DICOM–INTEGRATION IN A HETEROGENEOUS ENVIRONMENT

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Abstract **– DICOM applications often have to be included into heterogeneous environments and cannot be treated as standalone systems. We have developed a DICOM library that covers all aspects of communicating and storing images and patient related data. This includes retrieval from off-line storage as well as the integration of conventional ACR/NEMA datasets and their derivatives.**

In a prototypic implementation we used this library to build a database, which satisfies the requirements for archiving and retrieval of image data. By an interface based on the Hypertext Transfer Protocol (HTTP), the contents of the database may be examined and associations explicitly requested.

Currently, we are integrating DICOM applications into our existing Image Archiving and Hospital Information Systems, resulting in a hierarchy of a Meta Patient Record and dependent databases or applications.

I. INTRODUCTION

The use of DICOM applications cannot be restricted to standalone systems, e.g. considering single modalities and databases. In fact, DICOM applications have to be included into a heterogeneous system of other applications. In the concrete environment of the German Heart Institute of Berlin, the following sources of patient related data have to be considered (fig. 1):

- modalities which provide image data in conventional ACR/NEMA 1.0/2.0 formats or their derivatives like SPI or PMSnet [1];
- modalities submitting images and related data according to the DICOM standard via TCP/IP [2];
- modalities that produce off-line data stored on CD-ROM in DICOM format [2], [3];
- the Meta Patient Record (MPR) that manages patient data and references to images.

Our developments consist of applications to attain an integration of existing systems. The main features are submission of images and other patient-related data into databases, and retrieval and interpretation of the data via DICOM

II. METHODS AND DEVELOPMENTS

A. DICOM Library

We developed a DICOM library that covers all parts of the DICOM standard except the OSI and point-to-point communication stacks. Only the DICOM Upper Layer functional-

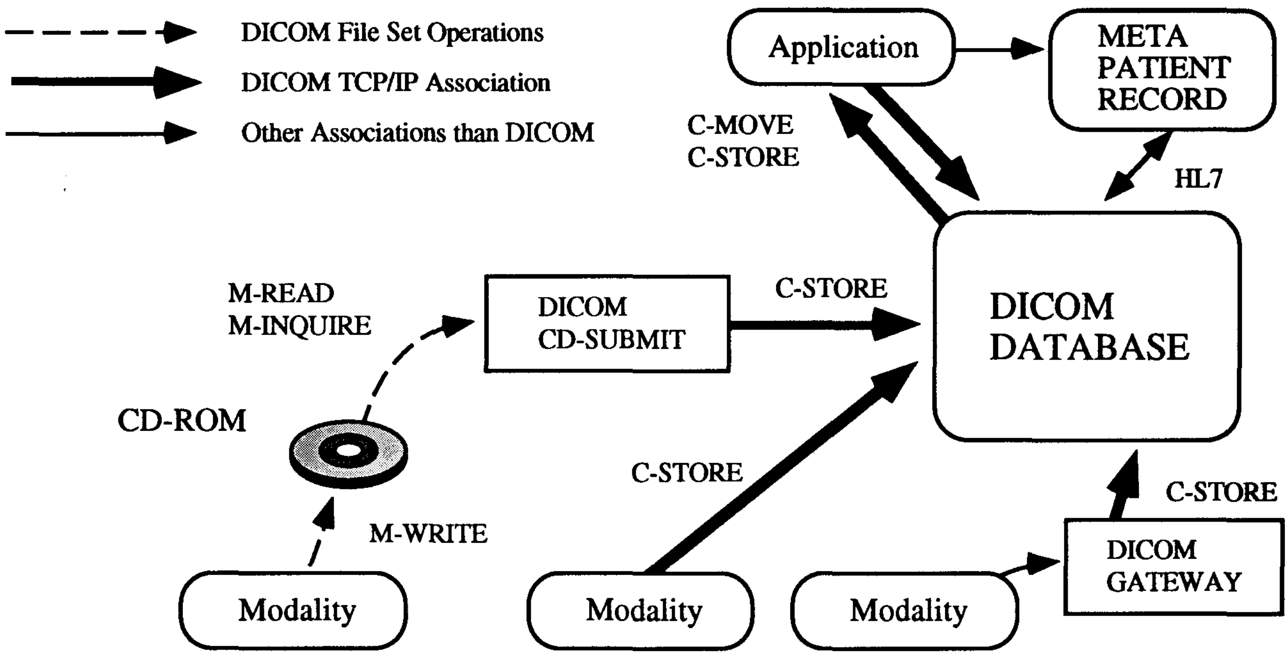

Figure 1: Environment Layout

ity was taken from the CTN implementation for RSNA [4]. Based on this, we added the required levels for dataset en- and decoding with all transfer syntaxes (implicit little endian, explicit little and big endians, lossy and lossless compressions) and the DIMSE-C services. A File Set Reader was implemented as well, including the interpretation of the DICOMDIR.

With this flexible software library, applications can easily be created or updated for DICOM usage. High level functions allow the complex data retrieval by C-MOVE, receiving the requested data by C-STORE, with a small number of function calls. The C-FIND service has not been implemented yet, since the administration of all data is performed by our MPR.

B. Transmission of Old ACR/NEMA Data Sets

Data as provided by conventional ACR/NEMA applications (e.g., by a spooler associated with a modality) cannot directly be used as a dataset of a DICOM 3.0 conformant message. We already met gateways from ACR/NEMA derivatives to DICOM, which simply delete or add some elements in the ACR/NEMA datasets and mask it as a Secondary Captured Object. Important information is still hidden in private elements, even if they could be stored in regular ones. In our opinion, modality data should not be submitted as Secondary Captured Objects. Even more, the original format should be retained. To submit ACR/NEMA datasets with DICOM 3.0, we published a new Storage SOP Class that allows datasets to be conformant to both standards [5].

C. Prototypic Implementation of a Database

To test the implemented modules and their behaviour in cooperation with other vendors, we developed a DICOM based database. It serves as a Service Class Provider for the Verification, Storage and Query/Retrieve Service Classes, and as a Service Class User for the Storage Service Class in response to C-MOVE requests. To satisfy requirements of access control, requesting applications are mapped for their Application Entity Titles on DICOM level, and for their hosts or networks on TCP/IP level. We have not focused on the implementation of the underlying database, because we were primary interested in the access mechanisms.

For a local access to the database, we added a HTTP-1.0 to DICOM gateway. Thus, the database may be accessed by common Hypertext-Browsers like Netscape. In addition to the security mechanisms on TCP/IP level, the HTTP access requires user authorization. This is controlled by temporary session and document instance UIDs, which seemed to be more appropriate than the use of the standard authentification mechanisms suggested for HTTP applications. Image data is retrieved from the dataset and transformed into GIF representation on request, or the database may be requested to move a dataset to another DICOM application entity (fig. 2).

III. Results and Conclusions

Our DICOM library has been successfully tested with applications of Siemens and Fuji (gateways), and the RSNA '95 Central Test Node. We have included DICOM modules into AVS (Application Visualization System™) for image data retrieval and for reading CD-ROMs directly. Currently, our MPR is completed by a DICOM interface. The image data is going to be stored in a Hewlett Packard archive, which provides DICOM and HL7 interfaces. Existing links in HL7 or proprietary formats for patient information are still active.

Our experience showed that DICOM applications must fit into existing and normally heterogeneous systems. All aspects of the DICOM standard have to be considered, the communication aspects as well as the archiving aspects. Relationships to other – already existing – components must not be impaired. Where a Hospital Information System (HIS) exists, e.g. as it is a part of our Meta Patient Record, the query of DICOM databases may be neglected. The knowledge about patients and images is kept in the HIS.

References

[1] ACR/NEMA 300-1985, and 300-1988: "Digital Imaging and Communications", National Electrical Manufacturers Association, Washington DC, 1985-89

[2] ACR/NEMA PS3.1-9 (199x): "Digital Imaging and Communications in Medicine (DICOM 3.0)", National Electrical Manufacturers Association, Washington DC, 1992-95

[3] ACR/NEMA/ACC PS3.10-12 (199x): "Digital Imaging and Communications in Medicine", Offline Storage, National Electrical Manufacturers Association, Washington DC, 1993-95

[4] RSNA and Washington University: "DICOM Central Test Node"; Mallinckrodt Institute of Radiology, St. Louis MO, 1993-94

[5] German Heart Institute of Berlin: "Old ACR/NEMA Format Storage", Conformance Statement Annex, 1996 (obtainable from the authors)

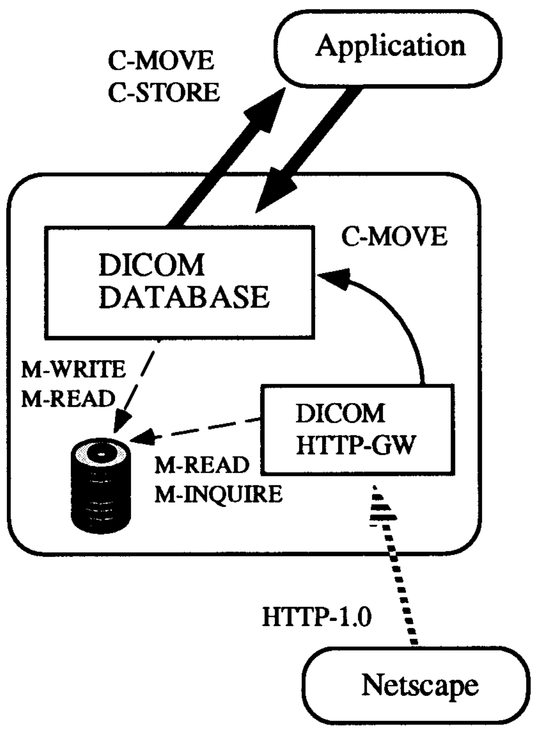

Figure 2: Database Prototype