Survey of Cloud Computing Web Services for Healthcare Information Retrieval Systems

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ABSTRACT
Cloud computing is a term used to describe a network with huge number of devices connected via the internet and can share a variety of data and information remotely. However, cloud computing has very limited facilities that may or can provide beneficial advantages for information retrieval; cloud should be independent and reasonable. Hence, in order to achieve an efficient cloud computing system that can highly help in information retrieving, web services are needed. For web services to be useful, more than one web service must be combined together. In this paper, we introduce a summary of the development of web services for information retrieval in cloud computing using agents, and also we compare between six developed systems based information retrieval using cloud computing.

Keywords
Information Retrieval, Cloud Computing, Agents, Web Services, Healthcare.

1. INTRODUCTION

As the volume of electronic text Different and distinct data collection and reporting requirements are increasing significantly in private and public institutes, a problem that health care organizations faced and still facing recently over the time. When patients vital data are inserted into databases manually it causes a lot of data duplications, high cost, huge number of workers or labor to collect and insert data, and increasing chance to lose an opportunity. Cloud computing is a model that enables network access to a shared pool of computing resources on demand, these resources can be provisioned and released rapidly with minimal service provider interaction or management effort. Recently, many researches were developed, investigating the case of cloud computing and its techniques and platforms such as Google and Amazon, but still we need more and more development and researches of cloud computing in the field of information retrieval and knowledge.

Since cloud computing has the feature to work as a service ("SaaS", "PaaS", and "IaaS"), the development and support of the cloud should be based on web services. Web services can be published across the web and also invoked. But if we get back to reality, the number of users and patients of health care institutions that use the web is increasing and unfortunately decrease the ability of users and patients to perform the required tasks efficiently. Related to this increase in the number of users and patients, no single web service can satisfy and afford the wanted services of users and institutions, hence there is a big need to combine and merge more than one existing web service in order to meet the required functionality of web to users. For this purpose, multi agent systems (MAS) are used. MAS demonstrate a computing platform for distributed systems in accordance to overlapping cooperating agents each of an efficient behavior.

Moreover, the increasing of health care and health awareness led to generate a huge number of medical records which makes handling such a huge data in the traditional ways very difficult, on the other hand, most doctors don't always have patients' information needed to make rapid decisions, the patients also don't always carry their health history records with them. So the

motivation has increased to use technology in the management of these medical records and how to retrieve them. Cloud computing increasingly plans to take the web application advantage to share its huge amount of data in a reliable way, so applying the information retrieval using cloud computing on health information systems will make dealing with and retrieving health information for the patients easier. Hence, this paper presents a comparison of many web services developed to deal with information retrieval in medical institutions using cloud computing.

The remainder of this paper is organized as follows. A short background is presented in order to illustrate the concepts of cloud computing, web services, and agent computing. The next section represents the number of related papers that use related web services and their techniques and structures. A conclusion of the paper is represented in the final section. Later, a small table of comparison between the represented web services is shown as an appendix.

2. CLOUD COMPUTING

Cloud computing is a model that enables network access to a shared pool of computing resources on demand, these resources can be provisioned and released rapidly with minimal service provider interaction or management effort, an example of applications on cloud computing is Gmail or Google Docs. The cloud computing is completely different from traditional systems since cloud computing allows for its users to use a wide range of sources of computing anytime and anywhere on demand. The user should pay for the use these resources. There are three models in cloud computing: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS), SaaS is the application which is hosted in the cloud service provider, these applications are available for all the customers over the network (usually the internet) an example of these applications Electronic health record system (EHRs). PaaS is the development tools which are hosted in the cloud service provider, these tools can be accessed through browser such as Microsoft Azure. IaaS is the equipment which used to support the operations, hardware, networking components, storage and servers.

3. Web Services

Web services are applications that are automatically accessible by humans and organizations as well. The application is said to be a web service if it met four major characteristics [1]:

1. Introduced specifically for inter medical and healthcare organizations and not for intra medical health institutions.
2. Independent from the SOC and specific computing schemes.
3. Portable and easy to be installed and combined with other web services with no need to extra sophisticated structures.
4. Reliable and meet the QoS properties and conditions.

However, there are a lot of problems not yet been solved and may affect the efficiency and functionality of information retrieval in web services. The first problem is the unstructured resources; the resources on the web are still not connected or related and they are presented in an unstructured form. Also, the resources are sometimes queued by humans and still not recognizable from the machine understandable interface. Finally, the most important problem in web services is the semantic problem; still some web services don't support the semantic information retrieval platforms, so some of the keywords of the resources are not retrieved because they don't exactly match the queued keywords.

4. AGENT COMPUTING

Web services are very much relied on the agent, as many web services perform better with multi-agent structure. The agent is an entity which performs and functions as a computational block to achieve a given goal by combining to the functionality of another entity. Agent systems are independent and take specific actions of their own, so to achieve a given goal. Moreover, agent systems are very efficient because they can handle operating in any environment that may change dynamically, and hence they have their own knowledge base in which they take their action decisions based on it. Agents should always be autonomic, proactive, reactive, cooperative, negotiatative, and learning. Autonomic means the level in which agents can function autonomously on other programs and agent's behalf and editing the way that they can achieve computing and users' goals. Proactive is the capability in which they can keep track of their own specified objectives.

On the other hand, reactive is the ability to contact with external actions and catch their behavior to take decisions on how and when they can simulate their tasks. Moreover, agents should always have the ability to communicate and cooperate with other agents so to receive and send instructions and to pass and get information so to facilitate the information retrieval process. Also, agents should be capable to negotiate with other agents and take decisions based on conversations between them. Finally, when agents connect and communicate with environments that are supposed to be external, then they have to make appropriate decisions so to improve efficiency and performance of the system.

5. RELATED WORK

5.1 Energy-Saving Information Multi-Agent System with Web Services for Cloud Computing

The authors of [2] proposed the Energy-Saving Information Multi-Agent System with Web Services for Cloud Computing. The researchers used the SQL IC concept to build the functional interface for cloud data computing. In the paper they showed the three main stage strategy for the process of decision making with its four agents: Reason Agent, Interface Agent, Web-Service-Based Information Agent System, and Data Mining Agent.

5.2 An Ontology based Agent Generation for Information Retrieval on Cloud Environment

The authors of [3] presented and explained the process of information retrieval in which the user send a queue on predefined ontology, then this queue is being translated into Mobile Information Retrieving Agent Description File (MIRADF) which have a specific format encoded by the Mobile Agent Description Language (MADF). They also developed a new agent that supports the proposed flat-text request that generate Mobile Information Retrieving Agent.

5.3 Information Retrieval Practical Model Through Multi-Agent System with Data Mining in a Cloud Computing Environment

The authors of [4] This paper proposed that users of cloud computing have to first make sure that their request to the infrastructure as a service is in the range of the warehouse data. Also the researchers encourage that the request should be simple and understandable [4]. In the architecture of Vishal Jain, users have the advantage of retrieving efficient information and hence reduce the computational cost of cloud storage and processing time.

5.4 Services Based Information Retrieval Agent System for Cloud Computing

The authors of [5] proposed a framework combining multi-agent web services in order to get an efficient information retrieval system in cloud computing. The development framework is designed to work with and support the medical and healthcare institutions. The researchers supposed that the medical and healthcare

environment is founded already in the cloud and that the environment has a huge number of clinics and hospitals which provide a number of web services. Each hospital and clinic has its own web service that includes and retrieves doctor's information and needed vital information about that medical institute using various methods of web. Using this framework that is supported by multi agent, it is easier now for users and patients to retrieve information based on their query (i.e. search by time, by date, by patients' name, doctor's info, etc.)

As to describe the system in [5], it starts running from the agent's interface. The interface agent receives the queries from the users whether they are patients or regular users, and then search for the needed information in the cloud then retrieves back the matching results back to those users. But how does this interface retrieve back the queries according to the user needs? This interface agent translates the user's query into specific format and sends it to the Information Agent. The Information Agent in turn takes the decision of which services are better for the queries based on a specific and predetermined Domain Knowledge Base [5] in cloud service, where Domain Knowledge Base [5] acts as a storehouse that stores all the conditions, rules, and principles of the system so to be used later for queries. Finally, the proposed framework in [5] achieved good results for efficient information retrieval from a cloud computing environment and also was flexible to be run on any area domain and different environments.

5.5 A Cloud Computing Solution for Hospital Information System

Hospital Information Systems (HIS) have been facing many problems during the last decades because they are shared separately among different hospitals and there is not a single thing that connects them with each others, which results in high cost and data redundancy and also inefficient retrieval of information. For these problems to be solved there should be some kind of information sharing between hospitals. In this paper the authors proposed a solution to directly connect all hospital subsystems and medical equipments with each others with safety, low cost, low error rate, and high efficiency and accuracy of information retrieval, but first of all the authors explain each problem of tradition hospital information systems in particular.

There are three main drawbacks of old HISs; the first problem is the deficiency of information sharing between hospitals; the patients of any hospital will not remain at the same hospital, they may have treatment at more than one, also there is a large number of hospital medical equipments such as monitoring equipment, radiology equipment, etc. Hence, this large number of distinct patients and equipment will need many categorizations and many encoding methods to be stored. Furthermore, as each hospital has a distinct number of patients, so each hospital will have a separate HIS, and since patients may have treated at more than one hospital then there will absolutely be a huge number of data redundancy between hospitals. The second problem of traditional HIS is the high cost of independent HIS; any hospital information system will need a complete platform of hardware, software, management, coding, and maintenance to be built, hence an independent hospital information system is considered as an encumbrance for any hospital either it is small or large.

Because of the high cost of independence HIS construction, most hospitals prefer to use the manual approach of storing data by using papers. Finally least and not last, the third problem of old HIS is the difficulty of data maintenance, data, upgrading, and data management; as each hospital will have separate HIS then each hospital will have separate maintenance of data, separate upgrade of data, and separate management of data, and as mentioned before, hospitals are dealing with a huge number of data records and huge information to be shared.

Therefore, dealing with each HIS separately will cause allot of problems, specially when

there are technical problems arising during the start-up phase such as wrong use of the software, shortage of professionals and experts, continuous maintenance, and so on. All the problems mentioned before will cause any hospital a huge amount of money. The authors of this paper proposed a new framework that contains the new control unit to connect directly to all hospital subsystems and medical equipments. The proposed solution aims to share data between hospitals using virtual private network (VPN) and through internet access public ally.

By using this structure hospitals will become more efficient because each hospital's subsystem will connect together and share the same data and thus construction costs will decrease and also data redundancy. The presented solution in [5] has many advantages; first, instead of spending huge amount of money to have a server for a hospital, it's better to have cloud services that share common information among a huge number of other hospitals, and thus this solution ensure the decrease of costs and increase of efficiency. Secondly, the proposed solution has the scalability feature, for example, if a medium hospital shared its data in the cloud and by the time passing this medium hospital has become a large one then it can easily update its information in the cloud. The third advantage integrates the health institute with medical institute so they can share information effectively.

5.6 Application of Cloud Computing in the Health Information System

Cloud computing expresses the ability to share data applications, information, services, etc. From and to the required users at any time they need these services by using some kind of internet connection. Cloud computing has three main services which are "Software as a Service" (SaaS), "Platform as a Service" (PaaS), and "Infrastructure as a Service" (IaaS), these applications or services are specialized to deal with medical organization issues.

The authors of [6] discuss the cloud computing advantages and techniques and propose a high performance integrated scheme for healthcare systems that efficiently improves the information retrieval process in cloud computing. The proposed scheme is implemented in the meaning of the three applications of cloud computing services which are SaaS, PaaS, and IaaS. The authors used these applications of cloud computing in order to achieve an efficient sharing of medical data between hospital systems and also to decrease the cost of constructing separate medical health information systems. The use of cloud computing platforms provides many benefits for the medical staff such as accessing the medical information remotely and easily which helps in supporting and improving the connected medical systems. However, as the usage of cloud computing is increasing significantly, there will be a high contention on it and hence the proposed scheme in this paper aims to use the cloud computing on a specific field which is health care in order to help the medical organizations efficiently.

5.7 MedCloud: Health care Information retrieval Cloud Computing System

The health care institutes and insurance organizations always have a huge number of customers and patients; hence they always need to store these huge data and information. These companies used to store their data in some form of Electronic Medical Records (EMR) in centralized databases [7]. However, each patient may have more than one insurance company and many health care experts like therapists, dentists, physicians, etc. This type of storing technique has been a very good technique until its problems started to increase significantly, the main problem with this technique is the sharing problem; each health care institution or organization needs a complete data of its patient status for example their insurance company, their doctor, etc. and hence each patient in each health care institute will have a huge number of records.

Since each health organization has a separate database, then health care organizations will need to exchange patient's EMR between each other and here comes the big problem; exchanging and sharing different EMRs is not easy and very slow. Therefore, there is a big need to have common place where these EMRs can be stored and accessed easily among healthcare organizations and medical staff. The authors of this paper propose a cloud computing system called MedCloud system to store the medical electric records in a common platform that can be accessed by all the experts and medical staff instead of the separated platforms. The proposed MedCloud system supplements the developers with the needed services so they can build many efficient cloud computing applications. The server implementation of the presented system is done using Hadoop ecosystem.

Three main layers in MedCloud Structure:

- *Data Storage Layer:* a special store is necessary to store the electric medical records and which have the ability to store big data with access availability. This special store is called Distributed File System (DFS) and it continue its functionality even if any device fails to continue working, a feature in which very important in guaranteeing the availability and reliability of the system. Because SQL databases can't handle the storage of big data, hence MedCloud uses NoSQL databases which are scalable and not relational databases. MedCloud uses the column-oriented data set of the NoSQL databases as follows: each table in the database will not have any foreign keys and will have one primary key.
- *Server Management Layer:* in this layer there is a master and a slave; the master is responsible for receiving requests from the application layer, managing schedules among the devices, monitoring the activities and functions of the system, and also giving each device the activity schedules and job for it to be done on time. The master part has two main components that control the mentioned responsibilities which are query manager and concurrency manager. On the other hand, the slave part of this layer is responsible for storing data and sharing between entities.
- *Application Layer:* this layer is responsible for supplementing the users and medical staff of the requested services and applications using the needed internet access technology such as HTTP.

However, MedCloud improved its high scalability among these changing environments.

5.8 Cloud Computing for Healthcare Research Information Sharing

The authors in [8] aimed to introduce the cloud computing, and study the challenge of using Health care Cloud (HC) in order to improve the research of Health Information Science (HIS). Where There are many challenges occurring in cloud computing infrastructure in order to maintain the level of protection the patient's data and maintain the basic functions of cloud computing required by the Health Care Services, so there are many restrictions on the storage and transfer patient data through the health cloud.

The challenges which occur are technical obstacles to implement the cloud computing which will affect on adoption of Cloud Computing. The first challenge of these challenges is about operations stability where any organization wants to use the cloud computing will have concern on enough availability. Interruption of the service will lead to huge loss especially when there is insufficient of backup plan. Because of the customers have high expectation with regard to services , the service provider of cloud computing using multiple network providers where the failure in single point will not lead to interruption the service, but to have more Cloud Computing availability, multiple Cloud Computing service providers are needed because the using multiple network providers will not suffice alone . The multiple cloud service providers should be having a similar accounting system and software infrastructure.

Another challenge which makes the organizations and users be aware of applying cloud computing in the research of health information science is Information privacy , because the patient, sensitive information as personal information could be publish to the public by any accidental information violation or criminal attacks. This challenge require from the software engineers create cloud services with less privacy risk and by ensuring legal compliance so we need to apply some legislation placing geographic and restriction on the processing , collection and transfer the patient information and reduce using the current design of cloud services . The researchers who search for health informatics topics, have some requirements on the patient information, where they need to minimize the personal information about the patient which will send and store in the cloud, provide user feedback, specify and limitation the usage of data, and maximize the user control

It is known that privacy and security in the health information science research for the electronic patient records is very crucial. In [8] the authors show the security challenges which facing the research of health information science and they proposed ways to reduce these barriers , the authors analysed a number of security concerns that related to the weaknesses and threats . The concept "patient-centric" is a unique concept which used in systems of community healthcare, this term shows the amount of confidence by the research groups or clients in the Cloud Computing architecture, this amount of confidence will definitely effect on the implementation.

The authors in [8] Suggested ways to mitigate the risks that the possible afflicting EHR systems which are:

- Work as much as possible on isolating the EHR from the network, and harbouring the EHR from all other network infrastructure. Otherwise, it becomes easy to pass any infiltration or virus to the EHR system by any medical device or provider's management system.
- Try to find any weaknesses through the system. Run risk assessments and management audit processes.
- Running the prevention data loss, program that runs on the external server.
- Make sure that there are security patches on all the internet applications such as Java, internet explorer and adobe reader which are connected with EHR systems , and if there is not any security patches, apply it on these applications
- Since the hackers waiting any opportunity to access the computer networks, always make sure that the firewall is correctly installed and that the anti-viruses work properly.
- Make sure that the contract for the suppliers of health IT and EHR systems support the off-the-shelf Anti-Virus.
- Set some People within an organization to be responsible maintenance and maintaining the system integrity.
- Make an Agreement with EHR- Health IT vendors In order to determine who is responsible for applying the security patches where there are many vendors don't do that.
- Make sure that there are not any medical programs working with "super user" where this will prevent any access to the records by the hackers.

5.9 Proposal of an Open-Source Cloud Computing System for Exchanging Medical Images of a Hospital Information System

Traditional Hospital Information Systems (HIS) have been facing many problems during the last years such as the lack of uniform standards for data-retrieval. HIS is achieved by being applied based on Computer- based Patient Records (CPR) , but before creating the CPR we should work first on the seek treatment problem where every hospital have its own information's system which differentiates in another hospital , so if the HIS is applied on different hospital which have different information systems, we will have no recognition and incompatibility information, on the other hand every hospital

has a huge number of medical equipment as audiology equipment, CT, ultrasound etc., So there are huge number of data generated which storage in different encoding method and code. Since that the integration between different subsystems is very difficult, therefore the information will enable shared among different hospital and also between the different department in the same hospital which will lead to waste of resources and duplication.

High cost for independent construction is another problem; it is very costly for the hospitals that apply HIS on their work, where applying it need to setup a full platform combining as hardware, software, maintenance and management. Large hospitals can accept these costs because they really need the HIS system in their work, on the other hand small hospitals with a small number of patients and less records do not need to apply this system and they prefer to use the paper material to record the clinical information.

These days, many insurance companies and healthcare providers use one of the form of medical records systems, these medical records is sorted as electronic records in the centralized database. Each patient can be having more than one health care providers or more than one insurance company. For each provider his own database which contains electronic medical records (EMRs). The process of sharing the information between the healthcare workers is translated to sharing the information between EMR systems. On the other hand sharing the information between different EMRs is called electronic health records (EHRs).

When the data are shared between different EMRs, the sharing processes will be very slow, poor usability and costly, which consider as obstacles to prevent using this method for the health IT, especially the systems of Electronic Health Records (ERR). Therefore the cloud computing is the best choice where it reduces EHR systems, both in term of IT maintenance and ownership.

Using open standards and cloud computing in health care will help with monitoring of patients, maintaining health records and managing diseases which will lead to improve the health care, also it help to reduce the cost drastically. The primary step to take advantage of the success applying the health care in cloud computing is to apply and implement the security and privacy in cloud computing as in [9].

5.10 Evaluating Private Information Retrieval on the Cloud

The author of [10] proposed the Private Information Retrieval (PIR) and explained that the goal of PIR is the security of the clients and user's, so no one even the coordinator of the process of data retrieval can see, modify, or even know the content of the query or retrieved results. The author represents a parallelized PIR system that can work efficiently in cloud computing to gain better information retrieval results and overcome the drawbacks of the old PIR platforms. This paper also discusses how to deal with multiple user queries and how to divide the work to get better and fast results to ameliorate scalability and performance. MapReduce was not used in this implementation of parallelized PIR scheme as it was used in the previously developed PIRs; instead, they used the message passing interface MPI because MPI is portable and scalable. This paper didn't develop a completely new PIR scheme, but continued at work introduced previously by Huang in parallelizing the server-side computation of Goldberg's PIR scheme. The difference is that in this paper the author didn't use Hadoop. Finally, the parallelized version of PIR in this paper improved the scalability, performance, and fast information retrieval process in cloud computing compared to the previous non-parallelized schemes.

6. CONCLUSION

A lot of solutions and enhancements were proposed to solve the problems of manually data insertions and retrieving of data. One of the efficient solutions was cloud computing, in this paper, we present a number of web services and application platforms that use cloud computing in order to improve information retrieval in medical institutions.

This paper aimed to compare these enhanced and combined web services and illustrate their limitations and advantages. The proposed applications and web services differ in the technique of using cloud computing facilities to develop their services, but on the other hand, they all were developed to handle the same problems and limitations that hospital information systems and medical staff face. There were many features added to the enhanced web services proposed, all in which aimed to increase efficiency, security, information retrieval, and decrease maintenance cost, set-up cost, errors, and duplication of data.

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8. APPENDIX

Comparison table of proposed systems and applications

Paper Name	Limitations	Proposed solution	Performance
"Cloud computing solution for hospital information system."	• Problems come from sharing data across multi-systems. • Huge cost for maintenance servers. • Human resources and staff. • Replication needed for data stored on that server	New framework contains new control unit to connect directly to all hospital subsystems and medical equipments. Cloud based computing	This unit will care about the entire network between both sides "send and retrieve data from and to all systems". The new unit will connect equipment directly, and transfer its data to the cloud network.
"Energy-Saving Information Multi-Agent System with Web Services for Cloud Computing"	• Increasing different and distinct data collection and reporting requirements • Lot of errors • Slow retrieval • Problems with single agent systems	The SQL IC concept to build the functional interface for cloud data computing Cloud based computing	• Low Cost • Efficient Information retrieval, since multi agent • Easily distributed to the medical staff • No redundancy or errors.
"Application of Cloud Computing in the Health Information System"	Lack of an enormous system that can save storage that contains all digital medical records automatically and retrieving information without losing privacy.	High performance integrated scheme for healthcare systems. The proposed scheme is implemented in the meaning of the three applications of cloud computing services which are SaaS, PaaS, and IaaS Cloud based computing	• Efficient retrieval of medical data and information from medical systems • Decrease the cost of constructing separate medical HIS • Accessing the medical information remotely and easily
"MedCloud: Healthcare Cloud Computing System"	• Huge number of customers and patients; a need to retrieve those huge data and information. • Sharing Problem; huge number of records	Exchanging and sharing different EMRs is not easy and very slow Cloud based computing	• Cloud computing system called MedCloud system to store the medical electric records in a common platform that can be accessed by all the experts and medical staff instead of the separated platforms • Fast and efficient retrieval • Hadoop ecosystem; advantage of linear scalability

"Ontology based Agent Generation for Information Retrieval on Cloud Environment "	• Deal with patient information and images in the system need more IT infrastructure. • Does not support synonyms	Develop an application to deal with (DICOM) server, and its run on Windows Azure system. Cloud based computing	• Predefined ontology • A specific format (Mobile Information Retrieving Agent Description File) • Mobile Agent Description Language • Mobile information retrieval support
"Services Based Information Retrieval Agent System for Cloud Computing"	• Problems with single agent systems • Lot of errors • Slow retrieval	A framework combining multi-agent web services in order to get and efficient information retrieval system Cloud based computing	• Efficient agent's interface • The storehouse that stores all the conditions, rules, and principles of the system • Multi agent advantages • Fast and efficient retrieval and match the user's query needs