

# Web Access to DICOM Objects (“WADO”)

## *Emerging Medical Information Standards in Medical Imaging*



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**Abstract**—Medical imaging markets have embraced DICOM as the de facto standard in medical imaging data exchange and storage enabling the loose coupling of disparate medical imaging systems across the healthcare enterprise. DICOM has allowed for the growth of PACS, and has spread to the referring physician provider where viewing DICOM images has become commonplace. However, access to DICOM data from “web portals” has evolved in a somewhat non-standard environment where “DICOM” data sent to physicians on optical media and viewed over the Web are not necessarily presented in an open DICOM format. An emerging DICOM initiative, Web Access to DICOM Objects, is poised to offer a platform independent framework to present data in lightweight viewing platform from optical media and Web browsers. In addition, WADO may present possible integration with emerging technologies in healthcare information exchange such as service oriented architecture.

**Index Terms**—PACS, SOA, DICOM, HL7, WADO

### I. INTRODUCTION

DICOM has long been the de facto standard for medical imaging exchange, allowing cross-vendor integration in the medical imaging market space. Today, one can leverage the DICOM standard in the Radiology practice utilizing disparate medical imaging vendors in a unified “PACS” environment. For example, it is not uncommon to find medical imaging practices utilizing vendors for modalities, a different vendor for their radiology information system (“RIS”), and yet another for PACS and other ancillary functions working coherently in a seemingly integrated workflow. DICOM allows this coupling of imaging information systems. Other standards such as HL7 and EDI can be “bridged” to the DICOM network using protocol brokers (commonly referred to as a “PACS Broker”).

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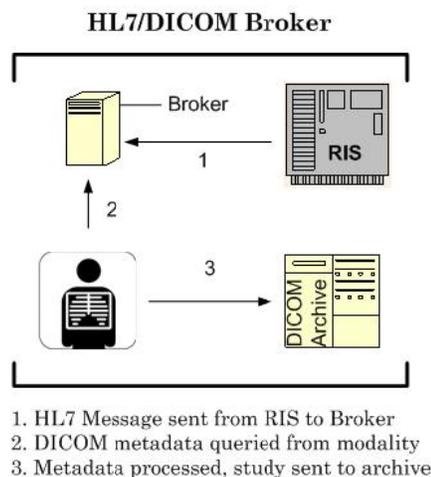


Figure 1

1. HL7 Message sent from RIS to Broker
2. DICOM metadata queried from modality
3. Metadata processed, study sent to archive

While DICOM has shown to be a reliable and accepted standard for coupling systems within a radiology practice, it typically operates in an “island” and is not widely accepted in other healthcare market spaces. While some healthcare markets such as cardiology and pathology have begun to embrace DICOM, the lions share of medical information systems offer little native support of the standard. [1]

WADO appears to be a solution to bridging the protocol gap, offering cross platform access to medical images for users not adapted to the DICOM standard. This paper will review traditional DICOM workflows, HL7, and the challenges in providing DICOM images and reports to referring physicians. WADO is explored, and how it can help bring medical images in a seamless portable format to referring physicians, and several use cases are examined.

### II. CURRENT STANDARDS

The DICOM, HL7, and an emerging standard, SOA, offer much of the medical information data exchange in use today. Each standard is reviewed with use cases in radiology workflows.

A. HL7

Healthcare Level 7 (named for its position in the OSI ISO model -- Level 7 is the “application” level, served by lower levels such as “Network” and “Data Link”) is a widely used standard in many areas of healthcare to exchange patient information. Currently, the most widely used iteration of HL7, version 2.3 [2], is much like other ANSI standards in its form, where lines of ASCII separated by designated characters present elements of data. For example, one might find an “ADT” HL7 message detailing the admission of a patient with the following:

```
MSH|^~\&|1|2|||20090324172104||ADT^A28|123792|P|2.3
EVN|A28|20090324
PID|1||528653||TEST^PATIENT||19800209|F|||BEDFORD
AVE^^BROOKLYN^NY^11221^11221
PD1|||22191^Acenas^Elizabeth
```

In the proceeding, we can see the message is divided into 5 lines. The first line, the Message Header (“MSH”) precedes all other lines in an HL7 message, and defines the message element separators (in this case each element is separated by the “|” symbol, while sub elements are separated by the “^”, and so forth) and tells us where this message originated, the intended recipient, the message type (“ADT^A28”) and other control information.

**COMMON RADIOLOGY HL7 MESSAGE TYPES:**

MESSAGE TYPE	DESCRIPTION
ORM	<u>O</u> rd <u>R</u> Message (i.e., an XRay is ordered for a patient.)
ADT	<u>A</u> dmit, <u>D</u> ischarge, <u>T</u> ransfer (i.e., patient admitted to a hospital, or entered into practice management system)
ORU	<u>R</u> esult (i.e., radiologist’s final report.)

Table 1

Following this line is the “PID” which describes the patient, in this case a patient named “Patient Test” with a medical record number “528653”, born on February 9, 2009. In the PD1 segment we see the admitting physician is Elizabeth Acenas, whose ID number is 22191.

Although a very simple example, this standard message format can be transmitted to other medical information systems. For example, in radiology the ADT message would tell the “radiology information system” (RIS) about a patient recently admitted, discharged or transferred to the hospital. However, the RIS may not necessarily need this data until a physician orders a radiology procedure, which would generate an “ORM” message that might look like the following:

```
MSH|^~\&|1|2|||20090324172104||ADT^A28|123792|P|2.3
EVN|A28|20090324
PID|1||528653||TEST^PATIENT||19800209|F
PV1|S|^DOCTORS ORDERS^^SW||
ORC||||100|||||22191^Acenas^Elizabeth
OBR||6955356|^PELVIS 2 VIEW^72170|||200903241200|||||PAIN
```

In this message, the RIS might be notified that a physician is ordering a radiograph of the pelvis for our test patient. The RIS would then trigger creation of an order, and workflow elements that should be initialized based on this action (for example, notifying a technologist of the order). At this point, the DICOM standard takes over the workflow.

B. DICOM

A DICOM/HL7 protocol broker could extract information from the HL7 message detailed above, to present this information to a computed radiography system, using the DICOM standard.

DICOM, unlike HL7, uses “tags” to represent metadata in a DICOM file. The payload of a DICOM file is typically the actual image generated by a modality, in TIFF format. Indeed, it can be said that DICOM at its most basic level is a TIFF with a modified header describing the image and relevant patient and clinical information. If one were to examine the anatomy of a DICOM file, we would find a DICOM “header” followed by the image.

Within the header, information is “tagged” using standard tag numbers represented in hexadecimal, with a “group” and “element” identifier. For example, the “Patient Name” tag 0x00100010 is a “patient” group (0010) whose element is the patient name. Likewise, tag 0x00100020 represents the patient’s medical record number. Another group, study, would contain tag 0x00081030, the study description, and likewise tag 0x00080050 describes the accession number. At the time of this writing, the DICOM standard describes over 16,000 DICOM tags and DICOM vendors describe countless additional ‘private’ tags.

**Conceptual Diagram of DICOM**

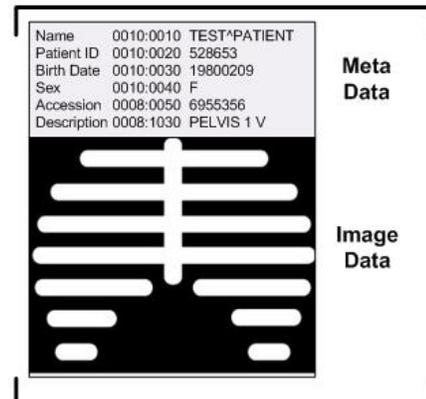


Figure 2

Data stored in the standard format that is portable is typically referred to as “DICOM Part 10” – the DICOM section describing how to store DICOM data. Although DICOM is portable in its stored format, it is typically transmitted over a network between DICOM systems (much like HL7). However, DICOM supports several basic command sets for managing this data.

C-Store describes the DICOM transmission of image data. Typically, devices take the role of a Service Class User (the device initializing the communication) or Service Class

Provider (the device accepting the communication), negotiate the parameters of the data to be transmitted (modality type, compression), and finally transmit the data.

In addition to the C-Store, DICOM supports C-Find which allows a DICOM device to query another DICOM device for information on the DICOM Objects it has indexed. C-Move commands a DICOM peer to send a DICOM object(s) to another DICOM device.

C-Find can be used by DICOM Modalities to query the HL7/DICOM protocol broker for information on patients whose data was received using HL7. In this way, modalities can be ‘integrated’ across the protocol bridge to HL7 information systems such as radiology and hospital information systems.

While DICOM has the ability to store the radiologist’s report as a DICOM object, typically this data resides natively in the medical record system. Once again, the DICOM/HL7 protocol gateway can be used to integrate the radiology report from an HL7 based system to the DICOM system. In many cases, this integration can be accomplished through web services, or service oriented architecture (“SOA”).

### C. Service Oriented Architecture

The Internet has allowed the explosive growth of information access using the hypertext transfer protocol, which is used when browsing the World Wide Web. Information is accessed from a browser using a Uniform Resource Locator (“URL”) as in <http://www.google.com>. When browsing the web, many web pages allow users to “submit” information using forms on web pages, which then loads the requested information. For example, when accessing [google.com](http://www.google.com), one would provide a search term in a form, submit the form, then view the results of that search. Web services take advantage of this simple architecture to allow the passing of information between loosely coupled systems.

The format of both submitted and retrieved data with web services is typically eXtensible Markup Language (“XML”). XML is a flexible method of presenting data, since users can “markup” the document with their own syntax. [3] For example, one might express the contents on their desk as:

```
<desk>
  <phone color="black">
    Handset
    Cord
  </phone>
  <pen_holder>
    <pen> black </pen>
    <pen> red </red>
  </pen_holder>
</desk>
```

In this simple example, the XML document tells us the “desk” contains a phone and a pen holder. The phone contains a handset and cord, and has the attribute of being a black phone. The pen holder contains two pens, one red, the other black. Applying this simple markup technique to a medical record, we could express a radiology report like so:

```
<report>
  <patient sex="f">
    <name>
      <last> Test </last>
      <first> Patient </first>
    </name>
    <medicalRecordNumber>
      528653
    </medicalRecordNumber>
    <birthDate>
      2/9/1980
    </birthDate>
  </patient>
  <study>
    TWO VIEWS OF THE LEFT HIP
  </study>
  <date> 03/13/2009 </date>
  <physician>
    Dr. Robert Jones
  </physician>
  <history>
    Status post hip surgery six days ago.
    Recent fall with pain.
  </history>
  <comment>
    There is an intertrochanteric fracture with
    three reduction screws traversing the site.
    Alignment and position are grossly anatomic. I do
    not see new or additional fractures other than the
    intertrochanteric fracture. The femoral head sits
    midline within the acetabular fossa with no
    islocation or deformities to the articular surfaces.
  </comment>
  <impression>
    Gross anatomic alignment position in this
    patient status post reduction of a left hip
    intertrochanteric fracture.
  </impression>
  <readingPhysician>
    Christopher Smith, MD
  </readingPhysician>
</report>
```

In this example, we see a report marked up with XML, but when read by an application, one might see this rendered in the more familiar human readable form:

```
STUDY: TWO VIEWS OF THE LEFT HIP, 03/13/2009

ORDERING PHYSICIAN: Dr. Robert Jones

CLINICAL HISTORY: Status post hip surgery six days
ago. Recent
fall with pain.

COMMENT: There is an intertrochanteric fracture
with three reduction screws traversing the site.
Alignment and position are grossly anatomic. I do
not see new or additional fractures other than the
intertrochanteric fracture. The femoral head sits
midline within the acetabular fossa with no
dislocation or deformities to the articular
surfaces.

IMPRESSION: Gross anatomic alignment position in
this patient status post reduction of a left hip
intertrochanteric fracture.

DICTATED BY: Christopher Smith, MD
```

This same report could likewise be expressed in an HL7 message. You can view an example of this patient's report as it transformed from a plain text report, to HL7, to XML at <http://demo.ultrRADcorp.net/demo>. [2]

While SOA is a relatively new standard in the medical information systems market, its ability to be easily adopted to exchange data between different systems and its widespread adoption in other market spaces is accelerating its growth as a complement to health information standards such as HL7. [4] [5] However, up until WADO, there was no clear way to use web services to facilitate access to medical imaging data. Disseminating DICOM data in a format that could allow seamless access is difficult in the pure DICOM environment. [6]

### III. CHALLENGES OF DICOM FOR PROVIDER ACCESS

While DICOM has been instrumental in providing integration between medical imaging vendors, it has been somewhat challenging in providing access to DICOM data outside the radiology department. In order to receive and visualize DICOM data, one must have specialized DICOM software.

Although there has been some wider acceptance of DICOM with the inclusion of DICOM in Adobe's suite of graphics design applications, and even in open source projects such as GIMP, referring physicians are reluctant to install unfamiliar software and spend time experimenting with display of DICOM data.

#### A. DICOM over the Network

In order to receive DICOM data in a purely DICOM format over the network, the physician must have a dedicated workstation and appropriate network connections in place such as a VPN. This requires an investment of time and money that referring physicians seem unwilling, and in many cases unable, to make.

In many cases, a dedicated network is established between facilities in a business agreement to exchange data. In this scenario, DICOM is sent directly between the facilities and viewed natively in their PACS.

While the direct access is an acceptable solution where creating a dedicated connection between facilities is feasible, this method is not conducive to exchanging data in an ad hoc topology. For example, if an ER patient is being transferred and their destination hospital's PACS is unknown, it is common to send the studies on optical media (CD/DVD).

#### B. DICOM Media

Where the DICOM network is not available, which is common in ad hoc scenarios as described above, the facility will either need to print films or burn a CD or DVD. Creating a DICOM media brings a host of questions, such as how to ensure the receiving facility can read the data, and import to their PACS? While such things should normally be technically feasible, industry experience tells us this is not always the case.

In an effort to ensure the data is usable, many DICOM media include a "free" simple DICOM viewing application which runs from the CD. While this provides a way to access

and view the data if a recipient of the media does not have DICOM or PACS capability, in many cases the software will not be compatible with the hardware or security policy in use by the recipient's facility.

In some cases, PACS fail to create true portable DICOM files, forcing the recipient to use their simple viewer with no method to import and view on their own PACS, limiting the usefulness of the data they have received. Anecdotally, this author recently found 12 PACS writing CDs, and only 4 actually created portable DICOM files that can be imported to another DICOM system.

#### C. DICOM Web Viewer

The term DICOM is used lightly when discussing DICOM web viewing. In this scenario, providers can view studies using the facilities "referring physician web viewer". However, the provider has no access to the DICOM data underlying the view from the web, and little control over its presentation.

This presents a challenge much like that of the CD Viewers distributed by many application vendors. However, the addition of more stringent security practices by both facilities and web browsers (like Microsoft's Internet Explorer) further complicates matters.

In order to provide visualization of DICOM data within a web browser, many vendors will use either ActiveX controls, or JAVA Applets to add functionality not available natively within a browser. The added functionality, and in some cases the ability to manipulate data just as if on a standalone DICOM workstation has made use of these technologies nearly ubiquitous in DICOM web viewers.

Both technologies offer an easy way to distribute an application for access over the web, however, both have downsides worth mentioning. ActiveX requires Internet Explorer, and therefore locks users not only to a specific browser, but also a specific operating system (Microsoft Windows).

While JAVA applets offer a bit more flexibility in that they are cross platform and can be run on most modern computers regardless of the operating system or browser, they require that the JAVA framework be downloaded and installed from Sun Microsystems prior to running the application. In many cases, users trying to access data (such as referring physicians) do not have the necessary security level, or expertise to install these components.

### IV. WEB ACCESS TO DICOM OBJECTS

WADO as a standard seeks to provide a solution to many of the classic DICOM distribution issues described above. It calls for the use of cross platform, simple display of DICOM objects using a web browser. While it seems that the standard is directed towards web access, IHE has embraced the concepts of WADO for presenting DICOM information on CD in order to maximize the possibility the data will be viewable on any workstation, regardless of the operating system or hardware. [7]

WADO creates a framework for truly portable and seamless DICOM data access either over the Web, or on DICOM media.

One method to achieve this portability is the use of more widely accepted standards to present image data, such as JPEG. JPEG has reached a level of saturation not possible with a limited use standard such as DICOM, and is therefore useful on nearly any modern computer. One would find it difficult to find a Web browser not capable of displaying a JPEG image. To display meta data (data about the data) such as patient name, sex, date of birth, etc, one could use HTML, again supported by most Web browsers on nearly every modern computer. [6]

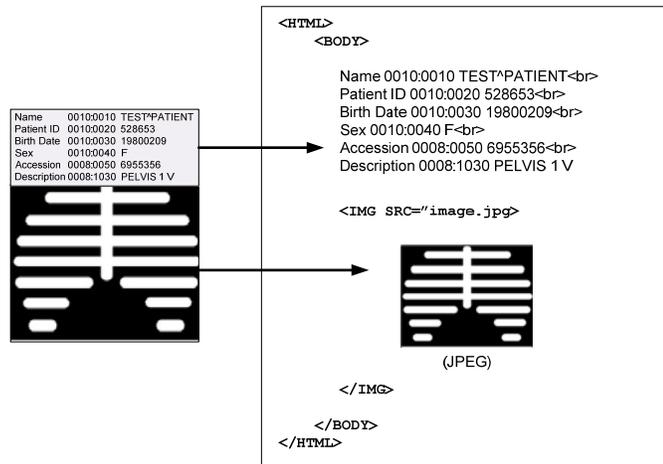


Figure 3

An initiative by healthcare organizations called IHE (<http://www.ihe.net>) has proposed a Portable Data for Imaging ("PDI") standard which is intended to create general purpose "simple" CD/DVD exchange to any unknown recipient with or without sophisticated workstations. PDI embraces the WADO concept in its recommendations to store not only DICOM data on media, but also include a simple browser based viewing option using an image format that can be natively displayed in the browser. IHE's PDI standard calls for support of several use cases when providing a disk with radiology images: viewing in simple DICOM viewer, Export DICOM, viewing in browser. [7] Below is a simple example of the file hierarchy on an IHE compliant medium:

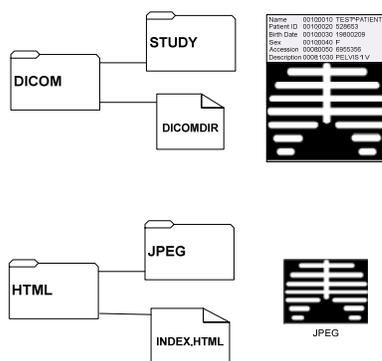


Figure 4

While presenting data as HTML and JPEG is useful in ensuring portability, it comes at a cost of functionality. Users can not manipulate the data as they may have been accustomed to in full DICOM viewers. To mitigate this, JavaScript can be used to add functionality such as panning and zooming. An intriguing use of asynchronous JavaScript and XML (AJAX) can even add functionality such as Window/Level, and other image processing by manipulating the data on the server and downloading to the browser.

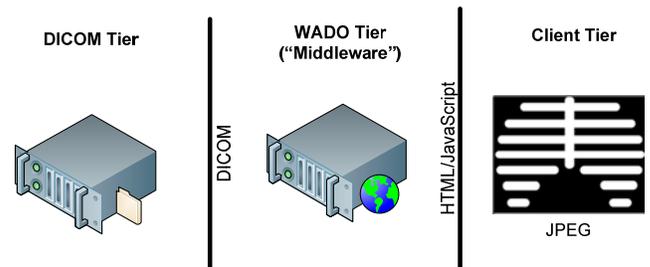


Figure 5

Like HTML and JPEG standards, JavaScript is another example of a widespread standard with nearly ubiquitous market penetration. While its portability and widespread use make it ideal for WADO, there are a few pitfalls: the script source is parsed on the client, meaning programs cannot be 'compiled' (thus copy protection becomes much more difficult). JavaScript also may be implemented slightly different depending on the Web browser; for example Microsoft's Internet Explorer may not be able to run JavaScript written for Mozilla's Firefox. In some cases, programmers would have to write functions twice, once for each browser type.

In spite of these minor issues, JavaScript presents us with an excellent cross platform mechanism for allowing simple referring physician friendly viewing of DICOM data, regardless of their local network security privileges, software or hardware platforms.

## V. INTEGRATING WADO

Because of WADO's cross platform capability, integration with other web based interfaces in the healthcare domain is the next logical evolutionary step. Rather than physicians using seemingly disconnected interfaces to access traditional medical records and medical images, a URL driven web service approach can be used to link to patient images and reports. [8]

To demonstrate the concept, consider a search on Google.com. When going to the URL <http://www.google.com> you will find a basic web page, where you can enter a search term to find web pages that may be of interest to you. However, if you were to place the search term directly in the URL as in <http://www.google.com/search?q=dicom>, a list of websites about DICOM will appear in the results.

With WADO running as a web service, one might be able to launch a patient's record by simply supplying the patient's medical record number in the URL as in: <http://demo.ultradcorp.net/demo/study/618-06-7611/>. In this

example, the URL directs the user to this patient’s medical record. The report is fetched into the browser using the same method, thus demonstrating a “mashup” of multiple medical record items. Likewise, going to the URL <http://demo.ultradradcorp.net/demo/study/15346612/> displays a different patient’s medical record.

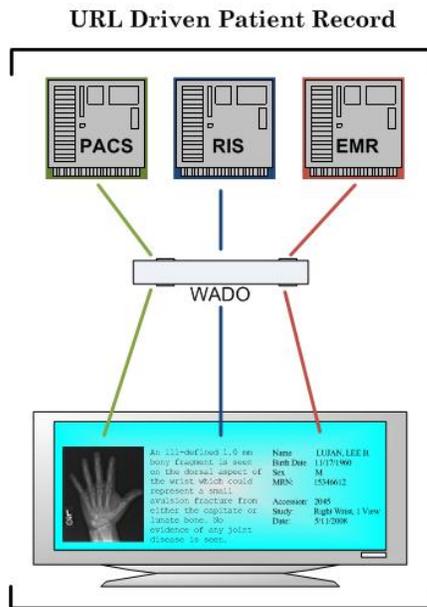


Figure 6

Using these concepts, it is possible to launch images from any client against a WADO server. Going a step further, it may be possible to ‘get’ the WADO-style images using other more traditional service oriented techniques, such as SOAP or ASP.NET Web Services.

The example below presents a simple web service example, where a client application such as an EMR requests study information from a WADO server running a web service SOAP interface. The request might look like:

```
<?xml version="1.0" encoding="utf-8"?>
<Envelope>
  <Body>
    <getStudy>
      <siuid> 1.2.124.113532.162.37 </siuid>
    </getStudy>
  </Body>
</Envelope>
```

A response is then generated and returned to the client, which can then parse and display the desired components:

```
<?xml version="1.0" encoding="utf-8"?>
<Envelope>
  <Body>
    <getStudyResponse>
      <siuid>1.2.124.113532.162.37</siuid>
      <name> LUJAN^LEE^B </name>
      <dateOfBirth>19601117</dateOfBirth>
      <sex> M </sex>
      <mrn>15346612</mrn>
      <accession> 2045 </accession>
      <study> Right Wrist, 1 View </study>
      <date> 20080511 </date>
      <series uid="1.2.124.113532.162.37.1">
        <image uid="1.2.124.113532.162.37.1.1"
          path="ima00000.jpg" />
      </series>
    </getStudyResponse>
  </Body>
</Envelope>
```

## VI. CONCLUSION

While DICOM has become the de facto standard in medical imaging integration, the addition of WADO to the DICOM standard offers the industry a framework to bring DICOM to the larger medical community. WADO mitigates the issues of cross platform access, and ever more stringent information security policies driven by technology and HIPPA.

## VII. REFERENCES

- [1] M. Eichelberg, T. Aden, and J. Riesmeier, "A Survey and Analysis of Electronic Healthcare Record Standards," *ACM Computing Surveys*, vol. 37, no. 4, pp. 277-315, Dec. 2005.
- [2] R. H. Dolin and P. V. Biron. Health Level 7 Organization. [Online]. <http://www.hl7.org/Special/Committees/sgml/hl7v231xml.pdf>
- [3] M. Papazoglou, *Web Services : Principals and Technology*. Harlow, Essex, UK: Pearson, 2008.
- [4] K. Sartipi and A. Dehmoobad, "Cross-Domain Information and Service Interoperability," *Proceedings of iiWAS2008*, pp. 25-34, Nov. 2008.
- [5] J. H. Weber-Jahnke and M. Price, "Engineering Medical Information Systems: Architecture, Data and Usability & Security," *29th International Conference on Software Engineering (IEEE)*, 2007.
- [6] G. Koutelakis and D. Lymperopoulos, "PACS through Web Compatible with DICOM Standard and WADO Service: Advantages and Implementation," *Proceedings of the 28th IEEE EMBS Annual International Conference*, pp. 2601-2605, Sep. 2006.
- [7] "IHE Technical Framework Volume I Integration Profiles," pp. 161-170, Aug. 2007.
- [8] S. Mohammed, O. Ahmed, J. Fiadhi, and K. Passi, "Developing a Web 2.0 RESTful Cocoon Web Services for Telemedical Education," *International Symposium on Applications and the Internet*, pp. 309-312, 2008.
- [9] J. Kim, T. W. Cai, and S. Eberl, "A Solution to the Distribution and Standardization of Multimedia Medical Data in E-Health," *Australian Computer Society, Inc*, vol. 11, pp. 161-165, Jan. 2002.
- [10] "Digital Imaging and Communications in Medicine (DICOM) Part 18: Web Access to DICOM Persistent Objects (WADO)," 2004.

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