SPIE Medical Imaging 2013

DICOM For Research and Clinical Quantitative Imaging

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Affiliations & Disclosures

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- Editor, DICOM Standard
- Co-chair, IHE Radiology Tech. Committee
- Member, QIBA CT Volumetry Committee

Overview

- Quantitative Imaging
- Range of research applications
- Clinical versus research context
- Commonalities and differences
- DICOM versus proprietary research formats
- Non-image stuff
- Workflow
- De-identification
- Hosted applications
- Web services

What is Quantitative Imaging?

- *"Quantitative imaging is the extraction of quantifiable features from medical images for the assessment of normal or the severity, degree of change, or status of a disease, injury, or chronic condition relative to normal … includes the development, standardization, and optimization of anatomical, functional, and molecular imaging acquisition protocols, data analyses, display methods, and reporting structures … permit the validation of accurately and precisely obtained image-derived metrics with anatomically and physiologically relevant parameters, including treatment response and outcome, and the use of such metrics in research and patient care."*

RSNA QIBA

"*https://www.rsna.org/QIBA_.aspx*"

Imaging Research Applications

- Acquisition technology
- Image processing and analysis
- Biomarkers
- Drugs, biologics & in vivo devices

- Animal trials
- Clinical (human) trials

Clinical versus Research

- DICOM is everywhere in clinical imaging
  - undeniable, unavoidable
  - medical IS folks get over it
- Not the same acceptance in research
  - whiners say DICOM is
    - too big, complicated, expensive, limited, slow, …
    - not XML, WS, SOA, SOAP, RESTful, …
- Missing an opportunity
  - to leverage huge base of codified expertise & tools
- DICOM still unavoidable for a lot of research

Clinical versus Research

- Research and clinical trials are “niche markets”
- Almost completely ignored by major medical device vendors
- Re-using (clinical) commercial off-the-shelf systems (COTS) may require creative workarounds
- Specialist 3rd party vendors often not especially DICOM aware or literate
- Research “platforms” often have rudimentary DICOM support (e.g., MATLAB, VTK, ITK, ImageJ)

Translation from Research to Clinical Application

- Quantitative imaging in radiology is migrating from research-only applications into clinical use
  - tumor size
  - FDG PET & amyloid PET
  - hippocampal volume
  - stroke perfusion CT & MR
  - …
- Has long been true in cardiology
- Translational … “bench to bedside”
- Different emphasis in narrative reports … more numbers

Commonalities

- Involves use of images
- Acquire images
  - human or animal
  - in vivo or ex
- Process and analyze images
- Store intermediate work
- Store and distribute results
- Search (query) and retrieval
- Repetitive non-trivial workflow

Differences

- Specialized acquisition technology
- Multi-subject acquisition (TMA)
- De-identified subjects
- Specialized processing & analysis
- Quantitative emphasis
- Complex form of intermediate data
- Different search (query) criteria
- Different (if any) regulatory burden
- Different workflow

What is needed from DICOM?

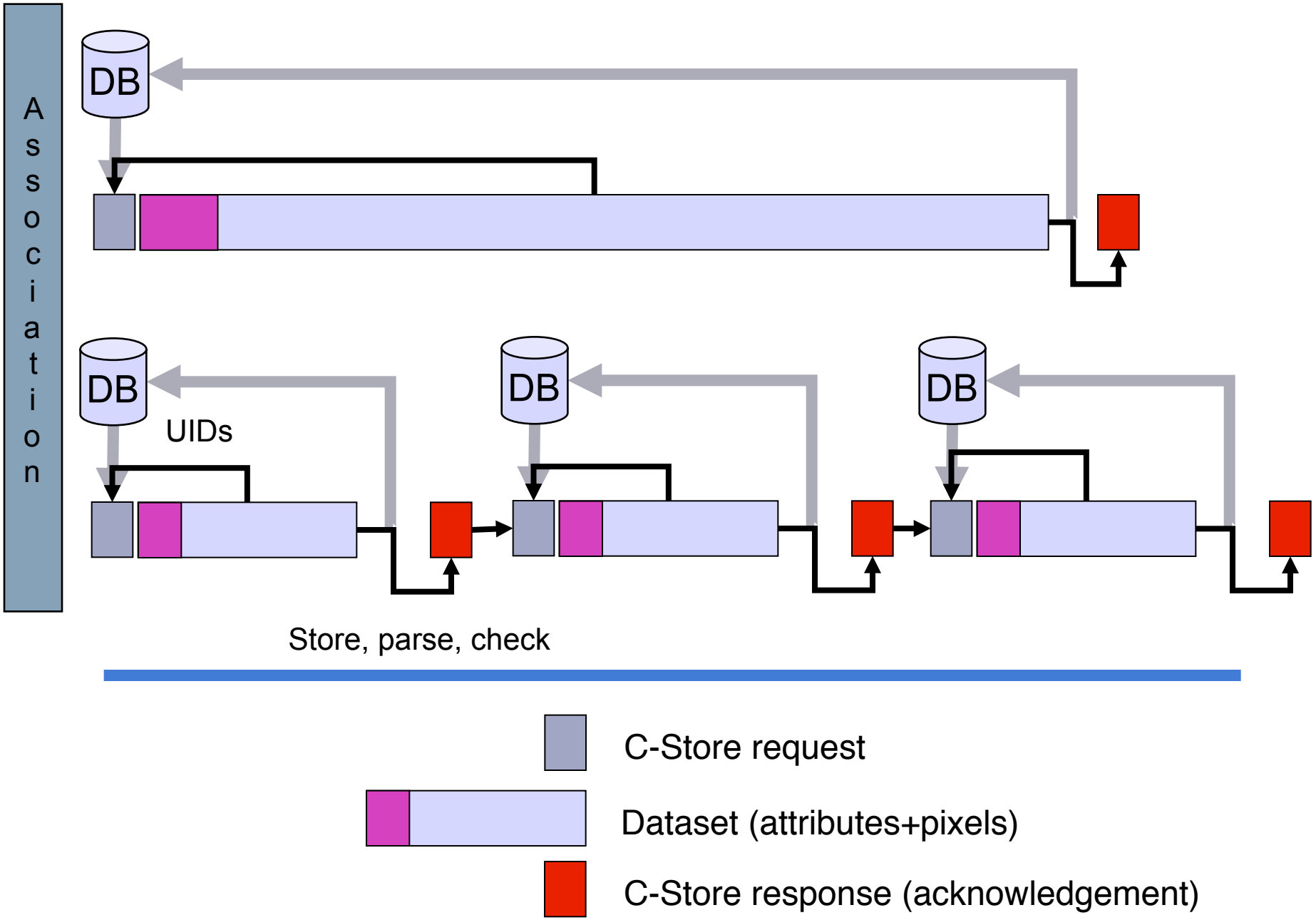
- Images in
  - classic (single frame cross-sectional)
  - enhanced (multi-frame)
- Images out
  - “pretty pictures” - not machine processable
  - quantifiable – labels, real world values
- Structured data out
  - measurements, segments, iso-contours, etc.

Acquisition Technology

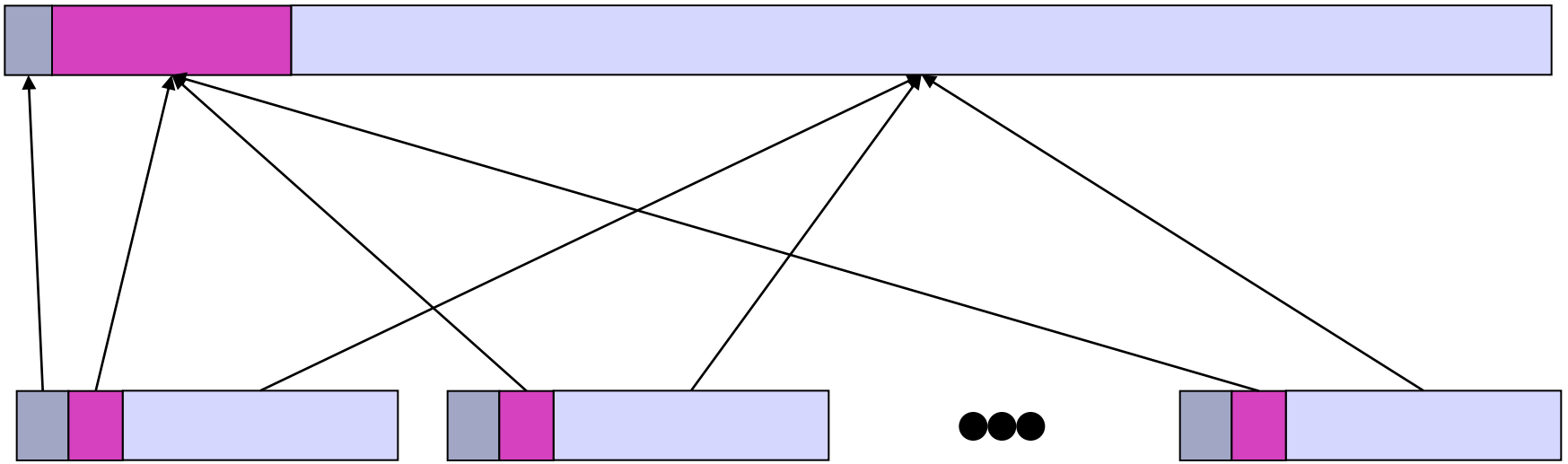
- Does DICOM have adequate coverage ?
  - to encode bulk (pixel) data
  - to manage data (demographics, etc.)
  - to describe acquisition
- Broad range of modalities
  - well beyond traditional radiology
- Improved secondary capture
  - multi-frame, vectors to describe dimensions
- Extensible with private attributes

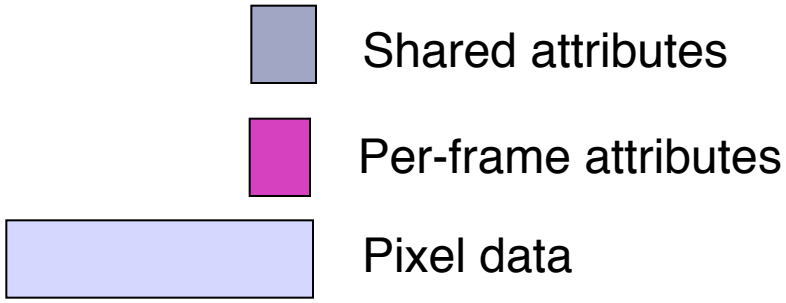
Acquisition Technology

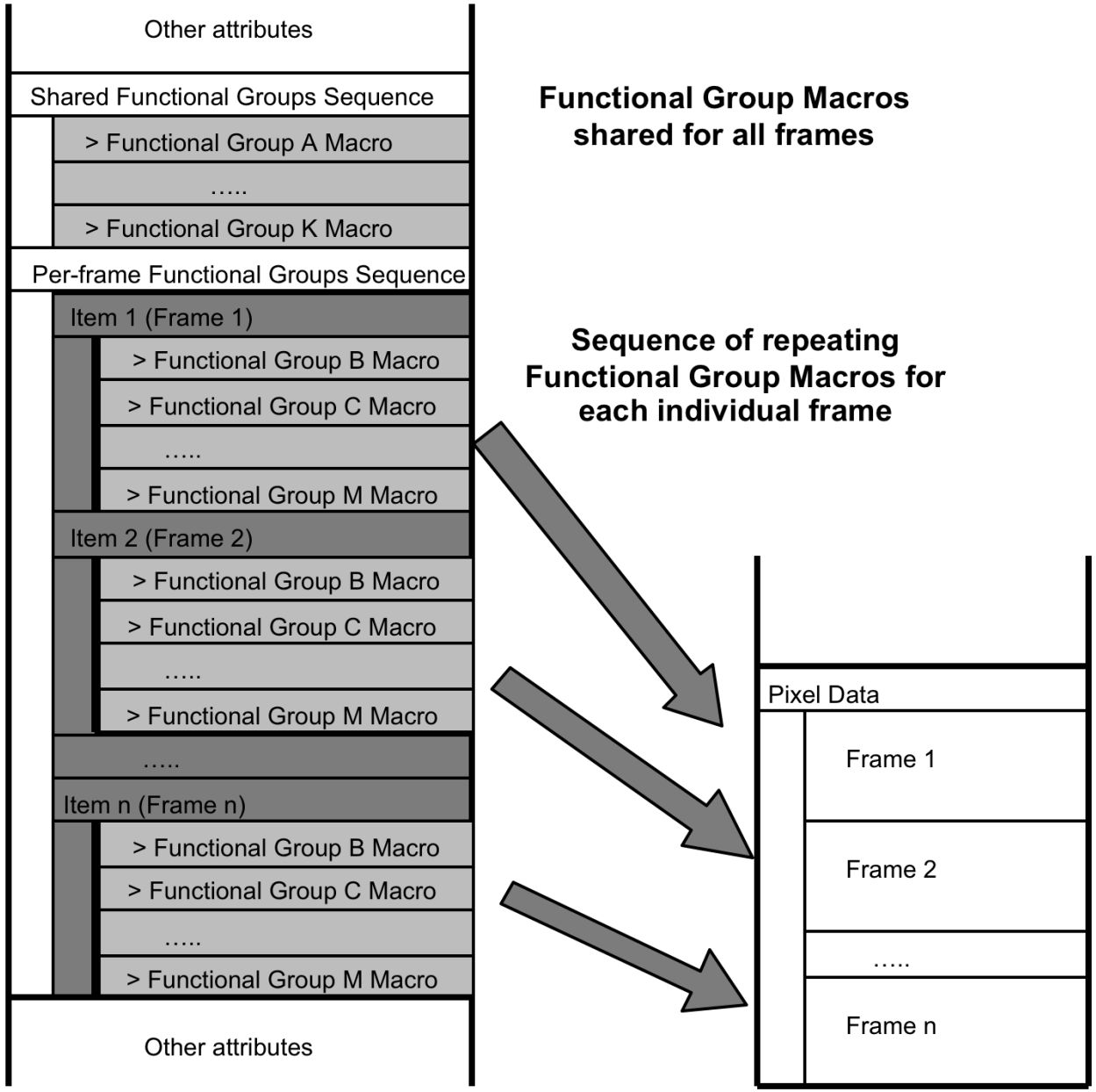
- Almost anything that is (or is like) an image
  - can be encoded in DICOM
  - should be encoded in DICOM
  - will be encoded in DICOM if from COTS device
- Use newer objects when possible
  - enhanced multi-frame family
  - more efficient access in single object
  - more robust descriptions (technique, timing)
  - extensible private functional groups

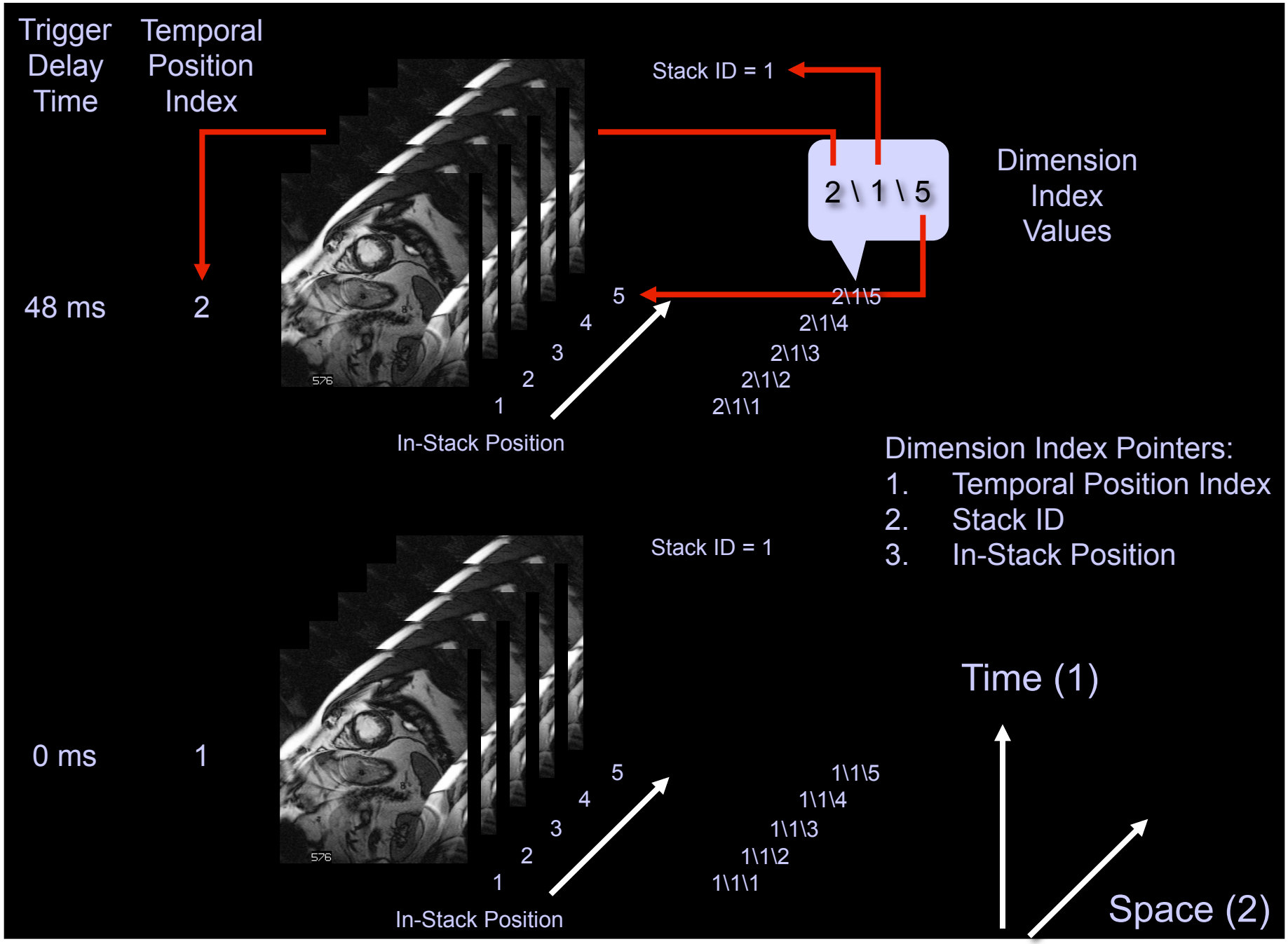

Association
DB
DB
UIDs
DB
DB
Store, parse, check
C-Store request
Dataset (attributes+pixels)
C-Store response (acknowledgement)

Multi-frame Functional Groups






Other attributes
Shared Functional Groups Sequence
> Functional Group A Macro
.....
> Functional Group K Macro
Per-frame Functional Groups Sequence
Item 1 (Frame 1)
> Functional Group B Macro
> Functional Group C Macro
.....
> Functional Group M Macro
Item 2 (Frame 2)
> Functional Group B Macro
> Functional Group C Macro
.....
> Functional Group M Macro
.....
Item n (Frame n)
> Functional Group B Macro
> Functional Group C Macro
.....
> Functional Group M Macro
Other attributes
Functional Group Macros shared for all frames
Sequence of repeating Functional Group Macros for each individual frame
Pixel Data
Frame 1
Frame 2
.....
Frame n


Trigger Delay Time
Temporal Position Index
Stack ID = 1
2 \ 1 \ 5
Dimension Index Values
48 ms
2
5
4
3
2
1
2\1\5
2\1\4
2\1\3
2\1\2
2\1\1
In-Stack Position
Dimension Index Pointers:
1. Temporal Position Index
2. Stack ID
3. In-Stack Position
Stack ID = 1
0 ms
1
1\1\5
1\1\4
1\1\3
1\1\2
1\1\1
In-Stack Position
Time (1)
Space (2)

DICOM Enhanced Objects for Research Acquisitions

- Easier to keep data for a single "experiment" organized
- Slices all together in one object
- Can explicitly describe dimensions
  - generic: space, time, cardiac cycle position
  - specific: standard or private
- True and "legacy converted" (Sup 157)
- Also multi-frame secondary capture
  - e.g., for novel modalities
- *Need for multi-frame support is no longer an excuse to use a research or proprietary format*

DICOM Enhanced Objects for Intermediate Work & Output

- To join processing pipeline components
- One gap is the absence of floating point pixel data representations
  - OF value representation (IEEE 32 bit float)
  - OD (IEEE 64) being added (CP 1261)
  - not yet defined for Pixel Data (7FE0,0010)
  - not yet supported by many toolkits for Pixel Data
  - use scaled integer values if sufficient (rescale) (SUV)
- Can define private IODs & SOP Classes
  - Internal use, document & share, store on PACS …
- Preserve “composite context”

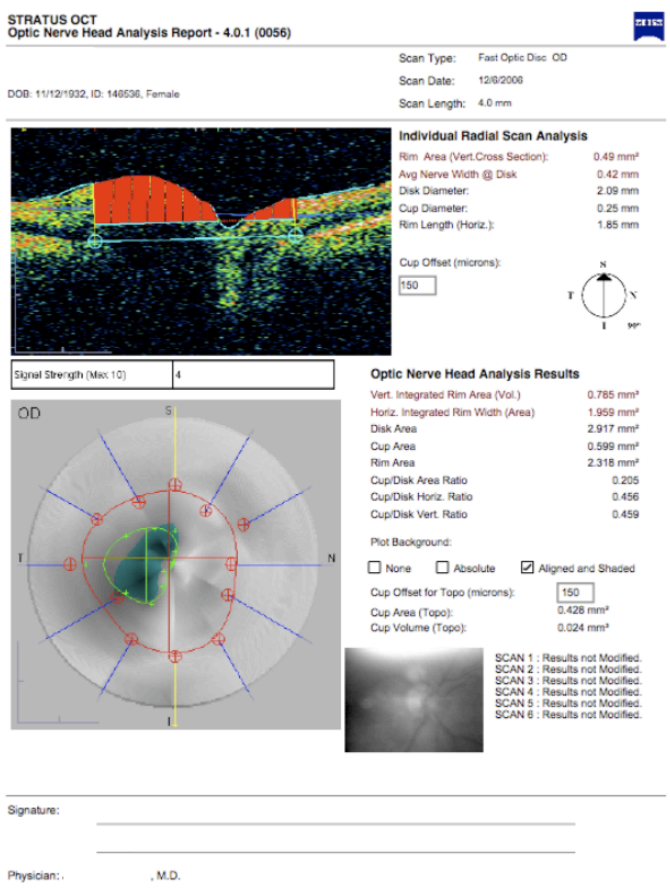
Composite Context

- Attributes of the information entities in the DICOM Composite Model
- Patient, Study, Series, Instance
  - identifiers (e.g., name, ID)
  - descriptors (e.g., height, weight, date)
  - anatomy, protocol, technique, contrast, timing
- Need to preserve whilst passing pixels through pipeline and restore in output
- New Series & Instance values
- Primary value proposition for use of DICOM

DICOM Output
Why ?

- For “Translational Research”
  - “bench to bedside”
  - clinical distribution of research tool output
  - composite context – patient identifiers, etc.
- Clinical systems (PACS)
  - all accept DICOM input (esp., images)
  - most will not accept non-DICOM input
  - almost none aware of research formats
  - DICOM SC or encapsulated PDF are options
  - “pretty pictures” are better than nothing at all

Encapsulated PDF
Pretty Pictures



STRATUS OCT
Optic Nerve Head Analysis Report - 4.0.1 (0056)

Scan Type: Fast Optic Disc OD
Scan Date: 12/6/2006
Scan Length: 4.0 mm

DOB: 11/12/1932, ID: 146536, Female

Individual Radial Scan Analysis

Rim Area (Vert.Cross Section):	0.49 mm²
Avg Nerve Width @ Disk	0.42 mm
Disk Diameter:	2.09 mm
Cup Diameter:	0.25 mm
Rim Length (Horiz.):	1.85 mm

Cup Offset (microns): 150

Signal Strength (Max 10)	4

Optic Nerve Head Analysis Results

Vert. Integrated Rim Area (Vol.)	0.785 mm³
Horiz. Integrated Rim Width (Area)	1.959 mm²
Disk Area	2.917 mm²
Cup Area	0.599 mm²
Rim Area	2.318 mm²
Cup/Disk Area Ratio	0.205
Cup/Disk Horiz. Ratio	0.456
Cup/Disk Vert. Ratio	0.459

Plot Background:

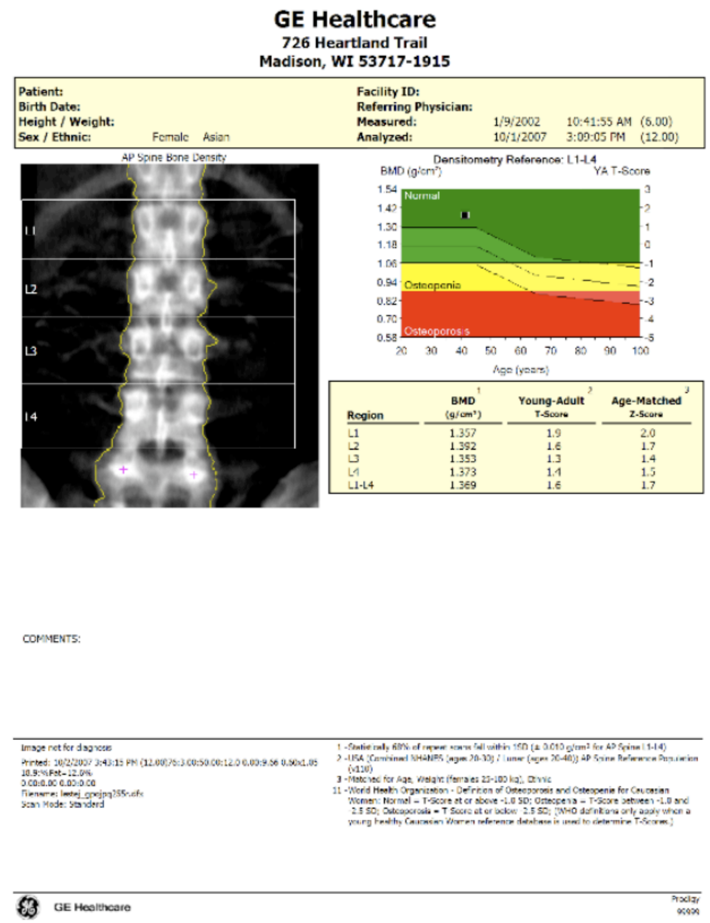
☐ None ☐ Absolute ☑ Aligned and Shaded

Cup Offset for Topo (microns): 150
Cup Area (Topo): 0.428 mm²
Cup Volume (Topo): 0.024 mm³

SCAN 1 : Results not Modified.
SCAN 2 : Results not Modified.
SCAN 3 : Results not Modified.
SCAN 4 : Results not Modified.
SCAN 5 : Results not Modified.
SCAN 6 : Results not Modified.

Signature:

Physician: , M.D.



GE Healthcare
726 Heartland Trail
Madison, WI 53717-1915

Patient:		**Facility ID:**			
Birth Date:		**Referring Physician:**			
Height / Weight:		**Measured:**	1/9/2002	10:41:55 AM	(6.00)
Sex / Ethnic:	Female Asian	**Analyzed:**	10/1/2007	3:09:05 PM	(12.00)

AP Spine Bone Density

Densitometry Reference: L1-L4

Region	BMD [1] (g/cm²)	Young-Adult [2] T-Score	Age-Matched [3] Z-Score
L1	1.357	1.9	2.0
L2	1.392	1.6	1.7
L3	1.353	1.3	1.4
L4	1.373	1.4	1.5
L1-L4	1.369	1.6	1.7

COMMENTS:

Image not for diagnosis
Printed: 10/2/2007 3:43:15 PM
Scan Mode: Standard

3 -Matched for Age, Weight (females 25-100 kg), Ethnic
11 -World Health Organization - Definition of Osteoporosis and Osteopenia for Caucasian Women: Normal = T-Score at or above -1.0 SD; Osteopenia = T-Score between -1.0 and -2.5 SD; Osteoporosis = T-Score at or below -2.5 SD; (WHO definitions only apply when a young healthy Caucasian Women reference database is used to determine T-Scores.)

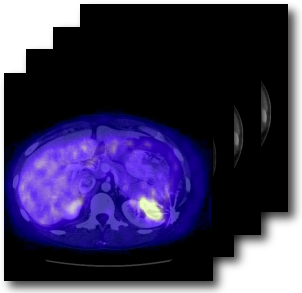
GE Healthcare
Prodigy

Non-Image DICOM Objects for Research

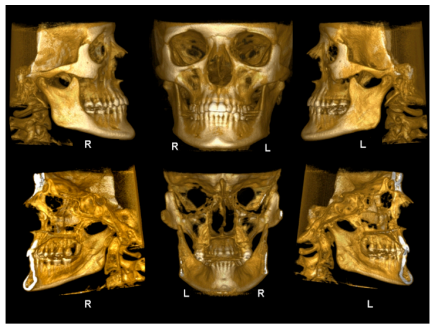
- Segmentation
  - raster – binary, fractional (occupancy, probability)
  - surfaces – mesh
- Registration
  - rigid – affine transform
  - non-rigid – deformation field
- Sorting and grouping
  - key object selection (KOS) document

Result Reporting
DICOM Objects for Research

- Numeric and structured results
  - structured report (SR)
- Image appearance
  - Grayscale and color presentation states



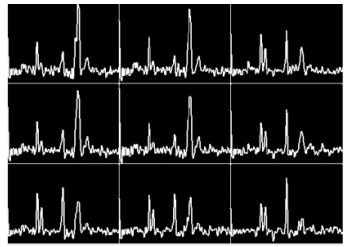
- Multi-modality image fusion
  - Blending presentation state

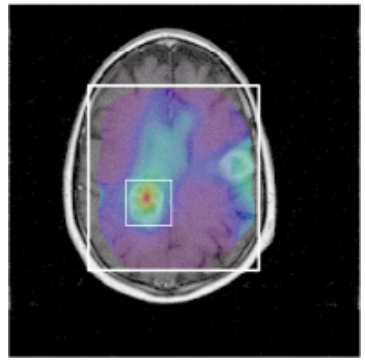


- Display Organization
  - Structured Display – specific images
  - Hanging Protocols – rules for classes of images

Other Bulk Data
DICOM Objects for Research

- Time-based Waveforms
  - ECG
  - Hemodynamic
  - Audio
- MR Spectroscopy
  - Single voxel
  - Multi-voxel
  - Multi-frame
  - Metabolite maps (CSI) as images





Measurements Out

- DICOM encoding of ROIs
  - Private elements (evil & must be stopped)
  - Curves in image (weak semantics, old, retired)
  - Overlays in image (weak semantics)
  - Presentation States (weak semantics, PACS favorite)
  - Structured Reports (best choice, but more work)
  - RT Structure Sets (coordinates only)
  - Segmentations (per-voxel ROIs; use with SR)

DICOM Structured Reports

- Hierarchical structure
  - codes, numbers, coordinates, image references, etc.
- Flexibility is constrained by templates
  - just as XML is constrained by DTD or Schema
- Standard DICOM binary representation
  - easily stored in PACS though visualization remains challenging
  - easily transcoded to XML for processing
- Widely used in existing quantitative modalities
  - echo-cardiography, obstetric ultrasound

DICOM SR – Questions & Answers

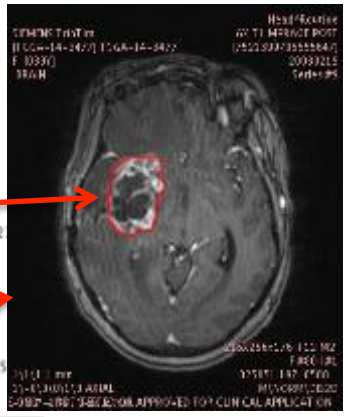
- Basic structure is name-value pair
  - name is the “question” (code)
  - value is the “answer” (text, code, numeric, etc.)
- Different style choices possible, e.g.
  - (M-54000,SRT,“Necrosis”) = (G-A203,SRT,“Present”)
  - (F-00005,SRT,“Finding”) = (M-54000,SRT,“Necrosis”)
- Template of questions & value sets
  - populated by human (pick lists from value sets)
  - encode image processing results (e.g., detection of signal)
  - rule based (e.g., too small to measure)

DICOM SR
Details Inside

DICOM SR
For Visualization or Extraction

- CONTAINS: CONTAINER: Time Point [SEPARATE]
  - HAS OBS CONTEXT: TEXT: Subject Time Point Unique Identifier = 1.3.12.2.1107.5.1564572511.384.1353518214.8
  - HAS OBS CONTEXT: TEXT: Procedure Description = MRI Brain w/+ w/o Contrast
    - HAS PROPERTIES: UIDREF: Study Instance UID = 1.3.6.1.4.1.14519.5.2.1.2783.4001.230122590826962481167637416253
    - HAS PROPERTIES: CODE: Modality = Magnetic Resonance
    - HAS PROPERTIES: DATE: Study Date = 20021207
    - HAS PROPERTIES: TIME: Study Time = 165411
  - CONTAINS: CONTAINER: Lesion [SEPARATE]
    - CONTAINS: UIDREF: Tracking Unique Identifier = 1.3.12.2.1107.5.1564572511.1752.1353368560.7
    - CONTAINS: CODE: Calibration = No
    - CONTAINS: CONTAINER: Measurement Object [SEPARATE]
      - CONTAINS: UIDREF: Measurement Object UID = 1.3.12.2.1107.5.1564572511.2560.1353371564.19
      - CONTAINS: CODE: Measurement Object Type = Volume
      - HAS OBS CONTEXT: DATETIME: Observation Creation DateTime = 20121120003244
      - HAS OBS CONTEXT: DATETIME: Observation Modification DateTime = 20121121175419
      - CONTAINS: CODE: Discarded = No
      - CONTAINS: CONTAINER: Image Region [SEPARATE]
        - CONTAINS: CONTAINER: Image Sub-region [SEPARATE]
          - CONTAINS: CODE: Include Flag = Yes
          - CONTAINS: CODE: Segmentation Method = Random Walker 3D
          - CONTAINS: NUM: Area = 957.772564572239 mm2
          - CONTAINS: NUM: Volume = 27080.9186434825 mm3
            - HAS CONCEPT MOD: CODE: Measurement Method = Integration of sum of closed areas on contiguous slices
          - CONTAINS: NUM: Attenuation Coefficient = 688.37109375 Unspecified
            - HAS CONCEPT MOD: CODE: Derivation = Mean
          - CONTAINS: NUM: Attenuation Coefficient = 204 Unspecified
            - HAS CONCEPT MOD: CODE: Derivation = Minimum
          - CONTAINS: NUM: Attenuation Coefficient = 1520 Unspecified
            - HAS CONCEPT MOD: CODE: Derivation = Maximum
          - CONTAINS: NUM: Attenuation Coefficient = 681 Unspecified
            - HAS CONCEPT MOD: CODE: Derivation = Median
          - CONTAINS: NUM: Attenuation Coefficient = 259.674053 Unspecified
            - HAS CONCEPT MOD: CODE: Derivation = Standard Deviation
          - CONTAINS: NUM: Attenuation Coefficient = 14137088 Unspecified
            - HAS CONCEPT MOD: CODE: Derivation = Total
          - CONTAINS: NUM: Pixel Count = 20537 count
          - CONTAINS: IMAGE: Region Raster = 1.2.840.10008.5.1.4.1.1.66.4 : 1.2.276.0.7230010.3.1.4.1564572511.384.1353521414.78 (PS 1.2.840.10008.5.1.4.1.1.11.1 : 1.2.276.0.7230010.3.1.4.1564572511.384.135352
        - CONTAINS: CODE: Measurement Object Type = Biorthogonal Line Segments
      - CONTAINS: CONTAINER: Simple Measurement [SEPARATE]
        - HAS OBS CONTEXT: CODE: Automation = Automated
        - CONTAINS: NUM: Long Axis = 49.4704627990723 millimeter
          - INFERRED FROM: SCOORD: Source of Measurement = POLYLINE (179.7[illegible]3530273,280.515991210938,205.328002929688,178.1410864257[illegible]
            - SELECTED FROM: IMAGE: = 1.2.840.10008.5.1.4.1.1.4 : 1.3.6.1.4.1.14519.5.2.1.2783.400[illegible] (PS 1.2.840.10008.5.1.4.1.1.11.1 : 1.2.276.0.7230010.3.1.4.1564[illegible]
        - CONTAINS: NUM: Short Axis = 26.6379356384277 millimeter
- CONTAINS: CONTAINER: Time Point [SEPARATE]

Date	Volume	Auto LD	Auto SD
20021207	27080	49	27
..	…	…	…



DICOM SR
Hyperlink from Extract

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      - CONTAINS: CODE: Measurement Object Type = Volume
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      - HAS OBS CONTEXT: DATETIME: Observation Modification DateTime = 20121121175419
      - CONTAINS: CODE: Discarded = No
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              - SELECTED FROM: IMAGE: = 1.2.840.10008.5.1.4.1.1.4 : 1.3.6.1.4.1.14519.5.2.1.2783.4001.305229388644192035439159616449[Frame 1] (PS 1.2.840.10008.5.1.4.1.1.11.1 : 1.2.276.0.7230010.3.1.4.15645
          - CONTAINS: NUM: Short Axis = 26.6379356384277 millimeter
- CONTAINS: CONTAINER: Time Point [SEPARATE]

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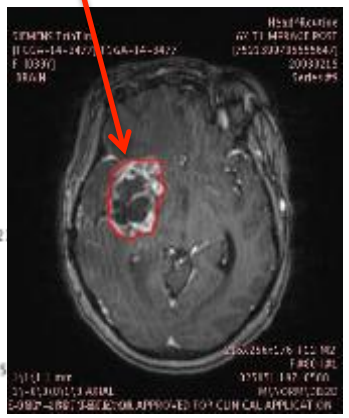
…	…	…	…



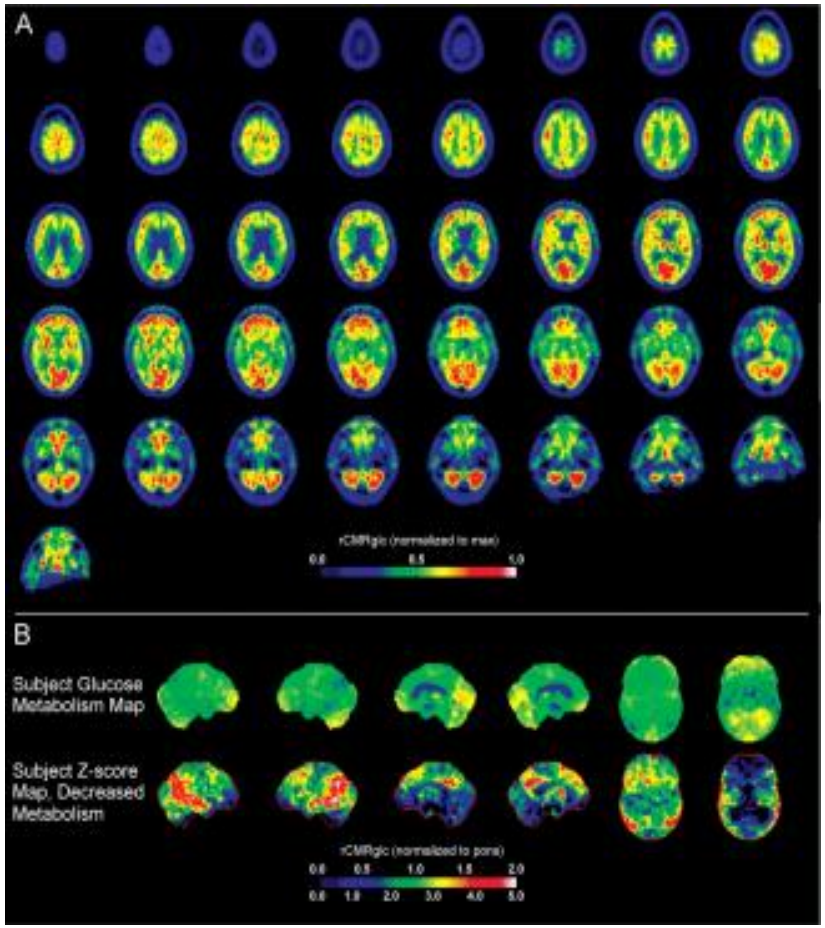
DICOM RT Structure Sets

- Simple structure
  - focus is iso-contour 3D coordinates of regions to treat & spare
  - very limited semantics
  - no standard or extensible measurements beyond simple volume
- Standard DICOM binary representation
  - easily transcoded to other DICOM objects like SR or PS if 3D (patient-relative) to 2D (image-relative) coordinate mapping is available (e.g., via source images or an SR image library)
- Widely used in existing RT & non-RT workstations
  - also understood by many academic software tools

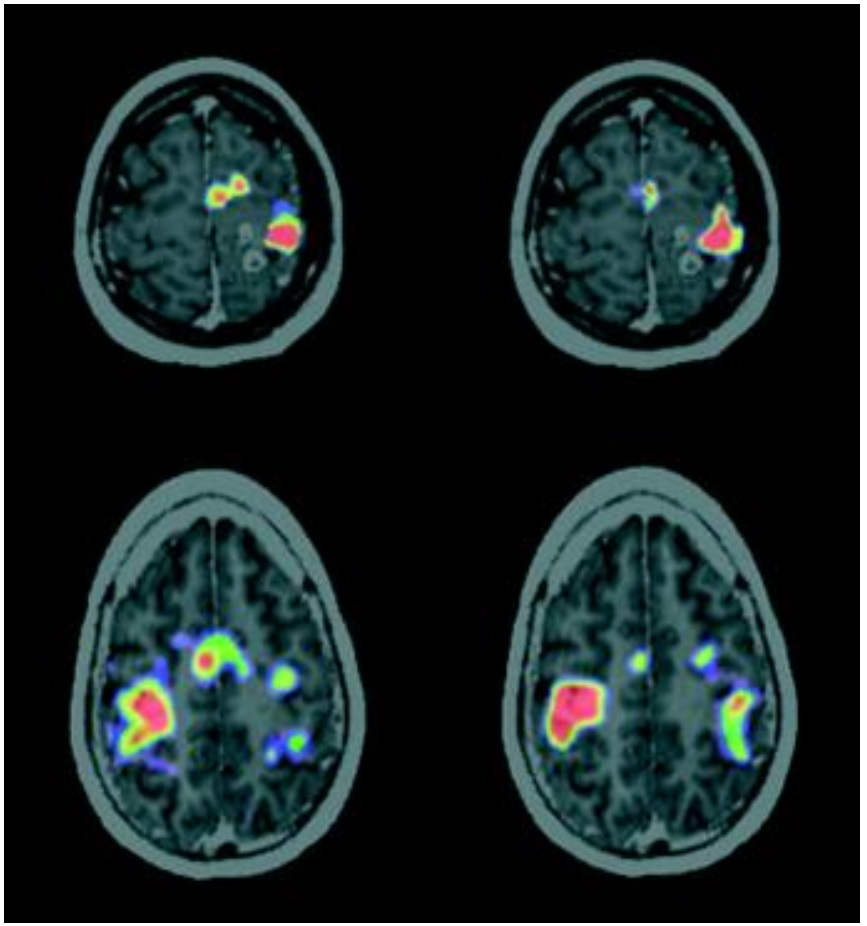
DICOM Presentation States

- Intended to preserve appearance
  - grayscale pipeline (window)
  - spatial transformation (pan/zoom)
  - annotation (text, overlays, vector graphics)
- Lack semantics
  - what does text “mean”?
  - which graphic is it associated with?
- Overall, a poor choice for quantitation
  - may be all that is available in many PACS (to create & view)

Parametric Maps

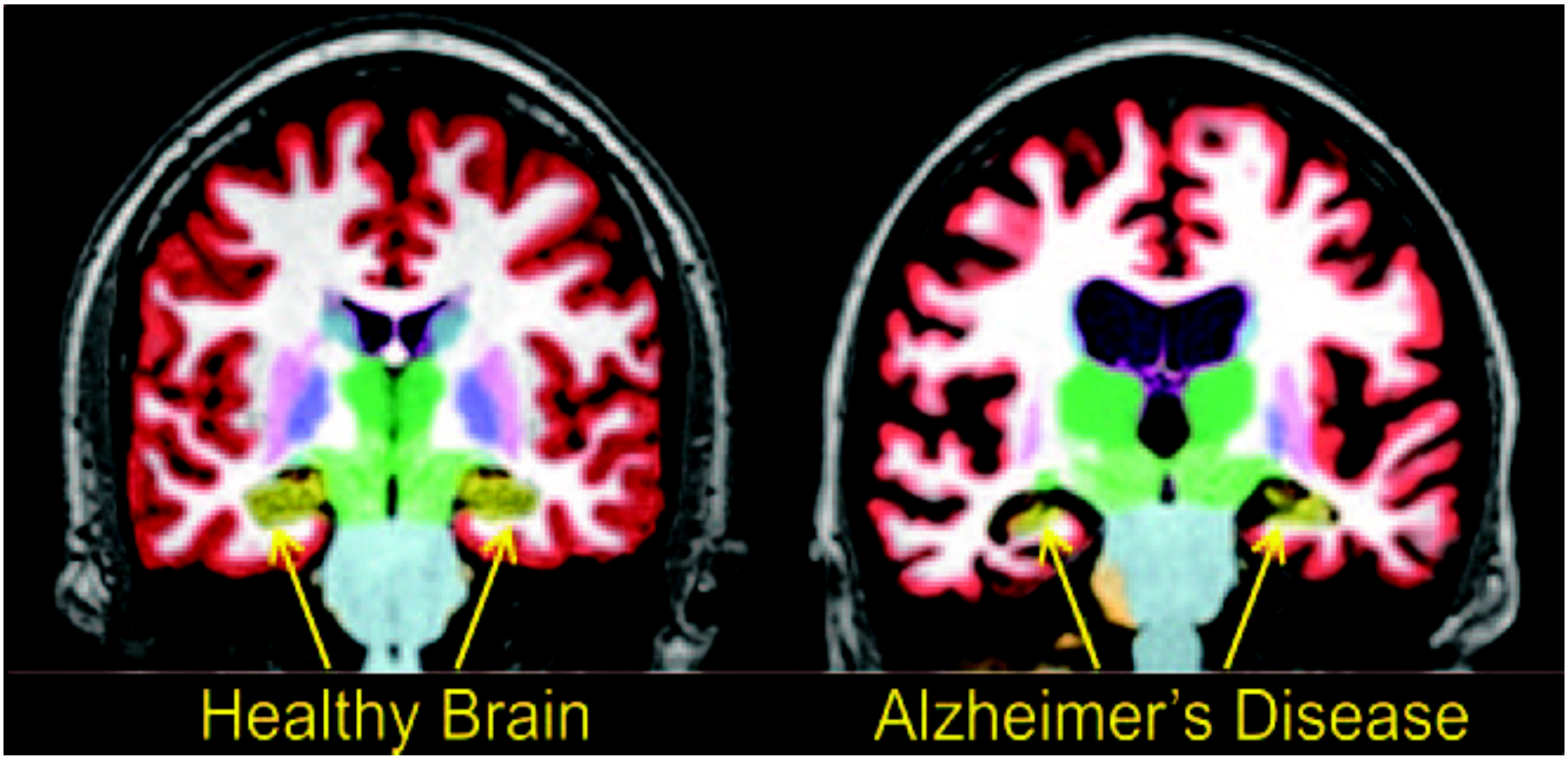


Foster N L et al. Brain 2007;130:2616-2635



Meyer P T et al. J Neurol Neurosurg Psychiatry 2003;74:471-478

Label Maps



Brewer J et al. AJNR 2009; 30:578-580

DICOM Parametric Maps & Label Maps

- Per-voxel encoding of numeric or label values
- Ordinary images
  - modality-specific or secondary capture; single or multi-frame
  - pixel values “processable”, not just “pretty pictures” (not color)
- Segmentations (label maps)
  - binary, probability, fractional occupancy
  - multiple segments (multiple labels)
- Images currently limited to integer values
  - can provide (linear) rescaling to floats (usable by any viewer)
  - future extension to floating point voxels (or private SOP Class)
- Leave “fusion” (superimposition) to application
  - Blending Presentation State to specify what to fuse

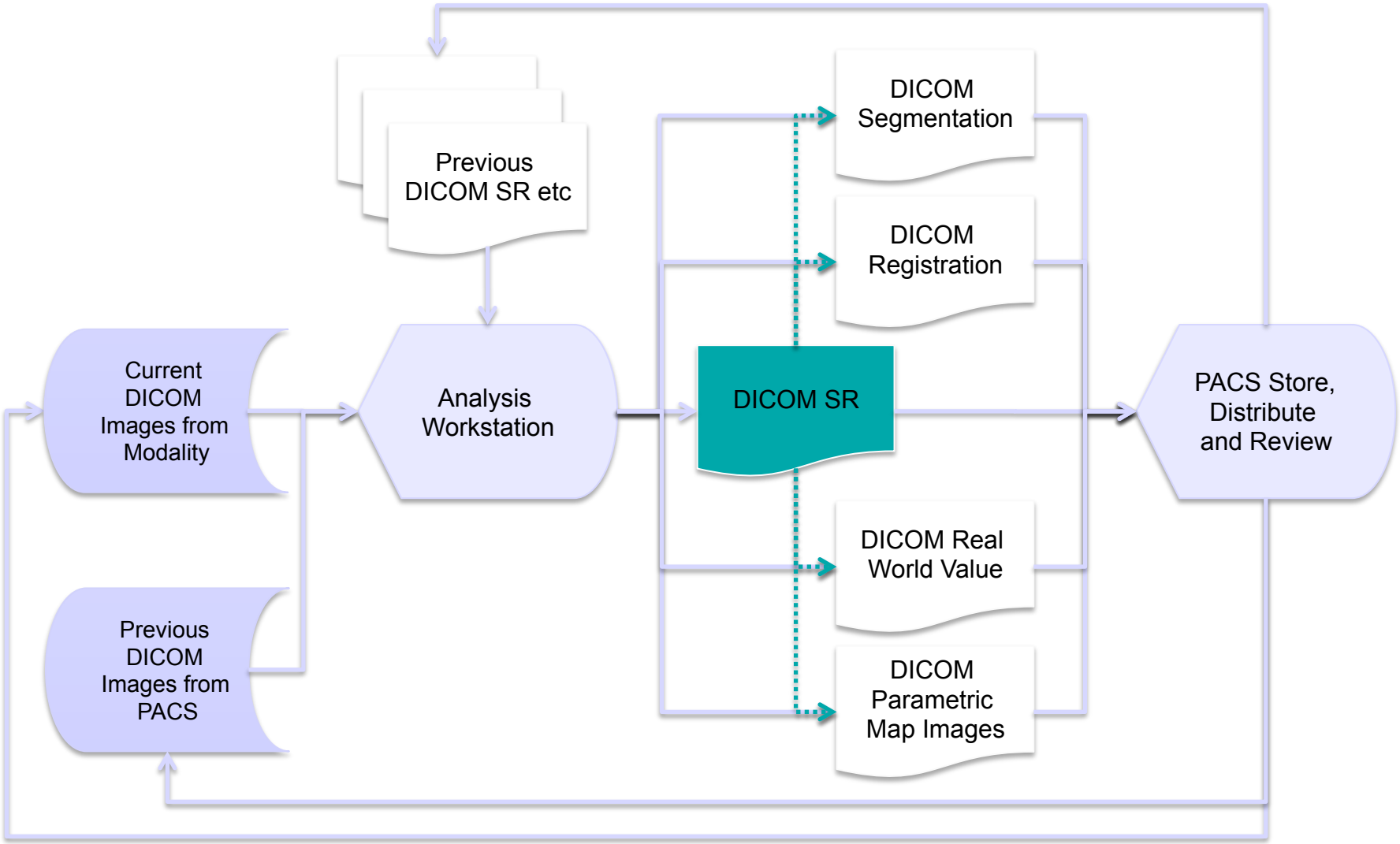
DICOM Registration & Fiducials

- Mapping between 3D coordinates
  - DICOM Registration – rigid matrix
  - DICOM Deformable Registration
- Location of specific points
  - DICOM Fiducial
- Used to save manual or automated results
  - save application state for further work later
  - re-use for other purposes (e.g., sync'd scrolling)

DICOM
Real World Value Maps

- Separate pipelines based on pixels
  - what to show on the display
  - what the pixel (voxel) “means”
- e.g., MR pixel values
  - signal intensity windowed for display
  - mapped to physical unit (e.g. velocity for phase contrast)
- DICOM implementation
  - within image or separate object (e.g., derived later)
  - linear equation or LUT, applied to all or sub-set of range
  - point operation (all voxels) (unlike US Region Calibration)

Putting it all together …



What about Codes?

- DICOM uses external lexicons
  - SNOMED
  - LOINC
  - RADLEX
  - defines DCM codes & definitions only if no good home
- EHR push towards more reliable codes
  - e.g., in USA, strong emphasis on codes in Meaningful Use
  - RIS, modalities and PACS implementations could do better
  - institutions really need to standardize internal procedure codes

Codes for Quantitative Imaging

- Codes needed for
  - entities, e.g., lesions, tumors, tissue types
  - location, e.g., anatomic site
  - characteristics, e.g., edges, enhancement
  - measurements, e.g., volume, sum of areas, mean
  - units, e.g., HU, mm
- Availability
  - many already - SNOMED, LOINC, RADLEX, DCM, NCI, UCUM
  - more being defined every day
  - can use private codes in the interim & re-map later

Reality Check

- The DICOM standards exist - are they implemented?
  - widely, where use is critical & reimbursable (e.g. SR in echo and OB US, RTSS in radiotherapy planning & QC)
  - increasingly so elsewhere, as quantitation grows in popularity (e.g., oncology, esp. PET)
- Need better and more widespread toolkit support
  - many toolkits do include basic multi-frame, SR and XML
  - many need more convenient APIs for abstractions
- Need greater 3rd party viewer & workstation support
  - many still use “proprietary” annotation formats, e.g., Osirix

DICOM as a Standard

- DICOM is a standard
  - long history of modality & PACS vendor support
  - global investment & stake holders
  - open – free to get it and free to implement it
  - many reference implementations/toolkits
  - commonality across many modalities/applications
  - grows to support evolving technology
  - patient and workflow centric

Anti-Standards Vendors

- Many systems do not go beyond images
  - mistaken perception that DICOM is only for images
  - hampered by lack of platform toolkit support
  - vendors do not see value in “sharing” (or saving) results
  - users satisfied with secondary capture “pretty pictures”
  - believe it is sufficient to save/restore “state” locally
  - or hidden inside private data elements or SOP Class
  - inertia after initial implementation – changing to standard

  - so, “Yet Another Proprietary File Format” (YAPFF)

Anti-Standards Academics

- Many academics don't like DICOM
  - DICOM is "old-fashioned" (e.g., not XML based)
  - not funded to be at the DICOM development table
  - easier to make up your own format than to learn
  - research funding leadership - "Not Invented Here" (NIH)
  - legitimate legacy of working code predating DICOM
  - effort required to retain composite context through pipeline
  - lack of follow through after publication/thesis

  - so, "Yet Another Academic File Format" (YAAFF)

Anti-Standards Barrier to Clinical Practice

- “Benchmark to Bedside”
  - for “quantitative imaging” to reach clinical practice, tools, formats and standards must be commercially viable
- No place for YA[PA]FFs & generic formats
  - no patient & workflow metadata (“context”)
  - no support in PACS
  - little or no support in viewers & workstations
  - can claim is a “standard” but doesn’t make it so

Research Workflow

- Needs
  - small projects often unmanaged, ad hoc workflow
  - reliability of repetitive tasks rapidly reduces as scale increases
  - multi-center phase III clinical trials demand rigorous workflow control
- Reliable and consistent
  - identifiers and status
  - sequence of operations

Research Workflow

- Solutions in DICOM
  - Worklists & Performed Procedure Step
  - Modality, Unified (General Purpose retired)
- Solutions in IHE
  - Scheduled Workflow (SWF)
  - Teaching file and Clinical trial Export (TCE)
  - Import Reconciliation Workflow (IRWF)
  - Post-Processing Workflow (PPWF) (revised to use UPS)
- Equally applicable to
  - novel device acquisitions
  - transfer from sites to central labs

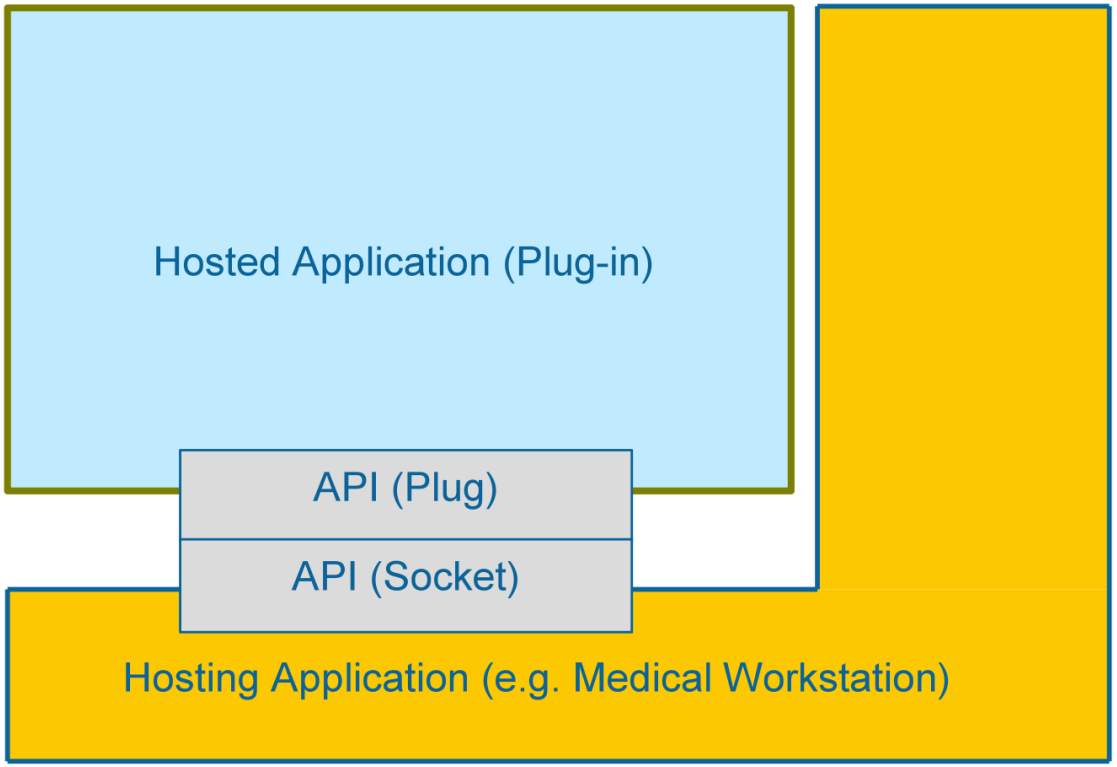
De-identification

- Images acquired with clinical meta-data
  - need to be interpreted and shared in PACS for safety
- Privacy is important
- Individual researchers are not lawyers
- IRBs/ECs are not always consistent/well-informed
- Use-cases vary
  - need body weight for PET, perhaps not for other stuff
  - need dates for longitudinal studies
- Researchers unfamiliar with DICOM tags
- DICOM profile for de-identification (Sup 142)
  - options for what to do with which attributes when

Research and Application Hosting

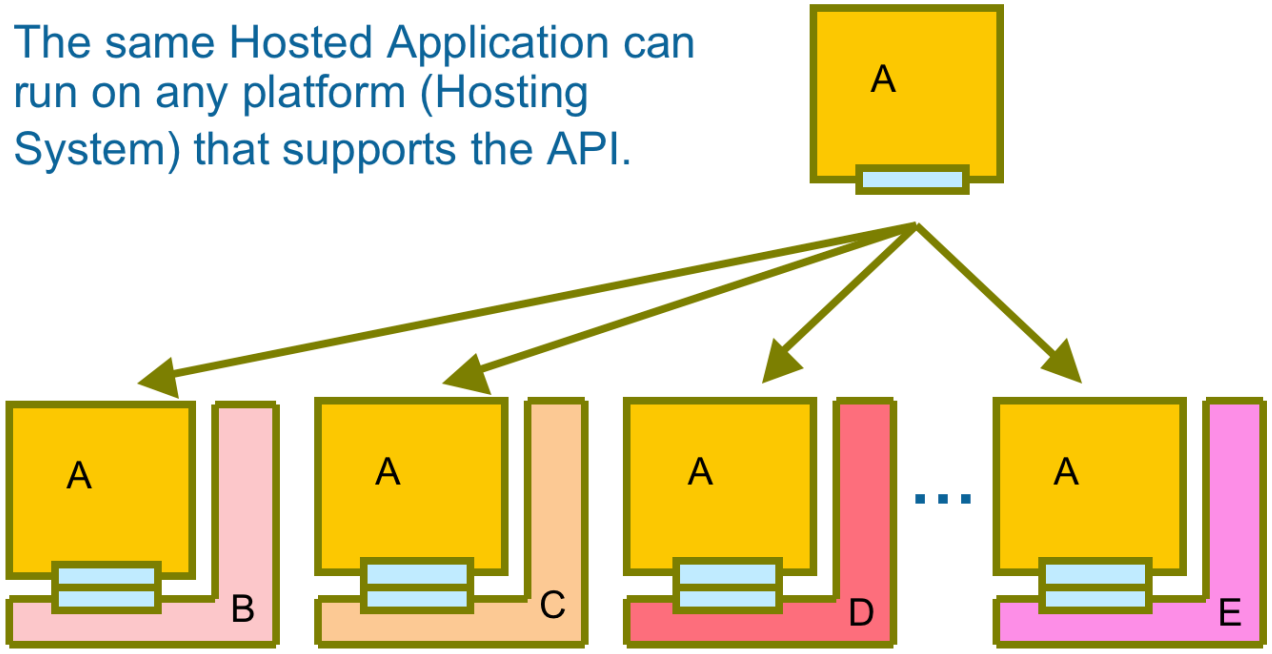
- WG 23 interface defined in PS 3.19 (Sup 118)
- Goal is reuse of existing infrastructure
  - engineers build the hosts
  - scientists write the application that is hosted
  - more rapid translation for clinical use and sale
- Hosts take care of
  - workflow
  - data selection, retrieval and persistence
- Hosted applications
  - do the processing +/- user interaction

Hosted Applications



Hosted Applications

The same Hosted Application can run on any platform (Hosting System) that supports the API.



Hosted Applications

- Platform neutral hosting
  - Web Services end points on local host
- Bulk (pixel) data transfer
  - via URI's which may be local files
  - memory-mapped files for efficiency
- Meta-data interfaces
  - binary – entire original file
  - native – XPath query of DICOM attributes
  - abstract – N dimensional model

DICOM, Web Services and Research

- DICOM is twenty years old
- Wide area distribution services have improved
- Leverage mobile devices
- WADO (http access to DICOM or JPEG version)
- Buzzword compliance requires XML, WS-*, SOA
- Genuine reasons to share SOAP & REST-based persistence, transport, caching and security infrastructure
- Strong relationship to IHE XD* (XDS-I, XDR-I)
- SOAP & REST transport of ordinary DICOM files
- More complex queries over web services (QIDO)
- Working Group 27

Conclusion

- DICOM is about more than just images
- DICOM is good for output too
- DICOM can do better than “pretty pictures”
- DICOM is good for research too
- DICOM facilitates translation to clinical use
- DICOM is here to help
- DICOM can accommodate specific needs
- DICOM has a clinical trials and research WG
- DICOM will assimilate you