Opportunities and Challenges in Bioinformatics for Implementing Mobile Cloud

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OPPORTUNITIES AND CHALLENGES IN BIOINFORMATICS FOR IMPLEMENTING MOBILE CLOUD

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Abstract : *Biomedical research has become a digital data-intensive endeavor, relying on secure and scalable computing, storage, and network infrastructure, which has traditionally been used, supported, and maintained locally. For some types of biomedical applications, cloud computing has emerged as an alternative to locally maintained traditional computing approaches. Accordingly, I think that Mobile Cloud Computing (MCC) is as the heart of healthcare system. MCC offers new kinds of services and facilities for patients and medical staff. For this I have tried to propose a new mobile medical online system. To this senario, I tried to implement a medical cloud expert system (MCES) solution using Google's Android OS. The developed system has been working using the CloudSim Simulator. This paper gives initial results of the system in practice. In fact the proposed solution shows that the MCES has a regulating capability to tackle the problem of existing application. The performance of the MCES is compared with the traditional system in polyclinic which showed that this prototype yields better performance than usual application.*

IndexTerms - *Healthcare ;Mobile web services;Cloud computing; CloudSim; Medical cloud expert system;Bioinformatics*

I. INTRODUCTION

Cloud computing, the inventive terminology for the extensive imagined vision of computing as a service [1], empowers appropriate, on-demand control access to an integrated place of configurable computing resources (e.g., webs, requests, application, facilities and information) that can be quickly arrayed with strong proficiency and nominal supervision overhead [2]. The advantages of Cloud Computing include: on-request self-service, network access to global system, position independent resource gathering, quick resource resistance, pay as per convenience, transferal of hazard, etc. [2, 3]. Thus, Cloud Computing could simply assistance its users in evading outsized principal amounts in the organization and controlling of both software and hardware. The major concepts involved are grid computing, distributed systems, parallelized programming and visualization technology. A single physical machine can host multiple virtual machines through virtualization. Problem with grid computing was that effort was majorly spent on maintaining the robustness and strength of the cluster itself. Big data technologies now have analyzed solutions to process huge collocated data sets cost effectively. Cloud computing and big data technologies are two different things, first is facilitating the cost effective storage and the other is a Platform as a Service (PaaS), respectively.[4]

Three types of clouds are: public, Private and Hybrid cloud. First one refers to resources like infrastructure, applications, platforms, etc. made available to normal public, available only through Internet on ''pay as you go'' basis. Second one refers to virtualized cloud infrastructure owned, reside and managed by an only organization. Third one refer to the relation of private and public, for scalability and fault tolerance via Virtual Private Networking (VPN). A fourth model is also proposed, namely Community Cloud.

Cloud types discussed above can use some more cloud services-Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). SaaS enables the consumer to handle the cloud provider's applications (e.g., Google Docs) that are running on a cloud provider's infrastructure, whereas PaaS enables consumers to create or achieve applications and tools and to setup them on the cloud provider's infrastructure. IaaS enables a consumer to provision handling, storage, networks, and other fundamental computing resources. Most public cloud providers like AWS, GCP, and Microsoft Azure provide IaaS, PaaS, and SaaS, and the customer can select the best applicable solution for their individual needs. Cloud adoption, regardless of type, has varied in industry because of different levels of security and other features required for operation. Previously, both public and private clouds have been used more in unregulated industries and to a lesser extent in regulated industries, but this are changing [5]. Federally funded scientific data sets are being made available in public clouds [6]. For example, Human Microbiome Project (HMP) data, funded by the National Institutes of Health (NIH), is available on AWS simple storage service (S3) [7], and more biomedical data sets are becoming available in the cloud.

The motivations for the use of Mobile Cloud Computing in healthcare comprises of several benefits that can be derived from the combinations of mobile and CC:

In my research, MCC offers relevant benefits to our healthcare solution such as:

- *Collaboration* MCC maintains collaboration and team care delivery.
- *Performance* MCC model can advance expeditious access to computing, share information more efficiently, large storage of big data (cloud-based medical records) and reduce costs.
- *Modernization* MCC will lower the boundaries for modernization and innovation of healthcare applications.
- *Scalability* several patients utilizing the healthcare applications.
- *Portability* the ability to remotely access applications and data to provide functionality for managing information in distributed and ubiquitous applications.

This research defines hybrid system that combines multi agent system (MAS), web service and MCC. In given research paper, we will only detail the MCC and our healthcare web services. This paper is organized as follows: firstly I started with an introduction, then I trid to describe the existing cloud healthcare solutions and a state of the art of MCC. In the next section, we present our cloud hospital architecture designed to mobile healthcare applications and we introduce the implementation details, the evaluation and discussion. Finally, I educed with a summary of the article with further praposal for additional advancement.

II. ISSUES AND CHALLANGES

A. Security

The procedure to keep data on the cloud and access that data from the cloud, the main things are intricate: the customer, server, and network among them [9].These three components must keep robust security to make mandatory of data security. User is liable for guaranteeing that no another party can approach to the model. In this case when consider the security issue of cloud storehouse, our motive is more about another two components i.e. server and the network among server and client.

All cloud server storing sources are handled by high achievement and high accessibility storehouse capacity system. Several cloud results work on personal hard-disks from the host network, which describes any computational or stowage let-down can cause in down period and probable data loss. As cloud servers are self-directed, if there occurs any server crash in kept data, these can be endangered against in house and external attacks.

a. Authentication and Identity administration

By using cloud services, clients can simply access their private information and make it accessible to several services across the web. An identity management (IDM) tool can support to validate users and services based on identifications and individualities.

b. Access Control and Accounting

Heterogeneity and variety of service area, as well as the domains' diverse access necessities in cloud computing surroundings, request fine-grained access control strategies. In individual, access control services should be flexible sufficient to detention dynamic, framework, or feature- or identity-based access requests and to impose the attitude of least honour. Such access control services might essential to incorporate privacy-protection necessities conveyed through composite guidelines.

c. Trust Management and Policy Integration

Although various service suppliers coincide in clouds and co-operate to deliver numerous services, they might have diverse security methodologies and privacy policies, so we must address heterogeneity among their mechanisms. Cloud service suppliers might require to comprise numerous services to empower superior application amenities. Therefore, mechanisms are compulsory to confirm that such a dynamic association is controlled securely and that security breaks are successfully scrutinized during the interoperation procedure.

d. Secure Service Management

In cloud computing environs, cloud service suppliers and service integrators comprise services for their users. The service integrator offers a podium that lets individual service providers compose and interwork services and supportively offer surplus services that meet users' safety necessities.

e. Privacy and data Protection

Privacy is an essential concern in all the issues we've deliberated so far, containing the requirement to secure individuality facts, strategy mechanisms during incorporation, and operation accounts. Many administrations aren't contented storing their data and records on systems that exist in outside of their on premise data centres.

In the secure information network service model, we consider security and privacy issues in two layers, since MCC is a combination of mobile devices and cloud computing: Mobile device-based security and cloud-based security Fig. **1**.

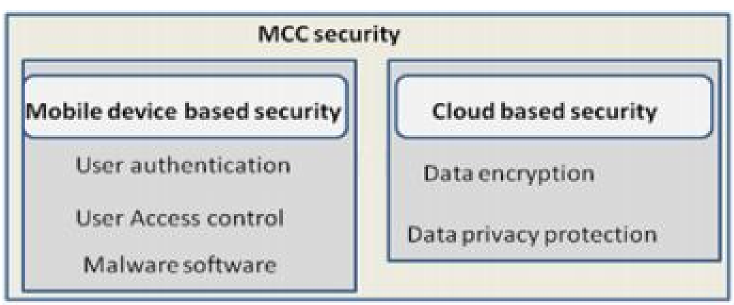

Fig.1 Security Layers of MCC

B. Data Integrity and confidentiality

Confidentiality and uniformity of data can be confirmed on the both adjacent of server i.e. server side and user side. Communication among user and server must be through a protected network, means the data should be private and uniformity during the transmission over server and user. Several protocol such as SSL [10] to attain to a secure communication.

C. Data Availability

Availability of resources as well as stored data and information to the server is confirmed, and then the server should always guarantee that kept information are available for clients [11]. The final component of significance also is the network among the server and the user.

D. Dynamic Environment

Data used on cloud computing should be in a dynamic auditing structure. The central theory in this self-motivated atmosphere is that all regulated and flexible setup should have lively action such as update, add, and remove. The cloud podium which has virtualized circumstances also should have some definite autonomous environs.

III. CLOUD COMPUTING AND MOBILE CLOUD COMPUTING IN HEALTH CARE SERVICES

3.1 Cloud computing in health care services:

As per NIST (National Institute of Standards and Technology, USA), “Cloud Computing is a model for enabling convenient, on-request work access to a shared pool of configurable resources (e.g., networks, servers, storage, applications and services) that can frequently be provisioned and released with minimal management effort or service provider interaction”.[12]

In simple words, Cloud computing is an architectural model that exercise many of the same components used in data collection centers around the world in a more flexible, responsive, and adaptive way.

The Cloud computing uses the information sharing from client to the organization through the virtual data centers. The cloud technology merges three models: SaaS (Software as a service), PaaS (Platform as a service) and IaaS (Infrastructure as a service).

Cloud in healthcare information is rapidly becoming the most significant course for the development of healthcare information systems.[13] Cloud Computing can improve health care services and benefit biomedical research providing Centralization, Collaboration and Virtualization.

Recent studies indicate that Cloud Compute can facilitate the biomedical informatics research communities. The study shows that as many healthcare organizations are using cloud-based solutions.

3.2 Mobile cloud computing in health care services:

The Mobile Cloud Computing Forum considers Moblie Cloud Computing (MCC) as “an infrastructure where both the data storage and the data processing happen outside of the mobile device”[16]. MCC is defined as a new model for mobile applications: “it will be transferred to a centralized and powerful computing platform in the cloud”[17].

The aim of Mobile healthcare is to facilitates mobile healthcare users easy and fast access to the resources (e.g., patient health records) and offer a variety of parallel and distributed services. The aim of applying MCC is used to moderate the limits of traditional medical applications (e.g., security, small storage, and medical errors ([14][15]).

In the literature, there are only few works about MCC applications in healthcare, such as Upkar Varshney[18], presents five key of mobile applications in the pervasive healthcare ecology.

1. Comprehensive health monitoring services enable patients to be monitored at anytime, anywhere.
2. Intelligent emergency management system can manage the large call volume received from accidents or incidents.
3. Health-aware mobile devices which detect blood pressure, pulse-rate and level of alcohol.
4. Pervasive access to healthcare information allows caregivers and patients to access medical data.
5. Pervasive lifestyle incentive management can be used for paying healthcare expenses and other healthcare charge.

In the same way, [19] proposed a prototype of mhealthcare information management system called @HealthCloud based on MCC and Android operating system.

In practice, Tang and his colleagues implement a telemedicine homecare management system [20] in Taiwan to monitor patients with hypertension and diabetes. The system exam ines 300 patients and stores more than 4736 records of glucose and blood data on the cloud.

Then, [21-23] present a solution to protect the patient’s health information: [21] utilizes P2P paradigm to ensure security and data in the clouds. In [22], authors present security as a service to defend mobile applications. In 2015, [23] present a secure mobile health application which is based on hybrid cloud architecture combined with cryptographic techniques.

In [24], the authors proposed an inference model based on ontology and a bayesian network to infer the depression diagnosis. Authors present a prototype using Multi-Agent System in the mobile cloud.

The system reported by Shan et al. [24] is most similar to the current study because both employ a mobile device interface. Nevertheless, Shan et al. only focused on the development of mobile environment based on depression ontology. However, the system did not exploit an inference model of other diagnosis.

Other studies have focused on the security level. However, most of these studies only provided a security model for healthcare [21-23]. Thus, these studies focused only on how to ensure security on medical data placed in the mobile cloud environment. By contrast, in our study, we implement a real prototype for patients and doctors to use on a practical mobile device, but we also exploited the mobile cloud (CloudSim) and MAS to deploy our healthcare system in the cloud environment.

In proposed system, I present our MCES solution that combines MAS and MCC in healthcare domain.

3.3 Big data manipulation of Genomics Projects

In the cloud computing model, computational resources such as processors and hard disks are thought of as utilities to be rented from a provider (Table 1). The term ‘cloud provider’ is most often used to describe major US-based commercial services such as Amazon Web Services (AWS), Google Cloud Platform or Microsoft Azure. However, the number of cloud vendors has proliferated recently, and many other cloud services, both commercial and academic (for example, Open Science Data Cloud, the

EMBL–EBI Embassy Cloud, Helix Nebula and Jetstream) are currently available worldwide (Table 1). These have matured rapidly in recent years, creating new data centres, lowering prices, adding services and generating newsworthy profits28. Providers control vast pools of computers and storage that are organized into data centres scattered across the world. Users request resources, use them and then release them back into the pool when the work is complete. Fees are incurred according to usage. Storage incurs a per-GB per-month fee, and computers incur a per-computer per-unit-time fee, where time units might be seconds, minutes or hours. Users are billed monthly, just as for a home utility.

Table 1: **Cloud providers**

Resource	Platform & availability
Data as a Service (DaaS):	
AWS Public Datasets	Cloud-based archives of GenBank, Ensembl, 1000 Genomes, Model Organism Encyclopedia of DNA Elements, Unigene, Influenza Virus, etc.; http://aws.amazon.com/publicdatasets
Software as a Service (SaaS):	
BGI Cloud (unpublished)	Cloud-based implementations of various genomic analysis applications; http://cloud.genomics.cn
CloudAligner [28]	Fast and full-featured MapReduce-based tool for sequence mapping; http://cloudaligner.sourceforge.net
CloudBLAST [31]	A cloud-based implementation of NCBI BLAST; http://ammatsun.acis.ufl.edu/amwiki/index.php/CloudBLAST_Project
CloudBurst [29]	Highly sensitive short read mapping with MapReduce; http://cloudburst-bio.sourceforge.net
Contrail (unpublished)	Cloud-based *de novo* assembly of large genomes; http://contrail-bio.sourceforge.net
Crossbow [30]	Read Mapping and SNP calling using cloud computing; http://bowtie-bio.sf.net/crossbow
EasyGenomics (unpublished)	Cloud-based NGS pipelines for whole genome resequencing, exome resequencing, RNA-Seq, small RNA and de novo assembly; http://www.easygenomics.org
FX [32]	RNA-Seq analysis tool; http://fx.gmi.ac.kr
Gaea (unpublished)	Cloud-based genome re-sequencing assembly; http://bgiamericas.com/data-analysis/cloud-computing
Hecate (unpublished)	Cloud-based *de novo* assembly; http://bgiamericas.com/data-analysis/cloud-computing
Jnomics (unpublished)	Cloud-scale sequence analysis suite based on Apache Hadoop; http://sourceforge.net/apps/mediawiki/jnomics
Myrna [33]	Differential gene expression tool for RNA-Seq; http://bowtie-bio.sourceforge.net/myrna
PeakRanger [36]	Cloud-enabled peak caller for ChIP-seq data; http://www.modencode.org/software/ranger
RSD [35]	Reciprocal smallest distance algorithm for ortholog detection using Amazon's Elastic Computing Cloud; http://roundup.hms.harvard.edu
VAT [37]	Variant annotation tool to functionally annotate variants from multiple personal genomes at the transcript level; http://vat.gersteinlab.org
YunBe [34]	Pathway-based or gene set analysis of expression data; http://tinyurl.com/yunbedownload
Platform as a Service (PaaS):	
Eoulsan [39]	Cloud-based platform for high throughput sequencing analyses; http://transcriptome.ens.fr/eoulsan
Galaxy Cloud [40, 41]	Cloud-scale Galaxy for large-scale data analysis; http://galaxy.psu.edu

Infrastructure as a Service (IaaS):	
Cloud BioLinux [42]	A publicly accessible virtual machine for high performance bioinformatics computing using cloud platforms; http://cloudbiolinux.org
CloVR [43]	A portable virtual machine for automated sequence analysis using cloud computing; http://clovr.org

IV. Proposed system

Our research defines a hybrid System that combines Multi Agent System, Web Service and MCC. In this paper, I will only detail the MCC and our healthcare web services. This architecture (Fig. 2) is a overview of the previous works in the healthcare domain when authors introduced MAS for healthcare and presented the interaction in an agent based architecture for healthcare [25,26]. This architecture is composed of a set of independent agents adapted to the interaction. The agents of the hospital can be classified into two groups or layers [25]:

• Intelligent agents or super agent (Agent doctor, Agent patient, Agents nurses….)

• Swarm layer inspired from the Swarm Intelligence fields (applies the collective behavior of groups to resolve a problem.) such as office, medical materials… This architecture consist of the two previous layers of intelligent agents, representing a medical organization with different roles and communication patterns, and facilitating interoperability, and the accessibility to information. The motive of my study consists in the development of a medical framework able to solve a large variety of medical problems. Therefore, I designed cloud architecture consisting of multiple distributed agents placed in the cloud environment.

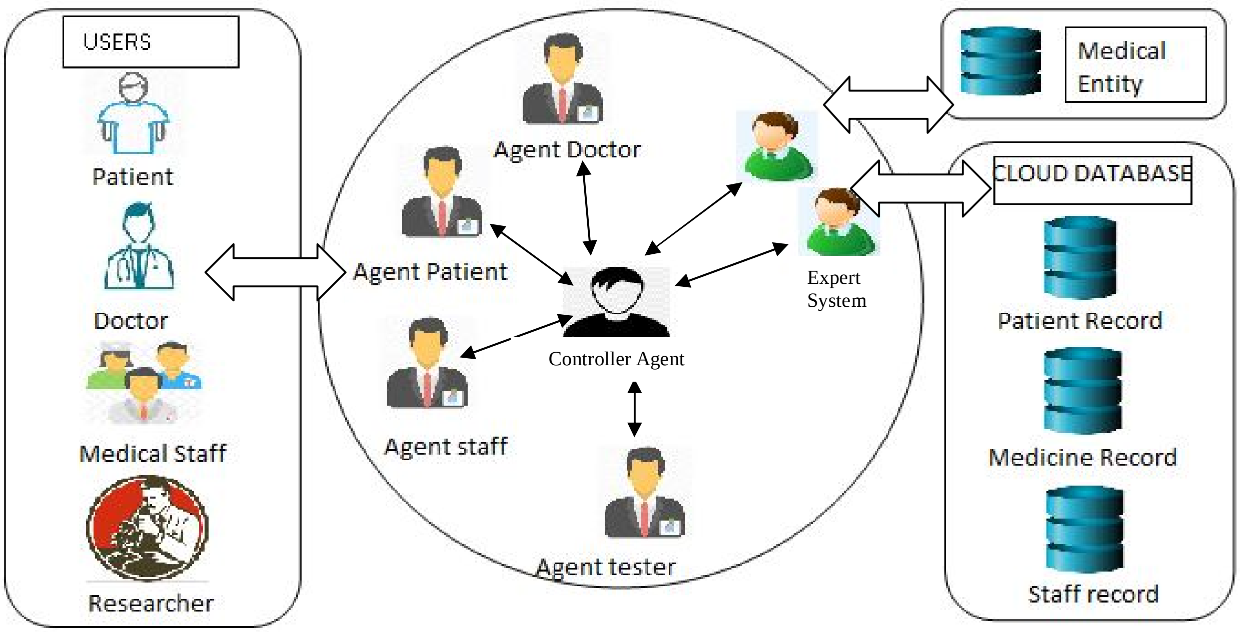

Fig.2 Proposed Model for Expert system

The main working of the prototype is to provide users with a mobile interface to handle healthcare information; the applications' platform is a tool for several users:

1. Hospital staff: it represents all the operators that are worried in giving consideration to patients in the human services framework. This people group ought to have the option to know and affirm the abstract representation of the theoretical model of the hospital as well as manipulate and utilize the results of the system. The main categories of this category are:

• Medical personnel: physician, surgeon, radiologist, anesthetist, etc.

• Nursery personnel;

• Technicians: such as diagnosis personnel

• Admit and discharge personnel;

• Medical support personnel: security personnel, archive, supplying and cleaning personnel, etc.

2. Team study: such as researchers, engineers.

3. Non admitted patients describe the main users of the healthcare infrastructure.

The aim is that agent's work in background in order to provide ambient environment to the consumer and users. In other words, the agents communicate with each other, acquire their behavior and receive information through medical cloud data.

V. IMPLEMENTATION AND RESULT

A new medical system called medical cloud expert system (MCES) is proposed. This is a complex system which integrates hybrid solutions, i.e., MCC and multi-agent system in healthcare to make care as efficient as possible. The web services and service-oriented architecture (SOA) technologies have been used in my research. This architecture offers a model combining the benefits of both Mobile technology and CC.

Corresponding mobile users defined above use mobile devices (Tablet, PDA, Smart phone...) attached to the networks via the base transceiver station (BTS) or satellite. Mobile users' requirements are broadcasted to the servers that offer mobile services, then the subscribers' requests are distributed to the cloud by the use of Internet and finally the controllers in cloud send to the users the requested medical cloud services. We define several services, such as:

- Patient appointment: patient can choose a date for remote consultation.
- Remote consultation: patient can make consultation in real time by sending and receiving messages from doctors.
- Resource allocation: doctors and patients can remote allocate resources (IRM, scanner...).
- Connection to CC storage (e.g., patient health records): The system application allows caregivers to save and upload distributed medical data.
- Image viewing by supporting the DICOM image
- Patient registration: patients can make registration remotely as well as choose the medical center and the suitable medical unit.
- Medical analysis results viewing: the content of the test resides remotely into the cloud storage.

Table **2** describes the comparison of the cloud computing simulators based on their characteristics such as platform, language software or hardware. Most of these simulators are software based and are developed using Java [27].

Table2 Comparison of cloud computing simulators [27]

Simulators	**Platform**	**Programming Language**
GreenCloud	NS2	C++,OTcl
CloudSim	Gridsim	Java
CloudAnalyst	Gridsim	Java
GroudSim	-	Java
DCSim	-	Java
NetworkCloudSim	CloudSim	Java
SPECI	SimKit	Java

VI CONCLUSION:

The presented content is an exercise towards the integration of Mobile Cloud Computing in the health information collection and implementation of its services. With the advancement of Information Technologies, such as mobile computing and CC, are creating new opportunities to improve the health care environment. So, Mobile and CC provide the essential services that make them suitable to be used in the remote domain.

A new medical system called medical cloud expert system (MCES) is proposed. This is a complex system which integrates hybrid solutions. The information technology services and service-oriented architecture (SOA) technologies have been used in our prototype. This architecture offers a model combining the benefits of both Mobile technology and CC. The comparison with previous research showed that the suggested MCES has the following benefits: an ergonomic user interface through a mobile device and a mobile cloud services accessed anywhere anytime.

As a future work, we can introduce the usage of several improvements or possible extensions to the architecture and deploy the prototype not only in one clinic but also in other healthcare environment to evaluate the applications in terms of user readability and performance. Illustrated MCES was designed and developed for just a health clinic.

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