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Digital imaging and communications in medicine: A basic review

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Introduction

The term DICOM stands for digital imaging and communications in medicine.[1] It is a "co-operative standard" that allows compatibility between imaging systems.[2] DICOM services are used in a large number of radiology departments across the world. DICOM is commonly considered a "behind the scene" event, in daily practice.

In radiology, DICOM enables efficient utilization of radiology modalities by adding a large variety of beneficial features. These useful features include network services with storage, query and retrieval, workflow management, storage commitments, worklist and procedure steps, instance availability notification and print & media creation management.[3] Evidently, besides radiology, DICOM is also used in other diverse image related medical fields, such as pathology, endoscopy, dentistry, ophthalmology, dermatology and veterinary medicine.[4]

History and evolution of DICOM standard

In early eighties, the American College of Radiologists (ACR) and National Electrical Manufacturers Association (NEMA) acknowledged an inherent need for a standard that would facilitate connectivity of imaging and associated medical equipments of different vendors. This was driven in part by modalities like CT and film printing and in part by the increased use of computers and related technologies in radiology; a situation that resulted in many modalities and multiple devices manufactured by various vendors, offering several digital image formats.

The first and earliest official Standards Publication titled ACR/NEMA No. 300-1985, referred to as version 1.0 was released in 1985, with an aim to "promote communication of digital image information, regardless of device manufacturer, facilitate development and expansion of picture archiving and communication systems (PACS)".[5]

Thereafter, it was revised several times, until its most radical version, which in 1992-1993 was titled ACR/NEMA Standards Publication PS3 and was popularly referred to as DICOM 3. Over the years, it has been revised, matching and meeting the evolving demands of radiologists, vendors, modalities, computers, networks and internet hardware and software technologies. The Standards Publications "specified a hardware interface, a minimum set of software commands, and a consistent set of data formats".[5] Today as much as ever before, "ACR is responsible for the technical and medical instructions, while NEMA is responsible for the publications and the legal problems, to avoid conflicts of interests or a possible infringement with the antitrust lobbies".[6]

A DICOM standards committee[7] under the aegis of NEMA, "exists to create and maintain international standards for the communication of biomedical, diagnostic and therapeutic information in those medical disciplines that use digital images and associated data".[8] It continuously creates standards as developed by working groups and approved by members of committee.

Need for DICOM standard

Why do we as radiologists need to know DICOM? Or here is a more fundamental question: why does radiology as a modality need DICOM? SC Horii sheds light on this by stating that "the essence of the DICOM standard is that it prescribes a uniform, well-understood set of rules for the communication of digital images" .[9] When analyzed, "electronic communication is functionally divisible into a set of layers with each layer performing a defined set of functions"[10-12] and DICOM precisely follows this dictum.

Getting to the point**,** DICOM is needed since it offers a range of beneficial features that includes the following:

a. It facilitates multi-vendor connectivity.[13]
b. It obtains the images of patient and all epidemiological information associated with it, in an identical format.[6]

Table 1: Role of digital imaging and communications in medicine in radiology practice

Role	Features
Image transfer	Extended to cardiology, radiation therapy, pathology, ophthalmology etc. Non-imaging data have also been included; like ECG waveforms and voice dictation
Print	Seamlessly integrates with devices like laser cameras and paper printers across a network
Storage media	Interchange using CD, DVD for transfer and sharing of images
Modality worklist	Data sharing of patient demographics, requested procedure, and scheduling information from hospital information systems (HIS)
Consistent display of images	Standardization of gray-scale display; gray-scale calibration and manipulations like flip, rotate, or zoom transformations and annotations
Structured reporting	Electronically record measurements and standardized reporting

[Adapted from Reference 18]

c. It obtains non-image data like waveforms, reports, ECG (12-lead, continuous, Holter), hemodynamic (pressure), voice, audio etc. by creation of explicit "information objects".[14]
d. It allows interconnection and interaction ("interoperability") of equipments and transfer of data.[6]
e. It enables integration of scanners, servers, workstations, printers, and network hardware from multiple vendors into a PACS. [15]
f. It therefore promotes the development of PACS and image networking in LAN and WAN.
g. It is applicable to an "off-line media environment by supporting industry standard media like CDR/ MOD/DVD and logical file systems like ISO 9660/ PC File System (FAT16)".[5] This further has led to the development of a large number of DICOM viewers.[16]
h. It is structured as a "multi-part document" that simplifies "addition of new features".[5]
i. It specifies levels of conformance in selecting specific options.[5]

The scope of DICOM standard

Fundamentally DICOM is not a concept solely restricted to radiology and/or images only.[17] Nor is it merely a unidimensional "feature-deficient" format. It deals with issues related to image transfer, print, storage media and modality worklist as detailed in Table 1. DICOM permits storage of images with their associated information. This allows the presentation states to be enriched with features like adjustment of windows, annotation, flip/zoom, or embedded with important information on measurements (SRs) or procedure logs.

DICOM conformance statement

This is essentially a vendor's claim of compliance to the DICOM standard, for a specific type of equipment. Simply put, it identifies specific DICOM capabilities of an equipment. A conformance statement allows "a user to determine which optional components of the DICOM Standard are supported by a particular implementation, and what additional extensions or specializations an implementation adds".[19] "By comparing the conformance statements from two different implementations, a knowledgeable user should be able to determine whether and to what extent communications might be supported between the two implementations."[5]

All that conformance statements offer is a simple and basic overview of their DICOM capabilities for easy comparison. It will not guarantee whether equipments will work together or not. In nearly all cases, a more detailed review and actual physical testing is often needed.[20]

Conclusion

DICOM is a communication standard of the American College of Radiology / National Electrical Manufacturers Association. By ensuring compatibility and integration, DICOM is now used world-over for digital processing, archiving and exchange of patient and images data between different imaging and non-imaging modalities, medical devices and information systems.

It must be remembered that DICOM is not merely a "file format", but can handle an awesome range of features. Of late it has been further enriched by managing newer features like voice dictation, CAD and structured reporting. Finally, DICOM can be truly considered as a "co-operative standard", a basic knowledge of which, is important to radiologists and radiographers.

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