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Benefit of Cloud Computing in Medical Imaging and Scanning

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ABSTRACT: ***Medical imaging archive has been a subject which the health care industry struggles with due to growing long-term cost of managing an onsite. As per the current trend, over hundred billion diagnostic imaging/scanning procedures will be performed in the generates about thousands of Petabytes of data. The high volume of medical images is leading to scalability and issues related to maintenance with healthcare providers' onsite picture archiving and communication system (PACS) and network. Cloud computing gives commitment of providing lower cost, high scalability, availability and disaster recoverability which can be a natural solution some of the problems which is faced in long-term medical image archive. This new model creates new opportunities to share information that can be always available. The proposed implementation is supported on the public cloud resources that are available on the Internet, creating the opportunity to exchange information among the medical devices inside the institutions with another device located in another institution i.e. anywhere, any time.***

Index terms **– archive, Cloud, image, Medical imaging, PACS.**

I. INTRODUCTION

Now a day's imaging and scanning as become an important field of diagnosis in medical field. This growing long-term cost of managing an onsite medical imaging archive has been a subject which the health care industry struggles with. Depending on the current trend, it is estimated that over one billion diagnostic imaging procedures will be performed, which will generate about thousands of Petabytes of data [1]. This huge and high volume of medical images has a scalability and maintenance issues with healthcare providers and also for onsite picture archiving and communication system (PACS) and network.

For some healthcare providers among the two thirds of the world's population who have no access to quality medical imaging services [2], secure on-site data center may not even be possible because of political or civil instability and due to non-availability of resources. For healthcare providers information technology needs long-term image archive solutions that balance cost, image volume, storage capacity and access demand.

To above given problem Cloud computing is the solution. In the rural places where it is difficult to install costly Scanning and imaging machine a mobile when can be used which can go to different village and can store the data of those patients on cloud.

The conventional hospital scanning healthcare IT stores and manages image archives or to be stored onsite using the internal hospital network which is protected by a firewall from the outside. Hence the rising capital and management cost of onsite systems as well as the lack of disaster recovery provision have motivated alternative offsite solutions.

Due to the drastic development in cloud computing technology it promises of lower cost, higher scalability, accessibility, availability and disaster recoverability. Computing and storage in the cloud has become a natural solution to many problems we face today for long-term medical image archives [3]. While researchers and policy definer are still undergoing, studying the security, privacy, and liability issues involving sensitive medical information in the cloud [4], various technology vendors such as IBM and Amazon have started to provide solutions to this problem[5][6].

II. PACS

Presently, PACS (Picture Archiving and Communication System) is one of most valuable tools and nice supporting medical decision and treatment procedures. It is a key point to store, retrieve and distribute medical images in the various steps of the clinical practices. Digital Imaging Communication in Medicine (DICOM) supports the

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distribution of the medical imaging, although this standard is oriented to a single institution. The communication of a wide domain composed by several medical institutions is still a challenge. Usually, the image repositories or PACS archive is not shared between medical centers due to technical challenges and security concerns.

Challenge to Pacs and Dicom: Though the DICOM standards support SSL/TLS layers, there are many medical devices that do not support these features. Due to this there are restrictions for the users located outside the institution from accessing the PACS archive in a secure way.
Solution:
VPN (Virtual Private Networks) are used by medical institutions to share medical resources. Yet, this solution requires point-to-point configurations, which is not scalable. Other methods to exchange exams between medical institutions are processed through CD/DVD delivered for instance, by conventional mail or email.

Way between PACS and DICOM: Cloud computing is large used to share files over the Internet and allow users to communicate with each other using external infrastructures. This technology allows access to applications and data without any infrastructure inside the medical institutions. [2]. However, there are also some important issues that must be considered during the implementation of a solution (infrastructure and/or application) in a public Cloud provider [3]. Namely, there are critical concern related with data security and privacy. DICOM inter-institutional communications, allowing the establishment of shared workflow and exchange of documents across them. The proposed DICOM relay service aims to be a communication broker, allowing search, store and retrieve of medical images over a group of hospitals, in different sites. This result allows, for instance, remote access to the institutional PACS archive. The communication between different islands is supported on the cloud services, but it keeps the interoperability with the devices adopted by the medical community. The recommended DICOM routing mechanism has a transparent application to end-user without any breaks with actual standards used by medical imaging devices and repositories. Finally, the architecture provides several security services associated to connections.

III. UNITS

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 a rising technology that allows the enterprises to hold scalable resources without having any IT infrastructure. There are several cloud providers, such as, Amazon AWS, Google and Rackspace that hold in many areas, since storage, databases, and notification systems. These providers supply variable computing power and unlimited storage [10] [11] to cloud user or customers.

IT Industry today is more interested in cloud computing because they have such infrastructure ready [12]. In order to response to their request, many cloud companies have been created to meet their demands. In this competitive world cloud providers are putting their significant effort to offer new features to clients and nowadays cloud computing is much more than a way to virtualize machines. For example, Amazon Web Services has released many services to fulfill their customers' requirements: S3 [13], SQS, Simple DB and many others. In turn, Google AppEngine [14], Windows Azure [15] and many others improved their solutions with new APIs to overcome the challenges of their targets. Hence computing-as-utility is a business model becoming existing in the electronic world and numerous institutions are adopting it. The existence of Cloud computing providers creates a great opportunity to handle the costs of purchase.
Hardware and software. Today the market is changing and there are new paradigms to deploy applications and to store information that are always available on the Internet. We believe that medical field should also adopt these new models to improve their business processes and improve health care functionality. Following the technological evolution, cloud computing has been adopted by several companies in the industry and in particular healthcare industry for imaging and scanning storage purpose.
System Architecture: Here architecture is discussed to solve the problems with sharing medical images across institutions. The component design and the process flows of the transfer and search over remote repositories and stored database is explained as in fig1.

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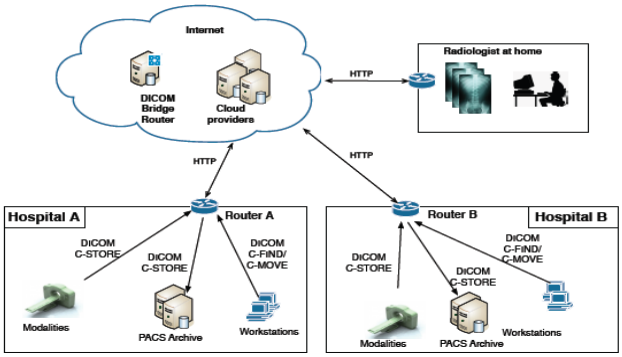

Fig.1. DICOM services and Cloud Computing Description

Initially DICOM was not accepted because of it limitation. Each hospital is an independent island, unable to communicate with other hospital infrastructures.

The PACS integration across medical institution is an temporary process, which has several barriers to deploy. Also it was difficult to access medical repository of the hospital across the network because of security and secrecy reasons.

Here we present a solution that creates an easy way to combine and integrate different medical repositories of different institutions supported on cloud computing services. Cloud computing is largely used to share files over the Internet at anyplace and at any time. Cloud providers offer a high quality of service, mainly in the availability and scalability with elasticity. Our proposed solution takes advantage of the cloud computing services to exchange information between different locations. The communication between the components of the digital medical laboratories is mainly used through DICOM.

This protocol runs over TCP/IP protocol, but contains its own addressing model through the AETitle that identifies the medical device [16]. Due to the firewall protection, this communication does not perform well in WAN (Wide Area Network). Hence to extend the communication to different institutions, the proposed approach takes advantage of the DICOM addressing mechanism to route the information to the correct location (i.e. AETitle is the DICOM address mechanism).

IV. SOLUTION OF ABOVE PROBLEM IS CLOUD

The public cloud infrastructure is used as communication method to support information transferring among the involved entities ie hospital and research centers through these routes. Also Cloud provider support is simplified due to a plugin-based system. To support abstraction with the cloud storage specially a Cloud IO (Input/Output) stream mechanism. It allows writing in the cloud storage as a data stream. New cloud providers can easy supported, only need to implement the interfaces supplied by Cloud IO. Additionally Notification systems were used to perform Communication between the several components of the following system architecture

V. COMPONENNTS OF DICOM

The proposed DICOM relay service has following main goals:

1. Grants the secure and reliable connection between the Users
2. Create an easy solution to access the internal medical repositories anytime and anywhere.

Our DICOM architecture (Fig 1) has two software components:

1. Bridge Router
2. Cloud Router.

Cloud Router:

The Cloud Router (Router) has the main responsibility of handling the services and forwarding messages to the correct place. To perform this process,

1. It uses AETitle routing tables, i.e. for each AETitle belonging to the DICOM network domain,
2. It contains associated the type of services that is providing and the username of the Router, which will allow to reach the correct router to forward the messages.

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These tables are managed manually because the DICOM standard does not provide a mechanism to auto-discovery of the DICOM nodes. Also, for security reasons, only allowed medical devices should be accessed from outside the medical institution and another job of tables is that they act as a control list.

Hence the Router should have

1. A graphical interface to setup the IP,
2. Port number and
3. The services available inside the medical institution.

In the Real world this objects are mapped directly in the DICOM standard, for instance DICOM equipment is represented as a "Device" in the defined concepts of the standard. The Router supports multiple devices (i.e. as many as are online in the WAN DICOM network), with a different AETitle and transfer syntaxes (i.e. the data codification supported) for each and every network.

Finally, each medical institution or isolated DICOM network that wants to share services to the WAN DICOM network needs to run a Router inside the private network that will be saw as a standard DICOM node supporting several services (Fig 1).

Bridge Router

The Bridge Router (Bridge), works as a relay mechanism between different Cloud Routers scattered over several locations. This component works in a partnership with the cloud providers. The huge amount of information that flows in WAN network needs to be uploaded/downloaded to the cloud providers. Since all devices (i.e. AETitles) and information of device supported in Bridge Router it is an important part of the architecture Also it has to keep accounts of routers and a list of cloud providers that routers can use to store the temporary information. Very important is it availability across the Internet any time because routers need to write information in the Bridge to provide communications. It can be deployed in several places, for instance, in a private cloud maintained by a medical institution or a public cloud provider. Due to privacy and secrecy concerns, it is strongly recommend deployment of this component in a authenticated provider or in-house (i.e. medical institutions). It provides the necessary information to validate authorized routers, AETitle of the DICOM networks and necessary information to access to the cloud provider. Only validated users register on this entity can access to the DICOM WAN Network.

The Bridge is considered the main component of the architecture because it performs the management of the relay service. It only contains a reduced amount of information, and during the dataflow it just stores a minimum amount of data, i.e., the confidential shared key. The remaining information is transmitted through the cloud in a encrypted mode.

The Cloud providers supply,

1. Temporary storage of blinded data (encrypted DICOM objects/commands) and,
2. A notification service that allows us to establish communication between the routers when an event is triggered.

VI. SERVICE PROCESS FLOW

The architecture was designed in such a way that it supports multi-center shared repositories and storage, for example, a regional PACS or a network of imaging centers. In this paper we presented the implementation of two mainly used DICOM services:

1. storage and
2. Query/retrieve.

The integration of the proposed solution in the PACS process flow is effortless using the developed Router. The DICOM services allow interoperability between different manufactures, i.e. with existent devices in the institution.

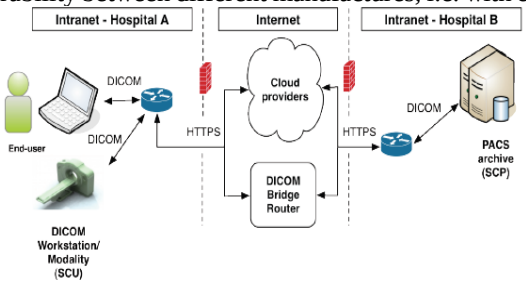

Fig.2. Process flow between hospitals, router, bridge and Cloud.

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The **Fig 2** presents the dataflow among devices in the medical institutions. In the Fig example, the Hospital A is accessing to the repository located in the Hospital B.

Complete process goes like this

1. The client workstation invokes the query to the Router inside their institution (i.e. Hospital A), with the AETitle of the PACS archive of Hospital B.
2. The Router will forward the information using the cloud providers and the Bridge.
3. The responses from PACS archive are forwarded via Router in Hospital B.

The existence of a relay infrastructure is transparent to institutional DICOM devices because the Routers follow the DICOM standard rules.

The Router is able to forward the DICOM STORE, FIND and MOVE commands.

The STORE is the most complex process, responsible to store images in a remote DICOM SCP, i.e. PACS repository.

The medical studies in transcript, data and records are stored in the cloud blob store and they are uploaded in parallel method to improve the medical image transmission. The FIND service is simpler, and the DICOM messages are converted to XML and are relayed through the cloud blob store and notification system.

Finally, in MOVE service, the router notifies the other router, via cloud notification systems and the STORE command is used to process the transfer the images in inverse way.

Features:

1. The design of this system using the cloud computing platform to provide a long term offsite medical image archive solution.
2. It has the potential to lower the cost of storage and management and to increase disaster recoverability.
3. The rich feature set, advanced tools and extensive library support made cloud (for example Azure) an ideal cloud computing platform for rapid development.
4. Each healthcare provider can easily customize the system to serve their unique requirement.

Advantage of including Cloud Services in PACS. The DICOM relay service has multiple benefits in the regional PACS according to their needs those are.

1. It perform well it is necessary if we have a good Internet connection in both sites.
2. Moving information will be less expensive than moving the patient.
3. Due to easier application in a hospital and even in any computer that can work “anytime, anywhere”.
4. It is benefited to those hospital and research center which till use CD/DVD to transfer huge volume of data.
5. Radiologists can work at home, in the same way that they do in the hospital, without changing their methods.

VII. WHAT IT CAN ADDITIONALLY USED FOR

For a regional PACS/Tele-imagiologic services, the proposed architecture can provide inter-institutional DICOM services and support specialized process flows:

Tele-image center: a shared repository between a group of hospitals and the PACS cloud archive meets their needs.

Remote Query/Retrieval: radiologists can perform query and retrieve to a remote PACS archive.

Auto forward auto (multiple repositories): an institution that has several distributed hospitals can have multiples repositories disperse the sites, shared with other hospitals. Hence all medical institutions of the same group have access to these repositories.

VIII. CONCLUSION

The presented solution allows DICOM standard communication between different medical devices located in distinct institutions.

The proposed architecture allows the creation of a independent DICOM network located over different medical institutions, creating a unique view of all resources.

Other solution this problem exist those are VPN (Virtual Private Network) and email (Electronic Mailing services. However, the VPN mechanism demand continuous administration and time-consuming actions and, Email, do not offer any privacy in respect to the email provider.

Hence DICOM relay service is a secure and easy to developed in an institution and the end user does.

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Major advantage is that

1. it does not need complex setups to start communicating with external repositories,
2. Allowing interoperability with any the DICOM standard device.
3. Also the required infrastructure is not excessive because it supports its main resources on the Cloud.

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