Picture Archiving and Communication System for Public Healthcare

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BACKGROUND

For the past 100 years, film has been almost the exclusive medium for capturing, storing, and displaying radiographic images. Film is a fixed medium with usually only one set of images available. Today, the radiologic sciences are on the brink of a new age. In particular, Picture Archiving and Communication System (PACS) technology allows for a near filmless process with all of the flexibility of digital systems. PACS consists of image acquisition devices, storage archiving units, display stations, computer processors, and database management systems. These components are integrated by a communications network system. Filmless radiology is a method of digitizing traditional films into electronic files that can be viewed and saved on a computer. This technology generates clearer and easier-to-read images, allowing the patient the chance of a faster evaluation and diagnosis. The time saved may prove to be a crucial element in facilitating the patient's treatment process. With filmless radiology, images taken from various medical sources can be manipulated to enhance resolution, increasing the clarity of the image. Images can also be transferred internally within hospital departments and externally to other locations such as the office of the patient's doctor or medical specialist in other parts of the world. This is made possible through the picture-archiving and communication system (Dreyer, Mehta, & Thrall, 2001), which electronically captures, transmits, displays, and saves images into digital archives for use at any given time. The PACS functions as a state-of-the-art repository for long-term archiving of digital images, and includes the backup and bandwidth to safeguard uninterrupted network availability. The objective of the picture-archiving and communications system is to improve the speed and quality of clinical care by streamlining radiological service and consultation. With instant access to images from virtually anywhere, hospital doctors and clinicians can improve their work processes and speed up the delivery of patient care. Besides making film a thing of the past, the likely benefits would include reduced waiting times for images and reports, and the augmented ability of clinicians since they can get patient information and act upon it much more quickly. It also removes all the costs associated with hard film and releases valuable space currently used for storage. According to Dr. Lillian Leong, Chairman of the Radiology IT Steering Group of the Hong Kong Medical Authroity, a single hospital can typically save up to 2.5 million Hong Kong dollars (approximately US$321,000) a year in film processing cost (Intel, 2007). The growing importance of PACS on the fight against highly infectious disease such as Severe Acute Respiratory Syndrome (SARS) is also identified (Zhang & Xue, 2003).

In Hong Kong, there was no PACS-related project until the establishment of Tseung Kwan O Hospital (TKOH) in 1998. The TKOH is a 600-bed acute hospital with a hospital PACS installed for the provision of filmless radiological service. The design and management of the PACS for patient care was discussed in the first edition of this encyclopedia (Tong & Wong, 2005). The TKOH was opened in 1999 with PACS installed. At the beginning, due to immature PACS technologies, the radiology service was operating with film printing. A major upgrade was done in 2003 for the implementation of server clustering, network resilience, liquid crystal display (LCD), smart card, and storage-area-network (SAN) technologies. This upgrade has greatly improved the reliability of the system. Since November 2003, TKOH has started filmless radiology service for the whole hospital. It has become one of the first filmless hospitals in the Greater China region (Seto, Tsang, Yung, Ching, Ng, & Ho, 2003; Tsou, Goh, Kaw, & Chee, 2003).

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MAIN FOCUS OF THE ARTICLE

The design of a PACS for such a system should be high-speed, reliable, and user friendly (Siegel & Kolodner, 2001). While most equipment is designed for high reliability, system or subsystem breakdowns can still occur, especially when equipment is used in a demanding environment. A typical situation is what could be called a "single-point failure." That is, the entire system fails if only one piece of equipment such as a network switch fails. If some of the processes that the system supports are critical or the cost of a system stop is too high, then implementing redundancy management into the system is the best way to overcome this problem. The continuous operation of a PACS in a filmless hospital for patient care is a critical task. The main purpose of a reliability design is to avoid the occurrence of any single point of failure in the system. This design includes a number of technical features. The technical features of the PACS installed in a local hospital include the archiving of various types of images, clustering of Web servers installed, redundancy provision for image distribution and storage channels, and adoption of bar-code and smart-card systems. All these features are required to be integrated with the electronic patient record system (ePR) for effective system performance and these are described below.

Archiving of Multiple Image Types

In order to make connections with different imaging modalities (e.g., Magnetic Resonance Imaging, or MRI, Computed Tomography, or CT, Positron Emission Tomography, or PET, etc.), a common international standard is important. The Digital Imaging and Communications in Medicine (DICOM) standard developed by the American College of Radiology (ACR) and the National Electrical Manufacturers' Association (NEMA) is the most common standard used today. It covers the specification image format, a point-to-point connection, network requirements, and the handling of information on networks. The adoption of DICOM by other specialties that generate images (e.g., pathology, endoscopy, dentistry) is also planned. The fact that many of the medical imaging-equipment manufacturers are global corporations has sparked considerable international interest in DICOM. The European standards organization, the Comitâ Europâen de Normalisation, uses DICOM as the basis for the fully compatible MEDICOM standard. In Japan, the Japanese Industry Association of Radiation Apparatus and the Medical Information Systems Development Center have adopted the portions of DICOM that pertain to the exchange of images on removable media and are considering DICOM for future versions of the Medical Image Processing Standard. The DICOM standard is now being maintained and extended by an international, multispecialty committee. Today, the DICOM standard has become a predominant standard for the communication of medical imaging devices.

Web Technology

The World Wide Web (WWW) began in March 1989 at CERN (CERN was originally named after its founding body, the Conseil Europeen pour la Recherche Nucleaire, that is now called the European Laboratory for Particle Physics). CERN is a meeting place for physicists from all over the world who collaborate on complex physics, engineering, and information-handling projects. Because of the intuitive nature of hypertext, many inexperienced computer users were able to connect to the network. The simplicity of the hypertext markup language, used for creating interactive documents, has allowed many users to contribute to the expanding database of documents on the Web. Also, the nature of the World Wide Web provided a way to interconnect computers running different operating systems, and display information created in a variety of existing media formats. In short, the Web technology provides a reliable platform for the distribution of various kinds of information including medical images. Another advantage of Web technology is its low demand on the Web client. Any computer running on a common platform such as Windows or Mac can access the Web server for image viewing just using Internet Explorer or Netscape. Any clinical user can carry out his or her duty anytime and anywhere within a hospital.

Clustering of Web Servers

The advantage of clustering computers for high availability (Piedad & Hawkings, 2000) is that if one of the computers fails, another computer in the cluster can then assume the workload of the failed computer at a prespecified time interval. Users of the system see no interruption of access. The advantages of clustering DICOM Web servers for scalability include increased

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