Digital Imaging COmmunications in Medicine

DICOM in a Nutshell

Ben Gorissen
Philips Medical Systems Nederland B.V.
ICS - ARC
Presentation Overview

- Scope and Goal of DICOM
- Functionality (Services)
- Information Model and Objects
- Protocol, Client/Server and Negotiation Aspects
- Conformance Statements
- RIS Example
- Connectivity Versus Interoperability
- References
Healthcare Communication Standards

- Healthcare Insurance's: e.g. EDIfact
- General Practitioners: e.g. EDIfact

Hospital:
- Finance
- Laboratory
- Pharmacy
- Wards
- Treatment (RT)
- Cardiology
- ICU
- Radiology
- OR Surgery
- DICOM

Teleradiology to clinics
Different Domains in Radiology

- Hospital Admin.
- Radiology Admin. & Reporting
- Archiving
- Viewing/Processing
- Modality Acquisition
Why DICOM?

- Need for Digital Image Generation
- More need for Digital Transfer/Archiving (PACS)
- More need for Post-Processing
- More need for Cross-Vendor Compatibility
- Need for Communication via Networks/Media
**DICOM Goals**

By:
- Definition of Semantics & Syntax of Digital Images and Messages
- Definition of Conformance Requirements for DICOM Implementations

Arrange:
- Interchange of Medical Images and Related Data
- Create an Open Environment among Vendors
- Enable/Facilitate Interoperability
DICOM - ACR-NEMA

History:

• ACR-NEMA 1.0 and 2.0 in 1985 - 1988
• DICOM (3.0) first parts in 1993
• Continuous Development on DICOM (also with HL7)

DICOM (3.0) improvements w.r.t. ACR-NEMA 2.0:

• Networking and Connection Negotiation
• More then only Image Transfer
• Formal Conformance Statements
• More Complete/More Acceptance
Example of Equipment with DICOM Connection

Modalities

DICOM (Network)

Connection to other Network or Teleradiology

Printer

Viewing System/Workstation

DICOM Media

Digital Archive

RIS
Simple Services Example

- **Modality**
  - WORKLIST
  - RESULTS
- **RIS**
- **WORKLIST**
- **RESULTS**
- **Printer**
- **Workstation**
  - PRINT
  - STORE
- **Archive**
  - STORE
  - QUERY/RETRIEVE

**PHILIPS MEDICAL SYSTEMS**

9 /Ben Gorissen/ICS-ARC/March 1997/XPB080-970021.01
DICOM Functionality: Service Classes

- Archive/Transfer Images: Store (across network)
- Archive/Interchange Images: Media Storage
- Query for Information & Retrieve Images
- Make Image Hardcopies: Print Management
- Patient, Study & Results Management
- RIS-Modality: Worklist Management
- Test Connectivity: Verification
DICOM Application Model (Real World) - Simplified

- Patient
  - makes
  - has
  - comprised of
  
- Visit
  - includes
  
- Study
  - makes
  - contains
  
- Study Component
  - includes
  
- Series
  - contains
  
- Images
Query/Retrieve Models (Image Information)

- **Patient Root** (all levels from Patient downwards)
- **Study Root** (all levels from Study downwards)
- **Patient/Study Only** (all images dealt with implicitly)

Note, for naming in actual service requests:
- **FIND** is used often for Querying Information
- **GET/MOVE** is used often for Retrieving Images
Objects Definitions - (e.g. Images)

Information Object Definition

Attribute

Attribute

Attribute

Pixel Data

MR

CT

XA

US

Image Types
Attribute Types

- (1) Mandatory - Always Present with a Value
- (2) Mandatory - But allowed to be Empty
- (1C), (2C) Conditional - Type 1 and 2
- (3) Optional - also allowed to be Empty

Objects (e.g. Different Image Types) can have different Type specifications for the same Attribute. For example:
- $X,Y,Z$ Image Orientation for CT type 1, not in plain X-ray
- Image Type Generic type 3, for XA and CT type 1
Attribute Definitions (Data Dictionary)

- Attribute Name
- Tag (e.g. 0008,0102) - Hexadecimal
- Value Representation (VR): date, integer, patient name, ...
- Value Multiplicity: number of values must/may be present
- Description: semantics

Private Attributes may be defined by vendors, and are always Optional. Conflicts in Tags prevented by DICOM.
Services on Objects

SOP Class: a Method to Operate on an Information Object

Object

e.g. MR, RF Images

Service

e.g. Store, Query/Retrieve

SOP Classes

“Store an RF image”
“Find which studies there are for a patient”
“Retrieve all studies of a certain patient”
Unique Identifiers (UIDs)

- Identification Method which is World-Wide Unique.
- Unique Identifiers are defined for all SOP Classes. Important for the Conformance Statement.

Also, a Unique Identifier is given to all:
- Studies (Study Instance UID)
- Series (Serie Instance UID)
- Images (SOP Instance UID)

These UIDs are for instance used for Retrieval.
Client/Server Concept

Application (Entity) A

User

"Store this Image Please"

Service Request

Response

Application (Entity) B

Provider

"Image has been stored"

Objects
**SCU/SCP Roles**

- Client is called “SCU” (Service Class User)
- Server is called “SCP” (Service Class Provider)

**Application Entity “A”**

1. Store my Image “X” on your system

**Application Entity “B”**

2. Storage of Image “X”

3. Done Successfully
SCU/SCP Role Combined

- A system is not limited to 1 role,
  It can be SCU and SCP both

1. Application Entity “A”
   Move Image “X” from Application “B” to “C”
   - Done Successfully

2. SCU
   Store Image “X”
   - Done Successfully

3. SCP
   Application Entity “C”
   Storage of Image “X”

4. SCP
   Image “X”

5. SCU
   Application Entity “B”
   - Done Successfully
DICOM - Can we Communicate?

System A

```
Implemented
Implemented

Unimplemented
Unimplemented
```

System B

```
Unimplemented
Implemented
Implemented
```

"Full" DICOM set SOP Classes

?
Association Handling

First:
- Initiate a Connection

Then Agree on:
- Which SOP Classes are to be used
- Client and Server Roles (SCU/SCP)
- Encoding (Transfer Syntax)
- Other Communication Parameters
Connection Identification required per Layer

- Medical Imaging Application
- DICOM Application Message Exchange & Upper Layer Protocol
- TCP/IP
- Physical layer ETHERNET, ATM, etc.
- Networked environment

**Application Entity Title**
- Unique for each Application in the Network

**Listen Port**
- Only relevant for SCPs SCU must configure this to send to
- Unique for each System in the Network

**IP Address**
- Only relevant for SCPs SCU must configure this to send to
- Unique for each System in the Network

**Note:** The host name is only for local reference on a system
Association Handling

• Which SOP Classes are supported by each system

• Client and Server Roles (SCU/SCP)

• Encoding (Transfer Syntax’s)
  Implicit Little Endian (DICOM default)
  Explicit Little Endian (attribute type added)
  Explicit Big Endian (byte swapped if necessary)
  JPEG Lossless
  JPEG Lossy (information loss)

• Maximum Package Size to be used
• Number of Associations Supported (by SCU and SCP)
Conformance Statement

• **Mandatory Document for all DICOM compliant systems**
  Request the document for all systems to connect with

• **Used to Check if/what level of Connectivity is possible**
  Compare list of Supported SOP Classes
  Compare list of Supported Transfer Syntax’s
  **BEFORE actual installation**

• **Retrieve Connection and Configuration Information**
  of the systems to connect to

• **Check for Extensions and Limitations**
### Conformance Statement - Example

#### SOP Classes supported as SCU

<table>
<thead>
<tr>
<th>Class</th>
<th>Syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR Image Storage</td>
<td>1.2.840.10008.5.1.4.1.1.4</td>
</tr>
<tr>
<td>CT Image Storage</td>
<td>1.2.840.10008.5.1.4.1.1.2</td>
</tr>
<tr>
<td>Patient Root Model Query</td>
<td>1.2.840.10008.5.1.4.1.2.1.1</td>
</tr>
<tr>
<td>......</td>
<td>......</td>
</tr>
</tbody>
</table>

#### Proposed Presentation Contexts

<table>
<thead>
<tr>
<th>Class</th>
<th>Syntax</th>
<th>Implicit Little Endian</th>
<th>Explicit Little Endian</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR Image Storage</td>
<td>1.2.840.10008.5.1.4.1.1.4</td>
<td>1.2.840.10008.1.2</td>
<td></td>
</tr>
<tr>
<td>MR Image Storage</td>
<td>1.2.840.10008.5.1.4.1.1.4</td>
<td>1.2.840.10008.1.2</td>
<td></td>
</tr>
<tr>
<td>......</td>
<td>......</td>
<td>......</td>
<td>......</td>
</tr>
</tbody>
</table>
DICOM Developments

- Security
- Reporting
- Storage Commit
- Print Storage
- New Image SOP Classes (e.g. RT and endoscopy)
- Extension of Standardization of Data Elements
- Display Standards (Image Quality)
- More focus on Interoperability
- Coupling with HIS/RIS World (e.g. HL7)
An Example - RIS Connection

- Non-Image Information:
  - Worklists
  - Requests
  - Reports
  - Patient Data
  - Bills

- Image Data:
  - Modality
  - Archive
  - Workstation

- Worklists:
  - HIS
  - RIS

- Requests:
  - HL7

- Reports:
  - DICOM

- Patient Data:
  - Workstation

- Bills:
  - Workstation
RIS Connection Models - 1

- **RIS Controlled** Connection (e.g. RIS-PACS)
  - Events by RIS (e.g. with UID values)
  - GET by e.g. PACS detailed information from RIS

- Detached Patient/Study/Results Management SOP Classes
RIS Connection Models - 2

- Modality Initiated Information Retrieval
  - Query by Modality
  - RIS provides information in Query Response

- Worklist Management SOP Class
Worklist Management - Query

1. Start new Exam
2. Query for Worklist Modality
3. Receive Worklist
4. Select Patient from Worklist

- Patient Name
- Patient ID
- Patient Sex
- Patient Birth Date
- Accession Number
- Study data
Results Management

Study Component: contains produced image as reference (no image data)

New “Performed Procedure Step” (extension Study Comp.) also includes X-ray dose, material used, contrast used, etc.
Connectivity Vs. Interoperability

Connectivity:
- DICOM conformance
- Matching Conf. Stmnts.

Inter-Operability:
- DICOM conformance
- Matching Conf. Stmnts.

**NOT guaranteed by DICOM**

Applications
- Acquisition, . . .
- MPR, 3D, . . .
- Acquisitions, . . .

Objects - Services
- send MR image
- receive MR image

Messages

Protocol

PHILIPS MEDICAL SYSTEMS
©1996 Philips Medical Systems Nederland B.V.
Application Interoperability Check

Applications can **Require** (!):

- Optional Attributes
- Private Attributes (not in DICOM Standard)
- Private SOP Classes (not in DICOM Standard)
- Special Semantics of Attributes/Special Rules for Usage

Thus, we need a **Detailed Description** of:

- Required Application Functionality
- Required Attributes for this

**Verify Interoperability** on before-hand
DICOM Standard about Interoperability

DICOM Part P.S. 3.1 - “Goals of the DICOM Standard”:

“Even though the DICOM Standard has the potential to facilitate implementations of PACS solutions, use of the standard alone does not guarantee that all the goals of a PACS will be met. This standard facilitates Interoperability of systems claiming conformance in a Multi-Vendor environment, but does not, by itself, guarantee Interoperability”
Further Information

Internet Sites for more General DICOM Information:
- http://www.nema.org/nema/medical/dicom
- news://comp.protocols.dicom

Philips Medical Systems specific Information:
- http://www.philips.com/ms/solution/connect
- ftp://ftp.philips.com/pub/ms/dicom/Medical_Images