Pain Diary

Pain Management Platform

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Abstract

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In the context of current human diseases and conditions, chronic pain is among the most typical reasons for seeking medical attention and is seen in 20 to 50 percent of patients attending primary care (Bajwa Z. H., 2012). With those figures in hand, the medical specialty of pain is of increasing interest to the scientific community and other parties involved in the management of chronic diseases. In the practical sense, chronic pain patients usually have, as of now, regular check-up appointments with their pain specialist, where medication is modified or maintained depending on the frequency and intensity of the patient's pain episodes. As a matter of fact, between appointments, patients are usually encouraged to write a comprehensive account of their pain episodes and their characteristics in the form of a pain diary. In such diary, they write the intensity of their pain in a relative scale from 1 to 10, the location of the pain in their body, and other relevant comments, namely medication side-effects or the activity they were performing when pain appeared. This set of data is then used by pain specialists to calibrate the patient's medication and follow their treatment.

Pain Diary, the project developed and described in the present document, seeks a more flexible, precise approach for patients to record their pain diaries. The project emphasizes on the interaction between the patient and an electronic pain diary, in the form of an application for the iOS platform. This document discusses the human-computer interaction analysis, usability tests, accessibility tests, and prototypes created to develop a comprehensive user-oriented solution for patients of cancer and other chronic diseases. Finally, the paper will present a functional prototype created for iOS, taking into account UX (user experience) design and interaction, as well as a RESTful back-end to consider in a future large scale implementation of the project.
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1. Medical background

This section of background information attempts to clarify specific concepts surrounding the project that are not strictly related to the field of computer science, especially those from the medical field and related to diseases or patient conditions.

1.1.- Pain specialist profile

Pain specialists are from different recognized medical specialties. In essence, the pain field is not recognized by all countries as a specialty per se, but it is more considered as a multidisciplinary approach to the management of pain. With that said, from the medical practice point of view, pain specialists are usually anesthesiologists, rheumatologists, oncologists, traumatologists or even general practitioners and family doctors. From a research point of view, specialists are usually the ones mentioned before and also pharmacologists and physiologists. As a matter of fact, there are no boundaries or limits as to be a pain specialist, since most medical specialties involve pain management, and the ones mentioned are simply the most frequent.

When mentioned in this project, pain specialists can be all kinds of medical personnel directly involved in pain management, which includes doctors, nurses, medical auxiliary personnel, and psychologists.

1.2.- Pain unit

Pain units are usually described as research and practice departments solely dedicated to pain management, inside hospitals or medical institutions. A pain unit is normally composed of a Head of Department and other doctors, nurses, and auxiliary personnel.

1.3.- Patient profile

The pain patient is usually a patient of cancer or other chronic diseases. In the case of cancer patients, extreme pain may arise from operations, cancer treatments, or the condition itself. Other chronic diseases may cause pain due to failed operations, nervous system issues, or psychological factors.

It must be noted that most patients are of an advanced age and are not necessarily used to mobile devices or electronic equipment. In fact, the average age of the pain patient is 51 and the most typical cause for medical consultation is arthritis/arthrosis (Krief, B., 1998).

It is also important to note that a considerable amount of patients are in cancer final stage. This type of pain management is called “Palliative care” and its main objective is to improve the quality of life and ensure absence of pain during the remaining lifetime of the patient.
1.4.- Patient cycle

It is important to describe beforehand the patient’s cycle to understand the problems surrounding pain management. This cycle is composed of the following steps: Patients are usually treated and screened by a general practitioner or family doctor in the first place. If the doctor’s diagnose reveals that the patient’s condition is related to a more specific area in medicine, they are referred to a specialist. The specialist will be the one leading the treatment of the patient’s condition. If the condition involves pain, the specialist will try to treat this pain with less severe painkillers, usually available without prescription. If such pain is extreme, specialists usually refer patients to pain specialists, more familiarized with powerful painkillers and pain medication.

Most patients that get to a pain specialist suffer extreme or unbearable pain due to a chronic disease. In fact, since we would be discussing about pain episodes that prevents patients from actually performing their daily tasks, 19.6% of pain patients need to take medical absence, and 3.3% need permanent government subsidies due to total incapacitation (Bassols A., et al., 1999).

Patients usually have a preliminary appointment, where the pain specialist analyzes the type of pain and the location, and prescribes the appropriate medication. Subsequent visits will be performed to analyze the progress of the patient’s pain episodes and medication.

1.5.- Intensity and measurement of pain

There have been many studies and different attempts to measure pain. However, up to now, it is impossible to measure pain in absolute terms. Because of this reason, pain is usually measured in relative terms, according to the description given by the patient. Although there are several available pain scales of intensity, pain specialists usually employ the visual analogue scale, which describes the intensity of pain from 1 to 10. This scale is widely used because of its simplicity for both patients and doctors.

1.6.- Types of pain

Pain is usually classified into three different categories: somatic, visceral, and neuropathic. (Jackson Memorial Medical Center, 2009). However, this classification is not standardized and there is not a common criteria among pain specialists on how to divide pain types. The IASP (International Association for the Study of Pain), the main entity on pain management worldwide, has an updated taxonomy of pain, with classifications of chronic pain and accurate definitions of types of pain from different perspectives (Loesser, J.D., 2011). This taxonomy is developed by the IASP Taxonomy Working Group and is constantly updated.

However, for the purposes of this project, and from the perspective of the patient, we will be working with two types of pain:

- **Basal Pain**: pain constantly suffered by the patient. This pain is usually treated with a continuous dosage of mild to moderate medication. In the analogue scale, this pain is usually between 1 and 4.
- **Breakthrough Pain**: also known as ‘incidental’ pain, this pain is suffered through sudden episodes that can last from seconds to minutes. This pain is extremely unbearable and
patients tend to describe it, in the analogue scale, from 7 to 10. This pain is usually accompanied by drowsiness and nausea. From a psychological perspective, breakthrough pain episodes are usually described as a ‘torture’ and some patients usually have suicidal conducts. Furthermore, these pain episodes are usually concentrated on a very specific part of the body and are usually depicted by patients in metaphorical manners according to the experienced feeling, namely as if a saw would start cutting the patient’s flesh. This pain is treated with extreme painkillers, usually opioids. An example of a currently used opioid for this type of pain is fentanyl. When the patient starts feeling the pain episode, instantly grabs a sublingual pill that places under his tongue, or administers the medication nasally, through a spray, depending on the brand. This kind of opioid has extremely fast effects and acts within seconds. (Poulain, P., 1997)

1.7.- Pain diary

A pain diary is a journal where patients include their basal pain and incidental pain episodes, indicating their date and time, intensity, location in the body, and any other relevant comments regarding medication or activities when pain erupted. This journal is usually handwritten and patients tend to write 4 to 6 entries a day. This number can vary depending on the number of breakthrough pain episodes they suffer. An example of a daily pain diary entry developed by the author of this thesis for a patient pain initiative online can be seen in Figure 1. Note that basal pain in this case would be between 3 and 4, with peaks up to 7/10.

![Figure 1: Example of pain diary entry. Intensity on y-axis, hours on x-axis. Medication comments and other relevant comments are also visible. (Bustamante A., (Contra el Dolor), 2010).](image-url)
2. Description of the problem

Currently, patients use handwritten pain diaries. These usually consist in a grid paper, where the patient can record pain episodes and their intensity and time, and a comments section to introduce activities, personal opinions and medication issues. This approach implies several problems.

For instance, handwritten diaries are a difficulty to manage patient’s data and analyze it. A significant amount of doctors discard them for the complexity of digitalizing the data in order to make statistics and pain management approaches. Furthermore, the task of updating the diary on a daily basis is tedious and tiresome. Some patients stop filling their diaries and give up, negatively affecting their health and quality of life.

Therefore, from the interviews performed to real patients and specialists during the development of the project, it was found out that the main problem of pain diaries is that they are paper-based and require patients to take manual initiative to fill them in a consistent manner. Truth to be told, pain diaries are not as effective as they should be due to these facts.

The lack of efficiency and utility involved in handwritten pain diaries causes pain patients to receive imprecise treatment that could be significantly improved and detailed if pain specialists would be able to extract the information from diaries in a comprehensive manner. This causes discomfort in professionals and patients, as well as additional cost for social security, health management companies, and other stakeholders involved.
3. Proposed solution and methodologies

The proposed solution is the project in hand, Pain Diary. Pain Diary is an online platform for patient and medical support on the field of pain treatment. It is a research and diagnostic tool for specialists and a pain diary for patients. It relies on applications for mobile devices as a user front-end. In fact, this bachelor thesis emphasizes on the interaction part from the point of view of the patient in mobile devices. The project offers an interface from any iOS device with Internet connection that allows the patient to promptly record pain episodes, automatically registering the date/time of the event and completing the process within seconds. The patient forgets about handwritten papers and hours of diary ‘paperwork’.

The methodologies employed to create this solution are standard to human-computer interaction analysis and prototyping, and involve extensive work and analysis during a timespan of approximately 2 years, both in Madrid, Spain, and Uppsala, Sweden. In the following sections, an extensive and detailed description of usability, accessibility, and human-computer interaction analysis will be given. After that, this paper features a detailed account of the non-functional prototypes developed during this time, both low and high fidelity. Finally, and the main purpose of this bachelor thesis, there will be a detailed description of the functional prototype for iOS devices. The author’s intention is to portray the iterations, progress, and transitions between phases until the final product.

NB: The proposed solution, with the used methodologies, including the interviews, analysis, and tests was developed by the author of this Bachelor thesis during a timespan of 2 years. The work portrayed in this thesis is incremental and iterative to the final delivery, a functional prototype based on a native approach.

3.1.- Human-Computer Interaction preliminary analysis

3.1.1.- Target of the project

The target of this project is mainly divided into two very distinct sectors. In fact, these two profiles are the ones benefiting directly from the solution:

- **Patients**: patients suffering pain, with any pathology, chronic disease or condition, that require a constant and updated pain diary.
- **Pain specialists**: doctors and other medical personnel directly involved in pain management clearly benefit from this solution, since analysis and review of pain data from patients is easier and more straightforward.

3.1.2.- User profiles

In this section, the different user profiles in the system are explained through the user role structured model. There will be two roles:

1. **User Profile: Patient**

   **Description**: the patient has basic or no knowledge of household computer devices. Subject does not usually navigate through the Internet and uses only the computer when it
is strictly necessary, for communication purposes as a tool, and not for entertainment. In a considerable amount of cases, patient is of an advanced age.

**Competences:** the patient is used to fill a handwritten pain diary, with pen and paper. The user knows the mechanics behind the project and is familiarized with the procedures and benefits of filling it and handing it to the specialist. He is conscious about the importance of the system and has been advised by the pain specialist to fill in the pain diary. In other words, a figure of trust, the doctor, has encouraged the patient to use it and he has received motivation from him.

**Interaction:** the frequency of usage is daily, minimum 3 to 5 times a day, depending on the number of breakthrough pain episodes that patient suffers. Therefore, the interaction between the system and the user is continuous and constant. The user’s concentration when using the system is instantaneous and will not be lost throughout the session, because each usage will have a time length of no more than a minute. Actions are predictable and linear in the system. Therefore, the system is the one taking the initiative into finding the information.

**Information:** the user submits information directly, according to the experienced episodes, and is of a simple nature in data complexity terms. The format of the information is advised and recommended by the specialist. Quantity of information is relatively small.

**Usability criteria:** system needs to be adapted to the user role, that is, not used to control computer systems and other electronic equipment, and must concentrate on the use effectivity. Frequency and usage must be efficient. Utility and motivation are considerable, since the user is aware that correctly filling the pain diary will cause a substantial improvement in quality of life.

**Functional support:** system must be able to store information send by the user on an external server, to avoid data loss, and ensure that the specialist is able to access information.

2. **User Profile: Pain specialist**

*Even though the project emphasizes on the interaction with the patient, a brief model description is given to understand the nature of the user that will review the patient’s information.*

**Description:** the specialist has basic or moderate knowledge of basic informatics and is used to employ computers for research, finding information, and diagnose.

**Competences:** is conscious about the importance of using the system and understand the mechanics behind it, as well as the necessities of the patient. Furthermore, the specialist takes the initiative in recommending the user to use the pain diary.

**Functional support:** system must ensure that the specialist is able to access information.
3.1.3.- User observation techniques

With the basis for human-computer interaction analysis in hand, as well as concrete specification for the user roles, it is important to analyze and observe users. This phase of the process is of vital importance, since it will be one of the foundations for subsequent prototypes and analysis.

For the project, throughout 2010 and 2011, context interviews were conducted to a reduced group of users. First, the project and main idea is portrayed to a group of 2 or 3 users of each role specified in section ‘3.1.2.- User Profiles’. Afterwards, interviews are conducted individually, due to the private character of the information. It is important to note that these two types of users, patients and specialists, have been previously identified, and their identities are not disclosed in this document.

The notes taken during the interviews were directly connected to the necessities of the users in the final goal of the system. In fact, to improve realism in the context interview, users were given a mockup handwritten pain diary, very similar to Figure 1. More specifically, the notes taken were the following:

In the case of specialists, the following information was noted:
- Which information is most important for treatment improvement and diagnosis? (For example, pain episodes, pain peaks, frequency, type, among others).
- Granularity of the information necessary for treatment and diagnosis. In other words, if the specialist will need the specific information based on hours and minutes or rather an abstraction based on days and weeks.
- Organization of the information, taking into account efficiency of the doctor. This aspect is especially important because the doctor will handle large sets of data from all his patients.

In the case of patients, the following information was extracted from interviews:
- The manner in which the user fills in the handwritten diary. This information was extremely important in following steps of development, and to extrapolate behavior of the user from a handwritten diary to an electronic one.
- The manner in which the user controls the granularity of the information was also noted. This affects the margin of error in data.

3.1.4.- User observation results

Taking the methodology discussed in the last section as a starting point, user observation gave clear results on how to approach the project in following phases. Therefore, user profiles were refined in the following manner, and results were quite satisfactory:

In the case of patients, useful information was extracted about profile and behavior:
- Regarding the patient’s profile, for project purposes, patients have an age of 40 or more.
- Most typical pain is muscle-skeleton pain, and inside this category, lumbar pain.
- Patient visits pain specialist in a regular manner and is subject of constant followup of pain. Vast majority end up abandoning their pain diaries or skipping important pain episodes.
• All of them agree on the fact that it would be of extreme usefulness to fill the diary in an electronic manner.
• Most of them are not used to web applications or electronic platforms.

In the case of specialists, useful information was extracted about profile and behavior:
• Considerable percentage of specialists use pain diary specially for research studies, being also reviewed by the coordinator of research.
• Due to the social and cultural level of the patients, some specialists do not recommend the pain diary.
• The average specialist has a considerable domain and knowledge of medical informatics as a work tool. They recommend the pain diary for their patients. There is a certain flexibility in this task.
• Most patients get to the appointment without doing their “homework”, having incomplete or blank pain diaries.
• Pain diary tends to be used to improve medication and treatment, not strictly for diagnosis.
• There is also interest in an electronic-based pain diary.

3.1.5.- Task Analysis
During this phase of the project, it was decided that the best approach to analyze user tasks was to design prototype situations corresponding to observed situations with users. The prototype situation for patients is described below:

**Scenario:** Any place or time in daily life of the patient.
**Description:** Patient suffers increasing, abrupt breakthrough pain episode.

**Task Flow:**
1. Patient detects sensation of pain. This pain may be incremental or during a timespan. For the purposes of this scenario, the pain is incidental and sudden, as well as increasing.
2. To avoid reaching a higher level of pain, patient immediately takes medication to instantly mitigate the pain. (Description of breakthrough pain mitigation in section “1.6 Types of Pain”).
3. In that precise moment or shortly afterwards, patient remembers to fill in pain diary and writes down details about the pain episode.
4. Patient evaluates his pain from 1 to 10 and finishes writing down the entry.

This process is repeated on a regular basis, in the periods between appointments.

**Possible difficulties:** it is important to note that the user has no knowledge or basic competence on computer-based equipment. Therefore, the interaction must be linear, clear, and the system has to be the one who takes the initiative when asking for the information.

**Usability and accessibility requirements:** regarding patients with disabilities, the system must be adapted for basic accessibility issues, and will be taken into account for following stages of development. Characteristics such as colors, sizes, and noises are of vital importance in this field.

**Preliminary conclusions:** task flow in the final product **must** emulate as accurate as possible the original handwritten pain diary task flow. Filling the entry must not take more than a minute and it must be fast and straightforward.
4. Product concept design and Design prototypes

4.1. Product concept design

In this section, comprehensive analysis of the problem domain is portrayed, including a set of axioms from which the project was to be developed.

Starting points:

- Filling the pain diary on a computer-based platform is not only more practical, but also lightweight for the stakeholders involved.
- Regarding the specialist, both in medical practice and research, a computer-based pain diary platform is useful and will eventually replace traditional handwritten approaches.
- This system clearly improves efficiency between patient and pain diary, and it will increase the percentage of users that successfully fill their pain diary.
- The scientific community is extremely interested in the project because it deals with direct innovation in the medical field.
- The platform will offer a flexible, state-of-the-art front-end to patients, featuring a linear interface with fast, straightforward usage and no learning curve.

Axioms:

- Pain Diary is the ideal system for pain management and improvement in patients, both for research and practice purposes.
- Specialists consider the computer-based pain diary an invaluable tool in their daily professional life.
- Pain patients are recurring users of Pain Diary and filling it requires no effort.

Objective: re-invent the pain diary

- As part of the problem’s frame of analysis, it was taken into consideration that pain diaries were being re-invented. In fact, this is the main purpose of the project. As discussed in the document so far, there is a strong need for the user to feel a direct connection between the previous handwritten task-flow with the new one.
- In reality, the computer-based pain diary will be a metaphor in itself, that has to be constant and loyal to the idea of the pain diary as the patients have pictured it so far.
4.1.1.- Low fidelity design prototypes

In essence, and from the experience of the author of this thesis, one of the most decisive and important phases of the project. The four design non-functional prototypes were developed during a timespan of 4 - 5 months. Three of these prototypes were of low-fidelity and one final high-fidelity prototype. These are presented in the current section.

Assumptions:

- There is a clear need from users to have a platform in which to fill and analyze pain data in a straightforward, low cost manner.
- Users assume current handwritten model as useful but faulty, and a similar design for computer-based systems shall be of extreme usefulness.

Objective:

- Develop straightforward, fast low fidelity prototypes for different platforms. These prototypes were developed as drafts.

4.1.1.1.- Personal computer prototype

**Description**: prototype developed from the concept of a web-based platform for computers (PC’s, notebooks, among others).

The prototype is displayed in the following figures, graphically:

![Prototype Image](image)

*Figure 2: Low quality, low fidelity prototype for web browsers. User clicks intensity and hour in a matrix.*
Figure 3: In next step, user specifies comments and activities during pain episode.

Figure 4: Finally, the patient indicates the location of pain.
4.1.1.2.- Prototype for mobile devices with graphical user interface

**Description:** prototype developed from the concept of a web-based or native platform for mobile devices (smartphones, PDA's, among others)

The prototype is displayed in the following figures, graphically:

*Figure 5: Prototype for mobile devices. First screen to decide if pain is recent.*

*Figure 6: Screen to indicate intensity of pain*
4.1.1.3.- **Standalone device prototype**

**Description**: independent keychain device to record pain.

The prototype is displayed in the following figures, graphically, with sketches and final low-fi mockup:
4.2.- Prototype evaluation

In order to test the different non-functional prototypes, usability tests were performed on real patients and doctors during several sessions. The evaluations were featured as follows:

Evaluation of prototype for “3.2.2.1.- Personal computer prototype”.

Test subjects: 2 patients, 3 pain specialists. Results:

- In the card, not all patients correctly appreciated gray lines.
- The numbers may be too small.
- Additionally, grid size would be enough so that it can easily be selected with a mouse click (the test pointing device is "a finger").
- Then they are invited to add a new event in pain diary by clicking on the appropriate time and pain and making it appear next to the "cursor" box. It is expected that patient doubts if
system response is incorrect, resulting mostly in a satisfactory response (one patient had no expectation about the reaction of the system).

- End of task flow generates a general question: Is that it? Lack of feedback to have completed the registration.
- Minority question: Can you check more than one area of pain?
- A time to complete the process returns to the screen grid filled with time / intensity marked in red to indicate it is completed.

**Evaluation of prototype for “3.2.2.2.- Prototype for mobile devices with graphical user interface”**

**Test subjects:** 2 patients, 3 pain specialists. **Results:**

- Patients again complain about the lack of feedback of the system, but results are in general more satisfactory.
- Users demand more feedback at the end of the task flow.

![Mockup of mobile device prototype](image)

*Figure 11: Mockup of mobile device prototype, used for prototype evaluation*

**Evaluation of prototype for “3.2.2.3.- Standalone device prototype”**

**Test subjects:** Due to the nature of the mockup, being simply a standalone device for patients, it is tested only on 5 patients. **Results:**

- Buttons seem too small and device is too big for a keychain.
- Users complain about the fact that it is very easy to accidentally send pain episodes when device is inside the pocket.

**Conclusions:** Taking a look at the notes, results, and feedback from users, it is decided to continue development with the prototype for mobile devices. Prototypes 1 and 3 are discarded.
4.3.- High fidelity prototype

Taking into consideration the conclusions drawn from the previous usability tests and prototype evaluations, a high fidelity prototype is developed in AJAX and HTML5 for mobile devices, more specifically, iPhone and iPod Touch. The prototype is displayed in the following figure (texts in Spanish):

Figure 12: High-fidelity prototype with different screens, for mobile iOS devices. (Texts in Spanish)
5. Final product development and implementation

In the end, the final product is developed and implemented taking into account all previous usability tests, human-computer interaction analysis, and product design and prototyping. The final product of the project is in the form of a functional prototype for iOS devices. The front-end has been developed and programmed in Objective-C (Cocoa Touch API for iOS devices) to run natively. Furthermore, a simple back-end was developed to allow interaction between the server and the application.

5.1.- Object-oriented analysis

In order to understand how the different objects and information travel between the front and back-ends, it is important to perform an object-oriented analysis. This analysis is clearly summarized in the following package diagram that also emphasizes on the MVC (model view controller) pattern:

![Package diagram emphasizing on MVC.](image)

*Figure 13: Package diagram emphasizing on MVC.*
Explanation of diagram:

Front-end
The package diagram on the Front-end side attempts to emphasize on the Model-View-Controller paradigm, of vital importance in the development of mobile applications. As a matter of fact, the class hierarchy and dynamics of the application follow this convention, preventing from runtime errors and ensuring clean code and inner workings.

The model of the application is in the package PainBrain. This stores the information of the Patient (PatientData), that is, user ID and password, and the information of the pain peak that is being recorded in that session. As a matter of fact, PainData is programatically depicted as a singleton, having a unique pain peak per session.

Interaction between user and application is concentrated on the views, which define how the elements of different screens will be displayed and analyze the different interaction artifacts, that is, from buttons and other graphical elements to user gestures such as taping and swiping.

Actions by the user are then controlled by the Controllers package, through the different views and screens. In the last screen, the controller will be in charge of obtaining the information of the current pain episode and will send it through an HTTP request.

Back-end
The back-end is primarily divided into Models, Controllers, Persistency handler, and the endpoint. The endpoint is the one receiving the HTTP requests. The different models define the data model of information of pain episodes, patients, and doctors. Controllers in each package define the access to this programatical information.

Persistency handlers define how data is stored and recovered from the database. By abstracting this part of the back-end, we ensure flexibility and scalability in future possible implementations.

A comment has been added regarding the database itself. For the purposes of this project, since its emphasis is on the interaction side, the database has been implemented in Datastore, solution embedded into Google App Engine, the platform in which the back-end is hosted. The reason behind this decision is to allow a non-relational, completely non associated database, in an implementation abstracted enough to allow other similar database management systems in the future. In fact, the data model is ready for an implementation in a non-SQL style Cassandra database, which would ensure distributed data management, and an ideal basis for BigTable implementations.
5.2.- Back-end as Database and REST interface

The back-end is in charge of the storage and management of the information of patients, doctors, centers, and, most importantly, pain episodes and their respective configurations. It was developed in Java through the Jersey implementation, with Jackson, JAXB and Jersey libraries. After developed, it was deployed in the Google App Engine platform, for continuous 24/7 access.

For the purposes of this project, the database is implemented in Datastore, used an abstraction for a future Cassandra database implementation. The data model in the back-end is completely non-relation and unassociated. This is made in order to prepare data for a Cassandra database, highly compatible with Big Data and Hadoop implementations that ensure large scale, secure data storage, scalable access, and fast queries.

The endpoint is in the form of GET HTTP requests through a REST interface, performed from the iOS client (front-end).
5.3.- Front-end as iOS application

The front-end, the final product directly connected to the interaction part of the project, has been deployed in iOS natively. Furthermore, for the purposes of the project, the author acquired an Apple Developer Account to be able to deploy it in real iOS devices. The graphical elements were designed by the author with a licensed Adobe Photoshop CS5 and Illustrator CS5. The iOS application is depicted below in the following figures:

![Main screen of Pain Diary, iOS application](image)

*Figure 14: Main screen of Pain Diary, iOS application*

*After configuration by specialist on medical visit or by patient, this will be the default screen. A small button in the left bottom corner also allows viewing the last 10 pain episodes. The question ‘Have you felt pain within the last hour?’ asks if the patient has recently felt a pain episode. In case of taping ‘No’, a date and time screen will appear to select the exact moment of pain. In case of taping ‘Yes’, it will lead the patient directly to the screen to select the intensity of pain.*
Figure 15: Screen for selecting date and time of pain episode

Straight-forward screen for patient to select date and time of pain episode, with steps of 30 minutes.
In this screen, the patient is able to indicate the intensity of pain from 1 to 10. As it can be seen, the language in the application’s questions is straightforward and simple, with the example of “How much does it hurt?”. 
Figure 17: Screen to choose pain. User is able to drag finger and ‘draw’ the area of pain.

In a way extremely similar to the traditional pain diary, patients are able to select the area of pain.
After they are ready, they tap “Next”.
By allowing patients to insert optional comments, they can specify medication side-effects, activities or other relevant aspects about their pain episode. This information is extremely useful to trace the origin of pain episodes and improve the specialist’s contextual information about the pain episode.

Figure 18: Screen for comments.
Usability tests on patients revealed that most of them needed explicit feedback from the application that information had been sent. Responding to this need from the user, a last screen of 'Information sent' is shown in case of a successful session.
6. Innovation, market target, business model, and liability

Pain Diary is a completely different and innovative strategy. It connects patients, specialists, and health administration staff through a robust, scalable cloud of services. It unifies pain diary processes: completion (patient) and reviewal (doctor). Furthermore, this approach eliminates the need for paperwork, lightening the tasks by the stakeholders involved. Patients’ pain diaries are securely stored, and are accessible from anywhere by the specialist. Regarding stakeholders, we can clearly appreciate three different kinds of stakeholders and their interest in the project.

Regarding the **business model and cashflow** of this project, it should be implemented on a hospital-by-hospital basis due to the fact that most hospitals have different IT systems or particular needs. As explained below, it could financed by pharmaceutical companies interested in PR campaigns in the field of pain management or healthcare administrations. In fact, this project represents a cost-effective solution for public and private healthcare pain management because the solution itself was developed by a single developer, with almost no notable infrastructural cost, and freely available development tools.

Stakeholders interested in possible financing:
- Private healthcare and HMO’s: to add value to existing private health infrastructure and reduce costs.
- Public healthcare and Social Security: to reduce costs and decrease waiting lists.
- Pharmaceutical companies: part of image campaign, financing equipment and services to introduce into the medical community association between pain treatment and company brand (product revenue increase).

Special consideration has been taken into **legal issues** arising in future implementations of the project. In fact, the most important liability topic would be privacy. Since databases for Pain Diary only store numerical data and comments, never names, the database would be ordinary and not subject to sanitary controls, although this may depend on the legal framework of each country. Hospitals are the ones who have the identity of the patient, that is identified in the Pain Diary database only by an anonymous ID.
7. The expert’s opinion

Due to the innovative side of the project, doctors and patients have already manifested their interest once it is deployed and finalized. During the development of the HCI analysis, opinion leaders in the pain field collaborated in usability tests, interviews, and conceptual advising. From all the comments, I would especially emphasize the brief interview with Dr. Fernando Cerveró, President-Elect of the International Association for the Study of Pain.

“I think it’s a very good project using current technologies, and I am sure it will work perfectly on the practical side.”

Dr. Fernando Cerveró
President-Elect of the IASP (International Association for the Study of Pain)
Director of The Alan Edwards Centre for Research on Pain
Professor of Anesthesiology, McGill University (Montreal, Canada)
8. Conclusions, critical analysis, and future of the project

From the innovation point of view, this project will affect healthcare in a positive way. We are looking at a solution that is cost-effective from a monetary and implementation point of view. As a matter of fact, this solution is not simply logistical, but it also has a considerable psychological component: allowing patients to have constant connection with their specialist.

Since the beginning of this project, which started at the end of 2010, the main focus was to create a user-oriented solution that would dramatically and positively affect the lives of millions of patients. In such case, I believe the objectives have been fulfilled. The final product is a meticulously designed approach, from the User Experience point of view.

However, every approach has roadblocks and obstacles, and throughout the development of the project, these have been taken into consideration because of their vital importance. The following are possible roadblocks to be found when implementing the project in the future:

**User skills**

Both patients and doctors, especially older patients, may have difficulties to interact with the system if they have no previous experience with similar technologies, or eHealth.

- Solutions:
  - Very visual and interactive front-end for patients and doctors, that requires little or no learning.
  - Brochure that both promotes the advantages of using Pain Diary and gives easy step-by-step instructions.
  - Care givers and family members to help patients with mobility problems in pain diary tasks

**Reluctance to new strategies**

Specialists may find the product as a professional intrusion, giving the impression that they are being replaced by an automated system.

- Solutions:
  - Introduction seminars to pain specialists, to avoid confusion in the medical community.
  - Involve pain treatment top specialists and opinion leaders in the development of the platform.

In conclusion, Pain Diary offers an interesting approach to re-consider medical informatics, especially in the management of pain and chronic diseases. The potential of this tool will improve the lives of countless pain patients.

The future of the project will be to implement this into a larger scale, with real hospitals, patients, and doctors. The author has decided that the platform will be implement on an ‘open’ framework. By making it as open as possible and not proprietary, more patients will be able to benefit from the tool without obstacles such as corporate interests.
9. Bibliography


