COMMUNICATION AND INTEGRATION OF HEALTH RELATED DATA IN ELECTRONIC HEALTH RECORDS USING INTERNATIONAL MEDICAL STANDARDS

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Abstract
Electronic Health Records can be seen as a pool for various health related data, where also different types of structured data can be stored. International standards serve as a unified framework for data communication and storage. We take different types of data sources as examples: a pulse oximeter, blood pressure monitor and a simple weighing scale. The data is collected at a single mobile device, where they are converted to corresponding ISO/IEEE 11073 profiles respectively and then communicated to a central EHR server via HL7 messages. The whole communication and storage is done without the classical media break fully electronically.

1. Introduction

Nowadays possibilities in patient care show a variety of different medical devices in use in parallel. Many health relevant parameters are available to a doctor or a nurse to assist them making their decisions. When these parameters have to be stored in an electronic health record (EHR) for documentation, the processes become complicated, because most of the medical devices do not share a common transfer protocol and also lack a common underlying standard for the data structure. Typically, vital parameters are only shown on embedded displays in the medical device itself and have to be read by a user and entered in an (electronic) form by hand in order to be saved in an EHR. And this has to be repeated for all different devices needed for a certain monitoring of a patient. A better integration of device data and interoperability between various medical systems is suspected to lead to a significantly more secure and efficient patient care and can therefore also help to save costs [6].

Meanwhile, most of the modern medical devices offer a kind of electronic data exchange interface. Commonly one can find simple serial ports like RS-232, more advanced manufacturers embed USB or Ethernet interfaces. To avoid “cable spaghetti”, also devices with wireless communication possibilities are available. The most common wireless technologies in use are WLAN (IEEE 802.11), ZigBee (IEEE 802.15.4) and Bluetooth (IEEE 802.15.1). The latter is widely embedded into consumer devices and offers some advantages in terms of master/slave relationships which enables manufacturers to design very low power, cheap and also small Bluetooth slave devices. Furthermore, it is also not a general use protocol, because the communication of slave devices can be con-

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trolled by the master and the transfer of data has to be done according to one of the so called Bluetooth profiles.

Lately a new interesting profile has been published that has been specially designed for the use in health care: the Bluetooth Medical Device Profile[1] (MDP) specified by the Bluetooth Special Interest Group [1]. During the development process, the Medical Devices Working Group coordinated with the IEEE 11073 Personal Health Devices Working Group to develop a common data standard that can be used by Bluetooth, USB and other transports. The Bluetooth MDP has some differences compared to the older serial port profile. In the MDP, encryption and authentication of all connections is required. Additionally, the MDP allows functions like an exactly timed synchronization of several Bluetooth connected sensors and offers the possibility to transfer data coming from different medical devices in parallel. This would be extremely useful in our application, where data is collected from several devices. The MDP can also be combined with other profiles, so that data can be transferred via different profiles concurrently or alternatively. But currently, most devices still use the standard serial port profile with a proprietary data format for communication of simple digital data.

In the recent years some standards relevant for the communication and storage of medical data have been agreed on, balloted and published by their hosting organizations. The relevant international standards in our case are especially HL7 [2], ISO/IEEE 11073 [3] (the successor of IEEE 1073) and also the EN13606. Research groups and commercial companies are only beginning to experiment with the adoption of these standards to production use systems. [5] for example describe their first experiences during the implementation of a patient monitoring solution based on these standards.

2. Methods

In our work we make use of the developments described in the previous section and show how these technologies can be used to set up a framework that can read various health care related data from medical devices, transform them on a local mobile device into the relevant standards and communicate them to an EHR server. A similar showcase has been demonstrated in [7]. They describe a system that is able to automatically collect data for a specialized pacemaker EHR. A more detailed description can be found in [4]. In this paper we widen the approach to integrate data from arbitrary medical devices that are (i) able to communicate their data via Bluetooth with at least the serial port profile after successful pairing and (ii) have an open interface that is documented and available to developers. Bluetooth uses this mechanism called pairing for security reasons: A user has to allow two devices to communicate with each other for the first time manually (e.g. by entering a pre defined password). Else data sniffing would impose a security threat and hence also prevent the usage of Bluetooth in medical applications.

The ISO/IEEE 11073 Personal Health Data Communication Standards are a family of ISO, IEEE, and CEN joint standards to facilitate the interoperability of medical devices, which are also often referred to as Medical Information Bus (MIB) or x73 standards. They describe transport independent application and information profiles between personal telehealth devices and monitors / manag-

[1] Some manufacturers also referred to this profile as „Health Device Profile“. We use the term Medical Device Profile in accordance to the press release of the Bluetooth Special Interest Group. See http://www.bluetooth.com/Bluetooth/Press/SIG/BLUETOOTH_SIG_ANNOUNCES_MEDICAL_DEVICE_PROFILE_AT_MEDICA_SHOW.htm for details.

ers (e.g. personal computer). See [8] for a good overview and explanation of these standards. Since they are still in the development phase, some are available as drafts only, others are marked as active already. A number of different documents or parts define different important aspects of the whole standard, like the nomenclature (part 10101, active), the domain information model (part 10201, active) and communication standards for many possible types of medical devices. Relevant for our work have been especially the device specialization profiles for pulse oximeters (part 10404, draft only), blood pressure monitors (part 10407, draft only), thermometers (part 10408, active) and weighing scales (part 10415, active).

There is ongoing work by standard committees on a general gateway standard that will enable the communication of device-level data directly into HL7-based medical records. This will provide the important link between the data collection process (measurements) and the long-term health record itself. Until this gateway specification is finished, we simply pack the x73 structured data into HL7v2 records to communicate them to our EHR server.

To be not restricted to a certain hardware or operating system, we decided to use only multi-platform programming frameworks. After evaluating multiple PDAs and smart phones, that offer Bluetooth and wireless LAN capabilities we chose to use Java as the application programming language, because Java virtual machines are offered for nearly all available mobile devices.

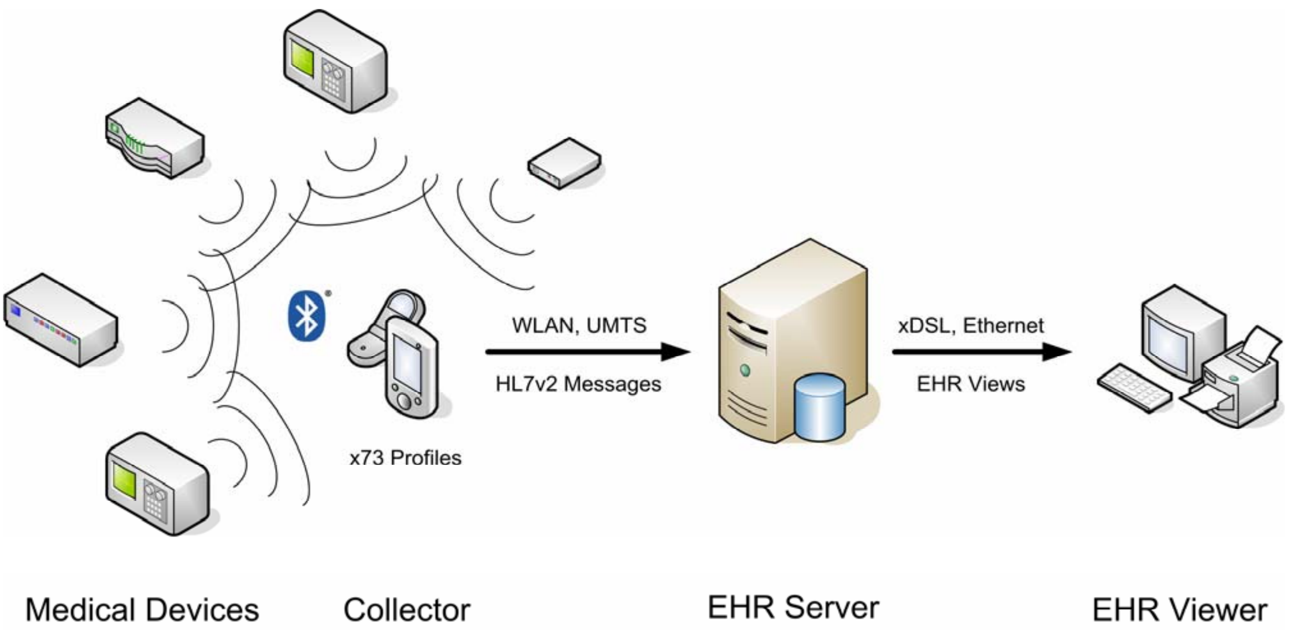

Figure 1: Overview about the complete system architecture. The medical devices transfer their data via Bluetooth to a (mobile) collector, which converts the data according to the appropriate IEEE 11073 standard and transfers them directly to the EHR server with HL7 (version 2.x) conformant messages. Finally, the EHRs can be viewed through different ways like HTTP, local clients, etc.

3. Results

We developed an application that can be used on any mobile device like a PDA or a mobile phone that is able to execute JAVA applications and has a Bluetooth interface. Preferably the mobile device should also have a TCP/IP based wireless network interface like WIFI or UMTS to easily communicate the data to the EHR storage server afterwards. Note that this is not a necessity, because the data could also be transferred via Bluetooth again, but since most EHR server are connected to the Internet, this enables our application to store the data directly on the server and we do not have to use e.g. a proxy. Finally, the EHR viewer has to be able to display the data correctly. Since the EHR server offers interoperable interfaces, “off-the-shelf” viewers capable of displaying x73 conformant data should be able to display these data correctly. Nevertheless we have implemented simple viewers for all data types in use, because no generic x73 open source viewers were available at the moment of implmentation. Figure 1 gives an overview about the system architecture, the media types and the standards used for communication.

After all corresponding medical devices have been paired with our PDA, the user can select which data should be collected, i.e. he can choose from which of the currently active Bluetooth connections data should be polled subsequently. In case of continuous values or values that are measured over a certain amount of time, the user has to select a time period over which data should be collected, too. The application can only collect the data by actively polling them from the devices. Although a Bluetooth Medical Device Profile has already been published, none of the devices available to us supported it yet. Hence, we had to use the available serial port profile as the standard communication protocol for the measurement devices. Communication based on x73 will be an issue for the medical devices themselves in the future. Until that, our application serves as a kind of x73 adapter which – depending on the kind of device being monitored – converts and structures the data according to the corresponding part of the ISO/IEEE 11073 standard described above.

We also make use of the HL7 version 2.x messaging standard, because it is (i) considered to be the most widely implemented protocol for data exchange in healthcare in the world and (ii) a direct gateway between x73 data and HL7 servers is not specified yet. The HL7 messages consist of a series of text and delimiters based electronic messages to support clinical as well as administrative, logistical and financial processes in healthcare. Currently, our application simply wraps the ISO/IEEE 11073 conformant data objects inside an ORU (“observation result message”) type message and sends it to an EHR server that is able to receive and store these types of messages. This approach using simple message types and a rather old (but widespread) HL7 version promises more interoperability with EHR servers.

The EHR server is represented by the eHealth platform from the Austrian Research Centers. This platform already hosts a range of telemonitoring applications for patien-centered health data acquisition. The architecture of this system consists of:

1. HL7 communication server: The Mirth project (Mirth 1.8, WebReach Inc., Irvine, CA) is a free and open source communication server for receiving HL7 messages.
2. Application server: The Zope server (Zope 2.7, ZOPE Corporation, Fredericksburg, VA) manages the data base queries and provides the information to the user via the browser-based EHR viewer.

3. Java server: Since the server system is based on Service Oriented Architecture (SOA) a Tomcat server (Apache Tomcat 6.0, The Apache Software Foundation, Los Angeles, CA) is used to host various services like chart and PDF generation.
4. Database: A PostgreSQL server (PostgreSQL 8.3, PostgreSQL Global Development Group) is used to store the data persistently.

The working system has been demonstrated in an interoperability workshop at the “eHealth 2009” conference in May 2009 in Vienna, Austria.

4. Discussion

When one wants to integrate many different data relevant for health care into an EHR, commonly these data have to be entered manually into some sort of patient care information system. In other scenarios, manufacturers of medical devices offer data collectors that can mostly read data only from their own devices. Hence, a multitude of devices have to be set up to collect different data. A great enhancement of medical data interoperability would be having devices, that (i) structure their own data strictly according to x73 standards for further processing and (ii) additionally offer wireless interfaces that utilize secure and open standards like Bluetooth with the new Medical Device Profile. This would simplify the use-cases demonstrated in this paper. The additional advantages of the MDP have already been described in the introduction. Until then, data adapters like the one presented here are necessary.

We showed that it is possible to develop a single application that is able to run on many mobile devices and that can collect vital parameters via the standard Bluetooth protocol. But this is also only possible when manufacturers offer standardized and well documented protocols for communication. Saying that, not many devices can be found on the market yet, that even conform to these requirements. Slowly some standards are having entry in the medical sector, too. HL7 and ISO/IEEE 11073 are good candidates to solve the data communication and interoperability problem. But the adoption rate of those standards in the health care market is slow.

Additionally, the Bluetooth Medical Device Profile offers a secure and robust way to collect data wirelessly, but not many devices support it yet. Developers have to use the common serial port profile. Our prototype application gives an impression about how easy interoperability and multi-device measurements could be. But for such an efficient way to collect and to store medical data in EHR, manufacturers of medical devices have to comply with international standards and offer open protocols for rapid adoption and also cost efficient implementation.

In future, such interoperability applications with the possibility to transmit and store data in EHR can provide a basis for efficient telemonitoring and home-care programs. Hence, the prototype will be improved in respect of usability and robustness. The research of this project will be extended with access to the EHR for patients, hospitals and practitioners to provide add medical feedback and surveillance for patients.

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