



Smart Vending Machine with Auto-Return Mechanism

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ABSTRACT

When money is placed in a vending machine a product is automatically dispensed to the consumer. The items available in these machines usually include some snacks such as chips, candies and soft drinks, juices or bottled water. You insert a coin, bill, or a card and press a few keys, and your snack or a drink falls out from the slot ready for you to take it. Furthermore, in many countries, there are vending machines that sell not only pizza, muffins, and French fries but also offer some other items like books. Some even prepare coffee for you while you wait. The advantages of starting a vending machine business are low risk, affordable start-up costs and relatively high returns. This is a very straightforward operation with very low operational costs. A wide range of items such as pretzels, drinks, meals that do not need further preparation, and dairy products can be offered. Reports published indicate that a fair return on investment characteristic of this particular industry is roughly 25%. And reducing food waste is important from both an ecological standpoint and for profit performance. Lower waste translates into higher income. It's safe to say that the vending machine business is pretty much set and established worldwide, and for India, it seems to be in its nascent stages which gives an opportunity to capitalize it. It is a low investment, high return, and low time and labor binding business. Moreover, it is also easy to scale up and gain revenues over the years. For regular returns, vending machines are a good option and if you venture into this line, it might just be for you.

1 Introduction

A vending machine is an electrical machine that is developed for the users to dispense different kind of items like snack foods, beverages, and other common items, and in return requires some payment. Gradually, from a single machine used in England in the early 1880s to sell postcards, vending machines have been a dominant feature in convenience retail across the world today. Nowadays, vending machines are located across the globe and have expanded their offerings far beyond snack foods and soft drinks to include footwear, cosmetics, and even full meals. Products like diamonds and platinum are also available in some vending machines [2]. Of course, as the technology of vending evolved, so did the maintenance and other operational challenges that come with these machines.

In the case of vending, placing a vending machine does not mean that you simply fill it with



products and wait for business to come in. This is where copies of Best Aluminum Water Bottles comes in. There is a need to be proactive in machine maintenance to make sure that machines can perform as required and addressing the needs of consumers can also assist with sales greatly. For example, popular items could be rotated frequently to keep them in stock while soft moving items could be replaced or minimized. As many other aspects of business, the effective management of composition of a vending machine can not only improve consumer satisfaction but also boost sales by eliminating overloading the vending machine with too many goods. In this regard, enhancing the speed with which a user can reach a machine as well as the speed with which an item can be retrieved from it is paramount to the delivery of good service.

Recalls and lost transactions are some of the most common frustrations that occur when customers are trying to retrieve the items from the machine. The reason tends to be internal component fatigue or other product/teller misalignment. In situations when products get jammed, it may be as simple as replacing some obsolete or broken parts, however, in most cases, it is possible to decrease the need for such measures with adequate maintenance of the system. Such problems are especially common with older machines, where components are simply used over many regular transactions. At times the access door or the retrieve panel is damaged making it hard for customers to get to their items. Rejuvenation of such components is easy and most times should take a short time to restore full operations of the machine.

It is very important for vending machine operators to develop a strategy that would help them whenever they have repair issues and even during normal usage of the machines. It is not uncommon for some clients to try to rock or bang a vending machine to release a jamming item. There are better methods of the fronting vending of which is even off professional help. The services can also help diagnose the primary cause of the challenges, recommend ways of preventing them in the future and even improve the durability of the machine. In some instances, however, fixing an old vending machine may not be economically viable. At such times, switching to a better model can offer enhanced operations, simpler forms of payment and greater overall satisfaction to clients of any business.

2 Recent Works

An advanced vending machine system has been designed by creating multiple integrations with already existing technologies and components in order to improve the second element of the system as well – customers' satisfaction. Before the recent designs of vending machines, majority of users would make a cash only payment and receive their chosen item from the machine with the help of mechanical means. However, it has become more normal nowadays to pay for items through mobile applications or websites. Thus, a contactless way of purchasing a product has been improved.

To make these advanced features possible, various core components and methods were adapted for use. For starters, ESP-32 Microcontroller (MCU) was used for its processing and wireless communication capabilities so that the machine and the web-based application can



communicate with ease. This was the machine that placed smartphones and web apps at the center stage of commands like receiving payment made and subsequently activating the dispensing unit. Michael provided the ESP- 32 with the ability to support remote control of the machine without interfering with the traditional operation because the machine did not have switches and buttons for use.

Furthermore, the engineers incorporated L293N Motor Drivers to control the motor responsible for the dispensing of products. The T-shape motors that are involved in the dispensing process have an accurate control using these motor drivers. To guarantee precision in product selection and dependable delivery, the T-Shape Motor (9V) facilitates rotating movements needed to pull out products from specific designated slots at designated positions. With this motor based dispensing, there is a shift from the spring loaded dispensing in older machines to enhance efficiency and avoid blockage of products. To make the machine more appealing and interactive for the user, the engineers inscribed LED strip lights on the inside of the vending machine in order to help illuminate the interior of the machine in the course of the product selection and retrieval process. Another important improvement has been made, the Servo Motor that is responsible for opening and closing the door allowing access to the products when they are ready to be picked. In contrast to the fixed access panels designed previously, the active servo motor mechanism makes sure that customer's access to the products has a clear perimeter so there are no problems of blocked or lost items.

Additionally, our project included a 12V Battery as a power source in order to achieve stable power supply in all components and to allow the vending machine to work properly under conditions where external power supply varies. Last but not least, Metal Springs ensured that the mechanical structure of the product slots was not distorted during assembly while increasing the durability of the machine.

All these components have been carefully adjusted for the better performance of the vending machine, as well as, for the facilitation of the vending unit's operation over the web. This system, through a combination of hardware and software advances, seeks to resolve the common challenges faced in vending technologies such as limited modes of payment, product retrieval and vending machine breakdowns.

3 Proposed Work Explanation

3.1 Hardware section

Constant State of Vending Machine

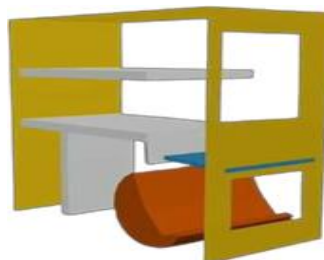




Figure 1: *(Front view of the machine)*

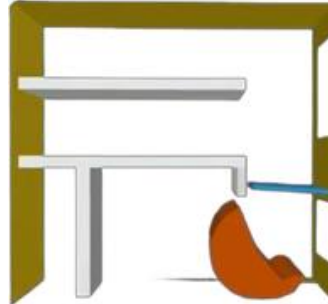


Figure 2: *(Side view of the machine)*

All products located within the vending machine are secured on a shelf inside a locked compartment in the first place. This system uses a web-based application that allows the user to connect the machine with their smartphone. As a customer moves closer, they can scan a QR code on the vending machine screen or body, which uploads the customer into a software web application that allows selection and purchase of goods.

The web application can be compared with any other e-commerce solution. After scanning a QR code, the customer is shown a list of products that are offered by the vending machine. In this way, customers can explore product catalogs, place purchase orders, and include certain items in their order list on the application.

Here, the consumer is brought to the checkout where their total expenditure is compiled and projected such that it integrates the mobile payment system that allows for UPI and other types of mobile payments that allows the consumer to complete a purchase without facing any physical contact. The payment goes through automatically and the vending machine is put on standby mode while waiting to go through the product delivery process.

3.2 Payment and Product Delivery



Figure 3: *Machine state while dropping product*

After payment has been received, the vendor loops the automatic system to send a notification indicating that the payment for the goods has been executed and turning on the internal parts of the vending machine to start the process of delivery. Such positive automation enables the vending machine to find out which particular item a customer has ordered from the electronic catalogue, thereby ensuring precision and heightening the level of accuracy and chances of



making mistakes. At this stage, a specific item which has been programmed into a shelf is ejected. Subsequently, a sliding door or bearing situated inside the compartment of the vending machine automatically opens, allowing the object to fall into the retrieval region.

At this stage, the user receives a notification through the mobile application indicating that the order he made is now in stock.

The challenge of this notification is that it confirms to the consumer that the transaction has been completed and their product is ready. It may also be the case that the app generates a prompt saying – “View your product and pickup” such that it is accompanied by an announcement that would fetch the customer’s attention. With the help of both seeing and hearing, the vending machine makes the task completely hassle free, and makes the customer’s belief stronger and stronger for the transaction to be completed.

The entire procedure is made simple, and efficient such that a consumer’s journey starts from the web application interacts with the system, and ends with obtaining the needed product from the vending machine. This combination of physical objects with the software makes the end user’s journey not only seamless but dependable and hence reduces the waiting time while increasing the comfort of the consumers.

3.3 Unclaimed product Handling and Storage mechanism



Figure 4: Machine state during unclaimed product handling

3.4 Unclaimed Product Handling

The other product offered by the vending machine is a backup feature that will not allow the customer equipment to remain unpicked for a long unforeseen period of time such as fifteen seconds. It is this feature that supervises the picking area, and determines whether the purchased product is still in its standby position or it has been taken. When the customer is unable to get their items after the order fulfilment period, the automated system interprets the situation that the item is forgotten or the customer is out of the area.

As soon as this time lapses, the machine will respond by shutting the sliding hatch and directing the product off the retrieval area, to a locked up compartment that could be located above the product shelves or below the shelves. This lockable storage area is meant for products that the



customer has never picked up hence acting as temporary storage until the machine is next serviced. These incidences are recorded and the system maintains a history of lost sales. Since the items are considered sold and the responsibility to pick them up lies with the buyers, no refunds are given. In that case, in order to acquire the item, the customer will have to order it again.

3.5 Restocking and Maintenance

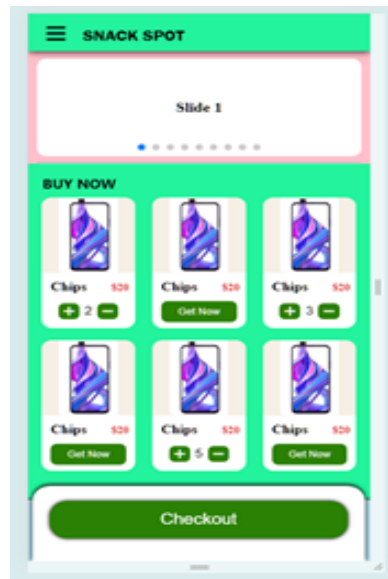
Regular maintenance is essential to ensure the effective operation of this storage system. Periodically, a machine operator or vendor visits the machine to handle unclaimed products stored in the temporary compartment. During these intervals, the operator retrieves these items and restocks them on the shelves, making them available for future customers. This restocking approach reduces product loss by preventing unclaimed items from being discarded, as they remain viable for resale.

This system is carefully designed to minimize waste and maintain efficient inventory control. The maintenance operator plays a pivotal role in this process, overseeing the product lifecycle to ensure that items are circulated back onto the shelves, sustaining the machine's smooth operation over time.

4 Software Section

4.1 Product Selection Interface

The last step that the customer makes when using the company's vending machines is the wireless contactless self-service transaction. The customer makes this contactless transaction by scanning the QR code that is found on the vending machine. Once the QR code is scanned, the customer is automatically directed to the home page on the vending machine website which is the first step of the process of using the company's website. This homepage helps the customer to get closer to the process of purchasing goods from the vending machine through the provided navigational tabs.



Normally, the customer is provided with easy access to a variety of products on the homepage, along with a picture, a description, and the ability to select the number of items desired. The quick scan system helps customers choose and pay for any purchased items with ease, much like the method of selecting items on the web. Once the customer has completed their selection and the amount of the products they would like to purchase, they can press the Checkout button which will take them to their next destination which is the Checkout Page, the image below attempts to demonstrate this.



4.2 Checkout Interface

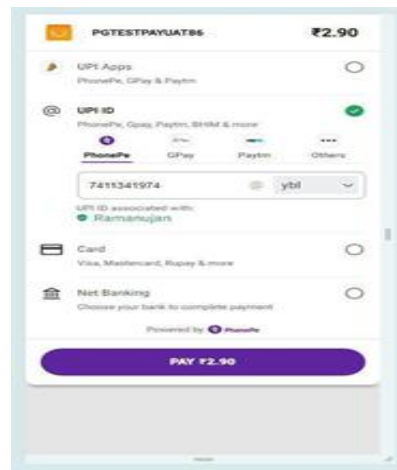
The Checkout Page contains all the bought items, their quantities and the total cost of the bill. This page enables the final check to the buyers since all the order details are visible and this minimizes confusion and errors when the purchase is completed.

After confirmation and review of the order details in this case the customer can engage the Order Now button. Such an operation leads to the payment gate where customers are instantly moved to the phone pe payment gate. This is the place where the ultimate transaction takes



place and customers are assured of making safe payments that is they pay what the bill shows. After making the payments, the system will go back and confirm the order status in relation to the order made through the vending machines online platform.

4.3 Payment Interface

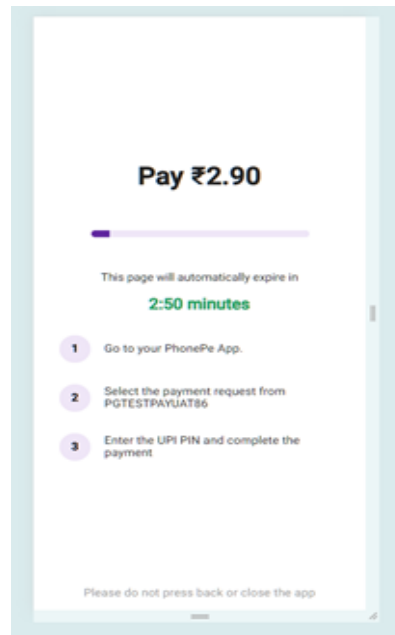


The Payment Page provides multiple ways of payments to make things easier for the users [3]. For customers, they can either directly input their UPI ID to pay, or opt for other methods available such as Card Payments, Net Banking, and QR Scan & Pay. This gives the customers several options on how they want to go about purchasing items.

Once the customer has chosen his/her mode of payment and filled in the appropriate fields, a button called Pay needs to be pressed. This begins the payment process, and through the gateway, the transaction will be performed online and authorization will be obtained. Once the payment has been made successfully, the customer will automatically reach the last confirmation stage, thus making the ordering process very effective in terms of switching positions during the process.

4.4 Payment Confirmation and Timer

When a payment is attempted by a user, he gets a period of 2:30 minutes to complete that payment transaction, known as a countdown timer. In such situations, the customer has to switch to his respective payment application (like PhonePe, Google Pay, or any other app which is supported) and furnish his secured credentials for the transaction to go through. This timer helps assure users of the necessary time to make payment without losing order session.³



Once the user has made the payment for the order and the payment has been made from his bank account to the merchant's account, the order is completed. The next step is the customer gets a confirmation notice both in the web application and in the payment application. This signifies that the vending machine has confirmed receipt of funds and is in the process of delivering the selected item.

5 Results and Discussion

When we put our smart vending machine into practice, the facilities which is provided by that is very convenient where it doesn't require the traditional service routine [4] we demonstrated cohesive hardware and software components that delivered the user journey from product selection to purchase and collection in a flawless manner. When choosing a product, making payments, and avoiding checkout, the QR-on- web Application Interface made it easy for users to use the web app, comparable to a number of e-commerce platforms.

Once users made a payment, the hardware components such as sensors and motors engaged and dispensed the purchased product while notifications warned and informed the users that their purchased items were ready. Besides, the system's fallback mechanism also managed unattended goods efficiently and thus added security and operational effectiveness to the system. On top of that, maintenance protocols also improved the consumer's product supply cycle by cutting down on waste and enabling fast replenishment.

What worked in favour of our design was the incorporation of multiple payment methods including, UPI and card payment options, which made the system more accessible and easier for many users. Nonetheless, future studies might seek to further test the system and see how it performs when there are many users and even improve response times, particularly in transaction verification.

6 Conclusion



To sum up, the presented vending machine system employs contemporary web application features to completely transform the traditional vending. With the inclusion of UPI transactions, we have improved the payment interface and procedures to be safe, simple and fast. The system's features are designed with the end users' ease of use in mind and this is achieved through a simple interface enabling easy product selection and fast checkout.

Also, these machines are placed in places where there is no direct sunlight [5] and the implementation of sophisticated monitoring devices offers up-to-date inventory control systems, which improve efficiency and lessen the chances of service breakdowns. Not only does this project solve the problems associated with automatic vending machines' limitations on payment methods and inventory checks but it also opens up opportunities for new developments in automated retailing machines in the future.

Our results reveal that there is also scope for improvement by using certain features of machine learning and recommending particular products to users based on their preferences. In all, this project illustrates the usage of technology and retail, germinating the bases for other advanced vending systems that are more cohesive and intelligent in the future.

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