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A Practical Guide to DICOM

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Preface

This handbook is about DICOM- the standard for digital imaging and communications in medicine, and has been designed as a ready-reference for those who need a clear source of information about the standard, but do not require highly technical information.

Contents: A Practical Guide to DICOM

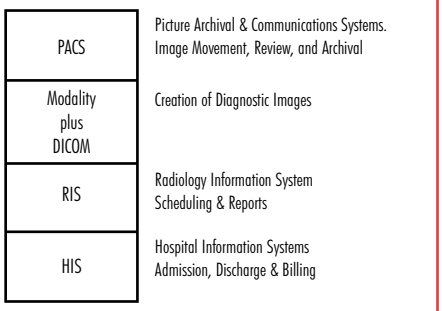
Introduction

Two types of information systems are widely used in healthcare facilities. A Hospital Information System, or HIS, is designed for managing the data associated with admission, discharge and billing. When a patient is admitted to a facility, his or her information is entered here. A Radiology Information System, or RIS, manages the scheduling of imaging exams and manages the reports generated after the exams.

Two other elements are involved in the flow of imaging information:

- Modalities [for example, CT and MR scanners] create images when exams are performed; and
- PACS — picture archiving and communication systems — receive, archive and deliver images on demand to review stations where reports can be generated.

Relevant Info Systems in Radiology



Important Information Standards

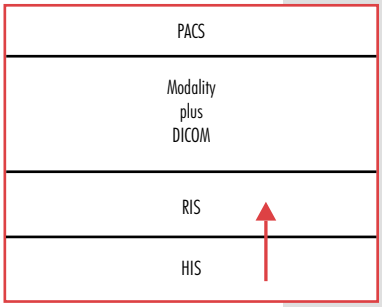
Information flow within a medical facility is a complex process involving equipment, hardware and software from many vendors. Communication among the various devices and programs is facilitated by the use of data standards.

Two different standards impact the flow of information relative to imaging modalities and procedures.

HL7 is the standard that facilitates communication and transfer of information between the hospital information system [HIS] and the various department information systems, such as the radiology information system [RIS] and the

laboratory information system [LIS]. Through use of this standard, patient information, demographics, payer and other data are entered in the facility's HIS and sent to various department systems, including the RIS when appropriate. This process eliminates the need to capture and re-enter the data on individual department systems.

DICOM is the standard that facilitates communication and transfer of information within the radiology function and enables communication among devices made by various vendors.



Information flows from the HIS to the RIS through HL7.

What is DICOM?

DICOM is an acronym that stands for Digital Imaging and COmmunications in Medicine. DICOM is a standard developed jointly by the American College of Radiology (ACR) and the National Electronics Manufacturer's Association (NEMA). Its use enables devices that create or handle medical images to exchange those images and/or related information.

DICOM version 3.0 (also known as DICOM 3) was released in 1993 and is the current standard. "DICOM" is synonymous with DICOM 3.0 as there were no previous versions named DICOM 1.0 or DICOM 2.0. However, before DICOM 3.0, the standard had a different name; it was called the ACR/NEMA standard 2.0.

DICOM 3 is widely used today by most vendors. Although the standard itself has not changed, 23 supplements have been added to address technological changes and needs arising since the original standard was prepared. These supplements extend the functionality of DICOM to many types of digital imaging communications.

What Does DICOM Do?

DICOM specifies **types of communications** called **DICOM Service Classes**. The functionality of DICOM is expanded when service classes are added and/or augmented.

DICOM also specifies the **types of data** to be sent, and the **format** for that data. These are called **DICOM objects**. For example, a DICOM object called CT is a specific data format for transmitting CT data.

How Do Vendors Implement DICOM?

Because DICOM covers almost every aspect of information transmission relevant to radiology, **no one vendor** has implemented every Service Class that DICOM offers. Each vendor chooses to implement a subset of the DICOM services that will increase the functionality of its particular systems. This does not reflect a limitation inherent in the standard, but a reality of the design and capability of individual medical devices. For example, a CT scanner does not need to be a laser camera too, so the CT scanner only meets requirements of those DICOM Service Classes that are aligned with its purpose.

- DICOM is a standard that allows devices manufactured by **different vendors** to communicate with each other.
- It allows for the exchange of digital images so that they can be created, archived, viewed or printed.
- It also allows for the exchange of other information like patient demographics, exam scheduling and exam reporting.

This leads to an important point.

- Because there are multiple Service Classes it is not appropriate to say that a system is "DICOM compliant."
- It is more accurate to identify for each system whether it does or does not support a particular Service Class.
- It is important to understand what Service Classes each system supports if systems are expected to communicate with each other, share data and images or print hardcopies.
- Understanding how DICOM is used in imaging equipment is important whether or not a facility has invested in a PACS.

What is a Service Class User and a Service Class Provider?

Two capabilities are important in understanding SCU and SCP and the communication capabilities of individual imaging technologies.

- For any particular Service Class a piece of equipment may be able to support only SCU, only SCP or both SCU and SCP.
- During any single DICOM communication, a particular piece of equipment will act only as an SCU or an SCP, but never as both.

When one piece of equipment is providing a DICOM Service to another piece of equipment, there is a DICOM communication involving two participants: a **user** of the service and a **provider** of the service. This is the origin of the terms **Service Class User [or SCU]** and **Service Class Provider [or SCP]**.

As an analogy, consider the situation when you dial up your Internet Service Provider. You initiate a call from your device [your computer or digital assistant, for example] and request use of the Internet service. You are therefore a service user. Your Internet Service Provider responds to your call and provides an access service. It is a service provider. The same holds true for a DICOM exchange.

Example: DICOM Service Class *Store*

Here a modality [CT, x-ray, etc.] usually supports DICOM Store as an SCU (user) only, and a PACS usually supports DICOM Store as an SCP (provider) only. In the DICOM communication that stores images on a PACS, the modality **"uses"** the storage on the PACS, and the PACS **"provides"** it.

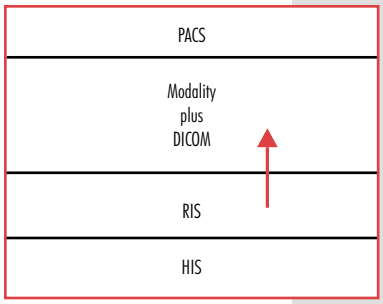
Example: DICOM Service Class *Query/Retrieve*

Suppose a modality like magnetic resonance [MR] supports Query/Retrieve as an SCU and an SCP. That is, it both **provides** images to users and it **uses** images from storage. With this dual role, two scanners could communicate in the following way: MR scanner #1 working as an SCU, sends a Query/Retrieve to MR scanner #2, acting as an SCP. Then, MR #1 queries and retrieves data from MR #2 back to itself. Because both scanners support SCU and SCP for Query/Retrieve, the communication also works in the opposite direction. MR #2 acts as an SCU to Query/Retrieve images from MR #1, which acts as an SCP.

What Are DICOM Service Classes?

There are seven service classes relevant for medical imaging modalities. These are defined in the following sections.

1. Verification
2. Modality Worklist Management
3. Performed Procedure Step [PPS]
4. Store
5. Storage Commit
6. Print
7. Query/Retrieve



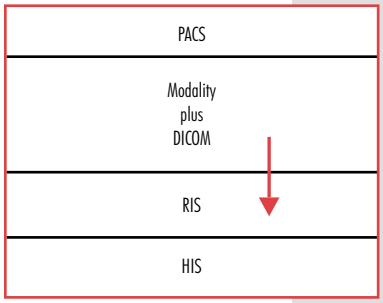
Information flows from RIS to modality through the DICOM service class 'Modality Worklist Management'.

Verification

It is useful to have a communication protocol for each device on a network to ensure that any particular device is properly connected before communication begins. If a device supports Verification SCU, it can "ping" other devices as a user to initiate a DICOM communication. If a device supports **Verification SCP**, it can receive a "ping" from another device to ensure it is ready to provide a requested service.

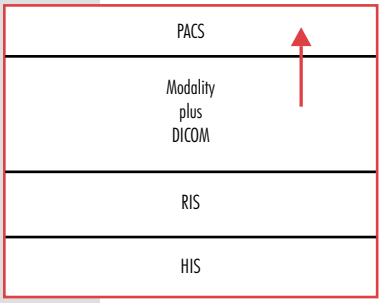
Modality Worklist Management

The DICOM service class **Modality Worklist** Management manages the flow of information from the RIS to the individual modality. Using this service class, the RIS can electronically schedule an exam on the modality. Here, the RIS acts as an SCU and sends the scheduling request, and the modality acts as an SCP and provides the scheduling information.

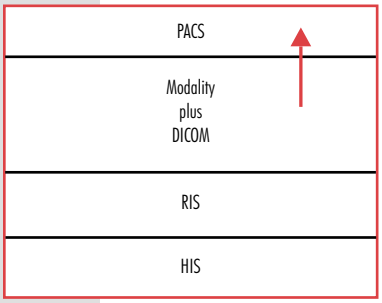


Information flows from modality to RIS through the DICOM service class 'Performed Procedure Step'.

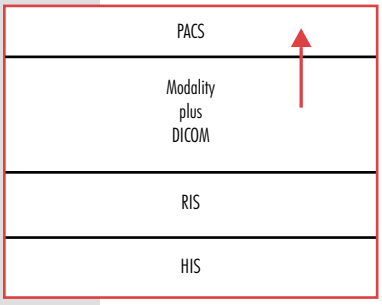
What Are DICOM Service Classes?



Information flows from modality to PACS through the DICOM service class 'Store'.



The modality knows that the images are archived on PACS through the DICOM service class 'Storage Commit'.



Images are printed in DICOM through the DICOM service class 'Print'.

Performed Procedure Step

Once the exam has been performed, the modality uses the DICOM service class **Performed Procedure Step [PPS]** to communicate to the RIS that the exam is completed. The modality, acting as a sender or SCU, informs the RIS that the exam has been performed, and that the report should be available sometime in the future. Here, the RIS is the receiver or SCP.

Store

The modality can send the images from the procedure to a picture archiving and communications system [PACS] for review and archival by implementing the DICOM Service Class called **Store**. In this case, the modality is the SCU, and the PACS the SCP, providing a storage service to the modality.

Storage Commit

Once the modality has sent images to the PACS it is important that the sending modality "know" that some other device has taken ownership of the images so the originating modality can free up local disk space by deleting those images. Using DICOM **Storage Commit**, the modality "transfers" ownership of the images to the PACS and knows they are now stored safely there.

Print

For a variety of reasons, the healthcare facility requires printed images in addition to digital images. Most PACS support printing on their networks when the modality implements DICOM **Print**. A modality can also print to a DICOM printer network whether or not there is a PACS available.

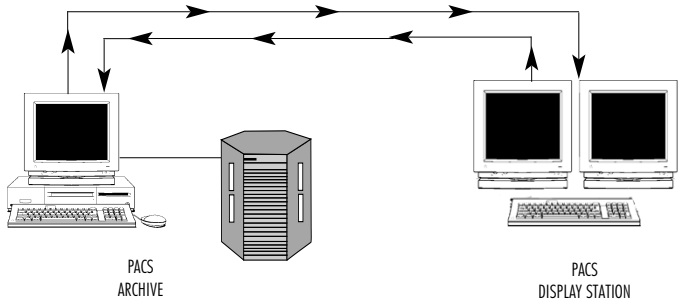
Query/Retrieve — Display Station/Archive Exchange

This function relates to an exchange between a display station and the archive. The picture or image is stored on a PACS archive. This archive is usually a server that manages the database using two tools: a local disk to store recent exams, and a jukebox for long-term archive of older exams. The images are communicated to display stations distributed in radiology or wherever else they are required.

When a user accesses a PACS display station and calls up an exam for review, the display station will call up the exam by executing a DICOM Query/Retrieve communication with the archive. This communication process is transparent to the user who simply sees the images pop up on the screen. To retrieve images, a review station will query the archive and retrieve images from there. Here, the display station acts as an SCU; the archive acts as an SCP

Query/Retrieve

Display Station/Archive Exchange



What Are DICOM Service Classes?

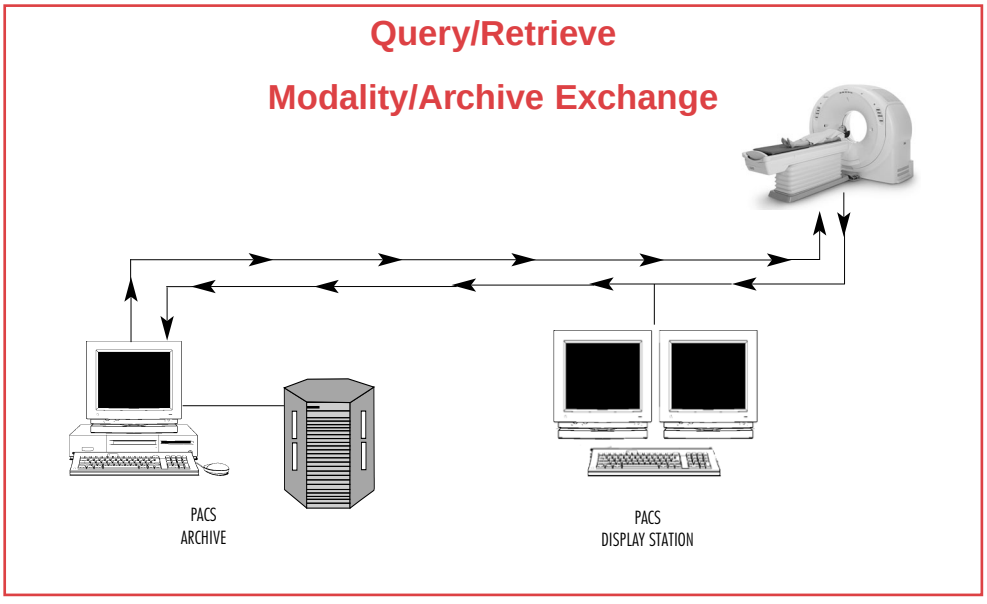
Query/Retrieve — Modality/Archive Exchange

Query/Retrieve processes are used among modalities and between a modality and the archive to retrieve information stored in a PACS or on another system [for example, one of several CT scanners the facility may use].

A modality may support DICOM **Query/Retrieve**. This process is valuable when a user wants to look into a PACS archive and retrieve a patient's historic study data from the PACS back to the modality for comparative purposes.

If a modality supports Query/Retrieve SCU and a PACS archive supports Query/Retrieve SCP, the modality can look into the PACS and pull these stored images.

As a similar example, if a CT scanner supports Query/Retrieve SCU and another CT scanner supports Query/Retrieve SCP, the first can pull studies from those stored on the second. If both scanners support both Query/Retrieve SCU and Query/Retrieve SCP, then these scanners can exchange studies.



What is a DICOM Object?

Medical images are not the same: CT, MR and x-ray images, for example, differ in image size (e.g., 512 x 512 for CT, versus 256 x 256 for MR) and acquisition parameters. Different text may accompany the images depending on the modality. DICOM allows for these differences by defining **Objects** for each modality. There are many types of image objects within DICOM to reflect the variety of images available for use today.

Defining images via DICOM objects lets the receiver know what's in the DICOM package before it's opened. In this way, the user knows how to open the image package and what to look for when the image is open.

DICOM Object	Stands for
• CR	- Computed Radiography Imaging
• CT	- Computed Tomography Imaging
• MR	- Magnetic Resonance Imaging
• NM	- Nuclear Medicine Imaging • There is both an old and a new version
• SC	- Secondary Capture Imaging
• US	- Ultrasound Imaging • There is both an old and a new version
• US multi	- Ultrasound Multi-fame Imaging
• XA	- X-Ray Angiographic Imaging
• XA bi	- X-Ray Angiographic Bi-Plane Imaging
• XRF	- X-Ray Radiofluoroscopic Imaging

Commonly Used DICOM Objects

What is a DICOM Service Object Pair?

The **Service Object Pair [SOP]** tells the user what service class the modality supports and with what DICOM objects [image types] it works. The specification for a device presents three elements of DICOM information: the service class, the role and the service objects it supports.

Example for CT Scanner

For example, if a CT scanner supports DICOM Store as a Service Class User [SCU], you would expect it to only send CT data. Then in the spec, you would see the following information presentation:

Service Class	Role (SCU, SCP)	SOP
Store	SCU	CT

Example for PACS

However, for a PACS archive, which is expected to store all kinds of modalities, the spec would be something like this:

Service Class	Role (SCU, SCP)	SOP
Store	SCP	CT, CR, MR, NM, SC, US, US multi, XA, XRF

What is an Instance UID?

Computers speak only in numbers, not in words. An **instance UID** is a unique ID number associated with a manufacturer's product that defines a DICOM communication numerically. This numeric identification is used instead of words like "Toshiba OPART - DICOM Store - SCU - MR Object."

As one example, for the OPART's DICOM Store function, DICOM specifies a unique ID number of 1.2.840.10008.5.1.4.1.1.4. Only technical experts will need to look for this number.

Summary of DICOM

DICOM is a communication standard that is implemented by manufacturers of products used in medical imaging. Its various elements are not all applicable to each type of equipment; therefore, it is simplistic to say that any piece of equipment or model is "DICOM Compliant."

Radiology professionals need to understand some elements of DICOM in order to interpret its relevance for a particular product need or setting. The information required for this purpose is straightforward and has been detailed in this handbook.

DICOM specifications for a device tell us what **class of service** it supports [there are seven classes], what **roles** it plays [user, provider or both] and what **objects** [modalities] it supports. With these three pieces of information, the relative communication and connection capabilities of devices can be assessed, and appropriate selections made for the imaging department or facility.

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