E-Health Transformation Model in Serbia: Design, Architecture and Developing

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E-health Transformation Model in Serbia: Design, Architecture and Developing

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***Abstract* - Electronic health (e-health), or the electronic health system, allows a more efficient performance of all participants in the healthcare chain reducing administrative costs. In developing e-health, healthcare institutions are given an opportunity to improve the quality of their services through the use of advanced electronic systems. This paper presents the strategy of designing and developing a health information system, i.e. storing of all information on health status of every citizen in a central database. It should take the form of an electronic health record, while the citizens will have their own personal health record - file, which will allow communication with the central database. Unlike some other types of electronic transactions, where security issues are predominantly concerned with payments, e-health has an added "complication" of sending confidential, important and sensitive information over the Internet. For this reason, introduction of electronic "smart" cards within the new health information system (HIS) is planned, as their security encryption mechanisms will ensure secure communication within the proposed system.**

Keywords: Electronic health, Electronic health record, Health Information System, Smart card, developing health system database.

I. INTRODUCTION

Until the end of the last century there were objective technological limitations on the exchange of large amounts of information generated in the process of treatment of every man, and those limitations are an obstacle for the active involvement of patients in the course of treatment [1]. Paper as a carrier of information has been physically transferred from doctor to a doctor, from one institution to another and during all this time the patient had to wait for the competent body to process his case. Modern information technologies fundamentally change the position of the patient and his role in the treatment process. New technologies for the first time in history, give man the possibility to make decisions concerning his welfare and to have control over the selection, quality and price of health care services.

The introduction of e-health eliminates paper as a medium allowing all information about the patient and his health status to be recorded in electronic form. Through Internet technology, a patient can freely gain insight into the stage of his problems at any time. Internet can serve patient as an instrument by which he will be able to get many useful information. Based on this knowledge he can make a better choice from a large number of suppliers of health services. With the development of electronic health care, health care institutions have an opportunity to introduce an advanced electronic management systems which improves service quality [2]. Business processes in health care facilities are extremely complex and involve the use of modern information systems of electronic health care.

The functioning of the health system meets many different models of e-health as follows: Government to Business (G2B), Government to Customer (G2C), Business to Business (B2B), Business to Customer (B2C) and Business to Employees (B2E). The most common model is B2C because it largely meets the needs of health care and the needs of health workers.

II. PREVIOUS WORK

Previous work primarily concerns e-health from a different perspective. In [3] experience with the design and implementation of the Health Information System in Fiji across medical facilities is presented. This paper discusses the synchronization of multiple databases, and various issues that have arisen since implementation. The report [4] describes the perception of the e-health progress in Romania and its further requirements. The paper [5] evaluates technical and organizational aspects of Dutch Electronic Health Record, partly based on practical experience.

In [6] factors for successful implementation and efficiency of Electronic Medical Record System based on templates are evaluated. Above mentioned papers as well as many other are discussing the possibilities and evaluates implementation without additional involvement in database design.

As we have noticed so far no one has presented database design for e-health institutions which would include the entire health system. This approach will help in future, to all who will work on further research and implementation of this issue.

III. COMPONENTS OF E-HEALTH

Using Information and Communication Technology (ICT) in the health care system should change and improve patient's care and public health, reduce costs, save money and time and provide information for technical, scientific, administrative, accounting and management use [4]. In this sense, the concept of e-health becomes more significant and important. This paper proposes the use of hybrid "smart card" (RFID and IC) as a starting point in the strategic planning of the new concept of e-health in Serbia. A hybrid smart card is a plastic card of standard format with RFID antenna and microchip. A small microchip is able to receive a relatively large amount of information, for example the same as a daily newspaper. Chip card is a small computer

capable to perform calculations and exchange information with the environment. RFID part of the smart card allows the use of contactless readers which can significantly improve procedures for registration, treatment and authentication. Basic components of the new e-health system, which will be developed in Serbia, are:

- The Health Information System (HIS) - allows authorized entities to access information, accurate records of costs and control parameters for each participant in the system. This approach allows the preparation of precise plans and strategies, which prevent arbitrariness and reduce the scope for abuse.
- Electronic Health Record (EHR) - is the storage for all information related to the health of the patient. This information is presented in the form that a computer can process.
- EHR applications – allow the creation of patient's records, scheduling proposal and recording of visits to personal doctors (medical history, diagnosis, treatment, services, ...), then the issuance of instructions and other medical documents.
- Personal Health Record (PHR) - a set of Internet tools that allow people to access their own health information accrued during life, coordinate their use. Some information can be available to those who need them (doctors).
- Electronic Health Card and Doctor's Card - an electronic card tending to replace traditional health booklet. It is usually made as a multifunctional smart card (Java, .NET,…) which is not only different in form, but also in function. Compared to the previous, Electronic Health Card has a microchip and RFID antenna (Figure 1.) that can store and transmit data and information.
- Electronic Recipe - is an electronic document which replaces traditional paper issued by doctors. Essentially, no difference between the recipe issued on the paper of Health Insurance Institute and the new electronic recipe [7].

Figure 1. The example of Electronic Health Smart Card

IV. Architecture of the new concept of e-health in Serbia

Implementation of e-health in Serbia represents a new, centralized system that would be installed and managed by the relevant institution. Also, within these institutions, there would be a special department for publishing of health cards and renewal of certificates – Certification Authority (CA) [8], [9]. All other health care facilities or their HIS would be directly connected to Central Database through the appropriate WAN network. They organize the Intranet Health Network. Health facilities in distant and rural locations access to a centralized database via the Internet. Central database is useful for management, but have to provide redundancy and data recovery in terms of performance failure or catastrophic events like earthquakes, tsunami etc. It is necessary to ensure disaster recovery on two physically locations with a minimum distance of 150 km.

Also, this approach would be possible for private clinics and other medical institutions which have signed contract with the relevant institution. Patients would have access to relevant information and applications of Central Database (HIS) via web portals. A system organized in such a manner would enable patients to have home access to PHR or other medical information [10]. In this case, patients must have appropriate equipment (PC with integrated or external card reader) that enables them secure communication and data exchange with the database.

The architecture of the network used in this work was done by a client-server model:

- Server process is started on the computer on which it is hosted, runs and then goes into sleep mode and waits to be contacted by a client process that asks it for a service;
- Client process sends a request over the network to the server and asks it for a specific service;
- When the server process completes its work demanded by client, it answers back and goes to sleep waiting for the next request.

In new architecture of network for the implementation of e-health in Serbia illustrated on figure 2., "server" is the central database. The basic advantage of using client-server architecture is that it is now independent of database applications, because the integrity of the database ensures its independence from the applications which run over database. For the successful functioning of the whole system and adequate response for developed applications on the client computers, high quality communication links must be provided. All clients access servers from remote locations through these links and all health institutions must be directly connected to the intranet network and the server room. TCP/IP (Transmission Control Protocol/Internet Protocol) and protocols for data encryption such as IP Security Protocol (IPsec), Layer 2 Tunneling Protocol

(L2TP), Secure Socket Layer Protocol (SSL) are being used for client/server communication. As a possible solution for communication links: they can be rented (e.g. optical SDH, E1 copper, ...) from Telekom Serbia or any other operator or the GSM/GPRS (Global System for Mobile Communication/General Packet Radio Services) modem can be used for communication with remote primary health care facilities in rural areas where there is no possibility of establishing a direct line links. Recommended bandwidth for these ways of communication is 0.2 Mbit/s. This bandwidth is optimized for sending/receiving of 1 MB scanned images. Estimated time for the transfer of such data is 40s which is acceptable for this purpose. All other customers (patients, private pharmacies...) access data that are stored on the server through a web portal or web sites of health centers.

Since the data anonymity and security in e-health system are important requirements for this system implementation, the new solution of the health organization, where almost all of the information exchange "electronically", pays special attention to security of information transfer and access restrictions [11]. For this purpose, new devices and systems are implemented and they prevent and restrict access to certain information. Therefore, firewall, smart card and cryptographic mechanism (PKI - Public Key Infrastructure) are used for security and encryption of information. In the public key database are stored data about authorized users who have access to documents on a variety security levels.

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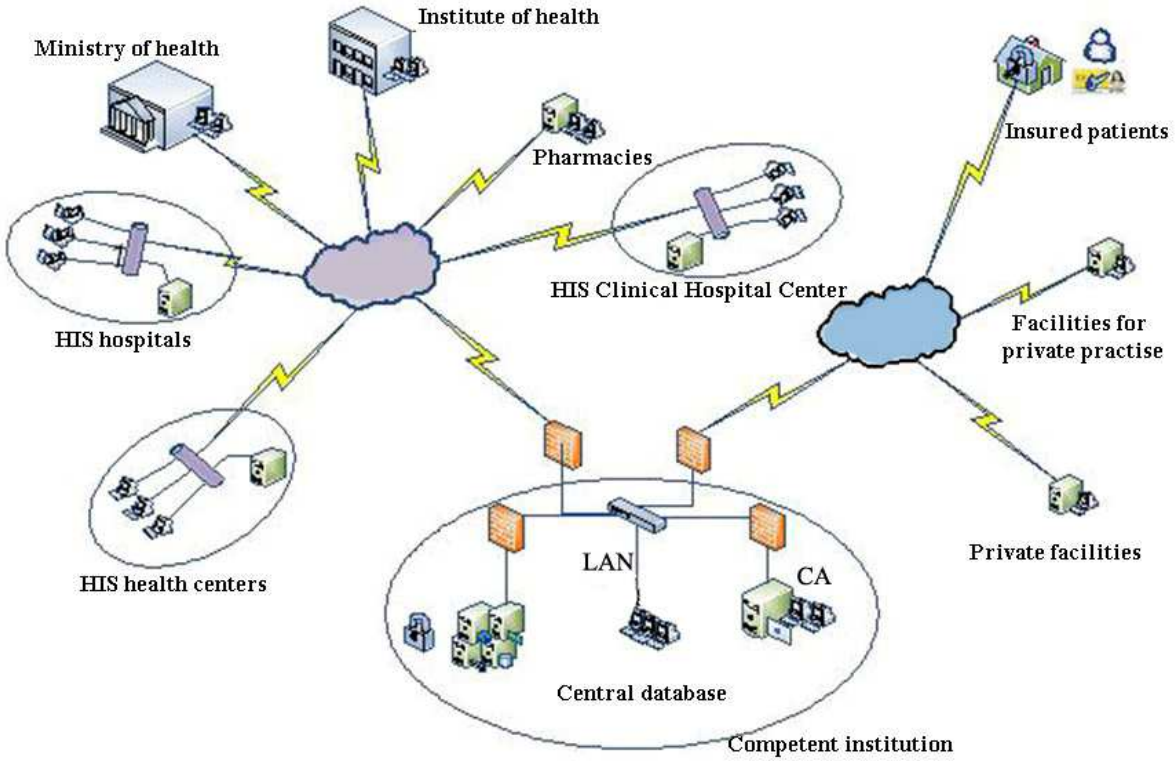

Figure 2. Architecture of new solution of E-Health in Serbia

A. The database

The database (Figure 3.) is implemented in SQL Server 2008 software. After populating the data into it, it becomes a complete unit, which includes everything from information about the patient, physician and the information about institutions that are an integral part of medical practice.

The database is very important for doctors because using it helps them see the history of the disease, prior therapy and on this basis they can make decisions about further treatment of the patient. All data are located in one database and each user can access the information he is authorized to. Also, through the interface it is possible to create different views depending on user rights and roles in the system (e.g. doctor should have the authorization to see sensitive information about a patient - social security number, etc.). Also, logged users can see information which is filtered through policies.

Information in the database are also used by the Ministry of Health, because of the possibility of monitoring and controlling the distribution of drugs and preventing the

double issue of drugs by either a doctor or other manipulations that are related to the distribution.

This database is accessed using the access hybrid smart card (ID card). When a user accesses it by ID card, then the user rights are loaded, so the available data structure corresponds to the user permissions. Database containing information on the time of serving patients in some health institutions (primary, secondary, tertiary), the number of examinations, number of surgical and other interventions, can be further used to improve medical practice when the need for expansion of resources in the medical center is recognized [12].

The main constraint is related to Internet availability. It is assumed that all medical centers have some stable Internet connection in order to use web application. Otherwise, it is necessary to synchronize data in databases doing replication at least once a day and instead of using web application, similar Intranet application can be developed based on Microsoft SharePoint technology.

The database scheme is shown on the Figure 3. Only crucial tables will be explained here. The central part of the scheme is table “Patient” where all data for all patients are stored. Table “Patient” is related to many tables, forming many-to-many relationships with “lab_analysis” (stores laboratory analysis for a patient), “medical_snapshot” (stores medical records for a patient), “alergy” (stores all kinds of allergies), etc. Although all patient’s data is stored in one place, different access roles are defined and regular users do not have access to the patient’s sensitive data. Also, depending on the role, not everyone will be able to change the data. In order to avoid unauthorized access on the database level, different views can be created and only administrators will have rights for managing the data.

Another table that plays crucial role is “Health_id_card” and is related to Personal Health Record (PHR). It represents a connection between table “Patient” and table “Illness” which contains data about all known diseases. In “Health_id_card” time periods for a patient suffering from any illness are stored. In addition, it is used for storing information about a patient’s chosen doctor.

In order to avoid different kinds of drugs manipulation, all drugs prescriptions must be tracked. Table “Therapy” is used for storing data related to patient’s therapy, amount of prescribed drugs, and checking doctor’s permission for prescribing it. This is the control of unauthorized drug usage.

From the customer’s point of view, the most important table is “Check” where all appointments are stored. In addition, this table can be used for tracking doctor’s effectiveness by calculating number of examined patients as well as for calculating the next available term.

If a patient wants to make an appointment it is enough to have Internet access, and to log on using his credentials. System is able to recognize him and to give him available terms for a chosen doctor. If he is unable to come, he can cancel and then that term will be automatically visible for another patient. The medical staff does not have any possibility of changing order of patients that will be examined. The scenario of patient’s arrival in an appointment term is shown in Diagram 1.

Many other checks can be done at the same time. Patient’s ID card can also be checked, if he has paid off his debts. Also, a prescribed receipt will be placed on his ID. A pharmacist, using a card reader will be able to read it and to sell it. In order to save user’s sensitive data, all other data except a prescribed medicine will not be visible. The information of a bought drug will be entered, and a patient will not be able to buy it elsewhere without renewing doctor’s prescription. Also, if a drug is marked as free, a refund costs will be retrieved.

When further examination is necessary, or when patient had to be transferred to some other medical centre, a chosen doctor is able to prescribe a reference for another institution. That prescription is stored in a central database as well as in a patient’s ID card. By querying available terms, a patient is informed about available terms and is able to confirm it. After his confirmation, the information becomes visible in another institution. The procedure of cancelling or changing an appointment is the same as in a regular medical centre. This scenario is described on Diagram 2.

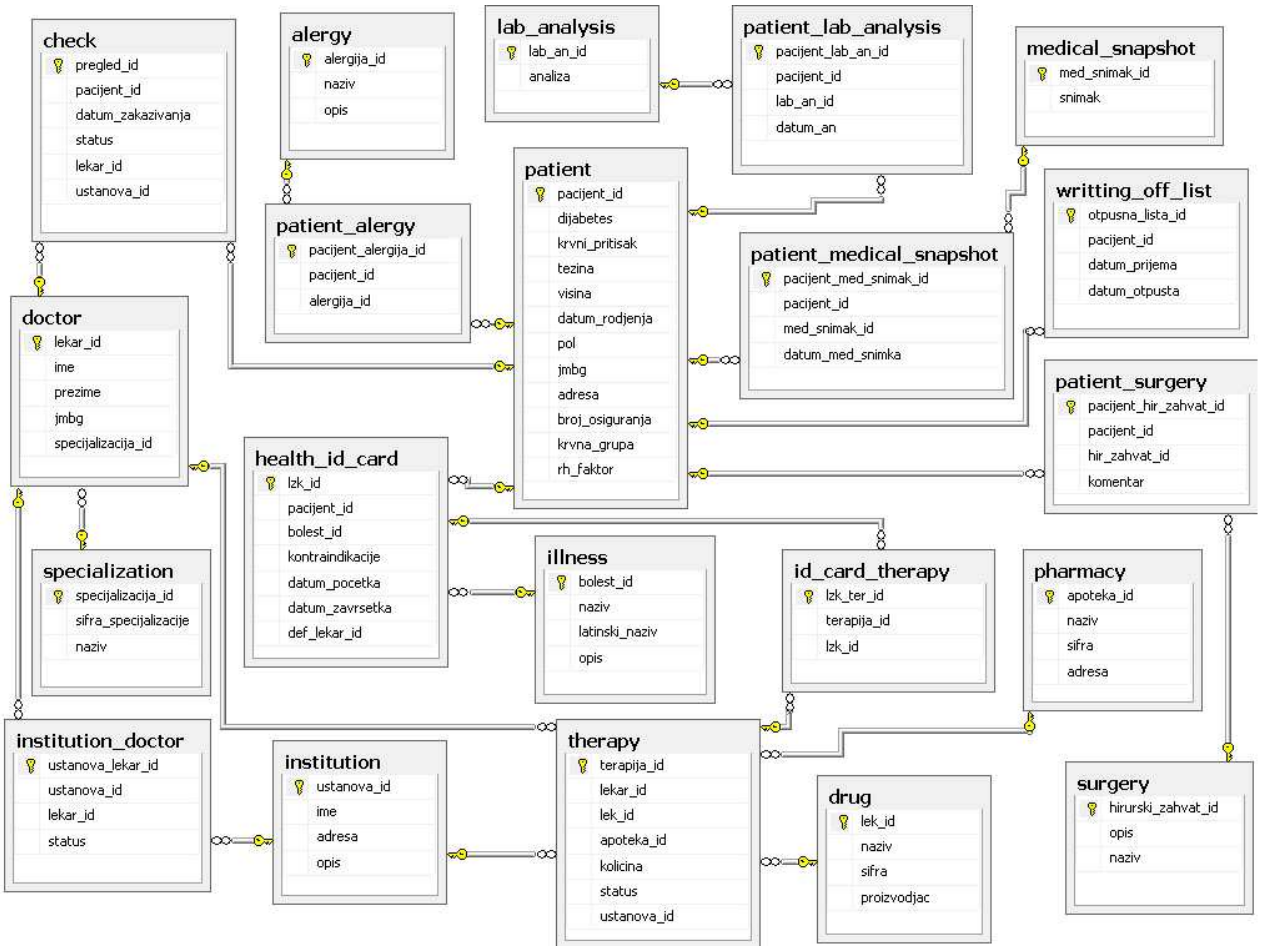

Figure 3. Electronic Medical System Database Structure – Central Database

V. USE CASE OF THE NEW E-HEALTH SYSTEM

The proposed system of e-health in Serbia is based on the electronic information exchange between participants (patients, doctors,...) of e-health system on one side and a central information system or database on the other side. It means that all medical data and all patient information are stored in one place and users of e-health system can access data from any point of any HIS. EHRs belong to doctors and they are stored in particular HIS (health centers, hospitals...), while the PHRs belong to patients and they are stored in a central database.

A. On line model

In the proposed model, web sites of health centers should represent an additional interface for patients enabling them to provide more information and certain services. It is intended that the patients can get information about the schedule of their doctor, control schedule and more. When the patient wants to schedule an appointment with the chosen doctor he can do it in two ways:

- From home - by visiting the web site of health center or health care institution at the primary level and through the patient portal, he schedules the examination selecting the corresponding free term of chosen doctor.
- In medical center - with the help of e-stand and related applications for an appointment, patient selects an available terms for his own doctor.

Selected term is recorded in the institution's HIS and it automatically makes a list of patients by day and by doctors. When the patient arrives to the appointment, he can see the expected waiting time on the e-stand. It gives a patient the possibility to cancel, change or wait for an examination. The appointment system is automatic and cannot be changed by medical staff. It helps to prevent examinations avoiding the queue.

When a patient comes to the doctor for examination, he/she proves identity with electronic hybrid smart card. The doctor inserts his ID card into the terminal along with the electronic health card of the patient in the same terminal, thus confirming in health center's HIS that patient has arrived at the scheduled time. To access the patient's electronic health card doctor enters his/her Personal Identification Number (PIN) code. In this way he opens the data that is visible to the card (under the public key, which is owned by his ID card), and which is needed to get access to examination of the patient and determine treatment. If

doctor wants, depending on the type of treatment, to access the relevant information from the patient's PHR, he can do that only with patient's approval, giving him PIN code. After the examination, doctor determines the diagnosis and close patient's EHR. Information about the examination, diagnosis, prescribed therapy, required laboratory analysis is stored in the EHR and PHR.

B. Off line model

The system needs to be applicable in all health facilities and because of that the proposed model in this paper includes so-called offline clients. Offline clients may be health care facilities or their terminals [14]. It is a situation when there are far-off health centers or their departments that can't be connected directly to the central HIS. This group also includes examinations that are performed beyond health centers, at patient's home. Offline mode involves the use of special terminals (with integrated contact and contactless smart card readers) that allow work with electronic health card and doctor's ID cards. System identification of patients is similar to the online mode. After performed examination these terminals make a connection to HIS through web applications or GSM card [15].

VI. PERFORMANCE EVALUATION

The effectiveness of Electronic Health Record is crucial fact due to the high costs of system deployment. There are six attributes for measuring performance that were postulated by DeLone and McLean [13], including: system quality, information quality, use, user satisfaction, individual impact and organizational impact [17]. These attributes can be measured only through system implementation, but it is obvious that proposed system outperform traditional approach. In table I. performance evaluation of EHR compared to existing model is presented.

This paper does not introduce EHR system that have decision support for managing patients, but overall platform can easily be updated.

Organizational impact is large as for the systems that have implemented the ERP into the company. The unique database system provides whole new perspective of managing and control of entire aspect of medical chain.

Proposed solution of e-health in Serbia processed in this paper allows better treatments for patients, reducing administration time and costs and significantly improves patient and user satisfaction. Patients are aware of potential risks related to the automation and sharing their medical information. This may lead them to refrain from giving information that could be crucial for their care. Distrust in privacy and security can lead to omitting sensitive information from medical records which reduces card's value for other specialist who treat patients, researchers and officials from the health sector. However, with conscientious reflection, constant care and attention, the use of information technology in health care can and should be strengthened, without threatening to the security and privacy of personal health information. In addition, organizational and individual aspects of this model are very important.

This model allows strengthening and networking health institutions, a comprehensive exchange of information and experience in treating patients among related organizations - thereby contributing efficiency and training of health workers and improving of the health system in global. Benefits from the introduction of this system are not only for users and health workers through increased user satisfaction and training of employees in health care, but also for other participants in Serbian health system. This system allows relevant institutions to follow public health and state decisions to introduce such system which have reflected in the fact that we get transparent, reliable and fast service.

As it is emphasized in [16], Web 2.0 can be used as tool for clinical decisions and drug adviser, for nurses and care providers; but also for medical students learning purpose. Web 3.0 is new standard which may be utilized in future system implementation.

This platform than can be used for specialization and learning on real life problems on populated database copy; but security expectations then must be reconsidered.

TABLE I. PERFORMANCE EVALUATION OF ELECTRONIC HEALTH RECORD

Attributes	**Performance**
System quality	Increased comparing to the traditional approach
Information quality	Outperform existing (all information on one place)
User satisfaction	Amply (more efficient work processes)
Individual impact	Large scale (reduced waiting, scheduling, etc)
Organizational impact	Extensive (all medical institutions)

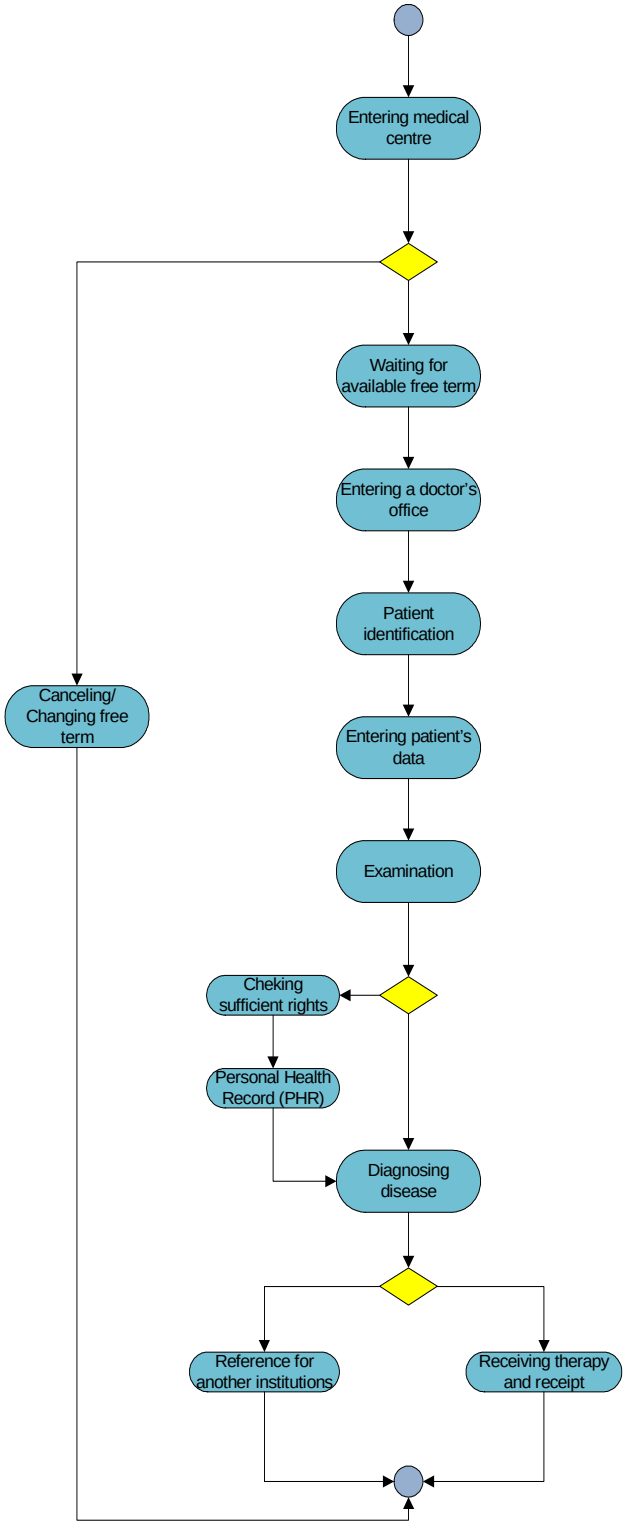

Diagram 1. Activities when patient visits health center

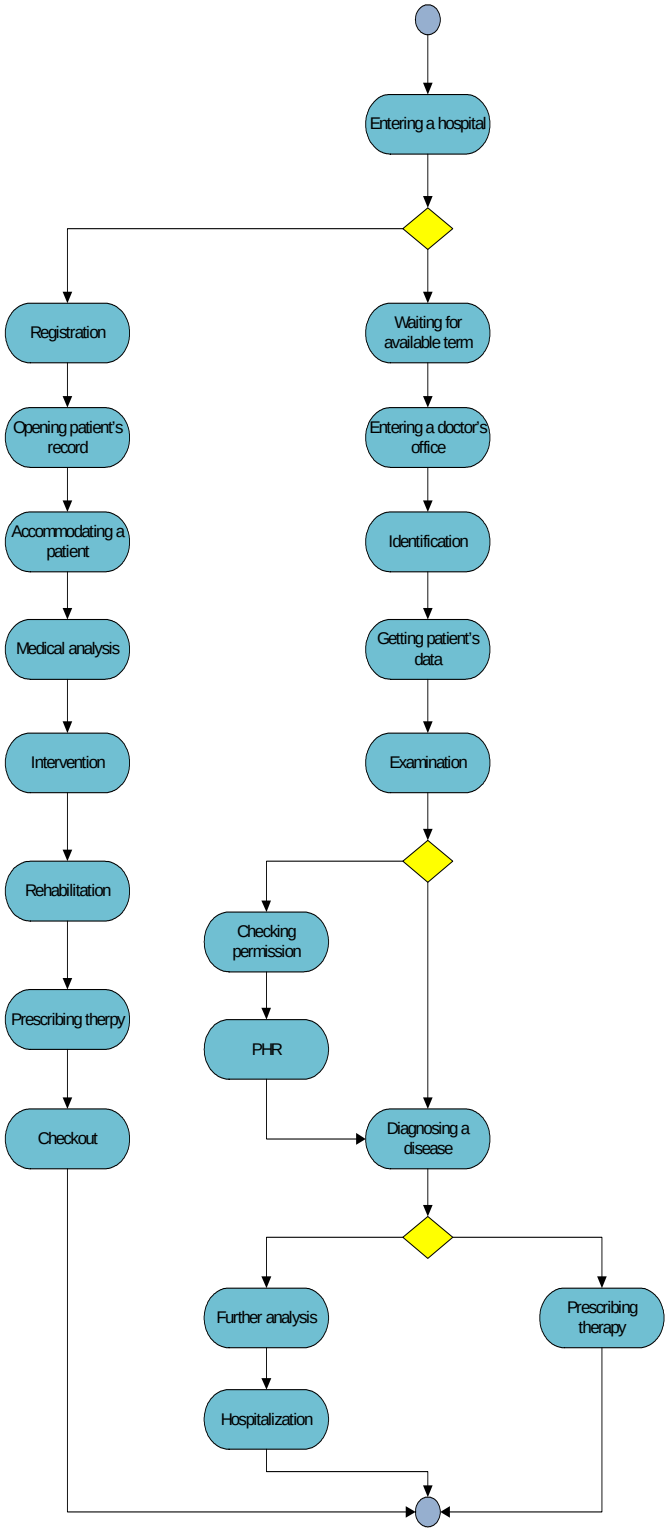

Diagram 2. Activities diagram - hospital

VII. Conclusion

In this paper design, architecture and developing strategies of the health information system in Serbia are presented; under which information about the health of every citizen will need to be archived in a central database. By establishing this new concept in Serbia, all participants in medical sector would get opportunity for better treatment, services and higher user satisfaction. It should be in the form of electronic health records, while the citizens will have a personal health record - a file that will allow communication with the database. The introduction of e-health eliminates paper as a medium allowing all information about the patient and his health status to be recorded in electronic form. Through Internet, patient can freely gain insight into his record at any time.

The most important contribution of this e-health system in Serbia can be reduced to the introduction of an entirely new kind of medicine - telemedicine, which is the basis of future health information systems in developing countries. Telemedicine (distant healing) is usually defined as a way of providing health services which includes the use of ICT or the transfer of medically relevant information from a distance. Concept presented in this paper can also be used to conduct examinations and remote medical procedures as a simple way of telemedicine. This approach is umbrella included all elements of telemedicine: electronic personal record, telecommunication infrastructure and information technology. Future telemedicine can use architecture presented in paper for next implementation and developing also for remote monitoring and interactive services as important types of telemedicine. The largest contribution can be benefits for people living in isolated and remote regions. In this, physical location of the patient, provider services, medical information and equipment do not play any role. This concept gradually improves the entire health care system, providing a range of comparative advantages over traditional methods, which primarily require physical proximity and contact of individual participants in the treatment process. In this regard, it is expected that future research will be directed toward this new type of treatment and using of mobile technology. Recent developments in mobile collaboration technology with the use of hand-held mobile devices allow healthcare professionals in multiple locations the ability to view, discuss and assess patient issues.

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