Design and construction of a token vending machine for wireless internet connection

Diseño y construcción de máquina expendedora de fichas para conectarse a internet inalámbrico

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Abstract

This paper presents the design and construction of a machine that automates the process of selling access credentials to a wireless network. For its construction, the V methodology for project management was followed. The machine consists of a closed box with two buttons on the outside to indicate the start and end of the transaction, a 16x2 LCD screen with an I2c conversion interface to show transaction, user and password indications, a multi-currency purse and four LED lights that serve as indicators of the amount entered. Internally the machine consists of an ESP-8266-E development board, an Mb102 breadboard source module, a 12V 2.5A eliminator, a 5.0 V universal charger cube and a breadboard. Logically, the web-based spreadsheet (*Google sheets*), *Google apps script* and the Arduino integrated development environment were used. The result is a low-cost prototype, which provides controlled internet access credentials for multiple users.

Resumen

En este artículo se presenta el diseño y construcción de una máquina que permite automatizar el proceso de la venta de credenciales de acceso a una red inalámbrica. Para su construcción se siguió la metodología en V para la gestión de proyectos. La máquina consta de una caja cerrada de lámina que muestra en su exterior dos botones para indicar inicio y fin de transacción. una pantalla lcd de 16x2 con interfaz de conversión I2c para mostrar indicaciones de transacción, usuario y contraseña, un monedero multimoneda y cuatro luces leds que sirven como indicadores del monto ingresado. De manera interna la máquina consiste en una placa de desarrollo ESP-8266-E, un módulo fuente para *protoboard* Mb102, un eliminador 12V 2.5A, un cubo cargador universal 5.0 V y una *protoboard*. De manera lógica se utilizó la hoja de cálculo basada en web (*Google sheets*), *Google apps script* y el entorno de desarrollo integrado de Arduino. Como resultado se cuenta con un prototipo de bajo costo, que proporciona credenciales de acceso controlado a internet para múltiples usuarios.

Prototype, Credentials, User, Automation, Process

Prototipo, Credenciales, Usuario, Automatización, Proceso

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Introduction

Currently, there are real cases where financial and process results have been improved, thanks to a set of planned actions applying best practices in the vending market. (Junco Lamus, R., 2021).

A vending machine is a mechatronic device that offers a certain commercial product for a certain monetary value. This type of machine is found mainly in places of high public concurrence where it is necessary to establish a simplified, effective and efficient trading protocol. (Calvachi, P. A. D. H., Naranjo, R. E. A., Merchán, P., & Ibarra, A, 2013).

Such is the case of the mechanical construction of a vending machine for handmade masks to be offered through the machine at the Museo de la Ciudad (Quito), the project is requested and financed by the United Nations Development Program (PNUD). (Chérrez Yugcha, J. A., 2022).

Also, the design and construction of a didactic vending machine has been carried out, the students simulate being immersed in a work with a deadline as many companies that work on a project basis do. (MORALES-AGUILAR, E., SANTILLAN-FLORES, S. E., GONZÁLEZ-LÓPEZ, J. M., & VILLALVAZO-LAUREANO, E., 2020).

In addition, we have implemented a business based on an automatic recycling system that provides incentives for users through RVM (Reverse Vending Machines), whose objective is to increase the formal recycling of PET bottles in Lima. (Barycki Korytkowski, H. C., & Soldi Vargas, F. M., 2022).

A great number of tasks and processes have been automated thanks to the fact that nowadays we have within reach technologies that, when combined, contribute to achieve the objective of making our tasks and processes easier.

One area in which the implementation of a vending machine can be used is in the sale of wireless internet access credentials in rural areas, which until now in many places has been done in the traditional way, by purchasing the access credentials at the local store.

Taking this business model as a starting point, the following problems arise regarding the administration and availability of the service:

1.   Limited time availability.

At present, in order to acquire access credentials, one must go to the point where the credentials are sold; the business in charge of selling the tokens has a defined schedule of operation and therefore purchases cannot be made outside those hours, which makes it difficult to acquire tokens outside of the hours of operation.

2.   Difficulty in tracking sales
.

Not having a shared sales record makes it difficult to track the number of tokens sold during the days when the business responsible for selling the access credentials is not physically present. This situation generates uncertainty because, without updated information, it is not known how many tokens are available and whether it is necessary to create new tokens to provide greater availability.

3.   Poor administration.

The only way to know the number of credentials sold is by physically going to the store in charge of selling the credentials.

As a result, there is poor administration of the tokens that are delivered.

In addition, the sale or acquisition of these access credentials can only be made if the business in charge is open. This particular situation limits the sale and acquisition of tokens, since the business may be closed for various reasons.

It has been observed that there is no optimal control that allows to know in an agile way the number of credentials sold and consequently there are no tokens available according to the different packages offered.

Having identified this situation, it has been determined that there is a need to have an option that is able to offer the sale and purchase in a 24-hour schedule.

It is intended to solve this problem with a web application to achieve the management of the tokens that are made available for sale, allowing efficient management through a real-time report of the tokens that have been sold, also performs a summation of the money that is in the vending machine credentials for internet access, you can also consult the set of credentials to identify whether it is necessary to add more.

For the implementation we used:

**1.	Google *Sheets***

Google Sheets is a cloud-based spreadsheet program hosted by Google. It is available to any user who signs up for a Google account. Users can easily upload or enter data and then write code to analyze the data. All data entered into Google Spreadsheets is stored on a cloud server (i.e., Google Drive), allowing accessibility whenever a person logs into their Google account, regardless of location or computer.

**2.	Google Apps Script**

It is a rapid application development platform that streamlines and facilitates the creation of business applications that integrate with Google Workspace. Apps Script. Among other things, you can: Add custom menus, dialog boxes and sidebars to Google documents, spreadsheets and forms. Write custom functions and macros for Google Spreadsheets. Publish web applications, either standalone or integrated into Google Sites. Interact with other Google services, including AdSense, Analytics, Calendar, Drive, Gmail and Maps. Create plug-ins and publish them to the Google Workspace Marketplace. (Google developers, 2022), Google Apps Script, (2022).

**3.	NodeMCU ESP8266 v3**

It is an open source firmware and open source development that plays a vital role in designing a suitable IoT product using a few lines of script. The module is mainly based on ESP8266 which is a low-cost Wi-Fi microchip that incorporates a full TCP/IP stack and microcontroller capability. It is presented by the manufacturer Espressif Systems. The ESP8266-E NodeMcu is a complex device, which combines some features of the ordinary Arduino board with the ability to connect to the Internet. (Al Dahoud, A., & Fezari, M., 2018), (Aprendiendo Arduino, 2022), (MakersChile, 2022) y (Mengual, Joan, 2022).

Figure 1 NodeMcu ESP8266 V3 Board

The objective of this research is to find the technology to solve these problems, as well as to present the proposed solution, which consists of building a vending machine that provides users with access to the Internet and is capable of operating 24 hours a day.

This article gives a brief description of the problem to be addressed and the tools that were used, then presents the methodology that was used: the functional requirements to build the machine, the functional design of the system, the technical design of the system, the specification of components, the code, unit tests, component tests and acceptance tests are listed; then the results and conclusions are presented.

Methodology to develop

The activities were ordered according to the steps of the V methodology for project management. (Digital Guide ionos, 2022) y (Ceras, Clara, 2022). como se muestra en la Figura 2.
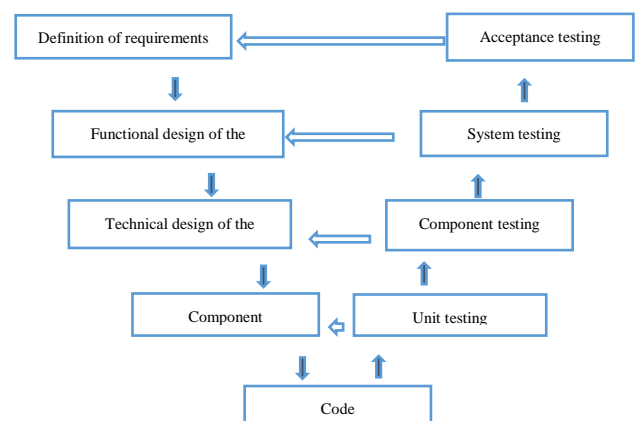

Figure 2 Methodology in V
Own Elaboration

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Definition of requirements

The functional requirements are as follows:

RF01: The vending machine must be able to read a text file containing the credential data that allows access to the wireless network.

RF02: The vending machine must have a multi-currency coin acceptor to accept payment for the sale of access credentials, the accepted currencies will be: $1.00, $2.00, $5.00, $10.00 pesos.

RF03: The vending machine must be able to identify the amount entered in the multi-currency purse to define the login profile of the access credential that the customer will be able to acquire according to the amount entered.

RF04: The vending machine must process the purchase of packages when any of the following amounts are covered: $5.00, $10.00, $15.00, $20.00.

RF05: The vending machine must have an LCD screen that serves as an interface between the user and the machine to display different messages.

RF06: The vending machine should record the credentials that have been sold to maintain optimal control of those available for sale.

RF07: The vending machine must update the list of credentials available for sale.

RF08: The vending machine must have a button to activate coin detection.

RF09: The vending machine must have a button to confirm the purchase of credentials.

RF10: The vending machine shall have a reset button.

1.   Functional design of the system

At this stage, a design was developed that was capable of functioning and satisfying the requirements.

Figure 3 shows the state diagram showing the activities performed by the vending machine.
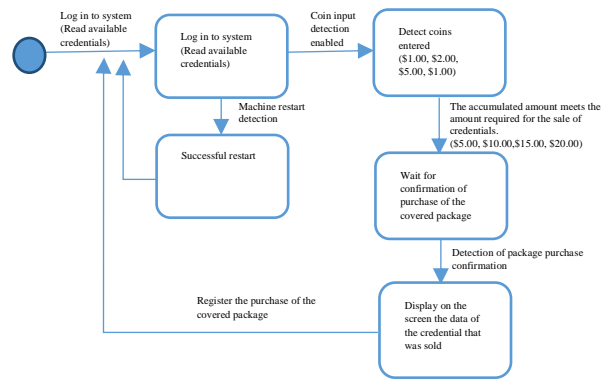
Figure 3 State diagram of the vending machine
Own Elaboration

The functional design approach took into account the actual operation of the vending machine.

2.   Technical system design

Figure 4 shows the design of the physical components that make up the vending machine.
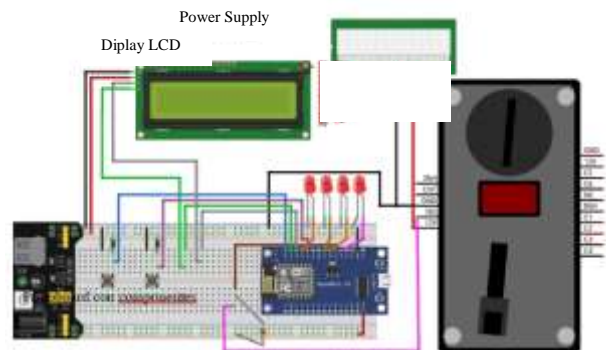
Figure 4 Technical design of the automaton machine

3.   Component specification

In this stage, the components used to achieve the correct operation of the vending machine were defined,

Table 1 shows the components used for the construction of the access credential vending machine:

Descripción	Imagen
Development board ESP-8266-E	
LCD display	
Multi-currency coin purse	

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Power Supply	
Push Buttons	
LED lights	

Table 1 Components used
Own Elaboration

4. Code

At this stage, as a first step, the Arduino IDE was configured in order to program the ESP-8266-E board. In Figure 5, we can see part of the code to be uploaded to the ESP-8266-E board.

Figure 5 Programming window of the Arduino IDE

It was necessary to configure the permissions within the Google account to allow writing to the Google Spreadsheet application.

Figure 6 shows how the script was configured and programmed to achieve communication between the ESP-8266-E board and Google Spreadsheet.

Figure 6 Google Spreadsheet Script Programming Window

Once the code was written in the script, the implementation was done so that the Google system would allow the script to work.

5. Unit testing

At this stage, the correct operation of the different components selected was corroborated.

The connections of the pins of the ESP-8266-E board with the buttons that will be used to activate the coin input detection to the multicurrency coin acceptor were verified.

The connection between the ESP-8266-E board and the multi-currency coin acceptor was corroborated since the negative wires must be joined in order to have a single circuit.

A very important component is the LCD display as it performs the function of informing the customer of the status of the machine, it shows information of amount that has been entered and once the customer presses the button to confirm the purchase, the LCD displays the user and password with which the customer will be able to connect to the wireless network.

Another very significant component is the power module, this component provides the necessary power to the ESP-8266-E board and also has a connection to the multi-currency coin acceptor.

6. Component testing

In this stage, the components that make up the project were tested. In order to perform these tests, it was necessary to corroborate the interconnection between the different components, as well as the correct operation of the code programmed for each component in particular.

The connections of the pins of the ESP-8266-E board were verified with the buttons that have been included in the vending machine, the first button is the activation of the detection of the coin entry to the multi-currency purse, the second button included in the system is the confirmation of the purchase of a package.

The tests were carried out by simulating the pressing of the coin deposit detection button and yielded the following results, which are shown in Figure 7.

Figure 7 Arduino IDE Serial Monitor when the coin detection button is pressed

The tests were performed by simulating the click of the purchase confirmation button as shown in Figure 8.

Figure 8. Image of the result on the serial monitor when clicking the purchase confirmation button.

When performing tests it was of utmost importance to focus on the multi-currency coin acceptor, as well as the different components, the connection between it and the ESP-8266-E board was verified; once the connection was verified, operation tests were performed with the programmed code.

The tests corroborated that the coin acceptor will send the correct number of keystrokes according to the inserted coin.

Once the connection has been established, the machine will wait for the button to be pressed to initiate the coin insertion detection and when the button is pressed, the machine will start to supervise if any interruptions are generated by the multi-currency purse to know if any coin has been inserted and also to know what denomination the coin is.

Once it has identified whether coins have been deposited in the vending machine, it will show the total accumulated amount. Figure 9 shows the accumulated amount on the screen.

Figure 9 LCD display showing total accumulated amount

Once the user has paid for the entire package, whether it is $5.00, $10.00, $15.00 or $20.00, he/she can press the purchase button and the machine will display the user and password as shown in Figure 10, with which he/she will be able to connect to the wireless network.

Figure 10 LCD screen showing the user and Password that has been acquired.

Once the time during which the user and password that was acquired will be displayed has expired, the machine will return to the standby state, where it will be monitoring the pressing of the coin input detection button.

7. Acceptance tests

Once the system tests were completed, the acceptance tests were performed.

To perform the acceptance tests, the first step was to verify the power supply, since it is essential that the machine is supplied with the correct voltage. Figure 11.

Figure 11 Power supply for the machine circuit

Subsequently, we verified that the machine turned on and successfully established the connection to the wireless network.

To verify that these steps are carried out correctly, the LED lights blink according to the number of coins entered once the amount is accumulating.

After having established the connection, the machine makes a record in the spreadsheet, this record contains the legend "Start" and in another cell, the date and time the record was made is stored. In Figure 12 we can see the start record highlighted in yellow in the Google Spreadsheet.

Figure 12 Startup record highlighted in yellow in the Google Spreadsheet

In order to provide a summary option of the information that is being stored in the spreadsheet, a tab was created that contains a summary of the information of the credentials that have been sold. As can be seen in Figure 13.

Figure 13 Summary of sales in the Google Spreadsheet

Results

The results obtained from the development of the project "vending machine for the sale of access credentials to a wireless network" are shown below.

By developing this solution, hardware and software products could be obtained, the first product is the vending machine shown in Figure 14.

Figure 14 Vending machine

Another product is the file that is responsible for separating the data that are provided through a text file, this spreadsheet separates in columns the user data, password and browsing time, as shown in Figure 15.
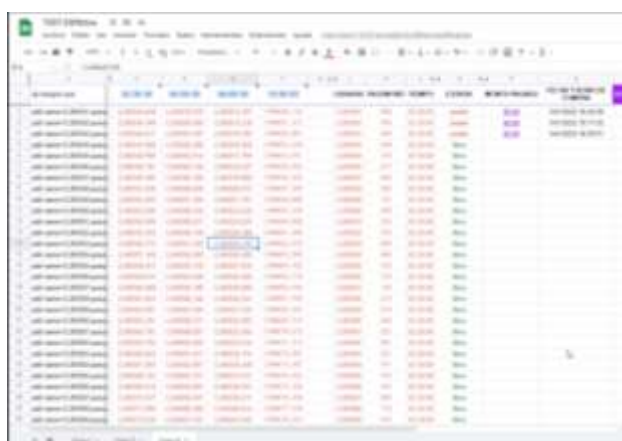

Figure 15 Google spreadsheet with required fields

Within this spreadsheet, there is a tab where the acquired credentials are registered, in this tab there is also the information of the date and time when the registration was made, as well as the amount accumulated so far, this action of registering the data is achieved through the Script that performs the function of intermediary between the ESP-8266-E board and the Google spreadsheet. As shown in Figure 16.
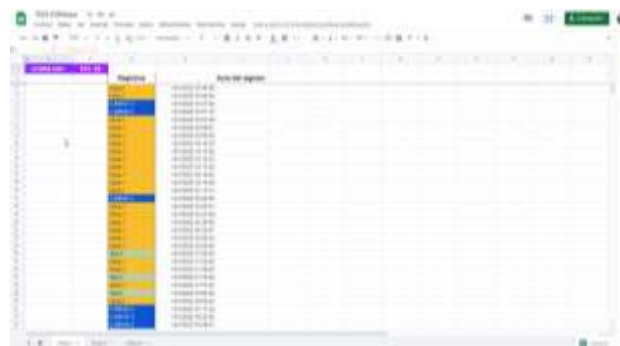

Figure 16 Google spreadsheet tab showing the log of purchased credentials

Within the spreadsheet, there is another tab that contains a summary of the records made, the summary shows the number of packages sold for each of the types of packages.

Figure 17 shows the summary of the sales made.

Figure 17 Spreadsheet tab showing the summary of sales made

Acknowledgment

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Conclusions

This paper presented the proposal for the design and construction of a machine for the sale of credentials for access to a wireless network, economic, which will be used to implement in a rural community in order to automate the process that is currently done in a traditional way.

The proposed machine will be used in businesses that already offer access credentials to connect to the internet, what was sought is a way to make these same tokens work with the equipment that is already in place, This process eliminates the problem of selling tokens that were printed on sheets of paper. With this proposal, the confidentiality of the passwords is guaranteed since only the person who enters the coins, selects the amount and authorizes the transaction will be able to see the user and the assigned password.

Finally, we can conclude that a prototype of a low-cost and functional vending machine was built that allows the acquisition of credentials 24 hours a day without the need to wait for a person to provide it.

In future work the vending machine will be implemented in a rural community to conduct a study on the level of acceptability of the machine to be introduced as a business model.

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