. It hosts the applications at its data center.

Healthcare industry is developing at a remarkable pace owing to its establishment of services, coverage and increasing expenditure by public as well private players. The size of

cloud computing market in India was valued over USD 1 billion for the year 2014 [13]. Service market uses advertisisng accounted for largest share owing to widespread use in digital advertising. Expanding growth in e-commerce sector is also likely to boost the demand.

The public cloud services market in India is forecasted to grow 30.4 % in 2016 to a sum of $1.26 billion, according to Gartner, Inc. The maximum growth would be from cloud system infrastructure services (infrastructure as a service IaaS) and it is expected to grow 32.5% in 2016. Platform as a service (PaaS) is expected to rise 31.7 % [12].

	2015	2016	2017	2018	2019	2020
Cloud Business Process Services (BPaaS)	92.5	114.3	146.9	188.8	242.4	311.5
Cloud Application Services (SaaS)	299.3	389.8	514.4	654.2	792.4	959.6
Cloud Application Infrastructure Services (PaaS)	62.4	82.1	106.9	135.0	160.4	184.7
Cloud System Infrastructure Services (IaaS)	338.9	448.9	615.4	839.7	1140.6	1558.0
Cloud Management and Security Services	79.4	104.2	134.5	167.7	206.2	247.8
Cloud Advertising	95.6	123.2	158.0	189.0	222.8	266.0
Total	968.1	1262.6	2174.3	2174.3	2764.7	3527.6

Table 3.1: India Public Cloud Services Forecast (Millions of U.S. Dollars) Source: Gartner (March 2016) [12]

An independent survey suggests that in the next two years, usage of public cloud among the companies surveyed, will increase by 28% year-over-year. Private cloud usage will also increase, but by a smaller percentage of 15%. The trend away from virtual and physical machines is expected to continue. The companies surveyed plan to decrease usage of virtual machines by 20% and physical machines by 18% year-over-year for the next 2 years [16].

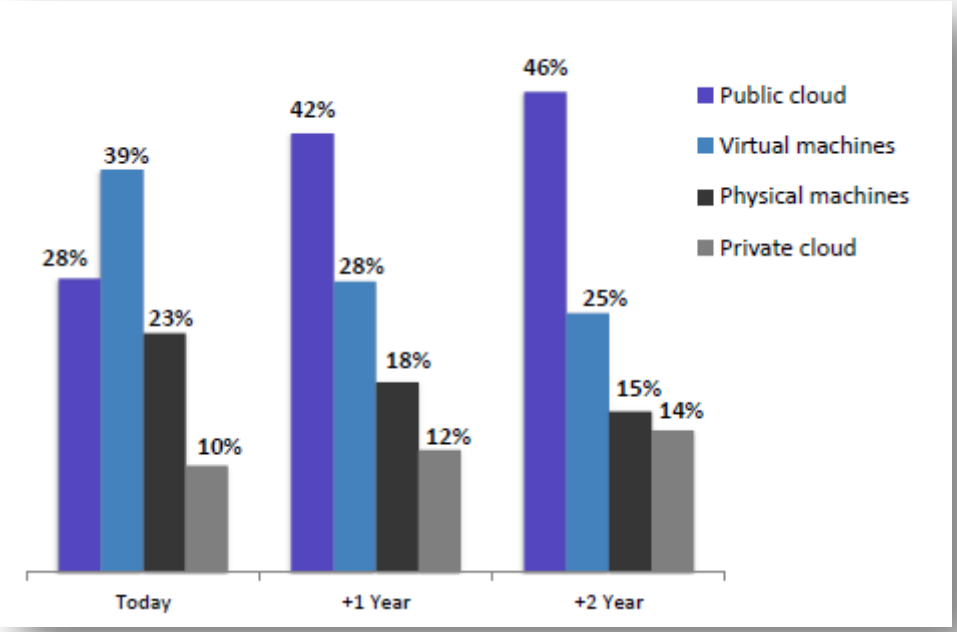


Figure 3.4: Comparison of different clouds and machines

Source: Third annual CloudEndure Cloud Migration Survey Report, January 2017 [16]

Chapter 3.2 Challenges and Opportunities of Cloud Computing in Healthcare

In last few years we have seen a change in paradigm in field of information technology. Organizations have moved to computerized information systems from manual methods. Several industries made this move and healthcare was of no exception. The main emphasis of healthcare service today is effective utilization of latest technologies and to reduce operational cost along with enhancement of the healthcare services. Cloud computing plays a critical part in comprising healthcare incorporation costs, leading in an era of innovations and optimizing resources. This latest delivery model can help in making healthcare far more efficient and effective, at a reduced cost to funds, and also it brings some hurdles due to apprehensions associated with safety of confidentiality of patient information and compliance with regulations such as HIPAA. Chen *et al.* "proposed to store patient's information in the Cloud in order to meet the rising demands of storage space for EMR and at the same time fulfilling the significant requirements for data safety and privacy protection [18]. Even with risk of privacy and security, healthcare organizations could undoubtedly take gain of cloud computing solutions and get huge benefits such as reduce healthcare costs and helping in improving the patient quality of service [18].

"Teng *et al.* (2010) provided a long term off-site medical image archive solution for digital imaging and communication in medicine (DICOM)" [19]. The major challenge faced by healthcare industry is increasing price of dealing with long-standing onsite medical imaging archives. The repeatedly rising necessity for large volumes of medical images results in maintenance & scalability issues with picture archiving and communication systems (PACS) [20]. In healthcare provisioning "Patient centricity" is becoming the key trend and leading to a stable growth in adoption of electronic medical records (EMR), personal health records (PHR), electronic health records (EHR) and technologies related to patient safety, point of care access to demographic, integrated care, clinical information and clinical decision support. Data Capture and Auto-Identification Reference (DACAR), purposes to develop, distribute and implement secure platform for capturing, consuming and storing data in a healthcare domain. With the use of single point of contact, the DACAR platform aims to provide solutions for the challenges of HCT services [19].

Opportunities of Cloud Computing in Healthcare:

Cloud satisfies to all requirements of healthcare organizations hence providing opportunity to advance services to their patients and customers to share information more easily. It aids to develop operational efficiency as well. Cloud computing can benefit organizations of all types and sizes by in many different ways.

- **Health Information Exchange:** It helps healthcare providers to share data confined in largely proprietary EHR systems. The patient's data is stored in distributed state where some portions are restricted within different departmental systems, areas of the healthcare providers or certain clinics as Health IT exists as separate clinical or administrative systems within departments of the healthcare provider's organization [20].
- **Electronic Medical Records:** The ability to deal with unified patient medical record which has patient data across all operators all patient encounters. Healthcare organizations and physicians have started to look at cloud based medical records and medical image archiving services as a means to unburden tasks from hospital IT departments and allow them to focus on supporting other necessities like improved clinical support systems or EMR adoption.
- **Reducing and controlling costs**: Cost decrease is the savings extended from making medical records available. Hence, no cost is acquired in sharing and exchanging patient's data. Optimizing human capital, consolidating facilities, reducing Capex, use of assets efficiently and charge for services.
- **Digital Imaging:** Picture archiving and communication system (PACS) is an instrument used in clinical settings for handling medical images. It is used to store, distribute and retrieve medical images that are necessary to support medical decisions and treatment procedures [21]. Digital Imaging Communication in Medicine (DICOM) is a standard that supports storing format and distribution of medical images [21]. The use of systems where cloud computing service are integrated with DICOM, facilitates access to medical images online directly from the PHR or EHR with the use of mobile device.
- **Improving agility and adaptability**: Increase capacity with simple scalability, virtualize resources, expand or contract services to meet requirement, deploy software rapidly and magnify flexibly to meet requirements. It enables healthcare organizations

to use remote medical services and data which helps in providing primary healthcare in such areas. It also permits various health care experts to provide their facilities remotely hence saving effort, time and reducing the necessity to have specialists available everywhere.

- **Enhancing collaboration and services**: Taking gain of leading edge applications, improve collaboration and provide broad access for stakeholders. Early accomplishments of cloud based physician, collaborative solutions like video conference with physician are being trialed. Extending the assistance to a mobile environment for disaster response or rural telehealth is becoming more attractive with smartphone adoption and broader wireless broadband.
- **Clinical Research:** Health care data stored on cloud can be accumulated and reported along for general acknowledged healthcare quality indicators. Many pharmacology vendors have started to use cloud for drug development and to improve research. Presently, pharma companies do not have the ability to run huge datasets especially DNA sequencing, as the size of the data can burden their devices. Commercial cloud vendors have established pharma specific clinical research cloud offerings with aim to develop new drugs and lowering the cost.
- **Addressing risk issues**: The cloud can serve as an alert system, monitoring the diffusion of any hazardous infectious diseases. It can be used to identify the infectious areas, spreading patterns and the reasons of the outbreak. Cloud data can be used by strategy makers for budgeting and planning for healthcare services. It can also be incorporated with other cloud services to support forecasting of future healthcare service needs. Example planning the need of doctors, nurses, patient beds, laboratory services and other medical services.

Challenges of Cloud Computing in Healthcare:

The e-Health cloud could offer valued benefits to the health care industry, it unfortunately inherits challenges of Health IT and cloud computing collectively and incorporate more to these challenges as they are used to process and store sensitive medical data. The risks of cloud computing orbits around confidentiality, data security, data availability, data segregation, data reliability and Service Level Agreement (SLA). Apprehension with cloud

computing is HIPPA compliance and the safety of sensitive information. Privacy protection and security of patient's records is of prime importance and encompasses various requirements. Current technology is progressively utilized in healthcare to boost and develop medical services and lessen charges. The application of information technology is becoming more significant in different aspects, continuous efforts are been done to standardize data exchange and interoperability to national and international level. It is said that Electronic Health Records (EHRs) will reduce prices in healthcare by reducing repetitive drug administration or by escaping expensive double diagnoses to advance personal health management in general.

The approach is to stock all medical information in central data centers that shape the principal concept of a centrally managed healthcare. These systems must provide accommodations to several work flows not merely to the patient's medical data but also billing and accounting of medication, treatments etc. It was observed by A. Sunyaev, J. M. Leimeister, and H. Krcmar (2010) that current e-health standards and solutions primarily focus on access control policies and network security. They do not address the client platform security i.e., the security of the hardware and software that is used by health professionals.

The movement of data files to a third party organization is a difficult task to be performed, particularly when moving sensitive information. There are various technical and non-technical challenges present in cloud for healthcare. A brief summary about a few challenges are enlisted below.

- **Technical Challenges:**

i. **Availability:** The healthcare organizations need instant availability to health cloud services. Data availability and service is vital for healthcare providers who cannot effectively perform unless patient's data and their applications are available.

ii. **Data Management:** Large number of images and medical records associated to loads of individuals are stored in cloud. All medical applications need efficient, secure, dependable and scalable access to these medical records.

iii. **Interoperability:** Interoperability is a biggest challenge when transferring healthcare data on cloud. The apprehension is about the capacity to transfer data to alternative cloud or back to the healthcare organization without conflicting claims to the data or

disrupting operations. The absence of integrity throughout systems and probability can make it challenging to transfer to a new cloud service provider.

iv. **Security:** Data privacy and security issues are manipulating factors that are important in the adoption of any IT based healthcare solution. In the existing IT infrastructure, not only must the appropriate security be implemented and potentially enhanced but into the core managing processes and cloud monitoring.

v. **Privacy**: The concerns comprises the ability to protect patient's records amongst the patients, other healthcare organizations or providers or the cloud service providers. Google, Microsoft and Amazon are the other cloud providers in the market that have committed to develop practices and policies to protect a customer's privacy and data [22].

vi. **Maintainability**: Unlike having system for a specific healthcare organization, a cloud can be used for many healthcare organizations along with increase in the difficulty of system maintainability in health cloud compared to an individual health system. The desires can be totally different while maintaining the cloud infrastructures, platforms or software must be completed without any damaging effect on any service delivered for any client [22].

- **Non-Technical Challenges:**

i. **Organizational change:** The movement to cloud will require noteworthy changes to business and clinical processes and also to the organizational limitations in the healthcare industry. Formation of new procedures, policies and workflows along with changes in how documentation and medical processes are done will also be affect the working for an organization. Example the healthcare providers are hesitant in accepting new system.

ii. **Legal Standards:** Computer software developers should not just only collaborate but should share a design with common products and data model that can work together with each other (Myers, 2012). The cloud developers should settle on adopting the defined classifications and standards to allow interoperability.

iii. **Data Ownership:** No clear guidelines are available for the ownership of document. Example a patient's record could be a sole belonging of the patient, still his physician or

hospital management or the patient's insurer claims ownership that cannot be said for sure.

iv. **Acceptance by end user:** Training and marketing should be done to increase the level and degree of acceptance by the cloud users including healthcare professionals, patients, insurance and administrative personnel. The end users must accept and understand the service which is difficult to achieve [23].

v. **Service Level Agreement (SLA): A**greements between providers and customers are known as service level agreements (SLA), and are a familiar part of almost every computing or information processing service arrangement [24]. However the unavailability of network services and issues connected to confidentiality and security have often surfaced in this arena, which has invariably questioned the validity and credibility of SLAs. In case of system crash data recovery in cloud has very serious problems.

Both benefits and risks associated with use of cloud in healthcare. With the adopting of cloud computing, there are probabilities for significant technological, financial and service-related profits that come along. Most of emerging technologies have their own hazards that are both known and unknown, which must be eliminated or reduced to realize the potential benefits and to certify the privacy and security of any data stored. Risks, benefits, IT needs and business of the organization must be balanced by healthcare executives to best determine where and how cloud computing could be highlighted in health IT provisioning strategy.

Chapter 3.3 To Compare Cloud Computing in Healthcare among Various Locations

Cloud computing aids an organization to reduce their operational and capital costs effectively. As industries are accepting a data centric approach for business, cloud computing is gaining traction in the global healthcare market. Technologies in healthcare are at a constant evolution phase. Various hospitals have changed their legacy systems to include a digital format of paper records, electronic health records (EHRs) which got directed by the Health Information Technology for Economic and Clinical Health Act (HITECH) and enforced by the American Recovery and Reinvestment Act of 2009 (ARRA) [25].

The Health Information Technology for Economic and Clinical Health Act (HITECH Act) of 2009 intended to accelerate the adoption and use of health IT. The HITECH Act authorized Centers for Medicare and Medicaid Services (CMS) to provide monetary incentives to Critical Access Hospitals (CAHs), eligible hospitals and professionals to embrace and meaningfully use certified EHR technology to improve patient care [26].

The global share for healthcare cloud computing is anticipated to reach US$12.8 billion by 2020, determined by changing healthcare economics amid emerging financial realities and the ensuing need for smarter healthcare IT management solutions [27].

The progression in the market is also motivated by other factors such as legislation of strict healthcare data compliance policies; growing demand for HIPAA compliant cloud, growing interest in load balancing benefits of hybrid cloud; rise of the hospital BYOD (Bring Your Own Device) concept and spurt in healthcare IoT [28].

The traditional model of public funding is increasingly becoming obsolete and unaffordable as governments struggle to fund spiraling healthcare costs of their aging citizens. Confronted with the necessity of tackling soaring deficits, and alarming increase in healthcare expenditure, governments worldwide are legislating healthcare reforms. Healthcare cloud computing stands at the forefront of this transformational change in healthcare delivery by enabling informative and collaborative decision making and

providing shared information at the point of care in a manner that makes healthcare processes more effective and less expensive [27].

Business agility represents the final stage of technology maturity and cloud represents the only viable tool to achieve the same. While traditional IT is not designed to be part of a patient's social ecosystem, the cloud brings in disruption by deemphasizing legacy systems in favor of agility and speed [27]. With this conversion in healthcare timely access to medical records when needed is delivered to both physicians and administration personnel. Hospitals are being driven to embrace agility, most importantly trust the cloud and decommission underperforming IT systems.

Largest market worldwide is of United States, according to new market research report on healthcare cloud computing and with a CAGR of 20.6% over the analysis period Asia-Pacific ranks as the fastest growing market, led by factors such as rise in the number of cloud ready Asian countries, focus on developing sustainable high quality care delivery models, and the growing popularity of lean healthcare management [29]. The application segment in the market for healthcare cloud computing is divided into clinical information system (CIS) and non-clinical information system (NCIS).

According to Transparency Market Research (TMR), the industry of healthcare in the middle of an ample move from paper based to digital based, which in turn upshot the enhancement of the EHR worldwide [36]. In government and private organizations the request of global healthcare cloud computing products and services is predicted to create more openings for the marketplace. Other contributing factors, in the growth of healthcare market including availability of varied range of services and application of Global Healthcare Cloud Computing Market such as Internet of things, EHR, patient records, payment methods and mobility solutions. Furthermore, new standards for Global Healthcare Cloud Computing Market will be contributed and set by R&D [35].

North America:

North America a foremost provider to the cloud across the global market in the health sector. Due to extensive use of digital record keeping systems, U.S. is the prime market for cloud computing in health sector in North America which allowed an easy amalgamation of

cloud computing into the present technological framework. The part of North America as a traditional hub for the IT industry as well as thorough research into many phases of health sector has helped the region's cloud computing market in the healthcare industry [33].

North American market is expected to preserve its dominance in the market for cloud computing in the healthcare sector in the upcoming years as well as displaying a intimidating CAGR of 23.40% from 2012 to 2018 [38].

The healthcare payers followed the healthcare providers that were leading the industry. Various organizations are working to reduce investments in sustaining and creating a physical IT infrastructure and moving towards cloud computing for uncomplicated management. The largest share of the industry is predicted to be accounted for private cloud. The safety of data integrity and access and many other benefits offered by cloud computing are valued to inspire the evolution of the market in coming years. However, data integration, data leakage concerns, data relocation and consistency are some of the factors estimated to contain the growth of the global cloud computing market in the healthcare sector in the upcoming years.

EHR Adoption Rates:

The Medicaid and Medicare EHR incentive programs were authorized by HITECH Act 2009 in which healthcare providers that demonstrate ''meaningful use'' of certified EHR systems were provided incentive payments [37]. There has been a significant increase hospital adoption of advanced functionality along with growth in over EHR adoption. There has been more than eight fold increase in hospital adoption of comprehensive EHR systems [39].

North America is predicted to grow at a swift pace and cover for a large share in the global market for cloud computing in the healthcare sector in upcoming years. The high growth of this region can be attributed to the presence of large majority of biopharmaceutical companies. The rising emphasis on R&D activities is predicted to contribute towards the growth of the market. Given below is the EMR Adoption Model for United States in the year 2006 to 2015.

Stage	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Stage 7	0	0	0.3	0.7	1	1.2	1.9	2.9	3.6	4.2
Stage 6	0.1	0.8	0.5	0.16	3.2	5.2	8.2	12.5	17.9	27.1
Stage 5	0.5	1.4	2.5	3.8	4.5	8.4	14	22	32.8	35.9
Stage 4	3.1	2.2	2.5	7.4	10.5	13.2	14.2	15.5	14	10.1
Stage 3	18.7	25.1	35.7	50.9	49	44.9	38.3	30.3	21	16.4
Stage 2	40	37.2	31.4	16.9	14.6	12.4	10.7	7.6	5.1	2.6
Stage 1	17.4	14	11.5	7.2	7.1	5.7	4.3	3.3	2	1.7
Stage 0	20.4	19.3	15.6	11.5	10.1	9	8.4	5.8	3.7	2.1

Table 3.2: EMR Adoption Model ^{SM} (2006-2015) United States Source: HIMSS Analytics Database [40]

Europe:

In Europe the initiatives begun or were mainly motivated by the Ministers of Health, with the purpose of improving care quality, access, and cost efficiency [41]. The 'Digital Agenda for Europe', an EU 2020 initiative goal is to promote health informatics research and development to produce innovative services and products that makes healthcare more efficient and meaningful for all. With the increase in aging population, chronic disease management, need for remote monitoring and establishment of healthcare information exchanges (HIEs) have provided a push to EHR adoption. The transition to personalized healthcare delivery and real time patient data management and are also adding to EHR adoption. The rise of web/cloud-based EHR has helped increase market penetration. But persistent challenges relating to data privacy and security, and lack of interoperability standards affect adoption of EHR [34].

According to a study, Denmark, the Netherlands, Finland, Sweden and the UK emerge as the European frontrunners in eHealth use by general practitioner. Almost all General Practitioner (GP) practices (87%) in the European Union use a computer with 69% of the EU27 GP practices having an Internet connection. The Healthcare Payer IT market is pegged at $2908.69 million in 2013 and is projected to grow to around $3686.13 million by 2018 in Europe, at an emerging CAGR of 4.9% from 2013 to 2018 [42]. The European EHR

market in 2014 earned $2.74 billion and by 2020 it is expected to reach $3.69 billion. Europe spend 10% of its GPD on healthcare as its expenditure. The electronic health records (EHR) market in Europe is in the growing phase with market penetration rates predicted to increase by average 10% by end of the decade [43].

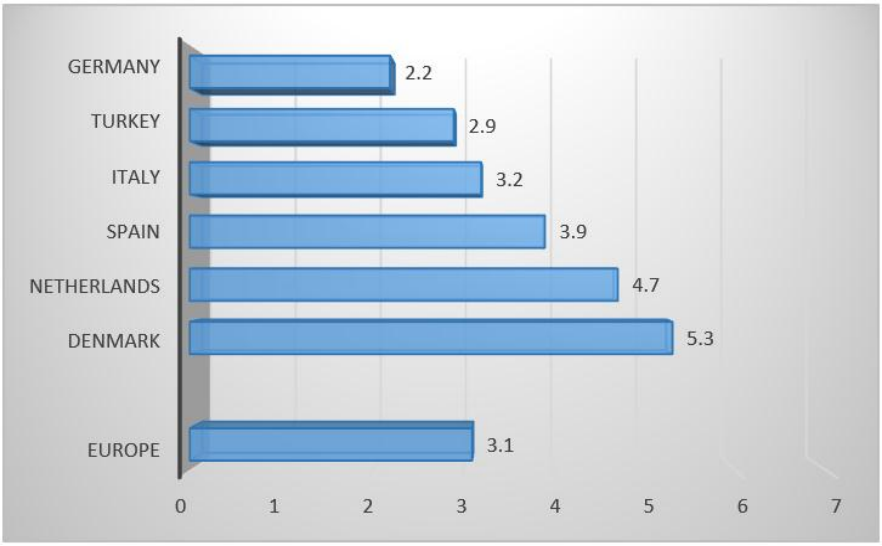


Figure 3.5: EMR Adoption in Europe

Source:http://www.himss.eu/sites/himsseu/files/HE_EMRAM_Score_Distribution_Q4_2016.pdf

The variable adoption rates are attributed to the robustness of the respective country's EHR strategy as well as the availability of budgets. The delay of timelines with respect to EHR implementation is due to most countries fail to execute the strategy. Europe has a high focus on the establishment of HIE for cross-border healthcare and establishing interoperability frameworks, which is predicted to elevate the maturity level of EHRs in various countries to a higher level by 2020 [45].

Asia Pacific:

Asia pacific is the third segment that is used in analyzing the EMR adoption model. It mainly comprises of countries like India, China, South Korea, Japan, Rest of Asia and Pacific. Growing requisite for combined healthcare facilities, joined with working efficiency profits are the main factors motivating adoption of EMR in end-use sectors, such as ambulatory settings or hospitals. Asia Pacific region, will witness a faster growth rate of 7.7% per annum to reach $4.0 billion by the end of 2015 and currently has a market size of $3.2 billion, [46]. Due to increasing EMR technology adoption, it is anticipated an increase

in the next decade EMR market is predicted to increase through 2025 at a CAGR of 6.2% [47]. In Asia Pacific region, adoption of Electronic Health Records (EHR) is low, these mostly use outdated IT equipment or paper-based solutions [49].

Increase in Asia-Pacific area is mostly determined by the increased government initiatives for eHealth, growing demand for quality healthcare, and rising medical tourism in this region. Moreover, factors such as increasing per capita incomes in emerging countries such as India and China are driving the growth of the Asia-Pacific healthcare IT market [48].

In Singapore, the National Electronic Health Record (NEHR) system was rolled out in 2011. It allows patient healthcare records to be shared across the entire healthcare system. It has invested US$128 million to develop Phase 1 of the NEHR, and is paying about US$15 million each year in maintenance costs.

According to reports, "the increasing life expectancy in the region will also result in more elderly requiring long-term care. Over the next decade, Asia Pacific market will require about 180 million new hospital beds to support the rising demand. Medical Tourism, will be driven by rising affluence and increasing demand for quality healthcare in short and medium term growth. These institutions are expected to invest extensively in installing, maintaining and upgrading IT capabilities" [50].

India:

In 2013, Electronic Health Records standards and guidelines for India has been improved and finalized by, Government of India. To uplift the adoption of EHR, various category of standards like Vocabulary Standards (ICD10, ATC etc.), Content Exchange Standards (HL7, FHIR, CCR and DICOM etc.), Clinical Standards and interoperability (to exchange the records between hospitals) parameters inculcated in documented polices [51]. The amplified utilization of health IT products and its acceptance is a key to implement the vision on digital India [53]. Out of the total Indian population around 70% lives in rural India and many of these lack access to hospitals, trained medical professionals, physicians, medical equipment and critical medicine supply [52].

On the other hand, growing consumer awareness and technological change are resulting in mounting pressure to improve the quality of services on healthcare providers [52]. According to Ministry of Electronics & Information Technology there are 73 public hospitals

registered for Online Registration System (ORS) in India with more than 644199 online appointments taken [54].

In 2015, AIIMS-Delhi successfully implemented cloud based EHR system to automate the patient appointment and create repository of patient record. The Integrated National Health System was created in 2011 and the government of India hopes to deliver universal health care by 2020 to all of its citizens. They want to accomplish this objective by increasing its public spending from its current 1% to over 6% of its gross domestic product meaning that more taxes (about 15% of revenue) would be allocated and enforced towards healthcare.

Stages	Cumulative Capabilities	North America	Europe	Asia Pacific
Stage 7	Complete EMR; CCD transactions to share data; Data warehousing; Data continuity with ED, ambulatory, OP	4.2%	0.1%	0.5%
Stage 6	Physician documentation (structured templates), full CDSS (variance & compliance), closed loop medication administration	27.1%	4.6%	3.9%
Stage 5	Full R-PACS	35.9%	17.5%	7.4%
Stage 4	CPOE, Clinical Decision Support (clinical protocols)	10.1%	5.5%	1.7%
Stage 3	Nursing/clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology	16.4%	3.2%	0.6%
Stage 2	CDR, Controlled Medical Vocabulary, CDS, may have Document Imaging; HIE capable	2.6%	30.2%	32.7%
Stage 1	Ancillaries - Lab, Rad, Pharmacy - All Installed	1.7%	14.2%	4.9%

Table 3.3: Regional EMRAM Adoption Model 2015 Source: HIMSS Analytics Database 2015

Chapter 3.4 To Analyze Various Healthcare IT Products That Utilize Cloud Computing

Technologies in healthcare are constantly evolving. The healthcare industry has experienced variations with legacy systems to include a digital format of paper records, electronic health records (EHRs), which was mandated by the Health Information Technology for Economic and Clinical Health Act (HITECH) and enforced by the American Recovery and Reinvestment Act of 2009 (ARRA) [56]. Cloud based services are gradually becoming more broadly adopted by healthcare organizations. A cloud computing based Healthcare platform was designed to support the integration and development of basic order entry functions, mobile services and CDS services, in a self-provisioning and scalable manner. The rising demands for low cost health information technologies and mobile accessibility in the healthcare industry. "The accelerating migration to cloud computing represents a change for the way the healthcare industry sources its information technology (IT)."The need for quality reporting and improved data management is rising exponentially as various healthcare reform measures take effect.

There have been vivid increase in the adoption of other health IT products along with electronic health records (EHRs). However, government incentive schemes targeted at the deployment of healthcare IT remain to be the largest driver for EMR adoption. New reimbursement policies and pay-for-performance programs to reward providers for generating better results are booming [58].

Healthcare is transforming to a digital platform and becoming more data driven patient centered, spreading access to health care means organizations need greater agility to adapt to change at low cost and high speed which can be solved by use of cloud computing. Medical facilities that are currently boarded on traditional client-server architectures with the adoption of EHRs also have an efficient and cost effective operational flow in them [56].

Reports suggest the use of EHR systems has been limited to large or medium-sized hospitals. The use of EHRs is predicted to upsurge significantly from 2015 to 2023 stimulating the global electronic health records market [59]. Compatibility is a major issue when electing an EHR services. Below discussed are the 8 most widespread EHR vendors [60, 61].

Epic-

Epic Systems Corporation is a giant in healthcare information technology. Applications support functions provided by Epic are related to patient care include scheduling and registration, clinical systems for nurses, doctors, emergency personnel and other care providers, systems for pharmacists, lab technologists and radiologists and also for billing systems for insurers [62]. Below is an independent survey conducted by Health IT News have the following results on the satisfaction of the end user in year 2016. The criteria chosen for survey were visual appeal, ease of use security features, medical devices interoperability, inter-operability with other systems, installation support and ongoing support operations. The overall satisfaction level for Epic was found to be 7.8 with minimum score of 6.8 for interoperability with other systems and maximum of 8.1 for ongoing support operations, installation support and security features.

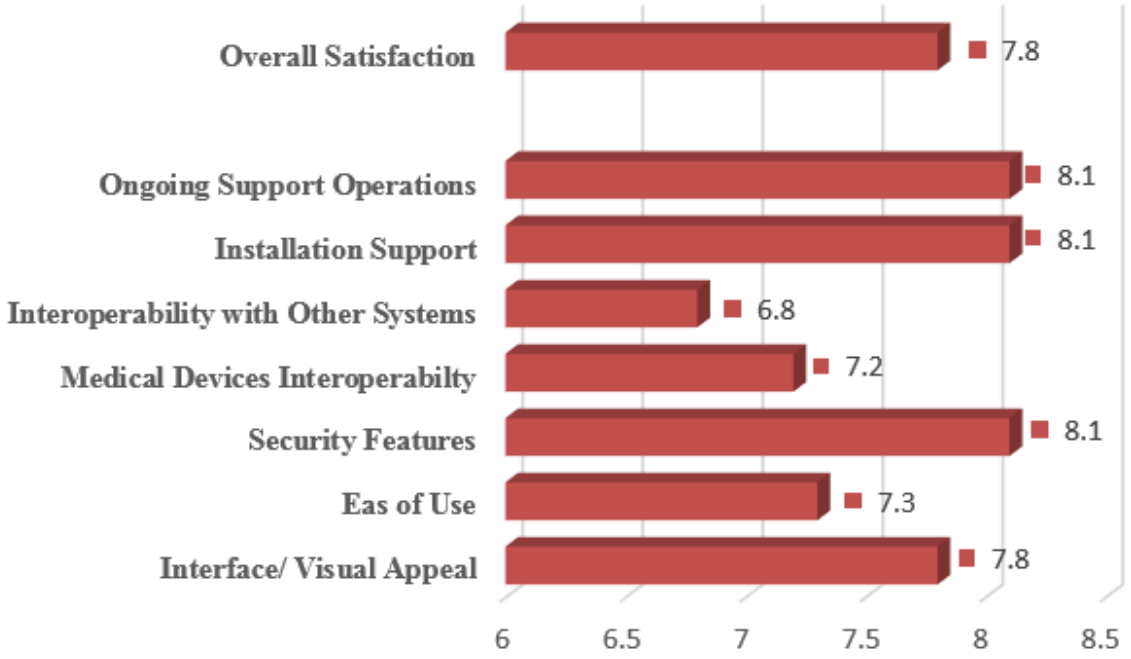


Figure 3.6: Satisfaction level of Epic

Source: http://www.healthcareitnews.com/news/2016-ehr-satisfaction-survey

Cerner-

In the year 1979 Cerner was founded with mission to provide systemic improvement of the health of communities and health care delivery. Cerner, one of leading provider of health care information technology (HCIT) offers comprehensive range of professional services, software, remote hosting, medical device integration, employer health and wellness services [63]. Below given is an independent survey conducted by Health IT News on the satisfaction of the end user in year 2016.

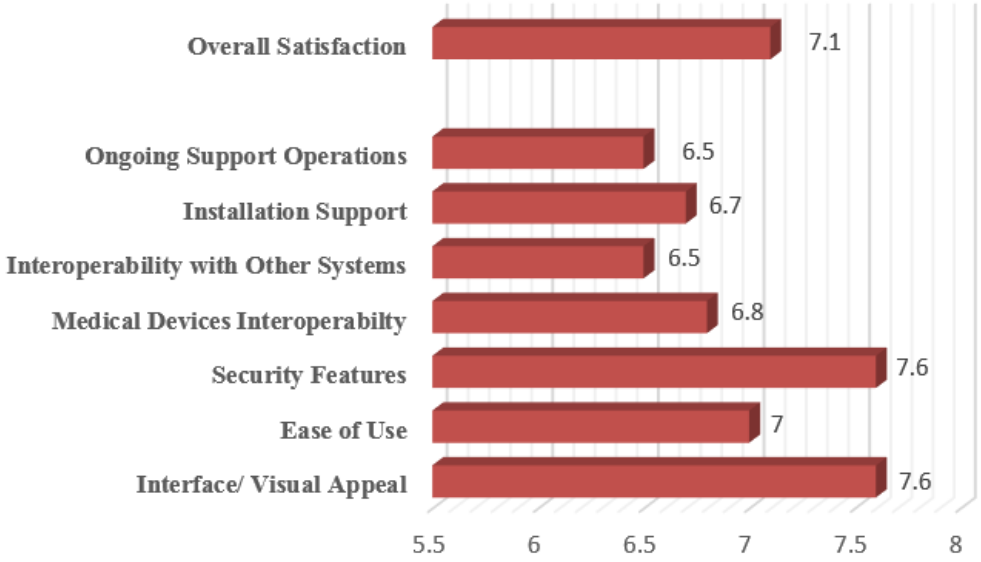


Figure 3.7: Satisfaction level of Cerner

Source: http://www.healthcareitnews.com/news/2016-ehr-satisfaction-survey

GE Healthcare:

GE Healthcare provide information technologies, medical imaging, patient monitoring systems, medical diagnostics, drug discovery, performance improvement and solutions, biopharmaceutical manufacturing technologies and services helping the customers to bring better care to people around the world at a lesser price [65].

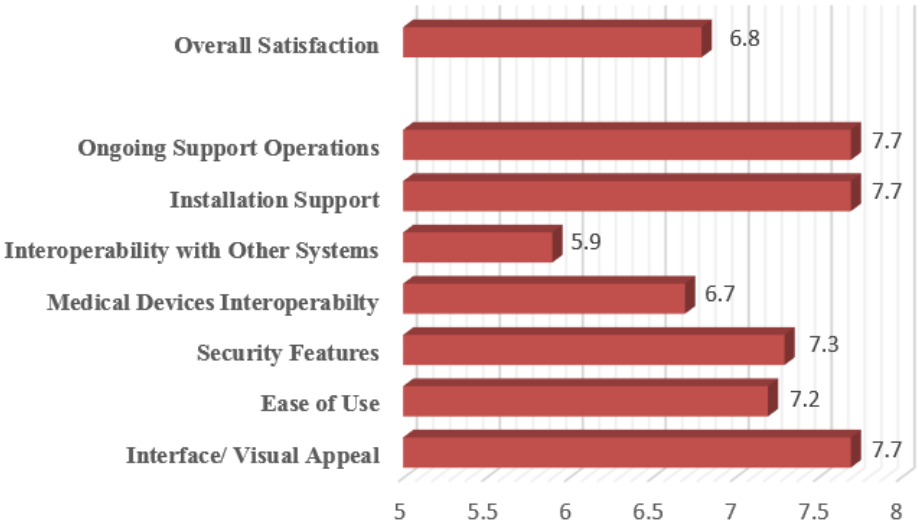


Figure 3.8: Satisfaction level of GE Healthcare

Source: http://www.healthcareitnews.com/news/2016-ehr-satisfaction-survey

Allscript:

It is a publicly traded American company that provides hospitals, physician practices and other healthcare providers with electronic health record technology and practice management. Allscripts also delivers solutions for care coordination and patient engagement, along with analytics and financial technology [66].

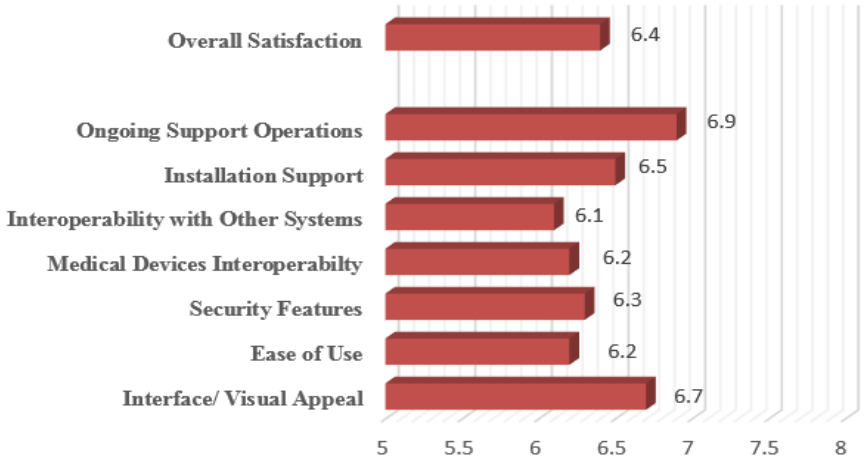


Figure 3.9: Satisfaction level of Allscripts **Source:** http://www.healthcareitnews.com/news/2016-ehr-satisfaction-survey

eClinicalWorks:

It is a Massachusetts based company that sells practice management, EMRs and personal health record services and software to healthcare organizations. By the use of its technology, the use of EHR is extended beyond practice walls creating a community wide record [67]. eClinicalWorks mainly aims at physician practices allowing them to use and view some personal wellness data but with the consent of patient.

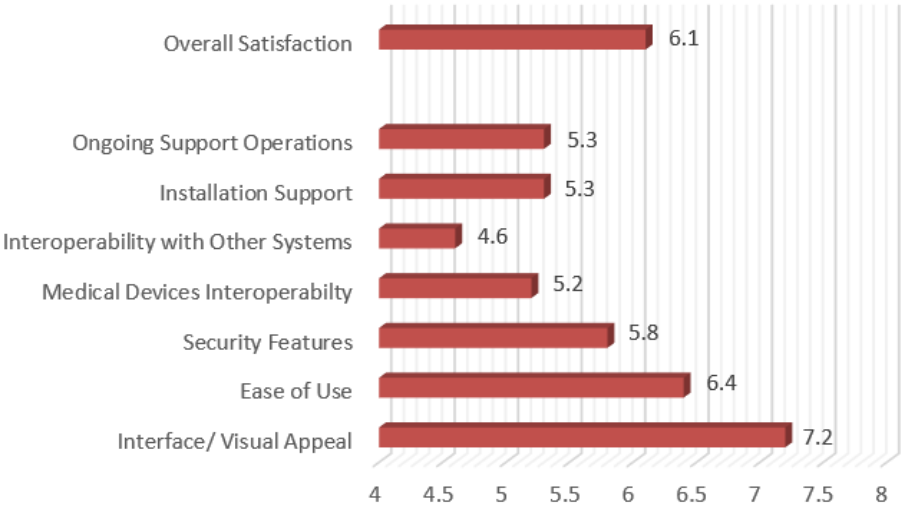


Figure 3.10: Satisfaction level of eClinicalWorks **Source:** http://www.healthcareitnews.com/news/2016-ehr-satisfaction-survey

Meditech:

Founded by A. Neil Pappalardo in 1969 it is a privately owned company that offers software for health care organizations of different sizes and types. Some software modules have revenue cycle, health information management, scanning and archiving, referral management and scheduling, emergency department management, data repository, cost accounting, general accounting, supply chain management, human resource planning, operating room management, long term care, patient discharge instructions, home and behavioral health.

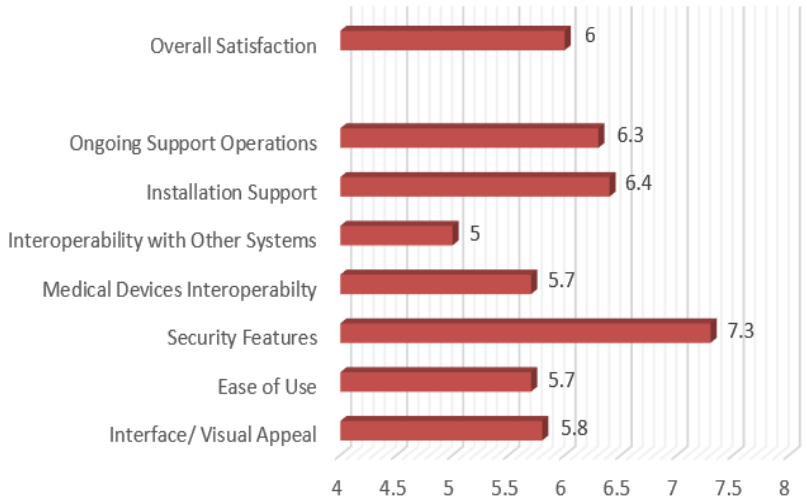


Figure 3.11: Satisfaction level of Meditech **Source:** http://www.healthcareitnews.com/news/2016-ehr-satisfaction-survey

Mckesson:

McKesson distributes medical supplies, healthcare systems, and pharmaceutical products. In addition, McKesson also provides extensive network infrastructure to healthcare organization. It was an early adopter of technologies like RFID tags, pharmacy robotics and bar-code scanning for distribution [68].

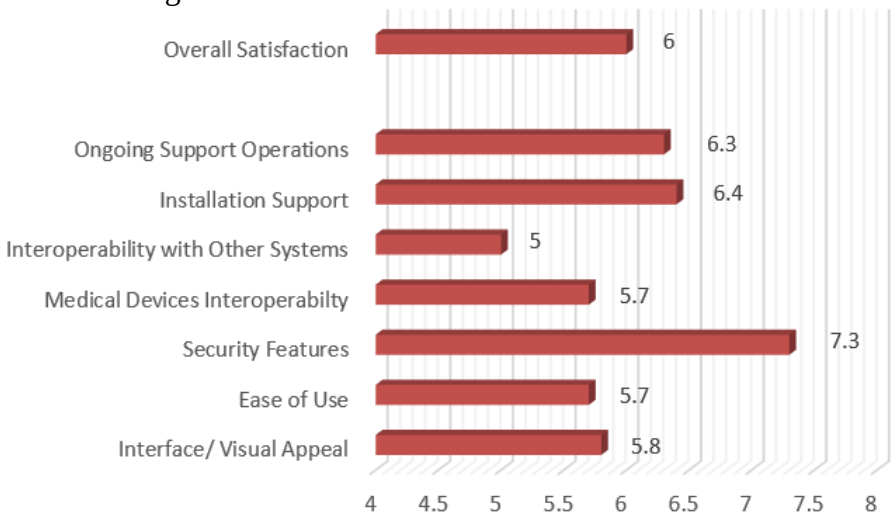


Figure 3.12: Satisfaction level of Mckesson **Source:** http://www.healthcareitnews.com/news/2016-ehr-satisfaction-survey

NextGen:

An American computer software company which has it headquarters in Horsham, Pennsylvania, USA. NextGen provides financial, Electronic Health Record (EHR), and HIE solutions for physician practices, hospitals, and other healthcare organizations. NextGen Healthcare Information Systems was created in 2001 after Quality System Inc. combined Clinitec and Micromed [69].

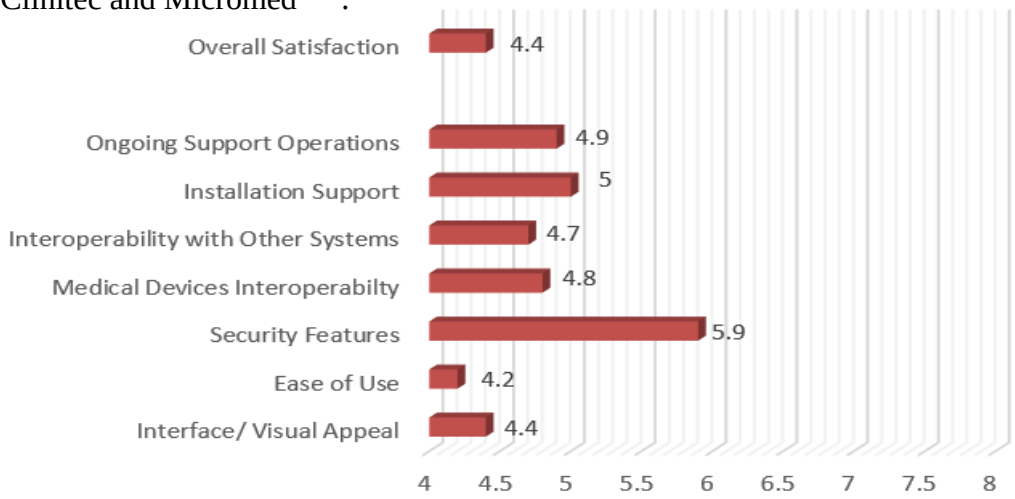
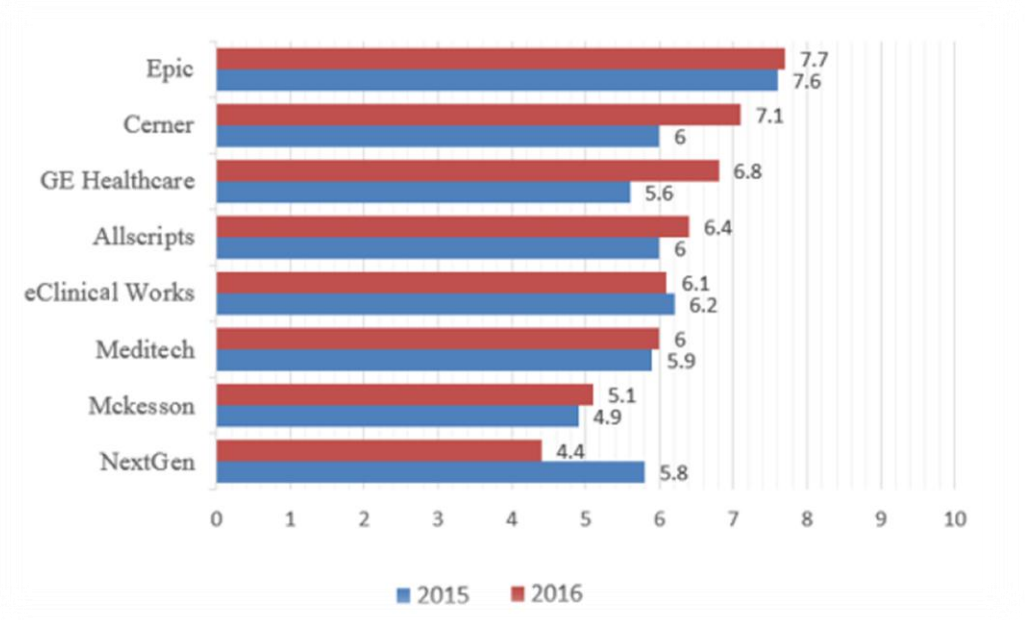


Figure 3.13: Satisfaction level of **Source:** http://www.healthcareitnews.com/news/2016-ehr-satisfaction-survey

The market share is of 69.9% which was maximum followed by Cerner Millennium which was 19.4% rest was for by other vendors. In terms of market share Epic and Cerner Millennium combine occupy around 62% of EMR market share in North America. Below is the comparison of satisfaction survey done by Health IT news for the year 2015 and 2016



Chap **Figure 3.14: Comparison of Overall Satisfaction for different EMRs 2015-2016**

This study was done with the objectives to analyze the current scenario and trend of cloud computing in healthcare domain along with the opportunities and threats present in cloud computing in healthcare domain. Moreover a comparison of cloud computing in healthcare among various location and to analyze the health IT products that utilize cloud computing were also the objectives of the study. With a thorough review of literature the following things were identified for cloud computing in healthcare domain.

- The evolutionary change from mainframe computer to client/server deployment models has eased the life of end users to a greater extend.
- The recent advances with the emergence of cloud computing has majorly affected the various delivery models provided by it.
- There has been a steep increase in the usage of cloud computing all around the world. Cloud computing is an approach where many systems are connected to a private or public network to provide scalable infrastructure for application, data and storage of data.
- It reduces the time for retrieval of data and time taken for delivery is reduced to a greater extend. Cloud computing signify in cost efficient manner of delivering the enterprise IT. Cloud computing is not only changing the business methods and models but also it is influencing the underlying architecture of deployment and application delivery.
- With recent advances, the healthcare can go beyond the boundaries of hospital industry. Fogg and dew computing can aid in providing services from regulating the traffic for quick and easy movement of ambulance, to analyzing of large healthcare data in healthcare setting that can be helpful in forecasting of diseases prevailing in the geographical area and country wide.

The second objective was to identify the challenges and opportunities in cloud computing in healthcare. The healthcare industry has always been reluctant to adopt a new model, but it is learning fast about cloud computing. During the course of study many factors were

seen but majorly the industry is affected by a few of these. The risks identified are cost of implementation, security, privacy and availability of services to the end user.

- For healthcare industry the best suitable option would be of SaaS as it is an economic and attractive solution as it will eliminate the need of a local IT express on a regular basis. It also reduces the cost of hardware, operating system and software development as they can be out sourced.
- The concern of security, interoperability and compliance are the major factors affecting the adoption in industry which can be resolved by use of double check-ins and frequently changing login with a reduced session durations.

Healthcare industry is a huge industry that needs highly available, effective low cost IT and secure solutions. As a result, it is exceedingly useful for the cloud owners and service providers to capitalize in the Healthcare Cloud market and offer widespread services that will supply the sector's requirements and simplify its operations. The opportunities identified for cloud computing in healthcare domain are as follows:

- It will aid to revolutionize businesses in terms of adaptability and availability.
- It can reduce "digital gap" between SME's and large companies.
- Increase collaboration and information exchange in between multiple parties by permitting the parties to profit from the information repository to enhance diagnosis, streamline processes, simplify administrative operations and support medical research activities.

The necessity for healthcare systems integration is a trans-dimensional approach and is determined by a number of medical, organizational, political and technical factors. The healthcare is an integrated environment that provides benefits that are substantial and numerous. The third objective was to compare cloud computing in healthcare in various locations.

- It is an agreed fact that the use of integrated healthcare systems and development are becoming essential to provide the delivery of high-quality patient care at low cost.
- The study identifies that the adoption is usually been higher in the hospital EHR segment when compared to the ambulatory EHR segment, as hospitals have more

budget compared to ambulatory clinics. But however, in the coming decade adoption of ambulatory EHR is expected to grow considerably.

- As far as IT adoption is concerned key issues for the healthcare industry are non-availability of trained manpower, upfront IT investment costs, and high cost of transition from legacy to new systems. Unlike the healthcare sector in developed economies, Indian healthcare ecosystem is at a nascent stage. For digitization of health records like remote patient monitoring and EMRs, currently the Indian healthcare industry is evaluating technology deployment models.

The last objective was to analyze various healthcare IT products that utilize cloud computing. Implementation of Electronic Health Records (EHRs) is not mandated in India still 'The Digital India Healthcare' a government of India's initiatives making their way into policy.

- It can be predicted that healthcare industry will favor SaaS cloud services. It was observed that the increase in the market for EMR adoption every vendor wants to have a leading edge over its competitor.
- Vendors keep updating there software to strive in a better manner than the other vendor. But the final decision is of the end user to decide which vendor to choose.
- The vendors try to place in front of the other vendor in terms of low cost of implementation, increase support, high interoperability, ease of use, security features and visual appeal whereas majority of vendor replacement occurs due to poor integration, cost of implementation, poor support from the vendor and difficult usability.

Chapter 5 Discussion

The latest trend in the field points to a benefit of patient care in absence of the care giver i.e. doctor, nurses, guardian etc. The patient can stay in his comfort environment and no compromise takes place on his care. BlockChain, another medium for transforming the healthcare industry in terms of lower compliance risks by increasing transparency in claim activities and data security of patients. BlockChain empowers the authorized entities in a network which could be payers, hospitals and patients to access verified information using a universal key or a private code.

The trend in upcoming two years will witness increase in usual of public cloud and decrease in virtual machines. As seen earlier, the public cloud usage in Indian market is expected to be around $1.26 billion and it is expected to be $ 35.27 billion by 2020. With the change in situation categorized by rising costs, growing aging populations, decreasing resources there is a growing inclination in the services provided by cloud computing for expansion. The new delivery models could open a gateway to make healthcare more effective and efficient, and lowering the cost to technology budgets. The combination of cloud services and smart solutions for healthcare will help the care givers to improved output by aiding in taking informed decisions increasing the quality of care services. The approach to store the medical data in a central data centers builds centrally managed healthcare, a core concept. The systems have to not only to ensure a smooth workflow but also the accounting and billing details of the patient.

The migration of data is a complex task with sensitive information. With the increase adoption of new models the complexity can be taken care of. It will help the patients to manage and maintain the data. Even hospitals, doctors, nurses will have less burden of managing patient information and can take timely decisions based on the information available. It will solve many collaborative information issues of various health organizations along with cost effective model. Sharing of information across many platform will aid in for a better care of patient. It will also provide easy approach in remote areas, in fields of research, telemedicine.

The sluggish adoption of cloud computing in healthcare is primarily because of issues related to interoperability, data management and security. The risk of loss of data and

confidentiality of it is a major concern for the industry. The increase in use of cloud computing also increases the data generated for medical records and to manage the data securely is of major concern. With the increase in number of third party vendors question arises about the security of data. On premises data storage increases the cost but maintaining the data on a distant server outside the geographical area increases the risk of data theft. The concern of security, interoperability and compliance are the major factors affecting the adoption in industry. Use of dual security checks can reduce the number of incidence of data piracy or theft.

The vendors need to develop a robust system of security to ensure the safety of data without affecting service level agreement and reliability. A constant improvement and changes in the legal procedures of EMR has evolved with time to support and promote use of electronic records. Acts like Health Insurance Portability and Affordability Act (HIPAA), Health Information Technology for Economic and Clinical Act (HITECH), American Recovery and Reinvestment Act (ARRA) of 2009 intended to increase the rate of adoption and utilization of health IT. The increased interest in cloud computing by healthcare industry resulted in raising demand for HIPAA compliant cloud services. The global market attained a maturity in providing support to hospitals with centralization and standardization of processes. With mandate of healthcare cloud computing services and products in private and government organizations, it is expected that more opportunities will be created for the market like Research and development, EHR, patient records and mobility solutions.

North America has the maximum adoption level for EMR as per HIMMS analytical report of 2015. It has been target market for most EMR vendors due to their extensive use of digital record keeping and easy incorporation of cloud computing into the existing technological framework. Several organizations worked towards cost reduction and creating a physical IT infrastructure environment and transforming to support an uncomplicated environment of cloud services. Increase hospital adoption of advanced functionality along with growth in over EHR adoption was triggered due Medicaid and Medicare EHR incentive program authorized by HITECH Act 2009 demonstrating "meaningful use" of certified EHR system. According to HIMSS Analytics database in North America, during the year 2006 around 57.4% hospitals were are stage 1 or stage 2 of

EMR adoption model and by the year 2015 63% of hospitals were at stage 5 and stage 6 of EMR adoption model which is a significant national improvement.

As discussed before, for Europe there is a variation among the countries with EMR adoption. In particular for Netherlands and Denmark was found to be maximum at around 4.7 and 5.3 mean score for the country where as for complete Europe it was 3.1 for EMR adoption model. According to HIMSS Europe report 2015, only 3 hospitals were at stage 7 and 59 were at stage 6 across Europe. A vast majority of hospitals in Europe with 44.4% in count are at stage 1 or stage 2 of EMR adoption model. The increase in aging population, chronic disease management, need for remote monitoring and establishment of healthcare information exchanges (HIEs) have provided a push to EHR adoption.

Asia pacific that mainly comprises of countries like India, China, South Korea, Japan, Rest of Asia and Pacific, is the third segment that is used in analyzing the EMR adoption model. A faster growth in adoption of EMR technology will be seen for Asia Pacific region as the growth rate of 7.7% per annum was predicted for the region. Mostly for Asia Pacific region the adoption will increase by the increasing government initiatives for eHealth, growing demand for quality healthcare, and rising medical tourism in this region along with increase in per capita income. The adoption would be an easy transition in this region as the western countries have already tested and practiced this for many years and hence the Asia pacific countries will not go for traditional digital health model but adopt the new digital health model which will be fully customized, coded and will require high skilled IT professionals to maintain and develop solutions.

In India, there are no strict and clear guidelines pertaining to EMR adoption model as it is not mandated to adopt it but with ‘Digital India Healthcare’ there are opportunities for growth in this sector with a mixed healthcare system comprising of both government and private hospitals. The Ministry of Electronics & IT has supported deployment and development of digital health solution. In many states they have deployed telemedicine systems. R&D projects are sponsored in areas like PHR management system, EMR system for oncology, technology for HIE. In India, EMR adoption is at a very nascent stage.

In India there are over 1700 public hospitals and according to Ministry of Electronics & Information Technology only around 72 public hospitals like AIIMS Delhi, and some state

government hospitals have registered for Online Registration System (ORS) that links many hospitals across the country for Aadhar based appointment system and online registration digitalizing Hospital Information System in India. The private sector has a limited access to EMR and has not yet started health information exchange to improve the care quality. EMR adoption is not common in Indian healthcare setups. The factors that affect its adoption model in India are lack of awareness, resistance in acceptance of EMR, high implementation cost and gap between information technology and healthcare. EMRs enable the use of health care resources, providing information of the patient with ease and quick access. Constant use of EHRs, increase the efficiency of healthcare systems within a country. The advantages of using EMRs along with strong IT support and government incentives will enable the growth of the market. Reports suggest the use of EHR systems has been limited to large or medium-sized hospitals.

The healthcare industry needs to carefully analyze and consider the type of application to be moved on cloud, as it will command the cloud deployment model and the type of service utilized. The rapid increase of geriatric population and rising need for remote monitoring along with an amplified pressure for the demand for improved patient care and containment of healthcare costs have directed to an rise in the market of electronic health records.

Figure 5.1: SWOT Analysis of Cloud Computing in Healthcare

Chapter 6 Conclusion

In the medical field adoption of cloud computing can improve various collaborative information issues and improve the quality of care at a reduced cost, benefiting both the patient and healthcare provider.

- Standardization of the cloud based processes will bring an apparent advantage in terms of HIE across many healthcare providers leading to better results. With increase adoption of cloud computing there will be increase in challenges like interoperability and security concerns of sensitive information.
- The benefits added are counterbalanced by privacy, security and issues of trust. In addition to numerous technical issues that should be addressed before healthcare sector can completely adopt and trust the cloud.
- Despite all the obstacles the implementation of best practices in deployment, design and use of cloud computing will attain future growth in adoption of cloud based adoption system.
- In future cloud computing may include security features by advanced techniques of user authentication and have a real time environment for evaluating the system. Choosing the right provider can be a real challenge for healthcare organizations that notice a potential benefit in cloud computing.

Chapter 7 Limitations of study

The study mainly had three limitations which are as follows

- Some of the data obtained contradicted each other resulting in low availability of updated data.
- Lack of control over data quality.
- Potentially bias in the studies available because the data collected are usually not same for the same purpose.

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