Contribution of Web Services to Improve Pain Diaries Experience

Nuno Pombo, Pedro Araújo, Joaquim Viana, Benjamin Junior, and Rita Serrano

***Abstract*—Web services allow a truly global, platform independent, and interoperable mean to access information, anywhere and at anytime. In this paper we propose a pain diary system that uses the interoperability of the web services in order to improve the ability to monitor chronic pain patients. The effectiveness of this monitoring in order to enhance therapeutic assertiveness, is particularly important, especially since the pain is considered the fifth vital sign for representing basic bodily functions, health and quality of life. In addition, due to its subjective nature, computerized systems are required to support clinical decision making during the monitoring of the patient. In this sense, the proposed approach uses web services to send pain data, to receive alert messages and also proceed to self-configuration according the physician's defined therapeutic to every patient and during follow-up of each one. The results obtained in the pilot study are very promising. On the one hand, the study reveals that through the use of web services, it is feasible to integrate the pain diary with other systems, in our case with a Personal Health Record, taking advantage of web connectivity from the mobile devices. On the other hand, the combination of web services with the pain diary allows the user to overcome several problems not solved by other solutions. With this work we hope to contribute to the adoption of web services as a means of integrating the patient's pain diaries in healthcare systems.**

***Index Terms*—Chronic pain monitoring; pain diary; m-Health; web services;**

I. Introduction

PAIN is the oldest medical problem and the largest physical affliction of mankind, yet it has been little understood in physiology until very recently [1]. According to the International Association for the Study of Pain [2], [3], pain is an unpleasant sensory and emotional experience related to past or potential tissue damage or it may be described through the concepts of tissue damage.

When the pain occurs quickly and can be intense but with relatively short duration, is known as acute pain. Conversely, when the pain manifests itself over a long period of time, *ie*, persists after the healing phase after an injury, is regarded as chronic pain [4]. Usually is difficult to identify the temporal and/or accidental circumstances that causes the suffering, since chronic pain can manifest itself with various features and generate various pathological stages.

Recently, pain has received the official assignment as the fifth vital sign for representing basic bodily functions, health and quality of life [5], [6], thus complementing the other traditional vital signs: blood pressure, body temperature, pulse rate and respiratory rate. However, the pain is distinguished from these vital signs, due to the fact that it is a subjective experience and manifests itself in a particular way in each individual and depends on the combination of physiological, neurological and psychological factors. In this sense, derived from this subjectivity, it becomes difficult to determine the right treatments for the patient in which pain is manifested [7]. In spite of this subjectivity, the understanding of pain and its measurement, in addition to technological and scientific aspects, also involves moral and ethical questions about the human condition, especially as the occurrence of pain reduces the quality of life and impairs the working abilities of people [8].

In this sense, it is common practice to use rating scales and questionnaires as a means of measuring pain, such that the pain rating scales have a fundamental place in clinical practice [9]. The input data are usually based on self-reporting, but can also be based on observation or physiological data. For patients suffering chronic pain, several daily measurements over a period of time, are performed in order to analyze the evolution and its relation to therapy defined by the healthcare professional (HCP). Thus, the pain dataset collected regularly give rise to the pain diaries and making them a valuable means to assess a patients clinical course and to identify changes in health conditions. Moreover, it enables the patients to actively contribute to their health care [10] as well as often providing pragmatic assistance such as medication record and medical appointment reminders [11].

Due to technological developments the pain diaries are increasingly based on small, portable computers instead of using pencil-and-paper [12], to the extent that can be used to assist the patients in assessing and reporting their pain, and such technologies can also help the professional caregivers to work with pain control in a more structured way [13]. The use of technology can provide several benefits including clinicians mobility, providing real-time access to data and information, reducing medical errors, saving time, supporting evidence-based practice, enhancing productivity and quality of care, and providing a tool for communication [14]. Furthermore, nowadays in a society where information is highly relevant, the patients want to be better informed of their health options and are, therefore, demanding easy access to relevant health information. Simultaneously, clinicians are eager to exploit advances in telecommunication technologies in order to put in practice new methods of data gathering and patient monitoring [15].

In this sense, we implemented a distributed system of self-reporting daily chronic pain, using the mobile device and a Visual Analogue Scale (VAS). Using the system, patients are asked to provide reports of their pain for a short period of

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time. The decision for using this rating scale was due to the fact that is a method for rapidly gathering quantifiable subjective ratings in both research and clinical settings [16]. The VAS ranges from 0 to 10, with the lower limit represents "no pain" and the upper limit represents the "worst pain imaginable." It can be stated simplistically that for values reported less than 2 is considered mild pain, for values between 3 and 7 is called moderate pain and for values between 8 and 10 and considered severe pain.

The remainder of the paper is organized as follows. Section II presents the web services, whereas Section III addresses the related work focusing on electronic pain diaries. Section IV presents the architecture of proposed system focusing on technologies, and relevant features. Finally, Section V concludes the paper.

II. Web Services

In recent years, Web Services (WS) have transformed the web from a publishing medium used to simply disseminate information, into an ubiquitous infrastructure that supports transaction processing [17]. The main purpose of WS is to ensure interoperability, in other words, they provide a standardized mechanism for heterogeneous information systems and applications to communicate with each other. They make use of open web protocols including HyperText Transfer Protocol (HTTP), Simple Object Access Protocol (SOAP), and Extensible Markup Language (XML) and are independent of their implementation language and operating platform [18], [19].

Arising from the use of WS, developers can produce functions for reuse and/or can consume functions created by others anywhere on a network. The proposed approach uses the WS to provide the integration of the pain diary running on mobile device and a remote database. Moreover, the use of the WS, through Internet access allows the user to take advantage of the mobile device's ubiquity and connectivity insofar as transactions consist of sending and receiving SOAP messages over HTTP. The use of the WS by the mobile device software allows sending data and also determines the behavior of the pain diary in terms of frequency of records and display of alert messages, making it an adjustable system to the patient and their therapy.

III. Related Work

In this section we discuss some approaches for electronic pain diaries and compare them to our proposal. Sufi *et al* [20] present a system to get the pain value based on mobile devices running software developed in Java 2 Micro Edition (J2ME). The value obtained is sent to a remote server, together with other physiological parameters such as heart rate or oximetry, using Short Message Service (SMS), Multimedia Messaging Service (MMS) or HTTP. With this approach however, the system is not the most appropriate for pain monitoring, due to the fact that it does not provide schedule to patient's data acquisition, neither sends warnings in accordance with the values obtained.

Ghinea *et al* [21], present a client-server architecture whose clients are running in Windows CE handheld devices to gather patient's data around the clock. The collected information is sent to the server via an WiFi hotspot using HyperText Transfer Protocol Secure (HTTPS). However, this system presents a significant limitation, since it only allows access to the data by the HCP (in a website developed for this purpose), which does not happen with the patient.

The electronic pain diary proposed by Page *et al* [22], consists in the software version of the McGill Pain Questionnaire (MPQ) and runs in Microsoft XP Tablet-PC with exporting data capabilities to Microsoft Access. This approach has some drawbacks, including the time taken to answer to the questions, and do not provide a real-time analysis of recorded data, which leads to a lag between the completion of patient data and the clinical analysis.

Finally, Bielli *et al* [23] present a pain diary based on mobile phones, whose pain information is sent to the server using a General Packet Radio Service (GPRS) connection or through web access. A peculiarity of the system is that it automatically sends SMS or MMS messages, to warn the patient about the need to fill data. This approach presents a problem regarding the need for data analysis by HCP before sending messages to the patients, *ie*, the system does not allow the generation of automatic responses, making it vulnerable to temporal availability of the HCP.

The several approaches afore mentioned, although with different technologies and methodologies, converge in their final purpose with respect to providing patients the pain diary records. The main objective arising from the approach focused in this paper is to solve several problems encountered in each of the projects mentioned above through technology in widespread use, such as mobile phones and the possibility of connectivity they provide, chiefly through the use of WS.

IV. System Architecture

This section presents the system architecture representative of the proposed approach. An illustration of this architecture is shown in Figure 1. The system uses a commercial Personal Health Record (PHR) [24] called Meu Sapo Saúde, provided by PT Comunicações/SAPO Labs, in which the pain module and its corresponding WS were developed in coordination with the project presented in this document. On the one hand, HCPs use the PHR to define the monitoring of each patient in terms of frequency of recorded values, automatic messages based on values obtained and allows the display of histograms for each patient. On the other hand, patients use the PHR to consult its values and alert messages. Although it is possible to enter data to the PHR (using browser in a non-mobile platform), in the context of this project, the smartphone's apps are used exclusively for this purpose.

The mobile application was developed for devices with Android OS and includes a SQLite database to store local data. The use of the WS enables communication between the smartphone application and the PHR, which consists of the execution of methods for obtaining the schedule of pain records, getting alert messages and also sending pain values. The WS associated with the PHR was developed on Microsoft technology, particularly by using Windows Communication Foundation (WCF). The mobile application, which contains the diary of pain, access the WS via HTTP requests, transporting SOAP messages that describe methods to execute and its arguments. The HTTP responses are also SOAP messages whose body content is defined in JavaScript Object Notation (JSON) [25]. The adoption of

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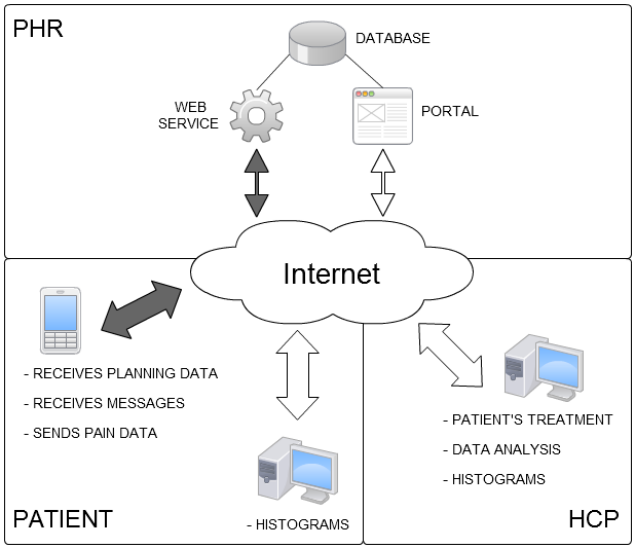

Fig. 1. Architecture of the proposed system.

the SOAP messages was due to the fact that it provides user certification, authentication of data integration and privacy of data [26].

The frequency of data recording in the diary of pain is defined by the HCP in the PHR, by indicating the number of times that the patient should be followed for registration of values, thus ensuring complete flexibility with regard to the adjustment of the system not only according to the treatment of each patient, but also according to the evolution of their state of health. Using the WS, the application periodically checks for changes in this configuration and updates them to the mobile device's database. Thus, on the one hand the application is always updated according to the defined therapeutic and on the other hand, this information allows the application to enable the appointed time in order to ask the patient to enter the pain data. This request is accompanied by an audible warning and remains on the mobile device's screen for a certain period of time. After this period, if the patient has not responded, a "no response" is assumed, which will then be statistically analyzed together with other values.

Whether a "no response" or a value are entered by the patient, they are immediately recorded in the database of the mobile device, as well as being sent by a WS to the PHR, thereby available for on-line viewing. If the data transmission is not successful, the records will be marked as pending and the system will try again to send them the next time planned for recording data. Automatically and without requiring intervention by the patient, the system ensures the sending of all data to the PHR and therefore allow a reliable data analysis. Immediately after sending and recording the values of pain, the application will go into background mode until the next moment of data entry.

Through the WS, the application periodically detects the existence of messages in the PHR, which may have been caused by the last data recorded or issued by an HCP. Whenever there are messages, they are saved in local database of the mobile device and are presented to the patient after the activation of the application following by an audible warning. The system provides two-way communication between the patient and HCP, to the extent that the data recorded by the first can trigger the issuance of warnings pre-defined by the second. This feature may contribute to the acceptance and effective use of the system by the patient as it will feel be monitored clinically and furthermore, the automation of messages emission will release the HCP's time spent in data analysis. The purpose of this approach is to solve one of the problems that may arise from the use of pain diaries which relates to the lack of regularity in the visualization and incorporation of obtained data in decision making by the HCPs [27].

Another important feature is that the feedback, under normal conditions, occurs in real time, due to the use of WS, since the sending of patient data and responses are carried out without the occurrence of gaps in time (beyond the inherent communications and data processing). This presents a great advantage of our system compared to others already developed, as it allows to implement or adjust their practices more quickly and immediately after the occurrence of an episode of pain.

Furthermore, the system also allows the patient to register unplanned pain records which submission process is identical to the planned records. For analytical purposes, the data are classified according to their nature, *ie*, each record indicates if it was planned or unplanned. All the information generated in the system can be accessed in the PHR, through the use of the browser, either by the patient or by an HCP.

V. Conclusion

In this paper we have explored the use of WS to enhance the integration of pain diaries with other systems in order to enable a better monitoring and implementation of clinical practice by the HCP. The results obtained in the pilot study are very promising and reveal that the presented approach, mainly due to the use of web services allows solving several problems encountered in systems proposed by other authors. These problems include the lack of timely feedback from the HCP or the adjustment of the system depending on the patient's treatment. Due to the detection and retrieval of messages via the WS, it is guaranteed that the patient is alerted in a timely manner with warning messages defined in the system or manually issued by the HCP. Since the system allows the definition of automatic responses according to the values obtained for the pain, it does not require the permanent expenditure of time by HCPs in analyzing and formulating responses. The proposed system will soon be applied in the follow-up consultation of pain in a Hospital Center, through its use by a wide group of patients in order to deepen the conclusions already established. We also want to implement additional studies for monitoring chronic pain, and accordingly we will develop the iPhone version of the pain diary that will share the presented WS.

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