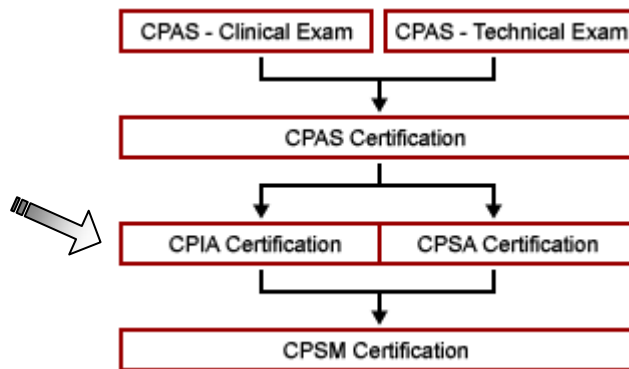


0 INTRODUCTION

This Study Guide is meant for students who are currently employed or are looking to become employed as a PACS Interface Analyst. It covers all of the Digital Imaging Communications in Medicine (DICOM) technical interfacing skills that are highly desired for these professionals to do their job in a proficient manner. There is a companion guide, called HL7 and IHE Component which, together with this guide, can be used to study for the CPIA certification as provided by PARCA, which fits as shown in the figure below.



This guide is based predominantly on the material contained in the following sources¹:

1. Book: OTech DICOM Basics by Mr. Herman Oosterwijk
2. CD : Introduction to DICOM (D-101)
DICOM Services (D-102)
DICOM Conformance (D-103)

¹ Available from www.otechimg.com

The Study Guide Map located at the end of the book lists all the topics that are covered by this guide and also contains the reference numbers of specific PARCA certification requirements. For certain topics, there is no direct PARCA corresponding requirement. They are nonetheless included in the guide so that a student/reader can cover study material in a more comprehensive fashion.

The guide is meant for people with either an IT or clinical background who need to familiarize themselves with the DICOM interfacing and standards required in the context of PACS. This guide covers the assessment of knowledge and skills with regard to DICOM basic concepts, architecture, message structure and objects, information model, SOP Class concept, networking, negotiation, the various DICOM services, image quality, media, conformance statements and troubleshooting.

0.1 How to Use the Guide

While preparing this guide, it is assumed that the user of the guide will have first gone through the above-referred CD's and textbook, as it provides an overview of the entire relevant subject matter. No previous knowledge of DICOM is required and/or assumed for this study guide. However, many clinical concepts, knowledge about certain modalities, and assumptions about familiarity with certain workflow concepts in an imaging department are made. Therefore, it is highly recommended that students have a basic clinical and IT knowledge, such as can be achieved by getting certified as a PACS Associate (CPAS).

Thereupon, a reader can use this guide to specially focus on topics that are relevant for his or her specific curriculum, and/or the PARCA examination by following the contents of this guide and reviewing the material, which is referred to on the CD and in the book. By doing so, the reader will cover all of the topics that are required for the CPIA DICOM component certification examination.

The durations as stated for each section are the estimated durations for a diligent reader of the relevant material. The time that a student may actually take to "learn" the material may vary depending upon a person's individual capability of grasping the content and previous knowledge (if any).

The reader is also encouraged to test his/her learning by downloading sample examination question papers from the certification website, e.g., PARCA, and to use these to evaluate the progress that he/she is making towards the certification requirements.

The guide also includes various exercises. These exercises are meant to be assignments that PACS System Administration professionals might be faced with in real-life work situations, and/or include terminology that might be used by vendors, IT personnel or other PACS committee members. These are most effective when performed individually and then discussed with a peer group and/or study group. There are not necessarily "correct" answers to these exercises. They are mostly meant to start the thinking process. Students/readers are strongly encouraged to attempt these exercises diligently because it will enforce the learning experience.

Last but not least, students are highly encouraged to do some experimenting with establishing DICOM connections, exchanging basic commands such as for exchanging images and inspecting the protocol exchange and evaluate header information. The last chapter provides two exercises to allow students to do this. In addition, each section has a set of test questions measuring whether the information has been retained.

<p>Note: Answers to the test questions and suggested answers to the exercises appear at the end of the guide.</p>

1 DICOM OVERVIEW



6 Hours

Overview

Over the years, DICOM has evolved into the de facto standard used by various medical imaging devices (modalities) and information systems that exchange image related information. The DICOM standard is administered by the DICOM Standards Committee, which works in collaboration with other healthcare entities such as the HL7 Standards Organization. The DICOM standard involves the use of objects, called Information Objects, and services performed using such objects. The Object and the Service collectively make up a Service Object Pair. DICOM services involve the use of DICOM protocols, which define the rules and commands used for communication between different devices and systems using DICOM. It would be accurate to say that DICOM has gotten a very important position in the area of medical imaging and virtually every vendor that makes equipment/systems in this area would need to conform with the standard in some form or fashion.

Section Learning Objectives

At the end of this section, the reader should:

- ★ Get an introduction to the DICOM standard and its history.
- ★ Know the most important DICOM Services and protocol.
- ★ Understand the relationship between DICOM and PACS workflow.
- ★ Understand the different levels or functionality at which DICOM Services can be provided.
- ★ Know how and why to use the various parts of the DICOM standard specification.

1.1 DICOM Architecture and Background



2 Hours

1.1.1 Learning Objectives

DICOM has been defined based on the ACR-NEMA standard; it has implicit version control through its negotiation mechanism. Know the relationship with ACR-NEMA and occurrence of "retired" attributes and services, as well as meaning of DICOM 3.0.

1.1.2 Study Assignments



Introduction to DICOM (D-101)



DICOM Basics, Pages 11-14, 16-18, 42

1.1.3 Key Terminology

DICOM (Digital Image and Communications in Medicine) Standard	
American College of Radiology (ACR)	
National Electrical Manufacturers Association (NEMA)	
ACR	
NEMA Standard	
CEN WG's	
DICOM 3.0	
MIME	

1.2 Common Issues & Why is DICOM So Complicated



1 Hour

1.2.1 Learning Objectives

“DICOM is not always DICOM,” it deals with interconnectivity, not interoperability. Many vendors use proprietary data elements in the image header, there are issues with missing attributes, as well as the use of interface boxes, and many optional features in the standard. Know the limitations and issues with the DICOM standard, most frequent problems and misconceptions.

1.2.2 Study Assignments



DICOM Conformance (D-103)



DICOM Basics, Pages 14-16

1.2.3 Key Terminology

DICOM Specific Language	
Concepts	
Object-Oriented Programming	
Information Objects	
Service Classes	
Service Object Pair (SOP) Classes	
Instance	
DICOMDE	

Stock keeping Unit	
Interface Box/Gateway	

1.2.4 Summary

- DICOM uses a specific language and concepts common in the Object-Oriented Programming world of software engineering.
- The standard itself contains several parts that are rarely or never used, some of them being “retired.”
- Objects in DICOM are called Information Objects.
- DICOM defines Service Classes (e.g., Storage) which groups Service Object Pair (SOP) Classes (e.g., CT Storage, NM Storage, etc.).
- The DICOM standard is for the most part, being used for medical imaging.
- DICOM is starting to be used for manufacturing engineering, called DICOM-DE as well as for Veterinary applications.
- Gateways and/or interface boxes are used to convert proprietary and/or non DICOM compatible devices to DICOM.
- The DICOM standard has many optional features which might cause incompatibility.

1.2.5 Exercises

1. How would one connect an old Nuclear Medicine device which supports the Interfile format to PACS?
2. What are some of the extensions of DICOM outside human imaging and what might be issues with these implementations?
3. What could be an issue if you find out that a device uses a “retired” SOP Class?

Notes:

1.3 The Different Dimension of the DICOM Standards



1 Hour

1.3.1 Learning Objectives

DICOM can be considered as having several levels. The most fundamental level is the support of an image exchange for both senders and receivers. Other levels include support for connecting to a database and retrieving image information or for enabling other devices to determine which images have been stored locally so that it can retrieve them. Different dimensions deal with image and information management, imaging integration, image quality, media storage and security.

1.3.2 Study Assignments



DICOM Basics, Pages 25-28

1.3.3 Key Terminology

Different Levels	
Verification	
Exchange Objects	
DICOM Storage Services	
Image Exchange	
Orphan Images	
Broken Studies	
QA Station	
Central Data Entry	

DICOM Modality Worklist (MWL)	
Scheduling	
Ordering	
Patient Demographic Information	
Modality Performed Procedure Step (MPPS)	
Procedure Communication	
Scheduling List	
Number of Images Generated	
Radiation Dose Management	
Storage Commitment (STC)	
PACS Takes Control	
Image Quality	
Consistency in the Image Presentation	
Imaging Integration	

Key Images	
Security Mechanisms	
Authorization Rules	
Audit	
Unauthorized Data Access	

1.3.4 Summary

- ❑ The DICOM standard provides many different services, each for a very specific purpose and these services can be of different levels or “dimensions” which when used in concert can provide an integrated digital imaging environment.
- ❑ The first level is the mechanism to exchange information by checking the presence of the other device (Verification) and exchange objects, such as images, using the DICOM Storage Services (Store).
- ❑ New imaging acquisition techniques require that all of the appropriate information be exchanged specific to those modalities; this causes additional DICOM Storage services to be defined continuously.
- ❑ The next level of DICOM deals with Image and Information Management.
- ❑ As people started to exchange images, the users found out they needed a PACS system administrator, dealing with “orphan” images. These are the ones that are lost, or being temporarily stored in the “broken” studies area at the archive or QA station.
- ❑ Central data entry and management and DICOM Modality Worklist (MWL), allows the scheduling, ordering and patient demographic information to be retrieved at a modality.
- ❑ The companion service of the Modality Worklist is the Modality Performed Procedure Step (MPPS) which allows a device to communicate what the exam performed actually was, to allow changes in the procedure to be communicated.
- ❑ MPPS also communicates when a procedure has been started, provides information about the number of images generated and provides radiation dose management
- ❑ Image quality is another dimension which achieves consistency in the image presentation.
- ❑ A “gold standard” is the Grayscale Standard Display Function (GSDF) for every monitor and hardcopy device, specifying exactly what luminance or density level would be produced for specific input values. This standard achieves consistency of grayscale presentation, potentially implementing a so-called presentation Look Up Table to map the values.

1.4 Road Map to Read the DICOM Standard



1 Hour

1.4.1 Learning Objectives

The DICOM standards are continuously evolving. Know the different parts of the DICOM standard and which ones are used for what part of the specification.

1.4.2 Study Assignments



DICOM Basics, Pages 18-22

1.4.3 Key Terminology

Part 1 – Overview Basic Concepts	
Part 2 – DICOM Conformance	
Conformance Template	
Part 3 – DICOM Objects	
Part 4 – Service Classes	
Part 5 – Data Structures	
Value Representations	
Part 6 – Data Dictionary	

Part 7/8 – Messaging Interface and Protocol	
Part 9 – Point-to-point Communication	
Part 10 – DICOM Media Exchange Format	
File Format	
Part 11 – Application Profiles	
Part 12 – Physical Media	
Part 13 – Point-to-point Communication	
Part 14 – Image Quality	
DICOM Grayscale Standard Display Function	
Part 15 – Security	
Part 16 – Codes	
Templates	
Part 17 – Explanatory Information	
Part 18 – WADO	

1.4.4 Summary

- ❑ The DICOM standard consists of several parts or sections, each one addressing a specific component of the standard.
- ❑ Part 1 provides an overview, explains some basic concepts, and is a good start when new at the DICOM standard. It also explains what is contained in the various parts, and their relationship to one another.
- ❑ Part 2 specifies DICOM conformance and deals with what DICOM conformance a product should comply with and gives a template with several examples of a typical DICOM Conformance Statement.
- ❑ Part 3 is considered as the heart of the standard and specifies the DICOM objects (image “headers”), and the type definition for each individual data element,
- ❑ Part 4 of the standard specifies the Service Classes. It describes all DICOM services, e.g., Print, Storage, Modality Worklist, etc.
- ❑ Part 5 contains the Data Structures that specify the value representations of the individual attributes covered in Part 6. Part 5, along with Part 6, supports Part 3.
- ❑ Part 6 contains the data dictionary which has a list of all individual attributes used to construct DICOM Objects.
- ❑ Part 7 and Part 8 deal with messaging and the interface of DICOM with the standard communication protocol (TCP/IP).
- ❑ Part 9 details the point-to-point communication that uses the 50-pin connector as defined by the DICOM predecessor (is retired).
- ❑ Parts 10, 11 and 12 deals with the DICOM media exchange format. Part 10 specifies the file format, including the directory structure. Part 11 contains the specific application profiles, which are defined for applications such as cardiology, ultrasound, etc. Lastly, Part 12 defines the physical media.
- ❑ Part 13 was defined early in the DICOM standardization process to standardize a point-to-point print protocol, and is retired.
- ❑ Part 14 deals with image quality. It contains the DICOM Grayscale and Color Standard Display Function, which maps the pixel values into standard range of luminance values for softcopy display and density values for hardcopy such as film.
- ❑ Part 15 contains security as defined in DICOM.
- ❑ Part 16 contains all the codes and structured reporting templates.
- ❑ Part 17 contains detailed information on how the SOP Classes might be used, often in the form of use-cases.
- ❑ Part 18 contains the WADO or Web Access to DICOM Persistent Objects definition.

1.4.5 Exercises

1. Which part would you use to look up the values that an Attribute can contain?
2. Where do you find what image objects you can write on a DICOM CD?
3. How would you find the information to validate the output of a modality, e.g., what should be stored in the image header?

1.5 DICOM Services and Protocol



1 Hour

1.5.1 Learning Objectives

DICOM consists of a protocol, which provides negotiation, commands, rules and data elements. DICOM offers an integrated environment which will facilitate an efficient workflow. Know how DICOM facilitates workflow.

1.5.2 Study Assignments



DICOM Basics, Pages 23-25, 28-30

1.5.3 Key Terminology

DICOM Services	
DICOM Protocol/Set of Rules	
Negotiation	
Two-step Process	
Relationship Between Entities	
Information Model	
Efficient Workflow	
Achieve Interoperability	
Typical Scenarios	

Selecting Patient Information	
Retrieving Prior Images	
Starting Procedure	
Sending Images	
Updating Exams	
Reading Study	
Making Image Available for Physician	
Creating Hardcopy	
Making Images Available for Primary Care Physician	

1.5.4 Summary

- ❑ The DICOM services use the DICOM protocol, which consists of a set of rules necessary for communication. This includes commands and an agreement about the meaning of the message.
- ❑ A protocol is a set of rules that all communication parties abide by, so that communication can occur effectively.
- ❑ The DICOM protocol consists of a two-step process, i.e., communication of the information which will be exchanged and actual information exchange.
- ❑ Negotiation is critical to ensure that the receiver can indeed understand and interpret the information.
- ❑ Relationship between entities is defined in the information model which might, for example, define that one should be able to support multiple procedures as part of a single study.

TEST QUESTIONS

DICOM Overview

1. On which standard is DICOM based?
 - a. DOD
 - b. ACR-NEMA
 - c. MEDIS-DC
 - d. HHS-VA

2. In DICOM, the Client is known as _____.
 - a. Service class user - SCU
 - b. Service class provider- SCP
 - c. DHCP
 - d. None of the above

3. In DICOM, the Server is known as _____.
 - a. Service class user - SCU
 - b. Service class provider -SCP
 - c. DHCP
 - d. None of the above

4. Objects in DICOM are known as _____.
 - a. Information model
 - b. Service object pairs
 - c. Service class information
 - d. Information objects (IOD)

5. Level 3 of DICOM standard deals with _____.
 - a. Workflow management
 - b. Image quality and consistency
 - c. Information management
 - d. Network Exchange

6. Level 2 of DICOM standard deals with _____.
 - a. Workflow management
 - b. Image quality and consistency
 - c. Information management
 - d. Network Exchange

7. Level 5 of DICOM standard deals with _____.
 - a. Workflow management
 - b. Image quality and consistency
 - c. Information management
 - d. Security

8. Which part of DICOM standard specifies information object definition?
 - a. Part 1
 - b. Part 2
 - c. Part 3
 - d. Part 6

9. Part 7 of DICOM standard deals with _____.
 - a. Message exchange
 - b. Network communication
 - c. Data dictionary
 - d. Media format

10. DICOM covers the following areas:
 - a. Medical Imaging
 - b. Veterinary Medicine
 - c. Aircraft Manufacturing
 - d. All of the above

11. MWL provides information related to: a) scheduling; b) billing; c) order.
 - a. a and b
 - b. b and c
 - c. a and c
 - d. a, b and c

12. DICOM includes the following: a) security; b) image display consistency; c) network management.
 - a. a and b
 - b. b and c
 - c. a and c
 - d. a, b and c

13. MPPS provides, among others: a) status information; b) information about the radiologist to read the exam; c) procedure information.
- a. a and b
 - b. b and c
 - c. a and c
 - d. a, b and c
14. DICOM Attributes can either be: a) optional; b) required c) conditional based on the PACS vendor.
- a. a and b
 - b. b and c
 - c. a and c
 - d. a, b and c
15. STC provides _____.
- a. Permanent storage on a remote archive
 - b. Storage on a tape or MOD jukebox
 - c. Hands-off between modalities and a PACS
 - d. Storage at a RIS instead of a PACS
16. DICOM facilitates _____.
- a. Interoperability
 - b. Interconnectivity
 - c. Interactivity
 - d. Intra-networking
17. DICOM facilitates _____.
- a. Billing and invoicing
 - b. Patient data entry
 - c. Material management
 - d. Workflow
18. An SR allows for _____
- a. An image to be sent as part of a report
 - b. Images to be sent as bit-maps
 - c. Images to be referenced
 - d. Images to be sent as PDF's

19. WADO means _____.

- a. Web Access to DICOM Objects
- b. Worldwide Access to DICOM
- c. Wide Area DICOM Objects
- d. Wide Area DICOM Orientation

20. GSDF stands for _____.

- a. Gray Scale Display Function
- b. Grayscale Standard Display Function
- c. Grayscale Standardized DICOM Function
- d. Gray Scale DICOM Feature