

# A Study on Autonomic Cloud Environment for Hosting Electronic Health Records

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**Abstract**—Cloud computing promises a more cost effective enabling technology to outsource storage and computations. Healthcare systems that are truly open, scalable, heterogeneous and capable of supporting the personnel. The use of cloud computing in healthcare will span both clinical and non-clinical applications. Electronic Health Records (EHR) offer patients the opportunity to access their own medical records. Apart from EHR, cloud computing will also apply to other clinical uses, such as physician order entry and software imaging and pharmacy use. Non-clinical uses will likewise benefit, including management apps for patient billing, claims and revenue cycle management.

**Index Terms**—Cloud Computing, HealthCare, EHR, EMR, HITECH, Google Health, Microsoft Health Vault, CloudSim.

## I. INTRODUCTION

### 1.1.1 Cloud Computing

The technical foundations of Cloud Computing include Service-Oriented Architecture (SOA) and Virtualizations of hardware and software. The goal of Cloud Computing is to share resources among the cloud service consumers, cloud partners, and cloud vendors in the cloud value chain. Cloud Computing is likely to benefit a number of sectors and health being one of them.

### 1.1.2 Health care in Cloud Computing

For all the innovations transforming the healthcare industry, one area where it remains almost universally behind the times is in the use of information technology. Even some of the best equipped hospitals still rely on telecommunication as the primary communications tool for doctors; coordinating care schedules and other administrative processes remain cumbersome. At the same time, consumers and patients have very little transparency on health plan costs and covered services, with health insurance websites providing very little clarity to alleviate the problem.

One reason for this slow adoption of installing advanced IT solutions is attributed to high equipment costs, which usually involves new servers, storage and applications. In addition, there are high maintenance costs associated with keeping these systems up-and-running with software patches and upgrades. As a

result, hospital administrators and boards would rather invest their limited financial budgets on new medical equipment or hire additional doctors, specialists and nurses. For smaller private clinics and doctors, the cost of technology is simply too high to even consider the option.

There is a way to eliminate the high capital expenses while still acquiring the latest IT solutions to improve healthcare services using cloud computing.

Imagine reading your electronic health record on your smart phone, or better yet consulting a doctor's opinion live from your tablet! These are great possible services enabled by cloud computing applications, which will change the nature of the competition between healthcare companies. To this end, like in any other field, CEOs of the health industry understand the paramount importance of cloud in their business.

Healthcare organizations will continue to see IT budgets being squeezed. CIOs and IT managers need to find creative approaches to delivering higher levels of service to their users. Cloud computing offers a viable alternative for many organizations of all sizes and health professionals seeking to solve current problems while delivering the best possible healthcare service.

Cloud computing can help clinicians and hospitals to coordinate and exchange information more efficiently. The use of cloud computing architecture helps in eliminating the time and efforts, needed to roll a healthcare IT application in a hospital.

### 1.1.3 Electronic Health Records

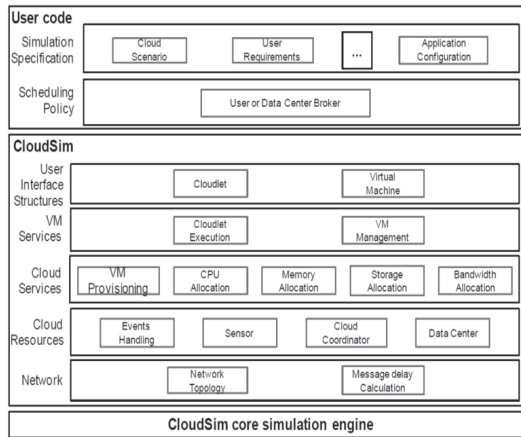
An electronic health record (EHR) is an evolving concept defined as a systematic collection of electronic health information about individual patients or populations. It is a record in digital format that is theoretically capable of being shared across different health care settings. In some cases this sharing can occur by way of network-connected enterprise-wide information systems and other information networks or exchanges. EHRs may include a range of data, including demographics, medical history, medication and allergies, immunization status, laboratory test results, radiology images, vital signs, personal stats like age and weight, and billing information. This transition provides numerous benefits for patients, health insurance companies and medical staff. For example,

patients gain detailed access to their records, which they can share with family members or the doctors of their choice, and insurance companies save money by avoiding repetition in patient care.

When lives hang in the balance and speedy treatment is required, cloud based EHR and cloud based EMR can provide fast and accurate access to patient medical information. Many times, doctors and ER physicians simply cannot wait for a manual search of patient information before beginning treatment. This waiting time can be dramatically reduced through the use of EMR systems and EHR systems. Cloud based systems offer the fastest, safest and most secure medical information available to any medical office, clinic or hospital.

#### 1.1.4 CloudSim

CloudSim goal is to provide a generalized and extensible simulation framework that enables modeling, simulation, and experimentation of emerging Cloud computing infrastructures and application services, allowing its users to focus on specific system design issues that they want to investigate, without getting concerned about the low level details related to Cloud-based infrastructures and services support for modeling and simulation of large scale Cloud computing data centers.



##### 1.1.4.1 CloudSim Features:

- support for modeling and simulation of virtualized server hosts, with customizable policies for provisioning host resources to virtual machines
- support for modeling and simulation of energy-aware computational resources
- support for modeling and simulation of data center network topologies and message-passing applications
- support for modeling and simulation of federated clouds

- support for dynamic insertion of simulation elements, stop and resume of simulation
- support for user-defined policies for allocation of hosts to virtual machines and policies for allocation of host resources to virtual machines

## II. RELATED WORK

Healthcare providers looking at automating processes at lower cost and higher gains. Cloud computing can act as an ideal platform in the healthcare IT space. A number of hospitals could share infrastructure with large number of systems linked together. By this pooling the hospitals automatically reduce the cost and increase utilization. The resources are delivered only when they are required. This also means real-time availability of patient information for doctors, nursing staff and other support services personnel from any internet enabled device.

#### 2.1 2009 HITECH Act

The Health Information Technology for Economic and Clinical Health Act set meaningful use of interoperable EHR adoption in the health care system as a critical national goal and incentivized EHR adoption. The "goal is not adoption alone but 'meaningful use' of EHRs — that is, their use by providers to achieve significant improvements in care.

#### 2.2 Google Health

Google Health is based on open standards (Continuity of Care Record for data exchange, SOAP for the web-services interoperability), and provides a development API, programming libraries and test infrastructure. Google guarantees it will protect the privacy of the information by giving the user complete control over it. To this end, Google Health features no advertising. Google Health is oriented towards the U.S market, as the third-party services it uses are exclusively American.

#### 2.3 Health Vault

Health Vault consists of two distinct products – an electronic repository for health data and a specialized search engine for health information on the World Wide Web, both free to users. Health Vault is sometimes described as “PayPal for health information” for being able to store and share medical information at the discretion of its owner, as well as for utilizing similar security features. Health Vault stands out from other EHR providers because of its extensive partner network, particularly in the area of EHR.

## III. SYSTEM DESIGN

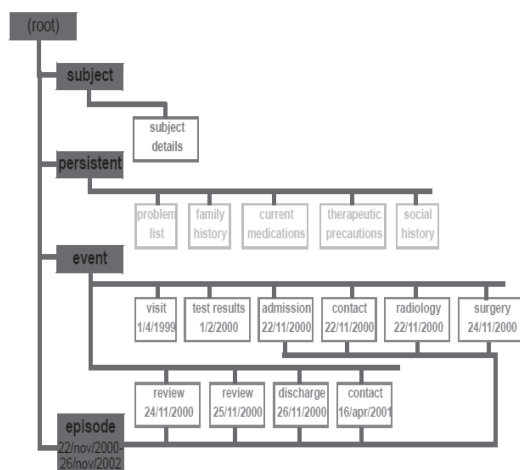
#### 3.1 cloud based EHR system

A cloud based EHR system works in the following ways:

- Relies on the Internet for record storage and retrieval

- Electronic transmission of patient health records and medical information
- Medical information is accessed using standard Internet applications
- Access on any PC, laptop or smartphone

3.1.1 EHR Reference Model:



**Subject:** A composition containing clinically relevant demographic data of the patient.

**Persistent:** Compositions containing information which is valid in the long term.

**Event:** Compositions containing information whose currency is limited to the short term after the time of committal.

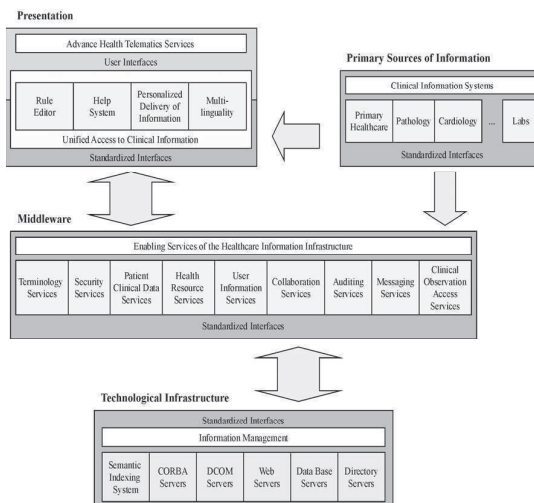
**Episode xxx:** rather than using a single ‘event’ folder, it may be convenient to group event compositions into episodes (periods of treatment at a health care facility relating to one or more identified problems) and/or other categories such as on the basis of type of healthcare (orthodox, homeopathic, etc).

A justification for these particular categories is based on patterns of access. The persistent category consists of a dozen or so compositions described above, and which are continually required by querying (particularly lifestyle, current problems and medications). The event category consists of clinical data whose relevancy fades fairly quickly, including most measurements made on the patients or in pathology. Compositions in this category are thus potentially very numerous over the patient’s lifetime, but of decreasing relevance to the clinical care of the patient in time; it therefore makes sense to separate them.

A patient’s EHRs are typically dispersed over a wide range of distributed EMR systems in clouds. Different EMR systems have different data schemas to manage logical and semantic relationships between data elements drawn from various medical domains. Such medical domains include patient demographics, labs, medications, encounters, imaging and pathology reports, and a variety of other medical domains from

primary, speciality and acute care settings. Each node in the hierarchical structure is labeled and the root of the hierarchical structure represents a particular EHR instance.

3.2 System Architecture



The above architecture is divided into

- Presentation-This Presents the Required information most effectively.
- Primary sources of information-where the key information about EHR is placed.
- Middleware-This is the layer which consists of various services like technology services, security services, collaboration services, patient clinical data services, user information services etc..
- Technological infrastructure-This consists of various Distributing Computing technologies like CORBA, DCOM etc.. for sharing and processing Electronic health records.

3.3 EHR Services Offered

- Infrastructure Hosting
- Software as a Service
- Desktop virtualization
- Unlimited storage capacity
- Managed backup and server maintenance
- Top tier security & reliability
- IT Consulting
- Remote connectivity
- Automated calling programs
- Interactive voice response (IVR) technology
- VoIP

IV. COMPARATIVE ANALYSIS

4.1 Cloud-Based EHR vs. Client-Server

EHR systems basically fall into two categories: cloud-based or client-server. In a cloud-based system, a practice’s data is stored on external servers and can be

accessed via the web, requiring only a computer with an Internet connection.

Client-server systems store data in house, requiring a server, hardware and software be installed in the physician's office. While in-house servers have traditionally been the norm, practices are increasingly switching to the cloud for a number of reasons.

#### 4.1.1 Benefits of Cloud-Based EHR

1. Implementation is much simpler with cloud-based EHR systems: EHR software runs on the web instead of the computer, meaning no hardware or software installation. Practices can prevent interruption of cash flow and get a faster return on investment with an implementation process much quicker than traditional client-server systems.
2. Practices realize tremendous savings from cloud-based EHR systems: One of the largest hurdles for small medical practices is the initial cost of EHR installation. Client-server systems can cost \$40,000 or more just to get set up, and then the licensing fees, maintenance costs, updates and patches cost more on top of that.

Since cloud-based EHR requires no hardware installation or software licenses, implementation is a fraction of the cost. Practices pay a monthly fee, like a utility bill, as part of an arrangement called software as a service (SaaS).

3. IT resource requirements are significantly reduced: when practices choose to move medical records to the cloud. Instead of requiring a team of IT experts to install, configure, test, run, secure and update hardware and software, all of that is done internally in the cloud by the SaaS provider. Updates are also done automatically in web-based systems, so practices are running on the most up-to-date version available.
4. Web-based software provides superior accessibility and collaboration: Over client-server systems because users are able to securely log in to the system from anywhere they have Internet connection. The ability to access the system outside of the office allows physicians, staff and patients to collaborate more effectively in a secure environment and provide better continuity of care.
5. Scalability is simplified with cloud-based systems: Small practices are able to expand without the standard IT growing pains. A web-

based EHR system makes it easy to add new users, doctors or locations. The flexibility of web-based software allows small practices to think big and grow without breaking the bank.

## V. CONCLUSION

### 5.1 Summary

Joining up diverse and sometimes discipline-specific and culturally specific kinds of clinical information to compose a whole-person EHR that can safely, legally and useably replace paper records is a complex challenge. A Cloud-based solution for healthcare requirements can bring quantifiable raw cost savings, as well as a number of strategic benefits designed for the betterment of the health care systems in a much broader sense. "These include operational cost, cost restructuring, competency alignment, risk management, rapid scalability and deployment benefits."

In practice, Today, 41.8 per cent of a healthcare organization's IT budget is allocated to a traditional IT deployment, whereas in two years' time this will decrease to 35.4 per cent, a decline of six percentage points. With this change comes an increase in the percentage of the overall IT budget allocated to private and public Cloud services. For infrastructure suppliers, this signals a very real change in how firms will procure services and solutions in future.

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