AN INTEGRATED HEALTHCARE INFORMATION SYSTEM: TOWARD NEW TECHNOLOGIES

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Abstract: *This paper presents several aspects of the migration of a former implementation of a prestige Project ("ICPC2000") toward the new Microsoft.NET technology. This project and its extensions has as a result an integrated primary care information system that allow information storing/retrieving and exchange for a GP network and the related entities (County Health Insurance Houses - CHIH, hospitals, laboratories, pharmacies etc.). The former results are described, in order to understand the structure and the functions of the integrated information system suggested. Then, the new structure is described, with emphasizis on the specific aspects this approach: WEB services. Several considerations about the migration are presented and conclusions are issued.*

Keywords: *Software development, Healthcare Information Systems, Migration, Microsoft.NET, WEB Services*

1. INTRODUCTION

During the last years the role of family medicine increased, in Romania as well. Romanian health professionals are concerned to create a new health insurance system. The main shortcoming in this process is the fact that there are no valid data concerning the activity from primary care, nor concerning morbidity. In order to improve the management of primary health-care, local and central authorities need to have correct and complete information about the specific activity from the primary care level and also the incidence and morbidity at the first contact. Also, the *National Society of Family Medicine/General Medicine* (NSFM/GM) must have data for negotiations with the *National Health Insurance House* and the *Ministry of Health*. Graduate, postgraduate and continuing medical education for Family Medicine need data for up-to-date curricula. G*eneral Practioners* (GPs) are responsible for continuity of care. Also, GPs play an essential role in identifying and labelling health problems. Prevention has an important role for the GPs and can be achieved by providing screening and taking preventive measures with patients attending for other reasons. The prolonged relationship that GPs have with their patients and patient's families allow those patient and family values and preferences to be taken into account as well as medical and social factors.

But as, stated and described in [1], in 1999, the health care reform was put into practice, this implying negotiations on many things and yet the relevant data is missing. In order to obtain data it is necessary that there be:

• a first-class network of dispensaries be spread over the country that could collect valid data.
• a classification system for data - ICPC and ICD10
• the training of doctors in data collection
• financial support for the Scheme.

Is obvious that establishing of this kind of networks is an important technological activity, that involves important software development effort.

This paper presents general aspects of the migration of a former implementation of a prestige Project ("ICPC2000") toward the new Microsoft.NET technology. First, the results of this project are described, in order to understand the structure and the functions of the integrated information system suggested. Then, the new structure is described, with emphasizis on the specific aspects for Microsoft. NET approach: WEB services.
The specific software development approaches have as common features the small and flexible teams, the implication of the students, rapid prototyping, iterative and incremental development, the use of Visual Basic and component-based techniques. The migration described in the paper was fulfilled by the student team from the authors list, coordinated by the first author, academic. These students used the expertise acquired due to the development of the former integrated information system.

2. A FORMER PROJECT: *MEDINS-MEDINET* INTEGRATED SYSTEM FOR PRIMARY CARE

A complete primary healthcare informatic system is presented in the papers [2][3][4].

The objective of the information system that we develop is to ensure information storing/retrieving and exchange for a GP network and the related entities (*County Health Insurance Houses* - CHIH , hospitals, laboratories, pharmacies etc.). A special consortium established for developing this system was the frame. The team included several academics from the Faculty of Automation and Computers, University "*Politehnica*" Timisoara, which worked in the medical informatics and in software engineering and programming domain, and the staff from the *National Institute of Hygiene* from Timisoara. The development of the software application for the general practice was the next step. This application resulted from the discussions between the members of the team mentioned above and has the main functionalities of a GP software. In addition this will make reports and will be able to send them to a server from which to be taken and processed and then made available to the entire GPs community. The resulted product was called *MedINS* (see Fig. 1):

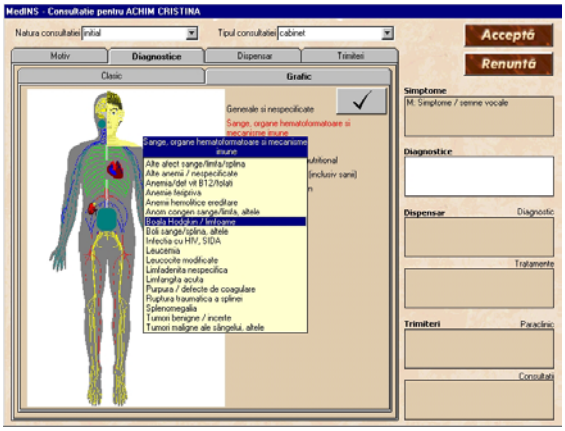

Fig. 1. The Consulting interface in *MedINS*

MedINS covers all the informational needs in a general practitioner consulting room: consultation recording, including codification, generation and printing of documents, generation of reports for CHIH, and other reports at request, sending these via INTERNET, scheduling, personalisation of the application, data security etc. [4]. MedINS alo integrates special features as *Episode of Care* – orientation and *SOAP Philosophy (Subjective, Objective, Assessment, Plan*). *MedINS* is written in Visual Basic 6 and is running under Windows 98/2000. The databases are *Access*-coded and password protected. The application was continuously improved with information from the real GP practice.

During the training and dissemination period of the *ICPC2000* project, new administrative & server components have to be developed, in order to ensure the tools needed for the automated report collecting system.

The *MedINS* software is a precious source of information for the *Server* component, where GPs send monthly reports containing information demanded by the *Server Administrator*. On the basic component level, the report is generated in *MS Access* format using an XML-like template file, generated by a component of Server application, *AdmINS*. Before generating a report, the basic component makes a connection with the *Server* component for downloading the report template. Once generated, the report is uploaded. After collecting all of the reports, these are concatenated in a database. This flexible system allows the modification of the reports structure anytime the project administrators consider necessary. This is the case when they want to change the goals of their research.

The next step was the development of new components as: interconnecting with the CHIH, with the clinical laboratories, with pharmacies, county hospital, mobile components, etc. In this way, finally we have a cvasi-complete primary care integrated information system, which allow to communicate between the actors involved in the healthcare process.

The actual status of the system is shown in the Figure 2.

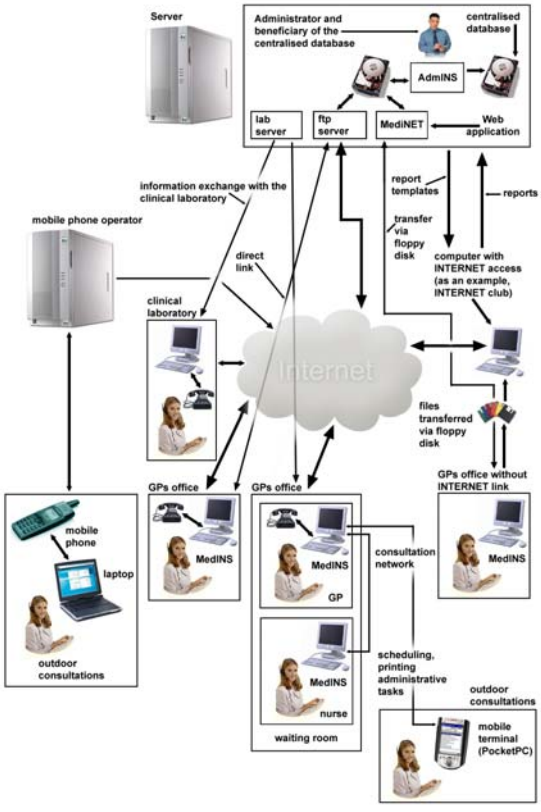

Fig. 2. The actual status of the health information system

Relevant conclusions related to the specific conditions of the development of the software are emphasized in the papers [3],[5]. These conclusions show that is possible to develop a large-scale and relative ambitious project in the Romanian academic environment, but the combination of many financing schemes is required, the team must be higlhly motivated, the consortiums are required, the technical solutions must be appropriate for low-cost and rapid development (this explains the use of Visual Basic, Access, component-based development like with ActiveX-exe, rapid prototyping etc.), as well.

All these demonstrate that the academic environment is (as expected !) important for innovation and promotion of the new technologies.

2. THE NEW SYSTEM DESCRIPTION

New concepts, technologies and paradigms are used now-a-days for the development of the integrated healthcare information systems. The new approaches like the use of XML [9], standards [10] or new techniques for specification level for multi-tier applications [11] improve the performances of the systems and of the development process itself. Several specific aspects concerning the information systems used in General Practice are described in [13].

The problem of the development of a new generation of the discussed integrated system occured once the issuing of the Microsoft.NET technology, that allows a highly network-oriented approach. Since the major effort of the development is oriented through communication (client-server, sockets, securing the communication, communication standards and formats etc.), the migration toward Microsoft.NET appear to be a good choice. In this respect, all the system was refactored and resulted a new architecture (see Fig. 3).
Although, an alternative technological solution was taken into account by our team, based on a JAVA peer-to-peer solution [12]. This solution is not described in this paper.

The new system consists of seven stand-alone applications, all communicating via web services. Those applications are, as follows:

- an application destined for the GPs, to help him organize his information (such as patients' files, history of consultations, etc.)

and also make the communication process easier e.g. by allowing him to renounce handwritten recipes that then must be taken to the pharmacy by the patient himself, and replacing them with virtual recipes sent directly to the farmacy via the Internet with

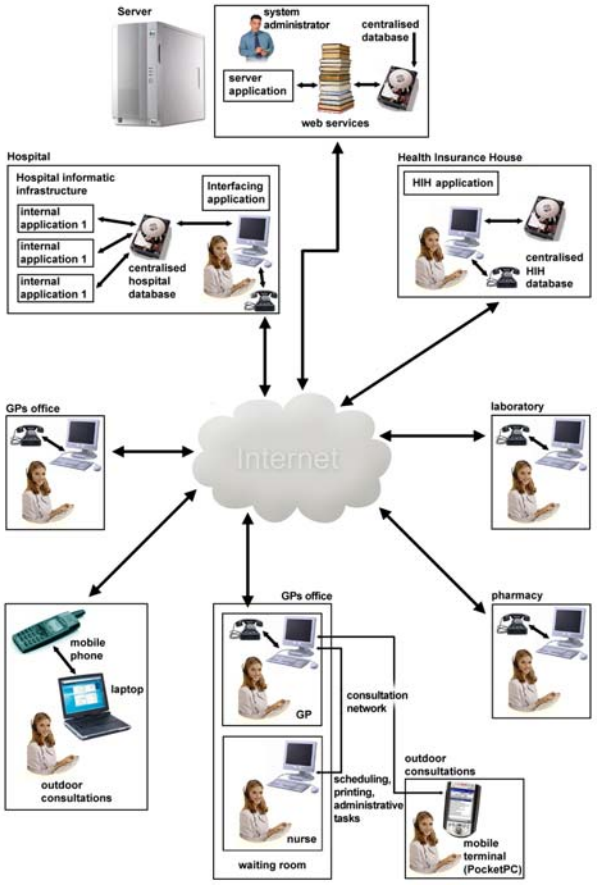

Fig. 3. The architecture of the new system

only a few mouse clicks

- an application for PocketPC, having mainly the same functions and allowing the GP to access his data wherever he is
- an application to be used in a hospital, conceived as an interface between the different programs used in its departaments and the exterior (such as a GP sending a pacient to be admitted by the CHIH)
- an application destined for a pharmacy, for a better interaction with the GPs and/or the hospitals analysis results) between it, the GP and/or the hospital an application to interface with the Health Insurance House, in order to collect the necessary informations (from the GPs, pharmacies, laboratories, hospitals) easier and in order to achieve a better summarization
- an application for the system administrator, allowing him to make different changes to the functionality of the system; this application allows adding new "members" to the network, granting and denying user rights, viewing the system logs and many other such administrative tasks.

The last application is located on a server, which also contains a database and set of web services. The system also allows remote access, meaning that a similar application, having almost all the features of the former can be run from anywhere in the world (with authentication).

Let's consider an example: a simple consultation. A patient comes to a GP. The later consults him, with the aid of his application, and realizes that he needs a set of analysis. So he sends a request to the lab. This request is uploaded on the server, and the laboratory application will download it from there. When the patient shows up at the laboratory, the results will be uploaded on the server, and of course will then be available for the GP to download. Seeing the results, the GP can then decide if the patient needs admitting in a hospital or a simple prescription will suffice. He will then send to the server either an admittance request (available to the application from the hospital) or a prescription (available to the pharmacy application). And of course the consultation (symptoms, conclusions, analysis results, etc.) will be recorded in that patient's file by the GP's application.

The server consists of a powerful computer running an IIS server (in order to support the web services) with SQL Server 2000 database support. Some of the information is permanent, such as the table with information regarding all the network "members", and some of it is only temporary such as analysis results (after receiving the acknowledge that the information has been safely downloaded by the recipient, the information is deleted, in order to save up space). On the server there are also hosted the web services, the actual communication channels.

4. WEB SERVICES

According to the site [6], "the term web services describes a standardized way of integrating web-based applications using the XML, SOAP, WSDL and UDDI open standards over an internet protocol backbone. XML is used to tag

the data, SOAP is used to transfer the data, WSDL is used for describing the services available and UDDI is used for listing what services are available. […] Web services allow different applications from different sources to communicate with each other without time-consuming custom coding, and because all communication is in XML, web services are not tied to any one operating system or programming language. For example, Java can talk with Perl, Windows applications can talk with Unix applications." In this way, the system becomes highly extensible, even with components developed with other technologies than the initial core.

The system uses six main web services:

- a web service dealing with establishing communications agreements (a GP can choose the laboratories he's working with, the pharmacies he's working with, and so on) and working with "members" data
- a web service responsible with all about prescriptions (upload, download, acknowledgements)
- a web service that contains all functions for working with patients' files (used e.g. for sending a patient file from GP to a hospital)
- a web service for exchanging information between GP/hospitals and laboratories
- a web service containing all functions necessary for the communication between a GP and a hospital
- a web service for sending and receiving informations to/from the application interfacing the Health Insurance House

There also are a few minor web services, such as one for legislations (every "member" of the network has access to the latest medical legislation), one for messages (the "members" or the system can send messages to each other), one for the administrative matters (such as coding), etc.

Let us consider an example. A GP wants to establish a communication agreement with a pharmacy (that is the former wants to be able to send data to and receive data from the latter). In order to do that, the GP will go to the section „Invites" of his application, will choose that pharmacy's name from a list and then will press „Invite".

The information actually sent is a small amount, which both speeds up the transmission, and makes it safer that if e.g. the names would have been used instead of identification numbers. Those numbers are valid only inside the system, and only the system knows which data corresponds to each number. The information sent is reduced to the minimum, containing only the identification number of the sender, the one of the receiver, and the message actually sent. „OH" comes from „on hold", and when the data will be interpreted by the receiver will be considerend an invitation to mutual agreement.

When the pharmacy will update its data from the server, it will receive another XML, also reduced to the minimum, containing only the identification number of the sender and the actual message. When the application receives an „OH" from the server, it will display a message, containing the name of the sender and asking to accept / reject his agreement request. As an example, in case of affirmative answer the application wil send to the server the following:

```
.....<!--header -->
<DSInvites
xmlns="http://www.tempuri.org/DSInvites.xsd">
<IDs diffgr:id="IDs1" msdata:rowOrder="0">
<id_exp>15</id_exp>
<id_dest>13</id_dest>
<msg>Da</msg>
</IDs>
</DSInvites>
```

When that information reaches the initial sender, he will receive a message that the other partner has either accepted or rejected the collaboration request. In that moment all the information uploaded to the server regarding the transaction will be erased.

Normally the information would have to be encrypted for safety reasons, but now we'll leave that aside, for clarity's sake

5. ABOUT THE MIGRATION TO MICROSOFT.NET IN THE ACADEMIC ENVIRONMENT: A TECHNOLOGICAL PERSPECTIVE

As seen in [5], the academic environment allow the experiment more than other, due to the availability of the students for innovation and high motivation of the academic staff for R&D activity. In this respect, the migration toward the

new system described above faced with the following activities:

- the preliminary activity with the team involved reffered to the Domain know-how and to the presentation of the former system; an initial team of 7 students was submitted to a formation period about these;
- next, the team established their own discussion group on the Server of the Campus; they also have their own installation of a Configuration Management System (WinCVS);
- the following activity was the writing of the Specifications, discussed on the discussion group and in the weekly meetings with the coordinator; the core of the discussions was the list of the WEB Services;
- then, small pilots allow them to experiment the specific solutions (as "the transmission of large files" or "secure the communication");
- finally, the classical way of the software development was followed for developing the components and integrating/testing them.

Several considerations about the migration itself can be done:

- the team rarely adopted the former source code as upgrade basis toward Microsoft.NET, due to the different approaches; the reuse was done at the know-how and Specifications level;
- the use of WEB services has as a result the increase of the extensibility even with components developed under other technologies and the use of XML contributes to the increase of the flexibility;
- this migration offers a basis for the use of the communication standards in healthcare information systems (as an example, HL7 [7]); the acquired know-how allows the Consortium presented in [4] to promote new Regional and National Projects which have as a goal the implementation of new and efficient integrated information systems.

6. CONCLUSIONS

This paper describes an integrated healthcare information system and its issuing, as a result of a former prestige Project ("ICPC2000"). This project and its extensions has as a result an integrated information system that allow information storing/retrieving and exchange for a GP network and the related entities (CHIH, hospitals, laboratories, pharmacies etc.). Then, a new, technologically evolved structure is described, that uses Microsoft. NET technology, with a special emphasis on the specific element: WEB services. Several considerations about the migration are presented.

The experience of the development of the two generations of the integrated systems shows that is possible to develop professional applications or even entire information systems in the academic environment. The use of different financing schemes, of the personal connections, of the different technical and software development management approaches that encourage the rapid development, of the students for experimenting solutions or even as developers are factors which contribute to the success of the development. This development has several benefits for the academic staff, from professional (improving the skills, doing research, developing own PhD theses) .

7. ACKNOWLEDGMENTS

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