Cloud Computing: A Boon to Healthcare

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***Abstract*—Cloud computing nowadays is becoming one of the new building blocks of major businesses spread around the world. They help in transporting platforms and services across the globe to support various infrastructures. Existing e-health practices face many challenges from development to implementation. This paper analyzes cloud computing and examines its applications in the context of e-Health to provide optimum, timely, cost effective health care to rural region in India.**

***Index Terms*—cloud in healthcare, e-health, telemedicine**

I. INTRODUCTION

Today Information technology has transformed human life to a different level. It has laid its print in almost all aspects revolving around human life, be it education, transportation, communication, financial sector. All these sectors have digitized, automated their services through Information technology. So utilizing the information technology services in the healthcare industry will be an important strategy for many healthcare organizations to enhance healthcare services and reduce operational costs. There is a high increase in the demand on healthcare services while the shortages in qualified healthcare professionals such as doctors, nurses and pharmacists form one of the toughest challenges confronting healthcare providers [4, 5 and 6] especially in rural areas of India. In addition, diseases are becoming more complex and there is a need to new advancements in technology and research to tackle these complexities with new and more effective diagnoses and treatment techniques. Also, the logistics behind managing such operations has become more complex and very costly.

Out of many new concepts in IT, Cloud computing is an emerging IT delivery model [2, 3] or a new concept of computing can significantly reduce IT costs and complexities while improving workload optimization and service delivery. Cloud computing is based on internet computing in which shared resources are provided on internet to other users on demand [1, 2].

Cloud Computing has been envisioned as the next-generation architecture of IT enterprise, due to its long list of unprecedented advantages in the IT history: on-demand self-service, ubiquitous network access, location independent resource pooling, rapid resource elasticity, usage-based pricing and transference of risk [2, 3].

As a disruptive technology with profound implications, Cloud Computing is transforming the very nature of how a business process uses information technology. One fundamental aspect of this paradigm shifting is that data is being centralized or outsourced into the Cloud.

India has achieved considerable progress in the provision of healthcare over the past few years. Recent reforms and innovations under the National Rural Health Mission (NRHM) in many states [4] have reported significant improvements in key health indicators such as complete immunization and disease control programs. However, the country's health system continues to face many challenges posed by:

Rural and urban gap: Rural India accounts up to 70-72% (that would be over 620 million) of India's population which lives in its 638,588 villages. There are considerable gaps between rural and urban areas with respect to healthcare facilities. There is 1 doctor per 1000 people, but there are 3.3 million NGOs, i.e. 1 NGO per less than 400 people in India [6].

Healthcare access gap: The biggest challenge of all is the substantial gap in accessing healthcare. Healthcare infrastructure gap remains substantial, with only 1.3 beds per 1,000 population [6], significantly lower than the other BRIC economies and the WHO guideline of 3.5 beds per 1,000 population.

Health system weakness: Clinical talent shortage projects a bottleneck affecting the growth of the sector and creation of healthcare access in the country. The last decade saw an increase in physicians from 0.55 per 1,000 population to a mere 0.65 per 1,000 [6], which substantially is substantially lower against the WHO benchmark of 2.5 per 1,000 population.

Alarming statistics of health related issues in India:

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According to WHO reports, India is likely to miss the Millennium Development Goals by 2015.The Millennium Development Goals of reducing IMR to 28(per 1000 live births) and MMR to 109(per 1000,000 live births) are unlikely to be achieved by 2015.While the maternal mortality rate has declined over the past 30 years from 460 to 212 per 1,00,000 live births, it still remains high relative to the targets set by the policy[6, 12].

Despite a considerable decline in child malnutrition rates over the past few decades, India continues to have the highest number of malnourished children in the world. Cardiac disease and cancer have emerged as the top two causes of mortality in India. It is estimated that by 2020 cardiovascular disease will be the cause of over 40 per cent deaths in India as compared to 24 per cent in 1990.

The state of healthcare facilities for these two diseases has not kept pace either in diagnostics or therapy. India has mere 1050 cardiac centres, adequate to perform about two million angiography procedures; woefully inadequate to cover the more than 50 million patients afflicted with coronary heart disease. Access to cancer care is a bigger challenge with only around 325 comprehensive cancer centres, despite about 1.2 million newly diagnosed cancer patients every year. India has a mere 90 PET and CT scanners, 1,300 MRI scanners and around 1,400 CT scanners (above six-slice) [6]. The existing shortage of diagnostic infrastructure across the country severely limits early detection of diseases and access to care. This lack of healthcare access has resulted in the country facing one of the highest mortality rates in the world.

Nearly 50 countries worldwide have attained universal access to healthcare, according to the International Labour Organization (ILO). Conspicuous gaps still exist, however, in Asia, Africa and the Middle East, and in particular, in India. Globally, there is a greater recognition of the need for health systems to adopt sustainable mechanisms that permit population-wide coverage and the efficient delivery of a wide range of health services. The 2005 World Health Assembly (WHA) urged health coverage, ensuring equitable distribution of quality healthcare infrastructure and human resources, to protect individuals seeking care against catastrophic healthcare expenditure and possible impoverishment.

The move from a high-ticket, low-volume operation to a low-ticket, high-volume operation is very difficult, this challenge can be met by the cloud computing technology, as it presents a platform to transform the quality of healthcare, improvise its efficiency and most importantly reaching the less facilitated regions more effectively. Sections II and III discuss how cloud provides a new frontier to healthcare.

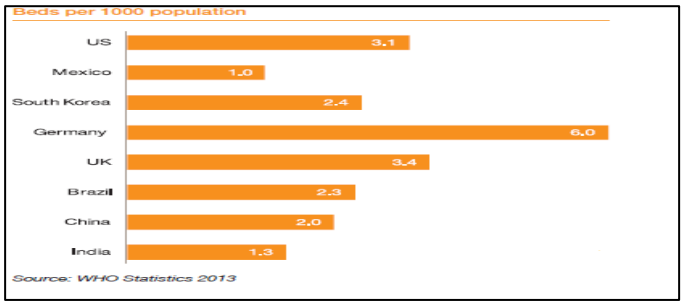

Fig 1: Statistics of Bed availability in India (WHO 2013)

II. WHAT IS CLOUD COMPUTING?

Cloud computing refers to an on-demand, self-service Internet infrastructure that enables the user to access computing resources anytime from anywhere [1, 2]. Cloud computing is internet-based computing, where shared servers provide computing power, storage, development platforms or software to computers and other devices on demand. This frequently takes the form of cloud services, such as 'Infrastructure as a Service' (IaaS), 'Platform as a Service (PaaS)' or 'Software as a Service' (SaaS). [1].

A. *Software as a service (SaaS):* The applications are hosted by a cloud service provider and made available to clients over a network, typically the Internet. The capability provided to the consumer is to use the cloud provider's applications running on a cloud infrastructure [2]. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

B. *Platform as a service (PaaS):* The development tools are hosted in the cloud and accessed through a browser. With PaaS, developers can build Web applications without installing any tools on their computer, and then deploy those applications without any specialized administrative skills. The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider [2]. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

C. *Infrastructure as a service (IaaS):* The cloud user outsources the equipment used to support operations,

including storage, hardware, servers, and networking components. The cloud provider owns the equipment and is responsible for housing, running, and maintaining it. The user typically pays on a per-use basis. The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications [2]. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components.

Users can access web-based tools or applications through a web browser or via a cloud-based resource like storage or computer power as if they were installed locally, eliminating the need to install and run the application on the customer's own computers and simplifying maintenance and support.
To deploy cloud computing, the US National Institute of Standards and Technology (NIST) [2] listed 3 models (see Figure 2):

Public cloud: A cloud service provider makes resources (applications and storage) available to the general public over the Internet on a pay-as-you-go basis.

Private cloud: A cloud infrastructure is operated solely for a single organization. In other words, the proprietary network or the data center supplies hosted services to a certain group of people.

Hybrid cloud: The cloud infrastructure comprises 2 or more clouds (private, public, or community). In this infrastructure, an organization provides and manages some resources within its own data center and has others provided externally.

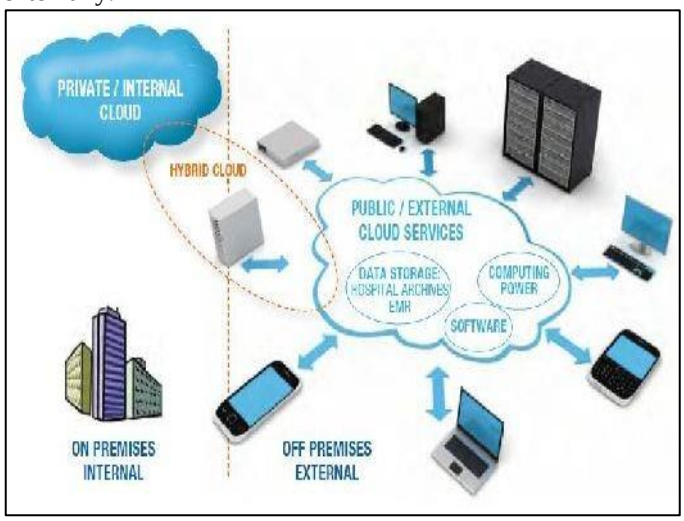

Fig 2: Cloud deployment architecture

III. CLOUD COMPUTING: A BOON TO HEALTHCARE

In today's world of cost cutting, many facilities must show benefit in order to justify expenditures, and the cloud technology has potential tools to do just that.
The single biggest advantage that the proposed e-health through cloud technology [7] can provide is access to applications that were previously unattainable. For example, the implementation of digital pathology, managed through cloud services, has a huge clinical impact on healthcare sector. The healthcare industry can roll out a service that would have cost millions just for the storage alone, but now can pay for it as they use it. New services can be offered to the local patient population (in rural area), by consulting remote experts (in urban area). Patient care can be improved by providing this service through the cloud faster and more efficiently. Since patients don't need to travel (from rural to urban area), waiting lists are more easily managed as more patients can have the same tests in more locations with a larger availability of experts.

These same experts can access patient data remotely and on demand through the Internet via a variety of connected devices. Physicians can review the latest diagnostic results from anywhere, anytime. Collaboration between researchers or physicians and allied health professionals suddenly becomes a reality, as patient information is centrally located and accessible to authorized users. Patient information is now being shared between caregivers, regardless of location, allowing for better-informed decisions.

Below is a non-exhaustive list of the recognized benefits of e-Health:

1.) *Facilitate access to healthcare:* e-Health can help deliver care to people located in remote places and who do not have access to a hospital through a tele-consultation.

2.) *Improve quality of care:* e-Health can help improve the quality of care by providing easier, safer and faster access to patient data, thereby allowing the healthcare professional to access the right data at the right time and make an informed- based diagnosis.
3.) *Improve quality of life of patients:* e-Health in general and telemedicine in particular can help improve the quality of life of patients by, for example, monitoring the condition of the patient at distance at home, rather than in a hospital. This is particularly relevant for elderly, chronically ill persons and people living in remote regions.
4.) Improve patient safety: The availability of information on the patient – such as his medical history, past diseases and interventions, allergies, reaction to medications – in an electronic health record (EHR) [8, 10] allows healthcare professionals to deliver a treatment tailored to the needs of the patient and thereby reduce risks of complications, adverse drug

reactions etc.

5.) *Improved response to shortage of qualified staff:* Adequate e-Health tools such as electronic health records allow healthcare professionals to access information on the patient faster and thereby avoid losing time

of communicable and non-communicable diseases [5, 6], healthcare professionals will be required to monitor more patients. E-Health tools can help them work more efficiently, by storing patient information in a single location, taking medical decisions better and faster with the support of decision support systems.

6.) *Save costs:* e-Health can help reduce costs (clinical and administrative costs) by, for example, avoiding the duplication of medical examinations and unnecessary visits to the general practitioners / hospitals.

7.) *Reduce carbon footprint:* e-Health allows the move from paper-based to electronic files. In this way, it also reduces the need to travel for patients, healthcare professionals and the requirement of vehicles for transmission of healthcare equipments and logistics; resulting in lower CO^2 emissions.

IV. PROPOSED CLOUD BASED SOLUTIONS

A. *Interoperable EHRs*

Hospitals using cloud based e-health record systems [8, 10] can save on upfront capital investments in hardware and data center infrastructure and pay only for the operational expenses of the cloud resources used. Hospitals can access patient data stored in the cloud and share the data with other hospitals. Patients can provide access to their health history and information stored in the cloud (using SaaS applications) to hospitals so that the admissions and discharge processes can be streamlined. Physicians can upload diagnosis reports to the cloud so that they can be accessed by doctors remotely (tele-consultation) for diagnosing the illness.

B. *Support research through a common repository*

When the information to be analyzed is stored and accessed through cloud, it will enable medical researchers who are developing and testing new treatments to compare large amounts of information and find common links, giving way to better decision making, new developments in treatment and drugs. This is great advantage for researchers and scientists working in fields like drug discovery, genetics, and protein component analysis. In all these sectors, research requires more investment in terms of infrastructure, clinical trials and also time. Rather than simply testing for a suspected condition, using the cloud technology could allow clinicians to test for a much wider range of complaints. Also, integrating cloud with bioinformatics [13, 14] can give rise to a new range of solutions in a lesser span of time at a lower cost.

C. Telemedicine for rural people

India is witnessing the world's fastest growth of telecom connectivity. India has network covering more than 85% of the terrain across 0.6 Million villages (with an average spacing of 25 Km and average 200 households), with this advantage, a patient in a rural area can receive preliminary treatment in the region where he resides before moving to the urban region for an enhanced treatment.

compiling information from different location/sources. By allowing healthcare professionals to save time, e-Health tools also address the issue of shortage of healthcare professionals. With the increase

D. *Tele- monitoring*

Considering the fact of bed shortage statistics [6], tele-monitoring [11] would be an ideal solution to tackle this issue. Tele-monitoring is the remote exchange of physiological data between a patient elsewhere and medical staff at a hospital to assist in diagnosis and monitoring. This could include support for people with chronic diseases and elderly people for whom travelling is a constraint. A tele-monitoring system [11] is an affordable and scalable health record system which is used to monitor physiological signals of a patient like blood pressure, body temperature, etc. It is cloud integration with wireless sensor networks.

E. *Tele-Assistance*

Tele-assistance can be a medical act when a doctor remotely assists another doctor carrying out a medical or surgical act [15]. The doctor can also assist another healthcare professional providing care or imaging services, even within the framework of an emergency, to remotely assist a person providing medical assistance to someone in danger while waiting for the arrival of trained medical professionals.

CONCLUSION

Cloud computing is a boon to health care in India. It can compensate all the above mentioned challenges and help in providing efficient, quicker and a quality of healthcare facility which will not be limited by cost and accessibility. Standardized applications can help the hospitals, physicians and clinics to coordinate their work and share data in a patient's diagnosis and treatment to yield better result irrespective of geographic location with the integration of cloud computing technology. Remote assistance can be leveraged successfully through cloud efficiently which proves to be one of the biggest advantages for improving quality of healthcare in rural areas. Also, when bioinformatics gets collaborated with cloud, it opens a new pathway which can change the whole experience of research and development. Thus, cloud computing can be a new frontier to the whole experience of healthcare.

REFERENCES

[1] Wikepedia, cloud computing [online]
http://en.wikipedia.org/wiki/Cloud_computing.

[2] NIST definition of cloud computing
http://csrc.nist.gov/publications/nistpubs/800-145/SP800- 145.pdf

[3] Bhushan Lal Sahu , Rajesh Tiwari "A Comprehensive Study on Cloud Computing " , Proceedings of the IJARCSSE, Vol 2, Issue 9, Sep 2012.

[4] NRHM,
Available:http://planningcommission.nic.in/reports/peoreport/peoevalu/peo_2807.pdf

[5]Mhealth in india,
http://healthcareindia-drruchibhatt.blogspot.in/2012/11/the- real-india-mhealth-and-beyond.html

[6] PwC (2013, Oct) Enabling access to long-term finance
For health http://www.pwc.in/en_IN/in/assets/pdfs/publications/2013/enabling-access-to-long-term-healthcare-funding-in-india.pdf.

[7] Jordi Vilaplana**,** Francesc Solsona**,** Francesc Abella**,** Rosa Filgueira and Josep Rius. " The cloud paradigm applied to e-Health", BMC, Vol 13, Mar, 2013.
Available: http://www.biomedcentral.com/1472-6947/13/35.

[8] OpenEHR, http://www.openehr.org, 2012

[9] KPMG, The Cloud Changing the Business Ecosystem. [Online]
Available:http://www.kpmg.in, 2012.

[10] Arshdeep Bahga, and Vijay K. Madisetti,, "A Cloud-based Approach for Interoperable EHRs," Proceedings of the IEEE, Vol 17, Aug 2013.

[11] Perumal.B, Pallikonda Rajasekaran.Mand Ramalingam.H.M, (2012) "WSN INTEGRATED CLOUD FOR AUTOMATED TELEMEDICINE (ATM) BASED e-HEALTHCARE
APPLICATIONS," at *2012 4th International Conference on Bioinformatics and Biomedical Technology IPCBEE vol.29 (2012) © (2012) IACSIT Press, Singapore* [Online].
Available: http://www.ipcbee.com/vol29/30-ICBBT2012-H10011.pdf

[12] WHO, World Health Statistics 2013[online]
Available:http://www.who.int/gho/publications/world_health_statistics/EN_WHS2013_Full.pdf

[13] Vikas Saxena, Shyam Kumar Doddavula* and Akansha Jain, "Implementation of a secure genome sequence search platform on public cloud-leveraging open source solutions", l. Journal of Cloud Computing: Advances, Systems and Applications 2012, 1:14[Online]
Available: http://www.journalofcloudcomputing.com/content/pdf/2192-113X-1-14.pdf.

[14] Ching-Hsien Hsu, Chun-Yuan Lin, Ming Ouyang and Yi Ke Guo, *"Biocloud: Cloud Computing for Biological, Genomics, and Drug Design",* BioMed Research International, Vol 2013. [Online]
Available: http://www.hindawi.com/journals/bmri/2013/909470/

[15] COCIR (2012, May) COCIR eHealth toolkit contributing to the European Digital Agenda , 2nd edition [online]
Available:http://www.cocir.org/site/fileadmin/Publications_2012/MAY_2012_-_COCIR_eHealth_Toolkit_2012.pdf

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