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## Image Lifecycle

![Image Lifecycle Diagram](image)

<table>
<thead>
<tr>
<th>Task</th>
<th>User</th>
<th>Location</th>
<th>Application</th>
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</thead>
<tbody>
<tr>
<td>Acquire Images</td>
<td>Technologist</td>
<td>In hospital</td>
<td>Modality</td>
</tr>
<tr>
<td>QA Images</td>
<td>Technologist / PACS Admin</td>
<td>In hospital</td>
<td>PACS</td>
</tr>
<tr>
<td>Read Images</td>
<td>Radiologist</td>
<td>In hospital</td>
<td>PACS</td>
</tr>
</tbody>
</table>

… but that’s not all!
Extended Image Lifecycle

Prior studies

Other modalities

Long-term archives

3D visualization

... but that's not all!
Tertiary Image Lifecycle

- Foreign studies
- Non-DICOM modalities
- Regional archives
- Medical Records
- Mobile Devices
- Sharing Portals
# Tertiary Image Lifecycle

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</tr>
<tr>
<td>Read Images</td>
<td>Radiologist</td>
<td>In hospital</td>
<td>PACS</td>
</tr>
<tr>
<td>Get Prior Exams</td>
<td>Radiologist</td>
<td>In hospital, get from remote location</td>
<td>PACS</td>
</tr>
<tr>
<td>Review Images</td>
<td>Referring Physician</td>
<td>Remote physician office</td>
<td>Lightweight viewer</td>
</tr>
<tr>
<td>Review Patient Record</td>
<td>Attending Physician</td>
<td>In hospital</td>
<td>EMR</td>
</tr>
<tr>
<td>Physician Rounds</td>
<td>Care Team</td>
<td>In hospital and telepresence</td>
<td>Web Portal</td>
</tr>
<tr>
<td>Archive regionally</td>
<td>Technologist / PACS Admin</td>
<td>In hospital to remote</td>
<td>PACS</td>
</tr>
</tbody>
</table>
Tertiary Image Lifecycle

Network security and performance

Foreign studies ➔

Regional archives ➔

Non-DICOM modalities ➔

Medical Records ➔

Mobile Devices ➔

Does not understand DICOM

Sharing Portals

August 2014, THE DICOM 2014 Chengdu Workshop
Problems in a Global Space

- **Network Security**
  - How do we encrypt in transit?
  - How do we authenticate and authorize?

- **Network Performance**
  - How do we negotiate protocols fast?
  - How do we deal with low bandwidth and high latency connections?

- **Understanding DICOM**
  - How do we cross the big gap for non-medical imaging solutions?

How do we do this today outside of medical imaging?
The rise of the Hypertext Transport Protocol (HTTP) delivers an effective means to transfer images. But how?
Internet File Transfer

- HTTP/1.1 is ubiquitous; readily available tools that form the foundation for data communication in the modern world
- Request/response protocol in the client/server computing model
- Can be streamed, multi-threaded
- Can resume after interruption
- Caching, authentication, and authorization all part of standard
## Weibo Photo Metadata

### Photo
- Height and width
- URL to retrieve
- Caption
- Tagged people
- Location
- Date and time

### Album
- Name
- Collection of images
- Cover photo
- Description
- Privacy
- Place
Each user contains $x$ albums, which contain $y$ photos.
**Weibo API**

(https://open.weibo.com/wiki/API%E6%96%87%E6%A1%A3/en)

**REST API**

**Timeline API**

- statuses/public_timeline Return the latest public weibos.
- statuses/friends_timeline Return the authenticating user’s and his friends’ latest weibos (Alias: statuses/home_timeline)
- statuses/user_timeline Return the authenticating user’s latest weibos.
- statuses/mentions Return the authenticating user’s mentions
- statuses/comments_timeline Return comments of the authenticating user made and received
- statuses/comments_by_me Return comments made by the authenticating user
- statuses/comments_to_me Return comments the authenticating user received
- statuses/comments Return the weibo’s comment list by the weibo ID
- statuses/counts Return the comment counts and repost counts of a list of weibos
- statuses/repost_timeline Return the latest of repost weibos of a original weibo
- statuses/repost_by_me Return the latest repost weibos of authenticating user
- statuses/unread Return the authenticating user’s unread weibo count
- statuses/reset_count Reset unread weibo count
- emotions Emotion interface, return the emotion list

**JSON Example**

```json
[
  {
    "created_at": "Tue Nov 03 14:54:15 +0800 2010",
    "text": "吃力不讨好的事情我是坚决不会干的，@你个仙人！发飙-----我只想说待会大事出现在哪里了，你也就只能在这种地方混了。"
  },
  {
    "in_reply_to_screen_name": "",
    "geo": null,
    "user": {
      "name": "习惯寂寞吗",
      "profile_image_url": "https://t3.sinaimg.cn/1676702942/50/1286448784",
      "created_at": "Wed Dec 30 00:00:00 +0800 2009",
      "province": "蜀",
      "location": "四川 成都"
    },
    "favorited": false,
    "in_reply_to_status_id": "",
    "id": 3757354129,
    "source": "<a href="http://t.sina.com.cn" rel="nofollow">新浪微博</a>"
  }
]
```
What are APIs? REST?

- **Application Programming Interface**
  - Methods to access an application’s data and workflow without using the application’s user interfaces

- **REpresentational State Transfer**
  - An architectural style for standardizing data and workflow operations over HTTP
  - Scalable, fault-tolerant, recoverable, secure, and loosely-coupled
Three Levels of REST

- Level 1: Resources
- Level 2: Verbs
- Level 3: HATEOAS
## Level 1: Resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>/patients</td>
<td>A list of all patients</td>
</tr>
<tr>
<td>/patients/bob</td>
<td>Details about “Bob”</td>
</tr>
<tr>
<td>/patients/bob/reports</td>
<td>A list of all Bob’s reports</td>
</tr>
<tr>
<td>/patients/bob/reports/1</td>
<td>Details about Bob’s first report</td>
</tr>
</tbody>
</table>
## Level 2: Verbs

<table>
<thead>
<tr>
<th>Verb</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET /patients/bob/reports/1</td>
<td>Returns details about Bob’s first report</td>
</tr>
<tr>
<td>POST /patients/bob/reports/1</td>
<td>Creates a new report with an ID of 1</td>
</tr>
<tr>
<td>PUT /patients/bob/reports/1</td>
<td>Updates report ID 1 with new information</td>
</tr>
<tr>
<td>DELETE /patients/bob/reports/1</td>
<td>Deletes report 1</td>
</tr>
</tbody>
</table>
Hypermedia as the engine of application state

```
"ids": [12345678, 87654321, 11223344]

"links": [
{
"rel": "Reports",
"href": "https://.../reports/12345678"
},
{
"rel": "Appts",
"href": "https://.../appts/87654321"
},
{
"rel": "Labs",
"href": "https://.../labs/11223344"
}
]```
Medical Imaging Metadata

Instance
- Instance UID
- Height
- Width
- Position

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

Study
- Study UID
- Date of Study
- Description
- Refer Physician
- Accession
- Availability
Each patient has $x$ studies, which has $y$ series, which has $z$ instances. … and could have $f$ frames.
Introducing DICOMweb™

- Web standard for medical imaging
- Covers basic imaging interactions
  - Query via QIDO-RS
  - Retrieval via WADO (-RS, -URI, -WS)
  - Storing via STOW-RS

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DICOMweb™ in practice

Query (QIDO-RS)
Retrieve (WADO-RS)
Store (STOW-RS)
## Compatible with DICOM

<table>
<thead>
<tr>
<th>Service</th>
<th>DICOM</th>
<th>DICOMweb</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query</td>
<td>C-FIND</td>
<td>QIDO-RS</td>
<td>Query by IDs for DICOM Objects using RESTful Services</td>
</tr>
<tr>
<td>Retrieve</td>
<td>C-MOVE</td>
<td>WADO-RS</td>
<td>Web Access to DICOM Objects using RESTful Services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WADO-WS</td>
<td>WADO using WS-* Services (SOAP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WADO-URI</td>
<td>WADO using URI</td>
</tr>
<tr>
<td>Store</td>
<td>C-STORE</td>
<td>STOW-RS</td>
<td>Store via the Web using RESTful Services</td>
</tr>
</tbody>
</table>
Web-friendly Structures

```
<DicomAttribute Tag="00080020" VR="DT" Keyword="StudyDate">
  <Value number="1">20130409</Value>
</DicomAttribute>

<DicomAttribute Tag="00080061" VR="CS" Keyword="ModalitiesInStudy">
  <Value number="1">CT</Value>
</DicomAttribute>

<DicomAttribute Tag="00100010" VR="PN" Keyword="PatientName">
  <PersonName number="1">
    <SingleByte>
      <FamilyName>Doe</FamilyName>
      <GivenName>John</GivenName>
    </PersonName>
  </DicomAttribute>

<DicomAttribute Tag="0020000D" VR="UI" Keyword="StudyInstanceUID">
  <Value number="1">
    1.2.392.200036.9116.2.2.2.1762893313.1029997326.945873
  </Value>
</DicomAttribute>
```
"00080020": {
   "vr": "DT", "Value": ["20130409"]
},
"00080061": {
   "vr": "CS", "Value": ["CT"]
},
"00100010": {
   "vr": "PN", "Value": [ {
      "Alphabetic": {
         "Family": ["Doe"], "Given": ["John"]
      }
   }
},
"0020000D": {
   "vr": "UI", "Value": [
      "1.2.392.200036.9116.2.2.2.1762893313.1029997326.945873"
   ]
}
### Discovery via QIDO-RS

<table>
<thead>
<tr>
<th>GET</th>
<th>URL/Path</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET</td>
<td>/studies?...</td>
<td>Look up studies (i.e., for a particular patient)</td>
</tr>
<tr>
<td>GET</td>
<td>/studies/{studyUID}/series?...</td>
<td>Look up series in a study</td>
</tr>
<tr>
<td>GET</td>
<td>/series?...</td>
<td>Look up series (i.e., for a particular patient)</td>
</tr>
<tr>
<td>GET</td>
<td>/studies/{studyUID}/series/{seriesUID}/instances?...</td>
<td>Look up instances for a study/series</td>
</tr>
<tr>
<td>GET</td>
<td>/studies/{studyUID}/instances?...</td>
<td>Look up instances by study</td>
</tr>
<tr>
<td>GET</td>
<td>/instances?...</td>
<td>Look up instances</td>
</tr>
</tbody>
</table>
QIDO-RS Example

What studies do you have for John Doe?

http://server.com/studies/?00100010=DOE^JOHN

<table>
<thead>
<tr>
<th>Study</th>
<th>Date</th>
<th>Link</th>
</tr>
</thead>
</table>
Retrieve via WADO-RS

<table>
<thead>
<tr>
<th>GET</th>
<th>URI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>/studies/{StUID}</td>
<td>Retrieve an individual study</td>
<td></td>
</tr>
<tr>
<td>/studies/{StUID}/series/{SeUID}</td>
<td>Retrieve an individual series</td>
<td></td>
</tr>
<tr>
<td>/studies/{StUID}/series/{SeUID}/instances/{InUID}</td>
<td>Retrieve an individual instance</td>
<td></td>
</tr>
<tr>
<td>/studies/{StUID}/series/{SeUID}/instances/{InUID}/frames/{FrameList}</td>
<td>Retrieve individual frames</td>
<td></td>
</tr>
<tr>
<td>/studies/{StUID}/metadata</td>
<td>Retrieve study meta-data</td>
<td></td>
</tr>
<tr>
<td>{BulkDataURL}</td>
<td>Retrieve bulk data items</td>
<td></td>
</tr>
</tbody>
</table>
WADO-RS Example

Show me images for the Abdomen CT

http://server.com/studies/1.2.3/series/4.5.6/
Upload with STOW-RS

POST /studies/{StUID}  Stores a set of instances

POST /studies/  Stores a set of instances
STOW-RS Example

Store this image

http://server.com/studies

Stored
WADO-URI

- Similar to WADO-RS, but with one resource and all URI parameters
- http://server.com/wado/?requestType=WADO&studyUID=1.2.1.2&seriesUID=1.3.1.1&objectUID=1.4.1.4
- One object at a time
- Supports rendering of objects in web formats, without metadata
- Also known as “plain” WADO
WADO-WS

- Access to DICOM objects via SOAP
- “Simple Object Access Protocol”
- Used in IHE XDS-I transactions
- XML – HTTP based protocol
- Supports rendering of objects in web formats
- Retrieves and filters metadata
Coming Soon in DICOMweb™

• WADO-RS to include rendering
  • Currently only a feature of WADO-URI, -WS
• Discovery of server capabilities via “Server Options”
• Web workflow via Unified Procedure Step for RESTful Services (UPS-RS)
In Summary

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DICOM

DICOMweb

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Thank You!

Questions?