



## Impact of Cloud Computing on Healthcare

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**Abstract**—Cloud computing is a colloquial expression used to describe a form of computing concept that involves a large number of computers connected in a network. Cloud computing paradigm enables the organization to share cloud services in seamless and cost effective manner. Cloud computing provides the great platform for health care organization to excel in their respective business. It is no secret that healthcare organizations lag behind other industries in adopting new technologies. Healthcare providers invest around one tenth of revenue into Information technology field as compared to other industries that regularly invest almost quarter of their revenue. The health-care industry is mostly using information technology for image digitization, payment and reimbursement applications etc. Health care organizations are looking forward to adopt the robust features (infrastructure, platform, software, etc) of cloud computing, which will help them to provide quality service to their patients. More over with the

combination of big data and recommend system, organization will able to draw the crucial health related analytic, which can be used at different levels to facilitate the clinical services.

**Keywords:**—Cloud computing, eHealth, Impact of cloud computing, Challenges, Data Security, Performance, Cloud Service Models

## 1. INTRODUCTION

Cloud computing [1] is a revolutionary computing paradigm for storing data and running applications that encompasses numerous benefits. Cloud computing allows to build inexpensive disaster proof systems with reduced response time for users, more over it reduces the development time, maintenance staff, infrastructure and resulting in better services. Cloud computing appears to attract all spheres of computing. The various service models of cloud like IaaS, PaaS, SaaS provides the low effort configuration, infrastructure, data repositories etc. that lures various data

centric organizations. Healthcare organizations are moving toward cloud based systems as they can get adequate resources with no huge initial capital. Based on the organization requirements, various cloud services model are offered by cloud providers like public, private, hybrid or community oriented model. These services can be made available between patients, doctors, and organization by working out proper authorization privileges.

## 2. SERVICE MODELS

### 2.1. Infrastructure as a service (IaaS)

Infrastructure as a service is kind of model in which organizations outsource the infrastructure like hardware, network, servers, repositories etc. to cloud service provider. The service provider will be owner of these devices and responsible for maintain these resources. The IaaS provides the abstract computing, storage and network capabilities, hence provides the flexible, virtualized and standard operating environment. In typical hospital scenario, where hospital owns PACS and repository, but it uses the facility of IaaS for storing its data, which can be stored in public server. The IaaS provider will act as the back-up repository server.

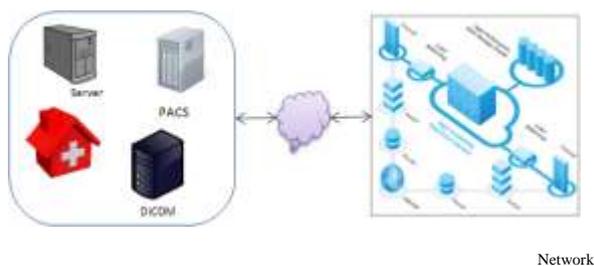


Figure 1: IaaS health care model

### 2.2. Platform as a service (PaaS)

Platform as a service [2] provides the platform and solution stack. The Health care application can able to develop their applications using the libraries provided by cloud service provider. They need not worry about the under lying hardware, software used by the service providers. The health care organization can able to deploy their

applications without maintaining any extra resources.



Figure 2 :PaaS Healthcare Model

The PaaS offers various features which will really ease the load from health care organizations like application instrumentation, security, scalability, disaster management, database integration, storage, web services, team collaboration, persistence etc.

The health care will utilize PaaS to develop their clinical information.

### 2.3. Software as a service (SaaS)

Software as a Service is kind of service in which the health care organization will utilize the standard software frameworks. There are various cloud software frameworks which utilizes by the various organization for their resources planning, recruitment, Database management, virtualization, content management, human resource management. In SaaS model the health care organizations will able to get infrastructure as a Service, platform as a service, and Information management as a service.

Software as a Service (SaaS) delivers business processes and applications, such as Gene analysis, ECG analysis, ERP, CRM etc. Digital pathology, PACS or even email could be utilized through the cloud. SaaS can be quickly deployed and utilized, without much capital consumption, reaping maximum utilization of resources and technology.

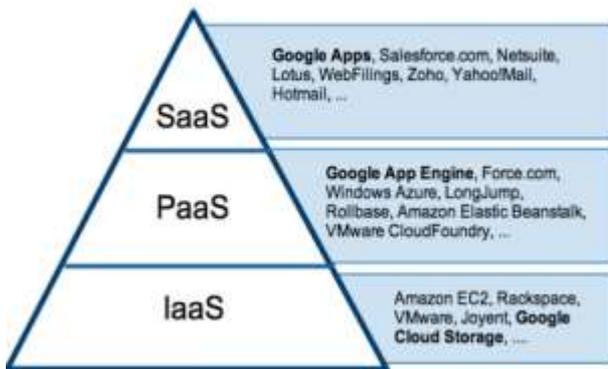


Figure 3: Service Models

The above figure present the service models with their corresponding service providers.

### 3. CLOUD DEPLOYMENT MODELS AND RUDIMENTS

Cloud deployment models demonstrate the variety of different models and providing the different benefits to the organizations, individual who are consuming their services. There are certain advantages and corresponding risks that need to be taken into the consideration while availing these cloud strategies.

#### 3.1 Public Cloud Deployment

A public cloud is the most cost-effective model of deployment, as economies of scale are maximized. The public cloud is open to the general public and is completely managed by the cloud service provider. The services and infrastructure are provided via public servers.



Figure 4: Public Cloud providers

The efficiency and utilization can be maximized using public cloud. However the

public cloud environment is more vulnerable to security threats and data security. The health care organization need to take into the account the risk associated with it.

The organization generally use the pubic cloud paradigm where they want to uses the SaaS model with application framework given by service provider or need scalability during the peak working hour of hospitals. The servers, storage and networking are shared among all subscribers and the applications are delivered over the Internet.



Figure 5: Public cloud

The various access point of public cloud is shown above. Public cloud deployments are more risky, as they are open to whole world. The disaster proof system of health care organizations can be achieved with the help of public cloud. Health care organizations keep their proprietary data in house so that it can be protected from unauthorized access.

#### 3.2 Private Cloud Deployment

Private cloud model is operated by a single organization and resources will be used by the owning organization only. Private cloud typically shares the various features of traditional client server paradigm apart from integrating features associated with other deployment models. The cloud computing resources are present in-house and resources can be managed by organization’s staff or third party organizations. The private cloud will be ideal starting point for adopting the cloud

computing model until or unless the organization becomes quite familiar risks, with associated of other models.

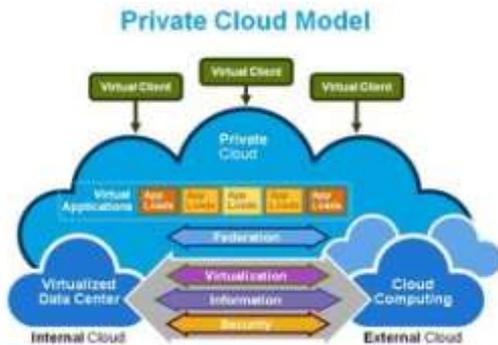


Figure 6: Private Cloud Model

In health care scenario the confidential information like patients data, proprietary data etc will be within the vicinity of organization. Typically, the private cloud infrastructure is expensive as compared to other model.

### 3.3 Hybrid Cloud Deployment

Hybrid cloud deployment [5] generally contains the features consisting of different cloud models like public model, private model etc. Hybrid cloud model are commonly used in large organizations. Hybrid model provides the flexibility of exploiting the features of both private and public cloud models.

Healthcare organization can use the private cloud to retain the clinical proprietary information and will use the public cloud to share the information to patients, doctors, staff or third party integrity.

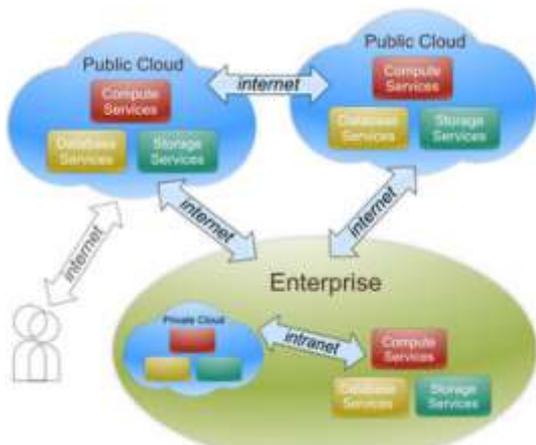


Figure 7: Hybrid Cloud Model

Hybrid cloud share the computing resources with any third party organizations having similar needs.



Figure 8: Cloud deployment model: buyer preference

The trends [7] shown above demonstrate the customers’ preference to cloud deployment. It has been observed the customers are more focused to private cloud even if there is more initial capital investment. But the customer does not want to compromise over the data privacy and security risks. The health care organizations can adopt the private cloud model for keeping their confidential information.

### 3.4 Cloud Adoption Rudiments

Cloud computing models have been analyzed and adopted by different organization across the world. Enterprise applications are looking into the pros and cons of cloud computing models. There are various challenges involved in adopting the cloud computing technology. The various benefit of cloud computing enables the various organizations to adopt it, after considering their challenges. The enterprise application can adopt any of cloud models like SaaS, PaaS, IaaS etc as per their business requirement.

The cloud adoption at SaaS layer is the strongest contender among all cloud models. With lots of security consideration the private cloud model will be adopted by organization who wants to keep their proprietary data in house. Health care organizations may take private cloud model for sensitive information like patient information, research data etc.

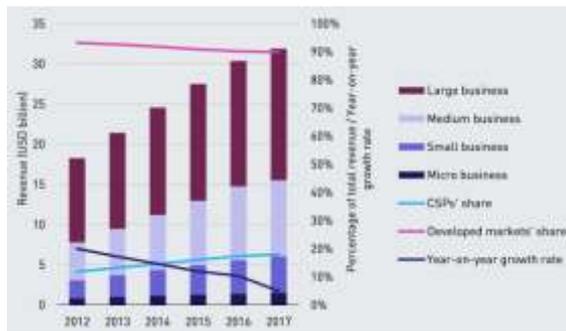


Figure 9: Enterprise cloud services revenue by enterprise size segment

Moreover, the enterprise applications are adopting [6] cloud computing due to various features like Fault tolerance, high data availability, performance, elasticity etc. Also, with the integrity with latest technological trends like Big Data analytics helps to draw the recommended results, which could draw useful forecasts for their business, in coming years.

The health care organizations can make use of analytics information, and take appropriate actions like recruitment of staff, focused research areas, infrastructure needs, required clinical integrations etc.

#### 4. CHALLENGES IN HEALTHCARE

The cloud computing is widely accepted by enterprise applications predominantly adopting SaaS layer model. CRM, ERP, healthcare business vertical are looking towards cloud computing to lure their customer and en-cash the various benefits the latest technologies offers. Enterprise applications are adopting cloud infrastructure to cater disaster recover, archiving, storage, performance, data availability etc.

Traditionally the health care industry is slow to cater the growing demand of patients. As the health care data keeps on increasing, the big data technology provides the answer in best possible way. Big data provides the various analytics trends which can be used by various government organizations, to define the vision of health care organizations.

Considering various benefits of cloud computing there are numerous challenges [5] involved, which needs to understand by health

care organizations. These organizations are source of various confidential data, which need to be protected from unauthorized users. We will discuss the various challenges faced by enterprise applications while adopting the cloud computing.

#### 4.1 Data security

The issue of security of data and privacy raises the loud alarms among the patients. The privacy and security of data is the concern which bothered most of the users. Keeping the health information in data centers of third party cloud service provider raises the serious concern. This confidential information can be misused and will result in harmful consequences for organizations that are using cloud services. The developed countries pose the hefty fines for these privacy violations. The public cloud model poses the vital security concerns, hence private cloud model is the first choice of the organization which would like to keep their information in house. All clinical research data, organizational trends and important artifacts will remain in organization's circumference.

The cloud service should use the cryptographic and remote attestation techniques to save the confidential cloud information.

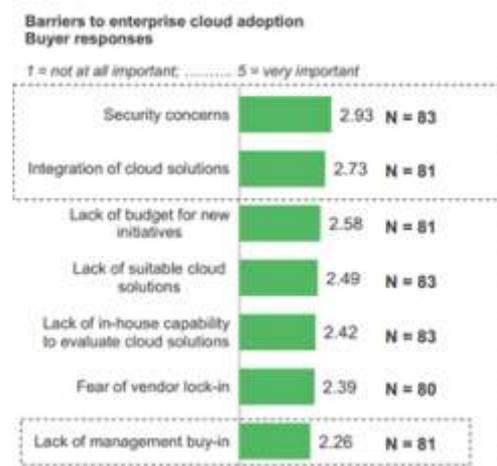


Figure 10: Barrier to enterprise cloud adoption

The trend [7] shown above demonstrates the buyer's response for adoption of cloud computing and depicts that they are feared the

most from security threats. So serious consideration need to be given while posting the highly confidential data over cloud. To curb the security issues the clinical data need to be encrypted with robust cryptographic techniques and use other technological way to protect their data.

#### 4.2 Automatic service provision

Cloud computing uses the various hardware, network, database resources etc. These resources are shared among the different users. So there is necessary demand to allocate the resources to cater the request coming to the public server nodes. The optimal provisioning solution needs to be provided. It is responsibility of service provider to provide the responsive service infrastructure to the users.

Highly operative hospital management solutions may have thousands of requests coming to cloud server. The reasonable techniques should be provided to allocate the resources. The automatic service provision can have following considerations:

- Performance model should be design to predict the load of the system.
- Continuous monitoring of the node of cloud server and provide better quality of service.
- Caching mechanism can be used to service the repetitive requests, coming to system.
- Intelligent provision model can be adopted by service providers.

#### 4.3 Reliability & Availability of service

Health care organizations planning to adopt the cloud computing paradigm are very much concerned about the service availability around the clock. Clinical data needs to be available at every moment of its operation. So, organizations are quite worry about the situation when they are unable to access data due various reasons like service unavailability,

blunt shutdown of data centers, any software failures etc. There are numerous questions because patient information should be available to hospital management all the time. Consider an example, during the emergency surgery operation, cloud service provider unable to provide the patients information record which may be crucial requirement in the operating scenario.



Figure 11: Cloud computing challenges

These kinds of situation can put the organizations in big trouble and may impact the business reliability. Such a scenario has happened in the past where business verticals have faced the service unavailability issues for quite number of hours.

These kinds of challenges are impacting the mind set of health care organization how to handle such scenarios. The cloud service providers are already working in such areas. They have devised the various fault tolerance techniques as a counter measures. Component redundancy check, geographical redundancy, software redundancy etc are various such primitives, widely used.

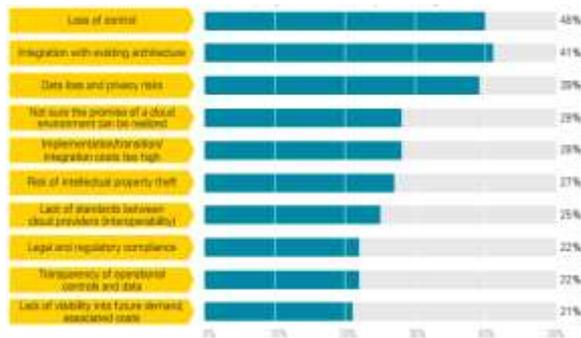


Figure 12: Challenges adopting cloud computing [8]

#### 4.4 Performance of the Cloud Server

Cloud computing is sea containing variety of resources having different capabilities. The user will have the feeling of dedicated infrastructure with available resources. The performance parameters may vary across the different service provider. The selection of cloud service provider will depend upon the performance of overall system. CPU capping is also one of the important feature that need due consideration while cloud selection.

#### 4.5 Workforce skill Challenges

With the introduction of cloud computing in health care organization, the traditional staff that is performing most of work in orthodox pattern like on paper etc may require training to work effectively with latest technologies [4]. More over cloud service provider need to provide considerable help to the management of healthcare organization. So adoption may require efforts to train the traditional staff.

#### 4.6 Service Level Agreement

Service level agreement is one of important aspect which needs due attention. The cloud service provider are sharing resources among the various customers, the underlying nature of cloud computing have shared infrastructure environment. Thus, service level agreements offered by service providers typically based upon the services provided rather than based on particular customer. Measuring, monitoring and reporting on cloud performance are based upon an end

user experience or the end users ability to consume resources. The downside of cloud computing, relative to SLAs, is the difficulty in determining root cause for service interruptions due to the complex nature of the environment. SLA management strategy considers two well-differentiated phases: the negotiation of the contract and the monitoring of its fulfillment in real-time.

The health care organization needs to look into the SLA and should have proper negotiation, so that they can minimize the business impact once the things go wrong.

## 5. BENEFITS OF CLOUD COMPUTING IN HEALTHCARE

### Infrastructure set up

The cloud service providers facilitate the health organizations to use cloud infrastructure as per their organization need. Health care organization do not required huge capital to build the IT infrastructure to draw the benefits of cloud computing. The initial setup cost will be reduced drastically. While any company can enjoy this benefit, typically it is particularly important for start-ups and small businesses, as they tend to have limited funding and no existing data centers. This is probably why start-ups and small companies are the early adopters of cloud computing.

The health care organization can have huge infrastructure, which will enable them to provide better services to their patients. The cloud service providers will procure data centers, fault tolerant servers, platform support, disaster proof system etc as a various service models.

### 5.1 Ubiquitous

Cloud computing benefitted the patients to access the data at their door step. All necessary information which was not present in traditional health care organization will be available via cloud computing. Patients can access information like their test results, recommendations from doctor, radiology

information etc from anywhere. Besides, doctors can share the reports among the specialist to discuss the case of their respective patients. Hence it will result in better clinical benefits to whole mankind. Moreover, clinical research data can be accessed and stored in cloud repository for their reference as it provides rich storage facilities.

The ECG analysis, Gene detection, radiology reports can be shared among the specialist. The doctors can share the prescription and demands the diagnostic report from the patient sitting at remote location. The cloud computing provides the central repositories which removes the geographical barriers.

### 5.2 Maintaining resources

Healthcare organization once adopted the cloud computing model need not worry of handling the cloud service faults or any kind of deficiency. Their staff need not care about the business of maintaining the data centers. They can focus on providing the better services to the patient in their respective area. The cloud service provider has their specialist in place that will take care of managing the cloud service deficiency as per their SLA.

Also, health care organization utilizes their resources very effectively, as they are paying what they are using. The hardware resources are not lying idle which was the case in traditional health care scenario, because organization makes the upfront investment of maintaining the repository servers taking into the consideration of future data requirement. So clinical organizations need not worrying about repository requirement. The cloud server have enormous data center to cater these kinds of scenarios.

### 5.3 Availability, Fault tolerance and Disaster Management

Cloud service provider ensures the data availability round the clock as they have presence of data centers all over the world. The flexibility of multiple data centers helps to

provide the disaster proof system, in case of failure of any particular data center. The performance of system can be improved by the presence of geographical servers besides they can use parallel hardware component to satisfy the high performance requirement.



Figure 13 Benefits of cloud computing

The health care services should be available all the time to health organizations, as it very critical data. Cloud computing provides the fault tolerance system, which ensures that organization does not suffer from data unavailability. The radiology report, important test results, patient information report will be needed all the time especially while performing surgical operations etc. The cloud service providers make sure that once any of physical nodes is down, they can switch to the node which can provide the optimal services to their customers within the stipulated time frame.

### 5.4 Performance and Elasticity of the Cloud

The Cloud computing is a pool of endless computing resources with unlimited performance. These cloud computing resources and their effective algorithm design provides the efficient round the clock. These algorithms have the capability to automatically judge the load of system and provide the balancing act to achieve optimize performance.

The health care organization will able provide the effective performance to its whole customer base with the help of cloud

computing. The customer base of health care organization is keeps on increasing day by day, the scalability of cloud computing helps to provide the platform for health care organization to service them effectively.

### 5.5 Mobility

Cloud computing services can be easily accessed through the internet with any internet enabled device like a PC, smart phone, or iPad etc, which enables users, employees, and administrators to access their systems from anywhere and at any time

The patients can able to login to their respective healthcare organization's portals and can perform the desired action. Mobility breaks the geographical barriers and enables to access their services.

## 6. CONCLUSION

There are enormous benefits which can be reaped from the cloud computing technology. The clinician can exploit the these area which will help them to scale up their business right from small practices to huge hospital's chain. The organizations can have scalability, extensibility features in place which can support the massive client supports which would be difficult to achieve via traditional approach. More over the technologies provide the fault tolerance, disaster proof system which can be attained without much upfront investment.

The viability of cloud base solution for health care organization depends upon the security of patient data and personal information. The cloud service provider must adapt to the departmental need and organizations sizes. The cloud computing should have highest level of availability and security to gain the acceptance in different business verticals.

## 7. FUTURE WORK

The traditional working style of health care organizations and many challenges like scalability, performance it faces, the cloud

computing will be front runner technology. Also, there are lots of challenges that the cloud service providers are facing that are major obstacle for cloud computing adoption. The various research and analysis are going on to curb the challenges. The cloud computing lays the foundation of health cares assistance at the click of handheld, portable gadgets. All the patient record can be accessed by various health care business verticals like pharmaceutical, insurance provider, hospitals etc.

All digitized reports, patient history are consolidated and publically available to authorized users. With the introduction of big data, better analytics result can be drawn. Government organization can place necessary policies after analyzing the analytics as per the region and take appropriate actions to mitigate unfavorable conditions. Big data record may be used in variety of different way and may gauge the performance of any healthcare organization at global level,

The cloud computing will prove the driving force for health care organization to provide effective, efficient, ubiquitous, cost effective and reliable services to their patients.

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