Integration Architecture of a Mobile Virtual Health Record for Shared Home Care

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Abstract

The coexistence of different information systems that are unable to communicate with each other is a persistent problem in health care in general, and in shared care in particular. This is especially critical when it comes to information access needed at the point of care, e.g. in the patient's home. The purpose of this paper is to present the technical architecture of a virtual health record (VHR) that both integrates information from different electronic health records (EHRs) and allows for documenting at the point of care using mobile devices. The VHR supports a seamless information and communication flow between different care providers giving them mobile access to selected patient-oriented information. A service oriented system architecture where database functionality and services are separated has been implemented. This guarantees flexibility with regard to changed functional demands and allows third party systems to interact with the platform in a standardised way. Major requirements for the VHR have been documentation support at the point of care, integrated presentation of the information from different feeder systems, and the possibility of offline access to the data on handheld devices. Therefore, publishing was chosen for the integration design. A patient centred XML schema is published as an interface for integration with the information broker. The feeder systems deliver their information in XML.-files that are mapped against the ideal schema and inserted into the mediator database. The paper describes both an online web application and an offline solution that was implemented on personal digital assistants (PDAs). The system has been introduced in a Swedish home care district with an established fiber-optical network infrastructure connecting all the locations forming the study site.

Keywords:
Medical Records Systems, Computerized; Integrated Advanced Information Management Systems; Information Storage and Retrieval; Internet; Home Care Services; Nursing Record

1. Introduction

The coexistence of different information systems that are unable to communicate with each other is a persistent problem in health care. This becomes particularly obvious when the care of a patient is shared between different health care providers. Health care professionals from different organisations will then have to work together in a team-oriented way to provide high quality care for a patient. However, they rarely have access to a common IT-support or even access to basic information from each others systems. If the care is performed in a

mobile environment, information access is needed at the point of care. Home care of elderly patients is a typical example [1]. In Sweden a shift in the responsibility for the domestic care of elderly and disabled people from the county councils to the municipalities is increasing shared care and the need for seamless and consistent information and communication flow. The growing number of senior citizens adds pressure to this situation, and tools for increasing the quality of care and supporting coordination and cooperation between the different care providers involved are greatly needed [2].

The electronic health record (EHR) is one of the most important tools of health care professionals, both as a source of information regarding a patient's health, and as a documentation tool [3]. It is however not likely that any single information system could ever cover all the needs of the different care providers [4]. An integrated version of the different EHRs from different care providers is needed to allow for adequate information access and documentation at the point of care. Such a Virtual Health Record (VHR) needs to gather the information needed from the different EHRs, or feeder systems, and to present it to the user in one view [5]. The view might differ depending on which user group is accessing the VHR, but the underlying structure and information source are the same. Moreover, the users' need to be able to document information at the point of care so as to spread the new information. Based on these conditions, the authors have developed a mobile VHR within the research project "Old@Home" [6]. It is the purpose of this paper to discuss the technical architecture of the VHR and its implementation.

2. Materials and methods

Technically, implementation is based on Microsoft .NET, using Biztalk Server 2004 as platform for information handling, SQL Server 2000 and SQL Server CE 2.0 for data storage, Sharepoint Portal Server for handling of Web-portals, and XML as format for data exchange. Microsoft Visual Studio.NET and .NET Compact Framework are used as developer platforms. Microsoft Authorization Manager (AZMAN) is used for handling of access rights.

The test site where the VHR has been implemented, and is currently being tested, has an established fiber optical network infrastructure connecting all the locations forming the study site: two primary care centers, the elderly patients' private homes and one nursing home for the elderly, from where the home care of elderly patients living in their private homes is coordinated. The VHR is used by the three main care provider groups involved in the home care of elderly citizens still residing in private homes: (1) general practitioners (GP) and (2) district nurses (DN), both employed by the county council and (3) home help service personnel (HHS), mainly assistant nurses, employed by the local authority (municipality).

2.1 Integration method

Two different methods for integration were considered when designing the technical platform; indexing and publishing. The major difference between the two methods is the place for storing the information. Indexing implies that the information remains within the data storage of the feeder system, i.e. the EHR, and the role of the integration functionality is to keep track of where the information is stored and how to access it. Each feeder system regularly sends updates of its index information, but the actual information is kept in its original storage. Publishing on the other hand means that there is a separate data storage in form of a mediator database to which the feeder systems publish the information agreed upon on a regular basis. Different types of information can have different timeframes. [7]

When indexing you know whom the information belongs to, and additional benefits are that the information is only stored in one place and that it is relatively easy to add or remove

feeder systems. However, indexing requires that all feeder systems are online when the VHR requests information and it is most suitable for so called vertical integration, showing information from one feeder system at a time. The method is mainly used for accessing information, and not for interacting with or updating it. With publishing, issues of ownership and responsibility for the information stored in the mediator database are more complicated to handle. It is also more difficult to add new feeder systems, and a mapping process for each system is needed before the information can be stored in the mediator database. The benefits are that feeder systems need not to be online in order for the VHR-applications to access the information and it is easier to create a horizontal integration, showing information from several different feeder systems in one view. Furthermore, interaction with the feeder systems can be implemented, updated or added information in the VHR can be published back to the respective feeder system. In addition, information which is not available in the feeder systems, such as multimedia information or information used for communication between the different care providers can be stored.

Since major requirements for the VHR have been documentation support at the point of care, integrated presentation of the information from different feeder systems, and the possibility of offline access to the data on handheld devices [8] publishing was chosen for the integration design.

3. Results

We implemented a service oriented system architecture where database functionality and services are separated. This way we guarantee flexibility with regard to changed functional demands and allow third party systems to interact with the platform in a standardised way.

The VHR described here gathers information from three separate feeder systems, used by three different care provider categories. Each feeder system is accessed through a web service. The publishing of information from the feeder systems is triggered by the information broker requesting information about the patients currently listed in the VHR, and the web services deliver the information in an XML-file in a pre-defined format. The format of these XML-files varies depending on the feeder system. The variation in the XML-files structures makes it necessary to map them so the information can be stored in the mediator database. Therefore an ideal XML-schema has been developed within the project. The information broker maps the XML-files from the feeder systems against the ideal schema so that the information regarding each patient is changed to the format of the ideal schema. This information is then sent as input to a web service which inserts it to the mediator database.

Once the information is in the mediator database the health care professionals can access it through their VHR-applications. Each user category (GP, DN and HHS) has a specific view, giving them access only to the information they need and are allowed to read. Two types of applications have been developed; an online web application used by GP and DN, and an offline application for a handheld computer used by the HHS. Each handheld device has a local SQL CE 2.0 database to which the data to and from the mediator database is synchronised using server based filters configured according to the different users' roles. Rule based synchronization is to be implemented, meaning that if synchronization is requested at the point of care and no connection to the Internet is available the client will try GPRS. If the HHS walks into a hotspot area of WLAN the device uses the best performance/lowest cost connection seamlessly, and the device will also drop the connection to the WLAN if it is connected to the fiber optic network.

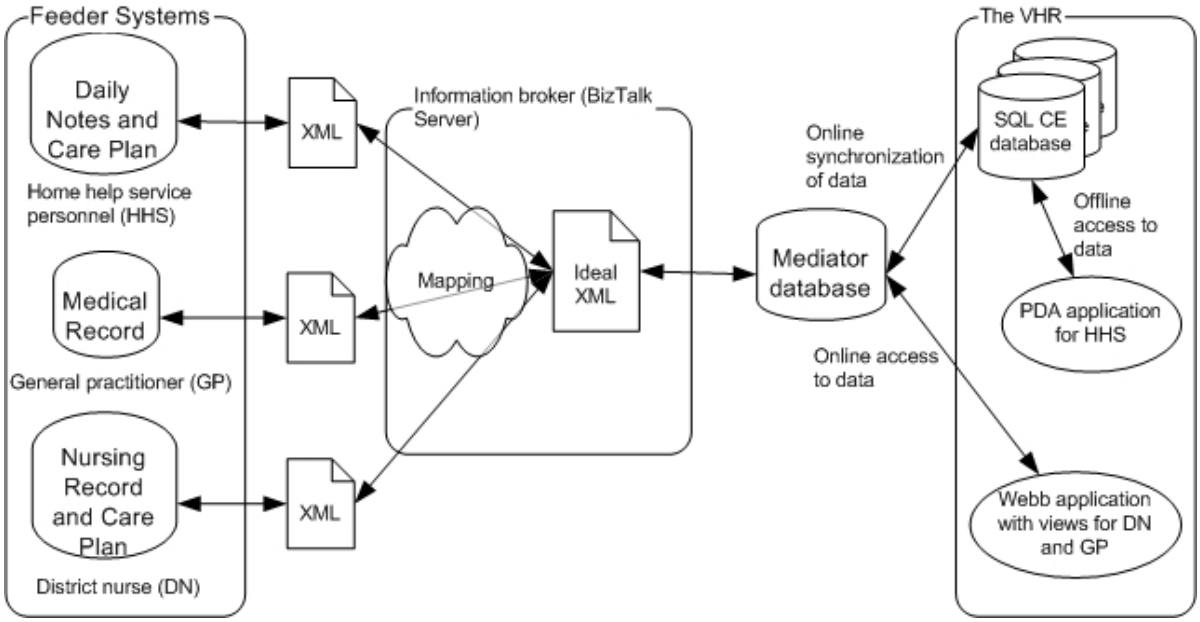

Figure 1: the integration architecture

3.1 Ideal schema

To reach flexibility towards existing feeder systems a patient centred XML schema for information exchange is exposed as a web service for connecting to the information broker. For selected patients, necessary information such as daily notes, prescription lists and care plans are fetched from the respective feeder system and sent to the information broker.

For the mapping between the information from the feeder systems to the ideal schema to be as straight forward as possible it is of course preferable if the XML output from the feeder systems is identical to or closely resembling the ideal schema. The system providers that develop web services in order to communicate with this information broker will be able to adapt to the format of the ideal schema. It is desirable for the ideal schema to be compliant with a standard for information sharing, such as ENV 13606 [9] or HL7 [10]. In Sweden today, no such compliance with the available standards exists. In expectance of national guidelines in this area our ideal schema has been developed taking the ENV 13606 and HL7 into consideration, and can be updated or replaced when a national standard is made available.

3.2 VHR Mediator Database

The publishing integration method requires a mediator database to which the information from the feeder systems can be copied. MS SQL server 2000 is used for the implementation. In this database it is also possible to store information which is not available in the feeder systems, such as certain multimedia information or information used for communication between the different care providers. This type of information is not published back to the feeder systems, but remains in the mediator database, connected to a specific patient. New information of the type that is fetched from the feeder systems can also be added to this database, for example a new daily note written by the HHS, and is subsequently published back to the right feeder system.

When information has been added or updated in the VHR, it is crucial to keep track of this information so that it can be published back to the right feeder system. Therefore a change log structure has been included in the mediator database, and whenever any information is added or changed a new post is created in the change log with information about when the information was changed, which patient it belongs to and where, which table, in the mediator

database it is stored.

3.3 Online and offline access

Both an online web application and an offline solution have been developed. The DN and GP access the VHR through a web application, either from the office desk top PC, or from a HP Compaq Tablet PC TC1100, used in mobile work situations such as in the patient's home. Their applications interact directly with the mediator database through a roaming session based virtual private network (VPN). The HHS use handheld devices, HP iPAQ h6340, and on these an offline solution is implemented. The information is synchronised between the mediator database and the local SQL CE databases, and the offline applications interact with the local SQL CE database while the HHS are using it. A filtering functionality ensures that only information about the patients which the current user is allowed to access is transferred to the handheld device when synchronising. Currently the HHS have to return to their office in order to synchronise with the mediator database, but a wireless solution with a roaming session based VPN for wireless applications is to be implemented and tested. This will ensure ubiquitous computing and the possibility to synchronise on the given bandwidth at any given moment.

3.4 Security and access rights

Due to the selection of a publishing and offline application, reliable security mechanisms are vital. Security, authentication and data classification is fundamental to give users, organisations, relatives and patients a feeling of trust and security. On a high level role based access rights enables each different user group (GP, DN and HHS) to only have access to information on the patients they work with, and only to a limited amount of information on each patient. A user needs analysis conducted within the project revealed which information each user group needs to have, the "Information domains". The patients also have the possibility to deny certain user groups access to certain information, although so far no one has chosen this alternative. On a low level all methods in the application have an equivalent operation in AZMAN and each user has one or more roles, all stored in the directory. Every method itself checks if the user has the right to perform that method. Access rights are granted to authenticated users stored in the directory, roles are synchronised to the PDA/SQL CE after a full authentication to the server online. When granted access the data leaving the server is in an encrypted secure channel (SSL or VPN). All data stored is encrypted. To ensure that data in the PDA is read by the right user biometry and certificates can be used. With this security model all security can be managed centrally.

4. Discussion and conclusions

Needing offline access to the VHR in mobile work situations naturally poses certain problems, and a proposed solution to these, is the two level synchronization described above, between the local SQL CE databases and the mediator database, and between the mediator database and the feeder systems.

When giving the health care professionals access to information gathered from several different feeder system one has to take the problem of information overflow into account. If the users are confronted with too much information they will not be able to process it, and therefore a thorough selection of which information each user group should access has been performed and implemented in the VHR. Easy access to the VHR is also crucial in order to facilitate and not hamper the work at the point of care.

The suggested architecture for a VHR, using triggered publishing as integration method,

makes mobile and/or offline access to information from different feeder systems and interaction with them possible. This enables a seamless flow of information between the care providers involved in the home care of the elderly patients, ensuring a higher quality of care.

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