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A New Approach for Hypermedia Medical Records Management

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Abstract. With the advent of information society, medical systems have to use integrated new technologies such as hyperdocuments, multimedia documents : texts, images and sound. In this paper we show how we can build a new generation of medical information systems based on the functionalities given by the World-Wide Web (W3).

1. Introduction

One of the challenges for the evolution of future medical information system is their ability to handle multimedia data in an integrated and efficient way (i.e. text, images, audio and also digitized video). The popularity of the W3 using Internet has grown tremendously for three main reasons : firstly it provides an easy use of interfaces based on hypertext ([6]); secondly the user does not have to be aware of the underlying technology : a simple click on the mouse is sufficient to retrieve data from any other computer and thirdly it integrates various media.

We propose to use this new technology on a local network in a hospital : a growing number of medical documents include pictures, sound and video. Using the standards of W3 we can build a distributed hypermedia information system for hospitals. The main problems in such a work are :

1) How to store and update medical data? Data have to be stored in different formats according to the format of the DBMS and as Hypertext documents.
2) How to obtain relevant data? Finding relevant data at a given time is not easy. Index services use mainly titles of documents, but in medical systems it is well known that it is not a good basis to decide whether a document is relevant or not (e.g. many documents may be called "radio").
3) How to find data in a reasonable amount of time? Due to the enormous number of medical documents the problem of access time is really important.
4) What is the quality of the data? Many people (and various doctors) put everything on the network. How to be sure that we have a quality control of the information?
5) How to couple traditionnally called databases (always necessary for computing data) and other sources such as documents?

In this work we try to give solutions to some of these problems in building a prototype based on some solution to this challenge.

2. Medical documents

The main idea of our approach is to provide the user a computerized system which would disturb his job as little as possible. The physician usually uses documents to store and transmit information. The medical record is the gathering of these documents. We thus decided to use documents as a metaphor for the user interface of the computerized system.

When he works a physician needs many information and many forms of information (text, images, sound and video) to have a good idea of the state of health of a patient. If he uses a computer, the doctor must be able to see on the screen on his workstation the different information at the same time. The main problem we meet with conventional systems is that doctors must stop the logical process to get external information and then come back to the main process (for instance, he wants to know the value of a biological parameter and look at the latest radio of an organ and then look at a set of radios made some months ago and come back to the starting point). Conventional systems need to interrupt a process and then call another one. These systems are not efficient because they cut the linear process of the thinking. Hypermedia systems ([7]) allow, only using a mouse, to navigate in the documents in the same way as when a doctor works without the help of a computer.

Another aspect of documents has been studied in our project. Usual systems manipulate filled documents which are stored directly on the disk as a whole file or as linked pieces. Such documents are not appropriate for our purpose. In our system, we have to keep a part of the data in a database. The system must be able to make processes on data in order to fill a form when necessary. So, a part of the data contained in the documents come from a database.

We therefore defined virtual documents (see figure 1). They are built from two elements :
- a skeleton (the form) which represents the specifications of the document,
- a gateway which gets data from the database and includes them in the skeleton.

Virtual documents are also used to store information in the database. Such a document is most of the time a form-based document, and each item of the filled document is sent to the database to be stored. The form may contain values from the database, or default values.

Figure 2 describes an example of user interface. It is composed of a main document which presents a synthesis of the pathology following of the patient Paul Durand. Each stage is presented as a date and description couple. Hyperlinks permit to go further with a simple click : additional information such as radios or oral comments is available in the other windows. The main document is a virtual document. It is build with data from a database, and a skeleton describing the format of the presentation. The two other documents are filled documents : they are stored and presented as they are.

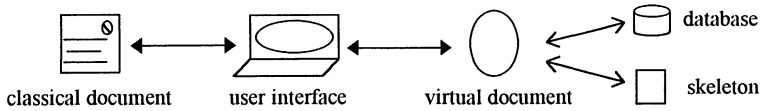

Figure 1 : Virtual documents management

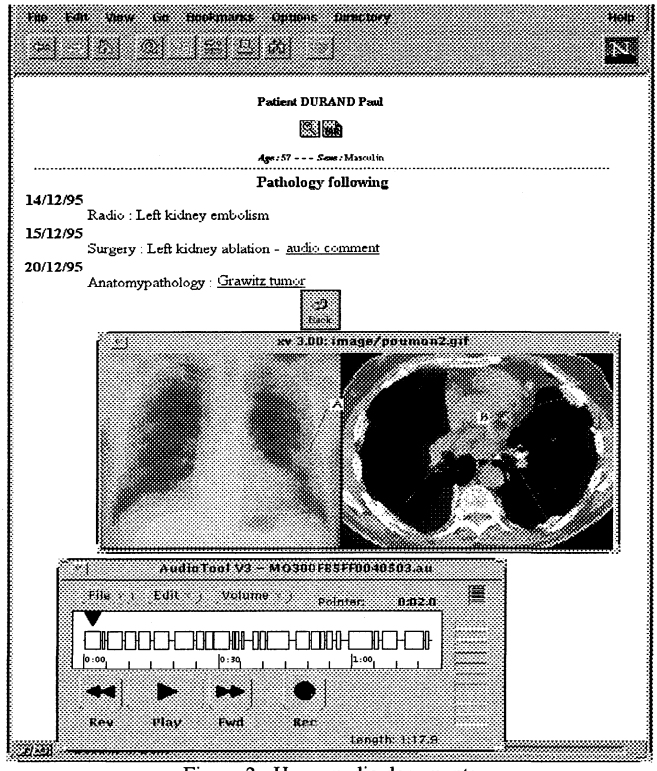

Figure 2 : Hypermedia documents

3. Electronic medical record

The problem of medical data sharing is very important in hospital([1], [5], [10]). Until now, two types of medical records were proposed :

1) All the data produced in the hospital concerning one patient are grouped in one medical record. This assures that all practitioners have access to all data concerning a patient. But the volume of medical information is so important that it is greatly difficult to capture relevant information.
2) A synthetic medical record is produced for each patient. It contains only the most relevant information about the patient. This type of record solves the data relevance problem but is sufficient for none of the practitionners : they cannot study in depth one specific facet of a patient's state of health.

As these two opposite propositions are not adapted, we propose a median solution, based on two kinds of medical records : the specialized medical record and the common medical record.

- Each service of the hospital maintains a Specialized Medical Record (SMR) for each patient. It contains all the data concerning this patient in the service.
- A Common Medical Record (CMR) represents a synthesis of the state of health of the patient. The CMR are at different levels. For example, the Hospital CMR contains the most important information about the patient. One can define as many levels as needed.

Connections between the SMR and the CMR allow one physician to access the specialized information of his service, the synthesis about the patient from other services and if needed he can access the specialized data of other services.

To insure quality of information, each information is automatically signed by its producer. It helps the reader evaluating the quality of information. For example, comments on X-Ray made by a radiologist has more impact than if made by a physician of another specialty.

4. Architecture

We have implemented Internet techniques into a private local network. The main technique used is the WEB, but electronic mail and ftp servers are also used. For each service whithin the hospital our system is composed of three components :

- A Database Management System
- A Multimedia/HyperMedia/Virtual Document Serveur
- One client application for each machine connected to the system

4.1. A DataBase Management System

The DBMS manages a bunch of databases conforming to the logical scheme on figure 3 :

The SMR are stored into specialized databases. Significant data are physically replicated (rather then dispatched) into the upper CMR level databases, in order to reduce the risk of data unavailability during a network crash for instance.

At the time (or just before) a patient is admitted in a service, the specialized database copies locally parts of the CMR produced by the other services. The CMR data are timestamped so as to copy only the updated parts of the CMR.

Access to the CMRs must be controlled. As a matter of fact, at a certain time only one service can modify the data concerning one patient. That is why we defined a token system. Once a service has the token for a patient, no other service can update any common data of this patient. When a patient leaves a service, the token is freed. The common data are either public (eg the address of the patient) or private (ie only the producer can update the data).

4.2. Multimedia document server

The multimedia document server is able to transmit data coming from the database to the user interface. The data are encapsulated inside a document as described before. The multimedia document server we used is the one used over the Internet : the WEB. The WEB server (or http dameon) is a standard of the Internet in order to upgrade the system as new versions are provided.

We developed a gateway between the WEB server and the database management system we use. Every standard daemons are able to run a program conform to the CGI (Common Gateway Interface) specification [11]. We developed such a program the only task of which is to transmit the request between the daemon and the gateway (figure 4).

The gateway is started every time a new user connects to the system. Its task is to request the data from the DBMS, encapsulate them into a document and transmit it back to the http daemon. The gateway manages one database session for each user. It has been developed in order to be database independent. It is written in perl [9] using the DBI (Database Interface) [3] and the DBD Oracle (DataBase Driver) [4] packages. If we change the database, we only need to get or develop the appropriate database driver.

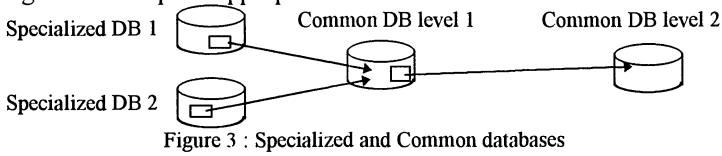

Figure 3 : Specialized and Common databases

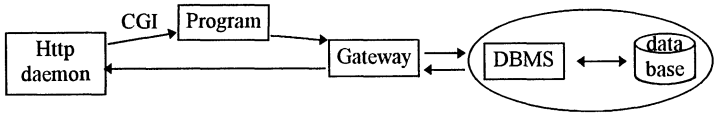

Figure 4 : A gateway between the Web and the DBMS

4.3. Clients

We use standard clients (Mosaic or Netscape). The documents are prepared at the Gateway level as HTML (HyperText Markup Langage) documents [8]. The main characteristic of this langage is to enable one document to reference other ones. So, the user can navigate into the patient record by just clicking on hyperlinks.

Since the clients are compatible with the most frequently used protocols (http, telnet, ftp, gopher) [2] we use those compatibilities to dialog with specific servers (examination servers for instance). The latest developments enable a user to directly consult a mailbox. We use this feature to manage the communication between the differents users of the system, or to warn a user of some modification concerning a patient.

5. Conclusion

Our approach allows many improvments in medical records management. The introduction of hypermedia gives our system a new way of navigation between many types of information. So, our system is closer to the usual physicians way of working. Virtual documents permit the association of both databases and documents advantages (data processing and presentation flexibility). Internet is also interesting in the fact that the system can integrate medical records management, electronic mail, bibliography consultation, and any other task which composes the physician's work in one software.

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