

DICOM and Imaging Tools

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Quick Introduction



Mohannad Hussain

- Software engineer
- Team lead at Agfa HealthCare, Integrations and Customizations
- Coordinator, annual SIIM Hackathon

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FUNDAMENTAL DICOM CONCEPTS

DICOM is Imaging



Standard for handling, storing, printing, and transmitting information in medical imaging, and includes both a file structure and communication protocol

<https://en.wikipedia.org/wiki/DICOM>

Main Actors



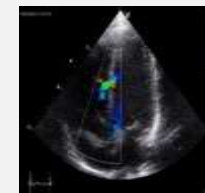
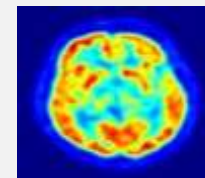
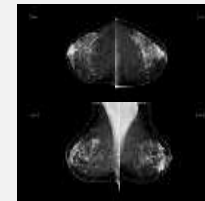
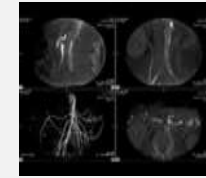
- Modality acquires images and transmits them to archive
- Images stored in PACS (Picture Archive and Communication System)
- Optional: Copy to VNA (Vendor Neutral Archive) for long-term storage
- Radiologists/users access images using viewers (whether thick client or web-based)

PACS/VNA at a glance

- Speak “traditional” DICOM, aka DIMSE
 - C-FIND for query
 - C-MOVE for retrieval
 - C-STORE for storage
- Some support WADO-URI for HTTP-based retrievals
- Some may speak “modern” DICOM, aka DICOMweb
 - QIDO-RS for query
 - WADO-RS for retrieval
 - STOW-RS for storage

Store Images

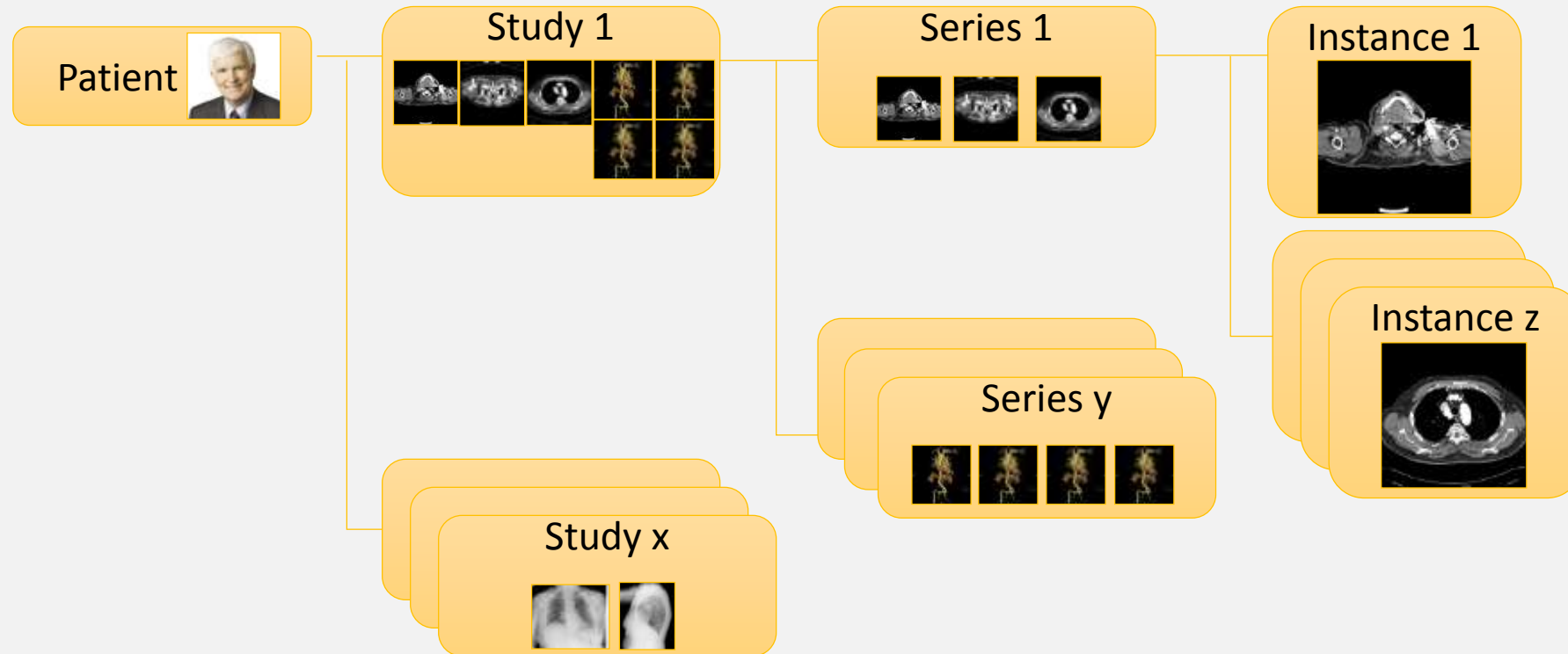
- DICOM stores images
 - All kinds of images
 - CT, MR, X-Ray, Ultrasound, Angiography, PET, Ophthalmology, Documents, ...
 - Single & Multiframe; Volumes & Cines; B&W & Color; Original & Processed
- DICOM helps to manage images
 - Not just pixels → significant meta-data
 - Patient identification & demographics, the order, acquisition, workflow context...
 - Can query / sort / autoroute / manage



Key Objects and Markup

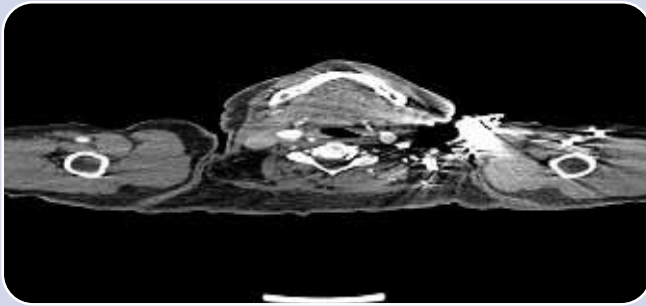
- Key Objects
 - Way to represent a set of images besides “all of the images”
 - For example, “marked for review”, “marked for quality issues”, “XDS publishable set”
- GSPS
 - Markup and annotations on the images
 - Includes factors like window/level
 - Applied on images or image sets

Image Hierarchy



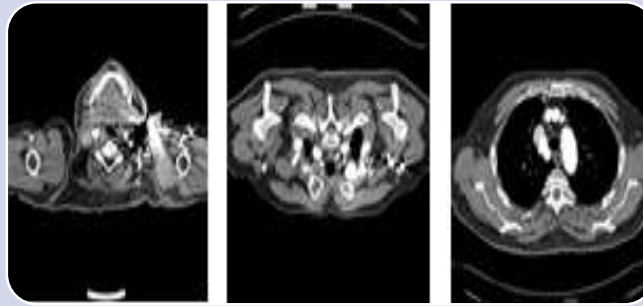
Each **patient** has **x studies**, which has **y series**,
 which has **z instances**
 ... and could have **f frames**.

Image Metadata



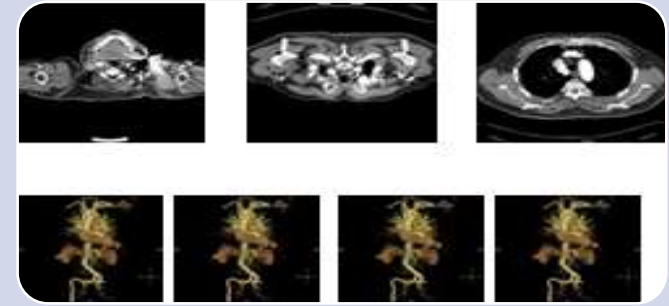
Study

- **Study UID**
- Date of Study
- Description
- Refer Physician
- Accession
- ...



Series

- **Series UID**
- Modality
- Description
- Series Number
- Body Part
- ...



Instance

- **Instance UID**
- Height
- Width
- Position
- SOP Class UID
- ...

Terminology

- Service + Object = Service Object Pair
 - “Image Storage” + “MRI” = “MRI Image Storage”
- SOP Class used to defined a file type
- SCU = Service Class User (“client”)
- SCP = Service Class Provider (“server”)
- AE = Reference to the Application Entity (a client or a server)
 - AET = AE Title

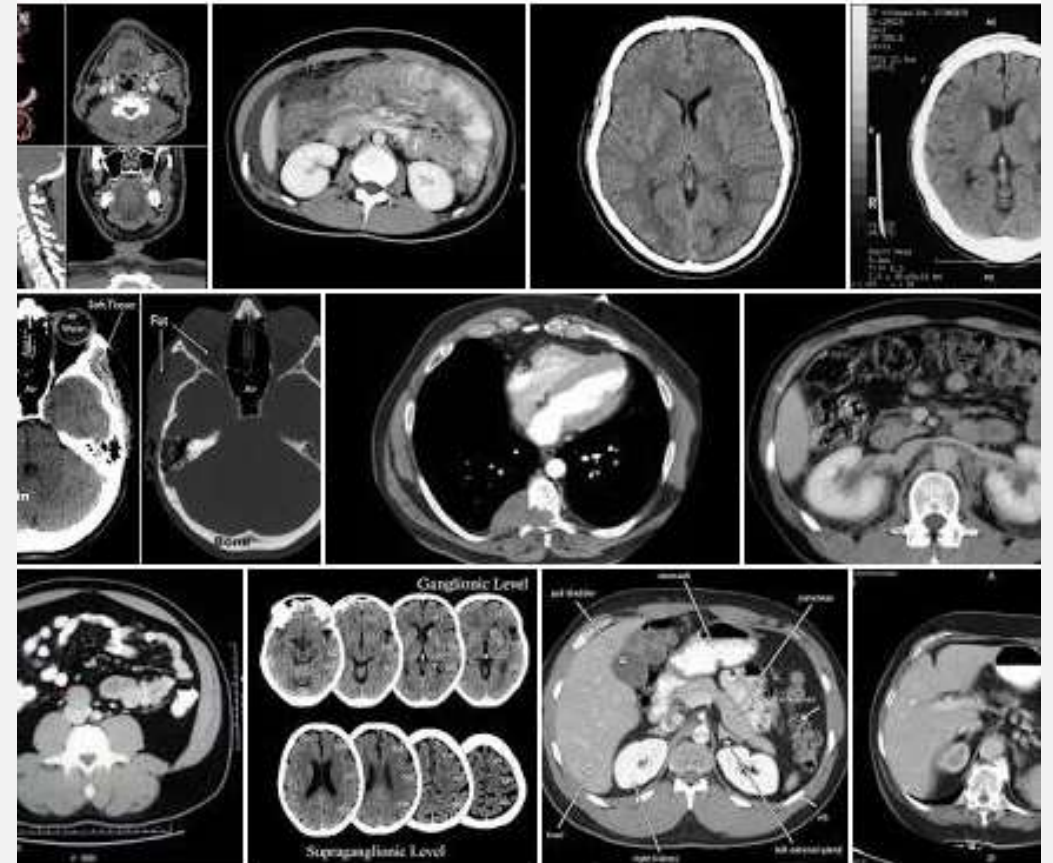
DICOM Metadata Tags

- DICOM's binary structure for representing metadata; i.e.,
 - (0010,0010) -> Patient name
 - (0008,0090) -> Referring physician name
- Described in DICOM PS3.6
- Tags are defined using a VR (a data type) and an VM (multiplicity factor)

DICOM HANDS-ON

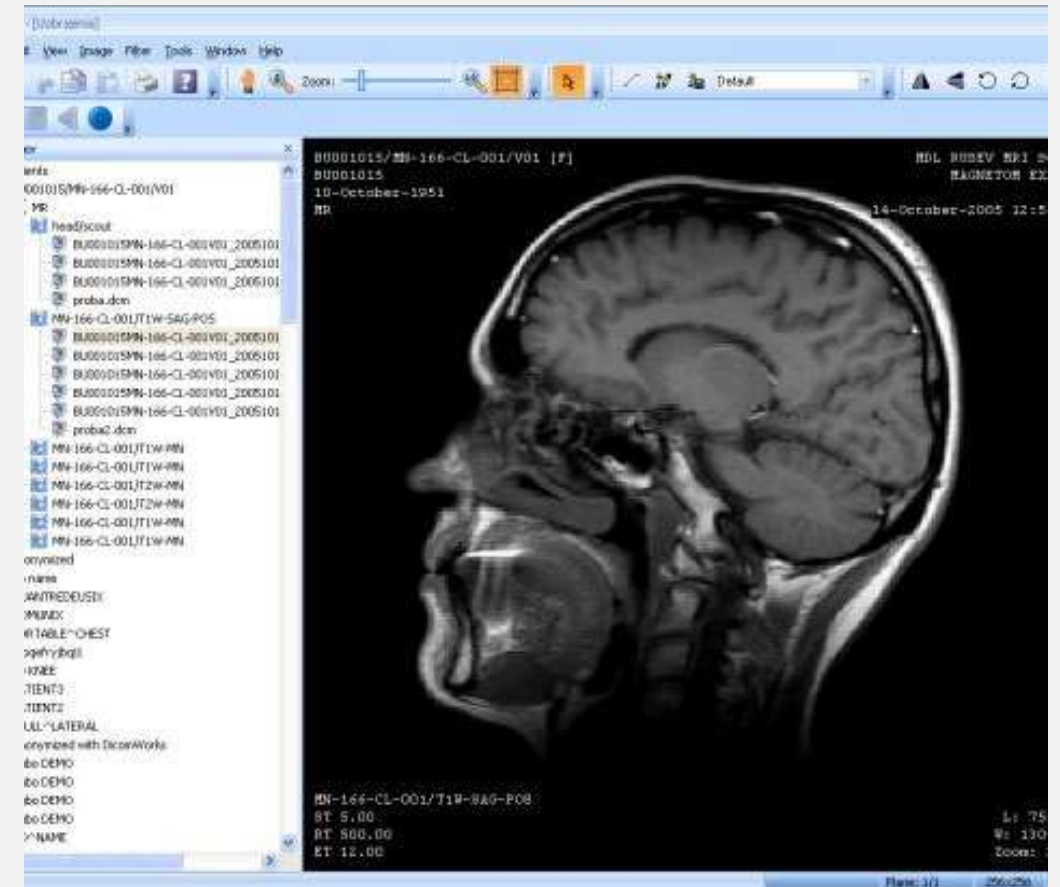
Get DICOM Images

- SIIM Hackathon Dataset
<https://goo.gl/k5LpP3>
 - Advantage: Lines-up with FHIR data
- Cancer Imaging Archive
<https://goo.gl/RY2cFD>
 - Advantage: Wide selection/variety



Get a DICOM Image Viewer

- MicroDicom - Native Viewer
<http://www.microdicom.com/>
- Cornerstone – Web Viewer
<https://goo.gl/hGa1AR>



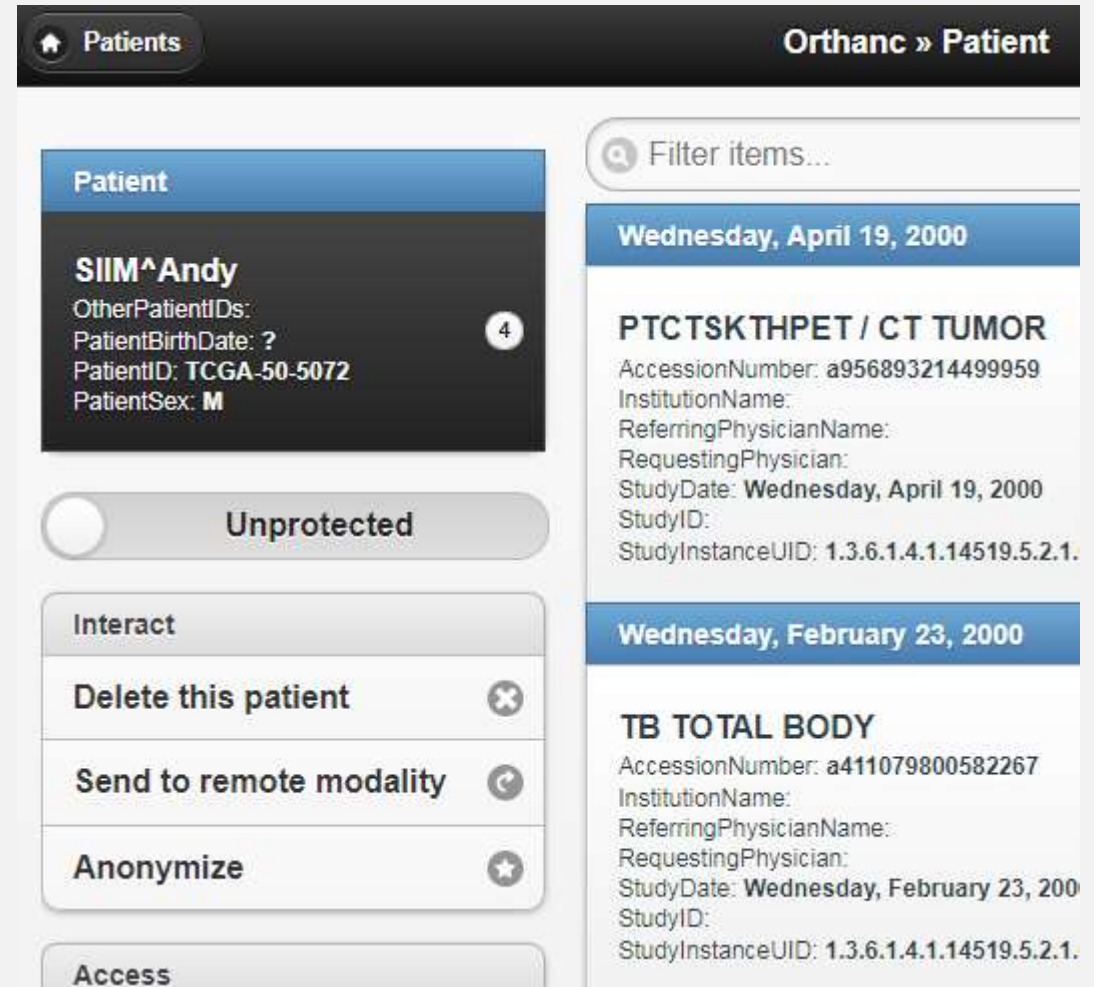
Get a DICOM Toolkit

- DVTk <http://www.dvtnk.org/>
- ConQuest <https://goo.gl/j6tzK4>
- Ginkgo <http://ginkgo-cadx.com>
- DCM4CHE – CLI (Win & Linux)
V2: <https://goo.gl/ojb2Qt>
V3: <https://goo.gl/JUR9Zb>

```
ln>dcm2xml "d:\2.25.1722452841778415109548490542"
oding="UTF-8"?><dicom>
="UL" len="4">182</attr>
="OB" len="2">00\01</attr>
="UI" len="30">1.2.840.10008.5.1.4.1.1.77.1.4</attr>
="UI" len="44">2.25.1722452841778415109548490542</attr>
="UI" len="22">1.2.840.10008.1.2.4.50</attr>
="UI" len="18">1.2.40.0.13.1.1.1</attr>
="SH" len="14">dcm4che-abc</attr>
="CS" len="10">ISO_IR 100</attr>
="CS" len="16">ORIGINAL\PRIMARY</attr>
="DA" len="8">20150412</attr>
="TM" len="10">214533.688</attr>
="UI" len="30">1.2.840.10008.5.1.4.1.1.77.1.4</attr>
="UI" len="44">2.25.1722452841778415109548490542</attr>
="DA" len="8">20150412</attr>
="DA" len="8">20150412</attr>
="TM" len="10">214533.688</attr>
="TM" len="10">214533.688</attr>
```

Store the images in a PACS/VNA

- Orthanc
 - Docker image: <https://goo.gl/nBMDpV>
 - Step by step: <https://goo.gl/Bm65La>
- DCM4CHEE
 - Docker image: <https://goo.gl/bn363J>



The screenshot shows the Orthanc web interface. At the top, there's a navigation bar with "Patients" and "Orthanc » Patient". Below this, a "Patient" card displays information for "SIIM^Andy", including "OtherPatientIDs:", "PatientBirthDate: ?", "PatientID: TCGA-50-5072", and "PatientSex: M". A "4" icon is visible next to the patient name. Below the patient card is a toggle switch labeled "Unprotected".

On the right side, there's a "Filter items..." search bar. Below it, two study entries are listed:

- Wednesday, April 19, 2000**
PTCTSKTHPET / CT TUMOR
 AccessionNumber: a956893214499959
 InstitutionName:
 ReferringPhysicianName:
 RequestingPhysician:
 StudyDate: Wednesday, April 19, 2000
 StudyID:
 StudyInstanceUID: 1.3.6.1.4.1.14519.5.2.1.
- Wednesday, February 23, 2000**
TB TOTAL BODY
 AccessionNumber: a411079800582267
 InstitutionName:
 ReferringPhysicianName:
 RequestingPhysician:
 StudyDate: Wednesday, February 23, 2000
 StudyID:
 StudyInstanceUID: 1.3.6.1.4.1.14519.5.2.1.

At the bottom, there's an "Interact" section with three buttons: "Delete this patient" (with a delete icon), "Send to remote modality" (with a refresh icon), and "Anonymize" (with a star icon). Below this is an "Access" section.

DICOM DIMSE Requests

- C-FIND for search
- C-MOVE for retrieval (aka download)
- C-STORE for storage (aka upload)
- C-ECHO for ping

DICOM Query/Retrieve

PACS

Search

Patient Id Q 51 Server DCM4CHEE (DCM4CHEE@19

Date

☒ Any date
 ☐ Yesterday
 ☐ Between:
 ☐ Today AM
 ☐ Last 7 days

☐ Today PM
 ☐ Last 30 days

☐ Today
 ☐ Last 3 months

Modalities

☒ CR
 ☒ CT
 ☐ DF
 ☐ MG
 ☐ MR
 ☐ NI
 ☐ RF
 ☐ RG
 ☐ SC
 ☐ XA
 ☐ XC
 ☐ ES

	Patient name	Patient id	Modality	Date Time	Description
	ABDOMINAL^CLOSURE	51	XC\CR	01/23/2002 13:19:18	RX ABDOMEN

Stored queries

Ginkgo Configuration

Ginkgo CADx settings

Settings

- Ginkgo CADx
 - General
 - Workstation
 - Local database
 - Electronic health record
 - DICOM nodes
 - Smart retrieve
 - Profiles
 - Modality settings
 - Hanging protocols
 - Locations

DICOM nodes settings

Local PACS

You must configure the local AET, which is used to communicate with the DICOM nodes. The specified port must be opened in the firewall, as it is essential for transfers.

Local AET GINKGO ?

Port

[Advanced settings...](#)

DICOM Nodes

Name	Use by default	
DCM4CHEE	Yes	

[New ...](#)
[Edit ...](#)
[Delete](#)
[Set Default](#)

[Export config...](#) [Import config...](#) [Accept](#) [Cancel](#) [Apply](#)

Dcm4che Demos

- dcmecho
- dcmqr
- dcm2xml
- dcm2jpg

DICOMWEB HANDS-ON

DICOMweb™ Services

Query

- **QIDO-RS (Query based on ID for DICOM Objects)**
- DICOM PS3.18 6.7

Retrieve

- **WADO-RS (Web Access of DICOM Objects)**
- DICOM PS3.18 6.5

Store

- **STOW-RS (Store over the web)**
- DICOM PS3.18 6.6

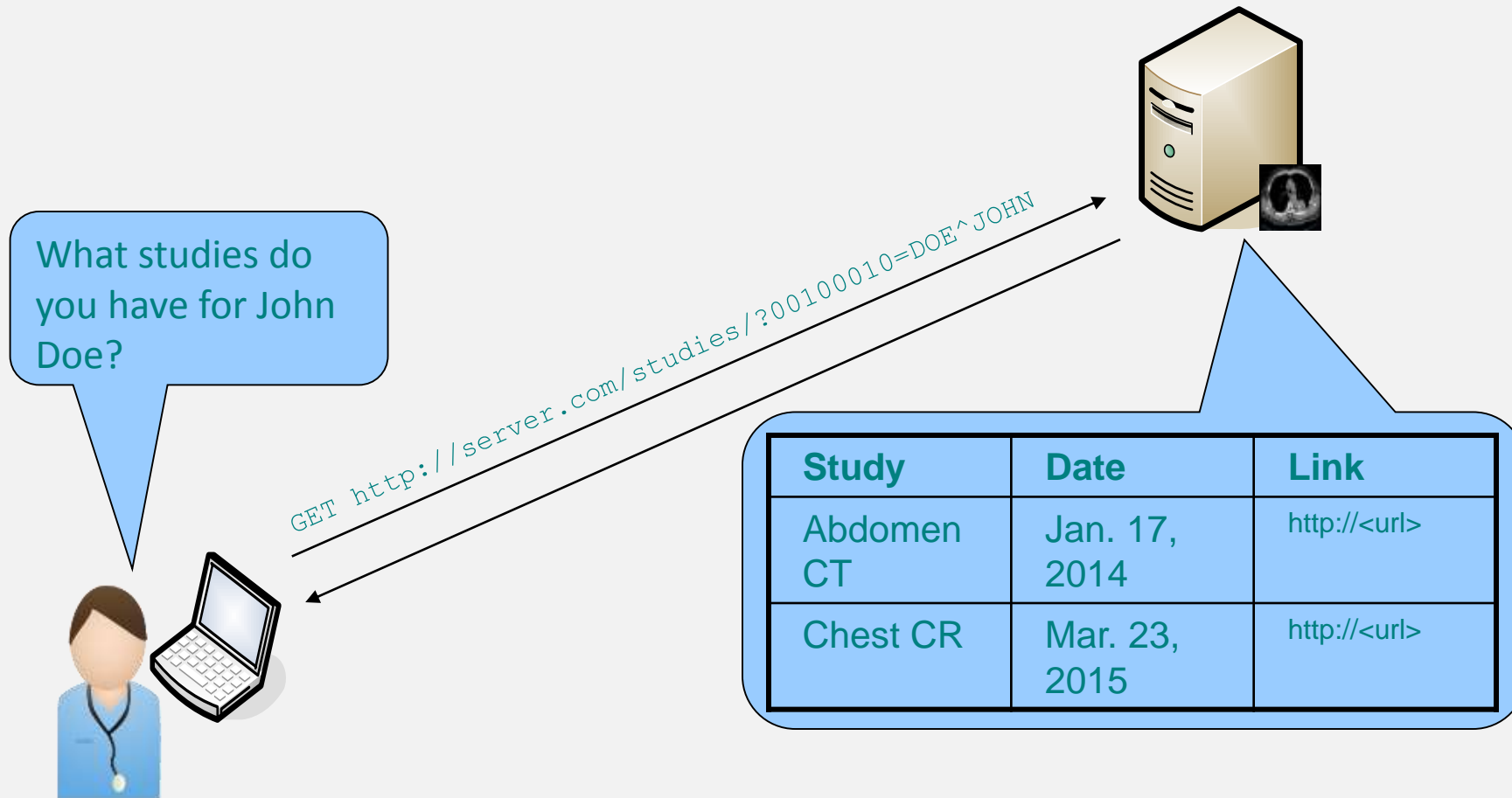
Tasks

- **UPS-RS (Worklist Service)**
- DICOM PS3.18 6.9

Server Info

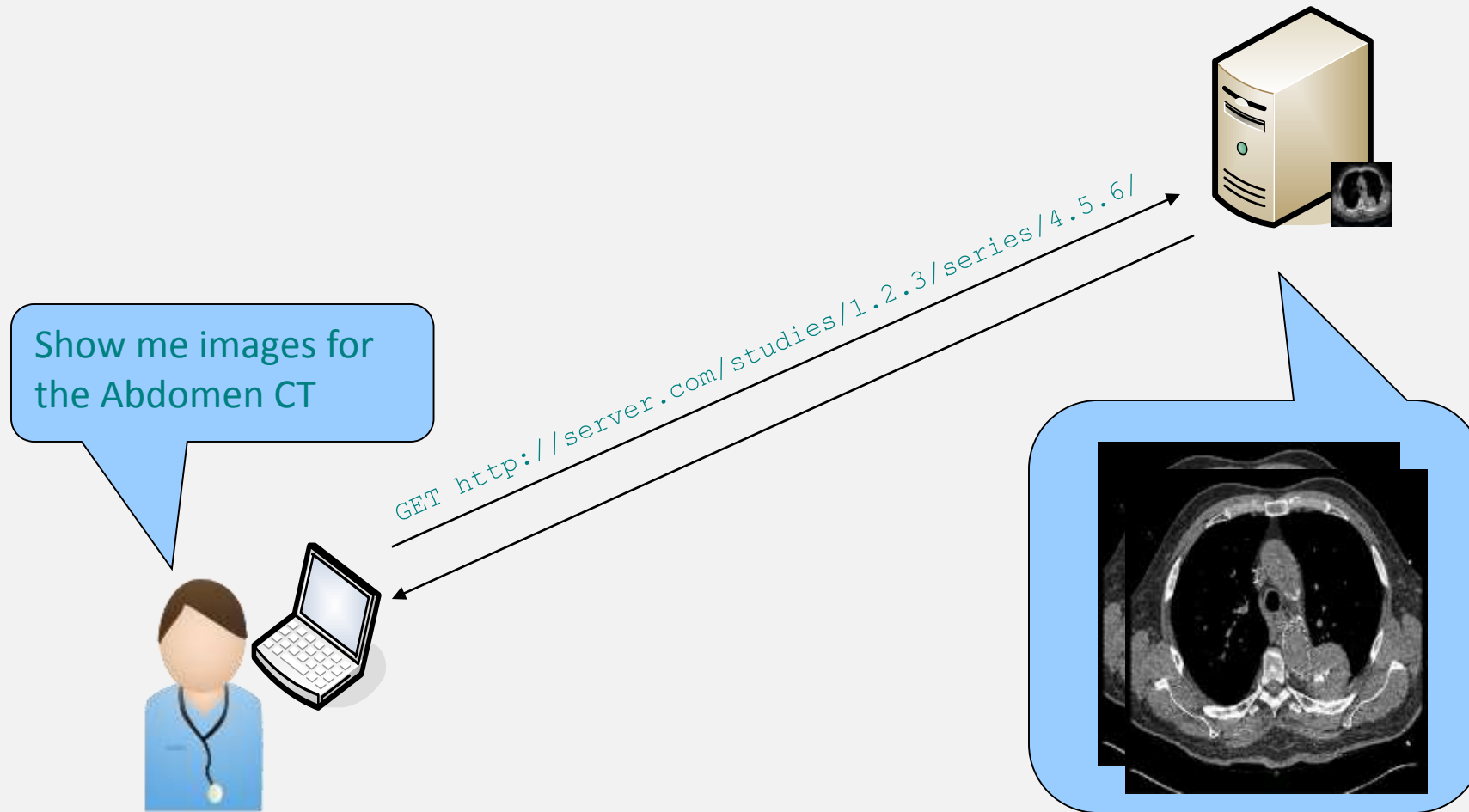
- **Capabilities Service**
- DICOM PS3.18 6.8

Query (QIDO-RS) Example

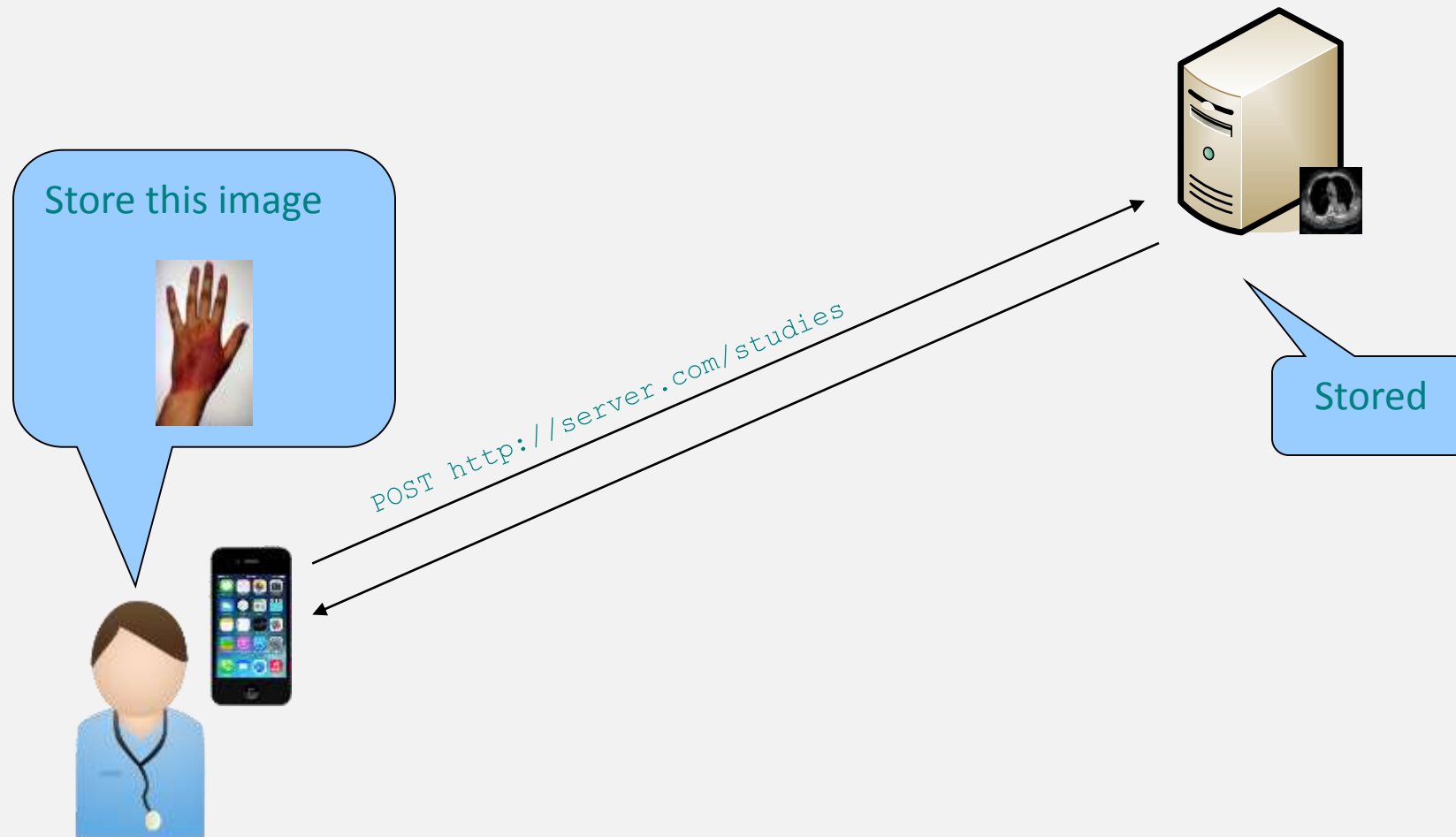


* There is synergy here with FHIR ImagingStudy

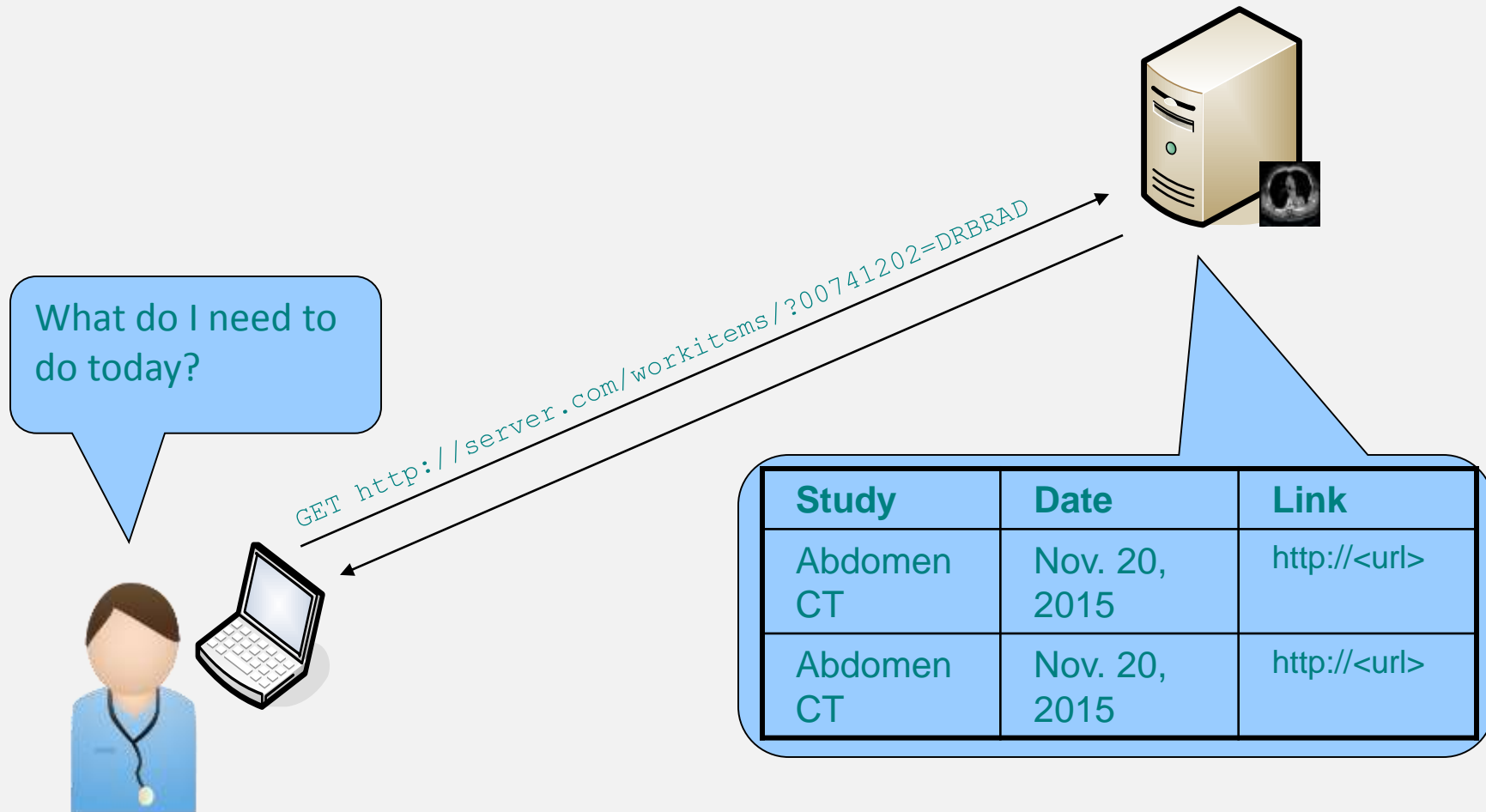
Retrieve (WADO-RS) Example



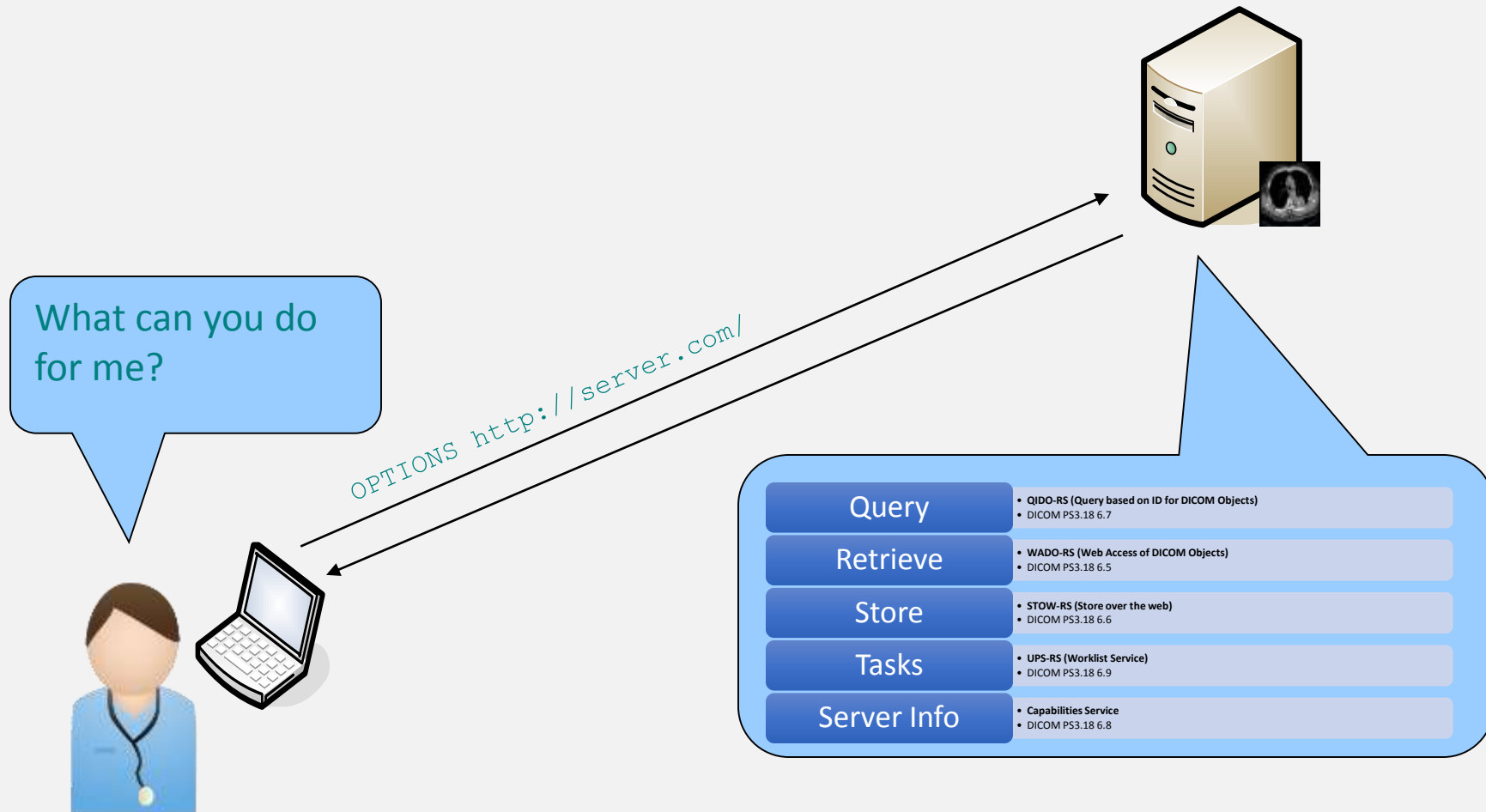
Store (STOW-RS) Example



Tasks (UPS-RS) Example



Capabilities Example



* There is synergy here with FHIR's Conformance

DICOMweb™ Cheatsheet

Verb	Path	Type	Description
POST	{s}/studies	Store PS3.18 6.6.1	Store instances
GET	{s}/studies?...	Query PS3.18 6.7.1	Query for matching studies
GET	{s}/studies/{studyUID}	Retrieve PS3.18 6.5.1	Retrieve entire study
POST	{s}/studies/{studyUID}	Store PS3.18 6.6.1	Store instances
GET	{s}/studies/{studyUID}/metadata	Retrieve PS3.18 6.5.6	Retrieve metadata
GET	{s}/studies/{studyUID}/series?...	Query PS3.18 6.7.1	Query for matching series in a study
GET	{s}/studies/{studyUID}/series/{seriesUID}	Retrieve PS3.18 6.5.2	Retrieve entire series
GET	{s}/studies/{studyUID}/series/{seriesUID}/metadata	Retrieve PS3.18 6.5.6	Retrieve series metadata
GET	{s}/studies/{studyUID}/series/{seriesUID}/instances?...	Query PS3.18 6.7.1	Query for matching instances in a series
GET	{s}/studies/{studyUID}/series/{seriesUID}/instances/{instanceUID}	Retrieve PS3.18 6.5.3	Retrieve instance
GET	{s}/studies/{studyUID}/series/{seriesUID}/instances/{instanceUID}/metadata	Retrieve PS3.18 6.5.6	Retrieve instance metadata
GET	{s}/studies/{studyUID}/series/{seriesUID}/instances/{instanceUID}/frames/{frames}	Retrieve PS3.18 6.5.4	Retrieve frames in an instance
GET	/[bulkdataReference]	Retrieve PS3.18 6.5.5	Retrieve bulk data

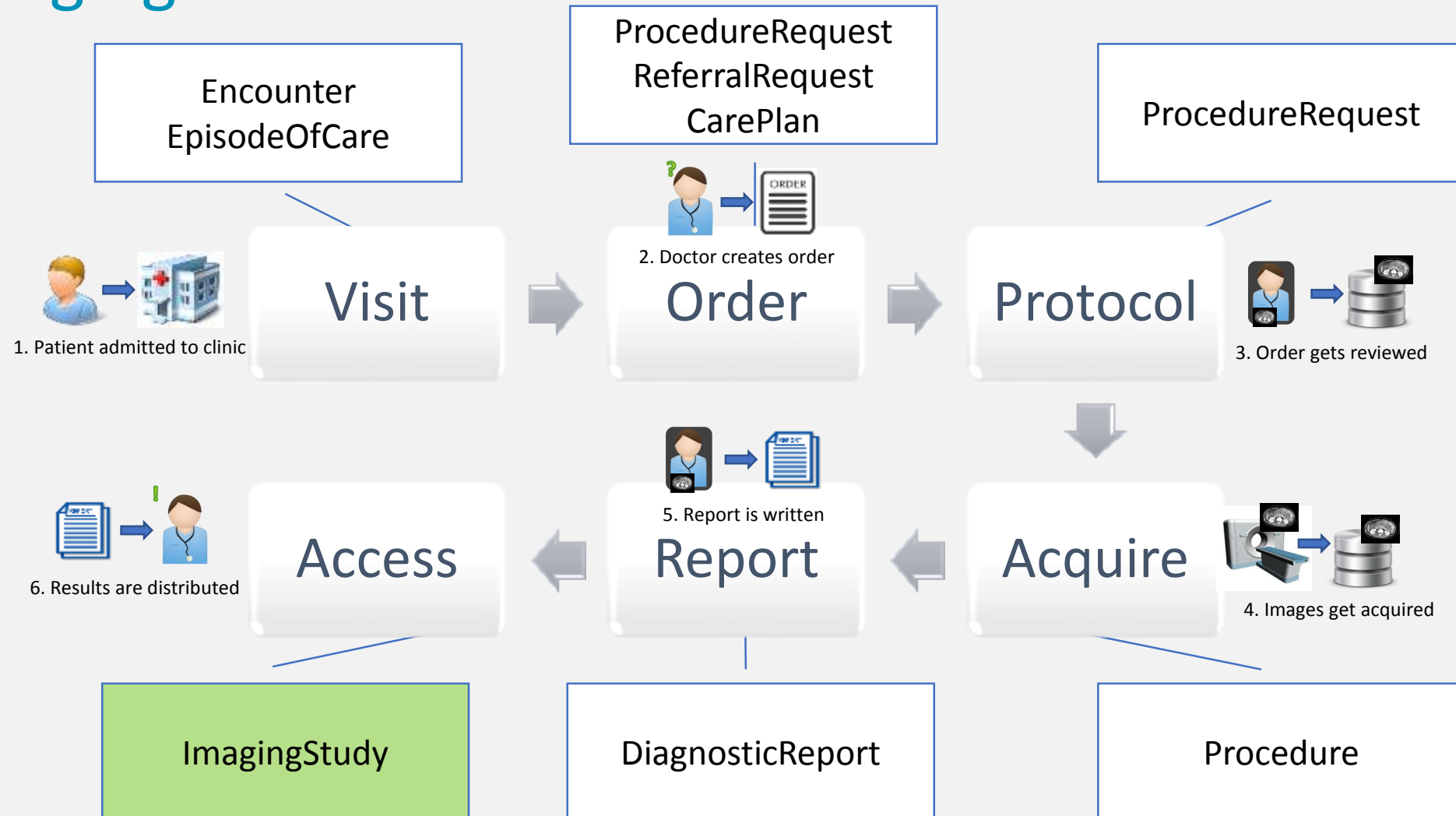
Verb	Path	Type	Description
POST	{s}/workitems {?AffectedSOPInstanceUID}	PS3.18 6.9.1	CreateUPS
POST	{s}/workitems/{UPSInstanceUID} {?transaction}	PS3.18 6.9.2	UpdateUPS
GET	{s}/workitems{?query*}	PS3.18 6.9.3	SearchForUPS
GET	{s}/workitems/{UPSInstanceUID}	PS3.18 6.9.4	RetrieveUPS
PUT	{s}/workitems/{UPSInstanceUID}/state	PS3.18 6.9.5	ChangeUPSState
POST	{s}/workitems/{UPSInstanceUID}/cancelrequest	PS3.18 6.9.6	RequestUPS Cancellation
POST	{s}/workitems/{UPSInstanceUID}/subscribers/{AETitle}{?deletionlock}	PS3.18 6.9.7	CreateSubscription
POST	{s}/workitems/1.2.840.10008.5.1.4.3.4.5/	PS3.18 6.9.8	SuspendGlobal Subscription
DELETE	{s}/workitems/{UPSInstanceUID}/subscribers/{AETitle}	PS3.18 6.9.9	DeleteSubscription
GET	{s}/subscribers/{AETitle}	PS3.18 6.9.10	OpenEventChannel
N/A	N/A	PS3.18 6.9.11	SendEventReport

Available at:

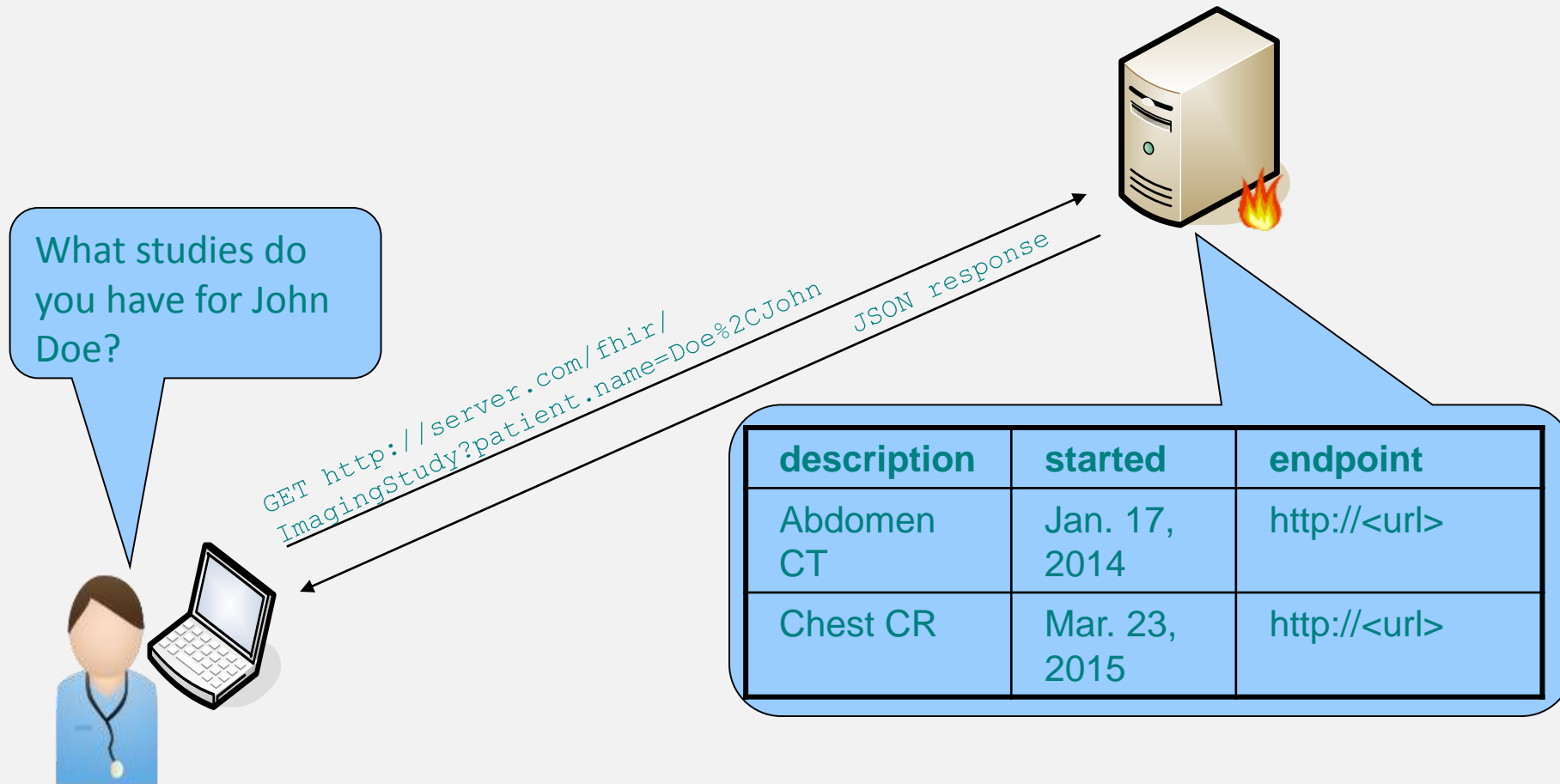
<http://dicomweb.org/DICOMweb-Cheatsheet.pdf>

MARRYING FHIR & DICOMWEB

Imaging Workflow on FHIR



ImagingStudy Example





ImagingStudy Result Snippet

```
{
  "resourceType": "ImagingStudy",
  "id": "example",
  "uid": "urn:oid:2.16.124.113543",
  "patient": {
    "reference": "Patient/12345"
  },
  "started": "2011-01-01T11:01:20+03:00",
  "endpoint" : [
    {
      "connectionType": "dicom-wado-rs",
      "address": "https://server.com/wado"
    }
  ],
  "series": [
    {
      "uid": "urn:oid:2.16.124.113543.2",
      "number": 3,
      "endpoint" : [
        {
          "connectionType": "dicom-wado-rs",
          "address": "https://server.com/wado"
        }
      ],
      "modality": {
        "system": "http://dicom.nema.org/resources/ontology/DCM",
        "code": "CT"
      },
      "description": "CT Surview 180",
      "bodySite": {
        "system": "http://snomed.info/sct",
        "code": "67734004",
        "display": "Upper Trunk Structure"
      },
      "instance": [
        {
          "uid": "urn:oid:2.16.124.113543.2.3",
          "number": 1,
          "sopClass": "urn:oid:1.2.840.10008.5.1.4.1.1.2"
        }
      ]
    }
  ]
}
```

Not a complete example

Hands-on

- Find Patient via FHIR
- Find ImagingStudy via FHIR
- Discover study structure via QIDO-RS
- Retrieve Image/DICOM binary file via WADO-RS
- Bonus:
 - Searching through DICOMweb
 - Bulk Retrieval of an entire study

Thank you! Questions?

- Reach out!
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