

Cloud Computing National e-health services: Data Center Solution Architecture

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Abstract

The global economic crisis has affected the health sector. The costs of healthcare services rise and healthcare professionals are becoming scarce and hard to find, it is imminent that healthcare organizations consider adopting health information technology (HIT) systems. Healthcare professionals must have all the information they require to make prompt patient-care decisions. The growing of mobility connections, people can access all the resources hosted in the cloud any time using any device. The adoption of Cloud Computing in healthcare system for delivering health information and services, driven by the fact that healthcare services in Jordan are almost provided manually from tools to technologies, the growth of inhabitants and refugees crisis, healthcare stakeholders ICT consciousness, and the technical challenges and delays faces the implementation e-Healthcare system. The different problems concerning the managerial, administrative and management aspects, to the concern of physician or researcher, that necessities the infrastructure to process, store, manage patient data, analysis, diagnosis, and so on. Cloud computing is a significant alternative to solve many of these problems providing several advantages in terms of resource management and computational capabilities. In this paper we propose a national cloud computing data centers architecture solution to host healthcare system services computing resources components, proposing building a national e-health cloud environment to overcome many of the challenges confronting the success of Hakeem the core of the National e-Health System (NHS) for the provision of e-Health as a Service.

Keywords:

National eHealth; Cloud computing; eHealth Services; Cloud Internetwork; Information Technologies

1. Introduction

In the recent years, the global economic crisis has affected all domains, including the health sector. Many governments have considered that the solution to this problem is to reduce public expenses on healthcare, to decrease the budgets for health services, to rationalize the medical plans for the population. Also, the health sector has enjoyed the continuous development of new information and communication technologies solutions that has allowed improving and speeding up the health services.

Jordan has one of the most modern medical healthcare infrastructures in the Middle East. The Ministry of Health

(MoH) Strategic Plan 2013-2017 main directions, has identified priority needs, the priority of interest is the use of knowledge management systems to computerize the medical records for all hospitals, comprehensive and primary health centers as part of the agreement with Hakeem. The strategy states that many advantages will be gained at the national level from this computerization through the institutionalization of health accounts, and activation of monitoring of health staff to improve management of human resources, in addition to the completion and application of the health map. Develop and disseminate electronic infrastructure supporting the transfer, sharing and dissemination of knowledge. Develop individual and institutional capacity for knowledge management [1,2].

Cloud computing is a major computing trend that implies the outsourcing Information Technology (IT) infrastructure via Internet. Cloud computing, in all its forms, will change the way we use technology – the heart of companies' business- and how we think about the computing landscape, e-Health to offer Electronic Medical Records (EMR) as a cloud Service. Cloud computing in healthcare system is an important research topic including cloud computing governance in the healthcare system, confidentiality and privacy issues, personal health information record, EMR and mobile cloud computing systems for E-Health. E-Health cloud computing services and deployment models are employed to reduce the expenses and to bring improvement in the management of the health system, the clinical decision-making, and the disease management for all public, private and NGO health care providers in Jordan [3, 4, 5, 6, 7, 8]

For the successful implementation of nationwide e-health program rigorous analysis has to be performed for the requirements of the program and its future growth. National healthcare programs including Hakeem system environments needs an extensive requirements analysis concerning datacenter solution architecture, data and file types for EMR and billing system, medical images databases, storage system, infrastructure and support services required for a unified solution. An architecture solution is dedicated to use and maintain the program production, development, pre-production, training and testing environments. Hakeem faces technical challenges, where by, Hospitals in Jordan generally lack Information

and Communication Technologies (ICT) infrastructure, and most public hospitals do not even have an IT department, and are not interconnected [5, 6, 8].

In healthcare, the use of cloud computing have been proposed as a means for maintaining health records, monitoring patients, managing diseases and cares more efficiently and effectively, or collaborating with peers and analyzing data [7].

In this paper we propose centralized data centers architecture for a national e-Health cloud solution based on three locations including their interconnecting network. The architecture will interconnect all MoH sites (Hospitals, and clinics) to the national data centers to provide EMR and other healthcare services as a cloud service, aligned with the best practices and healthcare security requirements. The architecture network ensures Hakeem services availability and security, this includes data center interconnect communication network and the WAN communication services provided by network service providers. All the connections shall be high available and shall be designed and implemented as a self-healing system. E-Health clouds services need to be scalable, resilience, fault-tolerant, highly available, high-performance, reliable and easy to use, manage, monitor and provision efficiently and economically.

The rest of this paper is organized as follows. Section 2 presents literature review of e-Health Cloud concepts and opportunities. Technical and non-technical challenges facing e-Health Cloud are discussed some research efforts to solve some e-Health Cloud challenges in Section 3. Section 4 discusses migrating e-health to the cloud, e-Health Cloud platform, National Cloud Implementation. Section 5 provides a discussion of different arrangements to address implementation issues of national cloud platform, data centers network connectivity recommendations. Finally, we offer our concluding remarks in Section 6.

2. Literature Review

E-Health cloud concept results by reunifying cloud computing and healthcare services technologies supported by electronic processes and communication. The cooperation between them occur and gained advantages facilitates accessing national healthcare services in the Cloud. Clouds or Cloud Computing (CC) are a large pool of virtualized compute, storage, and networking resources characterized by easiness in usability and agility to offer these resources on demand in a form of development platforms and/or services [3, 9, 10, 11]. The main principle of a cloud is that of applications and data are hosted on servers. The cloud infrastructure typically includes the compute, storage, network, software stacks and applications and its basic characteristic is agility. The

basic cloud service models: Web-based cloud services, Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) [2, 9].

In 2010, the first national e-health initiative in Jordan, the Hakeem project, was launched, to unify cloud computing and healthcare services. However, in spite of having an implemented Electronic Health Records (HER) continue to face a number of challenges and limitations. Thus, the ultimate promise of EHR systems may not be fulfilled and the work of staff not made easier. The main objective of this research focuses on solving the technical challenges that faces Hakeem nationwide implementation, whereby Hospitals in Jordan generally lack ICT infrastructure, and most public hospitals do not even have an IT department, and are not interconnected. The current limitations of current e-health systems are discussed in [4, 8, 10, 12, 13, 14].

Dua' A. Nassar et al. presented a comprehensive study on the EHR of Hakeem, the paper highlights the technical and financial challenges and proposes recommendations to overcome the challenges. As such, the research discussed several guidelines to overcome these challenges in Hakeem implementation and proposes ways to govern, and manage these challenges, they identified that Hakeem faces a number of challenges, include financial, technological, and policy and legislative challenges, while other challenges, such as stakeholder and organizational challenges, may be more specific to the country in question [6, 8].

Abu Khousa [16] identified and suggests recommendations to overcome challenges faced by the Hakeem project and suggests ways to govern and manage these challenges. Found that the expectation is that the implementation of Hakeem will provide a modern health information management system throughout Jordan. However, many technical and financial challenges still exist that could hinder the Hakeem implementation or limit its success.

[17] concluded that cloud computing in healthcare is of growing interest only few successful implementations yet exist and many papers just use the term "cloud" synonymously for "using virtual machines" or "web-based" with no described benefit of the cloud paradigm. The biggest threat to the adoption in the healthcare domain is caused by involving external cloud partners: many issues of data safety and security are still to be solved. Until then, cloud computing is favored more for singular, individual features such as elasticity, pay-per-use and broad network access, rather than as cloud paradigm on its own.

[9] discussed several efforts that contribute to building e-Health Cloud environment. Also, discussed the opportunities of the e-Health Cloud, and explore the limitations of current e-health systems; High cost of implementing and maintaining HIT, Fragmentation of HIT and insufficient exchange of patient data, Lack of

regulations/laws mandating the use and protection of electronic health care data capture and communication, and Lack of e-Health Cloud design and development standards. These networks will be flexible and scalable in integrating and sharing services and data; all of which help in reducing costs and increasing the effectiveness of the healthcare organization. Collecting patients' data in a central location as the e-Health Cloud results in many benefits.

3. Migrating E-Health to the Cloud

The evolving nature of cloud computing creates new opportunities for the E-Health system. The digital health applications, including electronic medical record system, communication system for digital medical images, laboratory information and reporting, early disease warning and trends, are designed for patients and doctors. The software used in cloud for the E-Health care system can be easily updated to the new standards, ensuring a high degree of compliance with the new requirements of the health care system. The applications provide care at a distance including videoconferences for live consultation, messages sent to patients, telephone calls with recorded messages [3, 18].

Among the many advantages of cloud-computing in E-Health can be mentioned: it increases the quality of care system and the speed of sending information, improving the daily workflow [9]. In this manner, the cloud-based systems of E-Health can face the new clinical needs, and the processes of charting, appointment scheduling, patient data management, billing and similar administrative tasks become easier and faster. The introduction of E-Health services and the implementing of electronic medical records provide the rapid transfer of medical information. They facilitate instant access to the patient health information from many locations, by linking various departments and connecting different medical institutions, being easily accessible at a low cost and offering anonymity of its users. There are many benefits in terms of diagnostic accuracy and time of response in systems that facilitate care at a distance but the cost of sustaining digital health systems could be very high and impede low-income countries to implement it. Cloud computing could be a solution by providing services at lower costs.

4. Hakeem E-Health System

Jordan has one of the most modern health care infrastructures in the Middle East. Jordan's health system is a complex combination of three major sectors: public, private, and donors.

4.1 Hakeem

Hakeem project is the first Jordanian initiative toward E-Healthcare. It was launched by His Majesty King Abdullah in 2010. The main objective was to improve quality of patient care and safety. This project started as a pilot in two public hospitals and one medical center. Hakeem will allow clinicians to view their patients' details safely online via their national ID number. It will be accomplished through phases until all the public hospitals and medical centers connected with each other. Details concerning the Hospitals and clinics to be computerized are presented in the MoH strategy [1].

"Hakeem" program consists of several sub-systems, the most important of them is computerized patient record system, patients booking, laboratory and pharmacy systems and others. Following the success of its application in the sites of pilot phase, including Prince Hamzah Hospital and Amman Comprehensive Health Center, a deliberate plan has been prepared to circulate "Hakeem" program in the coming years in all MoH hospitals and centers, the centers of the Royal Medical Services, King Hussein Cancer Center and University Hospitals, in order to improve health services provided to citizens [19].

4.2 Hakeem e-Health Cloud platform

Electronic Health Solutions (EHS) adopted VistA program as e-Health platform, taking into account the popularity of this software and its user base spread all over the world. The Veterans Health Information Systems and Technology Architecture (VistA) is an enterprise-wide information system used throughout the United States Department of Veterans Affairs (VA) medical system. It is a collection of over 100 integrated software modules that has been successfully implemented in many countries around the world. VistA offers a proven, open source, fully integrated, fully functional, scalable information system built around an electronic health record (EHR). Utilizing the VistA Electronic Health Record and a vast array of customized technology solutions, the implementation should deliver improved clinical outcomes for the citizens of Jordan. Its performance competes with many modern no-sql databases. Open Source MUMPS database engine FIS GT.M TM, is a high performance key-value database engine optimized for transaction processing and it is widely used in HealthCare and Banking sectors [20, 21, 22].

5. Proposed National e-Health Cloud Implementation

Migration methodology suggests that building an e-Health on Cloud is a process that must evolve through at least four phases: determine the e-Health Cloud model,

compare the offers of cloud providers, migrate the information to the data center, run and evaluate a pilot implementation. The proposed architecture uses the private cloud model to provide SaaS for MoH hospitals and clinics. Migration and implementation is as per MoH strategy to interconnect and serve the Hospitals and clinics in phases, a pilot implementation is considered in future work using Riverbed simulation tools.

5.1 eHealth National Data Center Solution Architecture

To solve Hakeem technical challenges to become the national eHealth catalyst, we performed rigorous analysis for the requirements of current Hakeem initiative and its future growth to serve all stakeholders in public, private sectors and NGO's. We propose to implement two identical data centers and a compliance site, located at two distinct locations (and a compliance data center) to provide high available secure e-Health cloud services for Hospitals, comprehensive clinics, and Primary Clinks. This section describes the proposed data center solution architecture covering all areas including the requirements of all stakeholders concerning the usage of its services.

The data center solution will host Hakeem systems for all stakeholders; this comprises VistA EMR system, Patient Billing system, and support services. Data center solution will be used to maintain all Hakeem system environments including production, development, pre-production and training as well any testing environments.

The proposed system is running a centralized model, which will serve all Hospitals, and clinics from national data center.

The network service plays a key role for providing Hakeem services for all MoH sites. Accordingly; we proposed the network architecture that ensures Hakeem services availability and security, this includes data center interconnect network and the WAN services provided by network service providers. All the connections shall be high available and shall be designed and implemented as a self-healing system.

Figure 1, illustrates the proposed national eHealth DC solution architecture that compromises of two redundant and the compliance sites to support a national eHealth Cloud solution. The solution supports and hosts the services required for a unified solution, it includes the datacenter architecture, data and file types for EMR and billing system, medical images databases, storage system, and infrastructure, for secure, highly available eHealth cloud services.

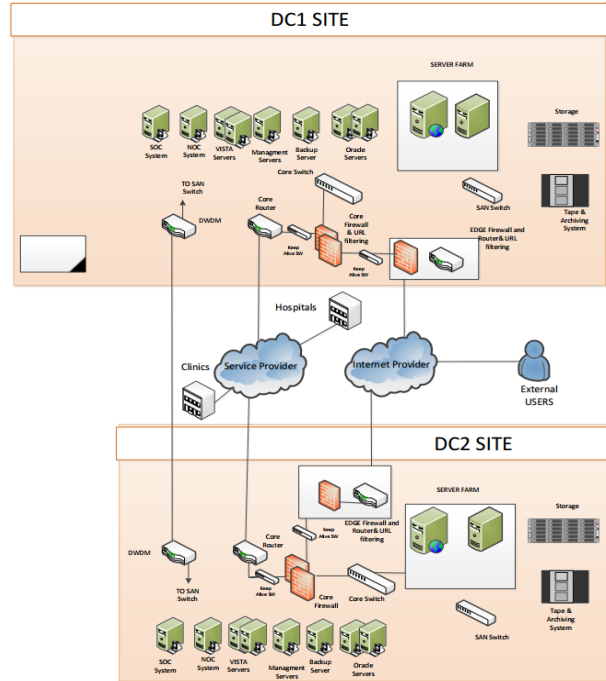


Figure 1, National Data Center Solution Architecture Components

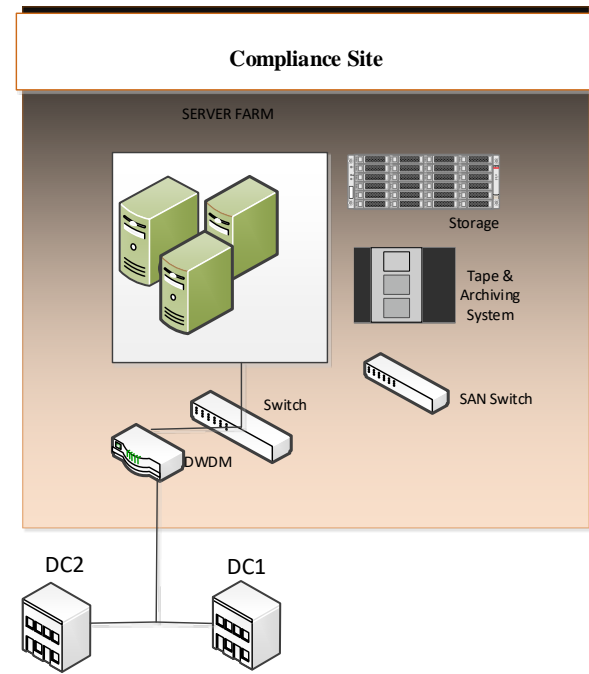


Figure 2 Compliance Site's Solution Architecture

5.2 Compliance Site

The compliance site presented in figure 2, will host the systems related to adhere to the requirements of Ministry

of Health regarding the usage of “electronic medical records and medical prescription”. The site will include the required components that will perform the function of the additional read only copy of the medical records including electronic medical records, financial records and PACS files, we suggest that the compliance site to be located at the Ministry of Information and Communication Technologies affiliated data center.

5.3 Data centers Network connectivity

Health care systems required a DC solution to achieve the 99.99% uptime, active/active status, and to provide the data replication at real time, to accomplish this as presented in figure 1, we proposed; (1) a wire speed connectivity at the physical layer using dark fiber on ring topology as an inter-connectivity medium with Dense wavelength division multiplexing (DWDM) technology for solution implementation, DWDM inter-connectivity is connected in each of the two sites locations to provide the required connectivity services. The solution assumes that all the required components and services to achieve links stability, security, and application level QoS, resiliency and self-healing. (2) a separate entity, not related to MoH to implement a national centralized data centers sites for all stakeholders including MoH. Also, it is more efficient and cost effective to adopt a phased approach in equipping the main two centers with the required compute, storage, and network.

6. Conclusions

In this paper we proposed national data center and network architecture solution to host e-healthcare system and applications based on Cloud Computing for the provision of eHealth services as a cloud service. The different kind and aspect of this specific solution make the Cloud the perfect solution to solve Hakeem actual problem and to satisfy the different health needs. The cloud data center solution ensures an efficient, robust and secure solution for Hospitals and clinical department services recognitions to the use of private aspect and advantages of the cloud distribution model. The use of such technologies opens the doors to a new age for the health consisting of high computational powerful, efficient data storage, rapid data retrieval and high interoperability. The paper emphasizes the four main highlights for the future of the health environment that cloud-powered integration can offer:

- by migrating to the Cloud computing, we solved current Hakeem technical issues, and healthcare professionals across the country can collaborate in real time and share information without the

need to invest in expensive infrastructure. So, they work with a centralized platform allowing to access reports, scans, electronic medical records (EMRs), prescriptions and patient information and medical history such as insurance claims, prescriptions, and lab reports from anywhere in the world.

- having a central repository for patient information will decrease the risks of misdiagnosis or the prescription of the wrong medication, as well as eliminating chances of conflicting treatments where multiple healthcare professionals are involved.

A health care national solution is important steps in the direction of upgrading the health system, with visible advantages for both the patients and the medical service providers. Thus, our view on moving e-Health on Cloud refers to the implementation of a solution meant to reduce infrastructure costs both in public and private sectors, improving the performance and QoS.

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