

Integration of an Evidence-based Careflow Management System into an Existing Electronic Patient Record

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Abstract

This paper describes a technological solution for integrating a guideline-based decision support system into an existing information system for patients admitted to a Stroke Unit. Since many years, the healthcare personnel were using a commercial product for the ordinary Electronic Patient Record management, and they were satisfied with it. For this reason, the decision support system has been integrated keeping attention to minimise changes and preserve the existing human-computer interaction. The driving idea is that users must perceive the new system just as an update of the previous one, which provides some additional functionalities. In particular, the paper illustrates the middleware layer that we developed in order to allow communication between the two systems: the existing information system and the newly developed decision support system, based on workflow technology.

1. Introduction

A big issue in the field of computerized decision support systems in real healthcare settings is their integration with local work organisation. Particularly, when an information system exists for the Electronic Patient Record (EPR) management, and users are familiar with a given interface, it is very difficult for them to shift to other systems or to use parallel ones. Medical informatics and artificial intelligence experienced several failures in the past, due to this problem. Learning new interfaces, double data input, boring interaction modalities have been the main causes of early abandon of several information systems and expert systems in medicine [1].

To avoid these problems, in the application described in this work, all steps of the new system

design and development have been performed in collaboration with the technical team responsible for the EPR and the healthcare personnel of the involved stroke units. We stress the paramount importance of this knowledge and experience sharing among working teams in order to give the final tool a high probability of success and users' satisfaction.

2. The Clinical Application

The StAGE project (Stroke Active Guideline Evaluation), funded by the Italian Ministry of Health, required to integrate a decision support system, based on the SPREAD guideline “The Italian guidelines for stroke prevention and management” [2], within a pre-existing EPR management system. The latter was implemented, some years ago, with the commercial tool WINCARE® (by TSD Projects), where the user's interaction is based on *events*: an *event* is a single form of the clinical chart, through which it is possible collecting patient data and generating textual reports. In fact, to each event a data entering form is associated. To access the system, a username and a password are required, grouped on the basis of the role (physician, professional nurse, physiotherapist, etc) in order to allow the visualization of competent events only (see Fig. 1). As shown, in the pre-existing version, the list of the events is not structured at all: it is given in alphabetic order and it is not tailored to the specific patient. To add the decision-support functionalities, which, among other improvements, will create dynamic list of events, reengineering of both structure and interface of the EPR was performed.

3. The Analysis of the Existing EPR

A deep analysis of the SPREAD guidelines, the existing EPR, its interface, and the clinical workflow in the Stroke Unit, allowed:

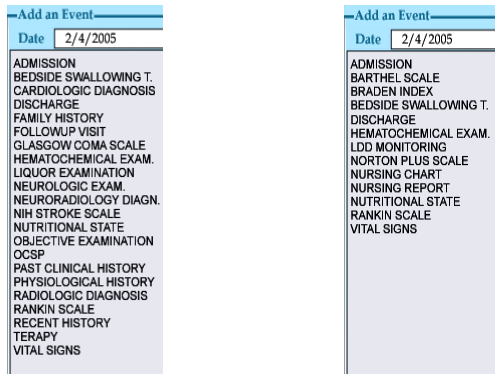


Fig.1 - List of the events shown to physicians (left) and to nurses (right)

- to determine the minimum data set required for implementing all the guideline recommendations;
- to check whether these data were or not already managed by Wincare®, and whether they were in the opportune format (e.g. coded versus free text);
- to devise an adequate interaction modality of the personnel with the new decision support functionalities.

Since users were satisfied of their EPR system, as the first step we analyzed how many changes were necessary in order to support the guideline integration, with the aim of minimising new interaction modalities.

4. Implementation of the CfMS

After the data model analysis, and its consequent update, we implemented the guideline recommendations through a Workflow Model, using Oracle Workflow™, thus developing a so-called Careflow Management System (CfMS). As defined in [3], it manages the execution of the guidelines through a workflow engine, interpreting the care process definition and interacting with users (called *Cf participants*). An *instance* of the Cf is the execution of the care process for a particular patient, specifying which medical tasks need to be executed, in which order, and by which professional role.

The Cf model (see a little portion in Fig. 2) is described on the basis of the SPREAD guideline, with some site-specifications decided by the neurologists involved. All the guideline recommendations were implemented, regardless of their scientific evidence level (SPREAD uses four levels, from A to D, where A stands for scientific evidence coming from meta-analysis or clinical trials, while D stands for case reports or expert consensus).

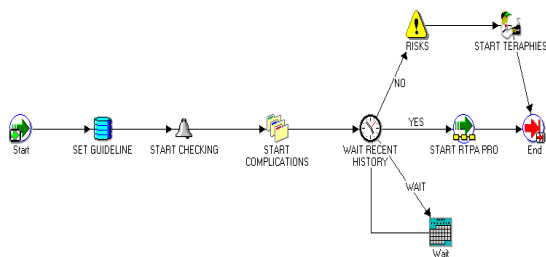


Fig.2 – The topmost view of the care process in Oracle Workflow Builder

The CfMS needs patient data in order to feed the workflow engine and to interpret guideline rules, then it must be able to communicate (Cf participants) the patient-specific recommendations to the users, through messages and to-do-lists. As already said, our choice was to integrate all the needed functionalities within the existing end-user application, making it more “dynamic”, according to the CfMS execution, without creating a new specific interface.

5. Integration of the decision support into the information system

A middleware layer (see Fig. 3) has been developed to keep the systems independent, while granting communication. It is composed by a supporting database (Oracle DB) and an Interpreter written in PL/SQL.

The middleware DB is composed of a set of tables

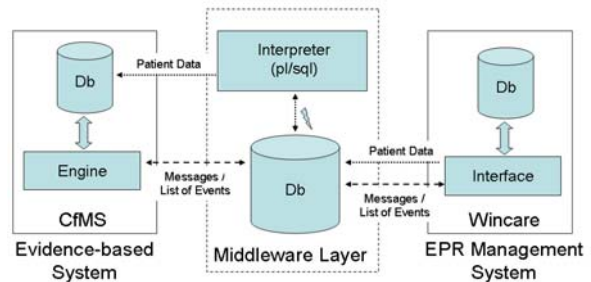


Fig. 3 Architecture of the Integration

with static content and of a set of dynamic tables which content is patient-specific. The most significant tables in these sets are: *Transcoding-Task* ; *Transcoding-Data* and *Mapping* (static); *Active-Patients*; *Messages*, *To-do-list*, and *Data-exchange* (dynamic).

The interaction is as follows: once a patient is admitted in the Stroke Unit, compiling the event Admission, an instance of the CfMS is activated by Wincare®, which inserts the patient ID into *Active-Patient*. Then, whenever there is a new data entry in Wincare® for a patient whose ID is in *Active-Patient*, the attributes that are useful for the guideline interpretation are transferred into *Data-exchange*, in accordance to the information stored in *Transcoding-Data* (see Fig. 4). *Transcoding-Data* contains, for each Wincare® *EVENT*, the *DATAFLOW*, i.e. the sequence of the required attributes, with names separated by the special character “\$”. These attributes are a subset of the complete form, and belong to the minimum data set mentioned in the third paragraph. We remark that

every future change of the required attributes or events, for example depending on clinical guideline periodic revisions, will only imply an update of the middleware DB static tables.

As a new record is inserted into *Data-exchange*, a trigger activates the Interpreter: its function is to read *Data-exchange* and to create a dynamic SQL query to store patient data in the right CfMS table, thanks to *Mapping*, which contains the name of this table and the corresponding sequence of fields. According to the data shown in Fig. 4 the query generated by the Interpreter will be “insert into *STAGE.OBJ_EXAM* (*P_ID*, *DATE*, *P_WEIGHT*, *P_HEIGHT*, *P_BMI*) VALUES ('1_75', '02/15/2006', '80', '1.65', '29.4');”.

On the other side, when the CfMS generates a suggestion, or a new list of Events, they are put into the tables *Messages* and *To-do-list* of the middleware DB, and Wincare® can read and show them through its interface. To refresh the interface, Wincare® executes a reading of these tables every minute. The same tables can also be updated by Wincare® and then read by the CfMS, again via the middleware DB. This may happen either when a user answers to a communication (table *Messages*), or when a user modifies the to-do list by adding events different from those proposed by the CfMS (table *To-do-list*).

The *Messages* table is composed by the following fields: *P_ID* (patient id), *M_ID* (an unique id for the message), *MESSAGE* (the text of the message or the suggestion), *RECEIVER* (target role of the message), *PRIORITY* (it modulates the message visualization and it can be low; medium; high), *MODALITY* (if the message is read-only or if it requires a response), *RESPONSE* (the response of the receiver to the message, only yes or no).

The *To-do-list* table contains the patient-specific list of events: it is very “dynamic” because it changes according to patient-data and response to the care process. In addition to the fields *P_ID* and *Event*, there are *POSITION*, that specifies the order of execution,

and *STATUS*, that specifies the status of the event (see next paragraph).

6. The Augmented Version of Wincare ®

Fig. 5 illustrates the new list of events: with respect to the former system (Fig. 1), this list is now no more unstructured nor static, because it is built on the patient's data and CfMS suggestions via the *To-do-list* table. Date and time of last update are shown on top of the list (see in Fig. 5 the text emphasized by a rectangle).

Different icons and colors are used to represent the field *STATUS*, whose meaning are:

- NULL- an event has to be done (no icon);
- OK- it is completed (icon with a green happy smiley);
- EXEC- it is currently being done (orange thoughtful smiley);
- EXC- it has not been executed due to an exception (red sad smiley);
- WINCARE- it has been added by the users (Wincare ® icon).

Together with the *STATUS* also the grade of recommendation is shown, as in the *SPREAD* guideline, by letters A-D.

According to the physician needs, special attention has been put in avoiding over-information: particularly in acute situations, only events necessary to face the urgency are listed.

An example of the importance to keep the list of events updated is the management of thrombolysis for a patient admitted to the Stroke Unit within less than

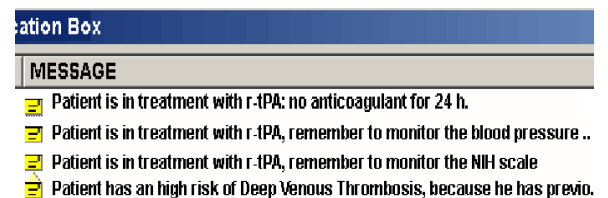


Fig. 7 – Particular of the communication box interface

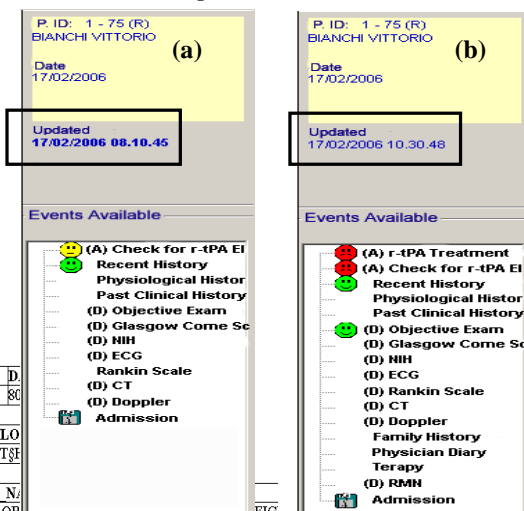


Fig. 4 – Attributes of the Data-exchange table
Fig. 5 – Lists of events for the same patient in two different points of his/her care process

three hours from the stroke onset (therapeutic window).

In Fig. 5a, the patient is potentially eligible for the thrombolytic drug r-tPA, according to information coming from the *recent history* event. Since this treatment is both extremely important (*SPREAD* level of recommendation A) and delicate (it may cause hemorrhages), the task list shows only the mandatory events to be done in order to detect possible contraindications. For example, CT scan could provide some findings advising against r-tPA. Fig. 6 shows the corresponding Wincare® event's interface: the

findings relevant for the guideline, which will be transferred to the middleware DB, are marked in yellow, in order to encourage a correct and complete editing of the EPR.

To facilitate users, the event “Check for r.tPA Eligibility”, which in Fig.5a is in EXEC status, reports the complete list of contraindications that can be tested by the CfMS, given the available data on the EPR.

Let us imagine that CT scan shows an intracranial haemorrhage: in this case, r-tPA cannot be administered. Consequently, as shown in Fig. 5b, “Check for r-tPA eligibility” and “r-tPA Treatment” switches to the exception status (red sad smiley). Contemporary, also less urgent events appear in the to-do list. Double clicking on the red events allows knowing the reasons for this exception.

Fig. 6 – The user interface for the event CT scan

To avoid intrusiveness, when the CfMS suggestions are neither urgent nor critical, they are translated into simple communications, stored in table *Messages* and sent to the appropriate roles. These messages are visualised in a separate window, the *communication box* (Fig. 7), and accessible by clicking an icon in the right bottom of the screen, which becomes red only when a new message arrives. CfMS suggestions are listed grouped by the patient identifier and ordered by date, and level of priority (represented by different icons). When a response is required, a checkbox appears near the text of the message allowing the *RECEIVER* to say whether he agrees or not with the SPREAD guideline (positive or negative answer).

In the case of positive answer, some data may be stored automatically into the EPR. For example, if a physician accepts a suggestion about a drug prescription, a record with the drug name, dosage, and timing is stored and at the same time a message is sent to the role “nurse”, which is responsible for the drug administration.

7. Conclusions

The application described in this paper is a demonstration of how a decision support system may be integrated within an information system without introducing dramatic changes in the end-user application. While this work has been done on top of a specific EPR management system, the middleware layer is general enough to allow integration of different models implemented through CfMSs with different EPR management systems.

[1] E. Coiera. The Guide to Health Informatics, 2nd Edition (Chapter 3). Arnold, London, October 2003.

[2] SPREAD 2003 (Stroke Prevention and Educational Awareness Diffusion). Ictus cerebrale: Linee guida italiane di prevenzione e trattamento, Edition of march 4th, 2003, www.spread.it

[3] S. Panzarasa, R. Bellazzi, C. Larizza, M. Stefanelli. A careflow management system for chronic patients, MedInfo 2004,ed Fieschi/Coiera Yu-Chan Jack Li ,pp. 773 - 777 ,(2004)