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DICOM Web HTTP Service over Traditional DICOM DIMSE Service

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ABSTRACT

Paper less offices is making a great impact all over the world including the healthcare industry with hospitals increasingly adopting this practice. The clinical images today are distributed across healthcare organizations and need to be catered to the physicians on demand, with Digital Imaging and Communication in Medicine (DICOM) standards playing an important role in the storing and transport of clinical records. DICOM DIMSE services like the C-Store transaction and web HTTP-based DICOM requests like STOW-RS or WADO-RS have been used for the distribution. The inefficiency to transfer large DICOM data sets that consists of thousands of DICOM objects due to the huge number of negotiations by the DICOM C-STORE led to the introduction to WADO. This paper compares the two methods of export, the native C-STORE and SToreOver the Web (STOW) protocol which is said to be twice as efficient, light weight, and twice as faster.

Keywords-DICOM, STOW, C-STORE, WADO, REST

INTRODUCTION

In the present world where most of the devices are connected to each other over the Internet. The huge improvement in the field of Internet of Things (IoT) in the past decade has completely transformed the way hospitals and the healthcare industry store, access, visualize, process and consume clinical data. Hospital information systems (HIS) have changed to provide with paperless offices by reshaping the borders to transform isolated departmental data repositories into interconnected chain of hospitals which calls for the repositories such as Picture Archiving and Communication System (PACS) to communicate with each other and share patient information and data to separate hospital departments or even distant enterprises. Scenarios where sharing patient records for collaborative clinical processes during which many physicians from various clinical departments discuss for the diagnosis and treatment of the patients, the sharing of clinical information across different parts of the organization is essential.

Clinical data can be shared across organizations by having a centralized cross-enterprise repository or to interconnect repositories distributed across multiple enterprises. The advantage of the first method lies in the simplicity, but this involves major investments in infrastructure and also it may also lead to the organization to lose controlover patient data. Sharing the patient's clinical data outside the borders of the hospital mitigating the security and increasing the complexity and risk of the solution deployment to fulfill regulations in some countries like the US. The second approach has multiple advantages where data repositories are interconnected across many enterprises. This approach allows the clinical organizations to maintain control over the clinical data. A distributed approach lowers entry barriers to network-based patient care. As the second approach has better advantages than a centralized approach and is aimed at sharing images distributed across multiple clinical organizations. The second approach is used as the center for this study. In order to share and

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transfer DICOM conforming clinical data sets two possible protocols, 1) DICOM C-STORE or 2) HTTP-based STOW request can be used.

The traditional DICOM C-STORE has many over-heads when it comes to the transferring of large DICOM objects. Over a slow connection though it is not very popular anymore if we consider the transfer of about 10,000 slices/DICOM objects for a size of about 200mb it would take about a few hours. The handshakes and negotiations cause the delay in the transfer of DICOM objects. The HTTP-based STOW request is said to divide the transfer time by 2. This is possible by reducing the number of negotiations and by using a stateless architecture like the RESTful service. In this paper, we investigate and evaluate the transfer of DICOM data set of various size using C-STORE and STOW. Experimental results show that an HTTP-based request can divide by about 2 the transfer time when compared to a regular DICOM C-STORE.

MEDICAL WORKSPOT – CLINICAL IMAGE SHARING

A Clinical data analyzer or a workspot is designed for the import and export of data from and to the storage which generally is the PACS. The setting up of this environment for the export and the import can be emulated using various tools like JDicom or DVTk. The architecture is given in Figure (1) where it shows the steps to export/save to the PACS and to import/query from the PACS so as to store on local device. The document which can be an Image or a report in PDF can be stored to the PACS by uploading the file to the repository (PACS) and then indexing and storing the metadata in a registry. Physicians can query the registry and import the data.The registry is used to avoid the duplication of the data, by storing some searchable metadata linking it to the manifest that is stored in the registry. This method not just avoids the duplication of files but also helps to query faster. The manifest corresponds to a Key Object selection. The medical work-spot allows connection to a local PACS or an HTTP-based DICOM request. Both the protocols are discussed below.

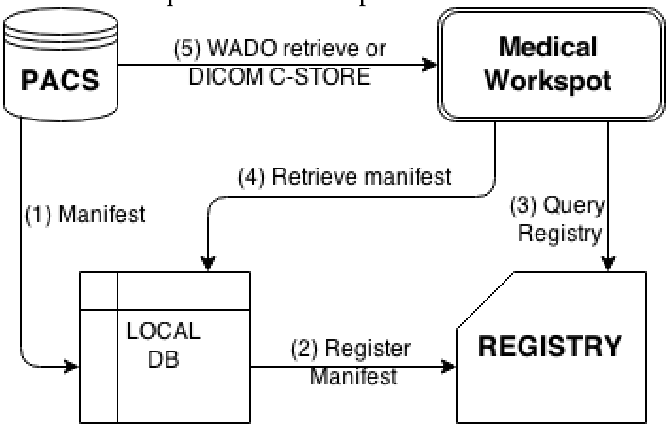

Figure. 1. Architecture overview of Image and Document Sharing System

DICOM connection: The DICOM Message Service Element, DIMSE-C services allow a DICOM Application Entity to explicitly request an operation by another DICOM Application Entity on Composite SOP Instances. The operations allowed are intended to be effectively compatible with those provided by previous versions of this standard. The DICOM C-Store service is invoked by a DIMSE-service-user to request the storage of Composite SOP Instance information by a peer DIMSE-service-user. The DICOM C-STORE requires the Application Entity (AE) of the remote node, a static IP Address and a port number for the communication. These necessities are overheads and categorize as disadvantages as the IP address is not always static for the servers and are usually present in the intranet and not visible to the outside or a common network. An alternative is to use the virtual private network which can be trusted but are extremely slow and have a lot of overheads for the setup, adds to the cost of implementation and does not constitute as a viable solution.

Web access to DICOM objects: DICOM PS 3.18 specified the web access to DICOM objects or WADO as an alternative to the DIMSE C-STORE service. This solution was strongly supported as it provides a wider modality support and also helps in Cross-Community Access for Imaging. This aims at sharing information across multiple healthcare enterprises. The information can be reports, clinical images or other patient related information that is to be shared with the help of web services which overcomes the issues that were mentioned by the regular DICOM connections. RESTful web services are preferred over the SOAP protocol for its simplicity and that the services can be consumed with the URL within the program, it decouples consumers from producers, stateless existence, its ability to leverage a cache, leverages a layeredsystem and leverages a uniform interface to mention a few advantages for choosing REST over SOAP. In this study performance investigation of the HTTP-based STOW-RS versus the DICOM C-STORE is carried out. It can be noted that for WADO we only need the AE title of the PACS. As a result, DICOM transactions such as C-STORE cannot be easily performed across multiple hospitals/enterprises.

TRANSFERRING DICOM PERSISTENT OBJECTS

In this section, the native DICOM transfer protocol (C-STORE) is compared with the recently improved HTTP-based DICOM STOW protocol.

The transfer using regular DICOM messages, the sender which is also called the service class user (SCU) initiates the C-STORE service to store the DICOM persistent object to the remote node or Application Entity (AE) which is also called the service class provider (SCP). The SCU and the SCP agree on transfer syntax, specified by the transferSyntaxUid which specifies the common encoding techniques. The AE (Application Entity) title of the SCP should be known by the SCU before the communication can begin. The disadvantage lies in the negotiations and that just one object transferred at a time. This makes the process fail at times or takes too long for the transfer to finish. The SCP on successful receipt of the object replies with a C-STORE response. The DICOM export protocol C-STORE is shown in figure 2.

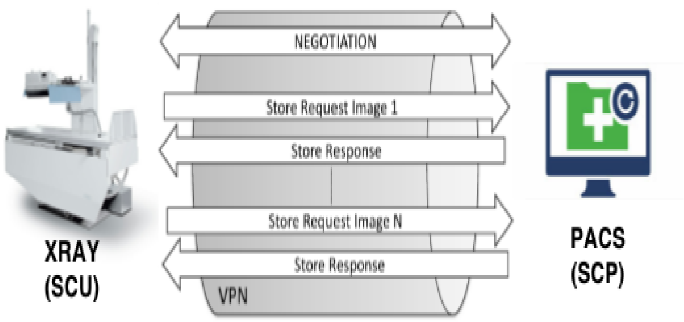

Figure. 2. DICOM C-STORE

WADO or Web Access to DICOM Objects is designed to export/import with the help of web services. We shall concentrate the export protocol called STOW or SToreOver the Web [1]. STOW is also a DICOM protocol similar to the C-STORE except that it is faster and more efficient especially with large studies like CT and MR. STOW-RS (STore Over the Web – RESTful Services) is designed to send the message in a multipart POST body that consists of multipart/related content with message boundaries for every object in a part [2]. Upon completion of the receipt of the complete message the SCP sends back a response with the HTTP status code and an XML or JSON response to notify the sender the status of the message received [3]. Figure 3 shows the STOW's architectural flow. The message is sent with an HTTP POST with suitable headers notifying the receiver about the type of message being sent. A few of the advantages of using RESTas the style of architecture is that it decouples consumers from producers, leverages a layered system and uniform interface, and is also known as a light weight transfer. Figure 4 gives the architecture of an REST communication. The advantage of using STOW over DICOM C-STORE is the transfer rate that is twice as faster than the native DICOM C-STORE, the reliability it offers and with the advent and increased usage of the internet and broadband speeds today it is easy for devices from different vendors to interoperate.

Figure. 3. DICOM STOW

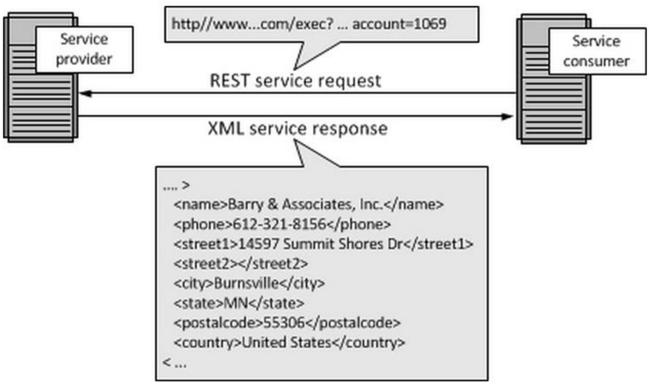

Figure. 4. REST Communication Architecture

EXPERIMENTAL RESULTS

This section compares the transfer of a few DICOM objects by HTTP STOW-RS with the native DICOM C-STORE. The main focus is to evaluate the gain in performance of STOW with different data sets of various number of objects and series of DICOM persistent objects. We mainly choose CT and MR data as the amount of objects are larger compared to those images generated from other modalities.

Implementation and Experimental Setup

For this study, the implementation of the network export for DICOM C-STORE and the DICOM STOW protocol was in C# using the DICOM libraries. The implementation was designed to be platform independent, compact and to have almost no software dependencies. The SCP used for the DICOM C-STORE was the Storage SCP Emulator (DVTk) and a server application for the DICOM STOW implementation to accept the store request and process the input and reply with a suitable response [4]. The use of the emulator helps in the association of the SCU and the SCP.DICOM C-

STORE initiates the transfer by negotiating an association. For that negotiation, a presentation context is constructed by parsing the Service-object Pair (SOP) classes and the transfer syntax that shall be employed and agreed upon. The parsing and the association is a time consuming operation which is omitted for the DICOM STOW.

Modality	No. of Objects	Time taken by STOW	Time taken by C-STORE
CR	1	6	12
CT Compressed	38	9	3243
MR	630	196	17528
CT Uncompressed	1000	51	9332
MR	3813	827	98011

TABLE I. EXPERIMENTAL DATA SET

Two experiments were conducted to compare the transfer export performance of the DICOM C-STORE with the DICOM STOW protocol. For this evaluation we setup a storage device with a 100 Mbit/s link between the SCU and the SCP. DICOM objects were transferred between the SCU and the SCP using (1) DICOM C-STORE and (2) DICOM STOW service. For each of these export methods timers were setup at the SCU. In the DICOM C-STORE the timer is started before the association and stopped after the process is completed. For the DICOM STOW, the timer is started when a request is sent and stopped after the response is received. Performance was evaluated gradually from smaller data objects to larger sets of data objects. We consider the following sets of data (Table 1):

1) CR images with one series consisting of just one image, to compare how STOW works with a small data.
2) CT images with two studies consisting of 38 objects in total.
3) CT images with 10 studies, with 10 series each, with 10 frames in each study with a total of 1000 objects.
4) MR images with 14 series and 630 images in total.
5) MR images with 2 series and 3813 images in total.

Transfer of CR, CT and MR images of different sizes of objects was chosen. We compute the transfer time using the DICOM C-STORE and STOW protocols to discuss the variations in time taken to transfer the images.

Experimental Results and Discussion

This section discusses the results obtained from exporting the data sets mentioned in the previous section.

The first transfer of a single CR image and found that the transfer rate is half of the rate of C-STORE when compared to STOW. We next transfer CT compressed and uncompressed images. It was found that the transfer by STOW is extremely fast when compared to the STOW protocol but the transfer for uncompressed images was comparatively faster than for the compressed images. Lastly we compared the transfer of MRimages of 630 and 3813 objects and came to a conclusion that the transfer using STOW is extremely fast. The size of the data set do matter when it comes to C-STORE as the C-STORE fails for larger data sets and the time to transfer is really large for bigger data sets. The STOW protocol on the other hand is very efficient as it does not send the multiple objects as single objects and sends them as a single message in a multipart format. The major reason for the STOW to be faster than the C-STORE, in the DICOM C-STORE the SCU waits for the acknowledgement by the SCP before the next transfer and the DICOM association between the SCU and SCP add to the overheads in the transfer.

Figure. 5. Experimental results

CONCLUSION

This paper discusses the two export protocols, DICOM C-STORE and the DICOM STOW protocol. It can be concluded that the DICOM STOW protocol is faster by a huge extent and more reliable than the DICOM C-STORE protocol. The change in the speed of transfer is easily identifiable with larger sets of data. With the advent and extreme use of the Internet in every part of our life, the HTTP web based STOW protocol overcomes the drawbacks of the DICOM C-STORE and provides as an alternative to the traditional DICOM C-STORE protocol with its simplicity, ease-of-use, ubiquity, statelessness, and its transparent deployment.

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