

DICOM

Digital Imaging and COMunications in Medicine

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A bit of history...

- The digital imaging and communications treatment (DICOM) was established in 1992.
- Is the standard for image exchange in digital format.
- Always a bit complicated to understand since it uses its own "idioms"
- Is always under improvement in order to integrate new digital imaging techniques

Fundamentals

- DICOM is based in the ACR-NEMA standard (first published in 1985). ACR (National Electrical Manufacturers Association) and NEMA (American college of radiology) are therefore the creators of DICOM.
- DICOM consists nowadays in 11 different sections that contains information about the protocol and DICOM's formats as well as the conformity specification. Plus this modules that are "less" relevant:
 - Physic Media
 - Gray Scales checking
 - Security Profiles
 - Mapping of content.
 - Final Presentation
- We can then see that DICOMS' history begins in the 80's.

Why was DICOM created?

- The standard makers were used to feel big confidence while giving data interchange and communication support because they pushed the clients to buy equipment of the same company.
- Imagine that you wanted to exchange a picture from a TAC (Tomography computerized equipment) with another user that was using a radiotherapy planification system.
 - Then you might have rewritten all the software code in the planification system so it would be aloud to read the picture.
 - The same would happened if you wanted to update the TAC system with the picture from the planification system.
- DICOM was created to solve these problems of compatibility. ☺

Radiologists can't read:

- Images without request
- Request without images
- Images without old images
- Images not on reading work list or station

Radiologists won't read or read slowly

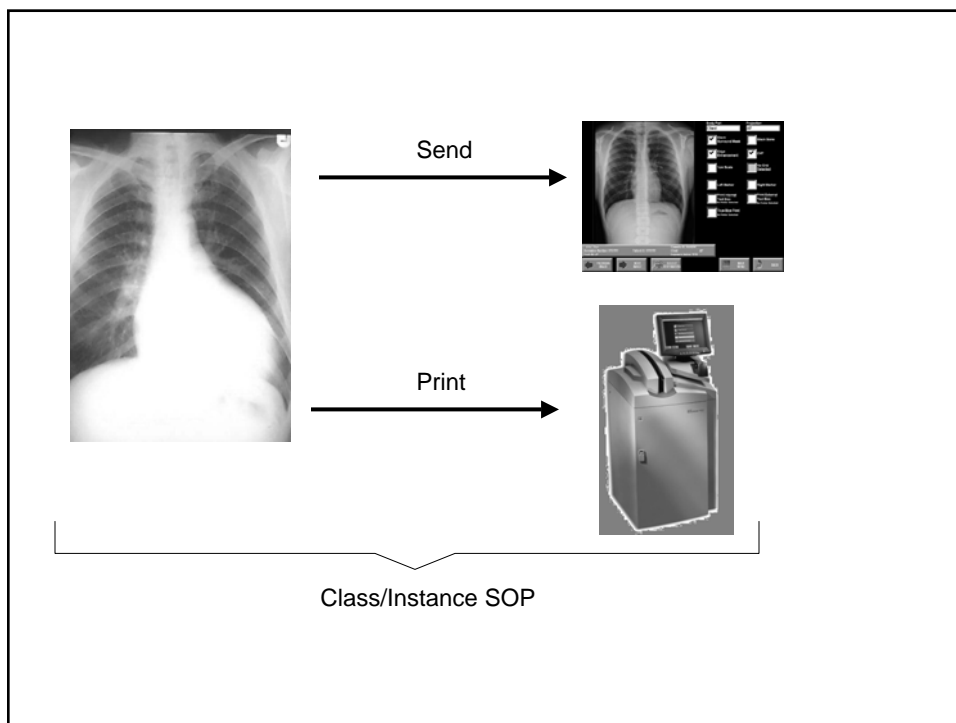
- Images in wrong order or upside down
- Images with wrong contrast.

Why is DICOM so complicated?

- DICOM uses an specific language and concepts which are commonly used in Object Oriented software engineering. Anyway there are many sections in DICOM which are not used often.
- For example ACR-NEMA defines images , while DICOM defines the objects that include this images and it always refers to them for printing, saving, moving or searching.

How DICOM works...

- The objects in DICOM are denominated as “information objects” while the operations and services are “services classes” that are generalized definitions.
- Any use of a class is called “instance” so if we want for example a “CT-Store” of a particular patient...



About the last diagram

- The rectangular boxes represents the entities in a single way. If they are used in combination then they represent information objects. The diamonds are relations. The lines should be quite understandable.
- IOD information Object Definition
- VOI value of interest
- LUT list of consulting
- Mod modality

Informative Objects in DICOM

Composed IODS

- Computerized radiography image.
- Computerized tomography image.
- Magnetic resonance image.
- Nuclear medicine image.
- Ultrasounds image.
- Ultrasounds Multi-Frame 1 images.

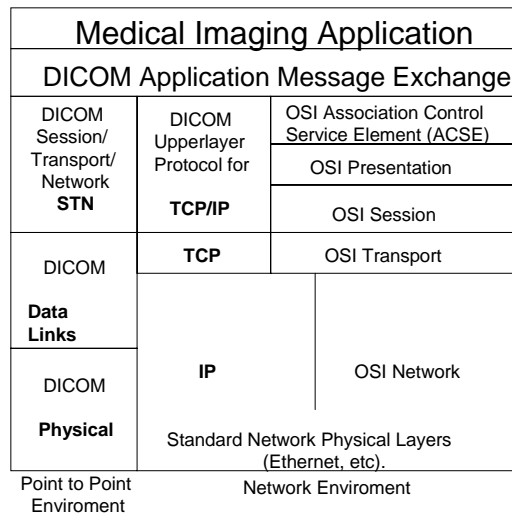
From the real world

Normalized IODS

- Patient information.
- Visit inspection.
- Studio image information.
- Studio component information.
- Information result.
- Image 1 interpretation information .

Standardizing Objects

Communication Protocol in DICOM





DICOM's Parts

- Since the versions 1.0 and 2.0 DICOM was divided in several parts in order for the parts to be expanded. This to avoid to remake the whole standard each time.
- Nowadays, DICOM consists in 11 parts. The parts 10 and 11 shows how DICOM can use removable media (discs) for the information exchange. Some of the parts (1,2,3,5 and 6) are used in both environments.

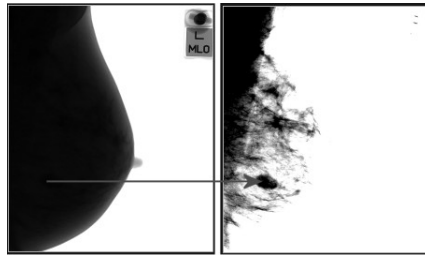
DICOM's Parts

Part 1: Overview		
Part 2: Conformance		
Part 4: Service Class Specifications	Part 3: Information Objects	Part 11: Media Storage Application Profiles
Part 5: Data Structures and Semantics		
Part 6: Data dictionary		
Part 7: Message exchange (Network operations)	Part 10: Media Storage & File Format	
Part 8: Net-Work Support TCP/IP & OSI	Part 9: Point to Point	Part X Part Y Part Z Specific Media formats & Physical Media

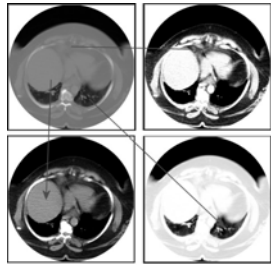
 PARTS OF DICOM V3
 Extensions to DICOM to support media storage

DICOM; Possibilities...

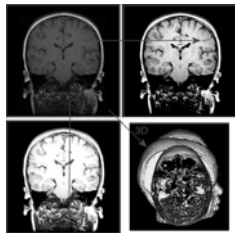
- DICOM is not (only) an image or file format, it is primarily a networking protocol built on TCP and designed to store and transmit medical data.
- DICOM governs truly all areas of digital medicine.
 - Complete encoding of medical data. DICOM files and messages use about 4000 standardized fields ("DICOM dictionary") to convey various medical data - from patient name to image color depth to current patient diagnosis. This data is often essential for correct diagnostics.



Mammography



Excellent image quality. DICOM supports up to 65536 (16 bits) shades of gray for the monochrome image display, still dominating many modalities. With this respect, converting DICOM images into JPEGs or bitmaps (with 256 shades of gray) makes them practically unusable for diagnostic reading. On the other hand, DICOM does include various image-encoding formats, from basic bitmapped data to wavelets.



Full support for image-acquisition parameters. Not only does DICOM store the image pixels, but it also records a multitude of other image-related parameters such as patient 3D position, physical sizes of the objects in the image, slice thickness, image exposure parameters, etc. This data enormously enriches the informational content of DICOM images, and facilitates processing and interpreting the image data in various ways - for instance, creating 3D images from the sequences of 2D CT slices.

PACS

Picture Archiving and Communication Systems

- Are complete medical systems with all hardware and software included, which are installed to run digital medicine workflow.
- They usually include archiving servers (one or many, for online and deep storage) and diagnostic workstations, integrated with digital image acquisition devices.
- Current PACS are DICOM based, which ensures their conformance to the standard and interconnectivity.
- Each PACS vendor releases a "DICOM conformance statement," explaining to what extent his PACS supports DICOM.



Important things to know...

- As we have seen it would take really long time to explain each of the parts of DICOM since they are really huge.
- JPEG 2000 is now the official compression method under DICOM.
 - Wavelet based , up to 16-bit pixel depth.
 - Lossless and lossy.
- DVD is now an official exchange medium under DICOM
 - Can use any DVD flavor (-ROM, +R, +RW, etc.)
 - Reader most support JPEG or JPEG 2000 lossy compression
- New work under way to Endoscopy
 - Visible Light Video (endoscopy, microscopy, photography).
 - MPEG video image encoding in DICOM!.

Schemes supported by DICOM

- JPEG : lossless and lossy.
 - Lossy JPEG for ultrasound
 - Multiframe 512x512x8 , 1024x1024x10
 - CD-R and on network
 - BUT... JPEG lossy limited to 12 bits unsigned!
- JPEG-LS: More efficient, fast lossless.
 - Lossless JPEG for cardiac angio:
 - 640x480 single and multiframe 8 bits gray/RGB, text
 - BUT... JPEG lossless not the most effective!
- Deflate (gzip-zip): For non-image objects.
- JPEG 2000: Progressive.
 - Added to DICOM the 14th. of January 2002.

Why JPEG 2000 (ISO 15444-1)?

- Lossless
 - Integer wavelet (+/- reversible color transformation).
- Either lossless or lossy
 - Integer or floating point wavelet
- Many features!
 - Region-of-interest coding. Fewer bits for background
 - Progressive by contrast.
 - Transform in 3rd. Dimension!.
 - Hyper spectral Imaging!.

Why not MPEG?

- Initially proposed by US cardiac echo.
- Tested and: Only superior to M-JPEG at bigger than 50:1
 - Just to refresh: in M-JPEG the quantization is given with a unique value for the whole frame
 - Worse, most MJPEG algorithms compute this value against the preceding frame's data, which may not give an optimum quantization value for the current frame
- Effect on burned in text at low bit rates.

Deflate Transfer Syntax

- Added The 16th. of May 2001.
- Goal: Compress all attributes.
 - 36,112 byte structured report falls to 3,014 (11.98 : 1).
 - And as we saw mainly used in DICOM text and reports.
- Algorithm used in zip, gzip utilities.
- Patients can take with them in CD or DVD the whole rapport of their status in a built-in viewer.

Conclusion

- DICOM is not only an image file format. Its is primarily a networking protocol built on TCP.
- It's the "boss" of the digital medical applications for data and images in medical activities.
- DICOM has several parts which describes the procedures of the digital object to analyze.
- DICOM uses several types of formats of compression for both images and text.
- PACS (hardware and software) and DICOM are closed related.

Links of interest

- <http://www.dclunie.com/> (maybe the best one! , here you can find almost everything)
- <http://www.juntadeandalucia.es/servicioandaluzdesalud/valme/fisica/PDF/Dicom.pdf> (in Spanish).
- <http://www.dejarnette.com/efinegan/pacspage.htm> (PACS information).