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Developing and Deploying Medical Information Systems for Serbian Public Healthcare – Challenges, Lessons Learned and Guidelines

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Abstract. This paper presents major challenges and lessons learned during the process of including and adapting modern medical informatics concepts in challenging circumstances of a health care organization in the Republic of Serbia. The processes of choosing the overall software architecture, application development and later software deployment are examined, and the most critical places (slow network, slow workstations, repetitive data entry, wrong data entered, inappropriate and complex GUI, and low IT knowledge of an end-user) are pointed out, and the general solving strategies are defined. The mentioned strategies are joined together as a general approach for maintaining a complete medical information system life-cycle. Eventually, this approach provides shorter training, efficient support during deployment, more comfortable and efficient work, and makes positive impact on adoption process. In a view of this, our main objective is to specify development and deployment guidelines that can be applied for the information systems developed in different developing countries facing similar problems.

Keywords: medical information system, GUI design recommendations, software architecture, software deployment strategy.

1. Introduction and Motivation

Public healthcare system in Serbia has been organized under the authority of the Ministry of Health (MoH) for more than 150 years. In that entire period, it has been significantly changed few times: from a “fee-for-service” system before the World War II, via a strictly state-owned but relatively well-funded system during the socialist era, to the present-day situation with both the public system offering universal healthcare and growing private practices. If we compare Serbian public health system with current classification [1] we can say that Serbian health system is in certain transition from the Scandinavian model (that it used to be during socialist era), to the Continental model up to a certain degree. It is hard to say which model will be adopted in several years, but for sure, the government tends to maintain strong public health system, while new insurance funds and strong private praxis seems to appear on the healthcare providing market.

The public healthcare system is now organized into several levels [2] – called “primary”, “secondary” and “tertiary” by the MoH’s nomenclature. Within this system, the term “primary care” is related to general and specialist ambulatory care. To denote healthcare services provided by general hospitals and clinics the term “secondary” healthcare is used. The highest level of delivering medical services is marked by the term “tertiary”. The term “tertiary” is used to define the set of the most complex diagnostic and therapeutic treatments along with research in the field of medicine and pharmacy.

Currently, complex organization of public health system results in many operational inefficiencies and serious degradation [3]. Since 2001, Serbian MoH has been making significant efforts [4], with financial help from the World Bank [5] and European Union [6], to introduce IT in the public healthcare as one of the preconditions for better efficiency. Initially, the main problem was the fact that almost no medical facility had enough computers, network equipment and Internet connectivity. In 2002, several clinics got computers and the first medical information systems (MIS) were developed. Mentioned systems were pretty much insulated and worked almost without any kind of data interchange. In the period 2002 to 2004 our research group was involved in the project of developing the basic clinical information system that should be used in Niš clinical centre. The project was named “*Developing medical information systems for medical institutions within the city of Niš*” and in the rest of the text it will be referenced as “project from 2002”.

Due to mentioned technical difficulties, all pieces of software developed at that time entered specialist and sub-specialist clinics only to a limited extent. Users of these information systems were enthusiastic medical researchers that led medical research projects and for this reason collected medical data. Luckily, by the end of 2008, the MoH finished the general reconstruction project and all medical facilities belonging to the government-run healthcare system got appropriate IT equipment and Internet connectivity.

At the same time (end of 2008), the Ministry of Science and Technology (MoST), after many years, started supporting projects that should develop prototypes of medical information systems. Immediately after that MoST announced the call for funding a research project and our group was awarded a grant for a project that should result in developing a new generation of MIS that could easily be integrated with other information systems. The project was entitled “*Improvement, integration and collaboration of information systems of medical institutions*” and it was generally dedicated to developing information system supporting not only healthcare, but organizational, administration and financial processes both in ambulatory and hospital healthcare institutions. in the Niš region of Serbia. In this paper it will be referenced as “our project”.

The main reason why our project was supported is the fact that at the moment when the project began, the only MIS software component that works in each medical facility and is truly interoperating is the financial reporting system that can be used both via Web service and Web site [7]. It has been developed under the authority of the MoH and its main purpose is creating lists of used material and medical services provided in a medical facility. Administrative workers collect paper forms from medical staff and make reports on a daily basis. However, no medical data are electronically interchanged.

The main goal of our project is to create software that will satisfy most of the needs of the Serbian public healthcare system, based on MIS-development related paradigms such as “evidence-based medicine” and “patient-centered-medicine”. The mentioned paradigms are basically defined for healthcare delivery processes, but they are adopted in the last two decades as driven paradigms for MIS development. Besides the fact that they are sometimes interpreted as totally opposite, and that medical processes defined by them raise dilemmas, they have, from the technological point of view, often to be seen as different sides of the same medal, and a modern MIS has to bridge the gap between as suggested in [8]. Evidence-based medicine is a newer concept and it is based on the fact that a doctor should choose the best possible treatment for the patient on the basis of the present medical evidence, while patient’s needs and requests could be easily neglected. Patient-centered medicine is an approach where every medical decision takes into account patient’s preferences and consults him/her during the entire healthcare process. Our system will follow recommendations from [8] and give a try to make evidence-based medicine more patient-centered by including patient’s observation into their medical record, and make patient-centered medicine more evidence-based by making all relevant medical data visible into to the doctor in the electronic health record (EHR).

Regarding the need to satisfy Serbian public healthcare structure, an important requirement for our work was to be compatible with the existing organization of the ambulatory segment of Serbian public healthcare system [3]. The ambulatory centers are organized around several departments. Usually, there is general practice, several specialist departments (commonly: gynecology, pediatrics, cardiology, and dental service), a laboratory, and a basic diagnosis department (usually providing X-Ray, ECG and ultra-sound examinations). A typical ambulatory center consists of the central facility and several smaller organizational units dispensed in suburbs and surrounding villages. A typical smaller ambulant has its own general practitioner’s office and an additional office for the visiting specialist. For medical institutions on the secondary and tertiary levels, we identified another important requirement – the system should be easily extendable and modular. As they consist of many different organizational units (clinics, institutes, pharmacies, laboratories), many different modules ought to be developed. In order to meet the main mentioned main requirements, we considered two possible architectural solutions – a Web based information system and service oriented information system implemented as distributed application.

This paper will present the most important challenges, lessons learned and crucial guidelines for developing of MIS envisioned to be used in some developing country. Section 2 presents related work along with the process of architectural model defining. A brief system overview together with the comparison to other systems from domestic and world market is presented in Section 3. Major challenges and tasks we had during the phases of modeling and development are described in Section 4. Reducing possibility for wrong data entries, eliminating multiple entries of the same data, creating GUI that is considered as friendly from the medical professionals' point of view, and having in mind that in some places the applications should work on slow computers were the most important goals in our development process. GUI user friendliness and a faster system response turned out as the most critical elements for the system adoption. This also led to a more effective training process and faster user adaptation to the new work environment. Section 5 presents issues and lessons learned during the deployment and maintenance process. At the end of the section 5 the list of development and deployment guidelines is presented. The closing remarks and future works are given in the final section.

2. Related Work

Our first choice was to develop Web based information system. Three main facts supporting our initial decision were following: number of efficient developing tools and environments, end user would have no need to install any new piece of software, and Web based information systems are well-known in health care delivery domain. Web based MIS are used successfully in many different areas of medicine as specialized systems, as well as general purpose medical information systems. They are considered successful solutions and are well positioned on the market. At the very moment there is a wide variety of systems offered by major companies such as Siemens Soarian [9], as well as complete open source solutions such is OpenERP [10]. Also, the most widely used MIS system in the Republic of Serbia, covering more than 50% of institutions of primary care, is Web based – Heliant [11].

The biggest drawback for choosing a Web-based solution was the bad telecommunication infrastructure and weak Internet connection; on some places distant medical offices are still forced to use a dial-up access via telephone land line. Unfortunately, a small number of remote medical stations do not have any kind of direct communication provided. This fact is the reason why Web oriented systems is not the best overall choice for areas without a secure and reliable network connection. Even a slow connection will lead to frequent stops in work and would not bring any real improvement. Also, Web based systems have slower response which combined with a bad connection could annoy the end user and eventually lead to system complete rejection. In [12] Web based GUI response time was compared with a MIS based on service oriented architecture (SOA). The result is that average response time for Web GUI was around 0.8s, while MIS based on SOA takes only 5% of that time (0.04s on average).

Colleagues working the IT department of Niš Ambulatory Center tried with a limited implementation of Web based information but it turned out that the effect was far from what they desired. Despite the slow response, the system works at the bottom line of acceptance in the central ambulatory facility, but due to a weak connection Web MIS was practically unusable in any distant medical facility. In this situation only system administration requires too much of extra effort of the IT department, while users were frustrated because of the slow response, especially on the web forms with many complex user controls. From their point of view, the update from time to time as a major problem with client based software is next to nothing compared with problems they have suffered with pilot Web MIS installation.

Anyway, we have explored many different and interesting Web based solutions in other authors' work that gave us many useful ideas for solving particular problems we faced in the development of our system. In [13] one can see web based information system for emergency health departments. Since emergency department tasks are pretty much time-limited and of higher complexity, authors choose Web based solution with a carefully designed user interface in order to make physicians' work more comfortable in hope that Web solution will improve communication with other medical information systems. From this work we acquire suggestions for careful user interface development as well as suggestions regarding effectiveness of multi-tier applications. From the other side [14] shows an effective modeling of Web based information system that supports one specific task – hemophilia care. In this paper we find an interesting definition on the use cases and domain model that could easily be adapted to be used in the support of some modules dedicated to specialist and sub-specialist examinations. Based on the domain model presented in [14] we defined our own domain model that has been successfully applied in our ambulatory information systems [15] and [16]. Furthermore, in [17] authors describe a successful use of Web oriented telemedicine system which distributes images to medical staff members on distant location via satellite communication. This was a very interesting idea for our further development, as a potential guideline, since authors dealt with similar problems related to bad internet connection or its total lack and trying to solve it via satellite communication.

Eventually, we choose not to develop Web based information system, but system based on SOA, offering smart clients to the end user [18] instead of Web GUI. We did not refuse Web GUI totally, since all patient related services will be developed as Web based applications, but for intra-clinical use smart clients is our choice. On the market the SOA based solutions offering some kind of clients to end users are also widespread. One can find such a solution offered by both domestic companies, such as ZipSoft [19], and major world companies, as GE Healthcare [20] and Allscripts [21].

SOA architecture also proves a good choice from the point of effective development and maintenance cost reduction. In [12] and [22] the authors prove that the newly developed SOA based information system could be successfully developed as an open and flexible environment that can be easily updated, configured and maintained. SOA based software can be easily integrated with other systems and can ensure better system collaboration and integration in future. Design and implementation of an interoperable MIS based on SOA can be found in many resources. The most interesting ones for us are given in [12] and [23], since the authors in detail describe their approach to the design of SOA systems to be used in healthcare service delivery organizations.

Regarding information sharing among different parts of a MIS we find the analysis presented in [24] exceptionally helpful. It discusses technological challenges and different approaches to health data aggregation during all interactions of an individual with the healthcare system. Based on this analysis and since our system has to be deployed in quite a distributed environment, we decided to develop desktop applications that would in most cases use local services and a database which only when needed would connect to central system. On the other hand, we needed to implement data replication [25] [26] to ensure data consistency.

Generally, we decided to develop an EHR based MIS which stands on SOA in combination with a distributed database. To solve a problem with distant community health centers we decided to develop standalone applications targeting local databases and use synchronization services in "on-demand" manner or scheduled when needed. We decide to develop an EHR since it has been proved as most common founding block for systems like MIS. It formats medical and other data, and prepares them for processing and/or interchanges them with other information systems. In [27] (there) is presented a study on how EHR improves efficiency of medical staff, which was very helpful in terms of developing user interfaces and plan implementation and deployment schedules.

Another benefit from using EHR and MIS systems is that medical data can be easily available for further educational and scientific work [28]. With a lot of data stored in an electronic format, different types of search and analysis can be done quickly. For example, EHRs are useful for "rare cases" for which paper data might be lost or forgotten. Researchers, students and other medical staff can access EHRs to improve their work. Our analysis of key capabilities of different MIS systems in conjunction with the results from [29], [30] and [31] concluded that the main uses of an EHR-based system were: patient care delivery, patient care management, patient care process support, education and research, improving policy and regulations, public health improvement and patient self-management. However, an important constraint is that data access must be strictly controlled to avoid misusage.

The research described in [32] proves that a well implemented EHR based MIS reduces a number of visits to ambulatory care institutions, thus allowing physicians to replace some visits with consultations over telephone or via the Internet. At the same time, doctors have more time for more serious cases and can offer better service during patients' visits. Also, EHR systems are quite cost effective according to [33], and in a short or mid-term period guarantee the return of investment. At last, but not the least important, analyzing data, retrieved during patients' visits, by an EHR system like in [34] can make further progress on the organization level and make a medical facility even more effective.

Comparing our software with other solutions present on the domestic and world market, we can say that our system supports all necessary common functionalities – from registering patients and registering information about given medical services, up to connection to imaging and laboratory devices. One, in our opinion, important feature offered by all products referenced from the world market [9][10][19][20[21] missing in our system is the so called single-sign-on. This feature will enable user that can by single logging, or even by logging to operating system, access all parts of the software where user's privilege level is sufficient. Another functionality that is missing within our system is e-prescribing. This is an option that allows a doctor to prescribe a medication distantly using some Web service. On the other side, we indirectly support free data import. Using our XML2SQL, administrators can define mappings to import data from external sources. We are supporting import from several types of structured files including XML and CSV.

A more interesting comparison is with Heliant [11], the widely used system in Serbian public health (at the moment of writing this article the total number of installations is more than 70) and ZipSoft [19] (more than 50 installations). The main difference is that Heliant is developed as a Web application and it uses all open source components. Due to that, it can successfully run on any platform in the target healthcare institution, while our software is built on Microsoft .NET technology and it needs Microsoft Windows as an operating system. Additionally, our system can run on two different database servers – Microsoft SQL Server (version 2005 or later) and open source Postgree SQL, while Heliant is based on MySQL. All three systems (Heliant, ZipSoft and our system) support the same set of basic functionalities defined by MoH (patient reception, EHR, communication with insurance funds, reporting, tracking patient's visit, laboratory module, imaging, scheduling and prescription service). They all passed verification of Serbian MoH and are certified to be used in Serbian public healthcare institutions. The differences on the level of basic functionalities are in the way of data presentation. While our system groups all patients visit into separate sub-medical records (following organization of Serbian public health system), Heliant rather displays the list of all visits while ZipSoft has an available list of all active medical documents as a tree. The list of all visits is available in our system too, but through a special form that can be started from any sub-record. All three systems support the same set of standardized nomenclatures (as ICD-10) but we prefer selection components (they will be mentioned later in the text) instead of a selection from the complete list or another form as with other two. Another difference is in a basic installation pack. Our basic pack includes a few more functionalities than other two solutions – advanced dental record, set of administrative software tools, call-center software, basic business intelligence, and advanced scheduling software.

3. A Brief System Overview

We have developed our MIS [15] [16] in a way that enables easy adaptation and localization in other countries as well as simple modeling and prototyping of new functionalities [35]. Labels on the every form are generated using translation resources, so the initial job during localization process is to fill translation resources with labels in a new language. As translation resources simple tabbed document (as Excel document) are used. When user needs to define translations for a new language, he just needs to create a new column in the tabbed documents and fill rows with adequate translations. If there are no changes in application's workflow, the time needed to develop a version in a new language is a time needed to type translations.

We tried to create the system that can easily exchange data with third party services. Using our XML2SQL tool mappings can be effectively changed when the system downloads data from some external service (e.g. medical data catalogues from Serbian MoH). Previously, administrators in Niš Ambulatory Center used some configuration tools provided by Serbian MoH and the public health insurance fund to change mappings when the structure of the downloaded data is changed by their source. The old system helped the administrators efficiently in the cases when some new data attribute is added or edited (e.g. the property *Description* on the entity *Medication* has been changed to *MedicationDescription*) but when some new classification appeared the administrators need to insert all segments of new classifications manually and update the connected entities in the database. This could happen when, by example, MoH defines sub types for certain medication group. In that case, the mapping for all medications belonging to this group need to be updated in the MIS. For example, there is a group of medications called *antifungals* (used to treat fungal infections) containing around 40 different medications. If MoH decides to define sub-types (such are *azole antifungals*, *polyenes*, *echinocandins*, and *miscellaneous*) this change has to be downloaded and all of the medications have to be updated by setting their new sub type. Instead of using two different tools, now they use only our XML2SQL that automatically updates both the structure and corresponding entities. Their intervention is needed only in the cases when a mapping, suggested by our tool, is not satisfactory. After the mapping update, the administrators have almost no need to update downloaded data in the database. Using the new tool the administrators managed to reduce the time needed for data mapping to two thirds of time needed before.

For security reasons, but also to enable easier changes, access to data from application-level services/modules can go only through the virtual EHR service. Since we have a full-scale system and a light functional structure we can easily define and update solutions for a certain institution. Light functional structure is a set of base functionalities implemented as a three-tier client-server application suitable for the installation on a single workstation or within a small primary care facility having up to ten workplaces. An additional advantage of our system is that application-level services can have a Web interface (an example is the Web-based scheduling tool) and in case where the network connection is reliable, users do not need to install the full application, but use some modules as Web applications.

In our initial deployment, the full scale system core is installed in Niš Central Ambulatory Facility, while light functional structure is installed in several small dislocated community health centers. Since we use a transaction-based replication we have not faced the problem with partial data loss, since all data from the transaction is either transferred or not. Data replication and exchange is tested between central server and few distant stations with the success rate above 99% in the case where both sides are parts of the same network. The success rate was lower with dislocated stations and was in the range of 78% with slow internet connection (dial-up), up to 94% with fast internet connection (ADSL, cable internet).

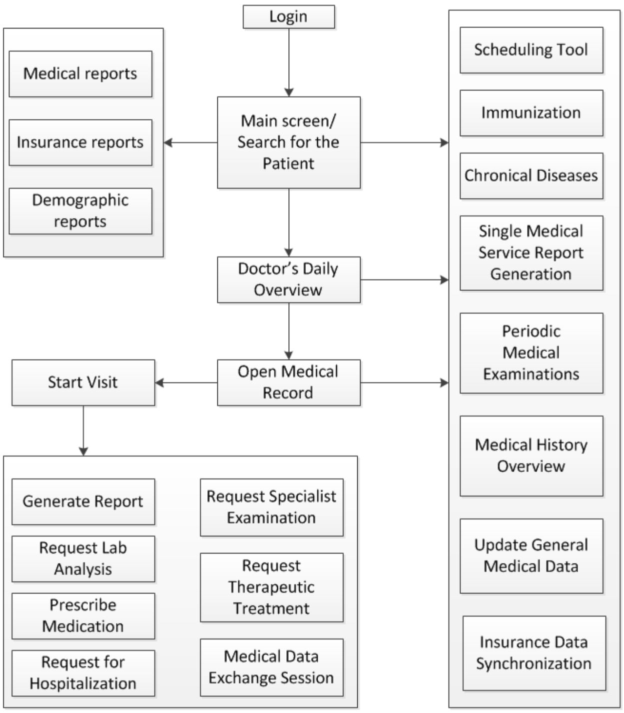

Fig. 1. Scheme of the common functionalities and most important medical procedures supported within ambulatory health information system

We have 32 user modules in active use while the next 10 are under evaluation. All data synchronization and exchange with MoH database and with the public insurance fund are up and running. Administrative and reporting [36] modules, along with the basic laboratory, dental, other specialists, and general practitioners (in the further text GP) supporting module are in full use together with scheduling and prescription services. The imaging service together with the improved laboratory module offering connection to multiple types of lab analyzing devices is in the final testing phase and during the next few months we expect for it to be adopted.

The standard set of functionalities supported within our ambulatory health information system is displayed in **Fig. 1**. Basic functionalities are login (containing account verification), search service (search for patient), gathering logically connected medical data (open specific medical record), start visit, define medical document, create specific report and start external software tool. All other functionalities are derived from previously listed. All processes that are connected to 'start visit' as a group extends basic action define on the medical document. Furthermore, the processes on the left of 'search for the patient' are subtypes of 'create a specific report', etc.

4. Application Modeling and Development – Tasks and Challenges

Before commencing our work we completed a series of interviews with a group of 28 doctors (twelve from ambulatory care and 16 from clinic centers) regarding their expectations on the future MIS. Although the primary goal is the development of an information system for primary healthcare facility; we included more doctors from the clinical center mostly because they already have some experience in using information systems The next reason why we interviewed more doctors from the clinics is that they were more interested to participate in MIS development process. The interviewed doctors are practitioners of different medical specialties, while ten of them are also professors and researchers at the Medical Faculty of the University of Niš.

The very first discussion was about the volume and the structure of data the doctors want to access using their MIS. The main problem that appeared here was related to patient's privacy. It is interesting that more than half the number of doctors (15) believe that they should have an unrestricted access to patient's data, next 8 think that only data marked as 'available' can be viewed, while the last 5 think that all medical data from other institutions has to be protected and available only upon request. The result of the first session of the interviews was a specification of an overall data structure and definition of the set of the rules applying on patient's medical data access. At the moment, our solution regarding patient's data privacy is defined by the guidelines of Serbian MoH. The solution follows the existing legislature in the Republic of Serbia and takes into account the international standard and recommendations in this area, such as European EN13606 and American HIPAA [37]. The complete system is based on well-known and widely used roles based access control model [38] supported by an administrative tool allowing the administrator to specify data access rights very precisely for any class of users and for any particular user.

From the patient's point of view this means that he/she has to initially select one GP, from the medical institution where his/her medical record is registered. The selected GP is patient's main physician with a privilege to see patient's complete medical history. Later, the patient may choose up to three specialists (e.g. cardiologist, gynecologist, and neurologist) and grant them full access. It is important to point out, that giving the permission of a full access to some doctor has to be covered by a grant document signed by the patient. If the patient visits some other doctors from the same institution they can see only the data about active treatments, so they can prescribe medications, etc. The patient can give them permission to see his/her other data, but just for the very visit, by entering a pin code. The pin code is generated when the patient's record is created and given to the patient in an envelope. Doctors from the other institution can get the patient's medical data only upon specific request. In urgent cases, more medical data can be provided, but these cases are covered by special requests defined by MoH.

The next session of interviews was related to the user interface. For a significant majority of doctors (19 of 28), the crucial requirement was that the MIS interface should resemble the actual paper documents. This was required by all GPs and gynecologists (those that have the most elaborate paperwork) while only 2 out of 8 researchers supported this requirement. The general conclusion was that we should follow paper-based documents, and try to keep GUI as simple as possible. This is an especially important factor for the better user response to the software. Since our main users are medical professionals having not much of IT knowledge, GUI that resembles paper documents turns out to be an important factor for a more efficient user training and makes the software adoption easier [39] [40].

To test how end users react on the developed software we used the response from Nis Ambulatory Center medical staff. In total, 630 medical professionals from mentioned institution were trained to use our software. In the beginning we interviewed them about their IT knowledge – 108 of them claimed they had not used computers before at all, 326 were using computers for Internet surfing only, next 149 except for the Internet used some additional applicative software, while only 47 of them had experience in work with some MIS. During the training process 82% of trainees (of the mentioned 630 persons) claimed that they were highly satisfied to have 'digitalized' documents. The interesting fact is that more than 35% of trainees suggested how to improve GUI. Facing the fact that we have many different suggestions for the GUI we realized that we should allow the personnel of client institution to update the appearance of some forms. For this reason, we have developed a set of configuration tools used by administrators in client institutions to fit the GUI upon their specific needs [35].

A further requirement was to minimize typing of personal, demographic and insurance-related data about patients and doctors. The main problem with paper-based documentation is that medical staff members have to write and write again many data on each document such are patient's demographics, code of diagnosis, code of medication, etc. Working with paper based documents, during a single patient's visit to a GP, the patient's name, along with their insurance number and the year of birth is written at minimum four times. This repetitive data entry leads to a significantly high error rate in paper-based documents. We have checked only 15 medical records containing the total of 476 different medical documents. In 56 documents the name and/or last name was mistyped (i.e. in author's record containing 24 documents the last name Rajković has been three times mistyped as Raković and once as Trajković). Also, much of the handwriting on medical documents written in a hurry tends to be quite hard to read later. In the mentioned set we were not able to positively identify the name and/or last name in 30 percent of all documents. In 24% of documents we could not identify code of diagnosis.

For this reason, our suggestion was to create catalogs of choices wherever possible in order to avoid free text enter. For example, it is highly possible that a doctor, in a hurry, types F41 for diagnosis instead of G41 since f and g are next to each other on the keyboard. For this reason we developed selection components applicable for each catalog [40]. Additionally, a user can search through catalogs of diagnoses (ICD-10), medicines, patients, immunizations, etc. The selection component is a GUI element that applies filters defined in search fields and when a MIS end user (e.g., doctor, nurse) types some text in these search fields, the selection component automatically displays a drop-down list of filtered results from which the end user can choose one. During training we realized that this kind of a component brings an important psychological impact on the prospective users, since they get an impression that the system is developed to really help them.

Sometimes, users want an improved GUI that looks different than paper-based document. The example for this is a specially designed form representing dental record (**Fig. 2**). Also, various specialists have customized "specialist workspace" forms for entering reports on their examinations. In the development of these forms our modeling tools [35] were real help. Based on the user request, the developer defines only the list of fields that should appear on the form together with their data types chooses display template and workspace where this form belongs. After confirming, new data structures in the database and data model are created and new windows form with all basic functionalities included. Since our modeling tool provides not only create but also update and merge options we were able to build specific forms fast and reduce the time we needed for building prototypes from the average 8 hours (without our modeling tools) to less than 2 hours. Generated forms contain already proven code requested for the mentioned basic functionalities. Only bug fixing should be done in specific functions needed for a single form. This results in reducing the time needed for initial bug fixing after smoke tests on newly generated forms from average 90 minutes to only 15.

Modeling tools can be used for extending some points of our MIS [35] even in implementation of EHR based systems in different medical institutions, hospitals primarily [41]. As with medical procedures and documents, where we tend to follow in as much as possible the existing use cases, we have applied the same approach with organizational procedures. Our solution does not change any of them. Instead, it offers complete support for the existing ones and improves them with better communication and decreasing paperwork resulting in better efficiency of health care and saving time and money of patients. The best example of this is the scheduling tool. Before the use of scheduling tool, Niš central ambulatory facility scheduled less that

300 examinations daily, where 250 were ‘in person’ and about 50 by phone. The average waiting time for a patient was about 90 minutes (the amount of waiting time is the result of interviewing patients). Now, more than 1000 examinations are scheduled daily, where only 5% are ‘in person’ and all the others are by the phone or via the Internet. The average waiting time is reduced to 10 to 20 minutes. This is also connected to the recommendation given in [42] regarding the choice of the right level of IT in healthcare at a given moment. All this combined with the high percentage of doctors interested in MIS [43] makes the probability of the system adoption higher.

The next challenge was the fact that doctors and nurses (especially older nurses) in Serbia do not have good computer user skills, so any MIS that is different from the existing administrative forms and procedures will became their nightmare and will not be used in practice. Of the mentioned 630 trainees we had to organize a basic IT training for 350 of them. For this reason Serbian MoH plans to stimulate the adoption of MIS is similar to the one described in [44]. Having the same in mind, we have tried not to change the user’s methodology of work and habits, knowing that making comfortable user environment is one of crucial factors [45] for the successful use.

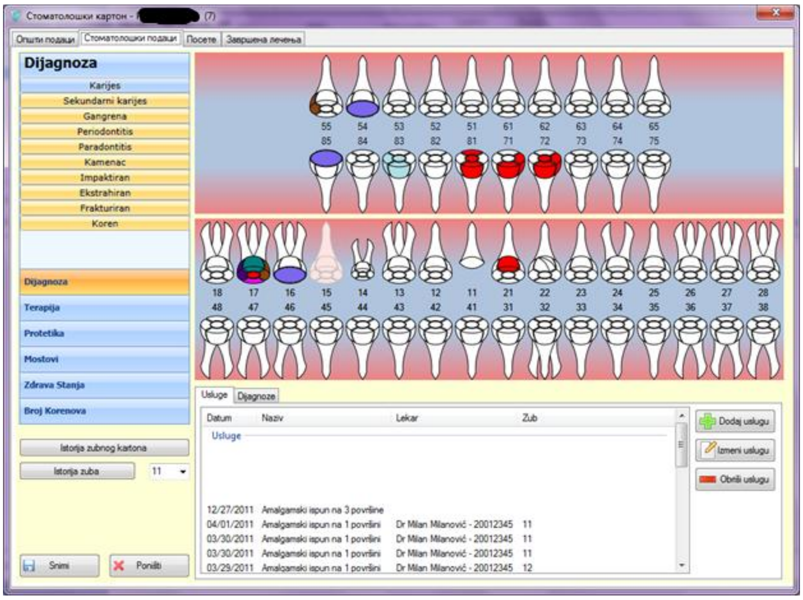

Fig. 2. Dental record – an example of an examination form

5. Deployment, Implementation and System Adoption – Lessons Learned

Information system design approaches, architectures, and developing methodologies have constantly been improved and upgraded during the past years. Information systems are being implemented in almost all areas of today's world and made many business processes more effective than they had ever been. Medicine could be just another field of a successful implementation, adoption and use of information systems, but this mission turns out to be not so easy. The MIS adoption process was a job that spared, in many cases, much more time than expected or even ends up in a complete failure. The causes for this were many, from too complex architecture that resulted in a slower system response than expected, to the user interface that did not medical professionals' needs. Many factors play important roles in the MIS adoption process [46] – medical staff's anxiety, overall response time, liability, and user interface design.

When we implemented the first MIS in 2002, our main problems were the lack of information infrastructure and the fact that doctors just didn't believe that information systems could help them. At that time we developed clinical information systems that should be used in neurological clinic, cardiologic clinic and general children hospital of the Niš Clinical Center. Doctors from the neurological clinic participated in the developing process and even tested applications and gave suggestions on every single development piece of software. Based on all these inputs the result was an information system of document management type offering to its users 135 different document types. The collaboration during the development was not so good with other clinics' staff. One of the main reasons was that in 2002 clinics had just few computers and no network, while the management did not treat the MIS development as an important activity. Providing medical documents to us and participating in the project from 2002 in that way was just a sign of collegiality on their side, and unfortunately nothing more. The next reason was that the Niš Clinical Center did not want to support the whole process because the installing information system and keeping medical documentation in digital format will not abolish keeping paper-based documentation. In the situation when one clinic had (roughly on average) five computers and one printer it was hard to expect that the system exploitation would start.

Table 1 the shows level of interaction of the staff from different clinics during the development and testing phase. In the first iteration of the development process, we created the total of 26 different documents (category A from the table) that represent a set of common documents.

Table 1. Level of interaction with prospective MIS users (Row A represents number of used common document types in information system, B number of specific document types developed upon request, C number of different issues reported on common documents, D issues reported on specific documents, E number of staff members included)

Category	Neurological clinic	Cardiologic clinic	Children hospital
A	24	22	26
B	75	16	18
C	33	4	8
D	105	8	25
E	11	2	6

We received the total of 45 different bug reports, issues and design suggestions (category C) on common documents, 33 of which were from the neurological clinic. Regarding the request for specific documents (categories B and D) and the number of reported issues one can see that the most agile were the people, again, from the neurology clinic. The overall result was that the neurology clinic initially adopted our system and started some exploitation, while on the other two clinics the system was never installed in full scale. Even on neurological clinic the system was used very short, and after that the developed software components were used by just few doctors who wanted to keep the detailed documentation for the research purposes. From this project we realized that it is crucial to have doctors involved into each step of the development in order to ensure better acceptance later, but at the same time adequate IT infrastructure and management support are required.

Luckily, today, medical professionals' leading view is that MIS systems became a necessity for a healthcare system. In 2002 we interviewed 95 clinicians and only 19 of them wanted to participate in the project, and less than one third (31) believed that MIS was a necessity. Seven years later, when we started our latest project, the percentage of doctors that supported MIS rose to more than two thirds; 451 out of our 630 trainees believed that an MIS system could improve their healthcare delivery process. Having the previous experience in mind, we included both the doctors and IT people from ambulatory center in development process. This turned out a better solution, since we can delegate some basic testing to ambulatory institution's IT department. IT professionals help a lot in identifying the design issues and reporting bugs – only four of them reported 276 different issues, bugs and requests (sum for categories C and D in Table 2), while 13 member of medical staff reported the total of 132.

The newer system developed since 2008 proved much more successful, since it was installed and actively used in 18 ambulatory centers and in additional four it is in the deployment phase. Only in Niš central ambulatory facility in 2012 the average number of generated documents daily is 12000, on 471 active users. The main lesson learned from our implementation is that including potential users as early as possible in the development process results with much more usable software and leads to a greater end-user satisfaction.

Table 2. Level of interaction with prospective MIS users in project started 2008 (Row A represents number of tested common document types, B number of specific document types developed upon request, C number of different issues reported on common documents, D issues reported on specific documents, E number of staff members included)

Category	IT Staff	Medical Staff
A	41	41
B	74	59
C	155	64
D	121	68
E	4	13

The current situation in the Republic of Serbia is that almost all ambulatory healthcare facilities use only some basic segments of MIS, which is related to recording the given medical services, medical material consumption, and generating reports needed for insurance funds and MoH [36]. Additionally, our system offers a business intelligence package that accelerates the process of generating the voluminous documentation and reports.

In developed countries this kind of science has reached advanced stages of research, such as preoperative risk predictions [47], or bio-signal-based systems for different kind of patient's monitoring [48], but in developing countries we are, in most cases, at the first stages of introducing and developing MIS systems. The next steps in healthcare IT infrastructure development, in Serbia, is introducing MIS on the secondary service deliver level – in hospitals and clinics.

As results of lessons learned we were able to define guidelines for system deployment and identify possible main problems that prospective users can be faced with, as well as to state the recommendations for their overcoming.

5.1. Deployment Strategy Guidelines

We were in the situation when needed to install and deploy a voluminous information system in the institution that already had just few pieces of software (or even no medical software) before. However, it was proven around the world that the introduction of wide software systems in health care has its negative side too. MIS users, especially the older ones, have a firmly established routine in their daily work, and each novelty can be disruptive to them.

Initially, we tried with deployment of software in all departments at the same time and perform trainings, but it turned that this approach was not appropriate. In the beginning, users seemed unsure about their actions, and in many cases refused to use the software. With this approach, we needed more people on site during training, and the support staff was much more loaded with support calls. It happened that support lines were overloaded and users had to wait for the answer. At the same time, users were not sure if there was anyone in the same facility who would be able to help them. For this reason we decided to use an incremental approach in the information system deployment and define a set of guidelines. This was tested in Niš central ambulatory facility and in several ambulatory centers where we deployed the software.

For each single deployment we first checked the current situation regarding other software usage, and then make deployment plan. Here it is important to point out that beside Niš Ambulatory Center; only two other institutions had some kind of an IT department, while 10 of them had only one, either full or part time employed administrator. In 5 out of 18 institutions where our software was implemented there was no IT personnel at all. The important guideline here is that at the very beginning at least one person (i.e. administrator) from the target institution should be trained much better than the other users in order to solve initial problems on site when no one of our team members is on site. Our software deployment usually started with the departments that already use some other software tools, since their staff, in most cases, has better information background than the others. We would install new software to them and performed training. In the meanwhile we did basic training for other departments' staff. After transition of the software to targeted departments, we started deploying our software in the departments where no software was used before. In our incremental deployment approach we had a situation where the initial implementation lasts longer, but the adoption process was much more effective. With this approach we have at the same time people using parts of the information systems and people having training. This situation brought two main benefits, first people on training could talk with people that already used the information system and were additionally introduced into the system; and second, during this process, there was always some of our technical staff on site for support cases, so users address this person directly. Also, people started using the information system in that initial period knowing that there is somebody already using it, so they feel more confident if they can ask a colleague instead of calling support.

It is interesting that we often had a situation within the same institution that some medical professionals use no software, some of them use one application, and some deal with several electronic systems during their work (ultra-sound devices, EEG, Roentgen, etc.), which are often provided by different manufacturers and have different user-interfaces. In the period of introducing and implementing MIS (which should act as an integrative system for all other electronic and computer systems) to health care facilities especially. It turned out that if MIS's user interface is not intuitive for its users, it can slow down their working process instead of speeding it up.

Table 3 displays the effect of incremental deployment strategy displayed on the cases of three ambulatory centers of similar size. In center 1 (located in the town of Babušnica, 75km southeast from Niš), our incremental strategy was used and in center 2 (in the town of Bela Palanka, 50 km east from Niš) we installed the software in all departments at the same time. It is important to point out that the two mentioned centers were among the first deployments where we had a higher number of support calls due to bug reports. In center 3 (Dimitrovgrad, 110km east from Niš) we used incremental strategy, but the system deployment started three months after the deployment in centers 1 and 2. Implementation and deployment were faster and much more efficient than in the center where incremental strategy was used (Table 3).

All three centers are about the same size when in terms of the number of active users, the number of generated medical documents and number of potential patients (categories A, B and C from Table 3). What is significantly different is the duration of deployment period. In center 1 and 3, the deployment period was about one month, while in center two it took more than 60 days until the system become fully operable. In this period we installed all necessary servers, client machines, performed training for medical staff members and administrators and monitored the initial use. During the installation period we usually received support calls when our prospective users mostly contacted us to verify different procedures. We got support calls both from medical and IT staff where the ratio of these calls was roughly 50:50. Most of these calls were related to some process verification, but, also we had some bug reports as well as system improvement suggestions (categories G and H, Table 3).

Another lesson we have learned for this is that the incremental approach gave significantly better results in most cases. The cases when we did not get significant improvement with this approach is when we installed MIS in some small privately held ambulatory facilities having fewer than ten users. In these cases the number of users is a factor that washes out all benefits of incremental deployment strategy. In the mentioned set of 18 public healthcare institutions, where the number of active users is in the range from 35 to 471, incremental strategy proved more efficient.

Table 3. Effects of incremental strategy use (Row A represents total number of inhabitants in covered area, B average daily number of generated medical documents in system full-scale use, C total number of staff members using MIS, D implementation period – from first installation to verified system acceptance (in days), E total number of support calls in deployment period, F total number of support calls in first 30 days of full-scale, G bug reports, H system improvement suggestions)

Category	Center 1	Center 2	Center 3
A	12259	12051	10056
B	1350	1490	1050
C	54	57	49
D	32	63	28
E	306	1116	227
F	51	173	35
G	17	19	2
H	14	21	6

5.2. GUI Related Problems and Solving Guidelines

The main users of medical information systems are doctors and nurses. Information system needs to be organized on the way that their daily work is more dedicated to patients' treatment and less to the information system. An additional difficulty for the adoption of the installed MIS is the fact that they have been much used to paper evidence for many years. Working on the MIS development, on the basis of multiple interviewing medical staff employed both in ambulatory and clinical centers we have attempted to categorize their current problems and issues they could have in working with other software systems and try to avoid them in ours.

A typical problem is that windows or Web forms for inserting and editing data look endless. In situations where users need to fill in a form with many entries, we realized it was recommended to split this kind of forms into a set of smaller forms having logically organized fields, or even put them together in tab control. Using tab control in this kind of applications is questionable, and developers should be very careful about it. If we decide to use tabs on the GUI, then we must ensure that all of them are visible in a single row despite of screen resolution changes.

The next problem is that in much software there is a lack of descriptions and ranges of normal values on the forms. Also, the suggested values are not properly spelled, especially Latin terminology and sentences. We solve this problem introducing a modeling tool in our software. In our modeling tool we can define and update all labels, notices and ranges of value that appear in forms and update translation resources.

In many cases users describe themselves as "lost in application". When the functionality of the medical process is such that it demands entry (or choice) of a large amount of data, and more than one windows form is opened, and more than one "save" action is necessary, users after a while do not know where they are, or what they have recorded yet, and what to do next. In order to avoid this, we designed our interface on the way that one opened form can have in a time active only one sub-form or notification.

Similarly to previous problem, medical professional sometimes claimed that they "lose a patient" in the system. If system demands moving patient from one list to another many times during a medical examination, in some systems, one wrong mouse click and the patient is completely "lost" in the system. We maintain lists of patients (waiting, active, examined) where access to those lists are done by a single click in the admission form. At the same time, a user can apply general search by patients and get a direct link to a patient whenever he/she is located in the system.

Another crucial problem in some systems is that the search for a right value is slow and endless. Also, somewhere combo boxes contain hundreds or even thousands of values which results in too much of the working time being lost in searching. Starting with a fact that all catalogues are similar as entities, that they usually have the name and some kind of code for every item, we made searching through 3 attributes (which are configurable). Every catalogue is modeled with a database table. *Search component* is independent and it links to a table. It addresses database after the third typed character (third is default, but configurable), and it gathers the appropriate dataset, which usually consists of a few dozens or only few items. Filtered items are shown under edit boxes, and user can easily, using mouse or keyboard arrows, choose the proper value, or can keep typing and narrow the selection to one or two items. Performing the same search process for every catalogue in all modules, we provided a kind of introduction of user applications in the daily routine and their getting used to working with the system quickly. Another important item that we avoided by this approach, which concerns the efficiency of the system, is the congestion that can occur when hundreds of concurrent users search through the same catalog in the database. Because the filtering is done after the third key typed, the dataset that the server returns to the client consists of ten or twenty records, the traffic in the network is greatly reduced compared to constant loading of entire catalogs.

Too many rows lost because application did not ask the user: “Are you sure…” and the wrong mouse-click were fatal. Any update or delete action within our system is prompted for confirmation before. Furthermore, update and delete actions could be configured to store the older version of the record instead of removing it. Scrolling up/down and scrolling left/right are too frequent. In every process we supported, we tried to fit all interface elements into one screen and maximally reduce the need for scrolling. Also, system support involves constraints for numeric values where user gets warned to confirm entering of values that are much (configurable) higher or lower than usual, or even to reject such value. That is, if user types 40 for body temperature, the value will turn red (marking high value), but if user accidentally enters 405 (instead of 40.5), the system will react and either forbid this entry or prompt user to confirm.

In most cases medical information systems are charged with a large number of users, hundreds or even thousands of them. It is almost impossible to satisfy the great population like that with user interface in any kind of area. However, health care as a very important feature of a modern society requires fast and reliable systems, considering the fact that one side of systems are live people, with limited response waiting time (babies, the old, ill people, etc.). Sometimes that time is critical, as when it comes to emergency situations. MIS instead of paperwork is a huge change, especially for medical staff with 20 or more years of working experience. It can seriously reduce their working performance, and produce long lines of patients in the waiting rooms, in its initial phase.

Thanks to the effective and “looking familiar” user interface we managed to reduce basic training time needed for GP doctors and dentists from the initially planned one to two days (on average, 8 hours effectively) to 3 – 4 hours. This is much better than average training time (2 – 3 days) provided by other MIS suppliers in the Republic of Serbia. Training time for specialist doctors is between one and two hours, since they have significantly less paperwork to do than GPs. On the other side, training for system administrators and administrative personnel from human resources and finance department lasts about a week, since they need to acquire some new concepts in their work, but this time is in line with other systems.

5.3. Guidelines – Summary

To summarize, we can divide our guidelines in three groups that will follow major information system initial life stages – system architecture design, system development, and system deployment including user training guidelines. In architectural design guidelines we can point out the following as most important – choose optimal architecture that will make your system response as fast as possible, provide support for work in disconnected environment, enable data merge and replication, and ensure that the system can work at least with two different databases. While the MIS is being developed, the following must be considered – involve prospective user in the development process from the beginning, let user test future system as much as possible, choose GUI layout on such way that it ensures that user does not get confused, make GUI look familiar (resembling the existing paper based forms), keep interface consistent, reduce the number of clicks, reduce the number of active forms at the time, avoid scrollable components as much as possible.

Deployment guidelines are also important because a wrong decision can significantly prolong the whole process. The main guidelines in the deployment stage are – ensure that the management of the target institution support the whole project, ensure that the target institution has at least one person with a sufficient level of IT knowledge, train IT support staff members in the client institution better and before the others, train future users group by group, do not start with active use in all departments at the time, rather one by one, encourage prospective users to share knowledge about the system and thus help each other. Without cooperation with future users we cannot even imagine a good MIS as a result, since the views are always different from the designers and user's points of view. Interaction with future users should not be a waste of time to the designer in any case. On the contrary, the more time spent in the data definition phase of the development process will result in less time spent looping, and users will be more satisfied, and give less resistance to the introduction of the new software.

Three things have proved to be important for designers of medical information systems in our project in the system-user interaction: neutralize the fear of introducing innovation in the work process with having these innovations presented in the user-close way; keep the user in the process of the similar daily routine work that was before the introduction of new system; and enable quick and easy way of using system functions without suggesting the user what is their future step or choice in working with the system. Consistency in the interface of the module and all forms is necessarily implied. In order to reduce user errors it is necessary to reduce the entrance of free text to the minimum, and wherever there is a predefined catalog, user should be given the choice of appropriate values. The lower number of values for choosing user gets, the quicker choice they will make, and the error count will be smaller. Appropriate search component can be a solution to that, as shown in the previous chapter. The order of fields in the form should follow the established working process, and the design of the form should always have at least one thing that user will recognize at the first human-system contact.

6. Future Work and Conclusion

Currently we are working on several modules that will support additional specialist and sub-specialist clinics and generally, improve parts of the system developed for secondary and tertiary care. In the near future we will start to deploy our system in clinical environment. All experience we got during the last ten years formulated in set of deployment guidelines will make our future work more effective, and our prospective users will work better on more efficient systems.

The further development of biochemical laboratory software is another ongoing development process. We have supported connection to several lab analyzing devices, but we need to enlarge this set and make available connection between our system and other types of medical devices. As part of same project, notification service for informing doctors and patients about significant events is about to come. In the next period we will give particular attention to enriching our MIS with business intelligence (BI) module and a special search engine for data retrieval. At the end of the project, our software should provide complete support for both ambulatory and clinical care and their collaboration, be fully appropriate for Serbian circumstances, have features of modern MIS from developing countries, and enable interoperation of our MIS with other information systems in Serbia and abroad. We hope that our solution will be applicable to other developing countries that have a similar organization of the health system as the organization in Serbia.

For this perspective, one of the next tasks we will have in the future will be moving some of previously developed applications to our new system. We had a good candidate in an information system developed for cardiologic clinic [49] that could be incorporated into our new system. In the case when one needs to move old software to SOA environment we found some interesting works presented in [50] and [51]. The paper [50] describes a system that incorporates the already existing middleware components and is based on SOA. Furthermore, the authors in [51] give a case study containing guidelines for transiting old software to SOA architecture. In this paper we wanted to present major challenges we have in the development of different medical information systems intended to be used in the Serbian healthcare system, and based upon ten years of experience in this domain. Also, we wanted to describe lessons learned and to present implementation and deployment guidelines, focusing on system deployment strategy and GUI development guidelines.

Some of the main requirements and challenges that we encountered were to keep MIS electronic documents and procedures/processes as close as possible to the existing paper documents (particularly due to low computer skills of many target users), to minimize direct entry (typing) of medical data, and to remain compatible with the existing organization of the Serbian public healthcare system. Also, we have in mind that the system should support both most important paradigms in healthcare delivery – patient centric and evidence based medicine. Having the previous experience with medical information systems we had to update our complete development process by higher participation of medical personnel.

Solving our major challenges, learning during complete system deployment process we manage to define set of guidelines to help us during complete MIS life cycle. We managed to make overall system deployment faster and to reduce time needed for medical personnel training. Having in mind that we involved medical staff from the beginning of the project, defining both architecture and GUI design guidelines and specify incremental deployment strategy we become able to deliver more suitable software product to our end user in shortened time and with higher acceptance rate.

References

1. Simonazzi, A.: Care regimes and national employment models, Cambridge Journal of Economics, Vol. 33, 211-232. (2009).
2. Health care system and spending in Serbia, Report, on current status www.healthsystems2020.org/.../2285_file_NHA_health_expenditures.doc
3. Gajic-Stevanovic, M.: Healthcare System and Spending in Serbia, report for 2003-2006, taken from http://www.healthsystems2020.org/ content/impact/detail/2285/
4. Jovanović, V., Milošević, B., Potter, B.: Improving quality of primary healthcare in Serbia, Int'l Journal on Total QualityManagement & Excellence, Belgrade, Serbia, Vol. 35. No.1 - 2, 347-352. (2007)
5. Serbia Health Additional Financing, World Bank Project Database, http://web.worldbank.org/external/projects/main?Projectid=P110593&theSitePK=40941&pagePK=64283627&menuPK=228424&piPK=73230
6. Revitalizing Serbian Health System, European CARDS Project Report, http://ec.europa.eu/enlargement/pdf/financial_assistance/cards/cases/036_en.pdf
7. Web site for upload financial reports used by Serbian health institutions http://www.lat.rzzo.rs/index.php/component/content/article/122.html
8. Bensing, J.: Bridging the gap. The separate worlds of evidence-based medicine and patient-centered medicine. Patient Education and Counseling 39 17–25. (2000)
9. Siemens Soarian website, http://www.siemenssoarian.com/
10. OpenERP website, http://www.openerp.com/
11. Heliant website, http://www.heliant.rs/health
12. Tzu-Hsiang Yang, Yeali S Sun, Feipei Lai: A scalable healthcare information system based on a service-oriented architecture, Journal of Medical Systems (impact factor: 1.13). 06/2011; 35(3):391-407. DOI:10.1007/s10916-009-9375-5
13. Amouh, T., Gemo, M., Macq, B., Vanderdonckt, J., Gariani, A.W.E., Reynaert, M.S., Stamatakis, L., Thys, F.: Versatile clinical information system design for

emergency departments, Information Technology in Biomedicine, IEEE Transactions on, Volume: 9 , Issue: 2 , 174 – 183. (2005)
14. Teixeira, L., Ferreira, C., Santos, B.S., Martins, N.: Modeling a Web-based Information System for Managing Clinical Information in Hemophilia Care, Engineering in Medicine and Biology Society, EMBS '06. 28th Annual International Conference, 2610 – 2613. (2006)
15. Rajković, P., Janković, D., Tošić, V.: A Software Solution for Ambulatory Health Facilities in the Republic of Serbia, HEALTHCOM 2009 - 11th International Conference on e-Health Networking, Application and Services, Sydney, Australia ISBN: 978-1-4244-5013-8, 161-168, (2009)
16. Rajkovic, P., Jankovic, D., Stankovic, T.: An e-Health Solution for Ambulantory Facilities, ITAB 2009, Vol. 1, Nr. 1, Fr. 1.5.1 1-4, Larnaca, Cyprus. (2009)
17. Hwang, S.C., Lee, M. H.: A web-based telePACS using an asymmetric satellite system, IEEE Trans. Inf. Technol. Biomed., vol. 4, no. 3, 212–215. (2000)
18. Smart client architecture, http://msdn.microsoft.com/en-us/library/ff647359.aspx
19. ZipSoft website, http://www.zipsoft.rs
20. GE Centricity website on GE Healthcare, http://www3.gehealthcare.com/en
21. Allscripts, http://www.allscripts.com/en/solutions/ambulatory-solutions/ehr.html
22. Sung-Huai Hsieh, Sheau-Ling Hsieh, Po-Hsun Cheng, Feipei Lai: Telemedicine and e-Health, April 2012, 18(3): 205-212. (2012)
23. Zhang Xiao-guang, Li Jing-song, Zhou Tian-shu, Yang Yi-bing, Chen Yun-qi, Xue Wan-guo, Zhao Jun-ping: Design and implementation of Interoperable Medical Information System based on SOA, IT in Medicine & Education, 2009, Volume: 1 Digital Object Identifier: 10.1109/ITIME.2009.5236236,1074 – 1078. (2009)
24. Tsiknakis, M., Katehakis, D. G., Orphanoudakis, S. C.: An open, component-based information infrastructure for integrated health information networks. Int. J. Med. Inf. [Online] 68(1–3), 3–26. (2002)
25. Stankovic, T., Jankovic, D., Pesic, S.: Public Health Care Distributed DBMS with Resolving Database Replication Conflicts in the Health Care Information System Project Early Phase, 9th TELSIKS, Vol. 2, 487-490.(2009)
26. Stankovic, T., Pesic, S., Jankovic, D.: Platform Independent Database Replication Solution Applied to Medical Information System, LNCS, Springer-Verlag, Berlin Heidelberg, Vol. 6295, 587-590. (2010)
27. Poissant, L., Pereira, J., Tamblzn, R., Kawasumi Y.: The impact of electronic health records on time efficiency of physicians and nurses: A systematic review, Journal of the American Medical Informatics Association**,** Volume 12, Issue 5, 505-516. (2005)
28. de Lusignan, S., Hague, N., van Vlymen, J., Kumarapeli, P.: Routinely-collected general practice data are complex, but with systematic processing can be used for quality improvement and research, Informatics in Primary Care, 14 (1), 59-66. (2006)
29. Thompson, D., Johnston, P., Spurr, C.: The Impact of Electronic Medical Records on Nursing Efficiency, The Journal of Nursing Administration, Volume 39,Issue 10,444-451. (2009)
30. Wilson, J. F.: Making Electronic Health Records Meaningful. ANN INTERN MED 151: 293-296. (2009)
31. Adler-Milstein, J., Bates, D.W.: Paperless healthcare: Progress and challenges of an IT-enabled healthcare system, Business Horizons, Volume 53, Issue 2, 119-130. (2010)
32. Garrido, T., Jamieson, L., Zhou, Y., Wiesenthal, A., Liang, L.: Effect of electronic health records in ambulatory care: Retrospective, serial, cross sectional study, British Medical Journal, 330 (7491), 581-584. (2005)

33. Wang, S.J., Middleton, B., Prosser, L.A., Bardon, C.G., Spurr, C.D., Carchidi, P.J., Kittler, A.F., Bates, D.W.: A cost-benefit analysis of electronic medical records in primary care, American Journal of Medicine, 114(5), 397-403. (2003)
34. Tai-Seale M, McGuire TG, Zhang W: Time allocation in primary care office visits**.** Health Serv Res 2007, 42(5)**:**1871-1894
35. Rajkovic, P., Jankovic, D., Stankovic, T., Tosic, V.: Software tools for rapid development and customization of medical information systems, 12th IEEE International Conference on e-Health Networking Applications and Services (Healthcom 2010), 1-3 July 2010, Lyon, France, 119-126. (2010)
36. Jankovic, D., Stankovic, T., Rajkovic, P.: Comprehensive data reporting approach in health care information systems, International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC), Valencia, Spain, 20-23 January, 456-460. (2010)
37. The standard about medical information privacy: HIPAA: medical privacy in electronic age, https://www.privacyrights.org/fs/fs8a-hipaa.htm
38. Sandhu, R.S., Coyne, E.J., Feinstein, H.L., Youman, C.E.: "Role-based access control models," Computer, vol.29, no.2, pp.38-47, Feb 1996
39. Stanković, T., Rajković, P., Milenković, A., Janković, D.: User Interface in Medical Information Systems – Common Problems and Sustainable Solutions, *Electronics*, vol. 14, No. 2, 59-64. (2010)
40. Stanković, T., Rajković, P., Milenković, A., Janković, D.: From optional talk to medical information system's user interface, INFOTEH, Jahorina, Vol. 9, E1-1, 894-898. (2010)
41. Rita Kukafka, et al,: Redesigning electronic health record systems to support public health, Journal of Biomedical Informatics Volume 40, Issue 4, 398-409. (2007)
42. Meyer, R.' Degoulet, P.: Choosing the right amount of healthcare information technologies investments, International Journal of Medical Informatics**,** Volume 79, Issue 4, 225-231. (2010)
43. Bates, D.W.: Physicians and ambulatory electronic health records*, Health* Affairs, 24 (5), 1180-1189. (2005)
44. Blumenthal, D.: Stimulating the adoption of health information technology***,*** New England Journal of Medicine*,* 360(15), 1477-1479. (2009)
45. Ash J.S., Bates D.W.: Factors and forces affecting EHR system adoption: Report of a 2004 ACMI discussion, Journal of the American Medical Informatics Association**,** Volume 12, Issue 1, 8-12. (2005)
46. Ludwick, D.A., Doucette, J.: Adopting electronic medical records in primary care: Lessons learned from health information systems implementation experience in seven countries, International journal of medical informatics 78, 22–31. (2009)
47. Iyatomi, H., Kasamatsu, T., Hashimoto, J., Emre Celebi, M., Schaefer, G., Ogawa, K.: Perioperative cardiac risk prediction, ITAB 2009, Larnaca, Cyprus, 1-4, (2009)
48. Katertsidis, N.S., Katsis, C.D., Fotaidis, D.I.: INTERPID, a biosignal-based system for monitoring of patients with anxiety disorders, ITAB 2009, Larnaca, Cyprus, 127-134. (2009)
49. Rajković, P., Vučković, D., Milojković, J., Janković, D., Cardio clinic information system realization, Electronics, Banja Luka, Bosnia and Herzegovina, Vol.9, No. 1, 41-45. (2005)
50. Katehakis, D.G., Sfakianakis, S.G., Kavlentakis, G., Anthoulakis, D.N., Tsiknakis, M.: Delivering a Lifelong Integrated Electronic Health Record Based on a Service Oriented Architecture, IEEE Transactions on Information Technology in Biomedicine, Volume: 11, Issue: 6, 639 – 650. (2007)

51. Cuadrado, F., Garcia, B., Dueas, J.C., Parada, H.A.: A Case Study on Software Evolution towards Service-Oriented Architecture, 22nd International Conference on Advanced Information Networking and Applications, pp 1399 – 1404, (2008)

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