APPLICATION FOR REPAIRING AND PRESENTING DICOM OBJECTS

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ABSTRACT

The standard for digital imaging and communication in medicine (DICOM[1]) is very flexible. Most retailers use this advantage in order to define their own structures which will be adapted to the offered equipment by those retailers. We develop a mechanism in order to prevent private structures. The application removes every private or retired structure from a DICOM file in order to make it readable for most of the offered viewers, so that every hospital and institute is capable to construct their own imaging and communication system by using software and equipment of different retailers instead of only one.

KEY WORDS

DICOM, Hanging Protocol, Compatibility,
Telemedicine, Standardization

1. INTRODUCTION

The use of computers in medical imaging and the development of applications which process images and which have been produced by imaging devices, creates the problem of how to exchange images with related patient data between devices of different manufacturers. A common interface has to be specified for the devices and applications. This interface, called DICOM, makes it possible to connect devices, PACS and databases which contain diagnostic data. The DICOM-standard is accepted and used by many manufacturers.

2. DICOM - A STANDARD FOR TELEMEDICAL APPLICATIONS

The status of the standard is represented by the core. This core consists of parts which specify the required elements which are needed to develop and to understand a DICOM-conform application. The required elements are: the definitions of attributes, the representation of these attributes, the transfer of a set of attributes and the storing of these attributes in a file. A statement declaring which attributes are defined in the DICOM-standard has been used and how they are represented, as well as defined attributes which do not occur in the DICOM-standard, has to be written additionally. The statement is important for a user who wants to buy a DICOM application or hardware with a DICOM interface. The statement may serves as information about the interoperability of two DICOM interfaces. Interoperability may not be guaranteed if the statement is vague, incompletely, not precisely or incorrectly. Developers of DICOM-conform applications as well as manufacturers of DICOM-conform devices must be sure to describe the features of their products thoroughly in order to increase the interoperability and acceptance of products which conform to the DICOM-standard.

The core of the DICOM-standard may be extended by correction-proposals or supplements. The evolution of DICOM is achieved by the integration of accepted supplements that have reached a final status and by the acceptance of correction proposals.

A SOP is a combination of a set of modules representing a DICOM document called 'Information Object Definition' (IOD) and a service that allows to work on the attributes of the modules and therefore on the IOD. Operations which move data from one point to another are examples of such a service.

The DICOM-standard was enhanced by a supplement called Structured Reporting (SR). This supplement is now part of the core. The SR defines a way to produce medical reports of radiological image interpretations. In practice the production of a report is achieved by using a dictaphone. The report recorded on tape is transcribed by a secretary. The secretary shows the transcribed report to the physician who recorded the tape. The physician verifies the report and signs it. To reduce the amount of text, the physician uses a medical code. The code is often a standard-code like logical observation identifier names and codes (LOINC) or systemized nomenclature of human medicine (SNOMED). Additionally, private codes of physicians who want their code to be understood only by themselves or by a group of people they trust, is also used. The supplement SR uses the supplements for coding medical data which are integrated in the core now in a pre-defined scheme. In the definition of SR, there are

three pre-defined kinds of reports: The basic-text, the enhanced, and the comprehensive Information Object Definition (IOD).

The structure of a SR report is complex [4, 5]. This structure is represented in DICOM by an IOD. There are three definitions for a report IOD[1]. These three definitions will be described in the following. The simplest definition is the SR-Basic-Text-IOD. This definition possesses the features of reference images and other reports. The structure of a report in this definition consists of the following elements: a document content which contains information about the examiner, as well as information pertaining to the time the report was created and the reason why the report was created. Medical Codes may be integrated. An observation context may be integrated by using relationships between predefined classes which are defined for the creation of a report.

The SR-enhanced-IOD provides additional classes such as coordinates to reference an area in an image. The coding scheme which was defined for these three IODs is the SNOMED DICOM micro glossary (SDM). This coding scheme is a medical coding scheme which assigns medical code words to their descriptions.

The comprehensive IOD allows the specification of relationships by reference instead of using values like in the other two IODs.

There are some implementations of SR which use SR to relate text to images. Currently, SR is regarded as very complex. The complexity can let applications run into difficulties while interpreting SRs because of too many variations of ways to construct a report exist.

Nevertheless, we decided to use SR because it provides the best way to relate images and reports. In order to reduce the complexity and the resulting problems and due to our aim of constructing a presentation, we chose not to use medical coding schemes.

3. A DICOM APPLICATION

Currently, we are developing a system called Engrane[6]. Engrane is a system which can be used to prepare and show presentations of radiological images, as well as reports which belong to these images. The presentations of Engrane consist of DICOM images and interpretations of the images represented as text. The Engrane system itself consists of three modules: a primary module to prepare the presentation, a module for actual presentation and a third module to organize the presentations. Additionally, a database is used to manage patient information data which is part of the DICOM images which are presented. Several operations can be performed on the images during the preparation and presentation, such as windowing and annotation. It is also possible to realize slideshows of series of images. Java is used to develop the user interface of Engrane in order to obtain a system independent interface. Engrane retrieves images by using the DICOM protocol. The system has a practical approach in order to store DICOM conform presentations of radiological images.

Engrane displays patient data in accordance to DICOM Patient, Study, Series, Image object hierarchy. Important values of attributes are listed for each level. At the series level it is possible to choose two series and compare them. This feature is important to compare series of patient images which are made at different times. Image operations which are integrated at series level and image level are rotation, zooming, flipping, annotation, adjustment of brightness, contrast, and windowing. The second module is developed in order to manage presentations and to arrange them into a calendar via drag and drop. Every presentation is presented as an icon containing the patient's name and date of birth. The third module contains the presentation service. The presentation can be started simply by a click on the corresponding icon. Afterwards, a walk through the presentation can be realized simply by pressing a button.

We examined if the usage of DICOM SR (structured reporting) or a new supplement called "hanging protocol" are useful storage tools in the discussion of radiological images. SR is part of the DICOM Standard and defines a way to generate medical reports such as radiological image interpretations. To produce a slide show of radiological images a SR log mechanism can be used. This SR log mechanism can be practically used for the presentation of radiological images and image series. But there is no definition in SR to ensure the order how images are selected during their loading and displaying. SR is a perfect solution for storage and exact retrieval of stored reports. Additionally, SR saves space on storage devices by referencing images and other objects, thus data redundancy can be avoided.

The SR log mechanism is practical to be used for a presentation of radiological images. But there is no definition in SR to ensure that the order in which the images are selected is regarded during loading and displaying of images. In contrast, the hanging protocol which is a supplement of the DICOM standard contains information about physician viewing preferences, related to display capabilities. The goal for physicians is to be able to define conveniently their preferred methods of presentation and interaction for different types of viewing circumstances. Image sets automatically hung according to the user's preferences on display systems of similar capability. Therefore the hanging protocol definition supposes to use the definition of "softcopy presentation state" and "grayscale standard display function" which are part of the DICOM standard to realize the configuration. In the case of presenting results SR is a better choice because it defines the relationship between

several multimedia elements, e. g. text and image, whereas the hanging protocol defines the order of these elements. Presentation states also allow those specifications but the elements specified in presentation states are integrated into an presentation object and therefore there is a lost of flexibility. SR does not specify that an element has to be a DICOM-object. Elements can be anywhere in the internet.

Engrane is intended for creating presentations. Presentations are multimedia documents which have ordered elements. All elements referenced by a document need not to be a DICOM object. Therefore, the module "UIDREF" of SR is important for DICOM-document files of Engrane. SR-Concepts has to be defined in order to retrieve such files, containing the information about the location of the files.

The "Hanging Protocol" contains information about physician viewing preferences, related to display capabilities. For physicians the goal is to be able to define conveniently their preferred methods of presentation and interaction for different types of viewing circumstances once, and then to have image sets automatically hung according to the user's preferences on display systems of similar capability. The main expectation is to facilitate the automatic and consistent hanging of images according to definitions provided by the physicians, sites or vendors of the display systems.

Specifically,

- save defined hanging protocols, and search for them by id (username, site, manufacturer), exam type, and display characteristics.

- allow automatic hanging of primary and comparison image sets to occur for all exams on defined displays, or similar displays by matching against user or site defined hanging protocols. This includes supporting automatic hanging when the user reads from different locations, or on different but similar display types. Allow shared use of hanging protocols to facilitate consulting on shared tele-reads (i.e., two physicians reviewing the same case from remote locations).

Further, it is anticipated that vendors will make it easy for users to point to a graphical representation they want to (like 4x1 versus 12x1 format with a horizontal alternator scroll mechanism) and select what they want to. Obtaining the images for comparison image sets is outside the scope of the Hanging Protocol IOD, and left up to vendor specific implementation. The following services are considered to be beyond the scope of the Hanging Protocol IOD and SOP Classes:

- the services required to retrieve the information (e.g. image sets) which has to be presented by an instance of a Hanging Protocol IOD.

A Hanging Protocol consists of a display tree which consists of a list of image displays. The image displays serve for specification of rendering, content and geometry and consist of a list of image boxes. The image boxes define the layout format, spatial resolution, size and the display content. In order to specify which images go in which image boxes you have to define several filter.

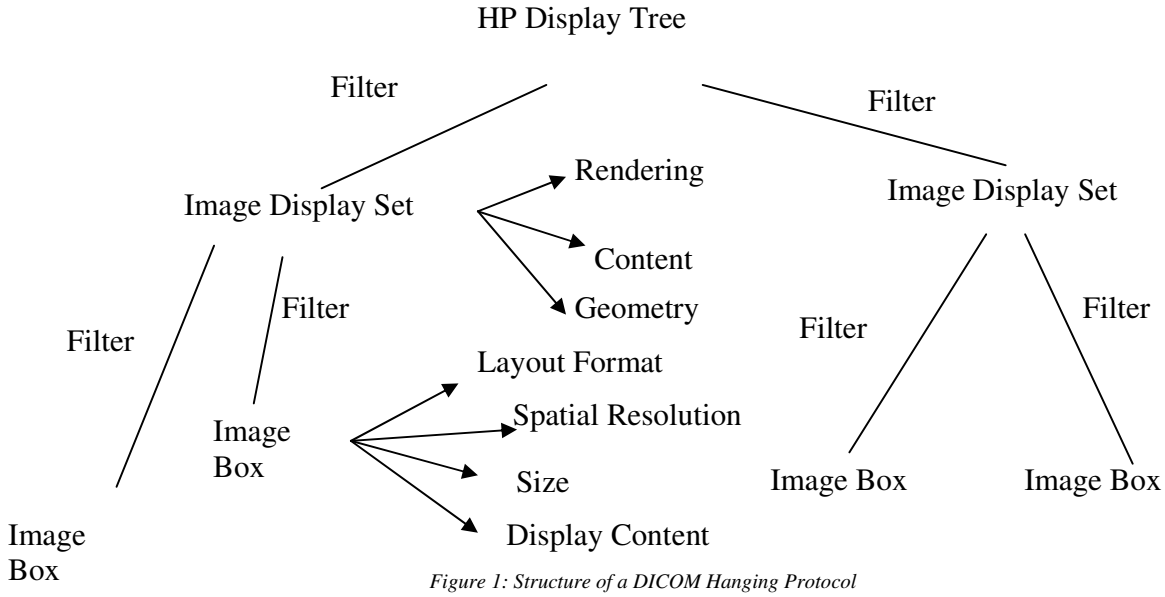

Figure 1: Structure of a DICOM Hanging Protocol

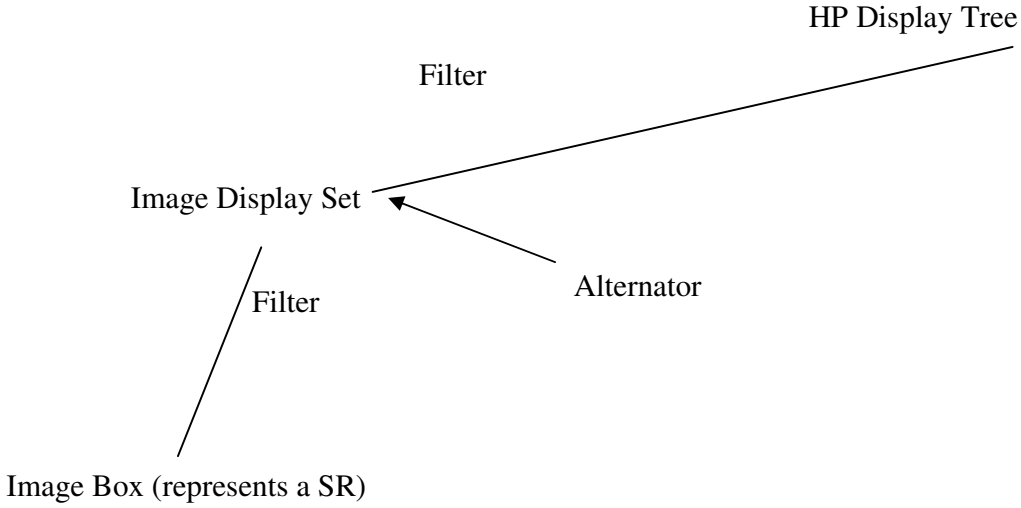

Figure 2: Adapted Hanging Protocol

In the case of storage format of the Engrane system we specify a simple hanging protocol in which the HP Display tree consists of a single image display set. The image display set has a single image box which is represented through an SR. The next picture shows such a Hanging Protocol.

4. DICOM DATA STRUCTURES

DICOM files consist of a set of data elements. Each data element is stored as depicted in figure 3. A data element contains a field for the tag number of the DICOM attribute specified in part 6 of the standard. The value representation may be defined depending on negotiated transfer syntax. There are four kinds of transfer syntaxes: little endian implicit, big endian implicit, little endian explicit, big endian explicit. Afterwards the value length and the value of the attribute follow.

A set of Attributes represent a dataset. The header of a DICOM file is such a dataset and specified as in the following table:

The DICOM Header starts with 128 empty bytes. In every DICOM file, there are 128 empty bytes at first. It is preserved for the future use. Behind the 128 Bytes 4 bytes follow. These four bytes contain the character string ”DICM”. The prefix is intended to be used to recognize

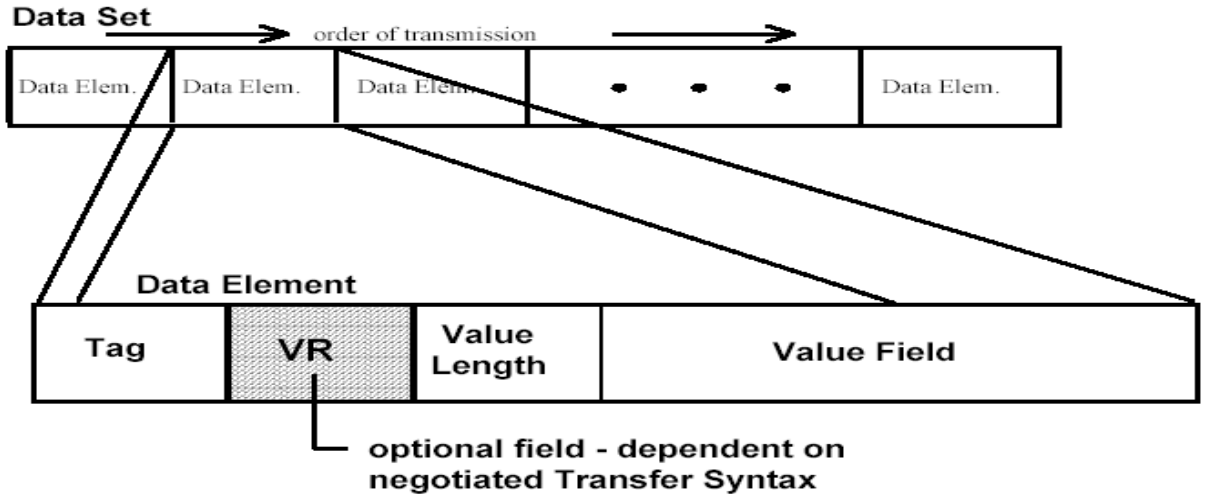

Figure 3: DICOM Data set structure consist of several Data Elements. Each data element consist of a tag a value representation, a value length and a value field.

that this File is a DICOM File or not. The Group Length is used because of the optional attributes and therefore the header does not have a fixed size. The Metafile version has a fix value. Afterwards the information what DICOM class and instance is contained in the file follows. Each kind of image (CT=computer tomography, MR=magnet resonanz tomography) has an identifier as well as the instance of such a class. Important thing for decoding the following data set is to define a transfer syntax: That mean to specify the way how to transfer the data. There are many kinds of transfer syntax and each of it has an identifier.

After the header a dataset follows which represent the content of the file. The dataset can be an image a presentation state, a structured report or another DICOM object. All data elements of DICOM header and DICOM document content contain standard attributes which group number of the tag is even. The datasets may contain private attributes which tags have odd group numbers. Other attributes are not used in newer versions of the standard and therefore they are defined as retired.

Attribute Name	Tag	Type
File Preamble	No Tag or Length Fields	1
DICOM Prefix	No Tag or Length Fields	1
Group Length	(0002,0000)	1
File Meta Information Version	(0002,0001)	1
Media Storage SOP Class UID	(0002,0002)	1
Media Storage SOP Instance UID	(0002,0003)	1
Transfer Syntax UID	(0002,0010)	1
Implementation Class UID	(0002,0012)	1
Implementation Version Name	(0002,0013)	3
Source Application Entity Title	(0002,0016)	3
Private Information Creator UID	(0002,0100)	3
Private Information	(0002,0102)	1C

Table 1: DICOM Header File

5. DICOM RETAILERS LEAD TO A NEW TOOL

Different retailers produce different equipment. This equipment should conform to the DICOM Standard as mentioned above. But there are many differences because DICOM allows to specify private attributes. Some attributes are specified as retired in newer versions of the standard. Private attributes as well as retired attributes must be processed by a DICOM application. While looking for a DICOM Viewer in the internet there are many offered solutions. But there is no application that supports all DICOM images. Most of the viewers will fail while reading files with private or retired attributes. This is the reason why we developed a solution to repair such DICOM files by removing private and retired attributes. After performing this process each viewer is able to display those images. The kind of storing image data differs from retailer to retailer. Our application is also able to display and repair such files.

6. CONCLUSION

The DICOM standard is very flexible. Many applications are not able to handle this flexibility. Therefore a tool in order to reduce the grade of flexibility was implemented. This tool serves in order to establish the DICOM standard. The tool removes all attributes from DICOM files which are not part of the standard and creates a header for DICOM files which does not possess one. The tool was a result of an implementation called Engrane which is used to create, manage and perform presentations of DICOM images. We will enhance the DICOM protocol by this feature in order to be compatible to the standard.

7. REFERENCES

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Size

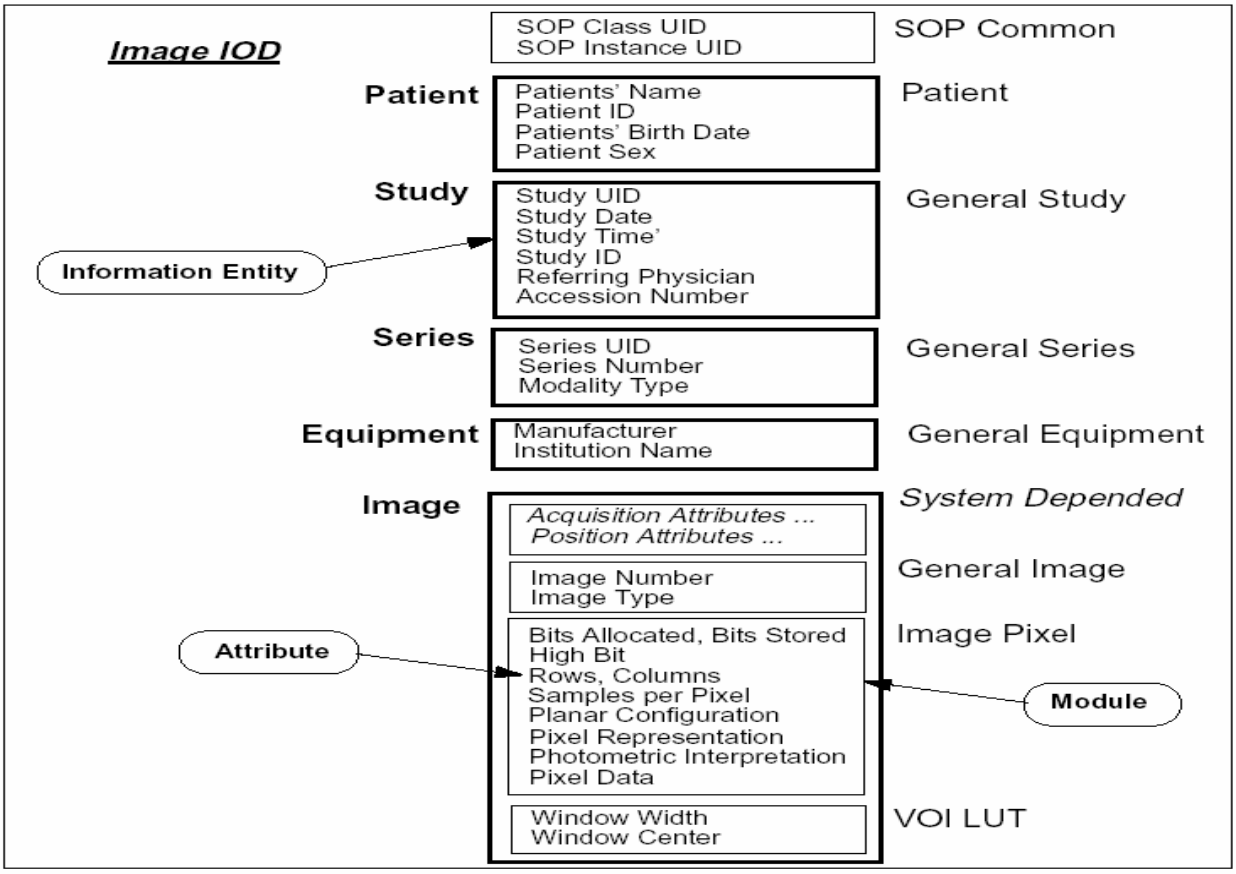

Figure 4: Example of a DICOM Image Data Set

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