Image Access Everywhere
DICOM Web Services

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JOHNS HOPKINS
MEDICINE

Image Access Everywhere

- Introduction
- <u>W</u>eb <u>A</u>ccess for <u>D</u>ICOM <u>O</u>bjects
  - WADO-URI
  - WADO-WS
  - WADO-RS
- <u>ST</u>ore <u>O</u>ver the <u>W</u>eb
- <u>Q</u>uery by <u>I</u>Ds for <u>D</u>ICOM <u>O</u>bjects
- Putting it all together
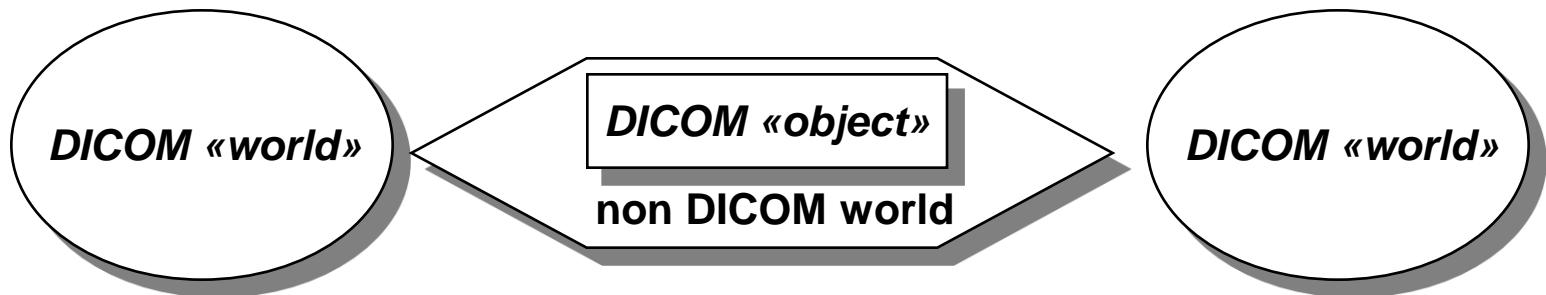
Why Do We Use DICOM?

- A good standard that continues to evolve

- Rich, Structured Information Model

- Compact representation

- Language independent

- Widely supported

- Because no specific Ad Hoc Group on Biomedical Imaging will be set up in ISO / TC215, new works on medical imaging must be done in DICOM (with a Category A Liaison Group between both)

- More and more it will be important that DICOM makes recommendations on the medical imaging aspects within non «pure» DICOM protocols

DICOM «world»

DICOM «object»

non DICOM world

DICOM «world»

*Courtesy of Emmanuel Cordonnier

A Brief History

- **WADO(-URI)**
  1999 - 2003
  - **IHE XDS-I.a**
- **WADO-WS**
  2008-2011
  - **IHE XDS-I.b**

- **MINT**
  2010 – 2011 v1.0
  2011 – 2013 V2.0
- **WADO-RS**
  2011 - 2013
- **STOW-RS**
  2011 – in progress
- **QIDO-RS**
  2012 – in progress

Web Access for (Persistent) DICOM Objects
WADO

Web Services

WADO: Web Access to DICOM (*persistent*) Objects

1. **WADO-URI**

   HTTP Universal Resource Identifier w/ parameters

2. **WADO-WS**

   SOAP & WS-* family of specifications

3. **WADO-RS**

   RESTful services

WADO-URI

WADO *Using Universal Resource Identifiers*

WADO-URI

- HTTP Universal Resource Identifier

- Parameters

- Supports DICOM & Rendered images

- Used in XDS-I.a (deprecated)

- GET one image at a time

Syntax of the WADO HTTP GET method

- Syntax defined by the RFC2396 (URI)

- `http://<authority><path>?<query>`

- e.g:
  - `http://www.hosp.fr/dicom/wado.asp?studyUID=1…`

  Path of the Web Enabled DICOM Server

  WADO Parameter(s)

- The « Web Access to DICOM Persistent Object » standard defines only the `<query>`

WADO-URI Use Cases

- Embedding images in reports or other documents by URL

- Browser based viewing of DICOM images for clinical use (one image at a time)

WADO-<u>WS</u>

WADO *Using WS-* Services*

WADO-WS

- SOAP + WS-*   (*Only* HTTP POST)
- Support DICOM & Rendered images
- Retrieve DICOM objects (studies, series, instances) referenced by an XDS-I Imaging Document Set
- Retrieve metadata (XML) for specified instances
- Either DICOM or Rendered objects
- Filtered metadata using XPath parameter

What is SOAP?
Simple Object Access Protocol

- Invented by Microsoft in 1998

- RPC for Client / Server

- Any transport protocol
  e.g. HTTP, SMTP, TCP, JMS

- XML based messages

- WSDL: Web Services Description Language

- WS-*: WS-Addressing, WS-Policy, WS-Security, WS-Federation, WS-ReliableMessaging, WS-Coordination, WS-AtomicTransaction, WS-RemotePortlets...

SOAP

- Structured XML SOAP envelope

```
<env:Envelope
xmlns:env="http://www.w3.org/2003/05/soap-
envelope">
  <env:Header>
    <!-- Header information here -->
  </env:Header>
  <env:Body>
    <!-- Body or "Payload" here,
         Fault if error -->
  </env:Body>
</env:Envelope>
```

WADO-WS Use Cases

- Accessing images and reports from another clinical application such as an EMR

- Embedding images in reports or other documents by URL

- Providing access to anonymized DICOM images for research and teaching.

- Providing access to images & reports for remote diagnostic workflows using the Web.

WADO-RS

WADO *Using RESTful Services*

What is REST?

- **Representational State Transfer[1]**

- **RESTful services follow certain principles**

  - Addressable Resources (URI)

  - Uniform, Constrained Interface (HTTP)

  - Representation oriented (content negotiation)

  - Stateless

  - Hypermedia*

1. *Coined by Roy Fielding, one of the principal authors of the HTTP, in his PhD thesis.*

SOAP vs. REST

SOAP

- Structured XML SOAP envelope

REST

- Supports hypermedia, multiple MIME types

```
<env:Envelope
xmlns:env="http://www.w3.org/2003/05/soap-
envelope">
  <env:Header>
    <!-- Header information here -->
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  <env:Body>
    <!-- Body or "Payload" here,
         Fault if error -->
  </env:Body>
</env:Envelope>
```

SOAP vs. REST

SOAP

- Structured XML SOAP envelope

- WSDL

- Transport agnostic

- Exception/fault in payload

- Steep learning curve, tools required

- Heavy weight; requires significant client and server logic

REST

- Supports hypermedia, multiple MIME types

- Manual documentation

- HTTP specific

- HTTP error codes

- Easy to develop, no tools required

- Lightweight; accessible via JavaScript and the simplest web frameworks

WADO-RS

- Just HTTP 1.1 with Resources,
  http:{service}/studies/{UID}

- Multiple objects per study

- ***No support*** for rendered images

- Metadata can be retrieved separately

- Headers specify transfer syntax & encodings:
  - DICOM Binary Instances
  - XML Metadata
  - Pixel data for Instances or Frames

WADO-RS Formats

- A set of one or more DICOM objects at a time
- An XML metadata
- A set of bulk data as a multi-part response

- Coming soon?... *Normalized metadata*

WADO-RS API

Name	Operator	Resource
RetrieveStudy	GET	/studies/{StudyInstanceUID}
RetrieveSeries	GET	/studies/{StudyInstanceUID}/series/{SeriesInstanceUID}
RetrieveInstance	GET	/studies/{StudyInstanceUID}/series/{SeriesInstanceUID}/instances/{SOPInstanceUID}
RetrieveFrames	GET	/studies/{StudyInstanceUID}/series/{SeriesInstanceUID}/instances/{SOPInstanceUID}/frames/{FrameList}
RetrieveBulkData	GET	{BulkDataURL}
RetrieveMetadata	GET	/studies/{StudyInstanceUID}/metadata

All API are prefixed by {SERVICE}/studies, e.g.
http://10.0.0.10:8001/studies, or http://somehost/archive/studies

WADO-RS Response

The response format depends on the Accept header of the request

- **Accept: multipart/related; type=image/dicom+xml**
  Specifies that the response should be DICOM XML metadata

- **Accept: multipart/related; type=application/dicom**
  Specifies that the response should be DICOM Instances encoded
  in PS3.10 format.

- **Accept: multipart/related; type=application/octet-stream**
  Specifies that the response can include uncompressed bulk or pixel data.

- **Accept: multipart/related; type=image/***
  Specifies that the response can include be compressed pixel data.

- **Accept: multipart/related; type=video/***
  Specifies that the response can include video-encoded pixel data.

WADO-RS Use Cases

- Retrieve DICOM (whole studies, entire series, or instances) by UID

- Retrieve metadata (whole studies, entire series or instances) in one set

- Retrieve pixel and other bulk data in one message regardless of whether the original study used multi-frame or multiple single-frame instances

STOW-RS

STOW-RS Capabilities

- Upload DICOM objects to the server
  (whole studies, append series / individual instances)

- Update/replace existing DICOM objects on server

STOW API

Name	Operator	Resource
StoreInstances	POST	/studies /studies/{StudyInstanceUID}

All API are prefixed by {SERVICE}/studies, e.g.
http://10.0.0.10:8001/studies, or http://somehost/archive/studies

STOW Formats

- **application/dicom**
  Specifies that the post is DICOM

- **application/dicom+xml**
  Specifies that the post is WADO XML metadata and bulk data

STOW Use Cases

- Viewer adding measurements, GSPS, etc.

- DICOM routers from modalities to PACS, VNA

- Securely push studies from outside firewall (e.g. between institutions)

- Web based QC tools (STOW.v2)

QIDO-RS

Query by IDs for DICOM Objects

QIDO Capabilities

- Look up DICOM objects based on any meta-data, to get additional meta-data and UIDs
- Pagination – search with offset & limit

QIDO API

Name	Operator	Resource
SearchForStudy	GET	/studies
SearchForSeries	GET	/studies/{StudyInstanceUID}/series
SearchForInstance	GET	/studies/{StudyInstanceUID}/instances /studies/{StudyInstanceUID}/series/{SeriesInstanceUID}/instances

All API are prefixed by {SERVICE}/studies, e.g.
http://10.0.0.10:8001/studies, or http://somehost/archive/studies

QIDO Request Parameters

- {dicomAttribute} = {keyValue}

- includefield = {dicomAttribute}

- {dicomAttribute} can be a Tag or Key Word as defined in DICOM PS3.6 or a sequence of the form *{dicomSequenceAttribute}.{dicomAttribute}*

- Parameters can be included 0-n times

- limit = {maxResults}

- offset = {num of results to skip}
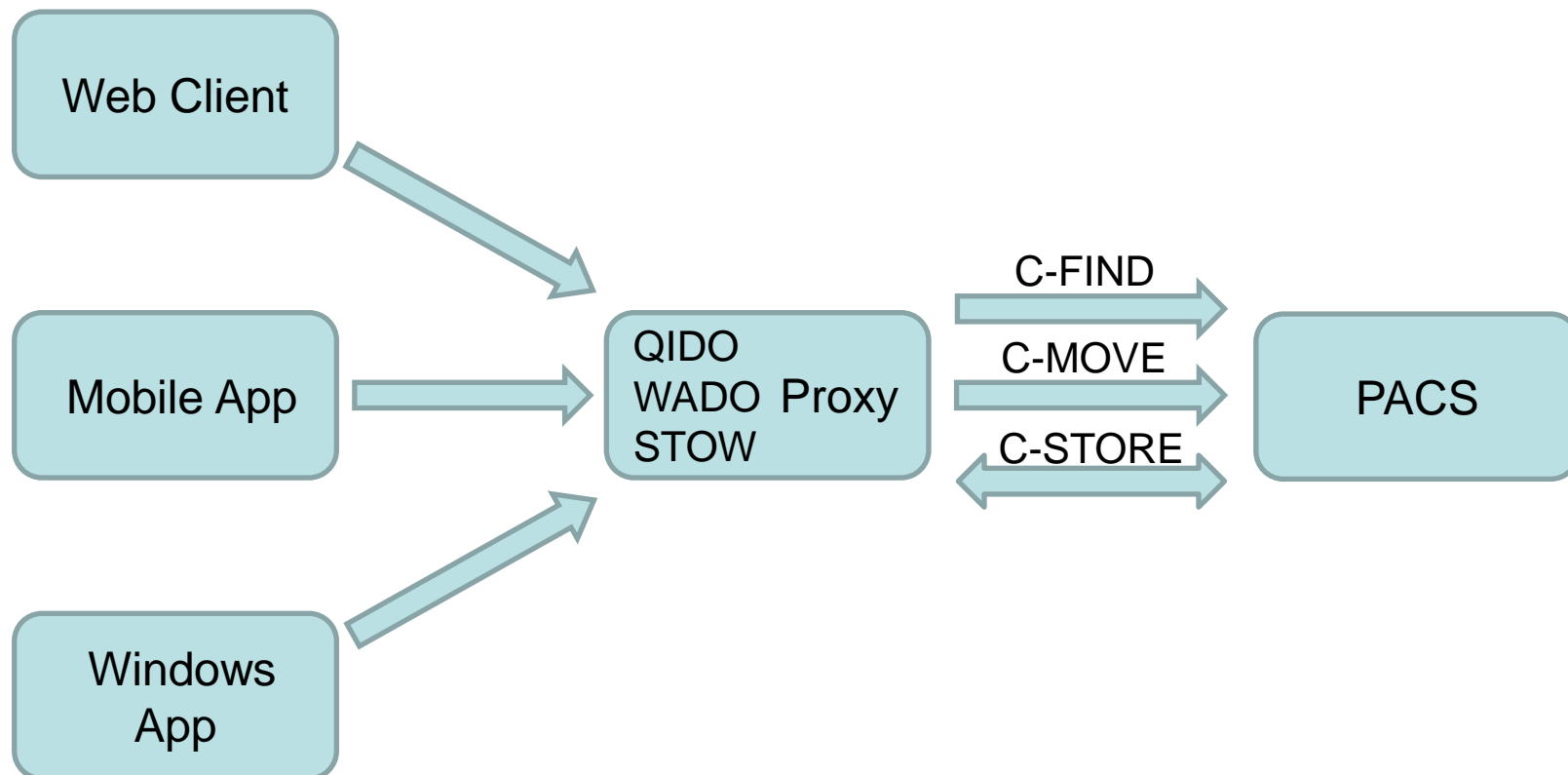
QIDO Use Cases

- Basic study search (patient, date range, type, description)

- Locate and filter for relevant priors

- Identify any new studies received
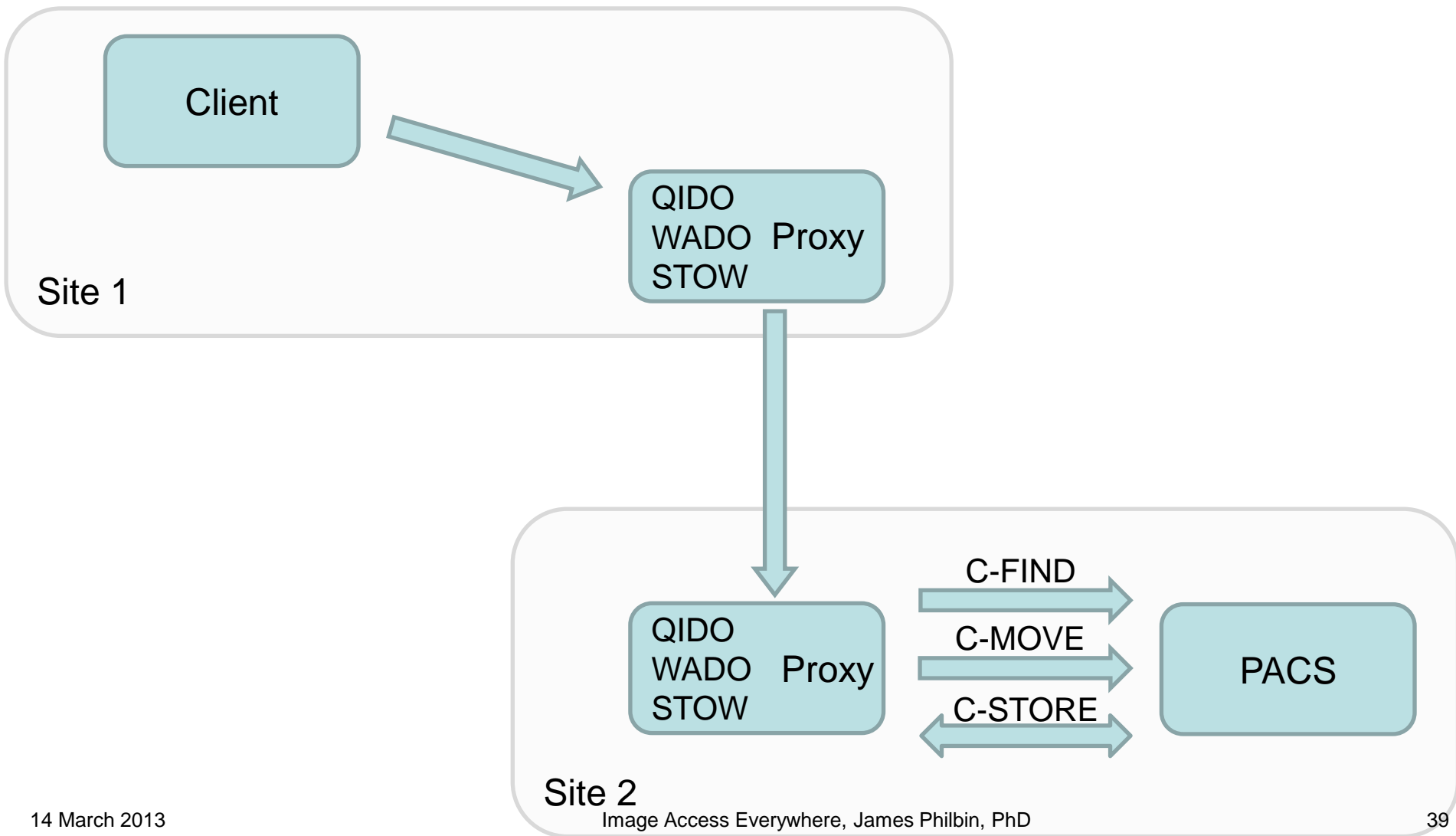
Putting It All Together

Putting it together…

- Simple URL-based search using QIDO
- Parse XML or JSON response
- Launch zero footprint viewer for selected study
- Download metadata and subset of images
- Download rest of study in background
- Upload new evidence / artifacts
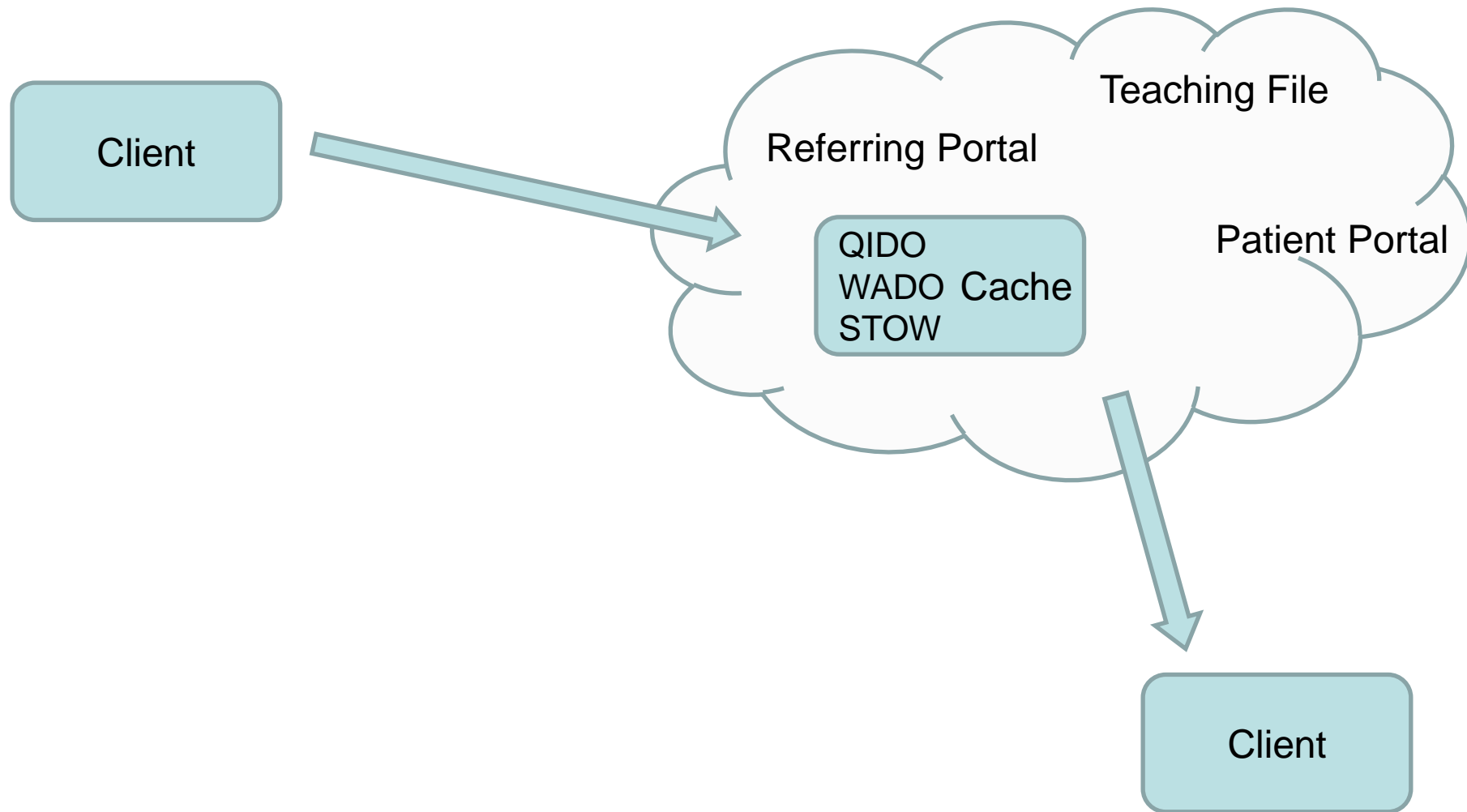- Upload entire studies

Use Case – Thin Clients

Use Case – Remote Access

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Use Case – Cloud Sharing

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Other Use Cases:

1. Physician referrals

2. ED transfer

3. Cloud Storage

4. Viewer Worklist

5. Integration with FHIR / HL7 RESTful services

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Thank you for your attention !

Backup Slides

Image Access Everywhere, James Philbin, PhD

DICOM & RESTful Services

- **WADO-RS**
  Web Access to DICOM Objects by RESTful Services
  Supplement 161– Final Text

- **STOW**
  STore DICOM Over the Web
  Supplement 163– Public Comment

- **QIDO**
  Query Interface to DICOM Objects
  Supplement 166 – Work In Progress

- **NADO**
  Notification for Availability of DICOM Objects
  Future – under discussion

- **Other: Normalized study level XML and JSON**

Security

DICOM doesn't define security mechanism

- Typical HTTP security mechanisms
  - Basic (over SSL)
  - Digest
  - Client certificate
  - Kerberos
  - Windows NT LAN Manager
  - **IHE-IUA:** *Internet User Authentication for HTTP profiles*
    - *Likely to be OAuth 2.0*

WADO-RS
Additional Use Cases

- Study Launch
    1. **Retrieve Metadata (one request)**
    2. **Determine images to display**
    3. **Retrieve initial image(s)**
    4. **Retrieve remaining images (e.g. by series)**

WADO-RS API

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RetrieveInstance	GET	/studies/{StudyInstanceUID}/series/{SeriesInstanceUID}/instances/{SOPInstanceUID}
RetrieveFrames	GET	/studies/{StudyInstanceUID}/series/{SeriesInstanceUID}/instances/{SOPInstanceUID}/frames/{FrameList} /studies/{StudyInstanceUID}/series/{SeriesInstanceUID}/instances/{SOPInstanceUID}/frames?calculated=…
RetrieveBulkData	GET	/studies/{StudyInstanceUID}/bulkdata/{BulkDataID}?offset={Offset}&length={Length}
RetrieveMetadata	GET	/studies/{StudyInstanceUID}/metadata

WADO-RS API

Name	Operator	Resource
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RetrieveBulkData	GET	/studies/{StudyInstanceUID}/bulkdata/{BulkDataID}?offset={Offset}&length={Length}
RetrieveMetadata	GET	/studies/{StudyInstanceUID}/metadata

Retrieve Types

	Study	Series	Instance	Rendered
WADO-URI	**No**	**No**	Yes	Yes
WADO-WS	Yes	Yes	Yes	Yes
WADO-RS	Yes	Yes	Yes	**No**

STOW Response

Service Status	DICOM Response	Code	HTTP1.1 Status Codes	STOW-RS Description
Failure	Refused: Out of Resources	A7xx	503 – Busy	This indicates that the STOW-RS Service was unable to store the instances because it was out of resources.
	Error: Data Set does not match SOP Class	A9xx	422 – Unprocessable Entity	This indicates that the STOW-RS Service was unable to store the instances because the Data Set does not match the SOP Class.
	Refused: Not Authorized	C1xx	401 - Unauthorized	This indicates that the STOW-RS Service refused to create or append instances because the client is not authorized.
	Failed	C1xx	403 - Forbidden	This indicates that the STOW-RS Service understood the request, but is refusing to fulfill it (e.g. an authorized user with insufficient privileges).
	Error: Cannot understand	Cxxx	400 – Bad Request	This indicates that the STOW-RS Service was unable to store the instances because it cannot understand certain Data Elements.
Warning	Coercion of Data Elements	B000	202 – Accepted	This indicates that the STOW-RS Service modified one or more data elements on reception. Image transmission is considered successful.
	Data Set does not match SOP Class	B007	202 – Accepted	This indicates that the STOW-RS Service encountered instances where the Data Set did not match the SOP Class. Image transmission is considered successful.
	Elements Discarded	B006	202 – Accepted	This indicates that the STOW-RS Service discarded some data elements. Image transmission is considered successful.
Success		0000	200 – OK	This indicates that the STOW-RS Service successfully stored the instances.
		0000	201– Created	This indicates that the STOW-RS Service successfully stored the instances to a new study and the response indicates the URI for the newly created study.

QIDO Response

- ## DICOM PS3.19 XML
  one message part per matching Study / Series / Instance

- ## JSON
  one message part with all matching Studies / Series / Instances

- ## For each entry:

  - response must include all Study Level attributes listed as Required for SCPs in IHE RAD TF Table 4.14-1

  - response should include any attributes used as query keys if used as matching criteria

  - response should include all attributes requested in *includefield* parameters if possible