Background & Disclosures

- Owner, PixelMed Publishing, LLC
- Radiologist
- Independent Consultant – GE, Carestream, Curemetrix, MDDX, Pathcore
- Editor of DICOM Standard (NEMA contract)
- Formerly co-chair DICOM Standards Committee
- Formerly co-chair IHE Radiology Technical Committee
Interoperability

“the ability of two or more systems or components to exchange information and to use the information that has been exchanged”

layers: technology, data, human, institutional

consumer empowerment

privacy, security

competition, homogeneity, innovation

efficiencies, complexity

by design

over time

architectures
Photoelectronic radiology department

M. Paul Capp, Sol Nudelman, Donald Fisher, Theron W. Ovitt, Gerald D. Pond,
Meryl M. Frost, Hans Roehrig, Joachim Seeger, Donald Oimette
Department of Radiology, University of Arizona Health Sciences Center, Tucson, Arizona 85724

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Fred C. Billingsley, Jet Propulsion Laboratory

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Th. Wendler, D. Meyer-Ebrecht, James M. Jemiola, Philips Research Center,
Hamburg, FRG

32 years ago – radiology PACS and DICOM ubiquitous 15-20 years later!
DICOM and Radiology Modality

Modality → Storage → PACS
DICOM and Radiology Modality

Modality

Worklist
Storage
Commitment
Completed

PACS
DICOM and Cameras
(Dermoscopes, etc.)
DICOM and Cameras (Dermoscopes, etc.)

Camera

Worklist
Storage
Commitment
Completed

PACS
DICOM Modality to PACS

Standard Boundary

PACS +/- RIS

Archive

Manager

Workstations
Camera to Black Box

Standard Boundary

Camera
Camera
Camera
Camera
DICOM Camera to PACS

Standard Boundary

PACS +/- Database, Departmental IS, EMR ...

Manager

Archive

Workstations
DICOM – Enterprise Imaging

- Standard Boundary
- Modality
- Modality
- Slide Scanner
- Camera
- PACS +/- IS
- Archive
- Manager
- Workstations
- Analysis Systems
DICOM – Deconstructed PACS
DICOM – Cloud Deconstructed
Enterprise Tele* PACS

Standard Boundary

Modality

Modality

Slide Scanner

Camera

Archive

Manager

Workstations

Analysis Systems
Enterprise IT (Someone Else)
Types of Metadata

- Identifying
  - patient, order/request, encounter/visit

- Clinical
  - reason for study, anatomic location

- Descriptive
  - device and settings
  - kind of image
  - pixel physical size (calibration against known size object)

- Encoding related
  - compression
  - color management

- ...
DICOM – More than a file format

- **Payload**
  - bulk data (pixels: uncompressed, JPEG, …)
  - metadata (structured, coded, standardized)

- **Services**
  - transfer (storage)
  - query/retrieve (find and request)
  - workflow management (worklists)
  - object management (errors, lifecycle)
  - annotation (contours, segments, classify)
DICOM Service Choices

- Traditional radiology PACS (“DIMSE”)
  - C-STORE, C-FIND, C-MOVE, +/- C-GET

- “DICOMweb” services (HTTP)
  - “Web Access to DICOM Objects” (WADO)
  - WADO-URI – DICOM PS3.10 file or JPEG
  - “Representational State Transfer” (RESTful)
  - STOW-RS, QIDO-RS, WADO-RS
  - DICOM PS3.10 file, XML, JSON
  - retrieve study/series/instance/frames
  - retrieve DICOM, rendered (JPEG, etc.), metadata
## Study Resources and Actions

<table>
<thead>
<tr>
<th>Verb</th>
<th>Path</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST</td>
<td>{s}/studies</td>
<td>Store</td>
<td>Store instances</td>
</tr>
<tr>
<td></td>
<td>6.6.1</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/studies?...</td>
<td>Query</td>
<td>Query for matching studies</td>
</tr>
<tr>
<td></td>
<td>6.7.1</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/studies/{studyUID}</td>
<td>Retrieve</td>
<td>Retrieve entire study</td>
</tr>
<tr>
<td></td>
<td>6.5.1</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>POST</td>
<td>{s}/studies/{studyUID}</td>
<td>Store</td>
<td>Store instances</td>
</tr>
<tr>
<td></td>
<td>6.6.1</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/studies/{studyUID}/metadata</td>
<td>Retrieve</td>
<td>Retrieve metadata</td>
</tr>
<tr>
<td></td>
<td>6.5.6</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/studies/{studyUID}/series?...</td>
<td>Query</td>
<td>Query for matching series in a study</td>
</tr>
<tr>
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<td>6.7.1</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/studies/{studyUID}/series/{seriesUID}</td>
<td>Retrieve</td>
<td>Retrieve entire series</td>
</tr>
<tr>
<td></td>
<td>6.5.2</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/studies/{studyUID}/series/{seriesUID}/metadata</td>
<td>Retrieve</td>
<td>Retrieve series metadata</td>
</tr>
<tr>
<td></td>
<td>6.5.6</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/studies/{studyUID}/series/{seriesUID}/Instances?...</td>
<td>Query</td>
<td>Query for matching instances in a series</td>
</tr>
<tr>
<td></td>
<td>6.7.1</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/studies/{studyUID}/series/{seriesUID}/Instances/{instanceUID}</td>
<td>Retrieve</td>
<td>Retrieve instance</td>
</tr>
<tr>
<td></td>
<td>6.5.3</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/studies/{studyUID}/series/{seriesUID}/Instances/{instanceUID}/metadata</td>
<td>Retrieve</td>
<td>Retrieve instance metadata</td>
</tr>
<tr>
<td></td>
<td>6.5.6</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/studies/{studyUID}/series/{seriesUID}/Instances/{instanceUID}/frames/frames</td>
<td>Retrieve</td>
<td>Retrieve frames in an instance</td>
</tr>
<tr>
<td></td>
<td>6.5.4</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>/bulkdataReference</td>
<td>Retrieve</td>
<td>Retrieve bulk data</td>
</tr>
<tr>
<td></td>
<td>6.5.5</td>
<td>PS3.18</td>
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## Workflow Resources and Actions

<table>
<thead>
<tr>
<th>Verb</th>
<th>Path</th>
<th>Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>POST</td>
<td>{s}/workitems</td>
<td>PS3.18</td>
<td>CreateUPS</td>
</tr>
<tr>
<td></td>
<td>?AffectedSOPInstanceUID</td>
<td>6.9.1</td>
<td></td>
</tr>
<tr>
<td>POST</td>
<td>{s}/workitems/[UPSInstanceUID]</td>
<td>PS3.18</td>
<td>UpdateUPS</td>
</tr>
<tr>
<td></td>
<td>?transaction</td>
<td>6.9.2</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/workitems/{query}*</td>
<td>PS3.18</td>
<td>SearchForUPS</td>
</tr>
<tr>
<td></td>
<td>6.9.3</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/workitems/[UPSInstanceUID]</td>
<td>PS3.18</td>
<td>RetrieveUPS</td>
</tr>
<tr>
<td></td>
<td>6.9.4</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>PUT</td>
<td>{s}/workitems/[UPSInstanceUID]/state</td>
<td>PS3.18</td>
<td>ChangeUPState</td>
</tr>
<tr>
<td></td>
<td>6.9.5</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>POST</td>
<td>{s}/workitems/[UPSInstanceUID]/cancelrequest</td>
<td>PS3.18</td>
<td>RequestUPS</td>
</tr>
<tr>
<td></td>
<td>6.9.6</td>
<td>PS3.18</td>
<td>Cancellation</td>
</tr>
<tr>
<td>POST</td>
<td>{s}/workitems/[UPSInstanceUID]/subscribers/AETitle/?deletionlock</td>
<td>PS3.18</td>
<td>CreateSubscription</td>
</tr>
<tr>
<td></td>
<td>6.9.7</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>POST</td>
<td>{s}/workitems/1.2.840.10008.5.1.4.34.5/</td>
<td>PS3.18</td>
<td>SuspendGlobalSubscription</td>
</tr>
<tr>
<td></td>
<td>6.9.8</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>DELETE</td>
<td>{s}/workitems/[UPSInstanceUID]/subscribers/AETitle</td>
<td>PS3.18</td>
<td>DeleteSubscription</td>
</tr>
<tr>
<td></td>
<td>6.9.9</td>
<td>PS3.18</td>
<td></td>
</tr>
<tr>
<td>GET</td>
<td>{s}/subscribers/AETitle</td>
<td>PS3.18</td>
<td>OpenEventChannel</td>
</tr>
<tr>
<td></td>
<td>6.9.10</td>
<td>PS3.18</td>
<td></td>
</tr>
</tbody>
</table>

## Payloads

### XML

```xml
<NativeDicomModel>
  <DicomAttribute Tag="00080020">
    <VR="DT" Keyword="StudyDate">
      <Value number="1" value="20130409"/>
    </Value>
  </DicomAttribute>
  <DicomAttribute Tag="00080030">
    <VR="TM" Keyword="StudyTime">
      <Value number="1" value="131600.00000"/>
    </Value>
  </DicomAttribute>
</NativeDicomModel>
```

### JSON

```json
{
  "00080020": {
    "value": "20130409"
  },
  "00080030": {
    "value": "131600.00000"
  }
}
```

(These payloads are excerpts to show payload structure; these are not complete.)

---

**More Information**

Below you will find the list of all of the resource types exposed by the ISIC Archive RESTful Web API. Click any of the resource links to open up a list of all available endpoints related to each resource type.

Clicking any of those endpoints will display detailed documentation about the purpose of each endpoint and the input parameters and output values. You can also call API endpoints directly from this page by typing in the parameters you wish to pass and then clicking the "Try it out!" button.

Warning: This is not a sandbox—calls that you make from this page are the same as calling the API with any other client, so update or delete calls that you make will affect the actual data on the server.

<table>
<thead>
<tr>
<th>annotation</th>
<th>Show/Hide</th>
<th>List Operations</th>
<th>Expand Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>dataset</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>featureset</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>image</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GET /image</td>
<td>Return a list of lesion images.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GET /image/{id}</td>
<td>Return an image's details.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GET /image/{id}/download</td>
<td>Download an image's high-quality original binary data.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POST /image/{id}/segment</td>
<td>Run and return a new semi-automated segmentation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GET /image/{id}/superpixels</td>
<td>Get the superpixels for this image, as a PNG-encoded label map.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GET /image/{id}/thumbnail</td>
<td>Return an image's thumbnail.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GET /image/{id}/tiles</td>
<td>Return an image's multiresolution tile information.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GET /image/{id}/tiles/{z}/{x}/{y}</td>
<td>Return a multiresolution tile for an image.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GET /image/download</td>
<td>Download multiple images as a ZIP file.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GET /image/histogram</td>
<td>Return histograms of image metadata.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DICOM and Analysis Systems

- DICOM encoding/services for both inputs and outputs
- Standard acquired image format
- Standard processed result format
- Standard metadata describing input to help analysis

- New images
- Annotations – contours, segmentations, measurements
- Saved to PACS, viewed normally, or as overlay
- Annotations in radiology – regions of interest
- Image fusion in radiology – PET on top of CT

- Facilitates separate regulatory approval and user validation of acquisition/analysis/display
DICOM objects working together

Current DICOM Images from Modality

Previous DICOM Images from PACS

Analysis Workstation

Previous DICOM SR etc

DICOM SR

DICOM Real World Value

DICOM Parametric Map Images

DICOM Segmentation

DICOM Registration

PACS Store, Distribute and Review
DICOM Dermatology Specifics
1993 to 2017

- 1993 – Initial standard – Secondary Capture, JPEG payload

- 1999 – WG 19 – formed (DSC Minutes 1999/06)
- 2001 – WG 19 – disbanded (DSC Minutes 2001/04)
- 2009 – WG 19 – proposal to reactivate (WG6 Minutes 2009/08)

- Just do it (or not) … no need for specific SOP Class, extras?

- 2010 – CP 1017 – Add ICC profile to all color IODs
- CP 1674 on anatomic locations (surface anatomy)
- CP 1736 on EXIF tag mapping to DICOM attributes
WG 19 – 2001 Report – Goals

• “The American Academy of Dermatology sponsored working group initially defined three high level goals.”
  • “Define those features that might be specific for a cutaneous imaging SOP class”
  • “Enlist vendors with enthusiasm for co-developing the cutaneous image SOP class and integrating it into image capture and display equipment.”
  • “Define a structured vocabulary for use in informatics and telemedicine applications in dermatology. These activities will interrelate with the activities of those individuals working on the structured reporting supplement to DICOM.”
• “In addition, we have recently been asked to comment on the importance of acquisition context for dermatology and the importance of accurate color reproduction across media in dermatologic images.”
Dermatology IOD: “… for dermatologic image capture, storage, transmission and associated meta data, DICOM supplement 15 provides adequate standardization. In contrast to our original thinking, … a specific dermatology IOD or SOP class is not necessary.”

Vendors: “… dermatologic digital imaging is a small, nascent market and that capture device manufacturers are not interested in writing to a standard such as DICOM.”

Structured vocabulary: “The American Academy of Dermatology has reviewed this issue and taken it out of the hands of the Telemedicine Task Force, the sponsor of Working Group 19.”

Accurate color reproduction: “There is more tolerance for color variation in dermatologic diagnosis than we think.”

Metadata: “It may be that with the advent of XML, this too will become an issue that can be solved without the involvement of DICOM.”

“One is forced to ask whether this group was formed “before its time”.”
"There is a reason why Working Group 19 has made no progress for a decade in the middle of a digital revolution ... missing key incentives ... before ... move to integrate digital imaging with diagnosis ...

Although dermatologists commonly capture digital images, they do not depend on them for diagnosis.

Since adequate dermatological diagnoses result from face-to-face physical exams, the status quo is viable (but not close to optimal).

Therefore, there is no concern about using COTS cameras and displays since the images are just for documentation and teaching.

Use of inexpensive COTS equipment is reinforced because it is all that can be supported by the low reimbursement level for most dermatologic visits.

The low level of capital equipment expenditure doesn’t attract sufficient vendor investment.

Unfortunately, the lack of vendor investment suppresses the development, validation and general clinical acceptance of applications for the use of digital images in dermatologic diagnosis and visualization.

The lack of vendor investment hasn’t caused clinical concern ..."
Table CID nnn1. DermatologyAnatomicSites

<table>
<thead>
<tr>
<th>Coding Scheme Designator</th>
<th>Code Value</th>
<th>Code Meaning</th>
<th>SNOMED-CT Concept ID</th>
<th>UMLS Concept Unique ID</th>
<th>FMA ID</th>
<th>NYUMCCG Numeric Code</th>
<th>NYUMCCG Description</th>
<th>Mayo Numeric Code</th>
<th>Mayo Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-D2702</td>
<td>SRT</td>
<td>Crena ani</td>
<td>45327009</td>
<td>C0230121</td>
<td>20234</td>
<td>238</td>
<td>Intralgluteal Cleft</td>
<td></td>
<td></td>
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<tr>
<td>T-D14AC</td>
<td>SRT</td>
<td>External structure of eye region</td>
<td>181142009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>508</td>
<td>Eyes</td>
</tr>
<tr>
<td>313052</td>
<td>99PMP</td>
<td>Eyelash of left eyelid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>105</td>
<td>Eye, left eyelash</td>
</tr>
<tr>
<td>313051</td>
<td>99PMP</td>
<td>Eyelash of right eyelid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>104</td>
<td>Eye, right eyelash</td>
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<td>T-81001</td>
<td>SRT</td>
<td>Female external urethral orifice</td>
<td>279479008</td>
<td>C0458493</td>
<td>85266</td>
<td>504</td>
<td>Urethral Orifice (Female)</td>
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<td></td>
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<tr>
<td>U000413</td>
<td>SRT</td>
<td>Hair</td>
<td>58240005</td>
<td>C0018494</td>
<td>53667</td>
<td></td>
<td></td>
<td></td>
<td>Hair</td>
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<tr>
<td>T-AA553</td>
<td>SRT</td>
<td>Iris of left eye</td>
<td>28153001</td>
<td>C0229192</td>
<td>58237</td>
<td></td>
<td></td>
<td></td>
<td>Eye, left iris</td>
</tr>
</tbody>
</table>
### CP-1736 – Add Photography Attributes [from] EXIF ...

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>DICOM Tag</th>
<th>DICOM Module</th>
<th>EXIF Tag (hex)</th>
<th>EXIF Tag (dec)</th>
<th>EXIF IFD</th>
<th>EXIF Key</th>
<th>EXIF Type</th>
<th>EXIF Tag description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ggpa,9405)</td>
<td>Camera Elevation Angle</td>
<td>VL Photographic Acquisition</td>
<td>0x9405</td>
<td>37893</td>
<td>Photo 231</td>
<td>Camera ElevationAngle</td>
<td>SRational</td>
<td>Elevation/depression. Angle of the orientation of the camera (imaging optical axis) as the ambient situation at the shot. The unit is degree(°). The range of the value is from -180 to less than 180. If the denominator of the recorded value is FFFFFFFF.H, unknown shall be indicated. Obtaining method or accuracy is not stipulated. Therefore methods like that the photographer manually input the numeric, as an example, are usable.</td>
</tr>
<tr>
<td>(ggpa,829a)</td>
<td>Exposure Time</td>
<td>VL Photographic Acquisition</td>
<td>0x829a</td>
<td>33434</td>
<td>Photo</td>
<td>ExposureTime</td>
<td>Rational</td>
<td>Exposure time, given in seconds (sec).</td>
</tr>
<tr>
<td>(ggpa,829d)</td>
<td>FNumber</td>
<td>VL Photographic Acquisition</td>
<td>0x829d</td>
<td>33437</td>
<td>Photo</td>
<td>FNumber</td>
<td>Rational</td>
<td>The F number.</td>
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<tr>
<td>(ggpa,8822)</td>
<td>Exposure Program</td>
<td>VL Photographic Acquisition</td>
<td>0x8822</td>
<td>34850</td>
<td>Photo</td>
<td>ExposureProgram</td>
<td>Short</td>
<td>The class of the program used by the camera.</td>
</tr>
</tbody>
</table>
DICOM & New/Exotic Modalities

- Re-use existing IODs (always, or interim solution):
  - If camera-like, use VL Photo IOD
  - if gross microscopy, use VL Slide
  - if high resolution microscopy, use WSI
  - can always add name-value pairs (Acquisition Context), private attributes, new standard attributes (e.g. EXIF)
  - Can always add new codes (e.g., anatomy, view, …)

- May want new IODs – add Supplements to DICOM
  - ? whole body photography if too large (e.g., need tiles, or non-Cartesian projection/coordinates (like wide-field retinal photography)
  - ? confocal microscopy
  - ? multi-spectral, if not 1 channel or 3 channel (RGB)
**Bottom Line**

- Can use DICOM just as it is, right now, for most devices
  - can use off-the-shelf conversion solutions if acquisition devices are not DICOM compatible out of the box
  - can use DICOM file format (metadata) and protocols
- Can improve DICOM incrementally as necessary
  - but not a reason to wait – “Just Do It” (Nike)
- Should use DICOM if you:
  - want “interoperability”
  - don’t want metadata to be trapped in a vendor-specific silo
  - ever want to migrate when vendor/product goes end of life
  - want to leverage enterprise infrastructure (archival, security, …)
  - want to analyze with 3rd party tools (“CAD”)
  - want to share (import/export/refer/teledermatology)
  - want “integrative” imaging (with other image types; MDTM, …)
DICOM WG 19 – Action Items

- Reactivate
- Secretariat – ISIC? IDS? AAD?
- F2F and virtual meetings – with conferences?
- Vendor engagement
- Success stories – existing use in institutions, teledermatology?
- Add DICOM format, services (esp. web) to ISIC archive?
- Terminology: free; relationship with SNOMED, FMA, UMLS
- Color: need dermatologists to join ICC MIWG
- Privacy: review/extend DICOM de-identification profile and options