Tools for DICOM Implementation

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Outline

• Tools for DICOM implementation

• Toolkits and sample/reference code

• Validators, test tools and sample data

• IHE as implementation guide and testing venue
Categories of tools

• **Purpose**
  – viewers
  – servers (PACS)
  – toolkits for implementers
  – reference for implementers
  – testing and validation tools

• **Availability and support**
  – freeware
  – open source
  – commercial
Viewers

- **Simple and primitive**
  - load single image & display

- **Media (CD) viewers**
  - view entire patients
  - various modalities (CT, MR, etc.)
  - from CD or local hard drive
  - +/- advanced visualization (3D, etc.)

- **Network capable**
  - DICOM store/query/retrieve
Servers

• **Applications**
  – testing
  – research PACS
  – clinical PACS

• **Capabilities**
  – store/query/retrieve
  – management functions (exceptions/edit/reconcile)
  – workflow enabled (HL7 RIS interface)
  – web server (WADO)
  – security (authentication/access control/audit trail)
Toolkits

• **Functionality**
  – read/write DICOM “files” and messages
  – access to lists of DICOM attributes
  – hide details of encoding from programmer
  – convenient access to bulk (pixel) data
  – memory management for large images
  – compressed image support
  – simplify creating/writing “correct” objects
  – implement network services
  – read/write DICOM media (DICOMDIR)
Toolkits

• Abstraction Level
  – network
    • send/receive sets of files
    • open associations, send individual commands
  – data
    • lists of attributes (data elements)
    • create/extract entire objects, modules, macros
    • create/extract structure (e.g., trees for sequences)
    • create/extract abstract models (e.g., in 3D space)
    • support for enhanced multi-frame descriptors
Toolkits

- **Choice**
  - free, open source, commercial
  - level of support – help desk, public forum
  - platform – single (windows) or cross-platform
  - language/framework – C, C++, Java, .NET
  - robustness – exceptions, logging
  - performance – input/output/network
  - comprehensiveness of support for DICOM standard
  - still under active development
  - support the evolving DICOM standard
Reference implementations

• Value
  – source code educates implementers
  – resolves ambiguities in standard
  – indicates of what parts of DICOM standard are used
  – may be well documented and/or designed
  – may have well-defined API
  – often multi-platform
  – if open source, reusable in products
  – faster time to market with lower risk
  – test target in the absence of other products
Standard API

• **Application Hosting**
  – DICOM PS 3.19 WG 23 Sup 118
  – web service between “Host” & “Application”
  – WS end-points on same machine
  – language neutral (C++, C#, Java, etc.)
  – file, native XML model, abstract XML model
  – bi-directional and symmetric
  – future common API for toolkits?
• **Types of tests**
  – development – unit/system/integration
  – deployment – user acceptance/cross-vendor
  – service & support – diagnostic tools

• **Types of tools**
  – testing utilities & frameworks
  – debugging tools
  – test objects
  – test servers
  – object and message validators
• **Interface to utilities**
  – command line or graphical user interface
  – usable from scripts and batch files

• **Typical functions**
  – dump DICOM file contents in readable form
  – extract attributes from files
  – create test files from script or template
  – edit attributes (add/remove/change values)
  – send/receive on network
Debugging tools

• **Usage**
  – site support staff
  – field service and support staff
  – during inter-vendor testing

• **Types of tools**
  – simulate device behavior
  – capture messages between devices
  – analyze captured messages
Test Objects

• **Image and other composite objects**
  – synthetic – generated *de novo*
  – real – from modalities (de-identified)
  – combination – modified real images

• **Test messages**
  – to use to test DICOM network services
  – e.g., test queries and responses
  – scripts & templates to use with toolkits

• **Test Media**
  – physical media or ISO image files
Test Servers

• Public
  – receive/query/retrieve
  – avoiding configuration issues
    • C-GET
    • C-MOVE assume same port as retrieve command
  – www.dicomserver.co.uk

• Local
  – within company or hospital or lab
  – tunnel in firewall to DICOM port
Validators

• **Validate for compliance with DICOM**
  – images and other composite objects in files
  – from media or received/captured from network
  – captured network messages (queries, etc.)

• **What to validate**
  – compliance with IOD (defined by SOP Class)
  – compliance with template (Structured Reports)
  – correct encoding of attributes
  – compliance with “profiles” (media, IHE)
  – warn of “undesirable” characteristics
% dciodvfy op.dcm

Ophthalmic Photography 16 Bit Image

Error - Value invalid for this VR
- (0x0010,0x0030) DA Patient's Birth Date  DA [0] = <9999/99/99>
- Character invalid for this VR = '9' (0x39)

Warning - Value is zero for attribute <Emmetropic Magnification>

Error - Attribute present when condition unsatisfied
(which may not be present otherwise)
Type 2C Conditional Element=<Mydriatic Agent Code Sequence>
Module=<Ophthalmic Acquisition Parameters Macro>
Validators - example

% dciodvfy cr.dcm

CR Image

Error - Missing attribute Type 2 Required Element=<Study ID> Module=<General Study>

Error - Lookup Table Data bad - VOI LUT - LUT Descriptor number of bits = 16 but maximum LUT Data value is 0xfd3

Warning - Retired attribute - (0x0032,0x1030) LO Reason for Study

Warning - Unrecognized defined term <LOG_E REL> for attribute <Rescale Type>

Warning - Attribute is not present in standard DICOM IOD - (0x0032,0x1032) PN Requesting Physician
What standard to test against

• **What needs to be tested**
  – does it “work”?
  – is it “correct”?

• **Compliance with DICOM standard**
  – does NOT mean that it will “work”
  – may not be necessary for it to “work”

• **For example**
  – device may “interoperate” by ignoring non-compliance
  – a compliant device may fail by ignoring a “feature”
Failure to apply Display Shutter to inverted DICOM image
- Modality vendor is compliant – sends Display Shutter
- PACS vendor is “compliant” – allowed to ignore Display Shutter
- PACS vendor promises this “feature” in new version only – requires complete PACS server hardware replacement !@#$
Customer “unsatisfied”
What to test

• **Standalone**
  – devices produce compliant objects
  – devices use compliant objects correctly
  – implement the features user requires
  – gracefully handle “bad” but usable objects

• **As pairs of devices**
  – that they successfully communicate
  – that they “work” to the user’s satisfaction

• **As sequence of multiple devices**
  – e.g., workflow from order/acquire/store/check/display
IHE and testing

• Original RSNA DICOM testing initiative
  – central test node(s), test tools and plans

• IHE developed “integration profiles”

• IHE “connectathons”
  – standalone testing with tools
  – test scenarios between “actors”
  – tests against reference implementations
  – tests between actual implementations
  – check logs to be sure “work” for right reasons

• Free and open source
Finding tools

• **Google**
  – “dicom toolkit”

• **Some useful web sites with links**
  – [http://www.dclunie.com](http://www.dclunie.com)
  – [http://www.idoimaging.com](http://www.idoimaging.com)

• **Forum for dicom discussion**
  – news:comp.protocols.dicom
Finding test images

• Not quite as easy as finding tools

• Google
  – “dicom samples”, “dicom images”

• Some useful web sites with links
  – http://www.dclunie.com
  – http://barre.nom.fr/medical/samples/

• There is no “official” test library
  – ftp://medicat.nema.org/MEDICAL/Dicom/DataSets
  – Is a non-public NEMA members-only test library? status
Conclusions

• Plethora of implementations and tools
  – many are free and open source
  – many are well supported
  – so, do not fear DICOM’s “complexity”

• Testing is important
  – failure to test is inexcusable
  – good testing leads to happy customers

• IHE can help
  – use the profiles, use the tools, participate