Eur Radiol (2002) 12:920–927
DOI 10.1007/s003300101100

Peter Mildenberger
Marco Eichelberg
Eric Martin

Introduction to the DICOM standard

Received: 8 June 2001
Accepted: 31 July 2001
Published online: 15 September 2001

P. Mildenberger (✉)
Department of Radiology,
University Hospital Mainz,
Langenbeckstrasse 1, 55131 Mainz,
Germany
E-mail: milden@radiologie.klinik.uni-mainz.de
Phone: +49-61 31-17 20 19/71 26
Fax: +49-61 31-17 66 33

M. Eichelberg
OFFIS (Oldenburger Forschungs- und Entwicklungsinstitut für Informatik-Werkzeuge und -Systeme, Escherweg 2,
26121 Oldenburg, Germany

E. Martin
Siemens Corp. Research,
755 College Road, East Princeton NJ
08540, USA

Abstract Digital Imaging and Communication in Medicine (DICOM) has become one of the most popular standards in medicine. In the beginning, DICOM was used for communication of image data between different systems. Actual developments of the standardisation enables increasingly more DICOM-based services for the integration of modalities and information systems (e.g. RIS, PACS). In this article a review of the historical background, the technological concept, the organizational structure and current developments is given.

Keywords DICOM · RIS · PACS · Information management

Introduction

In the past 20 years there has been an increasing use of digital systems in the medical world. Modern radiological centers or clinical departments are equipped with multiple digital modalities. Especially the modern CT and MRI procedures started this development. Many aspects, such as improving medical standards, as well as optimizing processes and economy, are involved in the process of digitization. The integration of different digital products, modalities, archives, and information systems is of primary interest [1, 2]. A vendor-independent standard is an essential goal. Digital Imaging and Communications in Medicine (DICOM) has turned out to be a central standard in radiology and is increasingly used also in other medical fields.

Overview

The objective of the DICOM standard is to enable communication of diagnostic and therapeutic information, images, and associated data of any kind. Connectivity, compatibility, and work-flow optimization are the main intentions. Cooperating with the users themselves, manufacturers define the main characteristics of this standard. Presently, most companies producing equipment for medical purposes are members of the DICOM

Committee, whereas users are represented by scientific societies and academies. Among the members are not only radiological societies, but also practitioners of, for example, cardiology, ophthalmology, and dermatology.

Historical background

The development of the DICOM standard is based on the cooperation of the American College of Radiology (ACR) with the National Electrical Manufacturers Association (NEMA). In 1983 they founded a joint committee in order to create a possibility for data transfer regardless of manufacturers' standards. In 1985 the ACR-NEMA standard version 1.0 was published as a first result (ACR-NEMA Standard Publications 300–1985). This was the first accepted way to archive data on media and to communicate in a non-proprietary form. This version was succeeded by a revision in 1988 and became public as ACR-NEMA version 2.0. These versions already included the main definitions regarding terminology, data structure, and encoding. The further development was presented as DICOM version 3.0 named "Digital Communications in Medicine" in 1993. The essential difference was the specification of a network protocol relying on the ISO/OSI-model and the use of TCP/IP to enable independence of vendor-specific solutions. Services beyond simple data transfer were included. The data structure was based on a model with unique identifiers for services and objects. These objects included images, patient data, waveforms, or reports. In the continuous process of developing the standard, DICOM is now changing from connectivity to interoperability and to work-flow improvement. Therefore, presently DICOM supports the development of Picture Archiving and Communication Systems (PACS) functionality and interfacing with medical information systems.

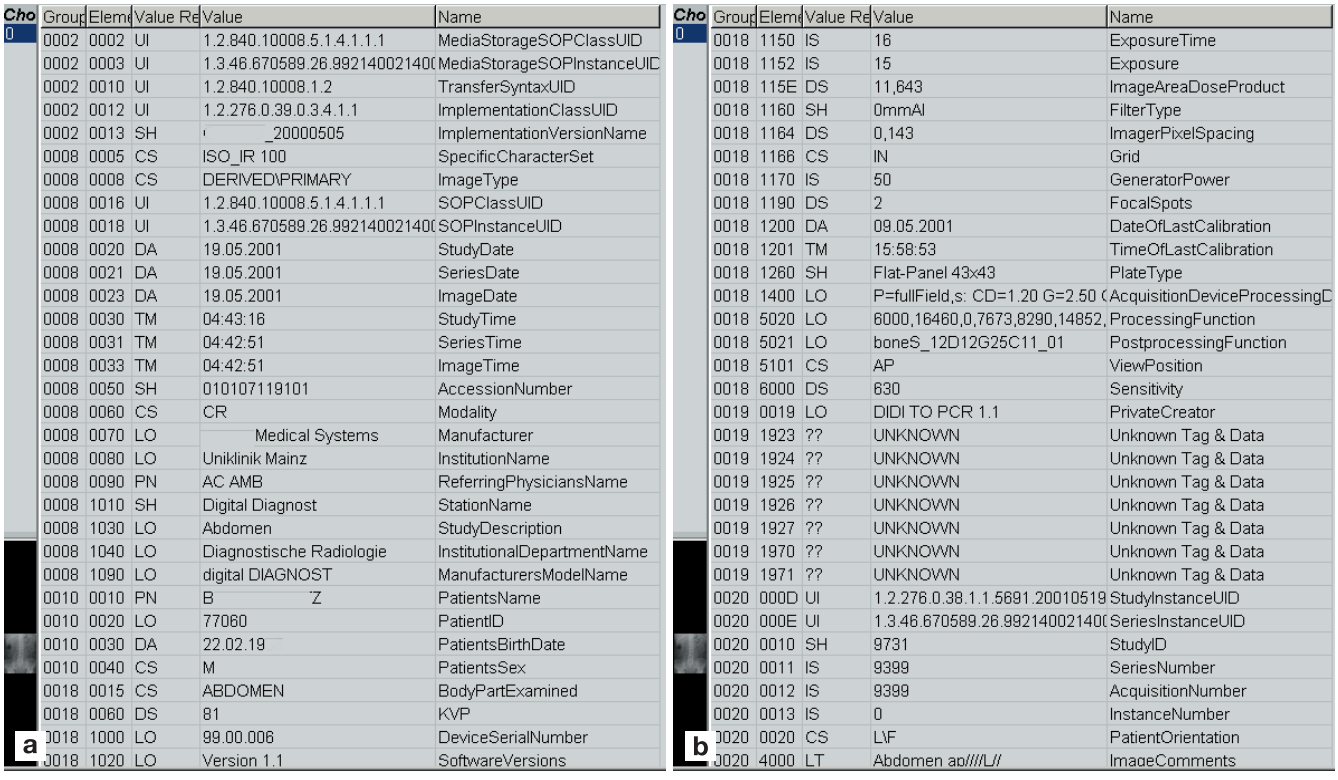
Technological concept

In relation to the ISO/OSI model the DICOM standard involves several layers. DICOM is defining an upper layer protocol (ULP) that is used over TCP/IP for an association negotiation process and for communication of messages, services, or information objects. DICOM is independent of the physical network connection [3, 4].

DICOM includes data structures for medical images and associated data, network oriented services for image transfer or printing, media formats for data exchange, work-flow management, consistency and quality of presentation, and requirements of conformance of devices and programs [3, 5]. Information Object Definitions (IODs) are the central components of the data structures. They are defined for image data (e.g., CT, MRI) as well as for data associated with those images like reports (DICOM Structured Reporting IOD). Therefore, there is a descriptive "header" containing a list of attributes describing the type of the object, patient data, and other information such as performed procedures or reports (see Fig. 1).

Each attribute in a DICOM Information Object Definition has a well-defined meaning. The data are divided into several groups. For example, group 8 includes the description of the modality and the characteristics of the examination or information about the referring physician (0008/0090), group 10 is reserved for patient data, etc. For IODS in which the documentation of the technical details of the image acquisition technique, such as the X-ray exposure, is relevant, this is possible too (for example: 0018/0060 for voltage and 0018/1150 ff for exposure data, filtering, grid, or processing). Especially the fields 0020/000D and 0020/000E are important. They contain so-called Unique Identifiers (UID) as unambiguous hints for identifying the study and the series. These UIDs are imported out of RIS or are created in a modality itself. They are supposed to exist just once worldwide. Different data structures (IODs) are defined for different modalities such as MRI, CT, CR, or reports (structured reporting). Some of the attributes are mandatory (type-1 fields) and are supposed to contain correct data (e.g., UIDs), whereas others are optional (e.g., referring physician). So-called private attributes can be used by vendors to save proprietary data which cannot be interpreted by workstations of other manufacturers. This is used mostly with data that are relevant for image postprocessing (e.g.,3D, Segmentation).

Network services are used for information transfer (e.g., images, reports). In these services the roles of the provider of a certain function (Storage Class Provider, SCP) and the user of this function (Storage Class User, SCU) are distinguished. While sending images of a CT examination from a modality to an image archive the CT is the SCU and the archive is the SCP. These roles can vary, e.g., the archive can be SCU when the images are sent to a workstation. These services can differ for specific IODs. There are, for example, workstations which are meant to be used exclusively for a subset of IODs (CT, MRI) and which do not accept angiographic images. For a successful communication between two DICOM stations a function agreement is necessary: Both stations have to support the same service (e.g., image transmission) and object (e.g., CT), but with different roles. This combination is called Service-Object Pair Class (SOP Class) in DICOM terminology. The encoding of the attributes for network transmission or media storage is also defined and describes Value Representation, Value Length and Value itself, for example. Besides the services for communication of objects, there are other services such as a query/retrieve service. Query/retrieve allows to query and retrieve objects with specific characteristics (e.g., names, PID, study descrip-



Cho	Group	Eleme	Value Re	Value	Name
0	0002	0002	UI	1.2.840.10008.5.1.4.1.1.1	MediaStorageSOPClassUID
	0002	0003	UI	1.3.46.670589.26.99214002140(	MediaStorageSOPInstanceUID
	0002	0010	UI	1.2.840.10008.1.2	TransferSyntaxUID
	0002	0012	UI	1.2.276.0.39.0.3.4.1.1	ImplementationClassUID
	0002	0013	SH	_20000505	ImplementationVersionName
	0008	0005	CS	ISO_IR 100	SpecificCharacterSet
	0008	0008	CS	DERIVED\PRIMARY	ImageType
	0008	0016	UI	1.2.840.10008.5.1.4.1.1.1	SOPClassUID
	0008	0018	UI	1.3.46.670589.26.99214002140(	SOPInstanceUID
	0008	0020	DA	19.05.2001	StudyDate
	0008	0021	DA	19.05.2001	SeriesDate
	0008	0023	DA	19.05.2001	ImageDate
	0008	0030	TM	04:43:16	StudyTime
	0008	0031	TM	04:42:51	SeriesTime
	0008	0033	TM	04:42:51	ImageTime
	0008	0050	SH	010107119101	AccessionNumber
	0008	0060	CS	CR	Modality
	0008	0070	LO	Medical Systems	Manufacturer
	0008	0080	LO	Uniklinik Mainz	InstitutionName
	0008	0090	PN	AC AMB	ReferringPhysiciansName
	0008	1010	SH	Digital Diagnost	StationName
	0008	1030	LO	Abdomen	StudyDescription
	0008	1040	LO	Diagnostische Radiologie	InstitutionalDepartmentName
	0008	1090	LO	digital DIAGNOST	ManufacturersModelName
	0010	0010	PN	B Z	PatientsName
	0010	0020	LO	77060	PatientID
	0010	0030	DA	22.02.19	PatientsBirthDate
	0010	0040	CS	M	PatientsSex
	0018	0015	CS	ABDOMEN	BodyPartExamined
	0018	0060	DS	81	KVP
	0018	1000	LO	99.00.006	DeviceSerialNumber
	0018	1020	LO	Version 1.1	SoftwareVersions

a

Cho	Group	Eleme	Value Re	Value	Name
0	0018	1150	IS	16	ExposureTime
	0018	1152	IS	15	Exposure
	0018	115E	DS	11,643	ImageAreaDoseProduct
	0018	1160	SH	0mmAl	FilterType
	0018	1164	DS	0,143	ImagerPixelSpacing
	0018	1166	CS	IN	Grid
	0018	1170	IS	50	GeneratorPower
	0018	1190	DS	2	FocalSpots
	0018	1200	DA	09.05.2001	DateOfLastCalibration
	0018	1201	TM	15:58:53	TimeOfLastCalibration
	0018	1260	SH	Flat-Panel 43x43	PlateType
	0018	1400	LO	P=fullField,s: CD=1.20 G=2.50 (	AcquisitionDeviceProcessingD
	0018	5020	LO	6000,16460,0,7673,8290,14852,	ProcessingFunction
	0018	5021	LO	boneS_12D12G25C11_01	PostprocessingFunction
	0018	5101	CS	AP	ViewPosition
	0018	6000	DS	630	Sensitivity
	0019	0019	LO	DIDI TO PCR 1.1	PrivateCreator
	0019	1923	??	UNKNOWN	Unknown Tag & Data
	0019	1924	??	UNKNOWN	Unknown Tag & Data
	0019	1925	??	UNKNOWN	Unknown Tag & Data
	0019	1926	??	UNKNOWN	Unknown Tag & Data
	0019	1927	??	UNKNOWN	Unknown Tag & Data
	0019	1970	??	UNKNOWN	Unknown Tag & Data
	0019	1971	??	UNKNOWN	Unknown Tag & Data
	0020	000D	UI	1.2.276.0.38.1.1.5691.20010519	StudyInstanceUID
	0020	000E	UI	1.3.46.670589.26.99214002140(	SeriesInstanceUID
	0020	0010	SH	9731	StudyID
	0020	0011	IS	9399	SeriesNumber
	0020	0012	IS	9399	AcquisitionNumber
	0020	0013	IS	0	InstanceNumber
	0020	0020	CS	L\F	PatientOrientation
	0020	4000	LT	Abdomen ap////L//	ImageComments

b

Fig. 1 a, b Example of a DICOM image header showing different groups (tags) and elements showing institutional, patient-related, and study-specific data

tion, referring physician) from other systems (e.g., an archive). There are other services available, e.g. DICOM Print (used increasingly by modalities and workstations and offers the possibility to transfer printing data via an existing network). A special interface to the camera or the printer is no longer necessary.

Work-flow management is supported by introducing multiple services. Basic Worklist Management for modalities (also called Modality Worklist, MWL) was one of the first published in 1996. The MWL is the first attempt to integrate information systems and modalities. The MWL allows the query of scheduled patients for a specific modality in an RIS, automatically or manually. Besides patient data there is the opportunity to transfer special requests (Procedure Steps) as to which examination is planned for the specific patient with this modality. The primary benefit using MWL is the consistency of the data because, for example, wrong input of names at the modality itself is no longer a problem. Presently, this service is supported by many modalities, but different solutions are found. Sometimes MWL is integrated in the modality software, and sometimes external interfaces are used as offered by vendors such as Merge or Mitra.

The MWL enables only the information transfer from RIS to modality. For feedback from modality to an information system the Modality Performed Procedure Step (MPPS) can be used. In 1998 this service was published. One of the first clinical implementations connecting an angiographic system (Integris, Philips Medical Systems, Best, The Netherlands) and an RIS (Kauz, GAP, Mannheim, Germany) followed in 2000 in Mainz, Germany. With this configuration it can be ensured that relevant data necessary for documentation, such as number of images, time of fluoroscopy, or exposure, is transferred to the RIS automatically (Fig. 2). This service also permits the transfer of changes of procedures; therefore, equivalent procedure codes can be reported back to RIS or can be applied for registration of billing data (e.g., material).

There is an additional service between image generating stations and image archives which organizes the safe storage of data: the Storage Commitment Service. It was published in 1996, but the first implementations are only now becoming used. Using Storage Commitment an archive can take the responsibility for permanently storing an object. Because of this feedback, a modality can delete images automatically, or if the feedback indicates an error it can induce the repeated saving of the image [5, 7].

Basically, the aforementioned services describe only the data communication or exchange. There is no definition about the interpretation by the application. In

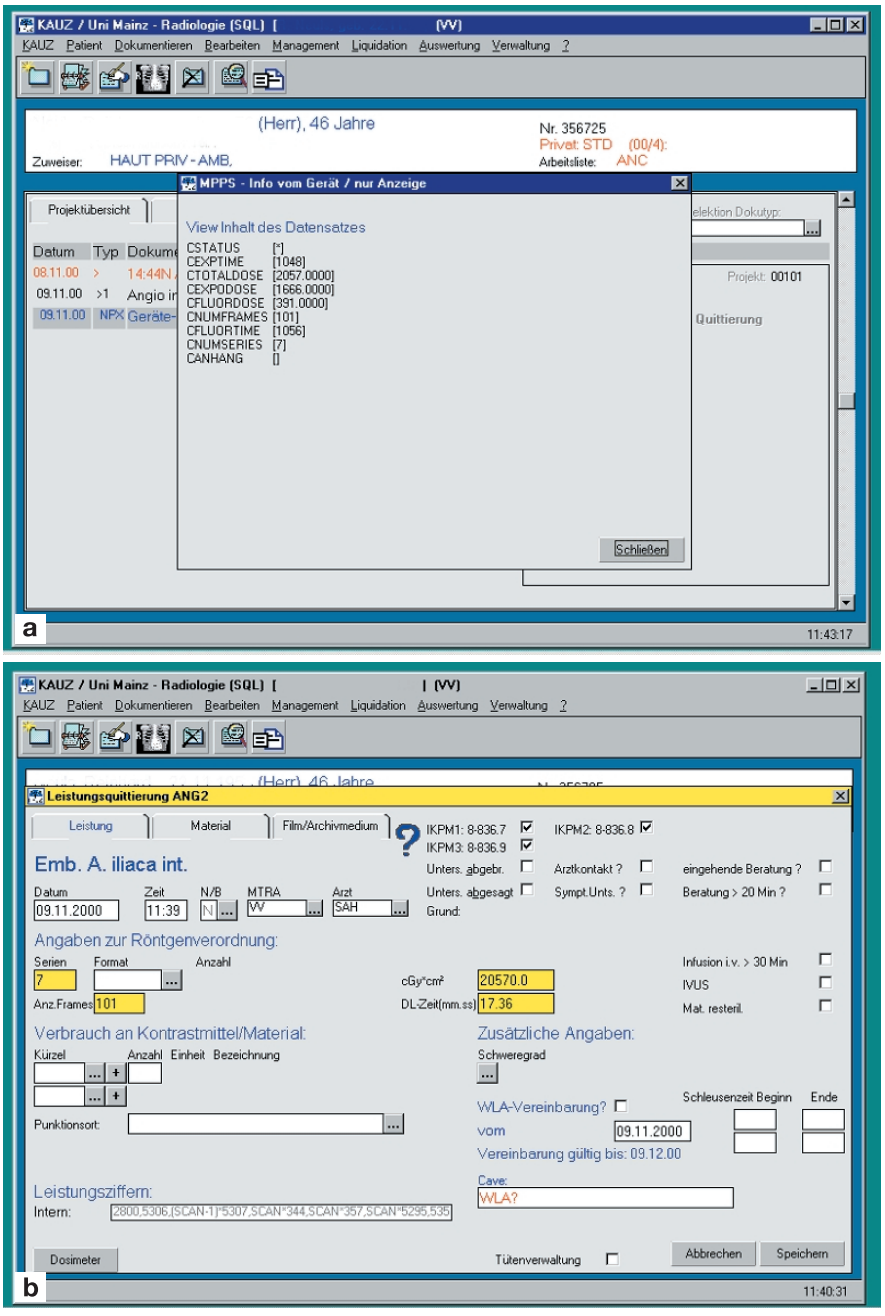


Fig. 2a, b Modality Performed Procedure Step in clinical use: data automatically received from modality (internal box in **a** and automatic registration in RIS 8 (yellow fields) for number of series and images, fluoroscopy time, and exposure dose (example of an embolization of internal iliac artery)

previous years much effort has been put into the definition of consistency and quality in image reproduction; therefore, two new essential services have been released, suppl. 28 for the so-called Display Grayscale Standard (now part 14 of the standard) and suppl. 33 for Grayscale Soft Copy Presentation State Storage (now integrated in parts 3 and 4). A test implementation was developed by OFFIS and coworkers in 1999, and the first demonstration took place at the ECR 1999 [8]. This service makes it possible to achieve a consistent image impression on different display systems and to define the modus of the displayed images (e.g., Zoom, Windowing, or Annotation; Fig. 3). This information is saved in a separate object which is linked to the source image. With this technique it is not necessary to archive the image for different display descriptions again.

A supplement that organizes structured reports in DICOM (suppl. 23) was published in 2000. DICOM Structured Reporting allows the creation and administration of reports in DICOM. The created objects can be

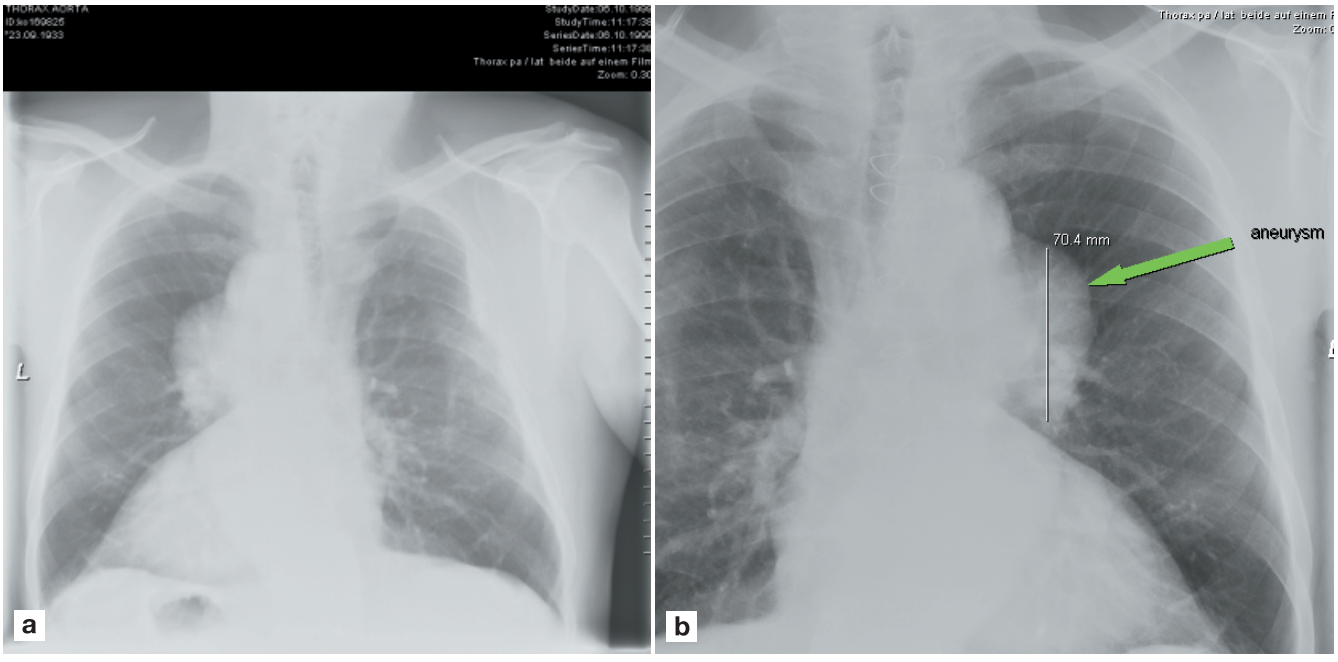


Fig. 3a, b Use of Softcopy Presentation State for windowing, zooming, and annotations. **a** Original format; **b** with Softcopy Presentation State

used with the usual communication services (send, receive, query, retrieve). Using DICOM SR there is the possibility to encode findings in a structured way. Besides free text, a structured template for documentation and coding of different attributes can be defined, e.g., procedure as well as diagnostic or billing information. Established codes can be used (ICD; CPT; SNOMED). DICOM SR allows a connection between single features and corresponding image regions. Since DICOM SR enables a computer-supported diagnosis, the system automatically generates report sections into respective fields of an SR template, and in the future DICOM SR will be of interest especially for computer-assisted documentation systems. A first example is the recently accepted SR template for mammography CAD (suppl. 50).

DICOM also defines exchange media formats, e.g., the construction of a CD-ROM with a DICOM-compatible directory. This enables vendor independent data access to objects by different workstations. This is used mainly for the storage of coronary angiograms and for the image distribution to referring physicians.

The DICOM standard is a framework that does not establish the specific architecture for a PACS or the specific progress/transfer of functions. For example, it is defined which information of images is necessary for transmission, but not how the images should be stored in a long-term archive. The DICOM standard is meant to transmit objects containing all the essential information in the header. This is called "Composite Services." Complementary to this, there are so-called Normalized Services for patient- and study management, for instance, in order to harmonize database contents in different information systems (e.g., RIS and PACS).

To establish successful communication between heterogeneous systems, DICOM prescribes the preparation of a conformance statement for each DICOM-compatible component (hard- and software). This document describes the supported services, the objects, and their encoding. This should possibly allow a judgment and a prediction of the possible functionality before two systems are connected [3].

The experiences with implementation and use of DICOM-compatible equipment show essential changes in the past years. When available systems started to be used in the mid-1990s, a special challenge was the establishment of the connection and a correct data registration in the appropriate elements. This led to time-consuming adaptation progress or display problems. Presently, these problems are widely solved. For the installation of new equipment in a PACS environment only the configuration of an application entity title (a DICOM-specific name for the single appliance), host name, and IP number is usually necessary.

The actual discussion is more often about the use of standardized coding for procedures, which are considered presumptions for the use of hanging protocols or the implementation of new services which are important for the work flow (such as MPPS or storage commitment) [3, 9, 10].

Organizational structure

The DICOM standard is structured as a multi-part document. Each part describes a single layer which can be used for different services and objects. Starting to understand DICOM, one might find it difficult to work with the horizontal structure [7]. The first version from 1993 had nine parts including an information model, a communication model, and definitions of different data models such as CT or MR. Further developments were published as supplements, e.g., supplements for Basic Worklist Management or security. These supplements were expanded and discussed by specific workgroups. Having been accepted, they became a part of the standard. Presently, supplements up to number 64 are in progress. Continuous quality assurance of the standard is guaranteed by different members' comments. It is possible for them to send a so-called correction proposal to the DICOM standards committee. This committee is, together with Working Group 6 (Base Standard), the central organization of the standardization process, while the main work is done in different working groups. The administration of DICOM as a standards organization is carried out by NEMA (http://medical.nema.org/) [11]. The DICOM standards Committee itself and most Working Groups have two chairmen, mostly one from a vendor and one from a user organization, and a secretary. An overview about the activities in the DICOM world can be obtained by a short review of the different working groups (see Table 1) [3].

DICOM's relationship to other standards

In the development of the DICOM Standard other international standards were incorporated wherever possible, e.g., the adoption of the TCP/IP network protocol in 1993. The cooperation with CEN (European Committee for Standardization, CEN/TC251 "Health Informatics": http://www.centc251.org/) resulted in some jointly developed supplements in the 1990s. Also there is a cooperation with JIRA (Japan Industries Association of Radiological Systems, http://www.jira-net.or.jp/e/), especially for exchange media formats. DICOM relies on healthcare standards developed by ANSI-HISBB in the USA, e.g., harmonized patient name structure. In 1999 an active cooperation with HL7 (Health Level 7, http://www.hl7.org) was started with establishing a joint DICOM-HL7 working group. A type-A liaison with the ISO Technical Committee 215 was created in 1999. ISO TC 215 decided to rely on DICOM for biomedical imaging standards.

Other standards from commonly used information technology were incorporated into DICOM where necessary and useful. Examples are standards for compression, for file formats, or the Standard Mime type for an e-mail exchange of DICOM objects.

For the DICOM Standard the integration with other standards is of increasing importance, even if the development of healthcare standards is a complex process (e.g., HL7 V3.0) or there is a delay in standardization (e.g., JPEG 2000).

Current developments

Within the DICOM workgroups there are different fields of development. Most of the improvements are motivated by change of technology or clinical needs. A typical clinical requirement is the inclusion of security functions which are almost not implemented in the DICOM installations today. Similar is the need of the work-flow support. Among these are the design of a general purpose worklist (suppl. 52), the discussion about hanging protocols (suppl. 60) or the use of DICOM structured report in multiple fields. Innovations based on new technology are, for example, the definition of new information objects (IODs), as for MR (suppl. 49) or CT (suppl. 58), with respect to new sequences or multi-slice CT or the integration of new compression techniques (JPEG 2000 in suppl. 61).

Especially in DICOM SR there are many activities in the workgroups being established. These are not only activities for typical radiological procedures, there are also activities especially in cardiology, endoscopy, and ophthalmology. This shows an increasing interest in DICOM also outside radiology. For these topics there is a direct relation to medical contents in the actual discussed DICOM supplements. The technical aspects (e.g., connectivity problems) from the beginning of DICOM drift relatively to the background. DICOM SR opens new possibilities in the integration of report and image. This is helpful for different purposes such as encoding for economical or scientific use, for a standardized classification of findings, and for an international exchange of information. A process for creating national versions of coded terminology has been started. These national versions will have a direct correlation to the superior international terminology sets. The transformation of the medical contents is of special interest for the increasing use of computer-aided diagnostic systems; thus, received findings, measurements, or classifications can be documented in a structured report and can be displayed in the user's language.

New DICOM services are often developed as a test implementation. In Europe the main partner of the DICOM committee for this is OFFIS (Oldenburger Forschungs- und Entwicklungsinstitut für Informatik-Werkzeuge und -Systeme). Many of the new services were implemented for the first time by OFFIS, e.g., DICOM MWL, presentation states, and gray-scale display

Table 1 DICOM Working Groups (WG) and specific work items (selection, summary in 3)

WG	Name	Work item(s)
1	Cardiac and vascular information	Digital interchange of the cardiovascular images, physiological waveforms, and relevant clinical information in combination with a catheterization procedure; comprehensive digital cardiovascular report; cardiovascular waveform exchange, with specializations for hemodynamics, electrophysiology and ECG; describing a template for a structured report
2	Digital X-ray	Digital projection radiography (currently not active)
3	Nuclear medicine	Identification of SNOMED terms for NM IODs; interfacing of PET
4	Compression	Tracking progress of JPEG 2000 standard; 3D- and Multiframe compression
5	Exchange media	Addition of DVD-Media and UDF-File format to PS 3.12
6	Base standard	Maintain and insure the overall consistency of the DICOM standard; execute the DICOM Maintenance Process (Correction Proposals); provide technical coordination and guidance for all WGs; coordination of activities in the relationship to other standard organizations
7	Radiotherapy	Ten new CPs dealing with brachytherapy and external beam therapy; extensions to handle proton therapy; incorporation of specific radiotherapy procedures in DICOM work-flow concepts
8	Structured reporting	To develop and maintain the DICOM Structured Reporting specification; to coordinate the development of codes and controlled terminology and templates for biomedical imaging applications
9	Ophthalmology	Work flow of eye-care environments; creation of templates for Structured Reporting; evaluation of existing objects or current work items for use in visual field and corneal topography applications
10	Strategic advisory	Consider issues and opportunities related to the strategic evolution of DICOM; explore and advise the DICOM Committee about new Web technologies and for the development of HL7 Clinical Document Architecture and the relation to DICOM SR; coordinate the relation to ISO TC 215
11	Display function standard	Hanging protocols; advanced presentation state; 3D presentation; structured display (integrating presentation state and structured reports and even hanging protocols)
12	Ultrasound	3D ultrasound acquisition and processing; JPEG 2000
13	Visible light	To develop the Visible Light IODs to support Visible Light color images or monochrome images produced by endoscopes, microscopes, or photographic cameras (currently not active)
14	Security	To develop extensions to DICOM with respect to security; secure communications (suppl. 31) and digital signatures (suppl. 41); working through select IHE profiles, to produce examples of how DICOM and/or other security measures sufficient to meet HIPAA and other governmental regulation could be added to those profiles
15	Digital mammography	Definition of SR templates/SOP Class for a complete Mammography report; reporting of CAD output results that are three-dimensional; DICOM SR for chest CAD (X-ray and CT)
16	Magnetic resonance	Develop a new MR object that contains a more extensive set of descriptive attributes and makes use of the multi-frame mechanisms
17	3D	Extending DICOM to represent data types greater than two dimensions; spatial fiducials (landmarks) to enable registration between data sets or to real-world coordinates, spatial transformations to describe the registration between data sets, multi-component data, derived data types such as segmentations
18	Clinical trials and education	Extend the DICOM Standard with respect to clinical trials information and the storage of images for educational purposes; to identify attributes necessary for use in clinical trials (e.g., client, clinical protocol, site number) and technique-related attributes
19	Dermatological standards	Analysis of other forms of cutaneous imaging such as epiluminescence microscopy and confocal microscopy to see if the current standard is applicable or any additional work would need to be done
20	Integration of imaging and information systems	To develop DICOM and HL7 standards for image-related information for areas where the consistent use of HL7 and DICOM is of prime concern and the coordination and mutual education and understanding between the HL7 and DICOM organizations and their technical committees/working groups
21	Computed tomography	To develop an extended CT image object to support the many technological and clinical advances in CT; enhanced CT IOD with multi-frame capabilities

standards or security. The results are regularly presented by OFFIS at the ECR [8].

To improve international acceptance and spreading of healthcare standards (DICOM, HL7, and others) a joint initiative of RSNA and HIMSS (Healthcare Information and Management Systems Society) was founded in 1999 and named "Integrating the Healthcare Enterprise" [11]. Several aims are of special interest for the integration of information- and imaging systems to be accelerated:

1. Complex communication processes in medicine needs standards, not extraordinary proprietary solutions.
2. Existing standards should be used, especially DICOM and HL7, but also CCOW, CORBA, and others when necessary and useful (CORBA: Common Object Request Broker Architecture, http://www.corba.org/ CCOW: Clinical Context Object Workgroup, http://www.hl7.org/.
3. The evolution of different standards should be coordinated.

In general, this will enable an investment protection for the user. A consent of standard organizations (ACR-NEMA, HL7, and others) with vendors of medical equipment (Siemens, Philips, GE, AGFA, and many more) and of hospital information systems (HBOC, SMS, Cerner, IDX, and others) is intended by the IHE Initiative.

There are two committees, one for technical framework and one for planning, which prepare demonstrations on international meetings (beginning 1999 at RSNA and 2000 at HIMSS). The technical framework focuses on existing problems in interoperability, e.g., interruptions in the information flow (e.g., inconstant identifiers), in procedures, or in work flow. This can be caused by overlapping functionality in different IT-systems (HIS-RIS-PACS), inconsistent information object definition or missing interoperability of the applications. So the same requests and tasks can lead to different solutions.

IHE is actually defining scenarios, within which the functionality is described and actors and roles are defined. For the communication between the various systems certain HL7 and DICOM services are fixed. Since the beginning of 2001 IHE is being expanded also to Europe. A separate planning committee is supposed to demonstrate the specific European requests of an integration process, involve European vendors and users, and organize connectathons and demonstrations during congresses. National activities should support that. A first national committee has been founded in France under the leadership of the SFR (Société francaise de Radiologie) and GIMSH (Groupement pour la modernisation du Système d'information Hospitalier). Support by the French government with a considerable financial amount was granted. In Germany appropriate planning of the scientific societies and companies are in progress. The definition of the IHE requests is annually revised, updated, and developed. Connectivity and interoperability tests take place before demonstrations.

IHE will create standard information frameworks which will allow a higher level of integration of different IT systems. This will reduce integration costs and increase efficiency. DICOM is one of the most important standards on which this integration in healthcare relies. It is very probable that DICOM will play this role for many years in the future.

Acknowledgement We thank Mr. St. Meier for assistance in preparing the paper.

References

1. Heiss D, Konig A, Endres S, Pfluger T, Pfeifer KJ, Hahn K (2000) A combined PACS and Internet information system in a university medical center. Fortschr Röntgenstr 172: 542–552
2. Foord KD (1999) PACS workstation respecification: display, data flow, system integration, and environmental issues, derived from analysis of the Conquest Hospital pre-DICOM PACS experience. Eur Radiol 9: 1161–1169
3. Martin E (2001) DICOM strategic document. http://medical.nema.org/dicom/geninfo/dicomstrategyv105/dicomstrategyv105.htm
4. Heautot JF, Eichelberg M, Gibaud B, Treguier C, Lemoine D, Scarabin JM, Piqueras J, Carsin M, Gandon Y (2000) The RETAIN project: DICOM teleradiology over an ATM-based network. Radiological Examinations Transfer on an ATM Integrated Network. Eur Radiol 10: 175–182
5. 5. Eichelberg M (1998) Einführung in das Konzept des DICOM Standard. In: Klose KJ, Mildenberger P (eds) 2. DICOM Treffen Mainz. @GIT, Mainz
6. Van Syckle D, Simon D, Helbig S (2000) Integration imaging into the healthcare enterprise: DICOM workshop. In: HIMSS 2000, vol 2. Dallas, Texas, pp 262–267
7. Clunie D (2000) Walking through the standard. In: Clunie D (ed) DICOM structured reporting. PixelMed, Bangor, Pennsylvania, pp 345–353
8. Eichelberg M, Riesmeier J, Demarmels M, Kleber K, Holstein J, Przybyolwicz J, Ossterwijk H (1999) Demonstration of the DICOM softcopy presentation state. Eur Radiol 9:S562
9. Mildenberger P (1999) Standards in digital imaging communication and archiving (editorial). Fortschr Röntgenstr 171: 1–2
10. Mildenberger, P, Jensch P (1999) Use of the DICOM standard in a heterogenous environment. Incompatibility or interoperability? Radiologe 39: 282–285
11. DICOM Committee (2001) DICOM documents. http://medical.nema.org/