University of Moratuwa

Department of Electronic and Telecommunication Engineering

EN3251 - Internet of Things

Project Report

(Vending Machines' Network)

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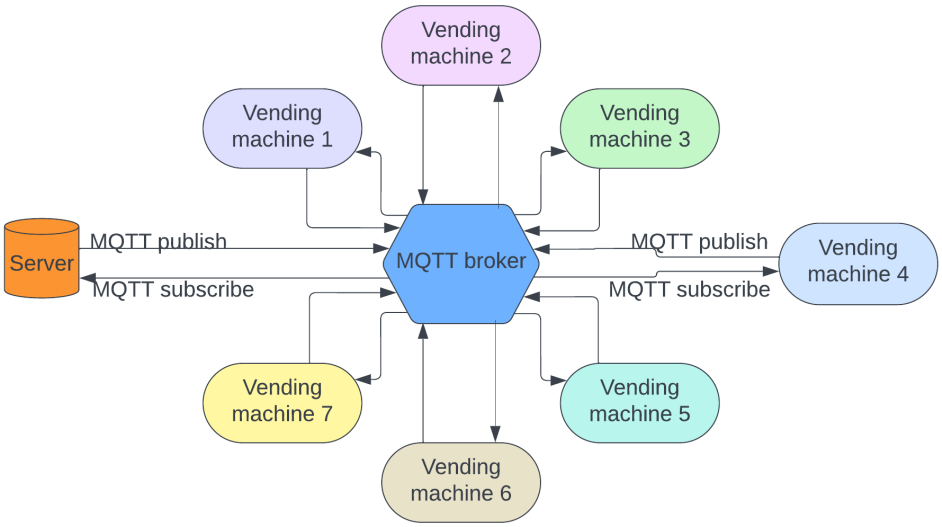
Introduction

This project is a network of vending machines of a company that sells a defined set of different products. The main idea is to connect the vending machines in a star topology to a main server (aka admin server), to monitor the product availability in each vending machine and to provide customer with valuable information such as nearby locations, product availability in nearby locations, details of resupply schedules. Each vending machine is equipped with convenient user interface for the customer where he/she can buy products or inquire info. This implementation also benefits the company due to real-time monitoring and features like notification when products run low, and location wise or product wise stats, to efficiently schedule supply routines and to accurately identify the market value of products by analyzing the trends to make informed decisions on future marketing aspects.

Project Architecture

This project is based on MQTT based publisher subscriber architecture while there is a server client functionality between the main server and the vending machines. Both the server and the vending machines act as publisher and subscriber in different instances.

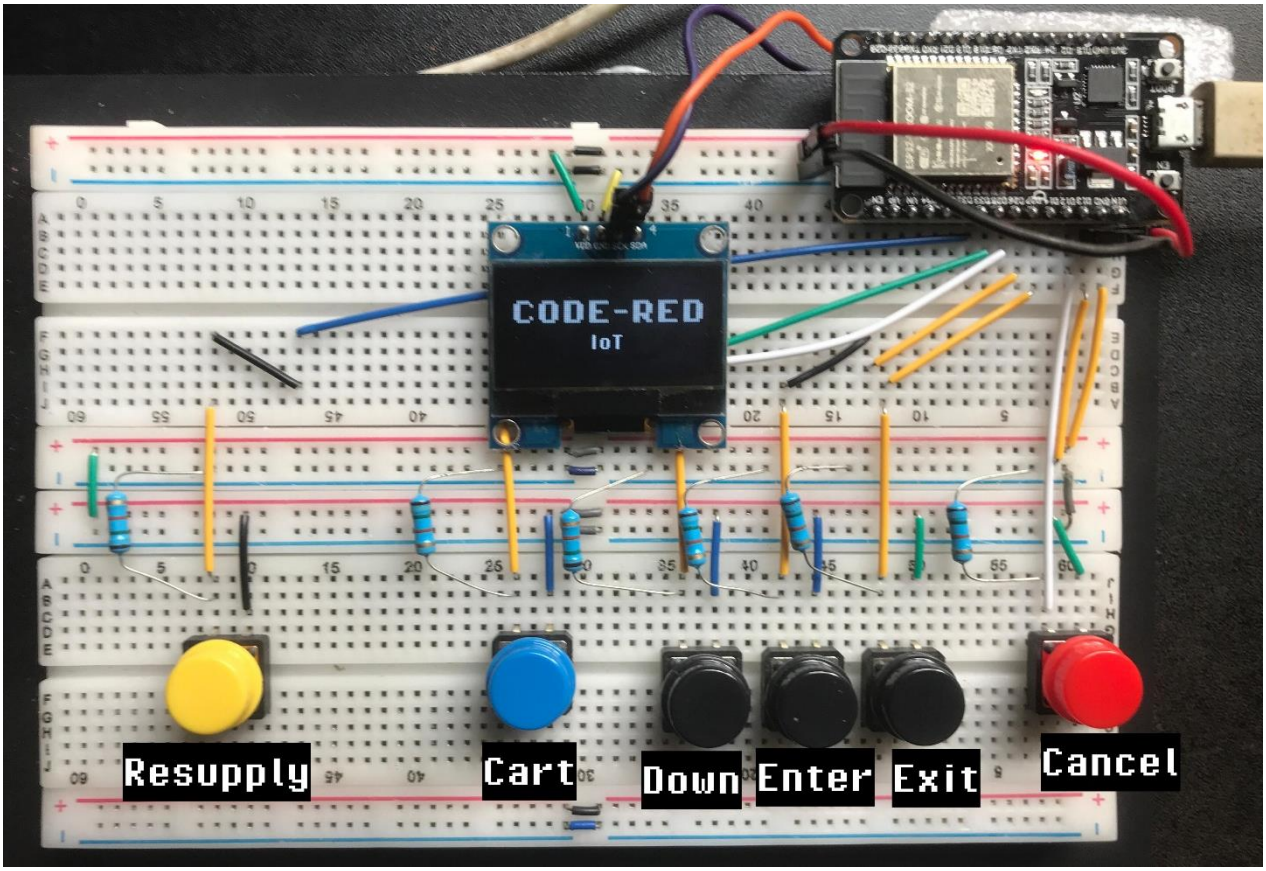


Each vending machine will communicate through the MQTT broker with the server. Vending machines will publish their queries and purchase details on respective topics for the server. The server will provide the vending machine with required information by publishing it to the topic of the respective vending machine. Here the vending machines and the server will be subscribed to the respective publish topics of the other.

Messages or data are transmitted through the internet as JSON strings. Each vending machine or server will form the JSON object upon receipt the string is formatted into JSON objects to later processing.

Hardware Design

Only the instance of the vending machine at UoM (University of Moratuwa) is implemented in hardware using ESP-32 development board, OLED (128×64) display and push buttons.



Implemented functionalities

1) Main menu
2) Product view for buying
3) Quantity setting
4) Cart view
5) Nearby location details
6) Product availability details

The resupply function is not yet implemented though button configurations are made.

Main menu

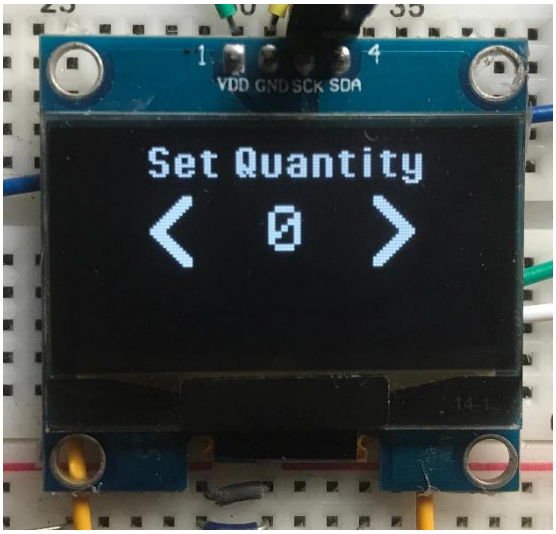
Three selections are available, user can move the curser (triangle) by pressing the ‘Down’ button. Pressing the ‘Enter’ button will get to the next interface.

Product view for buying

Selecting the ‘Buy Products’ tab will get to the product view interface where each product will be shown with the updated price and, quantity. Pressing the ‘Buy Products’ tab will trigger the internal MQTT communication and get the details from the server as a JSON string and parse it into JSON object and retrieve information from that object to view the details in this interface.

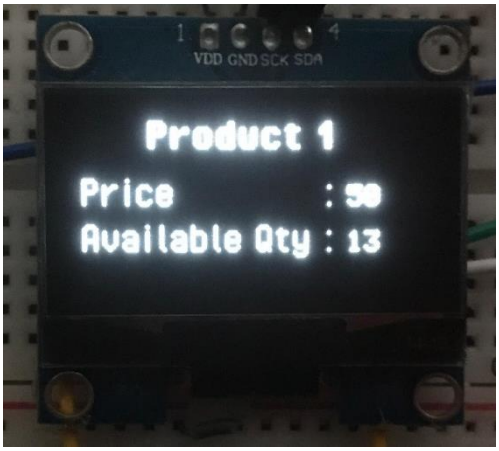
Pressing the ‘Down’ button will scroll through each product details. Pressing the ‘Exit’ button will return to the main menu. Pressing the ‘Enter’ button will get to the interface to set required quantity for purchase. The MQTT communication is triggered every time the ‘Buy Products’ tab is entered ensuring the up-to-datedness of the prices and quantity.

Quantity setting



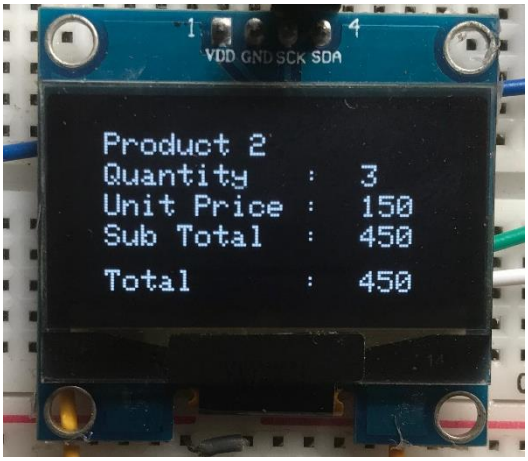
While in the product view in the ‘Buy Products’ tab pressing ‘Enter’ button while on a product view will get to the ‘Set Quantity’ the user set the quantity by increasing the amount by pressing the ‘Exit’ button or decreasing the value by pressing the ‘Down’ button. The maximum value is 25, increasing at 25 will return to 0, similarly decreasing from 0 will set the value to 25. After setting the value pressing ‘Enter’ will add the

product and quantity to the cart and exits to the product view. The user cannot set a value that is higher than the available quantity, doing so will display an error message.

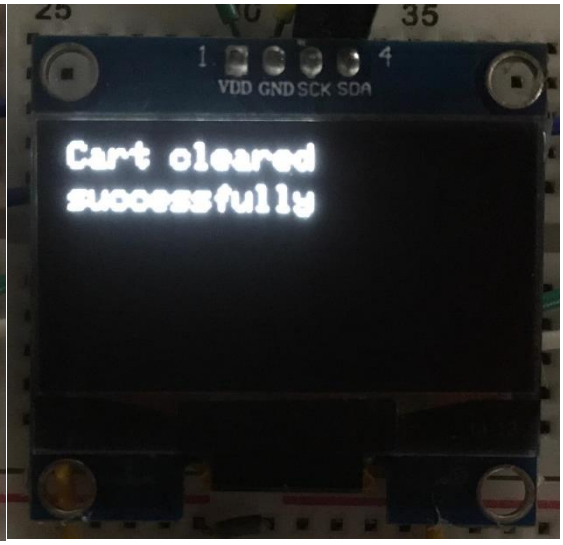


Cart view

After adding the products to the cart, the user can see the final cart before purchase. For viewing the cart user must return to the main menu and press the ‘Cart’ button to view the cart.

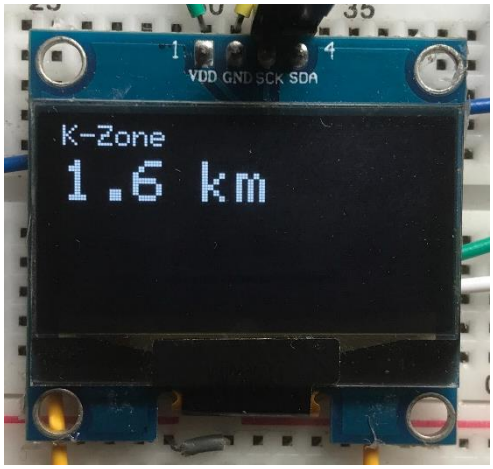


Here also the user can scroll through the cart items to view his selection and subtotal and total. To purchase the user must press the ‘Cart’ button again and the internal MQTT communication will be triggered to send the purchase details to the server. The user has the option to clear the whole cart by pressing the ‘Cancel’ button. Pressing the cancel button once will alert the user and confirm his decision, then pressing the ‘Cancel’ button again will remove the cart items. From the main menu if the user now press ‘Cart’ button the message will display ‘Empty Cart’.



Nearby location details

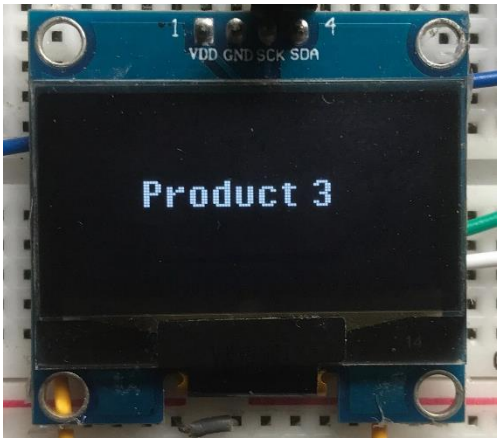
In the main menu selecting the ‘See Locations’ tab will get to the view of the nearby locations ordered by their distance from the current location.



Pressing the ‘Enter’ button will trigger internal MQTT communication to get the updated details in the respective vending machine from the server. Upon receiving the information, it will show the product details (price, quantity) of each product in the selected vending machine. The view would be the same as the view of the ‘Buy Products’ tab but pressing ‘Enter’ button will not do anything here only viewing is possible. Pressing the ‘Exit’ button will return to the location view.

Product availability details

In the main menu selecting the ‘See Products’ tab will get to the product wise view interface. The interface will show each product name, the user can scroll through it and press ‘Enter’ button to select the product.



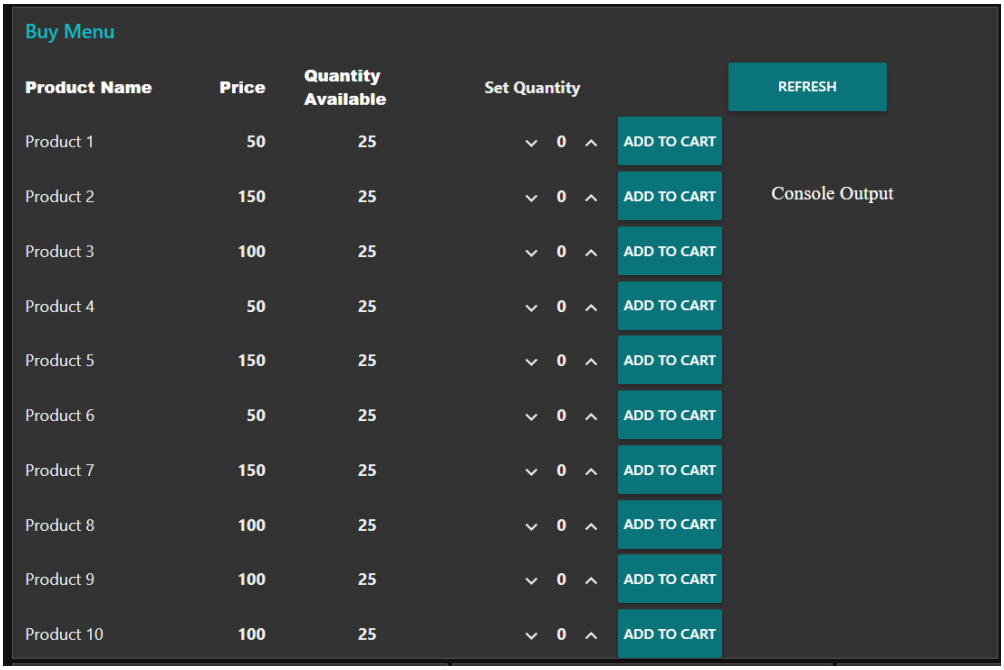
When pressing the enter button the internal MQTT communication gets triggered to get the current product availability details at every location from the server. Upon receiving the information, the products availability details at each location for the respective product will be shown, by pressing the ‘down’ button the user can scroll through each location.

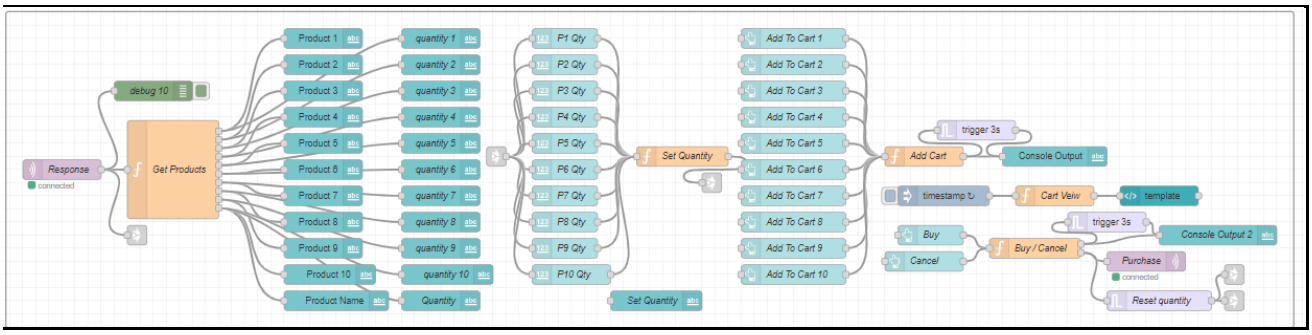
Functionality

Vending machine’s user interface

The first component is the 'Buy Menu' interface of the vending machine. In this interface, the user can view the price and quantity available for each product within a particular vending machine. Upon selecting a quantity and pressing the 'Add to Cart' button, the output will be displayed on the console. If the chosen quantity is less than the available quantity, the console will output 'Successfully added X number of product Y,' and the item will be added to the cart. However, if the selected quantity exceeds the available quantity, the console will output 'Maximum number of available products exceeded,' and nothing will be added to the cart.

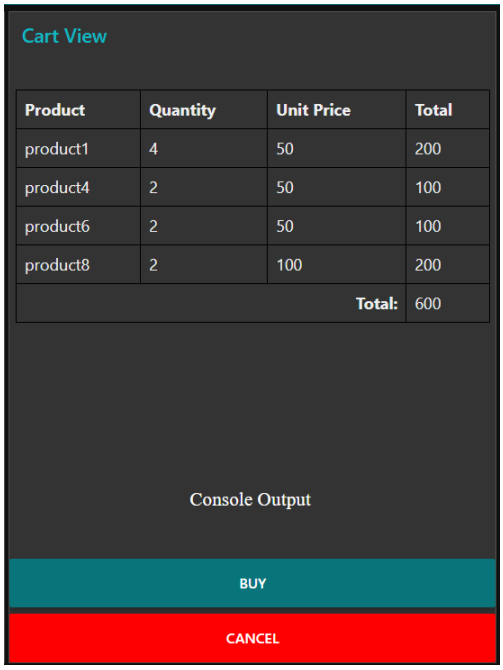
Before proceeding with any operations, it's necessary to click the "Refresh" button to obtain the current information about the products. Upon clicking the refresh button, the vending machine will publish a request using a query topic, and the server is subscribed to this topic. Upon receiving the request, the server sends the response via a response topic. As a result, the "Buy Menu" interface will display the real-time information.



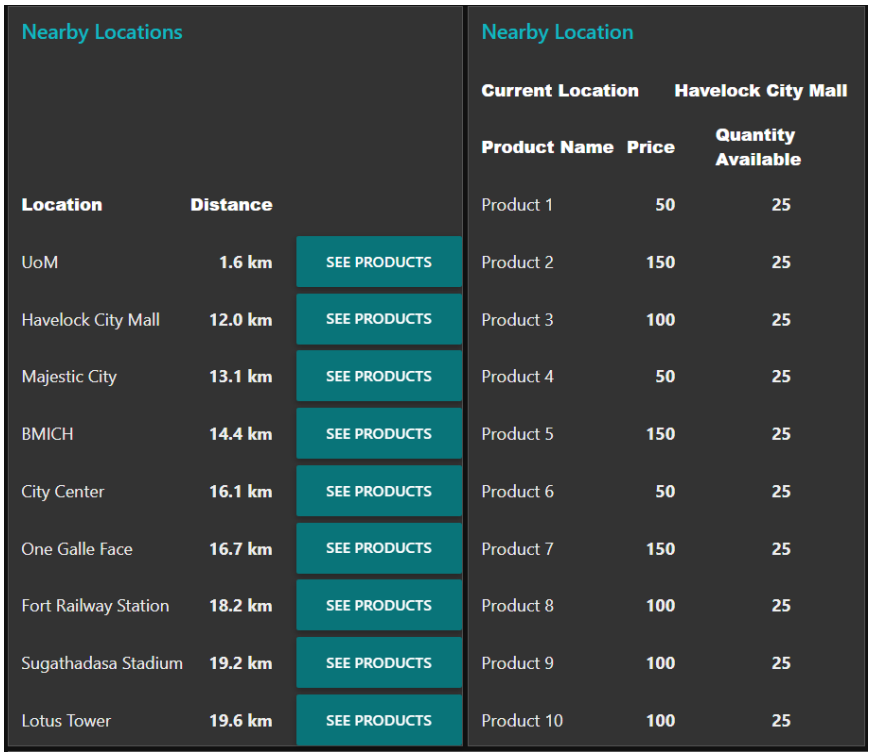


In the 'Cart View' interface, after the user adds the desired quantities of the products, they can initiate the purchase by clicking the 'Buy' button. The console will then output 'Successfully Purchased.' Alternatively, if the user clicks the 'Cancel' button, the cart will be cleared, and the console will display 'Purchase cancelled.'

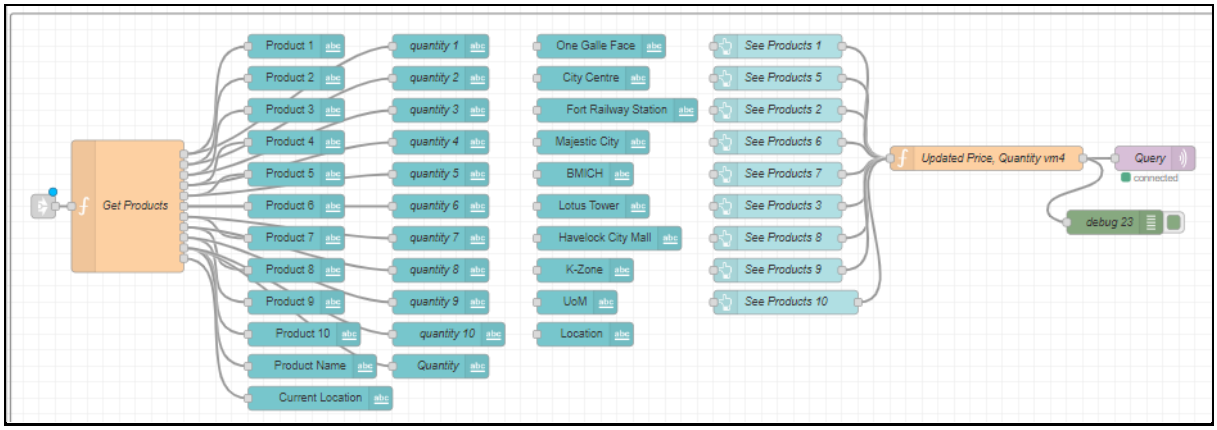
The purchase details will be published in a JSON object using MQTT, with a topic for purchase. The server is subscribed to the same topic. With this information, the server will update the availability of the product accordingly.



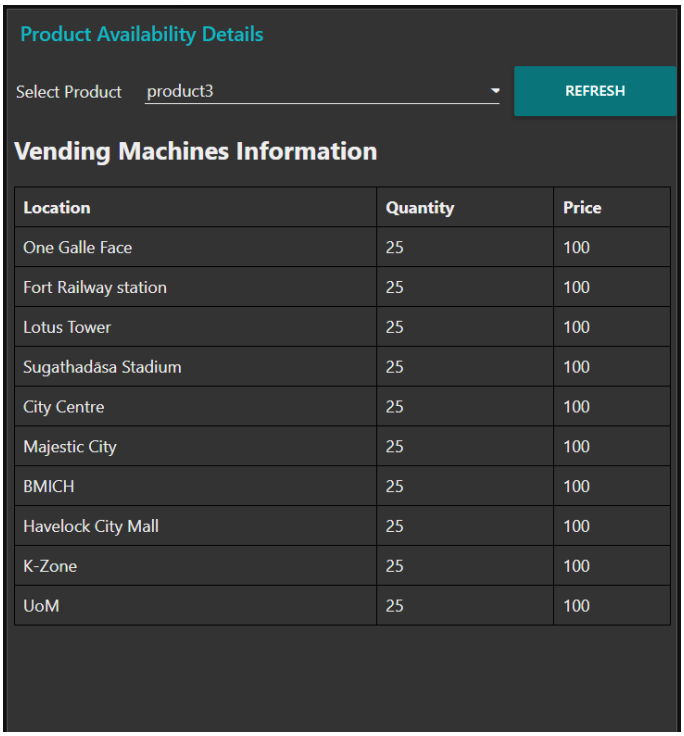
In the 'Nearby Locations' interface, users can view the available quantity of each product in a specific vending machine within the network. This information is accessible by clicking the 'See Products' button next to the respective vending machine. The locations of the vending machines are sorted by distance.

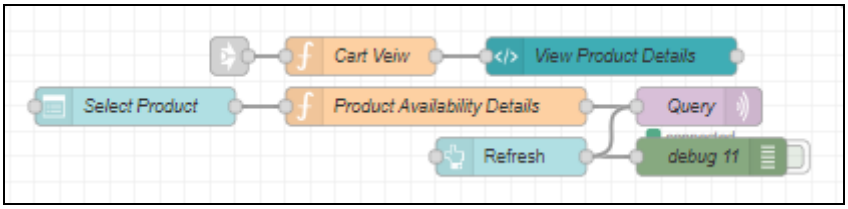


When the user clicks 'SEE PRODUCTS,' the vending machine will publish a request message using the query topic, along with the corresponding location. The server is subscribed to this topic and will receive the message. In response, it will publish information about the particular location using the respective response topic for the vending machine . Subsequently, the vending machine will retrieve and display this information.



Through the 'Product Availability' interface, users can quickly check the quantity of a specific product across all networked vending machines. The interface triggers a request, prompting the vending machines to publish query messages with product details. The server responds by publishing aggregated availability information on the response topic, which the vending machine displays for the user.

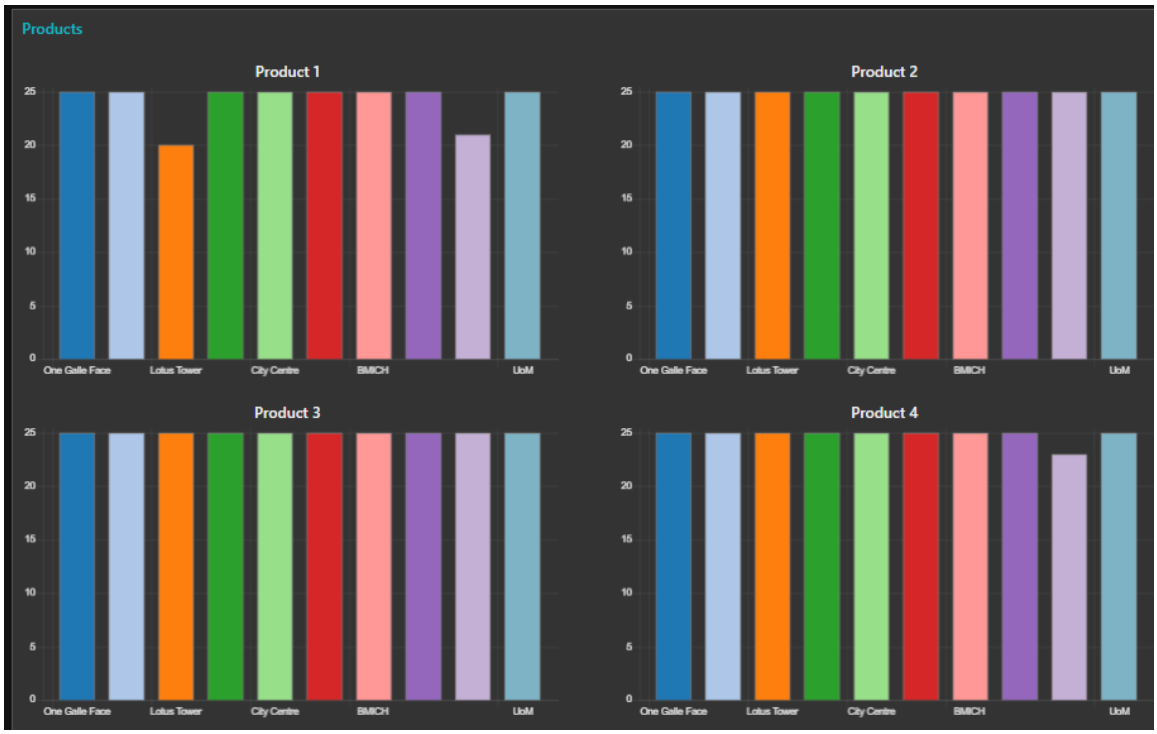




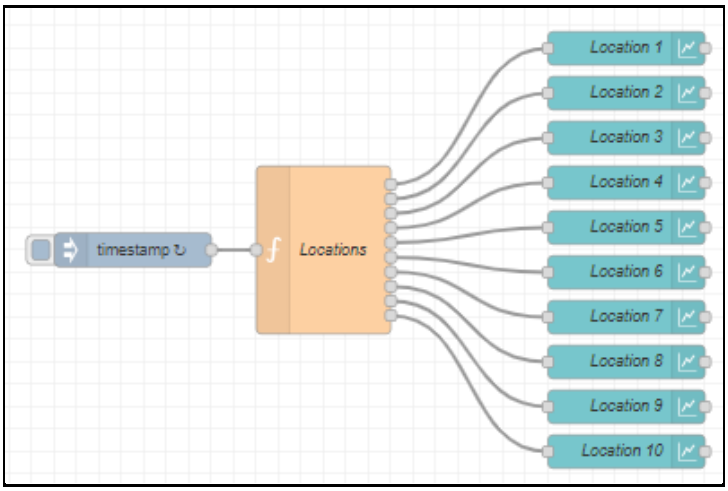
Server user interface

In the server's user interface, administrators have a centralized platform to efficiently manage all vending machines within the network. This main control hub facilitates remote oversight and control, allowing administrators to monitor and administer various aspects of each vending machine, ensuring streamlined network management.

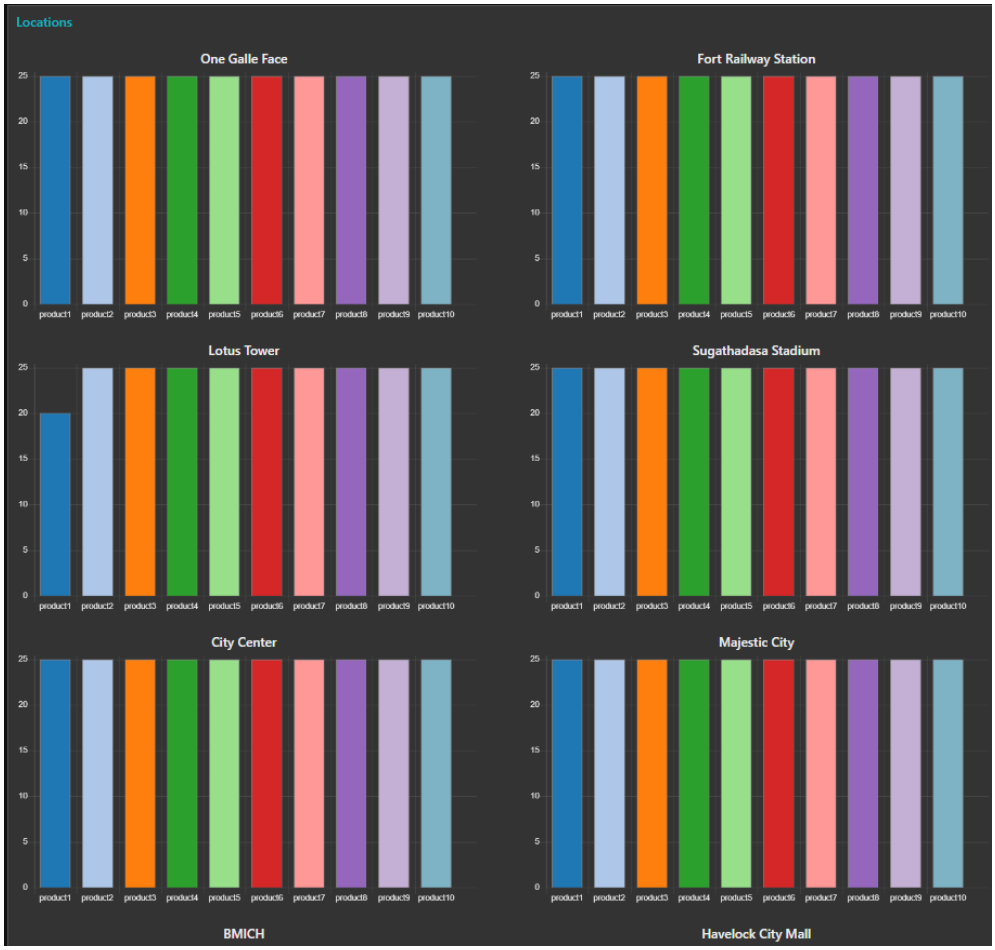
In the 'Locations' tab of the administrator interface, a comprehensive overview of all locations is provided. This includes visual representation of the available quantity of each product through a bar graph, offering a quick and intuitive way for administrators to assess product availability across different vending machine locations.



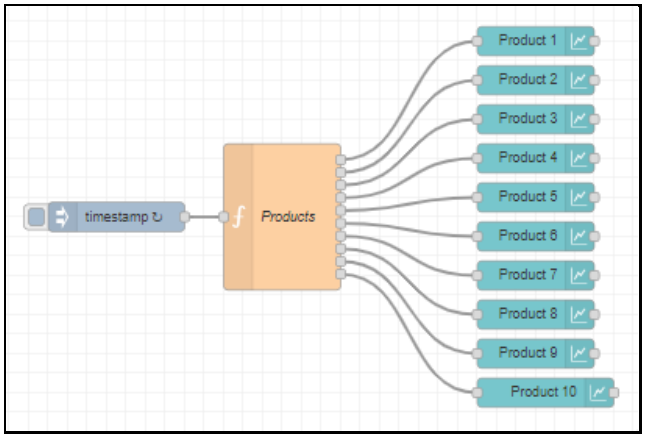
Using MQTT, the information for every location will change in real-time. This enables the administrator to observe real-time data updates across all locations.



In the 'Products' tab, administrators can access a comprehensive view of all products available at each vending machine location. This feature provides a detailed overview of the product inventory across the entire network of vending machines, enhancing the administrator's ability to manage and monitor product distribution efficiently.

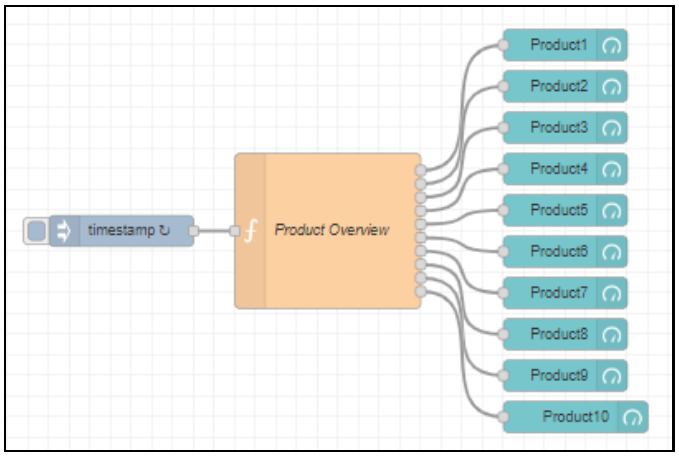


As mentioned earlier, the data is in real-time. Each vending machine publishes purchase information using the topic for the purchase, and the server receives this information in real-time.

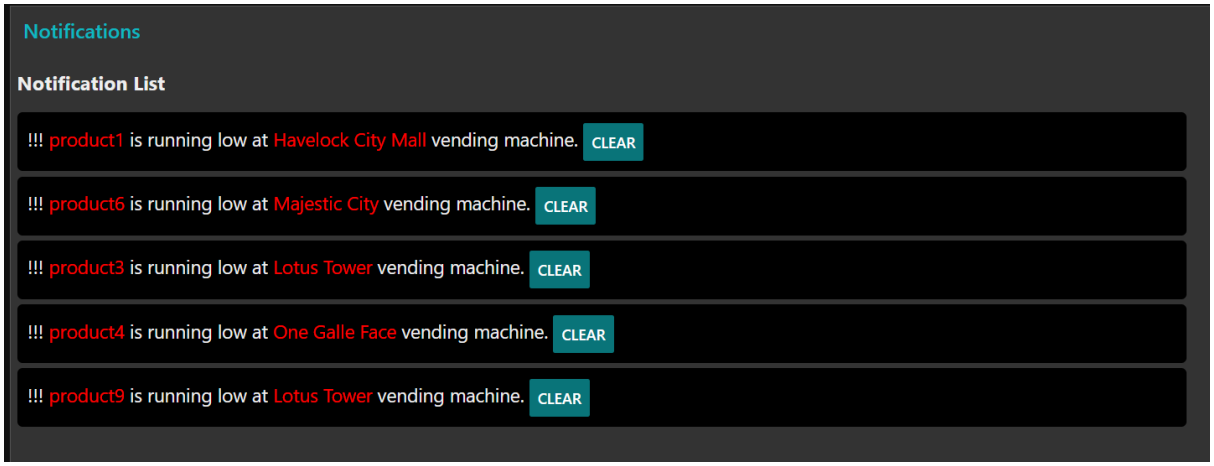


In the 'Product Overview' tab, administrators can access an overall view of the total available quantity for each product across the entire network of vending machines. This feature provides a centralized snapshot, allowing administrators to efficiently monitor and manage the overall product inventory in real-time.

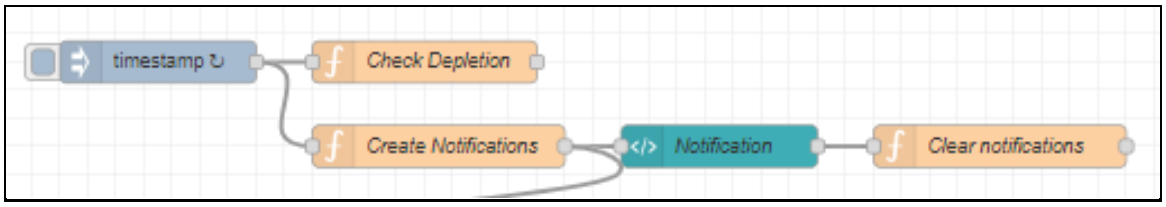
In a similar fashion, the data displayed in the 'Product Overview' tab is sourced in real-time from all vending machines within the network. This ensures that administrators have up-to-the-moment information, allowing them to monitor and assess the total available quantity of each product across the entire network in real time.



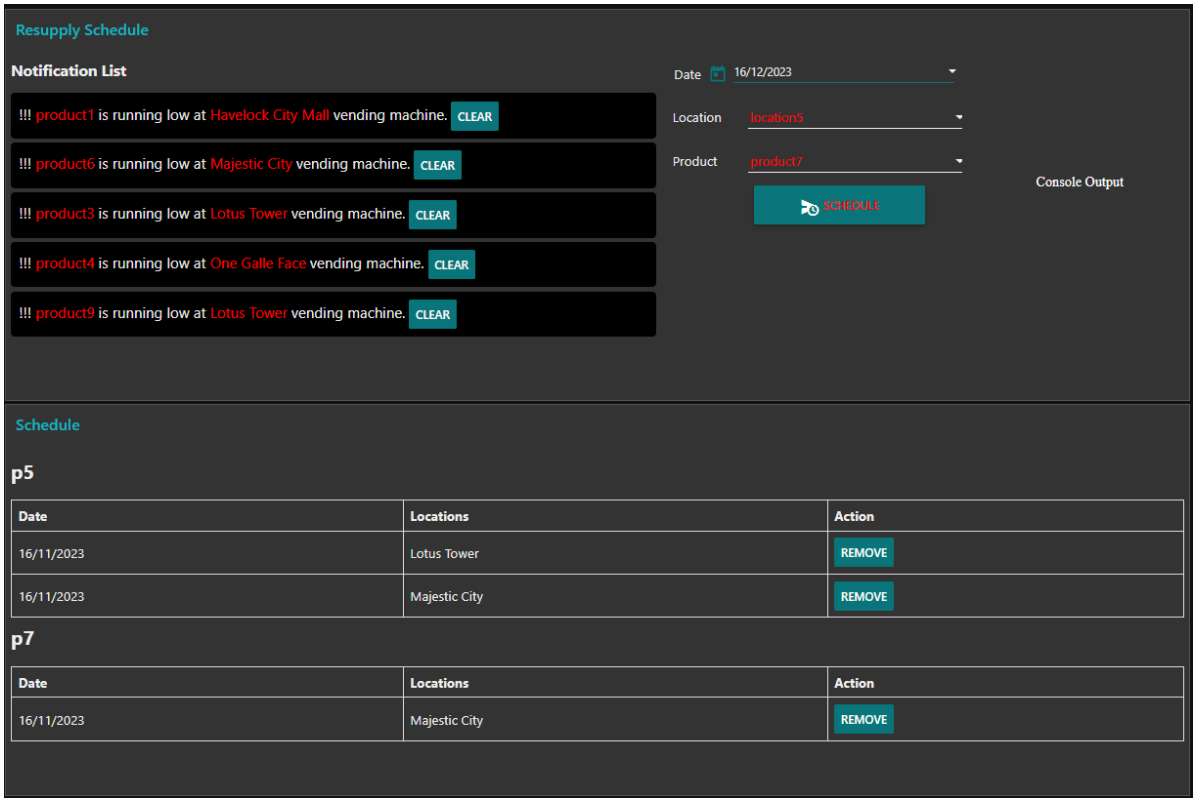
Notifications will be automatically sent to the server when a product falls below a predefined threshold value. This alert system allows administrators to stay informed about products in need of resupply, specifying the product and vending machine requiring attention.

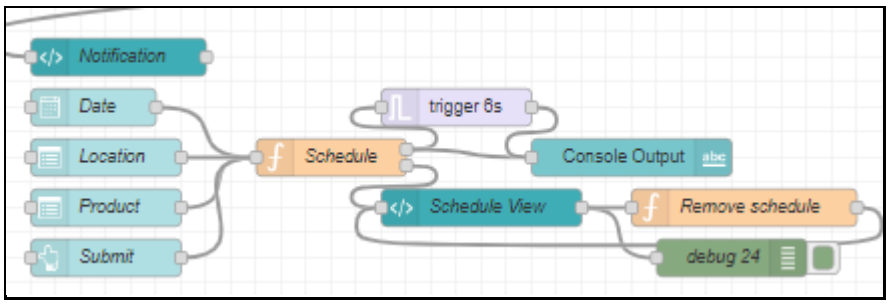


In the Node-RED function block, we define a function to create notifications when the quantity of any product in any location falls below a specified threshold value. The function block is responsible for generating notifications, ensuring timely alerts for products requiring attention.

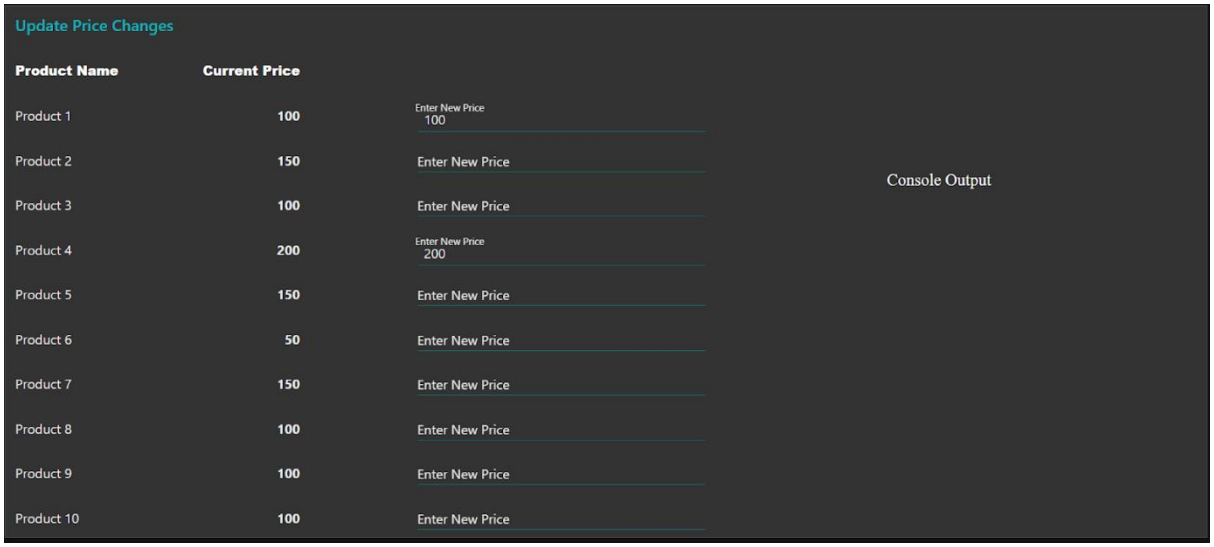


After receiving notifications, administrators can schedule resupply through the 'Resupply Schedule' interface. This involves selecting the resupply date, the location of the vending machine, and the specific product in need of resupply. By scheduling each resupply, a table is generated for products requiring restocking, sorted based on the date of resupply.

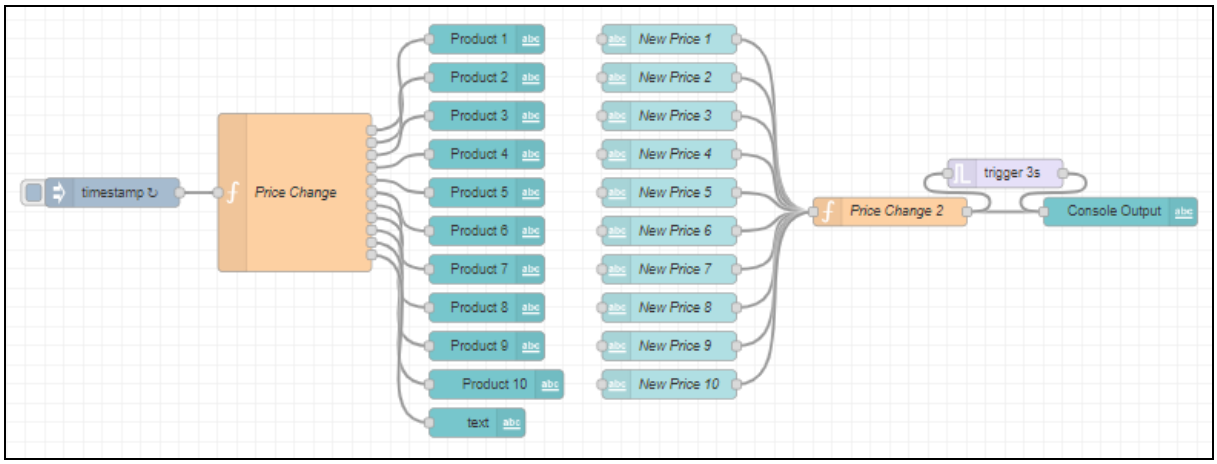




The 'Update Price Changes' interface allows administrators to easily modify the price of each product. In the event of a price change, administrators can update it here, ensuring automatic synchronization across all vending machines within the network.

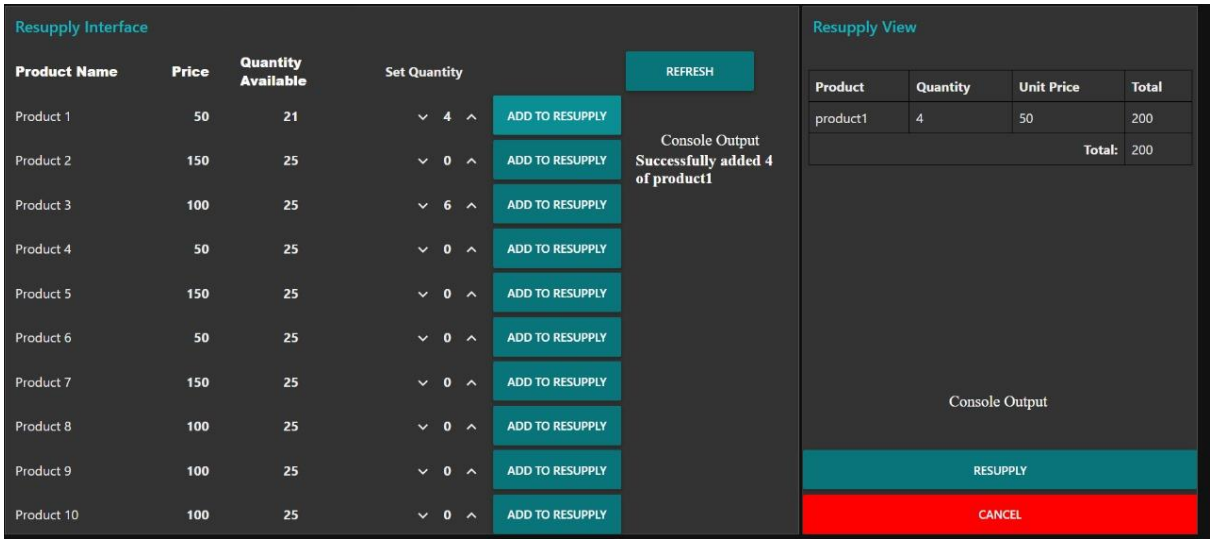


After changing the price, the information about the product in the server will be updated. Consequently, when the vending machine publishes a request for information, the server responds by publishing the updated product information.

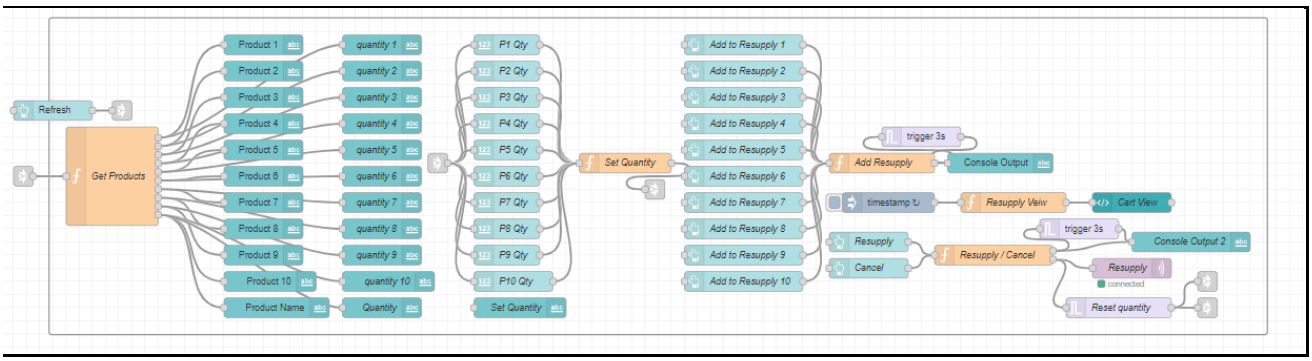


Hidden user interface

There's a hidden interface inside the vending machine which can be accessed only by the operators of the vending machine network. This will be used during the resupply of the vending machine. Once the resupply is done, the operator can update the resupplied quantity of each product, and this will be added to the number of quantities available, and it will be updated in the server too. This is the same as the Buy Menu interface of the consumer.



Upon clicking the "RESUPPLY" button, the resupply information is published as a JSON object through the topic for resupply. Simultaneously, the server is subscribed to the "Resupply" topic, allowing it to receive and process the resupply information. The server then updates the product availability based on this information.



Links

Git-hub repository : https://github.com/VijthanKurrshanth/iot-project-vending-machine-instance