Mobile wireless access to EHR and PACS in clinical practice

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Abstract: We present a mobile solution for wireless access to an electronic health record system in a large university hospital. A clinically proven electronic health record system, including PACS, is extended by a wireless interface to which laptops and PDAs are connected. Advantages and handicaps of this wireless approach are discussed.

1. Introduction

The Klinikum Innenstadt of the Ludwig-Maximilian-Universität München successfully employs a proprietarily developed electronic health record system (EHR) since six years. The system stores all patient based information electronically available and allows integrated presentation and instant availability of this information.

The Department of Radiology and the Department of Nuclear Medicine provide digital imaging material, i.e. pictures and video streams administered by the internal Picture Archiving and Communication System (PACS). These include x-ray images, computer tomography images, magnet resonance images (original and reconstructed), radionuclide imaging, digital subtractional angiography and radioisotope scanning. This data, retrieved from the house-internal Radiology Information System (RIS), is accessible for the client-computers via a web server and the Hypertext Transfer Protocol (HTTP) and presented in the Hypertext Markup Language (HTML) format. The imaging material, available in the DICOM-format, can be comfortably viewed by using a special ActiveX control which allows for windowing, zooming and cine loops. As platform for the DICOM-interface serve intel-based systems with Linux as operating system.

To enter the information system, the IP-address identifies the network client and every user has to pass a security-check with a specific username and password. Besides this, a firewall features an additional security measure. HTTP based authentication requires a login for every browser-session. The user identification and administration component of the system subdivides the provided data according to the department where the correspondent patient is currently in treatment.
In addition to the digital imaging material, the EHR comprises relevant data for the clinical routine work, including medical examination results, diagnoses, letters, laboratory data results, ECG examinations, ultrasonic examinations, lung function, intracardiac catheter results and further diagnostic procedures. Any medication detail can be modified and examinations can be scheduled. Laboratory data can be displayed. Since the user interface is controlled completely by a web browser, the information system is accessible via connected desktop computers on every hospital ward. Since patient identification numbers and studies are uniformized, the system provides all conducted examinations, images and laboratory results leading to an integrated medical image of the retrieved patient in the framework of a “digital hospital”. Furthermore, the patient’s address and the related general practitioner can be displayed as well. Figure 1 depicts the user interface of the EHR on desktop computers, Figure 2 on the PDA screen.

The system is integrated in the every-day work of the physicians and indispensable to the management of patient data retrieval containing about 350,000 patients, 2 Mio. diagnostic procedures, 300,000 images with an average use of 6000 hits per day. To provide all this functionality during a doctor’s round in a convenient way, an instant and ubiquitous wireless access to the EHR is required. Thus, we developed a mobile handheld application, using a Compaq iPAQ and wireless located area network (WLAN). Currently, both a laptop and personal digital assistants (PDA) are being compared regarding usability and manageability in clinical practice.

2. Materials and methods

To minimize operating costs and to provide high scalability as well as expandability, the electronic health record system completely relies on standard components, mostly Open Source applications. It is based on a three-tier architecture. The lowest level is based on a central mySQL database, governed by PHP scripts as a middleware on the second tier. A DICOM server cares for the connection to the imaging devices and archives. The user interface itself is fully web-based, Apache is used as the web-server. This allows to customize the user-interface easily and to adapt it to various platforms. The HTML layout has been optimized for both an Compaq iPAQ PDA screen of 320x240 pixels (Figure 2) and full screen displays with 1024x768 pixels (Figure 1). A special converter software, operating on the second tier, scales the image size down to the screen specific format, in order to minimize the rendering time on the computationally weak handheld. Currently, the ward in which the wireless access is being evaluated, is equipped with two access points. The round wagon is equipped with a laptop and three iPAQ handhelds have been distributed among the medical personnel. To provide maximum security for patient data, the central database requests user authentication and all transmitted data packets are encrypted with the WLAN WEP 128bit standard and Secure Socket Layer.

3. Result and Discussion

The evaluation of laptop and PDA is still in progress. Higher screen resolution and the faster response time of the user interface plead for the laptop. On the other hand, PDAs are smaller and lighter and as many physicians already use a PDA in clinical practice, the platforms main advantages are superior availability and personalizability. Moreover,
the size of common physician’s wear provides retaining place for a PDA but not for a laptop. The physicians using the PDAs emphasized this point of advantage. However, there is risk to damage the PDA by falling out of the physician’s pocket, especially during physical examinations. In this regard, the physicians using the PDA in clinical routine reported varying practical experiences, mostly depending on their former practice with information-technology related tools. Overall, the physicians showed a graduated ability to use the PDA in an efficient and intuitive way. Overall this WLAN PDA solution is widely accepted by the physicians employing that tool.

Meanwhile, DICOM-standards and PACS are commonly used technologies in modern radiology units [JK99] [HK00]. However, the implementation of mobile computers in PACS is rare in clinical practice [YN02]. In comparison to other approaches implementing PDAs in patient record systems [CS02] [DS01], our solution has proved its practical application as a non-wireless clinical information system since several years. Thus, the wireless component fits in an established EHR environment.

Since stationary desktop computers with large screens are used on the wards for regular clinical routine work, laptops have no applicability except the doctor’s round. Thus, additional purchase costs are reduced using PDAs for mobile data access. Moreover, in a large hospital, physicians usually attend meetings outside their ward, such as patient discussion rounds or educational sessions. Thereby, the easy accessible patient data and individual notes about points of interest, saved on the PDA, have been appraised as very helpful mobile tools by the majority of users. As bilateral data transfer is provided via an infrared interface of the iPAQ, physicians are able to share relevant patient data for consultation of colleagues. Although current form factor and weight of an iPAQ handheld with a WLAN jacket are not optimal yet, it is expected that with ongoing integration and the announcement of industrial availability of handheld devices with integrated WLAN capability, combined with increased processing power in the near future, this platform will become even more interesting. A further approach could be to implement an alerting function to point out critical clinical parameters [SL00]. In the course of this evaluation, the usage of web pads is also very promising and is planned for the near future. Taken together, our approach provides a mobile solution integrated into the existing clinical-information-system via WLAN with regard to high security aspects.
Figure 1. User interface on desktop computers showing the summary of patient-related diagnostic procedures (left) and written diagnostic results (right), respectively.

Figure 2. COMPAQ iPAQ Screenshots of patient’s laboratory data (left) and x-ray image (right)
References


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