DICOMweb™

Harry Solomon
GE Healthcare

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Incorporates material developed by Brad Genereaux, Agfa Corp, DICOM WG-27 Chair
Patient-centered care requires:
- Access to data from multiple institutions, anywhere
- Consistent access to all types of data, including images

Mobile technology changes access methods
- Smart phones / tablets, not fixed workstations
- Web services for data distribution

Applications ecosystem breaks system models
- Cloud based apps from multiple vendors
- Dynamic configuration
Classical Image Lifecycle

<table>
<thead>
<tr>
<th>Task</th>
<th>User</th>
<th>Location</th>
<th>Application</th>
</tr>
</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 / multi-monitor workstation</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!
Evolving Image Lifecycle

- Foreign studies
- Research analytics
- Non-DICOM modalities
- Regional archives
- Medical Records
- Mobile Devices
- Sharing Portals

DICOMweb™
Problems in a Global Space

Dynamic Environment
• How do we manage changing endpoints and apps on demand?

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?
It may be new to medical imaging …

… but it is not new to the Internet economy

How are these problems handled today outside of medical imaging?

- By the Web services ecosystem
HTTP Internet Data 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 HTTP or related standards
REpresentational State Transfer - architectural style for standardizing data and workflow operations over HTTP

Scalable, fault-tolerant, recoverable, secure, and loosely-coupled

Resources – smallest data units of transactions

Standard HTTP verbs – operations on resources

• GET - retrieve a resource
• POST - create a new resource
• PUT - update an existing resource
• DELETE - remove a resource

Standard HTTP headers, status codes, security
## 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>
## Verbs + Resources

<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>
<tr>
<td>OPTIONS /patients</td>
<td>Returns capabilities for actions on patients</td>
</tr>
</tbody>
</table>
Strategic Goals of DICOM

Extend medical imaging to a wider audience by leveraging cross-industry web protocols and web developer training

Maintain the investment in systems and image data by incremental capability enhancement, not wholesale replacement

Keep aligned with other healthcare web service developments (FHIR)
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
  - Storing via STOW-RS
  - Query via QIDO-RS
  - Retrieval via WADO (-RS, -URI, -WS)
  - Workflow via UPS-RS

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Protocol Stacks for DICOM

Applications

Services and SOP Classes | Web Services

DICOM DIMSE and Upper Layer Protocol

HTTP and related protocols

TCP / IP

Physical Networks and Link Layer protocols
DICOMweb™ in practice
Plugs into Web Infrastructure

User (clinician)

Client (browser)

DICOMweb™ APIs

Security

Web Platform (.Net, J2EE)

Backend Infrastructure (DICOM)

Server
## Compatible with DICOM

<table>
<thead>
<tr>
<th>Service</th>
<th>DICOM DIMSE</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>C-GET</td>
<td>WADO-WS</td>
<td>Web Access to DICOM Objects using WS-* Services (SOAP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WADO-URI</td>
<td>Web Access to DICOM Objects using URI</td>
</tr>
<tr>
<td>Storage</td>
<td>C-STORE</td>
<td>STOW-RS</td>
<td>Store Over the Web using RESTful Services</td>
</tr>
<tr>
<td>Unified Procedure Step</td>
<td>N-CREATE</td>
<td>UPS-RS</td>
<td>Unified Procedure Step using RESTful Services</td>
</tr>
<tr>
<td></td>
<td>N-SET</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N-GET</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C-FIND</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N-ACTION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N-EVENT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>REPORT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
<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">
      <AlphabeticName>
         <FamilyName>Doe</FamilyName>
         <GivenName>John</GivenName>
      </AlphabeticName>
   </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>
Web-friendly Structures

```
"00080020": {
    "vr": "DT", "Value": ["20130409"]
},
"00080061": {
    "vr": "CS", "Value": ["CT"]
},
"00100010": {
    "vr": "PN", "Value": [ {
        "AlphabeticName": {
            "FamilyName": ["Doe"], "Given": ["John"]
        }
    } ]
},
"0020000D": {
    "vr": "UI", "Value": [ 
        "1.2.392.200036.9116.2.2.2.1762893313.1029997326.945873"
    ]
}
```

JSON
## Discovery via QIDO-RS

**Query by IDs for DICOM Objects using RESTful Services**

<table>
<thead>
<tr>
<th>Method</th>
<th>Endpoint</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>
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**

**Web Access to DICOM Objects using RESTful Services**

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

Store Over the Web using RESTful Services

<table>
<thead>
<tr>
<th>Method</th>
<th>Path</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST</td>
<td>/studies/{StUID}</td>
<td>Stores a set of instances</td>
</tr>
<tr>
<td>POST</td>
<td>/studies/</td>
<td>Stores a set of instances</td>
</tr>
</tbody>
</table>
STOW-RS Example

Store this image

http://server.com/studies

Stored
**WADO-URI**

- **Web Access to DICOM Objects using URIs**
- 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

- **Web Access to DICOM Objects using WS-* Services (SOAP)**
  - “Simple Object Access Protocol”
  - Different style of HTTP based protocol using XML documents as controls
- Used in IHE XDS-I transactions
- Supports rendering of objects in web formats
- Supports retrieve of object metadata
Workflow via UPS-RS

Unified Procedure Step using RESTful Services
• Generalized workflow task management
• Transcoding of DIMSE-based UPS service

<table>
<thead>
<tr>
<th>Method</th>
<th>Endpoint</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST</td>
<td>/workitems?{ItemUID}</td>
<td>Create a work Item</td>
</tr>
<tr>
<td>POST</td>
<td>/workitems/{ItemUID}?{transactionUID}</td>
<td>Create a work item update transaction</td>
</tr>
<tr>
<td>GET</td>
<td>/workitems?...</td>
<td>Look up work Items</td>
</tr>
<tr>
<td>GET</td>
<td>/workitems/{ItemUID}</td>
<td>Retrieve a work item</td>
</tr>
<tr>
<td>PUT</td>
<td>/workitems/{ItemUID}/state</td>
<td>Update state of a work item</td>
</tr>
<tr>
<td>POST</td>
<td>/workitems/{ItemUID}/cancelrequest</td>
<td>Cancel a work item</td>
</tr>
<tr>
<td>POST</td>
<td>/workitems/{ItemUID}/subscribers/{AETitle}</td>
<td>Create a work item notification subscription</td>
</tr>
<tr>
<td>DELETE</td>
<td>/workitems/{ItemUID}/subscribers/{AETitle}</td>
<td>Delete a work item notification subscription</td>
</tr>
<tr>
<td>GET</td>
<td>/subscribers/{AETitle}</td>
<td>Open a Websocket channel for notifications</td>
</tr>
</tbody>
</table>
## Capabilities Discovery via Retrieve Server Options

Returns Web Application Description Language (WADL) document

<table>
<thead>
<tr>
<th>OPTIONS</th>
<th>Path Description</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>OPTIONS</code></td>
<td><code>/studies</code></td>
<td>Get capabilities for study level operations (search, store)</td>
</tr>
<tr>
<td><code>OPTIONS</code></td>
<td><code>/studies/{StudyUID}</code></td>
<td>Get capabilities for operations on a specific study (retrieve, store)</td>
</tr>
<tr>
<td><code>OPTIONS</code></td>
<td><code>/studies/{StudyUID}/series/{seriesUID}/metadata</code></td>
<td>Get capabilities for metadata operations on a specific series (retrieve)</td>
</tr>
<tr>
<td><code>OPTIONS</code></td>
<td><code>/instances</code></td>
<td>Get capabilities for direct operations on instances (search)</td>
</tr>
<tr>
<td><code>OPTIONS</code></td>
<td><code>/workitems</code></td>
<td>Get capabilities for work item management (search, create)</td>
</tr>
<tr>
<td><code>OPTIONS</code></td>
<td><code>/workitems/{ItemUID}/subscribers/{AETitle}</code></td>
<td>Get capabilities for a specific subscriber to a specific work item</td>
</tr>
<tr>
<td><code>OPTIONS</code></td>
<td><code>/workitems/1.2.840.10008.5.1.4.34.5/subscribers/{AETitle}</code></td>
<td>Get capabilities for a specific subscriber to global notifications</td>
</tr>
</tbody>
</table>
Full specification

DICOM Part 18 – Web Services

DICOM Part 19 – Application Hosting
• XML representation of DICOM data (“Native Model”)
**Fast Healthcare Interoperable Resources**

New standard from HL7

- Currently Draft Standard for Trial Use (DSTU)
- HL7’s response to same strategic needs that drive DICOMweb™

Defines healthcare information as resources

- Suitable for access using RESTful Web Services
- E.g., Patient, DiagnosticOrder, Procedure, Practitioner

Resources aligned with DICOM

- ImagingStudy, ImagingObjectSelector
- Allow navigation and reference of DICOM resources from FHIR
- WADO-RS specified as method to access DICOM objects
In Summary

Foreign studies

Other modalities

Regional archives

EMR

Non-DICOM modalities

Mobile Devices

Prior studies

Long-term archives

3D visualization

Sharing Portals

DICOM

DICOMweb
Thank You!

Questions?