Standardization and Interoperability: Basic Conditions for Efficient Solutions

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Abstract— **Information and communication technologies have already become inseparable part of healthcare sector activities. In the paper we discuss the issues of standardization and interoperability that are crucial for correct interconnection of medical and other devices and information systems. Our previous work in the area has led us to the conclusion that successful integration of partial solutions will be strongly dependent on the issue of interoperability of medical devices and information systems. It comprises problems of standardization of data acquisition, communication, processing, and storage; and connected problem: correct data mapping between different ICT applications.**

Keywords— **standardization, interoperability, information system, eHealth.**

I. Introduction

Information and communication technologies have become inevitable and almost inseparable parts of our lives. They have also penetrated many application areas, including medicine. In that way new term "eHealth" has appeared. It represents those activities in healthcare practice that are supported by electronic processes and communication. The term encompasses rather wide range of systems being at the edge of healthcare and information technology. The systems include electronic health records; telemedicine; consumer health infromatics; health knowledge management; medical decision support systems; mHealth (use of mobile devices for different applications in healthcare).

With boom of smart phones, iPhones and similar devices, mHealth has become an attractive application area. The mobile devices can be used for many different functions in healthcare. Let us mention the most frequently cited: collecting health data; delivery of healthcare information to clinicians, researchers and patients; real-time monitoring of patient vital signs; and direct provision of care (using tools of telemedicine). This technology obviously provides greater access to medical information, larger segments of population in developing countries, improving the capacity of health systems in such countries to provide quality healthcare. Many above mentioned functions of mHealth can contribute to better awareness of care for one own health, teleconsultancy, sending data about one's health to the doctor, informing people e.g. about air pollution and warning them of the situation. Gradually there appear new areas of interest in mHealth: emergency response systems (e.g., road traffic accidents, emergency obstetric care); human resources coordination, management, and supervision (e.g. natural disasters); mobile synchronous (voice) and asynchronous (SMS) telemedicine diagnostic and decision support to remote clinicians; clinician-focused, evidence-based formulary, database and decision support information available at the point-of-care; pharmaceutical supply chain integrity & patient safety systems; clinical care and remote patient monitoring; health extension services; health services monitoring and reporting; training and continuing professional development for health care workers; health promotion and community mobilization. Recently there have appeared additional application areas on the edge of medicine, social care, and technology, namely assistive technologies and ambient assisted living.

Integrating information deriving from different sources and implementing it with knowledge discovery techniques allows medical and social actions to be appropriately performed with reliable information, in order to improve quality of life of patients and care-givers.

Currently the mobile technologies, sensors and other devices enable collecting vast amount of data of individuals. This multi-parametric data may include physiological measurements, genetic data, medical images, laboratory examinations, and other measurements related to a person's activity, lifestyle and surrounding environment. There will be increased demand on processing and interpreting such data for accurate alerting and signalling of risks and for supporting healthcare professionals in their decision making, informing family members, and the person himself/herself.

Recent development in ICT shows that it is almost impossible to design and implement a complex system as fixed to certain hardware, operating system, and infrastructure. Thus it is necessary to develop such architectures that will be easily extensible and modifiable. For easy extensibility the basic requirement is to understand data exchanged between individual parts of the system. That means not only to recognize data syntax, but also semantic content of the data.

II. Standardization and interoperability

Although many technological issues have been successfully solved there still remain other open issues in the technology part. The most important ones include requirements on standardization of data formats (i.e. the ECG, electroencephalography, and other medical devices measuring biological signals generate proprietary data formats which are usually not publicly known thus it is impossible to integrate such devices into larger systems because the signals can be processed only by software delivered by the device producer), data transfer protocols; security and data privacy. Recently there have been published many papers analyzing these problems, comparing existing standards and recommending future standardization activities [1]. There are defined standards for wired and wireless communication between electronic devices [2], [3], [4]. However, these standards define communication protocols only and do not solve the problem of semantic content of the transmitted data.

If we want to develop flexible eHealth systems we have to define standard interface that allows “plug-and-play” type of connection. Advanced systems are composed of different hardware and software modules that must communicate. The basic condition is that the receiver understands correctly the content of the message. Thus it is not sufficient to be able to receive the message, i.e. to understand the syntax of the message, but it is necessary to understand the semantics. This requirement implies development of a data model that maps semantic content from the data received from the devices into an information system that is usually used for collecting and evaluating data from monitored persons. Current information systems in health care use mostly HL7 communication standard (http://www.hl7.org). It is based on several relatively simple principles: creation of formats and protocols for exchange of data records between health care information systems; format standardization and connected interface unification; improvement of communication efficiency; guide for dialogue between involved parties at interface specification; minimization of different interfaces; minimization of expenses for interface implementation. It is important that HL7 does not impose any limitation on the architecture of individual systems, operating systems, or programming languages for the implementation.

There exist examples of solutions where the models and modeling tools have been developed for exchange of data between devices and information systems. One of the examples is the iCARDEA project (http://www.srdc.com.tr/icardea/), in which the inteface Medical Device Modeling Tool has been designed and developed. It transforms measured data both from proprietary formats and from standard formats into IEEE 11073 format [5]. In the next step the data types from IEEE 11073 DIM (Domain Information Model) are mapped to HL7 v2.5 data types. Further there can be used mapping onto HL7 CDA (Clinical Document Architecture), HL7 PHMR (Personal Monitoring Report), HL7 v3 Observation message used in description of clinical processes, USAM (Unified Service Action Model) in GLIF (GuideLine Interchange Format) for clinical decision support, or any format of message/document based on HL7 RIM (Reference Information Model).

Another example is presented in [6] where the scheme for data exchange between HL7 and IEEE 1451 standards is proposed. The designed system monitors remotely the patient state and transmits measured ECG, temperature, glucose content and possibly other data. The sensors send data streams to a personal digital assistant (PDA) or smart phone. On the PDA there are implemented following functions: receiving commands from the server and responses to them, data collection from the sensors, and sending data to the server. Monitoring centre has the greatest number of functions in the proposed architecture. The basic functions are connected with data input and successive processing and control of subordinate units. The monitoring centre receives sampled data and responses to commands. The main commands serve for control of client devices. For each patient the XML data files are created. These files are defined according to HL7 v2.5 standard. Each patient has assigned one XML file. There are recorded personal information, symptoms, patient history, current illness and necessary sampled data.

From the above mentioned examples it is obvious that the greatest problems and at the same time the greatest space for future solutions are in the area of correct mapping of acquired data onto a data model that describes electronic patient record. Especially with respect to future development and possibility to sense and store far more larger volumes of heterogeneous physiological parameters the issue of interoperability becomes more and more important. Interoperability may significantly influence effectivity both at design and development of an integrated system and at its routine operation. Ontologies may represent a suitable approach to this issue. Recently there has been developed a framework for designing information systems on top of OWL ontologies [7]. This methodology can be advantageously used in applications with rapidly evolving domain ontologies where it allows insert, change, remove, and retrieve data and at the same time it checks compliance of the ontology with the application object model.

For the future it seems to be most advantageous to create an extension of basic standards and technologies that allow easier satisfaction of the requirement on interoperability than above described examples, in which it was necessary to define mapping of data types for used standards and implement corresponding interfaces.

III. Conclusions

There exist examples of solutions where the models and modeling tools have been developed for exchange of data between devices and information systems. From them we can conclude that the greatest problems and at the same time the greatest space for future solutions are in the area of correct mapping of acquired data onto a data model that describes electronic patient record. Especially with respect to future development and possibility to sense and store far more larger volumes of heterogeneous physiological parameters the issue of interoperability becomes more and more important. Interoperability may significantly influence effectivity both of design and development of an integrated system and of its routine operation.

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