



TELEMEDICINE AND TELERADIOLOGY

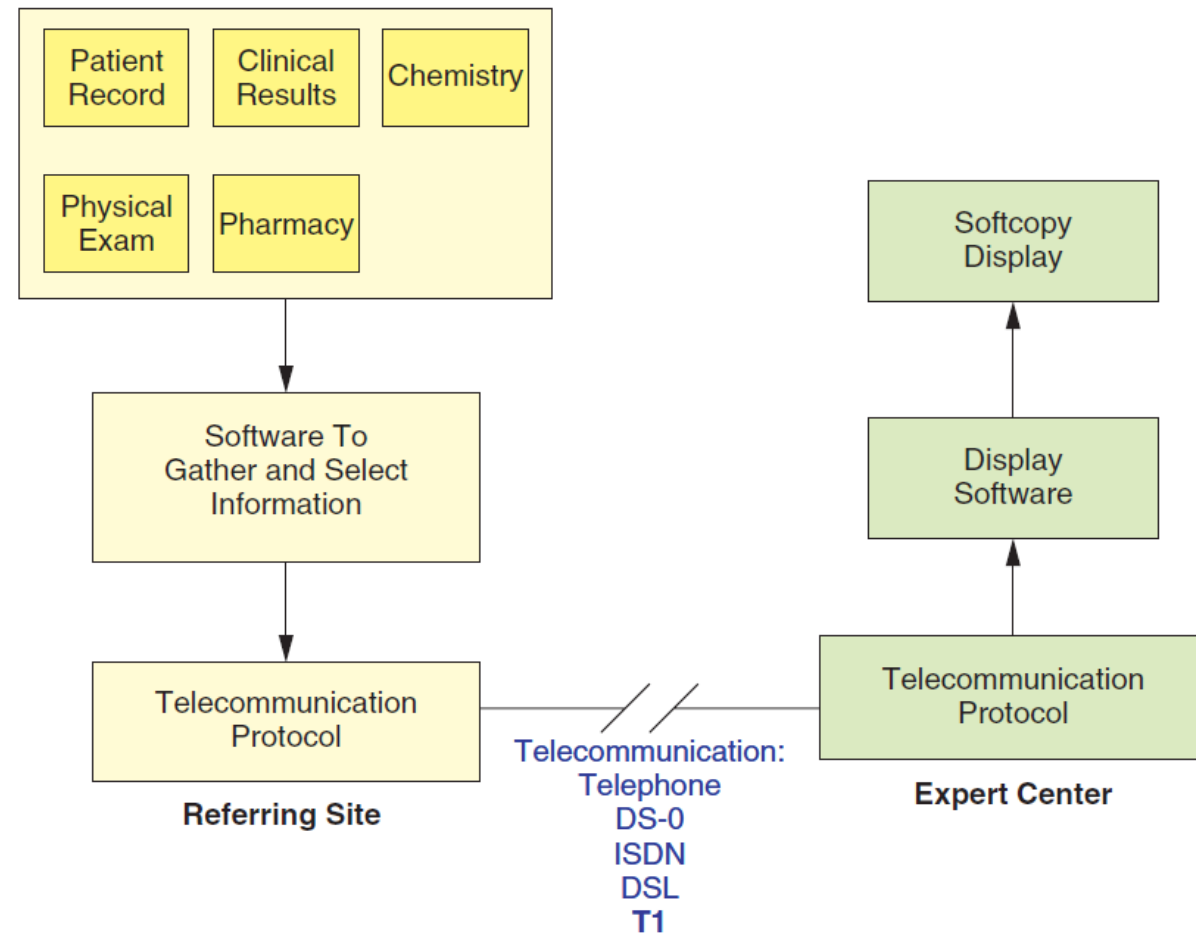
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Telemedicine Overview

- Delivery of healthcare using telecommunications, computer, and information technologies (IT)
 - Consultation by means of telephone conversation alone would not be qualified as telemedicine because it only uses telecommunications and not the computer or IT
- Two models in telemedicine
 - Referring physician can consult with specialists at various locations through network or
 - Referring physician can request opinions from consolidated expert center (more dominant model)
- Expert center consultation process has three modes of telemedicine
 - **Telediagnosis**
 - Examination done at referring physician's site then data are transmitted to expert center for diagnosis
 - Urgency of this service is nominal, and turnaround time can take from few hours to one day
 - **Teleconsultation**
 - Patient may be still waiting at site while referring doctor requests second opinion or diagnosis from expert center (Turnaround time can be half an hour)
 - **Telemanagement**
 - Patient may still be in examination room at remote site and expert is required to provide immediate management care to patient

Teleradiology

- Teleradiology is subset of telemedicine dealing with transmission, display, and diagnosis from images and other patient-related information, between remote referring site and expert center
 - ▣ Technology requirements for teleradiology are more stringent than general telemedicine because it involves images
- Telemedicine without teleradiology requires only very simple technology
 - ▣ Gathering and arrangement of all necessary patient information, examination results, and diagnostic reports on referring site computer
 - ▣ Transmission through telecommunication technology to second computer at expert center where information is displayed as softcopy on monitor

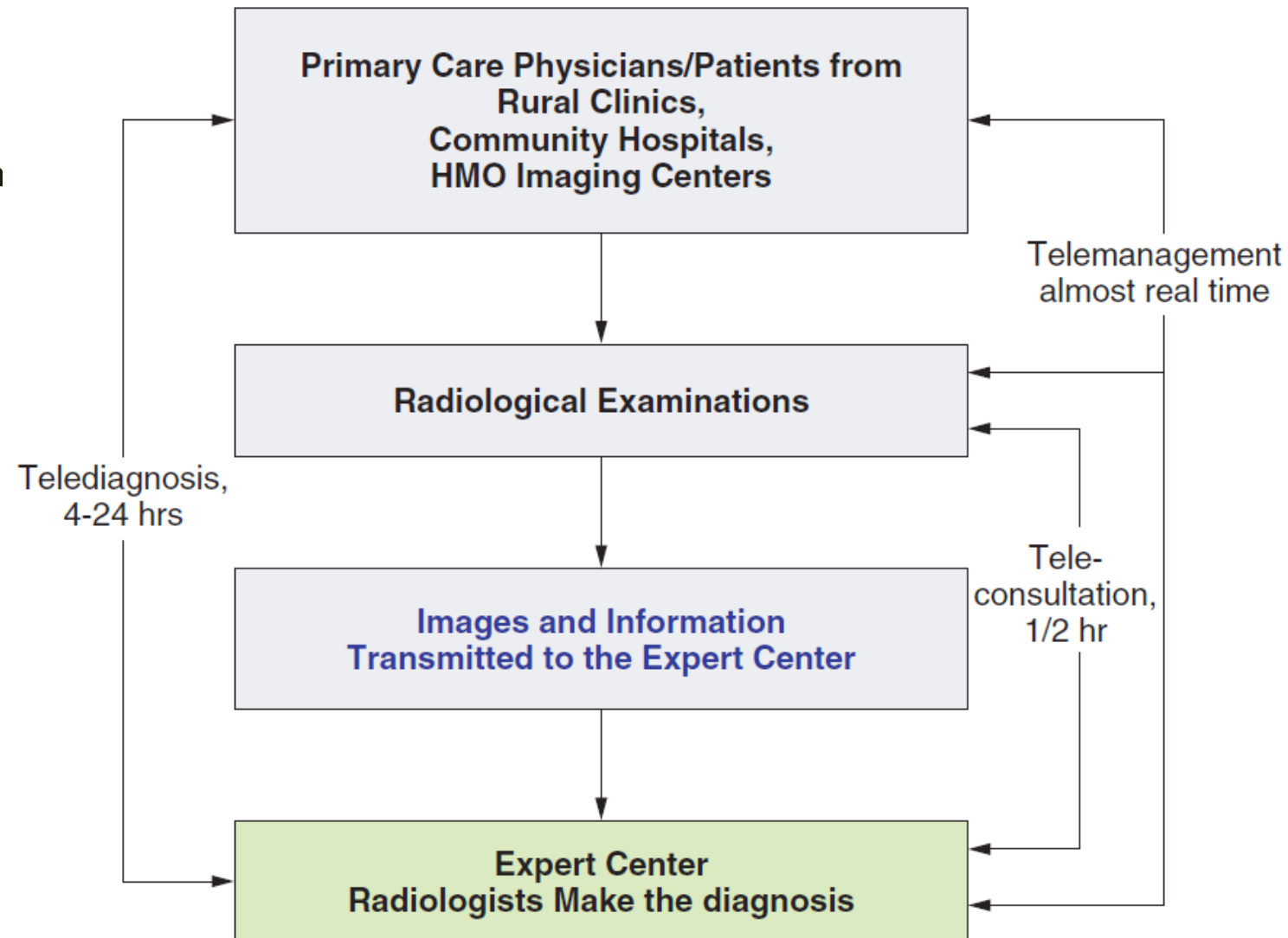


Issues in Telemedicine

- Privacy is considered seriously during delivery of telemedicine service
 - ▣ Proper data encryption/authentication must be incorporated
- Hardware and telecommunication choices vary according to required data throughput
- Software component includes information display with good GUI and some quality-assurance and communication protocol programs
 - ▣ Software programs can be supported by either HIS department or outsourced from vendor
- Recently, web client server model in telemedicine became very popular
 - ▣ In this case, Internet service provider (ISP) model can support both hardware and software services

Expert Center Models in Teleradiology

- ❑ Secures images for radiologists to read so that no images will be accidentally lost in transit
- ❑ Reduces reading cycle time from when the image is formed to when report is completed
- ❑ Because radiology is subdivided into many subspecialties, general radiologist occasionally requires expert's second opinion, which teleradiology facilitates
- ❑ Potentially increases radiologists' income because no images are temporarily lost and subsequently not read
- ❑ Cost effectiveness
 - ▣ Expert center serves multiple sites
 - ▣ Faster turnaround and no loss of images



Teleradiology vs. PACS

- When the teleradiology service requires patient's historical images as well as related information, teleradiology and PACS become very similar operationally
- Biggest difference is in image capture methods where some current teleradiology operations still use digitizer as primary method of converting film image to digital format, while in PACS direct digital image capture is mostly done using DICOM
- In networking, teleradiology uses the slower speed wide area networks (WAN) compared with the Intranet, whereas the higher speed local area network (LAN) is used in PACS
- In teleradiology, image storage is mostly short term, whereas in PACS it is long term
- Teleradiology relies heavily on image compression, whereas PACS may or may not

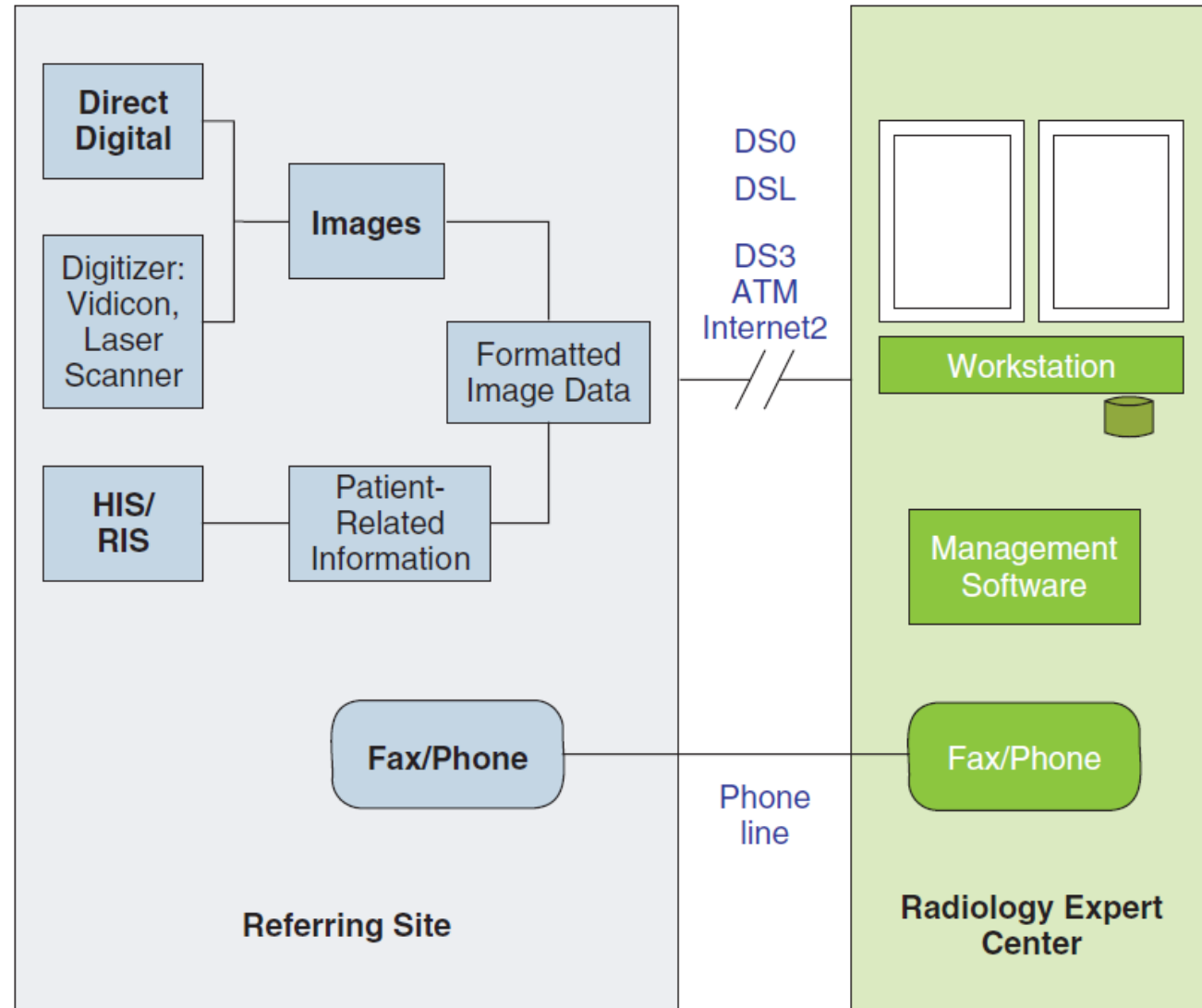
Function	Teleradiology	PACS
Image Capture	Digitizer, DICOM	DICOM
Display technology	Similar	Similar
Networking	WAN	LAN
Storage	Hard disk (short term)	Various tech (long term)
Compression	Yes	Maybe

Teleradiology Components

- Imaging acquisition device
- Image capture
- Data reformatting
- Image transmission
- Storage
- Display
- Reporting
- Billing

Specifications of high-end 1K and 2K workstations for teleradiology

- Two LCD monitors
- 1–2 week local storage for current + previous exams
- 1–2 second display of images and reports from local storage
- HL7 and DICOM conformance
- Simple image-processing functions
- Internet communication protocol available



Teleradiology Models: Off-Hour Reading

- Taking care of reviewing images during evenings, weekends, and holidays when most radiologists are not available at examination sites
- Reading center radiologists perform on-line digital reading and preliminary assessments of exams and transmit them to examination site instantaneously after reading images
- Radiologists at examination sites verify readings and sign off report next day
- Setup serves purpose of compensating for shortage of radiologists during off hours
 - ▣ Many such off-hour reading centers throughout the world taking advantage of time zone differences

Teleradiology Models: Application Service Provider

- ASP model takes care of radiology service where on-site interpretations are not available
- ASP can be used for supplying teleradiology equipment only
 - ▣ ASP sets up technical center housing network equipment, workstations, and reading rooms, and also provides turnkey connectivity for examination site where images would be transmitted to the center
- ASP can be used for both equipment and radiology reading
 - ▣ ASP provides technical support and radiologists for reading

Teleradiology Models: Web-Based

- Client-server model mostly used by hospital or larger clinics to distribute images to various parts of hospitals or clinics, or outside
- Web server is designed where filtered images from PACS are either pushed from PACS server to, or pulled by web server
 - ▣ Filtered images mean that web server has predetermined directory managing image distribution based on certain criteria like what types of images to where and to whom
 - ▣ Clients can view these filtered images from web server using web browsers equipped with diagnostic or review workstations
 - ▣ Clients can be referring physicians who just want to take a look at the images, or radiologists who want to make remote diagnosis
 - ▣ Web-based teleradiology is very convenient and low cost to set up because most of its technologies are readily available, especially
 - ▣ Drawback is that viewing capability and conditions are not as good as that in regular PACS workstation
 - In order to maintain DCIOM image resolution for visualization and manipulation at the client workstation, modifications have to be made at web server to receive full 12-bits/pixel data from PACS server, and at client to receive additional image display software

PACS and Teleradiology Combined

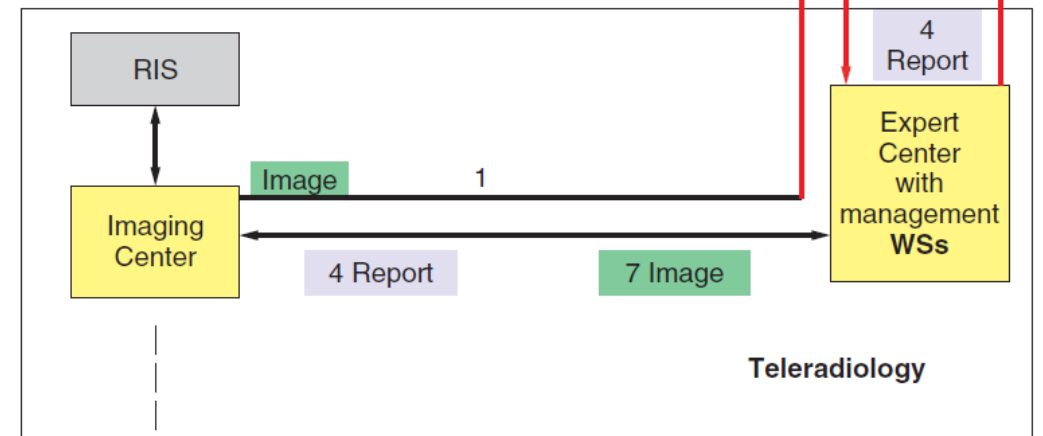
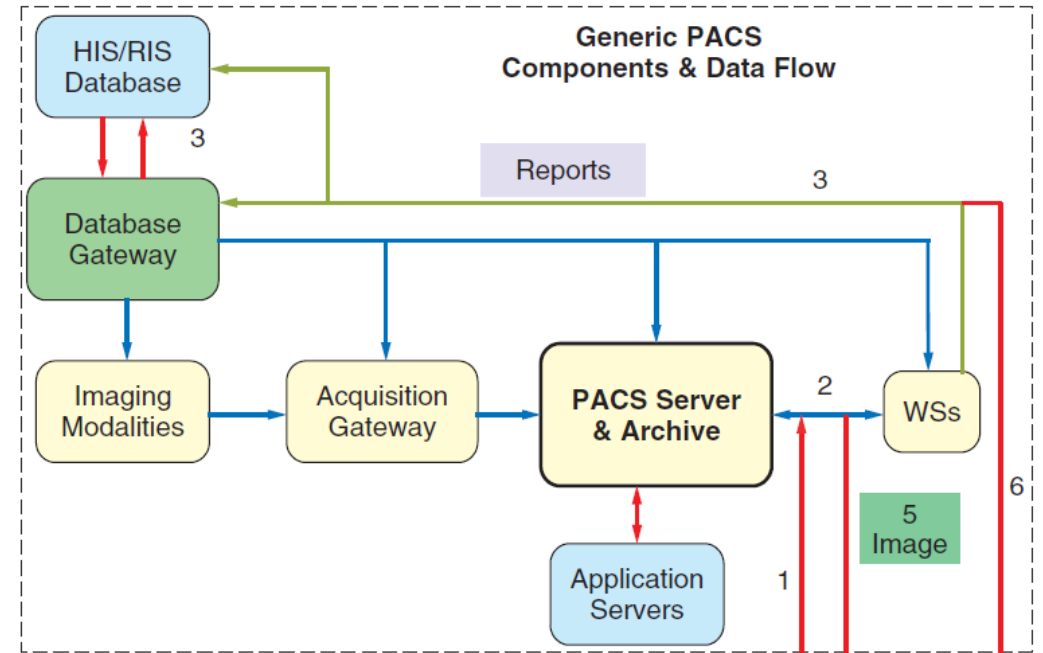
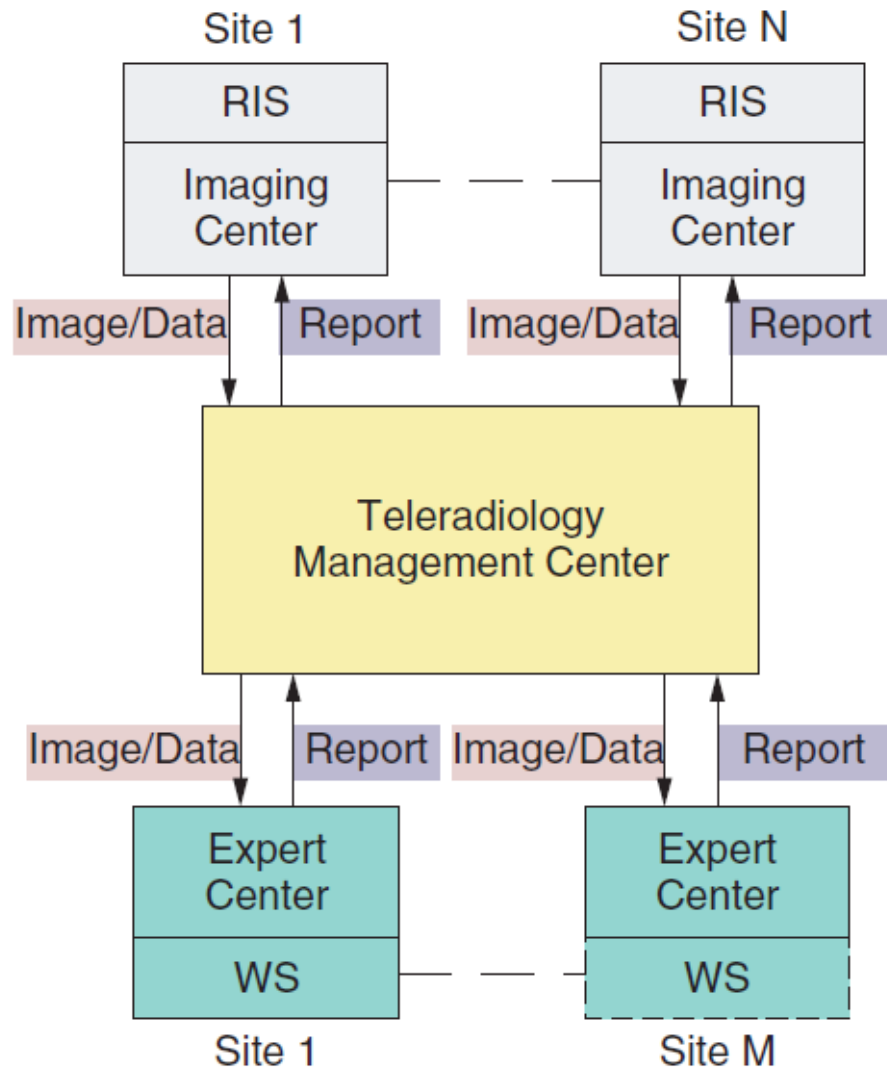


Image Compression

- Teleradiology requires image compression because of slow speed of transmitting large image data
- For lossless image compression, current technology achieve 3:1 to 2:1 compression ratios, whereas in lossy compression using cosine transform and wavelet-based MPEG and JPEG hardware or software, 20:1 to 10:1 compression ratios can be obtained with acceptable image quality
 - ▣ Wavelet transform has advantages over cosine transform of higher compression ratio and better image quality but hardware wavelet compression is still being developed
- Some web-based teleradiology systems use progressive wavelet image compression technique
 - ▣ Image reconstruction from compressed file proceeds progressively where lower resolution image is first reconstructed almost instantaneously and displayed and higher quality images would be continuously reconstructed to replace lower quality ones until original image in all its details is fully reconstructed and displayed
 - ▣ Another approach would be to only construct a region of interest instead of full image

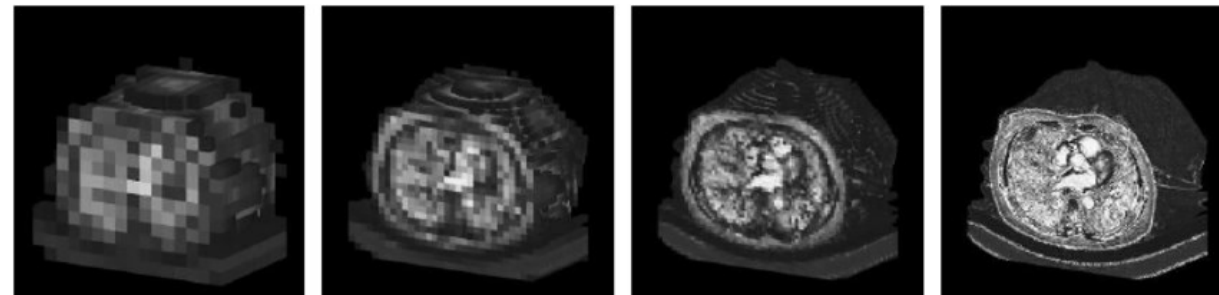
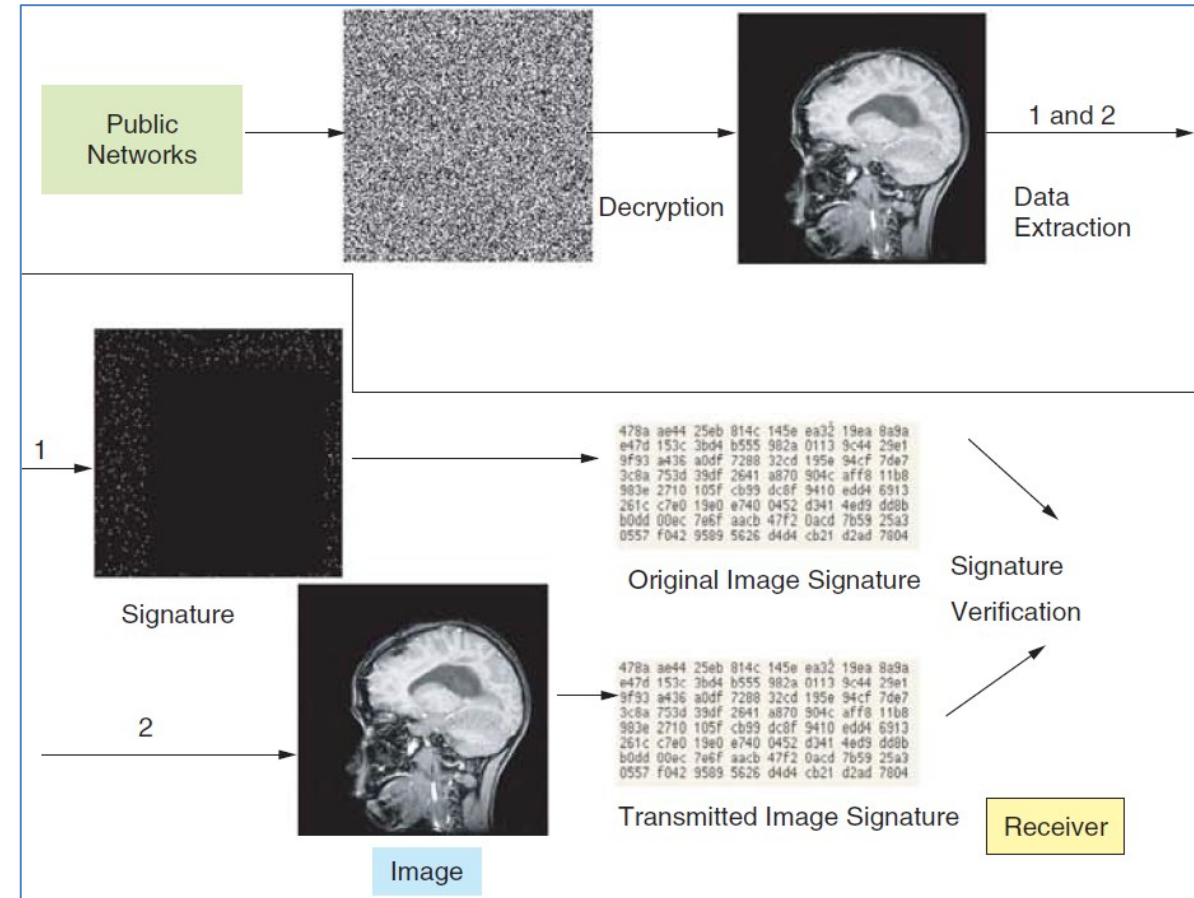
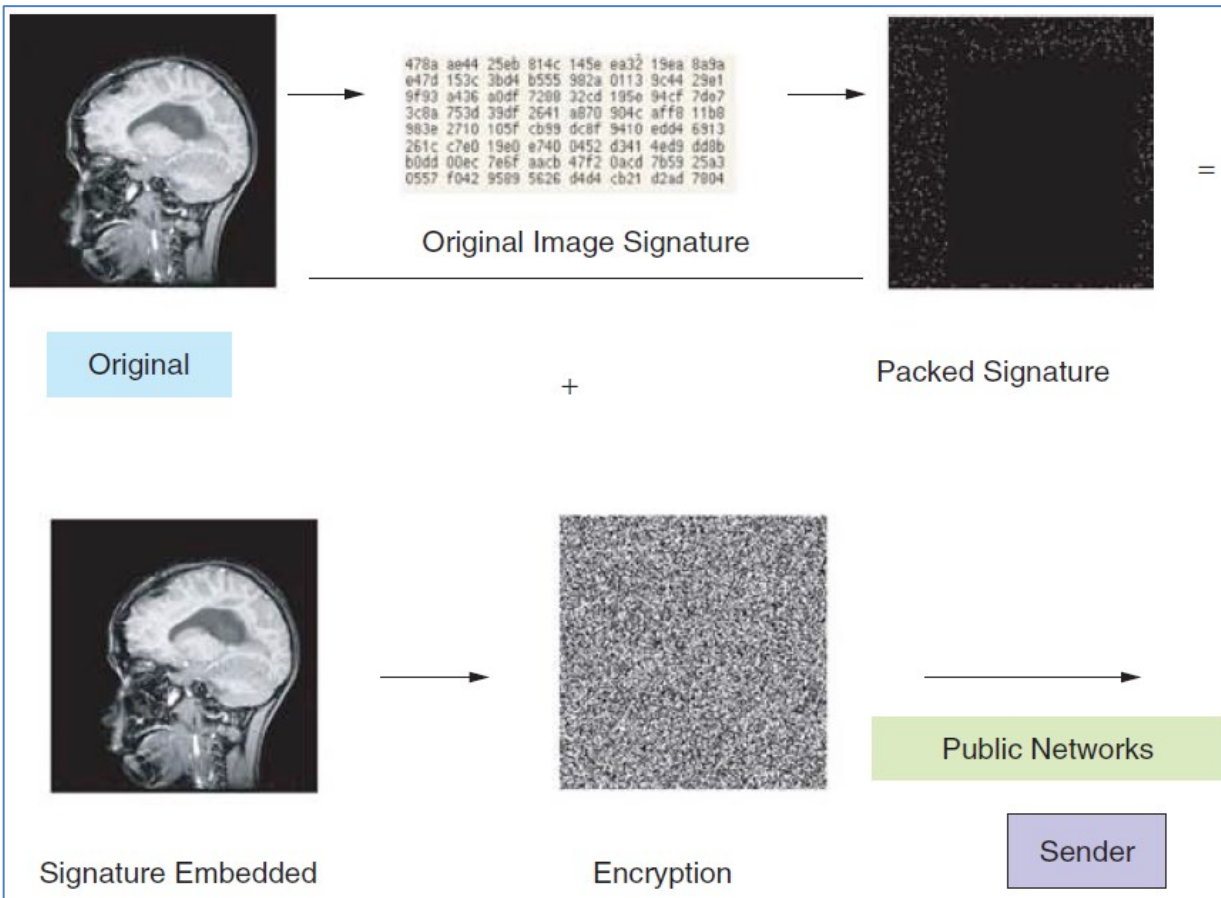


Image Data Privacy, Authenticity, and Integrity

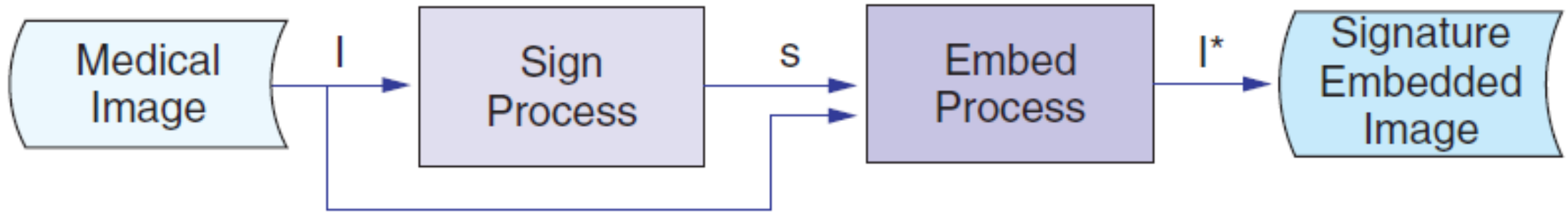
- Image transmission in teleradiology is mostly done through public networks (internet)
 - ▣ Trust in image data characterized in terms of privacy, authenticity, and integrity, has become important issue
- Privacy refers to denial of access to information by unauthorized individuals
- Authenticity refers to validating source of the image
- Integrity refers to assurance that image has not been modified accidentally or deliberately during transmission
- Privacy and authenticity are the responsibility of public network provider based on firewall and password technologies, whereas integrity is responsibility of end user
 - ▣ Imaging integrity is maintained mostly by using digital signature and encryption during generation

Principle of Data Integrity using Digital Signature

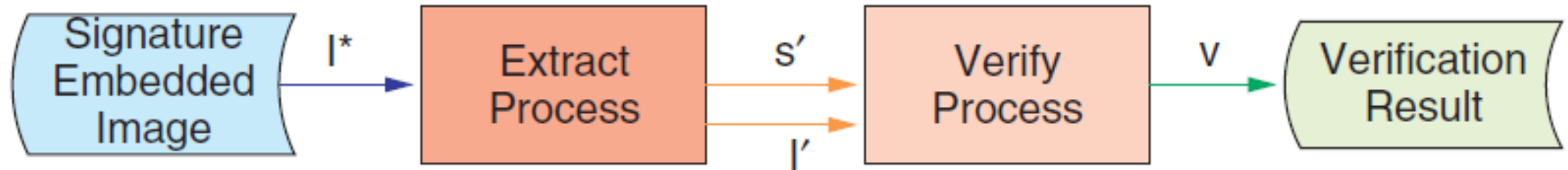


Lossless Digital Signature Embedding (LDSE)

Sign & Embed processes



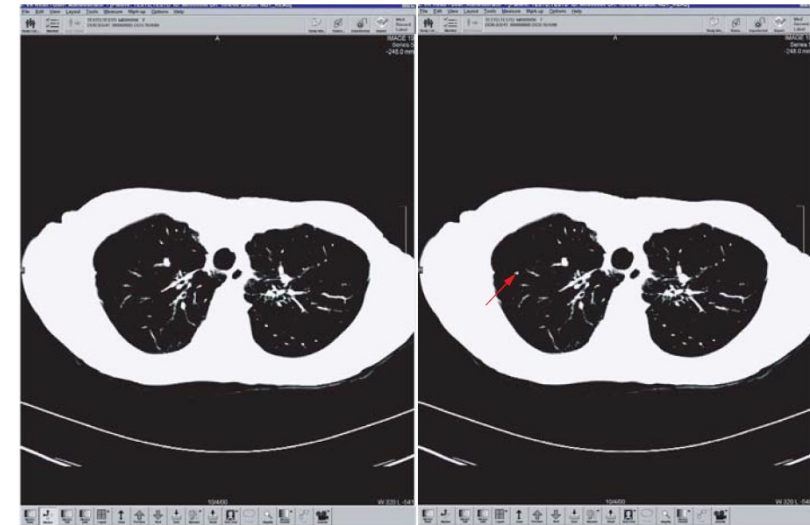
Extract & Verify processes



Teleradiology Trade-off Parameters

- First set of trade-off parameters consists of image quality, turnaround time, and cost
 - ▣ These three parameters are affected by method of image capture, type of workstation used, and degree of image compression
- Second set is data security, including patient confidentiality, image authenticity, and image integrity
 - ▣ Patient confidentiality as well as image authenticity must be considered
 - ▣ Because altering digital images is fairly easy, developing methods to protect integrity of image data is essential in teleradiology applications

	Image Capture	Workstation	Compression	Communication	Technology
Quality	X	X	X		
Turn-around time	X		X	X	
Cost	X	X	X	X	



Reference Material

- H. K. Huang, *PACS and imaging informatics : basic principles and applications*, John Wiley Blackwell, 2010.
 - ▣ Chapter 15

