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Intranet Health Clinic: Web-based Medical Support Services Employing XML

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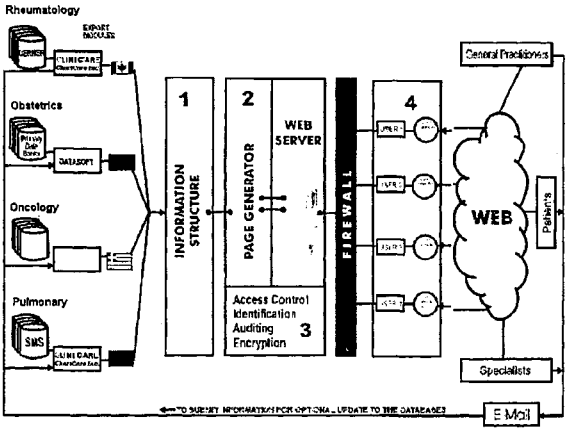
Abstract. In this paper, the implementation of an Internet-based telematic service for medical support is presented, which operates in pilot form within the INTRANET HEALTH CLINIC project - a two-year project supported by the European Commission under the Health Telematics Programme. The aim of the application is to offer high quality care to users of health services over inexpensive communication pathways, using Internet-based, interactive communication tools, like remote access to medical records and transmission of multimedia information. The XML technology was employed to achieve customised views on patient data, according to the access rights of different users. Strict security and access control policy were implemented to ensure secure transmission of medical data through the Internet. The system is designed to collaborate with existing clinical patient record systems and to be adjustable to different medical applications. Current pilot implementations are under clinical evaluation and include oncological patients (Greece), Lupus Erythrematosis (Canada), Obstetrics (Belgium) and Chronic Obstructive Pulmonary disease (Spain).

1. Introduction

INTRANET HEALTH CLINIC (IHC) [1] utilises Intranet networking to provide remote access to medical services and related support services, aiming at offering high quality care to users of health services over inexpensive communication pathways, using Internet-based, interactive communication tools, like videoconferencing, transmission of multimedia information and access to medical records [2]. The set of services to be offered constitute a network that connects specialised hospitals, secondary level hospitals, medical centers, general practitioners (GPs) and patients. Through this network, a number of supporting activities are offered:

- Specialised information is transferred from the tertiary centres to lower level health care providers and GPs, either as direct communication or in the form of accessing patient information and educational material. In this way, remote access to specialised support is offered to physicians, and the dependency of their patients on the tertiary centre is reduced, increasing the quality of care.
- Information between the tertiary centre and the patient is exchanged to support patient treatment and enable home care. The patient is able to communicate with the specialised centre in order to get medical advice and treatment follow up, avoiding the on site visit.
- An electronic patient record is accessible through the web by all doctors involved in the treatment (with authorisation from the patient) and by the patient himself. Strict accessibility and security policy ensures patient's privacy.

2. System Architecture



The approach, which was adopted for the implementation, was based on the concept of Common Information Structure and generic Web Page Generator (WPG). According to this approach, the "heart" of the system is the Web Page Generator, which is responsible for creating the patient data web pages and installing it on the web server. The latter then acts as the contact point for the user, contains the educational material and provides links for communication services.

Figure 1: System architecture

Since the WPG is defined as common to all sites, whereas the clinical database and the patient data fields are different, a common reference point for patient data was defined for all applications. Clinical partners produced a data dictionary containing all the data items to be included in the IHC application. A unique label was assigned to each data item and the complete dictionary was used as a reference for the applications comprising the Common Information Structure. A master dictionary was created, as the union of all data items reported to be useful in any application. All items are organised in sections. Each section corresponds to one type of data, e.g. lab examinations, demographic data, etc. Each local application-specific dictionary is then defined as a subset of the master dictionary. In this way sites are compatible with each other in the sense that the same patient data items have the same name and definition everywhere and records containing such data are valid universally. Future expansion is straightforward by adopting or defining additional items.

The overall system comprises the following components:

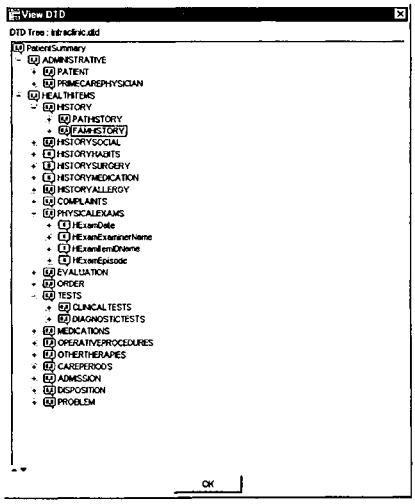
1. **The Computerised Patient Record (CPR):** contains the medical data of patients in their most complete and consistent version for the application. It is typically pre-existent and operational. New information on the patient that is being produced is fed back to the database. However, both access of data and return of new data by the IHC to the clinical database are subject to important restrictions.
2. **The Database Access Component:** accesses through ODBC mechanisms the CPR and exports the data in a well-defined form, suitable for web publishing. The CPR can be any proprietary system and its structure and content is already defined independently from IHC. The output of the component is in the common information structure form. The database access component is actually the interface between the site-specific clinical system and the common IHC software.
3. **The Web Page Generator:** transforms the patient data to web pages, suitable for presentation to the users. Customisation depending on the application and user group is implemented using the eXtensible Markup Language (XML). The output is sent as web pages to the web server.
4. **The Web Server:** central access point for the web-based services. The remote user connects to access educational material, patient records, to send and receive messages or to initiate a conferencing session. It contains the static educational material and the

pages corresponding to the patient data, as produced by the Web Page Generator. It also implements the access control features.

5. **The Security Component:** supplements the access control and provides the security functions. It is currently implemented as a firewall, which provides border defence for the web server and encryption for the data transmission.
6. **The Client Component:** consists of a common Internet browser and some plug-ins, according to the application, and runs on the user terminal.

3. The XML implementation

The adoption of the XML solution [3] for IHC applications allows a more simplified and elegant implementation which is, at the same time, more straightforward and flexible. The difference between conventional HyperText Markup Language (HTML) pages and XML is that, instead of creating pages using HTML "formatting" tags, an application specific Document Type Declaration (DTD) can be defined in order to use "content" tags in combination with stylesheets. The main advantage of XML solution is that: i) content is separated from presentation. Different appearance (stylesheets) can be applied to the same data. This is useful for IHC, since each patient file should be viewed differently by the patient, the specialized doctor, general practitioner, etc. ii) each end user can render the data appearance in a different way. iii) it is straightforward for a parser at the user end to extract the data items and achieve in this way a web-based data exchange application.



In our system, web-based access to patient data is provided using XML. For this purpose, a Document Type Declaration was defined for each pilot application. This was entirely based on the Common Information Structure. The XML tags were defined in this document and were given names identical with the data item names included in the data dictionary. The structuring of the data was also implemented according to the definition in the dictionary. The hierarchy tree which corresponds to this DTD can be seen in Figure 2.

Figure 2. The hierarchy tree of the XML structure. Only the first three levels are displayed, due to space restrictions.

Patient data are extracted from the clinical database by the Database Access Component and are stored directly in XML files, marked with the appropriate tags. This means that patient data are transferred in ASCII files as content and tags. The output of the Database Access Component that complies with the Common Information Structure, is actually an XML file. This file is consistent with the syntax of XML and with the definitions included in the DTD.

More specifically the Database Access Component has the following functionality:

1. Access to the clinical database using ODBC (Open Database Connectivity - a widely accepted application programming interface for database access). Since all major RDBMS (Relational Database Management Systems) have ODBC drivers, the application is able to retrieve data from any database, as long as the structure of the underlying tables is the same in all cases. Of course this is not the case for the different pilot sites, but the definition of "views" of the data of the different databases in a

common format compliant with the DTD definitions allows one application able to work with any of the databases.

2. Create one XML document for each patient. This document contains the data items from the clinical database that are useful for the IHC application. Each data item is in text form and is enclosed in the appropriate XML tag.
3. The created XML documents are stored as separate files for each patient at a location that is suitable for the Web-Server to access them. The produced software runs on a terminal at the same LAN with the database, uses the client software for the database and FTPs the produced XML documents to a different machine. The latter contains the Web server, XML patient data, stylesheets for each user group (XSL), software for transformation mechanism (ASP), access control data, application home page and supporting material.

All patient data that are used by the application are extracted from the database on schedule and are stored in static form, in order to achieve the restrictions required by the hospitals for isolation between the primary database and the web system. Since this form is XML, it only provides the content and does not define the layout.

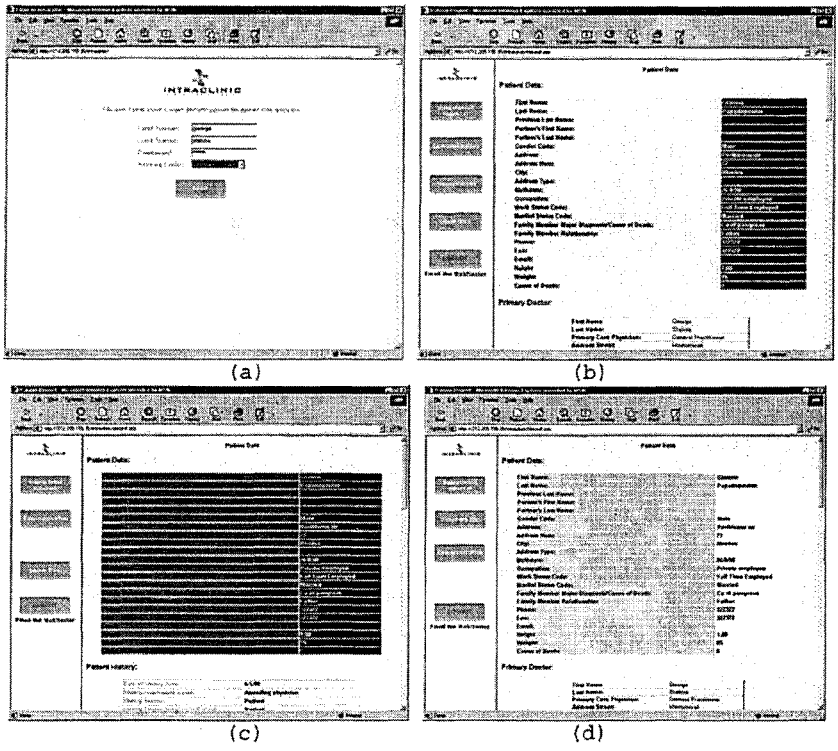


Figure 3. (a) Home page of XML web server. The user enters with the appropriate password. (b) A doctor accesses the data of one of his patients. (c) A nurse accesses a restricted view of the same patient's record. (d) The patient receives a different view of his data. The buttons on the left frame allow additional functionality, such as communication (mail or videoconference), educational material or management (only for doctors).

The Web Page Generator defines the layout of the patient files by the appropriate stylesheets. These are written in XSL language and define the way in which each data item will appear [4]. Tables, fonts, colors, etc. are all defined here. Stylesheets also define which items from the ones that are included in the XML files will appear and which will

not. In this way, access control is applied at user role level. One stylesheet is defined for each different user group and determines which fields and in which form will appear (Fig. 3).

Additional access control is applied at individual user level, where the user name defines the specific records that can be accessed, e.g. doctors are allowed to see the files of their patients only. This is implemented as a set of tables, which define the patient XML files to which each user has access.

4. Discussion and Conclusions

The system presented in this paper is intended to provide a platform for secure Internet-based provision of advanced telematic healthcare services. An elegant technical solution was given which employs the structure and flexibility offered by XML to implement web-based patient data access. The customisable tag definitions allow easy adaptation to the application and the stylesheet transformation capabilities enable powerful control on accessibility and layout. The definition of the Common Information structure is a concept that will make future expansion easier and provides a valuable reference towards interoperability and standardisation.

An important characteristic of the system is the smooth integration with existing clinical health record systems. This is achieved by importing a selected set of data, using the appropriate client application and introducing this data in an isolated web-based environment. The fact that all services are available through web-based interface introduces enormous flexibility, allowing platform independent service provision wherever on land, air or sea there is Internet connection and through a variety of media, such as phone line, ISDN, n-ISDN, satellite or xDSL.

During this work, it became clear that there is a need for further experimentation on the behaviour of XML and for updating of the authoring tools and server software, since considerable activity on this field is expected in the near future. The issue of security was of primary importance, since medical data are travelling through the quite insecure and uncontrollable Internet. The flexibility in access points was compensated with strict access control rules.

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