Picture Archiving and Communication Systems (PACS)

Basile P. Spyropoulos

Technological Educational Institution of Athens
Medical Instrumentation Technology Department

The PACS

- In medical imaging, picture archiving and communication systems (PACS) are computers or networks dedicated to the:
  - *Storage.*
  - *Retrieval.*
  - *Distribution.*
  - *Presentation.*

  of images.
- The medical images are stored in an independent format.
- The most common format for image storage is DICOM (Digital Imaging and Communications in Medicine).

The application areas of PACs

- Most PACSs handle images from various medical imaging instruments, including:
  - *Ultrasound.*
  - *Magnetic Resonance.*
  - *PET.*
  - *Computed tomography.*
  - *Mammograms.*
  - *Endoscopy etc.*
- The most common format employed in the above application areas is DICOM.

Standards in Digital Imaging

- A crucial issue in developing PACs is the Information Exchange Standards in Digital Imaging and Communication employed in Medicine
- The main aim of the medical information standards is to ensure that all data needed to accomplish a specific communication can be transmitted from one system to another.
- The two most important Standards employed presently in Digital Imaging are:
  - *Health Level 7.*
  - *DICOM.*

Health Level 7 (HL7)

- Health Level 7 (HL7) is a standards-developing organization that is accredited by the American National Standards Institute.
- The domain of HL7 is in clinical and administrative data.
- The HL7 standard is a specification, not software, for information exchange between medical applications, and it includes a protocol for data exchange.
- It defines the format and content of the messages that applications must use when exchanging data. (*Health Level Seven, I. Health Level-7 Standards Web site. Available at: http://www.hl7.org/.*).

The evolution of HL7

- HL7 standards are based on the reference information model.
- The current standard is HL7 version 2.4. Version 2.5 and version 2.6 were further constrained by the previous standard. *(R. H. Dolin et al. The HL7 clinical document architecture. J. Am. Med. Inform. Assoc. 8(6):552–569, 2001).*
- Recently, version 3 made fundamental changes to the existing HL7 messaging approaches that introduced Clinical Document Architecture (CDA). *(R. H. Dolin et al. HL7 clinical document architecture, release 2. J. Am. Med. Inform. Assoc. 13(1):30–39, 2006.)*

The Clinical Document Architecture (CDA)

- A feature of the CDA is its ability to be viewed in a browser using a single style sheet based on XML.
- Messages with CDA are, by definition, able to include text, images, sounds, and other multimedia content.
- A major advantage of HL7 is system independence resulting from open system architecture.
- Open system architecture discloses its specifications, and, by following appropriate protocols, add-on components can be developed without regard to vendor specifications.
- This avoids the need to develop an entire infrastructure simultaneously.
- Each component can be developed and integrated individually.

The evolution of the Digital Imaging and Communications in Medicine (DICOM)

- The move to digital images in radiology and their anticipated dissemination electronically prompted:
  - *The American College of Radiology (ACR) and*
  - *The National Electrical Manufacturers Association (NEMA)*

  to form a joint committee in 1983 to create a standard format for storing and transmitting medical images National Electrical Manufacturers Association. *(Digital imaging and communication in medicine strategic document version 4.0. Available at: http://medical.nema.org/).*
- The committee published the original ACRNEMA standard in 1985, which has been revised since then.
- In 1993, the standard was renamed to digital imaging and communications in medicine (DICOM version 3.0) and permitted the transfer of medical images in a multi-vendor environment.

Front page of ACR/NEMA 300 version 1.0, released in 1985

The DICOM standard contents

- The DICOM standard contains the network components required for file exchange.
- It uses transmission control protocol / Internet protocol to communicate between systems.
- DICOM files can be exchanged between two entities that have the capability to receive the information, both image and patient data.
- The patient data are encoded in a header, including the patient name, type of scan, image dimensions, and other information related to the scan.
- The concept of DICOM arose from a desire to integrate scanners, servers, workstations and network hardware from multiple vendors into a picture archive and communication system.

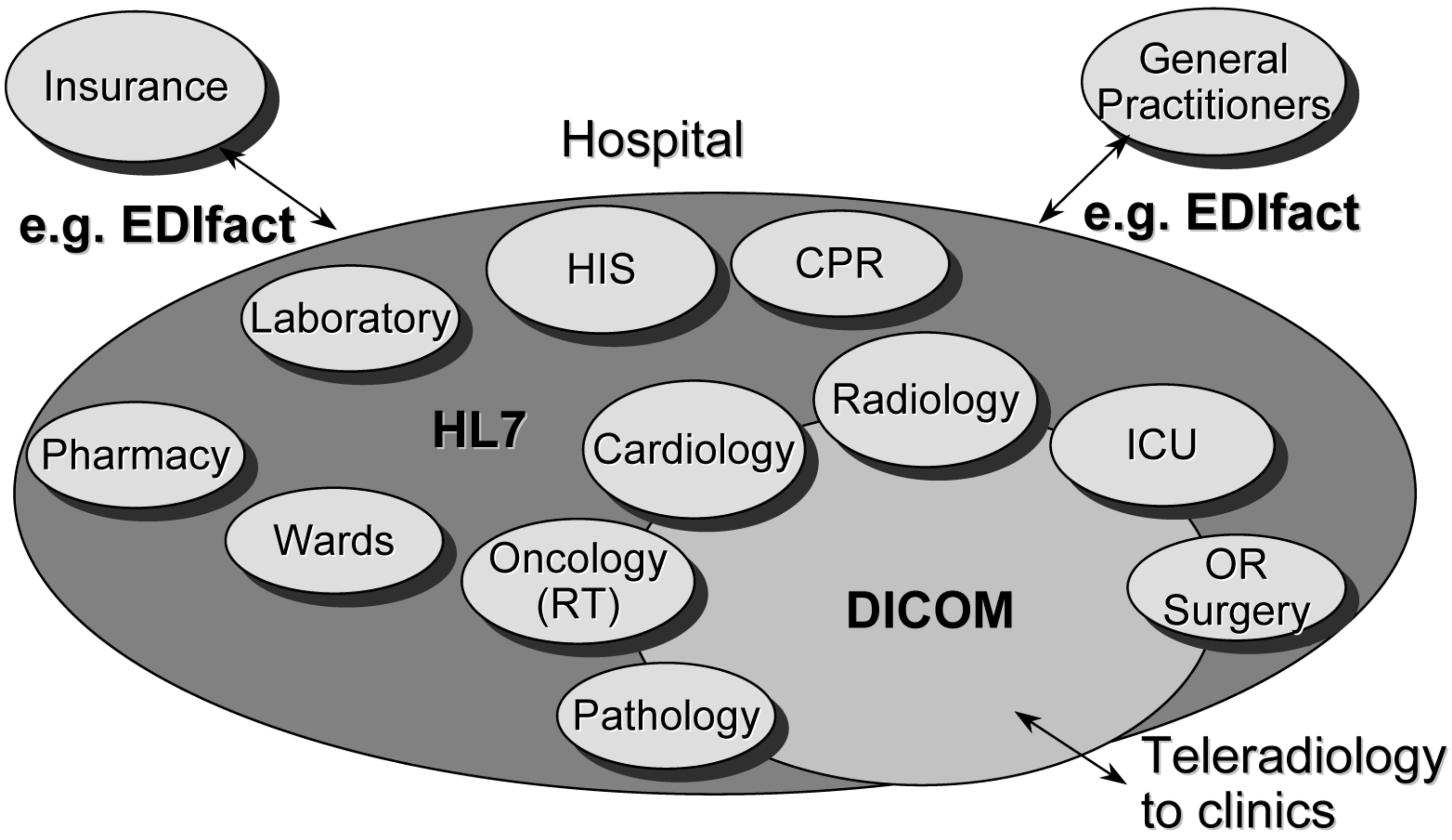
DICOM conformance statements

- For picture archive and communications system imaging devices, servers and workstations have DICOM conformance statements that identify the DICOM classes that are supported.
- DICOM has been widely adopted by hospitals because of its interchangeability.
- HL7 and DICOM require the definition of all data elements that are sent.
- In many cases, the content requires a specific vocabulary that can be interpreted between the systems.

Modalities supported in DICOM

Code	Modality Description	Code	Modality Description	Code	Modality Description
BI	Biomagnetic Imaging	GM	Gross Microscopy	RF	Radio Fluoroscopy
CD	Color Flow Doppler	LS	Laser Surface Scan	RG	Radiographic Imaging - film screen
CR	Computed Radiography	MA	Magn. Resonance Angiography	RT	Radiation Therapy
CT	Computed Tomography	MG	Mammography	SC	Secondary Capture
DD	Duplex Doppler	MR	Magnetic Resonance	SM	Slide Microscopy
DG	Diaphangraphy	MS	Magn. Resonance Spectroscopy	ST	Single-Photon Emission Computed Tomography
EC	Echo-cardiography	NM	Nuclear Medicine	TG	Thermography
EM	Electron Microscope	OT	Other	US	Ultra Sound
ES	Endoscopy	PT	Positron Emission Tomography	VL	Visible Light

Healthcare Communication Standards



The heterogeneity between the standards

- At present, there is heterogeneity between the standards.
- To improve the electronic interchange of clinical data, universal standard formats should be defined to include:
  - *Images.*
  - *Signals.*
  - *Multimedia.*
  - *Text.*
- In the absence of such a standard, a number of interpretation-based methods have been proposed; one of these uses a middleware system as an interpreter. *(I. Foster and R. L. Grossman. Data integration in a bandwidth- rich world. Commun. ACM. 46(11):50–57, 2003, and K. Schelfthout and T. Holvoet. Coordination middleware for decentralized applications in dynamic networks. In DSM '05: Proceedings of the 2nd Internat. Doctoral Symposium on Middleware. ACM Press, 2005.).*

PACs' uses

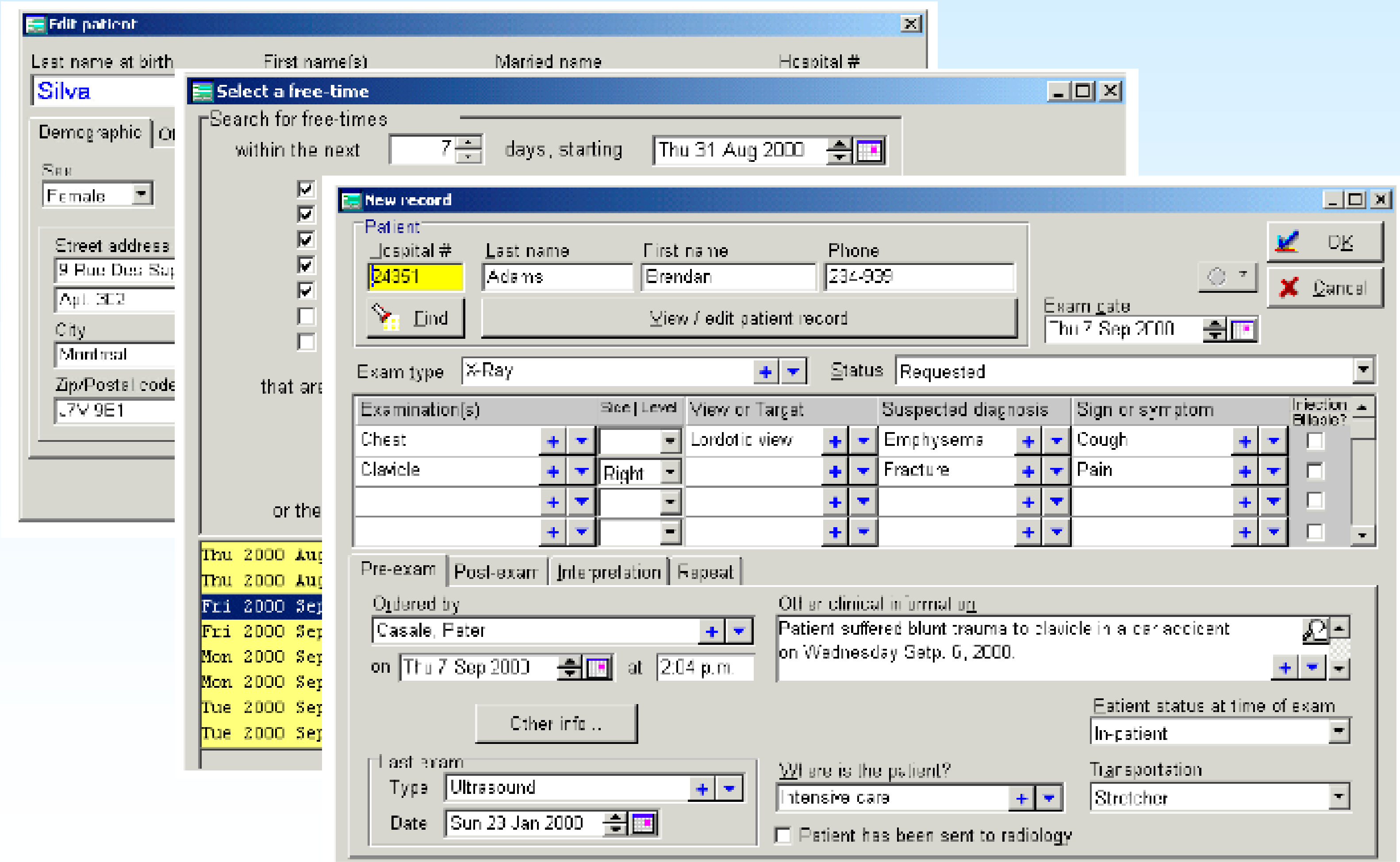
- PACs replaces hard-copy based means of managing medical images, such as film archives.
- It expands on the possibilities of such conventional systems by providing capabilities of off-site viewing and reporting (Distance Education, Telediagnosis).
- Additionally, it enables practitioners at various physical locations to access the same information simultaneously (Teleradiology).
- With the decreasing price of digital storage, PACSs provide a growing cost and space advantage over film archives.
- PACS is offered by virtually all the major medical imaging equipment manufacturers, medical IT companies and many independent software companies.

Interpreting the DICOM image format

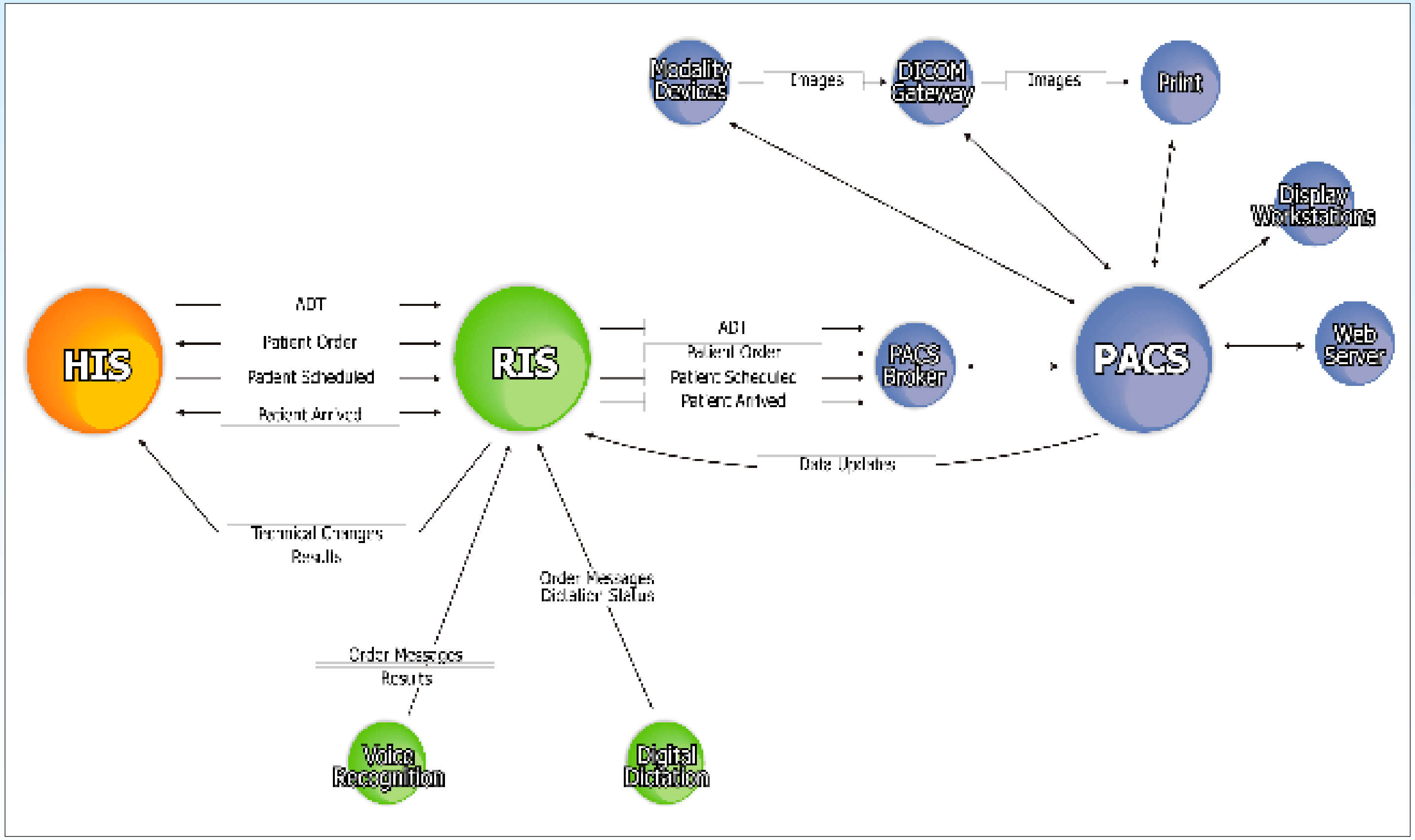
- The most difficult area for PACS is interpreting the DICOM image format.
- DICOM has enough latitude to allow various vendors of medical imaging equipment to create DICOM compliant and incompliant files that differ in the internal tags used to label the data and the metadata.
- A feature common to most PACS is to read the metadata from all the images into a central database.
- This allows the PACS user to retrieve all images with a common feature no matter the originating instrument.
- The differences between vendors' DICOM implementations make this a difficult task

Radiology Information Systems

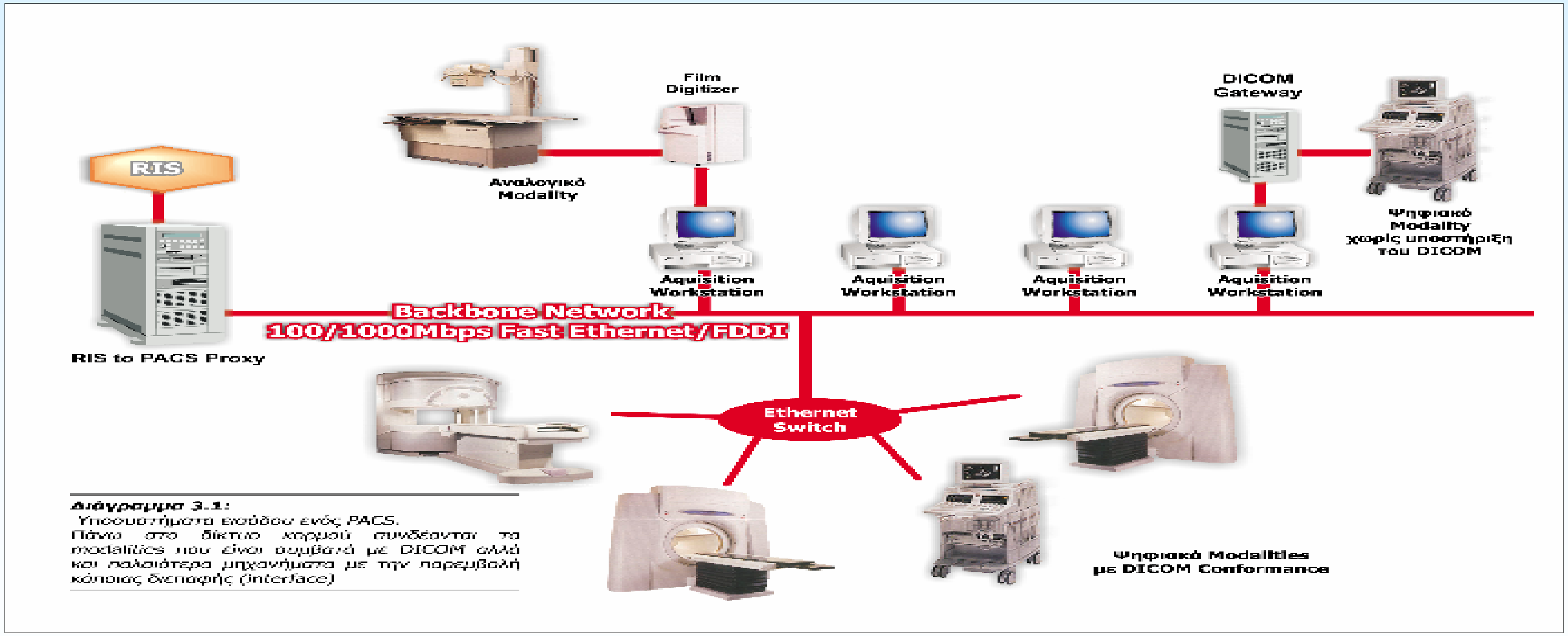
RIS Typical Menu



HIS-RIS-PACS

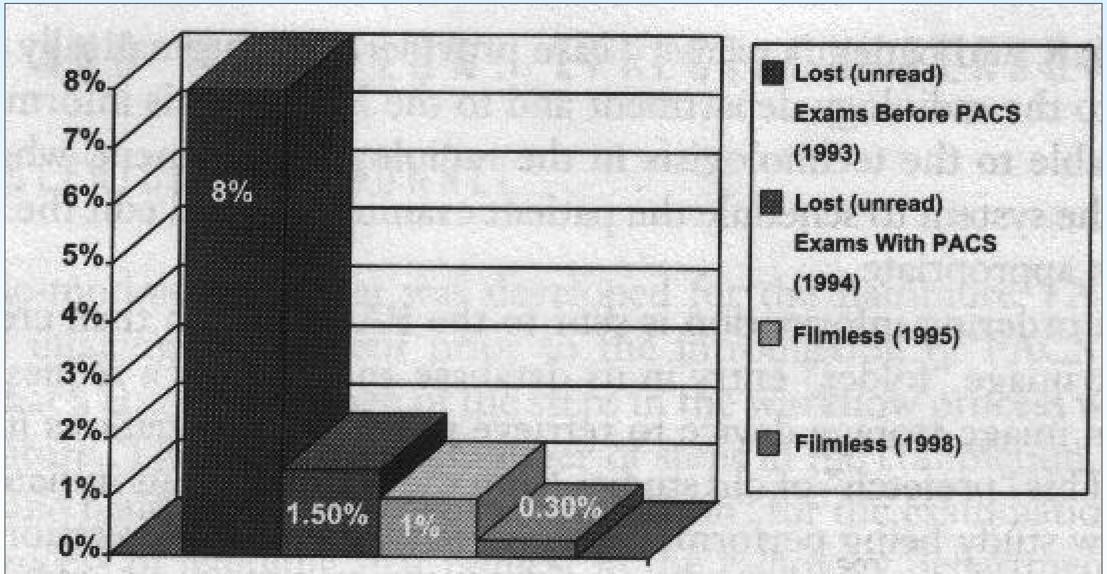

Modality Devices
Images
DICOM Gateway
Images
Print
Display Workstations
Web Server
HIS
ADT
Patient Order
Patient Scheduled
Patient Arrived
RIS
ADT
Patient Order
Patient Scheduled
Patient Arrived
PACS Broker
PACS
Data Updates
Technical Charges
Results
Order Messages
Dictation Status
Order Messages
Results
Voice Recognition
Digital Dictation

Input subsystem of a PACS



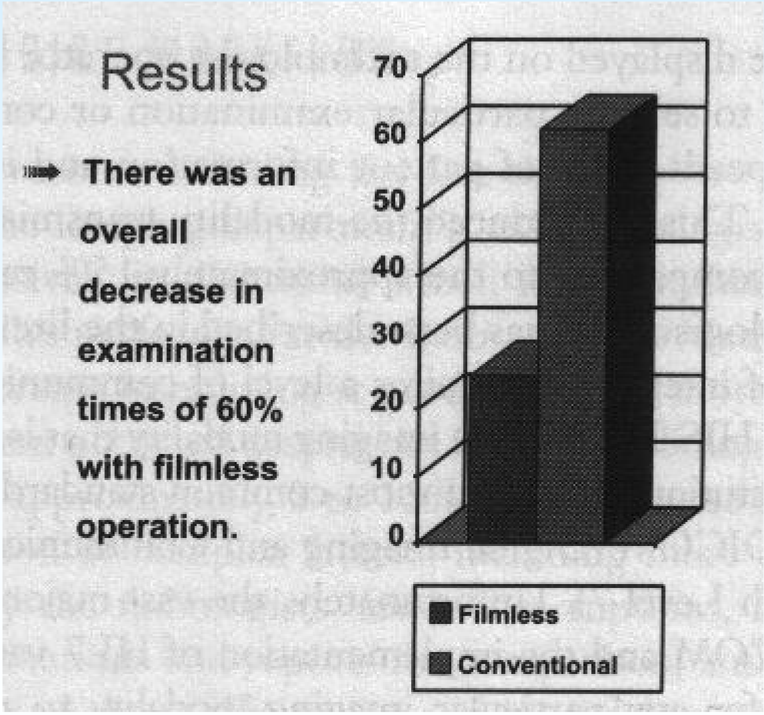
Διάγραμμα 3.1:
Υποσυστήματα εισόδου ενός PACS.
Πάνω στο δίκτυο κορμού συνδέονται τα modalities που είναι συμβατά με DICOM αλλά και παλαιότερα μηχανήματα με την παρεμβολή κάποιας διεπαφής (interface)

Reduction of lost exams

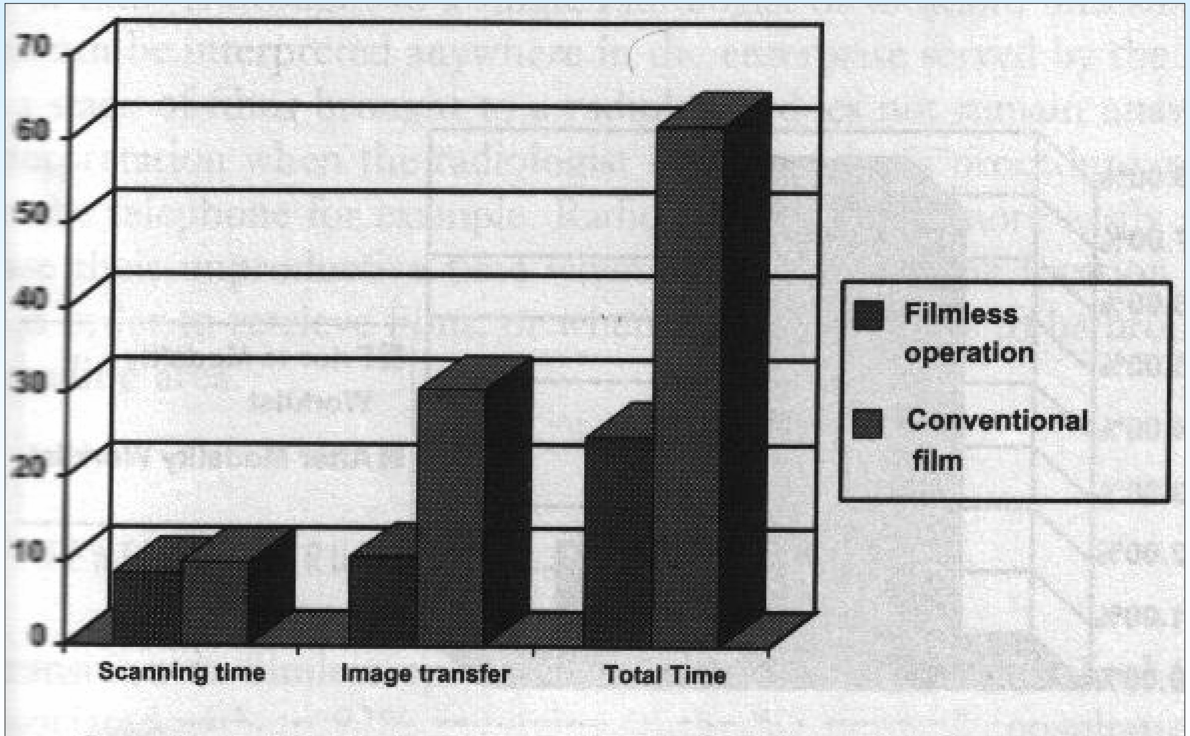


Lost films diagram.

Reduction of examination time

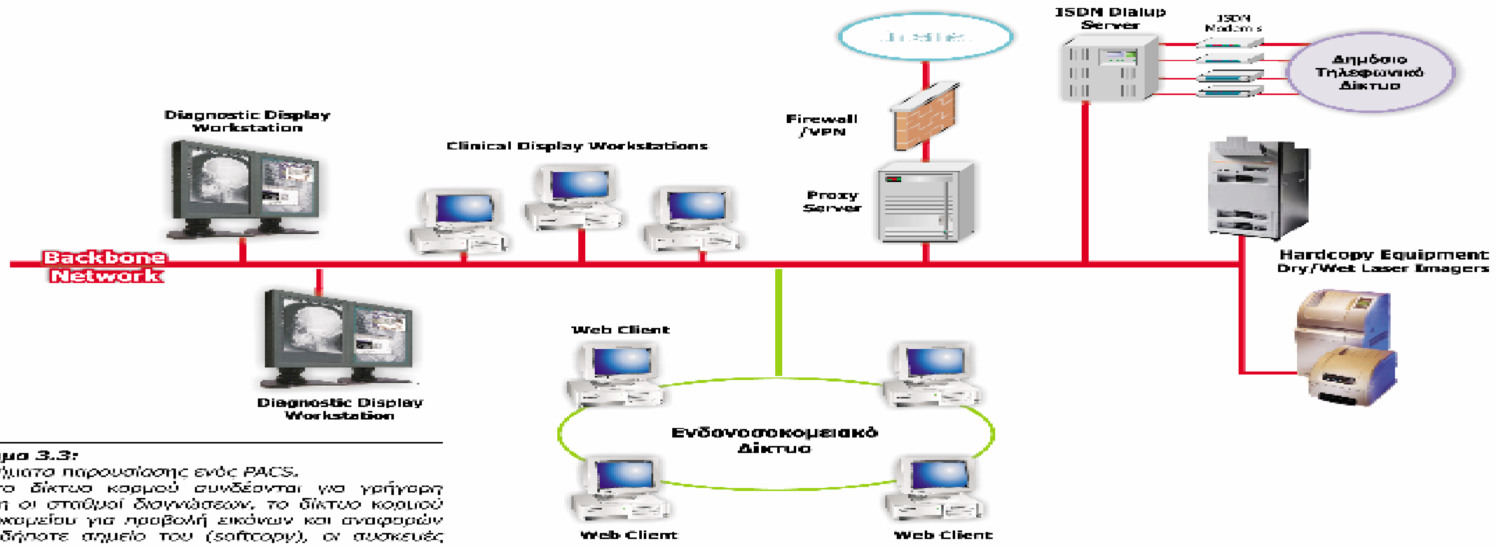


Reduction of Technologists’ time



Reduction in CT technologist scanner time with filmless operation.

Presentation subsystem of a PACS



Διάγραμμα 3.3:
Υποσυστήματα παρουσίασης ενός PACS.
Πάνω στο δίκτυο κορμού συνδέονται για γρήγορη πρόσβαση οι σταθμοί διαγνώσεων, το δίκτυο κορμού του νοσοκομείου για προβολή εικόνων και αναφορών σε οποιοδήποτε σημείο του (softcopy), οι συσκευές εκτύπωσης σε φιλμ για λήψη εικόνων σε σκληρό αντίγραφο (hardcopy) και ο τηλεπικοινωνιακός εξοπλισμός για μετάδοση ή λήψη εικόνων από άλλο διαγνωστικό κέντρο ή ιδιώτες γιατρούς.