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Stock Management System Using RFID and Geolocation Technologies

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Abstract

This paper is focused on radio frequency identification (RFID) technology which allows the wireless and remote identification of an entity (e.g. product or device). The high level of usability and security of this technology allows optimizing the processes of detection and location of items in an inventory system, generating great benefits such as increased productivity, decreased response times and costs. This paper shares our experience in developing and implementing and inventory system based on RFID technology. Our experience demonstrated that RFID technology greatly optimizes the inventory process by reducing the time allocation, identification and location of each item by up to 60%.

Keywords: RFID, stock management, process optimization, software development

INTRODUCTION

In recent years, Radio Frequency Identification (RFID) technology has been solving problems of commercial transactions inside the companies, allowing to facilitate and to improve of agile way the complex processes in less time [1]. RFID labels play an important role as an inventory tracking technology [4] since it provides easier way to manage the stock of an organization.

RFID has been the source of great technological solutions, empowering and facilitating the user in their daily lives. For example, we can mention Amazon Go, which has implemented a supermarket service where you put aside large rows of payments thanks to its detection sensors, thus minimizing time in product sales.

The purpose of this article is to demonstrate, through a case study, that RFID technology can improve the stock control processes of companies based on bar code, thus improving their costs and response times to their customers.

The paper is organized as follows. First, section 2 explains some background concepts used in the development of this paper. Then, section 3 details the development process of the inventory system based on RFID. Later, section 4 analyzes the results reached through implementation of the proposed system. Finally, the conclusions are made in section 5.

BACKGROUND

The following concepts and definitions have been used for the development of this paper.

Barcodes

The barcode is a coding system, created with the objective of identifying objects and facilitating the obtaining of information through parallel lines. The use of this coding system has been widely extended due to its reliability and easiness on its implementation. The barcode system is used to label tasks and contents to enable quick exchange and accurate collection of information [6], reducing possible human errors that can occur from manual data input. Bar code technology can improve the efficiency of logistics operations reducing management costs [7, 11].

Radio Frequency Identification (RFID)

Radio Frequency Identification or RFID is defined as the propagation of radio waves to automatically identify people or objects. Radio waves have the ability to penetrate matter, enabling the system to read a tag in a good that is not visible [13]. Currently, there are several methods of identification, but the most common is to store a serial number that identifies a person or an object (see Fig. 1).

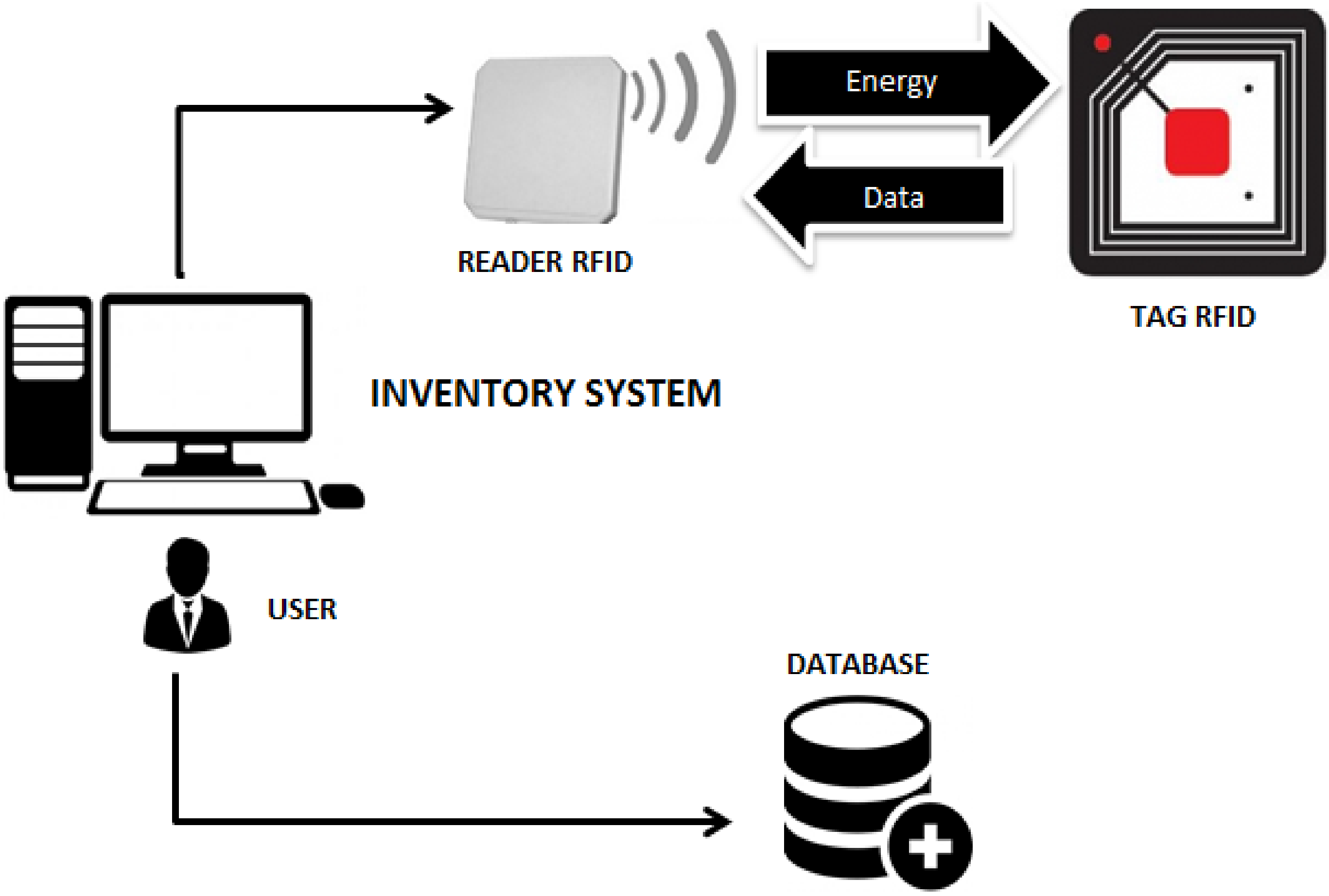

Figure 1: Stock Management System based on RFID

RFID refers to the technology of reading and writing data remotely using radio waves [5] which allows, basically, communication between the reader and tags. These systems allow to store data on the labels through radio frequency communications. The size of the data can go from a Bits to Kilobytes, depending mainly on the storage system that has the transponder [14]. Two key issues must be considered for the design of an RFID system. First, the number of possible codes that can be stored in a tag; second, the capability of manipulating and communicating information [3]. The tag is a passive transponder identified by a unique ID [8]. Major RFID sensing application domains include monitoring of physical items [9].

Extreme Programing

Extreme Programming (XP) methodology defines four variables for any software projects: cost, time, quality and scope. Extreme Programing fulfills the main function of enhancing feedback and fluid communication with the user within the life cycle. XP is executed by the following steps (see Fig. 2).

- Meeting with the client, which allows to define what is going to be implemented (requirement elicitation).
- Once with the general requirements, programmers analyze each of the requirements and estimate the effort required for their implementation.
- The client reviews each of the requirements, selects the most valuable for the construction of the software and verifies the time that can be implemented.
- The programmers feed user stories according to the priority that has been granted by the user and the software is built.

The advantage of Extreme Programming (XP) life cycle is that it allows the user to interact as many times as necessary, taking into account that at any moment, it is possible to go back to step 1 or generate new requirements. By completing all the steps, acceptance tests can be executed.

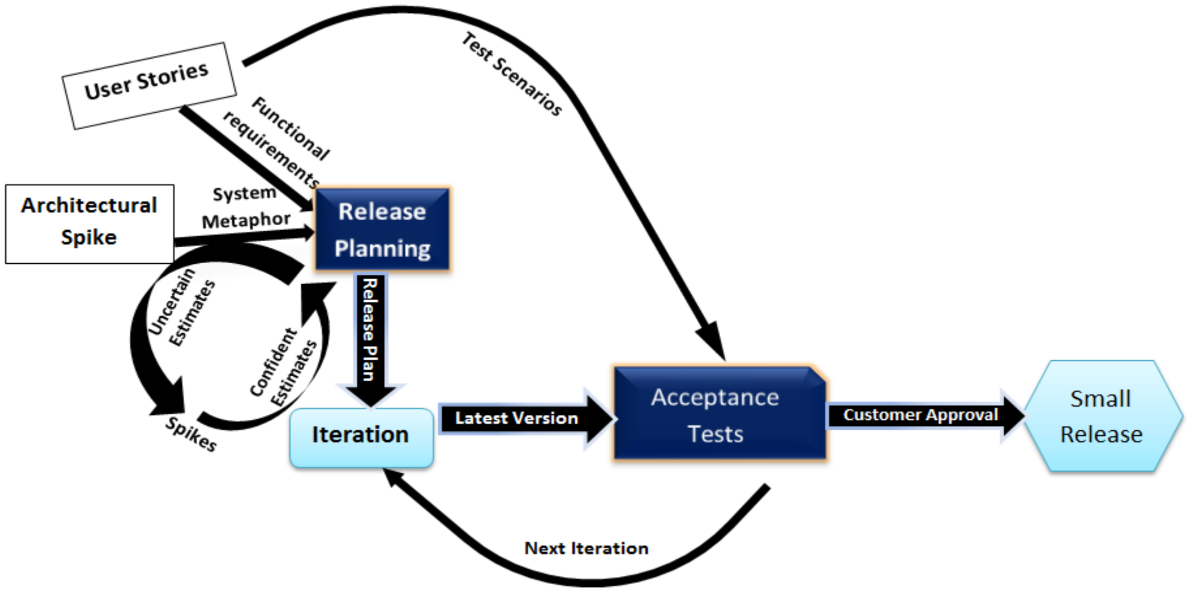

Figure 2: XP's Life Cycle

Development of the Stock Management System using RFID Technology

In this section, we share our experience in improving the inventory process through the use of RFID technology. The project meets important guidelines that helped to minimize efforts in the development phases. In the following, we details the executed phases.

Exploration and Planning

In the initial or exploration phase, we interacted with the stakeholders. They provided accurate information about each event/process, and with them, the implementation times and delivery tests were coordinated. In this phase, user stories were generated which contain the functionalities, priorities and risk of each requirement. The requirements included the following attributes.

- **Priority and Risk:** It is assigned according to the level of complexity of the process. It can be high, intermediate or low.
- **Estimated Points:** It is assigned according to the cost of implementation.
- **Assigned Iteration:** It is assigned depending on how the plan is being executed. It is assigned if the user history requires modification.
- **Programmer:** The person who is responsible for the implementation of the process.
- **Description:** It indicates the details of what is required to be done.

Fig. 3 shows an example of the user story.

User Story	
No.: 1	**User:** Administrator
Name of the Story: User Data Management	
Priority: High	**Risk:** Low
Estimated Points: 4	**Assigned Iteration:** 1
Responsible Programmer: Franz Gualoto	
Description: System Administrator will be able to créate user accounts following the templated. Several data such as name, last name, address, email, and phone must be input.	
Observation: Input mandatory fields which are marked with asterisk (*)	

Figure 3: User Story Example

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Once the exploration stage was completed, the final version of the functional requirements was obtained.

Iterations and Design

During this stage, it was planned how much it can cost to carry out each process and how much time is estimated in each of the user stories. Additionally, several models were designed such as use case model and database model.

Use Case Model

In the development of the system, the scope of the project was taken into account and the main roles and functions of the actors interacting with the system were established. In this process, three actors were identified and the activities that they carry out in the system. In the following figures, the main models that were generated in this stage are shown.

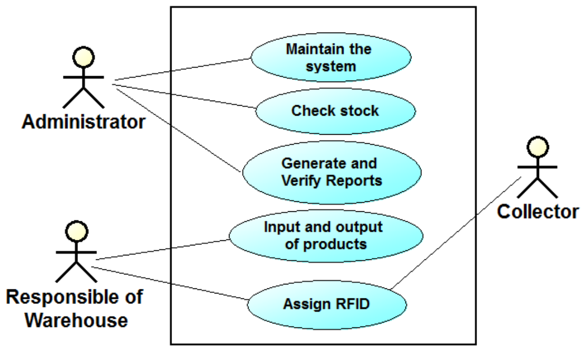

Figure 4: General Use Case Model

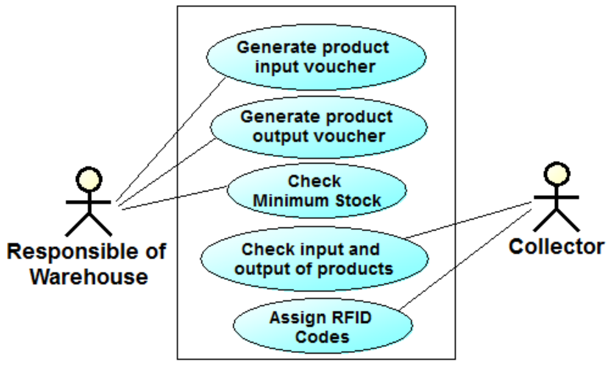

Figure 5: Control of Inventory Use Case Model

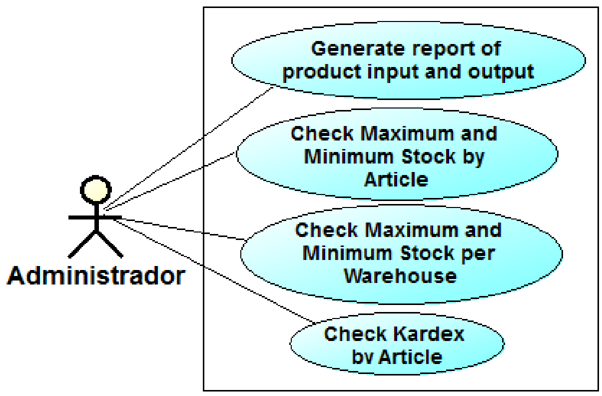

Figure 6: Administration of the system Use Case Model

Database Model

Database model allows programmers to see how the data is structured and they are related inside the system. Figure 7 shows the detail of the proposed data model.

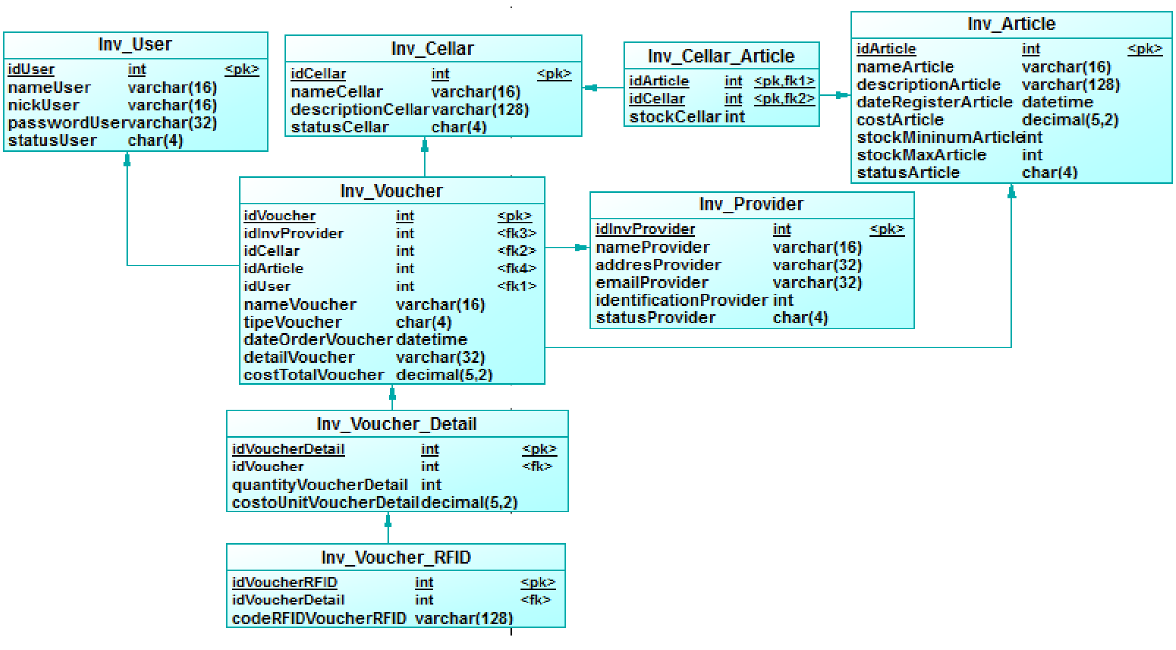

Figure 7: Conceptual Model

Production

A clear nomenclature of names was generated that allowed to identify with a word the functionality of each class. Additionally, the controller view model was implemented, which allows the programmer to layer the system and provide better separation of roles with the database and the web application server (as shown in Fig 8).

Main Components

Within the web architecture of the system, it is important to have a correct design of the relevant components. The main components of the proposed system are as follows (see Fig. 9).

- Database connection using a connector called“Mysql JDBC Driver”
- Controllers that allows the management of internal processes.
- Web application server that allows the unification of XHTML code with the backing beans to reach the interaction of users in a dynamic way.

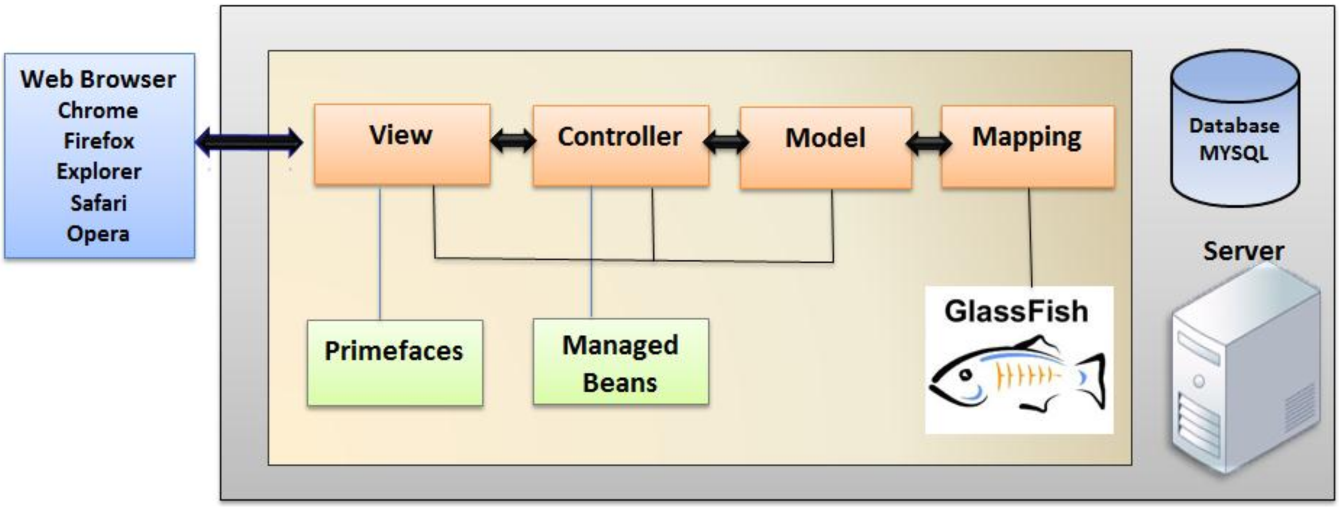

Figure 8: System’s Architecture

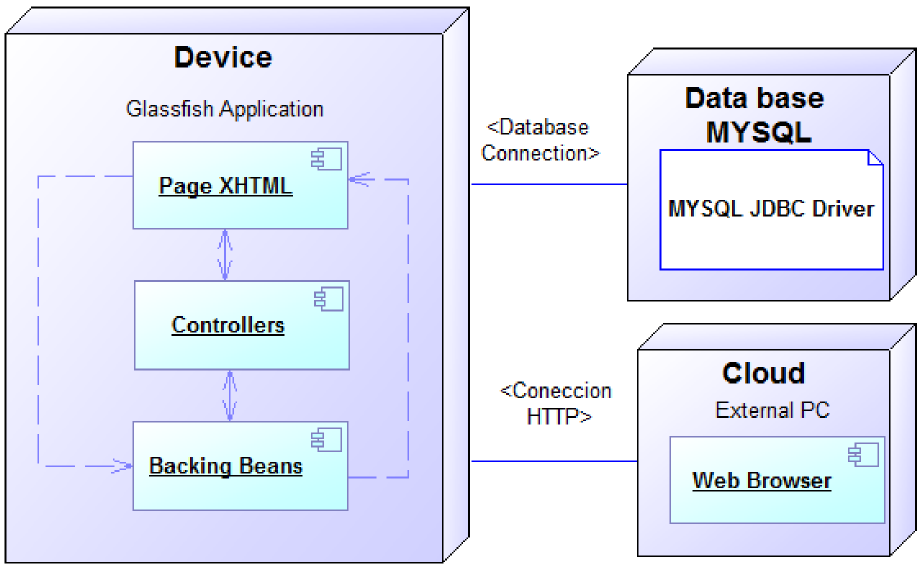

Figure 9: Components Diagram

Implementation

In this phase, two main process of stock management (inventory) were implemented i.e. products' input and output. The implemented system's screenshots are shown in Fig 10 and 11.

Products/Items Input: In this process, an input vouches is generated where the product (previously created) is selected and additional data such as quantity and Price are filled out.

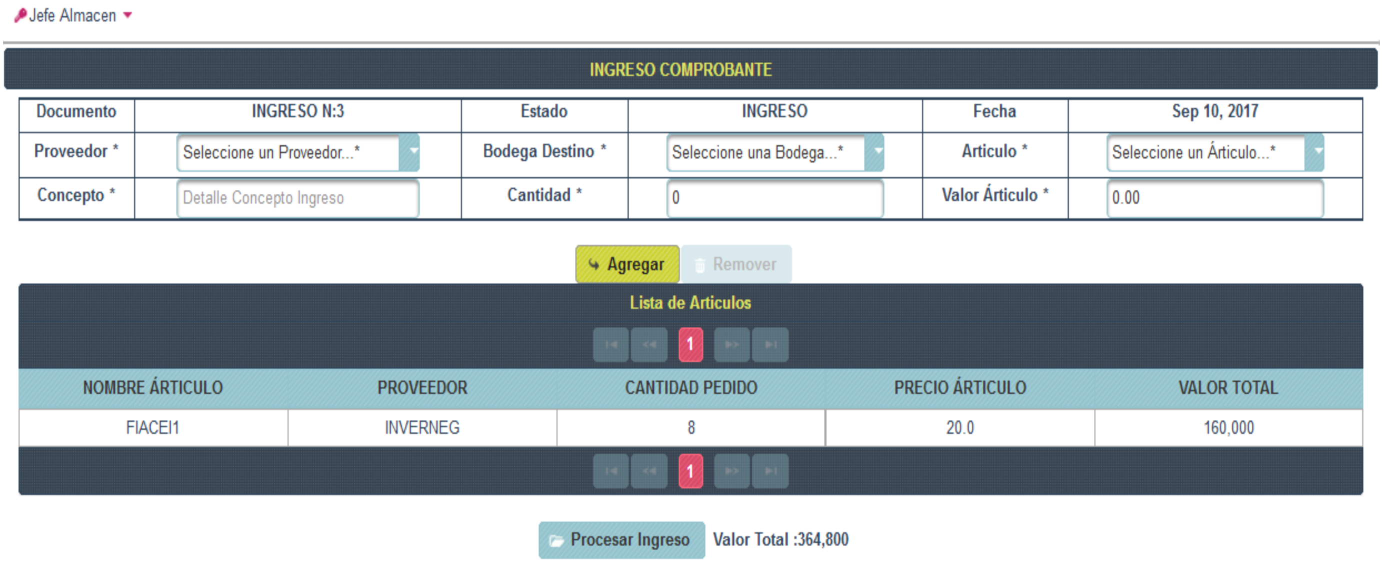

Figure 10: Item Input

Products/Items Output: The products to be taken out from the warehouse is input. In this module, the minimus stock value is also managed.

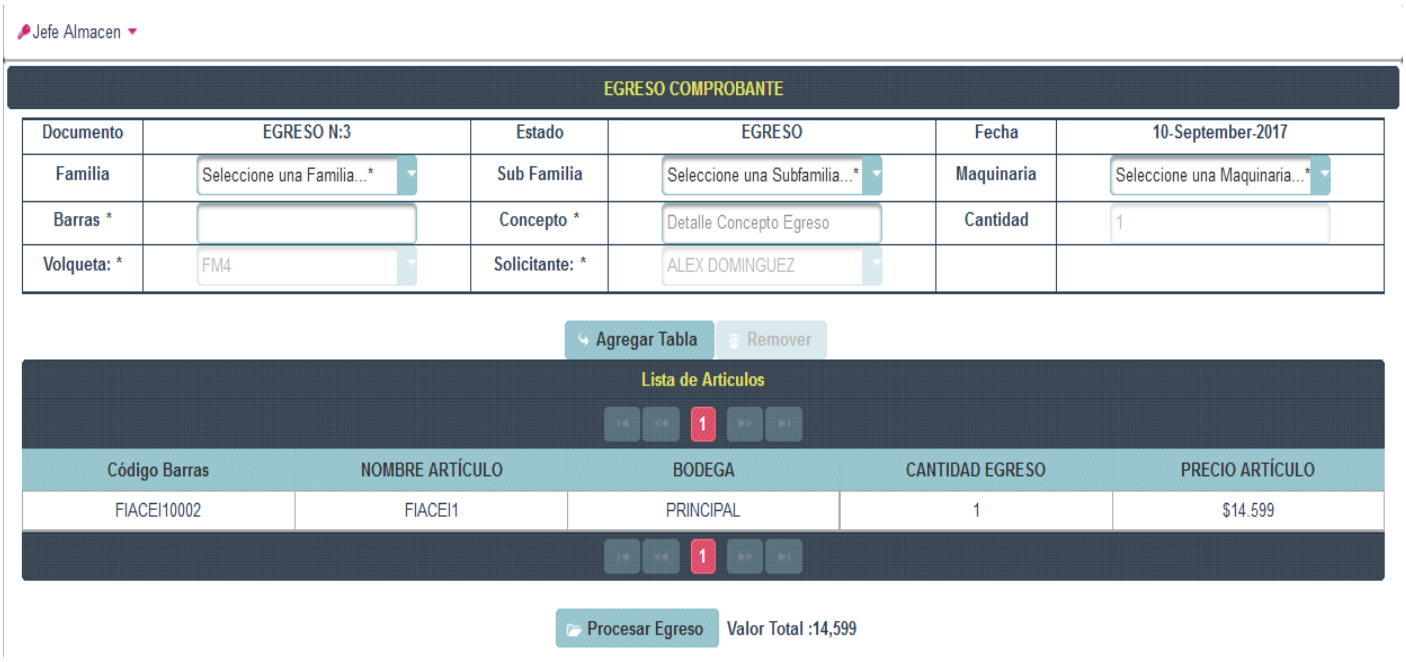

Figure 11: Item Output

Testing

In this phase, the acceptation test were executed with the user in each of the automated processes. The tests were executed according to the user stories created in the first phase to verify the adequate execution of all functionalities. The form filled out during the test included several attributes such as:

- Tested if the software incorporates functions of established processes
- Tested if the software produces any adverse effect e.g. database connection delay
- Tested if the software has any kind of errors

ANALYSIS OF THE EXPERIEMENT AND RESULTS

To measure the efficiency of the proposed system, tests related to the items management were executed. It is important to mention that the reading of 658 articles (items) was done in different angles, heights and line of sight. Table 1 shows the results obtained in the reading of articles generated by RFID and Barcode technologies. For the present test, RFID tags and barcode stickers were placed in different batches of articles. The results in RFID performance and processing were much higher than those in barcode due to the reading distance. RFID proved to be more effective in helping to reduce employee effort.

Tests carried out with the inventory of a real company gave positive results for RFID. The speed of reading of the mentioned technology had a superior performance over barcode (16.25 minutes over 38.9 minutes reading 658 items), allowing to optimize time and resource to the company (see Table 1 and Fig. 12).

Table 1: RFID Reading vs Barcode Reading

Group of Items	Number of Items	Reading Time using RFID (Minutes)	Reading Time using Barcode (Minutes)
1	50	1,51	3,55
2	45	1,22	3,21
3	60	1,62	3,82
4	69	1,69	3,89
5	55	1,53	3,68
6	78	1,71	4,15
7	85	1,82	4,62
8	68	1,68	3,81
9	81	1,8	4,32
10	67	1,67	3,85
TOTAL	658	16,25	38,9

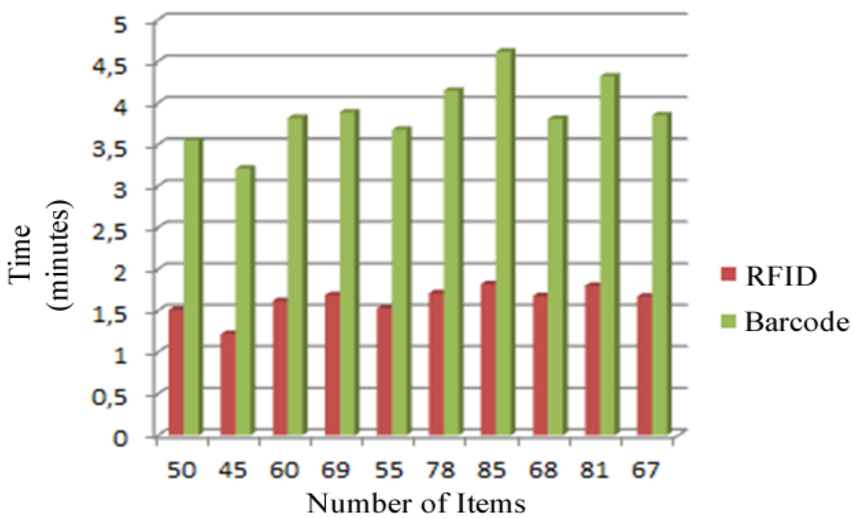

Figure 12: Process based on RFID vs Process based on Barcode

CONCLUSIONS

RFID technology allows us to store several storage codes inside products thanks to its internal chip contained inside tags, at the same time, it provides easiness for reading such codes. Therefore, RFID provides greater flexibility and performance for tracking products. In this paper, we have shared our experience in implementing an inventory system using the RFID technology and we also have demonstrated that it has better performance over systems based on barcodes. Our experiments indicates that the RFID reading speeds are 93% superior that barcode systems, and inventory systems based on RFID can reduce costs up to 30% compared to systems based on barcode.

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