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An Data Center Solution Architecture For Advanced Healthcare Monitoring System

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ABSTRACT

Electronic Health Record (EHR) is a digital record shared across different healthcare settings, by network-connected enterprise-wide information systems called EHR systems. Cloud computing paradigm is one of the popular Health Information Technology infrastructures for facilitating Electronic Health Record (EHR) sharing and EHR integration. Healthcare clouds offer new possibilities, such as easy and ubiquitous access to medical data, and opportunities for new business models. However, they also bear new risks and raise challenges with respect to security and privacy aspects. 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.

Key Words: *Cloud Computing, Healthcare Monitoring System (HMS), National e-Health System (NHS), Data Center Solution Architecture, Compliance Site's Solution Architecture.*

I. INTRODUCTION

Now days the entire world concentrates on ehealth care systems. The Austrian policy paper for eHealth "An information and communication strategy for a modern Austrian Health Care" was developed in 2006 and focuses on the following issues, Portability and interoperability aspects, such as standardisation, pecific eHealth applications, e.g. telemedicine and eCards, legal aspects regarding data protection and patient access. In Austria Principle laws are in the responsibility of the Federal Ministry of Health which is the supervisory authority on national issues; the implementation of the legal provisions in the healthcare system is in the responsibility of the federal provinces (nine Länder) following a decentralized model. The Federal ministry is supported by subordinated authorities such as the Federal Office for Safety in the Healthcare system. Since 1980, part of the responsibility for healthcare policy in Belgium has been devolved from the federal Government to the regional governments, with the Federal Ministry of Health to be the responsible body. The federal authorities determine the general legislative framework for the health system by issuing laws and by determining the annual budget.

Fig: The Basic Cloud Architecture.

They regulate and finance the compulsory health insurance; determine accreditation criteria; finance hospitals and so-called heavy medical care units, and register and control pharmaceuticals. The regional governmental structures (Flemish community, French community and Brussels) are responsible for health promotion and preventive healthcare; maternity and child health services; different aspects of elderly care; the implementation of hospital accreditation standards. Jordan has one of the most modern medical healthcare infrastructures in the Middle East. The Ministry of Health 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 heath care providers in Jordan. 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.

II. PREVIOUS RESEARCH WORKS

In 2013 Sangram Ray, Urbi Chatterjee and G.P. Biswas[1] proposed a Efficient and Secure Communication Architecture for E-Health System.In this work A digital public-key certificate based authentication protocol for registration phase and symmetric encryption/decryption based protocols have been proposed for secure communication of the proposed e-health system. The in-depth security and performance analysis of they proposed communication architecture shows that the system is efficient and well secured. 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 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. 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].

Public Key Infrastructure

Sangram Ray, Urbi Chatterjee and G.P. Biswas[1] proposed the existed system is supported by existing PKI (public key infrastructure) where each entity must posses a digital certificate issued by a Certificate Authority (CA).A CA is a federal or state organization that binds an entity's public key with its identity and issues a digital certificate with prior authentication. It maintains a directory that contains all the entities identity and the corresponding public keys. After receiving a request for a certificate from an entity, a CA first verifies the entity's identification and issues a public key certificate that contains all the information of the entity, its public key and a signature of the CA. The signed value contains the hash digest of all fields, encrypted with the CA's private key. Note that a CA has a well known public key that cannot be forged, so any user can use the public key of the CA to verify other user's certificate. For the sake of
clarity, an overall mechanism of certificate issuance is given in figure 1. However, it is not possible to have just one CA issuing all certificates for all users. So, the responsibility for creating, storing, issuing and revoking certificates is distributed among several CAs followed by several trust models such as hierarchical model, mesh model etc. In this architecture a use case diagram of the proposed ehealth system is described to represent the different ways to be used by the users. It consists of four actors as follows:

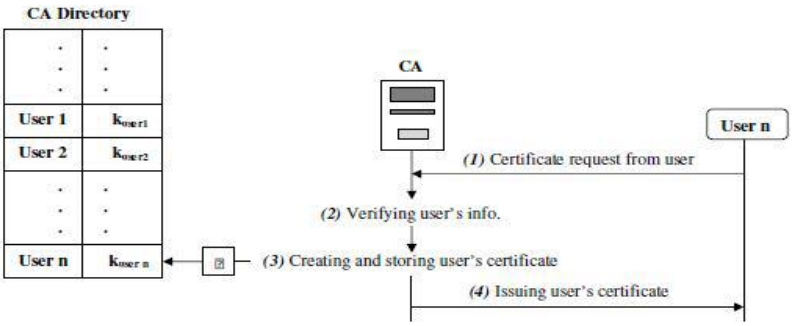

Figure: Mechanism of issuing a certificate by CA.

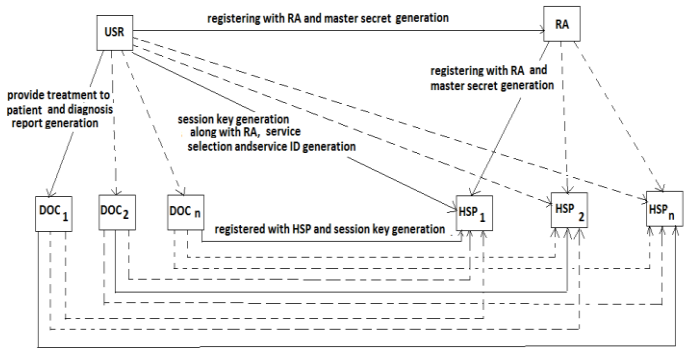

Figure: Existed e-health communication architecture.

PATIENT: It represents a patient with a public key certificate issued and signed by CA.
RA: It is a registration authority which is responsible for
the registration of users/actors such as patients, hospitals and is responsible for storing patient's PHI (protected health information) data. A user gets treatment only from those hospitals which are registered to the RA.
HSP: It is a hospital which provides medical services to the patients.
DOC: It represents a doctor who may register at different hospitals. After registration, he treats patients, gives medical advices and generates the patients' PHI data.The proposed system has two basic use cases –1) Registration and (2) Patient's treatment. The registration use case signifies the registration of the patients,
hospitals, doctors and the patients' treatment use case signifies the treatment procedure provided to the patients by the system.

Use case 1.1: Patients are registered to RA with prior mutual authentication using their public key certificates and negotiate a unique master secret key between a patient and RA.
Use case 1.2: Hospitals are registered to the RA and a unique master secret key is negotiated by each hospital with RA.
Use case 1.3: Doctors are generally associated to different hospitals and accordingly, they are registered to the different hospitals, and a unique master secret key is negotiated by each doctor during registration. Since a doctor may do practice at different hospitals, so it is necessary to negotiate a session key with the concerned hospital during treatment session and the same is deleted after completion of the treatment process. Thus, the session key, which is generated using the master secret key, remains active during each session.
Use case 2.1: Initially, a patient requests to RA for treatment at a particular hospital. The RA then generates a session key and a user token among the patient, hospital and itself.
Use case 2.2: A patient sends his/her disease symptoms to the hospital, and on receiving, the hospital decides the service type necessary and accordingly generates a service ID.
Use case 2.3: Hospital informs the doctors about the patient's diseases symptoms, and the doctor treats the patient with the help of the patient's previous medical reports (if any) retrieved from the RA. The doctor may interact with the patient for several times during treatment and finally generates the patient's PHI data.
Use case 2.4: The doctor uploads the patient's newly generated PHI data to RA and sends a copy to the patient.

III. PROPOSED ARCHITECTURE

Migration methodology suggest 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.

eHealth National Data Center Solution Architecture

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.

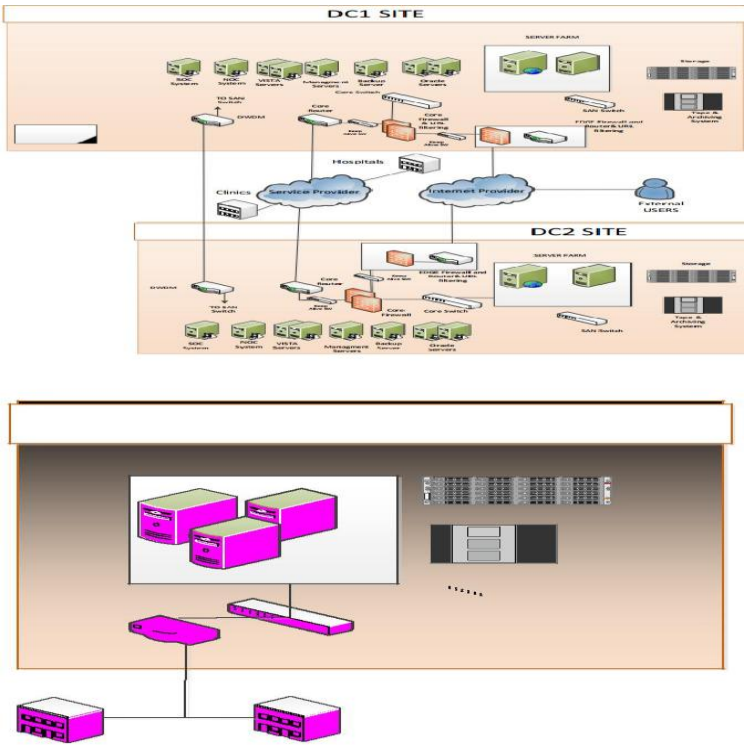

Figure: The proposed Data Center Solution Architecture Components & Compliance Site Architecture.

The below Figure 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.

Compliance Site

The compliance site presented in above figure, 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.

IV. CONCLUSION

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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