A COMPREHENSIVE WEB-BASED PATIENT INFORMATION ENVIRONMENT

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Abstract- **The paper describes a new type of medical information environment which is fully web-enabled. The system can handle any type medical information including text, physiological waveforms, images and moving images, etc. The key to the PiRiLiS design is advanced web-browser based software integrated with a full Dicom library covering all modalities. This has resulted in a fast and robust system. The system has been evaluated at a number of sites including the USC Radiology Department in Los Angeles where it is connected to a number of scanners and PACS systems in three hospitals.**
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I. INTRODUCTION

This paper describes a comprehensive, web-enabled, patient-centric medical information system called PiRiLiS. PiRiLiS is a Level 6 system on the international scale for EPR systems. In addition to providing the functionality of a Level 3 system, it has telemedicine and other multi-media, document imaging, access to knowledge bases and embedded guidelines. Another important feature of the PiRiLiS design is that it is fully compatible with the DICOM 3.0 standard - which has been widely adopted by all of the world's major manufactures of medical equipment. For an EPR system to act as an effective information integrator between the RIS, PACS (and their equivalents in other departments) and the HIS it must incorporate full DICOM 3.0 functionality into its design. The group responsible for PiRiLiS is amongst the leaders in DICOM 3.0 software; hence, PiRiLiS has full DICOM 3.0 functionality and its design allows ease of upgrading.

The PiRiLiS system is also capable of supporting a wide range of legacy systems. This means that current information systems do not need to be replaced when the PiRiLiS is installed. On the contrary, PiRiLiS enhances the existing functionality and allows existing systems to be compatible with the latest hardware and software.

II. METHODOLOGY

A. Key Features of the Design

The PiRiLiS system is designed to be equally suitable for both hospital departments and primary care. The system is capable of straightforward integration with existing medical information. This means that PiRiLiS has the ability to act as an efficient 'adapter' between, for example, UNIX based systems and PC based-systems. Consequently, in many cases, healthcare organisations do not have to replace their existing equipment (e.g. non-DICOM 3.0 compatible PACS systems which may cost millions of dollars).

Because of its communication facilities and full compatibility with the DICOM 3.0 standard, PiRiLiS can support a wide range of data transfer (including various types of images) with external organisations – e.g. between a primary care group and a hospital department, or between hospital departments. Ease of data transfer can be best achieved if both organisations have PiRiLiS systems; however, the PiRiLiS will facilitate data transfer for a wide range of facilities.

B. The PiRiLiS Architecture

The PiRiLiS comprises an open-architecture system that runs on any standard web-browser. This means that, in order to view the patient record, all that is required is a standard PC, MAC or Unix-based workstation running Windows 98, NT, Unix, etc - plus security clearance to access the information on the server. PiRiLiS is a modular system and supports a wide range of standard communication technology including ATM, Ethernet, ISDN and dial-up modems. It runs on any type of network hardware that supports TCP/IP. The system supports the complete multi-media medical record (text, images, waveforms, movies etc.), as well as on-line decision support. Information is stored in a full relational database, using a hierarchical data structure – this means that data has only to be entered into the system once and can be viewed at many locations in different ways - including full telemedicine functionality. The system has a full audit trail (date, time and staff member entering or reviewing data is automatically logged).

The system is designed to have maximum flexibility: this means that it is easily scaleable from a single workstation up to a hospital-wide system comprising thousands of users. The PIRILIS architecture comprises three types of station: the Review Station, the Server Station and the Archive Station (a typical system configuration is illustrated in Fig. 1).

The Review Station is frequently located on the desk of the care health care professional; however they can be placed at any other appropriate location. The Review Station is based on a standard web-browser and supports the viewing of multi-media information and the entry of text and numerical data.

The Server Station in its simplest form, provides the storage, processing and routing of data. With more complex system configurations, the Server Station can comprise multiple computers and databases working in unison. The Server Station configuration supports multiple Review Stations at different locations.

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Abstract

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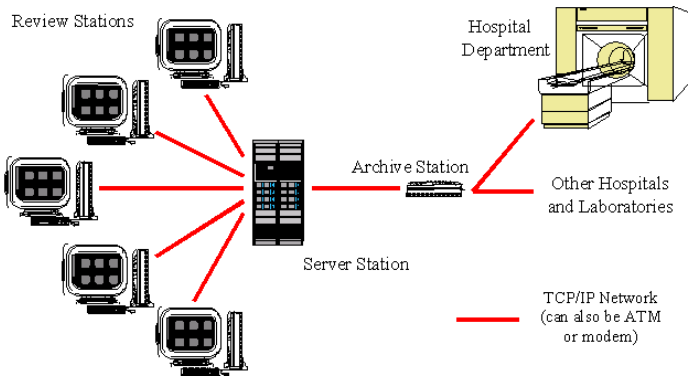

Fig. 1. A typical system configuration

The Archive Station forms the point of data entry for information from external systems (operating in both the analogue and digital modes). For example, the Archive Station supports high-resolution film scanners, audio and video clips, data from MR and other scanners, etc. The station software is designed to be fully compatible with the DICOM 3.0 standard.

C. System Evaluation

The technology described in the previous sections has been extensively evaluated within the Department of Radiology of the University of Southern California (USC) - which is located in central Los Angeles. The department performs more than 500,000 radiographic examinations a year at LAC/USC Medical Center and its companion health centers, USC University Hospital and Kenneth T Norris Jr. Cancer Hospital.

Within each radiology facility there was an abundance of vital imaging information. But, because of a lack of interconnectivity, it was not possible to transmit such information between the hospitals. Thus images were 'locked' into the proprietary PACS systems of each hospital. It was envisaged that some of these systems would be connected to PiRiLiS via industry standard protocols that are designed specifically for medical images and communications. For the purposes of the clinical evaluation, the PiRiLiS system ran alongside the existing Hospital Information System (HIS), the Radiological Information System (RIS) and the Picture Archiving and Communication System (PACS). PiRiLiS thus provided an 'information bridge' that connected the multitude of disparate clinical sub-specialities within the USC Department of Radiology. Clinical information was thus made readily available, economically and at all times, to clinicians at all points of care delivery within the Department of Radiology and beyond.

Network architecture was deployed whereby the PiRiLiS system was interfaced with the various CT & MR Scanners and PACS stations located throughout the hospital (Norris, LAC, UH). The system was configured for direct connection to the PiRiLiS DICOM Connector service. The overall architecture provided full support of the DICOM v3.0 standard.

III. RESULTS

The main findings of the system evaluation undertaken over the last year within the Department of Radiology can be summarised as follows.

- Diagnostic images and image sets can be selectively transferred as soon as they are acquired from the various CT & MR scanners into the PiRiLiS server and securely accessed by any physician remotely – 24 hours a day, seven days a week.
- The system provides network connectivity between the various PACS systems at USC. For example, from the Norris Cancer Hospital PACS system it was possible to view and transfer, to the PiRiLiS central server, any image within the PACS server at say, the LAC/USC General Hospital.
- Using the PiRiLiS system it was possible to have the whole of the patient case study (including images and relevant reports, etc.) available to clinicians at almost any point in the hospital. The evaluating clinicians endorsed the potential of PiRiLiS to significantly improve patient care and decrease the cost of patient care.
- Using the PiRiLiS system images were interpreted immediately after they were acquired, eliminating many of the process delays experienced during batch film reading.
- Using PiRiLiS, there was a distinct decrease in 'interpretation turnaround time' (defined as the elapsed time from patient arrival until a final report is printed).
- Archiving films in this manner also eliminated another risk associated with analogue images – the risk of loss.
- A distinct advantage of the PiRiLiS system was the ease and cost-effectiveness of utilising existing legacy systems (already in place within USC clinical sub-specialties) to function as Review Stations – without the need to replace them.

The current situation is that, for example, during the six weeks following the start of February 2001 82,000 images were automatically incorporated in patient records.

IV. CONCLUSIONS

The evaluation within the Radiology Department at USC has shown that it is possible to develop a comprehensive medical information system which is clinically focused. The system was found to reduce time for medical administration. The ability to view the entire patient record at anytime, anywhere in the hospital on a standard web-browser is considered highly beneficial. Within the context of the Department of Radiology, an integrated modular system that could be easily configured was considered important because of the range of equipment which had to be connected. This comprised both DICOM compatible equipment and non-DICOM legacy systems.