Modeling and Implementing a Drug Database within a Hospital Intranet

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Abstract

OBJECTIVE: to develop a drug information service implementing a drug database in our University hospitals information system. Thériaque is a database, maintained by a group of pharmacists and physicians, on all the drugs available in France. DESIGN: we modeled its content (chemical classes, active components, excipients, indications, contra-indications, side effects, and so on) according to an object-oriented method. RESULTS: we designed Web-style pages whose appearance translates the structure of classes of the model objects. Pages are dynamically fulfilled with results of queries to a relational database management system that stores information about drugs. DISCUSSION: such a development allows a fast implementation and does not imply to port a client application on the thousands of workstations over the network. The Web-style interface provides end-users with an easy to use and natural way to access information in an Intranet environment.

Keywords:
Database Management Systems; Drug Information Services; Hospital Information Systems; User-Computer Interface; Internet.

Introduction

Integration of documentation and knowledge computerized services in medical information systems is a tremendous mean to help health professionals in their daily practice and to improve its quality. One of the most important knowledge computerized services is related to drugs. End-users need a fast, easy, and efficient access to information on drugs in a Hospital Information System. Several databases have been developed worldwide for drug information functions: ABDA in Germany, Thériaque in France, Martindale in the United Kingdom, First Data Bank in the USA. They have in common the particularity to be poorly structured and to use much free text. This entails problems when integrating such a database within an existing information system due to the difficulties to retrieve information with full-text search technics. So, authors proposed data models sufficiently rich and general to avoid the use of free text and replace it by formalized data, specially for computerized drug prescription [1-3]. Then, the development of user-computer interfaces that favor the communication and the dissemination of information on drugs is a topical question today [4, 5].
The "Assistance Publique - Hôpitaux de Marseille" groups the five public hospitals located in various areas at Marseilles, France. A unique high-speed network links all the hospitals. Thousands of PCs are connected to the network. In this frame, our objective was to provide health professionals with an access to a drug database from any workstation. This paper presents the implementation we made of the French database Thériaque in the university hospital, and then reachable from any other hospital. Thériaque contains information about all the drugs available in France, including drugs delivered in hospitals only [6]. It has been created and it is maintained by a group of pharmacists and physicians. The database contains in a large set of relational tables the complete information related to drugs: pharmaco-therapeutic classes, active components, excipients, commercial presentations, indications, contra-indications, and so on. Our first work was to model concepts related to drug and represented by the entities in the database. The method used for modeling is object-oriented [7]. Our objective was to develop neither a specific object-oriented system for drugs, nor an object-oriented database to store and retrieve information. Our aim was to propose simple properties statements, and to take into account the whole content of the database. We intended to make apparent to the users the structure of the related concepts for better understanding and use. Thus, we made a conceptual model of information related to drugs. And, then we designed and implemented an interface in such a way that the displayed information translates the properties of modeled classes of objects. For the implementation, we had the choice either to develop a client application that queries a database management server, or to benefit from the currently emerging Internet technology and standards. The first solution imposes to develop the client application for each platform and to implement it on each workstation over the network. The second solution benefits from a universal client: an Internet browser already present on each workstation. We retained this second solution that allows a fast development, portability, and reuse.

An object-oriented model of drugs

The term "drug" belongs to everyday language but is not accurately understood. According to the context in which it is used a drug can be viewed as a pharmaco-therapeutic class (e.g., beta-blocking agent), as an active component (e.g., Acebutolol), as a manufactured preparation (e.g., Sectral® 200 mg), or as a presentation (e.g., Sectral® capsule 200 mg, 20-cap pack) [3]. Thus, a drug can be described by its pharmacological class, its active components, its commercial name or manufactured preparation, and its presentation. These entities form the core elements around which the concept of drug can be defined. The excipients or vehicle have to be added to obtain a complete view on drug. Active components and excipients are grouped into chemical classes according to the chemical properties they share. Following this approach, we can define the core concepts that are involved in the definition of a drug:

- **Chemical class.** The active components and vehicle belong to chemical classes. Since a chemical class may have interactions with other chemical classes and may have side effects, active components and excipients inherit these properties.
- **Pharmaco-therapeutic class.** Commercial presentations which share common therapeutic properties are grouped into pharmaco-therapeutic classes. Several classification systems are used to code these classes: ATC (Anatomical Therapeutic Chemical), EPhMRA (European Pharmaceutical Marketing Research Association), for
instance. The pharmaco-therapeutic class has relationships with the classes interactions and side effects.

- Active components and excipients. An active component is a molecule that has pharmacological properties used in therapeutics. An excipient does not have a therapeutic action but is used for the manufacturing of preparations. Both active components and excipients have relationships with other classes: incompatibility, interactions, and dosage.

- Manufactured preparation. It is the name of the product manufactured and marketed by a pharmaceutical company. Apart from its name, a manufactured preparation is defined by the active components it contains, its indications and contra-indications, dosage, possible interactions, side effects, overdose, incompatibilities, and so on.

Presentation. A manufactured preparation may have various presentations which differ by the number of units and the materials used for packaging.

Figure 1. Classes of objects involved in a model of drug (attributes of classes are omitted).

Simple lines indicate multi-valued association, links ending in a diamond represent composition.

The diagram of Figure 1 summarizes the structure of the above classes in a hierarchy in which subsumed classes inherit the properties and relationships from the subsumer classes. For instance, a manufactured preparation is composed of active components and excipients. These components belong to chemical classes that have pharmaceutical properties. The components as well as the preparation they belong to inherit these
properties. The description of the above core concepts involves other concepts such as indications, contra-indications, side effects, maximum dose, and so on. These are not directly connected to a manufactured preparation or a presentation, but they are linked to chemical or pharmaco-therapeutic classes, and then inherit properties according to the above mechanism. For instance, the relationships that hold between the chemical and the indications, contra-indications, and side effects classes are thus automatically obtained by the objects of the manufactured preparation class, through intermediate classes, such as active components and excipients.

With the intent to translate this structure, we designed screen templates. Each of them contains areas dedicated to display the same kind of information. The content of these areas is instanciated with respect to the class of the object currently displayed and to inheritance mechanism due to the hierarchy of classes. This means that each area proposes to retrieve information related to the currently displayed object according to the class it belongs to. So, the areas possibly displayed on a screen are the following.

- A first area (title) identifies the object currently displayed (a manufactured preparation, an active component, ...).
- A second area displays information related to the current object.
- A third area is a navigation bar that allows the user to obtain complementary information about the current object (pharmaco-therapeutic classes, maximum dose of each active component, side effects, ...).
- A fourth and last area is a menu bar that proposes different access points in the database independently from the currently displayed object.

The design of the general appearance of a page is presented in Figure 2. Following this method, we defined the template of each identified class of objects. Templates differ from a class to another. We will illustrate below how the display of a manufactured preparation differs from the display of its pharmaco-therapeutic classes (see Figures 4 and 5).

**Implementation of a drug database within an Intranet**

We adopted the principle of dynamic Web pages whose content is partially fulfilled by results of queries to a database management system. We used the Internet Database Connector (IDC) mechanism designed and implemented by Microsoft™. This solution allows an Internet browser to query a relational database management system, store the results in a template file in a HyperText Markup Language (HTML) format, and allows to display it as a Web page. In this section we will first detail the IDC mechanism, and then show how we used it.

The IDC mechanism exploits two types of files to control database access and build an output HTML page. These files are Internet Database Connector ("ide" extension) files and enhanced HTML ("htx" extension) files. The eight following steps are consecutively operated, as illustrated by the diagram of Figure 3:

1. An Internet browser submits a request to the Web server (Microsoft™ Internet Information Server) using the HyperText Transfer Protocol (HTTP).
2. The request is sent by the Web server to the IDC component by means of the name of a ".ide" file and parameters. This file identifies the appropriate database and contains the related query written in Structured Query Language (SQL).
Figure 2. General design of a Web page of the drug database.

Figure 3. Software architecture of the Internet Database Connector (Microsoft™).
3. The IDC component updates the SQL query with the above parameters.
4. The SQL query is sent, via the Open Database Connector (ODBC), to the target relational database management system where it is processed.
5. Results are sent, via the ODBC, to the IDC component.
6. The "htx" file is the template for the document that will be returned. It serves to format the results in HTML.
7. The final HTML page is sent to the Web server,
8. and then, to the Internet browser.

This mechanism can be applied to several queries simultaneously. This later property is of importance because it provides with the capability to chain queries and so avoid writing programs in many cases.

Let us illustrate this with an example. The page related to the composition of a manufactured preparation (e.g. Sectral® 200 mg capsule) is currently displayed by an Internet browser, as illustrated by the screen capture of Figure 4.

![Figure 4. Screen capture of a commercial presentation: "Sectral® 200 mg capsule". The navigation bar proposes complementary information related to this presentation.](image)

Buttons on the left of the page provide access to information related to this preparation. The button named "Classes" gives access to the pharmaco-therapeutic and other classes to which it belongs. Attached to this button is a HTML hypertext link, such as:
where "SP_Classe.idc" is the name of the "idc" file to use and %idc.num% is a parameter that identifies the current preparation. A mouse click on this button activates a query to the Thériaque relational database. The related "idc" file contains the identifier of the database, the name of the related "htx" file, and a list of SQL queries such as:

```
SELECT SP.NomFrATC, CATC.CodeATC
FROM SP LEFT JOIN CATC ON SP.CodeATC = CATC.CodeATC
WHERE SP.CodeSpec = %num%
```

where %num% represents the unique identifier of the manufactured preparation in the database. Its actual value is given by the displayed page and is replaced in the query. Thus the actual query concerns "Sectral® 200 mg capsule" and is sent to the database following the above described steps. Results of the queries instantiate the related "htx" file which contains sequences of an enhanced HTML commands, such as:

Figure 5. Screen capture of the classes of Sectral®.
This screen is obtained by a mouse click on the button named "Classes" in the navigation bar of the screen capture of Figure 4.
where %NomFrATC% and %CodeATC% are the results expected by the above SQL query. Results are formatted and then displayed as illustrated by the screen capture of Figure 5 which shows the ATC code of the Acebutolol class: C07AB04. The other data displayed in the same page have been retrieved in the database by means of the other SQL queries placed in the previous "ide" file.

Other pages do not share the same look-and-feel exactly, either because there is no information that can be reached through the navigation bar (as illustrated by Figure 5), or because they are index or menu pages and not pages related to database objects. Figure 6 shows an instance of this latter case which presents the search of information through clinical indications. A mouse click on "Angor", for instance, provides with a new page that proposes all the preparations in relation with this syndrome after a query had extracted information from the database. Clinical indications are displayed in a hierarchy which is translated by successive pages. The first level is the most general (e.g. Cardiovascular
Diseases), although the following levels are more precise (e.g. Angor). At the general level, hypertext links are static and give access to unvarying information such as a classification of diseases. At the most precise levels, hypertext links are dynamic. This means that information is reached by queries to the database. Another typical example is the information mark ("i") associated to active components as illustrated in Figure 5. A click on this icon provides with the page of Figure 7 that presents information related to "Acebutolol". Here again, this link is calculated. In the right upper part of Figure 7 is another anchor (illustrated by a finger) that proposes to retrieve all the preparations which contain this substance. This is a means, for instance, to retrieve that Sectral® is indicated in case of Angor. These two examples show that we implemented not only an interface to a database, but also a hypertext development that allows access to information using the well known browsing mechanism.

![Figure 7. Screen capture of the active component of Sectral®.](image)

This page is obtained by a mouse click on the information ("i") icon faced to the Acebutolol active component line in Figure 4.

**Discussion**

Disorientation is one of the main problems that end-users may encounter when searching information in a hypertext environment [8]. Our main objective was to disseminate the information on drugs contained in the database Thériaque over the network of our
university hospital in an Intranet environment. Nevertheless, if it does not exist today an effective method for the implementation of Intranet services, we followed the principle which says that "what perdures is that what is useful". In a first time we analyzed with practitioners the users needs in relation with drug information and prescription. Results of this analyze permitted to underline the ways to access information and to distinguish information the end-users may want to be displayed immediately from complementary information they may want to reach in a second time. This guided us to model the notion of drug in an conceptual (object-oriented) way and then to design the different screens.

The principle we adopted to implement a drug database in such an environment was to guide end-users by means of a homogeneous graphical appearance of screens. When information related to a drug is displayed, only the basically useful information is present. But, complementary information is proposed by the means of buttons and links. Buttons have always the same meaning: they give access to attribute values of objects that are modeled by their respective classes. A specific look-and-feel being designed for objects of each class must help users to locate their browsing in the database. A general frame has been proposed for all the classes of objects involved in the database. So, except some index or menu pages, the pages that display information share a common look-and-feel: a menu bar, a navigation bar, a title, and an area for information concerning the object currently displayed on the screen. Except the menu bar which is independent from a current context, the other areas are instanciated according to the information related to the current object. We expect that healthcare professionals will benefit from this organisation of data in hypertext style as opposed to traditional full-text drug databases. The database is now available in our network and we are waiting for feedback from the end-users.

**Conclusion**

Few years ago, the Internet and World Wide Web technologies emerged and has been exploited successfully by medical informatics researchers. Some efforts are intended to provide end-users with easy to use and universally available access to information databases [9, 10], when other efforts allow the integration of various kinds of biomedical information [11]. It seems not realistic to imagine a method for developing Web sites over the Internet. This would be unnatural. But, in the case of an internal Web, an Intranet, which is developed with the intent to increase the facilities of documentation, the capabilities of communication, to implement a collaborative work, and to improve productivity, rules of implementation seem now necessary [12]. In this framework, the use of a method for designing Web sites and the use of standard technics for implementation are sound. We designed and implemented access to the Thériaque drug database with these topics in mind.

Even if our implementation is strongly dependent of the database on drugs we chose to make available to health professionals in our university hospital, we think that the method and the techniques we used for that are general. First, even if we decided to not use an object-oriented database management system for storing and retrieving information, our modeling and implementation appear as an enhancement of relational databases [13]. Secondly, the choice of the Internet technology allows to have a universal client on the workstations over a large network. This avoids developing client applications that must be ported on each of these workstations. Secondly, techniques we adopted minimizes the
necessary developments. Effectively, the IDC technology from Microsoft™ allows to attach formal queries that are instanciated by data keyed by users, and answers templates that are fulfilled by the results coming from the database management server. This is in favor of a low cost in maintenance. Finally, the use of dynamic Web pages guarantees the useful life of the implementation along the successive updates of the database content.

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