The management of clinical incidents in ICT services through mobile applications

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Abstract

Mobile environment has revolutionized the health field. This fact and the rise of mobile technology have led to improve processes of care. In this paper, we present a practical application of BSC (balance scorecard) for Management of clinical incidents in ICT services through mobile devices in health organization. The objective of building of system is to integrate with main system of organization, for management of critical incident in ICT department of hospital and health centre. To do this, we have analysed and evaluated of process to management of incident that allow us to show the management information of way practical and we have applicated a real case. Results suggest that the integration of Balanced Scorecard helps with decision-making tasks because they allow decreasing response times and improving company management. In conclusion, make users satisfaction grow, objective sought by health companies
Keywords: Balance Scorecard, Mobile devices, Android, TIC, eHealth, management

1. Introduction

The use of mobile devices creates daily 2.5 quintillion bytes, being the 90% of the data created in just the last two years [1]. This is why companies, health services, governmental institutions and so on, are developing infographics that allow communicating the data in the form of charts and illustrations with the purpose of easing the understanding and retaining all the information by the staff members.

Therefore, a good management of this knowledge may increase the likelihood of success of healthcare organizations and can improve the quality of service received by customers [2, 3]. Several researches justify its relevance of ICT [4,5,6] and analyse the benefit in hospitals and health centres [7,8,9,10]. For example, taking into account the technological dependence that exists in healthcare organizations such as hospitals or health services, any failure in the related area with Information and Communications Technology (ICT) such as medical records

[11] or clinical applications of systems of integration of history [12] may cause a lack of service or care to the patient with important consequences.

In this field, Mobile Device Management (MDM) is the administrative area dealing with deploying, securing, monitoring, integrating and managing mobile devices, such as smartphones, tablets and laptops, in the workplace. The intent of MDM is to optimize the functionality and security of mobile devices within the enterprise, while simultaneously protecting the corporate network.

The management of mobile devices in an integral way is known as Enterprise Mobility Management (EMM). EMM is a strategy that helps employees be more productive providing them the needed tools to perform work-related tasks on mobile devices. In other words, EMM manages applications that use connections to business data [13].

Besides, keeping into consideration that the breakthroughs of tablets and smartphones have made possible a quick expansion of these products on the market. It is necessary to develop applications which help employees on their labour. To have an overall idea of this expansion, the European country with the highest number of smartphones is Spain (66%), where 23 million Spaniards use daily applications for smartphones and tablets. According to the 5th State report of apps in Spain [14], most of devices have Android as operating system (89%), followed by iOS (7.6%), Windows Phone (3%) and others BlackBerry, Windows offers, and so on (0.4%).The rest of European countries are very similar to Spain. According to BI Intelligence [15], Germany holds a market share as follows: Android 81% and iOS 11%. The market share is distributed in the UK as follows: Android 61% and iOS 29%. The market share is divided in France as follows: Android 71% and iOS 15%. The distribution in Italy is Android 76% and iOS 12%.

Therefore, our proposal is a system based on BSC, developed in Android that allow managing and administering ICT incidences of hospitals and health centres, providing information to users based on his position as employee and profile, filtering and simplifying the information received.

The paper has been divided as follows: Section 2 contains the analysis of prior researches made in this area. Section 3 shows the methodology followed to develop the system. Section 4 shows the experimental design of the application. Section 5 explains the resulting application, and the paper finishes with the discussion and conclusions obtained throughout of the research.

2. PRIOR RESEARCH

This section is split into three parts: the fundamental concepts of processes management, balanced scorecard, and use of mobile in health.

2.1. Process Management

Currently, Business Process Management (BPM) is one of the most usual ways to manage the companies, where its main standards are ISO 9001 [16] and EFQM [17]. Within these two standards, the most common is ISO 9001 which covers all processes related to the quality management and it focuses on four points:

(1) To define the responsibilities of the process management.
(2) To define resource management both in human and in infrastructure resources.
(3) To establish the stages of the product development and finally.
(4) To measure, analysis and improvement because the system must try to improve through the analysis of all stages.

BPM allows defining policies of continuous improvement through the definition of indicators that analyse the degree of compliance of each process over time [18] and allows improving the customer satisfaction [19]. These indicators can be depicted in a Balanced Scorecard [20, 21, 22]

2.2. Balanced Scorecard

Balanced Scorecard (BSC) was proposed by Kaplan and Norton [23] in order to manage and administer organizations, allowing to show the information in an organized way. The BSC is a method to measure the activities of a company in terms of strategic vision. In addition, it is management tool that helps companies to express their objectives and achieve with the defined strategy.

It is based on looking at the organization from four perspectives:
- Financial: encourages the identification of a few relevant high-level financial measures
- Customer: encourages the identification of measures that answer the question "How do customers see us?"
- Internal business processes: encourages the identification of measures that answer the question "What must we excel at?"
- Learning and growth: encourages the identification of measures that answer the question "How can we continue to improve, create value and innovate?

Dashboard applications on smartphones were analysed in order to identify common functionalities twelve existing from different vendors, the findings revealed that the analysed dashboard applications offer similar functionalities and the components are described using a structured format based on user interface patterns [6,24, 25,26, 27].

The BreathEasy project used a smartphone application for collecting asthma patients' observations of daily living and a clinician dashboard to increase communication and understanding between patients and their clinicians [28].

Xiaoli and Guangbin present a combined method, which applies the Balanced Scorecard (BSC), the analytic hierarchy process (AHP) and Fuzzy comprehensive Assessment (FCA) methods into measuring the performance improvement resulting from IT by a construction organization [29].

Finally, it is necessary to indicate important advanced in mobile Erp [30,31,32] and Quality Measurement for mobile [33].

2.3. Classification mobile applications

The World Health Organisation considers mHealth as a component of eHealth and it defines mHealth as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" [34]

Mobile health services can be categorised into two broad areas:
- Solutions across the Patient Pathway: Wellness, Prevention, Diagnosis, Treatment and Monitoring, entail direct touch-points with patients.
- Healthcare Systems Strengthening: Emergency Response, Healthcare Practitioner Support, Healthcare Surveillance and Healthcare Administration, do not involve direct interactions with patients, but are primarily aimed at improving the efficiency of healthcare providers in delivering patient care [35].

Mobile applications in health has two point of sight [36]: patient and professional side. From the point of view of patients, it allows them to have quick access to the information and training on topics related to the health. Moreover, it allows monitoring variables from their home without having to attend a clinic facilitating the application of treatments and its control. From the professional point of view, it provides quick and concrete access to information on the consultations facilitating decision-making.

The use of these tools facilitate and provide a new connection between the medical staff and the patient by improving communication. Besides, these tools make easier the decision makers. In addition, these tools can be used outside of consulting room or the clinic, either in the homes of patients or emergency services. It also provides an optimization of resources.

On the other hand, these tools have drawbacks too; for example, outdated data may lead to take erroneous or mistimed decisions, the dependence of one device rather than knowledge

itself and, what is more important, the risk of confidentiality infringement in case of loss of the device.

3. METHODOLOGY

Before starting with the work, we have started proposing a hypothesis to help us to analyse the process of data acquisition, treatment and subsequent presentation of results. This hypothesis has three main points:

- H1: The use of mobile applications allows optimizing processes management and administration. In our case, we focused on incident management of ICT issues.
- H2: The use of scoreboard makes easier the information management, and in our case, the incident and reducing time to access it.
- H3: The use of this kind of tools motivates employees.

Finally, we developed the system and we applied it to a real case in order to obtain the degree of implementation. For its development, we developed an interface easy to handle that reduce the transitions between screens.

4. ANALYSIS OF THE SYSTEM

In hospitals and health centres, the amount of information available on the Information Systems is very large, so we need to show information in time-real, because it is one of the fundamental principles of usability. Besides, the organizational processes of hospitals and health centres depend on a correct manage and control of information systems, so when a system failure occurs, it can be a loss of service. In addition, we must consider that the access to resources is limited; hence, the work is facilitated if worker teams have access to information in time-real.

Therefore the system that we propose attempt to provide solutions these problems. For it, we have development a balance scorecard and indicators, which permit us, make decision into health organizations.

In order to verify the proposed hypotheses, we have set a requirement to display the display information in the simplest way possible to simplify and streamline their use

We decide to develop this app in Android because it is the most common operative system in Europe.

This has been achieved by designing a customizable interface to the display, which redistributes the elements depending on size.

To easily the understanding of the system, this has been divided into two different parts interconnected between them: The first part contains server applications; this part is divided in two part: the first part contains ICT incidents and the second part contains the balance scorecard, and the last part is the different devices that can access to the information.
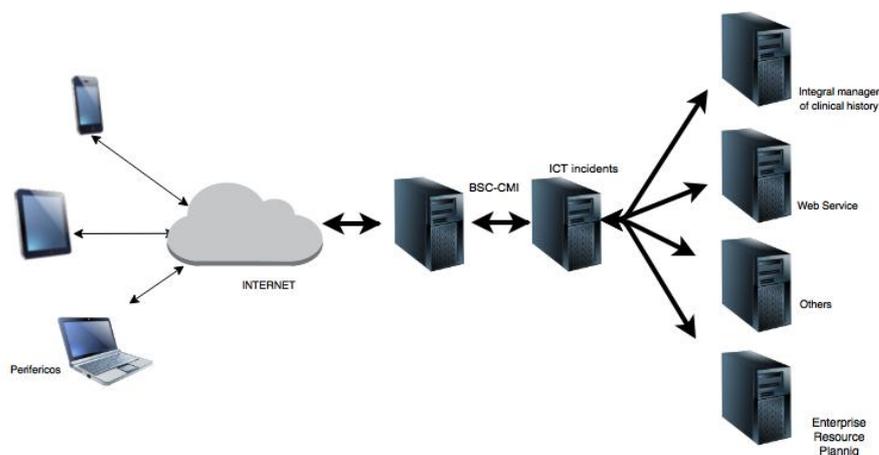

Fig. 1. Structure of system

4.1. Server applications

Every health organization has different servers, as integral manager of clinical history, web services or Enterprise Resource Planning, among others. These servers are interconnected providing status information. Besides, they have to control many devices as PCs, laptops, Tablets, mobiles, etc. Our server is called "ICTincident" and receives the information and BSC-CMI allows showing the information when it is required by the different devices.

4.1.1. ICT incidents Server

Our system allows the interconnection of several common business management systems, medical records and other centres servers, etc. This allows the management of incidents received via hardware, software or performed by users of the health organization.

When we conducted a management processing incidents received by the IT department, they can be treated and represented through the corporate balance scorecard to monitor their criticality, allocation resolution etc. In addition, the other indicators of the organization can represent it.

This allows the respective level staff of the organization to obtain information of several indicators such as indicators of quality of service provided, resolution of incidences, etc. this allows them a better allocate resources according to the urgency of incident.

Our system requires an interconnect layer between the server of incidents and the general set of devices and servers, for incident management system.

4.1.2. BSC-CMI Server

This system provides general information of organization, across the evolution of corporate indicators, it facilities the decision-making by the organization.

This server is called BSC-CMI, all users in the organization can access to it, and level access to information is determined for his role in the organization of health.

As has developed an interconnect layer between the server management of incident and Balance Scorecard server.

4.2. Mobile application

The application was developed using the Android SDK provided by Google and used as the Java programming language. As development environment, Eclipse has been used since the provided tools integrate seamlessly with IDE using the ADT plugin, which allows debugging code in connected devices and emulators included.

At all times we have followed the design patterns specified by Google for your system, using the theme "clear" (white and light colours) and maintaining consistency with the rest of the interface devices. The guidance is horizontally, because of its greater flexibility of space, and display menus is showed of intuitive way and leading to a partitioning of space in which several graphs simultaneously are appreciated.

During the development of the application, we have followed the MVC (Model View Controller), which is very useful to separate the operation of the visual layers. All the logic part is programmed in Java and visual part of an XML layer and is modified and improved by Java.

5. RESULTS

As a result, the application has been divided into 4 different screens: Login, main BSC screen, notification system and ICT Information panel.

To ease the movement between the different sections has been developed a lateral menu, which appear sliding the screen from the left side to the centre of the screen. From this menu, it is possible to access to several functions as come back to the main screen or logout among others.

5.1. Login

This first screen allows to access to the system information. Taking into consideration that the information has to be restricted, only authorized members can access to the application. To control the access, the credentials of the user will be checked on a database located on a remote server. This server is the responsible of store all the information of the patients and users. On this mode, the information will be not stored into the device for security reasons.

The user is also informed that the use of the application has been attributed to him due to his status as company personnel, fulfilling on that way the Organic Law on Protection of Personal Data (LOPD) [37].

5.2. Main BSC screen

Once the user has been validated, the application shows the main screen where the information is displayed. For its development, we have followed the design of the Heathrow Airport's scorecard [38] because it fulfils the content distribution proposed by Kaplan and Norton. This structure is based on four perspectives: Financial, Internal, Customers and R & D or growth and training as well as a central part with customized content depending on the profile.

The screen has been divided into 5 different areas, where four of them are connected with the perspectives proposed by Kaplan and Norton:
1. On the upper-left corner it is shown the results of the client perspective.
2. On the lower-left corner it is shown the information related to the financial perspective.
3. On the upper-right it is shown the indicators related to the intern perspective.
4. On the lower-right it is shown the information about training, growth and I+D sector.
5. On the centre area it is shown news and information of critic indications, alerts, and information about the defined indicators. In ICT department case, it is possible to show the incidences related to its level of importance and its state.

It is noted that the screen, as well as information shown on it, is different for each user because it is subject to permissions. Figure 2 shows two different options for each screen. The first example (Figure 2 (a)) shows the dashboard of a directive User with information of the Company, while the second screen (Figure 2 (b)) shows the application for a head of department ICT. As can be seen, the structure in both cases is Similar but each one adapts the information to each role.
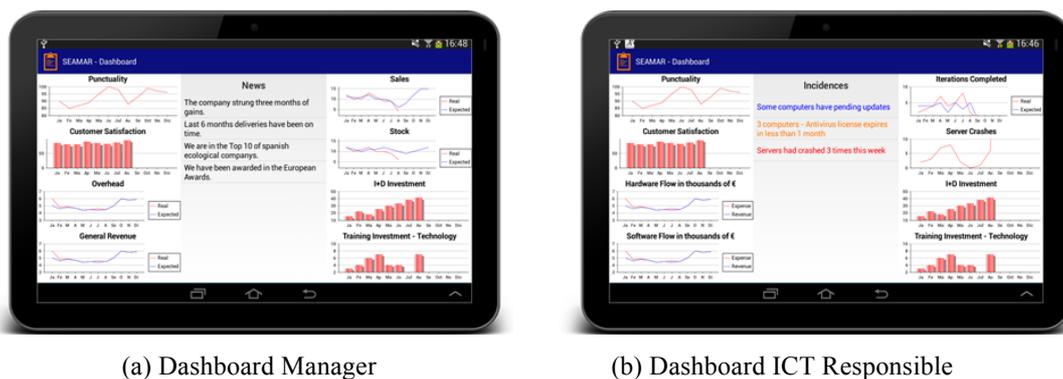

(a) Dashboard Manager   (b) Dashboard ICT Responsible

Fig. 2. Dashboard Manager

5.3. Notification and incidents system

To keep track and manage of the company's incidences of the ITC area, has been developed a special screen. In this screen, the persons in charge can see the list of open incidences and manage them, giving the opportunity of cut the time to fix the incidences, improving at the same time the level of client satisfaction.

It is possible to access to this section in two different ways: Pressing on the list of incidences shown on the centre area of the BSC, or through the lateral menu of the application.

Figure 3(a) shows the list of incidences where the priority level is reflected by traffic light colours where red is related to a high level of priority and green with a low priority. Figure 3(b) shows the all information of an incidence. It is possible to access to this information pressing on a specific incidence of the list.
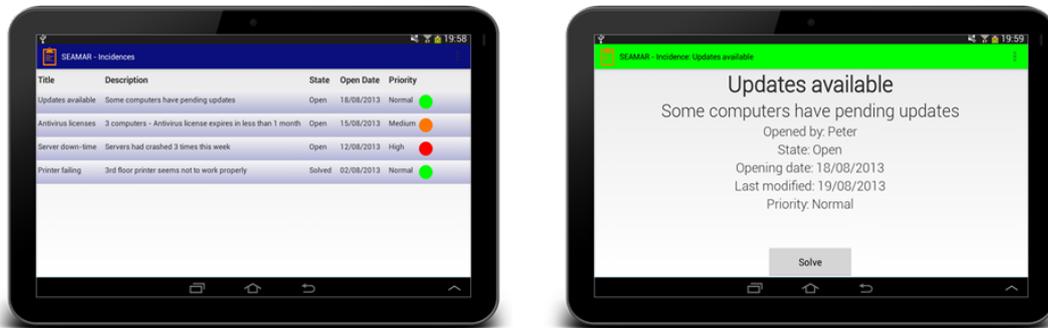
(a) Incidents Screen   (b) Incident Detail Screen

Fig. 3. Notification and incidents system

5.4. ICT Information panel

This screen shows information about the main indicators associated to ITC department as software incidences, hardware or the lack of services produced on the company. It is possible to access to this section in case of a user with level of ICT Responsible through the BSC's intern process perspective.

Once on this section it is possible to configure the information that user want to see, giving on this way the possibility to configure the number of charts and the information show on them. Figure 4 shows an example of this screen.

(a) Panel of information ICT department

Fig. 4. ICT Information panel

6. DISCUSSION

Once we developed the application, we have implemented and validated it through a questionnaire compound of three blocks and 10 questions where every question has been asked by a Likert scale questionnaire 5. This allows us to measure user satisfaction, usability of the application and accessibility of information in order to contrast results and validate the hypothesis.

The results of the questionnaire are: The degree of satisfaction with the application was of 4.40, degree of efficiency provided by the application was punctuated 4.54, the overall assessment of application 4.54. Regarding the question, the proposed mobile application facilitates the use, control and management of incidents, it was assessed 4.69.

On the use of mobile applications, you consider that these applications make work easier and motivates this question obtained a punctuation of 4.40.

As regards the group of questions concerning usability they have defined two questions: the first interoperability with the interface allowing 4.40 and second transitions between different screens and ordered control system has been valued 4.69. Finally, the group on accessibility of information has been rated 4.69 and the data entry and validation of the system has been rated 4.26.

At methodological level, this work contributes with the presentation and the implementation of a Balance Scorecard in an efficient way, adapting the content to the user role. An extensive use and promotion of interoperability is, in our opinion, the main advantage of our approach. It also has further consequences that contrast with traditional information systems.

In spite of there are some proposals about dashboard to information system, the main difference regarding to our system is that our system is perfectly integrated within the hierarchy of roles in the organization. Moreover, it allows adapting to these four ways (management by process, application of balance scorecard to mobile and desktop devices, information in real time, and information structure in function of worker role) at the same time.

Furthermore, this research answers our hypothesis. As for H1, we have observed that the use of mobile applications allows optimizing the processes management because it makes easier for workers, allowing them to have more information to make a correct decision and assign resources in function of the degree of criticality and provision of service. In addition, this statement is also supported by the value of 4.69 of the question proposed about if the mobile application facilitates the use, control and management of incidents. Regarding the second hypothesis (H2), we have observed along the validation that the use of the mobile Balance Scorecard facilitates information management because it controls every clinical incidents on ICT services, reducing time of access. In addition, as is shown in the questionnaire, both cluster of issues about usability (4.54) and accessibility (4.47) the users valuation is high allowing support the hypothesis. Related to the last hypothesis (H3), the use of this tool motivates employees, it was validated because it allows optimizing resources, reducing response times and the degree of satisfaction grows in the professionals, besides the managers can see the evolution of the different business indicators of lower levels, Furthermore, as we can see in the result to the question where was asked if these applications simplify work and motivates employees, the score of the evaluation was 4.40

To validate the application, as a feedback step, in the construction and implantation of the system as well as of the development of its interface, it was essential to make the validation with the purpose of verifying its effectiveness. For these two types of validations have been carried out, next both are detailed:

- Technical validation. It has been verified that the obtained results consistent with the theoretical results in each phases
- Practical validation. This validation was made in two levels:
  1. Operations In the presence of a determined real case which has been previously studied
  2. User's satisfaction with application from the point of view of usability, handling, questions etc. Moreover, satisfaction as application allows obtaining results.

Navigation within the application is simple because there are no more 3 or 4 levels deep. This objective was achieved through the use of a sidebar. Moreover, the number of steps was optimized to access any functionality by clicking on the possible graphics or items in a list.

Not everything are advantages; we found a relative disadvantage because it may be necessary to adapt the information content to the mobile devices, changing its graphical

interface. For instance, in the amount of graphics displayed or type of graphics used in small mobile devices. However, this can be solved by incorporating tabs and making a study about type of graphics to use in relation with mobile device size.

The main limitations are given because the system has been developed for a healthcare organization, but the article has focused solely on incident management in the ICT department. Therefore, one of the main problems that we encounter when introducing new technologies in the production process, even in the health area, it is the workers reluctance to adopt the new way to work and, in some cases, it may be thought that it can go in decrease of their labour free thinking that is designed to control instead of facilitating their work.

7. CONCLUSIONS

In this research, we designed, developed and evaluated a tool based in BSC (Balance Scorecard). Our aim was to gather information about management system and its integrating with main system of organization, for management of critical incident in ICT department of hospital and health centres.

Results suggest that the integration of Balanced Scorecard, help with decision-making tasks, allowing to decrease response times and improving company management.

Furthermore, mobile systems have great potential to transform the processes, and even the outcome, through of a good information system.

The implemented system was subjected to a practical evaluation and technical by technicians and ICT manager, who offered some feedback and suggestions about the system. The feedback from the ICT managers showed that the proposed system could streamline and improve the process through use of mobile BSC.

In sum, mobile technologies allow achieving better the processes management for health organizations and a better use of the resources of the health system.

Therefore, the contribution of our work has focused on developing a system which is running on mobile devices, that integrates with common health information systems. This system allows the management of TIC incidents arising in both hospital and health centres, allowing users to determine the criticality degree of each one and prioritized its resolution. This way they can optimize existing resources.

Likewise, we have designed an intuitive interface focused on using touch screen for the management and visualization of information using a balanced scorecard.

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