A Study on Significance of Adopting Cloud Computing Paradigm in Healthcare Sector

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***Abstract*— Healthcare sector is information critical industry that deals with human lives. Transforming from traditional paper-based to Electronic Health Records (EHRs) was not efficient enough since EHRs require resources, integration, maintenance and high cost implementation. Cloud computing paradigm offers flexible, cost effective, collaborative, multi-tenant infrastructure which assists in transforming electronic healthcare to smart healthcare that consists on the use of latest technologies such as smart mobiles, smart cards, robots, sensors and Tele-health systems via internet on pay-per-use basis for best medical practices. Cloud computing reduces the cost of EHRs in terms of ownership and IT maintenance, also it offers sharing, integration and management of EHRs as well as tracking patients and diseases more efficiently and effectively. This review paper represents the significance and opportunities for implementing cloud computing in healthcare sector.**

Keywords*— *Electronic Healthcare, Cloud Computing, Smart Healthcare

I. INTRODUCTION

Cloud computing evolved as a new IT paradigm that provides an agile method to deliver healthcare services in smart way (reducing IT cost, CO2 footprint and providing computing services on demand). It is a business model that has inherited the benefit of other technologies such as distributed, pervasive, ubiquitous, utility computing and virtualization to offer cost-effective and scalable IT services [1]. Cloud computing paradigm differs from other existing technologies such as Remote Hosting Options (RHO) which is data center space and infrastructure offered by several vendors that involves specification of the hardware and software required to support the contracting health organization for a fixed period besides guaranteeing performance and availability. Cloud computing includes all of these features beside Service Level Agreements (SLAs) which are aligned with healthcare organizations needs and scalability [2]. Also cloud differs from Client-Server network topologies in terms of its ability to provide robustness and improved traffic congestion issues [3]. Cloud is defined by the National Institute of Standards and Technology (NIST) as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service providers interaction" [4]. Cloud service providers are responsible for supplying the required computing resources such as hardware and software installation, upgrades, maintenance, backup, data storage, and security under the umbrella of SLAs. Moreover, this promising paradigm can support existing electronic healthcare and the future trend of implementing smart healthcare systems which are able to sense and diagnose complex medical situations. Smart healthcare systems are predictive and have the capability to decide and to interact with the environment. Also they can be energy independent and networked. Healthcare professionals will benefit from the integration of micro-sensors and micro-actuators in products to better treat and take care of patients in the hospitals and at homes which was not possible before [5]. The urgent need for pervasive and ubiquitous real-time access to patients' data from anywhere and from any digital device is essential for proper diagnosis and treatment procedure that leads to achieving high quality of medical services. This review paper is organized as follows. Section-II discusses current healthcare systems issues. Section-III presents emergence of cloud in healthcare. Section-IV defines the role of cloud computing in enabling smart healthcare. Section-V views cloud computing implementations in healthcare. Finally section-VI will present cloud security issues.

II. CURRENT HEALTHCARE SYSTEMS' ISSUES

Healthcare systems mainly include personal and public healthcare services, teaching and research activities. Personal healthcare services are offered at hospitals, homes and relevant organizations. Public healthcare services involve guidelines for drugs, food and safety policies to maintain a healthy environment. Teaching and research activities are essential for prevention, detection, tracking and treatment of diseases. Technology contributes in providing high quality of medical services for healthcare sector. IT solutions brought significant benefits to healthcare by solving issues of human errors and providing an agile way of accessing and processing large volume of patient's information besides saving papers and storage space. The accelerating innovations of smart electronic devices have facilitated the dynamic nature of healthcare delivery. However, still there are several challenges that are facing current electronic healthcare systems in terms of cost, connectivity, client assistant and disaster recovery. Canada Health Council second healthcare report in 2011 [6] described the current need for connectivity to handle

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heterogeneous healthcare computing infrastructure. Successful healthcare interoperability will be dependent upon the ability to connect people, processes, data, policies and procedures. Due to the advent of agile IT infrastructure and the continuous innovation of various smart electronic devices, concern of interoperability between these systems and the existing healthcare systems have been raised. Moreover, limited access to patient-related information during decision making and the ineffective communication among patients' care team members also resulted in the occurrence of severe medical errors which decreased healthcare quality of services [6]. Recently new home-based applications for monitoring elderly people and patients are being deployed with their specific electronic devices. For-example data produced by implantable biomedical devices used for home healthcare monitoring must be stored in healthcare organization's database. This stored data should be available for healthcare professionals to conduct instant and accurate interpretations of the patients' condition while they are at home. The current technologies such as distributed and grid computing are not sufficient enough to handle the existing and new healthcare applications in terms of dynamicity, scaling and low cost [7]. Healthcare sector contains huge amount of data that are increasing in its volume, velocity, and variety which creates two major problems for healthcare organizations regarding to complexity and increased IT expenditures. Managing and maintaining these large datasets is vital to the success of these organizations since their IT hardware and software needs maintenance, monitoring and upgrading by skilled IT personals. Furthermore, software cost, complexity, and inflexibility issues of EHRs have raised the need for low cost technology as service that frees healthcare organizations from buying or managing the computing resources [8]. In addition, healthcare organizations data resides on-premises which makes it under environmental and human threats all together.

III. EMERGENCE OF CLOUD IN HEALTHCARE

Cloud paradigm evolved as a utility computing that provides functionality for managing data in distributed, ubiquitous and pervasive methods supporting several platforms, systems and applications at independent locations [7]. It encompasses of shared computing and services delivered over the internet. It has unique features including on-demand self-service, ubiquitous network access, resource pooling, rapid elasticity and pay-per-use pattern. It facilitates variety of service delivery and deployment models that offers diverse services such Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). Within SaaS the latest standardize applications are offered, while software engineering tools for healthcare developers are offered via PaaS. Virtualized infrastructures such as virtual machines (VMs) are offered through IaaS. These services can be obtained through several service deployment models including Private cloud which is operated for a single organization with strong security features. Public cloud that is available to the general public or industry group. Community cloud which is shared by a group of organizations that have the same interests and Hybrid cloud which combines the features of one or more cloud deployment models. However, selection of these cloud delivery and deployment service models depends on clients' data sensitivity and management requirements [9]. Fig.1 [10] illustrates cloud computing operating environment as follows.

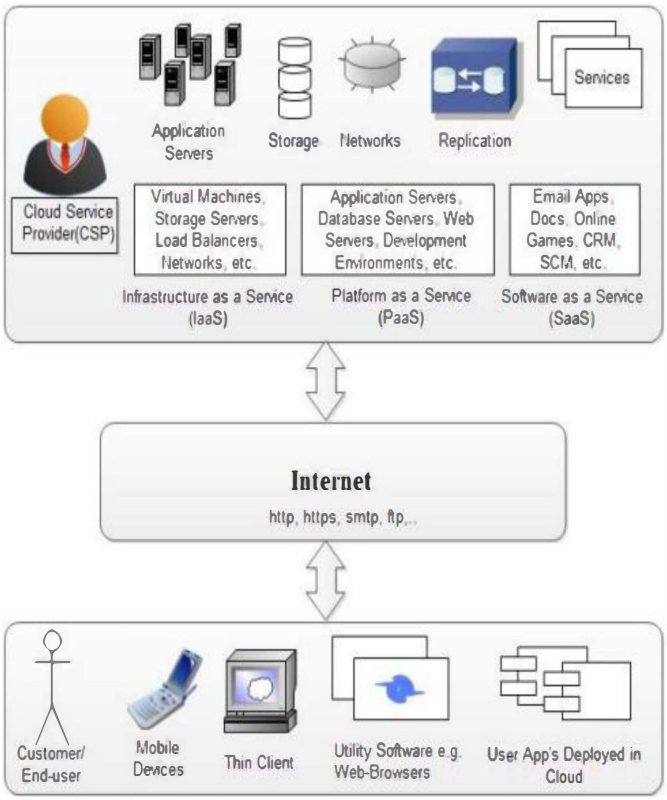

Figure 1. Cloud Computing Architecture [10]

Cloud computing is useful for healthcare sector since it reduces complexity and enables efficient administration of EHRs for improved care best practices. It facilitates the collaboration between the systems in healthcare sectors. Electronic Medical Records (EMRs) are entered once in the system but accessed from multiple places in order to retrieve the required information by authorised professionals [11]. Cloud based architecture can gather data from multiple sources, integrate and analyze that data in real-time also it allows healthcare practitioners to remotely monitor patients ubiquitously and pervasively which will save transportation cost, in-hospital cost besides considering patients comfort for best practices. Cloud computing as a pay-per-use model enables healthcare organizations to leverage the latest upgraded software while minimizing operating costs, covering only the essentials. It can reduce electronic health record start-up expenses, such as hardware, software, networking, personnel, and licensing purchasing cost [12-13]. Cloud offers backup data redundancy and disaster recovery capabilities which are significant for healthcare organizations since it replicates the data in various locations for more availability and robustness [14]. Gartner stated that cloud service revenues are about to reach 148.8 billion USD by 2014, with large percentage from the healthcare sector [15].

IV. ROLE OF CLOUD IN SMART HEALTHCARE

Not only cloud facilitates healthcare best practices also it opens the door for more innovations to take place, and for smart healthcare to assist in reaching patients and old people in rural and urban places as well as people in difficult situations. We are moving towards the era of next generation healthcare that includes smart hospitals, smart homes, smart devices etc, which are interconnected, intelligent and context aware. For example IBM [16] has launched Smarter Planet campaign where ubiquitous, pervasive technologies and ecosystems of organizations are urged to work together in various industries to solve technology issues. Transforming to smart healthcare requires development of personalized management approaches that addresses patients' requirements through empowering them to take the responsibility of their own advanced health informatics and enabling collaborative care through creative utilization of technology [17]. Cloud computing paradigm can assist smart healthcare in various fields such as improved emergency support since cloud interoperable systems provides an immediate access to patient's lab test results that allows the physicians to review those results immediately. In case of public health, cloud computing enables smart healthcare systems to perform information tracking which supports medical research and practices such as bio-surveillance, quick response to disease, chemical or biological attacks and improved monitoring of adverse drug effects [12].

V. IMPLEMENTATION OF CLOUD IN HEALTHCARE

Various research projects have been conducted on cloud computing as an IT business solution to improve healthcare services [17], [18-19]. For-example C. Rolim et al. [20] have proposed a cloud based system to automate the process of collecting patients' vital data via network of sensors connected to electronic medical devices, in order to deliver the data to the cloud storage, real-time processing and distribution. However, no further details were given on how the system ensures trust establishment and privacy protection. U. Lang [21] described a cloud computing protocol management system which provides multimedia sensor signal processing and Security as a Service (SCaaS) to mobile devices. This system has relieved mobile devices from executing heavier multimedia and security algorithms when delivering mobile healthcare services that would improve the utilization of ubiquitous mobiles and expand it to rural communities. A pervasive cloud project called Dhatri [22], has leveraged cloud computing and wireless technologies to enable doctors to access patients' health information anytime from anywhere. Koufi et al. [23] implemented cloud computing emergency medical system prototype for the Greek National Health Service that integrated the emergency system with Personal Health Records (PHRs) to facilitate physicians with easy and immediate access to patient data ubiquitously and pervasively in cost effective way. Moreover E. Schweitzer [24] discussed the significance of cloud computing paradigm in reducing EHRs start-up expenses. Some of the high reputable IT organizations have also invested in cloud medical records services such as Oracle's Exalogic Elastic cloud and Amazon Web Services (AWS), for processing personal health information online [25]. One example of cloud computing implementation in healthcare is "Biomedical Cloud" in form of community cloud. It could be filled with data relevant to biology, medicine and health care that would be accessible to individuals via any electronic digital personal devices [26].

VI. CLOUD COMPUTING SECURITY ISSUES

Cloud computing consists of a variety of service delivery and deployment models with the chance of more advent of new models according to the market and business needs. These existing cloud service models have their own security strengths and limitations with no current standards. These models require new security and trust mechanisms for each cloud deployment and service delivery type. Choosing the right service model depends upon information sensitivity and clients' requirements. For-instance, healthcare Software as a Service (SaaS) clients requires more security and privacy mechanisms to trust cloud computing, because they are outsourcing their data and infrastructure to the cloud. Clients do not manage or control the underlying cloud infrastructure including network, servers, OSs, storage, or even their individual applications capabilities [27]. While having no control over the infrastructure, data and applications which results on clients lack of trust on adopting cloud computing especially when they need high trust mechanisms during exchange of messages and critical information. In Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) securing the data are shared responsibility between the CSPs and the clients. They require two levels of protection for security from CSPs side who provides basic security mechanisms such as end-to-end encryption, authentication, and authorization, as well as from the healthcare client side that must define application dependent access control policies, authenticity requirements, and so forth. Fig. 2 [28] shows various protection measures that cloud service delivery models demands.

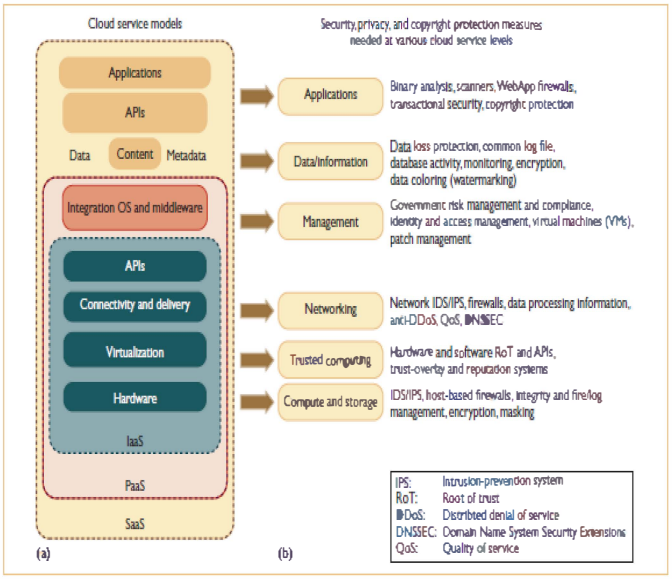

Figure 2. Security Measurements of Cloud Models [28]

VII. CONCLUSION AND FUTURE WORK

Cloud computing facilitates healthcare organizations to focus more on increasing quality of delivered healthcare services instead of managing their own IT infrastructure, and simplifies information sharing among various healthcare institutions involved in the treatment process, which is of utmost importance in healthcare. Continues evolvement of new healthcare devices have been invented to sense humans' vital signs and to monitor any critical change in their health status. The need for cloud computing raised as it provides a technology platform inform of services on demand that facilitates scalable communication without the need of buying new hardware or software to be able to deal with all technology innovations and to overcome current electronic healthcare systems issues. Moving the infrastructure and sensitive patients' data from hospitals to the cloud can pose severe security and privacy issues. However several security standards such as Trusted Platform Module TPM, Self Encrypting Drive (SED) have been implemented by cloud service providers, although healthcare organizations are not yet confident enough to trust and rely on the provided security procedures. In order to overcome the issues of security for implementing a smart healthcare we will propose a framework focusing on enabling security, privacy and trust mechanisms in healthcare cloud in our future publications.

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