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DICOM OVERVIEW & PROCESS

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PAST-CHAIR, DICOM STANDARDS CMTE
CANON MEDICAL RESEARCH USA
Protocol
• Specifies how two systems exchange information

Many kinds of Systems:
• Modalities, PACS, RIS, Workstations, EMR,…

Many kinds of Information:
• Images, worklists, measurements, surfaces, audit logs, …
Routine Clinical Practice

Scheduling Exams

Acquiring Images

Managing Images

Processing Images

Displaying Images

Distributing Images

Reporting Images

Medical Imaging
DICOM stores your images

- All kinds of images
- CT, MR, X-Ray, Ultrasound, Angiography, PET, … Ophthalmology, Scanned Documents
- Single & Multiframe; Volumes & Cines; B&W & Color; Original & Processed

DICOM helps manage your Images

- Not just pixels; Significant meta-data
- Patient identification & demographics, the order, equipment, acquisition, workflow, …
- PACS = database; DICOM = machine readable
- Can query/sort/autoroute/manage
Other DICOM Components

Store (Imaging) Data
• fetal growth, cardiac output, tumor size, CAD findings, ECG Waveforms

Manage (Imaging) Workflow
• Modality Worklists, Progress updates, Storage Commitment

Display Images
• Screen calibration, annotations, layouts, key image flagging
Other DICOM Components

Distribute Images

- Network push/pull, Media Transfer (CD, USB, Bluray…), Email Attachments, Web Protocols

Store Analysis Results

- Registrations, Segmentations, Image Markup, 3D Print Models, …

Security

- Audit Trails, De-identification Schemas, Encryption
DICOM is not Static

DICOM first published in 1993

Extended regularly to meet the expanding needs of Medical Imaging:

- Multi-slice CT
- 3D Ultrasound
- Web-based PACS
- USB Memory Sticks
- Clinical Measurements
- Radiation Dose Reporting
- Image Registration & Segmentation
- Computer Aided Detection/Diagnosis
- and Many, Many More . . .
Supplements for major changes
- New object types, new services, new compression schemes
- About 10 / year
- Developed by Working Groups
- Require Work Item approved by DICOM Standards Committee

Change Proposals for minor corrections
- About 100 / year
- Anybody can submit
- Backward Compatibility: Avoid changes that break existing implementations

Continuous maintenance process
- WG-06 (“Architecture Review Board”) meets five times per year
- All documents published for open Public Comment; later formal vote by Letter Ballot
Advanced Blending Presentation State (Example)

Anatomical (Relative Opacity 0.7) + DTI (Relative Opacity 0.3) → Relative Opacity 0.6

fMRI (Relative Opacity 0.33) + fMRI (Relative Opacity 0.33) + fMRI (Relative Opacity 0.33) → Relative Opacity 0.4
Some Recent Supplements

- **DICOMweb: RESTful Web Services**
  - WADO, STOW, QIDO, UPS, Rendering
- **CT Protocol Storage**
- **3D Printing**
- **Radiation Dose**
  - X-ray, Radiopharmaceutical, Patient Dose Estimates
- **TLS Security Update**
- **HEVC H265 Video Coding**
- **Transform NCI AIM & DICOM SR Measures**
Some Current Supplements

- Sup 202  **Real Time Video**
- Sup 147  **Second Generation Radiotherapy**
- Sup 175-9: 2nd Gen. RT continued
- Sup 207  **Conformity Assessment**
- Sup 208  **X3D Encapsulation for 3D Manufacturing**
# Multi-Energy CT

<table>
<thead>
<tr>
<th>Direct Angio</th>
<th>Lung PBV</th>
<th>Virtual Unenhanced</th>
<th>Lung Vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardplaque Display</td>
<td>Heart PBV</td>
<td>Calculi Characterization</td>
<td>Brain Hemorrhage</td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>Gout</td>
<td>Lung Nodules</td>
<td>Xenon</td>
</tr>
</tbody>
</table>

* COURTESY WG-21
Performed Administration SR

Contains

Programmed at injector device

Actually delivered by injector device

Programmed Plan

Delivered Plan

Steps

Steps

Phases

Phases

Pressure Vs. Time Graphs

Flow Rate Vs. Time Graphs
Working Groups

Modality, clinical domain, or function specific teams, assigned to develop Supplements or Change Proposals

WG-01: Cardiac and Vascular Information
WG-02: Projection Radiography/Angiography
WG-03: Nuclear Medicine
WG-04: Compression
WG-05: Exchange Media
WG-06: Base Standard
WG-07: Radiotherapy
WG-08: Structured Reporting
WG-09: Ophthalmology
WG-10: Strategic Advisory
WG-11: Display Function Standard
WG-12: Ultrasound
WG-13: Visible Light
WG-14: Security
WG-15: Digital Mammography and CAD
WG-16: Magnetic Resonance

WG-17: 3D
WG-18: Clinical Trials and Education
WG-19: Dermatology
WG-20: Integration of Imaging and Info Systems
WG-21: Computed Tomography
WG-22: Dentistry
WG-23: Application Hosting
WG-24: Surgery
WG-25: Veterinary Medicine
WG-26: Pathology
WG-27: Web Technology for DICOM
WG-28: Physics
WG-29: Education, Communication & Outreach
WG-30: Small Animal Imaging
WG-31: Conformance
Maintaining Stability

• No “Versioning”
  – It’s just “DICOM”
    Not “DICOM 3.1”, “3.2”, “2015b”, etc.
DICOM SOP Class

Service + Object = Service Object Pair
(Storage + MR Image = MR Image Storage)

SCU – Service Class User
• the system that uses the service (client)

SCP – Service Class Provider
• the system that provides the service (server)
Some Other SOP Examples

SOP Class = service and object

– Store a CT image
– Store an XR image
– Find the studies for a patient
– Find the worklist for a modality
– Move a set of images
– Create an image print job
Maintaining Stability

• No “Versioning”
  – It’s just “DICOM”
    Not “DICOM 3.1”, “3.2”, “2015b”, etc.

• DICOM evolves by adding new “SOP Classes”
  – New SOP Classes are added
  – Old SOP Classes don’t “break”
  – Most applications continue to support older SOP Classes when supporting new ones
Stability and Maintenance

• Don’t break existing implementations
  
  In existing SOP Classes:
  – Clarify but don’t change meaning
  – Add new codes, attributes, or behaviors BUT products don’t have to support them and can ignore them safely.
  – Exception: fix something that is already broken

• The Caveat
  – Vendors are still responsible to monitor CPs and fix their products when they are deficient
Publication vs Conformance

- DICOM Conformance is to SOP Classes
  - *not to a version of the Standard*

- New DICOM editions are published (e.g. 2018c)
  - SOP Classes are added but not changed incompatibly

- Each SOP Class is stable
  - forward and backward compatible across all editions
  - any data elements added are optional

- Products conforming to the same SOP Class interoperate
  - Humans compare DICOM Conformance Statements (DCS)
  - Machines do Association Negotiation
Documented Assertion of Product Conformance

DICOM Conformance Statement

- Required for every compliant product – *pro-forma* in DICOM Part 2
- Lists the SOP Classes / roles supported by a product
- Allows user organization (system integrator) to determine components that should work together
- Describes product implementation details and behaviors
Before two systems perform a DICOM transaction they first agree:

- what **SOP Class** they will use (e.g. MR Image Storage)
- who will be the SCU (client role), who will be the SCP (server role)
- what compression will be used (e.g. JPEG Lossless)

This process is called **Association Negotiation**
• New Objects conform to existing information/real-world model

• Allows reuse in implementation
  • Leverage standard modules in toolkits
  • PACS can handle new objects with minimal change

• Avoid temptation to “improve”
Simplified model of real world concepts and activities

- Study ≈ ordered procedure;
  Series ≈ performed protocol
- Sufficient for pragmatic needs of routine radiology
An Image (or other IODs) holds acquired data
A Series may group closely related Images from the same PPS, same protocol & same piece of Equipment
A Study groups all Series for a given Req. Procedure
A Patient may have many studies

Instances are actual data created based on an object definition

DICOM uses Unique Identifiers (UIDs) to identify:
- specific Instances
- specific SOP Classes
- specific Study / Series
- . . . and many other things
Starting from the bottom ...

MR Storage SOP Class

Storage Service

MR Object

Module Module Module

Attribute Attribute Attribute

DICOM
Digital Imaging and Communications in Medicine
**DICOM Terms: Attribute**

DICOM Data Stream = ...00100010Smith^John^^^...

<table>
<thead>
<tr>
<th>Tag</th>
<th>Attribute Name</th>
<th>VR</th>
<th>VM</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0010,0010)</td>
<td>Patient Name</td>
<td>PN</td>
<td>1</td>
<td>Smith^John^^^</td>
</tr>
</tbody>
</table>

*(See DICOM Part 6: Data Dictionary)*

- **Tag**: (Group #, Element #) to identify an attribute/data element
- **Value Representation (VR)**: data type used to encode the value(s)
- **Value Multiplicity (VM)**: how many values can be in the attribute
DICOM Terms: Module

**Patient Module**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Tag</th>
<th>Type</th>
<th>Attribute Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Name</td>
<td>(0010,0010)</td>
<td>2</td>
<td>Patient’s Full Name</td>
</tr>
<tr>
<td>Patient ID</td>
<td>(0010,0020)</td>
<td>2</td>
<td>Primary hospital identification number or code for the patient</td>
</tr>
<tr>
<td>Issuer of Patient ID</td>
<td>(0010,0021)</td>
<td>3</td>
<td>Identifier of the Assigning Authority that issued the Patient ID</td>
</tr>
</tbody>
</table>

(See DICOM Part 3: Information Object Definitions)

- **Module**: an architectural convenience; a logical group of attributes about a common topic
- **Macro**: purely an editing convenience; a table of attributes that can be easily copied into modules
- **Type**: (1) Required (2) May Be Empty if Unknown (3) Optional (1C or 2C) Conditional
### Enhanced CT Object

<table>
<thead>
<tr>
<th>IE</th>
<th>Module</th>
<th>Reference</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>Patient</td>
<td>C.7.1.1</td>
<td>M</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>General Equipment</td>
<td>C.7.5.1</td>
<td>M</td>
</tr>
<tr>
<td>Image</td>
<td>General Image</td>
<td>C.7.6.1</td>
<td>M</td>
</tr>
<tr>
<td>Contrast/Bolus</td>
<td>C.7.6.4</td>
<td>C – Required if contrast media was used in this image</td>
<td></td>
</tr>
<tr>
<td>CT Image</td>
<td>C.8.2.1</td>
<td>M</td>
<td></td>
</tr>
</tbody>
</table>

*See DICOM Part 3: Information Object Definitions*

**Information Entity (IE):** a group of modules representing a Real-World object.

**Reference:** a Section in Part 3 where it is defined.

**Usage:** (M) Mandatory; (C) Conditional; (U) Optional.
DICOM Services

Print – Printing Objects to a DICOM Printer

Storage – Storing Objects, e.g. to a PACS

Query/Retrieve – Getting Objects, e.g. from a PACS

MWM – Getting Scheduled Patients, e.g. from RIS
(Modality Worklist Management)

MPPS – Status (Started, Completed) back to RIS
(Modality Performed Procedure Step)

(...)

(See DICOM Part 4: Service Class Specifications)
• DICOM Standard is maintained in DocBook XML and published free on the Web in multiple formats:
  – PDF - the official version
  – XML - for automatic update of tools
  – HTML - for easy use with hyperlinks to references
  – MS Word - for extraction into project documentation

• Re-published several times per year to incorporate all approved Supplements and Change Proposals

http://dicomstandard.org/current
Administered and Published by:
- NEMA (National Electrical Manufacturers Association)
- MITA (Medical Imaging Technology Alliance)

Intellectual Property
- DICOM Trademark and Copyright is held by NEMA
- No license required to use the DICOM Standard in products

dicom.nema.org
- Download free electronic copies of all 20 Parts of the Standard
- Plans and activities are publicly posted
- ISO publishes Part 1 of the Standard as ISO 12052
Participate!

- DICOM invites new members & contributors
  - Application process
  - Patent disclosure policy
  - dicomstandard.org
  - dicom@dicomstandard.org

- Great opportunity to learn
- Great opportunity to contribute
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    Vernon Hills, IL  60061

Thank you for your attention!
WHAT IS A SECRETARIAT AND WHAT DOES IT DO?

MEDICAL IMAGING TECHNOLOGY ASSOCIATION (MITA)

LISA SPELLMAN,
DICOM GENERAL SECRETARY
DICOM Secretariat

About

- Staff
- Operations and strategy
- Member services
- Collaboration and participation

Current initiatives

- Expanded DICOM communications & outreach with DICOM WG-29
- Infrastructure review
- Tell us! Share your questions and stories
  - Cool things about DICOM you never knew (but should)
  - Member profile spotlight
Medical Imaging Technology Association (MITA)

- Is a division of the National Electrical Manufacturers Association (NEMA)
- Collective voice of manufacturers, innovators, and product developers in medical imaging and radiopharmaceuticals
- Represents companies whose sales make up more than 90 percent of the global market for advanced imaging technologies
- MITA hosts DICOM Secretariat

2018 initiatives include:

- Adopt Uniform Standards for Medical Imaging Service Providers
- Ensure Patient Access to Medical Imaging
- Promote Cybersecurity for Medical Imaging
- Improve Regulatory Environment to Promote Growth and Innovation
- Remove Barriers and Reduce Costs in Markets Worldwide
Thank you!

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