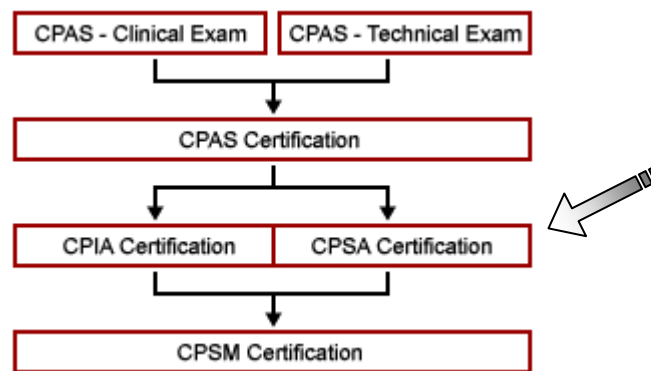


0 INTRODUCTION

This Study Guide is meant for students who are currently employed or are looking to become employed as a PACS Systems Analyst. It covers all of the skills that are highly desired for these professionals to do their job in a proficient manner. These skills build upon the basic skill set acquired by a PACS Systems Associate. This study guide can be completed to get credits from ASRT. It can also be used to study for the CPSA 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 : PACS Fundamentals by Herman Oosterwijk
2. CD : Introduction to PACS (P-102)
 PACS Workflow (P-204)
 PACS System Administration (P-105)
 Digital Acquisition CR/DR (P-203)

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. In addition, there is a reference to the sections included in the ASRT Category A exams for these sections², which totals 8 credits.

The guide provides a reader with an overview of what PACS is, details of the different components of PACS, pointers based upon the historical evolution of PACS, information on PACS providers, and knowledge on PACS workflows and tips on PACS implementation. It also covers areas such as security and areas that are typically considered to be beyond radiology, e.g., cardiology. In addition, it includes a special module on the roles and responsibilities of a PACS System Administrator and the challenges offered by such a job. Besides elucidating theoretical concepts, the courseware covers practical elements as well, e.g., tools used for workflow analysis and various case studies based upon real-life PACS implementations.

² Exams are available from www.otechimg.com

0.1 How to Use the Guide

While preparing this guide, it is assumed that the user of the guide will have first read the above-referred book and gone through the above-referred CD's, as the book and the CD's provide an overview of the entire relevant subject matter. No previous knowledge of PACS is required and/or assumed for this study guide.

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 in the book and on the CD's. By doing so, the reader will cover all of the topics that are required for the CPSA certification examination.

The durations 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, which include certain cases searched on the web. These exercises are meant to be assignments that SA 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. Some of these questions require Internet access to do research about current topics. 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 research about these subjects and read applicable articles and summarize these. These are included as so-called "essay questions" at the end of each section. 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 PACS OVERVIEW



12 Hours

Overview

This section provides the reader with an introduction to PACS and covers how PACS has evolved over the years. It also speaks about the productive impact of PACS and key lessons learned from previous PACS implementations. The section covers the architecture and components of a PACS system and introduces the reader to communication aspects.

Section Learning Objectives:

At the end of this section, the reader should:

- ★ Have an understanding of what PACS systems are supposed to accomplish
- ★ Acquire knowledge of how such systems have evolved over the years
- ★ Become familiar with the key components of a PACS system
- ★ Get an idea of the players in this industry
- ★ Learn the potential impact on productivity
- ★ Know approximately what the data rate is that is produced
- ★ Find out what the lessons learned are over the many years of implementation experience

1.1 Introduction to PACS



1 Hour

1.1.1 Learning objectives

Change can be frightening to people and the implementation of PACS technology is no exception. PACS follows the general trend to replace analog with digital technologies. Know the basic components of the PACS and the challenges involved in the implementation of PACS.

1.1.2 Study Assignments



Introduction to PACS (P-102), Slides 6 and 7



PACS Fundamentals, Chapter 1, Section 1.1, Pages 11-12

1.1.3 Summary

- PACS stands for Picture Archiving and Communication System.
- PACS technology is the representation of diagnostic images in an electronic form, typically referred to as softcopy.
- PACS deals with viewing, storing and retrieval, communication and managing of medical digital images and related information.
- PACS consists of an archive device, diagnostic viewing station for radiology, clinical review stations for physicians and requires database and workflow management software.
- Computerized or Digital Radiography are sometimes considered to be PACS components as well.

1.1.4 Key Terminology

PACS	
Archiving device	
Diagnostic workstation	
Database and workflow management software	

1.2 PACS Through the Years and Characteristics of PACS



1 Hour

1.2.1 Learning Objectives

PACS has been instrumental over the past 20 plus years in facilitating the exchange and integration of imaging into mainstream healthcare.

Know the history and evolution of these systems.

1.2.2 Study Assignments



Introduction to PACS (P-102), Slides 9-14



PACS Fundamentals, Chapter 1, Section 1.2, Pages 13-15

1.2.3 Key Terminology

Network standardization	
DICOM	
HL7	
IHE	
Virtual radiology department	

1.2.4 Summary

- The first large-scale PACS installation was in 1982 at the University of Kansas, Kansas City.
- Early PACS only replaced film; it based operation on a soft copy environment without an emphasis on re-engineering.
- The predecessor to the cable modem were CATV cable systems used for reading the first CT scanner images that were sent to the university diagnostic center.
- PACS requires abundant data exchange, better Ethernet connectivity, good display technology, an appropriate hardware, and correct display look-up tables to provide a consistent presentation.
- The vision of a single “virtual” radiology department by the US Department of Defense (DOD) and US Department of Veterans Affairs (VA): Veterans Administration helped grow and sponsored early PACS at Georgetown and University of Washington.

1.3 Productivity Impact



1 Hour

1.3.1 Introduction

PACS follows the general trend to replace analog with digital technologies, i.e., it converts imaging modalities into film-less systems and enables faster access and better diagnosis. Know the overall impact of film-less imaging to patients and physicians.

1.3.2 Study Assignments



Introduction to PACS (P-102), Slides 15-18

1.3.3 Key Terminology

Work efficiency	
Productivity	
Interpretation times	
CAD	

1.3.4 Summary

- PACS has in several ways revolutionized the medical imaging arena by empowering providers to obtain images and view images from even old exams in virtual real time.
- In addition, PACS has enabled the advent of new diagnostic methods such as Computer Assisted Diagnosis.
- PACS results in significant increases in productivity and reduction in interpretation times.
- Productivity increases more than 50% and interpretation times decreases by 8% to 15% for various modalities with fewer interruptions.
- Further, old exams and reports can be reviewed, organized and can be made available faster and more conveniently.

1.3.5 Exercises

1. You are tasked to suggest several CAD vendors to your management. Search the web for at least three vendors and find at least three different applications for CAD from the web.
2. Mention at least five reasons for productivity improvements that are achieved using PACS.

1.5 Lessons Learned



1 Hour

1.5.1 Learning Objectives

As PACS has evolved over the years, there are various lessons learned from previous implementations of PACS. Know the key lessons learned from the evolution of PACS.

1.5.2 Study Assignments



PACS Fundamentals, Chapter 1, Section 1.3, Pages 16-19


1.5.3 Key Terminology

Image management	
Image quality	
Archiving technology	
Hardware commodities	
GSDF	
RIS	
RAID	

1.5.4 Summary

- Image management is critical and workflow design is key to the successful implementation of PACS.
- Hardware and storage planning should incorporate future growth and needs.
- The Radiology Information System (RIS) should provide consistent and exclusive data entry of the patient information.
- The DICOM standard includes the Grayscale Standard Display Function (GSDF), used when the monitor requires calibration.
- On-line storage in a RAID or as a network appliance makes storage less dependent on archiving hardware media.
- Knowledgeable and trained staff is required to make the implementation and support of the PACS system successful.


1.6 PACS Architecture and Components


 2 Hours

1.6.1 Learning Objectives

PACS has several components, i.e., acquisition devices, with or without a preview monitor and/or QA station, archiving, and display/print as well as output media such as CD burners. Images flow in a certain way in this system. Know how to distinguish the different PACS components.

1.6.2 Study Assignments

 Introduction to PACS (P-102), Slide 8

 PACS Fundamentals, Chapter 2, Section 2.1, Pages 21-25

1.6.3 Key Terminology

Major Components	
Acquisition station	
Preview monitor	
QA station	
Archive	
Workstation	
Reporting station	
Printers	
Exchange media	
Software Architecture	
Operating System	
Databases	
Coding Languages	

1.7 Architecture



2 hours

1.7.1 Learning Objectives

PACS systems can use a thin or thick client to connect their workstations. Know how to distinguish between both architectures and the cons and pros of each one.

1.7.2 Study Assignments



Introduction to PACS (P-102), Slide 8



PACS Fundamentals, Chapter 2, Section 2.3, Subsection 2.3.2,
Page: 37 ; Chapter 2, Section 2.1, Subsection C, Pages 25 and 26

1.7.3 Key Terminology

Thin client	
Thick client	
Local storage	
Local device	
Client-server solution	

1.7.4 Summary

- Viewing stations can use thin client or thick client architecture.
- Thin client architecture implies that limited local storage/processing capacity is required but also means the requirement of a greater bandwidth over a network.
- Thick client architecture has locally residing software applications but also means greater needs for local storage and processing.
- The specific architecture to be selected would depend upon the needs encountered for an implementation. Thin client architecture is getting to be more popular and commonly found.

1.7.5 Exercises

1. Your institution IT department requires the use of thin clients for every new software application that is purchased. What do you think might be their reasoning for this requirement?
2. Windowing an image requires almost simultaneously updating all pixels on the image screen with a different grayscale value. Do you think this will be faster on a thick or thin client architecture (assuming the windowing is executed on the application software level)?

1.8 Acquisition Rate and Typical Data Generation



1 Hour

1.8.1 Learning Objectives

In order to size a PACS system infrastructure as well as database and archiving capacity, one has to calculate the data generation and retrieval rate, know how to develop a spreadsheet with the data rate generation, do a forecast of the required data storage capacity and infrastructure.

1.8.2 Study Assignments



Time Introduction to PACS (P-102), Slides 26-29



PACS Fundamentals, Chapter 2, Section 2.4,
Subsection 2.4.1, Pages 49-51

1.8.3 Key Terminology

Storage calculation	
Exams/year	
Data generation	
Data compression	
Lossy compression	
Lossless compression	

1.8.4 Summary

- Calculation of data generation and its storage requires predicting the expected future price of Mbytes storage and future capacity growth requirements.
- The use of image compression is an important factor to determine storage needs.
- To determine how much storage is needed and what is the archiving capacity should be, one really needs to determine the annual department production of studies at each modality, determine the image sizes for each study and take into account future expected rates of growth.

1.9 Communication



2 Hours

1.9.1 Learning Objectives

Image communications are carried out over a dedicated or shared network. Dedicated lines to offices and/or other facilities uses VPN's over DSL. Proper sizing and support are critical as is the know-how to size network capacity and recognize the need for proper support.

1.9.2 Study Assignments



Introduction to PACS (P-102), Slides 51-56



PACS Fundamentals, Chapter 2, Section 2.5, Pages 62-64

1.9.3 Key Terminology






Dedicated network	
Firewall	
Router	
VPN	
Ethernet networks	
DSL	
Internet protocol for PACS-WADO	

1.9.4 Summary

- A dedicated network ensures greater uptime and the PACS team does not have to rely on the external IT department.
- Virtual Private networks are used to maintain privacy and security requirements.
- Since images to and from the PACS are transferred over LAN and WAN networks, estimating the amount of data to be transferred and the desirable time of transfer become important.
- The joint effort between international ISO TC215 and the DICOM standard organization have standardized the web-based protocol by implementing WADO for Web Access to DICOM Objects.

ESSAY QUESTIONS:

Find two articles of at least three pages that involve any of the following topics, and produce for these a ½ page, double-spaced abstract:

-  implementation at a specific institution
-  productivity
-  workflow analysis
-  lessons learned
-  image archive sizing

TEST QUESTIONS

PACS Overview

1. What does PACS stand for?
 - a. Picture Archiving and communication system
 - b. Picture Authentication and communication system
 - c. Picture Authorization and communication system
 - d. Provide Archiving and communication system

2. PACS deals with _____.
 - a. Viewing & storing
 - b. Retrieving & communication
 - c. Managing of medical image-related information
 - d. All of the above

3. PACS consists of a/an _____.
 - a. Archive device
 - b. Diagnostic viewing station for radiology
 - c. Clinical review for physicians and database
 - d. All of the above

4. What is PACS referred to as?
 - a. Bleeding edge
 - b. Leading edge
 - c. Trailing edge
 - d. Lagging edge

5. When and where was the first large scale PACS installed?
 - a. 1982, at the University of Kansas, Kansa City
 - b. 1999, at the University of VA, in Baltimore
 - c. 1980, at the Michigan State University
 - d. 1990, at US Department of Defense

6. PACS requires abundant _____.
 - a. Data exchange
 - b. Ethernet connection
 - c. Display technology
 - d. All of the above

7. What technology did the first PACS use?
 - a. Broadband
 - b. CATV system
 - c. Ethernet
 - d. Internet

8. What was the early version of DICOM called?
 - a. ACR-NEMA
 - b. ARC-NEMA
 - c. ISO-OSI
 - d. ARO-DOD

9. Which is the most critical part of PACS?
 - a. Software management
 - b. Hardware management
 - c. Image management
 - d. None of the above

10. What does the DICOM committee specify when the monitor resolution does not perform as expected because it mainly requires baseline calibration and applies the measured calibration values when images are displayed?
 - a. Black Scale Display function (BSDF)
 - b. Grayscale Standard Display Function (GSDF)
 - c. RGB display function (RGBDF)
 - d. All of the above

11. What makes on-line storage in networks less dependent on archiving hardware media?
 - a. DVD
 - b. CR/DR
 - c. RAID
 - d. Tape drives

12. Major component of PACS are _____.
- a. Acquisition Station & Preview monitor
 - b. QA station, Archive, Workstations & Reporting stations
 - c. Printers & Exchange Media
 - d. All of the above
13. What is the QA station also called?
- a. Relay station
 - b. PACS gateway
 - c. Both a and b
 - d. None of the above
14. The function of a QA station is _____.
- a. To check the image quality
 - b. To check whether images actually made it to PACS
 - c. Both a and b
 - d. None of the above
15. PACS archive has several components, i.e., _____.
- a. Physical storage devices
 - b. Image Manager
 - c. Workflow Manager
 - d. All of the above
16. Who are the basic users of the PACS review station?
- a. Non-radiologist (for physicians)
 - b. Radiologist
 - c. PACS administrators
 - d. Technologist
17. What are the factors for PACS storage?
- a. Image data compression techniques
 - b. Report data non-compression techniques
 - c. Image data re-compression techniques
 - d. Report data compression techniques

18. What causes the use of a Virtual Private Network?
- a. To maintain privacy
 - b. To maintain security
 - c. Both a and b
 - d. None of the above
19. The definition reserved for DICOM images, which could enable a receiving application to recognize an email attachment as encoded is called _____.
- a. MIEN
 - b. NIEM
 - c. MIME
 - d. EMIN
20. What is the standardized web-based protocol called which came into effect by the joint effort between international ISO TC215 and the DICOM standard organization?
- a. WADO
 - b. DOWA
 - c. ARCNET
 - d. APRNET