Editorial

Jana Zvárová
Editor-in-Chief

Biomedical informatics is a burgeoning field, with important applications and implications throughout the biomedical world and healthcare delivery. The European Journal for Biomedical Informatics (EJBI) is reacting on the great European need to share the information in the multilingual and multicultural European area.

EJBI opens for the field of biomedical informatics a new model of electronic publishing. EJBI is publishing accepted peer-reviewed papers in English and other languages simultaneously. This opens new possibilities for faster transfer of scientific-research pieces of knowledge of many European countries to a large international community of biomedical researchers, physicians, other health personnel and citizens. Moreover, the journal now enables to make results of scientific-research work and practical experiences of foreign specialists accessible to wider health public in a more comprehensible way in each European country.

The aim of the editorial board is to reach the highest scientific level of the journal and show the best practices of biomedical informatics applications to wide readership. The European editorial board is composed from outstanding specialists in the field of biomedical informatics. We believe that their activities for EJBI will contribute to propagation of journal's good credit. The editorial board also presumes that presentation of English versions of scientific papers with their professional translations to other languages will significantly contribute to unification of applied scientific terminology.

Updating the BIOINFOMED Study: Recent Outstanding Developments in Biomedical Informatics

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Summary: In December 2001, the European Commission promoted a Conference in which more than 400 experts analyzed the synergies arisen between Bioinformatics (BI), Medical Informatics (MI) and Neuroinformatics. In November 2002, and in order to contribute to the strategy of the European R&D; policy for the following decade in such areas, the White Paper of the BIOINFOMED project was presented at the international congress BIOINFORSALUD 2002 (Valencia, Spain). In the strategic document entrusted by the Commission, the relations established between BI and MI were analyzed, resulting in a new definition of the discipline of Biomedical Informatics (BMI) that aims to facilitate the developments of Genomic Medicine. To elaborate the White Paper, a committee of 30 international experts coordinated by the Institute of Health "Carlos III" (ISCIII) designed the agenda with 18 lines of research that corroborated the existing synergy. They pointed out those areas in which the efforts had to be prioritized. In this article, we update this study by highlighting recent outstanding developments in this field. The projects presented respond to a careful selection carried out among the numerous initiatives that have arisen in the three years passed between the publication of the White Paper and this article. Some of the projects analyzed in this paper are: the IT infrastructure for biobanks under the Public Population Project in Genomics (P3G) Consortium, a Network of Excellence (INFOBIOMED) in Biomedical Informatics constituted within the European Union Sixth Framework Program for Research and Technological Development, the initiative headed by HL7 to include genetic information in the electronic health record, the proposal of a Human Phenome Project, a Spanish Cooperative Research Thematic Network (INBIOMED) in Biomedical Informatics, the new National Centers for Biomedical Computing (NCBCs), funded by NIH, under the BISTI initiative and the projects related with the simulation and modeling of Human Physiology.

Keywords: Biomedical Informatics, Bioinformatics, Medical Informatics, Neuroinformatics

1. Introduction

On December 14th, 2001 (http://14dec2001.ramit.be), the Conference "Synergy between Research in Medical Informatics, Bioinformatics and Neuroinformatics" was organised in the Brussels under the Belgian Presidency of the European Union, by the Belgian Federal Ministries of Social Affairs and Public Health and the European Commission – Directorate General Information Society and Directorate General Research. In this meeting about 400 researchers, professors, institution leaders, and industrial representatives gathered to share their vision on the prospect of synergy between medical informatics (MI) and bioinformatics (BI) as well as on the processes required to achieve that goal.

The Brussels Meeting was the kick-off point for the activities related to the EC IST BIOINFOMED Study. The aim of the project was to analyze the relationships and potential synergies between MI and BI. The goals of the project were the analysis of the state of the art in the area of the study, the proposal of an R&D agenda [1] and the identification of the key players as well as the dissemination of the study (http://bioinfomed.isciii.es).

The study gave a general overview of the evolution of each of the disciplines to achieve a better understanding of the possibilities of the synergy between them. Historically, MI and BI have developed separately and only occasionally have researchers of both disciplines collaborated in the past. Although the roots of BI and MI are located in different application domains, these domains increasingly overlap. Results of research in molecular medicine will have an impact on clinical medicine. This shared application domain will provide a natural space to collaborate. Medicine will benefit from the achievements of biological research, and biology will benefit from the use of clinical data for research. The conclusion was that as the domains begin to overlap, both communities increasingly would share a common goal, a common context, for exploring collaboration.

The results from our study crystallized in a White Paper that was presented in the International Congress BIOINFORSALUD held in Valencia (Spain) and in the HealthGrid Conference in 2003 in Lyon (France). The paper was published in a summarized version in February 2004 in the Journal of Biomedical Informatics [2].

2. Was our approximation correct?

Although it was rather difficult to anticipate the future needs that the intersection between MI and BI will introduce in health care and research, several new initiatives seem to reinforce the findings of the White Paper. To value for the time the consistency of our ideas, the best method is to determine what initiatives have started in BMI since the White Paper was published and in what thematic areas. The fact of finding projects that are fitted inside someone of the areas proposed in the research agenda implies some degree of consolidation of the discipline of BMI (see Table 1).

The projects chosen respond to a careful selection carried out among the numerous initiatives that have arisen in the years passed between the publication of the White Paper and the time of writing this paper that was presented in EuroMISE 2004 international congress, held in Prague (Czech Republic). The projects analyzed include: the IT infrastructure for biobanks under the Public Population Project in Genomics (P3G) Consortium, INFOBIOMED, a Network of Excellence in Biomedical Informatics recently constituted within the European Union Sixth Framework, the initiative headed by HL7 to include genetic information in the electronic health record, The Human Phenome Project (HPP), a Spanish Network of Cooperative Research (INBIOMED), the new National Centers for Biomedical Computing (NCBC), funded by NIH, under the BISTI initiative and the initiatives related to the simulation & modeling of Human Physiology.

3. Updated Information

3.1 P3G

Biobanks or population repositories are one of the proposed solutions for the integration of information obtained from environmental and life style data of populations together with their genetic and clinical data [3]. Recently five large Biobanks, Quebec's CARTaGENE, GenomEUtwin project (involving 8 countries), Estonia's genome project, the Center for Integrated Genomic Medical Research (CIGMR) and Western Australian Genome Health Program (WAGHP) have merged into an International Consortium called Public Population Project in Genomics (P3G, http://www.p3gconsortium.org/index.cfm) supervised by Professor Bartha Knoppers of the "Centre de recheche en Droit Public in Montreal". As it can be read at its web page: *"Its main objective consists of the creation of an open, public and accessible knowledge database"*.

It aims to make available to the scientific community under a single frame all clinical, genetic, lifestyle and environmental data collected from different sources. To carry out this ambitious project, the consortium will harmonize data collection of demographic, social and clinical data from the four repositories. Phenotypes that present common characteristics among them will be standardized and a common nomenclature system will be developed to denominate variations found in the five resources. Both genotypes and phenotypes will be stored in the databases.

The access of all members to the information contained in the databases will be coordinated by P3G, that will develop all the security measures needed, taking into account regulations currently in force in each of the countries of origin. To obtain these objectives it will promote the development of the tools needed as technical support for the population genomic research. This characteristic is in complete agreement with the focus presented in BIOINFOMED (Fig. 1) where technologies enabled the synergy between two areas that search for common nexus: MI and BI (line 17 of 18, see Table 1).

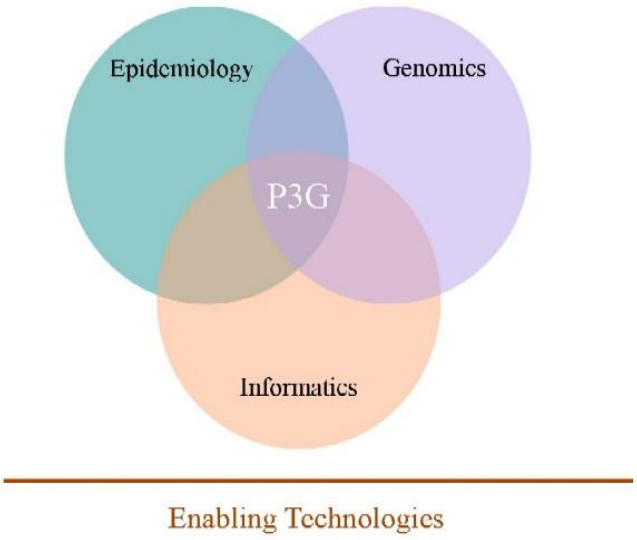

Fig. 1. Synergies between Informatics, Epidemiology and Genomics in the context of Biobank information infrastructures.

This international initiative will encourage geographical mobility of researchers to facilitate the interchange and transfer of knowledge, abiding by the ethical aspects involved in genomic research, following the philosophy of an international consortium.

Lastly, and as a paradigm of any the biomedical project, the results obtained in the genetic epidemiological research of both diseased and healthy populations will be compared and evaluated, consolidating the ultimate objective of BMI, where we frame this initiative: health.

3.2 INFOBIOMED

One of the main achievements of the BIOINFOMED project was the development of a research agenda with eighteen lines of research proposed to meet the gaps that hinder collaboration between BI and MI. There is no doubt that the best corroboration that could be made to consolidate the agenda is to create a network of international groups that will set specific objectives in a given term.

On the 4th of February 2004 took place in Barcelona, Spain, the kick-off meeting of the European Network of Excellence INFOBIOMED (IST-2002-2.3.1.11 e-Health), within the VI framework program of the R & D that counts with the participation of 16 European partners in the next three years [4]. Under the name "Structuring European Biomedical Informatics to Support Individualized Healthcare" and with a budget of 4.8 M Euros, INFOBIOMED is coordinated by Professor Ferran Sanz from Research Group on Biomedical Informatics (GRIB) of the IMIM in Barcelona, Spain.

INFOBIOMED (http://www.infobiomed.org) was born with the purpose of developing tools that will be implemented in the integration of clinical data with genetic data in four research pilots embedded in BMI (see Figure 2). To carry this out, the exchange of methodologies, tools and technologies between BI and MI will be promoted within a European BMI network that will be an open forum of knowledge interchange and dissemination. The training and mobility of the research staff will be a constant in the search of full research capability in this area in Europe, expecting it to last in time.

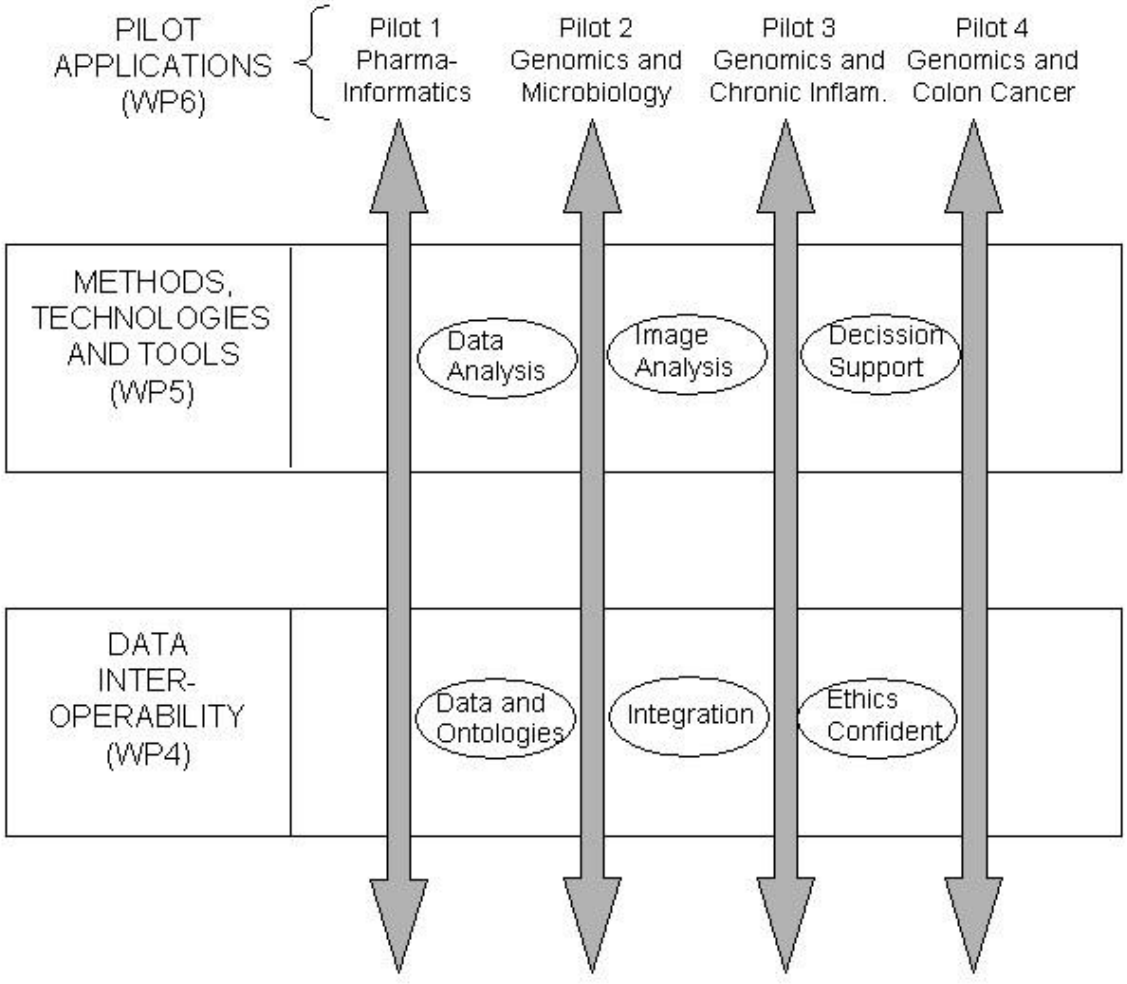

Fig. 2. Overview of INFOBIOMED Network of Excellence Technical Workpackages.

The four pilots planned will show the importance of the synergy because it will mean the materialization of the objectives pursued in four large thematic areas, Pharmainformatics, Microbiology, Chronic inflammation and Colon cancer.

3.3 HL7 Clinical Genomics Special Interest Group

One of the challenges for daily clinical practice in the coming years is the incorporation of the patient's genetic information in the electronic health record. Health Level Seven (HL7) is an organization responsible for harmonizing protocols or specifications in the area of clinical and management data being one of several ANSI-accredited Standards Developing Organizations (SDOs). HL7 is divided in turn into Technical Committees and Special Interest groups (SIG) and, recently, the HL7 Clinical Genomics Group (http://www.hl7.org/special/Committees/clingenomics/index.cfm) has been created.

Among the main objectives of this last group are to support application of genomics in clinical medicine, to specify use-cases and data requirements, to review existing genomics specifications and to recommend enhancements to HL7 standards to support genomics. This SIG met in Memphis, USA on September 8th – 10th, 2003, to debate about how the Electronic Health Record must support clinical genomics including genetic testing, storage and retrieval of genomic and proteomic information.

This SIG is presided by four people: Jill H. Kaufman (IBM Life Sciences), Scott Whyte (Catholic Healthcare West), Amnon Shabo (IBM Research Lab in Haifa) and Peter L. Elkin, (Professor of Medicine, Director, Laboratory of Biomedical Informatics, Department of Internal Medicine, Mayo Medical School).

They have developed a functional module of EHR system that was balloted and has had its first phase approved for its use in trial mode.

3.4 The Human Phenome Project (HPP)

HPP is a proposal of an international project whose main objective would be to obtain phenome databases, this is, the complete phenotypic representation of a species [5]. The phenotype is the morphological, biochemical, physiological and gestural expression of the genotype under certain environmental conditions. To create a phenome, we first have to enumerate the characteristics that make up a phenotype and the relations that could be established between them, which constitute the traits. HPP is an international initiative that would establish the protocols to choose, collect, store, quantify, retrieve and integrate those phenotypic data with their corresponding genotypic data.

The ultimate goal of HPP is to gather and provide knowledge about diseases. Reason why the phenotype defined through the enumeration of its characteristics and traits will be a disease oriented phenotype. To be able to define the phenotypes, several aspects related to the diseases will be researched:

- Phenotypic parameters used for diagnosis that are inherited. HPP will carry out epidemiological studies that will include these phenotypes directed towards inherited diseases.
- Making association studies of endophenotypes, phenotypic characteristics of intermediate heritability, easier to monitor than the direct disease phenotype.
- Quantitative measure of phenotypic parameters in metabolic pathways to improve rational drug design.
- Protocol standardization for measuring phenotypic parameters.
- Comparative phenomics with animal models.
- Protocol standardization for the collection of large volumes of phenotypic data from a sample.

In this same line of work it is also worth mentioning a web-based initiative called PhenoFocus that tries to group all those laboratories, researchers and institution interested in this field (http://www.phenofocus.net/). It is "*an open collection of researchers interested in developing optimal public-domain solutions for computational handling of phenotype data*".

3.5 INBIOMED

INBIOMED (http://www.inbiomed.retics.net) is a national thematic network of cooperative research in Biomedical Informatics supported by the Biomedical Research Agency (FIS) of Spain [6]. The network has 13 nodes belonging to 11 research centers and universities geographically distributed and groups more than 100 researchers. The INBIOMED network allows the collaboration between researchers coming from several areas of bioinformatics and medical informatics. Other groups are experts in areas like: computer technologies, genomic epidemiology, pharmacogenomics, and molecular and image-based diagnosis. The structure of the cooperative work is defined in such a way that a technological platform provides help to the "bio-users" nodes. The platform is developed by the technological groups and updated, almost weekly, with new solutions implemented following the proposals of the "bio-users" nodes.

Several bio-computational tools have been developed within the INBIOMED network. Moreover, the "bio-users" nodes have seen how their work becomes easier with the procedures and methods provided by the technological nodes. The produced platform includes modules for integration of heterogeneous, distributed databases, gene expression data management, visualization and renderization of 3D images, medical decision support, cell count tools, gel strips analysis procedures and text mining methods among others. All these tools, procedures and methods have been enlarged with another more specific tools to solve some of the problems suggested by the "bio-users" nodes. An overview of the technologies used in INBIOMED is shown in figure 3 below.

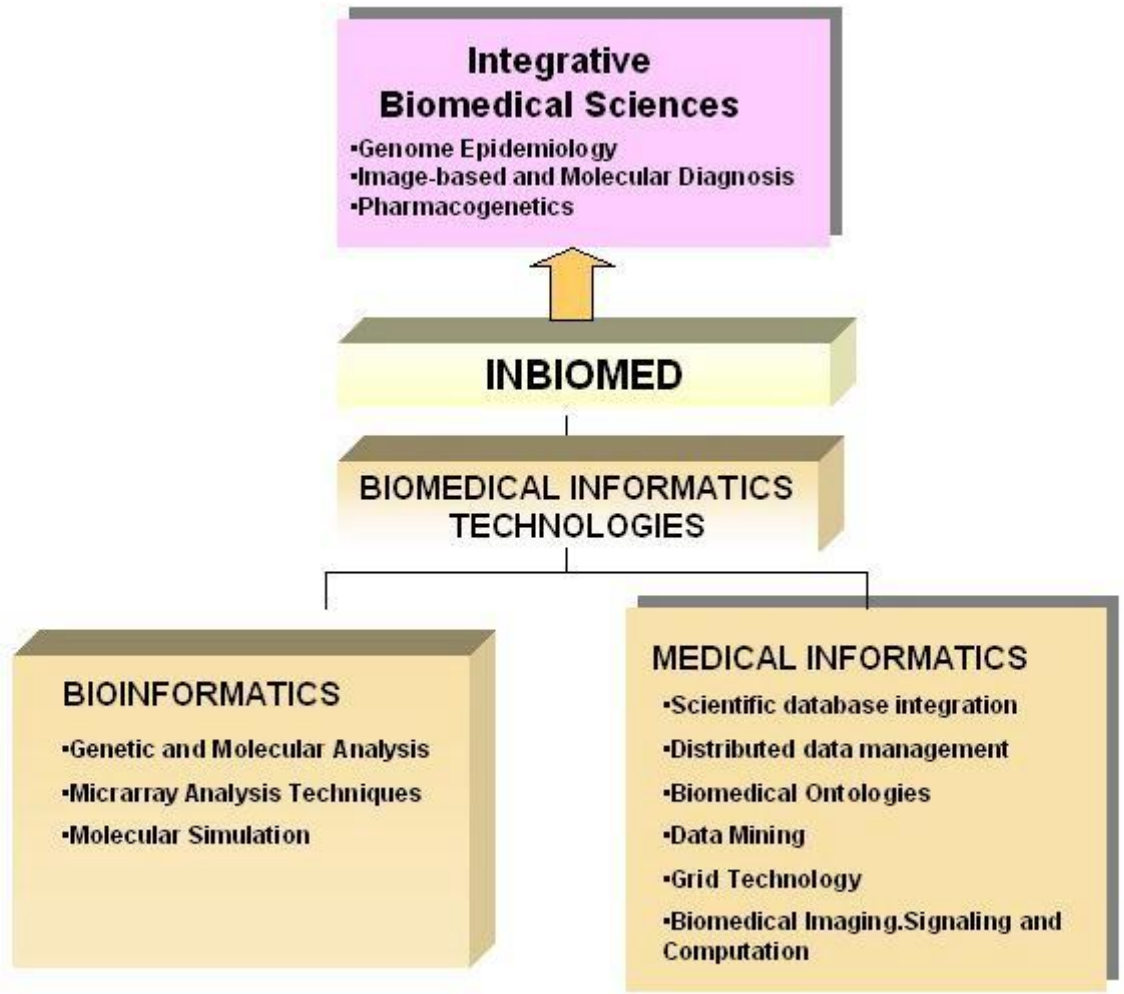

Fig. 3. Schema of the Biomedical Informatics Technologies used in INBIOMED.

3.6 National Centers for Biomedical Computing (US)

The United States of America has approved the creation of four new national centers, called National Centers for Biomedical Computing (http://www.bisti.nih.gov/ncbc), to develop an international computing framework in biomedical computation. They are funded by the NIH, under the BISTI initiative (http://www.bisti.nih.gov/ncbc/index.cfm). These centers' main goal is to create the core of a computing infrastructure to speed progress in biomedical research. New software programs and other tools will be developed to enable the research community to analyse, model, simulate and share data of human diseases.

The centers are part of the National Institutes of Health RoadMap for Medical Research. Researchers related to the four centers will create new computational tools by means of data collected in both the lab and the clinic. A main goal of the centers is to distribute the developed tools and to train future users.

Research teams of the four new centers consist of experts in computation, biology and behavioral science to collaborate in several projects.

The four new centers awarded in 2004 are Physics-Based Simulation of Biological Structures Center, (http://cbmc-web.stanford.edu/simbios/index.html), National Alliance for Medical Imaging Computing (http://www.na-mic.org/), Informatics for Integrating Biology and the Bedside (http://www.partners.org/i2b2) and Center for Computational Biology (http://www.loni.ucla.edu/CCB/).

3.7 Virtual Human Physiology

The Human Physiome project is a worldwide public domain effort that attempts to provide a comprehensive framework for modeling the human and other eukaryotic physiology (http://www.bioeng.auckland.ac.nz/physiome/physiome_project.php). *"It aims to develop integrative models at all levels of biological organisation, from genes to the whole organism via gene regulatory networks, protein pathways, integrative cell function, and tissue and whole organ structure/function relations. Current projects include the development of:*

- *ontologies to organise biological knowledge and access to databases,*
- *markup languages to encode models of biological structure and function in a standard format for sharing between different application programs and for re-use as components of more comprehensive models,*
- *databases of structure at the cell, tissue and organ levels,*
- *software to render computational models of cell function such as ion channel electrophysiology, cell signalling and metabolic pathways, transport, motility, the cell cycle, etc. in 2 & 3D graphical,*
- *software for displaying and interacting with the organ models which will allow the user to move across all spatial scales.*

Within this section we also mention the initiative for the development of the EuroPhysiome project. This possibility is explored in the White Paper recently presented by the European Commission "Towards Virtual Physiological Human: Multilevel Modeling and Simulation of the Human Anatomy and Physiology". This paper reviews the needs and challenges identified to achieve the objective of the "Virtual Physiological Human". They span from making a better use of data, methods and tools to the development of new methods, standards libraries and tools for future research.

4. Conclusions

After the analysis of the previous initiatives, we can come to the conclusion that the initial approach of the BIOINFOMED study was correct. All these ambitious projects such as the P3G Consortium, the Network of Excellence INFOBIOMED or NCBCs among others, can be directly mapped to some of the 18 research lines identified in the White Paper (see Table 1). This shows that the analysis and conceptualization done at the time in the project was consistent and durable.

However, we are detecting parallel lines of research, and therefore having no intersection point, of BI towards phenotype and MI towards genotype. This lack of collaboration brings about the danger of falling in the trap of continuously reinventing the wheel, which will take time from better focusing towards a faster and more productive movement forward of research.

Table 1. Mapping of the project analyzed with the lines of research proposed in the BIOINFOMED white paper.

ENABLING TECHNOLOGIES		UPDATE
1	Grid	
2	Security	
3	Data communication standards	INFOBIOMED
4	Knowledge representation to facilitate the virtual integration of heterogeneous clinical and genetic databases	INBIOMED
5	Data and text mining	
MI IN SUPPORT OF FUNCTIONAL GENOMICS		
6	Phenotype databases suitable for genomic research	HPP, Phenofocus

7	Disease Reclassification	INBIOMED
8	Pharmacogenomics	INFOBIOMED
BI IN SUPPORT OF INDIVIDUALIZED HEALTHCARE		
9	Genetics data model for the EHR	HL7-CG-SIG
10	Clinical guidelines and decision making using genetic information	
11	Telegenetics	
12	New methods and information platforms to manage genetic data in clinical Research	
13	Point-of care data acquisition systems	
14	Microbial Genomics	INFOBIOMED
BMI IN SUPPORT OF GENOMIC MEDICINE		
15	Molecular and Functional Imaging	
16	Modelling and Simulation	NCBC, Simulation of Human physiology
17	Populational Repositories	P3G
18	e-Learning	

Acknowledgements

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Distance Learning at the Medical Faculty of University of Sarajevo

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Summary: Possibilities of introduction of distance learning in medical curriculum are the title of project which has been realizing at Department of Medical Informatics, Medical Faculty since year 2002. The Project is approved by Federal and Cantonal ministries of science and education. The purpose of this project is to support improvement educational process at biomedical faculties using contemporary methods, methodologies and information technologies in accordance with strategy and objectives given by Bologna declaration. The pilot project is realized during three years, the theoretical and practical parts of the subject Medical Informatics are adapted to modern concepts of education using world trends of distance learning. One group of students from the Medical Faculty was involved in this project, which was finalized by electronic registration of an exam and electronic testing on 20 June 2005, in public in the Physiological amphitheatre of the Medical faculty in Sarajevo. In this article we have given description of the project and phases of its realization, and basic adventages and disadvantages we have noticed so far.

Keywords: distance learning, biomedicine, medical curriculum

1. Introduction

The health sector is one of the most evident potential beneficiaries of the Internet revolution and World Wide Web resource in the present and in the future, when the tools now available and the system's reliability and efficacy as a whole will be further incremented and improved [1], [2], [3], [4].

- Low level of education in secondary schools is improving, but it is still low,
- shortage of modern equipment,
- lack of LAN, connection to Internet, organized web design,
- problem of the maintenance,
- free access to a computer room.
- Students are not informed about functioning of education and health systems in whole, especially at universities.
- All new measures and decisions must be formalized through legislation.

Fig. 1. Web site of University e-learning centre.

In our system the power of knowledge should be prevailing, instead of the power of authorities.

Distance learning presents the type of education where a professor and a student communicate and learn from each other via an electronic system [5], [6], [7], [8]. Since distance learning takes us away from the traditional student-teacher "face to face" classroom learning, good educational system planning and organizing is a necessary new educational platform, necessary due to professor's atempts to convey his or her knowledge to students learning from a distance successfully [9], [10]. The platform for the course of distance learning is accomplished due to collaboration with UTIC. With their help the center for distance learning, "LUCIS CENTRUM", is created (Figure 1). We hope that this is just a beginning step towards improvemetns of the Bosnia-Herzegovinian education system and that this project will serve as an indicator towards the future [11], [12], [13], [14], [15], [16], [17].

Fig. 2. Web site of University E-learning centre- Lucis Centrum/contents.

2. Methods and contents of Distance learning education at the Medical Faculty of University of Sarajevo

Lecture contents will be presented in our virtual classroom. In our case, learning materials from the subject of medical informatics, and later, hopefully from other medical subjects, will be available on the web site, www.e-learning.ba (Figure 2) and www.imasic.org/mi/.

In this "classroom", learning materials, power point lecture presentations as well as practice exercises with step-by-step instructions, are easily accessible to students. Moreover, on this web site, students will be able to find subject relating literature as well as the English version of the presentations.

Fig. 3. Links of contents.

To access this information requires only one click on a download option (Figure 3) as well as one second patience depending on student's Internet speed connection.

Shortly, our virtual classroom gives students the opportunity to access needed information, at any time, and in any place without having to be bound to the classroom.

A student is able to browse through the "classroom" using standard navigations (Figure 3). Using these simple navigations, maximal efficiency and fast access to needed materials is possible (Figure 4).

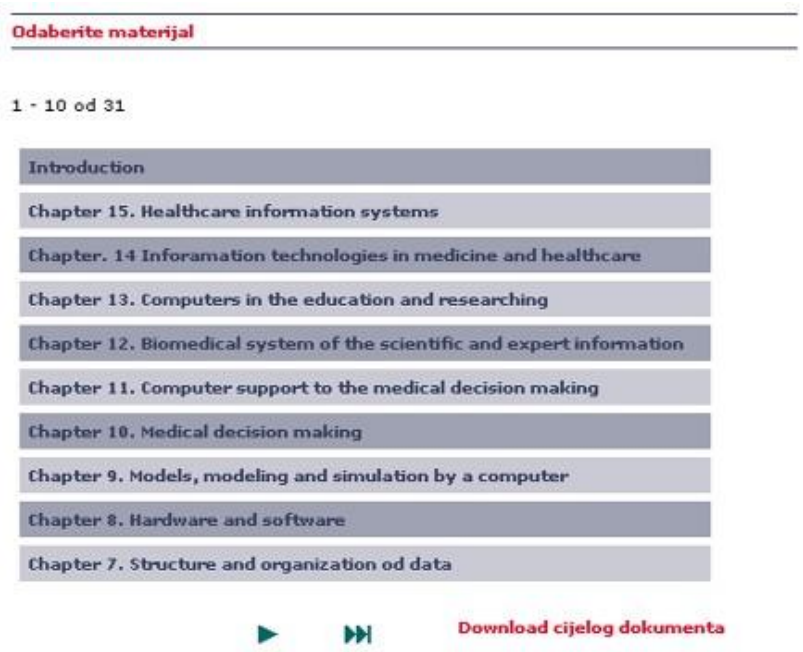

Fig. 4. Contents of medical informatics education (lectures units).

As we can see in the picture, all links are in an chronological order according to the plan and program of the lecture as well as practice. Special attention is given to the link "kvizovi."

In order for the student to check his/her progress (to test his/her knowledge of the lecture he/she studied), every lecture is followed by quizzes. Quiz questions are multiple choice questions (Figure 5) and they are based on the lecture content.

After every quiz, student receives the "feedback" regarding his/her progress. Results are given in terms percentages (one needs 51% to pass). This way students had total control over their work.

Fig. 5. Multiple choice quiz.

3. Advantages and disadvantages of Distance learning education

Distance learning compared to the traditional way of learning have many its advantages as well as disadvantages [3], [6], [9], [12], [15], [16], [17]. Some of the main advantages of distance learning are: the economical factor; a student has 24 hour access to needed information; he/she is given the opportunity to learn the subject in his/hers own time and speed; he/she can access learning materials independently of a place or time; he/she is given the opportunity to learn how to work independently; using e-mail or chat rooms he/she is able to contact a professor or his/hers assistant if there are any questions or confusions regarding lectures; etc. Many critics consider that using e-mail or chat rooms to obtain a contact with the professor is actually the main disadvantage of this system of learning [1], [3], [13], [17]. A question arises whether this way of the professor-student communication is helpful to students as the face-to-face contact is missing as well as the opportunity of student-professor relationship building. However, in many universities across Bosnia and Herzegovina student's contact with a professor is almost impossible (unless one needs to take the exam orally), due to many professors having other jobs or responsibilities; students are mainly able to communicate with professor's assistants. Moreover, through the traditional way of teaching, during the lectures, students obtain from their professors mostly the information, which they can find in the literature or on the Internet. Rarely, there is a student-professor interaction or lecture discussion during the class. From this one can conclude that an ambitious student using teleeducation will experience minimum lose.

Prezentacija na Medicinskom fakultetu

Prvo elektronsko polaganje ispita

U amfiteatru Medicinskog fakulteta jučer je održana završna prezentacija projekta „Uvođenje učenja na daljinu u medicinski curicilum", tako što je po prvi put u historiji Univerziteta u Sarajevu organizirano elektronsko polaganje ispita.

Ovaj projekt se realizira na Katedri za medicinsku informatiku Medicinskog fakulteta od 2002. godine i odobrili su ga Federalno i Kantonalno ministarstvo nauke i obrazovanja. Cilj projekta je unapređenje obrazovnog sistema primjenjivanjem savremenih edukacijskih metoda u skladu s preporukama Bolonjske deklaracije o reformi obrazovnog procesa na Univerzitetima u BiH.

Tokom prezentacije prikazana je procedura učenja na daljinu, prijavljivanje ispita putem računara, te elektronsko polaganje ispita. *Z. P.*

Prikazana procedura učenja na daljinu

Fig. 6. Public presentation of electronic exams at Medical Faculty of University of Sarajevo held in June 2005.

4. Conclusion

The rise of IT as an artefact of everyday life in the modern world has brought with it the dawn of a new era, often doubbed the "Age of Information". These technologies are changing the way we perceive the world, how we think and communicate with others. Established cultures are being transformed and new cultures are forming. New virtual environment affects the way we build our sense of who we are.

Some characteristics of the Internet:

- Large volume of users and potential users,
- lack of physical boundaries, which allows for the manipulation of time and space,
- information can be accessed in a concurrent fashion using different media,
- concept of redundancy.

In the virtual environment we are applying for information in a way that is expanding our senses and one must take into account that experience is occurring in the context of the virtual environment. Information without a context has no meaning.

Expected outcomes of the project Introduction and Implementation of Distance learning in medicine are:

- Development and integration of informatics-computer technologies in medical education,
- creation of flexible infrastructure which will enable access to e-Learning by all students and teaching staff,
- improvement of digital literacy of academic population,
- ensure high educational standards to students and teaching staff and
- to help medical staff to develop "Lifelong learning way of life".

The health sector is one of the most evident potential beneficiaries of the Internet revolution and World Wide Web resource in the present and in the future, when the tools now available and the system's reliability and efficacy as a whole will be further incremented and improved.

- Low level of education in secondary schools is improving, but it is still low;
- shortage of modern equipment;
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- problem of the maintenance;
- free access to computer rooms;
- students are not informed about functioning of education and health systems in whole, especially at universities;
- all new measures and decisions must be formalized through legislation.

In our system the power of knowledge should be prevailing, instead of the power of authorities.

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A New Web, Multi-service Tool for Regional Management of Allergies, Asthma and Rhinitis

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Summary: In this paper, a new web solution for administering allergies, asthma and rhinitis in a pan-European level is described. The proposed system was designed to provide: professionals with easy workload and access educational and informational material; sufferers with personalised management tools and educational sources; and citizens with rich informational material. The IREMMA system architecture embeds the existing information networks and data sources on allergy by offering high data integration and multi-modal access to its users, through a multi-service tool and high-distributed architecture. Hence, IREMMA sets the ground for establishing a wide integrated network for environmental monitoring and diffusion of health information. User feedback was collected through extensive pilot trials with real users and the results were used to improve the IREMMA services and the designing and the content specification.

Keywords: telematic services, allergies, environmental monitoring, web applications

1. Introduction

Nowadays, in the area of health care two interlinked states dominate. From the one side, health informatics has faced a great number of critical issues, providing continuous, effective and qualified medical care, through advanced telematic services and novel technologies' use. From the other side, the requirements of health professionals and citizens grow rapidly for more such services, as IT attainments support their mobility with useful tools. These demands become more imperative for a special domain in health care, this of allergies, asthma and rhinitis. Considering the mass of people that are involved in that domain in the worldwide level, and the fact that the treatment and monitoring of sufferers are dependent on a huge number of non-medical factors – basically environmental – that domain becomes very critical.

From the technical point of view, thre are three basic approaches that have been established for solutions in the area of health care: a) patient-oriented, b) professional-oriented and c) knowledge-oriented. Each of them is easily applied for solutions regarding applications limited in the environment of a hospital. But in the case of administering allergies, asthma and rhinitis these become hard to use and a hybrid solution is required for managing a number of fundamental issues. These issues are mentioned with the following statements:

- There is a lot of spatially and regionally distributed information,
- sufferers are characterized by intense mobility that may influence their health,
- there is a great demand for citizens' information about environmental conditions of the area that they live or visit,
- the continuous provision of medical care and monitoring of sufferers is needed, even far from their doctor,
- citizens need to be updated for news and novel products regarding allergies and asthma,
- citizens should be educated to perform self-monitoring with the use of easy tools, and
- professionals need to exchange their knowledge about special issues in allergies and asthma and access information of novel researching and technological attainments.

There have been a lot of proposed solutions for administering these issues, especially applied in the national level, and cover partially a number of the above issues. IREMMA is a new, integrated multi-service tool that provides the environmental monitoring and management of allergies, asthma and rhinitis in a pan-European perspective. IREMMA manages the citizens' and professionals' needs described above, through a number of basic services. IREMMA provides its services with an integrated way, establishing an electronic workspace that enables the users to access it according to their profile, while sharing the same distributed information sources. The related work was done within the project "Integration of Regional Environment Monitoring and Management for Asthma (IREMMA)", which is partly funded by the EU eTen program.

In the first part of this paper, the design method and considerations of IREMMA are presented, through the analysis of users' profiles, the basic IREMMA services and the distributed information sources. In the second and third parts, the basic and special implementation issues are presented, respectively, describing the general architecture of IREMMA and the individual components of it. In the last parts of the paper, the results and discussion issues are included.

II. DESIGN METHOD AND CONSIDERATIONS

Citizens, sufferers and health professionals are considered as the main types of users of the IREMMA system. Each user may alter his type according to his needs and requirements. IREMMA's basic concept is the integrated administration of the multiple users' roles, establishing a number of distinct profiles and providing a number of basic services using the available distributed information sources, as shown in the tree-level design diagram of Figure 1.

A. Users' Profiles

IREMMA defines three different user profiles, which are available to all types of users (citizens, sufferers and professionals), the 'Citizens Profile', the 'Sufferers Profile' and the 'Professionals Profile'. Users are enabled to choose one or more profiles, in accordance with their requirements and the type(s). Each profile specifies a number of services that are accessible to the corresponding type user, applying special management, control, authentication and authorization mechanisms. Among the services that each profile provides, each user is enabled to select these that he is willing to have access to. The 'Citizens Profile' is the only one that every user can utilize, independent of his type, without posing any limitation.

B. Basic Services

IREMMA distinguishes five basic services: *Informing, Communication and Advising, Education and Training, Personal Data Management* and *Monitoring*. These basic services are provided differently to each user profile through specialized services that are presented in the following paragraphs, based on the user profile that they are available to.

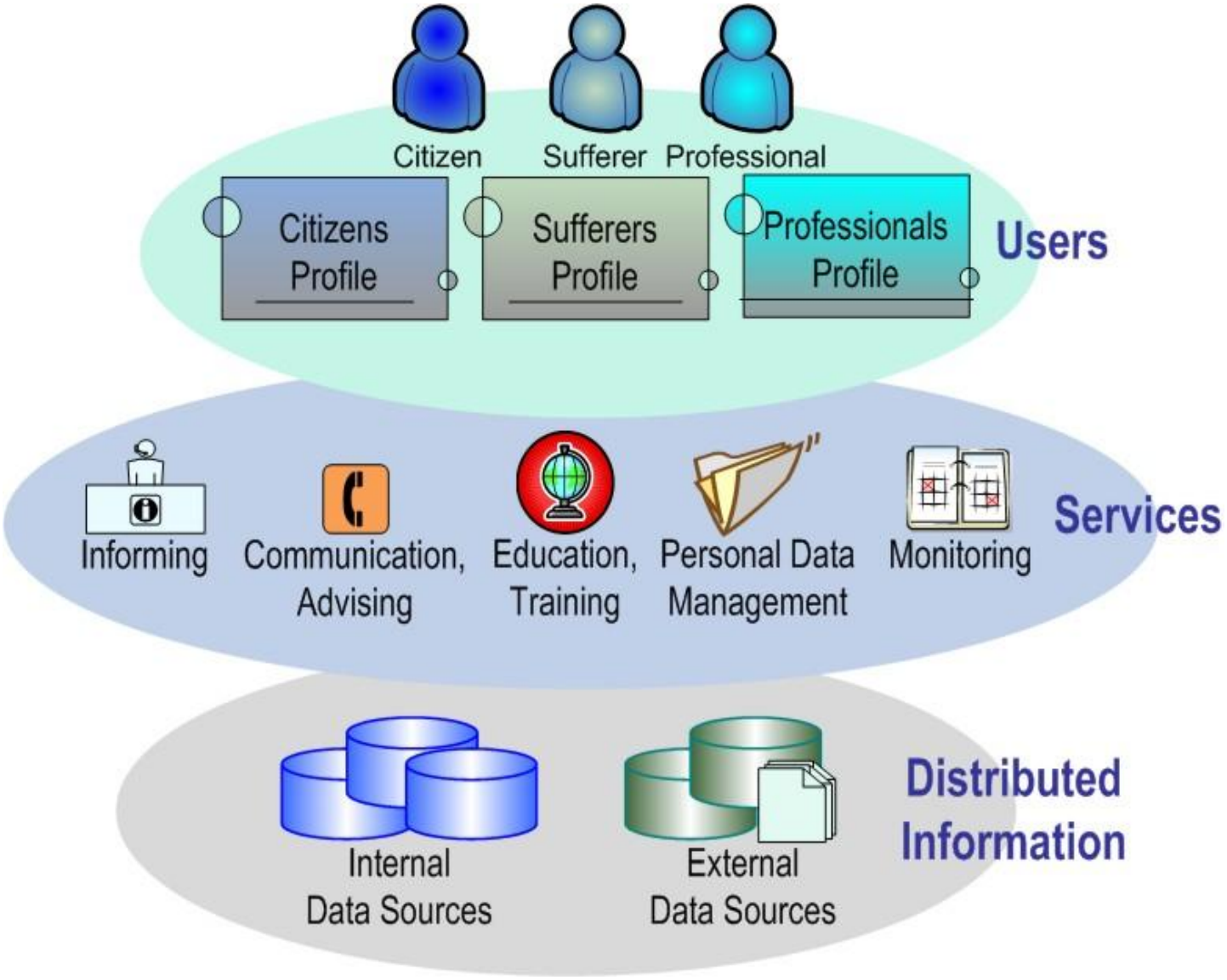

Fig. 1. IREMMA three-level design.

Specialized Services for 'Citizens Profile'
All the specialised services those are available for 'Citizens Profile', come under the 'Informing' basic service.

Allergy Maps: The use of IREMMA Pan-European Pollen Trap Network data from the IREMMA web site provides mapping of allergens concentration in each European country. Following collection of data from pollen traps across Europe, aero-allergen data from each country are stored. Collection of historical data, according to the area and the season, is used for forecasting purposes. The user, through a web-based application has the ability to search for all or a specific allergen existing in a geographical area.

The service provides pollen measurements for selected aeroallergens and for selected location and time. The result can refer to the latest actual measurements, the prediction for next week or to a specific date around the year. In the latest case, estimation based on statistical data is used. A high-medium-low indication per aeroallergen is displayed and in the case of actual measurements, also the precise pollen count is available. It is also possible to display the yearly distribution of aeroallergens for a specific location, according to statistical data.

Information Library: The purpose of IREMMA information library is to provide to each user, Internet based information on allergies and asthma on demand like:

- Reference medical information in the form of a Medical Encyclopaedia.
- New advancements/developments in Rhinitis and Asthma.
- Description of most common allergens.
- List of precautions and useful tips for sufferers.
- Specialised medical centres across Europe.
- Information on medicinal products in collaboration with pharmaceutical companies.

Latest News: The user can access scientific news on allergies, rhinitis and asthma in the form of short articles that are updated on a daily basis.

Frequently Asked Questions: The Frequently Asked Questions (FAQ) screen displays a set of questions and their corresponding answers. It is accessible by all users and intended as a basic reference of information. It is frequently updated as new questions and information arise.

Useful Links: A set of frequently updated links to relevant sites is offered, such as allergiological societies and organizations, medical sites, pharmaceutical companies, health organizations, etc.

For Travelers (includes the visitors of the Olympic Games in Athens): The services to travelers and in particular to the visitors of the Olympic Games are in principle the same as those for all other allergy sufferers. However, in order to address in a better way the needs of this special user group, additional designing features are added to the IREMMA website. More specifically, a link has been added in the home page with the symbol of Olympic Games, which links directly to special information about the Olympic sites and the health system in Greece.

Specialized Services for 'Sufferers Profile'

SMS and e-Mail Alerts: This is a 'Monitoring' service and enables sufferers to receive SMS or email alerts when increased pollen levels are expected in the atmosphere. Each such user defines the corresponding preferences in his personal profile, including allergens of interest, email address, mobile phone, location, etc. The user can also activate or deactivate the alarms and he is able to view the messages he has received and the corresponding charging.

Personal Allergy Map: This is a 'Monitoring' service and provides the user with aeroallergen levels for the area where he lives and only for the allergens that he has chosen, as selected in his personal profile. The displayed data are the latest live measurement or the forecast for the following week, and are provided in the form of a report, depicting graphically the aeroallergen levels.

e-Learning: This is an 'Education and Training' service and offers information that is useful for the sufferers in order to increase their knowledge on specific issues related to their health problem, through a number of specific themes. The sufferers are enabled to search the available information of IREMMA internal and external data sources using special criteria.

Self-management Tool for Asthma: This is a 'Monitoring' service and facilitates sufferers with a special tool for monitoring their asthma by measuring their peak flow. The measurement of their breathing flow helps in assessing their current breathing status. A common Peak Flow Meter is used to measure the peak flow and the user records the obtained measurement to IREMMA system, in his personal account, in order to monitor his condition. The Self-Management Tool uses a personal best value (calculated according to the sufferer's age, sex and body measures) and peak flow history in order to:

- Inform the user immediately for his status and whether he needs his doctor help or not, and
- present him a chart which figures his progress. This chart shows in graphical form the history of the patient's measured values. The graph can be either 15-day, or 6-month. There are 3 color zones, the Green zone which means that everything is going well, the Yellow zone which suggests to take additional measures to control his asthma and the Red zone which is an emergency situation and urges the patient to ask for medical help.

Travel planning: This is an 'Informing' service and allows sufferers-travellers to view the pollen levels for a specific location in Europe. Pollen levels can be displayed as follows: the latest live measurement, the forecast for next week, the yearly distribution or the expected levels at a specific date. The yearly graph allows the user to view the occurrence of specific allergens in the specific area around the year and plan for the best period to visit the specific location. The user can also view pollen levels on the specific date of interest, based on statistical. In case he is interested for an immediate trip, he has access to live measurements and forecasting for the following week. The user can view pollen levels at the location of interest according to his personal allergy profile. After selecting the location, the user can also access local information, such as a presentation of the allergy profile of the area and information on the local health system.

Personal profile: This is a 'Personal Data Management' service and enables the registered user can to view and update his personal allergy profile and preferences. The information contained includes:

- the allergens in which the patient is sensitive,
- the area for which he wants to be informed,
- the presentation of his personal allergy maps,
- information necessary for the self management tool,
- preferences about SMS or email alerts,
- info about his subscription and chargeable services.

Discussion List: This is a 'Communication and Advising' service and provides to the users an electronic discussion room in order to either read comments and contributions on issues that may interest them or to participate actively in posing questions and commenting on ongoing discussions. An expert assigned by IREMMA enters the discussion list on a frequent basis and adds comments to ongoing discussions. In this way, certain posed questions are also answered by an expert and the attention of the users is drawn to opinions that have been expressed and are not acceptable by the medical expert.

Specialized Services for 'Professionals Profile'

Medical Education: This is an 'Education and Training' service and is offered to health professionals through recorded training sessions, ground rounds and recorded telemedicine sessions. Participants are able to attend in teleconferencing rooms close to the area where they live and work. The event is organised by IREMMA with the collaboration of local organisers who provide the room and specialised canters in Europe, who provide the training sessions. Special announces in IREMMA web interface make the scheduled sessions known to the users and they are able to register their participation. Tele-education sessions are eligible for CME credits and have a specific cost. Users can be informed about the cost, summary, provider and place/date of each session through the site. Users are also informed about the sessions for which they applied for participation.

e-Learning: This is an 'Education and Training' service and offers information that is useful to the health professionals in order to increase their knowledge on specific issues related to their specialization.

Personal profile: This is a 'Personal Data Management' service and through of it health professionals are able to define, view and update their profile information and preferences. The data screen is accessible only by the corresponding professional after successful authentication procedure. The displayed data are derived from the record of the specific doctor who enters the screen. The displayed items are:

- Personal information, address, medical specialization, contact information, username & password.
- Information about the professional's account, such as charging info for medical education & e-learning (date downloaded, title, price and total).

Discussion List: This is a 'Communication and Advising' service and enables the professionals to take enter the discussion list, either to read comments and contributions on issues that may interest them or to participate actively in posing questions and commenting on ongoing discussions. The discussion list for health professionals is separate from the discussion list for sufferers and the discussions are on a professional level.

C. Distributed Information Sources

As shown in Figure 1, the distributed information is distinguished in two categories, the Internal and the External Data Sources.

The Internal Data Sources consist all the special inputs of data into the IREMMA system, containing allergens' measurements and informational material. The allergens' measurements are introduced to the IREMMA system using a data acquisition mechanism from assessed pollen traps (such as University Clinics, Local Health Units, Hospitals and Botany Institutes). These pollen traps are positioned in the geographical areas covered by the specific project and follow a standard procedure for the collection and archiving of pollen data in IREMMA system. The internal informational source is enriched by the users of IREMMA and relative organizations, enterprises and local initiatives, which provide their informational material, in order to enable the rest of the users to access them, through the IREMMA system.

The External Data Sources consists of external databases and informational sources. IREMMA places connections with other databases that are used to provide environmental data, allergy information, weather reports and other information relevant with the IREMMA services. These databases belong to collaborating institutions, weather agencies and independent networks. The external informational sources are independent web-sites, libraries and databases of informational material, that provide to IREMMA with their content through special links.

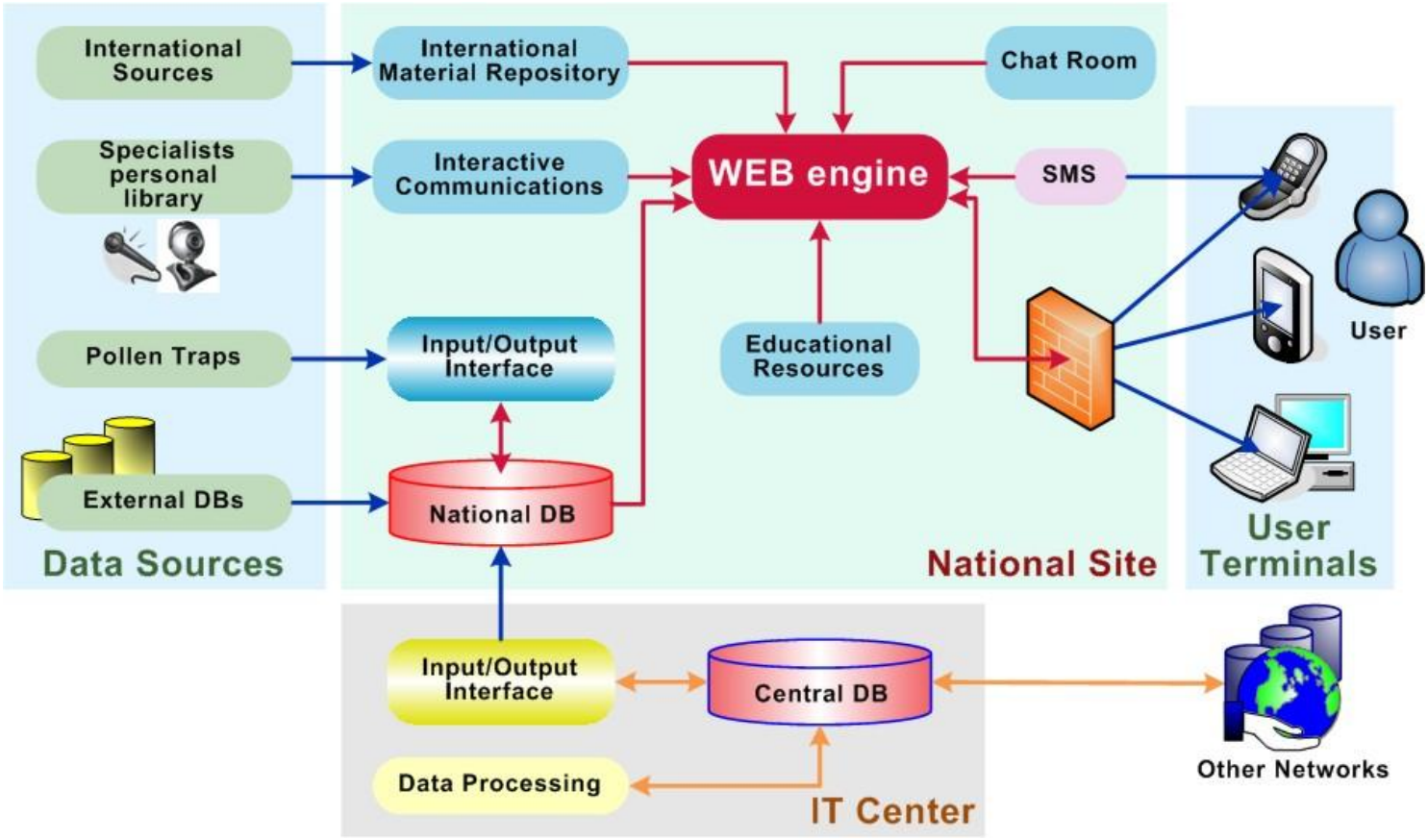

Fig. 2. IREMMA general system architecture.

III. IMPLEMENTATION

A. The General Architecture

The IREMMA system architecture, as depicted in Figure 2, is basically comprised of the IT Centre and a network of National Sites. The structural components and functions of IREMMA system are distributed in these two parts. The National Sites act as interface between the local Data Sources, the IT Centre and the IREMMA users. The communication between the National Sites and the IT Centre are standardised in order to every National Site can be easily connected to IT Centre. The communication between the National Sites and the local Data Sources are specified conditionally, according to the data source, not only technically, but also organisationally.

From the functionality point of view, in each National Site the procedures of data collection and presentation are executed as the service provision and user management are performed too, while information integration and processing are performed in the IT Centre, setting it as the heart of IREMMA information network. This concept of integration of all data from many information sources, internal and external, into a single point, centralising the processing procedures, is the basic advantage of IREMMA architecture.

IREMMA users access the provided services through their terminals, establishing the communication with a special access point of National Site, which they come under, according to their geographical position. The user terminals may be mobile phones, PDAs, personal computers or laptops, in respect with the type of service they use.

B. Implementation Structure of National Sites

The National Sites, while playing multiple roles in IREMMA system, are the most complex part of the general architecture and their development platform is based on a three-level approach. The lower level is the Allergy Warehouse which comprises the infrastructure for information collection and management, user administration, inbound data management and security issues. The second level is the Multi-Service Tool Provider, which acts as the service implementation level. This is an intermediate level which accesses internal procedures of the Allergy Warehouse and provides processed data to support the provision of all specialised services. The third level is the End-User Applications, through of which the IREMMA users are enabled to access the IREMMA services, be choosing the willing profile.

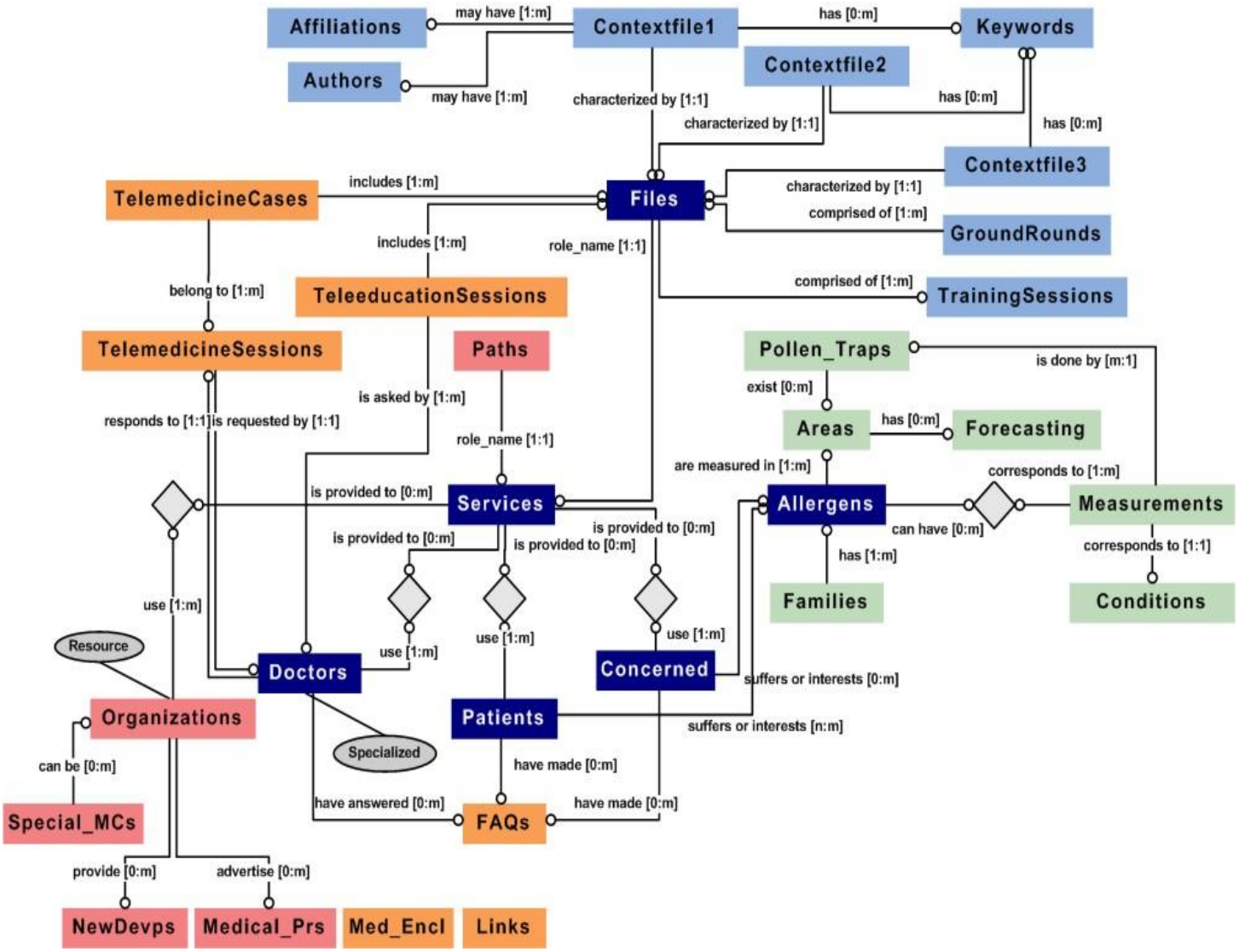

Fig. 3. Entities relationship diagram of Allergy Warehouse.

Allergy Warehouse

Allergy Warehouse is the central internal information source of IREMMA system and its entities relationship diagram is depicted in Figure 3. Its main scope is hosting all the native allergy data, derived from measurements that come from specific pollen networks, and are introduced after special processing in a standard format, for supporting the environmental monitoring services. Furthermore, includes distinct entities for supporting the specialised services that are based on the informational material of IREMMA and real-time services.

The data that are hosted by Allergy Warehouse are of different types. Apart from these of allergy measurements that are native text in a special format, multimedia content is also registered. This special content is basically binary files, including images, videos and document

files of various formats. The management of this content becomes a critical issue, considering the mass of the data they include. Thus, a special protocol has been applied, in order to achieve efficient storage, browsing, indexing and retrieval [1]. This protocol is based on the distinction between the content and the context data of these files. A special indicator object is used as an encrypted alias name of the physical path, where the content is located and it is registered to the corresponding entity in conjunction with the rest features of the specific file, combining the context of it. This information is used for the indexing and retrieval of IREMMA multimedia data. For the retrieval of images an approach of knowledge-based method is implemented. The users who attempt to collect the available files follow an assessed set of steps. The users undergo the constraints of the authentication data; (1) call an already fixed special query for the context and indicator; and (2) the host's operation system restrictions are enforced to them. It is recommended that these steps must be passed successfully as to obtain the target information [2], [3].

Regarding the security issues, a number of special mechanisms have been established. First of all, Allergy Warehouse includes an upper level, above native data, for communicating with the user application programs, as shown in Figure 4. This level is an interface that serves the inbound Data Manipulation Language (DML) calls, after identifying and committing the validation of them. Extra access control is performed by authentication mechanisms. For data protection issues a special management protocol is employed to certify the secure and correct transaction when registering the inbound data. Cases of incorrect registration, unfinished or incompatible records are handled via different control mechanisms in a number of different levels. Therefore, the registered data are accurate, complete and up to date so as to fulfil data integration and compatibility and are used only for the declared purposes. Finally, for tracing of users' actions a real-time tracing model has been applied. This is activated after every successful action that effects a change to the status of data and when a user accesses any kind of the stored information. For each such action the elements that concern the kind of access or modification, the user who caused it, the exact time of the actions performance and the features of the user's domain are transcribed [1]. Special attention is given to facilitate administration (for instance data upload), which is done by the data providers (no system administrator or other technical personnel is involved) and consists of preparing a data file and clicking on a button.

Finally, for the maintenance of the system the Allergy Warehouse includes procedures for backup and restoring of the application data, the application programs and the exact structure of the repository entities in case of a failure. More frequently the backup will be applied for information related with users' attributes and allergy data, imported from the pollen networks. Also automated are system auto-diagnostics and auto-recovery, for instance backup systems automated notification to the relevant personnel in cases of, for instance SMS gateway failure-even though the backup system takes over transparently to the user.

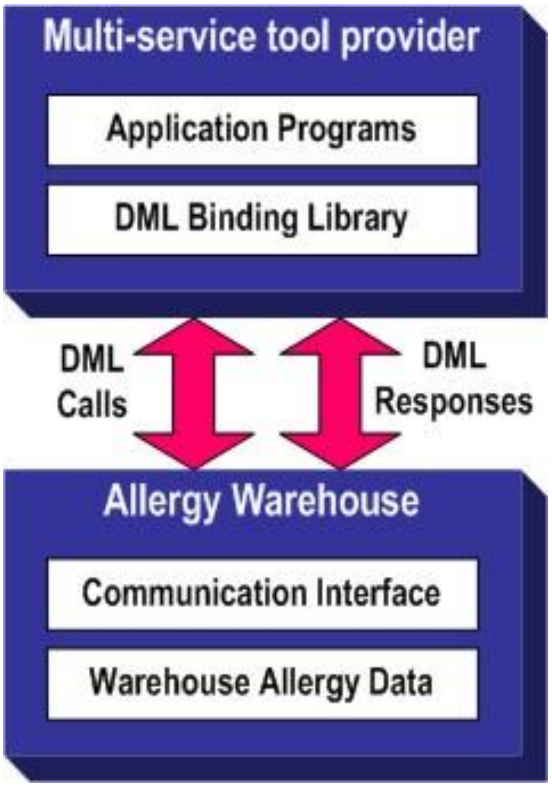

Fig. 4. Multi-service tool provider secure the communication between the users and the Allergy Warehouse.

Middleware multi-Service tool Provider

The Multi-service Tool Provider is the middle level in the proposed development platform of National Sites. It is the core of the Application Layer and implements the functionality and application logic of the supported services. It performs a number of tasks in order to manage the users' data and transactions, routing the application data and translate the users' requests to understandable statements for the

functional interface of the Allergy Warehouse. In Figure 4 the structure of the Multi-service Tool Provider and the communication with the Allergy Warehouse is depicted.

The basic consideration is the users' identification and management of their profiles, ensuring their rights of access and the personalized nature of the provided specialized services. This enables the proper mode of usage, depending on the user identification. End-users are provided with an enriched presentation mode while professional-users may exploit the intranet application benefits (intranet mode). Secondly, it channels the information to and from the users according to their preferences and needs and finally their location and access mode.

For the routing and transfer of application data, apart from the above mechanism, the definition of the participating entities for each communicating session is required. The conversion of information to the appropriate mode according to the participants' access modalities is being performed based on a logic table, which implements the correspondence between the supported transactions and the array of services.

The lower layer of the Multi-service Tool Provider performs the translation of the application user requests to sets of multiple statements, defined using a high level Data Manipulation Language (DML) [4]. This mechanism makes a search for the appropriate already fixed functions and addresses their specified interfaces as calls to the communication interface of Allergy Warehouse.

User Applications

The End -User Application level, including the user interface is web based. The users of the services are mainly using PCs to access the information needed and mobile phones to receive SMS alerts. The use of devices such as PDAs with mobile access is foreseen, which are also web based. The user access for all types of users is through an Internet browser window, which contains all the information, navigation capabilities and functionality. Three different levels of service provision are identified, each one being targeted to a different end user group, namely general information services –for 'Citizens Profile'–, services to patients –for 'Sufferers Profile'– and services to health professionals –for 'Professionals Profile'–. An access control component, gives access to the functionality corresponding to the specific user group. Differences also exist in the informational content, presentation of data and level of information depth. An additional set of applications is offered to experts who maintain the content and to the administrator. These comprise a set of tools for information and user management and they are accessed through a similar web-based interface, which however has slightly different designing than the end-user interface. The screenshots of IREMMA user applications in Figure 5 depict the homepage (a) and the user interface of self-management tool service page (b).

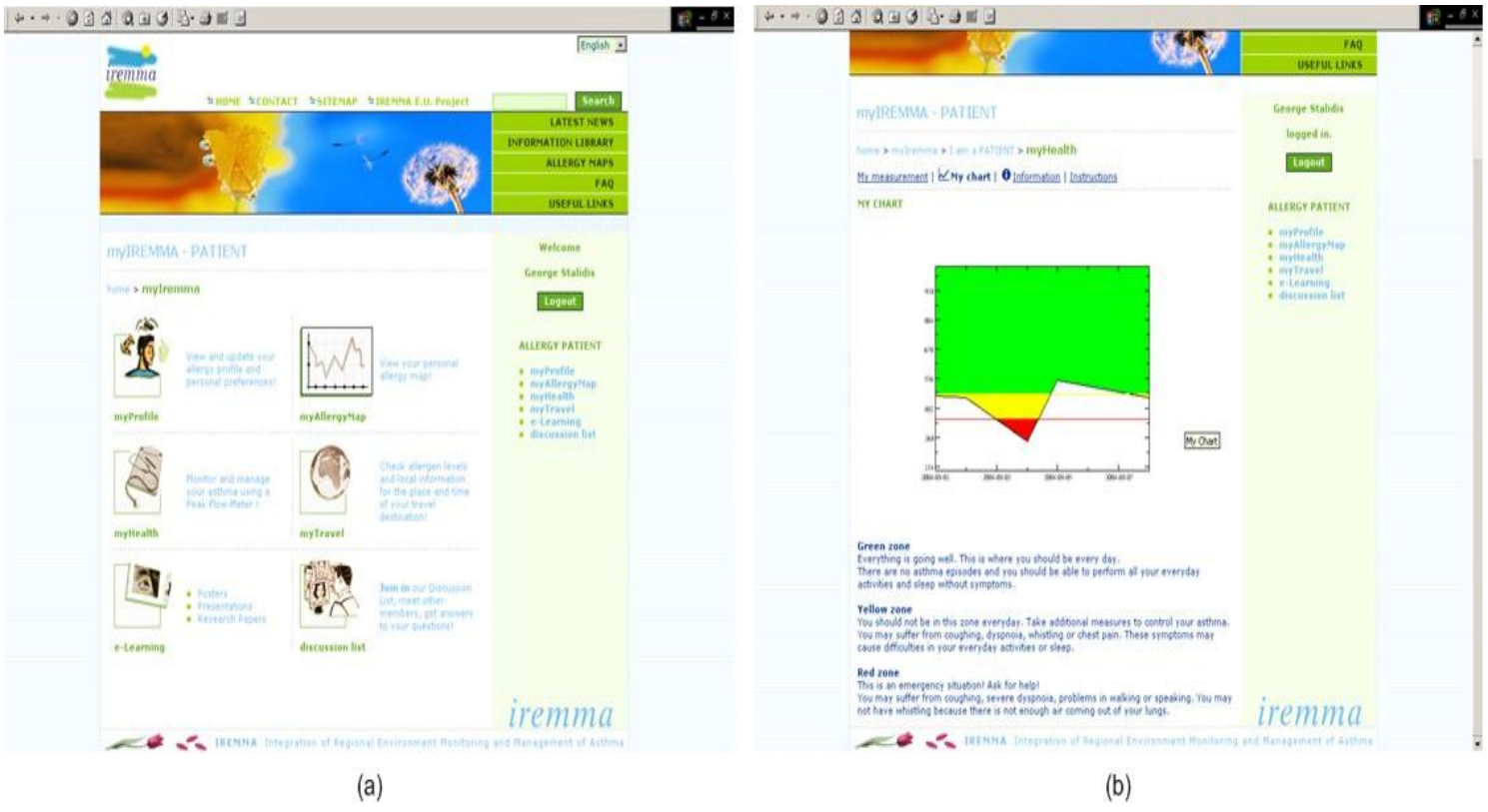

Fig. 5. (a) Homepage for registered sufferers, giving access to personalized services; (b) the progress chart presented by the self-management tool for asthma.

IV. SPECIAL IMPLEMENTATION ISSUES

In this part, a number of special implementation issues are presented, analysing the methods that were followed for the structure of IREMMA data and the integration of the information sources.

A. IREMMA Data Structure

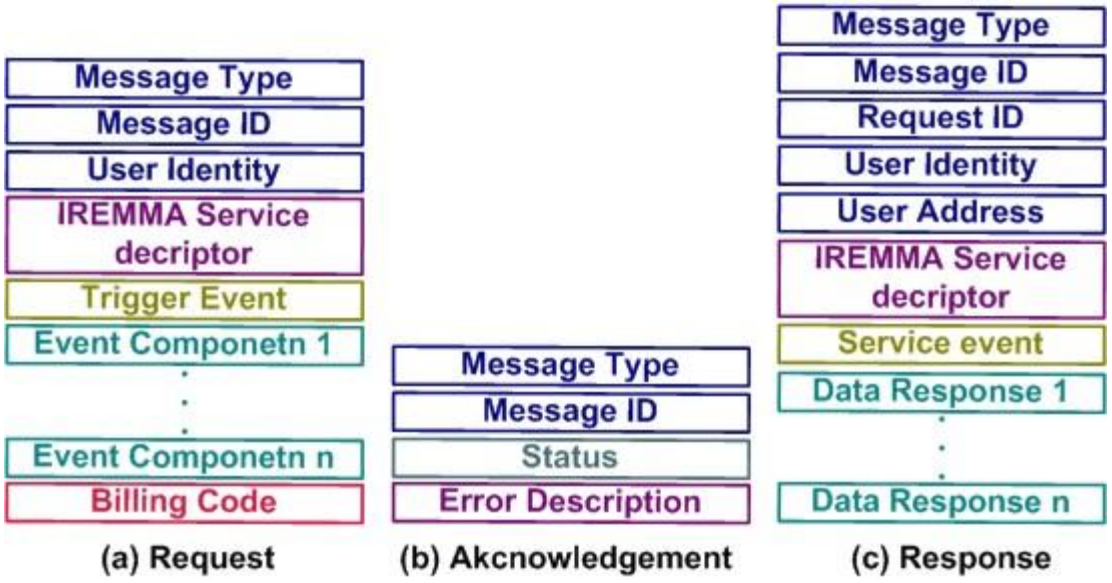

Fig. 6. Structure of IREMMA application data.

Transferred data structure

The structure of data that are transferred between the various components of IREMMA architecture and especially between the users and the National Sites is formed in messages of three different types: the user requests, the acknowledgements and the response (application data). In the following paragraphs these types are described.

User Requests: Each time a user accesses an IREMMA specialised service, a special request is sent through his application interface to the National Site, including specific information in predefined data fields. Such a request structure is pictured in Figure 6.(a). The exact data fields of message are presented in Table 1.

Table 1. 'Request' message's data fields

Message Type	This field defines the type of the transferred message. For the described case its value is always 'Request'.
Message ID	It contains the identification number of the exact message.
User Identity	The value of this field is the identification parameter of the user if registered, or the user domain access features if not registered.
IREMMA service descriptor	It contains the descriptor parameter of the service for which the user makes the request. Its value can correspond to these services that the exact user can have access. This and the previous fields are the two criterions according to which the provider will decide if the requested service can be served for the user or not.
Trigger Event	For each IREMMA service a number of actions can be done. In this field the exact requested action is defined.
Event Components	To serve the requested action the provider needs a number of parameters that are specified in these fields.
Billing Code	For services that is charged the Billing Code of the user is required in order to administer the related procedures.

Acknowledgments: These are ancillary messages that are addressed from National Site to IREMMA users with an unsolicited way, as confirmations or error messages in response of the requests. The data fields of these messages are presented in Table 2 and graphically depicted in Figure 6.(b).

Table 2. 'Acknowledgement' data fields.

Message Type	This field defines the type of the transferred message. For the described case its value is always 'Acknowledgement'.
Message ID	It contains the identification number of the message whose confirmation receipt is performed.
Status	This field can have the value 'Confirmation' or 'Error'. In the first case no errors have been arisen. In the second case a reason produces an error and the response of user request has not been arrived to the user-domain.
Error description	In the case of error this field specifies exact the error that took place.

Application Data: The messages that are addresses form the National Site to the users and include the data that correspond to a specialised service, as responses to a user request are of different structure. Their data fields are shown in Figure 6.(c) and presented in Table 3.

Table 3. 'Application data' data fields.

Message Type	This field defines the type of the transferred message. For the described case its value is always 'Response' .
Message ID	It contains the identification number of the message.
Request ID	Its value is the identification number of the message request whose response is.
User identity	The value of this field is the identification parameter of the user to who the message is sent.
User address	The user-domain features to who the response is addressed comprise the value of this field.
IREMMA service descriptor	It contains the descriptor parameter of the service that is provided.
Service event	Each service includes a number of actions that can provide to the users. This field define exactly the event that the user has been requested for.
Response data	In each such message these fields include the appropriate data elements, which are the real response to the user request. These data has been arisen as a result, after processing the message request internally to the provider's domain a. These, according to the service and the 'Trigger Event' of the message request, can be: Informational data Maps Statistics E-learning data

Regarding the conferencing data for Telemedicine and Tele-Education services, these include the audiovisual conversational data, which are transferred during the online sessions and are in accordance with the ITU H320 video-conferencing standards.

Pollen data structure

A special class of information of IREMMA internal data source is the pollen data, which are gathered from specific pollen traps. The transfer of these data follows the previous structure; independently of the final presentation format from the user application programs (maps, statistics, simple text, etc). It is important to notice the structure of organization of this information.

For each group of measurements the following attributes are defined and recorded:

- percentage of grains in the atmosphere,
- frequency of data acquisition,
- dates of acquisition,
- frequency of database update,
- dates of database update,

- pollen trap,
- country,
- covered area,
- statistics.

B. Integration with data sources

During pilot trial of IREMMA, all dat aand informational material were collected by a number of providers and made available to the users. During real operation of IREMMA, a number of independent national sites collect the all the data (pollen and informational) and send them to the IT Centre, which act as a controller of data flows. The transfer of information between the different components of IREMMA architecture and the special nature of aeroallergen data that are exchanged pose a critical number of issues, regarding the integration of these data among the different components. These issues focus on the following communications:

- Pollen data collected and owned by national site are sent to the IT Centre.
- Pollen data collected by IT Centre form each European national site are provided to all national sites.
- Informational material collected and owned by national sites are sent to IT Centre.
- Informational material collected by IT Centre is provide to national sites on demand.

In order to manage these issues, a number of special mechanisms have been applied and are described in a following way.

A standardized codification of aeroallergens has been defined, which includes all the types of aeroallergens that may appear throughout Europe. The produced codification is usable and possible causes of confusion regarding the naming or categorization of individual species have been clarified. Using this codification, it is possible to exchange and integrate data on aero-allergen levels at pan-European level.

A template file in Ms-Excel and a definition of XML message have been produced allowing the easy transfer of measurement data through Internet-based communication.

It has been decided that aeroallergen levels are recorded and communicated as actual levels measured as spores/m3 and not as danger levels. Because of the danger levels involve a degree of subjectivity according to other environmental conditions, each national site estimates them individually. Additionally, recorded measurements are stamped with the time period and the location to which they correspond. More specifically, the location of each pollen trap is numbered and named uniquely so that there is no overlap of measurements coming from different sources. Measurements can also be daily or weekly.

The collection of pollen data is performed by TCP/IP based communication between pollen networks, pollen traps and national sites. Aeroallergen data is received either by pollen traps through the hospital or institute which operates them or by existing networks which act as providers. A survey was performed in pollen trap technology and it was found that in most of them the measurement is acquired after manual processing and cannot be automatically transmitted (usually sent by fax or e-mail). The result is expressed in standard units (spores/m3) and the only subjectivity lies in the categorization and naming of the aeroallergens. There are also different types of pollen traps, according to the measurement period (e.g. one day, one week, etc.). Pollen networks collect data from many pollen traps and keep them in their own format.

The solution given in order to integrate existing and new pollen data sources into a unique allergy data repository as:

- to standardize the coding of aero-allergens,
- to develop a web interface for manual insertion of the measurement by the pollen trap operator directly in IREMMA database,
- to propose a file template which can be used by the data provider in order to insert the data and upload it to IREMMA, where it is automatically imported in the database,
- to propose an XML schema to allow pollen data exchange through http connection,
- to develop filters that import data provided by pollen networks, according to the format used by the providers.

The scientific partners within the IREMMA project consortium concluded to a specific codification of allergens and technical partners have implemented a message format for data transmission. The operators of pollen traps (hospital clinic or allergiological institute) send the live pollen measurements and forecasting to the National Sites, wgich are in agreement for data provision. This can be done either by sending a message in an agreed format (defined in XML and alternatively in EXCEL file) or by using the provided web interface, which allows the manual insertion of the pollen data directly by the experts to the database. In addition to live measurements and forecasts sent on a regular basis, there is provision for the exchange of statistical data covering the pollen levels at specific locations during past years. Such data has been successfully exchanged within the pilot phase by developing a configurable importing component which has been adjusted to the format of origin. Since the format of pre-existing data can not be controlled, such interfacing components are necessary in order to import external data. A standard coding of aeroallergen types is also used, such as the one proposed within this project.

Informational material can be inserted, edited and revised directly on the National Sites by authorized experts through a web interface dedicated to information management. The “Administration” tool of IREMMA, which is addressed to information providers, experts and the IREMMA administrator, offers the corresponding functionality. The implemented tool offers the required functionality to experts in order to insert and manage News articles, Frequently Asked Questions, eLearning items, Useful Links, descripiton and schedule of Medical Education sessions. It also allows them to edit or upload content for the Information Library. The tool offers the ability to the administrator to define new languages, areas and locations of pollen traps, providers of Medical Education sessions and a user management window for viewing and managing user accounts. Finally, a usable web interface is offered to experts acting as providers of pollen data to insert manually live measurements and forecasts and to upload already prepared files with measurements.

C. Development tools

The IREMMA services are offered through a telematic platform that is designed, implemented using mature technologies and operated in pilot form within this project. This platform is the basis for future expansion to fully blown commercial services. Information delivery and supporting transactions are offered over both wire line and wireless links to a set of end devices, such as desktop PC, laptop PC, mobile phone and PDA. Modular design allows future expansion to additional user devices, such as Digital TV, MMS and others. The telecommunication infrastructure is based on public switched digital networks and data networks. Internet-based communications ensure universal user access and high expandability of the services.

The databases of IREMMA were developed using the Oracle8i Database Management System. The web user interfaces were built with HTML and the access to databases was based on ADO technology and SQL data manipulation language.

The hardware and communications infrastructure of OTE were used in order to run the services for pilot trials. The platform used is UNIX-based which was considered as the most appropriate for future expansion to wide scale service provision. The database has been implemented in Oracle 9i and the implementation language of the web application is php. An Apache webserver was used [6].

V. RESULTS

The proposed system was implemented by OTE - the national Greek PPT, Pouliadis Associates Corp. and the University of Patras within the activities of IREMMA project. The platform is currently operational in pilot form and services are offered to groups of trial users in Greece and Spain. Data is collected by aeroallergen networks with the participation of Corporacio Sanitaria Clinic – Spain, Royal Brompton Hospital – UK, Venizeleio hospital – GR, Sotiria hospital – GR, Laiko hospital – GR, Municipal Institute of Medical Research – Spain and the Italian National Research Council, who also provide the medical expertise and informational content.

The system has been evaluated by expert users regarding usability and functionality and by developers regarding technical issues (correctness, efficiency, reliability). The focus of the work presented in this paper was to establish the technical feasibility of collecting, processing and redistributing information within a highly diverse set of providers and recipients. The exchanged information is health related and intended to support the management of aeroallergen-initiated diseases. In this respect, the obtained results were encouraging regarding the successful addressing of a number of challenges.

Aeroallergen information is successfully collected and integrated by a non-uniform and expandable set of pollen trap networks. The defined standard for information exchange, expressed as an XML schema, was based on international allergen coding. Issues, such as spatial overlap and sampling, were compatibility managed with by coding locations and stamping samples with time period and method.

A Distributed Allergy Data warehouse was developed, in order to allow the exchange of information at a professional level, including measurement data and scientific informational/educational content. These services enabled health professionals, health administrations and the scientific community to handle medical issues regarding allergens, asthma and rhinitis, in a more effective way.

Information is delivered to patients and health professional users in a highly usable, personalised and multi-modal fashion. Designing was performed in close collaboration with users and preliminary feedback indicated the effectiveness of the approach.

Finally, the adopted architecture and technologies allow for future expansion to large geographic coverage, large scale of users and additional services, which set the ground for commercial exploitation.

VI. CONCLUSIONS

IREMMA has set the ground for establishing a pan-European network to support groups concerned with common environment-related allergic diseases. Based on this network, it supplies health, environmental and informational data to citizens, sufferers and professionals, through a number of basic services, while managing distributed internal and external data sources. During IREMMA implementation and pilot operation the standards and European legislation issues were covered by written contracts and license agreements between the

IREMMA consortium and the data providers. The efficiency and functionality of the whole solution were confirmed through the evaluation of the system, in pilot and real conditions operation. The implemented IREMMA services were proved useful and efficient for the users and set the proposed IREMMA architecture a promising solution for creating sustainable integrated network of data sources throughout Europe. The future work on IREMMA is focused on expanding its network of data sources throughout Europe and to collect credible informational content. In this way, it can be transformed realistically into a fully blown high-quality service of considerable value to an extremely high number of users.

VII. ACKNOWLEDGEMENTS

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A Distributed Database System for Glaucoma Monitoring

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Summary: This paper describes, from a practitioner's point of view, the concepts, methods and tools involved in the design of a practical and potentially low cost distributed information system, with web-based capabilities, for monitoring glaucoma.

Our experience with existing Hospital Information Systems (HISs) found them unsuitable in the very important monitoring process of patients with glaucoma. Actual Electronic Patient Record (EPR) schemes are more to do with management and appointment simple aspects than with clinical and decision-making processes. In a closer relationship to the specific of the affection, we found that demographic patient databases, usually known as Patient Administration Systems (PASs), have not been designed for being shared or concurrently exploited by different programs or even several replicas of the same program.

Many of the early deficiencies in the process of following-up glaucoma patients by dozens of different ophthalmologists in many independent offices from different clinics (with heterogeneous information recording, not very well managed by the existing office capabilities) could only be solved by specifying, designing and implementing a new EPR scheme in a mixed distributed environment, based on a distributed database as a demographic core (or PAS) of patients with glaucoma. A specialized health record management system, with core functionality in monitoring glaucoma, and core data organized as a distributed database system, has been designed in a bottom-up manner to meet the immediate needs. Its pilot implementation was intentionally kept flexible, taking in account developing standards, to accommodate any anticipated future requirements. Among many other benefits, the new EPR allowed medical doctors (ophthalmologists) to view and modify patient information and records in a safe, flexible and efficient manner. Improvements in all the managerial and decisional aspects (regarding costs and time delays) could also be remarked rapidly.

Keywords: medical databases, Electronic Patient Record (EPR), glaucoma management

1. Introduction

Today, computers are a key factor in bringing technology to the clinical practice. Since the first attempts to introduce computers during the late 80s, Electronic Patient Record (EPR) schemes and Medical Database Management Systems (MDBMS) have evolved. This means that today, in most European countries, the National Health Services are investing large amounts in Information Technology (IT). This brings a unique opportunity for medical doctors (MDs) to use IT more in their clinical practices.

All over the world, Patient Classification Systems (PCSs) are now used for financing, clinical management, planning, budgeting, evaluation and control purposes in hospitals and in other health care services. Back in the 80s, uncontrolled increases in the U.S. Medicare expenses have determined the adoption of a case-based financing system. Diagnostic Related Groups (DRGs) had been developed by a group of researchers at Yale University in the late 60s as a tool to help clinicians and hospitals monitor quality of care and utilization of services. They proved to be so useful that in 1983 they became the only system used by Medicare in the United States to pay hospitals.

Thus, DRG is used now not only to classify different types of patients, but also to ease the implementation of IT management support systems, to create economical stimuli and to address hospital efficiency. DRGs permit to classify the patients based on the diagnosis, the procedures and other information (the complexity of each case) and to link this type of patients that each hospital treats to the expenses needed [1]. Among the necessary data for the patient classification on the basis of the diagnosis and the procedures in DRG categories are: age, sex, hospitalization period, principal diagnosis, secondary diagnosis, procedures, and health condition when leaving hospital. These data define the DRG classification system.

In a growing number of countries a similar system has been implemented. The Romanian Government has been implementing since 2002 the DRG-based classification system in support to the management of an increasing number of hospitals (276 hospitals, since April 15th, 2005), and it plans to extend this number in the following years.

The Clinical Districtual Hospital in Craiova was among the main units where a successful pilot implementation of this System has been fulfilled. Patient information is gathered using the DRGNational v4.0 specialized software program that is delivered through the district agencies. The electronically registration for a patient, one for the whole period the patient stays in hospital, is in concordance with the

new clinical observation form introduced by the Romanian Health and Family Ministry. Once collected, the data are added to a database that has to be sent monthly to the DRG department from the National Health Institute for Research and Development, Bucharest.

With such complete instruments available for the hospital financial management, an increased general tendency was to address only diseases and patients with increased severity inside hospitals, while simpler procedures are performed outside the hospital. Patients and families may thus have more responsibilities during the treatment, but following up patients may become a difficult and more challenging task for MDs.

In this case, a simple expansion or a mapping of an EPR scheme inside a Hospital Information System (HIS) was not possible. Actually, our experience with HISs showed that EPR schemes are now more about managing simple aspects like appointments than clinical and decision-making processes. The demographic databases for patients, usually known as Patient Administration Systems (PASs), do not have the capability to be shared or concurrently exploited by different programs or several replicas of the same program – a critical feature for the case of an inherently distributed system as the ambulatory setup we are talking about.

Regarding the concrete aspects of the glaucoma disease, this limitation of PASs may explain many of the shortcomings in following-up with glaucoma patients in the area covered by the University Clinic of Ophthalmology in Craiova. This area has five districts and about 2000 monitored glaucoma patients. With dozens of independent ophthalmologic offices in different clinics, tens of different ophthalmologists and heterogeneous information records – this area is a mixed distributed environment where existing office capabilities do not manage very well the flow of patient information.

As shown in the following table and graph, the number of new glaucoma cases grew slowly every year. In our opinion this increase was the result of more careful examinations that resulted in accurately diagnosing more of the existent glaucoma affections and *not because the number of actual affections significantly increased.*

Table 1. Primary Open–Angle Glaucoma (POAG) Cases by Year.

Year	#Hosp	#POAG	#New	% of POAG
1989	2854	393	218	55%
1990	2792	422	225	53%
1991	2250	385	213	55%
1992	2573	413	226	55%
1993	2610	408	229	56%
1994	2553	461	258	56%
1995	2417	432	251	58%
1996	2513	425	261	61%
1997	2479	406	257	63%
1998	1932	367	221	60%
1999	1831	398	236	59%
2000	2379	341	202	59%
2001	2035	317	194	61%
2002	2169	367	228	62%
2003	2128	309	193	62%
TOTAL	35515	**5844**	**3412**	**58%**

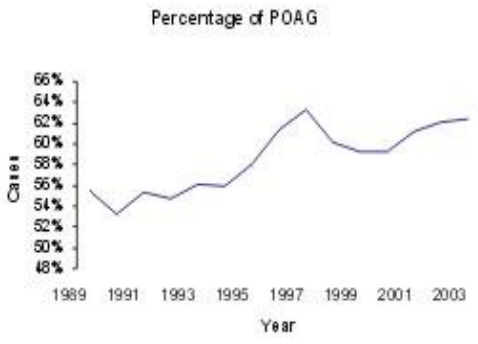

Fig. 1. Percentage of new POAG cases, by year.

The great number of glaucoma cases and complex treatment also called for a system to assist the physicians in the new setup depicted by patient distribution outside hospitals. Our primary goal was to design and rapidly implement such a system, with limited on-site assistance from medical doctors (MDs). For that reason, agile methodologies and extreme programming (XP) were employed, to do the job.

Material and Method

The term *"glaucoma"* in our system specifications refers to a group of diseases that have certain common features, such as increased intraocular pressure leading to the atrophy of the optic nerve head and visual field loss, insidious and slow progress, and absence of pain [2], [3]. Higher intraocular pressure (IOP) compared to the individual tolerance (normal limits), leading to the atrophy of the optic nerve head and visual field loss. Primary open-angle glaucoma (POAG) is insidious in onset, slowly progressive, and painless. Because the visual acuity generally is spared until late in the disease, the visual loss progresses without symptoms [2]. It is estimated that 1-2% of our district population above 40 years has POAG, this representing 12-15% of causes of blindness. This emphasizes the importance of correct monitoring of the disease.

Moreover, a particular form of POAG, the *normal tension glaucoma* - NTG (also called low tension glaucoma), does not show elevated intraocular pressure, although it resembles the primary glaucoma in all other respects. In the absence of any deterioration of visual acuity and of increasing of ocular pressure in NTG, one of the most important investigations for the diagnostic and stadialization of this disease is represented by visual field examination and recording, which has the same importance in supervising medical and surgical treatment [3]. This also calls for cross-examining, sharing and periodical reviewing of information.

Glaucoma is thus a major ocular affection, with maximal incidence in people over 60 years of age. Medical treatment, if correct, may slow down or stop the evolution of the disease. Surgery (classical, laser, or ultrasound) as the ultimate solution must be done within weeks. Statistics show this is performed more and more rarely; this is largely due to correct monitoring and new medication.

As for the other aspects of our *system specification*, the general picture may be put simply like this:

- Ophthalmologic cabinets are provided with at least one computer per office, powerful enough to run database management systems or servers. Terminals are mostly used to display simple screens (for data entries and record examination), with low variability in terms of customization for specialty or particular affection (disease).
- Patients are examined and receive a free prescription, usually once a month from the same medical doctor. Patients may change doctor sometimes – this simple fact leads to a series of complications, which may become critical for an invalidating affection like glaucoma.
- Although previous investigations for a patient may be available locally, there is little room now to make them easily and immediately available for every office. Thus, further correct treatment is heavily dependent on previously issued records carried by patients themselves (and sometimes lost).

All these problems lead us to conclude that designing and implementing a new EPR scheme, based on a distributed database as a demographic core or PAS, is necessary for monitoring glaucoma. This will allow medical doctors (ophthalmologists) to view and modify patient information and records in a safer, more flexible and efficient manner. The very compact and efficient design should allow our system, in a longer-term perspective, to incorporate efficient methods for storing medical images and facilities like content-based medical image retrieval – necessary in the monitoring and comparing visual fields in POAG and NTG, or physician assisting capabilities for which there is an ongoing research [4].

The *structural specifications* derived from the goals of the system were:

- To create a low cost back-office distributed information system.
- To provide web-based capabilities.
- To provide a flexible and efficient manner to manage patients data.
- To allow all registered medical doctors (ophthalmologists) to view and securely modify patient information and records.
- To facilitate future extensions and additions as well as scale-up of the system, without a drastically reduced performance in operation, and exponentially increasing cost.

As foreseen, the correct implementation of an HIS/ EPR scheme in our system was meant to support:

- Availability to more MDs at a time.
- Off-site availability.
- Data backup.
- Audit.

- Decisions.
- Reports on activity, patients etc. (that can be created automatically).

Since the existent information was spread in many different existing databases, managed by different database management systems (DBMS) under the control of several types of operating systems (OS) running on different computers, the envisaged solution was to design the software system (package or application) in a client-server or distributed manner. This also had to account for the possible diversity in inter-networking, and to provide transparency.

The *logical structure* of the system has to retain much of the key characteristics of the initial process, as showed in Figure 2.

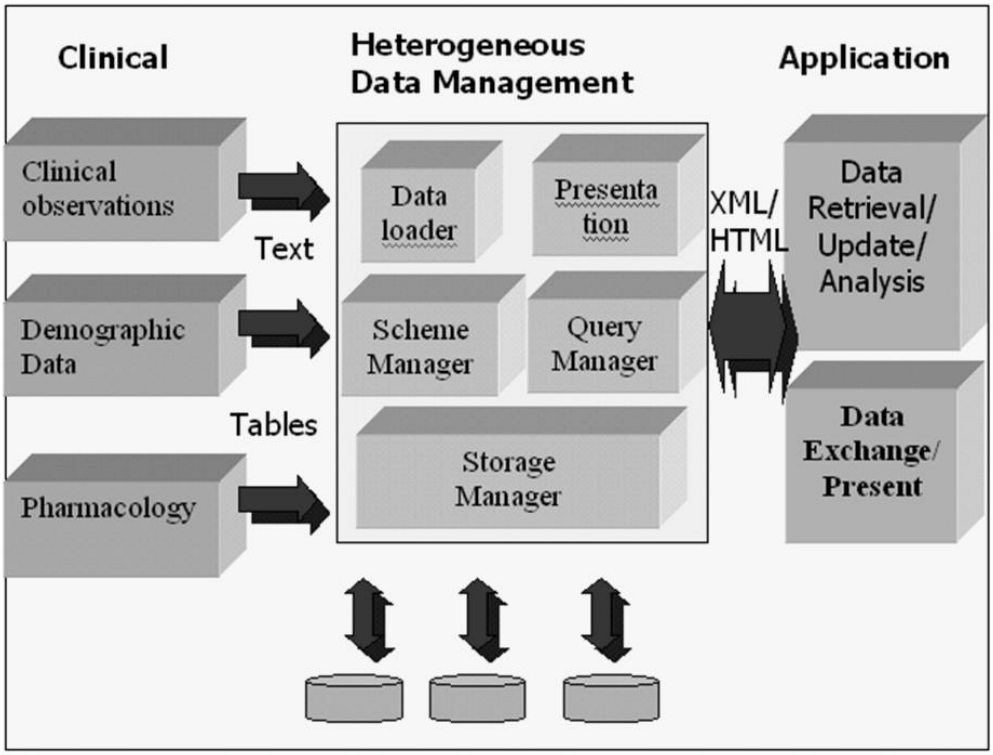

Fig. 2 . Software system architecture.

The core of the system can be seen as a distributed database system, primarily handled by a server program linked seamlessly to several types of clients. This software, making use of the Internet infrastructure and adopting up-to-date technologies, addresses the urgent need to handle medical information flow and management.

As we followed up the above ideas in the implementation, in order to reach all the goals and benefits of the project, we found important to provide firstly a simple and correct network design. The number of levels was kept to a minimum – a central powerful server in the Clinic of Ophthalmology and the existing client computers in the physician offices form two levels. A third level, consisting of dispersed computers accessing data using Internet browsers has been considered but not (yet) implemented.

As for the application, the main functions foreseen were also two:

1. *Simple Network Management* (or *Back-office*) with respect to the physicians and patients assigned to a node, providing:

- Local management of information in the node, regarding patient and physician identification, patient disease and therapy history, current therapeutical decisions for a patient.
- Cumulative statistics, regarding all patients of a given physician, or other activity aspects such as: number of patients, medication costs.

2. *Data-distribution* (obviously this function refers to the data collected from nodes).

- Data collected for a patient in a local node is uploaded, at least once a day, on the server, thus being available for other nodes as well.

To achieve this functionality, the local database in a node must implement some minimal relationships, i.e. for patients, physicians, current therapy, disease history, investigations. The central database must implement additionally some other relationships, such as the one for medical offices (locations), for events during therapy, a.o.

To implement the functionality of the databases, the DBMS must provide the operations as transactions; a large amount of data and network traffic must be natively supported, especially if we consider keeping the consistency of data for a large number of nodes. A simple method can be similar to the following: if one link (field of a record) in a table points to another table with a missing corresponding record, an update field in the original record must be properly positioned. The management of a large number of concurrent requests and collision avoidance can also be provided by software design, using generalized semaphores specially conceived.

As for the usual communication manager present in such a system, we have considered a dispersed design, i.e. its functions are distributed among several modules (scheme manager, storage manager, query manager). For instance:

- *A server* part can log all the chat data (as a Java Application).
- *A client* side can be composed by applets and designed to be platform independent.

The design for data retrieval/ update/ analysis considered only a few main components, of paramount importance being:

- The *back-office management* module: any physician may access personal data about any patient from any host computer where the software is available.
- The *Internet* module: this allows other ophthalmologists on one hand, patients on the other hand, to consult most relevant data managed by back-office management module, like latest prescriptions.

The implementation used a standard 3-tier **MVC** (model-view-controller) architecture. This MVC outline is standard in implementing a formal separation of the tree layers: **view** (manages graphical output), **controller** (business logic) and **model** (data and its behavior). We employed this strategy in previous projects [5]. As a remark to facilitate the understanding in our approach: MVC was originally developed to map the traditional input, processing, output roles into the GUI design field, i.e. “Input --> Processing --> Output” is roughly the equivalent of “Controller --> Model --> View”.

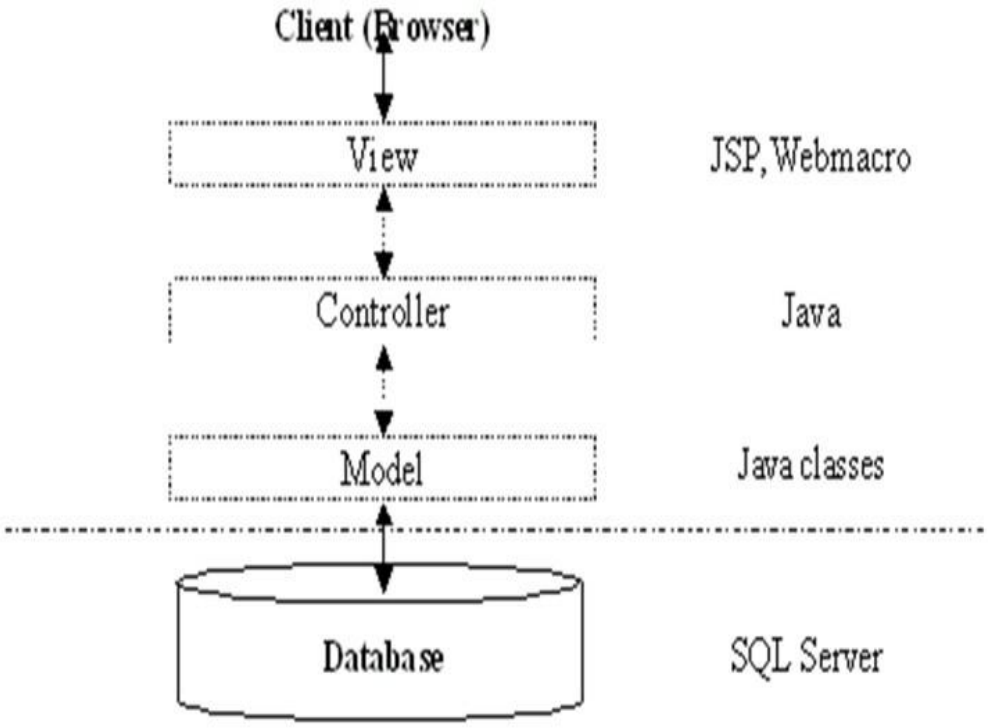

Fig. 3. The standard MVC architecture.

Because one of our implementation goals was to develop a uniform system that can be easily modified, extended and updated in the future we also chose Java technologies (Java Server Pages and Servlets) for the Web part implementation. For Web presentation of information, main features considered were the following:

- Data should be available from any computer connected to the Internet through a secure protocol (HTTP over SSL).
- The only purpose of the Internet module is to present data.

One of our objectives is to smoothly cross over our actual pilot implementation to a fully HL7 – based system (Health Level 7). HL7 is widely used in healthcare systems and our previous working experience recommends it as the best healthcare information standard that we can adopt [6]. Because the existing applications and their back-end databases that have been used in the private cabinets were not using any standard, we tried to make a compromise between using medical information systems standards and our primary goal. The communication in our implementation is done using Extensible Markup Language (XML), which is also used by HL7 v3 messages. The usage of Java for implementation will help us to easily integrate the HL7 standard in our system using HL7 SDK, which is a set of libraries that are adding support for HL7 to Java applications [7].

The back-office software architecture is composed of two modules, as showed in Figure 4:

- Server back-office software.
- Client back-office software.

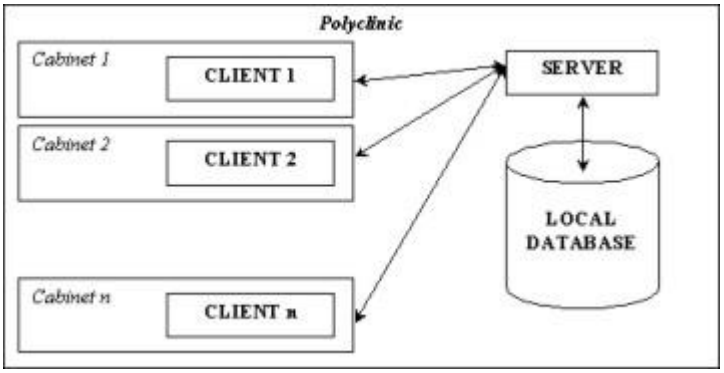

Fig. 4. Back-office system architecture.

Asynchronous communication among physicians and patients, and entity aggregation must be provided: information may reach one patient, a target group of patients or all patients. This includes not only medical information – the patients may be easily informed about community events.

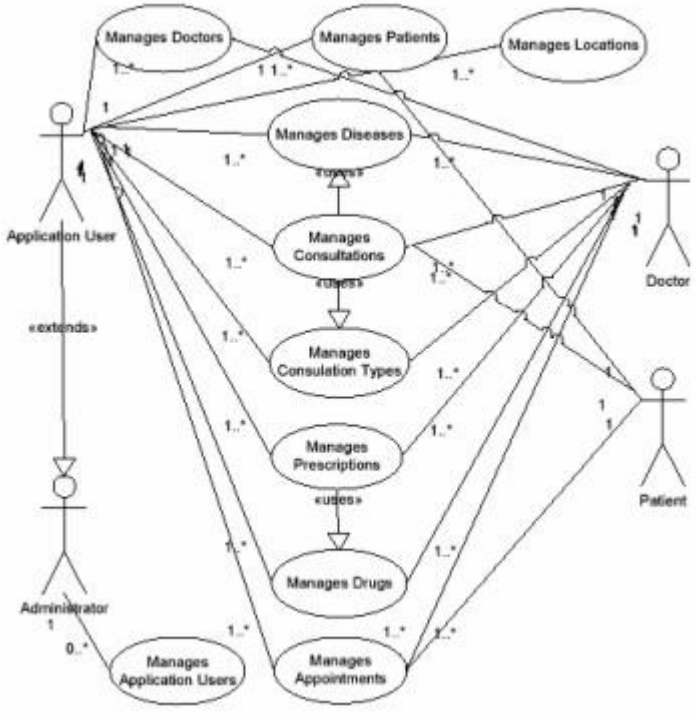

Fig. 5. UML diagram showing how requirements are collected.

Use case diagrams (UML), like the one in Figure 5, have been used to describe this functionality during requirements gathering, across members of the design team and MDs as consultants.

Final aspects considered during design were those regarding possible optimizations, such as: information archiving, garbage collection, and ordering of information using multiple indexing to provide faster response time. Although reviewed in the system documentation, they were not considered in the current implementation.

Results

The technology chosen for the implementation was standard. We considered Microsoft SQL Server 2000 the most suited DBMS and Java capabilities proved sufficient for interfaces and distributed communication among small client programs running locally.

As for the database structure, the back-office management module is also based on a RDBMS (Relational Database Management System). As it can be seen in Figure 4, two different architectures for the databases needed may be used:

- The local database at the server (denoted from now as *central* DB), that is used to gather information from all polyclinics or cabinets enrolled into the system, and maintained for consistency.
- The local databases at clients – installed and maintained for each polyclinic or cabinet.

The main relationships found in local databases are:

- For patients (Patients).
- For physicians (Doctors).
- For current therapy (Prescriptions).
- For disease history (FoundDiseases).
- For investigations (Consultations).
- For doctor's appointments (Appointments).
- For location of:
  - Ophthalmologic cabinet (Location)
  - Patients/doctors (Towns & Counties)

They can be depicted as follows:

- **USER** (id, Firstname, Lastname, sex, Birth date, address, phone1, phone2, email, status)
- **Role** (id, name)
- **USERROLE** (Userid, Roleid)
- **INVESTIGATION** (id, Phisicianid, Patientid, date, Prescriptionid, Diagnisisid, observations, status)
- **PRESCRIPTION** (Id, Startdate, Enddate, Medicineids, Observations)
- **DIAGNOSIS** (Id,Name,Observations)

Or, in a pictural view, like in Figure 6:

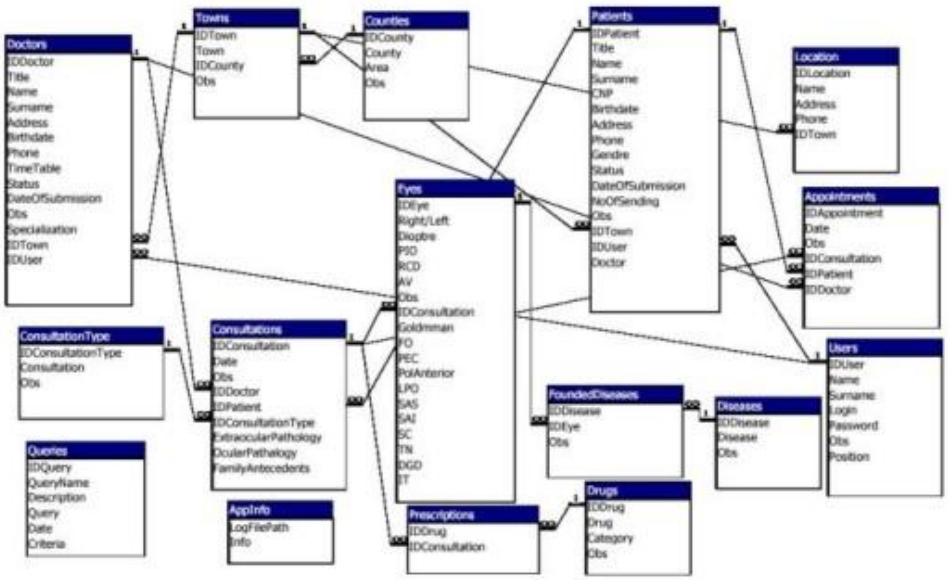

Fig. 6. Database relationships.

The overall system architecture - projected on the distributed database functionality needed – is shown in the next diagram.

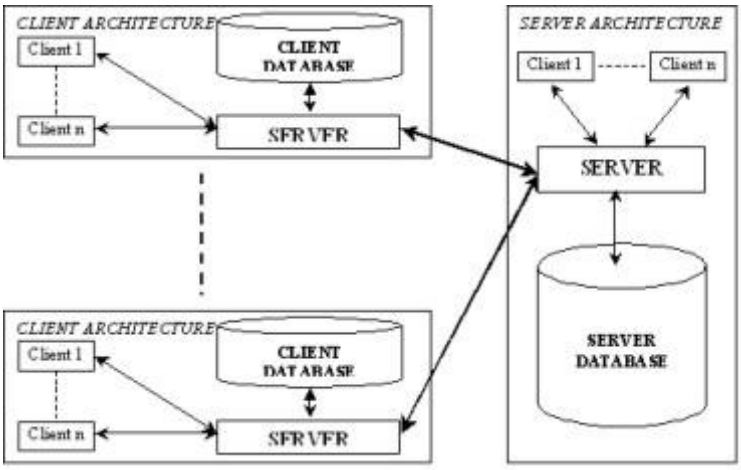

Fig. 7. Distributed database system architecture.

Grouping relationships can be done with a view to obtain:

- Demographic information and statistics (*Demographic Data Block*).
- Clinical information and statistics – number of investigations, treated diseases, evolution of diseases through time (*Clinical Observations Block*).
- Pharmacology information and statistics – drugs prescribed (*Pharmacology Block*).
- a.s.o.

Because a distributed DBMS represents a unitary logical system physically distributed in nodes, compatibility was required between the server and local DB implementations (i.e. the table structure of the local DB is similar to the server database structure). Microsoft SQL Server has been chosen because it is good for large databases with many concurrent accesses, offering support for all databases operations. Local databases may use Microsoft Access, MySQL or Microsoft SQL Server as DBMS, according to the platform, number of patients and the power of target computer machine.

The approach in the implementation can be broadly described as bottom-up, that is, the system grew from small applications to a complex functionality. The requirements and basic features provided by design for the initial local applications implemented were:

- Capability to run as an independent application – i.e. to run with or without a server.
- Local management of information in the node (regarding patients and physicians identification, patients disease and therapy history, current therapeutical decisions for a patient).
- Cumulative statistics (regarding all patients for a given physician, or other activity aspects such as: number of patients, number of investigations, evolution of diseases etc.).
- Possibility of searching patient's data through distributed medium (formed by all computers where the software is available), a.o.

In the local implementations, rapid application development was applied on the basis of user scenarios (UML), and then Java was used, because of:

- Platform independence (use on different platform without changes)
- Its unequaled distributed facilities offered for:
  - o Network applications
  - o Secure communication
  - o Databases support
  - o Graphical statistics
- A lot of classes already implemented providing an attractive Graphical User Interface (GUI)
- Possibilities of extension (Java is a pure Object Oriented Language)

Use case diagrams (UML), similar to the one depicted in Figure 5, have been used to describe the functionality of the local system at level II.

In terms of local application presentation, some of the main features foreseen were:

- Friendly User Interface.
- Good security.
- Options for novice/advanced computer users.
- Statistics at different levels:
  o Local (cabinet level),
  o Global (town/zone level).
- Backup solutions for local database.
- Query facilities for both local/distributed databases.

For instance, the local application record management refers to doctors (physicians), patients, timetables, and administration data - the usual access being provided only to the physician public information (retained by Doctors table in local DB).

Physician public data can be viewed with few restrictions, but private data can be viewed only under administrator password. A supplemental level of security is required if data has to be erased, added, or modified in the DB.

Patient searches can be performed easily both in the local database, and in the entire system, when a proper tag is checked. The explicit local and global searches were preserved for both historical reasons and to speed-up the process in certain situations.

Information can be added to the database only by using the local application, as shown in Figure 8. This is a restriction due to the existing systems and has an important consequence: a local DB is needed even at the location of the server DB. For maintaining consistency, reasonable assumptions have been made (i.e. a patient may be consulted several times a day in the same cabinet or polyclinic and local updates are done each time; he can go to another office that will be happen the sooner after one day, interval in which the central database has to be updated).

The local subsystem actually provides two data security levels, as shown in Figure 9:

- Database level (defined when local database is created).
- Application level (defined by application).

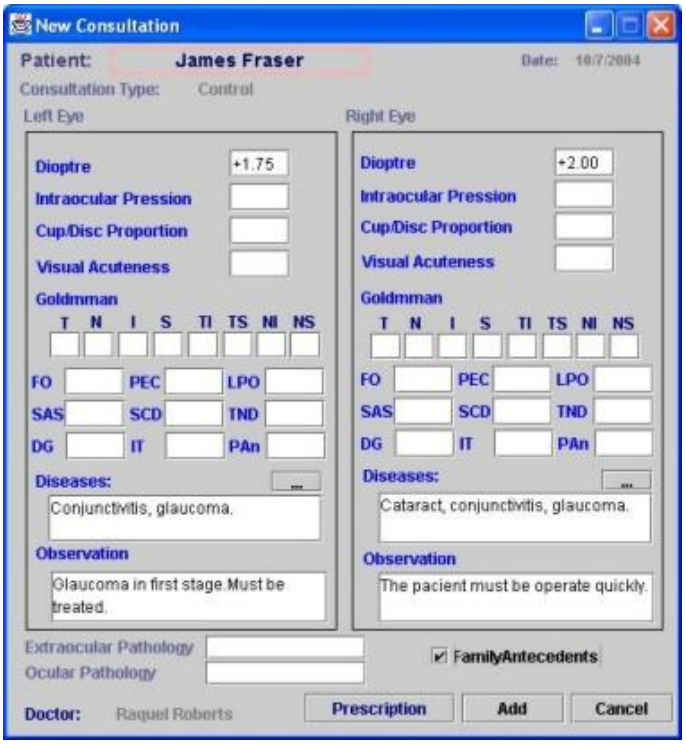

Fig. 8 . Data collection in the local application.

Fig. 9 . Data security.

Transferring sensitive information over Internet can be a risky process; therefore we secured the communication between clients (cabinets) and server, using the Secure Sockets Layer Protocol (SSL). SSL supports a flexible client-server authentication scheme and provides an encrypted client-server communication. SSL runs as a layer between the Transport Control Protocol (TCP) and application layer protocols, such as HTTP and SMTP. It uses public key cryptography to provide authentication and private key cryptography and digital signatures (certificates) to provide privacy and data integrity. To use the power of SSL in our system wealso made use of the Java Secure Socket Extension (JSSE) libraries that are a standard part of Java 2 Standard Edition (J2SE) platform (version 1.4).

Conclusions

The specialized health record management system presented here with core functionality in monitoring glaucoma, and core data organized in the form of a distributed database system [8], is designed to match the existing standards for information systems in the medical field. Its bottom-up implementation was kept flexible with the main purpose to accommodate any anticipated future requirements.

By providing a very intuitive interactive environment and a user-friendly interface in use for medical doctors, medical assistants and managers, supplemental envisioned benefits of such an approach are:

- Supervision of treatment and possible change of opinions among physicians.
- Correct planning of investigations (liquid test probe, perimetry - including computer perimetry, ophthalmoscopy, retinography).
- Avoidance of therapeutic “disasters” due to interruption of medication.
- Improvements in all the managerial and decisional aspects (regarding costs and time delays).

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Electronic Health Record

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Summary: This paper describes, from a practitioner's point of view, the concepts, methods and tools involved in the design of a practical and potentially low cost distributed information system, with web-based capabilities, for monitoring glaucoma.

Our experience with existing Hospital Information Systems (HISs) found them unsuitable in the very important monitoring process of patients with glaucoma. Actual Electronic Patient Record (EPR) schemes are more to do with management and appointment simple aspects than with clinical and decision-making processes. In a closer relationship to the specific of the affection, we found that demographic patient databases, usually known as Patient Administration Systems (PASs), have not been designed for being shared or concurrently exploited by different programs or even several replicas of the same program.

Many of the early deficiencies in the process of following-up glaucoma patients by dozens of different ophthalmologists in many independent offices from different clinics (with heterogeneous information recording, not very well managed by the existing office capabilities) could only be solved by specifying, designing and implementing a new EPR scheme in a mixed distributed environment, based on a distributed database as a demographic core (or PAS) of patients with glaucoma. A specialized health record management system, with core functionality in monitoring glaucoma, and core data organized as a distributed database system, has been designed in a bottom-up manner to meet the immediate needs. Its pilot implementation was intentionally kept flexible, taking in account developing standards, to accommodate any anticipated future requirements. Among many other benefits, the new EPR allowed medical doctors (ophthalmologists) to view and modify patient information and records in a safe, flexible and efficient manner. Improvements in all the managerial and decisional aspects (regarding costs and time delays) could also be remarked rapidly.

Keywords: Electronic Patient Record (EPR), Occupational Health Services, Medical Information System (MIS), OHS specialists

1. Introduction

The aims and purposes that we had to perform for the development of the already working model of EPR for Occupational Health Services are listed below:

- The model should mirror the practice of an OHS physician and his/her information contacts – with the health provided worker and his GP.
- To observe and pay attention to the documental medical economy, to describe all examined medical and auxiliary parameters and their standardized characteristics. Performing this quite new indexes in the electronic version is facilitated, because of the fact that this is a very new practice and still there are no traditions for applying their paper version.
- To enforce the automated document turnover through the *ELECTRONIC PATIENT RECORD* (EPR), as the first step of MIS integration on the national level. In this way, it would be possible to make all kinds of the health risk analysis at the working place, distinct health providing and control on the employer.
- EPR should be the basis of the routine report analysis of workers health conditions, as well as allow for substitution of mainly one-dimensional with multi-dimensional statistical examinations.
- EPR should combine the center-oriented with decentralized method of approach of examine group health conditions of employees, considering the International Classification of Diseases (ICD).
- EPR and the Information System, destined for, should both allow multi-access of the specialized Database for the purposes of national responsible institutions – mainly for the Center of Hygiene, Medical Ecology and Nutrition and National Register of Occupational Morbidity in Sofia, Bulgaria.
- Stage enlargement of the section "Inquiries (Statistics)" should be also considered – as various algorytmic processing of the collected through work time information. The summarized examined characteristics should be based on the relative contingent of illness in all necessary sections – by sex, by age, by profession, by production work and etc, accounting for selected case-effect relationships and correlations. This will optimize management of socially significant diseases in the relevant professional categories.
- Such information approach will help to promote initiatives directed to workplaces with health risk, work expertise and socio-medical behavior.

Presentation

This article is devoted to the Private Health-insurance Company, which maintains Occupational Health Services (OHSs) for insured persons in Sofia, Gabrovo and Bourgas. At the present moment, two OHSs begin their work with our EHR in Sofia.

OHS in Bulgaria are organised in coordination with the "Law for healthy and safety work conditions"(1997) and the Decree N17 (1998) of the Ministry of Health. These regulations are applied everywhere, where the right for healthy and safety work conditions is guaranteed. The role of OHS is to help and consult in an expert way the employers when they apply the law; to register the status of work environment; to control all activities for health protection; to adapt both the employee and environment to each other and to control the injurious factors in the work process.

The functional characteristic of OHS consists of three main groups:

1. Examination, prevention and improvement of a workplace with:

- measuring the factros of the workplace in the following subgroups: physical-chemistry factors, toxico-chemical factors and specialized factors, which are followed by evaluation of health risks from their influences and reorganisation of the workplace, considering the results in an adequate way. It is obligate to maintain the whole specialized infromation for these inconstant factors.

2. Tracing health conditions of an employee with:

- medical and health examination at the moment of entrance of a new employee, preventive medical examinations, preparing individual health records, the periodic generalized health analysis of all employees.

3. Education for prevention from work traumas through:

- preparation for the first and urgent medical aid, self-aid and mutual aid, development and application of rules, instructions and norms for healthy work conditions.

At the beginning of the below described *Electronic Patient Record*, we began with implementation of the listed functions, their archiving and the usage of specialized information. All of the functions in EPR are performed in consideration with the requirements. Patient records have traditionally been developed to support the clinical practices of individual clinical professions. The records in general describe the planned interventions, observations and relevant specialized test results.

EPR is a computer-stored collection of health information about one person where the items are linked.

MIS and EPR are designed in a way to be the first step in the integration at the national level. The compatibility of computer electronic files for processing information, connected with Occupational Health Services (OHSs) is a significant part of the aims, which are pursued by the reorganizing national health care.

By trying to co-ordinate the specified requirements ad conforming with relatively limited information technology use in this specialized area that is searching for its place among the new forms of health care, we are introducing some basic screens of the working EPR : This is the *main screen* for work, which is structured by activity types : for patients – on the left and for experts, working in Occupational Health Services (OHSs) – on the right.

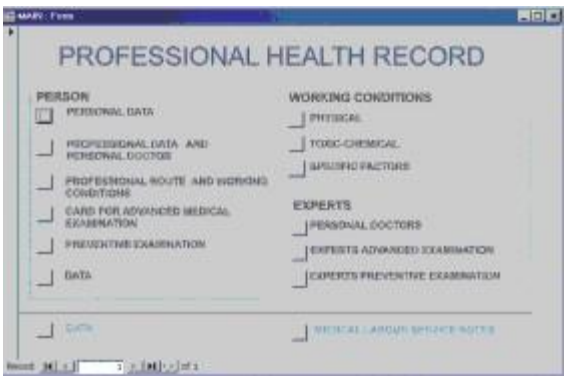

Fig. 1. The main screen.

Then there is an *entry screen* for each health insured individual, passing the medical examination. The basic primary information for creation of an electronic record has the following sources :

Fig. 2. The entry screen.

1. Passport – professional data – constant administrative-passport data and professional characteristics, through which a reference information in the enterprise's department "Human Resources" and for health-insurance fund is created :
2. Section "Health Condition" – current health and medical information – performed medical examinations by type, decisions of medical commissions and other medical documentation:

Fig. 3. The "Card for preventive medical examination" screen and Fig. 4. The "Professional Route of:" screen.

In the "Card for preventive medical examination" (Fig.3) there are described the specialized requirements, made by profiles in the field "Finding" from therapeutists, surgeons, neurorlogists, according to the specific characters of the workplace. There are filled in the results – including diagnostic conclusions, which argue the possibility of the employee to work exactly at this workplace.

At the "Proffesional route of:" screen (Fig.4) it is important to describe the factors, which have a constant influence on the work environment, presented in the following groups:

a. Physical factors: electrical safety indicators, noise and vibration measurements, light intensity, temperature, dust. It is obligate to describe the recommended personal and team precautions in the time with a constant or temporary character, including the personal safety measures.
b. Toxico-chemical factors: chemical products in the enviornment, toxical components and their concentration, time of impact. There should be also the record of the recommended and executed precautions in the time with a constant or temporary character.
c. Specific factors: unique features of the work – connected with stress, emotions, work in a conflict environment, including the medical and health professional`s recommendations.

3. Information inquire and health indicators:

The "Preventive medical examination" screen (Fig.5) is for registration of regular medical examinations of all employees and for individual visits in a case of a special occasion. At the "Health disease with temporary work disability" screen (Fig.6) there are registered the patient charts for home treatment, days at home and the IDC number.

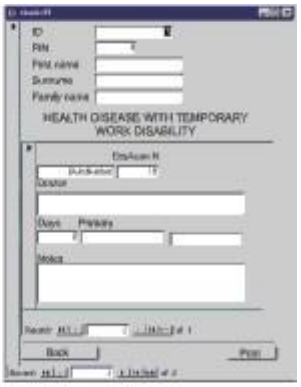

Fig. 5. The "Preventive Medical Examination" screen and Fig. 6. The "Health Disease with Temporary Work Disability" screen.

EPR gives a possibility for information treatment not only from and for the patients, but also for experts to work and apply this information for improvement of health care.
In the “Note” field of Fig.7 every medical specialist can mark her/his observations and work in their uniqeness.

Fig. 7. The "Note" screen.

4. Work of OHS specialists and their connection with GP:

The purpose of the following three screens – Fig.8, Fig.9 and Fig.10 is to create enviornment for information exchange between three types of medical experts, who examine the employee: a doctor at his workplace (with speciality – Occupational medicine), a specialized physician (surgeon) and her/his GP.

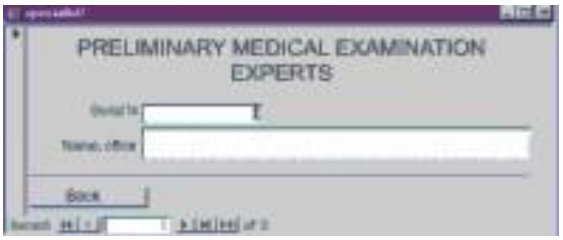

Fig. 8. The "Preliminary Medical Examination Experts" screen.

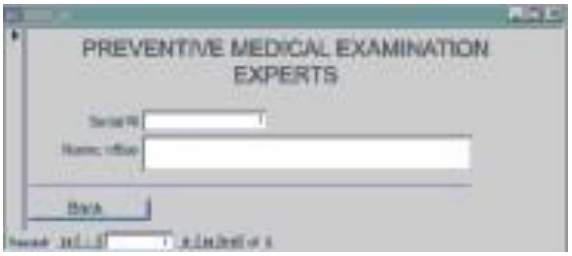

Fig. 9. The "Preventive Medical Examination Experts" screen.

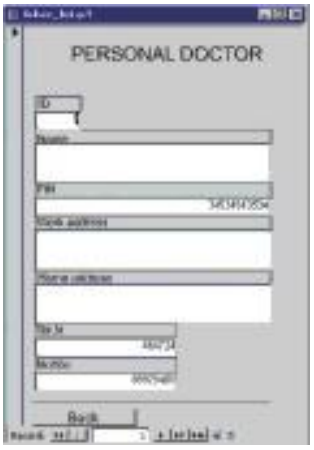

Fig. 10. The "Personal Doctor" screen.

Every entry is connected with the system date, which allows future references and with the administrative-passport data of employed – his/her national identifier. Besides, MIS performs entrance "Auto-number" function, which gives the employed his/her system identifier. The searching function could be made by one of these three modes. The "Card for preliminary medical check up", that is performed once before each employment at a new job, is unique for each patient. It is provided with standardized attributes according to the chosen graphical design of the fields. The number of prophylactic check ups are unlimited – after complaining or after OHS's initiative.

Conclusion

From the big importance for the realization of this project the focus was on the pragmatic aspects of specialized medical and health information and its management use. This information is a very expensive product, which serves for financial reports and analyses at the Health Insurance Fund. It is used by many users in a dialog regime. In future – there are intentions about a packet, epidemiological processing and terminals.

This ELECTRONIC PATIENT RECORD is a stage model of Occupational Health Services functions. It is in a process of optimization – the best vision of its formalized structure is still not found, because there is not any paper version to compare with.

The graphical design of EPR is realized on the basis of the present, modern medical electronic documents and it would develop in the practice.

The practical implementation of this product since the end of year 2003, could be generalized in the following frame: in Sofia : CiBank (900 employees) and Bank Biochim (2000 employees), in Mezdra – "Sunytex enterprise" (600 employees), in Gabrovo – "Podem enterprise" (600 employees) and in Bourgas – "Hemus enterprise" (350 employees). The general profit for one year is about 7 000 EUR for 4 450 employees.

This product is used and applied for education of New Bulgarian University students, the Department "Biomedical science" and there are two new diploma theses, based on it, in the program "Health management and politics".

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Formalization of Medical Guidelines

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Summary:

Formalization of medical guidelines by means of a general GLIF graphic model is demonstrated in the formalized 2003 European Guidelines on Cardiovascular Disease Prevention and 2003 ESH/ESC Hypertension Guidelines. It leads a user through the decision algorithm in diagnostics of several diseases, total cardiovascular risk estimation and appropriate treatment. Moreover, it can show both the basic information and the appropriate part of guidelines (GL) complete text concerning the selected GLIF model element. The formalization of GL can function as a feedback for authors to remove uncertainties and information inconsistencies in GL. Estimation of the total cardiovascular risk and selection of a drug class is easier compared to a time consuming manipulation with tables of paper guidelines. It offers to physicians a system for a decision support and it checks their decision algorithms in comparison with those of GL. It could serve as a tool for an audit of physicians work by their professional society using the automatic system, preferably with a direct data access from a structured electronic health record in future. Computer GL presentation has the potential for an easier GL knowledge implementation than the classical paper GL form and thus to improve the primary care of cardiovascular diseases.

Keywords: GLIF model, formalization of guidelines, prevention of cardiovascular diseases

1. Introduction

Primary care faces the problem of increasing and quickly changing knowledge in the field of preventive cardiology. Recent surveys have shown that in the vast majority of cases methodological standards were not complied with guidelines (GL). Therefore, the new methods for better knowledge implementation of the joint 2003 European Guidelines on Cardiovascular Disease Prevention in Clinical Practice (CDPGL) in primary care are mandatory. The main point is to learn the quickly updated correct decision algorithm in diagnostics of several diseases, total cardiovascular disease (CVD) risk estimation using the SCORE Model and appropriate treatment given by the CDPGL [1], [2]. It seems to be useful to add some more detailed essential information about the management (mainly treatment) of associated risk factors such as hypertension, dyslipidemia and diabetes mellitus. This means to add not overlapping parts of appropriate guidelines for management of mentioned diseases, e.g. 2003 ESH/ESC Hypertension Guidelines (HGL) [3]. Computer GL presentation has the potential for an easier GL knowledge implementation than the classical paper GL form and thus to improve primary care.

Materials and Methods

The essential presumption to work with medical guidelines (GL) on computer is their formalization that means their transformation to a structured form the computer can work with. Medical guidelines usually consist of diagnostic and therapeutical procedures for individual diseases or groups of diseases. Diagnostic and therapeutical procedures are usually given in a free text, in a better case partially as a flow chart, which in fact presents a way of text formalization of GL paper form. Generally, a formalization process means transcription of relations, processes, conditions and time relations by means of formal tools (e.g. logical formulae).

The most important and nowadays mostly used tool for a formalization is the GLIF (Guideline Interchange Format) model [4], [5], [6]. We use this GLIF model in two versions. The first one is educational and the other one (processing) enables suggestion of partial steps according GL linked to the information about patient either by direct input or from electronic health record (EHR).

We have created two separate systems. Educational version of GL is portable and is designed to be lightweight. Processing version of GL is designed for guidelines verification on a sample or real-life patient data.

Educational version of GL presentation system was designed to meet the following criteria:

- Internet distribution.
- Possibility of off line browsing (files can be downloaded and then viewed off line).
- Easy modifications and adaptability to various guidelines.
- Possibility of combination of HTML text, GLIF model graphs and specialized presentation modules where standard GLIF model presentation would be too complex.

Guidelines are shown in any Java enabled Internet browser (e.g. Internet Explorer with installed Java Runtime Environment).

We developed several Java applet modules used to show guidelines graphically.

- Glifview is a GLIF model browser that can present any formalized medical guidelines in a user-friendly manner.
- Risk calculator is used to calculate cardiovascular risk and show it graphically.
- Drugs selection module is used to manage indications and contraindications for drug classes and selection of rational drug therapy.

All modules are universal with all presented data stored in XML files, so they can be easily adapted to various guidelines.

Processing version of GL has the following properties:

- Internet distribution.
- All data are stored in mySQL tables.
- After entering data defined parameters are calculated.
- Processing of GL is performed during their displaying using Macromedia Flash technology.
- Processing of GL starts from a chosen input step.
- For each step processing GL check all conditions (strict in, strict out, rule in, rule out, see [6], [7]) and verify the explicit further step. In case of the explicit further step it is processed. Otherwise the GL processing is stopped.

Results

The educational version of GL using the GLIF model leads a physician through the decision tree usually with yes-no alternatives in dependence on the physician's knowledge of patient's data. If a value of some variable is not available the physician can continue and simulate both possible alternatives at the concerned decision step (Figure 1).

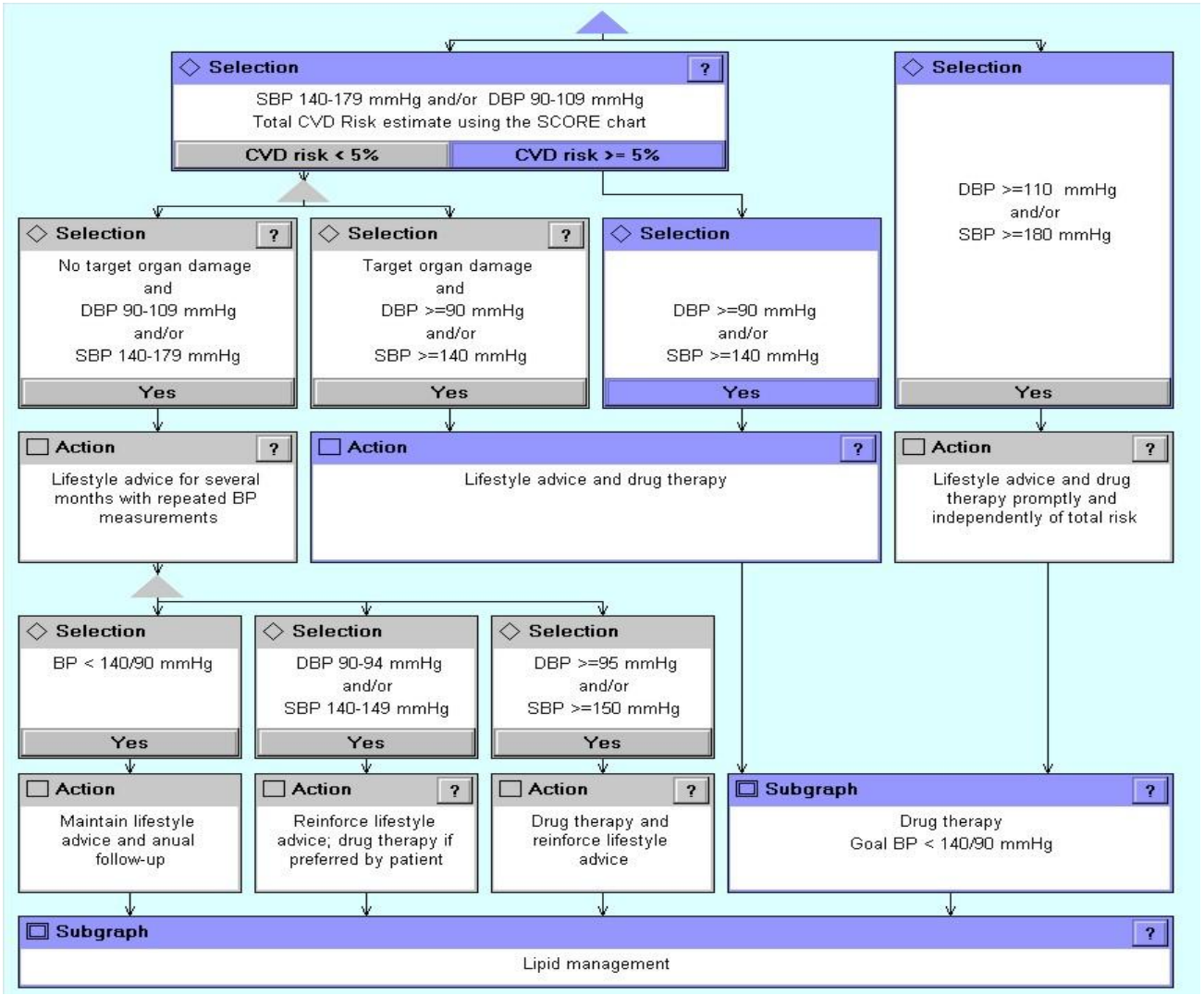

Fig. 1. Glifview example.

Moreover, it can show both the basic information and the complete text of guidelines belonging to the selected GLIF model element. The Risk calculator system serves for calculation of a total cardiovascular risk from entered data of an individual patient (Figure 2).

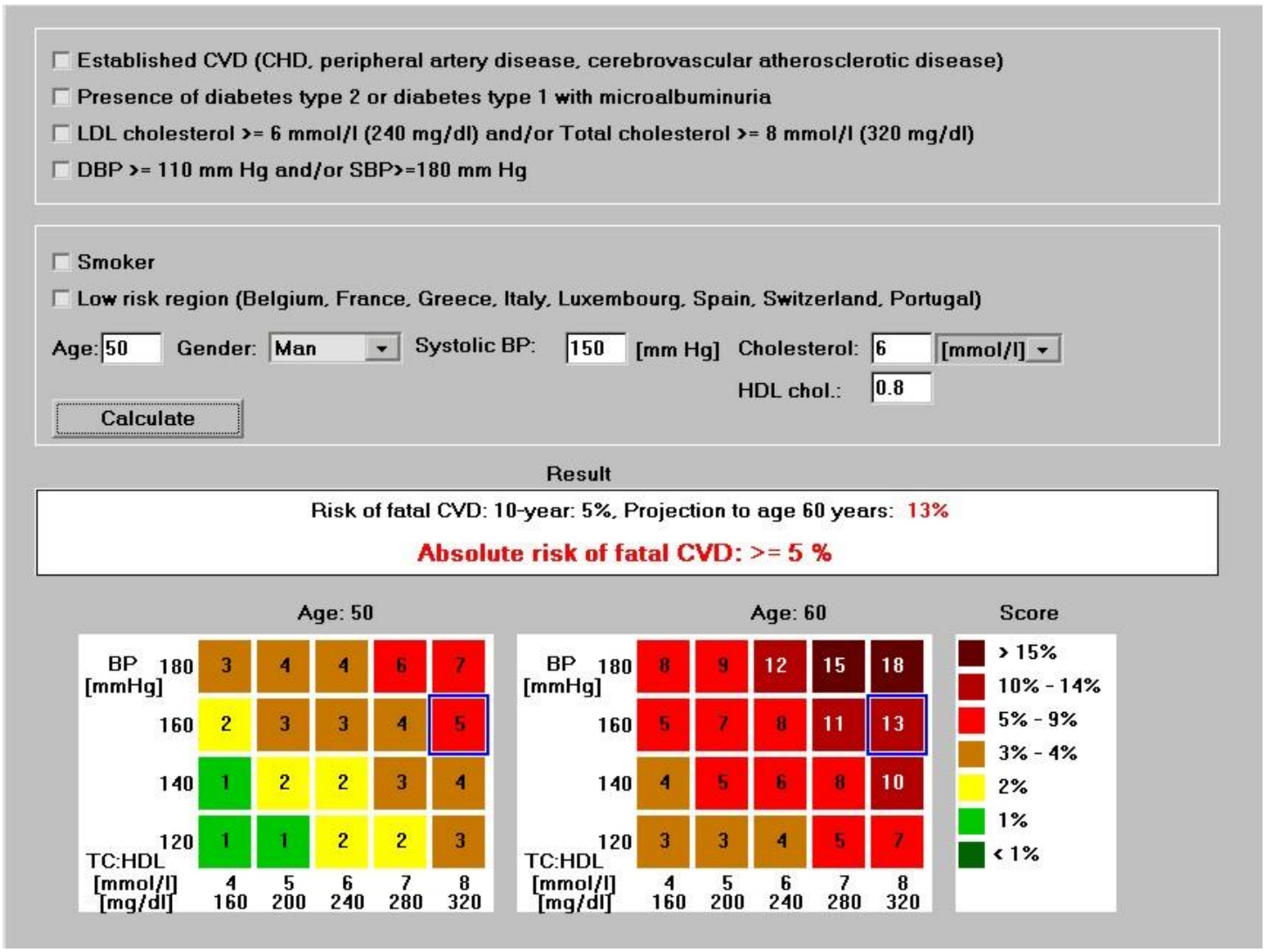

Fig. 2. Estimation of total cardiovascular disease risk – SCORE chart (high risk region).

Estimation of total cardiovascular risk determinates the term of starting the pharmacological therapy of hypertension and other risk factors. This decision could be speeded up by the preferential estimation of some variables as it is used in the educational system. These are associated clinical conditions, diabetes mellitus, items of target organ damage and extreme values of some risk factors. Each of them individually corresponds to a high cardiovascular risk, which indicates starting the pharmacological therapy. If one of such variables is present it is sufficient for the decision to start the pharmacological therapy itself and estimation of other risk factors is not at the moment necessary.

The Drugs selection system enables selection of a drug class according to its indications and contraindications.

The dynamic table compared to the static table of the classical paper HGL makes the drug selection much easier (Figure 3). It has an extra column with items in groups mainly according to body systems. Marking a certain item (e.g. heart failure) in this column is associated with automated marking of the same item in rows of several drug classes in the cells crossing both indication and contraindication columns.

An indicated drug class is highlighted in green; the contraindicated drug class is highlighted either in red (compelling) or yellow (possible). No colour is used when the drug class is neutral. The system shows also combined situations - a combination of an indication and contraindication within one drug class (Figure 3).

Class	Conditions favouring the use	Contraindications
Diuretics (thiazides)	☒ Congestive heart failure ☐ Elderly hypertensives ☐ Isolated systolic hypertension ☐ Hypertensives of African origin	☒ Gout ☐ Pregnancy
Diuretics (loop)	☐ Renal insufficiency ☒ Congestive heart failure	
Diuretics (anti-aldosterone)	☒ Congestive heart failure ☒ Post-myocardial infarction	☐ Renal failure ☐ Hyperkalaemia
Beta-blockers	☐ Angina pectoris ☒ Post-myocardial infarction ☒ Congestive heart failure * (up-titration) ☐ Pregnancy ☐ Tachyarrhythmias	☐ Asthma ☐ Chronic obstructive pulmonary d. ☐ A-V block (grade 2 or 3) ☐ Peripheral vascular disease ☐ Glucose intolerance ☐ Athletes and physically active
Calcium antagonists (dihydropyridines)	☐ Elderly hypertensives ☐ Isolated systolic hypertension ☐ Angina pectoris ☐ Peripheral vascular disease ☐ Carotid atherosclerosis ☐ Pregnancy	☐ Tachyarrhythmias ☒ Congestive heart failure
Calcium antagonists (verapamil, diltiazem)	☐ Angina pectoris ☐ Carotid atherosclerosis ☐ Supraventricular tachycardia	☐ A-V block (grade 2 or 3) ☒ Congestive heart failure
Angiotensin-converting enzyme (ACE) inhibitors	☒ Congestive heart failure ☐ LV dysfunction ☒ Post-myocardial infarction ☐ Non diabetic nephropathy ☐ Type-1 diabetic nephropathy ☐ Proteinuria	☐ Pregnancy ☐ Hyperkalaemia ☐ Bilateral renal artery stenosis
Angiotensin II receptor antagonists (AT1-blockers)	☐ Diabetic nephropathy ☐ Diabetic microalbuminuria ☐ Proteinuria ☐ Left ventricular hypertrophy ☐ ACE-inhibitor cough	☐ Pregnancy ☐ Hyperkalaemia ☐ Bilateral renal artery stenosis
Alfa-blockers	☐ Prostatic hyperplasia (BPH) ☐ Hyperlipidaemia	☐ Orthostatic hypotension ☒ Congestive heart failure ☐ Monotherapy? (less suitable for monotherapy)

Selection list based mainly on body systems

Heart
- ☐ A-V block (grade 2 or 3)
- ☐ Angina pectoris
- ☒ Congestive heart failure
- ☐ Left ventricular hypertrophy
- ☐ LV dysfunction
- ☒ Post-myocardial infarction
- ☐ Supraventricular tachycardia
- ☐ Tachyarrhythmias

Blood vessels
- ☐ Bilateral renal artery stenosis
- ☐ Carotid atherosclerosis
- ☐ Isolated systolic hypertension
- ☐ Orthostatic hypotension
- ☐ Peripheral vascular disease

Kidney
- ☐ Diabetic nephropathy
- ☐ Diabetic microalbuminuria
- ☐ Renal failure
- ☐ Renal insufficiency
- ☐ Non diabetic nephropathy
- ☐ Type-1 diabetic nephropathy
- ☐ Proteinuria

Lung
- ☐ Asthma
- ☐ Chronic obstructive pulmonary d.

Metabolic disorders
- ☐ Glucose intolerance
- ☒ Gout
- ☐ Hyperkalaemia
- ☐ Hyperlipidaemia

Various special conditions
- ☐ ACE-inhibitor cough
- ☐ Athletes and physically active
- ☐ Hypertensives of African origin
- ☐ Elderly hypertensives
- ☐ Monotherapy?
- ☐ Pregnancy
- ☐ Prostatic hyperplasia (BPH)

Explanation
- Indications
- Possible contraindications
- Compelling contraindications

The most rational combinaton therapy Drug class 1 + Drug class 2	
Diuretics (loop)	**Beta-blockers**
Diuretics (anti-aldosterone)	**Beta-blockers**
Diuretics (loop)	**ACE inhibitors**
Diuretics (loop)	**AT1-blockers**
Diuretics (loop)	**Calcium antagonists (dihydropyridines)**
Diuretics (anti-aldosterone)	**Calcium antagonists (dihydropyridines)**
Beta-blockers	**Calcium antagonists (dihydropyridines)**
Beta-blockers	**Alfa-blockers**
Calcium antagonists (dihydropyridines)	**ACE inhibitors**
Calcium antagonists (dihydropyridines)	**AT1-blockers**
ACE inhibitors	**Alfa-blockers**

Fig. 3. Indications and contraindications for the major classes of antihypertensive drugs and their combinations.

Moreover, a physician can differentiate between indicated drug classes according to the number of indicative items when there are more drug classes indicated. This is also beneficial from educational point of view.

Similarly, in a drug class selection, the estimated compelling contraindication (to a lesser degree also the possible contraindication) disqualifies the drug class from using in the individual patient. For optimal drug combination only those drugs are suitable, which are indicated both for monotherapy and effectiveness of their combination (Figure 3 at the bottom).

The obstacle to a practical use of such decision support systems is the repeated input of patients´ data. This can be prevented by retrieving data directly from a structured electronic health record (EHR). Therefore, the pilot testing of the formalized HGL for research purposes was realized in cooperation with two Czech companies producing hospital information systems. Thus we had the chance to know the way of collecting data in their systems. Data were mostly in a free, not structured text, which disabled their automatic extraction into the formalized GL.

A sufficiently structured electronic health record would be needed for this purpose containing all the variables used in GL for decision-making. Moreover, values of the variables would have to be expressed in an appropriate form, e.g. diagnoses in codes of International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, defined conclusions of some examinations etc.

Therefore, meanwhile an alternative version of processing HGL was created and a physician can put patient's data directly in the website version on http://guidelines.euromise.cz/). There is a list of all the variables used the values of which are to be filled in by a physician - shown at the left part of Figure 4. Compared to the educational system the browser goes automatically through the GLIF model graph evaluating conditions of decision steps. If some condition could not be evaluated, as the needed data items are not available, the browser stops and highlights the branch from the root to the current step. Thus it can serve as a reminder of missing data necessary for the correct decision. Then the user can input missing data manually (or simulate data) to the browser to continue in visualization.

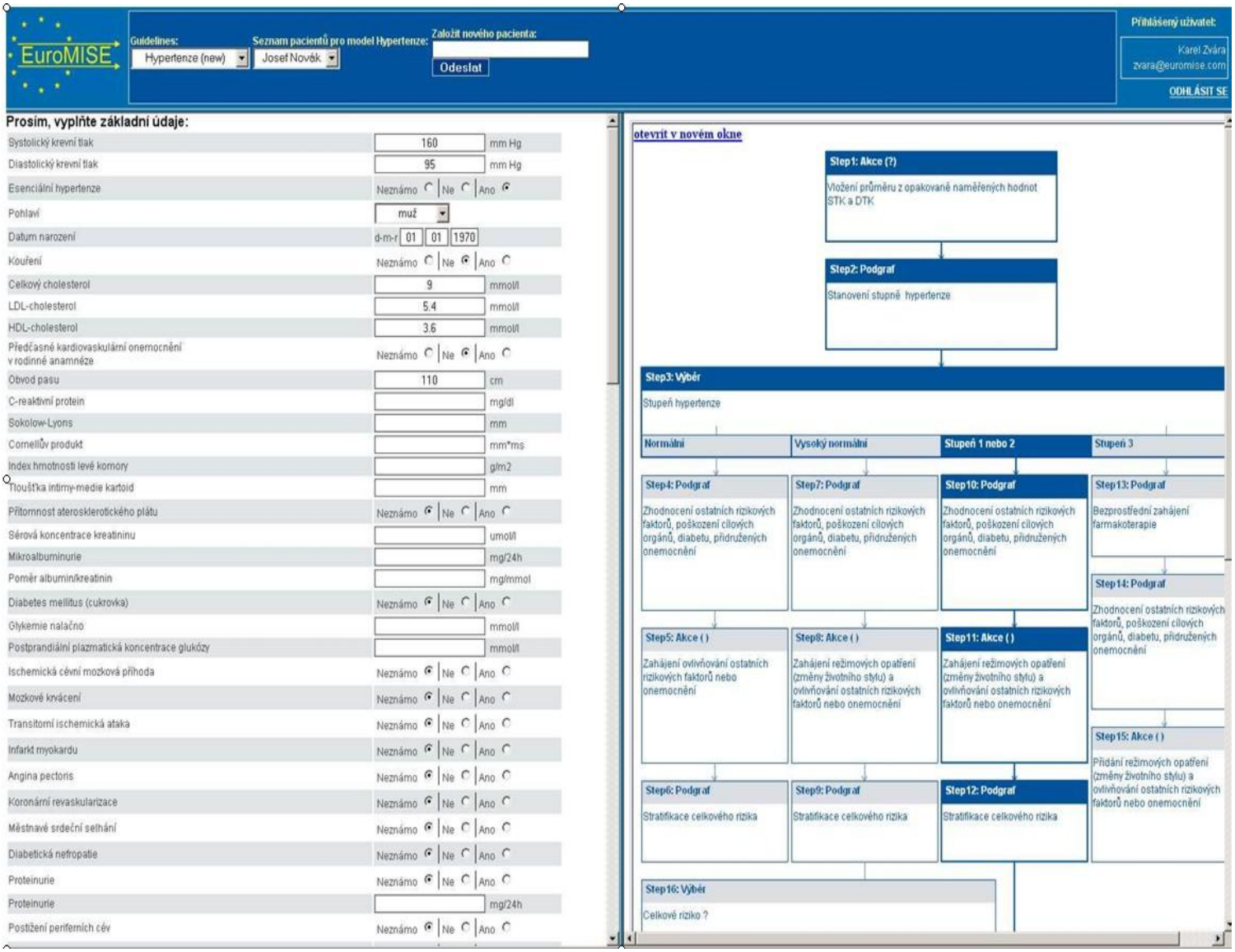

Fig. 4. Processing version of GL.

Discussion

Both qualitative and quantitative variables are used in GL for decision-making. The continuous quantitative variables are also presented as categorical due to the arbitrary given limits between normal and pathological states (blood pressure - BP, cholesterol or creatinine concentration, left ventricle hypertrophy according to ECG or echocardiography).

The presence or absence of a pathological state (yes-no) in a certain variable has to be expressed for the correct decision-making. In practice the third possibility occurs frequently that a variable value was not estimated yet or is less probable that it will be estimated at all due to financial or other reasons (not available).

The processing version of GL solves the problem of the three-value logic with a missing value that the browser stops and highlights the branch from the root to the current step. Thus it can serve as a reminder of missing data necessary for the correct decision.

Then a physician can manually simulate both variants of the decision algorithm and evaluate their risks for a real decision in an individual patient or input the missing value.

In case of a low or medium added cardiovascular risk based only on accessible data it is essential to complete the majority of missing items, it means only the results of examinations that are performed without clinical suspicion can miss.

The processing GL system also solves problems associated with a transformation of a static flow chart or pure text of paper GL in a system providing the decision algorithm repeatedly as during repeated patient visits with already started pharmacological therapy with possible quantitative (lowering of BP due to a therapy) and qualitative (recently estimated target organ damage, associated clinical condition or diabetes with possible consequent change of goal BP value) changes which can modify a patient's total CVD risk and conditions for drug class selection.

The system gives a short explanation of appropriate decision step by means of a summary of used items – shown at the left bottom part of Figure 4. This is an important property of the system to keep its educative function and prevent its degradation to a cybernetic "black box" with putting data on one side and receiving a recommendation on the other side.

All the possibilities used in decision algorithm could be expressed by means of formalization steps as we could check during formalization of several medical GL in cardiology - 1999 WHO/ISH Hypertension Guidelines, HGL, CDPGL, Czech GL for treatment of atrial fibrillation, Czech GL for management of pulmonary arterial hypertension and Czech GL for treatment of unstable angina pectoris in cooperation with the Czech Society of Cardiology.

In a stage of GLIF model construction from text guidelines, it is important to find a logical and process structure of guidelines, all fundamental parameters and their interrelationships.

Cooperation of an expert in informatics and medical specialist, preferably one of the authors of text guidelines was especially effective. Thus uncertainties and information inconsistencies in their free texts, which were not found out, by opponents and medical public could be explained and removed. The Czech Society of Cardiology is interested in its each new GL checking by means of formalization before its classical publication.

In future the system could offer the possibility of keeping data and selected steps of the GLIF model which were used for decision, possibly with a graphical follow up of selected variables – modifiable risk factors.

Future research will probably bring a development of general module, which could be connected using a suitable interface to a sufficiently structured information system in hospital and physician's office using international standards.

Conclusions

Formalization of guidelines by means of general GLIF model presents a suitable additional educational tool for their easier knowledge implementation in comparison with the classical paper form.

- It offers to physicians a system for a decision support and it checks their decision algorithms in comparison with those of guidelines.
- It could serve as a tool for an audit of physicians´ work by their professional society.

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