Patient Data Integration in Electronic Health Record Systems

Galidiya Ivanova Petrova

Abstract - **This paper presents an overview of the employed approaches for integrating patients data in hospital electronic health records systems. Three basic models of electronic health records (EHRs) and health information exchange systems are presented. The arguments for adoption of Personal healthcare systems and Tele-health monitoring systems approaches for integrating patient data in EHRs in Hospital information systems are discussed.**

Keywords – **Electronic Health Record, Tele-health monitoring, Personal Healthcare Systems, Hospital Information Systems**

I. INTRODUCTION

The definition of e-health, as it is given in [1], is the application of information and communication technologies across the entire range of functions involved in the practice and delivery of healthcare. This includes a range of information such as patient's medical records, billing and payment information, employees and hospital information. One of the recognized implementations of e-health today involves the use of the Internet for storing, accessing and modifying healthcare information. However, e-health is a much broader field covering digitization of many healthcare processes and tasks, resulting in new names such as e-billing, e-payment, e-prescription, e-supply and e-records.

In order to be able to provide optimal patient care, it seems essential to guarantee optimized information logistics, which means providing the right information, at the right time, in the right quality, quantity and form, to the right addressees and at the point of care [2].

The concept of electronic health records (EHRs) has been introduced in order to deal with these challenges [3, 4]. Following the definition from ISO/TR 20514, the term EHR is understood as: "a repository of information regarding the health status of a subject of care in computer processable form, stored and transmitted securely and accessible by multiple authorized users. It has a standardized or commonly agreed logical information model which is independent of EHR systems. Its primary purpose is the support of continuing, efficient and quality integrated health care and it contains information which is retrospective, concurrent and prospective" [5]. In this aspect it is important to estimate the process of patient data integration in EHRs in hospital information system (HIS).

In this paper an overview of the employed approaches for integrating patient data in hospital electronic health records systems is presented.

G. Petrova is with the Department of Electronics, Faculty of Electronics and Automation, Technical University of Sofia, Plovdiv branch, 25 Tzanko Djustabanov str., 4000 Plovdiv, Bulgaria, e-mail: gip@tu-plovdiv.bg

II. MODELS OF EHRS

Looking from the point of view on the Hospital Information System and Clinical Information Systems (CIS) concept, three principal models of EHRs and related database are often used: Basic EHR model, Centralized universal EHR model and Distributed universal EHR model [6]. In the basic model a centralized EHRs Database is developed in the hospital, while in the hospital clinics and departments only workstations and terminals are located. All information systems in clinics, laboratory, radiology and other departments are connected to the centralized EHRs Database and the patients' data are accessible in the process of healthcare services – Fig. 1.

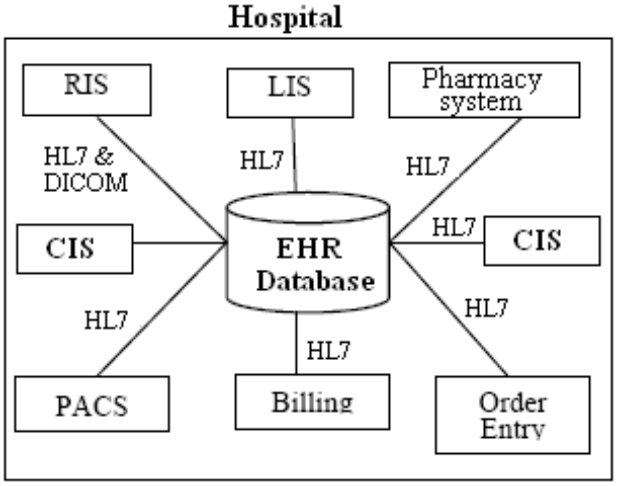

Fig. 1. Basic EHR model

The specific of the Centralized universal EHR model is the development of a national and a number of regional EHRs Databases, while the hospitals store only partial information for the patients – Fig. 2.

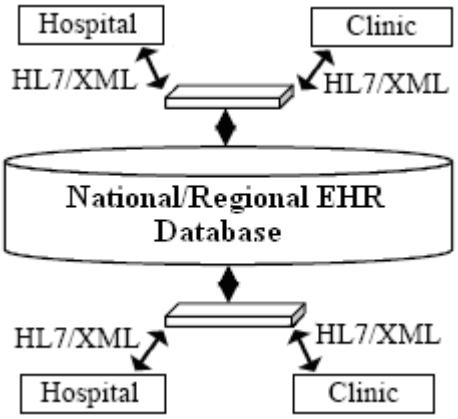

Fig. 2. Centralized universal EHR model.

The complete patient EHRs are accessible thought HIS via the hospital gateway. This model could be implemented only in case there are already established national standards for electronics patient records (EPRs) and EHRs.

The Distributed universal EHR model, presented in Fig.3, allows more freedom in using different standards for EHRs, especially when the implementation of the Hospital Information System is based on service oriented architecture (SOA). Within this model the EHRs Database is distributed between hospitals and is accessible thought the information system of the corresponding hospital.

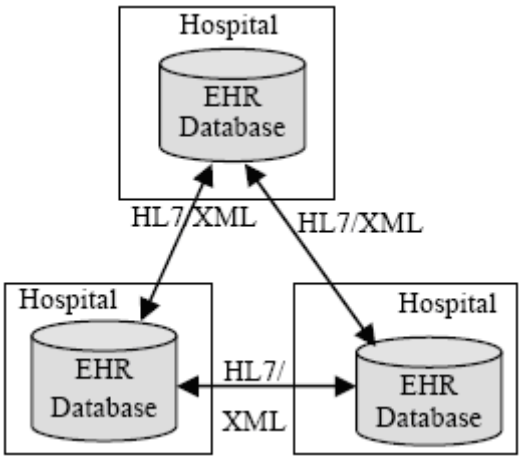

Fig. 3. Distributed universal EHR model.

It is desirable the three EHR models to use the imposed standards, in particular HL7, CEN TC 215 and ASTM E31 [7], which describe the structure, the content, the compatibility and the relations of the documents in the EHRs. In this way, the main EHRs design problems such as the exchange of messages between the sub-systems in the EHRs, the presentation of messages and their objects, the used terminology and their description in the electronic dictionaries will be solved.

Table 1 presents the basic characteristics of the above mentioned standards.

TABLE 1. EHRS STANDARDS

	HL7	**CEN TC 215**	**ASTM E31**
Messaging	HL7 V3	EVN 13606-4	ASTM E1238
EHR Object Model	No standard	Partially: EVN 13606-1 EVN 13606-2	Partially: ASTM 1384
Terminology	LOINC SNOMED UMLS etc.	No standard	ICD9/ICD10 SNOMED etc.

Despite adherence to standards' specifications some conflicts and incompatibilities are possible when unifying the HIS in the national EHRs system and its further integration to the European community level. For example:

1. Utilization of different semantic models and schemas of the Databases;
2. Utilization of different interfaces and different data interpretation;
3. The information for the ones and the same primitives to be essentially different despite of the used standards.

III. AUTOMATIC DATA INPUT IN EHRS

A crucial problem faced in realization of EHRs in the hospital and clinical information systems is connected with the deferent sources for the data input. Hence, the sources of errors, as it is illustrated on Table 2 [7], are also different and with different probability. One possible approach to reduce the influence of the wrong information in EHR is the utilization of special methods and techniques for extracting information from the EHRs. This approach is applicable especially for generalized survey of the related cases, scientific research, statistical processing, etc. The other approach is to minimize the manual data input from laboratory examinations, image diagnostic, vital signs monitors or monitoring systems and to utilize the automatic data input from the medical devices.

TABLE 2. DATA SOURCES AND ERROR SOURCES IN EPRS

Electronic Patient Record		
Part of EPR	***Data Source***	***Error source***
Text	Clinicians	Human
Numeric	Laboratory tests, personal monitors and BSN	Measurement
Image	Image diagnostic instruments	Measurement, instrumental
Nomenclatures	Nomenclature codes "ICD-10", lists of predefined values	Human

On Fig. 4 the common models for automatic data input in EHRs in the hospitals, as they are described in [8], are presented. The data are generated from different medical devices for measurement and acquisition of biological parameters and images. According to the output data type the medical devices are classified in five groups with corresponding data formats and the communication protocols used:

- Group A - medical devices that generate both Health Level 7 (HL7) text data and Portable Network Graphics (PNG) image files;
- Group B – medical devices such as an ECG recorder, whose output is not an image, but rather, eXtensible Markup Language (XML) data;
- Group C – medical devices whose outputs are printed on paper as texts, but the output is acquired as images by a Gateway PC;
- Group D – medical devices whose store images as medical records and whose outputs are video files - Picture Archiving and Communication System (PACS);
- Group E – medical devices whose output text files are sent through the RS232 port and stored directly into the interface servers.

Device type	Specifications (output data type)	Communication protocol	Additional resources
A	Medical devices that create both the HL7 data type and images through a vendor gateway. Ex. patient monitor, ventilator and so on at the ICU and OR.	TCP/IP	Central monitor
B	Medical devices that create XML data such as an ECG recorder, etc. Old fashion devices need a vendor gateway.	HTTP	The old fashion need trace master
C	Medical devices that print out medical examination results and they have to be converted to images to communicate, such as an audiometer, OCT, biofeedback and so on.	Print port or TCP/IP	White box or black black box
D	Medical devices whose outputs are video files and they have to create still-cut images to communicate, such as ultrasound devices, an endoscope and so on.	Video gate	Gateway PC
E	Medical devices whose outputs are plain texts and this can be communicated with ease, such as an Auto IOP, auto R/K, lens meter and so on.	Serial port (RS232C)	Gateway PC

Fig. 4. Classification of the medical devices and corresponding methods for interfacing to the EHRs in hospitals.

The compatible data formats and the used communication protocols (TCP/IP or http) for the medical devices from group A and some models from group B allow direct automatic input of the patient data in the EHRs system. Whilst, the data format conversions are necessary with the older medical devices from group B and the devices from group C. The data should be converted in another format which is compatible with the EHRs system. With the medical devices from groups D and E, in addition to the data format conversion, the data transfer protocols and the communication protocols are transformed to be compatible with the EHRs system. Usually they are implemented by means of a Gateway or personal computers performing these functions (PC Gateway) [8]. In these cases the patient data are presented in a platform independent self-describing format, such as XML, and the software is realized by means of web services [9].

The functional scheme for data integration from the classified five groups of medical devices to a hospital or a clinical EHRs system is presented on Fig. 5. If the implementation of this universal functional scheme is based on service oriented architecture (SOA), any one of the three principal models of EHRs could be employed.

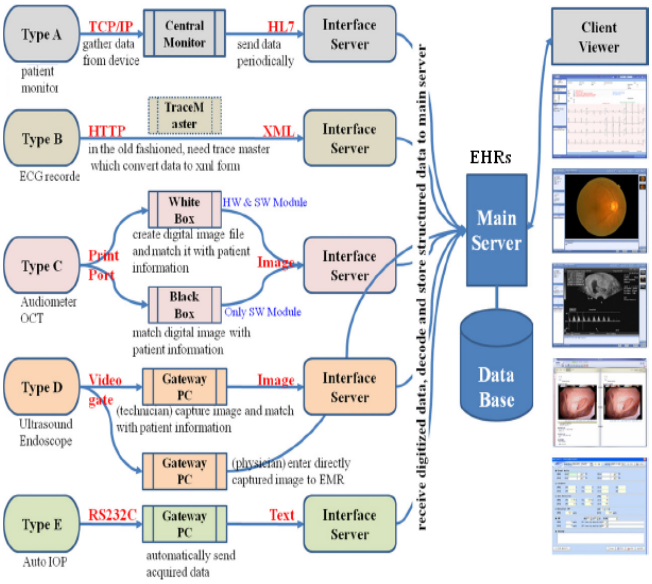

Fig. 5. Functional scheme for data integration from the five groups of medical devices to the EHRs system.

IV. Automatic Data Input in EHRs from Personal Healthcare Systems and Tele-health Monitoring Systems.

The development of Personal Healthcare Systems (PHS) and Tele-health monitoring systems allows the health data of patients who are not in the hospitals to be integrated to the EHRs systems by means of automatic data input. The main functions of these two types of systems are the long-term measurement, registration and monitoring of important physiological parameters of high-risk patients, patients with chronic diseases and elder people, outside the hospitals living in their every day environment. The development of PHS and Tele-health monitoring systems usually is based on three-tier architecture. A typical example for such architecture is illustrated on Fig.6. [10].

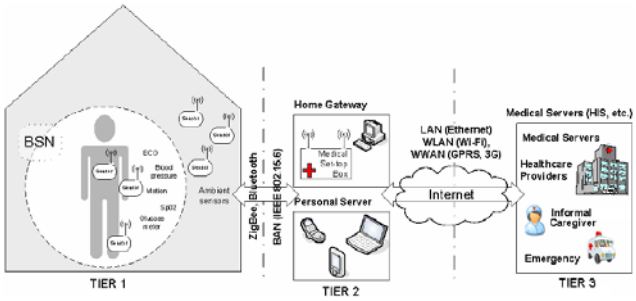

Fig. 6. Three-tier architecture of PHS and Tele-health monitoring systems.

The first tier (TIER 1) comprises a set of biomedical sensors placed on, in (implanted) and around the patient body. The wireless body sensors network (WBSN) connects all sensors to the second tier (TIER 2) - the Personal monitor (Personal Server) or Gateway. It controls and coordinates the BSN, receives data for the measured physiological parameters, performs data processing and transmits the corresponding data to the remote medical server (TIER 3). The Personal monitor performs the first level of patient data processing as: normalization, filtration, data conversion in XML format, etc. Typically, the realization of Personal monitor is based on Smartphone, although the alternative approach is the employment of embedded systems which provides higher functionality. The third tier - medical server is responsible for the second level of data processing, data analyzing and data storage

[10]. Using PHS and Tele-health monitoring systems the high-risk patients or patients with chronic diseases are under continuous observation and the current values of their blood pressure, ECG signals, heart rate, respiration rate, body temperature, blood glucose level and some others are measured on a pre-defined time intervals. The values of these important physiological parameters are sent to the medical center where the corresponding actions from the healthcare service providers are initiated.

The adoption of approaches used in development of PHS and Tele-health monitoring systems for integrating patient data in EHRs in hospital information systems (HIS) is proposed, giving promising perspectives and potential for immediate implementation. Employing the three-tier architecture a new sixth group of medical devices based on the concept of WBSNs for automatic data input in EHRs systems could be developed. Further, two approaches for realization of this idea are possible:

- The first is concentrated to the second tier. The suggestion is to add more functionality in the Personal monitor to be able to prepare in XML format a message which contains patient data ready for automatic input in Hospital or Clinical EHRs system.
- The second approach is concentrated to the third tier by adding one software module to the information system of medical center for automatic input of patient data in XML format to the corresponding EHRs system.

The second approach is easier for immediate realization because usually the medical centers for personalized healthcare and monitoring of elder people keep in store partial electronic health records for the patients under observation. Thus, it is necessary only to upgrade the corresponding information system by adding one software module for automatic data input in EHRs system.

From the other point of view, the first approach is more perspective for further development looking toward the recent innovations in Cloud computing platforms and their pervasive spreading in tele-health monitoring, data sharing and Cloud-based EHRs (EHR integration and sharing) [11]. Through virtualization of the medical centers for personalized healthcare and observation of elder people, a larger integration of the patient data could be achieved using the advantages of the distributed universal EHR model. This approach is more perspective also from the patient point of view, because the patients are not connected to the particular medical center and they have freedom for moving from one place to the other without restrictions.

V. CONCLUSIONS

In this paper an overview of the employed approaches in integrating patients data in hospital electronic health records systems is presented. The different models of EHRs and health information exchange systems are discussed.

Nowadays, smart devices, mobile Internet and Cloud services contribute to the continuous and systematic innovations of healthcare and enable cost effective, efficient, timely and high-quality ubiquitous medical services.

The future work will be concentrated to practical implementation of the first proposed approach for automatic patient data input from the personalized healthcare systems in the EHRs in Hospital and Clinical Information systems.

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