Application of open-source software as a tool for systems development in maintenance management of computer equipment

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— Abstract—

In recent years, computer equipment in higher education institutions has become a key element for access to information and services; both hardware and software are essential elements to maintain the information, becoming an asset to companies and institutions. The present investigation has allowed the development of an inventory and maintenance record system for the computing equipment for the Instituto Tecnológico Superior "San Gabriel" of the city of Riobamba-Ecuador. It was developed through waterfall methodology, Java programming language, and the MYSQL database manager. With the system's implementation, 90% of the maintenance plans were fulfilled in the department of information and communication technologies (ICT) of this institution.

Keywords:

Maintenance is an activity that every company or institution must carry out according to established standards and techniques (Cantos, 2018) to avoid risking the loss of information and devices, and to preserve the equipment throughout its useful life, with the greatest possible availability at the lowest cost, hand in hand with the manufacturer's recommendations.

Suárez *et al.* (2015) and Andreu (2018), agree that Java programming language is widely used in the business environment, highlighting the programming of desktop and web apps. These apps have been extended for their easy deployment to customers, their not excessively complicated development, easy update, and their security, both for the customer and the server.

For Boasberg *et al.* (2019), the measures and actions that are taken to keep computer equipment in proper operation, without memory dump occurring or emitting error messages frequently, can be one of the two types of maintenance such as preventive and corrective, when the first thing that must be determined is the time of use and technological delay thereof.

The purpose of the Instituto Tecnológico San Gabriel is to provide quality services to the student sector of the province of Chimborazo. According to reports of the Department of Information and Communication Technologies, the institution has a network of computer equipment consisting of 40 computers, both desktop and personal; in addition, they have five printers distributed throughout the institution. The problematic situation that is identified by direct observation is that the institution has a maintenance plan, but this is not fulfilled with total normality due to different factors.

Based on the above, the present work aims to develop a system for the inventory and maintenance record of the computer equipment of the Instituto Tecnológico Superior "San Gabriel" in the city of Riobamba, Ecuador.

MATERIALS AND METHODS

Study Area Location

The present research was developed in the department of information and communication technologies (ICT) of the Instituto Tecnológico Superior "San Gabriel" located in the Veloz parish, canton Riobamba, province of Chimborazo, Ecuador.

Methodology

For the development of this system, two proposals were handled within the research part, a preliminary proposal in which the process of information collection was carried out, the research process begins at theoretical, scientific,

and legal levels, where we reviewed sources from Scielo, Scopus, Latindex, where authors such as Ferro (2020) or Rosenfeld & Irazábal (2016) stand out, which specify, from a judicial point of view, the protection of hardware. Through this synthesis, the understanding of the study variables (maintenance plan, registration of computer equipment) was achieved, and that is the basis that determines the extent to address the problem. On the other hand, the use of the Unified Process methodology proposed by García & Vásquez (2019), in which the focus of the research begins in the Conception phase, where the current management and the obtaining of basic operational information are evaluated, to then begin with the Elaboration of the maintenance system, its Construction, and Transition. According to Zumba (2018), these processes allow the development of systems quickly. In our programming we used the Java language, the MySQL database manager, and Netbeans as an integrated development environment (IDE); it should be noted that all the applications used are open-source software.

Interviews were applied to six users who are in charge of computer equipment within the institution to determine how often they encounter a malfunction in terms of hardware and software. We also registered on the files whenever a user called to request help for an inconvenience in the equipment.

RESULTS AND DISCUSSION

For the development of the IT equipment maintenance management system, the stages of Beginning, Development, Construction, and Transition were planned.

Beginning Stage

At this stage, the scoping study of the project was carried out where the costs, profitability, and feasibility were evaluated. The feasibility study resulted in a general description and list of use cases such as registration of computer equipment assets, managers, users, assignment of assets to users, equipment to be maintained, user who carries it out, and reports.

Development Stage

This stage allowed us to generate a specific solution based on the use cases of the previous stage, resulting in a detailed design plan such as interfaces, and buttons like Save, close, return, search, and print.

The messages that will appear in Windows window format were defined according to the following:

- When the user has entered the wrong username and password.
- When no information has been entered in the forms.
- By entering the data and sending it to save.
- When a new confirmation username and password are created, it is not the same as the main one.
- When a new person in charge is created and the ID card is incorrect.

Based on the above, the interfaces for the Windows environment were made because it is a desktop application, so it was designed based on menus, labels, text boxes, buttons, and radio buttons, among others, thus forming a friendly interface. The work environments were Netbeans as an integrated development environment (IDE), Java as a programming language, and MySql as a database manager. Based on the above, the main screen would be established according to Figure 1.
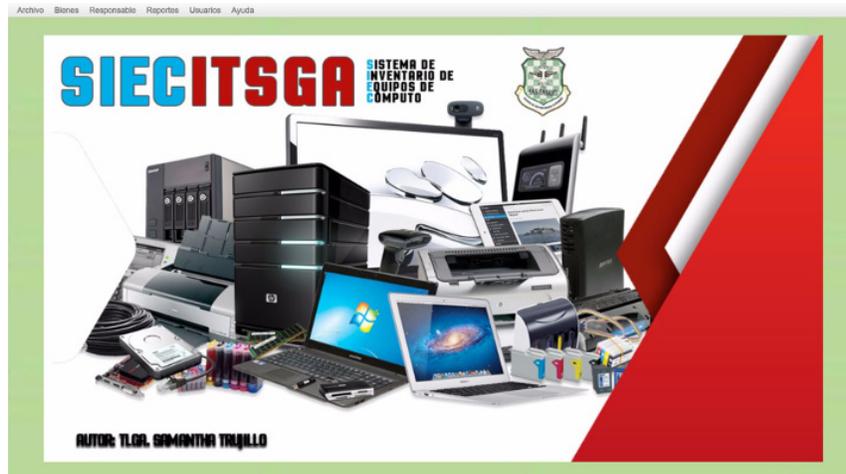

Figure 1. Computer Equipment Maintenance Management System Main Window. Source: Own elaboration

Construction Stage

At this stage, several iterative loops were created in which use cases are merged sequentially based on project risk factors. For example, this approach allows for older versions of the system that satisfy the primary use case. Changes to requirements are not merged until the beginning of the next iteration.

Transition Stage

At this stage, the first version of the system was developed and culminated with a system in production. Later the final product was sent to the users of the ICT department (see table 1), once the system was implemented the first test was acceptance, which allowed determining if the software complies with what was defined in the beginning stage, the requirements, once they passed this phase we proceeded to other validation tests.

Below are the results of the maintenance software validation through surveys applied to the personnel of the ICT area. The evaluation was applied through the software technical evaluation guide (Largo, 2005), in table 2, you can see the criteria on which it is based.

Table 1
Teachers and faculty board

Institution	Teachers	Faculty Board	Total
Instituto Tecnológico "San Gabriel"	5	1	6

Source: Own elaboration

Table 2
Software Evaluation

Scope	Description
Utility	Aspects related to what it fulfills
Interface	Aspects related to the interface
Technical aspects	Aspects related to functionality

Source: Adaptation (Medina-chicaiza, 2018)

The evaluation proposed for this system allows us to know its usefulness, whether or not it meets the established requirements, if the interface is intuitive, if it contains a high degree of usability, and if it facilitates the transmission of information and interaction to its maximum. The technical field is the systems' characteristic that allows verifying that the system is light, with low hardware requirements, easy to install, and scalable. Below is the score range handled by the user acceptance test managed by software quality metrics according to López *et al.* (2016), in which 18 questions covering the adaptation of table 2 are handled; the evaluation criteria in this metric range from 1 to 3 respectively.

Table 3 shows the evaluations obtained from all the staff of the ICT area of the institution, teachers, and managers, to draw up work guidelines and improve them in terms of preventive and corrective maintenance of computer equipment.

Table 3
Evaluation of ICT personnel

QUESTION	Rating from 1 to 3 (3=Excellent, 2=good, 1=bad)						
	1	2	3	4	5	6	Average
1. Are there terms mixed in different languages?	3	3	3	3	3	2	2.83
2. Is the vocabulary used simple?	3	2	3	3	3	3	2.83
3. Is there enough time to perform keyboard inputs?	3	2	3	3	2	3	2.67
4. Is there any assistance for users who are using the system for the first time?	3	3	3	3	2	3	2.83
3. Is the system easy to operate for someone who was not trained in its operation?	3	2	3	3	3	2	2.67
6. Can the interface and its content be understood?	3	2	3	3	3	3	2.83
7. Is it easy to identify an object or an action?	3	3	2	3	3	2	2.67
8. Is it easy to understand the outcome of an action?	1	3	2	3	3	3	2.50
9. Is the interface designed to facilitate the efficient performance of tasks in the best possible way?	3	2	1	3	2	3	2.33
10. Are the messages presented by the system appropriate?	3	2	3	1	3	3	2.50
11. Does the system act in the prevention of errors?	2	3	3	3	2	3	2.67
12. Does the system report on the errors presented?	3	2	3	2	3	3	2.67
13. Are descriptive messages and texts used?	3	2	2	3	3	3	2.67
14. Does it allow convenient navigation within the product and easy exit from it?	2	3	3	3	2	3	2.67
15. Is the user allowed to customize the interface?	3	2	3	1	2	2	2.17
16. Is visual information provided of where the user is, what are they doing, and what can they do next?	2	2	2	3	2	2	2.17
17. Are there keyboard shortcuts?	3	3	3	3	3	3	3.00
18. Is the user presented only with the information they need?	2	3	3	3	3	3	2.83
Total Average							2.64

Source: Adaptation by Medina-chicaiza (2018) and López *et al.* (2016)

According to the scores obtained from the evaluation measured through the parameters, usefulness, interface, and technique, a good evaluation was obtained with an acceptable quality, which makes it easy to install, access, and manage for any user in the ICT area.

CONCLUSIONS

The evaluation technique applied to the development of systems in maintenance management of computer equipment allows us to appreciate the quality and acceptability of the system developed through open-source software.

All kinds of management and administration software are considered as a software quality model in our country, in addition to that, it allows to obtain an evaluation score for academic accreditation purposes by educational entities, therefore, the software developed for maintenance control fits within the established considerations, allowing the processes to improve continuously with its implementation.

The Unified Process methodology with its four stages, iterative, structured, and adaptable, allowed the development of the system according to the needs of the institution. The result is an incremental and modular system for possible future changes.

By developing the system through open-source software, it is possible to know that Java as a programming language is an optimal platform for the development of desktop applications, and with excellent work in its graphical interfaces, the functions and source code that were used are simple so that other users can understand and modify it, in case it is necessary for subsequent maintenance of code or modular increments.

This research contributes to the importance of adaptable methodologies use for developing software with specific organizational requirements, the use of open-source software as a development language for management systems that serve as a quantitative evaluative means in educational accreditations in our country, the implementation of software metrics adapted by current authors and, finally, in being a tool for registration of computer equipment and maintenance plans in the ICT department of our Institution.

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