

Wireless networking with a PDA: the Ward-In-Hand project

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Abstract

The paper briefly describes Ward-In-Hand, a project aiming to support the day-by-day activities of doctors and nurses within an hospital ward by providing a tool for workgroup collaboration and wireless access to the patient's clinical records. The project, which is at present experiencing its first prototype, is based on accessing the information system from the patients bedside, with a wireless connection through a PDA client.

Ward-In-Hand is not intended to replace or compete with current Hospital Legacy Systems, it is rather meant to complement them. It exchanges information with existing tools, updates data in real time and makes it available to doctors and nurses adding a new dimension to capabilities currently available in hospital information systems: mobility and ubiquitous computing

Introduction

Ward-In-Hand aims to provide the healthcare professionals with a handy IT tool to get assistance during their daily activities. The project starts from the consideration that most often doctors and nurses do not have easy and timely access to the patient's information when they work at the "bedside". Information is often recorded on paper and subsequently transcribed on paper for further processing. The solution sought is to replace the current procedures based on manual transcription and transmissions of data, using wireless connectivity to complement conventional data entry to the hospital existing information system (called "the legacy system").

Ward In Hand is an international project co-funded by the European Commission within the IST (Information Society Technologies) Work programme, and it is being developed by a consortium made up of 4 industrial and academic partners and 3 pilot users (Hospitals) representing 5 European

countries. Development started in January 2000; the final deliverable, planned for release in mid-2002, will be a complete system ready for commercial exploitation. At the time of the preparation of the present paper, users in a real hospital environment are installing a first prototype at the pilot sites for validation.

The Ward-In-Hand acronym stands for Mobile Workflow support and InformAtion distribution in hospitals via voice-opeRateD, wIreless-Networked HANDheld PCs. The architecture is modular, designed to serve a single ward where doctors and nurses are equipped with a mobile device (currently a Compaq Ipaq 3630 is being tested) connected to a ward server through an IEEE 802.11 wireless LAN. The server in turn communicates with the hospital's legacy system.

Though the architecture (shown in Figure 1) allows to access the application through any terminal (including desktops) connected to the LAN, its main purpose is to support doctors and nurses while they operate "at the bedside", where timely and up to date information availability is most required.

The main features of the system are:

- the ability to maintain a "personal organiser" that provides the actors with a real time list of tasks to be executed; once performed, a task can require scheduling of new tasks according to "workflows" that have been configured for that particular installation. A typical example is a drug prescription by a doctor, which will trigger a new task (or perhaps a repeated series of tasks) for the nurse to give the patient that particular drug.
- the capability to display on the mobile unit the relevant information contained in the patient's clinical records, and update these data

The rationale for such a system is quality improvement (higher quality of the healthcare services, elimination of errors, better security

and safety standards enforcements); and increased efficiency of the process (improved synchronisation, reduced wastes of time and materials).

The novelty of Ward-In-Hand with respect to other hospital information systems lies in the use of wireless networking through PDAs: these devices can be operated at patients bedside and will soon be equipped with voice interfacing features, thus giving the medical personnel the possibility of hands-free operation. However, the new features may hardly be useful, unless they are fully integrated within the existing hospital information systems.

Let us consider in more details the underlying ward architecture: it is a client- server one, where mobile clients on a PDA interact via a web-based interface, communicating with the ward server by means of XML documents. The Electronic Patient Record itself is kept as an XML document, divided into three different parts: Personal Data, Clinical History, Stay.

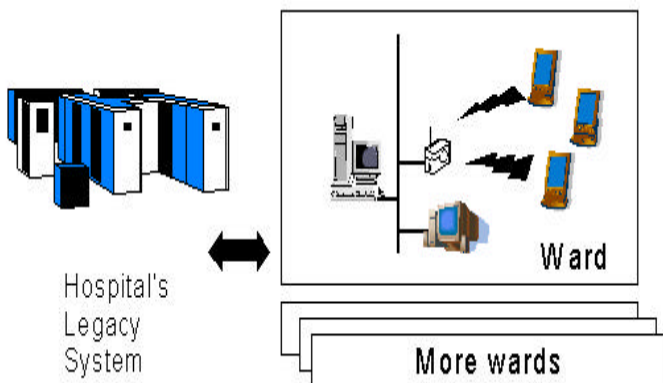


Figure 1. The Ward-In-Hand system

The first part is taken from the administrative databases, that is the "legacy systems" of the hospitals; the medical information contained in the second and third part of such a document may originate from a medical database (another legacy system, possibly different from the administrative one), or may be internal data, originated inside the ward, and stored in the Ward-In-Hand server only. In the following section, a brief summary of healthcare proposed standards for the clinical record integration is shown. More information can be found in [WIH-D23] and [Blair96].

Electronic HealthCare Records (EHCR) standards

Healthcare institutions devote a great attention to integrate all information related to the delivery of healthcare to a patient over his or her lifetime, allowing an easy interchange of electronic medical records among different management systems. The major problem is the different systems used

by healthcare organisations to record Patient's Record elements.

One technically feasible way to implement seamless interchange of patient care records is simply to require all hospitals and health care agencies to use a single standard system dictated by the government. However, this solution is unpractical, since it would require the replacement of existing heterogeneous systems with a single new system. Moreover, it is not possible to impose a universal data model or architecture to the healthcare industry.

A standard for electronic data interchange is then mandatory, to allow the sharing of healthcare records among different systems, and several standards consortium have been created for defining any sort of useful standards, for different kind of data and application.

Standardisation works in this direction have been performed in US and in Europe. Presently, the most important standards in Europe and US are **CEN TC251** and **XML/EDI** in Europe and **HL7** in US. For what concerns the system architecture, where of course no standard models can be proposed, CORBA and DCOM are the two competing approaches that allow controlled access to remote objects, without forgetting simple WEB applications (message exchange between client and server).

CEN/TC 251 [TC251] is supported by the European Commission DGIII, healthcare authorities, suppliers of ICT-solutions and users, to develop standards that enable compatibility and interoperability between independent systems in healthcare. The use of XML for messaging in healthcare has been investigated inside the European XML/EDI Project, co-ordinated by the CEN ISSS Electronic Commerce workshop. The team of XML/EDI Project has considered if XML can help to capture, validate and disseminate information that companies need to exchange to do business. A draft set of XML document type definitions (DTDs) related to EHCR Request, Provide and Notification Messages (defined by TC251) has been delivered.

HL7 (High Level 7) is a group founded in 1987 to develop standards for the electronic interchange of clinical, financial and administrative information among independent health care oriented computer systems; e.g., hospital information systems, clinical laboratory systems, enterprise systems and pharmacy systems. HL7 uses a message format similar to UN/EDIFACT messages, however, the community is currently investigating the possibility of changing its messaging structure to an XML format (HL7 Version 3).

Since the dominant trend is towards the use of open standards such as XML and HTTP, rather than proprietary protocols that are not well suited to the Internet, our choice for WARD-IN-HAND EHCR was in this direction. With respect to the message format, XML is considered a way to make data available from Legacy Systems to a large number of users over an intranet or the whole Web. Healthcare standardisation groups consider XML technology advantageous, for patient record exchange, and superior to Un/Edifact messages.

Legacy Systems Integration

The WardInHand EHCR definition reflects the kind of data particularly suited for the specific application. However, a mapping between our XML representation and its standard representation according to TC251, or HL7 Version 3, can be done efficiently with XSLT. XSLT also allows data from multiple sources to be used to create a customised data presentation format, for example to take into account factors like the preferred language of the person viewing the message and the type of device that is being used (HTML-based web browser or WML-based mobile phone).

With respect to the integration system architecture, even if the project is based on Windows NT, we decided not to be limited to a proprietary solution like DCOM, and considered both the approaches using CORBA, or a WEB application. CORBAmed [CORBAmed] is the Healthcare Domain Task Force (from October 1994) of the OMG, the Object Management Group. It defines standardised interfaces to many healthcare "Object Oriented Services," across most usual platforms, and available in the public domain. By providing an object-oriented view of clinical information, CORBA allows hosts to "protect" the data by exposing only specific "methods" to clients. Clients can rely on CORBA hosts to provide information on demand and need not keep duplicates of information in local storage, obviating problems of freshness and authenticity which are inherent in message exchanges. The utility of CORBA in this field is proved by TeleMed [Kilm97], a prototype for virtual patient record developed at the NJC in Denver, that allows multiple physicians to consult, interactively in real time, on the same patient record.

However, our choice was limited to a simple WEB application, mainly for two reasons. The first is that interactive sessions are not needed in our system, thus, even if the HTTP protocol is stateless and poor for managing

interactive connectivity, it is sufficient for our needs. The second is that it is much easier to develop a Web-based interface rather than a CORBA-based interface. Healthcare organisations are considering the cost-savings and ease of use that the WEB provides, and are ready to provide themselves a WEB interface. For a Web application, different technologies can be exploited, from the server side, such as CGI-Bin, Java and Java Servlets, Scripting server Side (ASP, JSP, PHP). A good solution, due to its platform independence, is the PHP technology, working on the majority of the Web servers, with performance similar to ASP.

The integration architecture finally chosen for WardInHand system is shown in figure 2. The two agents LSI and LSA, respectively on the WARD-IN-HAND server, and on the Legacy System server, exchange data as XML documents, using the HTTP protocol.

XML is an important feature of the project, since data in the Patient Record database are XML documents, as well as the parameters returned by the Patient Record Agent functionalities. Data managed by means of the Legacy System Integration Layer are XML documents, which conform to the general Patient Record DTD of WardInHand: each document is a Patient Record Part and corresponds to a record, object or other kind of data maintained in some external database.

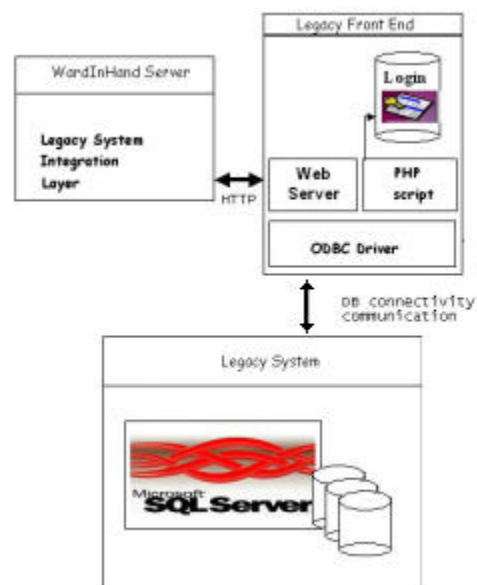


Figure 2. Legacy Server Organization

The Legacy Server Agent virtually acts as an XML Server, able to translate the WARD-IN-HAND query in some other format acceptable by the Legacy System, and to convert an XML document in the format required by such a

System, and vice versa (as shown in the example of Figure 3).

XML servers are platforms that allow to access data in the form of XML documents, to and from distributed applications, such as e-commerce and business-to-business applications. They generally provide access to data in a variety of data stores, including legacy databases, email messages, and file systems.

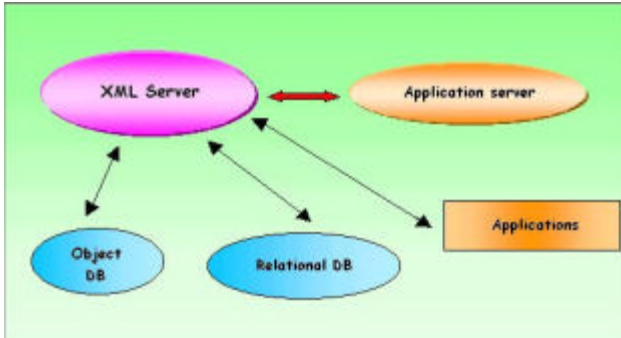


Figure 3. Legacy Server organization

In order to define a WardInHand query, we referred to XQL, that, even not yet a standard, has been considered as a good starting point, and the resulting WARD-IN-HAND query is a subset of it. XQL is an XML Query Language that allows to address the elements of XML documents. The data model is the node tree representing the XML document, labelled (with the tag names) and ordered. The selection of the results of the query is

performed by means of filters on the values of the XML document nodes.

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