Digital Healthcare Empowering Europeans
R. Cornet et al. (Eds.)

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doi:10.3233/978-1-61499-512-8-919

A Cloud Based Real-Time Collaborative Platform for eHealth

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Abstract. For more than a decade, the eHealth initiative has been a government concern of many countries. In an Electronic Health Record (EHR) System, there is a need for sharing the data with a group of specialists simultaneously. Collaborative platforms alone are just a part of a solution, while a collaborative platform with parallel editing capabilities and with synchronized data streaming are stringently needed. In this paper, the design and implementation of a collaborative platform used in healthcare is introduced by describing the high level architecture and its implementation. A series of eHealth services are identified and usage examples in a healthcare environment are given.

Keywords. Electronic health records, collaborative environment for EHR, cloud based collaboration environments

1. Introduction

In an eHealth environment the collaboration among health care professionals is a reality of their everyday work. One can say that almost all aspects of healthcare practitioners are accomplished only after interacting with computers. A series of applications and health delivery platforms are available. As an example, in Canada the eHealth Infoway initiative has been proposed since 2001. The architecture of such a system ended up to be too complex to be implemented. For the 40,000 general practitioners using approximately 38,783 applications/systems the integration of the above application in a unified system required linking 4527 simple, 20,081 medium and 14,175 complex interfaces (API), which resulted in prohibitive efforts and costs. However it is clear that collecting intelligence from healthcare applications by practitioners and enabling knowledge sharing is extremely useful for the deployment of healthcare activities despite the challenges [1] it presents. An alternative to the Infoway concept is to provide an environment in which practitioners shall be able to explore the plethora of professional information repositories and connect if needed with each other.

In this paper an alternative architecture for health care application unification is introduced. The solution relates to a collaborative environment allowing health care

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practitioners to collaborate and share only what information is needed for respective case of the patient(s), all activities being centered over collaborative sessions. The core of the system is a video-conference application which allows users to activate any of the eHealth documents to which the the user has access to. The application of the collaborative platform presented targets telemedicine, medical imagistic, clinical decision support systems (CDSS), and geriatric procedures related to active ageing.

A synthetic review of collaborative platforms in the above mentioned areas will be given in Section Related Works. Then in Section 3 the architecture of a new collaborative platform is introduced. In Section 4 the real-time collaborative services for *eHealth* are then explained. In Section 5 examples of using the platform for eHealth are briefly discussed.

2. Related Works

Huge efforts are made in the whole world for the development of a communication system for health care professionals to get access to applications providing a unitary view of patients' eHealth data such that a better treatment can be achieved. However, it was demonstrated that due to the complexity of such a system, many attempts, even in countries where the capital resources are available, failed to be properly implemented [10]. Central to all collaborative application is the security of accessing private information [8][11]. Obviously such an ambitious country level system is stringently needed as it allows the dissemination of data through a collaborative environment, in real-time. To date there are a few reports in the literature which discuss design or implementation issues in regards to collaboration in medicine.

The paradigms of collaborative environments used in telemedicine were explored in [1]. The need for ensuring access to "second opinion" justifies the use of a computer supported collaborative environment. The platform introduced in [1] was applied to health care provisioning to remote patients. Raman et al. [2] discuss a solution for the particular requirements of nomadic healthcare providers. That includes a Messaging System and had planned to extend it to voice chat. The system envisaged by the authors was to make available documents for health practitioners for Decision Support Service through services provided by the JEE, in order to get access to medication covered by insurance plans. Another example of a collaborative platform is presented in [3] where the importance of "facilitating access to the high quality telemedicine facilities" was substantiated especially for countries where the health network is not well developed. The ability to "significantly transform both professional-to-professional and professional-to-patient practices, especially in places where the access to technology has a high cost and a high impact like in Africa" was also stressed. The system makes intensive use of the JEE platform to implement various functionalities. It is clear that at the time it was developed the tools did not allow the designers to use virtualization, cloud techniques, or modern tools like html5.

The area of telemedicine requires collaborative platforms capable of sharing simultaneously and synchronously images or other medical data by specialized views, as well as text co-editing and voice/video streaming. Medical imagistic could benefit, too, from services offered by collaborative platforms, as described in [4].

The implementation of CDSS is important for reducing the knowledge gap between clinical research and practice. The collaborative platforms are useful to "flexibly integrate a large variety of multi-scale models and can leverage the efforts of a large community of modelers" [5], allowing "comprehensive datasets from clinical trials and care [to be] brought together in the medicine collaborative research projects".

Monitoring systems are dedicated to send values read from medical and ambient sensors. To ensure continuous healthcare management, the incorporation of teleconference sessions between the health experts, the patient and the family [6], which requires role-based collaboration could improve the quality of care. Using mobile devices to operate collaboratively is described in [7].

Finally, in medicine, *eLearning* is used as in other education fields. Collaborative platforms allow the development of learning support, and collaboration between students, and health care professionals.

Unfortunately, most existing systems require the installation of specialized software rather than providing the accessibility of a typical web browser as they were developed in the time where the software technologies did not allow the implementation of smart objects in conjunction with the modern web technologies (as html5 and the boostraped GUIs). In addition, they fail to take advantage of modern videoconferencing, co-editing and cloud technologies that are now available for enhancing collaboration over real-time data.

3. eHealth Platform

To address the requirements previously embedded in the *eHealth* collaboration scenarios presented above, an original web-based collaborative platform has been designed and implemented. In Figure 1 below the general architecture of the collaborative environment for health care professionals is introduced. The architecture is built such that the system can be deployed on the cloud, with a rich client interface based on Java Script and html5 technology, video streaming being enabled by it in both

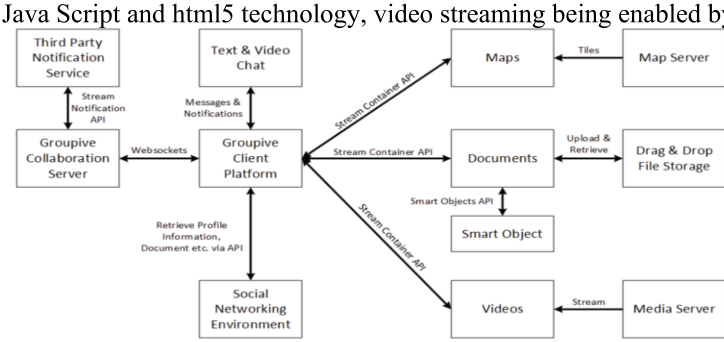

Figure 1. General architecture of the collaborative environment for ehealth

client-server and P2P communication paradigms. The platform provides a cloud-based real-time transfer of applications data model to and from collaborators while communicating using a messenger or a video/audio chat tool. The concept is based on synchronizing data streams across the platform, exchanging XML data which regenerate the HTML5 representation of data on the client of session peers. As such, the bandwidth consumed by the platform can be kept at low levels. The platform for *eHealth* applications is modular, in order to make it easy to add additional collaborative services, or to improve existing ones. The client side user interface consists of three key sections: *Content*, *Icon,* and a *Session Section*. The *Content* contains the application content that is synchronized among all users in a session and contains the Media Modules. The *Icon* contains icons representing the different applications available for collaboration. The *Session* contains boxes that indicate the users in the current session and displays their live webcam streams. Client-side Media Modules contains four Media Module types: *Search*, *Viewer*, *Control*, and an *Information Module*. The *Search Module* allows the user to search for a specific media item to share with other peers (eg. an image from a medical database). The *Viewer Module* displays the actual media content selected from the list provided by the Search Module. The *User Control Module* displays the controls for interacting with the media content which is synchronized with other users. The *Information Module* displays information related to the currently selected media content, such as the image metadata. Each of the four Media Module types implements the Model-View-Controller (MVC) software pattern.

The server functionality is split into four core modules/services. A *UserStateService* is used to indicate changes in user presence (coming online, going offline, busy), to retrieve the list of connected users, as well as to store the list of contacts for all connected users. A *SessionService* manages the sessions created by users, and it is also responsible for synchronizing new users to the state of a session. A *WebcamVideoStreamService* is responsible for managing each user's audio/video streams. Finally, a *ServerStatsService* generates statistics regarding the server's performance, as well as gathers statistics from the other modules. The cloud architecture of the eHealth Platform is available in [9]. The resulting architecture is summarized in Figure 2.

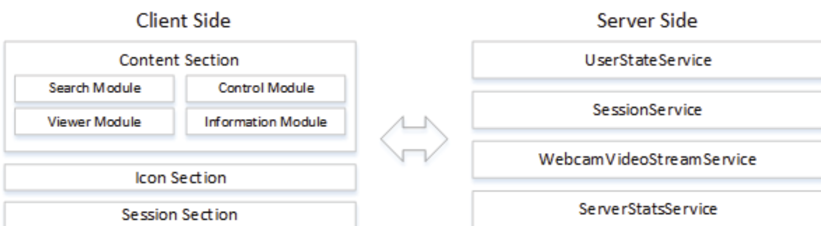

Figure 2.Client and server side components for an eHealth Collaborative Platform.

4. Evaluation of the eHealth Platform

In what follows several collaborative eHealth applications were created and deployed on top of the Collaborative Platform. The resulting user interface, as it appeared within a user's web browser, is shown in Figure 3. The session is controlled via a scalable videoconference application. The cloud-based design allows multiple users, geographically distributed, to participate in a collaborative videoconferencing session. The middle (Icon Section) of the figure shows the eHealth Platform giving all the users


Figure 3. Multiple users and eHealth applications within the Collaborative Platform.

synchronized streams of data containing real-time sensor data, images from a medical database in the Digital Imaging and Communications in Medicine (DICOM) format, a video application for accessing medical *YouTube* videos, a data graphing application, a document co-editing application, an application for connecting to live video streams, and a mapping application.

The eHealth Platform can be used in both eLearning and also in the sterile environments by using a special camera which allows for controlling the Platform via gestures. By combining real-time data with modern real-time communication abilities, the platform therefore allows medical students and professionals to exchange and discuss medical data available in a variety of formats.

5. Discussion

This paper presented the design and implementation of an eHealth Collaboration Platform. Several eHealth applications were implemented on top of the platform and a collaborative session involving numerous participants was shown. The flexibility and real-time web-based multimedia nature of the platform make it unique and ideal for collaborating over a variety of medical resources, including text, imaging data, and video streams. Future work will focus on providing annotation tools that allow users to draw on top of documents, photos and videos, thereby further facilitating collaboration.

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