Transfer of medical images in DICOM standards using WADO and WADA services.

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Abstract-DICOM is a medical file format that is been designed in order to eliminate vendor interoperability, hence but this has to be presented without any requirement of any advanced medical applications. WADO specifies a web based service for accessing and viewing DICOM persistent object, which provides a best mean to distribute medical information.
This paper analyzes the transfer of medical images from PACS to client using WADO and extension of WADO i.e.., WADA services with a brief over view of REQUEST and RESPONSE model, and Future Enhancements.

Keywords: DICOM, SCP, SCU, PACS, WADO, WADA.

Introduction

Transfer of medical information and images for diagnosis in the case of emergency is very essential. Therefore the patient study should be able to access easily from any part of the world. The way the transfer takes place and the format in which the transfer happens is very important, along with these the patient data has to be very confidential and it should be available only to authorized person. Hence in this paper it is explained how the data transfer happens and how the study can be retrieved from the server using different services like WADO(Web Access to DICOM Objects) and WADA (Web Access to DICOM Archives) through a standardized format called DICOM.

In the first session the detailed explanation of DICOM is given followed by PACS(Picture archiving systems), then details about WADO and WADA are put into picture.

In the second session the overview of image transfer is been explained briefly followed by future enhancements and discussion.

DICOM(Digital Image Communication For Medicine) is a standard designed for image communication.

ACR (American College for Radiology) and NEMA (National Electrical Manufacturers Association) formed a committee in 1983, their mission was to develop a standard for representing the medical images so that images could be transferred and viewed across different machines which are manufactured by different vendors [2].

First version was ACR/NEMA version 1.0 in 1985 followed by a revision of first version called ACR/NEMA version 2.0 in 1988.
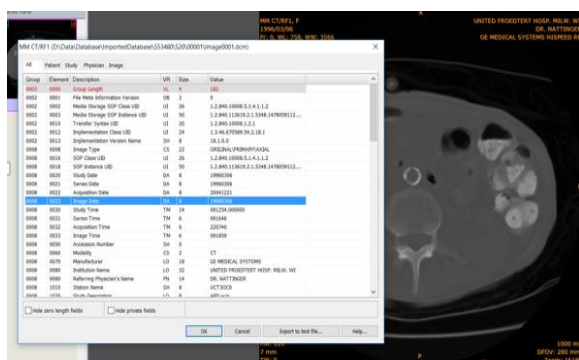

Fig.1. DICOM Format

They both used point to point connection. DICOM Version 3.0 was released in 1993.It used networking concepts for secure transmission. DICOM is a standard format commonly used for the communication and management of medical imaging. DICOM allows effective medical imaging transfer and Storage widely, making basis for PACS(Picture Archiving and Communication Systems).

The architecture of DICOM network protocol

Network →TCP/IP→DICOM ULP for TCP/IP→UL Service Boundary→DICOM Message Exchange→Medical Imaging Application.

DICOM objects are known as IOD(Information Object Definitions)[3]. The data like patient study, images, medical devices and patient schedule list are the informations that are exchanged between a SCU(Service Class User) and SCP(Service Class Provider), this transfer can be provoked through WADO and WADA services.

A DICOM modality refers to CT, MRI, X-rays etc., DICOM message consist of 2 parts a command set followed by a conditional data set. The DICOM applications provide the services which are required for data exchange. AE(Application Entities) uses DIMSE(DICOM Service Element) which has services like Composite DIMSE-C and Normalized DIMSE-N. These support notifications and operations like printing, storage, retrieve etc., on the SOP(Service Object Pairs instances). AEs (Application Entity Title) in each host will be identified by its title which has an IP address assigned and a port number. They are case sensitive and unique. SOPs are having a UID(unique identifier) which are the fundamental and basic unit that is a part of DICOM interoperability.

Establishment of association

PACS is a medical imaging technology which provides storage and it also provides access from modalities to multiple images. It is a kind of storage helped in eliminating X-ray film, files, folders transport film jackets. The universal format for PACS image storage and transfer is DICOM.

PACS include web-based interfaces to utilize the internet, this is usually done via VPN (virtual private network) or SSL (Secure Sockets Layer). WADO is a solution which could create necessary standard to expose or distribute images and reports to referring physicians and patients.

QUERYING (C-FIND) and image (Instance) Retrieval (C-Move and C-Get)

Association has to be established between client and server. At the first the client prepares C-FIND request message which is a DICOM attribute and also fills the message with key that should be matched for example should be filled with patient ID attribute. Client also creates zero length attributes, example: Zero length SOP UID(Unique Identifier) (0007,0018) in C-FIND. The C-FIND

message is sent to server/PACS. The server send back a C-FIND response message which is a DICOM attribute list, generated for each match.

The client extracts the objects and then images are retrieved from PACS through C-MOVE or C-GET request with the help of DICOM protocol. C-MOVE specifies where the retrieved instance should be sent and C-STORE indicates the destination, the retrieved instance should be sent with identifier along C-STORE message called destination Application Entity Title for C-MOVE to work it has to be configured with mapping AE title to TCP/IP address port.

In order retrieve any information first the connection has to be established between SCU and SCP. During the establishment of association it has to check for SOP class and UIDs, which has to match with the remote DICOM node. Import and export job and job manager Import and export job from or to the PACS is taken care by service manager. And the service manager handles store, query, load from network storage device proxy. Transfer is handled by Transfer Performer. Transfer performer shall be responsible for handling the transfer request, processing them and providing the result back to request initiator (either network storage device proxy or job manager itself). It relies on studies respective storage device performers to perform the DICOM object transfer from one storage device to another. Behavior of storage device performers varies based on source and target device. It acts as the integration point with Job Service via AII.

Transfer performer inherits cancel, pause and resume behaviors of All Performer Base and delegates to respective transfer task defined below. Cancel, pause and resume behaviors are asynchronous. Performer state shall transition from executing to cancel and pause state after processing respective request. Cancel and pause request are processed based on current state of transfer task. Performer shall move to completed state, if the transfer of last image is in progress while it received cancel or pause request. Resume is applicable only when the performer state is in paused state. For export and local device copy use cases, resume shall happen from the transfer save point. Import shall always start from first on resume request.

DICOM file accessibility using WADO and WADA

WADO defines specific set of entities such as patient image series, studies and composite objects which are called as IE (information entities).
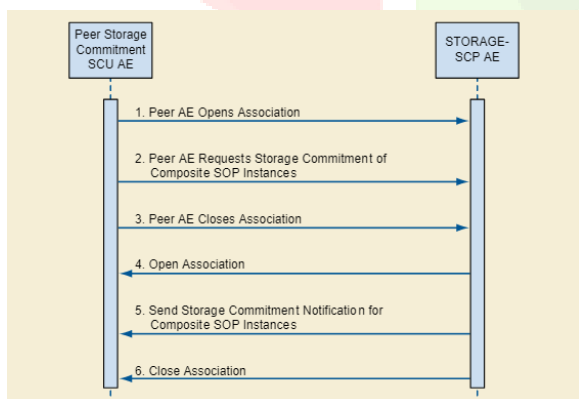

Fig.2.Establishment of Association between SCU and SCP.

The above figure 2 shows the communication method between a SCU and SCP.

WADO

WADO (Web Access to DICOM Objects- Request/Response) standardizes the web access over the objects using HTTP(Hypertext Transfer Protocols) or HTTPs (secure protocols). It enables the client server to retrieve objects which are handled by web-enabled DICOM server or W server. The study is identified by determining the UIDs of study root-information model levels.

An association is established before retrieval or transfer. Query parameters are sent when the data has to be required, that is HTTP get request is sent, or the client can also request Wserver(web enabled DICOM server). On requesting Wserver the data can be converted into different presentation-ready format e.g.., html reports and jpeg images as shown below in Figure 3.

Fig.3.Xml and image format obtained from PACS

The Wserver sends http response by sending single or multiframed images in a proper MIME(Multipurpose Internet Mail Extension) type[4] Other characteristics for query can also be passed to Wserver that is to anonymized DICOM object before transmission i.e.., by anonymizing the patient identification from the data. Other parameters like size frame- number can also be selected by the client of the image for non-DICOM images.

Features that are not supported by WADO

- One SOP(Standard Operating Procedure) instance for a call is initiated.
- Suitable only for web based applications.
- URL based query is easy to write, but not adapted for being parsed.
- Application Development through WSDL(Web Services Description Language) is not easy

OVERVIEW OF DICOM IMAGE TRANSFER

The main task is to transfer DICOM objects across storage devices by understanding the type of storage device and their corresponding services they provide.

Its responsibility is to act as a DICOM object transfer Manager which enables to connect multiple storage devices and also provide convertors to resolve some interoperability issues. The figure 4 shows the data flow in order to transfer the DICOM images.
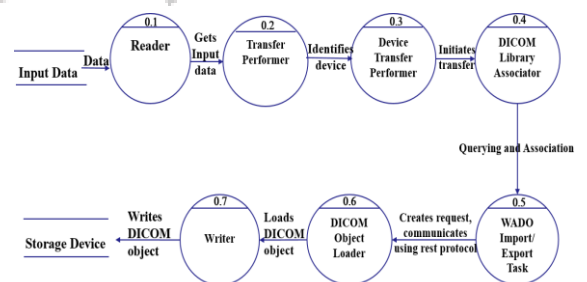

Fig.1. Data Flow Diagram to transfer DICOM images

The location of DICOM data that is to be queried, stored, load or retrieved need to be identified. The data could be DICOM entities such as image, series, study, presentation states for processing. The data is generally stored in PACS which is a repository used in imaging especially in medical field which enables storage and easy access to medical images that may be obtained from different modalities that is different machine types like MRI, CT scan, X-Ray and so on that are provided by different vendors and can be accessed from anywhere in the world.

Next performers need to be instantiated that is able to read the data from storage device, variations that is interoperability and write the data to target device. This may vary based on the data loaders and writers to achieve the transfer. The type of storage device and transfer is chosen and corresponding performers will be

accordingly initiated for the transfer process. The next process is to query the data that is to be retrieved. For the querying purpose the SCU client will query the data Query-Retrieve SCU for a particular data. Query-Retrieve SCU will return the some information related to the query to the SCU client. The client verifies if the information requested is the same and if needed, the client can request for the retrieval of the data for the clients storage purpose [5]. Once the Query-Retrieve SCU receives a retrieval request it sends a notification to the Storage SCP to transfer data. Now, an association needs to be established between the two devices/ hosts that are involved in transfer process for which DICOM provides DICOM Library which enables to employ and share the anonymized results. WADO is used as a way of transfer of medical images through web. It makes use of REST protocol to communicate with each other [4]. WADO mainly uses a tier architecture, which consists of Client tier, Server tier and Database. In client tier, the user interface helps the user to select the data that is to be transferred between devices. Next the server tier mainly has two severs that is, application server and integration server. They enable the client authentication and communicates the request to database. The last tier consists of three databases. The first one is the control database which enables the communication between server and the database tier. Second is the image database which stores all the DICOM images which are received. Report database consists of reports related to the DICOM images stored in image database. The GET request can be obtained by specifying the UID of the DICOM image. The IP address in a hospital environment will be a private one so that the information will be safe and secure. WADO services has a big advantage of using dynamic IP addresses for transfer thus increasing the security feature of transferring DICOM images which was not possible in C-STORE as it used static port number and relayed on public IP addresses. This dynamic mode could be embedded in the medical systems that requires the capabilities.

Figure5 explain about the communication process in WADO. Query parameters are sent to the web based server through *http* GET and the server give the response by sending one or more images or objects in MIME (Multipurpose Internet Mail Extension) type. The DICOM objects that are to be transferred will be loaded by using the DICOM Object loader.

It will check for the DICOM image format while loading the images. Only if the image conforms the file structure of DICOM it will exported or imported to the storage device. The export or import will be done by the writer which will write the data to the storage device. Thus the transfer will be completed and an optional user message could be displayed to notify the user about the transaction.

Fig.5. WADO Request-Response Model

A packet analyzer is been used to capture the data or traffic, i.e.., tool such as wireshark.
It can edit the captured files programmatically, data display can be refined, VoIP calls that are captured can be detected if it is encoded the media can even be played. It also displays response and request messages.

WADA SERVICES

WADA(Web Access to DICOM Archives) is an extension of WADO which enables query mechanism that the preview of IE attributes to identify the UIDs.

It also supports encryption and provides transport level security. IP address is private for a particular hospital hence this is secure when compared to WADO. Each UID should be unique and it should be not be changed when images are sent to HIS/RIS archives. Patient ID, patient name and date of birth are the attributes that are considered as patient UID. WADA provides a procedure that includes UID of series or study in the query field of HTTP request.
In order to query for the data C-FIND service is been used. C-STORE to store the data into media and C-MOVE for transfer of data.
The services include 3 modes dynamic, direct and hybrid mode.
Dynamic mode where each attribute of patient UID is detected one-by-one. In direct mode it first allows the client to interact with remote DICOM archives and then to preview all patient attribute. Hybrid mode first access patient's table, studies and then obtain the object[1].

Future enhancements

Similar to wireshark a tool can be designed which can be used to check vendor interoperability and validation and support various protocols like DICOM, HL7 and HTTP. To provide an efficient and productive way of testing Interoperability of Healthcare systems. Additionally, this tool can be used by Field Service Engineers for quicker diagnose of any interoperability issues in the field.
IHE (Integrating the HealthCare Enterprise) Framework can be used to define the terminology used and some of the functionality that is implemented, in order to provide a full range of features and capabilities needed to ensure the interoperability of any healthcare product.
Features could be as listed below:

- Tool provides all the possible DICOM and HL7(Health Level Seven) transactions for each of the emulators. For example – Modality emulator can Query Work list from RIS, create emergency studies, can report MPPS(Modality Performed Procedure Steps) to RIS(Radiological Information System), store images to PACS, store Presentation State and Key Image Note to PACS, can do Storage Commitment to PACS and DICOM Echo service to any other node. These are all the possible services that a modality can support in real scenario.
- Tool should provide a functionality to validate the DICOM messages against DICOM standard and HL7 messages against HL7 protocol. It also provides functionality to compare the messages, edit them and save as message files.
- Network capture can also be available in this tool which internally uses the command line version of Wireshark to capture the network packets. The captured network packets are reassembled into messages that can be validated, compared, edited and saved.
- Other saved DICOM files, DICOMDIR and DICOM Media can be viewed and validated against DICOM standard.
- HL7 message support – for the exchange of HL7 V2.0 messages using the MLLP (Minimum Lower Layer Protocol).
- HTTP message support – for testing web server based functionality – like WADO-RS.

Conclusion

Data retrieval from any part of the world just by providing URIs is also made possible which is very useful and essential in medical

diagnosis in case of emergencies, hence it could be called as a boon for the field of Medicine.

This paper describes services that can be used to access the data where WADA proved to be the best service for query and retrieval of the patient study and the future scope to develop a tool which would support both interoperability and also provide features of Wireshark where the combination of both would lead into a beautiful concept of a tool supporting various protocols like DICOM, HL7 and HTTP. To provide an efficient and productive way of testing Interoperability of Healthcare systems and also provide validation.

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