

DICOM Concepts

Kevin O'Donnell

Toshiba Medical Research Institute – USA, Inc.

Chair, DICOM WG10 (Strategic)

Past-Chair, DICOM Standards Cmte

DICOM: A Family of Protocols



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**

**Distributing
Images**

**Acquiring
Images**

**Medical
Imaging**

**Reporting
Images**

**Managing
Images**

**Displaying
Images**

**Processing
Images**

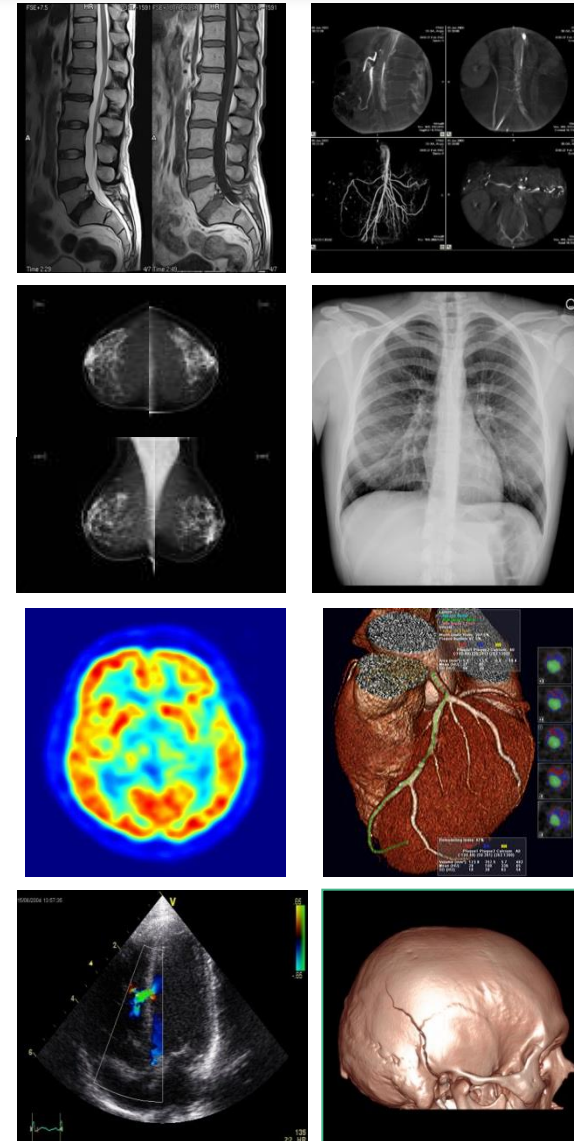
Store Images

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

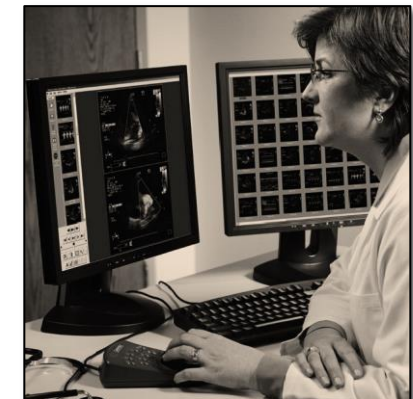
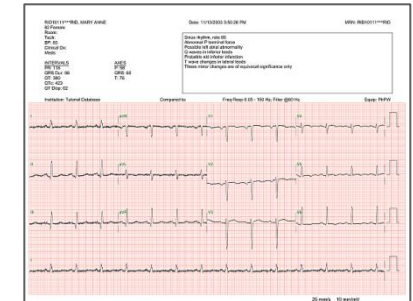
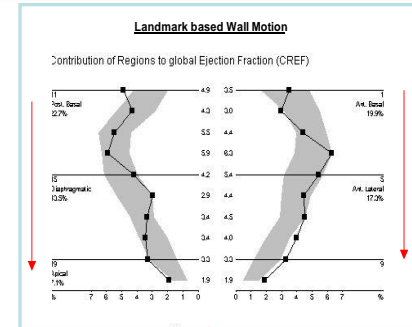
- fetal growth, cardiac output, tumor size, CAD findings, ECG Waveforms

Manage (Imaging) Workflow

- Modality Worklists, Progress updates, Storage Commitment

Display Images

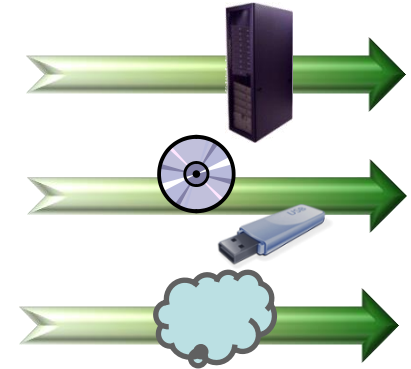
- Screen calibration, annotations, layouts, key image flagging



Other DICOM Components

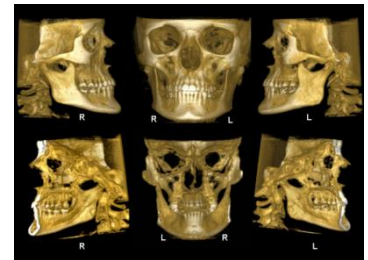
Distribute Images

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



Store Analysis Results

- Registrations, Segmentations, Implant Models, Image Markup



Security

- Audit Trails, De-identification Schemes, Encryption

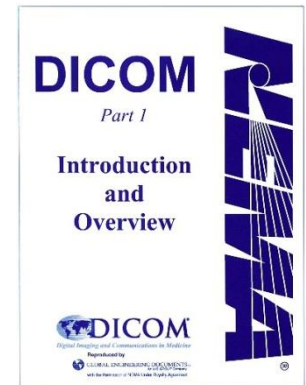
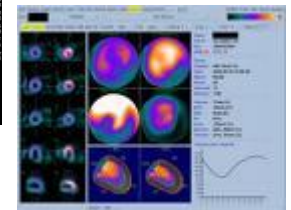
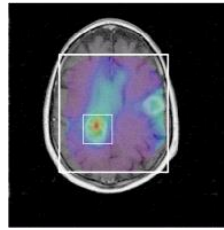


DICOM is not Static

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

- **DICOMweb – RESTful Web Services**
 - WADO, STOW, QIDO, UPS
- **Radiology Reports using HL7 CDA**
- **Radiation Dose**
 - X-ray, Radiopharmaceutical
- **Breast Tomosynthesis**
- **Magnetic Resonance analytics**
- **Ophthalmology**
 - many devices

- **DICOMweb – RESTful Rendering Service**
- **Next Generation Radiation Therapy**
- **Advanced Visualization (MPR)**
- **CT Protocol Storage**
- **Multi-energy CT Images**
- **Contrast Injection records**
- **... and others**

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 (NEW!)

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



SCU

MR Image Storage SOP Class



SCP

SCU – Service Class User

- the system that uses the service (client)

SCP – Service Class Provider

- the system that provides the service (server)

No “Versioning”

- It’s just called “DICOM”;
Not “DICOM 3.1”, “3.2”, “2015b”, etc.

DICOM evolves by adding new SOP Classes

- DICOM is a family of SOP Classes
- New SOP Classes are added;
Old SOP Classes don’t change
- Most applications continue to support older
SOP Classes when supporting new ones

DICOM Conformance is to Service-Object Pair (SOP) Classes – *not to a version of the Standard*

A SOP Class stays forward and backward compatible across all editions of the DICOM Standard

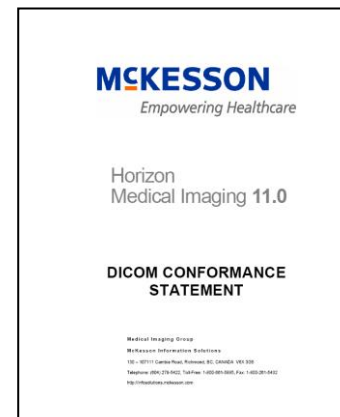
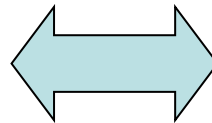
- May add optional data elements as uses evolve

All products claiming conformance to that SOP Class should be interoperable

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

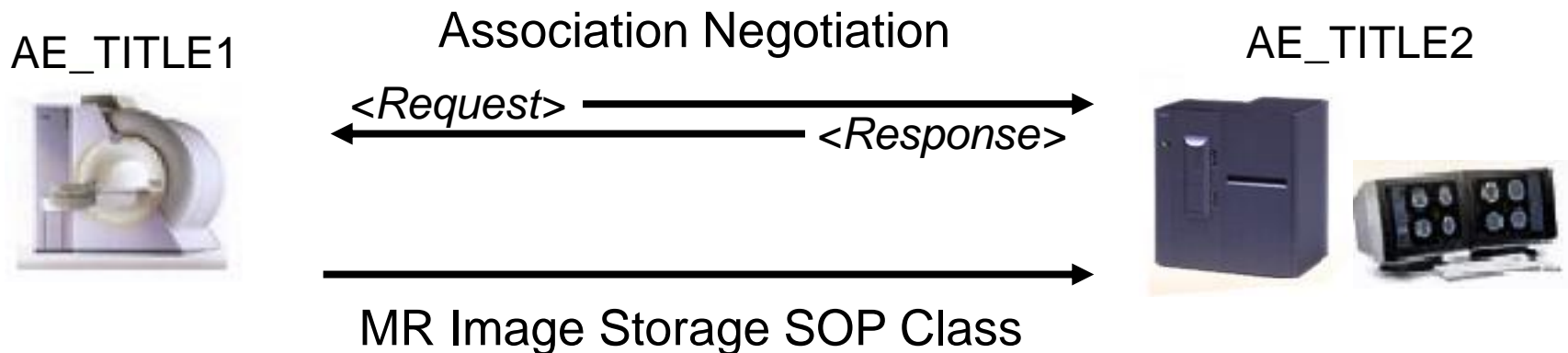


Machine Negotiation of Conformant Capabilities

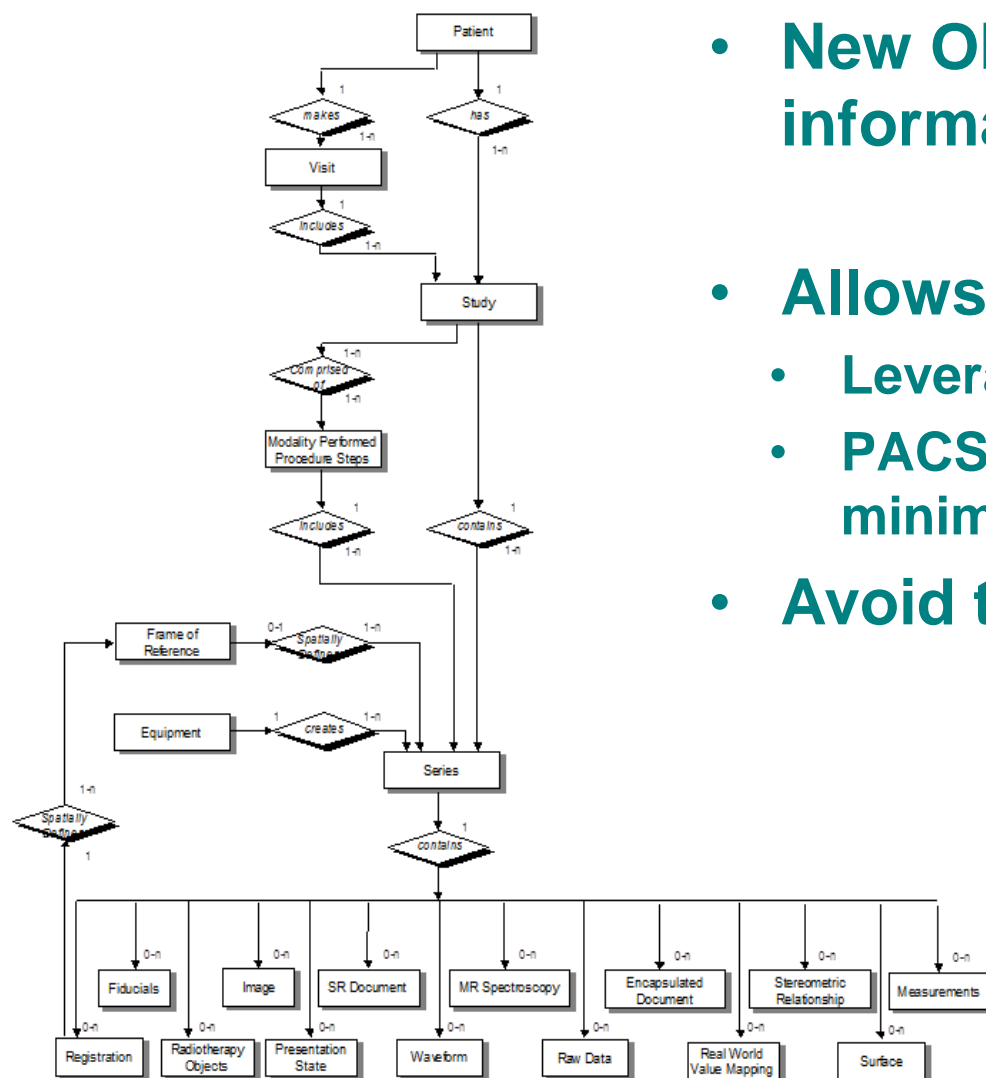
Before two systems perform a DICOM transaction they first agree:

- 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



Information Model Stability

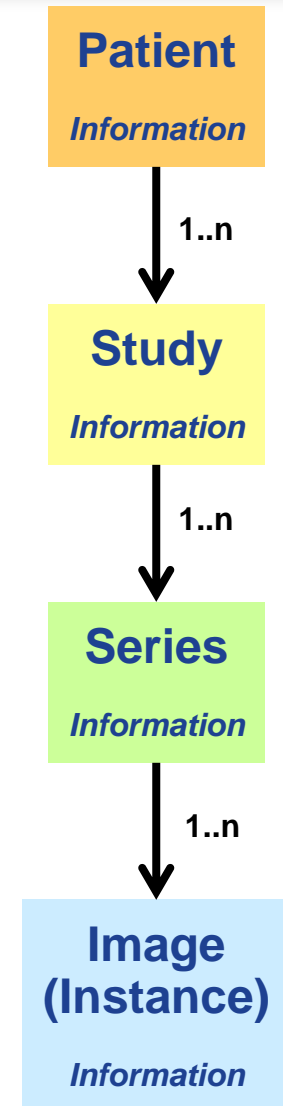


- **New Objects conform to existing information/real-world model**
- **Allows reuse in implementation**
 - Leverage standard modules in toolkits
 - PACS can handle new objects with minimal change
- **Avoid temptation to “improve”**

The Information Model

Simplified model of real world concepts and activities

- Study \approx ordered procedure;
Series \approx 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 ...



Service
Class
User

MR Storage SOP Class

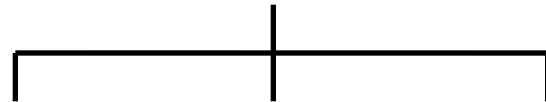


Service
Class
Provider

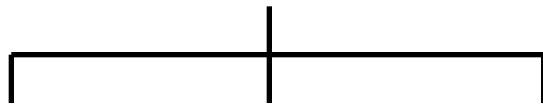
Storage Service

+

MR Object



Module Module Module



Attribute Attribute Attribute

DICOM Terms: Attribute

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

<i>Tag</i>	<i>Attribute Name</i>	<i>VR</i>	<i>VM</i>	<i>Value</i>
(0010,0010)	Patient Name	PN	1	Smith^John^^^

(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

<i>Attribute</i>	<i>Tag</i>	<i>Type</i>	<i>Attribute Description</i>
Patient Name	(0010,0010)	2	Patient's Full Name
Patient ID	(0010,0020)	2	Primary hospital identification number or code for the patient
Issuer of Patient ID	(0010,0021)	3	Identifier of the Assigning Authority that issued the Patient ID
...			

(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

DICOM Terms: Object (IOD)



Enhanced CT Object

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

(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

- 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)

The DICOM Standard



Administered and Published by:

- *NEMA (National Electrical Manufacturers Association)*



and it's medical imaging division:

- *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*

DICOM Standard is maintained in DocBook XML and published free online 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://dicom.nema.org/standard.html>

Kevin O'Donnell, MASc.

- **kodonnell@tmriusa.com**
- **Toshiba Medical Research Institute – USA**
706 N. Deerpath Drive,
Vernon Hills, IL 60061

Thank you for your attention !

Internationalization (i18n) and Localization (L10n)



DICOM is an **internationalized** standard

It includes capabilities to support the languages and needs of users worldwide:

- Selectable character encodings (GB2312, GBK, UTF-8, ...)
- Multiple name representations (alphabetic, ideographic, phonetic)
- Language independent data encoding

DICOM supports **localization** to national/local health and workflow policies without deviating from the Standard

- Locally specify code sets (e.g., procedure codes)
- Locally profile data element usage (optional -> required)

2014.02 Initially proposed

2015.05 Approved

2015.08 In formation – all stakeholders welcome

Initial task: Collect stakeholder needs for improvements in DICOM conformance testing, e.g.

- Simplify and improve rigor of vendor test processes
- Define test report formats and contents that support the tasks of regulators and healthcare organizations
- Common conformance assessment requirements
- Reference test plans, data sets, and pro-forma reports