



A Web-Based Query and Retrieval System of Federated DICOM Image Archives

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Background

- **Digital Imaging and Communications in Medicine (DICOM)** emerged because of a need to standardize the storage and transfer of digital medical images and its associated information between **Picture Archiving and Communications Systems (PACS)** and medical imaging equipment manufactured by different vendors.
- Since its inception in 1985, it has been widely adapted by most medical imaging companies and has become the de facto standard for medical imaging.



Background

- Explosion of Medical Imaging Content
- 2003: 308,000 terabytes
- 2006: 1,250,000 terabytes
(four-fold increase)



Background

- Need for a storage infrastructure that is scalable and adaptable to the rapidly changing needs and requirements of the medical industry.



Background

- **Grid Computing**

= distributed computing across virtualized resources with the goal of creating a virtual supercomputer out of a collection of connected and heterogeneous systems.



Background

- **Application of Grid Technology in Medical Information Storage and Retrieval**

Examples:

- GLOBUS Medicus
- IBM's GMAS (Grid Medical Archive Solution)



Background

- **ONCO-MEDIA Project**
(www.onco-media.com)
- = **ON**tology and **CO**ntext Related **ME**dical **I**mage **D**istributed **A**ccess
- = An international collaboration between France, Switzerland and Asia (Singapore, China, Taiwan, Japan, Philippines)
- = Funded under the ICT-Asia Program of the French Government



Background

- **Goal of ONCO-MEDIA:**

To develop new representations and algorithms in the following areas:

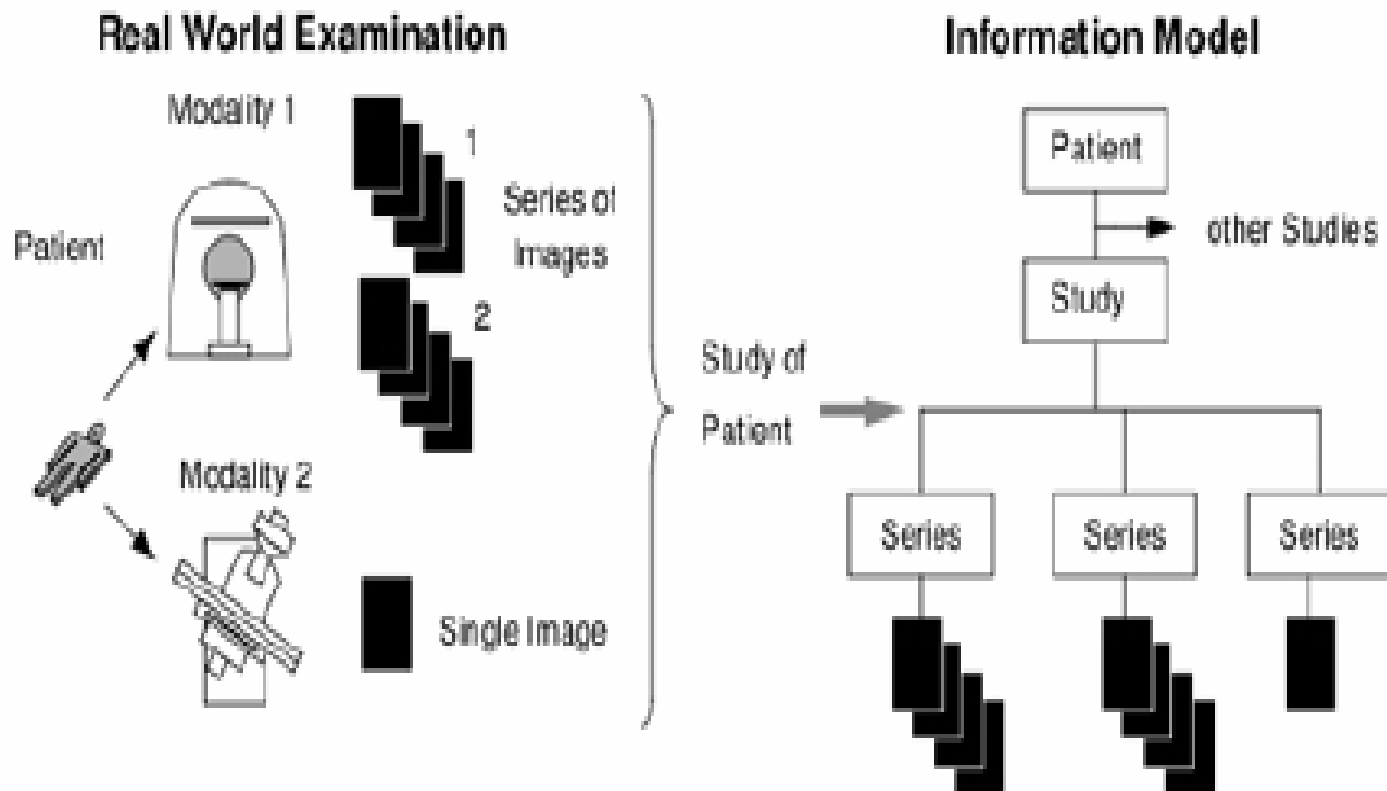
- **Semantic indexing of medical cases (images and reports) using medical ontology;**
- Contextual information retrieval, navigation, and query;
- **Visual feature discovery and collaborative annotation;**
- Invariant image feature extraction and image intelligent matching/fusion
- **Grid distributed medical image retrieval specification and prototyping**



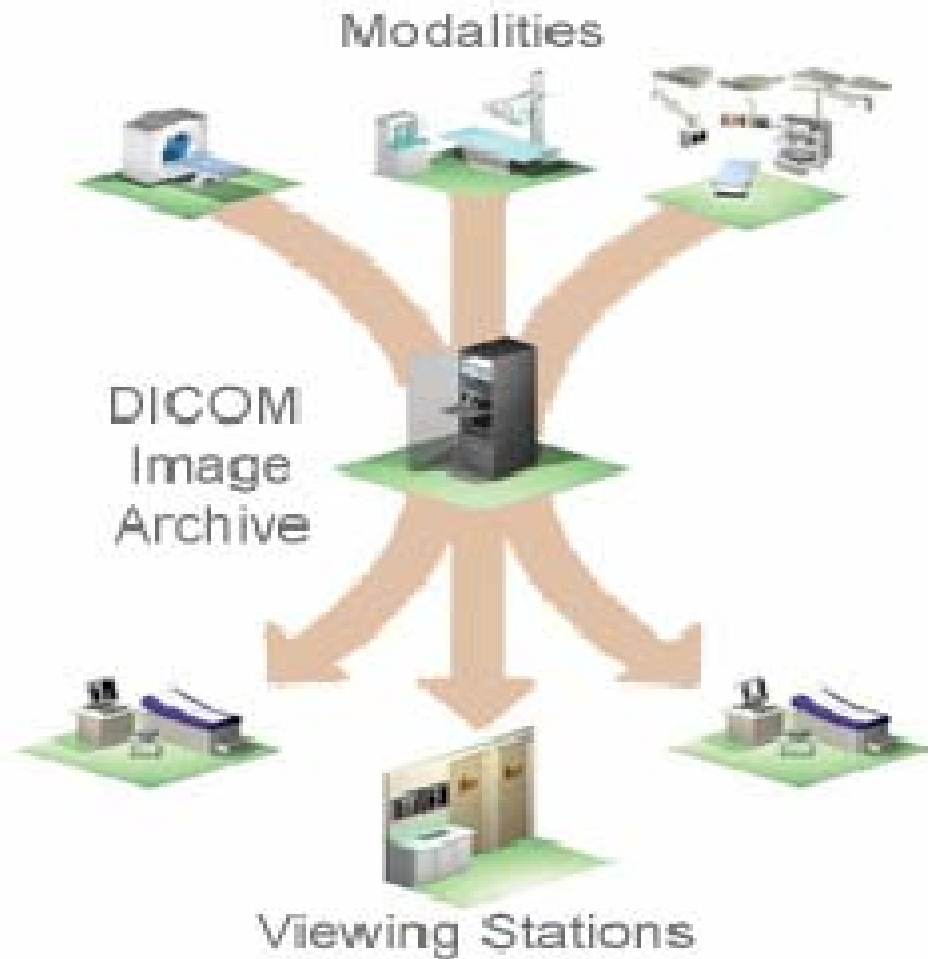
Background

- **Ateneo de Manila University**
(www.ateneo.edu)
- = **ONCO-MEDIA partner in the Philippines**
- ***Tasks:***
 1. To make local clusters available as part of the Grid for testing.
 2. Help investigate Grid technologies and image analysis algorithms.
 3. Create a Web-based medical image viewer application that will make possible the semantic content-based medical image retrieval in a Grid context

DICOM Image Information Model



DICOM Image Workflow



System Architecture

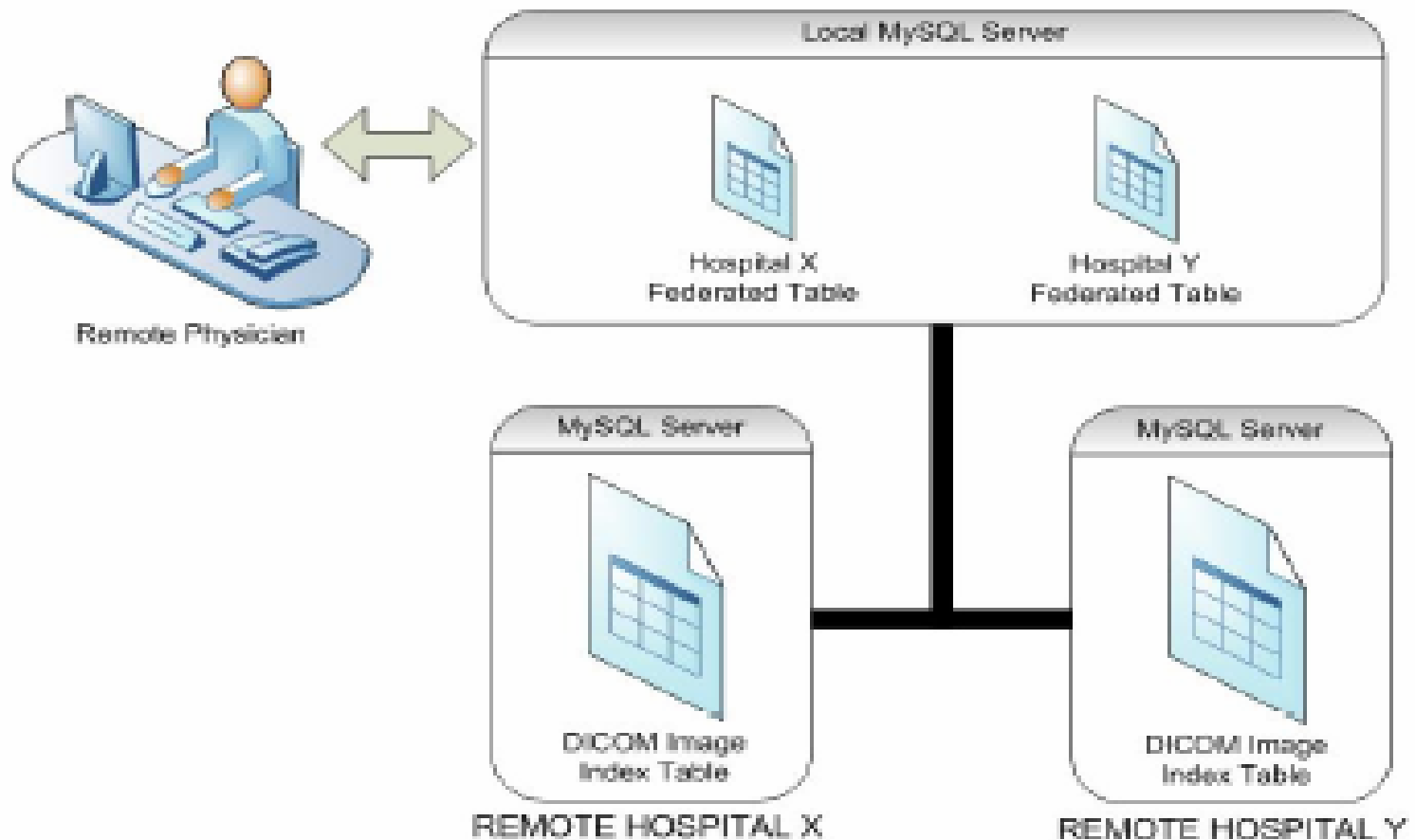


Figure 2.1. Query of Multiple DIISs Using Federated Tables

System Components

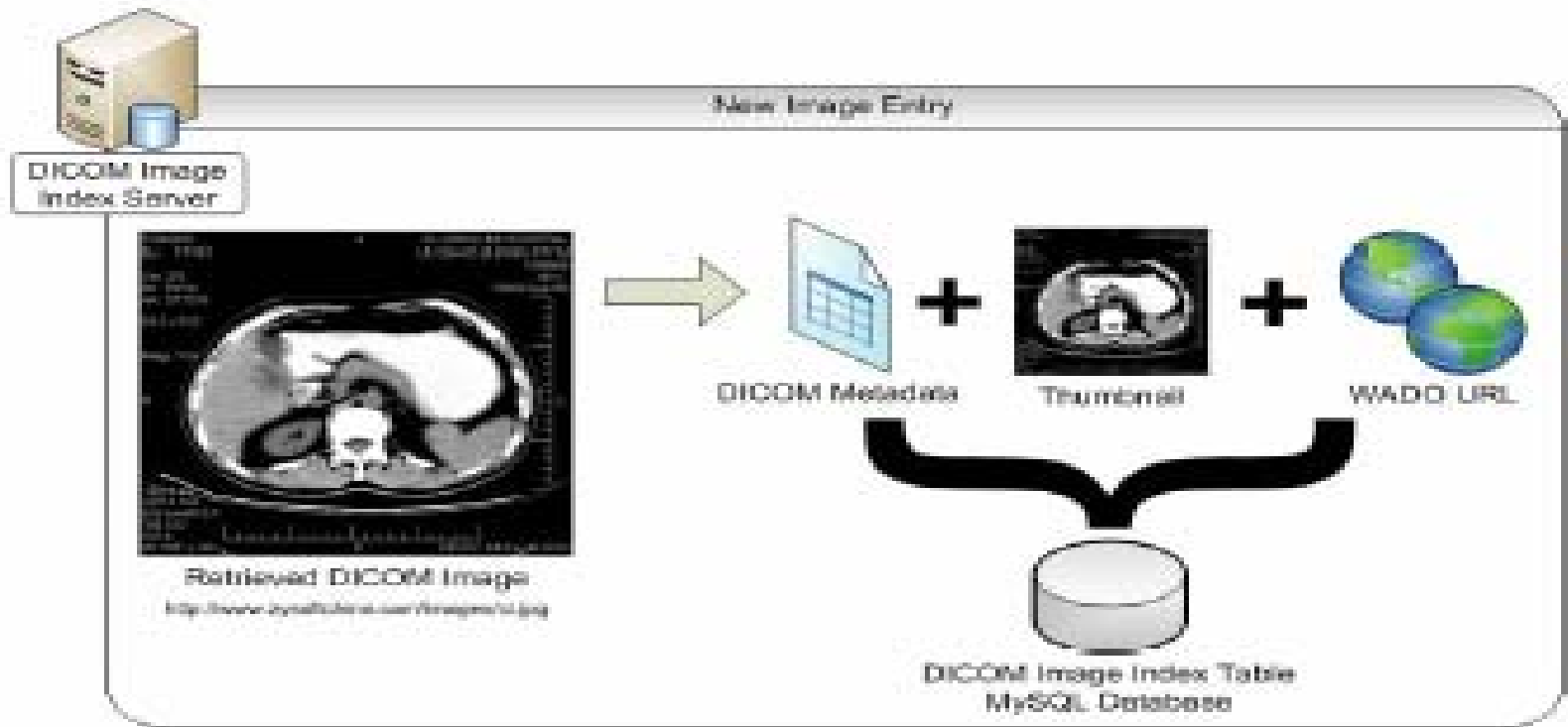
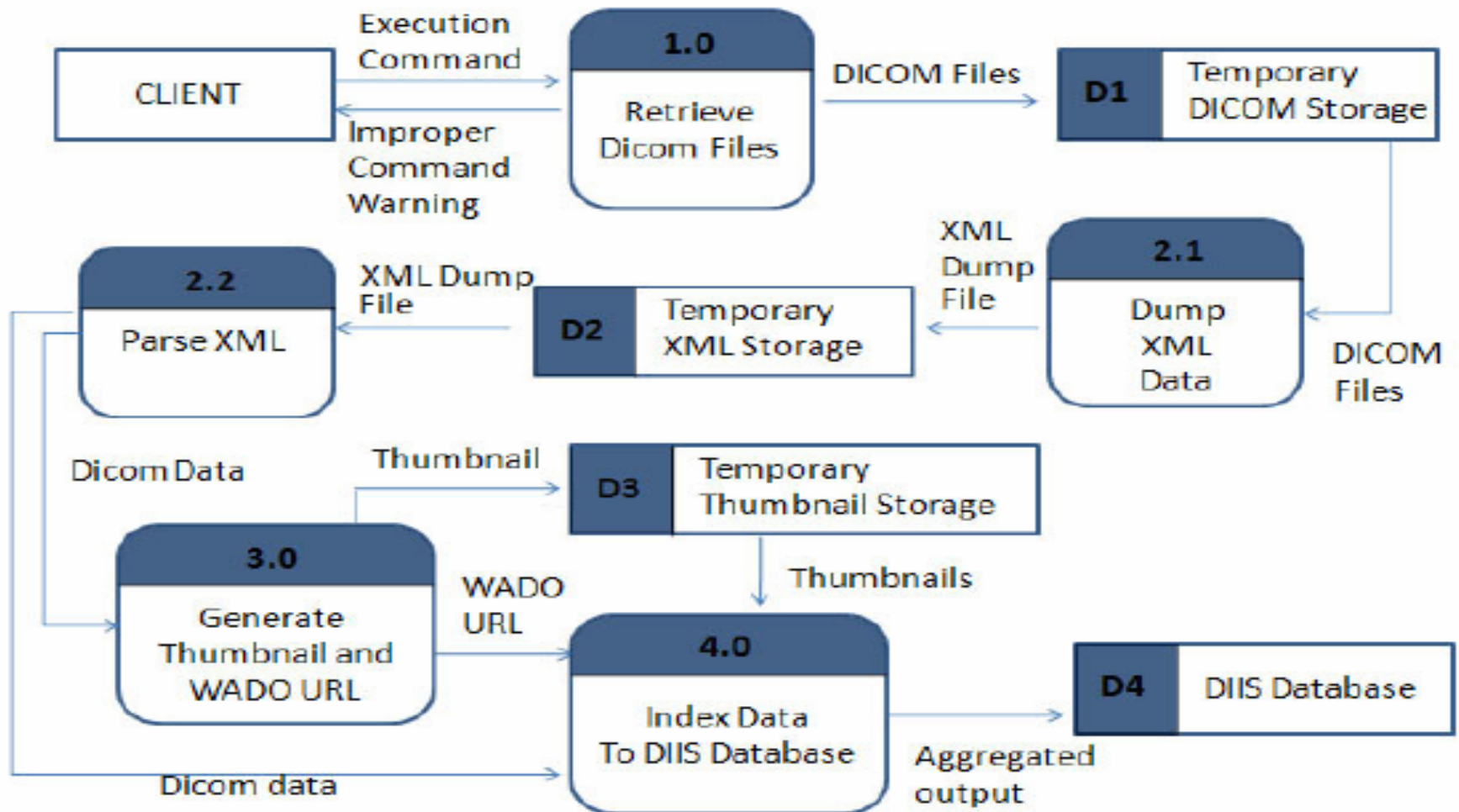
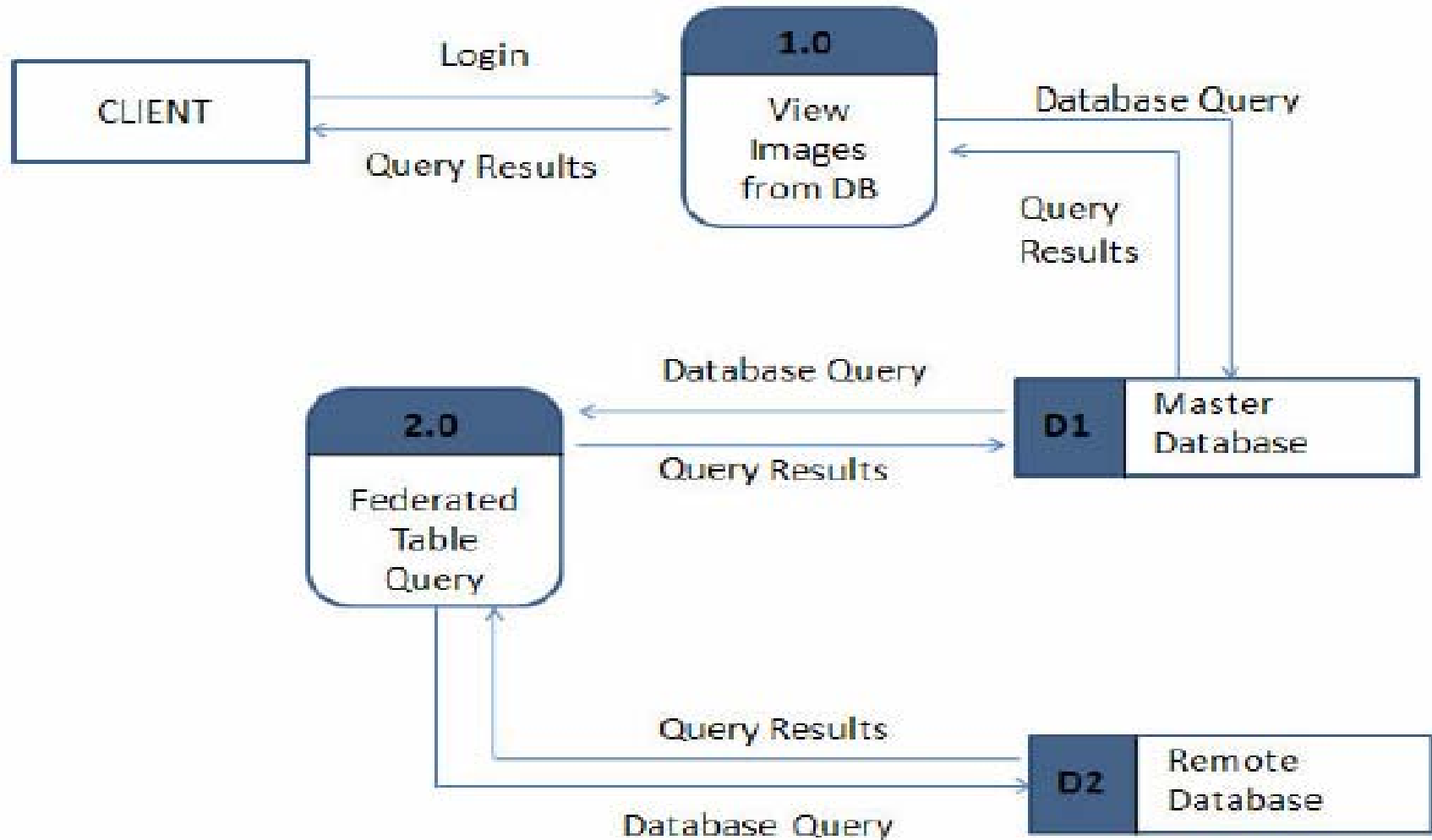


Figure 3.1. Processing and Storage of a New Image in the DIIS

Data Flow Diagram: DICOM Image Index Server



Data Flow Diagram: Web Application Server



Results

Search Bar

PATIENT **IMAGE**

Institution Name

Last Name

First Name

or ID

Study Date

Search Bar

PATIENT **IMAGE**

Institution Name

Modality Type

Figure 6.1. Patient Level Query (left) and Modality Type Query (right) Search Boxes

Results



DICOM Query and Retrieve Web Application

Search Bar

PATIENT **IMAGE**

Institution Name

Last Name

First Name

or ID

Study Date

Search Reset

Search Results

Query Methods:

1. Patient Level Query

Use this if you are looking for a specific patient.

- Patient-Institution-Date

In this type of query, the patient's last and/or first name is required. If no institution is selected, all institutions will be queried. Study date is optional.

- Institution-ID

In this type of query, both the patient ID and institution name is required.

2. Modality Type Query

Use this if you are looking for images of a specific modality type. Modality type is required. If no institution is selected, all institutions will be queried.

Figure 6.2. Search Page

Results

The screenshot shows a web browser window with the URL `http://localhost:8080/mrwa/search.php?ip=patient`. The page title is "DICOM Query and Retrieve Web Application".

Search Bar: Includes tabs for "PATIENT" and "IMAGE". Fields include "Institution Name", "Last Name", "First Name", "or ID", and "Study Date". There are "Search" and "Reset" buttons.

Search Results:

- Institution Name:** AJ
- Last Name:** FIDDLE'S
- First Name:** [REDACTED]
- ID:** [REDACTED]
- Study Date:** 0-0-0
- Buttons: [hospitalA](#), [hospitalB](#)

Hospital A: (1 matches) [back to top](#)

- patient:** [REDACTED]
- Sex: F
- Birthday: 1921118

Hospital B: (1 matches) [back to top](#)

- patient:** [REDACTED]
- Sex: F
- Birthday: 1921118

Figure 6.3. Patient Query Results

Results

The screenshot shows a web browser window with the URL `http://localhost/atcmjwa/search.php?ip=image`. The page title is "DICOM Query and Retrieval Web Application". On the left, there is a "Search Bar" with a dropdown menu for "Modality: MR" and buttons for "Search" and "Reset". The main area is titled "Search Results" and shows "Modality: MR" and "4076" results. Below this, it says "Hospital A: (34 matches)" and "Back to top". The results are displayed in a grid of 10 thumbnails. Each thumbnail contains a small image preview and the following metadata:

- Series: 2
- RefNumber: 14407112, Age: 4076
- Modality: MR
- Physician: [Redacted]
- Study Date: 20070228 - 141912 000000
- Series Date: 20070228 - 141712 000000
- Acquisition Date: 20070228 - 141912 000000

The first five thumbnails show a cross-sectional MRI slice of a brain. The last five thumbnails show a similar slice but with a large black redaction box covering the top portion of the image.

Figure 6.5. Modality Query Results

Results

CLOSE X

DATA IMAGE

Group	Element	Name	VR	Length	VM	Value
0008	0009	Specific Character Set	CS	16	1	ISO_IR 100
0008	0008	Image Type	CS	22	4	DERIVEDPRIMARYLEFT
0008	0016	SOP Class UID	UI	28	1	1.2.840.10008.5.1.4.1.1.1.2
0008	0018	SOP Instance UID	UI	36	1	1.1.12.2.1107.5.12.7.15P5.30000070226004C0229000000000
0008	0004	Study Date	DA	8	1	20070328
0008	0021	Series Date	DA	8	1	20070328
0008	0022	Acquisition Date	DA	8	1	20070328
0008	0023	Content Date	DA	8	1	20070328
0008	0020	Study Time	TM	14	1	000000.700000
0008	0021	Series Time	TM	14	1	002900.700000
0008	0023	Acquisition Time	TM	14	1	000000.700000
0008	0023	Content Time	TM	14	1	000010.701000
0008	0050	Accession Number	SH	5	8	
0008	0052	Query/Retrieve Level	CS	5	1	IMAGE
0008	0054	Retrieve AEC Title	AC	8	1	DOM4CH02
0008	0056	Instance Availability	CS	6	1	ONLINE
0008	0060	Modality	CS	2	1	MG
0008	0068	Presentation Intent Type	CS	16	1	FOR PRESENTATION
0008	0070	Manufacturer	LS	8	1	SIEMENS
0008	0080	Institution Name	LD	16	1	The Medical City
0008	0081	Institution Address	ST	38	1	Ortigas Ave. Pasig - Philippines
0008	0090	Referring Physician's Name	PN	5	8	
0008	1010	Station Name	SH	10	1	RevaSoft
0008	103E	Series Description	LD	26	1	Diastolic Mamm. Screening
0008	1040	Institutional Department Name	LD	12	1	Mammography
0008	1070	Operator's Name	PN	8	1	RODANR
0008	1090	Manufacturer's Model Name	LD	20	1	Meridianal Navigation DR
0008	1111	Referenced Performed Procedure Step Sequence	SC	-		None

Group Element Name VR Length VM Value

Figure 6.6. Metadata of Image from Remote Hospital Through WADO

Results

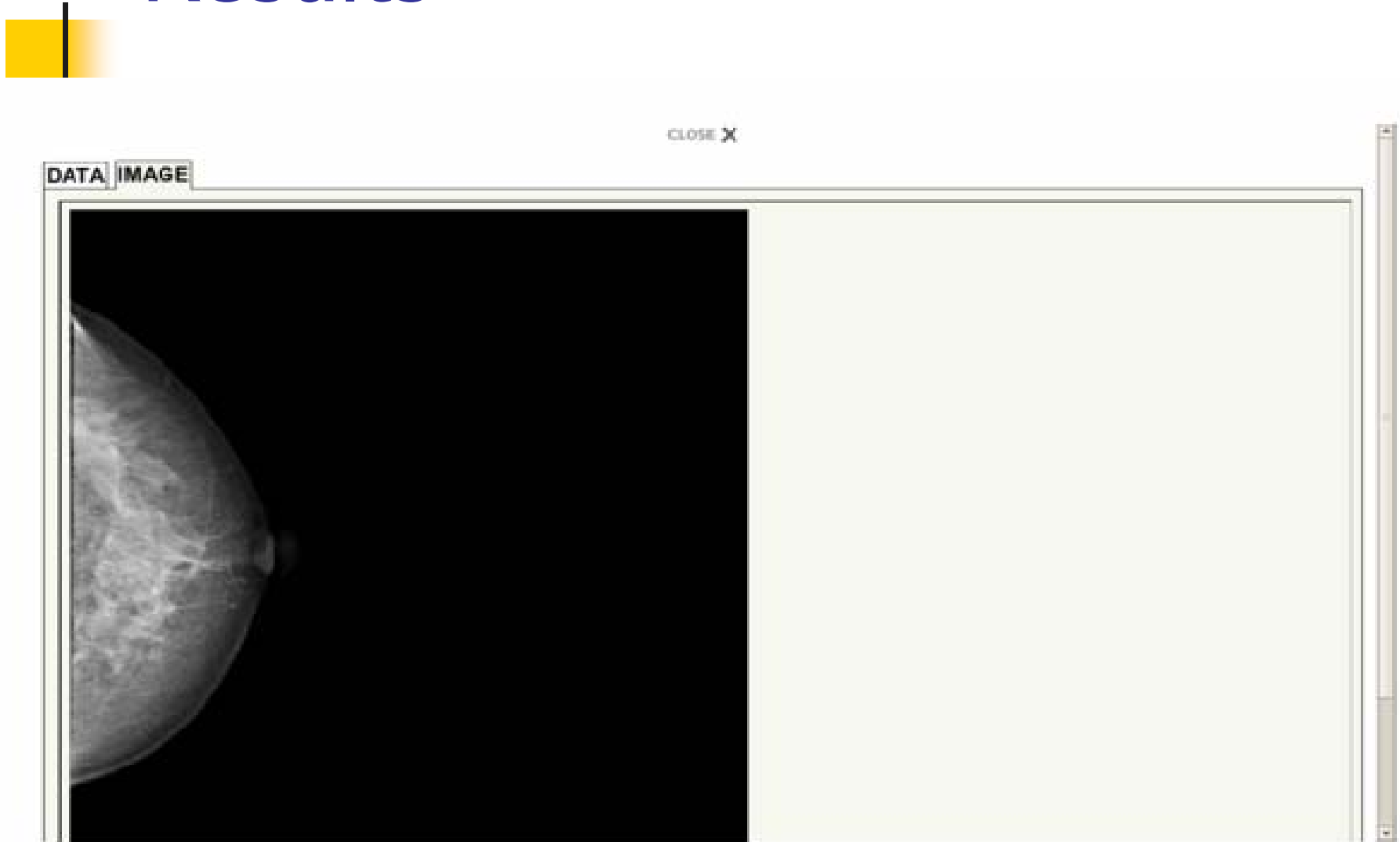


Figure 6.7. Actual Image from Remote Hospital Through WADO

Performance Benchmarking

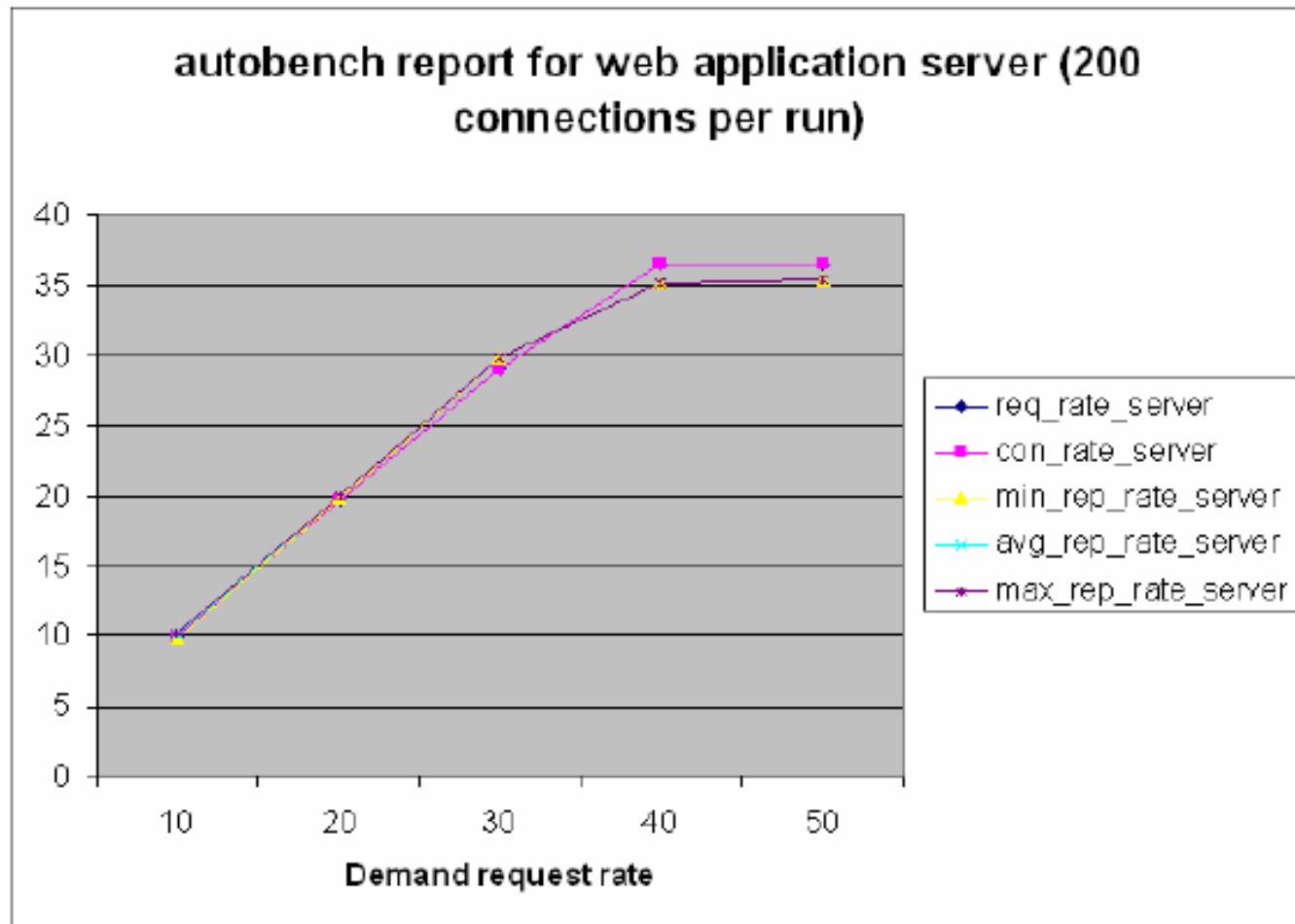


Figure 6.8. Autobench Report on Web Application Server with 200 connections per run

Performance Benchmarking

Benchmarking 10.2.3.17 (be patient).....done

```
Server Software:      Apache/2.2.3
Server Hostname:     10.2.3.17
Server Port:        80

Document Path:       /hAO.dcm
Document Length:     4324160 bytes

Concurrency Level:   1
Time taken for tests: 18.412094 seconds
Complete requests:   1
Failed requests:     0
Write errors:        0
Total transferred:   4324441 bytes
HTML transferred:    4324160 bytes
Requests per second: 0.05 [#/sec] (mean)
Time per request:    18412.094 [ms] (mean)
Time per request:    18412.094 [ms] (mean, across all concurrent requests)
Transfer rate:       229.36 [Kbytes/sec] received
```

Connection Times (ms)

	min	mean[+/-sd]	median	max
Connect:	43	43 0.0	43	43
Processing:	18368	18368 0.0	18368	18368
Waiting:	14	14 0.0	14	14
Total:	18411	18411 0.0	18411	18411

Figure 6.9. Apachebench benchmarking log accessing DICOM file

Performance Benchmarking



Copyright 1996 Adam Twiss, Zeus Technology Ltd, <http://www.zeustech.net/>
Copyright 2006 The Apache Software Foundation, <http://www.apache.org/>

Benchmarking 10.2.3.17 (be patient).....done

```
Server Software:      Apache-Coyote/1.1
Server Hostname:     10.2.3.17
Server Port:        8080

Document Path:       /wado?requestType=WADO&studyUID=
                    1.3.12.2.1107.5.12.7.1575.30000007032800391307800000013
                    &seriesUID=1.3.12.2.1107.5.12.7.1575.30000007032800402029600000038
                    &objectUID=
                    1.3.12.2.1107.5.12.7.1575.30000007032800402029600000042

Document Length:    500027 bytes

Concurrency Level:   1
Time taken for tests: 12.219941 seconds
Complete requests:   1
Failed requests:     0
Write errors:        0
Total transferred:   500266 bytes
HTML transferred:    500027 bytes
Requests per second: 0.08 [#/sec] (mean)
Time per request:    12219.941 [ms] (mean)
Time per request:    12219.941 [ms] (mean, across all concurrent requests)
Transfer rate:       39.93 [Kbytes/sec] received
```

```
Connection Times (ms)
      min    mean[+/-sd] median    max
Connect:    11      11   0.0      11     11
Processing: 12208  12208  0.0   12208  12208
Waiting:    10017  10017  0.0   10017  10017
Total:      12219  12219  0.0   12219  12219
```

Figure 6.10. Apachebench benchmarking log accessing WADO url



Conclusion

- Using existing DICOM tools, Java, Linux, Apache, MySQL and PHP, we developed a prototype system that enables query and retrieval of digital medical images from multiple remote sources through a single point of query.



Conclusion

- The system developed consists of two major components: (1) DICOM Image Index Server (DIIS) and (2) Web Application Server (WAS).
- The DIIS (installed in a local hospital) serves as a mirror to the contents of the hospital's DICOM Image Archive.
- The WAS connects all of the remote DIISs using MySQL Federated Storage Engine to form a Virtual DICOM Image Archive (VDIA).
- Using a PHP web application connected to the VDIA, users are able to query and retrieve DICOM images from multiples remote sources.



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