Automated Vending Machine

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Abstract

A vending machine is a machine that can operate in a standalone environment to provide snack and beverage purchase interactions. Internet of Things (IoT) can provide major upgrades to existing Vending Machine (VM) Technology. IoT is a new technology paradigm that can make devices connected over the internet interact with each other. The true value of IoT can only be realized when connected devices can communicate with each other and can be integrated with seller and vendor mechanisms. The major components that are involved in an Automated Vending Machine is a physical vending machine, a QR code on the vending machine that can be scanned by users with their handheld device, an application or website linked to the QR, a database linked to the website and the vending machine that tracks users, storage and orders. The vending machine strives to have minimal contact with the machine and remove any human to human interaction. This report discusses the application of Automated Vending Machine with a successful software implementation under the hood.

Figure 1: Basic Idea of The Vending Machine

Introduction

The "Tutti-Frutti-Gum" vending machine was the first vending machine to exist and soon after specialised vending machines started, like peanut dispensers and water dispensers. Soon after vending machines started selling multiple products, at this point of time, a lot of products could be purchased with a single coin. In the modern era, there are plenty of vending machines with a screen and cash/online payment system using IoT.

During the onset of the pandemic, grocery shopping for generic everyday items including milk, bread, butter etc was extremely difficult and required standing in long lines and traveling far distances as half the stores were closed. This created a demand for services that use minimal human to human contact. Vending machines were a previous solution that already existed which improved this,.Unfortunately the Vending machines that already exist have too many drawbacks which is why we don't see many vending machines.

In the present age,It is quite easy to connect anything and everything via the net by simply adding a small chip that makes these otherwise "dumb" devices intelligent. These chips enable them to communicate real - time data to other computers or devices and act a certain way without any human intervention. IoT has a vast range of application ranging from small bulbs that can be switched on and off from your phone to a driverless car which requires a much more intricate design, The Automated Vending Machine also comes under IoT;as you place orders from your phone which is conveyed to the vending machine once the payment process is successfully completed. There is a live order tracking and storage update system. This happens without the need of any human interaction.

In a traditional vending machine, there existed a coin system where you would put in the correct denomination along with the amount of coins after which you would press the appropriate button and would receive your desired product. Continuous maintenance check, no concept of change and machine down-time leads to losses. Since the introduction of IoT,we can improve on the machine immensely by having a constant system check, having a portal for online payment since no change is required and in today's digital world online payment is a necessity. Hardware status information

gets posted by the machine on the website. Notifications to the administrator are sent as soon as a fault occurs or there is a lack of a certain item which can be instantly dealt with. These upgrades with the help of IoT and new innovations can deal with most of the issues of older generation vending machines.

Research Questions

- Why is there a need for an upgrade to an already established vending machine?

    Vending machines started out with coins and due to inflation, the number of coins required per product increased and then the mechanism required serious changes. So this makes the mechanism of the product much more complicated than it has to be. This brought out the need for a vending machine that has to deal with the concept of "change". In the older versions of vending machines people could exploit "loopholes" to extract products out of the vending machines without paying the necessary amount of money required for the product. The constant need for someone to check if the machine was working properly required staff which partly defeated the purpose of the vending machine.

- Why is the Internet of Things necessary for a small scale vending machine?

    To deal with the aforementioned problems in the previous question, there is a solution which involves IoT. The electronic payment system deals with any requirement of "change" required. The security aspect of the vending machine is dealt with state of the art systems involving cameras that detect and alert any sort of mishaps involved. A hardware status check that the system reports to the admin removes the necessity of a worker sitting at the site. This all can be done in other ways such as the introduction of IoT, but IoT can allow for many more upgrades in the future, like order tracking, auto ordering for more stock instead of a person doing it himself. Data analysis on the items which are more frequently bought and items that are bought seldom to make the machine more profitable.

- Feasibility of IoT based vending machines

This question raises whether an IoT based vending machine is feasible or not. To add any machine to the IoT network one has to just add sensors onto existing machines to transmit data over the internet to other computing devices to use the data. This adds an IoT functionality to any device. In case of the vending machine we can add a hardware status checks if the machine is working properly or not. One can also see the response if the machine has successfully dropped the desired item for the customer.

Research Objectives

- To implement a working web application to operate a vending machine.

  We decided to go for a web application as the front - end part of the project since building of a working android application requires certain proficiency and time which seemed unfeasible at the time of the decision, which is why we chose a web application. This web application can be accessed by the user by scanning a QR code which will be pasted on the vending machine. This QR code can be scanned using any QR scanner available on all smartphones. This reduces the requirement of a user to use the vending machine, since if the machine front - end was an android application, it would require a download. This web - based application would have all the items that are present in the vending machine and a system of a cart and then lead to payment options once the user is done with accessing the products the user desires.

- To build an efficient Database that can be used to store and retrieve information

  An important aspect of this project is to constantly maintain information of the items in stock, information about the users and track of all the orders placed. This database must be extremely efficient since it has to be hosted as the backend of the website. The data also should be well organized as there is a constant retrieval of data in the functionality of the website. It is also important that the retrieval and storage of data in the database is efficient and does not take too much time since there are constant changes in the database at every

order. The database is accessed every time an order is placed, every time one opens the item menu since stock of the items is also necessary.

Research Statement

Different elements involved in the project:

- Front – End → HTML, CSS, Bootstrap
- Back – End → Django
- Database → SQLite3
- QR Construct → Python

Main idea of the project

To build the software part of a vending machine that can be used from your device directly from a web application that is linked to by a QR code that can be scanned by all smartphones. As a user, the steps that would be taken to buy items from the vending machine would be:

1. Scan the QR code pasted on the vending machine
2. Open the web-application and go to the menu of items
3. Select the items you want and the quantity you would like to purchase
4. Check out from that page once you are done\
5. Enter your phone number and check the details of your order
6. Go to the payment page
7. Make the payment
8. The vending machine will drop the items that you purchased.

The administrator of the vending machine can access the admin part of the website using the correct username and password. The administrator then can check all the orders placed, the stock of all the items present. If a stock is low he can call the suppliers, for the item that is low on stock and then restock the vending machine. The administrator can then, using a menu driven program developed on python, restock all the items that are low on stock. This would update this amount

to the database. The administrator also can check all the descriptions of the products available on the vending machine. The above mechanism is what the entire implementation includes.

Literature Review

We reviewed multiple articles and research papers, which we found to be extremely informative however we found certain things lacking in those implementations. This paragraph explains those points:

This paper discusses the idea of minimizing the time spent in operating vending machines and standing in long queues waiting for your turn to come. Traditional vending machine is replaced with a high-tech vending machine which uses fingerprint sensors to open and close the doors of the vending machine. Also, fingerprint sensors are not the best option when it comes to security of the machine. In the paper IEEE Transactions on Information Forensics and Security it was stated that 3D-printed models of one's fingers can be used to mislead a fingerprint sensor[1].

The mentioned research paper contains the design of an automated vending machine that sells different types of chocolates, only accepts two different types of coins, and returns money when cancellation or change is required. This implementation clearly solved the problem of change and cancellation, which was a problem in the aforementioned vending machine[2].

The paper "Automatic Vending Machine Prototype Model" aims at building a portable vending machine for dispensing small and easily available tools. Although a portable vending machine would be really useful to manage, relocate and refill, their prototype lacks any IoT device[3].

While the design mentioned in the research paper of the vending machine solves the problem of not creating new systems every time a new product is introduced into the vending machine, it does not seem to solve the problem of having a personnel on site to conduct maintenance checks on the machine[4].

Research Gap

The research paper titled "Design of a high-tech vending machine" proposes the idea of a modern vending machine with a fingerprint scanner for security purposes. The issue with such a security system is that it requires authentication for each and every user. This is resolved by our model wherein everybody's free to use the vending machine. In our model we do the authentication during the payment process thus ensuring easy access to everyone and also maintaining safety at the same time[1].

The research paper has only two denotations of coins which everyone may not have and furthermore the two denominations limit the value of products since spending more than 20 or 30 rupees would require more than 5-6 coins which most people don't carry. This is solved in our implementation as we have an electronic payment system and there is no concept of carrying a certain amount of money. This payment system includes most payment options which everyone is bound to have[2].

The portable vending machine prototype suggested in the research paper lacks in accommodating a proper IoT system. This is fixed in our model as an add-on to the traditional vending machines. We have incorporated IoT mechanisms to tackle security, availability and payment issues[3].

The research paper includes the solution of adding new products and on the administration page of the website we can add and remove products with a very simple GUI. We have also included another option of having a python program to restock and view item details. Another drawback of the implementation is that there is a need for maintenance checks which we hope to remove by having a Hardware status check of the machine which can be shown on the admin page at any given time which removes the need of personnel on the site of the machine[4].

Methodology

Django

- Web Framework to help create web applications with ease
- Write only the functional bits of the code and not having to "reinvent the wheel" every time.
- Has templetas and versatile with many front-end and back end softwares
- Secure and safe way to manage users
- Extremely easy to maintain, repetition of code can be avoided

HTML, CSS, JS

- HTML is the standard language to create the structure of the webpage.
- CSS is used to add styles to web pages; it does not require multiple changes on the code.
- JS is lightweight and essential to handle user interaction such as text fields, buttons, etc and also to make the webpage dynamic by rendering information onto the site.

QR Code Technology

- Quick Response codes are generally used to lead to applications or websites.
- A QR code always has three dots on three corners of the square, this is to show the orientation of the QR.
- Another feature of a QR code is that it has 4 error-correction levels which show the amount that can be restored. There is also an encoding mode to each QR code.

Python QR Code

- Extremely simple and feasible to make QR generation using a library in python (pyqrcode).
- It helps us create QR codes for our use and has all the features in the function arguments itself.
- We can change size, colour, error correction level and type of encoding.

Experiment

The design of the entire project was thought upon in the initial stages of the project after people were familiarized with the technicalities. Below given is the UML diagram (Figure 2) that shows the entire structure of the project.
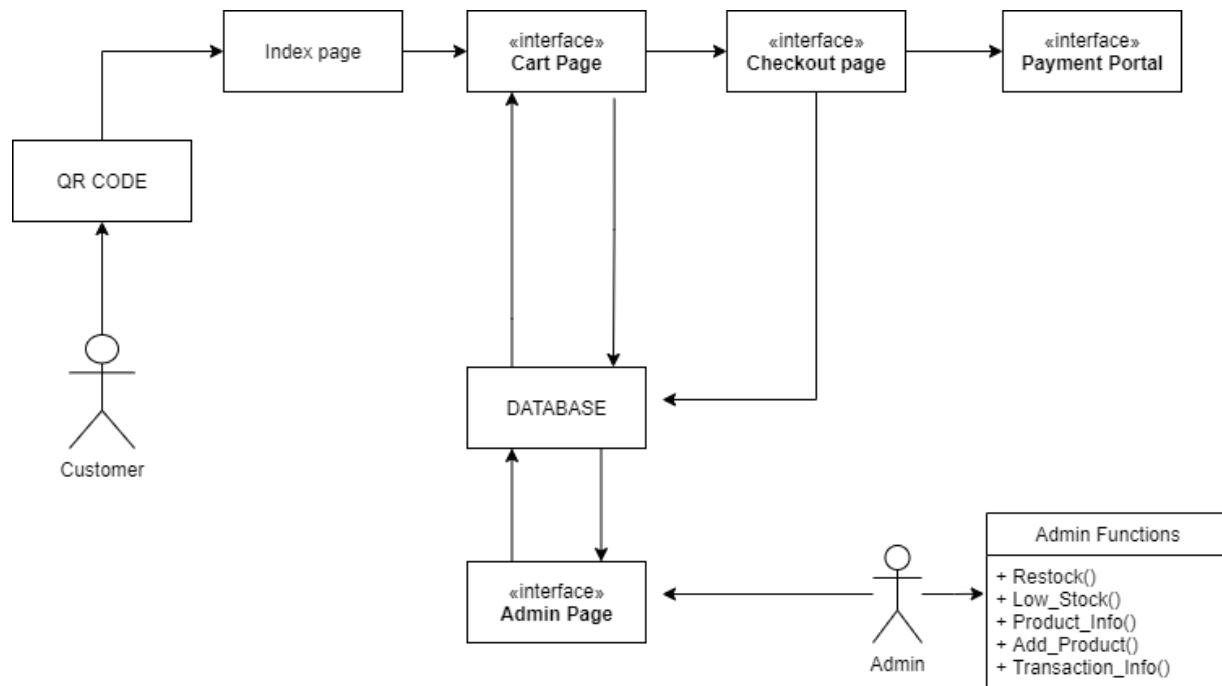
Figure 2. UML Diagram for the project

QR

First we have a user who will scan a QR code using his or her smartphone. This QR code will be generated by a python program (Figure 3) which has been implemented and generates a QR code, when scanned leads to the webpage once hosted.

```python
import pyqrcode
import png
url = pyqrcode.create("https://pythonhosted.org/PyQRCode/moddoc.html")
url.svg('uca-url.svg', scale=8)
url.png('first_qr.png', scale = 3, module_color=(3, 0, 0, 0), background= (255, 255, 255, 255), quiet_zone=4)
```

Figure 3. Script for QR code generation

<u>WebPages</u>

Next we have the user on the website, which is generated by the django application on launch. The website consists of several sections or webpages which are crucial for functioning.The website interacts with the database and also provides a clean UI for the user to interact. Namely:

- Index Page
- Cart Page(Figure 7)
- Checkout Page(Figure 8)
- Portal for payment and exit(Figure 9)

The first page visited by the user on scanning the QR code provided on the machine is the index page. This serves minimal functionality and is meant to serve as an introductory site. The goal is to provide a comfortable User Interface and lead to other sections of the website. On top of the page there is a mention of the machine being used, this functionality is included since we can have multiple machines.

The cart section is where the user selects an item and also picks the quantity to be bought. The cart section communicates with the database to render the items available. The page includes the price and stock available of the item. The stock is live data and does not need manual entering. Adding more items to the database would automatically allow the site to render that item available to the customer without additional changes being made to the front end of the page. This works as the django application dynamically renders items to the page. After the customer selects their items, they can click the checkout button to be led to the checkout page.

The checkout page is made so the user can confirm the list of items he has purchased and go back to the cart in case he has missed or added an extra item. This is done using the local storage of the website and is not committed to the Database since if payment fails we need to undo this transaction. There is a text field to add a phone number which is used to verify the user using a one time password that would show up on their phones. The phone number is added to a post request to the django application. Once the user is done entering their phone number, they are directed to the payment portal.

The next page is the payment page. The payment mode is initialized to paytm since it is one of the most widely used electronic payment methods. This payment page is only a dummy payment page since an official payment page requires verification and requires us to put our billing information into the website, which is not feasible. The payment page has the amount to be paid in Rs which is calculated from adding all the the products prices kept in the local storage of the website. This information is calculated as you are adding items on the cart page and is stored in a variable and then displayed on the payment page.

Database

An SQLite3 Database is used to store all the generated information through post requests to the django application and admin activities. SQLite3 is used since it is more compatible with the django application. A schema(Figure 4) was designed in an earlier stage of the project which was used here. From the schema of the database, we have used two tables to store all necessary information.

The first table contains the information regarding the products in stock. It contains the item id which is treated as a primary key of the table. It also contains the item name and quantity to be used by the website. Along with this information, it also contains the url of the image and videos corresponding to the product. These urls are included in the database to facilitate the rendering of the product image and video on the webpage.

The database also includes another table to maintain information corresponding to the transaction information. This table contains the order id for the transaction. It also contains the phone number for the transaction. It contains a json string to store information in a compact manner in order to avoid consuming too much space in the database..Most of the information related to the items ordered and their quantities are given in the json string.
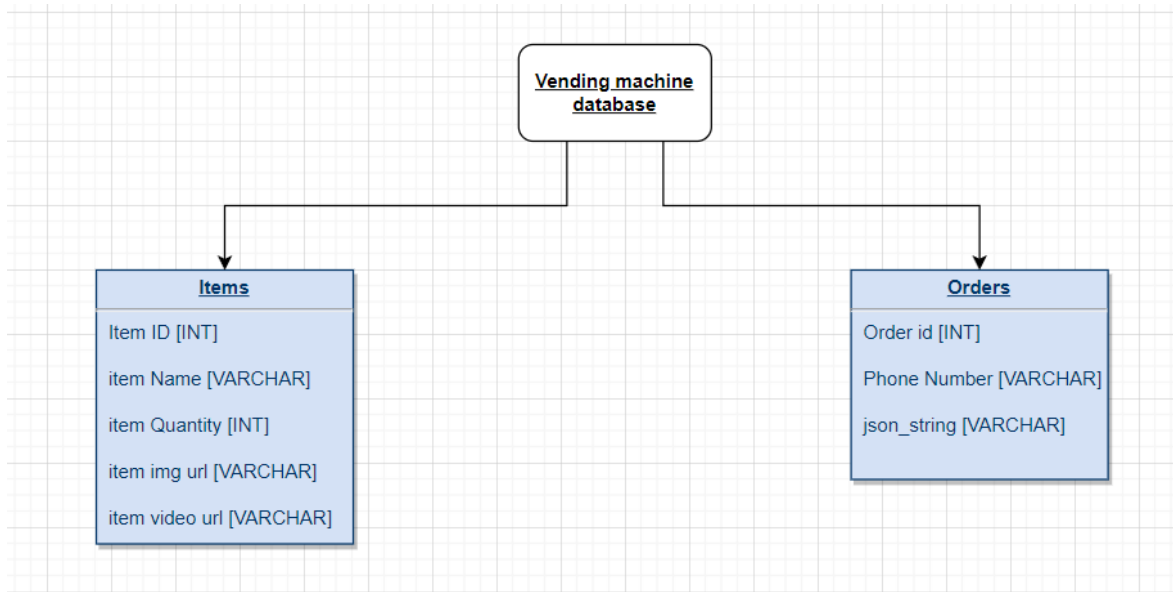
Figure 4. Database schema

The format for the json string is as follows

{"pr2":[1,"Lays - Masala Potato Chips - 100g"],"pr3":[1,"Cadbury Dairy Milk Silk - 50g"],"pr4":[2,"Parle - Parle-G bisuit - 50g"],"pr5":[2,"Haldirams- Bhujia Sev 500g"],"pr6":[5,"Bisleri - Water Bottle 1L"],"pr1":[1,"Coca cola - 250 ml"]}

Figure 5. JSON string with transaction results

This can be loaded as a json object to make the most of the information in this string of data. The json string is then converted into a json object given below, which is used as a dictionary (Figure 6) in python and can be easily parsed.

Figure 6. Dictionary object formed by the JSON string

The string contains the item id as the key. In the list associated with each key, the quantity of the item and its name are included. This can also be converted to a dictionary object in python to be utilized better.

This format can be feasibly used to create a menu driven python script (Figure 10a, Figure 10b) managed by the admin to perform several actions such as restocking products, acquiring order information, etc.

Results and Discussions

The output of the written code is represented in the images below.

Figure 7. Web Page -1: [The cart page which accesses the items from the database]

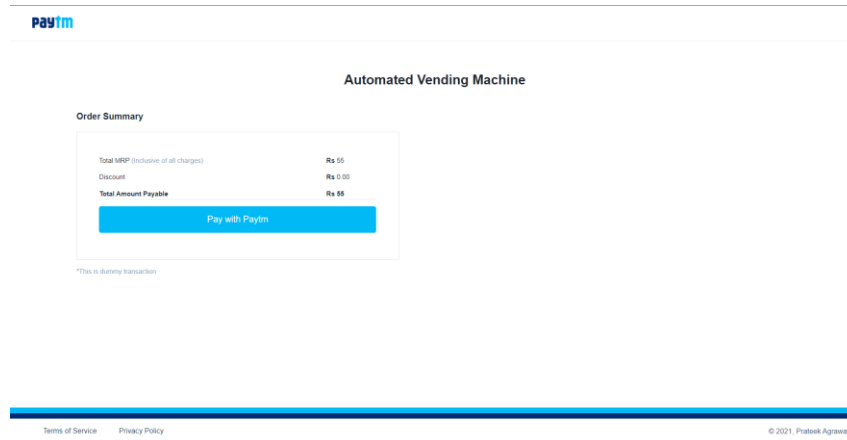Figure 8. Web Page -2: [The checkout page which lists the items selected]

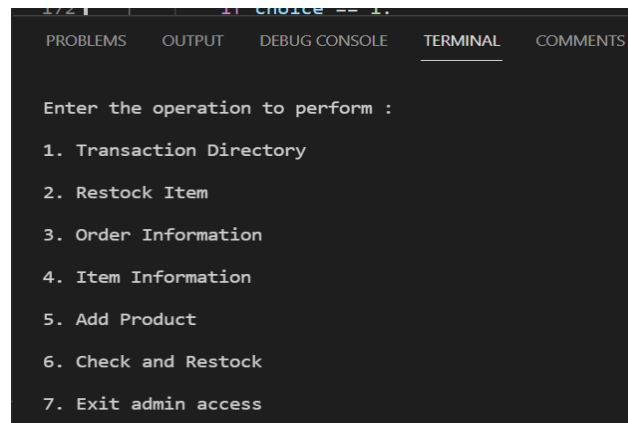Figure 9. Web Page -3 : [Payment portal after checkout]

Figure 10a. [Admin Database administration script, menu driven]

Figure 10b. [Example of console, Admin Database administration script]

Future Prospects

The project built now, which is successfully implemented, is not very complex and has complete basic functionality, however it is built in such a way that it can be upgraded to meet requirements of any client.

Ideas to further improve the vending machine after hardware is put into place:

- The vending machine can have some sort of cashback system that incentivises consumers to purchase products. This cashback system would be if they bought an item for more than a certain amount of money. This is not a loss for the owner since, otherwise the consumer would not have bought the product. The discount system can be implemented just by upgrading the code a little since the front-end has the text for discount.
- Vending machines when placed in institutions or companies can be given healthy options to promote healthy lifestyles.
- Since all the data for the orders is saved we can analyse this data to know which items are being bought frequently and which items are not being bought so those items can be replaced with different items. This can be changed in the website very easily by the admin by just entering new items and deleting old ones.
- The vending machine web - application can be upgraded to have a wallet system, wherein the users are constant (example in an office or a school). This wallet system can be updated by the operator, to have a monthly balance automatically that the user can use for his/her purchases. A reward/punishment system can also be implemented by decreasing or increasing the monthly balance

Conclusion

To conclude, there was a successful software implementation of the vending machine. We understood why there is a need for such a machine due to its various advantages and improvement opportunities.

Vending machines before the introduction of IoT did not have much to offer. IoT overall in all fields of engineering and other fields has proved to be extremely advantageous and in the future we can see that every single device, machine, thing operated by a computer will be connected to

the internet and can be accessed from anywhere from their handheld devices. Vending machine is a much smaller implementation of an automated store which could have multiple machines in a single place with a place to buy from. Even though online shopping has taken over even the grocery market, there is still a demand for buying goods physically as it reduces the time taken to receive the requested product. The automated vending machine offers this and has minimized human contact.

This project has been very helpful for us to learn to adapt and learn new technologies when required. It has also helped us learn to work together in a group to produce good results.

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[3] → Jasmin, M., Hemalatha, S.B. and Udayakumar, R.,(2016) Automatic vending machine prototype model. J. Chem. Pharm. Sci, 9(3), pp.S154-S158.

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Links Reviewed

https://docs.djangoproject.com/en/3.2/

https://www.sqlite.org/docs.html

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