MEDICAL WORKSTATION FOR THE MANAGEMENT OF THE TRANSPLANTATION UNIT OF A HOSPITAL

C. Blanco, V. Cuervas-Mons(*), A. Muñoz, A. Dueñas, M.A. Gonzalez and C.H. Salvador
Lab. Bioingenieria, Clinica Puerta de Hierro, Madrid, Spain.
(*) Unidad de Trasplantes, Clinica Puerta de Hierro, Spain.

ABSTRACT

A prototype for a workstation (referred to as the "Transplant Unit Workstation", TWS) that attempts to satisfy the information management needs of the Transplant Unit of a Hospital (HTU) is described in part. The system allows the user to: 1) create and gain access to Donor Folders (DF) and Recipient Folders (RF); 2) transmit all types of documents contained in them -text, images, graphics, etc.-; 3) apply tools to scan, edit and print these documents; and 4) run application programs such as statistical analysis or aid in decision making concerning the most suitable recipient for a given donor organ. The implementation, which at present only covers liver transplant, is written in C language, under the Unix System V r3.2 OS, in the X-Windows environment, with the OSF/Motif toolkit and SQL as the language of access to a relational database. The scope of this paper is focused only on the first two sections.

INTRODUCTION

There are numerous registry and information systems [1],[2],[3] to manage data related to the types of organ transplantation currently being performed (heart, kidney, liver, marrow, etc.), and the ongoing research activity in this area is significant [4],[5]. However, in general, the activity of a HTU is not contemplated as a whole. The process associated with most transplants involves the efforts of a great number of people in different hospitals, requiring complex coordination in order to realize the goal successfully. In Spain, the 'Organización Nacional de Trasplantes'-ONT, like similar Organisms in other countries, is responsible for coordinating the preliminary steps associated with transplantation, by designating the recipient hospital [6]. The process implies an exchange of information which at present is carried out (at least in Spain) by means of fax and/or phone among the ONT, the donor hospital and the recipient hospital(s) (in the case of multiple
organ donation). The TUWS system attempts to achieve the following goals: 1) provide a more powerful means of coordination among the medical professionals involved in the pretransplantation activities, working, through the transmission of more and more exact information, to avoid to the greatest possible fruitless moves on the part of the donor hospital; 2) to manage the information generated during the surgical operation and the post-transplant hospital stay, information which may reach a considerable volume; 3) optimize the outpatient follow-up, a good part of which can thus be carried out in another hospital that is geographically more convenient for the patient.

This paper describes the major aspects of our conversion of a general purpose platform into a workstation which can fulfill the proposed needs. The sections dealing with document acquisition via scanner, edition and printing are not included, nor are the programs implemented in the database.

DESCRIPTION OF THE SYSTEM

Database and Organization

In the DF, the possibility of multiple donation has been taken into account

![Diagram of DONOR structure](Figure 1: Structure of the donor folder.)

(Figure 1); it consists of some 500 fields.
The RF reflects the whole process of transplantation, and is subdivided into: patient general data, pretransplant assessment, post-transplant hospital stay and outpatient follow-up (Figure 2). It consists of some 1000 fields.

![Diagram of recipient folder structure](image)

Figure 2: Structure of the recipient folder.

There are two databases: one for recipients and the other for donors. In both, the data is structured in the form of a relational database. The tables or relations are set up in the normal Boyce-Codd form [7]. The structure of the relations is simple, containing only one key (the number of the patient's medical history) allowing us to guarantee the integrity of the data, protecting it from incongruences caused by the deletion and insertion of data [8].

The image support within the database has been resolved indirectly; the image is not stored in the base, but in a file, the name of which does correspond to a field of one of the tables of the base. The other fields which refer to images are: patient's name, user-defined name of the image, filename, date, image type and associated images. Thus, for the user's benefit, the base is made to support a new type of data, the image.
User Interface

In the first place, it allows the edition and viewing of the folders. The user can select one of the leaves on the tree, which will be translated into a later X-window presentation [9]. In this situation, the user can see the data stored in the selected subfolder, edit them, save them and view images when they exist. If a subfolder contains fields referring to images, it is possible to select one and view it. In addition, there are tools which can improve the visualization; thus, for example, the image can be equalized, zoomed in on, subjected to brightness control, filtered, scrolled when it surpasses the dimensions of the window, etc.

Figure 3: Aspect of a TUWS session.

At all times, the system helps the user, indicating in a window created for this purpose his alternatives, or simply showing information associated with the interface element signaled by the mouse cursor. Likewise, messages for the user indicating an error on his part or inviting him to enter data required by the system are common.
Software architecture

Basically, TUWS is an X application that determines the user interface [10]. For integration of the X application into the database, SQL embedded is used, that is, the system software, is made up of two processes [11]: one is the application as a whole, and the other, an SQL interpreter. Communications between the two processes takes place via pipes. One is used to transmit consultations from the application to the SQL interpreter, which executes them and responds via the other pipe [13]. This response is analyzed by the system and displayed to the user (see Figure 4).

In view of all the preceding information, the system's software architecture can be broken down into several modules: 1) the user interface module, defining the system layout, that is, where the different windows and elements that permit the user to gain access to the functionality of the TUWS are created; 2) the module responsible for defining the behavior of the system in response to the actions of the user via the interface; 3) that related to the database, where all the functions responsible for communications with the SQL interpreter are found; its purpose is, on the one hand, to construct the queries and, on the other, to gather and analyze the results for their later presentation to the user: 4) the communications module containing the software that provides two work modes for the transmission of information between stations: Transfer and Dialog; 5) the peripheral module, controlling a scanner and a printer which permit the acquisition of documents for the database and the printing of the data stored in it, respectively; 6) finally, the software for image editing, which allows the user greater flexibility in viewing medical images. This software structure can be observed in Figure 5.
Hardware

In Figure 6, we can see the composition of the necessary hardware. The platform on which this first version has been implemented is a PC 486 running Interactive 386/ix r2.0.2, with an X-terminal that provides the graphic capabilities necessary for an application of the type being dealt with here (8 color planes, 1280 x 1024 pixels).

In the TU of an average hospital, there are usually between 40 and 60 'hot' RFs, the information of which (including images) is stored on the hard disk. Of the remainder, whose use is not immediately foreseeable, only the textual-numeric information is stored; the images are stored on an auxiliary disk; backup tools have been provided to assure friendly loading and unloading.

An average RF (including images) occupies between 3 and 4 Mb and the DF, approximately 1 Mb. Thus the storage capacity required by the system can be estimated: approximately 300 Mbytes of hard disk and any auxiliary system: streamer, DAT, optical and magneto-optical disk.

The working prototype is completed by a scanner, in our case a Sharp JX600 with a GPIB IEEE-488 interface, for digitalization of the documents, and a laser printer to print out the data gathered from the base by the user, or a color videoprinter if images are to be reproduced.

Communications

TUWS permits the transmission between remote machines of documents stored in the database. Two modes of communication are provided:

- Transfer mode: a user sends a patient folder, or part of one (any
subfolder) or associated documents (images, graphs, handwritten text.) The transfer is done directly from one machine to another, and the information is stored in the mailbox of the receiving machine, whose user, upon viewing the information, decides whether or not to include it in his database.

- Dialog mode: The dialog process allows two users, located at a distance from each other and working in an X-Windows graphic windows environment, to view simultaneously and in the same positions on the screen, one or more medical documents (WYSIWIS - What You See is What I See), whether images or text. It is equipped with two cursors, one which follows the movements of the local user's mouse and the other to reflect at every moment what the remote user is indicating; finally, a voice line between the two professionals is also provided.

The tool employed has been designed by our laboratory as part of a project financed by the RACE Program of the European Community [13]. Although it can be utilized in a local network or in any broadband network, for example, FDDI, its main purpose is for use with a V.32 modem via a switched telephone network (STN). This allows medical professionals to make remote consultations from any point that has a telephone line, in spite of the limited extension of the Integrated Services Digital Network (ISDN). It must be taken into account, however, that the latency of the public X.25 data communications network it too great for dialog of this type to be agile.

The presentation and communications process is controlled by the Dialog Manager, which also permits management of documents sent (by ftp: Transfer mode) prior to the dialog session when, due to the low speed of the link being used, their large size renders it convenient. It was necessary to adapt the X-protocol, a protocol for transferring queries, responses, events and errors in X which has been prepared to operate with TCP/IP or DecNET and, thus, will operate with a telephone model, as well. For this purpose, the SLIP (Serial Line Internet Protocol) is being used; once installed, it manages the transmission of TCP/IP packets, and thus permits the transparent use of the X-protocol and maintenance, within certain limits, of the philosophy and mode of operation of X-Windows.

CONCLUSIONS

TUWS is an X application focused on the management of a Transplantation Unit. However, its conception, from a general point of view, makes it possible to apply it to other activities within the medical environment; there are only two re-
requirements: the information must be stored in document folders and the users must be able to communicate with colleagues.

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