Submission Instructions

1. Each group submits one copy of the report via Assignment in CANVAS, pdf format only; Filename: "FR-Lx-Gpy.pdf" (x: lab session number, y: group number)
1. Each group also submits the program code (in a zipped file, .zip) via Assignment in CANVAS; Filename: "FC-Lx-Gpy.zip" (x: lab session number, y: group number)
2. Deadline for submission: 11:59pm 30-April-2021

No late submission will be accepted.

EE3070 Project Final Report

Group No: L02 Gp 8

Project Name:

"Tab & buy"

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Contribution of each member for this report (Enter a "X" or Percentage to the part of which the person is in charge)

Item	Person in charge		
	Wong Ka Ho	Wong Ho Kit	Chan Tsz FUng
1. Summary	X		
2. Introduction	X		
3. Objectives			X
4. Functional Specification		X	
5. Technical Background	X		
6. Hardware and Software Architecture		X	
7. Project Schedule			X
8. Testing and Discussion	X		
9. Conclusion and Suggested Improvement			X

10. References	X		

Student Declaration Form

Academic Honesty Regarding EE3070 Project Design

The following are examples of academic dishonesty extracted from "Student Handbook" that are more applicable to final year projects.

- plagiarism, i.e., the failure to properly acknowledge the use of another person's work;
- submission for assessment of material that is not the student's own work;
- collusion, i.e., obtaining assistance in doing work which is meant to be solely the student's own work;
- use of fabricated data claimed to be obtained by experimental work, or data copied or obtained by unfair means;

It is important that the student reads the Student Handbook and understands the seriousness of academic dishonesty. The student should pay particular attention on how to avoid plagiarism.

Project Design Declaration

I have read the student handbook and I understand the meaning of academic dishonesty, in particular plagiarism and collusion. I declare that the work submitted for the project does not involve academic dishonesty. I give permission for my project report to be electronically scanned and if found to involve academic dishonesty, I am aware of the consequences as stated in the Student Handbook.

You made the declaration by giving the electronic signature below.

Member Name	Electronic Signature
Wong Ho Kit	
Wong Ka Ho	Isaac
Chan Tsz Fung	Frank

Note: Zero mark will be given to member who didn't sign in the above table.

Summary

This report mainly introduces the development process of the “tab & buy” system. “tab & buy” is a unmanned self-help system. It aims to provide an optimal solution to solve the difficulty facing buy different stores under the epidemic of the coronavirus. The “tab & buy” system will focus on the automation of taking products. After customers buy the product through an online shop, the goods will be sent to the target place and customers can take the goods via the “tab & buy” system. In addition, the “tab & buy” system has a server for recording the goods taking history. Ensuring the integrity of the products inventory. In our designation, we target to design a user friendly and simple controlling system. Thus, the system can be controlled easily. When the customer is in front of the system, it will provide a user guide on the OLED board. Thus, the user can use the “tab & buy” system step by step. Make the difficulty of using the system as low as possible.

Introduction

As the new coronavirus outbreak continues, the hygiene consciousness is rising between various Hong Kong people and even global citizens. The living habits of people have been changed. People tend to shop at home more than go to shopping malls or reality stores. Thus, numerous stores are facing a difficult time due to the decreasing number of customers. Some stores are planning to stop and even shut it down. Hence, we developed a “tab & buy” system to solve this urgent problem. Providing an alternative way in trading between store and customer.

From the perspective of the store, “Tab & buy” system can decrease the inventory space. In reality shops, shop owners are required to display the product in the shop and build up a good shopping environment. Thus, the shop owner needs to pay money for decoration and reserve the space for product display. If the owner adopts the “Tab & buy” system, they can have a better space utilization. It is because customers will select the product online and then take the product through the “Tab & buy” system. Therefore, The Shop owner only required to prepare a warehouse for product storage. And send a product to the “Tab & buy” system when the customer orders the products.

From the perspective of the customers, “Tab & buy” system can provide an alternative way to buy a required product. And the whole shopping process is more convenient and hygienic. “Tab & buy” system is a platform which combines the network and reality shop. The system provides a convenient way for people to stay at home and shop. Afterwards, the customer can take their product through the “Tab & buy” system by their own membership card and the card has the unique member ID to confirm the property product taking process. Furthermore, the customer will not contact any people directly in the whole shopping process. Thus, it is a more hygienic shopping system under the threat of COVID-19.

In addition, as we know many people like to try some new interesting things. “Tab & buy” system can provide an experience of a new intelligent shopping process. The system includes

many human-machine interaction designs. For example, the system has an auto-detection. When the customer is in front of the system. It will display a greeting on the OLED board and start the system tutorial for guiding the user make use of the system. The system will have a different interaction with the customer for building up a user-friendly environment in the whole shopping experience.

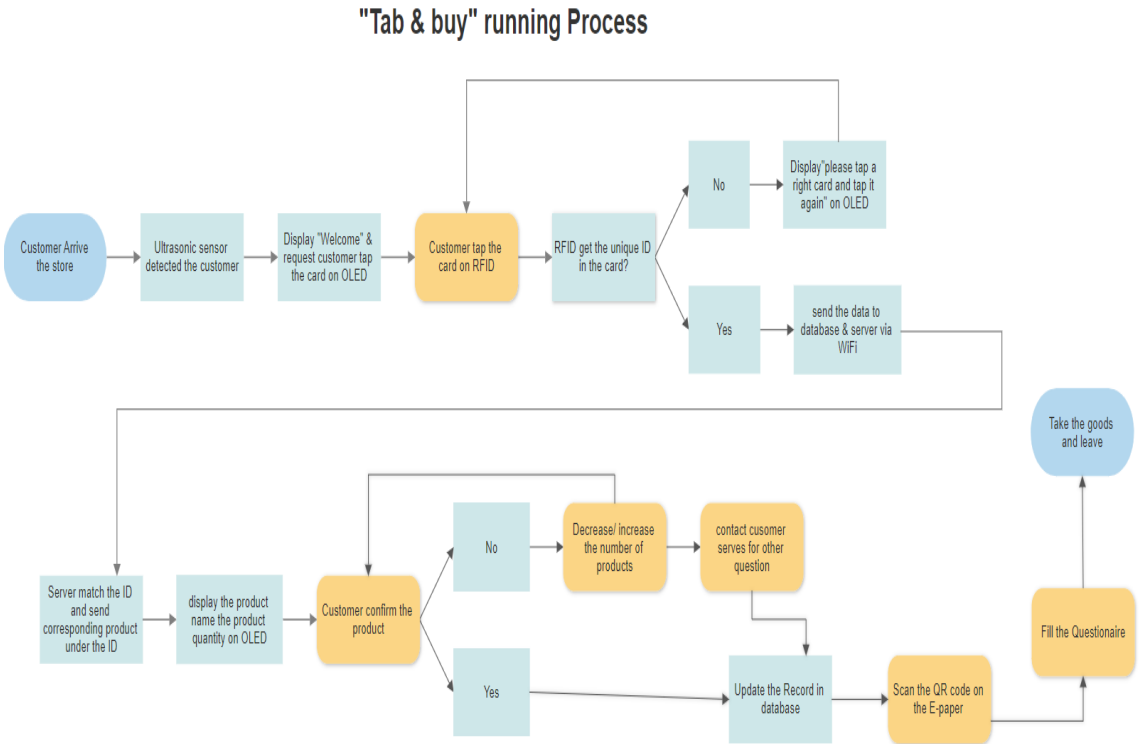
Objectives

- Cut down revenue and cost of the stores
- Provide a temporarily/first step for physical shops to transform to online shop
- Helping the shops to survive the current market
- Can be easily reversed to physical shop when needed

Function Specification

- Human-machine interaction
    - Human detection
- Authentication
    - User identification
- User interface
- HTTP communication
- Data Encryption

Technical Background



[1]

[1] https://drive.google.com/drive/u/4/folders/1fgMmLwjcefNAFcuuPug-QRVEcofOGC9p

In our “Tab & buy” system we used an ultrasonic sensor for detecting the customer and driving the system. The principle is that The ultrasonic transmitter emits ultrasonic waves in a certain direction, and starts timing at the same time as the transmitting time. The ultrasonic waves propagate in the air and return immediately when encountering obstacles on the way. The ultrasonic receiver stops timing immediately after receiving the reflected waves. The propagation speed of the ultrasonic wave in the air is 340m/s. According to the time t recorded by the timer, the distance (s) between the launch point and the obstacle can be calculated, namely: s=340t/2. This is the so-called time difference ranging method.

The principle of ultrasonic ranging is to use the known propagation speed of ultrasonic waves in the air, measure the time that sound waves reflect back from obstacles after launch, and calculate the actual distance from the launch point to the obstacle based on the time difference between launch and reception.

The formula of ranging is expressed as: $L=C\times T$

In the formula, L is the measured distance length; C is the propagation speed of ultrasonic waves in the air; T is the time difference of the measured distance propagation (T is half of the value of the time from emission to reception).As a result we can determine the is in front of the system. And send a signal to the OLED through arduino and display the greeting.

We adopt a RFID reader and RFID card act as membership card to confirm the identity of the customer when taking the product. The RFID working principle is that The RFID reader (reader) communicates wirelessly with the RFID electronic tag through the antenna, which can read or write the tag identification code and memory data. A typical reader includes a high-frequency module (transmitter and receiver), control unit and reader antenna.

Among them, electronic tags are also called radio frequency tags, transponders, and data carriers; readers are also called reading devices, scanners, communicators, and readers (depending on whether the electronic tags can rewrite data wirelessly). The electronic tag and the reader realize the spatial (non-contact) coupling of the radio frequency signal through the coupling element. In the coupling channel, according to the timing relationship, the energy transfer and the data exchange are realized. Thus, When the customer taps the membership card to RFID reader, arduino will receive the signal from the card reader. The OLED board will show the product list that the customer has bought. Customers can confirm or change the number of products by clicking on the button.

The “Tab & buy” system uses the LED for reminder the customer is successful in tapping the card or detected by the ultrasonic detector. The working principle of LED is that The LED photodiode is mainly composed of PN junction chip, electrode and optical system. The light-emitting process includes three parts: carrier injection under forward bias, recombination radiation and light energy transmission. When electrons pass through the wafer, the negatively charged electrons move to the positively charged hole area and recombine with it, and the electrons and holes disappear while generating photons. The greater the energy (band gap) between the electron and the hole, the higher the energy of the photon produced. Thus, the system can drive the LED light bulbs to show specific color when the customer is in front of the “Tab & buy” system. It turns off the LED when the reader reads the data in the membership card successfully.

In the “Tab & buy” system, it applies an OLED board as a main display. The working principle of OLED board is that OLED mainly driven by an electric field, organic semiconductor materials and luminescent materials achieve light emission through injection

more clear flow

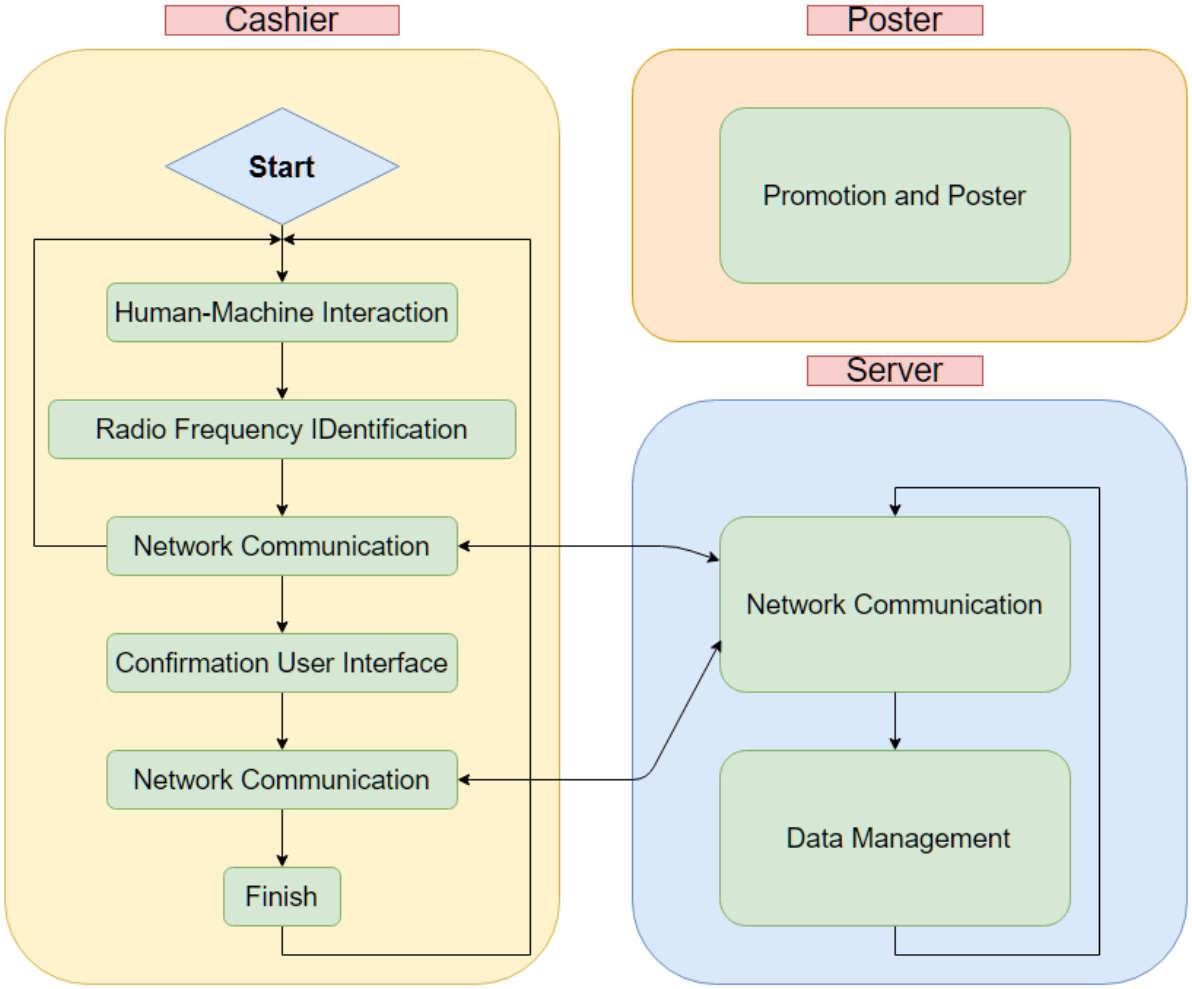
and recombination of overload carriers. Essentially, the ITO glass transparent electrode is used as the device anode, and the metal electrode is used as the cathode. Driven by the power supply, electrons are transported from the cathode to the electron transport layer, and holes are injected from the anode to the hole transport layer, and then migrate to light emission. After the two meet, excitons are generated to excite the luminescent molecules, and the light source is generated after radiation. Thus, OLED can display the required information and guide the customer to control the “Tab & buy” system properly.

In addition, “Tab & buy” system installed an E-paper as a second display system. The E-paper has the characteristics of lightness and portability of traditional paper. In addition, the electronic paper uses an electronic screen to repeatedly delete and write, and can also store a large amount of information; it does not need to be plugged in, it can be stored for a long time, and the data is stable and not easy to lose. Moreover, there is no need to waste any forest resources at all. It is a very attractive product in the modern era that emphasizes energy conservation and environmental protection. And E-paper working principle is that it is a two-layer transparent film (usually film) placed colored small particles with static electricity, the particles have two colors, each with different positive and negative static electricity, plus positive and negative electrodes on the outside of the film to repel the same polarity, different The principle of polar attraction is to move the position of small particles to make the arrangement into a font or pattern. However, E-paper has a significant display delay on the arduino system. Thus, E-paper acts as a second display but not the main display even though it has many advantages.

Hardware and Software Architecture

In this part, we would talk about the whole architecture of the project, to let you know how the product works step by step. The architecture of the product can break down into cashier parts and server parts, and each part would use different hardware and software. Before we talk about this two-part, we can have an overview of the product.

Product overview



This is the block diagram of the project. We group the function into different modules and use some simple input and output to communicate between them. Let me introduce the detail and design for the block design.

Product block design

Human-Machine Interaction Module

The first block of the project diagram is human-machine interaction modules, or we can just call it the human detection part. This is the part of the module on the cashier.

In this part, we would keep sending the ultrasonic with the ultrasonic sensor first and checking the echo signal from the ultrasonic sensor. Using the time of echo to calculate the distance between the ultrasonic and object. When the customer walks before the cashier machine and it is a short distance between the customer and the machine, it will trigger the LED on the cashier and pass to the next module.

Radio Frequency IDentification Module

The second block of the project diagram is Radio Frequency IDentification modules, or we can call it Card Reader. For each customer, they will have their own User ID card which will connect to their online shop account. So we can use the user id to identify their online shop account.

When the modules get triggered by the previous module, the OLED module will turn on and show the Instruction for how to use this machine. Until the customer uses the correct card to tap the machine, it will keep waiting to check the card on the card reader. When the customer uses the correct card, the LED will turn off and send the user ID to the next module.

Network Communication Module on Cashier

The third block of the project is the network communication module, which will be used to communicate with our Server. The data management and identification function would complete on the server-side since we need to care about the security reasons and the data synchronization between different cashiers. In our product, we would use the module multiple times to make sure we wouldn't get mistakes on the trading. The data will encrypt before we send it to the server, it can make the communication become secure. We only introduce the first communication of this module here, all details will show later.

When we get the user id from the previous module, we would use the encryption function to encrypt the id to id code. After we combine the id code and the trigger command, we can use HTTP to send it to the online holder, Dweet.io. After the cashier sends the HTTP request, it will keep waiting for feedback from the server-side. We will get three types of feedback with different number, 1 is mean the trade of this ID have found but not yet finish the payment, 2 is mean the trade of this ID have found and already finish the payment, 3 is mean can't find the trade of this ID. It will have two different actions with different feedback number:

- When we get feedback with number 3, it will show the message about the trade not found and turn back to the first module.
- When we get feedback with number 1 or 2, the cashier will access another online holder which holds the product list of the trading with using id code.

The product list and feedback code will pass to the next module.

Network Communication Module on Server

This is the Module that holds on the server and does the same job as the communication module on the cashier. This module will keep checking the request from cashiers. After the server gets the request, it will analyze the data and make it useful information. Since the data is already encrypted on the cashier-side, we should decrypt the data before we use it.We also only introduce the first communication of this module here, all details will show later.

When we turn on the server that holds on the computer, it will run this module first. At the beginning of this module, it will keep checking requests from the cashier by checking the data that holds on the Dweet.io holder. When it gets the request, we need to break down the data string to get the encrypted ID. Using the Decrypter to get the original ID. Then, the encrypted ID and original ID will pass to the next module.

Data Management Module on Server

The Data Management Module on the server-side can do multiple jobs on managing data, like comparing the data with the database and adding new data to the database. Since it is easier to protect all data in a single server or database than to protect all cashier machines which are sitting in different shops, the data management part and database will be set on the server-side. We will show the first data management function below.

When the module gets the encrypted ID and original ID from the cashier, it will be used to compare to the id inside the database of the trading list. After the comparison, we can get three different results, 1 is ID have found but not yet pay, 2 is ID have found and already pay, 3 is ID not found. It would have two different actions.

- When ID is not found, we would send back message 3 by the Network Communication Module.
- When the ID is found, it will upload the product list of the trading to the online holder using the encrypted ID, since all data is saved in the database inside the server. This part is done from the Network Communication Module.

Then the server will pass back to the network communication module and keep listening to the next request from the cashier.

User Interface Module

The User Interface Module is setting on the cashier, and the aim of this module is to let the customer confirm the trading is correct and finish the trading. To confirm the customer trading is correct after we get the product list from the network communication module, we should display the product list which they already choose on the online shop. Since we want to make the confirmation more user-friendly to customers, we design this module into an interactive user interface module to provide more operations. Customers can know the product list, number, and price by looking at the OLED display. At the same time, they can use different buttons to control the UI. So that the customers don't need to access the online shop in real-time to change the number of products.

When it gets the product list and feedback code from the network communication module, it will show the product name, number, and price one by one with a list on the OLED. Since it is two different feedback codes, it will take different actions.

- When it is already paid, the customer doesn't need to confirm it with the UI, since they already paid it online. The machine will display the product in a few seconds and print out the receipt. They just need to use the receipt to get the item on the counter.

- When it is not yet paid, the module will pass into the confirmation user interface. It can let them confirm the products list and use it to change the number of products that they want to buy and to confirm the trade. In the control panel function, we can define all steps into 2 levels. The first level is the confirmation level, we can confirm the product that point by the arrow in this level, we just need to push the enter button to confirm it one by one. The second level is the Change Mode level, we get in the change mode by pushing the circle button. We can change the number of the product which is pointed, by pushing the up and down button. After completing the confirmation. The machine will display the product in a few seconds and print out the receipt. They just need to use the receipt to pay and get the item on the counter.

After the trading is done, the cashier will send the receipt to the server by the Network Communication Module. All work is done, turn back to the first module (Human-Machine Interaction Module).

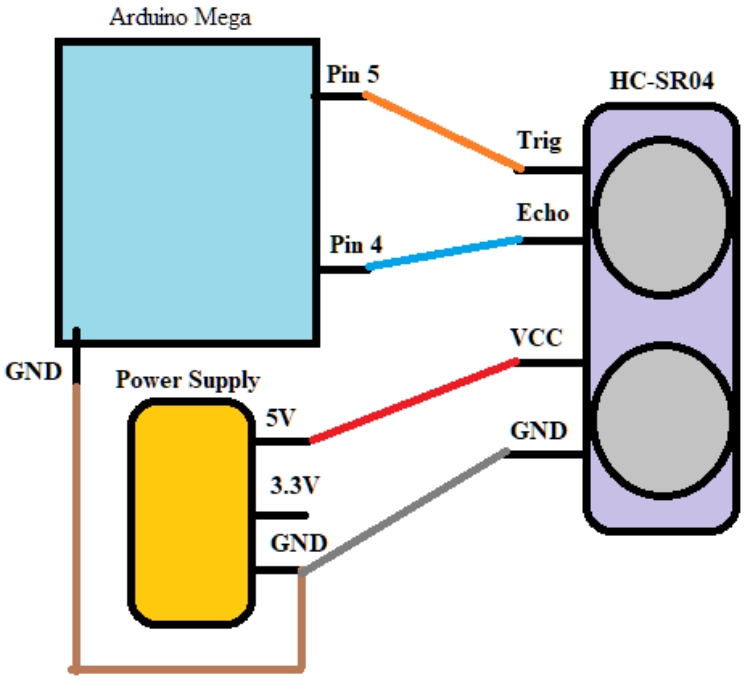
Promotion and Poster Module

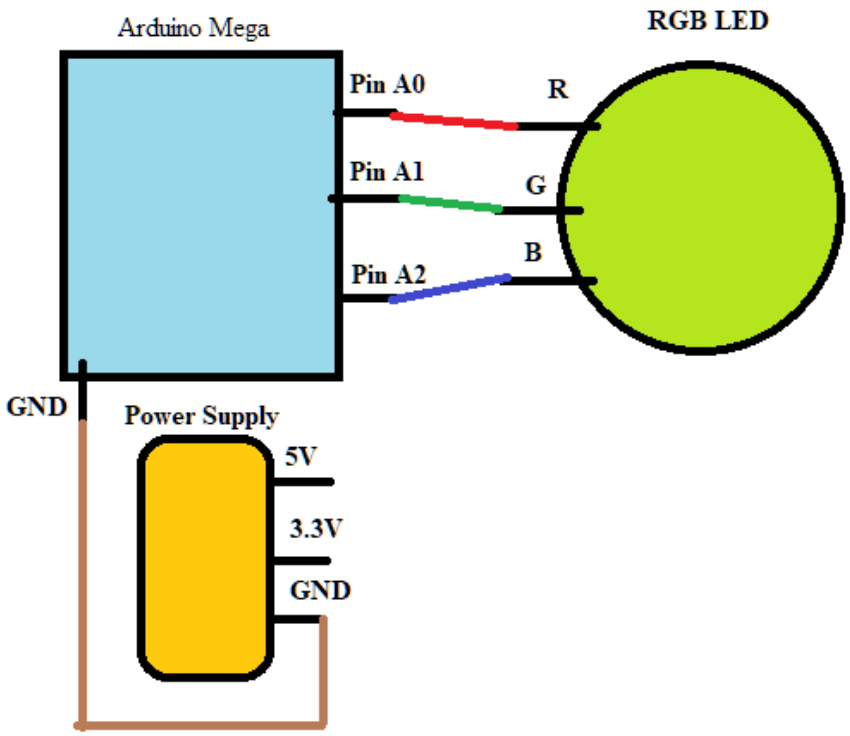
This is the extra module setting in the shop to display useful information. We want to have an area to display the promotion and poster for a long time, so we design this module outside of the cashier system. E-paper is a good choice for display posters since it wouldn't be a high frequency to reflash, and it is no energy using on hold the image.

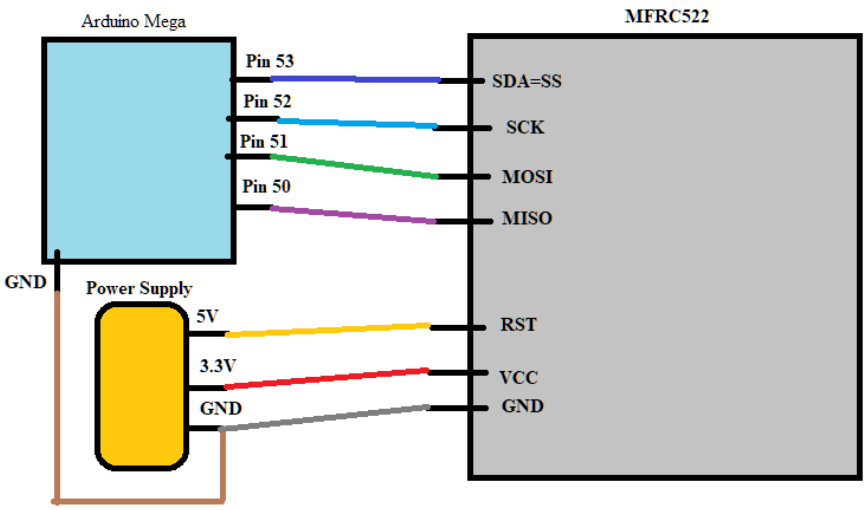
In this module, we use the e-paper to display the QR code of the questionnaire. We can get feedback and do research by the questionnaire, to improve the service.

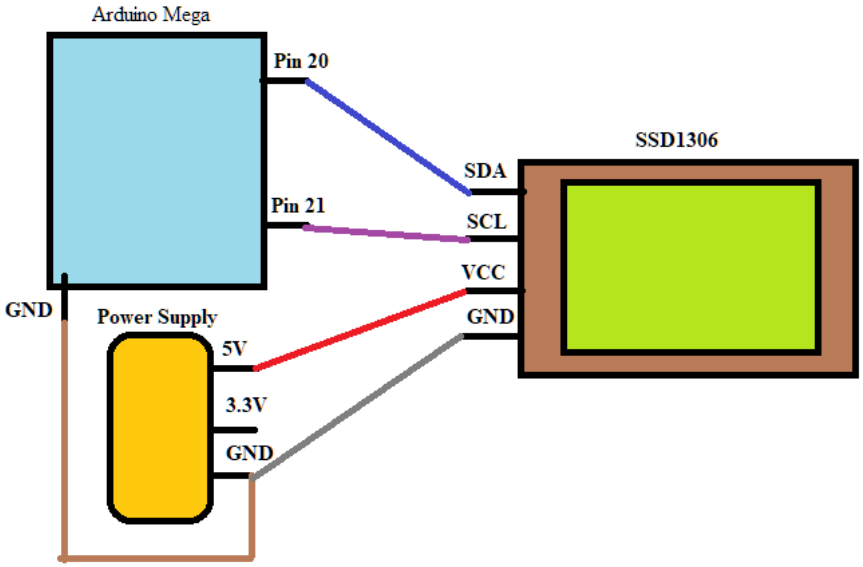
Hardware Components

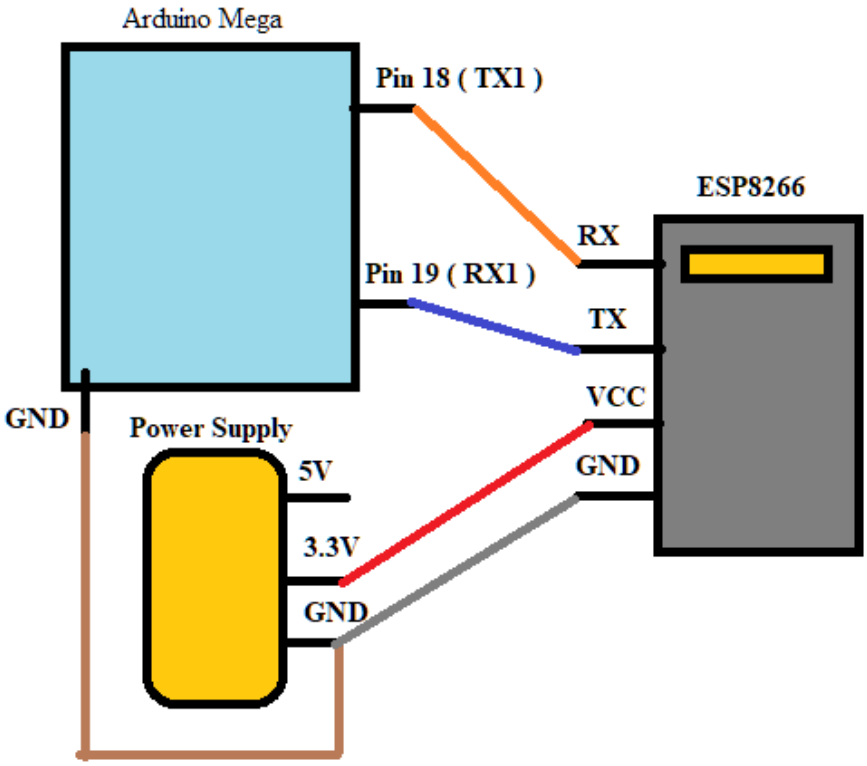
Since the server-side is held on the computer, we only list out the hardware components of the cashier machine.

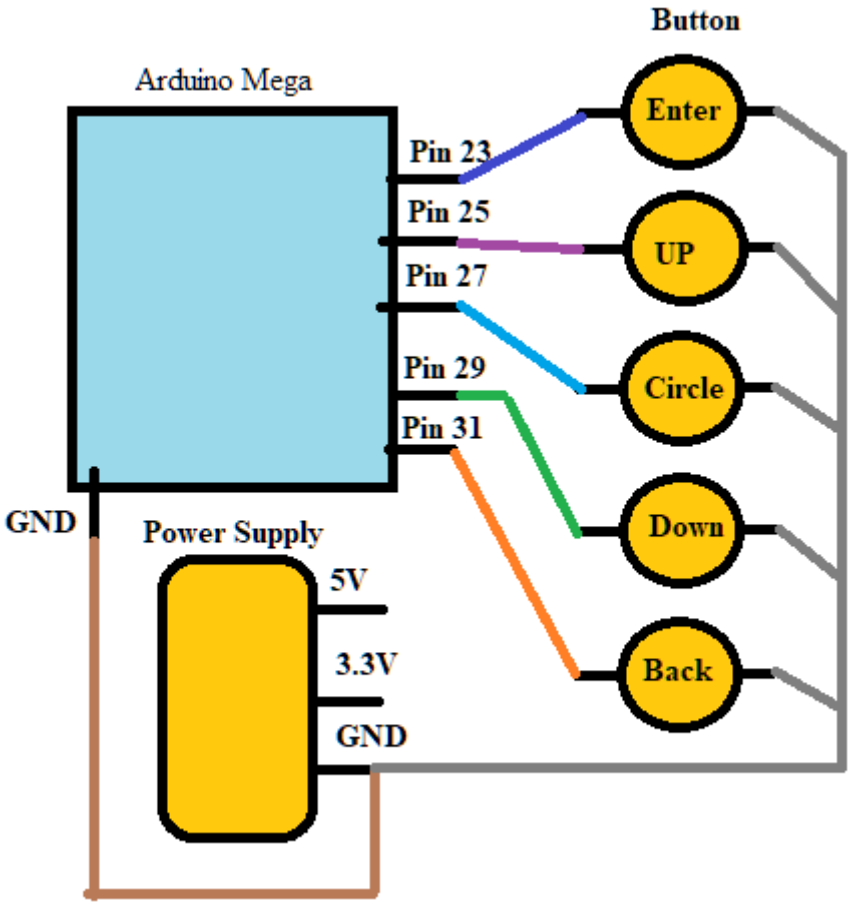
Components Name	Ultrasonic Distance Module (HC-SR04)
Hardware connection diagram	
Usage	**Human-Machine Interaction Module**
Setting and Libraries	It does not need to include libraries. Pin 5 connects to the trigger pin, with output mode. Pin 4 connects to the echo pin, with input mode. We would use pin 5 to trigger HC-SR04, and listen pin 4 to get feedback.

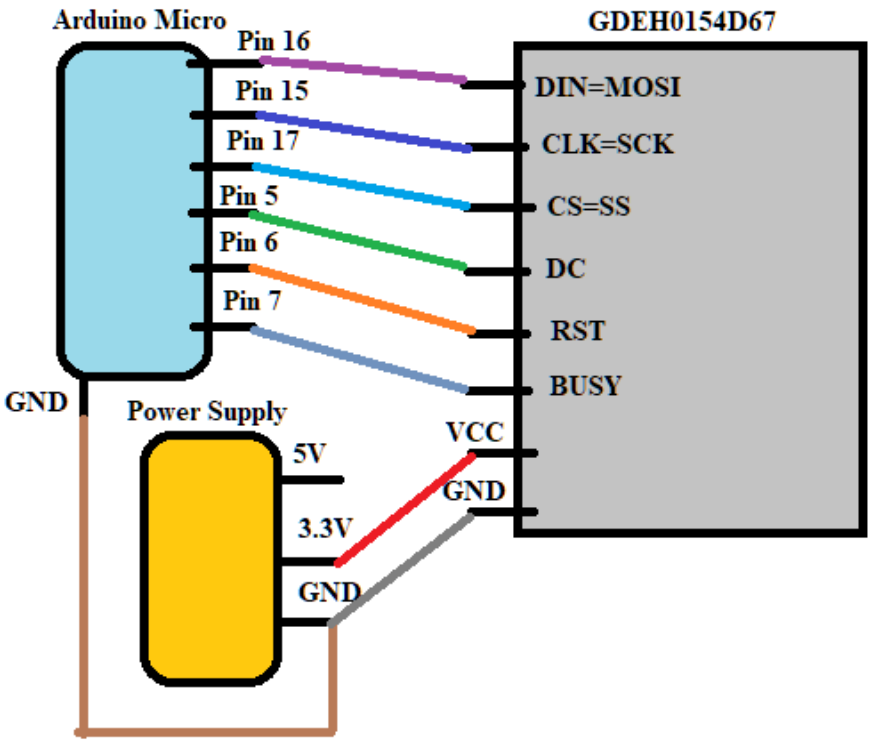
Components Name	LED
Hardware connection diagram	
Usage	**Human-Machine Interaction Module** **Radio Frequency IDentification Module**
Setting and Libraries	It does not need to include libraries. Analog pin A0 connects to the R pin, with output mode. Analog pin A1 connects to the G pin, with output mode. Analog pin A2 connects to the B pin, with output mode. We can output the int between 0 to 255 in 3 analog pins to control the color of the LED.

Components Name	RFID (MFRC522)
Hardware connection diagram	
Usage	**Radio Frequency IDentification Module**
Setting and Libraries	We can include the following libraries: • <SPI.h> • <MFRC522.h> Pin 53 connects to the SS pin. Pin 3 connects to the RST pin. Create an MFRC522 instance by MFRC522 mfrc522(SS_PIN, RST_PIN). Pin 51 and Pin 50 are the SPI ports.

Components Name	OLED (SSD1306)
Hardware connection diagram	
Usage	**All Module**
Setting and Libraries	We can include the following libraries: ● <Adafruit_SSD1306.h> ● <SPI.h> ● <Wire.h> ● <Adafruit_GFX.h> Set the SCREEN_WIDTH to 128. Set the SCREEN_HEIGHT to 32. Pin 20 connects to the SDA pin. Pin 21 connects to the SCL pin. Set the text size of OLED to 1. Set the text color of OLED to white.

Components Name	Wireless transceiver module (ESP8266)
Hardware connection diagram	
Usage	**Network Communication Module on Cashier**
Setting and Libraries	We can include the following libraries: ● "WiFiEsp.h" ● "SoftwareSerial.h" Set the ESP_BAUDRATE to 115200, since we need to have enough baud rate to send data. Pin 18 connects to the RX pin, for serial communication. Pin 19 connects to the TX pin, for serial communication. We communicate to the ESP8266 by using serial 1. Create the WiFiEspClient name client.

Components Name	Button
Hardware connection diagram	
Usage	**User Interface Module**
Setting and Libraries	It does not need to include libraries. Pin 23 connects to the Enter Button, with input pullup mode. Pin 25 connects to the Up Button, with input pullup mode. Pin 27 connects to the Circle Button, with input pullup mode. Pin 29 connects to the Down Button, with input pullup mode. Pin 31 connects to the Back Button, with input pullup mode. Before we push the button, we will keep getting signal 1, since it is pullup mode. When we push the button, the signal we get the button becomes 0 since it is connected to GND.

Components Name	Epaper (GDEH0154D67)
Hardware connection diagram	
Usage	**Promotion and Poster Module**
Setting and Libraries	We can include the following libraries: ● <GxEPD2_BW.h> ● <Fonts/FreeMonoBold9pt7b.h> Define max display buffer size to 800. Include the image bitmap which we already created before.

Project Schedule

Week 1	● Discussing the main function of our project ● Making the flow chart of or project ● Testing the simple function(s) such as E-paper
Week 2	● Writing the function of OLED, RFID and ultrasonic sensor ● Brainstorm the flow of python server side
Week 3	● Choosing Dweepy as the bridge of the WiFi module ● Constructing the WiFi function in Arduino ● Starting to write the log in function in python
Week 4	● Making a very simple database ● Expending the python functions to match the RFID with the database ● Test-run the simple version of our project and debug
Week 5	● Doing calculation with the product quantity and price in database with python ● Polishing the display (E-paper and OLED) ● Adding button control ● making an online survey
Week 6	● Adding a simple ID encryption to Arduino and decryption in python ● Rearrange the flow to shorten the run-time ● Final test-run and debug
Week 7	● Preparation of the demonstration

Testing, Results and Discussion

Test	Result	Discussion
Drive the OLED to display difference information	success	OLED can display the information properly and have a low delay in control.
Drive the E-paper to display difference picture	success, but have a delay	there is significant delay while changing difference picture it will affect the user experience on the system Solution : use OLED as main display and E-paper as second display to display static pictures.
Drive the RFID reader and read the RFID card	success	we develop the RFID system to be a base of membership system. Each customer will have a RFID card as a membership card and it can tap the card on the RFID reader to get the product form “Tab & Buy” system.
Drive the Ultrasonic sensor to detect the distance of the object	success	We drive the ultrasonic sensor to detect when the customer is arriving at the “Tab & Buy” system. The sensor will send the signal to drive the system for energy saving and maintenance cost reducing.
Drive the WiFi module with connect to different network	success, little delay when connect in certain WiFi	We connect the arduino and database server via WiFi. But there will be a slight delay when connecting to a specific network. Solution: avoid connecting to the network that will appear delayed.

build a membership point system for shopping	success, but it is little complicate for customer	We have designed a membership point system but it is not very suitable for our system because we prefer to provide a simple platform to customers. And different stores will have different business strategies. Some stores may not want to have a membership point system.
build a simple database server	success	We build a database for storing and data and it will sort the data properly. when the arduino sends a data request. The serve will send a corresponding data to arduino.
Create a online survey	success	As we want to Improve the quality of the “Tab & Buy” system continuously. We use an online questionnaire and set up a few simple questions to analyze the user feedback after using the “Tab & Buy” system.
product quality adjustment system	success	Customers can click the button to adjust the number of products. It can make sure the quantity of the product is correct.

Conclusion and Suggested Improvement

After this 7 week project, the most prize we learnt is that the flow of a project has a serious impact on the performance. The response time of our system improves quite a bit after we rearrange some of the functions we had. Also, to design a system that is easy to use, it is better for us to think about it in the view of users. Some steps or procedures may seem obvious to us (the designers) but it is unreasonable to the users.

Our system is a platform that provides a mix-mode of physical and online shop. Customers were to use a membership card to login and get the shopping list that he previously made with a smartphone online, which he can pay right away with a credit card or make the payment in cash later, and get the goods in the physical shop. Upon confirming his identity and shopping list with the membership card, our system will make a checkout ticket for him and the shopkeepers. He can then get his products and make the payment (if he hasn't with the credit card) from the shopkeepers. The test-run time for the final version is about a minute which is acceptable and there is no error that we can observe.

To the retail, we are not really an online shop but more like a physical shop that is enhanced by online features. While the shop is not as "convenient" as an online shop and may seem pointless, there are many shops that still have a contract on revenue and may not want to become an online shop. Our system provides them a quick way to survive in the current market and leave them the choice to decide should they switch back to a physical shop or continue as a hybrid of both.

Of course, being a 7 week project, our system is very simple. The login system is as simple as just a match line by line in the database which is going to cause a significant increase of time when the number or membership increases. To solve this, we might have to break the database into smaller sections with different prefixes. Our system will first search for the prefix and find out the according database before matching the actual ID, that should shorten the login time by a lot. Also, we should use a higher level of encryption such as Advanced Encryption Standard (AES) or Triple Data Encryption Standard (TripleDES) to ensure the privacy of the customers.

Reference

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Format: font size – 12 points, single-spaced

Section 1 - Summary (about 150 words)

- A concise and qualitative overview of case;
- No specific technical terminologies;

Section 2 – Introduction (300 words)

- Give a brief description of the problems, how they are tackled; and how your customers can be benefited;
- Provide an overview of how the work was performed, and highlight the most interesting results and the innovation.

Section 3 – Objectives (in point form)

- List of objectives of the whole project

Section 4 – Function Specification (in point form)

- List the functions provided by system
- If possible, list out some distinct features

Section 5 – Technical Background (800 words)

- Briefly discuss relevant background theory for the whole project [This part is different from Section 2. It gives readers with the general picture about the system. However, it is unnecessary to describe the hardware and software design, as the details will be given in Section 6]

Section 6 – Hardware and Software Architecture (1500 words)

- Introduce and describe your design work
- Give clear figures to describe the hardware design, eg. how to connect different modules or communicate
- Give flow chart or block diagram for your software design.

Section 7 – Project Schedule

- Describe the actual schedule for the whole project development.

Section 8 – Testing, Results and Discussion

- Give a list of functional tests on the system, with reference to Section 4

- Describe the results obtained and give comments on the performance
- Discuss the difficulties faced in real implementation and expected outcomes and how it can be improved

Section 9 – Conclusion and Suggested Improvement

- Do a reflection on what you learnt
- Summarize the functions and performance of your design
- State the impacts of your design to Retail
- Suggest improvement on the design

Section 10 – References

- If you are referring to any external source or my lecture notes, state the source here.
- If the reference is an article, give the author name, article title, publication title, volume no., issue no., page no., year of publication.
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Appendix: Submit your code to CANVAS

- Submit your codes (in zipped file) to CANVAS. Filename: FC_Lx_Gpy.zip (x is the lab session number and y is the group number)

Note: You may add other sections if appropriate.