Computerized Health Information System

Tiberiu Laczko
„Tibiscus” University of Timişoara, România

ABSTRACT: Today, medical doctors are dealing with more complex diagnostic methodologies, and with increasing volumes of medical information related to delivery of health care in various medical centres and institutions around the world. Modern information technology offers new opportunities in the ability to deliver cost-effective health care to patients, and in addressing the challenges posed by increasingly complex procedures involved in medical diagnostics and investigations.
KEYWORDS: electronic medical record, electronic health record, electronic patient record, health care.

Introduction

The era that we live in today can be described as the "Information Age". No matter what area of science and technology we look at, it is obvious that we are dealing with an "information overflow" without precedent in the history of mankind. Medical sciences are no exception, and recent advances in this field would have been unthinkable, unmanageable and unattainable, without the support offered by modern information technology.

Clinical practice in the medical field is confronted with an immense volume of medical information, complex diagnostics procedures and methodologies, as well as complicated legal frameworks, which are sometimes specific to the geographical area where the Health Care Delivery Organization (CDO – such as a hospital, medical clinic, or family physician's practice) is located.

It is worth noting the terminology and conceptual differences between North America and Europe, with regard to acronyms used in medical informatics.

Below is a list of North American acronyms:

- CDO (care delivery organization) - it is used to denote a generic health-care delivery organization, such as a hospital
- EMR (electronic medical record) – usually means a computerized legal medical record created in an organization that delivers care, such as a hospital and doctor's surgery. Electronic medical records tend to be a part of a local stand-alone health information system that allows storage, retrieval and manipulation of records (source: [wik**])
- EHR (electronic health record), or EPR (electronic patient record) – it is an evolving concept defined as a systematic collection of electronic health information about individual patients or populations. It is a record in digital format that is capable of being shared across different health care settings, by being embedded in network-connected enterprise-wide information systems. Such records may include a whole range of data in comprehensive or summary form, including demographics, medical history, medication and allergies, immunization status, laboratory test results, radiology images, and billing information (source: [wik**])
- PHR (personal health record) - a health record that is initiated and maintained by an individual. An ideal PHR would provide a complete and accurate summary of the health and medical history of an individual by gathering data from many sources and making this information accessible online to anyone who has the necessary electronic credentials to view the information (source: [wik**])

For a discussion of EMR versus EHR in terms of conceptual meaning, please read [him**].

In addition to the acronyms listed above, in Europe we note the usage of the term HCE, which means Health Care Establishment (similar to the North American counterpart CDO) – such as a hospital, or medical doctor's practice.

In Europe, the acronyms EHR and EPR are used more frequently (versus EMR), although the context in which they are being mentioned can sometimes be confusing or unclear, with regard to their specific semantic meanings. For example, EHR could mean something in a specific North American context, but it could imply something quite different, when utilized in a European context. Therefore, it is always important to clarify the intended meaning of all the acronyms used, in order for the reader to understand the accurate and "localized" context.

There is no universal standard in the medical practice worldwide, with regards to how the clinical observation notes, and medical diagnostics, are being written on paper, and eventually stored into electronic form in computer systems. Various legal requirements worldwide might dictate that "hard copies" (i.e. printed copies, or written paper notes) be kept archived for a number of years, even if medical doctors utilize computerized systems for storing patient, clinical and diagnostic information in electronic formats.

With all the proprietary computer systems available on the market for medical professionals to utilize in their daily practice, it is important that universal standards be defined and adhered to, in order to facilitate the exchange of medical and patient information between the various institutions involved in providing and administering health care, such as hospitals, medical doctor's practices, surgeon's clinics, insurance companies, pharmacies, medical laboratories, government agencies (where health care is paid for, at least partially, by government programs funded with public monies). Such standards should clearly define the meaning and attributes of electronic medical and health records, and their specific utilization among all the actors involved in providing and administering health care at a national or regional level.

Also, these standards should emphasize the format and attributes of the information needed to be stored and exchanged, while at the same time, be flexible about how specific vendors would implement the physical storage details of such information. In other words, such standards need to be generic enough, and be defined at a level high enough, in order to allow a market of compliant software vendors and implementers to develop and sell software, without dictating the actual implementation details of how those information systems should function: **good standards should define the interface of communication between systems, but leave the implementation and storage details, open to the software developers and vendors.**

By defining the interface of communication between systems, but leaving open the actual data storage and system implementation details, it is possible to allow for a heterogeneous environment and market to develop, where multiple vendors follow clear interface and communication formats and standards for system development, while at the same time having the freedom to implement those requirements using the technological platforms of their own choice.

This freedom of choice in implementation, offered by well-thought-out "generic" standards, also is applicable in regards to how those medical records are actually being stored on media within the systems.

1 Proof of concept for a Computerized Health Information System for a generic Health Care Provider in Romania

This paper introduces the reader to a "proof of concept" client-server application, designed to be used within a generic organization providing health care in Romania, as part of the National Health Care System. The application is generic and yet customizable enough, to be able to function within almost any kind of health care provider, such as a Family Physician's practice, a Hospital, or a Clinic for diagnostic and treatment of disease.

The application is based on a multi-user, two-tier client server architecture, consisting of several Windows-based thick clients, connected to a central Oracle database, where the actual patient and clinical data is being stored (see Fig. 1).

The Windows client application has been implemented using the development environment Sybase Powerbuilder version 10, and has been deployed as a compiled, 32-bit Windows executable application.

The database server has been implemented on an Oracle 10g RDBMS, where the patient and clinical data are being stored.

In order to ensure data integrity in a multi-user environment, the "optimistic locking" approach has been implemented, by using timestamp columns stored in database tables, as "witness values" which are used to detect whether database records have been modified in the time interval from reading until an update attempt is made (see Fig. 2 for logic flowchart). Triggers automatically update the values of the timestamp columns whenever an update or insert is performed against certain database tables. The whole process is transparent to the user, who is alerted only when there is a mismatch between the local and the database version of the data record being updated (see Fig. 4 for example).

The main window of the application is organized into three main areas, which are logically interconnected from top to bottom, in master-detail arrangement (see Fig. 3). The top area represents the list of patients; the middle area represents the medical folders associated with a specific patient, and the bottom area represents the list of observation records for a specific patient, and for a specific observation record. Whenever the user clicks on a specific patient, the middle area is refreshed automatically with the list of medical folders for that patient; then, the first row in the list of medical folders is selected automatically, and the bottom area is refreshed with the list of observation records for that patient and for that medical folder. When the user clicks on another row in the middle area, the bottom area is again refreshed with the list of observation records for that patient and for that medical folder.

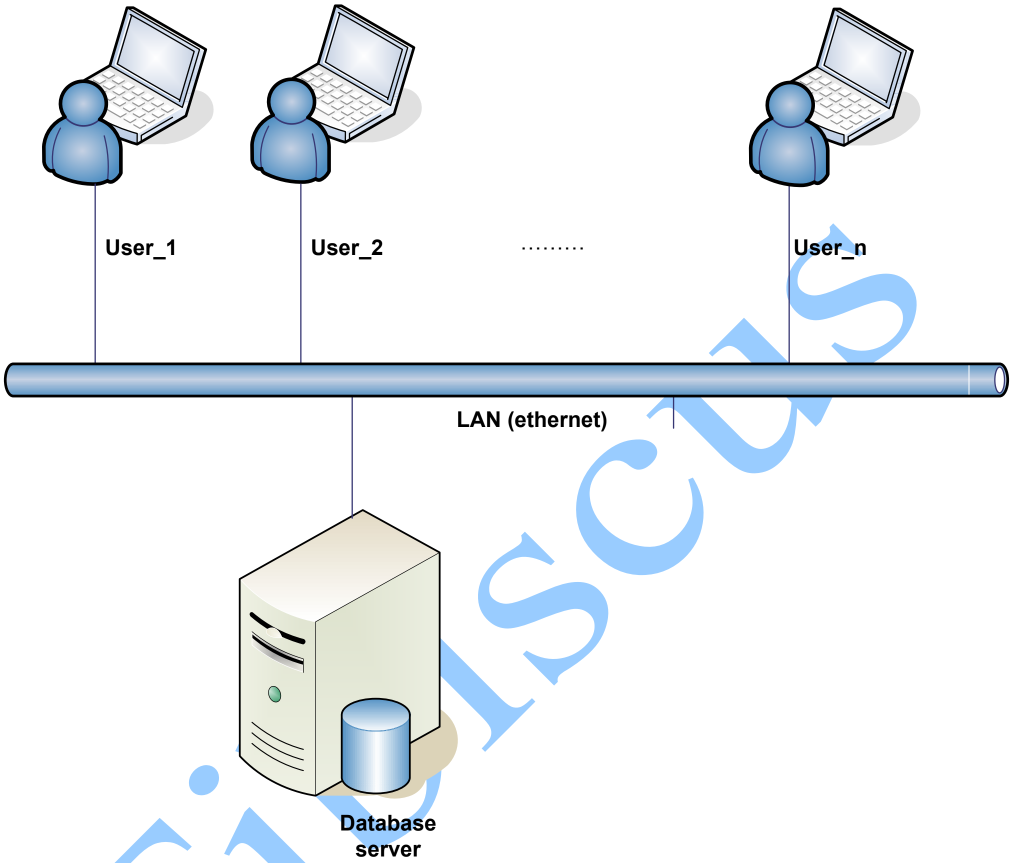

Figure 1. High-level layout of multiuser, two-tier client-server application with several users and thick-client applications, connected to one database server

On the right side of each of the three main areas on the screen, there are various command buttons, which, upon pressing or clicking, shall invoke functionality specific to that region on the screen (such as viewing or editing patient, medical folder or observation record information) – see Fig. 3.

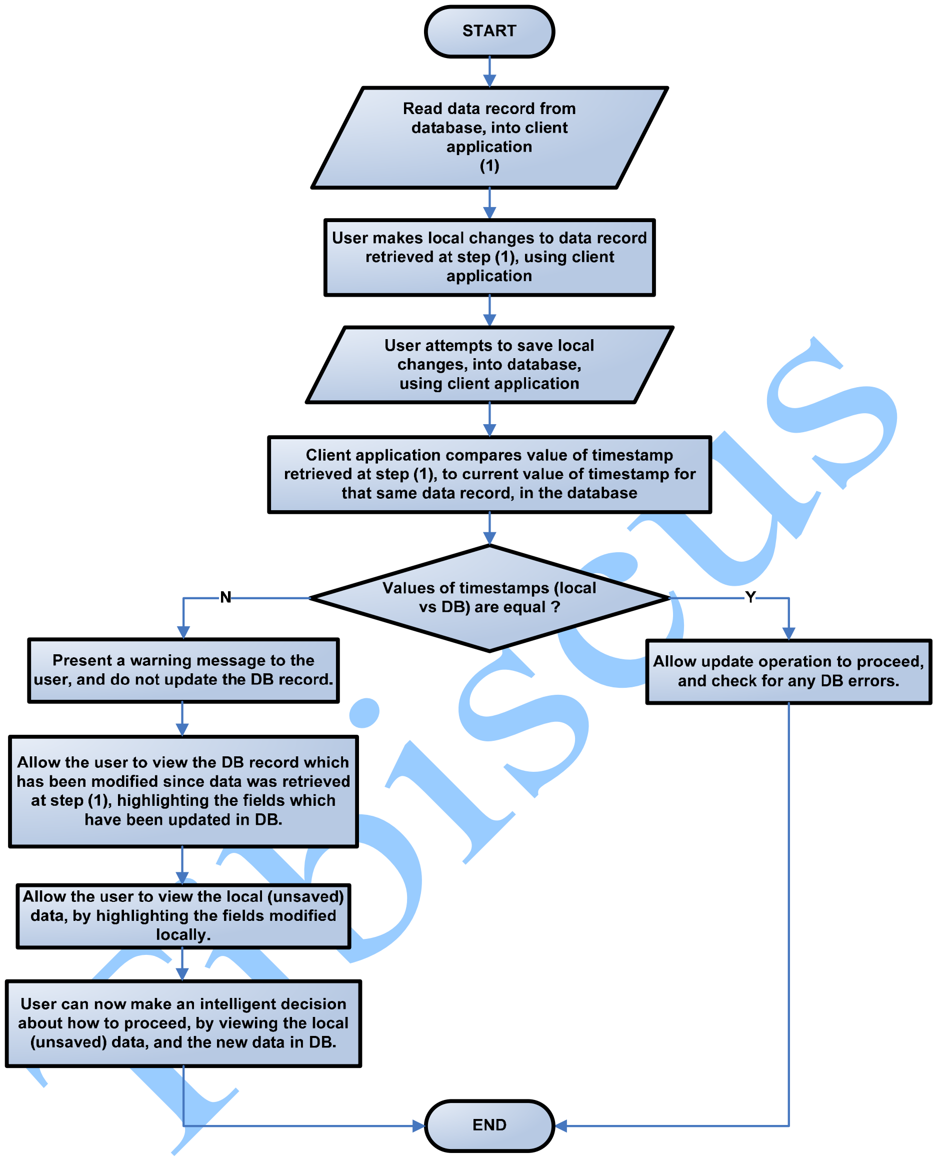

Figure 2. High-level logic workflow when updating a database record, using "optimistic locking" approach

For example, in the top area of the main screen (see Fig. 3), we can invoke the following patient-specific functionality: view / edit patient details, add new patient, refresh patient list from database, search for a patient.

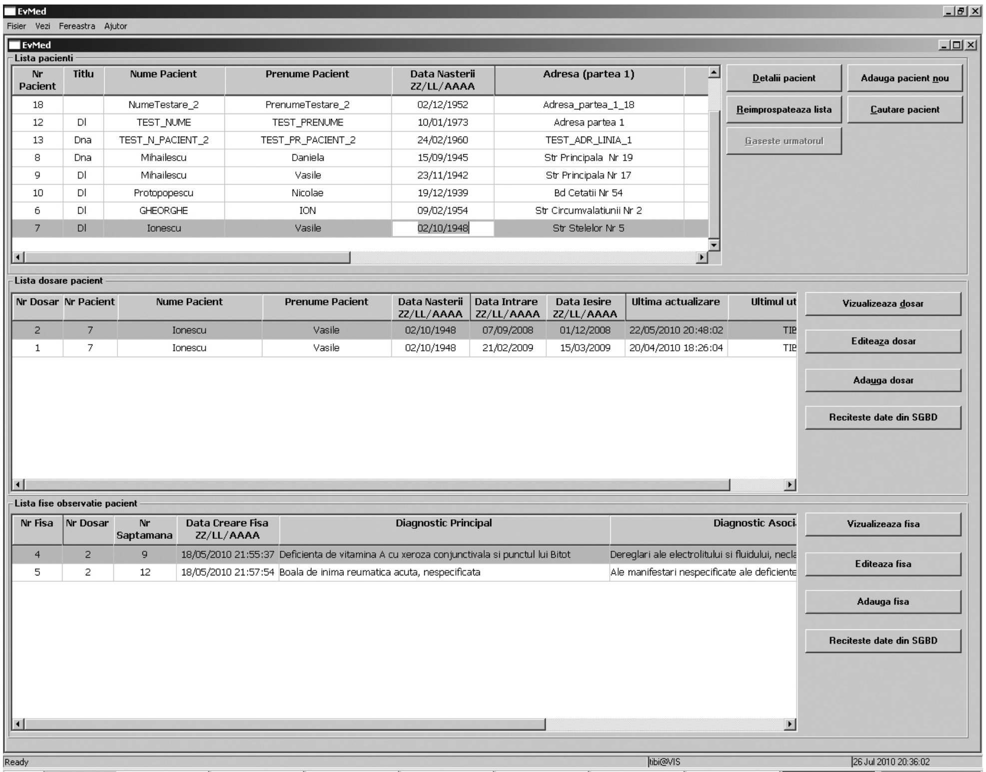

Figure 3. Main window in the application, with top-down, master-detail lists of patients, their medical folders, and the associated observation records

In the middle area of the main screen (see Fig. 3), we can invoke the following medical-folder specific information: view / edit / add medical folder, refresh list of patient-specific medical folders from database.

In the bottom area of the main screen (see Fig. 3), we can invoke the following specific information for an observation record: view / edit / add observation record for a specific patient and medical folder, refresh list of patient and folder specific observation records from database.

For the sake of brevity, the patient / medical-folder / observation record specific functionality is not presented in this paper. It is worth noting that one element of novelty consists in the ability for the user to view both changes to the local data record, as well as changes to the database record, in case there is a mismatch between the two records, at the time of update (see Fig. 4 for such a warning message being presented to the user).

<u>Legal information for screen captures presented in this material</u> (see Fig. 3 and Fig. 4): all patients, personal and clinical data presented on these

screens is fake, and does not represent actual physical persons. Screen captures have been converted to black and white for illustration purposes.

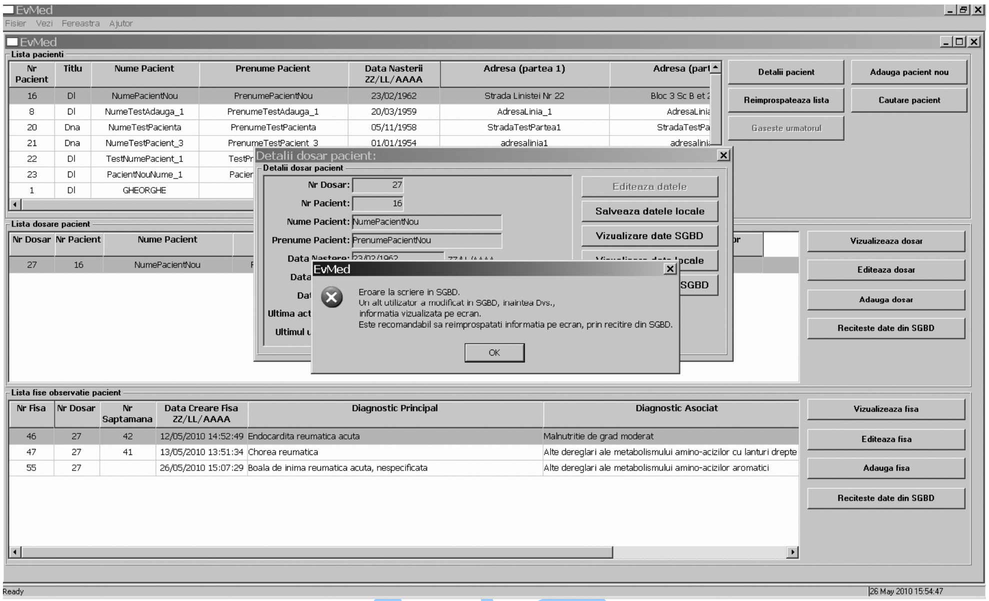

Figure 4. A warning message is presented to the user, in case when there is a mismatch between the local and the database version of the data record being updated

Conclusions and considerations for future work

The implemented prototype aims to be generic enough for usage in almost any kind of health-care organization, such as a Family Physician's practice, a Hospital, or a Clinic for diagnostic and treatment of disease. However, depending on the intended use, certain customizations and additions in terms of functionality would be necessary and unavoidable.

The following features have not been implemented, for practical reasons and due to time constraints, in this limited-functionality proof-of-concept application:

- Ability to interface with other computer systems, such as the National Medical Insurance House, to exchange patient and medical data
- Ability to keep a historical log of changes done to any of the medical records on file, for audit and legal purposes

- Ability to calculate and issue medical bills for services provided, and to reconcile with payments received
- Ability to keep evidence of internal and external transfers of patients
- Ability to capture and store multiple medical notes for a specific observation record belonging to a certain patient and medical folder
- Ability to perform statistical analysis of stored data
- Ability to generate and print reports
- Ability to print, import and export data, such as patient, medical folder and observation record data
- Ability to import, export and maintain static data related to definition of medical diagnostic groups, and the corresponding medical diagnostics, as per international standards.
- Ability to define roles and responsibilities specific to different medical occupations (i.e. a medical doctor should have different privileges than a medical nurse).
- Ability to import, export, store and visualize X-ray, MRI and other visual diagnostic data
- Ability to import, export, store and manage data related to various laboratory tests, investigations and procedures
- Ability to import, export, exchange, store and manage data related to medical prescriptions.

In the future, one area of new functionality that should be addressed before all others, is the ability to interactively define security profiles within the application, which are specific to different medical occupations (i.e. a medical doctor should have different privileges than a medical nurse, in terms of what he or she is allowed to edit and view in the application).

This involves making changes to the underlying data model in the oracle RDBMS, as well as functional changes to the database code, and to the application code.

References

[BA95] **Joseph J. Bambara, Paul R. Allen** – *Powerbuilder – A guide to developing client / server applications* (1995)

[Her96] **Michael J. Hernandez** – *Database Design* (1996)

[hi**] http://www.himss.org/content/files/EHRAttributes.pdf

[Hot01] **Dan Hotka** - *Dezvoltarea bazelor de date in Oracle9i, prin exemple* (2001)

[Ili09] **Silca Ilici** – *Programare SQL-Oracle.Caiet de laborator* (2009)

[LB05] **Kevin Loney, Bob Bryla** – *Oracle Database 10g DBA Handbook* (Oracle Press - 2005)

[Maf09] **Eugen Maftei** – *ORACLE de la 9i la 11g pentru dezvoltatorii de aplicatii - Vol.1 (part. 1+2) - Manual complet* (Ed. Albastra 2009)

[Ora10] **Oracle Corporation** - *Oracle Database SQL Reference, online documentation* (2010): http://download.oracle.com/docs/cd/B19306_01/server.102/b14200/toc.htm

[pe**] http://www.providersedge.com/ehdocs/ehr_articles/Electronic_Patient_Records-EMRs_and_EHRs.pdf

[wik**] http://www.wikipedia.org/

[Wor10] **World Health Organization** – *International Classification of Diseases (ICD) – online documentation* (2010): http://www.who.int/classifications/icd/en/