High-Fidelity Interactive Prototyping: An Experience in the Domain of the Veterinary Area

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***Abstract*— The results obtained from the development of a computerized system for issuing alerts in the event of zoosanitary occurrences based on interactive prototyping are presented in this article. The Animal Health Research and Development Center of the Biological Institute of São Paulo is a reference center accredited by the Ministry of Agriculture, Livestock and Food Supply and it conducts exams to diagnose diseases in order to promote the control of animal health in the country. The creation and implementation of a computerized system for epidemiologic alerts was designed to automate the processes and manage the flow of diagnosis to permit real time decision-making by the competent agencies. The use of high-fidelity interactive prototypes was adopted in this project in order to enable the understanding and validation of the requirements of the proposed system, meet the development deadline, minimize risks, and engage in a realistic and evolutionary experience in a software development project to promote final user satisfaction.**

Keywords: Agile methodologies, Requirement analysis. Information and Communication Technologies, Animal health, Zoosanitary alerts.

***Resumen*— En este artículo se presentan los resultados obtenidos en el desarrollo de un sistema automatizado de emisión de alertas en casos zoosanitarios basado en el prototipado interactivo. El Centro de Investigación y Desarrollo de Sanidad Animal del Instituto Biológico en São Paulo es un centro de referencia acreditado por el Ministerio de Agricultura, Ganadería y Abastecimiento y realiza pruebas para diagnosticar enfermedades con el fin de fomentar el control de la salud animal en Brasil. La creación e implantación de un sistema automatizado de alertas de riesgo epidemiológico tiene el objetivo de automatizar los procesos y gestionar el flujo de diagnóstico para que los órganos competentes puedan tomar decisiones en tiempo real. En este proyecto se ha adoptado el uso de prototipos interactivos de alta fidelidad con el fin de viabilizar el entendimiento y la validación de los requisitos para el sistema propuesto, cumplir el plazo para su desarrollo y minimizar los riesgos, así como vivir una experiencia realista y evolutiva en proyectos de desarrollo de programas informáticos que promueven la satisfacción del usuario final.**

Palabras clave: Metodologías ágiles. Análisis de requisitos. Tecnologías de la información y la comunicación. Sanidad animal. Alertas zoosanitarias.

I. Introduction

Information and Communication Technologies (TICs), as well as information systems, applied to the heath area, have made important contributions to epidemiologic surveillance. The use of technology has promoted the production and dissemination of information with regard to collection, processing, analysis, interpretation and recovery of data, as well as the evaluation of measures that help managing agencies in the decision-making process. The adoption of technologies has aided governmental agencies in their control and prevention of diseases, in addition to promoting a discussion on the preparation of the country's public policies [1].

In order to ensure animal health and comply with the legislation that provides for quality inspections of products of animal origin, as well as to eradicate diseases, several reference centers is different Brazilian states are accredited by the Ministry of Agriculture, Livestock and Food Supply.

Among the several reference centers in the country, the Biological Institute of São Paulo is a pioneer in diagnostic analysis and it has received encouragement from the government to modernize its processes in order to promote sanitary control. This has made the use of technologies inevitable, not only to map samples that arrive at the institute, but to also issue findings that can generate alerts in cases of diseases requiring notification.

Many areas of knowledge, emphasizing the veterinary area in this article, have used computer technology to support the process of control and management of information, with environments that meet the specific needs of users being increasingly necessary. Consequently, in systems design it is essential to consider needs, expectations and, primarily, user requirements.

However, to identify user needs, it is not enough to make a list of intended characteristics, it is necessary to collect data that demonstrate the user reality, his/her routine and the context of his/her work [2]. For validation and eliciting of requirements, it is necessary to understand this context, such that the system under development can provide them support in achieving their objectives.

The second step after identification of user needs is to consider the design aspects taking a combination of stable requirements into consideration. To consolidate a requirements base developed from user expectations and needs, the data collection phase is of extreme importance.

There are several basic techniques for data collection, many of which are quite flexible and can be combined to generate a range of possibilities in this regard. Use of questionnaires, formal and informal interviews, workshops, natural observation and study of documentation are examples of techniques applied for data collection. In addition to the techniques mentioned, the description of tasks to be completed by users and the generation of prototypes for identification of possible features serve as support material for the data collection phase [2].

In this work, high-fidelity interactive prototyping was chosen, a technique that involves the creation of more convincing prototypes based on an understanding of user needs.

The objective of this work, therefore, is to show how use of high-fidelity prototypes, prepared in the phase of eliciting requirements for a zoosanitary occurrence alerts system, provided positive results for the software design in the veterinary area, in addition to promoting the active participation of the user.

II. METHODOLOGY

The requirements survey is normally identified as one of the most difficult tasks by software engineers. This is no different in the field of health. In this article, we describe an experience based on the preparation of interactive prototypes used as a basis for validating and eliciting requirements for a system of alerts of occurrences in the veterinary area. The results indicate that the technique of interactive prototyping allows early identification of problems that would only be identified in later phases, when it would be much more costly to make modifications. However, use of the technique requires relevant technical knowledge in order to propose a solution planned to promote user satisfaction.

Among the challenges in this phase of eliciting requirements, Sommerville [3] points out some factors that make the process difficult:

- The stakeholders usually do not know what they want or have difficulty articulating the ideas to be expressed to the analysts;
- The stakeholders describe the requirements using terms considered in the implicit environment of their own work, which the software engineers do not understand since they have no experience in the domain of the final user;
- Different stakeholders have different requirements, in other words, they see their needs in accordance with the function they exercise;
- The organizational environment in which the analysis occurs is dynamic and, consequently, the volatility of the requirements can be high.

A. Prototyping

Before the final scenarios in fact exist, the prototypes are constructed as representations of a system [4]. They are very useful in the discussion of ideas with all the stakeholders, since they can be used as devices that facilitate communication between members of the team and are an efficient way to test ideas [2].

To achieve the usability desired for a computer system, the use of prototyping can be a resource for creating, evaluating and refining design options. Generally, the more advanced the stage of the software development process, the more appropriate is the use of high-fidelity prototypes, since they, in addition to providing more complete feedback on usability problems in the design, are more in tune with the reality of the user.

B. Case Study

In light of the challenges of this project, the decision was made, in this phase of eliciting requirements, to use high-fidelity prototypes. Among the higher priority challenges, the following can be noted:

- The tight deadline for delivery of the final product due to the period set for finalizing the project and funding justification;
- The system should provide support to the public fiscal authorities for the decision-making process, whose objective is to issue alerts in cases of diseases requiring notification;
- Because it is a system in the veterinary area, aspects of usability should also be considered when constructing the software interfaces in order to facilitate the operations executed by the users.

The project in question aims to implement a system to computerize the entire process of recording zoosanitary analyses and issuance of findings, contributing to the modernization of the entire diagnosis process at the Biological Institute of São Paulo. The objective is to facilitate the identification and receipt of samples, speeding up communication and ensuring traceability of all diagnostic operations, from the processes related to Animal Triage (AT) to performance of exams in the specific laboratories made by Responsible Technicians (RT), issuing findings to the various profiles depending on the results and activation of alerts to the competent authorities for decision-making.

For preparation of the prototypes to be possible, it was essential to experience the routine of the Biological Institute employees to gain full understanding of the business rules and map the functionalities to be considered in the system. Based on the data survey, documentation was generated expressing the business rules and the scope of the system, subsequently approved by the client.

In this article, some of the important artifacts for understanding the business or visualizing the system functionalities are presented and they will be useful in preparing and refining the prototypes. In this way the flow of processes relevant for each profile identified in the Biological Institute, the use case diagram that considers the overall view, and the prototypes generated based on these documents will be addressed.

The process mapping prepared after visiting the Biological Institute of São Paulo, illustrating the flow of processes and the respective specifications, is described below.

Initially, the client or veterinarian responsible for the rural property should collect and identify the samples according to the reference of the Veterinarian Manual for Collecting and Sending of Samples, a document provided by the Biological Institute [5].

When receiving samples in the Animal Triage sector of the Biological Institute, they should be checked to ensure that what is in the test requisition is in agreement with the samples identified by labels, verifying only the quantities. Under no circumstances should the Animal Triage employees open the flasks containing the samples due to the risk of contagion. If there are samples without identification labels, they should be sent for disposal and an email is sent to the client. This is necessary because every animal must be identified individually or as part of a lot. Sample identification is an important step in the process to ensure traceability in the system. Fig. 1 shows the flow of processes described that should be executed by the Animal Triage sector of the Biological Institute of São Paulo.

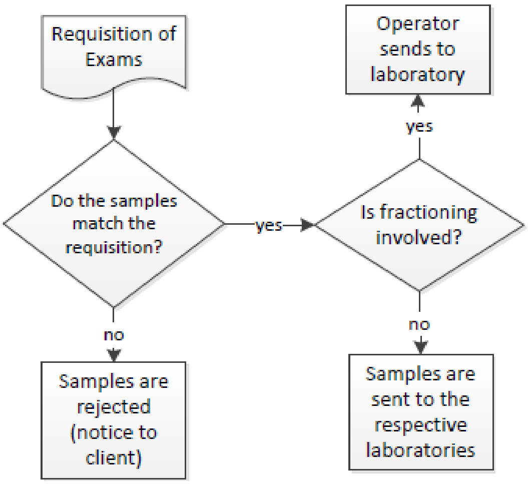

Fig. 1. Flow of processes performed by Animal Triage.

After the samples are sent, the respective laboratories are ready to start the analyses. The responsible technicians are in charge of performing exams and issuing reports. It is noteworthy that the state of the sample is a prerequisite for every exam to be performed. At this stage of the process, the Responsible Technician assesses whether the state of the sample is adequate or inadequate for performance of the exam requested. Even if a sample arrives at the Biological Institute in a decomposing state, depending on the exam requested it might be possible to conclude the analysis. After the Responsible Technician performs the exam requested, he/she should enter the result (positive, negative or inconclusive). Should the analysis indicate suspicion of a disease, the Responsible Technician may request or perform complementary analyses. When results are obtained that indicate precise diagnosis of a disease, the technician must create a record with the diseases found and issue a report. According to the disease detected, the system will automatically indicate the agencies to be notified, depending on the alert criticality level. After this, the Agricultural Defense Coordination may be notified so that security measures can be executed. Certain diseases, like foot-and-mouth disease, may require the herd to be slaughtered if confirmed. In these cases the client cannot be alerted and exportation is immediately interrupted to prevent the disease from spreading and contaminating human beings, if that is the case. Fig. 2 shows the process flow performed by the Responsible Technicians at the Biological Institute of São Paulo.

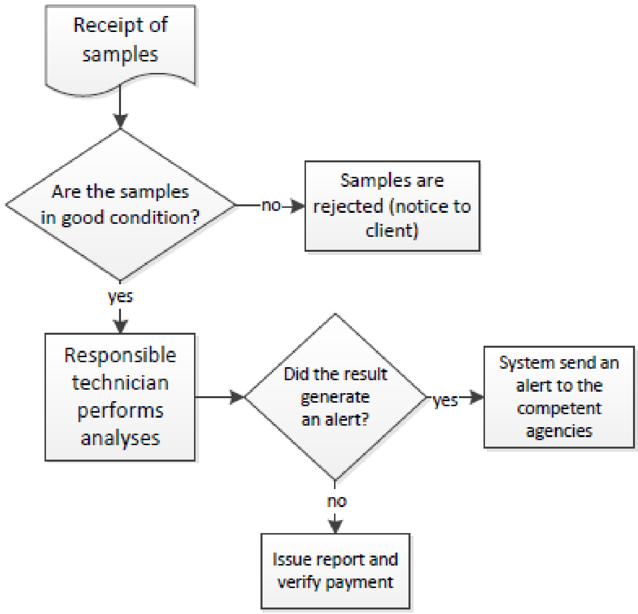

Fig. 2. Flow of processes performed by the Responsible Technicians (veterinarians of the Biological Institute).

Taking into account the functionalities of the Epidemiologic Risk Alert System, we can observe in Fig. 3 the Use Case overview diagram. This diagram is a UML 2.0 resource that allows even someone unfamiliar with topics related to software engineering to understand the business rules applied to a system. Use cases help people involved in the project understand the business rules and everyone's role in the systemic context in greater detail [6].

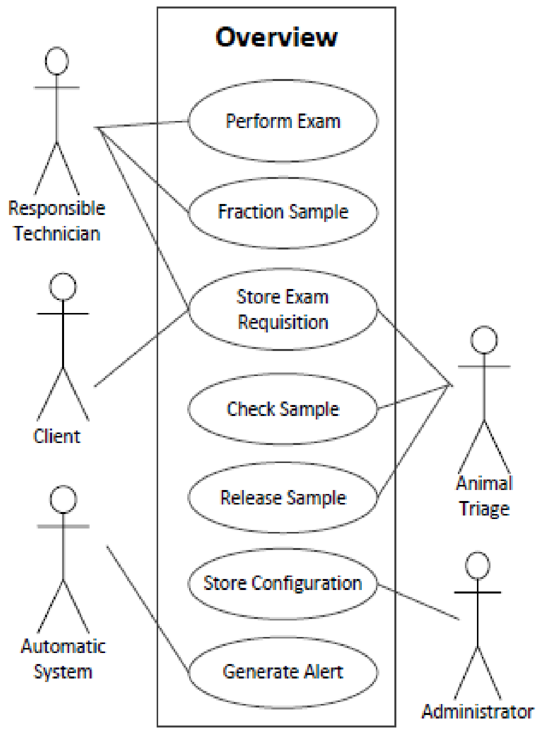

Fig.. 3. Flow of processes performed by the Responsible Technicians (veterinarians of the Biological Institute).

After all the system features are documented and the flows of processes to be executed by the parties involved (system users) are defined, we moved on to the implementation phase of the interfaces based on interactive prototyping. [7].

Employees of the Biological Institute (later identified with system access profiles) could express their opinions indicating usability and user experience goals for system development by means of a questionnaire administered by the team of analysts [2].

With regard to usability, characteristics such as use efficiency and being easy to learn, use and remember were identified. As for the user experience goals, aspects such as ease of navigation and pleasant aesthetics were indicated; and the analysts were required to consider the information contained in the documents already in use, for example, the general exam requisition form.

Based on an understanding of the processes, the features identified and the questionnaire results, some screens were produced. The first version of the prototype aimed to evaluate navigability properties, graphic components and control over the screens the system offered users. One of the tasks that contributed to this observation was: (1) accessing the general exam requisition. The usability tests were executed with employees of the Biological Institute and a controlled population composed of approximately 30 users involved in the project. All responded to the questionnaire during the phase of understanding the use context of the system. Evaluation continued through direct observation of user interaction with the prototype by carrying out the tasks prescribed. The main problems found by users were discussed making it possible to refine the prototypes.

The new prototype version solved the problems revealed in the first tests and included other requirements that had not been evaluated.

Later, these prototypes became system screens. A very relevant aspect experienced in this project was the ability to see a faithful reflection of the business rules in the prototypes. The client identified few changes impacting business rules after navigating the screens and executing the tasks prescribed.

C. *Understanding the Proposed System*

The prototypes were made in HTML (HyperText Markup Language), CSS (Cascading Style Sheets) and JavaScript. Some prototyped screens are shown below.

All users, as well as system accesses, are controlled by an auxiliary tool developed specifically to control the modules where the information on users and their permissions is stored. In this way, the system makes total access customization possible through profiles created for user groups, allowing permission or blocking access to the screens individually in order to ensure integrity. Fig. 4 shows administrator access. Notice that the user can be a client, a veterinarian or an employee of the Biological Institute. For the "veterinarian user" the CRMV (Regional Veterinary Medicine Council) registration number is required. To request Brucellosis exams, for example, it is compulsory to provide this number, since this exam may only be requested by veterinarians.

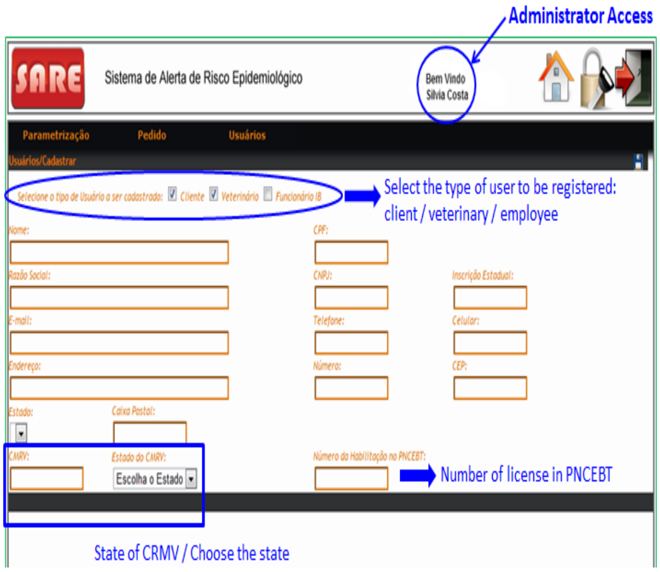

Fig. 4. Initial user registration screen.

All the system features are parameterizable, allowing non-specialists to make changes easily. Among the system features are registration of users, diseases, laboratories, animals, exams, samples and requisitions. After entering all the registration data into the system it is possible to request exams. The system search feature is available to both clients and veterinarians. Every field must be filled in by the requester according to the manual requisition currently used for this purpose at the Biological Institute of São Paulo.

A noteworthy feature is shown in Fig. 5, highlighting how the user can register diseases and add alert levels. Notice that according to the criticality level of a disease, the agencies that will receive the alerts for decision-making can be defined.

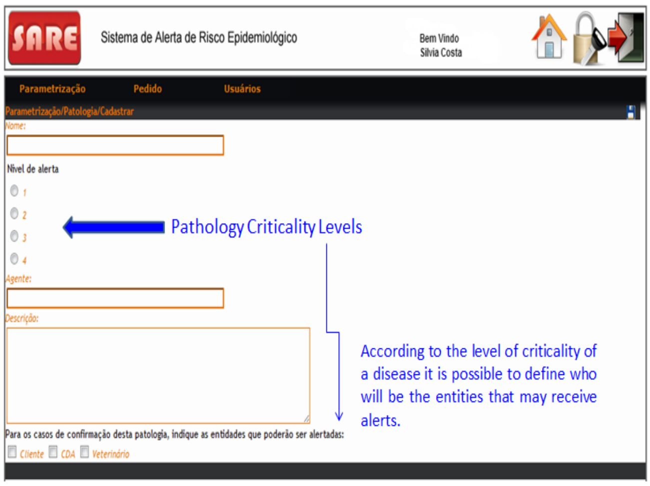

Fig. 5. A record of diseases and their respective alert levels.

The Responsible Technicians (RT) are the Biological Institute veterinarians authorized to perform exams and issue reports. Thus, they can select an order, perform the exams requested and issue the final results. In case of an "evidence-based clinical suspicion," the Responsible Technician may perform new exams, according to Fig. 6.

Fig. 6. A screen showing an evidence-based clinical suspicion.

Several other interfaces were included in this system following the same approach through conclusion and client approval.

It is important to stress that the proposed system deals with the internal processes of a reference center and is designed to contact the competent inspection agencies. The reference center is not responsible for taking measures beyond official communication to the responsible agencies.

Final system implementation was made in Java EE (JSP) and JavaScript with MySQL databank using AJAX. To model the diagrams during the project phase, Ms-VISIO and MySQL Workbench were used.

III. Results

Using high-fidelity prototypes in eliciting requests brought several benefits to the project:

- Improved discussions: the use of visual artifacts substantially improved the discussion and absorption of ideas among all team members. In addition, it enabled interactive tests of the projected screens;
- Identification of requests: with the use of prototypes, requests were detected that had not been included initially, making final user interaction with high-fidelity prototypes a fundamental task;
- Anticipation of problems: problems were anticipated that would only have been spotted in later phases, when changes would be much more costly to make;
- Team involvement: use of prototypes enabled greater user involvement in the system development process and, especially, promoted active client participation with the team;
- Meeting the deadline for final product delivery.

IV. Conclusion

The case study presented showed the benefits obtained from high-fidelity prototyping in eliciting requirements for a system for the veterinary area. The results indicate various advantages, among which we highlight increased user satisfaction and meeting the project deadline.

It is worth noting that certain factors influence the kind of prototype to be used in a particular design context, such as the complexity of the system to be developed, the stage the project is at, and available resources, among others [8].

It was possible to observe how the high-fidelity prototype-based technique used in this project promoted engagement of the team and of the other stakeholders, improving the discussion of business rules and generating solutions that meet the real needs of end users.

In two months of onsite observation, the Animal Triage employees interviewed claimed that the number of emails and phone calls, as well as the mistakes made while filling out the exam requests, fell approximately 41% compared to the same number of monthly requests before implementation of the system (approximately 400-500 requests/month).

According to the simulation carried out in the production environment (Biological Institute of São Paulo), it is possible to say, in regard to the alerts sent to the competent bodies, especially the Agricultural Defense Coordination, that the alerts sent via SMS (Short Management System) or email reduced the time of operational procedures, which used to be approximately 2 weeks, to 3 to 4 working days, as observed by employees. Unfortunately, this system procedure does not eliminate the issuance of official documents, such as official letters and internal communiqués, among others, due to the involvement of government agencies. It does, however, promote more effective communication in order to anticipate necessary measures.

Finally, with regard to the occurrence alert system in the veterinary area, it must be said that this is the tip of the iceberg, since it is a proposal implemented internally at a reference center in the state of São Paulo. This system can also be implemented in other reference centers across the country, promoting procedure integration and standardization aiming to enable rapid communication for sanitary actions.

It is noteworthy that reference centers, in this case the Biological Institute, do not perform sanitary defense interventions, only diagnosis and notification of the competent agencies, such as the Agricultural Defense Coordination of the state of São Paulo, the Ministry of Agriculture, Livestock and Food Supply, and clients in general.

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